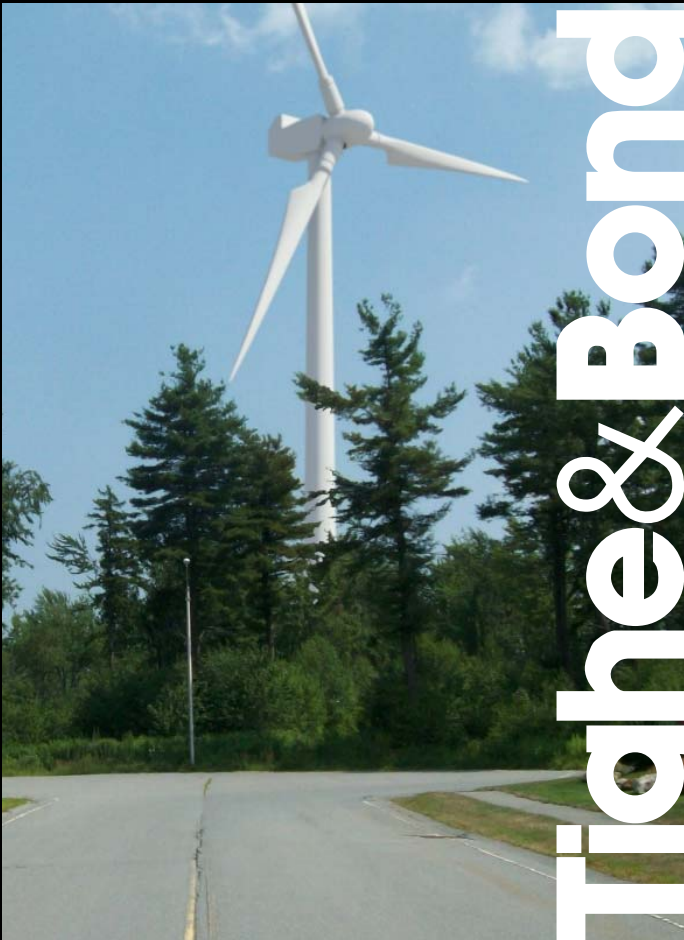




Tighe & Bond

Summit Industrial Park
Wind Turbine

City of Gardner Wind Turbine Feasibility Study

Prepared For:

**City of Gardner
Gardner, Massachusetts**

January 2011

Executive Summary

Tighe & Bond has completed this Feasibility Study on behalf of the City of Gardner, Massachusetts to analyze the potential for wind energy development at the Summit Industrial Park. This report was funded through the Massachusetts Clean Energy Center (MassCEC) Community Wind Incentive Program: Community Scale and satisfies the criteria outlined in Solicitation No. 2010-CWIPCS-01 (Block 2). The City of Gardner began the process to study the feasibility of installing a wind turbine in 2009 through the completion of a Site Assessment, completed by DNV Global Energy Concepts. Since the Site Assessment did not identify any fatal flaws with the project, the City worked with Tighe & Bond to obtain a grant for the Feasibility Study under the solicitation listed above.

The purpose of the Feasibility Study is to provide the City of Gardner with the tools needed to make planning decisions regarding the development of a wind turbine. The study also includes recommendations for further action towards the design and construction of a turbine. As noted herein, after further analysis, the Feasibility Study did not identify any fatal flaws with the project and the financial indicators are favorable. **Therefore, it is recommended that the City move forward with the project, and pursue funding for design and construction activities.**

1 Background

The City of Gardner is in Worcester County, in north-central Massachusetts. Gardner is neighbored by Westminister to the east, Hubbardston to the south, Templeton to the west, and Winchendon and Ashburnham to the north. The City is located 30 miles northwest of Worcester and 60 miles northwest of Boston and encompasses 23 square miles. Gardner is a city of 20,770 people (2000 Census) established in 1785.

The City has selected the Summit Industrial Park ("Park") to be developed for wind energy based on the zoning, topography and available land. The Park was developed in 1997/1998 by the Gardner Redevelopment Authority (GRA), an independent economic development agency for the City of Gardner. The Park is located on Suffolk Lane off of Pearl Street (Route 101), two miles to the North from Route 2. The Park is nearly 100 acres and already has six current tenants. Infrastructure, including the roads and electrical service, was built to industrial subdivision standards. The proposed wind turbine site is approximately 20 acres of relatively level land on Lots 4 and 5 of the Park. Nearby lots are occupied by five manufacturing facilities as well as the Highridge Wildlife Management Area (WMA), a permanently protected open space owned by the MA Division of Fisheries and Wildlife (DFW). Figure 4-2 shows the Summit Industrial Park in detail.

2 Summary of Evaluations

The Feasibility Study documents data, calculations and research to support conclusions on the wind resources, site considerations, environmental and regulatory requirements, and financial indicators applicable to development of a wind turbine. Data and conclusions are summarized in each section of the Feasibility Study outlined below.

In the Site Assessment for the Summit Industrial Park site submitted to the Massachusetts Technological Collaborative (MTC) (now MassCEC) on October 16, 2009, DNV Global Energy Concepts, Inc. (DNV) recommended that wind resource assessment proceed with data from meteorological towers located at the North Central Correctional Institute (NCCI) and Mount Wachusett Community College (MWCC), which are approximately 1.0 and 1.8 miles from

the turbine location, respectively. Since NCCI is closer and at a similar altitude to the turbine location, it was found that the measured data was more representative and all calculations presented are based on that data set.

Wind Resource Assessment.

The wind resource assessment and energy analysis strategy followed these steps in succession:

- Determine which data set of the NCCI/MWCC data was most complete and would provide the best wind statistic
- Generate a long term wind statistic for the project site
- Analyze multiple turbines and configurations for Annual Energy Production (AEP) and time-varying production
- Analyze typical losses and model uncertainties for each turbine to get 20-year average P50 and P90 AEP and Capacity Factor

In order to document the viability of this process, the following reports from WindPro are attached in Appendix B of the Feasibility Study: PARK, Loss & Uncertainty, and SHADOW. These reports list assumptions made for each calculation as well as results. WindPRO reports for all turbine configurations are included.

According to the analysis, there is a good (class 3) wind resource at the Site. The average annual wind speed at 80 meters above ground level is 6.8 m/s when the average tree height is conservatively taken as a displacement height in the model. The analysis performed included long term correlation, losses, uncertainty and development of P50 and P90 AEP and capacity factor estimates. The P50 and P90 AEP for each turbine is included in Table 1-3 in the report. The P50 AEP ranges from 2,110-4,624 MWh/year and the P90 AEP ranges from 1,754-3,895 MWh/year, depending on the turbine configuration. The analysis was found to be viable, but further viability could be achieved by obtaining a more accurate long term data set or placing a wind monitoring device on the Site. The uncertainty was carried through the economic analysis and it is evident that the larger turbines are viable at the upper and lower bounds of AEP uncertainty. Therefore, additional wind resource modeling and purchase of more accurate long term data is not recommended at this time. However, depending on the funding sources sought, some additional field data collection may be required to satisfy the lender / bond issuer.

The Feasibility Study evaluated five representative wind power generating systems. We attempted to evaluate the impact of varying hub heights, rotor diameters, plant configurations, and nameplate capacities on project economics, through the evaluation of representative turbine models available from several manufacturers. Our study did not include an exhaustive evaluation of all manufacturers and models currently available on the market. Accordingly, while our study includes a recommendation on an optimal configuration concept, it should not be construed as a recommendation of a specific manufacturer and model for this project. Once the project advances to the design stage, the turbine selection process will be influenced not only by the characteristics recommended in this study, but by the design team chosen and the existing relationships each firm has with turbine manufacturers.

As determined through the AEP calculation, it would be most economically (and environmentally) feasible to place one large turbine on the Site due to the loss in energy

capture due to wake effects, as well as the relatively small zone of high winds on-site. The turbine with the highest AEP at the Site is the Vestas V82, which is to be expected due to its tall hub height and large rotor diameter. The Vestas V82 also has the best capacity factor, which shows that the turbine also has an appropriate power curve for the Site and wind speeds.

Site Evaluation

The Site Evaluation described the characteristics of the Site that will effect turbine selection and the characteristics of the turbine that will affect the Site and surroundings. The following detailed subsections were included:

- **General Description:** Description of the Site, neighboring properties, physical land characteristics and expected community acceptance. The project is consistent with the City of Gardner's recent and historic development.
- **Land Use:** Description of the existing uses on the Site and abutting parcels, and evaluation of potential project impacts to these uses. Impacts to abutting land uses are not anticipated.
- **Zoning:** Description of the zoning requirements for the project, including a discussion of the City of Gardner Wind Energy Conversion System Bylaw. A Special Permit is required and the project may require a fall area easement.
- **Airspace Restrictions:** Description of the Federal Aviation Administration (FAA) process for the project. Note that a Determination of No Hazard currently exists for the Site
- **Interconnection Analysis:** Description of existing electrical infrastructure, proposed interconnection, and City of Gardner electrical load, and an overview of the National Grid interconnection study process. Interconnection is anticipated to occur at the end of Summit Drive.
- **Site Access:** Description of the likely turbine delivery route, potential restrictions and weak points, and a discussion of staging areas. A Super Load Permit from MassDOT will be required and permits related to minor roadway modification, such as temporary sign removal, will likely be required from the City and MassDOT.
- **Turbine Noise:** Analysis of potential noise impacts on residential and commercial abutters. Due to the turbine location, unacceptable noise impacts are not anticipated.
- **Shadow Flicker and Viewshed:** Description of calculations, mapping and visualizations performed to assess the visual and shadow flicker impact of the turbine. Some shadow flicker mitigation may be required, specifically for the manufacturing facilities in the Summit Industrial Park.

Through the Site evaluation it was determined that no turbine evaluated presents a fatal flaw based on the above factors. In order to accommodate a turbine as large as the Vestas V82, a fall area easement may be required from the Highridge Wildlife Management Area (WMA). Also, some shadow flicker mitigation may be required for any turbine installed.

Permitting and Regulatory Review

The Environmental and Regulatory review expanded upon the Site discussion in the previous section by including detailed analysis of wetlands, flora, and fauna; avian and bat considerations; and historic/cultural resources. This section also includes anticipated permitting obligations at the local, state and federal level and a permitting plan which describes the strategy for successful completion of the pre-construction permitting. It is critical that the City have a good understanding of the potential level of effort associated with these tasks for future project planning. Permitting for the project is not expected to be onerous.

Financial Analysis

The financial analysis was formulated to express the data collected in this Feasibility Study in economic terms for the City to use as a tool for decision making. The Section gives an overview of the major economic drivers in the wind industry followed by a discussion of potential and expected revenue and cost for each turbine configuration. The Feasibility Study includes a preliminary pro-forma for the project that takes the above into account as well as financing mechanisms and the time value of money. The turbine configurations being included in this financial analysis are the same as were modeled in the energy analysis. These include a Vestas V82, Furhlander FL MD77, GE1.5sle, PowerWind 56 and two PowerWind 56 configurations. While our study includes a recommendation on an optimal configuration concept, it should not be construed as a recommendation of a specific manufacturer and model for this project. Turbine selection will be influenced by the design team chosen and the existing relationships each firm has with turbine manufacturers as well as the current turbine market conditions.

It was concluded that the project will not be installed unlevered (I.e. a debt-free scenario), since the City would be required to allocate up to \$4 million to the project during design and construction. It is our understanding that the City does not have the capital available. However, this project appears financially viable with 100% debt, which is the likely model to be used by the City. Despite the high capital costs expected for wind energy projects, the revenue captured through net metering could completely offset the capital cost and the cost of debt in 8 to 12 years, for the larger turbines. The most economically viable turbine configuration modeled is the Vestas V82, which has an 80m hub height and 82m rotor diameter, due to the higher revenue from generated electricity.

3 Conclusions and Recommendations

The above factors affecting the feasibility of wind energy development at the Summit Industrial Park were summarized in Table 1, below. The table shows that although the permitting effort may be slightly higher due to its size and associated impacts, installation of the Vestas V82 or similar size turbine would be the most beneficial to the City in terms of energy production and financial payback.

It is recommended that the City continue to pursue the development of a wind turbine at the Summit Industrial Park. Based on the information in this Feasibility Study, it would be beneficial to pursue further study and design and construction of a single turbine in the 1.5 – 1.65 MW range. The turbine should have a hub height between 70 and 80m and a rotor diameter in the same range in order to utilize the medium wind speeds on site. Since the turbulence intensity of the wind is relatively high, an IEC Class A turbine is recommended. Since the wind speeds are medium to low at hub height, an IEC Class IIA turbine will be appropriate.

The largest turbine, the Vestas V82 or equivalent, would provide the most financial benefit for the City. However, the V82 may not meet zoning requirements regarding setbacks, and

development of the project may depend on the ability of the City to obtain a Fall Area easement from the Highridge Wildlife Management Area. It is recommended that the City begin negotiation for the easement during business planning. In the case that obtaining the easement becomes a fatal flaw, it is recommended that the City reduce the size of the rotor or the hub height in order to meet the requirements of the zoning ordinance. Two turbines of slightly lesser size (GE1.5sle and FL1500) were modeled to compare similar technology at both 80 and 65m hub heights. The 80m hub height performed significantly better due to higher wind speeds. It is possible that an 80m hub height may be necessary to achieve a satisfactory financial result from this project and the City is encouraged to pursue a fall area easement or reduce the rotor size to meet regulations before siting a lower turbine. Overall, the City has a good Site for wind energy development, and should take further action to develop the project.

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TABLE 1
Overview of Feasibility

Factor	Vestas V82	FL1500	GE1.5sle	PowerWind 56	PowerWind 56 (x2)	Comments
Rated Capacity (kW)	1650	1500	1500	900	1800	
Hub Height (m)	80	65	80	71	71	
Rotor (m)	82	77	77	56	56	
Maximum Tip Height (m)	120m	100m	119m	97m	97m	
Capacity Factor	32.0%	25.8%	30.6%	26.8%	25.8%	
Turbine Availability	6-12 months	8-9 months	6-12 months	8-9 months	8-9 months	Availability not expected to be the limiting factor for schedule
AEP (MWh; P50, 20-yr average)	4,624	3,395	4,016	2,110	4,071	
Land Use	No Conflict Expected	No Conflict Expected	No Conflict Expected	No Conflict Expected	No Conflict Expected	
Zoning	May require fall zone easement in Highridge WMA	No Conflict Expected	May require fall zone easement in Highridge WMA	No Conflict Expected	May require fall zone easement in Highridge WMA	The City may seek an easement from Highridge Wildlife Management Area (WMA)
Airspace	DNH	DNH	DNH	DNH	Must obtain DNH for second turbine location	Current determination of no hazard (DNH) is sufficient for all turbines, but will require modification to add a second turbine
Electrical Equipment	\$65,000	\$65,000	\$65,000	\$65,000	\$80,000	Added cost for the double turbine configuration is for additional materials
Site Access for Turbine Delivery	Good	Good	Good	Good	Fair	Turbine Delivery Route will require little modification for any turbine
Environmental Factors:						
Wetlands	Minimal/No Impact	Minimal/No Impact	Minimal/No Impact	Minimal/No Impact	Minimal/No Impact	Impact related to transport of turbine on roads through wetland buffer zones
Rare Species	Impact Not Likely	Impact Not Likely	Impact Not Likely	Impact Not Likely	Impact Not Likely	
Bird and Bat	Moderate Impact	Low Impact	Moderate Impact	Low Impact	Moderate Impact	Estimates based on hub height as well as swept area
Shadow Flicker Impact	Moderate Mitigation Required	Minor Mitigation Required	Minor Mitigation Required	Minor Mitigation Required	Minor Mitigation Required	Mitigation refers to measures to reduce flicker at the manufacturing facility next door
Noise Impact	Possible Noise Study	Possible Noise Study	Possible Noise Study	Possible Noise Study	Possible Noise Study	If a concern for health and safety is raised by the manufacturing industries within 1000 feet of the turbine
Permitting Requirements	Moderate Permitting Effort	Minimal Permitting Effort	Moderate Permitting Effort	Minimal Permitting Effort	Moderate Permitting Effort	Estimates based on additional permitting/review related to larger turbine models
Est. Capital Cost	\$4,184,500	\$3,973,900	\$4,114,300	\$3,060,900	\$5,933,100	
Est. O&M Cost	\$60,000	\$60,000	\$60,000	\$60,000	\$120,000	
Financial Viability (leveraged)						
IRR	13.3%	9.4%	11.3%	7.3%	5.7%	
NPV (6% Discount)	\$4,342,600	\$1,805,500	\$3,040,700	\$476,400	(\$243,500)	
Payback Period (years; 6% Discount)	7.3	12.2	9.2	18.8	32.6	
Feasibility	Feasible	Not Feasible (65m)	Feasible	Not Feasible	Not Feasible	The FL1500 with an 80m hub height would most likely be feasible



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Acronyms

MTC	Massachusetts Technology Center (Former name of MassCEC)
MassCEC	Massachusetts Clean Energy Center
DNV	DNV Global Energy Concepts, Inc.
NCCI	North Central Correctional Institute
MWCC	Mount Wachusett Community College
AEP	Annual Energy Production
WASP	Wind Analysis Program
RERL	UMASS Renewable Energy Research Laboratory
IEC	International Electrotechnical Commission
MCP	Measure Correlate Predict
NCEP	National Center for Environmental Prediction
NCAR	National Center for Atmospheric Research
USGS	United States Geographical Service
agl	above ground level
GRA	Gardner Redevelopment Authority
WMA	Wildlife Management Area
DFW	Department of Fisheries and Wildlife
REC	Renewable Energy Credit
USDA	United States Department of Agriculture
NRCS	National Resources Conservation Services
WECS	Wind Energy Conversion System
ZBA	Zoning Board of Appeals
FAA	Federal Aviation Administration
DOD	Department of Defense
Awg	American wire gauge
MassDOT	Massachusetts Department of Transportation
EDIP	Economic Development Incentive Program
EWG	Exempt Wholesale Generator
EPA	Environmental Protection Agency
NPDES	National Pollutant Discharge Elimination System
ENF	Environmental Notification Form
MEPA	Massachusetts Environmental Policy Act
RDA	Request of Determination of Applicability

WPA	Wetlands Protection Act
TOD	Time of Day factor



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Section 1

Wind Resource Assessment

In the Site Assessment for the Summit Industrial Park site submitted to the Massachusetts Technological Collaborative (MTC) (now MassCEC) on October 16, 2009, DNV Global Energy Concepts, Inc. (DNV) recommended that wind resource assessment proceed with data from meteorological towers located at the North Central Correctional Institute (NCCI) and Mount Wachusett Community College (MWCC), which are about 1.0 and 1.8 miles from the turbine location, respectively. The data from these two monitoring sites was collected over a period from 2006 to 2009 and has been used in two previous MassCEC funded feasibility studies that have advanced to design and construction. The Site Assessment Deliverable for the Summit Industrial Park, a MassCEC form including information from the Site Assessment is included in Appendix A.

Since meteorological measurement was not being conducted at the Summit Industrial Park, modeling software was used to predict wind speed and annual energy production (AEP) at the turbine site. The software used for the analysis was WindPRO, created by EMD International. WindPRO operates in conjunction with Wind Analysis Program, WASP, developed by Risø DTU, the Technical University of Denmark. Initially, data collected by the met towers was cleaned for bad data due to icing and evaluated at potential hub heights using a simple vertical extrapolation at the met tower locations. Once the data was considered sufficient in accuracy based on evaluations described below, it was extrapolated across the terrain by the WASP model to yield wind profile information at the proposed turbine location. The calculation modules of WindPRO used in the resource assessment were: STATGEN, MCP, PARK, Loss&Uncertainty and SHADOW. The PARK and Loss&Uncertainty modules perform calculations with data sets developed in STATGEN and MCP to yield the standard indicators of the resource assessment, Annual Energy Production (AEP) and capacity factor, at various probabilities and with a particular uncertainty. SHADOW was used in the visual impact assessment.

Although initial wind speed calculations for the Feasibility Study were performed using data from both NCCI and MWCC, only the NCCI data set was used to complete the entire wind assessment since it became apparent that the MWCC data would significantly increase the uncertainty of the analysis for several reasons, such as a greater horizontal and vertical distance from the turbine location. Furthermore, the MWCC site did not meet a basic criteria of good modeling practices for the WindPRO software: site similarity. The MWCC site is considered significantly dissimilar due to its proximity to a water body and the downtown City of Gardner as well as the relatively flat surrounding terrain. While some of these factors could have been accounted for in the model, it is expected that the MWCC data would have induced a higher level of error in the wind speed predictions than the NCCI tower, which is at a site very similar to the turbine location. Use of MWCC data was not justified.

Section 1.1 gives a description and background information for the wind data collected at the NCCI measurement location. Section 1.2 and 1.3 describe the methodology used for transformation of the data from the NCCI measurement location into a long term corrected wind statistic. Section 1.4 describes the wind profile at the measurement location and Section 1.5 describes the same wind profile characteristics for the turbine location at an 80m hub height. Sections 1.6 and 1.7 give an overview of the turbines that were modeled on the site and the energy production expected from each configuration.

At NCCI and MWCC wind speed and direction were monitored with redundant anemometers and wind vanes at multiple elevations on a 50 meter tower for at least a year. Both towers and instrumentation configurations are described in detail below, in Table 1-1. The University of Massachusetts Renewable Energy Research Laboratory (RERL) was responsible for tower installation, as well as data collection and analysis at the NCCI site. At MWCC, wind resource assessment was provided by E.F. McCarthy & Associates. Both wind resource assessments were conducted according to standard industry practices.

TABLE 1-1

Wind Resource Data - Meteorological Tower Configuration

Tower Characteristic	NCCI Tower	MWCC Tower
Type	Guyed Wire	Guyed Wire
Location	N 042° 34.86 W 071° 56.34	N 42° 35.428 W 71° 59.026
Dates Recorded	January 23, 2007 – January 29, 2008	March 2006 – December 2008
Interval Recorded	10 min	10 min
Logger Time Zone	GMT -5, EST	GMT -5, EST
Height	50 m	50 m
Instrumentation		
Logger	NRG Symphonie Data Logger	Second Wind NOMAD
Wind Speed	NRG Max # 40 (m/s)	NRG Max # 40 (m/s)
Measurement Heights	2 at 49m 2 at 38m	2 at 48m 2 at 30m 1 at 20m
Wind Direction	NRG Wind Vane #200P (degrees)	NRG Wind Vane #200P (degrees)
Measurement Heights	1 at 49m 1 at 38m	1 at 49m 1 at 30m 1 at 20m
Temperature	NRG #110S Temp (°C)	N/A

1.1 Measurement Location Data

The NCCI met tower average monthly wind speeds at measurement heights (38m and 49 m) are shown in Table 1-2.

TABLE 1-2

Mean Monthly Wind Speed (m/s): NCCI Met Tower

Month	38m	49m
January	5.79	6.25
February	6.46	6.93
March	6.44	6.95
April	5.45	5.83
May	5.08	5.53
June	5.07	5.54
July	4.60	5.01
August	4.43	4.82
September	4.80	5.23
October	5.12	5.61
November	5.54	6.03
December	5.30	5.73
Average	5.34	5.79

Wind Shear

Wind shear is the change in wind speed with height. On rough land (“roughness” determined by factors such as nearby forest and buildings), such as at the NCCI met tower location, the shear is best represented by the power law:

$$\frac{U(z)}{U(z_r)} = \left(\frac{z}{z_r} \right)^\alpha$$

$U(z)$ = Wind Speed at reference height z

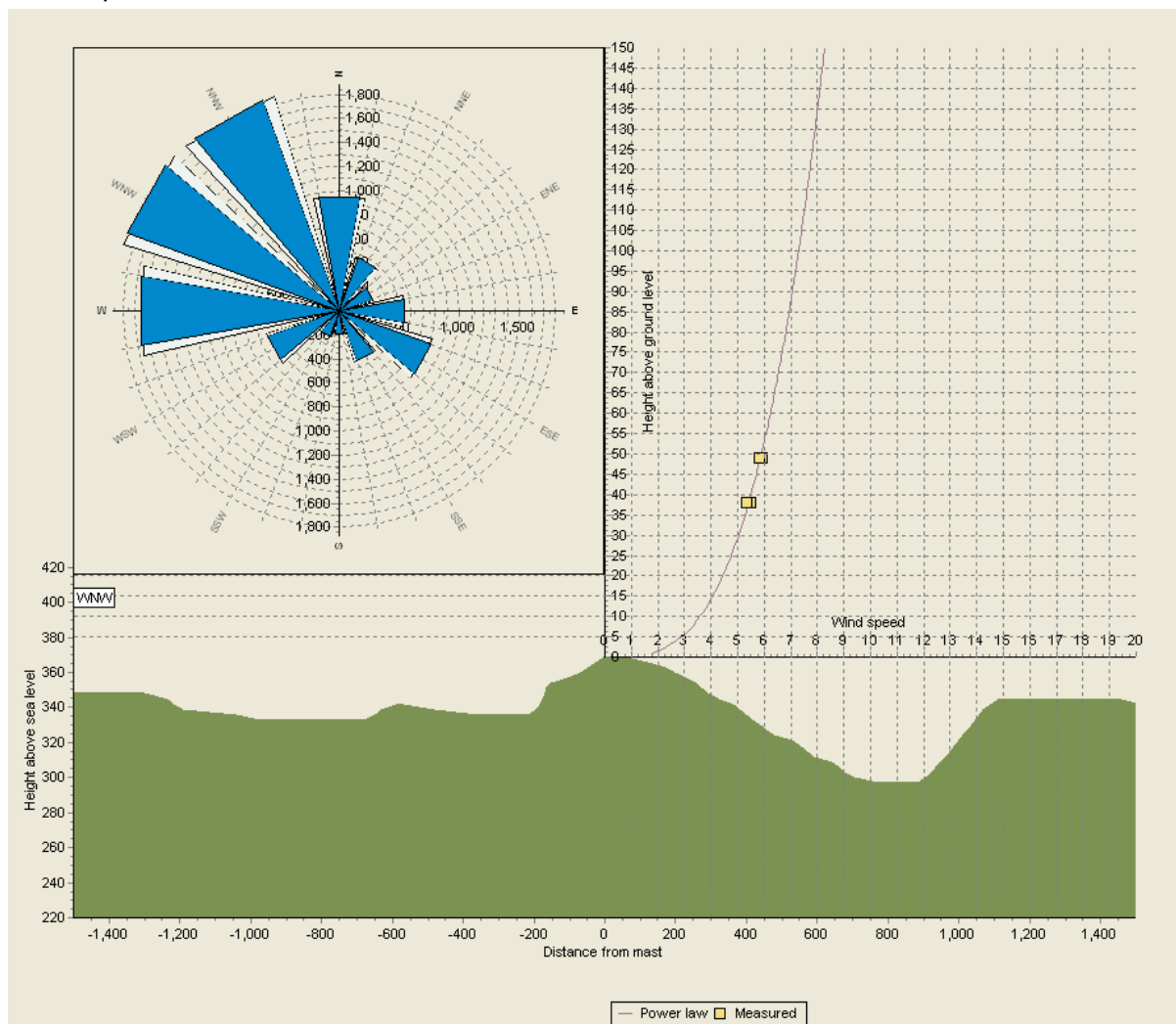
$U(z_r)$ = Wind Speed at reference height z_r

Using the measured wind speed data in the above formula, the power law exponent (α) is equal to 0.322. Since wind shear is a function of the frictional conditions at the ground, this value should be consistent with the value expected for the type of terrain. Typically, heavily wooded areas with tall trees have a shear exponent between 0.25 – 0.45. Since the shear exponent is in the expected range, a vertical extrapolation of the measured data at the met tower location was performed. Hub height wind speeds of 6.27 m/s at 60m and 6.70 m/s at 80m were calculated with the raw data at the measurement location. Figure 1-1 is a wind speed profile including the terrain surrounding the NCCI met tower that shows wind speeds measured and calculated using the power law. The terrain profile is a cross section cut from the west-north-west (prevailing wind direction) and elevation and profile height are shown in meters.

A high shear exponent is good for wind energy development because it implies that wind speeds will increase rapidly as height increases to the hub. However, shear can cause excess mechanical stress on the turbine parts since the difference in wind speed in contact with the blades will vary greatly from top to bottom. In order to anticipate the maximum shear a turbine will need to withstand at this site, the exponent was calculated for the day and night seasonal data. The highest seasonal shear exponent achieved was nighttime in autumn. Turbine selection will take this value, 0.41, into account. Manufacturers pay attention to this value since it will dictate the degree of wear and tear their machine might need to withstand and it may not be possible to procure a turbine for a site with a very high shear value.

FIGURE 1-1

Wind Speed Profile at Measurement Location, NCCI Met Tower Data



1.2 Measurement Location Wind Statistic

Data from the NCCI met tower was analyzed with WindPRO to create a wind statistic for the area around the met tower and proposed turbines. A wind statistic is a wind speed

data set that has been created by extracting the effect of the terrain and surface roughness from the measured data. This data set can then be used in WAsP to translate wind speeds to other locations where the effect of terrain and roughness is added back in.

1.2.1 Terrain Characterization

In order to create the wind statistic from the met tower data, the characteristics of the land were digitized in WindPRO.

The topography and surface roughness for the area surrounding the met tower at the NCCI site and turbine were characterized according to industry standard and guidelines recommended in WindPro. The terrain was created from a GIS shape file of United States Geographical Society (USGS) 3m contour lines. Contour lines were thinned using the WindPRO line data tools in order to reduce the data size for use in WAsP while maintaining accuracy.

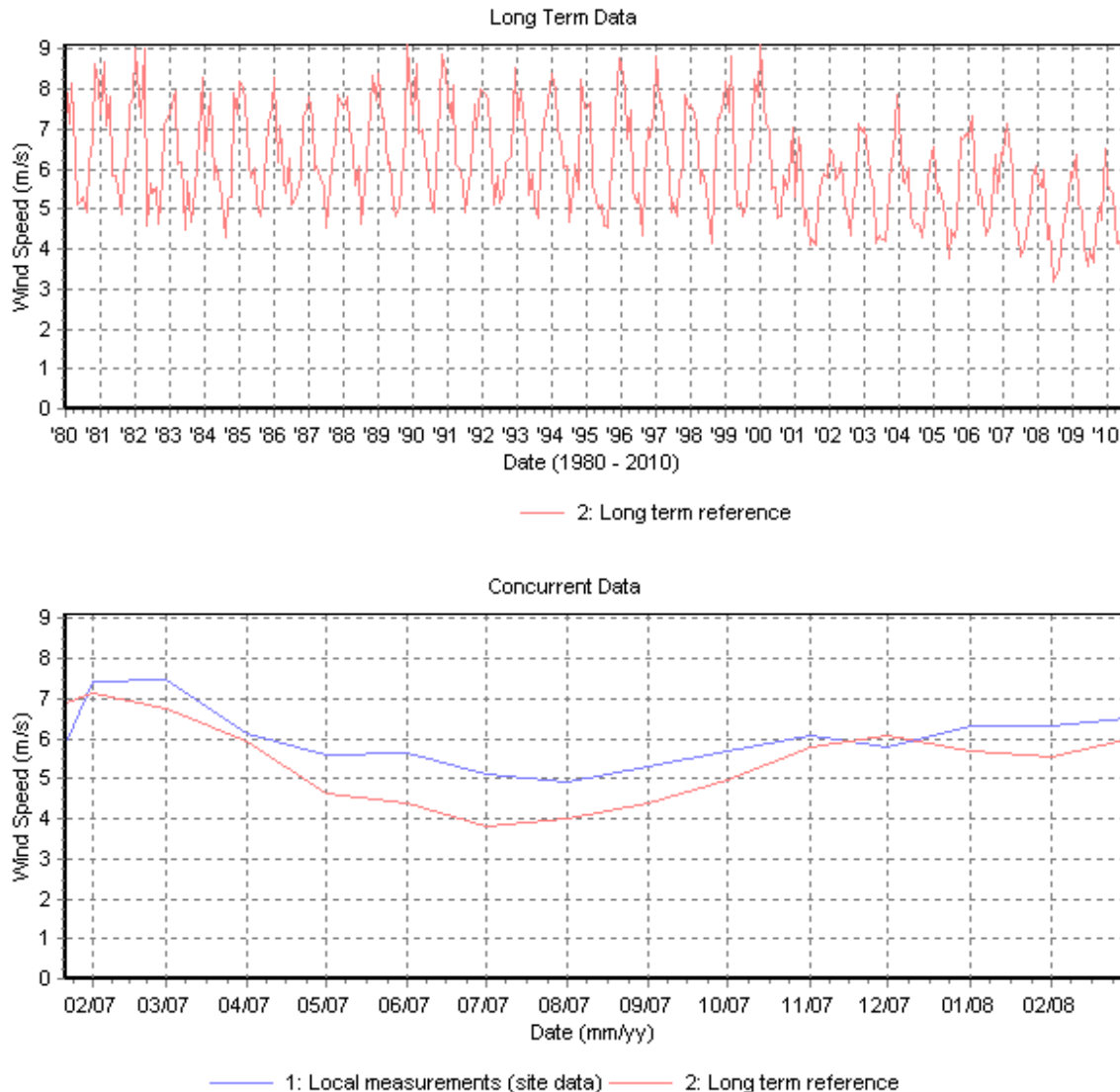
The surface roughness was mostly characterized as a 3.0 with a roughness length of 0.4m, typical of dense forested areas. Large water bodies and cleared areas were identified with a lower roughness classification (roughness 0.2 and 2.0, respectively). Background roughness was set to 3.0 to ensure a conservative estimate.

1.3 Long Term Corrected Data Series

The measure-correlate-predict (MCP) process was then used to adjust the wind statistic to better match long-term meteorological trends for the area and create a long term corrected data series. It is important to correlate the measured wind speed data to long term data to be sure the collected data set matches the wind climate. The long term data set used for correlation is from the National Center for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) reanalysis project. The NCEP/NCAR reanalysis model is a global assimilation model that takes a wide range of measured climate data into account. The model provides assimilated data at a 42.0 m height every 2.5 degrees at a temporal resolution of 6 hours. Thirty years of NCEP/NCAR data, from 1980 – 2010 was used as the long term data set. NCEP/NCAR data consists of wind speed, wind direction and temperature. The data is similar to proprietary Virtual Met Mast data, but does not offer flexibility in location of the virtual mast. The NCEP/NCAR data set used for this study is from a location about 29 miles away from the turbine location to the West. Figure 1-2 shows the total NCEP/NCAR data set as well as the period where long term and measured data are concurrent. Note that the measured data shown is from 49m while the long term data is a 42m measurement.

FIGURE 1-2

Long Term Data Set



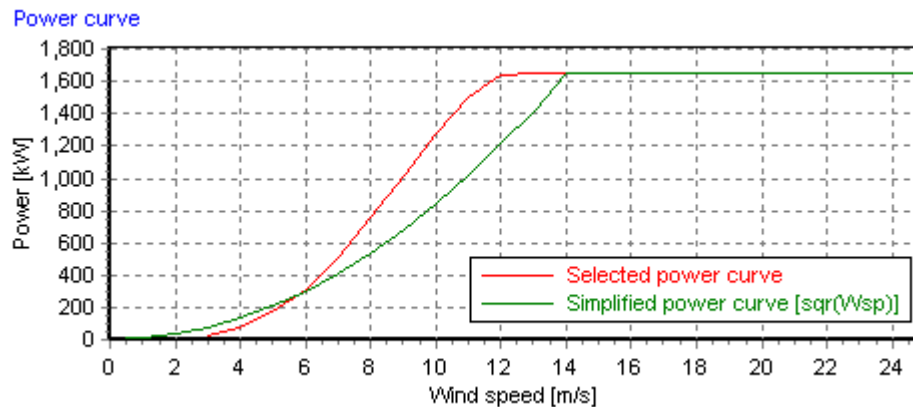
NCCI measurement location data correlates to NCEP/NCAR data well, with a correlation coefficient of 0.9484 (classified as “very good”). The quality of long term correlation will not affect the energy production estimates, but a poorer correlation will increase uncertainty in the annual energy production estimates.

Since the NCEP/NCAR long term data was used for correlation, a wind index prediction method was used to complete the MCP process, as recommended in WindPRO literature. The wind index prediction uses monthly averages of the energy yield to predict long term wind speeds at the site based on the short term data set. The directional distribution of the wind is not considered and a power curve, either general or turbine specific, is required in order to calculate the energy yield. The method is less sophisticated than other methods commonly used, but offers stability in performance.

For this study, the wind index was calculated using a general turbine power curve to check the correlation factors and compare the prediction method with others. Figure 1-4, below, shows the general power curve that WindPRO suggests for use with the wind index method. The “selected power curve” shown on the figure is the Vestas V82 power curve, included for comparison.

FIGURE 1-3

General Power Curve



In order to conservatively account for the uncertainty of the correlation process, year-to-year variability of the long term data was included in uncertainty calculations. Section 1.6.2 provides more detail on the uncertainty estimate.

1.4 Measurement Location Wind Statistic Profile

Average Annual Wind Speed (80m)

Average annual wind speed was calculated at the measurement location using the long term corrected wind statistic created with MCP. Wind shear, described above, was used to extrapolate the wind speed data from 49m to 65m and 80m. Figures and data included in the remainder of this section will be for an 80m hub height, typical for the Vestas V82 and GE 1.5sle turbines. Calculation results for 65m hub height can be found in Appendix B. The wind statistic (effects of terrain and surface roughness extracted) mean wind speed for all directional sectors at the NCCI measurement location and at 80m agl is 7.7m/s. It is important to consider not only the mean wind speed, but how often it will be occurring as well as its directional distribution; these factors are discussed below.

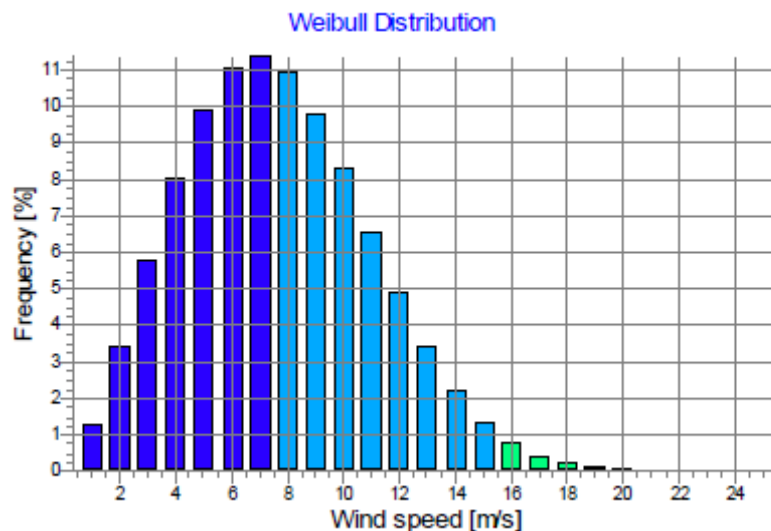
Weibull Distribution (80m)

The frequency of occurrence of wind speeds is typically called the frequency distribution, or probability distribution. A probability distribution is a graphical representation of the probability that a particular value in a data set lies between two bounds. Two probability distributions are generally used for wind data sets: the Rayleigh Distribution and the Weibull Distribution. These distributions are each described mathematically by a probability density function. The Weibull probability density function was used to create a frequency distribution for this study because it offers two factors that can be adjusted to better fit the probability distribution to the data. The Rayleigh distribution only has one characteristic factor.

The Weibull factors k and c describe the shape and scale of the graph, respectively. The optimal wind speed frequency distribution, also called the probability density, for energy generation and turbine selection has a sharp peak shape and a large scale, which dictates the area under the curve. A higher k -value means a sharper peak and constant wind speeds. A higher c -factor means a greater area under the curve and greater mean wind speed. Figure 1-2 shows the Weibull distribution at the NCCI measurement location and 80m agl. The shape factor, k , averaged over all directional sectors is 2.424 and the scale factor, c , is 8.63. Weibull factors for each directional sector are included in the PARK section, Appendix B.

FIGURE 1-4

Weibull Distribution at Measurement Location 80m agl, NCCI Met Tower Data



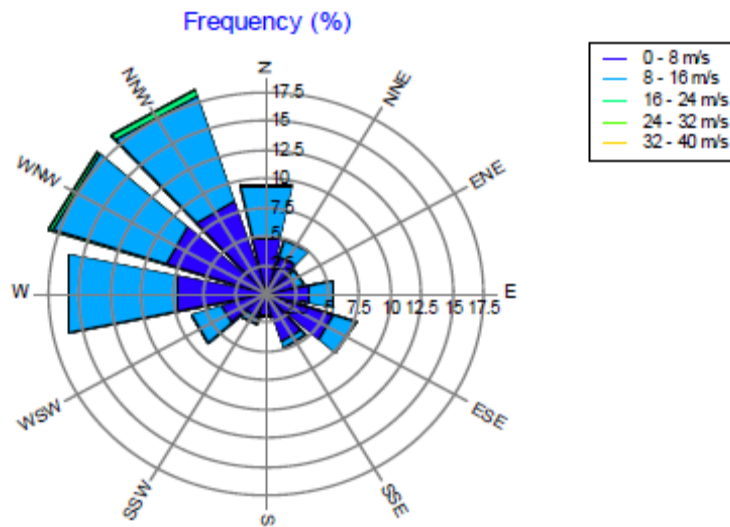
Directional Distribution (80m)

The wind speed directional distribution is a critical factor in assessing the wind resources. For both the NCCI and MWCC met towers, the prevailing wind is from the west-north-west and north-north-west direction. Figure 1-3 shows the distribution of wind from the NCCI monitoring location by speed and directional sector. A directional distribution with a strong prevailing wind from one direction will benefit the AEP since less time will be spent changing yaw (rotation of the rotor around the tower).

Directional distribution also dictates environmental factors such as shadow flicker and noise projection.

FIGURE 1-5

Directional Distribution at Measurement Location 80m agl, NCCI Met Tower Data



Turbulence Intensity

Turbulence in the wind is the dissipation of kinetic energy in the wind by the formation of eddies caused by flow obstacles and separation. The simplest measurement of turbulence is turbulence intensity, the ratio of the standard deviation of the wind speed to the mean wind speed. Turbulence intensity usually has a value between 0.1 and 0.4 where low wind speeds tend to generate higher turbulence intensity. The International Electrotechnical Commission (IEC) standard 61400-1 classifies wind energy conditions for wind turbine operation as Class I, II, or III based on wind speed and as A, B or C based on turbulence. These standards dictate the materials and manufacturing process for turbines to help the wind industry supply turbines constructed appropriately for different environments. Since the turbulence intensity of the wind data is relatively high (from 0.15 to 0.2 depending on wind speed), a Class A turbine will be required.

1.5 Turbine Location Wind Resource Profile

The WASP software uses the long term wind statistic, information on the terrain and surface roughness of the surrounding area entered in the WindPRO PARK module (see PARK section of Appendix B), and climate data including air density to extrapolate wind data vertically and horizontally to different hub heights and tower locations. WindPRO and WASP were used in this study to transform the data from the NCCI measurement location to the proposed turbine location at the Summit Industrial Park. The terrain characteristics are not expected to significantly change between now and turbine installation, so the terrain characterization model described in Section 1.2.1 was not changed.

1.5.1 Wind Resource

WindPRO and the WAsP model were used to predict the wind speed at the turbine location at 80m and 60m heights above ground level (agl). Refer to the PARK section of Appendix B for a complete profile of the Site.

Resource Map

A resource map was created to provide a visual representation of the extrapolation at 65m and 80m heights at the Summit Industrial Park. See Figures 1-6 and 1-7 below. The yellow shading (highest wind speeds) shows the area on the Site appropriate for wind energy generation. The Site property lines are represented by the dark blue boundary line. The wind resource maps helped to properly locate the turbine in the optimal position. These maps show that there is not a large area with high wind speeds on the site and not only is turbine placement crucial, but the performance of a second turbine, if it met basic siting requirements, would be lower.

FIGURE 1-6

Average Wind Speed Resource Map at 65m at Turbine Location

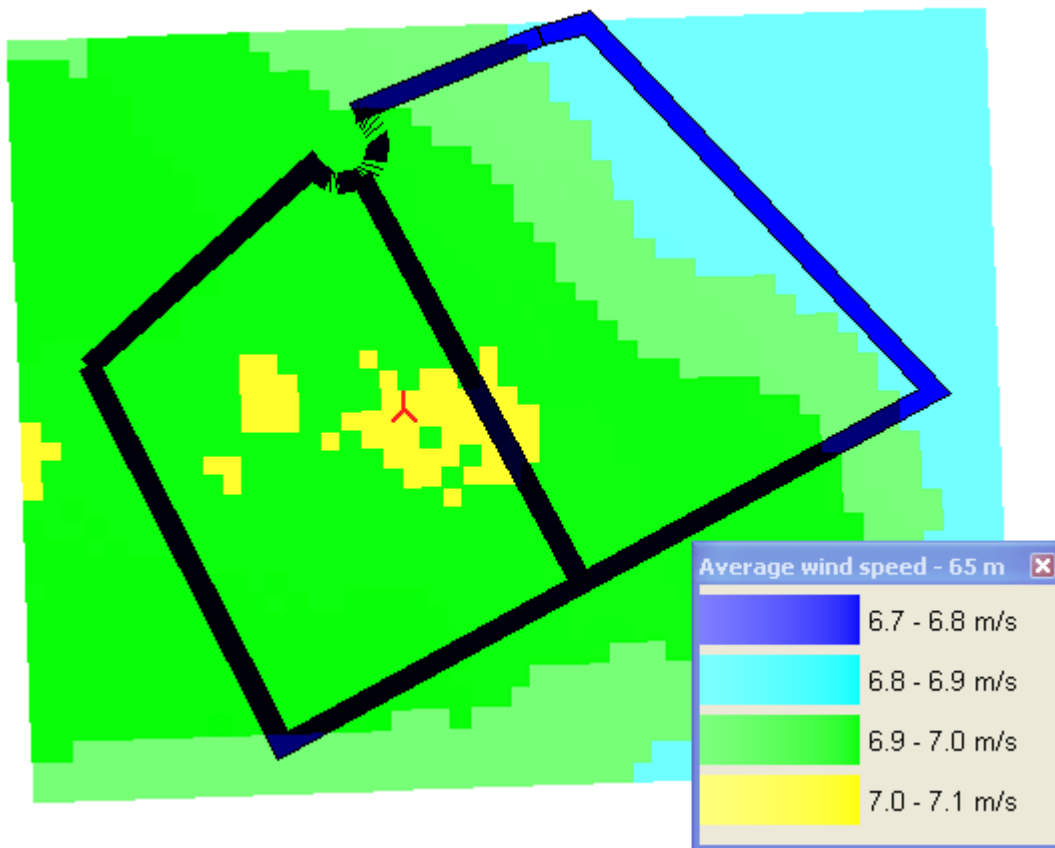
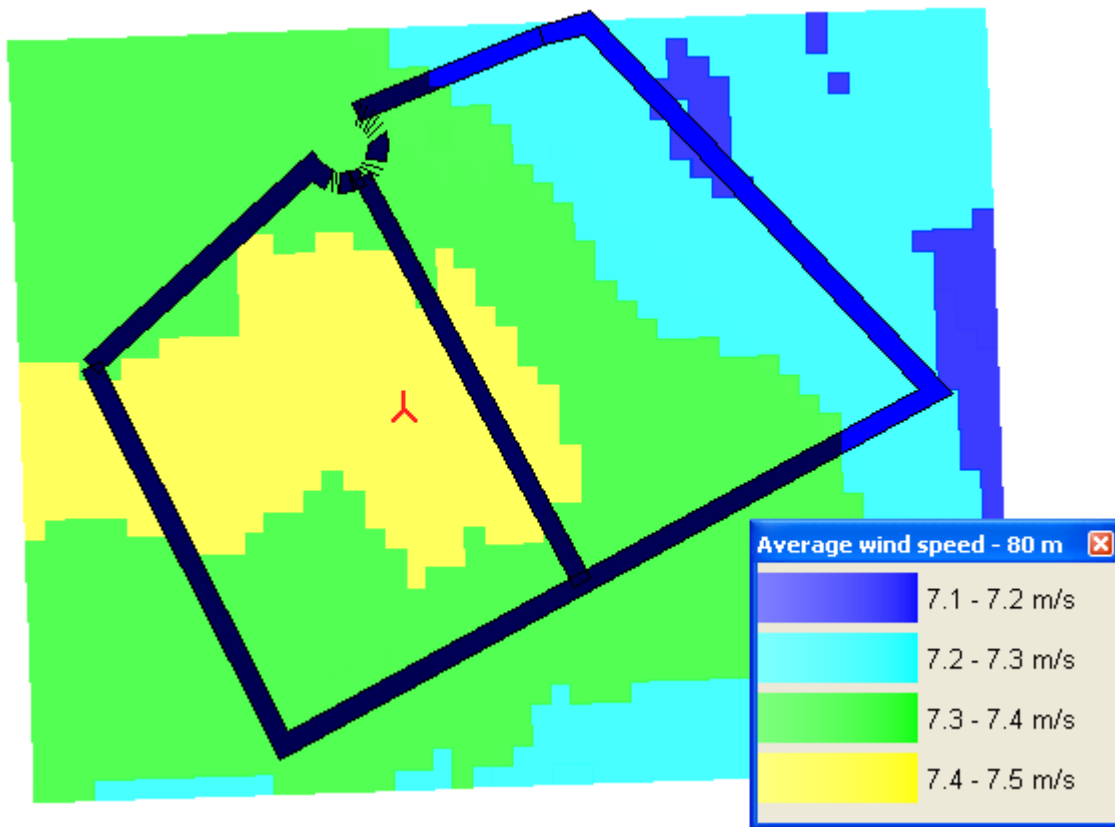


FIGURE 1-7

Average Wind Speed Resource Map at 80m at Turbine Location

**Average Annual Wind Speed (80 m)**

The average annual turbine location wind speed for all directional sectors at 80m is 6.8 m/s. This speed takes into account the effect of topography and surface roughness. This wind speed is nearly identical to the hub height wind speed estimated from the raw data at the measurement location. Since the sites were similar in topography and surface roughness, this was expected. Note that the tree height, 23m, was included as a displacement height at the turbine location to conservatively reflect the conditions around the site. This type of tree cover effectively reduces the turbine hub height and while it is likely that the tree cover will be reduced when the turbine is installed, current understanding of the effect of tree clearings on wind turbine performance does not suggest a major wind speed advantage will be achieved. Displacement height of 23m is very conservative according to industry practices and it significantly reduces the AEP. Addition of the displacement height is the primary reason that the average expected wind speed is lower than apparent on the resource mapping. The hill-top nature of the turbine location caused the wind speeds to increase between 6% and 40% from the roughness-based wind speed estimate, depending on the sector.

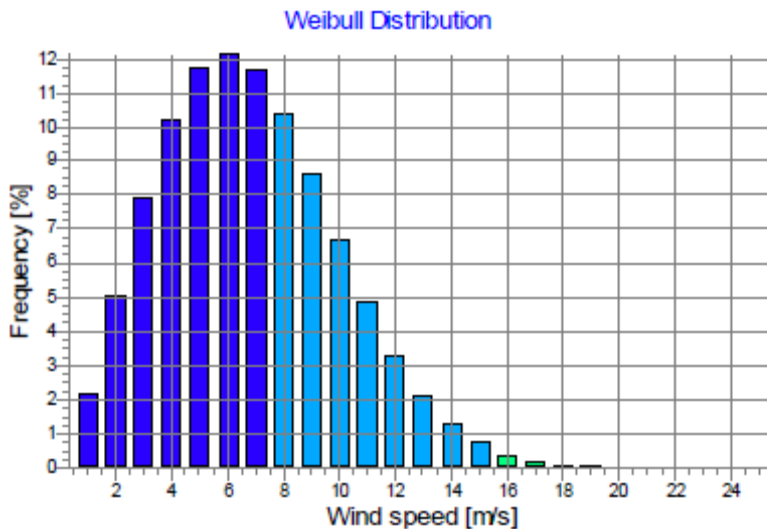
Weibull Distribution

Figure 1-8 shows the Weibull distribution of the data at the turbine location. The shape factor, k , averaged over all directional sectors is 2.268 and the scale factor, c , is 7.70. This means that the wind characteristics decreased in quality slightly (less sharp Weibull

peak and a lower total area under the curve) which was expected, as previously discussed, and is mostly due to the tree displacement height. Weibull factors for each directional sector are included in the PARK section, Appendix B.

FIGURE 1-8

Wind Speed Frequency Distribution at Turbine Location, 80m agl

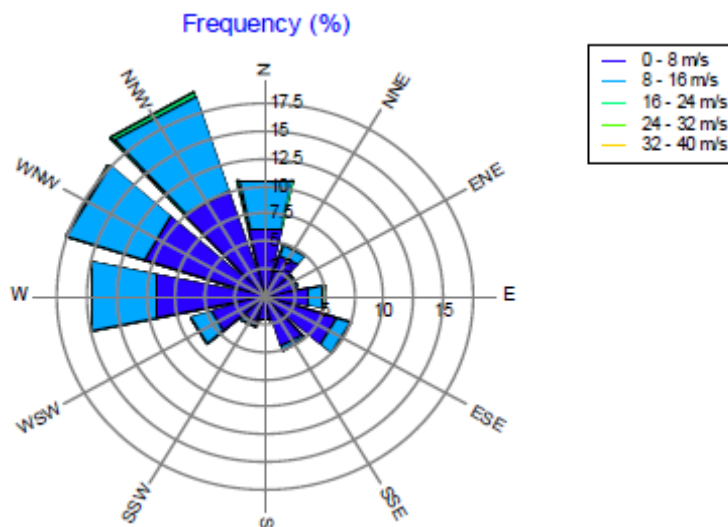


Directional Distribution

The directional distribution of wind speed is similar at the turbine location to the NCCI measurement location. At the turbine location, prevailing wind is from the west-north-west and north-north-west direction. Figure 1-9 below shows the distribution of wind by speed and directional sector.

FIGURE 1-9

Mean Wind Speed Directional Distribution at Turbine Location, 80m agl



Intermittency

The intermittency of wind is an important characteristic for evaluation of interconnection options and revenue management. The resource analysis evaluated the intermittency of energy available in the wind on a daily and monthly scale, and as shown in Figures 1-10 and 1-11, there is relatively small daily fluctuation, but a significant seasonal bias. Since the project is expected to be net metered which does not account for the time of day generation occurs, the diurnal fluctuation will not have a financial impact on the project. Also, the net energy production at the facility will be compiled monthly so diurnal production and use fluctuations will not be recorded. However, the income that the City receives from the project will fluctuate by month, with greater financial benefit for excess generation during the winter months. It is likely that generation and revenue will decrease to one-half or one-third of winter generation in summer months.

FIGURE 1-10

Diurnal Potential Energy Fluctuation

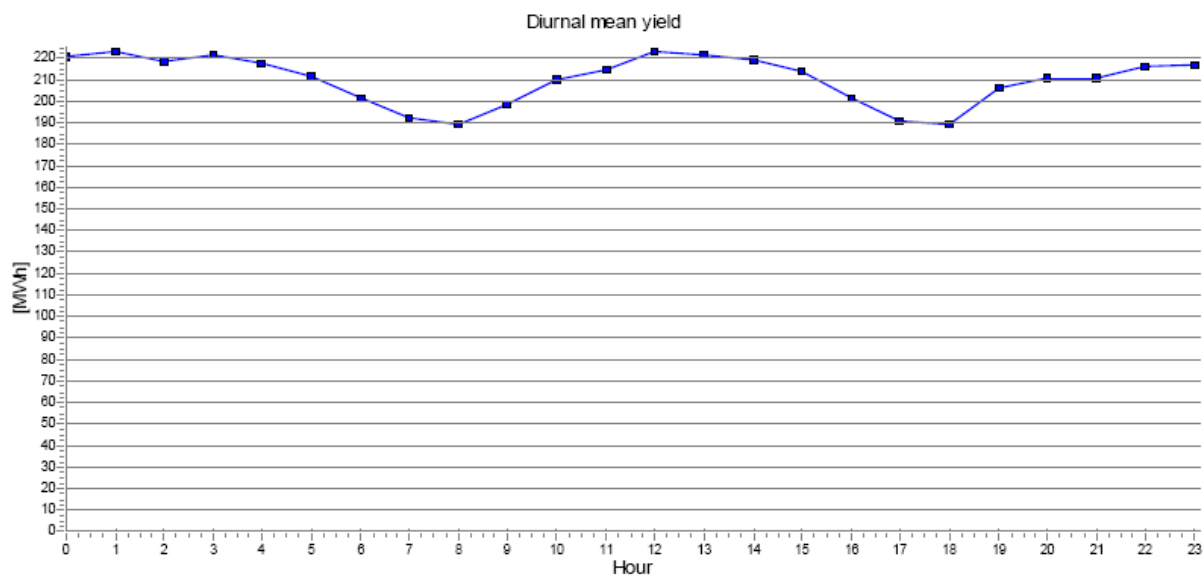
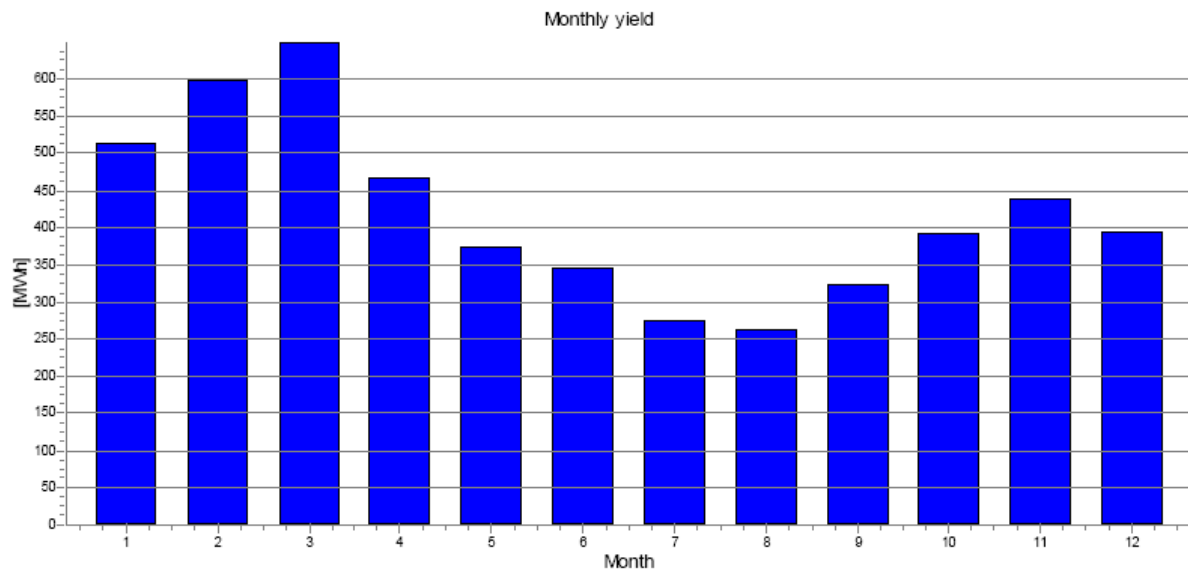


FIGURE 1-11

Monthly Potential Energy Fluctuation

**Wind Resource Profile Conclusion**

The average expected wind speed at hub height (80m) at the Summit Industrial Park Site is 6.8 m/s including the conservatively estimated effects of topography, roughness and tree cover. Based strictly on wind speed, the turbine model selected must be no worse than an IEC Class III turbine. Due to cold climate in Massachusetts and the probability of additional loading due to icing, it is recommended that the City pursue procurement of a Class II or Class I turbine. As discussed previously, the turbulence intensity is also a critical design factor. Since the Site has high turbulence intensity, it is recommended that the City pursue a Class IIA or IA turbine. The turbine manufacturer will require confirmation that the turbine model is suitable for the site, particularly with respect to extreme wind speeds and turbulence intensity.

1.6 Representative Turbine Models

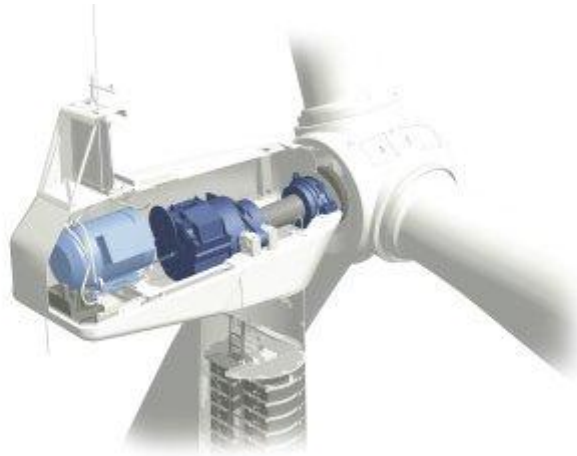
Following the generation of wind resource data, five turbine configurations were preliminarily modeled on the Site to determine which layouts should be refined for in-depth AEP and financial calculation. In order to best meet the property line setback requirements in the Gardner Wind bylaw and avoid wake effects impacting energy generation, one large (900 kW - 1.65 MW) or two smaller (650 - 900 kW) will fit on the site. The Feasibility Study evaluated five representative wind power generating systems. We attempted to evaluate the impact of varying hub heights, rotor diameters, plant configurations, and nameplate capacities on project economics, through the evaluation of representative turbine models available from several manufacturers. Our study did not include an exhaustive evaluation of all manufacturers and models currently available on the market. Accordingly, while our study includes a recommendation on an optimal configuration concept, it should not be construed as a recommendation of a specific manufacturer and model for this project. Once the project advances to the design stage, the turbine selection process will be influenced not only by the

characteristics recommended in this study, but by the design team chosen and the existing relationships each firm has with turbine manufacturers.

The turbines Tighe & Bond selected to be used in the simulation are described in detail below. Important factors include hub height, rotor diameter, power limitation and speed control, cut-in wind speed (speed at which the turbine begins to spin), cut-out wind speed (speed the turbine stops turning), and nominal or rated wind speed (the optimal wind speed to achieve rated power production). It is recommended that the turbine be IEC Class IA or IIA, to meet wind speed and turbulence intensity design standards.

1.6.1 Vestas V82 Turbine

The Vestas V82 Turbine is rated for 1.65 MW capacity and is an IEC Class IIA, meaning it can withstand the wind speeds at the site as well as high turbulence intensity. With an 80m hub height and an 82m rotor diameter, the V82 is optimized for low and medium wind speeds, which is appropriate for the Site. It is a hydraulic stall-regulated turbine with pitch control capability, optimized for a site with an average wind speed of 6.5m/s at hub height and a cut-in wind speed of 3.5 m/s. The V82 meets most grid demands and can include an advanced grid compliance system to help stabilization of the grid. DNV has certified the V82 as meeting the strictest standards in the wind industry and over 1400 turbines with the V82 nacelle platform design have been installed globally. A profile of the selected turbine that was used in the WindPro simulations is attached in Appendix C. Recently, Vestas has been phasing out the V82 in favor of a larger machine, the V90. There could be some advantage to procuring and installing one of the remaining V82 machines since there are four others in the City of Gardner and locating them near to each other offers an advantage for the manufacturer and maintenance crews.

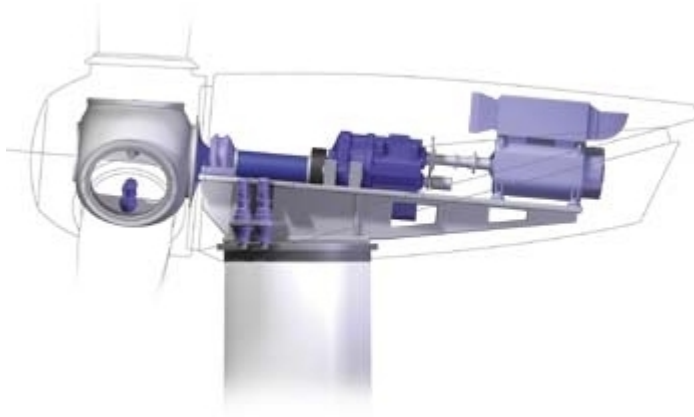


Vestas V82, www.vestas.com

1.6.2 Fuhrlander FL1500

The Fuhrlander FL1500 is customizable to a range of hub heights and rotor diameters to optimize each order to the site. For this simulation a 65m hub height was selected along with the largest rotor diameter available, 77m. This combination is rated IEC Class IIA. It is also possible to install the 77m rotor at an 80m hub height, in which case performance is expected to be similar to the GE1.5sle. The FL1500 is manufactured in Germany, rated for 1.5 MW and has a double fed asynchronous generator. The FL1500 is a pitch regulated machine that changes the angle of the rotor blades to control rotor

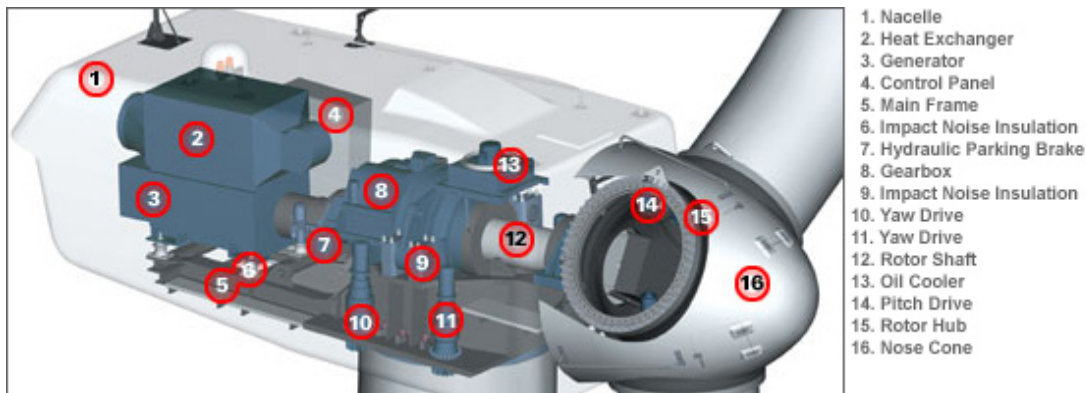
efficiency and, therefore, the power being produced. This Fuhrlander turbine has a cut-in speed of 3 m/s, a nominal speed of 13 m/s, and a cut-out speed of 20 m/s. It has been estimated that a single Fuhrlander turbine could be obtained within approximately 9 months from placing an order. A profile of the FL1500 that was used in the WindPro simulations is attached in Appendix C.



Fuhrlander FL1500, www.fuhrlaender.de

1.6.3 GE 1.5sle

The GE 1.5sle is an IEC Class IIA turbine, meaning it is designed to easily withstand the moderate wind speeds at the Site as well as high turbulence intensity. With a 77m rotor and 80m hub height, the machine is active yaw (angle of rotor), pitch-regulated for power control, and has an asynchronous generator. It uses a bedplate drive train design where all nacelle components are joined on a common structure and to minimize noise emissions, the generator and gearbox are supported by elastomeric elements. Cut-in and cut-out wind speeds are 3.5 m/s and 25 m/s, respectively, and nominal wind speed is 8.5 m/s. A profile of the GE1.5sle that was used in the WindPro simulations is attached in Appendix C. The GE 1.5sle has become a ubiquitous turbine with many successful installations. The GE1.5 is currently being re-rated as a 1.65 MW machine. GE's website reports that their turn-around time has improved and contact should be made with sales to determine the availability of the turbines. It is expected that a turbine could be obtained in 6-12 months.



GE 1.5sle, www.gepower.com

1.6.4 PowerWind 56

The PowerWind 56 is a 900 kW turbine that has a 71m hub height and a 56m rotor diameter. The turbine has pitch-controlled power and meets IEC standards for a Class IIA turbine (moderate wind speed, high turbulence intensity). The turbine has a cut-in speed of 3 m/s, a nominal speed of 12 m/s and a cut-out speed of 25 m/s. The PowerWind 56 has an asynchronous generator built into a modular drive train system which can accommodate options such as a synchronous permanent magnet generator. More than 80 PowerWind 56 turbines have been sold from the company's German manufacturing facility. A PowerWind 56 turbine could most likely be procured within 9 months of placing an order, similar to the Fuhrlander model. A profile of the Powerwind 56 that was used in the WindPro simulations is attached in Appendix C.



PowerWind 56, www.powerwind.de

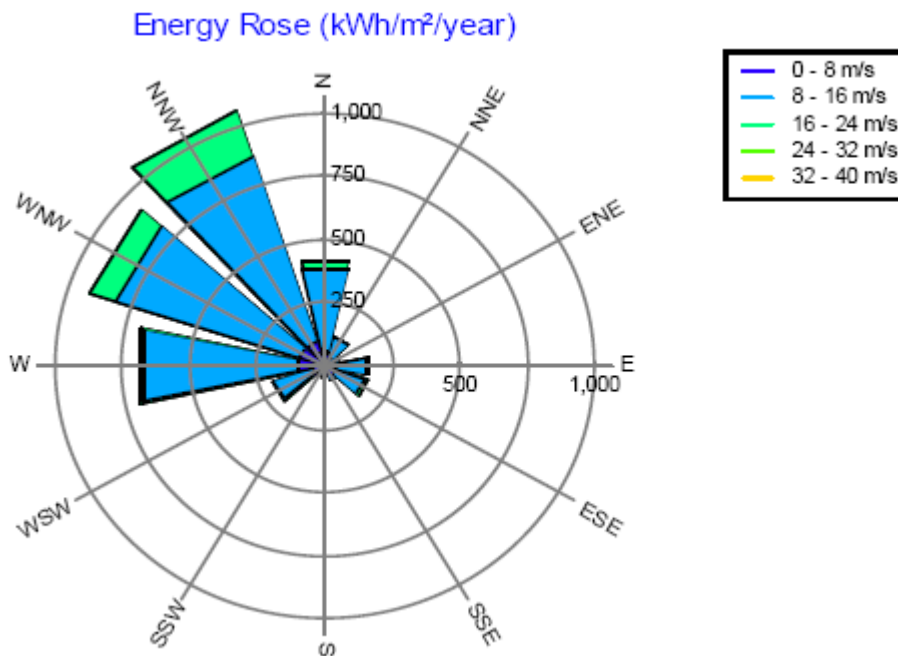
1.7 Energy Production

The AEP and capacity factor at the site were calculated using WindPRO and WAsP. Detailed calculations were completed for a Vestas V82 (1.65 MW), Fuhrlander MD 77 (1.5 MW), GE 1.5sle (1.5 MW), and one and two PowerWind 56 (900 kW) turbines. The turbines are all proven, common models that were selected to examine a variety of hub height and rotor diameter options, as described in Section 1.5. Although the size of the site may limit the Town to installation of a single turbine, one double turbine configuration was also simulated using the PowerWind 56. Based on siting conditions, it would be very difficult to install two larger turbines and maintain the manufacturer's minimum separation distance. Also, such an installation would likely result in unacceptable energy losses due to wake impacts.

The potential for energy production based on the wind speed can be graphically displayed in an energy rose. Similar to the wind speed rose, the energy rose shows the amount of energy available in the wind per square meter of rotor area (energy density) by directional sector. The energy rose is a useful tool for quickly estimating potential energy generation based on rotor size. The energy rose in Figure 1-11 illustrates that the average annual energy density for all sectors is 3,785 kWh/m².

FIGURE 1-12

Energy Available in the Wind at the Turbine Location



Energy production estimates are summarized below. For a complete profile of the wind energy characteristics at the Site, refer to the PARK section in Appendix B. The capacity factor is a measure of how much available energy in the wind the turbine is able to capture for power generation. The amount of available energy that is captured for power generation is the AEP. The best P50 capacity factor, 32.0%, results from a single turbine, a Vestas V82 1.65MW with an 80m hub height. This is a good capacity factor for the industry, particularly for land-based New England sites. Capacity factors are typically below 40% and generally a capacity factor over 20% is a developable project. Please see Table 1-3 for an overview of the turbine AEPs. The P50 20-yr average AEP is given. This value represents the annual production that the turbine is likely to exceed 50% of the time over a 20 year period, taking into account standard losses and uncertainties. Likewise, the P90 AEP represents the annual production that the turbine is likely to exceed 90% of the time over a 20 year period. The P90 AEP and capacity factor estimates are more conservative estimates of turbine performance than the P50 values. Please see Section 1.7 for detailed discussion on loss and uncertainty and Section 1.5 for a description of each turbine.

TABLE 1-3

Annual Energy Production (20 yr average)

Turbine Type	Configuration	P50 AEP (MWh/y)	P50 Capacity Factor	P90 AEP (MWh/y)	P90 Capacity Factor
Vestas V82, 1.65 MW, 80m	Single Turbine	4,624	32.0 %	3,895	26.9%
FL1500, 1.5 MW, 65m	Single Turbine	3,395	25.8 %	2,823	21.5%
GE 1.5sle, 1.5MW, 80m	Single Turbine	4,016	30.6 %	3,351	25.5%
PowerWind 56, 0.9 MW, 71m	Single Turbine	2,110	26.8 %	1,754	22.3%
PowerWind 56, 0.9 MW, 71m	Two Turbines	4,071	25.8 %	3,386	21.5%

1.8 Loss and Uncertainty

The bias, loss and uncertainty estimates were calculated using WindPRO. A complete loss and uncertainty report for the Vestas V82, including all assumptions and mathematical inputs, is in the Loss & Uncertainty section of Appendix B.

1.8.1 Loss Analysis

Typical sources of loss for wind energy were included in calculation of the AEP and uncertainty. Sources of losses and the percentage of the AEP deducted for each are outlined below:

1. Wake effects – Wake effects in the double turbine configuration were determined in the PARK analysis and the AEP was reduced accordingly. For the configuration including two PowerWind 56 turbines, the energy estimate decreases due to wake effects was 3.44% of the roughness-based energy production estimate.
2. Availability (3.0%) - Downtime due to turbine service
3. Balance of plant (0.2%) - Substation Maintenance
4. Grid availability (1.0%) - Grid unavailable due to external circumstances
5. High wind hysteresis (Varies by hub height and turbine power curve) - Required restart after high-wind cut-out, as defined by each turbine's power curve. Cut out events include gust, minute and 10-minute wind speed events, defined as follows:
 - Gust: 2 second high wind speed over 26 m/s
 - Minute: 1 minute high wind speeds over 22 m/s
 - 10-minute: 10 minute high wind speeds over 20 m/s
6. Electrical losses (2.0%) - Transformer and line losses

7. Performance degradation due to icing (0.8%) - Ice accumulation on blades
8. Grid curtailment and ramp-rate (0.1%) - Power outage during low wind (requires restart, which demands power)

Although loss effects on the AEP vary for each turbine based on hub height (high wind hysteresis varies) and turbine configuration (i.e., wake effects), the percentages listed above were applied to each turbine. Total loss in MWh varies between 407 MWh (8.1%, V82) and 177 MWh (7.8%, PowerWind56). Table 1-4 is a summary of losses for each turbine.

TABLE 1-4

Summary of Losses, Turbine Specific

Turbine, Configuration	Loss (% of AEP)	Loss (MWh/yr)
(1) Vestas V82, 1.65 MW, 80m	8.1%	409
(1) FL1500, 1.5 MW, 65m	7.4%	271
(1) GE 1.5sle, 1.5MW, 80m	8.2%	359
(1)PowerWind 56, 0.9 MW, 71m	7.8%	177
(2) PowerWind 56, 0.9 MW, 71m,	10.9%	499

1.8.2 Uncertainty Analysis

Sources of uncertainty in the data and calculations must be accounted for to create an accurate analysis. For most sources of uncertainty the same standard of deviation as a percentage of wind speed was used. The exception is vertical extrapolation since the uncertainty varies with hub height. Table 1-5 shows the sources and total effect of uncertainty for the each modeled turbine.

TABLE 1-5

Summary of Uncertainty Sources, General and Turbine Specific

Uncertainty Source	Std. dev. (% Wind Speed)	Std. dev. (% AEP)					Comments
		V82	FL 1500	GE1.5 sle	PW56	PW56 (x2)	
Wind Measurement/ Data	2.5	4.9	5.8	5.1	5.6	5.6	Average Std. dev. of wind speed over 12 sectors, calculated in MCP
Long Term Correlation	3.0	5.8	6.9	6.1	6.7	6.7	Typical value for mid-quality reference data (NCAR with Wind Index Correlation)
Year to year variability	9.9	19.2	22.9	20.3	22.1	22.1	Variability of long term data, calculated in MCP
Future Climate	1.0	1.9	2.3	2.0	2.2	2.2	Typical value for low climate uncertainty (30 yrs historical data for 20 year simulation)
Vertical Extrapolation	Varies	6.0	3.7	6.4	4.9	5.0	Recommended incremental value for complex terrain (1%/10m change) used
Horizontal Extrapolation	2.6	5.1	6.1	5.4	5.9	5.8	Recommended incremental value for complex terrain
Power Curve Uncertainty	--	3.0	3.0	3.0	3.0	3.0	Typ. Value for manufacturer power curves
Uncertainty Total (1 yr average)		22.4	25.9	23.6	25.2	25.2	
Uncertainty Total (20 yr average)		12.3	13.2	12.9	13.2	13.1	

As mentioned previously, the uncertainty due to the long term data set (year to year variability) is high and by far the greatest source. According to a study by Justus, Mani

and Mikhail (*Interannual and Month-to-Month Variations of Wind Speed*, 1979) year to year variability in the Northeast region is on average 6% of the wind speed. It is possible that a higher quality long term data set may have a lower year to year variability and reduce uncertainty. In that case use of higher quality long term data would reduce uncertainty. All of the 20-yr average uncertainties are between 11% and 14% of each turbine's AEP. This is a significant number, but it is well within the sensitivity analysis bounds (+/- 20% AEP) required as a part of the financial analysis in Section 4. The uncertainty was carried through the financial analysis to evaluate the upper and lower bounds of payback period based on the variability of the AEP. Please refer to Section 5.4.3.

1.8.3 Ruggedness Index

The Ruggedness Index is a number developed by the WindPro software to classify the terrain around a particular location. Due to the hilly terrain in the area of the Site and Met Tower location, the Ruggedness Index (RIX) was assessed to find whether the area around the Site or Met Tower has a steepness greater than 40%. It has been found that at this steepness, flow separation occurs and the WASP model results have significant error. If the steepness is over 40% and there is a significant difference in RIX from the measurement location to the turbine site, significant wind resource prediction error is probable. Therefore, if the change in the RIX between the measurement location and the turbine location is greater than 5%, a correction factor must be used to produce more accurate model results. Since the RIX at the met tower location was 0.2% and the RIX at the turbine was 0.1%, the change in RIX is only -0.1% and the WASP model is valid without further correction.

1.9 Viability Characterization

In order to document the viability of this analysis, several reports from WindPro are attached in Appendix B, as referenced throughout the document. These reports list assumptions made for each calculation. The Vestas V82 reports were chosen for inclusion since this turbine has the best AEP for the site and is well known in the wind industry.

The energy analysis strategy included the following steps in succession:

- Determine which data set was most complete and would provide the best wind statistic
- Generate a wind statistic and long term corrected wind statistic with MCP
- Analyze multiple turbines and configurations for AEP and time-varying production
- Analyze typical losses and model uncertainties for each turbine to get 20-yr average P50 and P90 AEP and Capacity Factor

The viability of the calculations is most affected by the quality of the input data, the measured data and the long term data set. As discussed previously, there was a good correlation between the measured data and long term data set, indicating viability. However, the long term data set could be improved by increasing the measurement time resolution or by finding a data set located closer to the turbine location. Uncertainty associated with the long term data set was accounted for by conversion of the year to year variability in the long term data to uncertainty in the wind speed and AEP estimates. Potential vertical and horizontal extrapolation error was also accounted for in

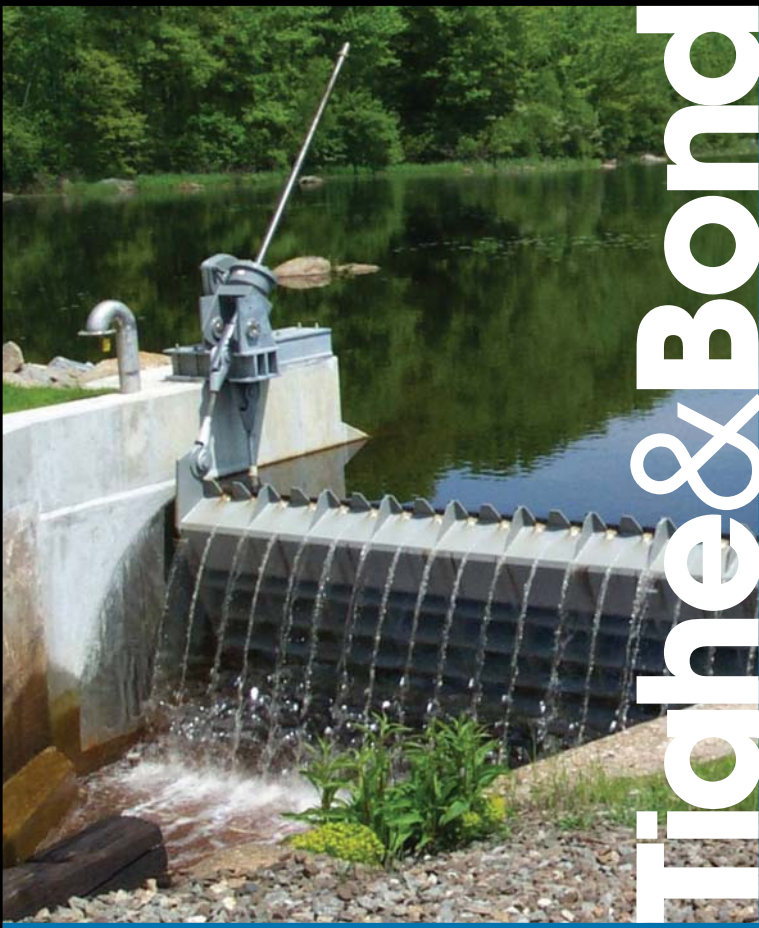
the uncertainty analysis. Extrapolation error is likely, since the met mast is about 1.0 mile from the turbine location.

If it becomes necessary to improve the viability of this energy analysis, a more accurate long term data set could be purchased and/or a wind speed monitoring device could be installed at the turbine location. The uncertainty was carried through to the financial evaluation and it is shown that the larger turbines remain viable projects at the upper and lower bounds of AEP uncertainty. Therefore, additional wind resource modeling and purchase of more accurate long term data is not recommended at this time. However, depending on the funding sources sought, some additional field data collection may be required to satisfy the lender / bond issuer.

1.10 Resource Assessment Conclusion

As described in the above sections, wind resources at the Site are good. The analysis performed included long term correlation, losses, uncertainty and development of P50 and P90 AEP and capacity factor estimates. The analysis found that a project at the site is viable. Further viability could be assessed by obtaining a more accurate long term data set or placing a wind monitoring device on the Site.

As determined through the AEP calculation, it would be most economically and environmentally feasible to place one large turbine on the Site due to the loss in energy capture due to wake effects as well as the relatively small zone of high winds on-site. The turbine with the highest AEP at the Site is the Vestas V82, likely due to its tall hub height and large rotor diameter. However, the Vestas V82 also has the best capacity factor, which shows that the turbine also has an appropriate power curve for the Site and wind speeds. The Vestas V82 is the largest turbine in scenarios evaluated and, the following sections, Site Evaluation and Environmental and Regulatory Review are critical to determining whether using such a large turbine is feasible. In the case that the V82 is too large for the Site or causes unacceptable visual or acoustic impacts, a 1.5 MW or smaller size turbine may be more suitable.



Tighe & Bond

Section 2

Site Evaluation

The Site Evaluation is intended to determine the characteristics of the Site that will affect turbine selection and, similarly, the characteristics of the turbine that will affect the Site and surroundings. The section includes a general description of the Site including physical characteristics, abutting land use, zoning and airspace restrictions, and site access considerations. The impact of the turbine with regard to noise, shadow, and visual impacts is evaluated. A preliminary discussion of community acceptance for the project is also included. The Site evaluation will determine what size of turbine is feasible on the Site and what potential mitigation will be required.

2.1 General Description and Physical Characteristics

The City of Gardner is in Worcester County, in North-central Massachusetts. Gardner is neighbored by Westminster to the east, Hubbardston to the south, Templeton to the west, and Winchendon and Ashburnham to the north. The City is located 30 miles northwest of Worcester and 60 miles northwest of Boston and encompasses 23 square miles. Gardner is a city of 20,770 people (2000 Census) established in 1785.

The Summit Industrial Park ("Park") was developed by the Gardner Redevelopment Authority (GRA) in 1997/1998. The Gardner Redevelopment Authority is an independent economic development agency for the City of Gardner. The Park is located on Suffolk Lane off of Pearl Street (Route 101), two miles to the north from Route 2. The Park is nearly 100 acres and already has 6 current tenants. Infrastructure, including the roads and electrical service, was built to industrial subdivision standards. The proposed wind turbine site is approximately 20 acres of relatively level land on Lots 4 and 5 of the Park. The Site was selectively logged three years ago, resulting in wooded areas with limited dense underbrush. Nearby lots are occupied by five manufacturing facilities as well as the Highridge Wildlife Management Area (WMA), a permanently protected open space owned by the MA Division of Fisheries and Wildlife (DFW).

In a Memorandum of Understanding dated November 5, 2009, the Gardner Redevelopment Authority agreed to lease the land required for the turbine to the City in return for one half of the net revenue resulting from operation of the turbine, including money from net metering and the sale of Renewable Energy Credits (RECs). The City will be financially responsible for all studies, permitting, design and construction costs. The Memorandum of Understanding is attached in Appendix D and will be expanded into a legal agreement as a part of business planning activities. For the purpose of this Feasibility Study, we have considered the City of Gardner as one entity.

2.1.1 Physical Characteristics

The proposed wind turbine site is two lots at the southern end of Suffolk Lane in the Summit Industrial Park, located off of Pearl Street (Route 101). The site is nearby the Park's highest elevation, directly at the end of the Suffolk Lane cul-de-sac, and is comprised of approximately 20 acres of land. The western lot contains topography that is generally flat ($2\% \pm$), however the rear of the lot becomes slightly steeper ($8\% \pm$) sloping away in a southerly direction. The eastern lot has steeper topography ($5\text{-}25\% \pm$) that slopes away from the western lot towards a bordering vegetated wetland east of the site. The steep topography on the eastern lot will limit the extent of development

on this section of the site due the necessary requirements for construction staging and access.

The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soil mapping indicates that the site consists primarily of a “Becket-Skerry association”. The Becket series consists of very deep, well drained, fine sandy loam soils located on drumlins and glaciated uplands, while the Skerry series consists of very deep, moderately well drained, fine sandy loam soils on drumlins and glaciated uplands. Both the Becket and Skerry series are identified with a hydraulic group of “C”. Groundwater elevations below existing grade can be expected to have an upper limit of 2.0–3.5 feet for the Becket series and 1.5-2.5 feet for the Skerry series.

2.1.2 Community Acceptance

Four MW-scale wind turbines have recently been successfully permitted and funded for design and construction within the City of Gardner: two at Mount Wachusett Community College and two at the North Central Correctional Institute. Due to the familiarity of the City with the technology and permitting requirements, community acceptance of a turbine on City property is likely. In addition, development of green power at the Summit Industrial Park will likely serve to attract additional tenants to the Park and to Gardner. Other projects such as the Massachusetts Green High Performance Computing Center in Holyoke, MA have demonstrated that clean energy projects and economic development often go hand in hand. Furthermore, due to the relatively small opposition for the wind turbines at Mount Wachusett Community College and North Central Correctional Institute, as well as the minimal number of residences proximate to the Site, it is not likely that public opposition will be a fatal flaw for the Summit Industrial Park turbine. Installation of a wind turbine at the Summit Industrial Park will bring revenue to the City and possibly attract more business owners to the area. This type of development is consistent with the City of Gardner’s history of industry and innovation. Visualizations and a shadow flicker map are provided with this Feasibility Study to help the City manage resident relations and create a public acceptance campaign. It is recommended that the City organize a public outreach strategy and develop informational materials that will be used for public outreach throughout design and construction before proceeding with the project.

2.2 Land Use

Currently, the site of the proposed wind turbine is forested. The site was selectively logged in the past. To the north of the site along the Suffolk Lane are industrial buildings. Residential areas are located approximately 2,000 feet to the west and northeast. Directly to the south of the site is the High Ridge WMA, owned by the MA DFW.

As evident by the designation of the Summit Industrial Park as a 43D Priority Development Site under MGL Chapter 43D and an Economic Opportunity Area under the Economic Development Incentive Program, the City’s intent is to develop the area including the site. Welcomed land uses at the Industrial Park include manufacturing, office space, wholesale, distribution, warehousing, scientific development or educational space. Other parcels in the Park are currently occupied by manufacturing facilities and office space. Surrounding the Summit Industrial Park is mostly residential. However, the Gardner Economic Redevelopment Plan specified a zoning change near the Summit Industrial Park, encouraging commercial development to better serve the residents of the area as well as workers in the Summit Industrial Park.

It is not anticipated that the proposed turbine would adversely impact the surrounding land uses and the site seems well suited for development of a renewable energy project as innovation and technology are encouraged in the area.

2.3 Zoning

The Gardner Zoning Ordinance requires that a Special Permit be obtained for a Wind Energy Conversion System (WECS), such as the proposed turbine, in an Industrial Zone. A WECS is not permitted in any other zone. The Summit Industrial Park is zoned as Industrial 1; therefore a Special Permit will be necessary.

Special Permits are granted only upon written determination that the adverse impacts of the proposed turbine do not outweigh the beneficial impacts to the City. Section 1182 in the Zoning Ordinance outlines specific criteria that the Zoning Board of Appeals (ZBA) will consider in judging the Special Permit Application. It is anticipated that only one of the Special Permit Criteria will require a significant level of investigation before the Permit can be granted. Criterion number 5 says that, "the proposal shall not constitute a nuisance due to air and water pollution, erosion, flood, noise, odor, dust, vibrations, lights or visually offensive structures or site features." In Section 2.1.3 of this Feasibility Study the noise and visual impacts of the proposed turbine were evaluated, to determine whether a fatal flaw exists in obtaining a Special Permit. Both noise and visual analyses did not present a fatal flaw, but some mitigation for shadow flicker may be required. Since the wind turbine is within the 43D Priority Development Site, the Special Permit process will only take 180 days from the application being deemed complete. It is anticipated that the Special Permit process will not cause delay in the project schedule since the Zoning Board of Appeals, the Special Permit Granting Authority, is aware of the project and will continue to be included in planning. Site Plan Review will also required for the proposed wind turbine.

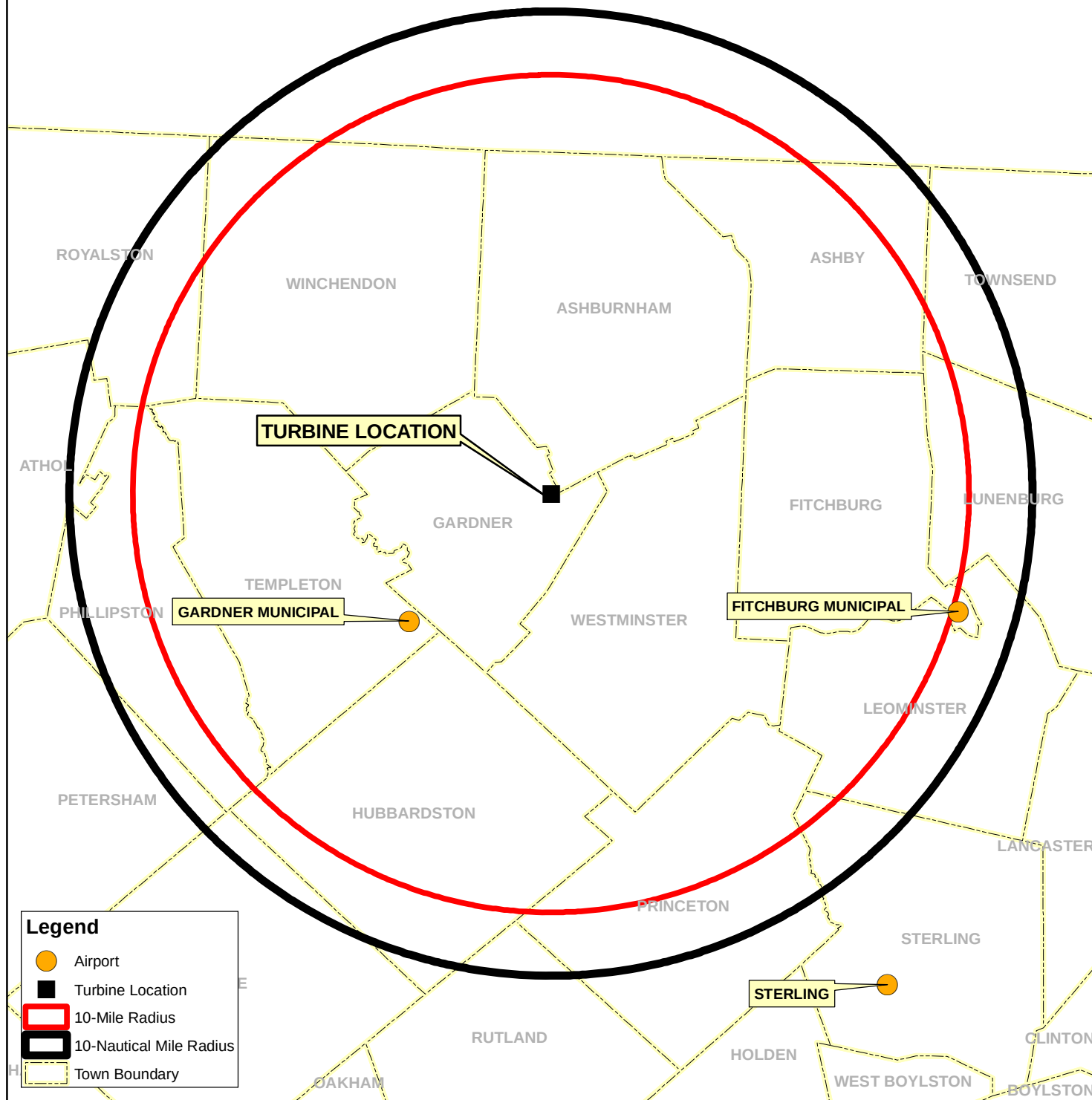
The City of Gardner Zoning Ordinance also requires that a WECS must be set back from every property line a distance of the highest tip height. It is possible that a fall area easement may need to be obtained from the MA DFW, owner of the Highridge Wildlife Management Area for the largest turbine modeled in this study, the Vestas V82. The fall zone created with the maximum tip height of the turbine overlaps into the Highridge Wildlife Management Area by approximately 25 feet. This distance may be reduced during the micro-siting process, but survey and design development level information will be needed. The WECS must also be a distance equal to its total height (maximum tip height) from any public way or utility lines. This is not anticipated to be a problem for any turbine modeled in this study. Lastly, the structure must comply with the Massachusetts Building Code.

2.4 Airspace

As shown on Figure 2-1, Airport Map, there are three airports in the Gardner area and two within approximately 10 miles of the site. The two nearby are the Gardner Municipal Airport and Fitchburg Municipal Airport. The FAA has issued a Determination of No Hazard to Air Navigation, dated July 16, 2009, for a wind turbine with a 121m maximum tip height in the proposed location. Refer to Appendix E for a copy of the Determination of No Hazard. The determination concludes that "the structure does not exceed obstruction standards and would not be a hazard to air navigation" provided it is painted and lit accordingly. In the case that the turbine location changes by 100 feet or greater horizontally or the height above mean sea level increases by more than one

foot, the determination would need to be re-filed. The turbine location change due to the wind resource assessment and the maximum tip height of all modeled turbines do not exceed these criteria and no re-file is required at this time. The FAA was contacted in September 2010 to determine when the current Determination should be renewed and it was recommended to wait for the expiry date in order to maximize the permit length. Therefore, the determination should be renewed with the FAA by July 16, 2011. Also, the FAA requires that a Notice of Actual Construction of Alteration be completed within 5 days after the installed turbine reaches its maximum height.

NEW HAMPSHIRE



Legend

- Airport
- Turbine Location
- 10-Mile Radius
- 10-Nautical Mile Radius
- Town Boundary

1:18,000
0 18,000
Feet



Data source: Office of Geographic and Environmental Information
(MassGIS), Commonwealth of Massachusetts
Executive Office of Environmental Affairs.
Data valid as of September 2010.

FIGURE 2-1 AIRPORT MAP

Gardner Wind Turbine
Gardner, Massachusetts

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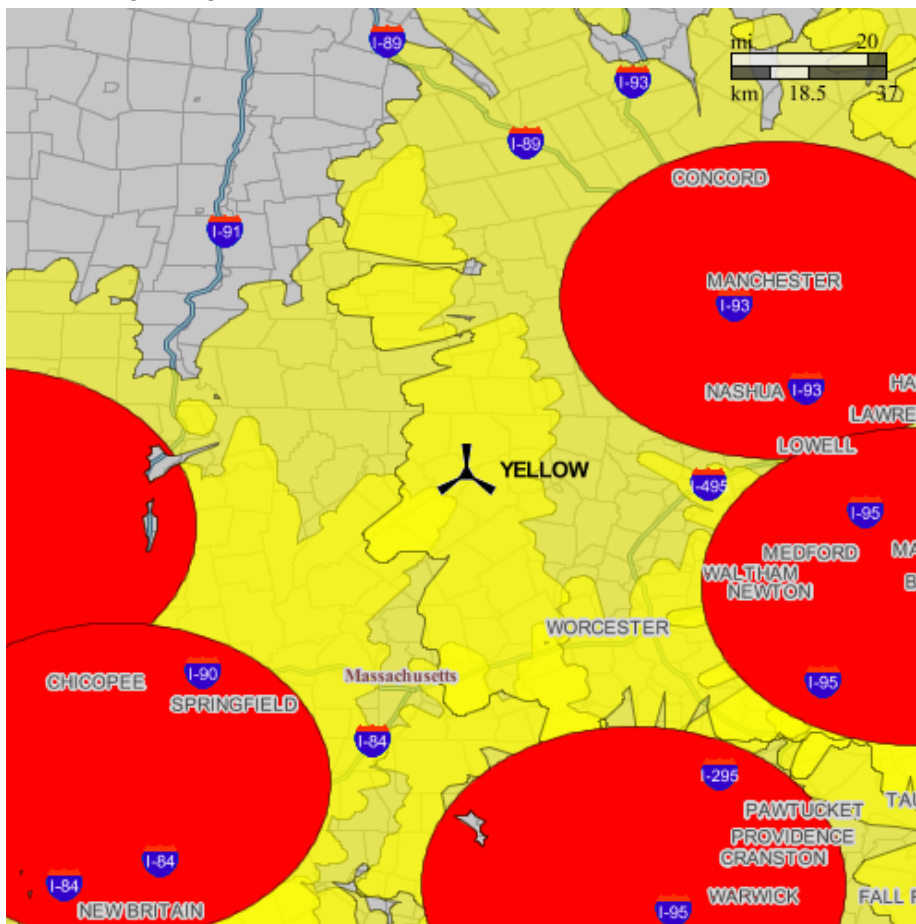
October 2010

2.4.1 Communications Interference

Wind turbines can potentially interfere with the operation of non-Federal microwave telecom systems, US Department of Defense (DOD) radar, and FAA radar installations. Microwave telecom systems have microwave beam paths surrounded by a Fresnel Zone, the area that should be avoided by wind turbines. Since these paths are linear and narrow, it is possible to avoid interference, even if several paths cross the Site, during micro-siting of the turbine. The DOD has a GIS tool online that allows for preliminary screening of wind turbine location relative to long range radar equipment. This tool was used for the Summit Industrial Park Wind Turbine and it is apparent that the wind turbine is in an area with "Impact likely to Air Defense and Homeland Security radars." For this area, an aeronautical study is required. See Figure 2-2, below, the DOD preliminary evaluation. The FAA-issued Determination of No Hazard to Air Navigation, dated July 16, 2009, included the completion of aeronautical study No. 2009-WTE-4273-OE. Refer to Appendix E for a copy of the Determination of No Hazard. It should be confirmed with FAA that the level of communications interference associated with the project is acceptable when the Determination of No Hazard is renewed.

FIGURE 2-2

DOD Long Range Radar Evaluation



Yellow: Impact likely to Air Defense and Homeland Security radars. Aeronautical study required; Red: Impact highly likely to Air Defense and Homeland Security radars. Aeronautical study required.

2.5 Interconnection

2.5.1 Existing Conditions

The probable location for interconnection at the end of Suffolk Lane is a 13.8 kV 3-phase radial circuit that receives power from National Grid overhead distribution lines. The overhead distribution lines are fed from the National Grid Park Street Substation in Gardner, which transforms 69 kV transmission circuits to 13.8 kV. The distribution circuit in Suffolk lane serves several customers located in the Summit Industrial Park.

The proposed wind turbine location is at the end of Suffolk Lane on land owned by the Gardner Redevelopment Authority. If the proposed project moves to the design phase, an application will be made to National Grid for an interconnection study. In the application, the end of Suffolk Lane should be the proposed location of interconnection. In the study National Grid will evaluate the ability of the local distribution network, substation, and transmission line to handle the additional power from the generator as well as the intermittency of the generation. All National Grid requirements, including metering, interconnection, line protection, and equipment installation are outlined in the "Standards for Interconnecting Distributed Generation- M.D.T.E. No.1088" dated April 2, 2007. While the National Grid study will determine much of the interconnection design, some expected design components are described in the following sub-section.

2.5.2 Electrical Interconnection

A padmount transformer is typically located on the project site, in the vicinity of the turbine. The primary feed leaves the wind turbine generator, in the nacelle of the turbine to the base of the tower and to the primary switch in the transformer. The transformer will likely be rated at 575 – 690 V (varies with Turbine selection), 1600 amps and 2,000 kVA. The primary side of the transformer will need to meet the specifications of the wind turbine manufacturer. The transformer allows for adjustment of the secondary voltage to +/- 5%. Since the turbine also has a main circuit breaker, a secondary disconnect switch is not typically necessary. The transformer will typically be oil-filled and self-cooling. Oil types vary and can be decided by the Gardner Redevelopment Authority. The cable required for connection of the turbine to the 13.8 kV system is 15 kV cable. Power will be taken from the same National Grid distribution circuit for turbine start-up and control systems.

The grounding design for the wind turbine is typically based on soil conditions on-site. The specific ground design should follow a formal site soil assessment, including measurement of soil resistivity. The turbine will typically be provided with a copper bus ground bar throughout the tower base and around the door. All interior electrical devices are then connected to the ground bar, with #4/0 American wire gauge (Awg) cable. The ground bar is connected to a buried pad ground loop with the ground cable and the loop is connected to no less than three ¾-inch by 10 foot long grounding rods at the foundation corners. The transformer should be grounded with a similar ground loop and grounding rods.

When National Grid power service is interrupted, a relay disconnects the incoming service and the turbine generator. The same relay will bring the generator back on line when service resumes. The protective relaying will also sense overload and overcurrent conditions in the distribution line and open the wind turbine switchgear. It is expected that National Grid will require a reverse read meter so that generated electricity can be

recorded as it enters the grid. National Grid will perform a design review and may require adjustments, upgraded equipment, or additional equipment.

An expected cost for interconnection of the turbine and transformer are outlined in Table 2-1, below. The electrical protective instrumentation is typically provided with the turbine as a part of the manufacturer's cost. Therefore, it is not carried in this table.

TABLE 2-1

Costs of Interconnection

Item	Cost
Metering	\$10,000
5" RGS	\$2,000
5" PVC	\$15,000
15 kV cable	\$10,000
600 kcmil cable	\$8,000
#6 bare copper stranded grounding cable	\$1,500
¾" x 10' long copper grounding rod	\$2,000
Wood Poles	\$2,500
National Grid Review	\$8,000
Padmount Transformer	\$5,000
TOTAL	\$65,000

2.5.3 City of Gardner Electrical Load

The City will be allocating net metering credits generated from the distribution of electricity from the wind turbine to off-site municipal accounts with National Grid. This is allowed under the MA Green Communities Act. Therefore, all City electricity accounts for fiscal years 2007 – 2010 were reviewed to evaluate the potential for the City to utilize the credits. The City's annual electricity use (excluding use for Water and Wastewater, which is currently paid by the operator) is, on average, 3,257 MWh. The trend over the past four years indicates increasing electricity use and use in FY2010 was 3,568 MWh. It is expected that this load will vary diurnally as well as seasonally, since a large percentage of it is from schools and buildings that operate during daytime hours. Table 2-1 shows total annual load. Since the AEP varied from 4,624 MWh (V82) to 2,103 MWh (PowerWind56), the City has the potential to supply its entire demand with the turbine and receive compensation for excess generation (AEP is 141% of demand for the V82). Alternatively, the FL1500, GE 1.5sle, PowerWind 56 single turbine and PowerWind 56 double turbine would supply about 95%, 122%, 64%, and 124% of the average demand, respectively.

City of Gardner Electrical Use and Cost by Account

Building	Account #	Department	FY07		FY08		FY09		FY10	
			Use (kWh)	Billed Cost	Use (kWh)	Billed Cost	Use (kWh)	Billed Cost	Use (kWh)	Billed Cost
	1580245004	Parks	0	\$ -	0	\$ -	0	\$ -	0	\$ -
	6544262013	Golf Course	166	\$ 45	1,255	\$ 302	1,266	\$ 333	1,254	\$ 308
	6559709014	PW	1,601	\$ 352	5,231	\$ 948	6,480	\$ 1,169	1,914	\$ 421
	7789095019	Golf Course	12,451	\$ 2,089	36,045	\$ 5,903	22,684	\$ 3,779	26,672	\$ 4,539
Animal Shelter	2841108014	Health	11,849	\$ 2,037	12,076	\$ 2,049	11,123	\$ 1,922	12,475	\$ 2,110
Bickford Pla.	5329236012	Parks	960	\$ 172	2,680	\$ 7,042	3,360	\$ 645	2,154	\$ 433
Cemetary	2821383011	Parks	3,010	\$ 582	3,298	\$ 636	3,220	\$ 634	3,087	\$ 609
City Hall	5296928012	Building	155,460	\$ 22,286	192,720	\$ 27,577	160,860	\$ 22,012	160,860	\$ 25,827
Cottage Street	1579932014	Parks	11,184	\$ 2,014	17,302	\$ 2,915	3,156	\$ 628	1,484	\$ 352
Council on Aging	2821762012		46,511	\$ 7,784	58,196	\$ 9,475	49,079	\$ 8,115	40,729	\$ 6,853
Crystal Lake	6558951014	Parks	1,724	\$ 373	2,037	\$ 433	2,299	\$ 483	2,422	\$ 502
Elm Street	1562017011	School	261	\$ 59	1,963	\$ 407	1,986	\$ 449	1,967	\$ 415
	7789093015	School	194,220	\$ 11,471	257,400	\$ 27,750	242,100	\$ 29,793	219,690	\$ 42,378
	346679016	School	189	\$ 119	15	\$ 99	10	\$ 109	8	\$ 115
Gardner HS	5346096012	School	527,700	\$ 77,805	388,800	\$ 44,614	692,100	\$ 17,871	824,700	\$ 144,880
	9085962017	School	4,160	\$ 754	5,360	\$ 955	4,960	\$ 899	4,000	\$ 787
Gardner MS	9086060012	School	524,800	\$ 74,652	824,400	\$ 61,855	793,200	\$ 71,266	732,800	\$ 124,350
Golf House	4086557015	Golf Course	569	\$ 170	3,251	\$ 628	2,842	\$ 554	3,034	\$ 607
	5329484018	Golf Course	6,068	\$ 1,095	5,706	\$ 1,023	4,646	\$ 863	4,443	\$ 830
	6562744018	Golf Course	3,065	\$ 570	6,017	\$ 1,072	6,177	\$ 1,107	3,613	\$ 705
	7821547010	Golf Course	2,866	\$ 562	0	\$ -	0	\$ -	0	\$ -
Greenwood Memorial Pool	329071016	Recreation	332	\$ 89	2,511	\$ 603	2,529	\$ 666	2,509	\$ 615
	347646011	Recreation	9,605	\$ 1,607	22,636	\$ 3,749	23,603	\$ 3,912	18,872	\$ 3,207
	5312800011	Recreation	33,572	\$ 5,736	41,476	\$ 6,776	34,390	\$ 5,756	35,135	\$ 5,912
Headquarters	2805421016	Fire	60,799	\$ 10,171	71,297	\$ 11,587	64,269	\$ 10,603	58,875	\$ 9,874
Helen Mae Sauter ES	5349248012	School	28,560	\$ 1,778	32,640	\$ 3,536	27,120	\$ 3,185	27,520	\$ 5,005
	6543162014	School	102,440	\$ 5,197	159,480	\$ 8,859	151,960	\$ 17,354	148,840	\$ 28,025
Landfill	2809842011	Health	99,884	\$ 16,821	70,817	\$ 11,514	57,770	\$ 9,546	44,415	\$ 7,399
	4050958028	Health	0	\$ 64	1,341	\$ 323	652	\$ 215	1,006	\$ 272
	6575704037	Health	3,789	\$ 687	10,467	\$ 1,792	10,542	\$ 1,840	9,827	\$ 1,679
Maintenance	7790226011	Golf Course	26,636	\$ 4,478	35,480	\$ 5,816	33,377	\$ 5,550	27,446	\$ 4,543
Monument	7804780011	Parks	0	\$ 17	0	\$ 15,808	0	\$ 107	0	\$ 114
Police	6543159017		132,529	\$ 18,088	163,810	\$ 22,559	165,644	\$ 21,319	137,465	\$ 21,205
Pro Shop	6575688010	Golf Course	13,187	\$ 2,231	17,858	\$ 2,975	15,399	\$ 2,607	10,204	\$ 1,760
Prospect Street ES	1562020018	School	166	\$ 28	1,255	\$ 236	1,266	\$ 282	1,254	\$ 327
	4050940017	School	1,210	\$ 160	9,113	\$ 1,452	9,200	\$ 1,755	9,126	\$ 2,112
PW Garage	2805408013	PW	166	\$ 45	1,255	\$ 302	1,266	\$ 333	1,254	\$ 308
	2855026016	PW	73,482	\$ 12,473	70,942	\$ 11,526	60,781	\$ 10,064	51,606	\$ 8,657
	4102704007	PW		\$ -	10,449	\$ 1,848	16,085	\$ 2,403	15,815	\$ 2,334
Restaurant, Golf Course	7821547038	Golf Course		\$ -	1,840	\$ 368	2,454	\$ 532	0	\$ -
S. Gardner Station	4083480017	Fire	4,583	\$ 852	6,086	\$ 1,085	5,758	\$ 1,049	7,318	\$ 1,285
	4086694013	Fire	372	\$ 149	1,002	\$ 267	808	\$ 240	994	\$ 273
Street Lighting	1562019015	PW	33	\$ 14	246	\$ 89	249	\$ 98	247	\$ 91
	1562031011	PW	23,531	\$ 4,051	27,084	\$ 4,474	25,947	\$ 4,361	25,529	\$ 4,243
	5301939010	PW	64	\$ 20	488	\$ 134	494	\$ 148	490	\$ 137
	5313092013	PW	10,863	\$ 1,917	11,537	\$ 1,966	10,513	\$ 1,831	12,100	\$ 2,058
	6560658019	PW	10,128	\$ 3,486	26,729	\$ 4,414	26,857	\$ 4,509	26,205	\$ 4,350
	6577385012	PW	1,410	\$ 321	1,378	\$ 327	1,329	\$ 325	1,491	\$ 353
	7789072016	PW	8,139	\$ 3,881	65,510	\$ 25,865	66,208	\$ 28,766	65,681	\$ 29,633
	7790069007	PW	90,643	\$ 17,746	432,597	\$ 85,253	437,193	\$ 98,366	433,702	\$ 92,966
	7822922017	PW	4,114	\$ 780	4,992	\$ 911	3,869	\$ 740	4,598	\$ 852
Stuart Street	6558957016	Parks	0	\$ 16	0	\$ 105	0	\$ 107	5,120	\$ 954
Traffic Lights	244111019	Building	78	\$ 53	156	\$ 107	156	\$ 109	156	\$ 112
	346750016	Building	187	\$ 118	219	\$ 141	212	\$ 142	209	\$ 148
	349600013	Building	224	\$ 124	267	\$ 148	280	\$ 153	279	\$ 159
	1480942015	Building	90	\$ 55	180	\$ 111	180	\$ 113	180	\$ 116
	1580221013	Building	258	\$ 130	172	\$ 133	243	\$ 147	366	\$ 173
	1597073018	Building	493	\$ 169	571	\$ 197	513	\$ 192	493	\$ 193
	1597287012	Building	1,684	\$ 366	2,040	\$ 434	2,014	\$ 436	1,853	\$ 411
	2725271010	Building	78	\$ 53	156	\$ 107	156	\$ 109	156	\$ 112
	2728361011	Building	216	\$ 76	432	\$ 151	432	\$ 154	432	\$ 156
	2821796018	Building	1,031	\$ 257	1,274	\$ 311	1,279	\$ 316	1,269	\$ 318
	2822840015	Building	291	\$ 118	447	\$ 178	339	\$ 163	317	\$ 165
	2822908012	Building	284	\$ 134	328	\$ 158	315	\$ 159	280	\$ 159
	2838036018	Building	912	\$ 237	1,134	\$ 288	1,029	\$ 275	1,130	\$ 295
	3971208011	Building	84	\$ 54	168	\$ 109	168	\$ 111	168	\$ 114
	4083530012	Building	759	\$ 222	707	\$ 219	620	\$ 191	0	\$ -
	4085737019	Building	915	\$ 140	1,164	\$ 201	991	\$ 216	954	\$ 282
	5217506016	Building	90	\$ 55	180	\$ 111	180	\$ 113	180	\$ 116
	5312954014	Building	167	\$ 114	200	\$ 138	202	\$ 140	184	\$ 143
	5329300017	Building	1,753	\$ 377	2,109	\$ 445	2,028	\$ 439	2,018	\$ 438
	6464289018	Building	96	\$ 56	192	\$ 113	192	\$ 115	192	\$ 118
	6559612016	Building	957	\$ 254	625	\$ 138	0	\$ -	941	\$ 318
	6562797019	Building	968	\$ 231	3,006	\$ 591	1,673	\$ 380	1,659	\$ 380
	7805336017	Building	1,252	\$ 294	1,485	\$ 344	1,536	\$ 358	1,967	\$ 428
	8957749010	Building	72	\$ 52	144	\$ 105	144	\$ 107	144	\$ 110
	9052374016	Building	450	\$ 170	427	\$ 162	0	\$ -	0	\$ -
	9068286018	Building	223	\$ 132	228	\$ 142	215	\$ 142	237	\$ 152
Waterford Street Primary	4050941014	School	1,566	\$ 213	11,787	\$ 1,913	11,904	\$ 2,309	11,809	\$ 2,777
	7789094016	School	32,480	\$ 2,001	50,800	\$ 5,285	50,240	\$ 5,998	47,920	\$ 8,742
	9036042019	School	332	\$ 63	2,511	\$ 493	2,529	\$ 564	2,509	\$ 655
	9052067016	School	99,600	\$ 3,457	259,800	\$ 21,886	245,760	\$ 19,249	257,640	\$ 43,128
	Total		2,396,641	\$ 327,669	3,468,977	\$ 467,061	3,594,610	\$ 434,100	3,567,592	\$ 657,982
	Average Cost per kWh (all accounts)		-	\$ 0.137	-	\$ 0.135	-	\$ 0.121	-	\$ 0.184

2.6 Site Access

The wind turbine components needed for the Summit Industrial Park project will likely be manufactured in distant states or other countries and transported to the site. Large megawatt-size wind turbines contain components that will exceed Massachusetts highway weight and size limits and must be transported as "Super Loads". In Massachusetts, a permit will be required if the load exceeds 22,400 pounds, is over 40 feet long, is 8.5 feet or wider, or is 13.5 feet tall or higher. Some wind turbine components such as the lower tower sections will trigger up to three of these criteria, and therefore will require a permit and engineering review prior to permits being issued for transportation. Sharp horizontal or excessive vertical curves are obstacles for transporting Super Loads. Furthermore, a weight-restricted long bridge or an overpass with low clearance could block an otherwise acceptable route to the site.

Ultimately the turbine vendor is usually most capable to investigate possible routing concerns, as they are familiar with the specialized equipment that may be necessary to manage transportation constraints. As part of a future wind turbine solicitation process, prospective equipment suppliers should be asked to provide their own analysis of all transportation issues, considering the sizes and weights of their own equipment and the availability of specialized transportation vehicles that may be available.

As part of our review of the project site, Tighe & Bond performed an assessment of potential access to the site as well as construction and staging considerations for the project.

The site, on Suffolk Drive, can be accessed from Route 2 by travel along Route 140 and Pearl Street (Route 101). The majority of Route 2 as well as the section of Route 140 located between Route 2 and Pearl Street is owned and maintained by the Massachusetts Department of Transportation (MassDOT), while Pearl Street (Route 101) between Route 140 and Suffolk Drive is municipally owned and maintained.

Route 2 is located approximately 4 miles from the site and contains major junctions with Interstate Highways 91, 190, 495 and 95. Although Route 2 is a four-lane divided roadway in Gardner, its lane count and configuration is variable depending on its location throughout Massachusetts. Route 2 intersects Route 140 at the Exit 24 interchange. Route 140 is initially comprised of a four lane undivided roadway, but transitions to a two-lane undivided roadway approximately one mile north of the Route 2 interchange. The Route 140 and Pearl Street (Route 101) intersection is located approximately three miles from the Route 2 interchange and is a wide intersection with multiple lanes for turning on both Route 140 and Pearl Street. Pearl Street is a two lane undivided roadway and contains a right hand turning lane approaching Suffolk Drive. The intersection of Suffolk Drive and Pearl Street also contains a wide intersection for the industrial park and an island separates traffic entering and exiting the industrial park.

The most critical point of transport appears to be turning movements required to exit Route 2 onto Route 140, turning from Route 140 onto Pearl Street, and turning from Pearl Street onto Suffolk Drive. Minor roadway modifications (temporary sign removal, guardrail removal, etc.) will likely need to be completed in order to facilitate the turning movements. Roadway modifications on Route 2 or Route 140 will require MassDOT

approval while roadway modifications to Pearl Street (Route 101) and Suffolk Drive will require municipal approval.

There is no rail access directly to the Site. While a rail line does come within half a mile of the Site, there is no rail access directly to the Site and additional transport of turbine parts by truck would be required if equipment was to be transported by rail.

2.7 Noise Assessment

The Wind Energy Conversion System section of the City's zoning ordinance does not include specific provisions for noise impacts. However, the turbine will be subject to the Massachusetts noise regulation (310 CMR 7.10). This regulation requires no increase of ambient sounds levels at the property line and at the nearest occupied building by more than 10 dB(A) and no pure tone conditions. The purpose of the noise assessment is to evaluate the likelihood of significant noise impact from the turbine on the surrounding properties to determine whether detailed acoustic modeling should be performed.

The turbine site is not immediately surrounded by residential areas. The closest residential property, the housing complex on Dinan Lane, is approximately 2,000 feet away. For reference, MassCEC now requires an acoustic study to be performed as a part of the Feasibility Study for projects funded under Block 4 that have a residential property within 3.5 times the hub height of the turbine location. No residential properties are within 3.5 times the hub height of the tallest turbine proposed (80m hub height, 908 feet noise radius) for this project. In general, wind turbine noise is expected to be a concern for receptors less than 1,000 feet from the turbine and may be a concern to receptors located between 1,000 and 3,000 feet from the turbine depending on the topography and sound obstacles. In this case, the turbine is located at a higher elevation from the receptors and there is dense tree cover in all directions. It is expected that sound emissions from the turbine will not pose a health, safety, or nuisance concern for residential properties.

There is a manufacturing facility within 350 feet of the turbine. While it is likely that the turbine noise will not significantly exceed the noise that is produced in that facility, the City should be prepared to conduct a detailed noise study in the case that a concern is raised.

2.8 Visual Assessment

Visual receptors have been modeled in WindPro to assess shadow flicker and viewshed. Shadow flicker is the flashing of light perceived when the turbine blade passes between a receptor and the sun. Shadow flicker has been shown to cause much annoyance and is a primary concern for residents living close to wind farm facilities. Viewshed is a description of locations from which the turbine can be seen. Viewshed analyses take the terrain and tree cover into consideration. Viewshed impacts can be a concern in Massachusetts when a turbine viewshed impacts historic places known for natural features and unhampered views.

2.8.1 Shadow Flicker

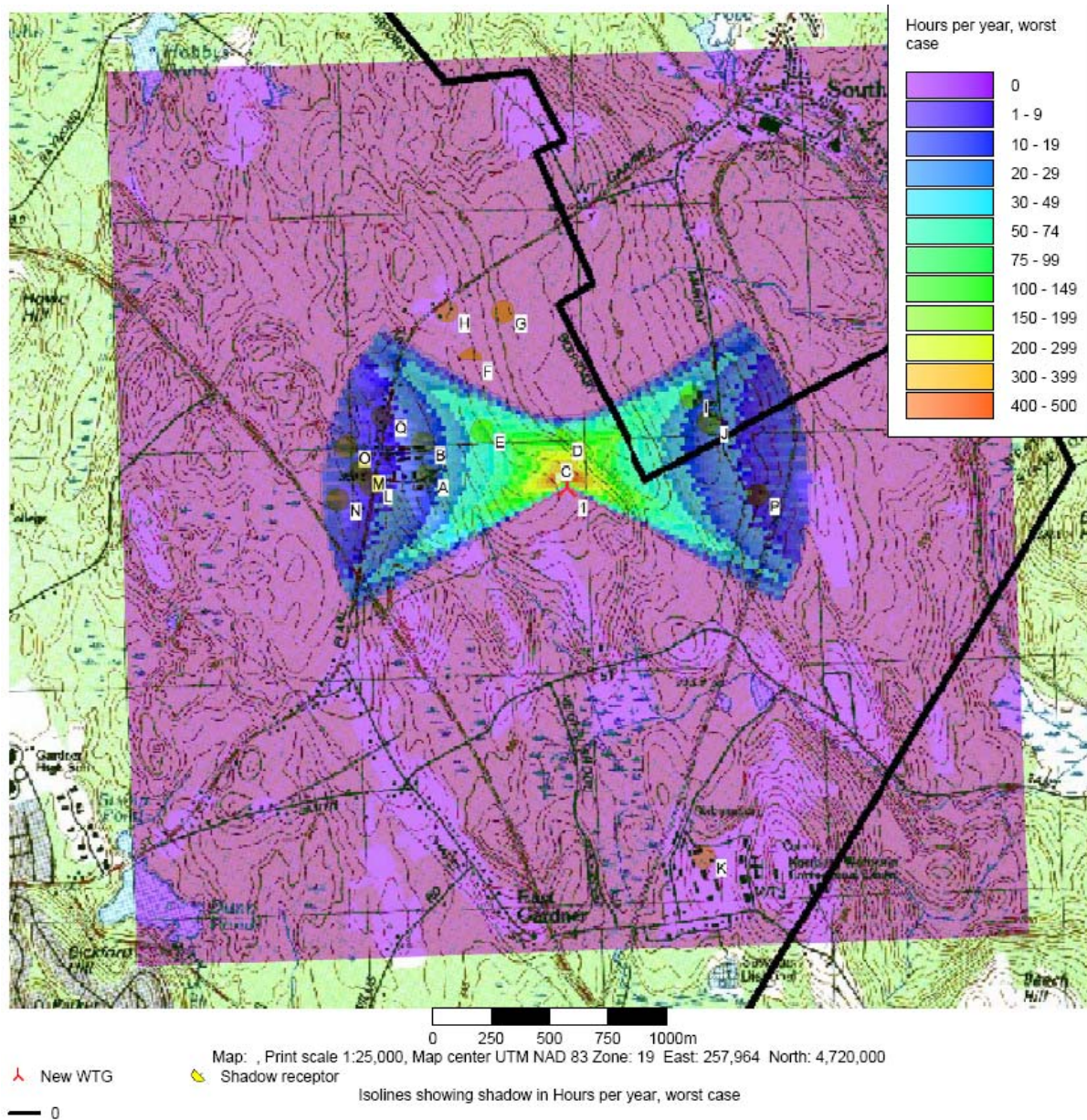
A map showing the distribution of shadow flicker in the area of the turbine is below. The map was generated for the Vestas V82, which is the expected worst case due to its hub height and rotor diameter. The following worst case conditions were initially used to assess shadow flicker:

- Turbine operational 24/7
- Turbine rotor facing the sun at all times
- Turbine rotor spinning at all times
- Receptors are modeled as “greenhouses” representative of windows 360 degrees around the building
- Clear skies and sunshine all day, every day

A shadow flicker map was developed based on this scenario. See Figure 2-3, below. The red triangular symbol represents the wind turbine location and each letter corresponds to a shadow flicker receptor, described below. The figure is also included in the complete shadow flicker report, Appendix B.

FIGURE 2-3

Shadow Flicker Map



Since the manufacturing facilities proximate to the site potentially receive an unacceptable number of shadow flicker hours under the unrealistically conservative worst case conditions, they were modeled more realistically in an expected case, according to window location. The expected case also takes average daily sunshine hours into consideration and was modeled to remain conservative, but provide a comparison to the worst case scenario.

Seventeen (A – Q) potential shadow receptors on all sides of the turbine location were identified for shadow flicker analysis. See Figure 2-4 for each shadow receptor location and Table 2-2 for the name and type of each receptor and the total hours of shadow flicker they will receive.

FIGURE 2-4

Shadow Flicker Receptors

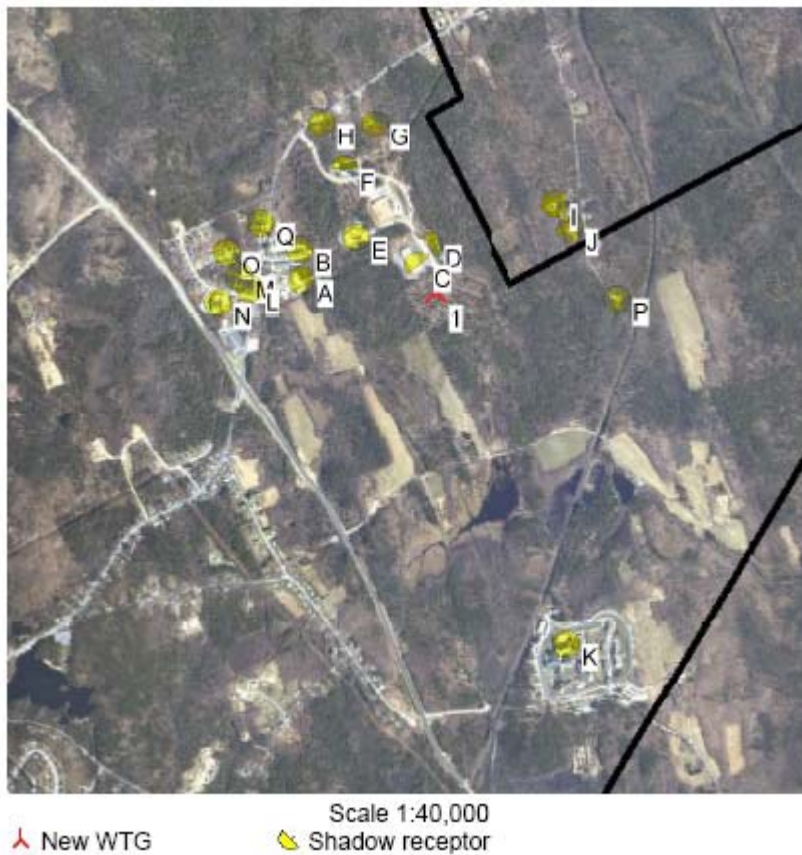


Table 2-2 shows the results of the shadow flicker analysis. In the worst case scenario, the two industrial properties closest to the site receive a considerable amount of shadow flicker hours. However, in the expected case, it is likely that moderate mitigation measures can be implemented to reduce the shadow flicker hours affecting the two industrial buildings adjacent to the site to below 30 hours per year, the industry standard accepted level of flicker. Analysis of the detailed tables which record when each minute of shadow flicker is occurring (located in the Shadow Flicker Report, Appendix B) shows that mitigation may be successful by turning the turbine off for about an hour in the mid-morning from November through February. Other mitigation efforts can include leaving as much tree cover as possible between the turbine location and the buildings and supplying the buildings with appropriate shades for the few windows that face the turbine. Since there are so few windows on the buildings in question, shadow flicker is not expected to be a fatal flaw.

TABLE 2-3
Shadow Receptor Analysis

Shadow Receptor	Type	Worst Case Shadow Hours per year	Worst Case Shadow Days per year	Worst Case Max Shadow Hours per day	Expected Shadow Hours per year
A	Condo	16:14	40	0:31	5:55
B	Condo	15:06	39	0:30	5:55
C	Industry	283:49:00	181	1:59	95:20
D	Industry	118:59:00	93	1:31	32:15
E	Industry	46:53:00	82	0:45	17:10
F	Industry	0:00	0	0:00	0:00
G	Residence	0:00	0	0:00	0:00
H	Residence	0:00	0	0:00	0:00
I	Residence	24:04:00	63	0:30	6:56
J	Residence	14:55	40	0:29	4:58
K	Residence	0:00	0	0:00	0:00
L	Residence	8:04	29	0:23	2:56
M	Residence	6:52	26	0:21	2:29
N	Commercial	5:18	26	0:18	1:58
O	Residence	5:40	25	0:20	2:09
P	Residence	9:20	30	0:24	3:38
Q	Residence	8:32	32	0:23	3:23

The residential buildings around the turbine location will receive relatively small amounts of shadow flicker, never exceeding 31 minutes in any day (Receptor A, maximum). The residential receptor that will receive shadow flicker on the most days of the year (63 days at Receptor I) will only receive a total of 7 hours of flicker per year.

These calculations are for the Vestas V82, the expected worst case due to its hub height and rotor diameter. However, since many factors affect shadow flicker for each receptor, the residential shadow receptor receiving the most hours of flicker in each configuration is compared for each turbine in Table 2-3. If there are any receptors that are expected to receive over 30 hours of shadow flicker per year, they are included in the table as requiring mitigation.

TABLE 2-4

Most Sensitive Shadow Receptor in Each Turbine Configuration

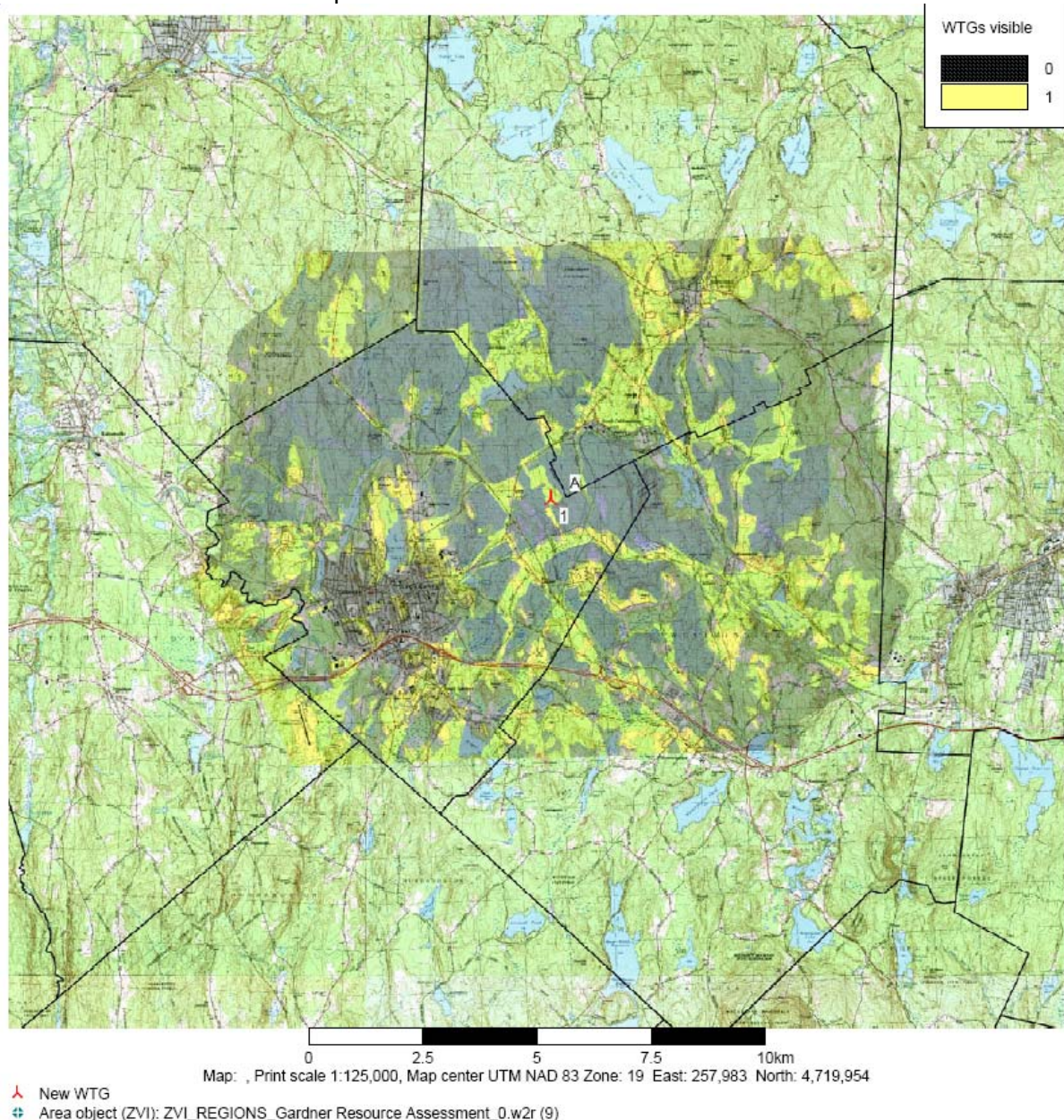
Turbine, Configuration	Shadow Hours per Year, Worst Case, Worst Residential Receptor	Shadow Hours per Year, Expected, Worst Residential Receptor	Receptors Requiring Mitigation (>30 hrs/yr)
Vestas V82, 1.65 MW, 80m	24:04	6:56	C, D (Industrial)
FL1500, 1.5 MW, 65m	25:44	6:40	C (Industrial)
GE 1.5sle, 1.5MW, 80m	21:10	5:41	C (Industrial)
PowerWind 56, 0.9 MW, 71m	11:52	3:24	C (Industrial)
PowerWind 56, 0.9 MW, 71m, Two Turbines	24:11	6:36	C (Industrial)

2.8.2 Viewshed

A map showing the viewshed, or zones of visual influence has also been developed using WindPRO, taking topography into consideration. The Vestas V82 was used in the simulation since it has the highest hub height and largest rotor diameter, and is therefore the worst case scenario. The other turbines, with the exception of the double turbine configuration will all have less visual impact. Since trees are a large source of visual interception, tree cover was digitized into the analysis using orthographic photos and knowledge of the surrounding areas. A conservative tree height of 20 meters was used. Tree height on the Site was measured to be about 23 meters. With these assumptions, only about 27% of the surrounding land has visibility of the wind turbine. Figure 2-5 shows the areas from which residents will be able to see the turbine from an average standing height of 1.5m.

FIGURE 2-5

Zone of Visual Influence Map



Visualizations of the wind turbine have also been developed by Tighe & Bond to simulate what residents would see from three key vantage points in the City. The visualizations confirm what the zone of visual influence map indicates, which is that tall tree height in the Gardner area greatly affects visibility. Even the most critical visual receptors (see photos below) have a very limited view of the turbine. Figure 2-6, the rendering location map, shows where the viewer is located and the direction they are facing looking at each rendering. Figure 2-7 is the view from Suffolk Lane in the Industrial park. This is one of the few locations where the majority of the turbine is visible. Figures 2-8 and 2-9 are from Dinan Drive and Murray Rd, respectively, and show that only a portion of the turbine will be visible from these locations.

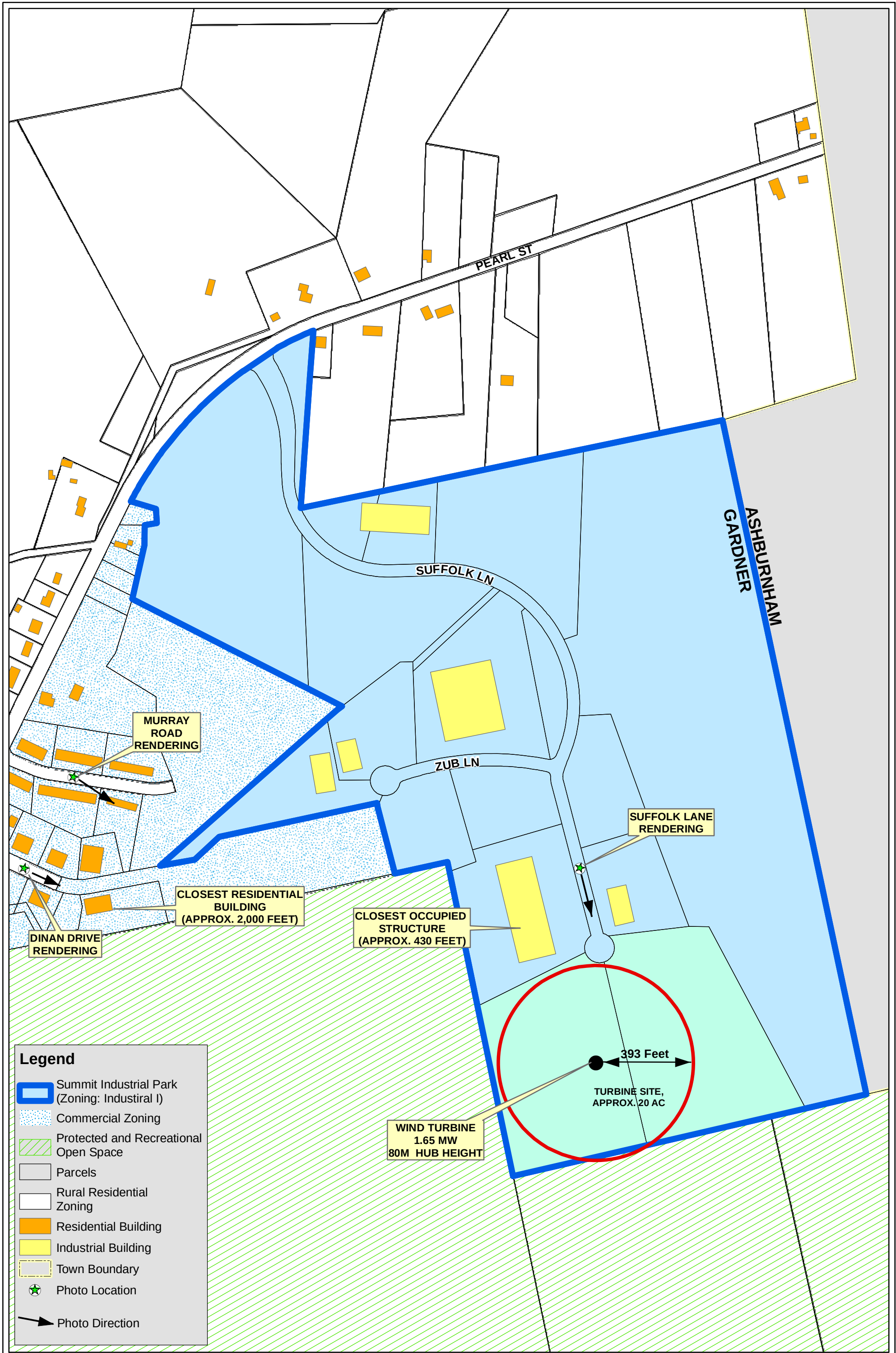


FIGURE 2-6
RENDERING LOCATION MAP
GARDNER WIND TURBINE
GARDNER, MASSACHUSETTS

OCTOBER 2010

Tighe&Bond





**FIGURE 2-7
SUFFOLK LANE**



FIGURE 2-8
DINAN DRIVE

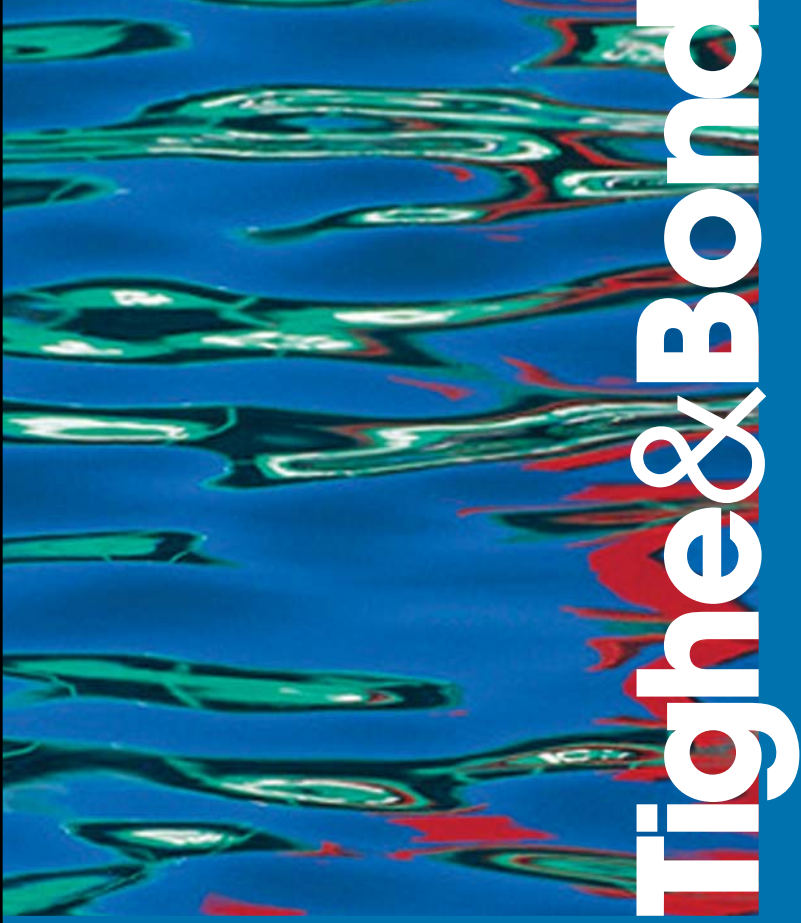


FIGURE 2-9
MURRAY ROAD

2.9 Site Evaluation Conclusions

Through the Site Evaluation it was determined that no turbine presents a fatal flaw based on impacts to the Site, land use, zoning, or airspace restrictions. Interconnection and site access are also possible at the Site due to the existing industrial grade infrastructure.

In order to accommodate a turbine as large as the Vestas V82, a fall zone easement may be required from the Highridge Wildlife Management Area. Also, some shadow flicker mitigation may be required for any turbine installed. Since no fatal flaws or turbine prohibiting factors have been found, all turbines will be evaluated in the financial analysis.



Tighe & Bond

Section 3

Environmental and Regulatory Review

The Environmental and Regulatory review in this section expands upon the Site Evaluation discussion in the previous section by including detailed analysis of wetlands, flora, and fauna. The analysis consisted of reviewing existing site conditions and available scientific databases, and using MassGIS data layers to determine preliminary potential environmental impacts. This section also addresses potential and expected permitting obligations and presents a permitting plan that outlines a strategy for successful completion of the pre-construction permitting. It is critical that the City have a good understanding of the potential level of effort associated with these tasks for future project planning.

3.1 Environmental Characterization

The City of Gardner is in North-central Massachusetts, approximately 50 miles northwest of Boston. The Summit Industrial Park is located on 20 acres of relatively level land. The Site was selectively logged three years ago, resulting in wooded areas with limited dense underbrush. Onsite trees species are primarily conifers. Adjacent properties include five manufacturing facilities as well as the State-owned Highridge Wildlife Management Area (WMA).

At 364 meters above sea level, the Summit Industrial Park is a suitable location for the proposed wind turbine because of the results of the wind resources assessment discussed above. Environmental factors critical to the siting of the turbine are discussed below. Please refer to the Priority Resource Map in this section for an overview of critical environmental and cultural resources.

3.2 Wetlands, Flora and Fauna

A preliminary wetland assessment of the entire site (two lots) was conducted on July 16, 2010. The assessment was conducted in accordance with state (Massachusetts Department of Environmental Protection, MADEP) guidelines, the Wetlands Protection Act regulations [310 CMR 10.55(2.c.1)], and the City of Gardner Wetlands Protection Ordinance (December 20, 2003). No jurisdictional wetland resource areas were noted within the limits of Lots 5 and 6. Additionally, no wetland resource areas were noted within 200 feet of the outer perimeter of the lots.

The assessment methodology entailed walking the outer perimeter of the lots, as well as walking in a general grid pattern (southeast-northwest-southeast). General vegetation data was collected, and soil characteristics observed to a depth of 12 inches where feasible. Field observations regarding site soil characteristics and vegetation are described below.

It should be noted that the Gardner Wetlands Protection Ordinance also includes as Protected Resource Areas vernal pools, any floodplain and any lands under or any lands subject to flooding or inundation by groundwater, surface water or storm flow that are determined by the Commission to fall within the Purpose and Intent of the Ordinance. The ordinance definition of “vernal pool” includes *“any confined basin or depression not occurring in existing lawns, gardens, landscaped areas or driveways which, at least in most years, holds water for a minimum of two continuous months during the spring*

and/or summer, **contains at least 100 cubic feet of water at some time during most years**, is free of adult predatory fish populations, and provides essential breeding and rearing habitat functions for amphibian, reptile or other vernal pool community species, regardless of whether the site has been certified by the Massachusetts Division of Fisheries and Wildlife". At the time of the site visit, no potential or presumed vernal pools/confined basins or depressions (dry or flooded) were noted. However, early spring (March through May) is the easiest and optimal time to locate and document any potential vernal pools.

FEMA Flood Insurance Rate Map (FIRM) Community Panel No. 250305 0003B (effective date: July 2, 1981) was reviewed during the preparation for the field assessment. According to the FIRM, the Site, as well as Suffolk Lane and the remainder of the Summit Industrial Park are located in Zone C and outside the limits of 100-year flooding.

Soil characteristics were checked to a depth of 12 inches across the site using a hand auger. Soils at this site are consistent with the Worcester County Soil Survey mapped soils, which are well drained fine sandy loams. Use of the Munsell Soil Color Charts to further characterize the soils indicated soil characterization of 10YR 5/6 between 6 and 12 inches, indicating upland soil conditions.

The two parcels consist primarily of upland soils and upland vegetation. Because the parcels have been selectively logged within the past three to four years, dominant vegetation consists of thick "understory" shrubs and saplings. Typical "understory" vegetation includes the following: lowbush blueberry (*Vaccinium angustifolium*), highbush blueberry (*Vaccinium corymbosum*), yellow birch (*Betula alleghaniensis*), mountain laurel (*Kalmia latifolia*), red maple (*Acer rubrum*), and white pine (*Pinus strobus*). Herbaceous vegetation includes ground pine (*Lycopodium dendroideum*), Canada mayflower (*Maianthemum canadense*), starflower (*Trientalis borealis*), partridgeberry (*Mitchella repens*), wild strawberry (*Fragaria vesca*), and bracken fern (*Pteridium aquilinum*). Royal fern (*Osmunda regalis*) was also a non-dominant species present in the herbaceous layer. The remaining tree canopy consists primarily of white pine and other conifers (including spruce), and some red maple (*Acer rubrum*). Some downed logs and snags remain on both lots.

According to desktop analysis of available mapping, and based on the July 16, 2010 site visit, there are jurisdictional wetland resource areas located to the east and west of Suffolk Lane and the Summit Industrial Park (both located on Gardner Redevelopment Authority land, Parcel Y-36-68-7). It appears that an unnamed intermittent stream flows out of jurisdictional resource areas located on the north side of Route 101 via a culvert into a Bordering Vegetated Wetland (BVW) located on the south side of Route 101 west of Suffolk Lane. Portions of the truck access to the Summit Industrial Park along Suffolk Lane would likely occur within the 100-foot Buffer Zone of this intermittent stream and BVW. The intermittent stream is not depicted on the most recent USGS topographic quadrangle or on the USGS StreamStats mapping. However, the USGS quadrangle does depict a perennial stream originating just north of Dinan Drive within the BVW. This perennial stream flows to the south, and is located more than 200 feet from the west boundary of the Site. Therefore, it is assumed that the 200-foot Riverfront Area associated with this perennial stream is located west and outside the perimeter of the Site.

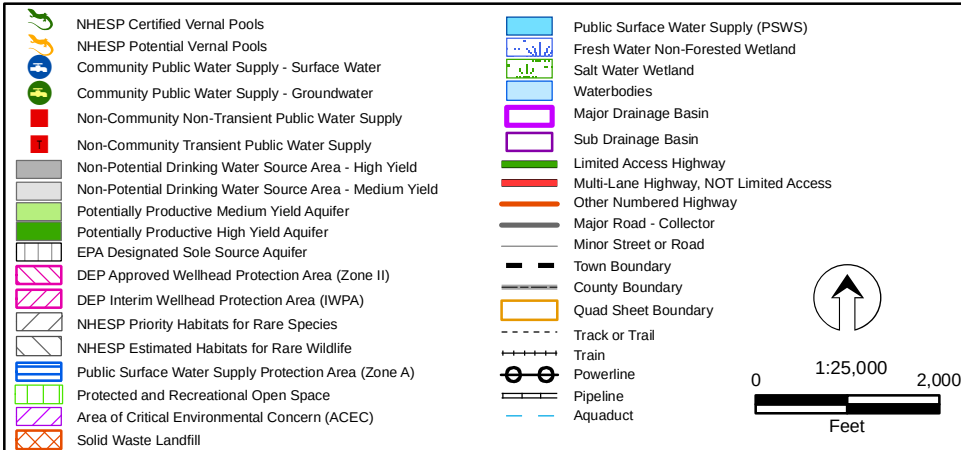
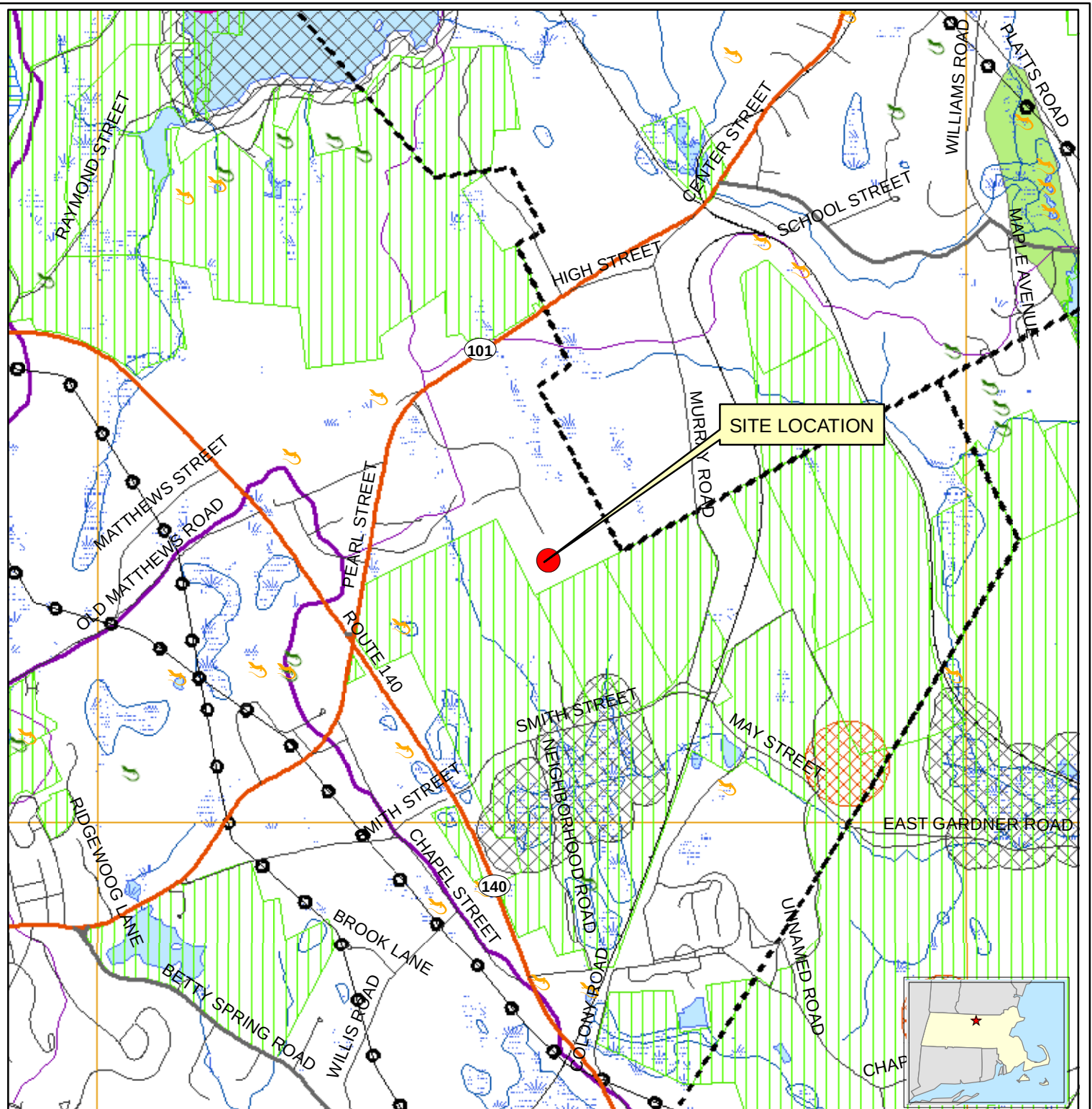


FIGURE 3-1
PRIORITY RESOURCE MAP

Gardner Wind Turbine
Gardner, Massachusetts

Tighe&Bond

October 2010

Data source: Office of Geographic and Environmental Information
(MassGIS), Commonwealth of Massachusetts
Executive Office of Environmental Affairs.
Data valid as of September 2010.

A BVW is also located on the east side of Suffolk Lane, to the north and east of the Industrial Park. According to the U.S. Fish and Wildlife Service National Wetlands Inventory (NWI), the wetlands are characterized as freshwater palustrine forested or scrub-shrub wetlands with needle-leaved evergreens and broad-leaved deciduous dominant vegetation. No wetland resource areas were observed within 200 feet of the eastern perimeter of the Site.

It should be noted that the site reconnaissance described above was a general assessment of the Site parcels to determine the presence of wetland resource areas. A formal delineation of wetland resource areas was not performed. An early spring assessment for the presence of potential vernal pools should be conducted. Should the City wish to confirm that no resource areas are present on the project site, it is recommended that a Request for Determination of Applicability (RDA) be submitted to the Gardner Conservation Commission.

A preliminary assessment of other environmental factors showed no state or federally listed rare species mapped habitats and no Area of Critical Environmental Concern on or within close proximity to the Site. The Site is adjacent to the Highridge Wildlife Management Area, a protected open space owned by the MA Division of Fisheries and Wildlife. MassGIS also does not list any certified or potential vernal pools near the Site. Please refer to Figure 3-1, the Priority Resource Map for an overview of critical environmental resources.

3.3 Avian and Bat Considerations

Two general types of avian impacts have been documented at U.S. wind energy projects: 1) displacement as a result of the construction and operation of wind turbines and related infrastructure, and 2) fatalities resulting from collisions with wind turbines, meteorology towers, and other infrastructure. Displacement risk relates to the probability that bird densities around wind turbines decrease to the point of having a population effect.

Although there are no state or federally listed species at the project site, there is the potential for birds to pass through the site and potentially be impacted by the project. To identify potential project-related impacts to avian species, Tighe & Bond conducted a preliminary assessment of bird species within the project area.

The MA NHESP maintains a list of wildlife in each Massachusetts community with endangered, threatened, or special concern status. In Gardner, the following two birds are on this list: American Bittern (state-listed endangered species) and the Sharp-shinned hawk (state-listed species of special concern). No federally listed bird species are noted in Gardner.

The project site is not located within or within close proximity to a MassAudubon-designated Important Bird Area. An Important Bird Area is a site that provides essential habitat to one or more species of breeding, wintering, or migrating birds. As noted in the Site Assessment conducted for this project, the Summit Industrial Park is located 15 miles north of the Ware River Watershed IBA, 8 miles southwest of the Mt. Watatic IBA, and 8 miles northwest of the Wachusett Mountain IBA.

Tighe & Bond also consulted MassAudubon's Breeding Bird Atlas to learn about species composition in the project area. The Breeding Bird Atlas (BBA) is a collection of data

about all of the birds that breed in a particular state or region. A figure showing the BBA Block for the project site and the list of 100 birds present in this block during the 2007 to 2011 count is provided in Appendix F. Of the two state-listed bird species present in Gardner noted above, only the American Bittern is listed in the BBA. The BBA results were also compared to the American Bird Conservancy's United States Watchlist of Birds of Conservation Concern. The U.S. Watchlist identifies birds in greatest need of immediate conservation attention. The list is separated into the Red List: Highest Continental Concern and the Yellow List: Declining or Rare Continental Species. Three species that are present in the Breeding Bird Atlas data for the project site are included on the Yellow List. These are the Willow Flycatcher, the Wood Thrush, and the Canada Warbler.

The state of Massachusetts does not have a current formal policy for pre- and post-construction evaluations for non-endangered avian and bat species. Based on Tighe & Bond's experience with recent projects, we are aware that NHESP currently only requires pre-construction monitoring for projects on the coastline or on ridgelines. Because the Summit Industrial Park is not located in either of these areas, it is likely that pre-construction evaluations are not required.

Although no state or federally-listed bat habitat appears to be present at the project site, the City should be aware that state and federal wildlife agencies have significant concerns regarding all bat populations in the Northeast due to the white nose syndrome. Hibernating bats in the northeastern United States are dying in record numbers, and limited information is available regarding the cause of the deaths. White-nose syndrome (WNS) is named for the white fungus evident on the muzzles and wings of affected bats. Due to overarching concerns about bat populations, regulatory agencies may have heightened concerns about the impacts of a wind energy project to further impact bats. As a result of population losses, some common bat species may become protected under state and federal regulations in the near future. In light of heightened concern for bat species in general, the City may want to consult with NHESP and the USFWS regarding the need for post-construction data gathering regarding bat activity at the site.

The project should incorporate construction guidelines to reduce risk to avian and bat species. Measures include:

- Electrical lines should be underground to avoid potential collisions.
- Size of roads and turbine pad should be minimized to disturb as little habitat as possible. After construction, any habitat should be restored or encouraged to regenerate as close to turbines and roads as possible to minimize habitat fragmentation and bird displacement.
- Lighting of turbines and other infrastructure should be minimal to reduce the potential for attracting night migrants.

3.4 Historic and/or Cultural Resources

Several online or publicly available resources are available to ascertain whether cultural resources exist at a project site. Cultural resources include historic buildings (e.g., homesteads, mills, churches), structures (e.g., dams, roads, stone walls), and archaeological sites (prehistoric and historic). Due to the sensitive nature of archaeological resources, the only way to confirm data regarding potential presence is to

contact the Massachusetts Historic Commission (MHC) through a Project Notification Form (PNF), discussed in further detail below.

Currently, there is no MassGIS layer for historic and cultural resources. The former layer that displayed relevant data was removed at the request of the MHC, as it updates locational inaccuracies and omissions in the data. Tighe & Bond conducted a search for historic properties in Gardner using the Massachusetts Cultural Resource Information System (MACRIS) database. MACRIS data are compiled from a variety of records and files maintained by the Massachusetts Historical Commission (MHC), including but not limited to, the Inventory of Historic Assets of the Commonwealth, National Register of Historic Places nominations, State Register of Historic Places listings, and local historic district study reports. The system includes no information on archaeological sites. The MACRIS report is included in Appendix F. Tighe & Bond also reviewed the 2007 Edition of the State Register of Historic Places. Both the MACRIS database and the State Register indicate that no historic properties are located in the immediate vicinity of the project site.

MHC jurisdiction can be triggered by “indirect” impacts on a resource, as well as by a proposed demolition or other direct impacts. This means that an activity outside of a historic district or site may require MHC review if it would potentially cause visual, shadow, noise, or other impacts on the historic site. Recent examples have included the shadow impacts of a Harvard dormitory on the Charles River Basin parks, the visual and noise impacts of MBTA trains on nearby properties, and the visual impacts of the Cape Wind project on landside resources located between 5 and 14 miles away.

There may be numerous state-listed resources in Gardner or abutting communities from which the project may be visible. As previously noted, during its review of the Cape Wind project, MHC required an evaluation of viewshed impacts from historic properties. A viewshed analysis has been conducted as part of the Feasibility Study (see Section 2.8.2). As part of the MHC review process outlined in more detail below, the City may be required to identify any historic properties within the viewshed of the turbine.

3.5 Regulatory Requirements

The City of Gardner is an Economic Target Area under the Commonwealth's Economic Development Incentive Program (EDIP), and the Summit Industrial Park has been designated as an Economic Opportunity Area under the EDIP. The City of Gardner has approved nineteen Certified Projects throughout the City including four in the Summit Industrial Park. The Summit Industrial Park is an approved Priority Development Area under the Commonwealth's 43D Expedited Permitting Program, which guarantees permit review and approval of eligible projects within 180 days.

Permits and approvals that will likely need to be procured before construction and the current application status include the following:

3.5.1 Federal

As noted in Section 2.4, a **Determination of No Hazard to Air Navigation** was issued from the FAA for the proposed turbine location on July 16, 2009. Since the Determination will expire on July 16, 2011, it is likely that a renewal will be required. Furthermore, as a condition of the Determination, Gardner must file a **Notice of Actual Construction or Alteration** (Form 7460-2, Part II) with the FAA within 5 days after construction reaches its greatest height. Completing these two permitting requirements

is not expected to be labor intensive. Based on the outcome of consultation with the FAA, it is possible that an Application for a Construction Permit may be required from the Federal Communications Commission (FCC).

Administered by the US Environmental Protection Agency (EPA), the National Pollutant Discharge Elimination System (NPDES) requires a **Stormwater Discharge General Permit for Construction** to be obtained prior to construction. Similarly, a **Stormwater Discharge General Permit for Operations** must be obtained prior to turbine operation.

Depending on the size of the proposed turbine and the development/ownership model, the City of Gardner may be required to submit an application to the Federal Energy Regulatory Commission (FERC) to obtain **Qualifying Facility Status**. This approval is required in order to enter into a power purchase agreement with the electric utility.

The **U.S. Fish and Wildlife Service (USFWS)** is responsible for administering the Endangered Species Act (ESA), the Migratory Bird Treaty Act, and the Bald Eagle Protection Act. The Feasibility Study conducted for the site indicates that no federal or state listed, threatened, endangered or proposed species are present at the project location. In addition, the site is not located within rare species habitat designated by the Massachusetts Natural Heritage and Endangered Species Program (NHESP); if a federally listed species is present at a project site, it will also show up on state maps. As the project proceeds to permitting, the City should consult with the USFWS regarding the siting of the wind project, and to determine compliance with the recommendations of the USFWS Wind Turbine Guidelines Advisory Committee (March 2010). Pre-construction avian and bat surveys may be requested as a result of this consultation.

3.5.2 State Permitting

Tighe & Bond does not anticipate that project review will be required pursuant to the **Massachusetts Environmental Policy Act (MEPA)** for the project. MEPA review is required for projects that involve a state agency action (i.e. permit, financial assistance) and that exceed a MEPA review threshold at 301 CMR 11.03. While the project will likely move forward with some state funding, no MEPA review thresholds are anticipated to be exceeded. The review thresholds typically exceeded for wind energy projects relate to land alteration. For projects that alter in excess of 25 acres of land, an Environmental Notification Form (ENF) is required. Because the project site is approximately 20 acres only, this threshold will not be met. The project is also not likely to exceed other thresholds related to impervious surface, wetlands, rare species, energy, transportation, air quality, wastewater, water, or solid waste. Should the City require confirmation that MEPA review is not required for the project, it can request an Advisory Opinion from the MEPA office to that effect.

As outlined above, the project site is not located within or adjacent to areas of Estimated or Priority Habitat. Therefore, review pursuant to the **Massachusetts Endangered Species Act (MESA)** through the **Natural Heritage and Endangered Species Program (NHESP)** is not anticipated to be required.

Any new construction projects that require funding, licenses, or permits from any state or federal governmental agencies must be reviewed by the **Massachusetts Historic Commission (MHC)** for impacts to historic and archaeological properties pursuant to MGL C. 9 § 26-27C. Any projects that require funding, licenses, or permits from federal agencies must also be reviewed by MHC in compliance with Section 106 of the National

Historic Preservation Act of 1966 pursuant to 36 CFR 800. MHC's jurisdiction is broad, and not only extends to resources listed in the State Register of Historic Places or the Inventory of Historic and Archaeological Assets of the Commonwealth, but to any resources that *may be eligible* for listing in the Register or Inventory. To initiate the MHC review process, the City will need to submit a **Project Notification Form (PNF)**. As noted above, a viewshed analysis may be required to assess impacts to off-site historic resources.

The Massachusetts Aeronautics Commission (MAC) also requires **Notification of Proposed Construction** through the completion of a Form e10. Notice is required by 780 CMR 111.7, Hazards to Air Navigation. Pursuant to MGL Chapter 90, Section 35B, the Massachusetts Aeronautics Commission (MAC) will perform an airspace review to identify any violation of state airspace laws. The MAC review generally coincides with the FAA findings.

MassDOT may require an **Access Permit** if any modification to state roads is required by the project. A **Super Load Permit** may be required if the load exceeds 22,400 pounds, is over 40' long, is 8.5' feet or wider, or is 13.5' high or higher. An application for this permit will require a full structural analysis and a one month review period.

3.5.3 Local Permitting

Pursuant to Section 1040 of the Gardner Zoning Ordinance, the project will require a **Special Permit** from the Zoning Board of Appeals for the siting of a wind turbine in an Industrial Zone (the use is not permitted in other zoning areas). **Site Plan Review** with the Gardner Planning Board will also be required for the project pursuant to Section 1010 of the Gardner Zoning Ordinance. These processes will require a demonstration that the wind turbine does not adversely affect the City and neighborhood by changing the land use or existing character of surrounding areas, or by creating health, safety, or nuisance issues. It is not expected that the turbine's effect on any of the above factors will be determined significant by the Zoning Board of Appeals or the Planning Board. Noise and visual analysis are included in Section 2.1.2 and 2.1.3 of this Feasibility Study because they are historically important in wind turbine development and they are critical factors to understand in order to obtain siting approval. As noted in Section 2.1.2, the noise and visual effects of the turbine on surrounding receptors is expected to be minimal due to topography and distance of the Site from key receptors.

The City may choose to submit a **Request for Determination of Applicability (RDA)** to the Gardner Conservation Commission to confirm whether any portions of the project site include areas subject to jurisdiction under the MA Wetlands Protection Act and the Gardner Wetlands Ordinance (WPA Form 1 Section B.1.d.). As discussed in Section 3.2, no jurisdictional wetland resource areas were noted within the limits of Lots 5 and 6. Additionally, no wetland resource areas were noted within 200 feet of the outer perimeter of Lots 5 and 6. It is not anticipated that a Notice of Intent (NOI) filing will be required for this project.

Finally, the City of Gardner requires an electrical permit and a building permit to be obtained prior to construction. These permits will require coordination with the City during the Design Phase and must be procured before construction.

3.6 Permitting Plan

Based on current knowledge of the proposed project, anticipated impacts, and likely permitting requirements outlined above, Tighe & Bond has prepared the following preliminary permitting plan for the project. The plan outlines a suggested strategy for regulatory review and an estimated timeframe for each task. Note that the duration of each permitting task includes time to prepare permit applications, comply with public notification, review, and regulatory coordination.

3.6.1 Final Pre-Permitting Evaluations/Consultation

Once the turbine location, model, and associated impacts are finalized, the following final pre-permitting steps should be taken by the City:

- Confirm lack of/ or presence of wetland resource areas on site, determine need to file Request for Determination of Applicability (RDA) with Gardner Conservation Commission
- Consult with NHESP/USFWS to confirm any requirements for pre-construction avian or bat monitoring
- Prepare/submit PNF to Massachusetts Historic Commission, determine need for viewshed survey and/or archaeological investigations
- Based on anticipated project impacts, confirm that no MEPA filing is required for project
- Determine need for easement from DFW, obtain easement

Pre-Permitting Evaluations/Consultation Estimated Timeline: 60 days

3.6.2 Project Permitting

The following tasks will likely be associated with project permitting:

- Resubmit FAA Determination of Hazard. Estimated timeline: **45 days**
- Initiate MAC Airspace Review process. Estimated timeline: **45 days**
- Initiate Interconnection Study process with NGrid, seek Interconnection Agreement. **Estimated timeline: 8 months**
- Complete additional studies required for City of Gardner zoning review, to potentially include noise, visual, shadow. **Estimated timeline: 60 days**
- Prepare final Site Plan, submit Site Plan Review Application to Gardner Planning Board and Special Permit Application to Gardner Zoning Board of Appeals, obtain approvals. **Estimated timeline: 6 months**
- Confirm MassDOT permitting requirements associated with delivery of turbine components. **Estimated timeline: 45 days**
- File Notice of Intent and Stormwater Pollution Prevention Plan (SWPPP) to EPA prior to construction. **Estimated timeline: 30 days**

As outlined herein, the permitting requirements for a wind turbine at the Summit Industrial Park are not expected to be onerous, given the lack of sensitive receptors at

and around the project site. While the estimated timelines provided above are very preliminary, and subject to change based on final project design and related impacts, it is expected that project permitting could be complete within 8 months.



Tighe & Bond

Section 4

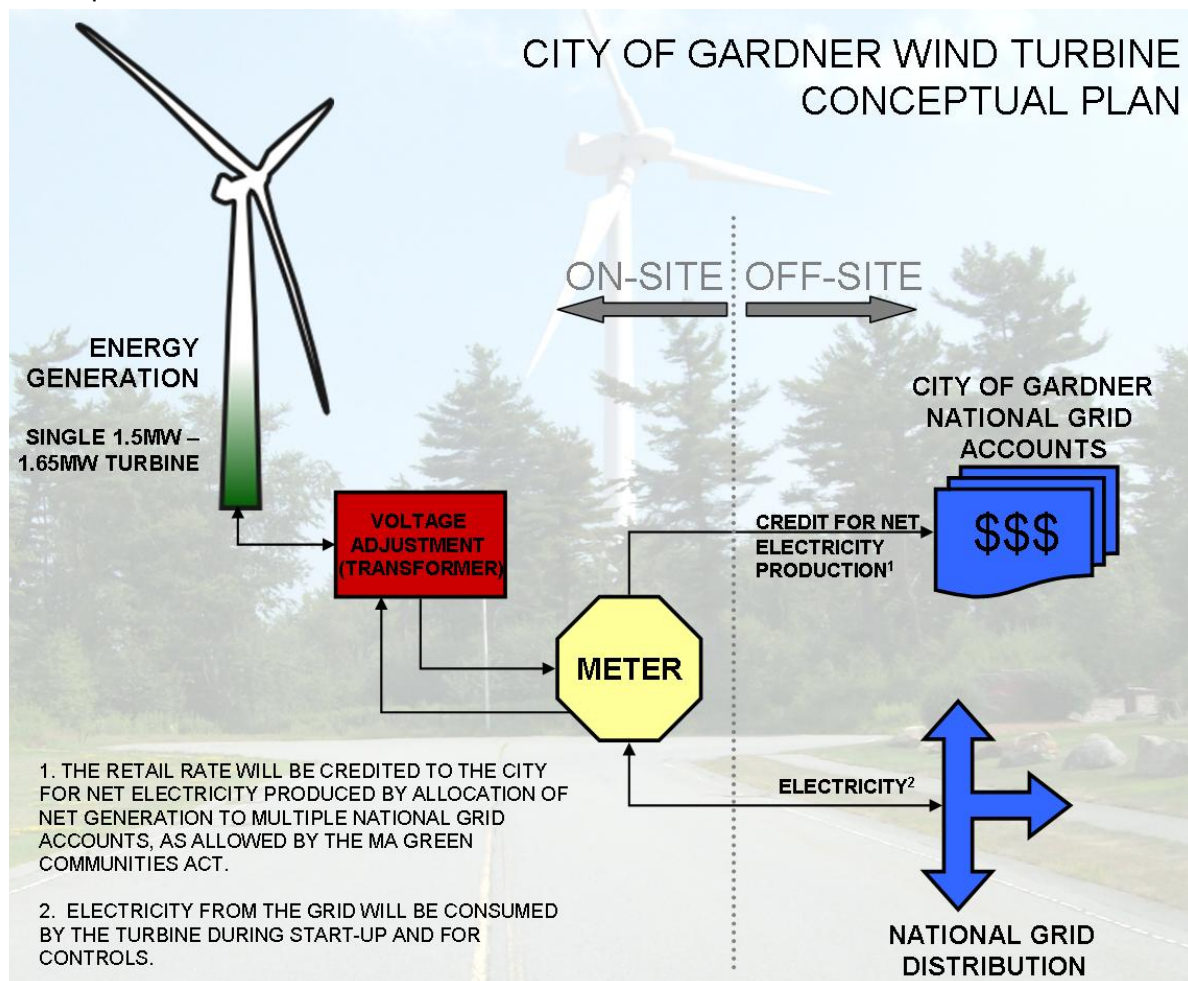
Wind Plant Layout

4.1 Conceptual Plan

As determined through the AEP calculation, it would be most economically and environmentally feasible to place one large turbine on the Site. A turbine with a large hub height and rotor diameter, such as the 1.65 MW Vestas V82, is recommended. However, due to possible zoning setback conflicts, the Feasibility Study also evaluated turbines in the 1.5MW range. The turbine should be placed in the area with the greatest wind speed where the property line setback can be met. A conceptual plan has been prepared to show the system layout and aid the City with public presentations and approval (Figure 4-1).

FIGURE 4-1

Conceptual Plan



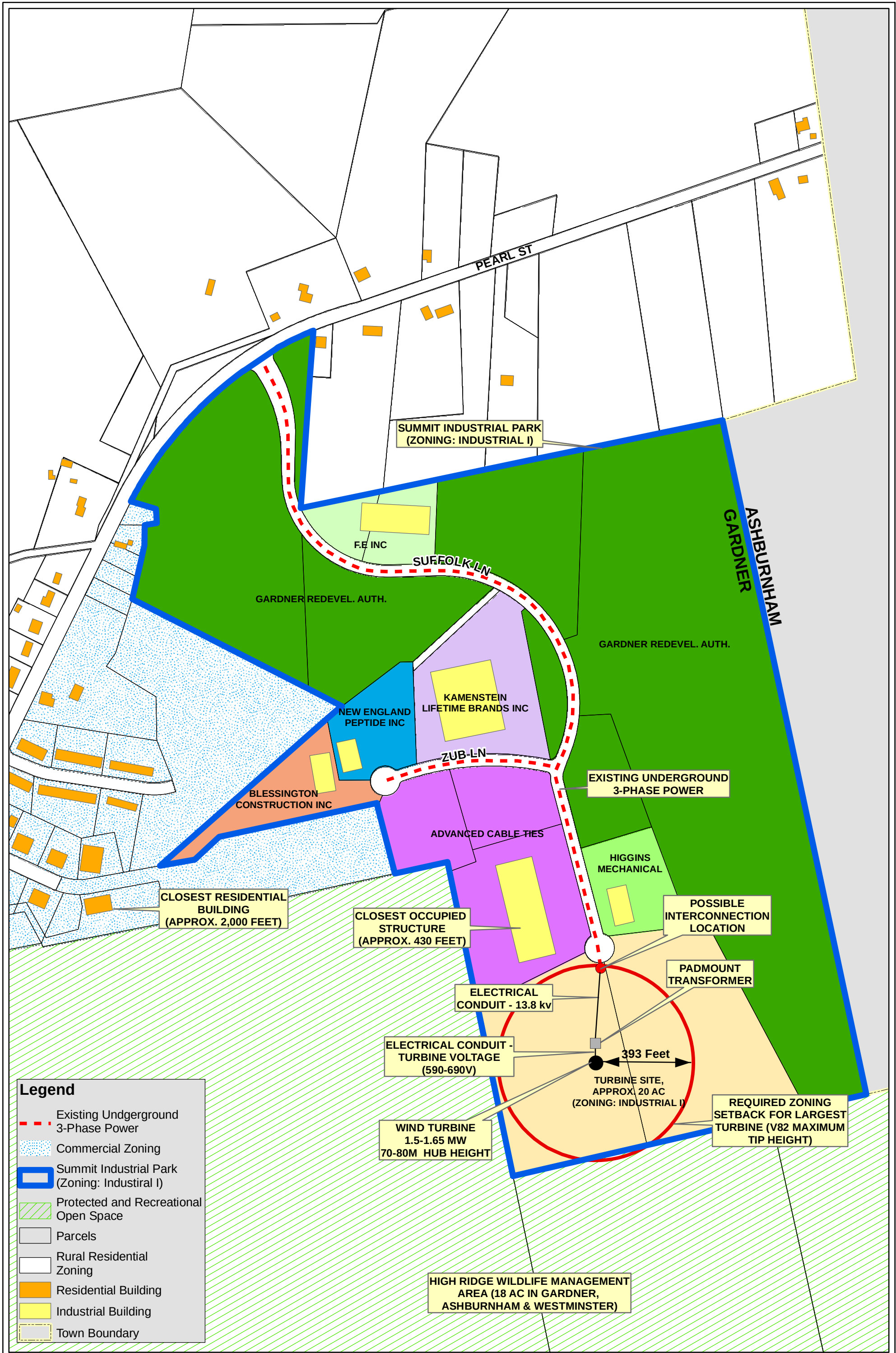
The figure shows a single turbine, voltage adjustment equipment and the meter, which will record electricity use and generation on-site. Electricity will be used and accounted

for at locations off-site, as also shown on the Figure. The MA Green Communities Act net metering provisions at 220 CMR 18.05(1) allow for off-site allocation of net metering credits as long as the customers receiving credit for the generation are in the same ISO New England load zone and distribution company's territory. Both of these requirements are met by Gardner's municipal accounts.

4.2 Schematic Site Plan

During the wind resource analysis, the turbine location was placed at North American Coordinates UTM NAD83 257978E 4720007N. Due to the small size of the Site and limited area with high wind resources, the locations for placing a turbine are limited. Several wind turbine locations were evaluated during the resource assessment, but the site shown in the Schematic Site Plan was selected due to optimal wind speeds and because it meets zoning setback requirements. In this location, any of the turbines modeled have an adequate Fall Area from occupied buildings, power lines and public ways. The largest turbine may require a Fall Area easement from the Division of Fisheries and Wildlife, owner of the Highridge Wildlife Management Area. Currently, there are no known underground electrical conduits or water, sewer and gas pipes on the Site.

Using the selected location, a Schematic Site Plan was created. The most likely interconnection location, property setback requirements, residential sensitive receptors, the neighboring industrial facilities, and electrical details are shown on the Schematic Site Plan, Figure 4-2. Note that the entire Site is bordered by land owned by the Gardner Redevelopment Authority or permanently protected open space.



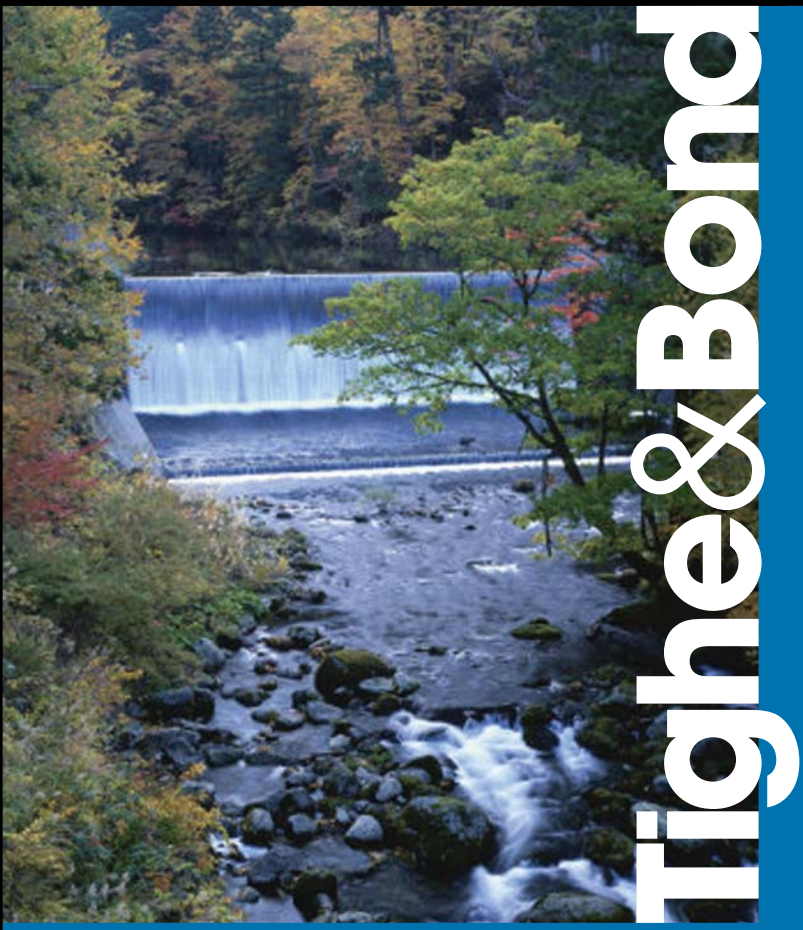
0 175 350 Feet

**FIGURE 4-2
SCHEMATIC SITE PLAN
GARDNER WIND TURBINE
GARDNER, MASSACHUSETTS**

OCTOBER 2010

Tighe&Bond





Section 5

Financial Analysis

The financial analysis is intended to express the data collected in this Feasibility Study in economic terms for the City to use as a tool for decision making. The Section will give an overview of the major economic drivers in the wind industry followed by a discussion of potential and expected revenue and cost for the turbine configurations. The Feasibility Study includes a preliminary pro-forma for the project that takes the above into account as well as financing mechanisms and the time value of money. Conclusions drawn from the financial analysis will be presented along with data from the previous sections in the Feasibility Study for a total comparison of the turbine configurations.

The Feasibility Study evaluated five representative wind power generating systems. We attempted to evaluate the impact of varying hub heights, rotor diameters, plant configurations, and nameplate capacities on project economics, through the evaluation of representative turbine models available from several manufacturers. Our study did not include an exhaustive evaluation of all manufacturers and models currently available on the market. Accordingly, while our study includes a recommendation on an optimal configuration concept, it should not be construed as a recommendation of a specific manufacturer and model for this project. That selection will be made during the procurement process based upon market conditions at that and the findings of this study.

The turbine configurations being included in this financial analysis are the same as were modeled in Section 1 of this report. This includes a Vestas V82, Fuhlander FL1500, GE1.5sle, PowerWind 56 and two PowerWind 56 configurations. The Vestas V82 has the highest AEP and capacity factor and Table 1-3, shows results of energy analysis for each configuration.

5.1 Wind Power Economics

The wind power market has been changing rapidly since the 1980s and is expected to continue to change. There are many factors that affect the cost of wind energy; several of them are outlined below to provide context for the following preliminary discussion of the costs and revenues expected for this project.

The cost of producing wind power at a particular location is foremost affected by the wind speed and other site-specific factors. Since the energy available in the wind is proportional to the wind speed cubed, small changes in wind speed have dramatic effects on the amount of energy a turbine can produce. Due to the importance of wind speed, tower height is very influential on the energy output of the turbine and it is often cost effective to increase vertical elevation, particularly in a wooded area like the City of Gardner.

Along with taller towers, other improvements in wind turbine technology can also affect the cost of wind energy. Since the amount of energy captured by the turbine is highly dependant on the rotor swept area of the blades, improvements in materials and blade design that have allowed longer, lighter blades can reduce the cost of wind energy. For this reason, it is generally economical to obtain a turbine with the largest swept area that can be accommodated at the site. Other advances in technology that have recently

decreased the cost of wind energy include monitoring devices, controls systems, and active pitch and yaw controls.

Typically, there is an economy of scale with wind energy cost. Therefore, a large wind farm will be more economically viable than a small one due to the distribution of siting and permitting costs and a lower cost of equipment per kW. In the case of community wind projects, which are generally one or two turbine projects, larger turbines will usually be more economical than smaller turbines. This is because the cost of permitting, installing and commissioning the turbines is generally similar for any size machine. Operations and maintenance costs will also be similar for single turbine projects of varying sizes, as opposed to large wind farms where maintenance costs per MWh are greatly decreased.

Since wind turbine projects are so capital intensive in comparison to traditional forms of energy generation (with the benefit that fuel is free once the turbine is installed), the cost of financing the project is also relatively high. It is generally accepted that privately owned wind farms have a higher cost of financing than publicly owned because of the amount of low-cost debt and grant funding that is available to public entities.

Since much of the technology used in wind projects is relatively new, there is also an added cost to the project associated with the perception of higher investment risk compared to traditional energy generation. Lenders often offer less favorable financing terms and demand a higher return on investment, adding cost to the energy produced.

Another factor that can drive the cost of wind energy production is policy. The regulatory structure under which the project is taxed and revenue is generated can greatly affect the project finances. The Summit Industrial Park turbine will qualify for net metering, but will not qualify for certain tax benefits available to private developers if ownership is maintained by the City. Since net metering and ownership structure are critical factors in the financial analysis, they are discussed in more detail below.

5.1.1 Net Metering

Since the Gardner Wind Turbine will be under 2 MW in size, it qualifies to be net metered under the Green Communities Act, passed July 2, 2008. Net metering allows the City to be credited the retail rate for the excess amount of electricity the turbine produces that is not used “behind the meter” (net excess generation). Since the City has no “behind the meter” load at the project site other than the load of the turbine, the City will allocate the electricity being produced by the turbine to various municipal accounts, and effectively reduce energy bills for municipal buildings as permitted under 220 CMR 18.05 (1). In the case that the turbine produces more electricity than will be consumed by municipal buildings, the electricity bill credit will “roll over” until a time when consumption is higher than production. This allows wind energy to be a good source of income for the City, despite the intermittency of both production and consumption. However, as discussed in the energy analysis section, the City must be capable of managing seasonal revenue fluctuations.

5.1.2 Project Ownership Structure

There are two basic project ownership structures available to the City: public ownership and private ownership (through a power purchase agreement). There can also be some combination of the two and recently there have been many innovative ownership structures to lower costs.

If the wind farm remains publicly owned, it is expected that the cost of design, construction, operation and maintenance would be incurred by the City. The City would manage electricity generation and retain all revenue from net metering and the sale of Renewable Energy Credits (RECs; See Section 5.2.1(2)). Cost of the project would be mainly driven by turbine choice and an associated operation and maintenance contract. In this case, it is recommended that the City procure an operation and maintenance contract at the time of turbine procurement in order to secure terms and rates. Revenue would be driven by the amount of electricity produced, or wind speed. If a project is publicly owned, it generally has a lower capital cost due to the lower cost of debt and grant funding available to public entities. However, public entities also do not have tax liability, which means that annual tax benefits and accelerated depreciation will not be applicable and annual costs will be relatively high and consistent from year to year in comparison to privately owned projects.

The wind turbine could also be privately owned through a power purchase agreement (PPA). The PPA would include a long-term lease between the City and the developer that would give the developer rights to construct and operate the turbine on City land. PPAs are typically 20 year agreements. This agreement would also include a long-term contract between the City and an energy developer for the purchase of power from the developer. Since the developer would generally need a steady income source to secure financing, a price would be set in the contract. In this case the capital cost of the project, as well as operation and maintenance, would be assumed by the developer. Cost to the City would be on a long-term basis, driven by the price written into the contract. Revenue would be driven by the lease agreement. In a PPA model, revenue can also come from cost avoidance, lease payments, and/or REC sharing. For privately owned projects, the capital cost is typically high since funding available to public entities does not apply. However, since some private entities have a significant tax liability, benefits will be available through accelerated depreciation and yearly tax credits. The yearly cost of a privately owned project is expected to be less.

Several innovative structures exist to combine public and private ownership in a way that maximizes the benefits in both structures. However, there are provisions in Federal tax benefit policy specifically to prevent “double dipping” by claiming public and private ownership. While a joint-ownership structure is possible, it would require robust legal documentation and consequently high legal fees. Furthermore, the private developer would have to adhere to public procurement law and the associated cost premiums.

One innovative ownership structure that helps organizations with no or little tax liability to take advantage of tax benefits that has been successfully implemented is the “flip” structure. This ownership model requires landowners and equity investors (wind developers with significant tax liability) to create an LLC. For the first ten years of the project (duration of the Production Tax Credit benefits) the equity investor/developer will own the majority of the project, which could be up to 99%. Costs and benefits of the project will be split among the members of the LLC according to the share of investment they hold. This will allow the developer to take advantage of the PTCs. After year ten, the investor will sell the majority of the project to the landowners. The amount of ownership transferred at year ten is formulated to a level acceptable to the legal system in order to avoid an audit.

Since the City of Gardner will likely pursue further grant funding for the project and because net metering is available to the City, it is unlikely that the City will enter a Power Purchase Agreement. It is recommended that the City further evaluate the

difference in benefit between public and private ownership during business planning. For this financial analysis, it will be assumed that the City owns the project.

The Feasibility Study includes a preliminary pro-forma for the project that takes into account project cost, financing mechanisms and incentives, and potential post-construction revenue. A brief discussion of these three factors is provided below. The preliminary pro-forma is provided in Appendix G.

5.2 Revenue and Finance

5.2.1 Potential Sources of Revenue and Funds

Wind turbine projects have a variety of potential sources of revenue, outlined below:

1. **Net Metering:** Revenue from electricity produced as net excess generation is received at the retail rate. While retail rates generally follow wholesale rates, they are higher due to the cost of other services, energy reserves, RPS compliance, market obligations and profit margin.
2. **Renewable Energy Credits (REC):** Revenue is generated from the sale of the “environmental attributes” of the electricity produced. In Massachusetts, investor-owned utilities are required to meet the Renewable Portfolio Standard (RPS), and a certain percentage of their generation must be from qualified renewable energy sources (4% in 2009 and 1% increase each year after). Therefore, RECs, which are accumulated proportionally to energy generation, are bought and sold on an established market to help utilities meet the RPS. REC value is expected to stay relatively stable while the renewable energy market establishes itself in the US. This is because the new renewable generation is not expected to increase at a rate much higher than the RPS standards increase of 1% per year. However, on a longer basis, once the many large renewable energy projects being planned now are established, the value of RECs will decrease due to a supply greater than demand. Therefore, it is assumed that REC value will remain around \$40 per MWh for the next ten years. Following that, REC value is assumed at \$30/MWh.
3. **CO₂ Emissions Credit:** The Regional Greenhouse Gas Initiative (RGGI) is a system of ten states that require power plants over 25 MW of capacity to obtain greenhouse gas (GHG) allowance certificates. Each certificate permits one ton of GHG to be emitted. Allowances are bought and sold at auction. The most recent auction clearing price (9/2010) was \$1.86 per ton of CO₂ produced. Since the maximum potential size of the Summit Industrial Park wind turbine would avoid the production of only about 1000 tons of CO₂ per year and there would be some cost associated with management of the CO₂ offset and credit sale, selling allowances from energy produced without GHG emissions would be a negligible source of revenue. Estimation of avoided CO₂ production was performed according to the MA Green House Gas Protocol Initiative Stationary Combustion Tool.
4. **Grants:** MassCEC design and construction grants can offset capital costs by up to \$400,000 (for a MW-scale turbine) for the City. Furthermore, numerous sources of funding in the form of grants may be available from federal sources, including the Department of Energy (DOE). Note that some sources of federal

funding associated with the American Recovery and Reinvestment Act (ARRA) will expire before this project is able to take advantage of them. One potentially available grant program, through US Department of Agriculture Rural Development is Section 9007 Rural Energy for America Program (REAP). REAP grants are available for government entities in rural areas. The City of Gardner meets the criteria and it is recommended that the City investigate this funding opportunity further. The available funding is 25% of total eligible costs, with a maximum of \$500,000. It is anticipated that Gardner would be eligible for the maximum funding amount, \$500,000. To remain conservative, we included a \$250,000 REAP grant in the pro forma analysis. Grant funding levels are subject to change.

5. **Other Government Funding:** Programs such as the Renewable Energy Production Incentive (REPI) and Clean Renewable Energy Bonds (CREBs) administered by the US Department of Energy were initiated to provide publicly owned projects with benefits similar to the tax benefits available to privately owned projects. The REPI incentive is in the form of a payment of 1.5 cents per kWh for the first ten years of turbine operation. The CREB program was implemented to make zero interest funding available to qualifying projects. Renewable energy facilities eligible for CREBs are also eligible for Qualified Energy Conservation Bonds (QECBs), a similar low-cost debt.
6. **ISO New England Forward Capacity Market (FCM):** The Independent System Operator (ISO) New England has created a market for electricity generators to bid the amount of kWhs they can supply and the price they will supply it at three years in advance of commitment periods. The FCM includes all generation types, including wind. Commitment periods can last between one and five years. Every bidder clearing the market will receive the clearing price (\$/kW-month), the lowest bid, for the energy they sell. It is expected that the City of Gardner, due to behind the meter use and net metering of excess electricity, will not bid into the ISO market.
7. **Tax Benefits:** If the City of Gardner pursues private ownership of the wind turbine through a power-purchase agreement, the private partner would be eligible for tax benefits. Tax benefits come in the form of accelerated depreciation as well as tax credits. Since wind turbine equipment qualifies for accelerated depreciation, it is possible for a private company to decrease the value of their taxable assets early in the assets' lifetime. Another benefit for entities with tax liability is the Production Tax Credit, a Federal Tax Code provision for a tax credit equal to approximately 1.9 cents per kWh produced by the turbine.
8. **Financing:** There is a variety of low-interest financing available to municipal governments. A conservative municipal bond rate is 4.0% over 20-years. That was assumed for this project. In the case that the project is owned privately, financing will likely cost more.

5.2.2 Revenue and Financing Estimate

For the last four years, the City's annual energy consumption was on average 3,256 MWh for applicable accounts. The load includes municipal buildings including administration, schools, fire, police, recreation and public works. Non-applicable accounts include some water and wastewater accounts that are not currently paid

directly by the City. Since the Summit Industrial Park project will not have any behind-the-meter load, per the Green Communities Act, the City will allocate net excess generation credits to offset load generated by the City of Gardner in one or more municipally-owned buildings or facilities. It is assumed that 100% of the energy produced by the wind turbine will be net metered. Table 5-1 summarizes possible funding sources and expected values.

TABLE 5-1

Revenue Estimates, Gardner Wind Turbine

Funding Source	Estimated Value	Comments
Net Metering	100% of production at retail rate (14.5 cents per kWh ¹)	City demand = 3,256 MWh annually ²
RECs	Y1-Y10 - \$40/MWh Y11-Y20 - \$30/MWh	REC forecast based on market conditions and RPS requirements
Grants		Max. Design and Construction Grant Award, Block 4, 1.5+MW Turbines
MassCEC	\$400,000	
US DOE/Other federal source	\$250,000	REAP
Tax Benefits	1.9 cents per kWh	PTC, only for privately owned turbine
Other Financing	4% Rate, 20 year bond	Municipal Bond for public owned turbine
	6%, 20 year bond	Privately owned turbine

¹ Retail electricity rate is the average rate for all applicable City accounts over fiscal years 2007 - 2010

² Annual electricity consumption includes all applicable accounts over fiscal years 2007 – 2010

5.3 Cost

5.3.1 Capital Cost Estimate

Equipment

The turbine configurations being included in this financial analysis are the same as were modeled in Section 1 of this report. This includes a Vestas V82, Fuhlander FL1500, GE1.5sle, PowerWind 56 and two PowerWind 56 configurations. The Vestas V82 has the highest AEP and capacity factor and Table 2-3, shows results of energy analysis for each configuration.

The cost of equipment for the Summit Industrial Park wind turbine includes the cost of the turbine, transformer and interconnection materials. According to market data, the expected cost of a 1.65 MW turbine is approximately \$2.5 million. A transformer and associated equipment is expected to be around \$200,000. Therefore, the total equipment cost for the Vestas V82 equipment is about \$2.7 million, or about \$1,650 per kW of rated capacity. The remaining turbine configuration equipment costs were pro-rated from the Vestas V82 cost with knowledge of the current market and cost estimation experience. It is expected that the incremental cost of equipment of a

smaller project would increase due to the economy of scale gained by the use of multiple units in a larger project, but in the case of a single turbine installation, this difference may be minimal. Estimated equipment costs are summarized in Table 5-2 below.

TABLE 5-2

Total Equipment Cost

Turbine Configuration	Incremental Cost (\$/kW)	Total Equipment Cost
Vestas V82, 1.65 MW, 80m	\$1,800	\$2,965,000
FL1500, 1.5 MW, 65m	\$1,876	\$2,815,000
GE 1.5sle, 1.5MW, 80m	\$1,943	\$2,915,000
PowerWind 56, 0.9 MW, 71m	\$2,400	\$2,165,000
2 PowerWind 56, 0.9 MW, 71m	\$2,340	\$4,210,000

Feasibility Study

Since the cost of the Feasibility Study is being funded by the MassCEC Community Wind Grant, no cost has been included in this line item of the Pro-Forma analysis

Engineering Design, Permitting, Construction

Due to the early stage of the Summit Industrial Park Wind Project (pre-turbine selection) it is too preliminary to develop a detailed design, permitting and construction cost estimate. Therefore, these line items are estimated as a percentage of the equipment cost in the Pro-Forma calculations. Estimates of design and permitting, and construction costs, including site preparation, foundation, installation, and commissioning, are based on our experience scoping similar projects. A contingency has also been included for an electrical interconnection study with National Grid. This cost can vary greatly and is subject to change.

Transaction Cost

Transaction costs were assumed to be simple; in the case of the Gardner wind turbine the only negotiation will be between the City of Gardner and the Gardner Redevelopment Authority (GRA). Since the parcels are owned by the Redevelopment Authority, title insurance is expected to be negligible. Some legal fees are assumed to account for the structuring of an agreement between the City and the GRA. Also, 0.14% of the cost of equipment was assumed as builders insurance. This is industry standard for the cost of protection against installation errors. Delayed start-up insurance could be included (0.15% of equipment) in the case that the turbine had made a commitment to provide energy and then unable to start by the contract date. Since the financial analysis is being modeled with a net-metered turbine and the City will not be bidding into the market, this cost is not included.

Financing Cost

Since it is likely that the project will have a relatively simple financing structure, the cost of financing is negligible. Costs will include preparation of grant applications and

procuring of municipal bonds. Part of these tasks may be performed in the Business Planning phase, upon the completion of this Feasibility Study.

5.3.2 Annual Cost Estimate

Annual costs associated with the wind turbine are mostly related to operation and maintenance. The operation and maintenance costs vary by turbine size and were estimated to be \$30,000 (900 kW), \$50,000 (1.5 MW and 2x900 kW), and \$60,000 (1.65 MW) for the purpose of this study. Management costs have been included for efforts on behalf of the City including activities to manage net metering credit allocation, the sale of RECs, site maintenance and security, and website information on generation and educational programs.

5.4 Life Cycle Analysis

5.4.1 Life-Cycle Cost

In order to simulate a 20 and 30-year project life cycle analysis for the turbine, several assumptions were made regarding the time value of cost and revenue. The operation and maintenance, insurance, and management escalations were all set to 3% to anticipate inflation and rising materials' values. The price of electricity and cash interest rates were also escalated, at 2.5% per year. Several factors that are typically incorporated into the Pro-Forma were not included because they were accounted for in the wind turbine modeling in WindPro that served as an input for capacity factor, such as line loss. Other factors were not included because the ownership was assumed municipal (no tax liability or benefits). Lastly, the nature of net metering as a revenue stream is relatively simple; therefore, time of day (TOD) factor and escalation were also not included.

For the life-cycle analysis, the turbine performance was also considered in detail. Using the WindPro software, a 20-year evaluation of annual energy production (AEP), loss and uncertainty was generated. Please see the Wind Resource Analysis section for more detail on assumptions. The report generated by WindPro is included in Appendix B.

Since the City of Gardner will pursue further grant funding for the project and because net metering is available to the City, it is unlikely that the City will enter a Power Purchase Agreement. Therefore, the life-cycle analysis was conducted considering municipal ownership, zero tax liability, 100% net metered revenue and low interest funding sources. The detailed Pro-Forma inputs and outputs can be seen in Table 5-3. Similar tables for each turbine configuration are included in Appendix G. A summary of the Pro-Forma results is included in Table 5-4, Turbine Summary.

TABLE 5-3
Gardner Wind Turbine Financial Analysis: Inputs & Outputs (USD)

Project Summary	
Project Summary:	
Project	Garnder Wind Turbine
Location	Gardner, MA
Operation Commencement	12/31/12
Operation Duration	30 years
System & Installation Summary:	
Turbine	Vestas V82
System Capacity (MW-ac)	1.650
Annual Capacity Factor (20-yr Average P50)	32.0%
Cost Assumptions	
Equipment Costs:	
Turbine	\$2,900,000
Electrical Equipment	\$65,000
Other	\$--
Equipment Price	\$2,965,000
Sales Tax	\$--
Total Equipment Cost	\$2,965,000
Development Costs¹:	
Engineering Design	\$444,800
Permitting	\$--
Construction	\$593,000
Site Preparation	\$--
Foundation	\$--
Installation	\$--
Commissioning/Startup	\$--
Development Costs (General)	\$148,250
Total Development Cost	\$1,186,050
Transaction Costs:	
Land Purchase	--
Title Insurance	\$8,900
Legal Transactions	\$20,000
Builder's Risk (Erection) Insurance	\$4,500
Dev Security Deposit	\$--
Total Transaction Costs	\$33,400
Financing Costs:	
Equity Placement	--
Debt Placement	--
Other Financing Fees	--
Total Financing Cost	\$--
Total Project Costs:	
Equipment Cost	\$2,965,000
Development & Transaction Costs	\$1,219,450
Construction Interest	\$--
Financing Cost	\$--
Utility Interconnection Cost	\$--
Utility Interconnection Upgrade Payment	\$--
Credit for Power Sales pre COD	\$--
TOTAL PROJECT COSTS	\$4,184,500

¹ Includes contingency for National Grid interconnection study. Costs may vary

Revenue Assumptions	
Average Annual Production (kWhs)	4,625,280
Initial Bid Price (\$ / kWh)	\$0.1440
TOD adjustment factor	1.000
Initial TOD Adjusted Price (\$ / kWh)	\$0.1440
Annual Price escalation	2.5%
REC Value (Y1-10, \$/MWh)	\$40
REC Value (Y11-30, \$/MWh)	\$30
Annual Output Degradation	--%
Utility Interconnection Upgrade Payment	
Terms	5 years
Rate	7.5%
Line Loss & Other Losses	--%
Estimated CO2 Emission Credit	\$--
Operating Assumptions	
	Annual Cost \$
Annual O&M	\$60,000
O&M Escalation	3.0%
General Property Insurance	\$5,100
Insurance Escalation	3.0%
Business Interruption Insurance	\$8,400
Insurance Escalation	3.0%
Management	\$17,100
Management Escalation	3.0%
Property Tax	--
Land Rental Payment	--
Land Rental Escalation	0%
Tax Assumptions	
No Tax Liability	
Tax Incentives	
ITC (30% of project costs)	\$--
% ITC not Depreciable	--%
Tax Depreciable Basis	\$--
Tax Rates:	
Federal Tax Rate	--%
State Tax Rate	--%
State Sales Tax	--%
State Incentives:	
State Tax Credit	\$--
Commonwealth Wind	\$400,000
Tax Depreciable Basis	\$--
Years Depreciable	1 years
Federal Funding	
Federal Grant	\$250,000
Financing Assumptions	
Construction Interest	\$--
IRR Leverage Effect	x0.65
Debt Sizing (% Long Term)	
Long Term Debt	\$3,757,600
Rate	4.0%
Term	20 years
Letters of Credit	\$--
Rate	--%
Term	0 years

Project Indicators	
leveraged:	
IRR	13.3%
NPV (Discount 6%)	\$4,342,600
Payback Period (Discount 6%)	7.3
Unleveraged:	
IRR	20.4%
NPV (Discount 6%)	\$7,466,100
Payback Period (Discount 6%)	4.6
Sensitivity Anaysis	
leveraged	
Project Cost at -20%	\$3,347,600
NPV (Discount 6%)	\$5,882,000
Payback Period (Discount 6%)	5.3
Project Cost at +20%	
NPV (Discount 6%)	\$5,021,400
Payback Period (Discount 6%)	\$2,858,400
	13.0
AEP at P90 CF (kWh)	26.90%
NPV (Discount 6%)	3,888,126
Payback Period (Discount 6%)	\$2,614,900
	12.0
AEP at +20% (kWh)	5,550,336
NPV (Discount 6%)	\$6,572,600
Payback Period (Discount 6%)	6.1
Other Assumptions	
Amortization of Financing Fees (\$/yr):	
Debt Financing Fee (leveraged Scenario)	\$--
Equity Financing Fee (leveraged Scenario)	\$--
Equity Financing Fee (Unleveraged Scenario)	\$--
Initial Equity Investment (Unleveraged Scenario):	
Equity Investment	\$3,619,200
Equity Fees	\$--
Total Equity Investment	\$3,619,200
Fund Allocation (leveraged):	
Total Project Cost	\$4,184,500
Cash Reserves for O&M & Repair Work	84,700
Working Capital	\$--
Federal Grant	(250,000)
State Grant	(400,000)
Federal Investment Tax Credit	--
Funds Required	\$3,619,200
Debt Service Account	138,400
TOTAL FUNDS REQUIRED	\$3,757,600
Fund Source (leveraged):	
Equity	\$--
Debt	\$3,757,600
Total Funds	\$3,757,600
Summary Financial Metrics (leveraged):	
% Equity	--%
% Debt	100%
Last Updated: 12/17/2010	

5.4.2 Turbine Performance

The Feasibility Study evaluated five representative wind power generating systems. We attempted to evaluate the impact of varying hub heights, rotor diameters, plant configurations, and nameplate capacities on project economics, through the evaluation of representative turbine models available from several manufacturers. Our study did not include an exhaustive evaluation of all manufacturers and models currently available on the market. Accordingly, while our study includes a recommendation on an optimal configuration concept, it should not be construed as a recommendation of a specific manufacturer and model for this project. That selection will be made during the procurement process based upon market conditions at that time and the findings of this study.

Table 5-4 is a summary of the results from the Pro-Forma analysis described in the preceding sections. The summary shows that the Vestas V82 is the most economically viable turbine. Furthermore, the added cost of a 1.5MW turbine with an 80m hub height is beneficial due to the significantly better wind speeds at 80m.

5.4.3 Risk Factors and Uncertainty

Losses and uncertainty related to the modeling, calculations, climate and turbine were incorporated into the AEP estimate and the capacity factor estimate. These factors have also been incorporated into the financial calculations through use of the 20-year average AEP and capacity factor.

Since there is an uncertainty associated with the AEP estimate from WindPRO (see Section 1.6), an analysis of the effect of that uncertainty on the economic analysis was performed. See Table 5-5, which shows the difference in the payback period for a Vestas V82 under the maximum and minimum standard deviation conditions (+/- 12.3% AEP). As shown, the V82 remains a financially viable project, even at these uncertainties. Therefore, additional wind resource modeling and purchase of more accurate long term data is not recommended at this time. However, depending on the funding sources sought, some additional field data collection may be required to satisfy the lender / bond issuer.

TABLE 5-5

Vestas V82 Uncertainty Analysis

Uncertainty Effect	AEP (MWh; 20-yr average P50)	Payback Period (P50)	Payback Period (P90)
-12.30%	4056	9.4	14.0
0	4624	7.3	10.3
12.30%	5194	6.0	8.1

A sensitivity analysis at +/- 20% of the project cost as well as at +20% AEP and the P90 AEP was also performed to evaluate the effect of varying these key parameters on the results. The majority of the scenarios become unfeasible, with payback periods too high, when the cost is 20% higher or the AEP is at P90 level. However, the Vestas V82 and GE1.5 remain relatively feasible.

TABLE 5-4

Overview of Proforma

Factor	Vestas V82	FL1500	GE1.5sle	PowerWind 56	PowerWind 56 (x2)
Rated Capacity (kW)	1650	1500	1500	900	1800
Capacity Factor (P50, 20-yr average)	32.0%	25.8%	30.6%	26.8%	25.8%
AEP (MWh; P50, 20-yr average)	4,624	3,395	4,016	2,110	4,071
Est. Capital Cost	\$4,184,500	\$3,973,900	\$4,114,300	\$3,060,900	\$5,933,100
Est. O&M Cost	\$60,000	\$60,000	\$60,000	\$60,000	\$120,000
Financial Viability (leveraged)					
IRR	13.3%	9.4%	11.3%	7.3%	5.7%
NPV (6% Discount)	\$4,342,600	\$1,805,500	\$3,040,700	\$476,400	(\$243,500)
Payback Period (years; 6% Discount)	7.3	12.2	9.2	18.8	32.6
Financial Viability (unleveraged)					
IRR	20.4%	16.1%	18.2%	13.9%	12.2%
NPV (6% Discount)	\$7,466,100	\$4,728,900	\$6,094,800	\$2,592,000	\$4,383,500
Payback Period (years; 6% Discount)	4.6	6.2	5.3	7.5	8.8

TABLE 5-6

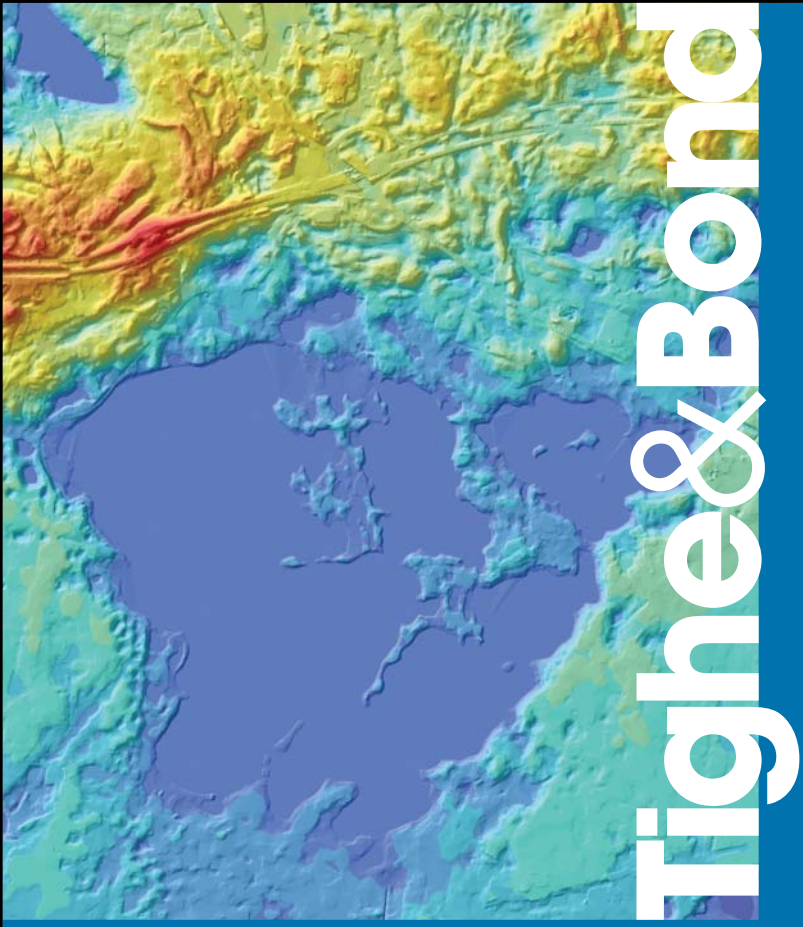
Sensitivity Analysis

	Turbine				
	Vestas V82	FL1500	GE1.5	PW 56	2 x PW 56
Base Project Cost	\$4,184,500	\$3,973,900	\$4,114,300	\$3,060,900	\$5,933,100
Project Cost at -20%	\$3,347,600	\$3,179,080	\$3,291,400	\$2,448,680	\$4,746,480
NPV (Discount 6%)	\$5,882,000	\$3,241,197	\$4,527,300	\$1,582,300	\$1,900,063
Payback Period (Discount 6%)	5.3	8.1	6.5	10.7	16.1
Project Cost at +20%	\$5,021,400	\$4,768,620	\$4,937,100	\$3,673,020	\$7,119,720
NPV (Discount 6%)	\$2,858,400	\$369,730	\$1,554,500	(\$629,492.0)	(\$2,387,061.6)
Payback Period (Discount 6%)	13.0	32.6	18.5	N/A	N/A
AEP at P90 CF (kWh)	3,888,126	2,825,100	3,350,700	1,758,132	3,390,120
NPV (Discount 6%)	\$2,614,900	\$463,799	\$1,447,900	(\$366,567.1)	(\$1,853,864.3)
Payback Period (Discount 6%)	12.0	28.3	17.1	N/A	N/A
AEP at +20% (kWh)	5,550,336	4,068,144	4,825,008	2,535,494	4,881,773
NPV (Discount 6%)	\$6,572,600	\$3,415,963	\$4,950,200	\$1,479,153	\$1,689,085
Payback Period (Discount 6%)	6.1	9.6	7.5	13.6	19.8

The additional uncertainty associated with the inputs used to generate the financial estimate is understood to be high at this stage due to the preliminary nature of the cost estimates (no turbine selected, so detailed cost estimates cannot be developed). Also, the debt structure is subject to change according to what additional funding is available to the City. Ownership and debt structure will be assessed in more detail during the business planning phase.

5.4.4 Financial Viability

It was concluded that the project will not be installed unleveraged (i.e. a debt-free scenario), since the City would be required to allocate up to \$4 million to the project during design and construction. It is our understanding that the City does not have the capital available. However, this project appears financially viable with 100% debt, which is the likely model to be used by the City. Despite the high capital costs expected for wind energy projects, the revenue captured through net metering could completely offset the capital cost and the cost of debt in 7 to 11 years, for the larger turbines.

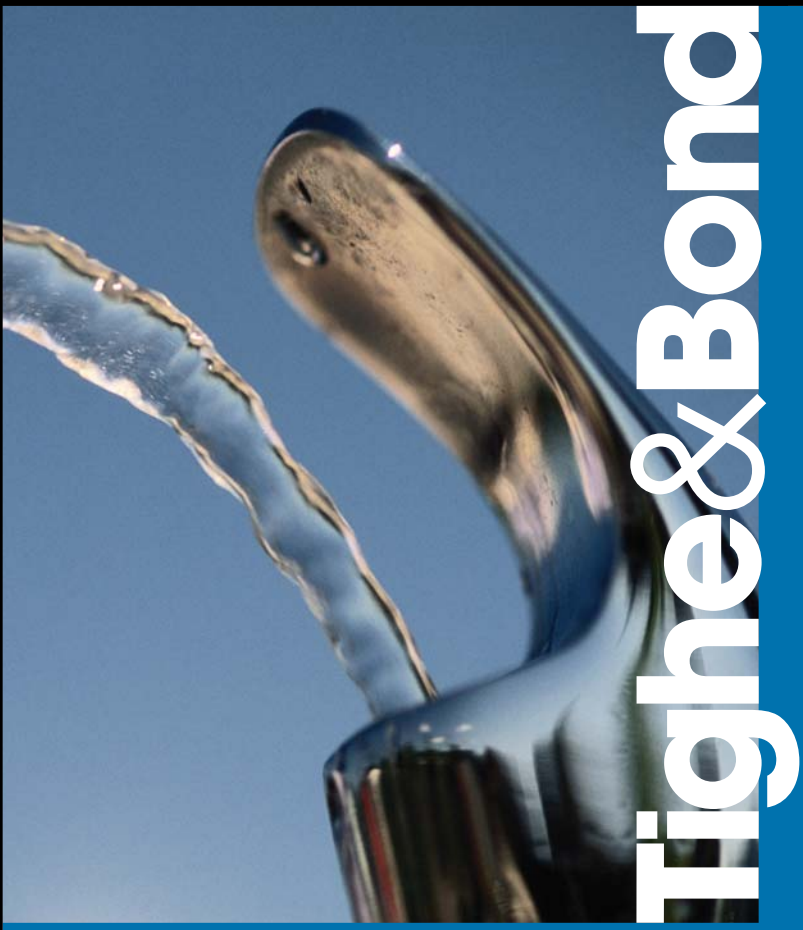


Section 6

Business Planning

During the business planning phase it is recommended that the City pursue additional funding sources as well as submit an application for a design and construction grant from MassCEC. It is also recommended that the City coordinate with the Highridge Wildlife Management Area and begin negotiation for a small easement of land to be designated in the turbine fall zone. The City should hold a public meeting to assess the public acceptance for the project, particularly with regard to noise and/or visual impacts. Depending on the outcome of this process, more detailed acoustic or shadow analysis may be required prior to project permitting. Lastly, the City should initiate the process for an electrical interconnection study with National Grid. Other tasks that could occur during the business planning phase include:

- Develop the MOU on property ownership between the City and the Redevelopment Authority into a legal document
- Organize a public outreach strategy and develop informational materials that will be used for public outreach throughout design and construction
- Planning and completion of test pits, borings, survey and other work required for design
- Identify historic properties in the City and evaluate visual impact
- Perform Pre-permitting evaluations and consultations with key agencies



Tighe & Bond

Section 7 Summary

7.1 Critical Factors

Table 7-1 is a review of the critical factors in determining the feasibility of a wind turbine at the Summit Industrial Park.

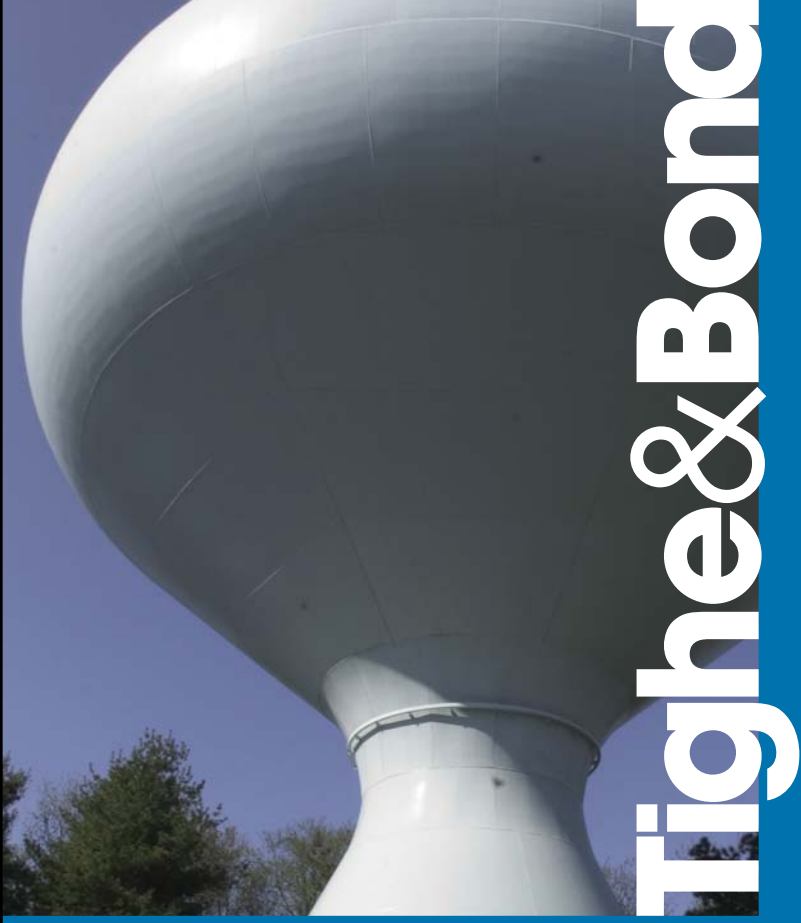
7.2 Recommendations

It is recommended that the City continue to pursue the development of a wind turbine at the Summit Industrial Park. Based on the information in this Feasibility Study, it would be beneficial to pursue further study and design and construction of a single turbine in the 1.5 – 1.65 MW range. The turbine should have a hub height between 70 and 80m and a rotor diameter in the same range in order to utilize the medium wind speeds on site. Since the turbulence intensity of the wind is relatively high, an IEC Class A turbine is recommended. Since the wind speeds are medium to low at hub height, an IEC Class IIA turbine will be appropriate.

The largest turbine, the Vestas V82 or equivalent, would provide the most financial benefit for the City. Further analysis is required to determine whether the V82 meets the zoning requirements, and development of the project may depend on the ability of the City to obtain a Fall Area easement from the Highridge Wildlife Management Area. It is recommended that the City begin negotiation for the easement during business planning. In the case that obtaining the easement becomes a fatal flaw, it is recommended that the City reduce the size of the rotor or the hub height in order to meet the ordinance. Two turbines of slightly lesser size (GE1.5sle and FL1500) were modeled to compare similar technology at both 80 and 65m hub heights. The 80m hub height performed significantly better due to higher wind speeds. It is possible that an 80m hub height may be necessary to achieve a satisfactory financial result from this project. Micrositing of the turbine will enable the City to know whether a fall easement is needed with the Highridge WMA, or whether the rotor size should be reduced to meet regulations before siting a lower turbine. Overall, the City has a good Site for wind energy development, and should take further action to develop the project.

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TABLE 7-1						
Overview of Feasibility						
Factor	Vestas V82	FL1500	GE1.5sle	PowerWind 56	PowerWind 56 (x2)	Comments
Rated Capacity (kW)	1650	1500	1500	900	1800	
Hub Height (m)	80	65	80	71	71	
Rotor (m)	82	77	77	56	56	
Maximum Tip Height (m)	120m	100m	119m	97m	97m	
Capacity Factor	32.0%	25.8%	30.6%	26.8%	25.8%	
Turbine Availability	6-12 months	8-9 months	6-12 months	8-9 months	8-9 months	Availability not expected to be the limiting factor for schedule
AEP (MWh; P50, 20-yr average)	4,624	3,395	4,016	2,110	4,071	
Land Use	No Conflict Expected	No Conflict Expected	No Conflict Expected	No Conflict Expected	No Conflict Expected	
Zoning	May require fall zone easement in Highridge WMA	No Conflict Expected	May require fall zone easement in Highridge WMA	No Conflict Expected	May require fall zone easement in Highridge WMA	The City may seek an easement from Highridge Wildlife Management Area (WMA)
Airspace	DNH	DNH	DNH	DNH	Must obtain DNH for second turbine location	Current determination of no hazard (DNH) is sufficient for all turbines, but will require modification to add a second turbine
Electrical Equipment	\$65,000	\$65,000	\$65,000	\$65,000	\$80,000	Added cost for the double turbine configuration is for additional materials
Site Access for Turbine Delivery	Good	Good	Good	Good	Fair	Turbine Delivery Route will require little modification for any turbine
Environmental Factors:						
Wetlands	Minimal/No Impact	Minimal/No Impact	Minimal/No Impact	Minimal/No Impact	Minimal/No Impact	Impact related to transport of turbine on roads through wetland buffer zones
Rare Species	Impact Not Likely	Impact Not Likely	Impact Not Likely	Impact Not Likely	Impact Not Likely	
Bird and Bat	Moderate Impact	Low Impact	Moderate Impact	Low Impact	Moderate Impact	Estimates based on hub height as well as swept area
Shadow Flicker Impact	Moderate Mitigation Required	Minor Mitigation Required	Minor Mitigation Required	Minor Mitigation Required	Minor Mitigation Required	Mitigation refers to measures to reduce flicker at the manufacturing facility next door
Noise Impact	Possible Noise Study	Possible Noise Study	Possible Noise Study	Possible Noise Study	Possible Noise Study	If a concern for health and safety is raised by the manufacturing industries within 1000 feet of the turbine
Permitting Requirements	Moderate Permitting Effort	Minimal Permitting Effort	Moderate Permitting Effort	Minimal Permitting Effort	Moderate Permitting Effort	Estimates based on additional permitting/review related to larger turbine models
Est. Capital Cost	\$4,184,500	\$3,973,900	\$4,114,300	\$3,060,900	\$5,933,100	
Est. O&M Cost	\$60,000	\$60,000	\$60,000	\$60,000	\$120,000	
Financial Viability (leveraged)						
IRR	13.3%	9.4%	11.3%	7.3%	5.7%	
NPV (6% Discount)	\$4,342,600	\$1,805,500	\$3,040,700	\$476,400	(\$243,500)	
Payback Period (years; 6% Discount)	7.3	12.2	9.2	18.8	32.6	
Feasibility	Feasible	Not Feasible (65m)	Feasible	Not Feasible	Not Feasible	The FL1500 with an 80m hub height would most likely be feasible



Attachment D-1

Site Assessment Deliverables Template

(1) Project Data

Site Information	
Elevation (ft)	1,194 ft
Annual Behind the Meter Electricity Consumption (kWh)	6,100 MWh *
Property Owner	Gardner Redevelopment Authority
Project Contact Name	Robert Hubbard
Project Contact Phone #	(978) 630-4011
Project Contact Email	rhubbard@gardner-ma.gov

*6,100 MWh is the consumption cited in the GEC Report. Tighe & Bond has calculated 5,672 MWh, as explained in the application.

(2) Site Description (1-2 Paragraphs – expand the boxes, as needed)

Provide a site description that includes a general property description, a summary of open spaces on site, description of buildings and trees, and summary of surrounding neighborhood.

The City of Gardner is in Northern Massachusetts, approximately 50 miles northwest of Boston. The Summit Industrial Park is 20 acres of fairly flat land. The site was selectively logged three years ago, so wooded areas are light with dense underbrush. The trees on site are primarily conifers. Adjacent properties include five manufacturing facilities as well as the State-owned Highridge Wildlife Area.

At 364 meters above sea level, the Summit Industrial Park is a suitable location for the Gardner Wind Turbine because of the ample wind resources available. Data from the near by NCCI Met tower has been used to predict wind speeds between 5.9 and 7.1 meters per second at 70 m above ground level. Access to the site for turbine parts is not expected to be a problem since the manufacturing facilities on-site regularly receive large trucks. Aviation, environmental and cultural site characteristics have been examined at a high-level and are not expected to pose significant problems to project development.

(3) Wind Resource Assessment

Generate and attach the MRET Commonwealth Wind Site Resource Report from <http://cwest.cadmusweb.com/>

Please see the attached Wind Resource Report, extracted from the attached Preliminary Survey of a Potential Wind Project Site in the City of Gardner (Referred to as the 'GEC Report,' as in the Feasibility Study Application).

(4) Energy Production and Usage Estimate

Provide an energy production estimate for up to three of the turbine models being considered for the site. For each turbine size being considered, this should include the following (add copies of this Table, as needed):

See the following Table, extracted from the attached GEC Report.

Table 6. Estimated Net Energy Production at the Summit Industrial Park Site

Turbine Model	Vestas RRB PS600		Elecon Turbowinds T-600-48DS		Enertech E-48		Aeronautica Norwin 47-750		Americas Wind Energy AWE 54-900		GE 1.5 SLE	
Hub Height	55		65		65		65		50		65	
Turbine Rating (kW)	600		600		600		750		900		1500	
Hub-Height Wind Speed (m/s)	5.9	6.6	6.2	7.0	6.2	7.0	6.2	7.0	5.7	6.4	6.2	7.0
Gross Annual Energy (MWh)	1171	1511	1507	1892	1479	1857	1545	1977	1686	2190	3754	4705
Net Annual Energy (MWh)	995	1285	1281	1608	1257	1578	1313	1681	1433	1861	3191	3999
Net Capacity Factor	19%	24%	24%	31%	24%	30%	20%	26%	18%	24%	24%	30%
% of City's Annual Energy Consumption ¹	16%	21%	21%	26%	21%	26%	22%	28%	23%	31%	52%	66%

[1] Based on municipal energy consumption for the City of Gardner for July 2008 – July 2009 as provided to DNV-GEC by the City of Gardner.

(5) Aerial Site Map

Insert an aerial site map of the proposed turbine location that outlines the major property lines. Draw concentric rings on the aerial site map at 200 and 500, and 800 feet from the proposed turbine location.

The following map, prepared for the GEC Report, shows the aerial turbine location.

Concentric Circles:

- Blue Circle: 292 ft
- Green Circle: 341 ft
- Yellow Circle: 436 ft
- Red Circle: 508 ft

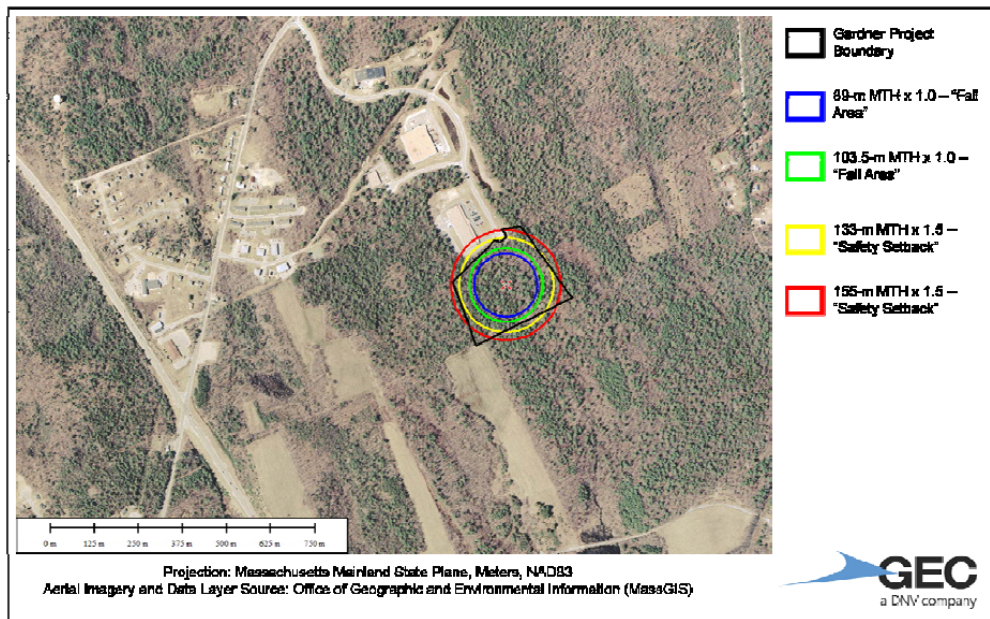


Figure 13. Gardner Property Boundary and Proposed Turbine Location with Range Rings

(6) Site Map (3 Mile Radius)

Insert an aerial site map indicating any airports within 3 miles of the property.

There are no airports within 3 miles of the property

(7) Distance Reporting (Residences, Property Lines, etc...)

Provide the shortest distance, in feet, from the proposed turbine location to:

	Distance (ft. or miles)
Closest offsite neighboring residential structure	2500 feet
Closest property line	390 feet
Closest wetlands	574 feet
Communication towers/microwave towers	2 miles
Airports (miles)	4.4 miles

(8) Environmental/Permitting

Insert aerial property maps with a GIS overlay of:

- ♦ Areas of Critical Environmental Concern
- ♦ National Wetlands Inventory
- ♦ Protected and Recreational Open Space
- ♦ Scenic Landscapes
- ♦ State Register of Historic Places

The following map was extracted from the GEC Report.

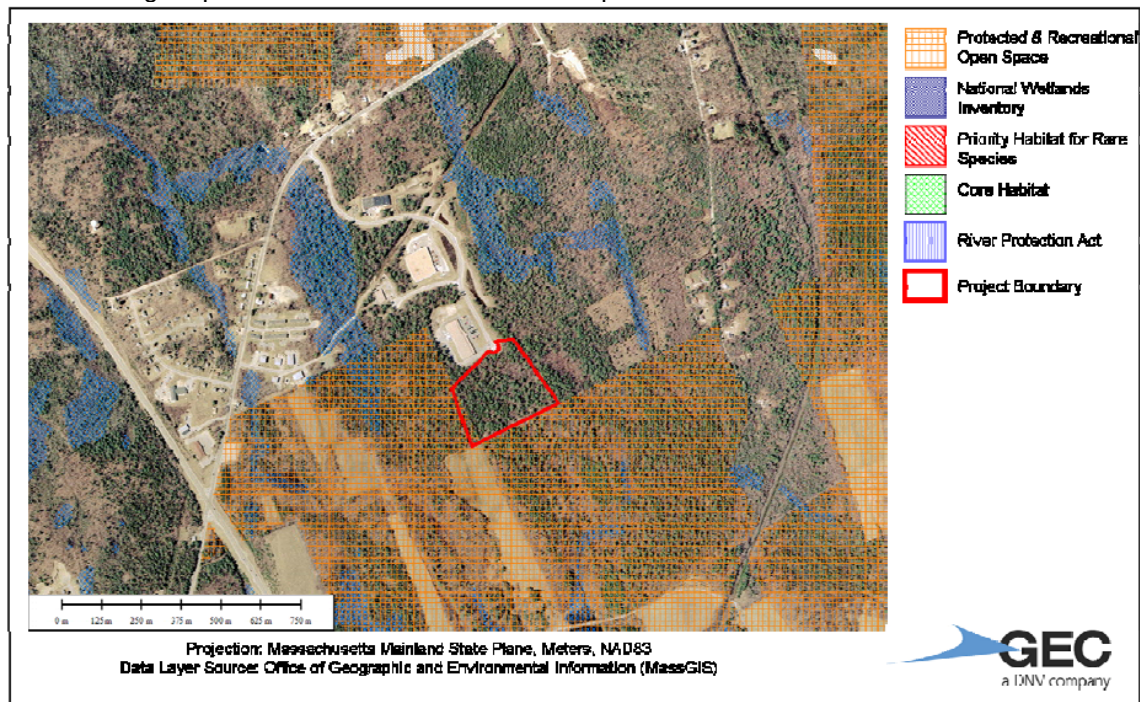


Figure 10. Areas of Environmental and Cultural Significance in the Vicinity of Summit Industrial Park

Provide a commentary (1-2 paragraphs) on whether any of these items could be a fatal flaw to the project. In addition, summarize the Town's zoning ordinances, if applicable, including required heights, setbacks, and distances.

Based on the review, map above, it is not likely that these environmental factors will be a fatal flaw to the project. However, further consultation with the USFWS, NHESP and MHC will be required.

The only zoning ordinance that is critical to the project is the “fall area” ordinance that regulates the height of a structure based on a required setback from nearby buildings or occupied areas. The City of Gardner has adopted the following zoning bylaw: *“The wind machine tower shall be set back from every property line by a distance equal to it’s height as measured to the highest tip of the blades (hereinafter “Fall Area”), except when a Fall Area easement has been obtained from the appropriate abutters, not including any private or public ways or other areas open to public use.”* –Section 1043, Setbacks

(9) Fatal Flaws (1 Paragraph)

Summarize any potential project fatal flaws. For example, address the availability of 3 phase power or the transportation/site access potential, along with any other potentially relevant issues.

Site access, 3 phase power and transmission systems are not potential fatal flaws for this site due to the proximity of multiple industries that regularly receive large trucks and require a robust transmission system.

Potential safety issues, regulated by the setback bylaw, pose the largest threat to the development of this project. It is possible that a 1500 kW turbine, for example will not be feasible for the site based on height. If smaller turbines do not prove to be economical enough for the City the project would derail. According to initial cost-benefit evaluations, contingent on the ability to net-meter the facility, installation of a smaller turbine would be economically feasible.

(10) Recommendations (1 Paragraph)

Provide a summary of recommended turbine sizes, if any, that merit investigation in a feasibility study. Highlight any potential fatal flaws that need to be addressed early in the early stages of a feasibility study.

Turbine sizes recommended range from 600 kW to 1500 MW, with special concern for the turbine height, which will be a critical factor for choosing a model. Issues that need to be addressed early in the feasibility study include the setback requirements, energy assessment for each turbine and a cost-benefit analysis for each turbine.

Attachment 1: Wind Resource Summary:
(Excerpts from the GEC Report)

Table 1. Wind Speed Estimates Based on New England Wind Map

Site	Coordinates (UTM Zone 19, NAD83)		Estimated Annual Wind Speed Range at 70 m agl ² (m/s)	Class ¹	Rating
	Easting	Northing			
Summit Industrial Park	257964	4720000	5.9 – 7.1	2	Marginal

[1] Based on the U.S. Department of Energy National Renewable Energy Laboratory's Wind Power Classification System for wind power densities at 50 m.

[2] agl = above ground level.

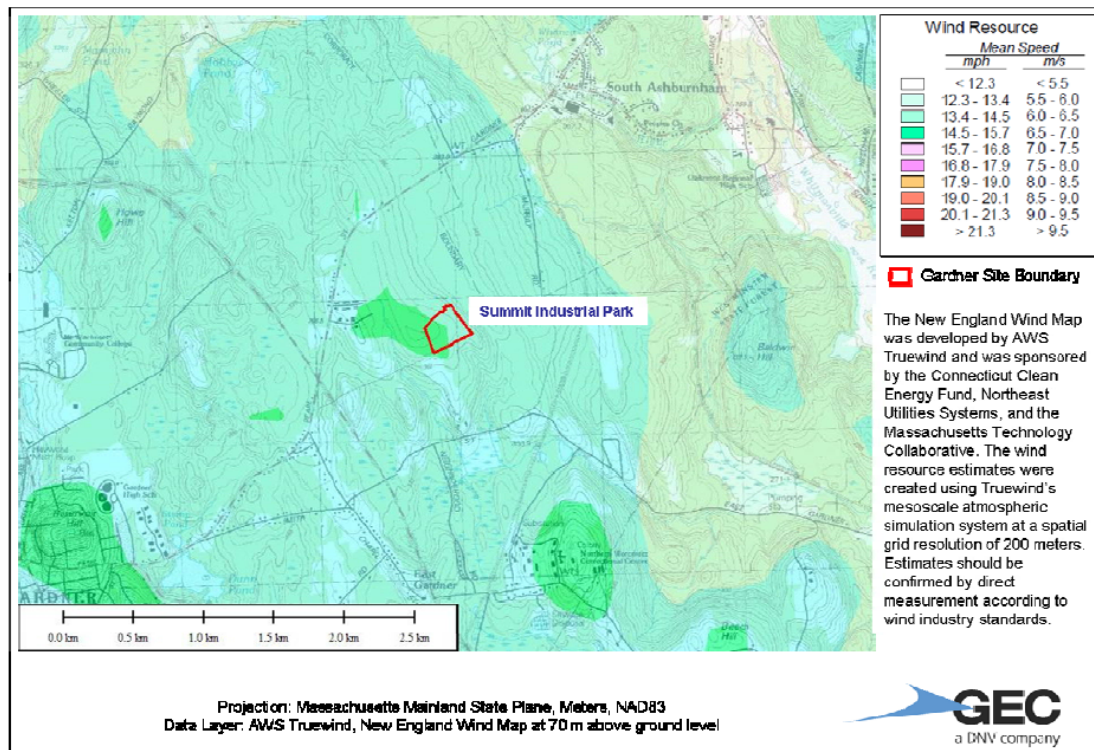


Figure 4. 70-m New England Wind Map and Proposed Project Location

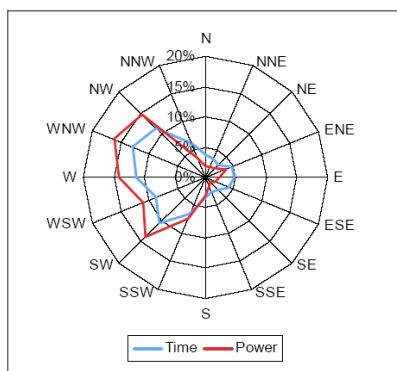
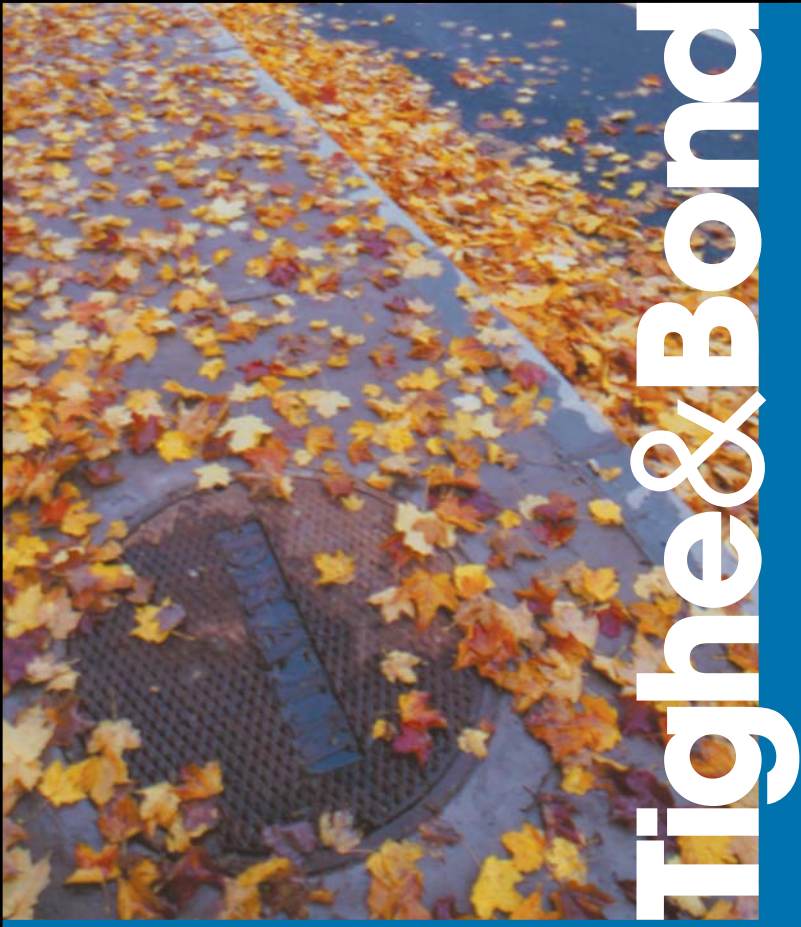


Figure 6. Wind Rose for Proposed Gardner Site

(Source: New England Wind Map)



Project:

Gardner Resource Assessment

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Licensed user:

Tighe & Bond, Inc.

53 Southampton Road

US-01085 Westfield, MA

4736

Ellen Ebner / eebner@tighebond.com

Calculated:

12/6/2010 2:49 PM/2.7.468

PARK - Main Result**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC**Wake Model**

N.O. Jensen (RISØ/EMD)

Calculation Settings

Air density calculation mode Individual per WTG
 Result for WTG at hub altitude 1.195 kg/m³
 Air density relative to standard 97.5 %
 Hub altitude above sea level (asl) 447.1 m
 Annual mean temperature at hub alt. 6.4 °C
 Pressure at WTGs 958.8 hPa

Wake Model Parameters

From angle	To angle	Terrain type	Wake Decay Constant
[°]	[°]		
-180.0	180.0	Very closed farmland	0.100

Wake calculation settings

Angle [°]			Wind speed [m/s]		
start	end	step	start	end	step
0.5	360.0	1.0	0.5	30.5	1.0

Wind data

Wind statistics	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50



Scale 1:40,000

New WTG

Site Data

WASP version WASP 10 for Windows RVEA0151 1, 6, 0, 0**Key results for height 80.0 m above ground level****Terrain UTM NAD83 Zone: 19**

East	North	Name of wind distribution	Type	Wind energy [kWh/m²]	Mean wind speed [m/s]	Equivalent roughness
A 258,820	4,718,477	SDO for WASP NCCI GenPC	WASP (WASP 10 for Windows RVEA0151 1, 6, 0, 0)	3,785	7.7	2.1

Calculated Annual Energy for Wind Farm

WTG combination	Result PARK [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Specific results ^{a)}			
				Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	Mean wind speed @ hub height [m/s]
Wind farm	5,032.8	5,032.8	100.0	34.8	5,032.8	3,050	6.8

^{a)} Based on wake reduced results, but no other losses included**Calculated Annual Energy for each of 1 new WTGs with total 1.6 MW rated power**

WTG type				Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Displacement height [m]	Power curve Creator Name	Annual Energy Park			
Terrain	Valid	Manufact.	Type-generator						Result [MWh]	Efficiency [%]	Capacity factor [%]	Mean wind speed [m/s]
1 A	No	VESTAS	V82-1650/900-1,650/900	1,650	82.0	80.0	23.0	EMD Level 0 - - - 11-2007	5,032.8	100.0	34.8	6.82

Annual Energy results do not include any losses apart from wake losses. For expected NET AEP (expected sold production), see report Loss & Uncertainty.

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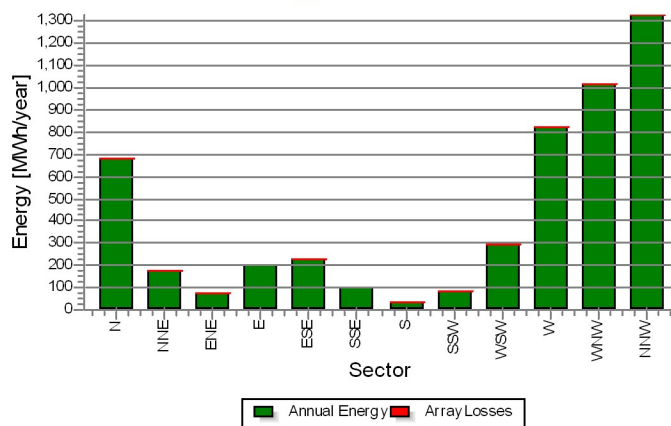
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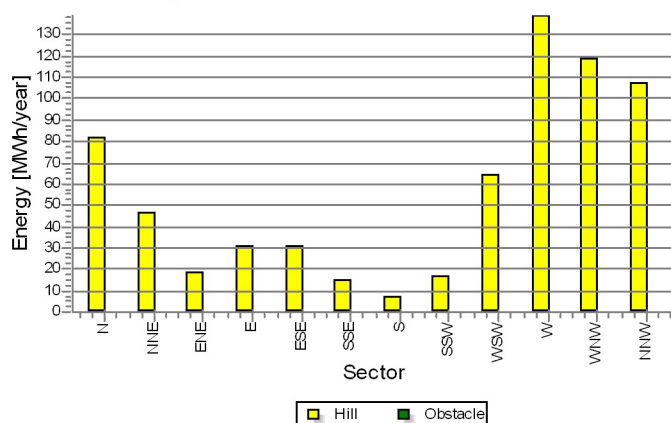
PARK - Production Analysis**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC**WTG:** All WTGs, Air density 1.195 kg/m³**Directional Analysis**

Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	596.3	128.8	54.0	174.9	195.7	83.1	26.7	64.0	226.3	688.5	896.8	1,220.4	4,355.6
+Increase due to hills	[MWh]	81.8	46.7	18.6	30.5	30.8	15.0	7.3	16.7	63.9	139.2	119.2	107.6	677.3
Resulting energy	[MWh]	678.1	175.5	72.6	205.4	226.5	98.1	34.0	80.8	290.2	827.7	1,016.0	1,328.0	5,032.8
Specific energy	[kWh/m ²]													953
Specific energy	[kWh/kW]													3,050
Increase due to hills	[%]	13.7	36.2	34.4	17.5	15.7	18.0	27.4	26.1	28.2	20.2	13.3	8.8	15.55
Utilization	[%]	31.1	41.8	41.6	36.9	37.7	42.0	42.5	41.3	40.0	39.1	34.4	28.4	33.7
Operational	[Hours/year]	905	411	242	424	633	424	190	235	542	1,248	1,477	1,626	8,356
Full Load Equivalent	[Hours/year]	411	106	44	124	137	59	21	49	176	502	616	805	3,050

Energy vs. sector



Impact of hills and obstacles vs. sector



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PARK - Power Curve Analysis**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPWTG: 1 - VESTAS V82-1650/900 1650-900 82.0 !O! Level 0 - - - 11-2007, Hub height: 80.0 m**Name:** Level 0 - - - 11-2007**Source:** Manufacturer

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type
11/1/2007	EMD	7/31/2003	11/25/2008	20.0	Active stall	User defined

Power- and Ct-curve based on item no: TSD 4000256-04 EN dated 2007-11-01.

HP curve comparison - Note: For standard air density and weibull k parameter = 2

Vmean	[m/s]	5	6	7	8	9	10
HP value	[MWh]	2,498	3,868	5,248	6,528	7,624	8,607
VESTAS V82-1650/900 1650-900 82.0 !O! Level 0 - - - 11-2007	[MWh]	2,658	4,051	5,405	6,587	7,519	8,173
Check value	[%]	-6	-5	-3	-1	1	5

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m^2) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.

For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see WindPRO manual chapter 3.5.2.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

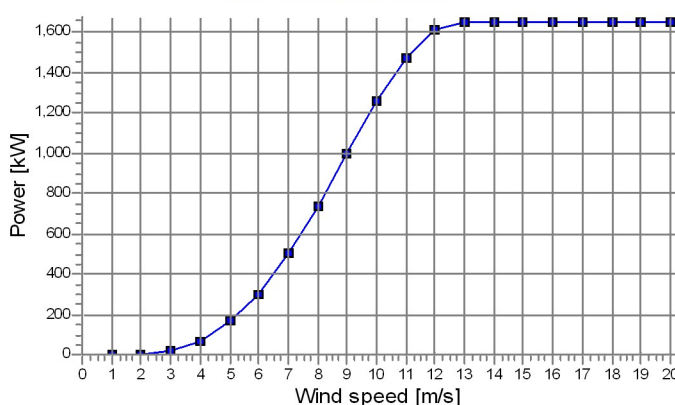
Power curveOriginal data from Windcat, Air density: 1.225 kg/m^3

Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
3.0	20.0	0.23	3.0	0.93
4.0	69.0	0.33	4.0	0.86
5.0	172.0	0.43	5.0	0.85
6.0	310.0	0.44	6.0	0.93
7.0	511.0	0.46	7.0	0.84
8.0	758.0	0.46	8.0	0.77
9.0	1,017.0	0.43	9.0	0.70
10.0	1,285.0	0.40	10.0	0.64
11.0	1,504.0	0.35	11.0	0.58
12.0	1,637.0	0.29	12.0	0.51
13.0	1,650.0	0.23	13.0	0.44
14.0	1,650.0	0.19	14.0	0.38
15.0	1,650.0	0.15	15.0	0.33
16.0	1,650.0	0.12	16.0	0.30
17.0	1,650.0	0.10	17.0	0.27
18.0	1,650.0	0.09	18.0	0.25
19.0	1,650.0	0.07	19.0	0.23
20.0	1,650.0	0.06	20.0	0.22

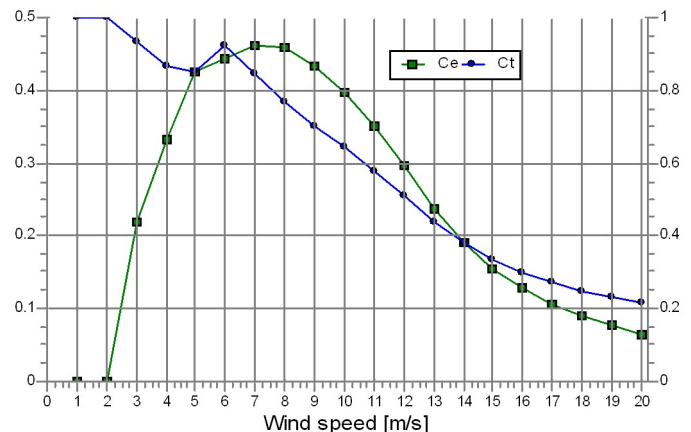
Power, Efficiency and energy vs. wind speedData used in calculation, Air density: 1.195 kg/m^3 New WindPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Ce	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1.0	0.0	0.00	0.50- 1.50	0.0	0.0	0.0
2.0	0.0	0.00	1.50- 2.50	0.0	0.0	0.0
3.0	18.7	0.22	2.50- 3.50	17.2	17.2	0.3
4.0	67.3	0.33	3.50- 4.50	74.4	91.6	1.8
5.0	167.6	0.42	4.50- 5.50	183.5	275.1	5.5
6.0	302.9	0.44	5.50- 6.50	341.8	616.9	12.3
7.0	498.9	0.46	6.50- 7.50	523.2	1,140.1	22.7
8.0	740.8	0.46	7.50- 8.50	675.6	1,815.6	36.1
9.0	995.0	0.43	8.50- 9.50	744.6	2,560.2	50.9
10.0	1,255.7	0.40	9.50-10.50	713.0	3,273.3	65.0
11.0	1,472.6	0.35	10.50-11.50	598.7	3,871.9	76.9
12.0	1,613.2	0.30	11.50-12.50	443.7	4,315.6	85.7
13.0	1,647.4	0.24	12.50-13.50	295.3	4,611.0	91.6
14.0	1,650.0	0.19	13.50-14.50	182.9	4,793.8	95.3
15.0	1,650.0	0.15	14.50-15.50	109.2	4,903.0	97.4
16.0	1,650.0	0.13	15.50-16.50	63.1	4,966.1	98.7
17.0	1,650.0	0.11	16.50-17.50	35.1	5,001.3	99.4
18.0	1,650.0	0.09	17.50-18.50	18.8	5,020.0	99.7
19.0	1,650.0	0.08	18.50-19.50	9.6	5,029.7	99.9
20.0	1,650.0	0.07	19.50-20.50	3.2	5,032.8	100.0

Power curve
Data used in calculation



Ce and Ct curve



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PARK - Terrain

Calculation: 80m Park Calculation, Long Term Data, V82 GenPC **Site Data:** A - SDO for WASP NCCI GenPC

Obstacles:

0 Obstacles used

Roughness:

Calculation uses following MAP files:

C:\...leee.DOMAIN\My Documents\WindPRO\WindPRO Data\Projects\Gardner Feasibility Study\ROUGHNESSLINE_Gardner Resource Assessment_2.wpo

Min X: 248,696, Max X: 275,482, Min Y: 4,709,243, Max Y: 4,734,513, Width: 26,785 m, Height: 25,270 m

Limited by a square on 40.0 km x 40.0 km around the current site

Orography:

Calculation uses following MAP files:

C:\Documents and Settings\leee.DOMAIN\My Documents\WindPRO\WindPRO Data\Projects\Gardner Feasibility Study\Height Contour Lines 6 thinned.wpo

Min X: 250,349, Max X: 266,009, Min Y: 4,710,727, Max Y: 4,727,946, Width: 15,659 m, Height: 17,218 m

Limited by a square on 10.0 km x 10.0 km around the current site

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PARK - Wind Data Analysis**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC**Wind data:** A - SDO for WASP NCCI GenPC; Hub height: 80.0**Site Coordinates**

UTM NAD 83 Zone: 19 East: 258,820 North: 4,718,477

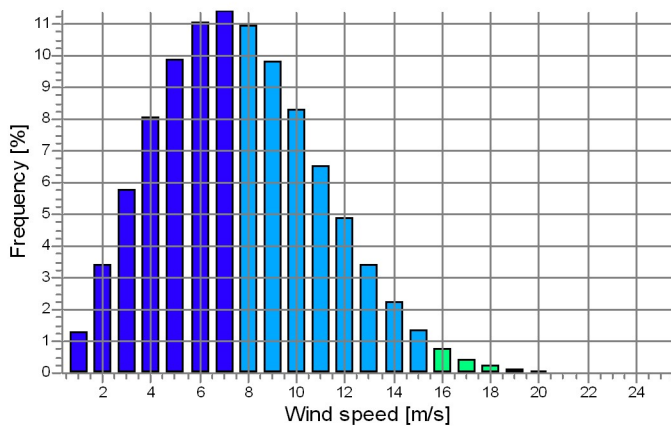
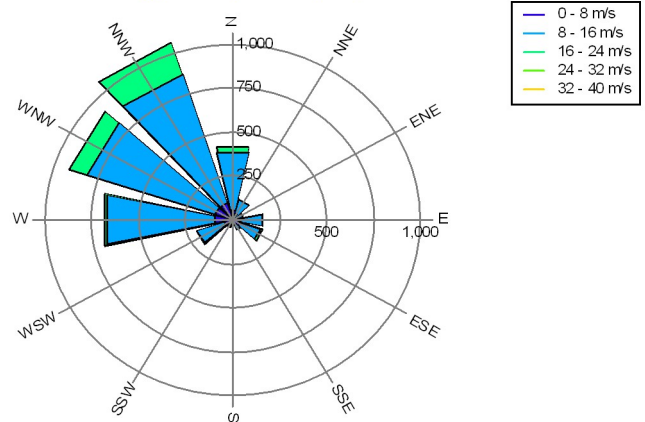
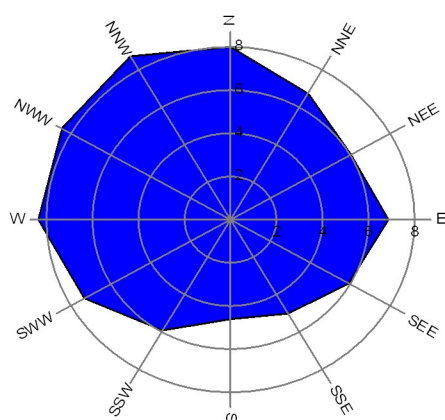
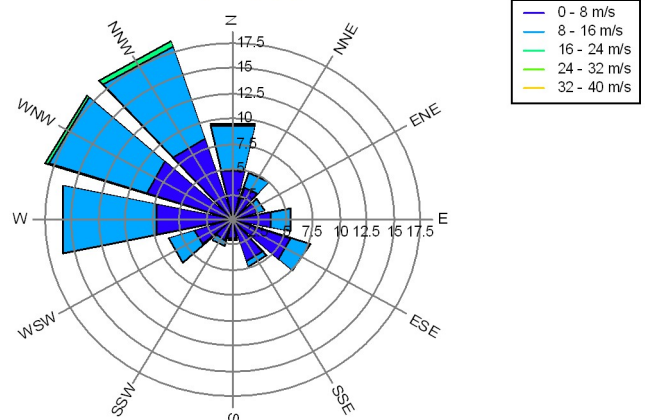
Wind data

Wind statistics

	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50

Weibull Data**Current site**

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	9.05	8.03	2.557	9.7
1 NNE	7.58	6.75	2.846	4.9
2 ENE	6.80	6.03	2.502	3.1
3 E	7.78	6.89	2.295	5.6
4 ESE	6.77	6.00	2.037	7.6
5 SSE	5.73	5.08	2.299	4.9
6 S	5.22	4.64	2.654	2.0
7 SSW	6.67	5.92	2.467	2.7
8 WSW	8.30	7.40	2.912	6.3
9 W	9.36	8.40	3.295	16.2
10 WNW	9.55	8.49	2.689	18.4
11 NNW	9.85	8.74	2.514	18.6
All	8.63	7.65	2.424	100.0

Weibull Distribution**Energy Rose (kWh/m²/year)****Mean wind speed (m/s)****Frequency (%)**

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PARK - Wind Data Analysis**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC**Wind data:** A - SDO for WAsP NCCI GenPC; Hub height: 80.0**Site Coordinates**

UTM NAD 83 Zone: 19 East: 257,978 North: 4,720,007

Gardner WTG Vestas

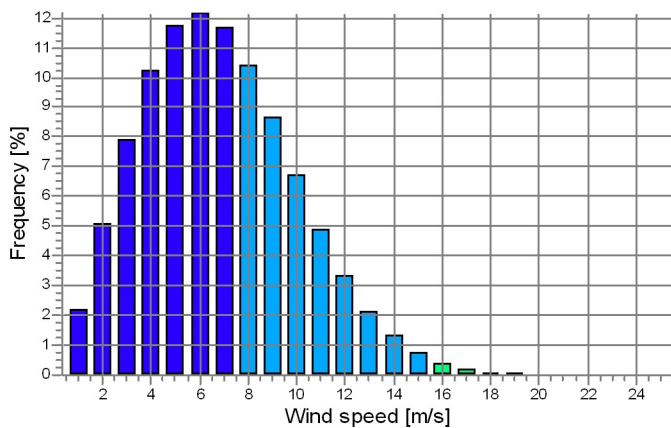
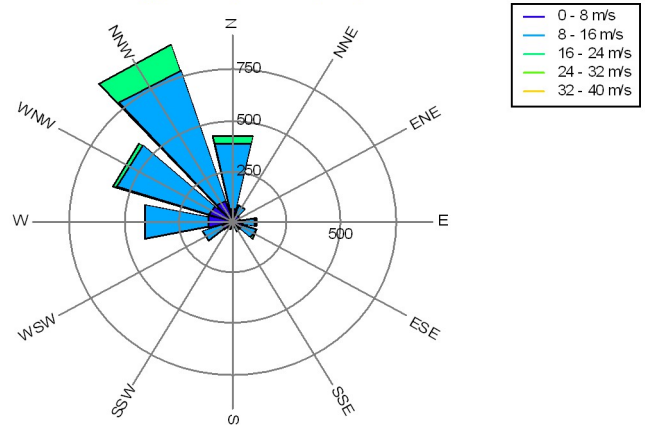
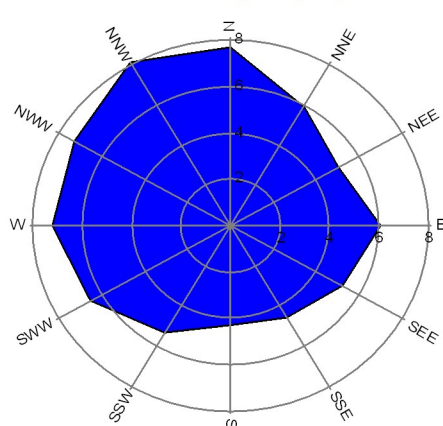
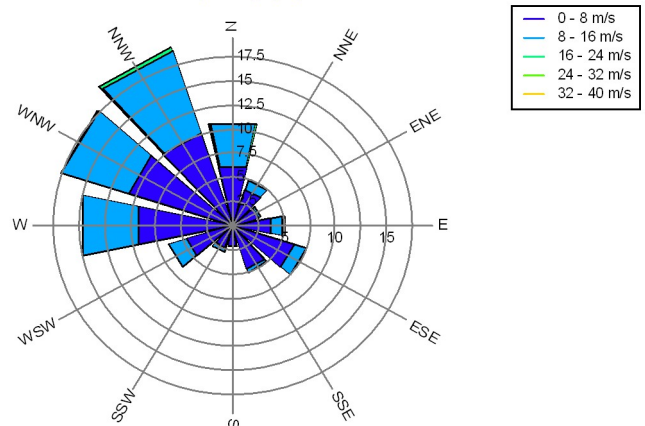
Wind data

Wind statistics

	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50

Weibull Data**Current site**

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	8.65	7.67	2.416	10.8
1 NNE	6.67	5.94	2.756	4.9
2 ENE	5.69	5.04	2.271	2.9
3 E	6.88	6.10	2.189	5.1
4 ESE	5.91	5.24	1.920	7.6
5 SSE	5.15	4.56	2.182	5.1
6 S	4.86	4.31	2.475	2.3
7 SSW	6.02	5.33	2.342	2.8
8 WSW	7.32	6.51	2.787	6.5
9 W	8.06	7.21	3.150	14.9
10 WNW	8.22	7.30	2.549	17.7
11 NNW	9.14	8.10	2.381	19.5
All	7.70	6.82	2.268	100.0

Weibull Distribution**Energy Rose (kWh/m²/year)****Mean wind speed (m/s)****Frequency (%)**

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PARK - Park power curve**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC

Power															
Wind speed	Free WTGs	Park WTGs	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	
[m/s]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
4.5	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117
5.5	234	234	234	234	234	234	234	234	234	234	234	234	234	234	234
6.5	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399
7.5	618	618	618	618	618	618	618	618	618	618	618	618	618	618	618
8.5	868	868	868	868	868	868	868	868	868	868	868	868	868	868	868
9.5	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125
10.5	1,367	1,367	1,367	1,367	1,367	1,367	1,367	1,367	1,367	1,367	1,367	1,367	1,367	1,367	1,367
11.5	1,549	1,549	1,549	1,549	1,549	1,549	1,549	1,549	1,549	1,549	1,549	1,549	1,549	1,549	1,549
12.5	1,641	1,641	1,641	1,641	1,641	1,641	1,641	1,641	1,641	1,641	1,641	1,641	1,641	1,641	1,641
13.5	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650
14.5	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650
15.5	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650
16.5	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650
17.5	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650
18.5	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650
19.5	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650
20.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description:

The park power curve is similar to a WTG power curve, meaning that when a given wind speed appears in front of the park with same speed in the entire wind farm area (before influence from the park), the output from the park can be found in the park power curve. Another way to say this: The park power curve includes array losses, but do NOT include terrain given variations in the wind speed over the park area.

Measuring a park power curve is not as simple as measuring a WTG power curve due to the fact that the park power curve depends on the wind direction and that the same wind speed normally will not appear for the entire park area at the same time (only in very flat non-complex terrain). The idea with this version of the park power curve is not to use it for validation based on measurements. This would require at least 2 measurement masts at two sides of the park, unless only a few direction sectors should be tested, AND non complex terrain (normally only useable off shore). Another park power curve version for complex terrain is available in WindPRO.

The park power curve can be used for:

1. Forecast systems, based on more rough (approximated) wind data, the park power curve would be an efficient way to make the connection from wind speed (and direction) to power.
2. Construction of duration curves, telling how often a given power output will appear, the park power curve can be used together with the average wind distribution for the Wind farm area in hub height. The average wind distribution can eventually be obtained based on the Weibull parameters for each WTG position. These are found at print menu: >Result to file< in the >Park result< which can be saved to file or copied to clipboard and pasted in Excel.
3. Calculation of wind energy index based on the PARK production (see below).
4. Estimation of the expected PARK production for an existing wind farm based on wind measurements at minimum 2 measurement masts at two sides of wind farm. The masts must be used for obtaining the free wind speed. The free wind speed is used in the simulation of expected energy production with the PARK power curve. This procedure will only work suitable in non complex terrains. For complex terrain another park power curve calculation is available in WindPRO (PPV-model).

Note:

From the >Result to file< the >Wind Speeds Inside Wind farm< is also available. These can (e.g. via Excel) be used for extracting the wake induced reductions in measured wind speed.

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PARK - RIX calculation**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC**Assumptions**

Radius for calculation 3,500 m
 Directional step 5 °
 Steepness threshold 40.0 % / 22 °
 Directional weight Frequency distributed
 Height contours used HCLs

Reference sites**Terrain UTM NAD83 Zone: 19**

East	North	Z [m]	Name of wind distribution	Type	Reference site RIX [%]
A 258,820	4,718,477	369.0	SDO for WAsP NCCI GenPC	WAsP (WAsP 10 for Windows RVEA0151 1, 6, 0, 0)	0.2

WTG sites**UTM NAD83 Zone: 19**

Terrain	East	North	Z [m]	Reference site RIX [%]	WTG RIX [%]	Delta RIX (WTG site - Reference site) [%]
1 A	UTM NAD83 Zone: 19 257,978	4,720,007	367.1	0.2	0.1	-0.1

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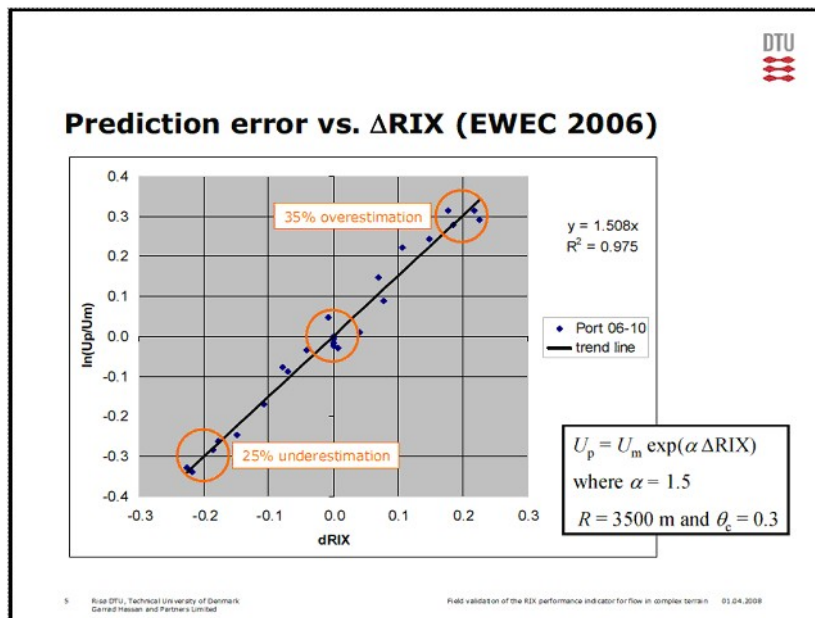
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12/6/2010 2:49 PM/2.7.468

PARK - RIX calculation**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC

Latest research /Risø/ show that the threshold in RIX calculation typically work best with 40% (new default), and that delta Rix within +/- 5% should not give corrections. Cross predictions based on more mast can fine tune the threshold, see Cross predictor tool in WindPRO Meteo Analyzer. In WindPRO LOSS&&UNCERTAINTY module, RIX correction can be calculated automatically as a bias based on most recent recommended correction formulas, which can be found in EWEC2006 && 08 papers on Rix from Risø, see extract below:

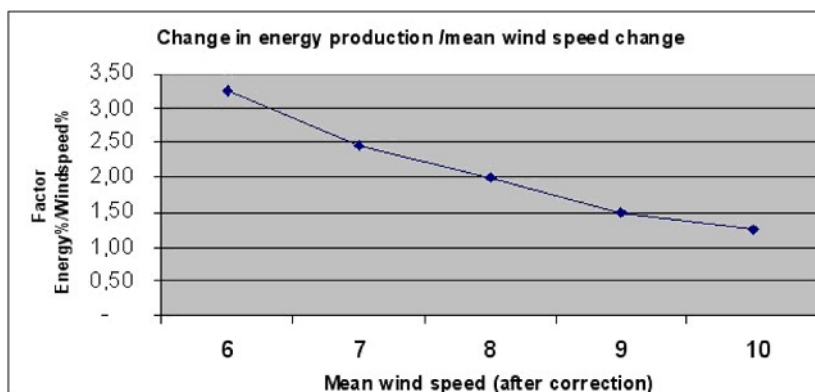


The main conclusion based on use of the RIX method is that if both reference site (measurement mast) and predicted site (WTG) are equally rugged (Delta RIX < 5%), very small calculation errors are expected.

If reference site (measurement mast) is very rugged, e.g. RIX = 0.2 and predicted site (WTG) are less rugged (e.g. RIX = 0), Delta RIX will be -0.2 and according to the graph, 30% too low wind speed prediction at WTG site could be expected. This could lead to around 60%*) too low calculated energy production.

If the reference site is less rugged, e.g. RIX = 0, and the predicted site (WTG) are very rugged (e.g. RIX = 0.2), Delta RIX will be +0.2, and according to the graph, 30% too high wind speed prediction at WTG site could be expected. This could lead to around 60%*) too high calculated energy production.

*) Doubling of energy prediction error based on mean wind speed error is a rough conversion, which holds for wind speeds around 8 m/s. At 6-7 m/s tripling is more right, while only 1.5 factors should be used for 9 m/s, see graph below based on a typical WTG.



Source: EWEC06 paper:

IMPROVING WASP PREDICTIONS IN (TOO) COMPLEX TERRAIN

Niels G. Møller, Anthony J. Bowen and Ioannis Antoniou

WindPRO is developed by EMD International A/S, Niels Jernesvej 10, DK-9220 Ålborg Ø, Tlf. +45 96 35 44 44, Fax +45 96 35 44 46, e-mail: windpro@emd.dk
Wind Energy Department, Risø National Laboratory

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PARK - Time varying AEP**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC

Windfarm: 1.7 MW based on 1 turbines of type VESTAS V82-1650/900 1650-900 82.0 !O!.

Calculated mean yield per month and hour [MWh]. The result includes wake losses but no other losses.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%

Hour/Month [MWh]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	21	22	26	18	17	19	13	13	17	18	21	15	221
1	21	22	27	19	16	19	13	14	16	17	20	18	223
2	20	23	28	18	17	17	13	13	13	17	21	17	218
3	20	24	28	19	18	16	13	14	13	19	21	17	221
4	22	24	27	18	18	15	13	13	15	19	19	15	217
5	22	25	26	17	15	14	11	13	16	17	20	15	211
6	24	25	26	16	12	11	10	10	14	15	21	15	201
7	25	25	23	18	13	11	8	9	12	12	20	16	192
8	21	26	24	17	14	10	8	9	11	12	20	16	189
9	22	27	24	20	14	12	10	9	13	11	20	15	198
10	23	28	25	22	14	13	13	9	11	15	20	17	210
11	24	29	27	22	14	13	13	9	12	14	20	18	215
12	23	30	29	22	16	15	13	10	12	15	19	19	223
13	22	29	28	23	16	15	13	10	13	16	17	20	222
14	21	28	29	21	17	15	13	11	13	18	15	19	219
15	19	26	30	22	19	16	12	11	12	15	15	16	214
16	18	25	30	20	17	15	12	11	10	14	14	16	202
17	17	22	28	20	15	14	10	9	10	16	14	17	190
18	21	21	27	19	13	11	9	8	13	17	15	16	189
19	23	24	29	18	15	11	9	11	15	19	16	17	206
20	22	23	27	18	15	14	11	11	16	19	17	16	210
21	22	22	27	18	17	15	11	11	15	19	18	15	211
22	21	23	26	19	18	16	12	13	15	18	19	15	216
23	20	23	25	19	16	19	12	14	16	18	19	15	217
Grand Total	513	597	649	466	375	346	275	264	323	392	439	394	5,033

Hour/Month [MW]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	0.7	0.8	0.8	0.6	0.5	0.6	0.4	0.4	0.6	0.6	0.7	0.5	0.6
1	0.7	0.8	0.9	0.6	0.5	0.6	0.4	0.5	0.5	0.5	0.7	0.6	0.6
2	0.6	0.8	0.9	0.6	0.6	0.6	0.4	0.4	0.4	0.6	0.7	0.6	0.6
3	0.7	0.9	0.9	0.6	0.6	0.5	0.4	0.4	0.4	0.6	0.7	0.5	0.6
4	0.7	0.8	0.9	0.6	0.6	0.5	0.4	0.4	0.5	0.6	0.6	0.5	0.6
5	0.7	0.9	0.8	0.6	0.5	0.5	0.4	0.4	0.5	0.5	0.7	0.5	0.6
6	0.8	0.9	0.8	0.5	0.4	0.4	0.3	0.3	0.5	0.5	0.7	0.5	0.6
7	0.8	0.9	0.8	0.6	0.4	0.4	0.2	0.3	0.4	0.4	0.7	0.5	0.5
8	0.7	0.9	0.8	0.6	0.4	0.3	0.3	0.3	0.4	0.4	0.7	0.5	0.5
9	0.7	1.0	0.8	0.7	0.4	0.4	0.3	0.3	0.4	0.4	0.7	0.5	0.5
10	0.7	1.0	0.8	0.7	0.4	0.4	0.4	0.3	0.4	0.5	0.7	0.5	0.6
11	0.8	1.0	0.9	0.7	0.4	0.4	0.4	0.3	0.4	0.4	0.7	0.6	0.6
12	0.8	1.1	0.9	0.7	0.5	0.5	0.4	0.3	0.4	0.5	0.6	0.6	0.6
13	0.7	1.0	0.9	0.8	0.5	0.5	0.4	0.3	0.4	0.5	0.6	0.6	0.6
14	0.7	1.0	0.9	0.7	0.5	0.5	0.4	0.3	0.4	0.6	0.5	0.6	0.6
15	0.6	0.9	1.0	0.7	0.6	0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.6
16	0.6	0.9	1.0	0.7	0.5	0.5	0.4	0.3	0.3	0.5	0.5	0.5	0.6
17	0.6	0.8	0.9	0.7	0.5	0.5	0.3	0.3	0.3	0.5	0.5	0.5	0.5
18	0.7	0.7	0.9	0.6	0.4	0.4	0.3	0.3	0.4	0.5	0.5	0.5	0.5
19	0.7	0.9	0.9	0.6	0.5	0.4	0.3	0.3	0.5	0.6	0.5	0.5	0.6
20	0.7	0.8	0.9	0.6	0.5	0.5	0.3	0.4	0.5	0.6	0.6	0.5	0.6
21	0.7	0.8	0.9	0.6	0.5	0.5	0.4	0.4	0.5	0.6	0.6	0.5	0.6
22	0.7	0.8	0.8	0.6	0.6	0.5	0.4	0.4	0.5	0.6	0.6	0.5	0.6
23	0.6	0.8	0.8	0.6	0.5	0.6	0.4	0.4	0.5	0.6	0.6	0.5	0.6
Grand Total	0.7	0.9	0.9	0.6	0.5	0.5	0.4	0.4	0.4	0.5	0.6	0.5	0.6

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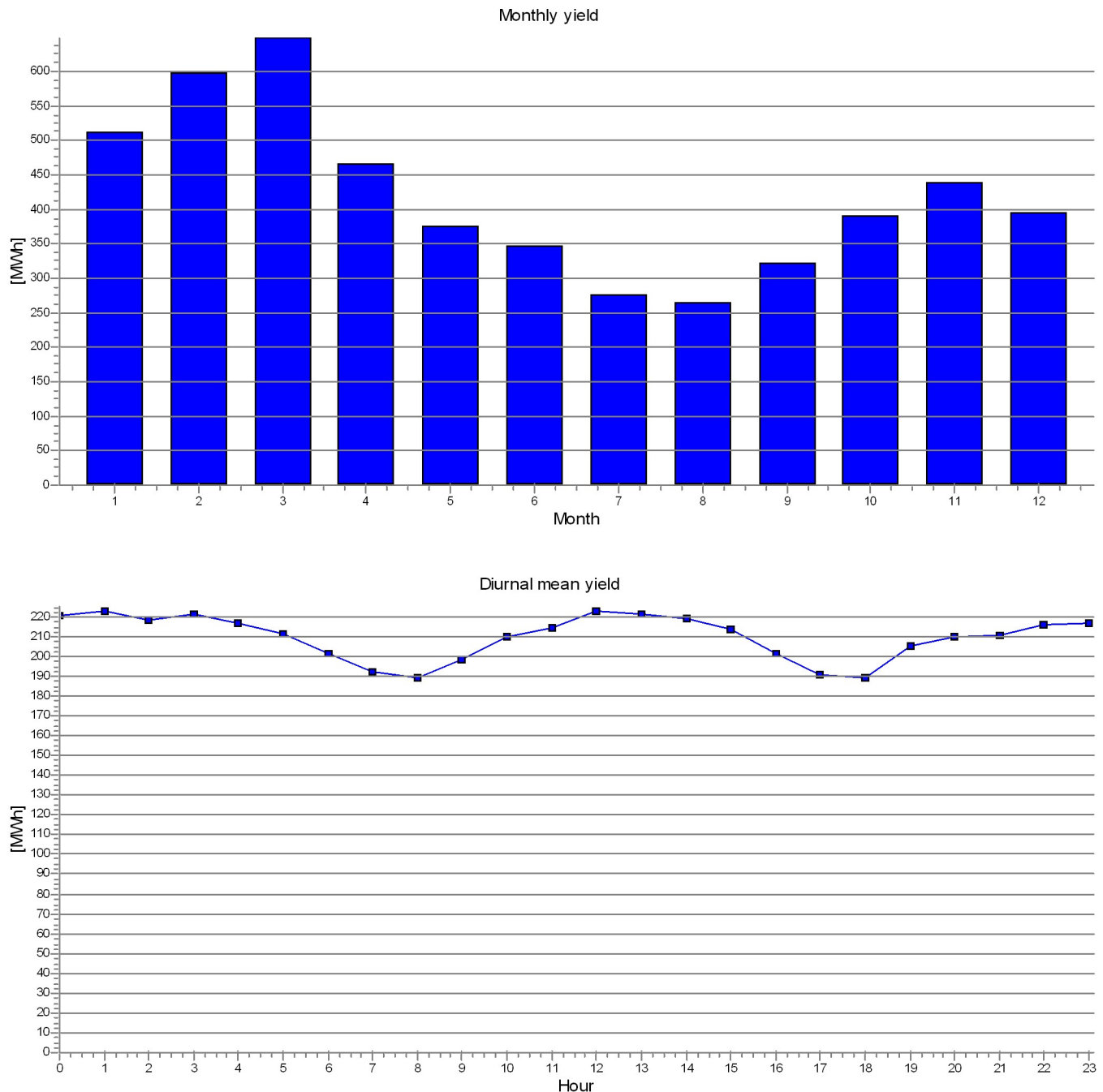
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PARK - Time varying AEP**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC

Windfarm: 1.7 MW based on 1 turbines of type VESTAS V82-1650/900 1650-900 82.0 !O!.

Calculated mean yield per month and hour [MWh]. The result includes wake losses but no other losses.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%



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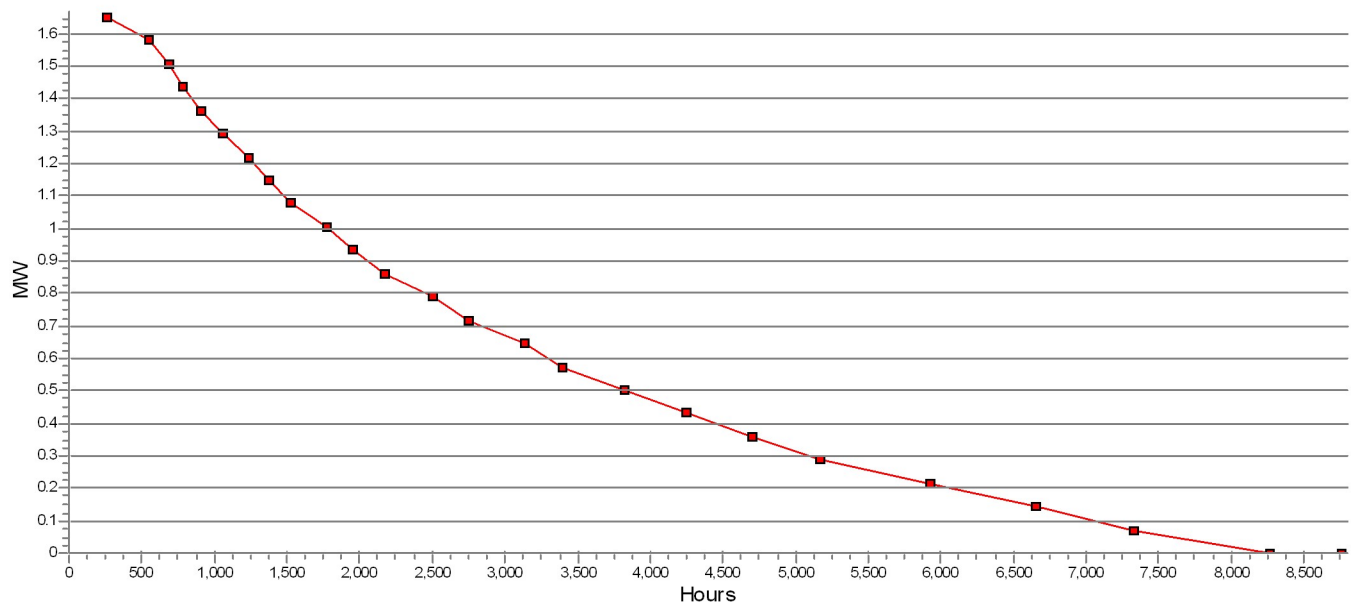
PARK - Time varying AEP**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC

Windfarm: 1.7 MW based on 1 turbines of type VESTAS V82-1650/900 1650-900 82.0 !O!.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%

Hours	Hours [%]	Hours accumulated	Rated power [MW]	Rated power (MW/WTG)
265	3.0	265	1.7	1.7
291	3.3	555	1.6 - 1.7	1.6 - 1.7
127	1.4	682	1.5 - 1.6	1.5 - 1.6
105	1.2	787	1.4 - 1.5	1.4 - 1.5
126	1.4	913	1.4 - 1.4	1.4 - 1.4
148	1.7	1061	1.3 - 1.4	1.3 - 1.4
177	2.0	1238	1.2 - 1.3	1.2 - 1.3
140	1.6	1377	1.1 - 1.2	1.1 - 1.2
149	1.7	1526	1.1 - 1.1	1.1 - 1.1
245	2.8	1771	1.0 - 1.1	1.0 - 1.1
189	2.2	1959	0.9 - 1.0	0.9 - 1.0
210	2.4	2169	0.9 - 0.9	0.9 - 0.9
336	3.8	2504	0.8 - 0.9	0.8 - 0.9
241	2.7	2745	0.7 - 0.8	0.7 - 0.8
389	4.4	3133	0.6 - 0.7	0.6 - 0.7
269	3.1	3402	0.6 - 0.6	0.6 - 0.6
421	4.8	3823	0.5 - 0.6	0.5 - 0.6
430	4.9	4253	0.4 - 0.5	0.4 - 0.5
455	5.2	4708	0.4 - 0.4	0.4 - 0.4
466	5.3	5174	0.3 - 0.4	0.3 - 0.4
759	8.7	5932	0.2 - 0.3	0.2 - 0.3
718	8.2	6651	0.1 - 0.2	0.1 - 0.2
683	7.8	7333	0.1 - 0.1	0.1 - 0.1
929	10.6	8262	0.0 - 0.1	0.0 - 0.1
498	5.7	8760	0.0	0.0

Duration curve 1.7 MW WindFarm



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PARK - Main Result**Calculation:** Park Calculation, Long Term Data, FL 1500**Wake Model**

N.O. Jensen (RISØ/EMD)

Calculation Settings

Air density calculation mode Individual per WTG
 Result for WTG at hub altitude 1.196 kg/m³
 Air density relative to standard 97.7 %
 Hub altitude above sea level (asl) 432.1 m
 Annual mean temperature at hub alt. 6.5 °C
 Pressure at WTGs 960.5 hPa

Wake Model Parameters

From angle	To angle	Terrain type	Wake Decay Constant
[°]	[°]		
-180.0	180.0	Very closed farmland	0.100

Wake calculation settings

Angle [°]			Wind speed [m/s]		
start	end	step	start	end	step
0.5	360.0	1.0	0.5	30.5	1.0

Wind data

Wind statistics	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50



Scale 1:40,000

New WTG

Site Data

WASP version WASP 10 for Windows RVEA0151 1, 6, 0, 0**Key results for height 65.0 m above ground level****Terrain UTM NAD83 Zone: 19**

East	North	Name of wind distribution	Type	Wind energy [kWh/m²]	Mean wind speed [m/s]	Equivalent roughness	
A	258,821	4,718,465	SDO for WASP NCCI GenPC	WASP (WASP 10 for Windows RVEA0151 1, 6, 0, 0)	3,426	7.3	2.1

Calculated Annual Energy for Wind Farm

WTG combination	Result PARK [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Specific results ^{a)}			Mean wind speed @ hub height [m/s]
				Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	
Wind farm	3,666.2	3,666.2	100.0	27.9	3,666.2	2,444	6.3

^{a)} Based on wake reduced results, but no other losses included**Calculated Annual Energy for each of 1 new WTGs with total 1.5 MW rated power**

WTG type			Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Displacement height [m]	Power curve		Annual Energy Result [MWh]	Park Efficiency [%]	Capacity factor [%]	Mean wind speed [m/s]
Terrain	Valid	Manufact.						Creator	Name				
1 A	Yes	FUHLÄNDER	FL 1500-77-1,500	1,500	77.0	65.0	23.0	EMD	Level 0 - - - 07-2004	3,666.2	100.0	27.9	6.32

Annual Energy results do not include any losses apart from wake losses. For expected NET AEP (expected sold production), see report Loss & Uncertainty.

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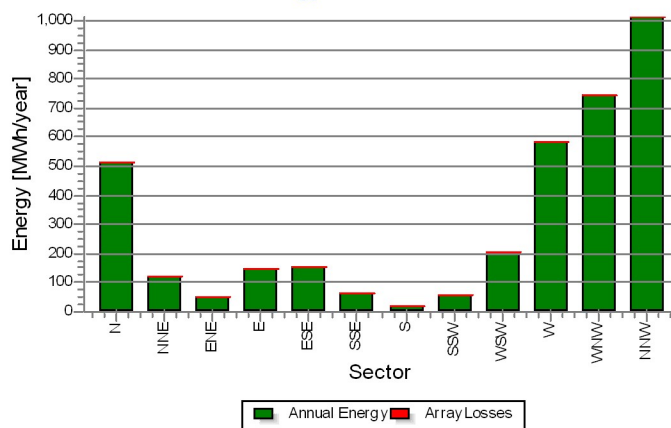
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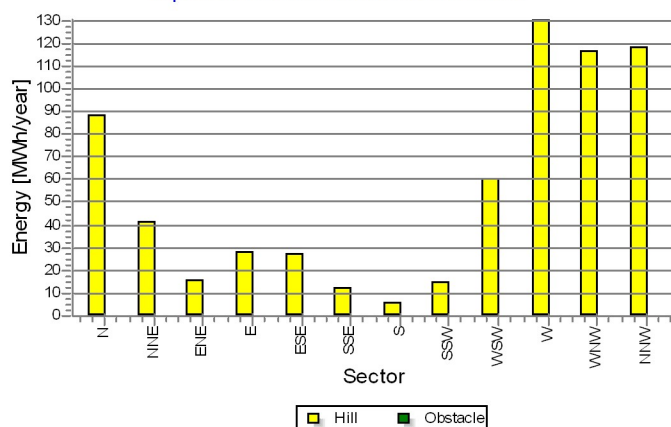
PARK - Production Analysis**Calculation:** Park Calculation, Long Term Data, FL 1500WTG: All WTGs, Air density 1.196 kg/m³**Directional Analysis**

Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	425.3	79.6	32.6	116.5	129.2	49.4	14.9	39.8	147.0	450.6	626.2	894.8	3,005.9
+Increase due to hills	[MWh]	88.3	41.4	15.6	27.9	27.6	12.7	6.0	15.1	60.5	130.5	116.5	118.4	660.4
Resulting energy	[MWh]	513.7	121.0	48.2	144.4	156.8	62.0	20.8	55.0	207.5	581.1	742.7	1,013.1	3,666.2
Specific energy	[kWh/m ²]													787
Specific energy	[kWh/kW]													2,444
Increase due to hills	[%]	20.8	52.1	48.0	23.9	21.3	25.7	40.1	38.0	41.1	29.0	18.6	13.2	21.97
Utilization	[%]	32.3	38.3	37.0	35.7	35.4	36.2	34.6	37.4	38.0	38.3	34.8	30.1	33.9
Operational	[Hours/year]	823	374	220	382	568	381	173	213	496	1,122	1,323	1,462	7,537
Full Load Equivalent	[Hours/year]	342	81	32	96	105	41	14	37	138	387	495	675	2,444

Energy vs. sector



Impact of hills and obstacles vs. sector



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PARK - Power Curve Analysis**Calculation:** Park Calculation, Long Term Data, FL 1500WTG: 1 - FUHLÄNDER FL 1500-77 1500 77.0 !- Level 0 - - 07-2004, Hub height: 65.0 m**Name:** Level 0 - - 07-2004**Source:** Manufacturer

Source/Date Created by Created Edited Stop wind speed Power control CT curve type

7/29/2004 EMD 8/11/2003 11/28/2005 [m/s] 25.0 Pitch Standard pitch

theoretical PC

HP curve comparison - Note: For standard air density and weibull k parameter = 2

Vmean	[m/s]	5	6	7	8	9	10
HP value	[MWh]	2,126	3,366	4,628	5,833	6,826	7,716
FUHLÄNDER FL 1500-77 1500 77.0 !- Level 0 - - 07-2004	[MWh]	2,141	3,414	4,686	5,842	6,833	7,638
Check value	[%]	-1	-1	-1	0	0	1

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m²) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.

For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see WindPRO manual chapter 3.5.2.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

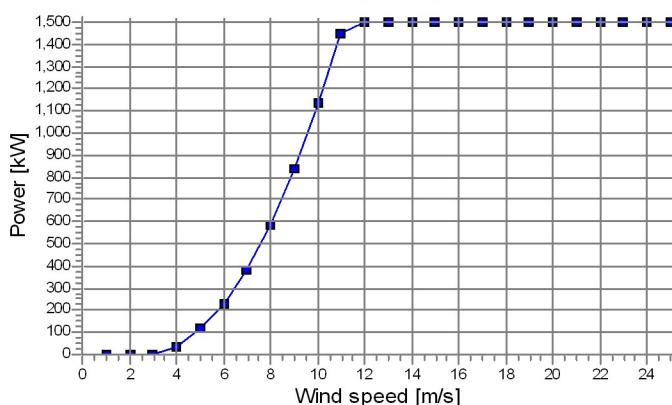
Power curveOriginal data from Windcat, Air density: 1.225 kg/m³

Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
3.0	0.0	0.00	1.0	0.10
4.0	36.9	0.20	2.0	0.10
5.0	122.2	0.34	3.0	0.10
6.0	233.0	0.38	4.0	0.80
7.0	389.1	0.40	5.0	0.82
8.0	597.1	0.41	6.0	0.84
9.0	861.8	0.41	7.0	0.79
10.0	1,166.0	0.41	8.0	0.72
11.0	1,495.4	0.39	9.0	0.66
12.0	1,500.2	0.30	10.0	0.59
13.0	1,500.2	0.24	11.0	0.53
14.0	1,500.2	0.19	12.0	0.46
15.0	1,500.2	0.16	13.0	0.40
16.0	1,500.2	0.13	14.0	0.33
17.0	1,500.2	0.11	15.0	0.28
18.0	1,500.2	0.09	16.0	0.23
19.0	1,500.2	0.08	17.0	0.20
20.0	1,500.2	0.07	18.0	0.16
			19.0	0.13
			20.0	0.12
			21.0	0.12
			22.0	0.11
			23.0	0.11
			24.0	0.10

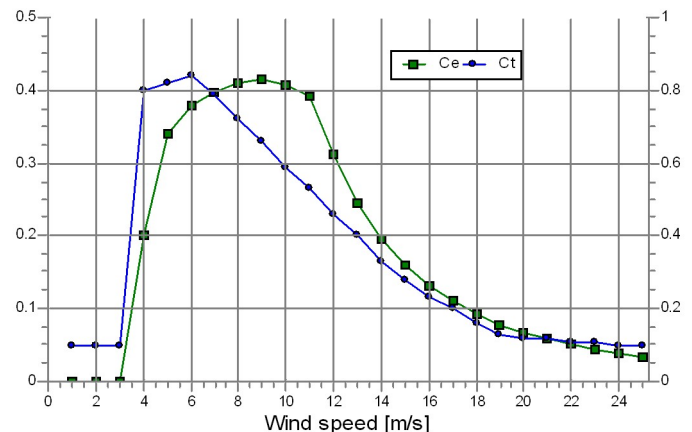
Power, Efficiency and energy vs. wind speedData used in calculation, Air density: 1.196 kg/m³ New WindPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Ce	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1.0	0.0	0.00	0.50-1.50	0.0	0.0	0.0
2.0	0.0	0.00	1.50-2.50	0.0	0.0	0.0
3.0	0.0	0.00	2.50-3.50	8.1	8.1	0.2
4.0	35.7	0.20	3.50-4.50	49.8	57.9	1.6
5.0	118.7	0.34	4.50-5.50	140.4	198.3	5.4
6.0	227.6	0.38	5.50-6.50	263.6	461.9	12.6
7.0	380.2	0.40	6.50-7.50	393.8	855.7	23.3
8.0	583.5	0.41	7.50-8.50	501.5	1,357.2	37.0
9.0	840.7	0.41	8.50-9.50	554.8	1,912.0	52.2
10.0	1,134.7	0.41	9.50-10.50	538.7	2,450.7	66.8
11.0	1,450.8	0.39	10.50-11.50	450.7	2,901.4	79.1
12.0	1,499.4	0.31	11.50-12.50	315.4	3,216.8	87.7
13.0	1,500.2	0.25	12.50-13.50	193.9	3,410.7	93.0
14.0	1,500.2	0.20	13.50-14.50	114.9	3,525.6	96.2
15.0	1,500.2	0.16	14.50-15.50	65.9	3,591.5	98.0
16.0	1,500.2	0.13	15.50-16.50	36.5	3,628.0	99.0
17.0	1,500.2	0.11	16.50-17.50	19.5	3,647.5	99.5
18.0	1,500.2	0.09	17.50-18.50	9.9	3,657.4	99.8
19.0	1,500.2	0.08	18.50-19.50	4.9	3,662.3	99.9
20.0	1,500.2	0.07	19.50-20.50	2.3	3,664.5	100.0
21.0	1,500.2	0.06	20.50-21.50	1.0	3,665.6	100.0
22.0	1,500.2	0.05	21.50-22.50	0.4	3,666.0	100.0
23.0	1,500.2	0.04	22.50-23.50	0.2	3,666.2	100.0
24.0	1,500.2	0.04	23.50-24.50	0.1	3,666.2	100.0
25.0	1,500.2	0.03	24.50-25.50	0.0	3,666.2	100.0

Power curve
Data used in calculation



Ce and Ct curve



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PARK - Terrain

Calculation: Park Calculation, Long Term Data, FL 1500 **Site Data:** A - SDO for WASP NCCI GenPC

Obstacles:

0 Obstacles used

Roughness:

Calculation uses following MAP files:

C:\...leee.DOMAIN\My Documents\WindPRO\WindPRO Data\Projects\Gardner Feasibility Study\ROUGHNESSLINE_Gardner Resource Assessment_2.wpo

Min X: 248,696, Max X: 275,482, Min Y: 4,709,243, Max Y: 4,734,513, Width: 26,785 m, Height: 25,270 m

Limited by a square on 40.0 km x 40.0 km around the current site

Orography:

Calculation uses following MAP files:

C:\Documents and Settings\leee.DOMAIN\My Documents\WindPRO\WindPRO Data\Projects\Gardner Feasibility Study\Height Contour Lines 6 thinned.wpo

Min X: 250,349, Max X: 266,009, Min Y: 4,710,727, Max Y: 4,727,946, Width: 15,659 m, Height: 17,218 m

Limited by a square on 10.0 km x 10.0 km around the current site

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PARK - Wind Data Analysis**Calculation:** Park Calculation, Long Term Data, FL 1500Wind data: A - SDO for WASP NCCI GenPC; Hub height: 65.0**Site Coordinates**

UTM NAD 83 Zone: 19 East: 258,821 North: 4,718,465

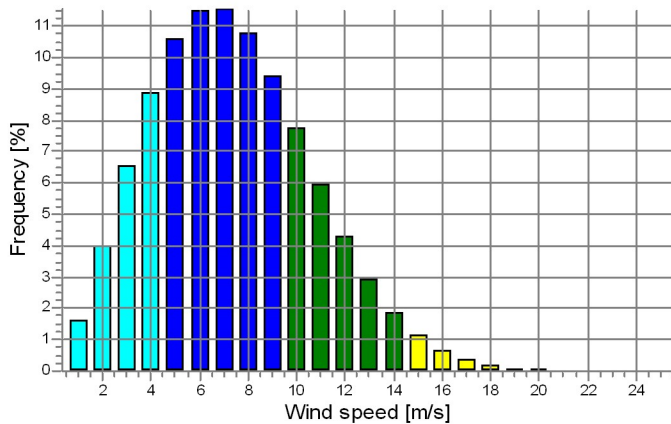
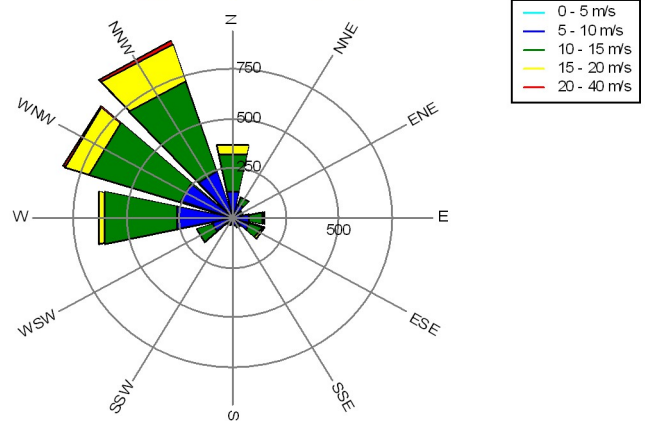
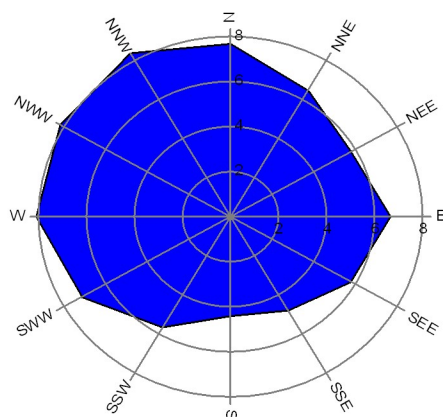
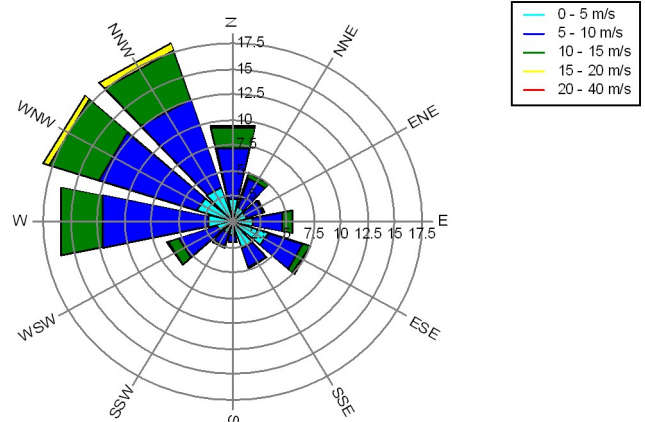
Wind data

Wind statistics

	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50

Weibull Data**Current site**

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	8.64	7.66	2.475	9.6
1 NNE	7.29	6.48	2.740	5.0
2 ENE	6.54	5.80	2.424	3.1
3 E	7.51	6.65	2.213	5.7
4 ESE	6.50	5.76	1.967	7.6
5 SSE	5.46	4.84	2.225	4.8
6 S	4.99	4.43	2.564	2.0
7 SSW	6.37	5.65	2.381	2.7
8 WSW	8.01	7.14	2.811	6.3
9 W	9.04	8.10	3.174	16.3
10 WNW	9.19	8.17	2.596	18.4
11 NNW	9.40	8.34	2.432	18.5
All	8.29	7.34	2.354	100.0

Weibull Distribution**Energy Rose (kWh/m²/year)****Mean wind speed (m/s)****Frequency (%)**

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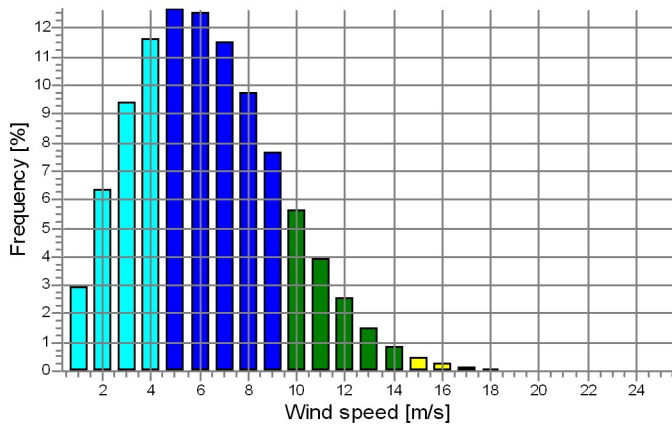
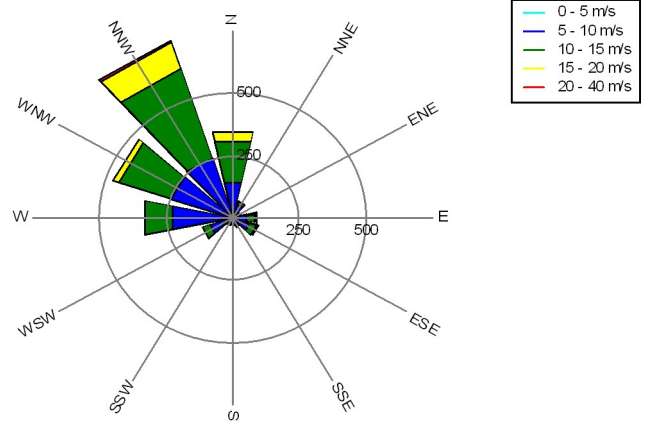
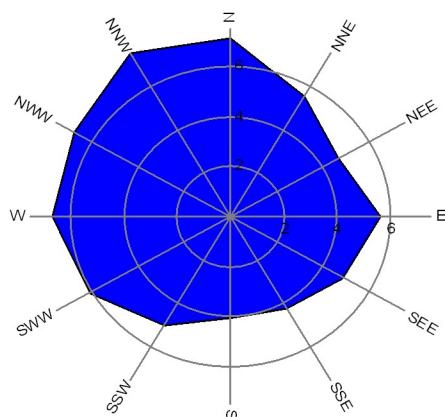
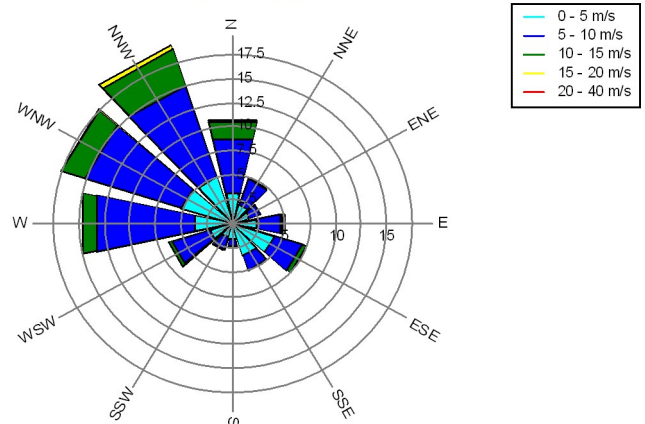
PARK - Wind Data Analysis**Calculation:** Park Calculation, Long Term Data, FL 1500 **Wind data:** A - SDO for WAsP NCCI GenPC; Hub height: 65.0**Site Coordinates**UTM NAD 83 Zone: 19 East: 257,978 North: 4,720,007
FL 1500**Wind data**

Wind statistics

	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50

Weibull Data**Current site**

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	8.00	7.09	2.311	10.9
1 NNE	6.25	5.56	2.635	5.0
2 ENE	5.30	4.69	2.170	2.9
3 E	6.37	5.64	2.096	5.1
4 ESE	5.48	4.87	1.838	7.5
5 SSE	4.78	4.23	2.088	5.1
6 S	4.54	4.02	2.361	2.3
7 SSW	5.63	4.99	2.240	2.8
8 WSW	6.85	6.09	2.674	6.6
9 W	7.48	6.68	3.010	14.9
10 WNW	7.63	6.77	2.439	17.6
11 NNW	8.45	7.48	2.279	19.4
All	7.14	6.32	2.186	100.0

Weibull Distribution**Energy Rose (kWh/m²/year)****Mean wind speed (m/s)****Frequency (%)**

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PARK - Park power curve**Calculation:** Park Calculation, Long Term Data, FL 1500

Power															
Wind speed	Free WTGs	Park WTGs	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	
[m/s]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3.5	17	17	17	17	17	17	17	17	17	17	17	17	17	17	
4.5	76	76	76	76	76	76	76	76	76	76	76	76	76	76	
5.5	172	173	173	173	173	173	173	173	173	173	173	173	173	173	
6.5	302	303	303	303	303	303	303	303	303	303	303	303	303	303	
7.5	480	480	480	480	480	480	480	480	480	480	480	480	480	480	
8.5	709	710	710	710	710	710	710	710	710	710	710	710	710	710	
9.5	984	986	986	986	986	986	986	986	986	986	986	986	986	986	
10.5	1,289	1,292	1,292	1,292	1,292	1,292	1,292	1,292	1,292	1,292	1,292	1,292	1,292	1,292	
11.5	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	
12.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
13.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
14.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
15.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
16.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
17.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
18.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
19.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
20.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
21.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
22.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
23.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
24.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
25.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
26.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
27.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
28.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Description:

The park power curve is similar to a WTG power curve, meaning that when a given wind speed appears in front of the park with same speed in the entire wind farm area (before influence from the park), the output from the park can be found in the park power curve. Another way to say this: The park power curve includes array losses, but do NOT include terrain given variations in the wind speed over the park area.

Measuring a park power curve is not as simple as measuring a WTG power curve due to the fact that the park power curve depends on the wind direction and that the same wind speed normally will not appear for the entire park area at the same time (only in very flat non-complex terrain). The idea with this version of the park power curve is not to use it for validation based on measurements. This would require at least 2 measurement masts at two sides of the park, unless only a few direction sectors should be tested, AND non complex terrain (normally only useable off shore). Another park power curve version for complex terrain is available in WindPRO.

The park power curve can be used for:

1. Forecast systems, based on more rough (approximated) wind data, the park power curve would be an efficient way to make the connection from wind speed (and direction) to power.
2. Construction of duration curves, telling how often a given power output will appear, the park power curve can be used together with the average wind distribution for the Wind farm area in hub height. The average wind distribution can eventually be obtained based on the Weibull parameters for each WTG position. These are found at print menu: >Result to file< in the >Park result< which can be saved to file or copied to clipboard and pasted in Excel.
3. Calculation of wind energy index based on the PARK production (see below).
4. Estimation of the expected PARK production for an existing wind farm based on wind measurements at minimum 2 measurement masts at two sides of wind farm. The masts must be used for obtaining the free wind speed. The free wind speed is used in the simulation of expected energy production with the PARK power curve. This procedure will only work suitable in non complex terrains. For complex terrain another park power curve calculation is available in WindPRO (PPV-model).

Note:

From the >Result to file< the >Wind Speeds Inside Wind farm< is also available. These can (e.g. via Excel) be used for extracting the wake induced reductions in measured wind speed.

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PARK - RIX calculation**Calculation:** Park Calculation, Long Term Data, FL 1500**Assumptions**

Radius for calculation 3,500 m
 Directional step 5 °
 Steepness threshold 40.0 % / 22 °
 Directional weight Frequency distributed
 Height contours used HCLs

Reference sites**Terrain UTM NAD83 Zone: 19**

East	North	Z [m]	Name of wind distribution	Type	Reference site RIX [%]
A 258,821	4,718,465	369.6	SDO for WAsP NCCI GenPC	WAsP (WAsP 10 for Windows RVEA0151 1, 6, 0, 0)	0.2

WTG sites**UTM NAD83 Zone: 19**

Terrain	East	North	Z [m]	Reference site RIX [%]	WTG RIX [%]	Delta RIX (WTG site - Reference site) [%]
1 A	UTM NAD83 Zone: 19 257,978	4,720,007	367.1	0.2	0.1	-0.1

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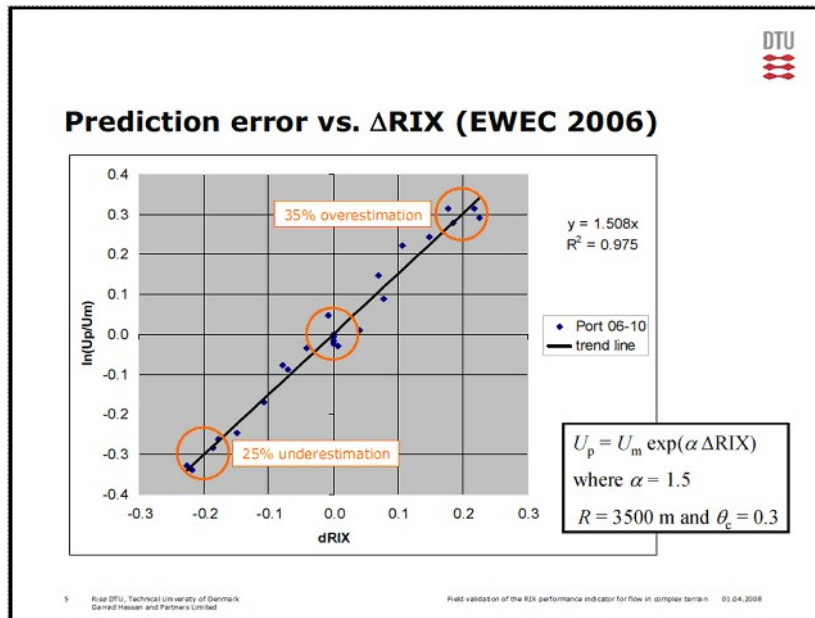
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PARK - RIX calculation**Calculation:** Park Calculation, Long Term Data, FL 1500

Latest research /Risø/ show that the threshold in RIX calculation typically work best with 40% (new default), and that delta Rix within +/- 5% should not give corrections. Cross predictions based on more mast can fine tune the threshold, see Cross predictor tool in WindPRO Meteo Analyzer. In WindPRO LOSS&&UNCERTAINTY module, RIX correction can be calculated automatically as a bias based on most recent recommended correction formulas, which can be found in EWEC2006 && 08 papers on Rix from Risø, see extract below:

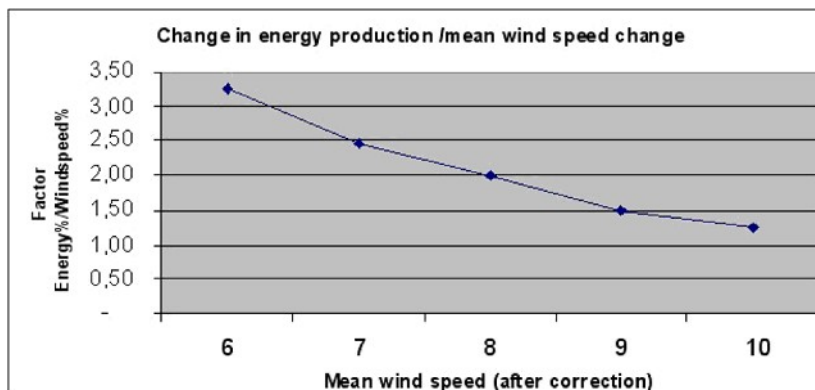


The main conclusion based on use of the RIX method is that if both reference site (measurement mast) and predicted site (WTG) are equally rugged (Delta RIX < 5%), very small calculation errors are expected.

If reference site (measurement mast) is very rugged, e.g. RIX = 0.2 and predicted site (WTG) are less rugged (e.g. RIX = 0), Delta RIX will be -0.2 and according to the graph, 30% too low wind speed prediction at WTG site could be expected. This could lead to around 60%*) too low calculated energy production.

If the reference site is less rugged, e.g. RIX = 0, and the predicted site (WTG) are very rugged (e.g. RIX = 0.2), Delta RIX will be +0.2, and according to the graph, 30% too high wind speed prediction at WTG site could be expected. This could lead to around 60%*) too high calculated energy production.

*) Doubling of energy prediction error based on mean wind speed error is a rough conversion, which holds for wind speeds around 8 m/s. At 6-7 m/s tripling is more right, while only 1.5 factors should be used for 9 m/s, see graph below based on a typical WTG.



Source: EWEC06 paper:

IMPROVING WASP PREDICTIONS IN (TOO) COMPLEX TERRAIN

Niels G. Møller, Anthony J. Bowen and Ioannis Antoniou

WindPRO is developed by EMD International A/S, Niels Jernesvej 10, DK-9220 Aalborg Ø, Tlf. +45 96 35 44 44, Fax +45 96 35 44 46, e-mail: windpro@emd.dk
Wind Energy Department, Risø National Laboratory

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PARK - Time varying AEP**Calculation:** Park Calculation, Long Term Data, FL 1500

Windfarm: 1.5 MW based on 1 turbines of type FUHLRLÄNDER FL 1500-77 1500 77.0 !-!

Calculated mean yield per month and hour [MWh]. The result includes wake losses but no other losses.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%

Hour/Month [MWh]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	16	18	20	14	12	13	8	8	12	13	16	11	159
1	16	18	21	15	11	13	8	9	11	12	15	13	161
2	14	18	21	14	12	12	8	8	9	12	16	13	157
3	15	19	21	14	12	10	8	9	9	14	16	12	159
4	16	19	21	12	13	10	8	8	10	14	13	11	154
5	16	20	20	12	10	9	7	8	10	12	14	10	150
6	19	20	19	11	8	7	6	6	9	11	16	11	144
7	19	20	18	13	9	7	5	6	8	9	15	11	139
8	15	21	19	12	9	6	5	6	7	8	14	12	137
9	16	23	19	15	9	8	6	6	9	8	15	12	147
10	17	24	21	17	10	8	9	6	7	11	15	13	156
11	18	25	22	17	9	9	9	6	8	10	15	14	160
12	17	26	24	17	11	10	9	7	8	11	14	14	167
13	15	24	23	18	11	9	9	7	9	12	13	16	166
14	15	24	24	17	12	10	8	7	8	13	11	16	164
15	13	22	25	17	14	10	8	7	8	11	10	13	159
16	12	21	24	16	12	10	7	7	6	11	9	12	148
17	12	17	22	16	10	9	6	6	6	12	9	12	137
18	15	16	21	15	8	7	5	5	8	12	11	12	135
19	16	19	24	14	10	7	6	7	10	14	11	12	149
20	16	19	21	14	10	9	6	7	11	14	13	12	152
21	16	17	21	14	12	10	7	7	10	14	13	11	153
22	16	18	20	15	12	11	8	8	10	13	14	11	156
23	14	18	19	15	11	13	8	9	12	13	13	11	155
Grand Total	373	488	508	353	257	226	175	171	216	283	322	294	3,666

Hour/Month [MW]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	0.5	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.4	0.4	0.5	0.4	0.4
1	0.5	0.6	0.7	0.5	0.4	0.4	0.3	0.3	0.4	0.4	0.5	0.4	0.4
2	0.5	0.7	0.7	0.5	0.4	0.4	0.3	0.3	0.3	0.4	0.5	0.4	0.4
3	0.5	0.7	0.7	0.5	0.4	0.3	0.3	0.3	0.3	0.4	0.5	0.4	0.4
4	0.5	0.7	0.7	0.4	0.4	0.3	0.3	0.3	0.3	0.5	0.4	0.3	0.4
5	0.5	0.7	0.6	0.4	0.3	0.3	0.2	0.3	0.3	0.4	0.5	0.3	0.4
6	0.6	0.7	0.6	0.4	0.3	0.2	0.2	0.2	0.3	0.4	0.5	0.4	0.4
7	0.6	0.7	0.6	0.4	0.3	0.2	0.2	0.2	0.3	0.3	0.5	0.4	0.4
8	0.5	0.8	0.6	0.4	0.3	0.2	0.2	0.2	0.2	0.3	0.5	0.4	0.4
9	0.5	0.8	0.6	0.5	0.3	0.3	0.2	0.2	0.3	0.3	0.5	0.4	0.4
10	0.5	0.9	0.7	0.6	0.3	0.3	0.3	0.2	0.2	0.3	0.5	0.4	0.4
11	0.6	0.9	0.7	0.6	0.3	0.3	0.3	0.2	0.3	0.3	0.5	0.4	0.4
12	0.5	0.9	0.8	0.6	0.4	0.3	0.3	0.2	0.3	0.4	0.5	0.5	0.5
13	0.5	0.9	0.7	0.6	0.4	0.3	0.3	0.2	0.3	0.4	0.4	0.5	0.5
14	0.5	0.9	0.8	0.6	0.4	0.3	0.3	0.2	0.3	0.4	0.4	0.5	0.4
15	0.4	0.8	0.8	0.6	0.4	0.3	0.3	0.2	0.3	0.4	0.3	0.4	0.4
16	0.4	0.8	0.8	0.5	0.4	0.3	0.2	0.2	0.2	0.3	0.3	0.4	0.4
17	0.4	0.6	0.7	0.5	0.3	0.3	0.2	0.2	0.2	0.4	0.3	0.4	0.4
18	0.5	0.6	0.7	0.5	0.3	0.2	0.2	0.2	0.3	0.4	0.4	0.4	0.4
19	0.5	0.7	0.8	0.5	0.3	0.2	0.2	0.2	0.3	0.4	0.4	0.4	0.4
20	0.5	0.7	0.7	0.5	0.3	0.3	0.2	0.2	0.4	0.5	0.4	0.4	0.4
21	0.5	0.6	0.7	0.5	0.4	0.3	0.2	0.2	0.3	0.5	0.4	0.4	0.4
22	0.5	0.7	0.6	0.5	0.4	0.4	0.2	0.3	0.3	0.4	0.5	0.4	0.4
23	0.5	0.6	0.6	0.5	0.4	0.4	0.2	0.3	0.4	0.4	0.4	0.4	0.4
Grand Total	0.5	0.7	0.7	0.5	0.3	0.3	0.2	0.2	0.3	0.4	0.4	0.4	0.4

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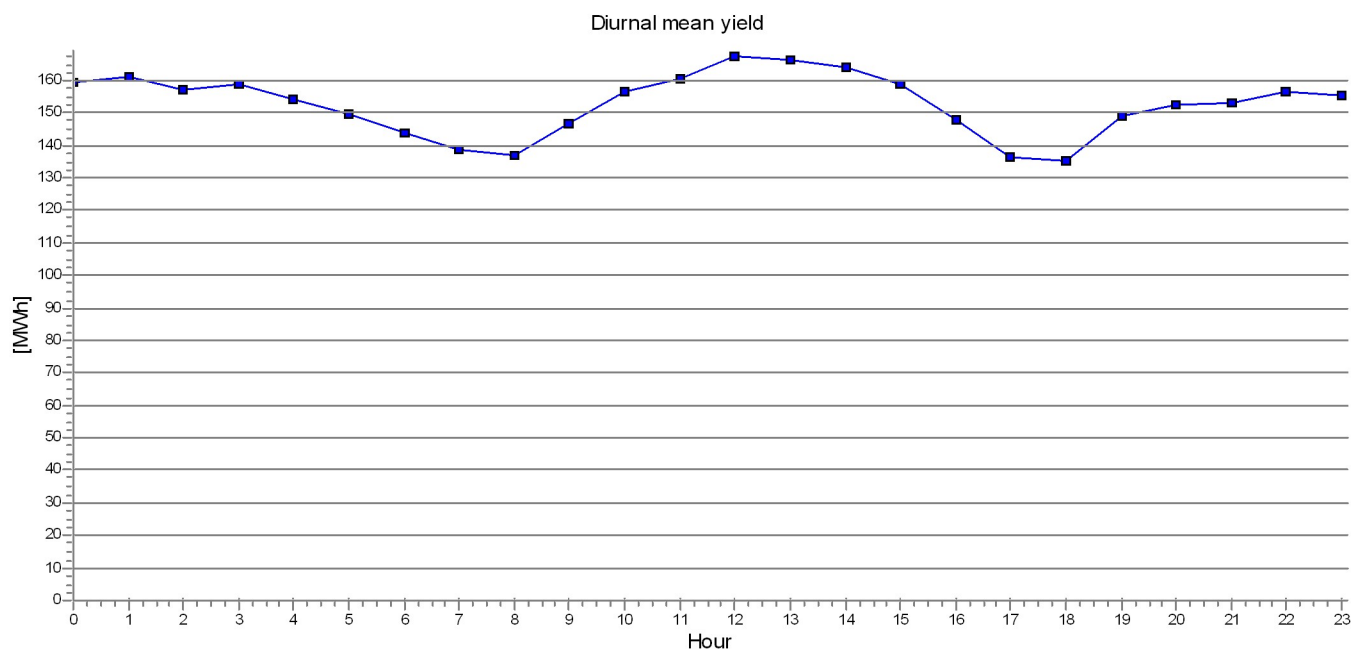
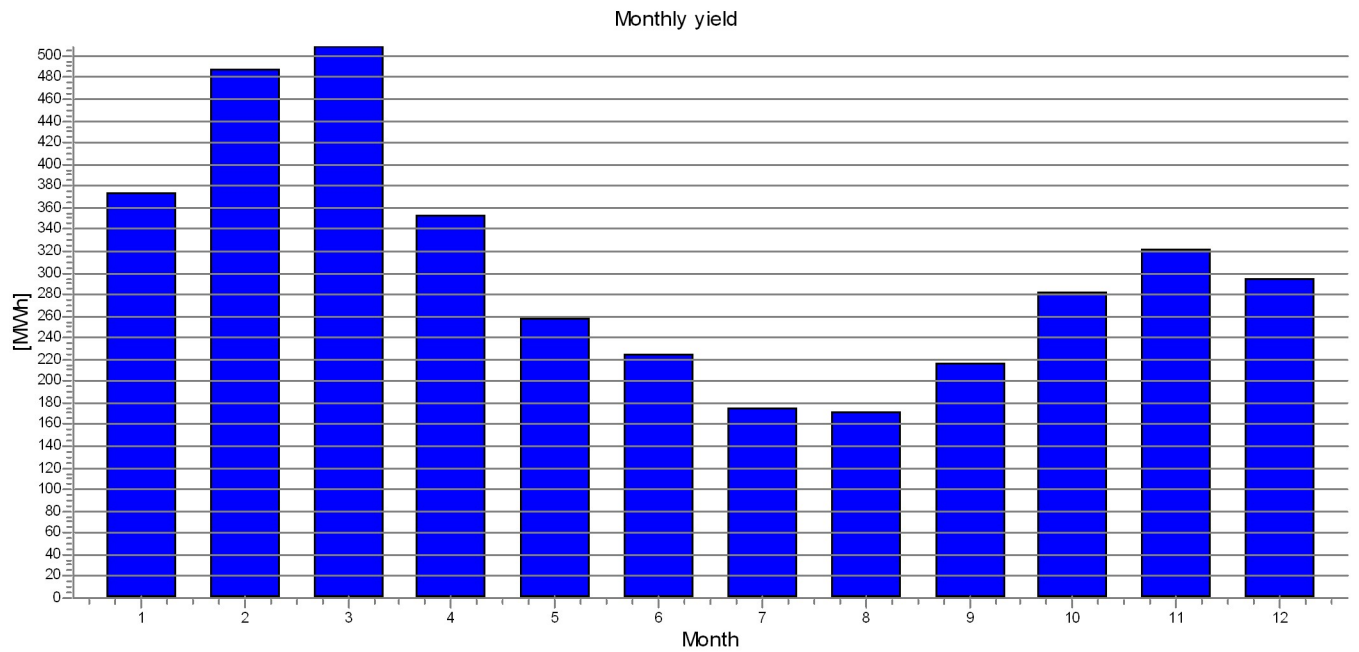
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PARK - Time varying AEP**Calculation:** Park Calculation, Long Term Data, FL 1500

Windfarm: 1.5 MW based on 1 turbines of type FUHLÄNDER FL 1500-77 1500 77.0 !-!

Calculated mean yield per month and hour [MWh]. The result includes wake losses but no other losses.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%



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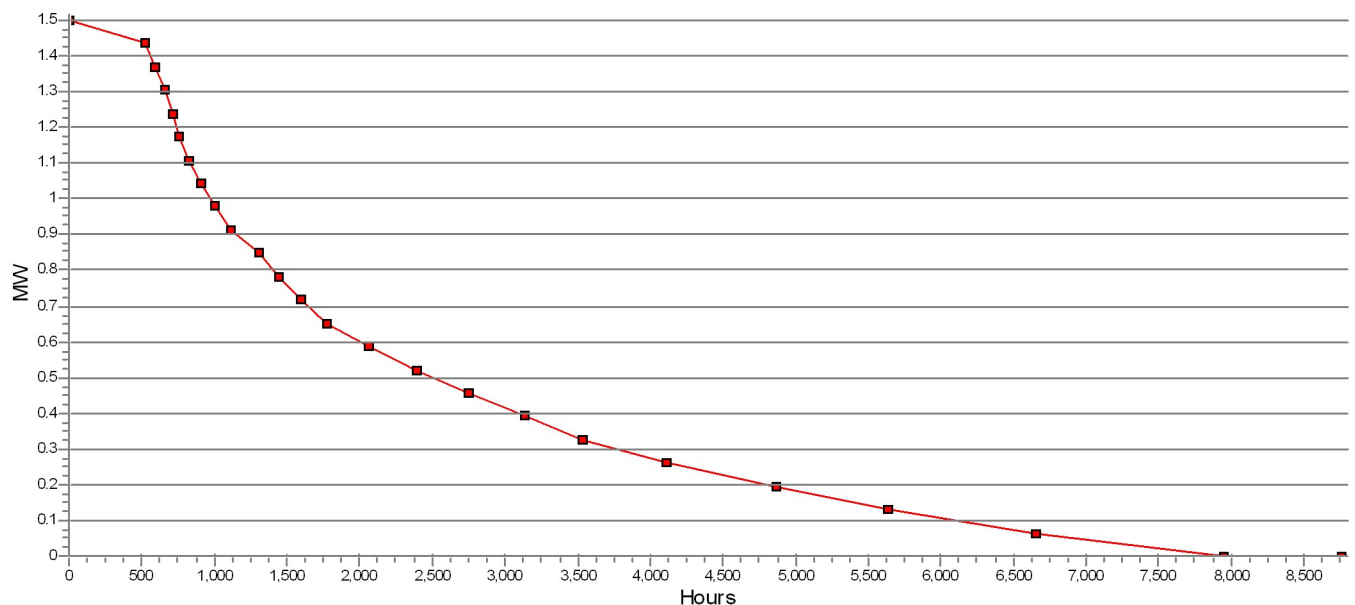
PARK - Time varying AEP**Calculation:** Park Calculation, Long Term Data, FL 1500

Windfarm: 1.5 MW based on 1 turbines of type FUHLÄNDER FL 1500-77 1500 77.0 !-!

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%

Hours	Hours [%]	Hours accumulated	Rated power [MW]	Rated power (MW/WTG)
0	0.0	0	1.5	1.5
529	6.0	529	1.4 - 1.5	1.4 - 1.5
61	0.7	590	1.4 - 1.4	1.4 - 1.4
63	0.7	654	1.3 - 1.4	1.3 - 1.4
63	0.7	716	1.2 - 1.3	1.2 - 1.3
37	0.4	753	1.2 - 1.2	1.2 - 1.2
74	0.8	827	1.1 - 1.2	1.1 - 1.2
87	1.0	914	1.0 - 1.1	1.0 - 1.1
95	1.1	1009	1.0 - 1.0	1.0 - 1.0
107	1.2	1116	0.9 - 1.0	0.9 - 1.0
192	2.2	1308	0.8 - 0.9	0.8 - 0.9
138	1.6	1445	0.8 - 0.8	0.8 - 0.8
153	1.7	1598	0.7 - 0.8	0.7 - 0.8
174	2.0	1772	0.7 - 0.7	0.7 - 0.7
294	3.4	2066	0.6 - 0.7	0.6 - 0.7
323	3.7	2389	0.5 - 0.6	0.5 - 0.6
357	4.1	2746	0.5 - 0.5	0.5 - 0.5
389	4.4	3135	0.4 - 0.5	0.4 - 0.5
405	4.6	3540	0.3 - 0.4	0.3 - 0.4
569	6.5	4109	0.3 - 0.3	0.3 - 0.3
754	8.6	4863	0.2 - 0.3	0.2 - 0.3
773	8.8	5635	0.1 - 0.2	0.1 - 0.2
1017	11.6	6652	0.1 - 0.1	0.1 - 0.1
1297	14.8	7949	0.0 - 0.1	0.0 - 0.1
811	9.3	8760	0.0	0.0

Duration curve 1.5 MW WindFarm



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PARK - Main Result**Calculation:** 80m Park Calculation, Long Term Data, GE1.5**Wake Model**

N.O. Jensen (RISØ/EMD)

Calculation Settings

Air density calculation mode Individual per WTG
 Result for WTG at hub altitude 1.195 kg/m³
 Air density relative to standard 97.5 %
 Hub altitude above sea level (asl) 447.1 m
 Annual mean temperature at hub alt. 6.4 °C
 Pressure at WTGs 958.8 hPa

Wake Model Parameters

From angle	To angle	Terrain type	Wake Decay Constant
[°]	[°]		
-180.0	180.0	Very closed farmland	0.100

Wake calculation settings

Angle [°]			Wind speed [m/s]		
start	end	step	start	end	step
0.5	360.0	1.0	0.5	30.5	1.0

Wind data

Wind statistics	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50



Scale 1:40,000

New WTG

Site Data

WASP version WASP 10 for Windows RVEA0151 1, 6, 0, 0**Key results for height 80.0 m above ground level****Terrain** UTM NAD83 Zone: 19

East	North	Name of wind distribution	Type	Wind energy [kWh/m²]	Mean wind speed [m/s]	Equivalent roughness
A 258,821	4,718,465	SDO for WASP NCCI GenPC	WASP (WASP 10 for Windows RVEA0151 1, 6, 0, 0)	3,793	7.7	2.1

Calculated Annual Energy for Wind Farm

WTG combination	Result PARK [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Specific results ^{a)}			Mean wind speed @ hub height [m/s]
				Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	
Wind farm	4,375.2	4,375.2	100.0	33.3	4,375.2	2,917	6.8

^{a)} Based on wake reduced results, but no other losses included**Calculated Annual Energy for each of 1 new WTGs with total 1.5 MW rated power**

WTG type			Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Displacement height [m]	Power curve Creator Name	Annual Energy Result [MWh]	Park Efficiency [%]	Capacity factor [%]	Mean wind speed [m/s]
Terrain	Valid	Manufact.										
1 A	Yes	GE WIND ENERGY	GE 1.5sle-1,500	1,500	77.0	80.0	23.0	EMD Level 0 - Calculated - 10%<Ti<15% - 2006	4,375.2	100.0	33.3	6.82

Annual Energy results do not include any losses apart from wake losses. For expected NET AEP (expected sold production), see report Loss & Uncertainty.

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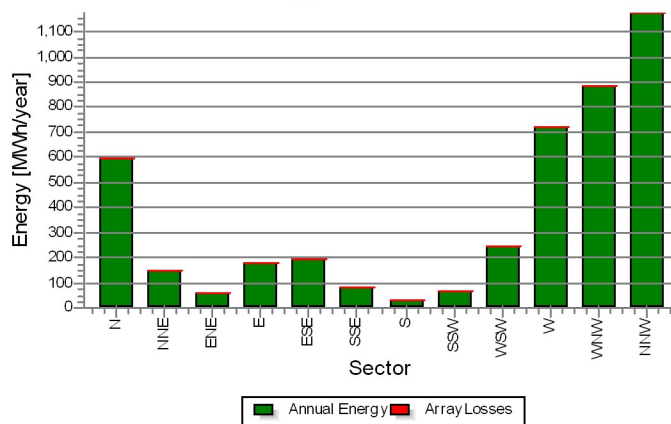
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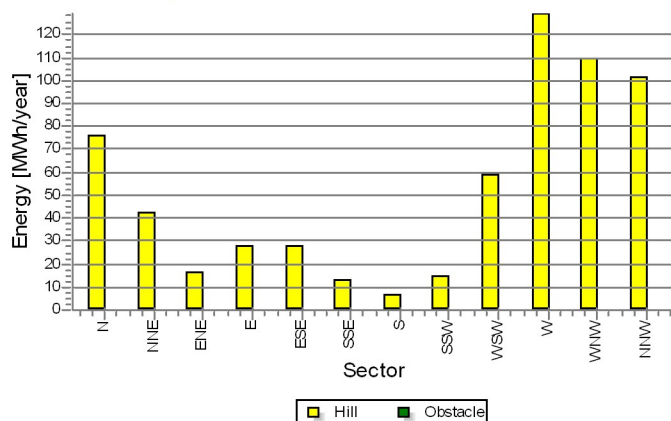
PARK - Production Analysis**Calculation:** 80m Park Calculation, Long Term Data, GE1.5WTG: All WTGs, Air density 1.195 kg/m³**Directional Analysis**

Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	520.2	105.4	43.4	148.4	163.8	66.2	20.2	52.3	190.1	589.7	777.5	1,073.4	3,750.6
+Increase due to hills	[MWh]	75.9	42.5	16.6	27.9	27.8	13.2	6.2	15.1	58.8	129.3	110.0	101.6	624.7
Resulting energy	[MWh]	596.0	147.8	59.9	176.3	191.6	79.4	26.5	67.3	248.9	718.9	887.5	1,175.0	4,375.2
Specific energy	[kWh/m ²]													940
Specific energy	[kWh/kW]													2,917
Increase due to hills	[%]	14.6	40.3	38.2	18.8	17.0	19.9	30.8	28.8	30.9	21.9	14.1	9.5	16.66
Utilization	[%]	31.0	39.9	39.0	35.9	36.2	38.5	37.5	39.1	38.9	38.5	34.1	28.5	33.3
Operational	[Hours/year]	843	383	226	395	590	395	177	219	505	1,163	1,376	1,514	7,785
Full Load Equivalent	[Hours/year]	397	99	40	118	128	53	18	45	166	479	592	783	2,917

Energy vs. sector



Impact of hills and obstacles vs. sector



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PARK - Power Curve Analysis**Calculation:** 80m Park Calculation, Long Term Data, GE1.5WTG: 1 - GE WIND ENERGY GE 1.5sle 1500 77.0 !O! Level 0 - Calculated - 10%<TI<15% - 2006, Hub height: 80.0 m**Name:** Level 0 - Calculated - 10%<TI<15% - 2006**Source:** Manufacturer

Source/Date Created by Created Edited Stop wind speed Power control CT curve type

12/31/2006 EMD 11/21/2000 1/10/2007 [m/s] 25.0 Pitch User defined

Based on GE document 1.5sl_sle_PCD_allComp_XXXXXXX.ENxx.03.pdf. Special adapted power curves for air densities 1.02-1.20 kg/m³ available from manufacturer. When using this PC, WindPRO's standard algorithm for air density adaptation will be used.**HP curve comparison** - Note: For standard air density and weibull k parameter = 2

Vmean	[m/s]	5	6	7	8	9	10
HP value	[MWh]	2,126	3,366	4,628	5,833	6,826	7,716
GE WIND ENERGY GE 1.5sle 1500 77.0 !O! Level 0 - Calculated - 10%<TI<15% - 2006	[MWh]	2,230	3,492	4,738	5,867	6,837	7,627
Check value	[%]	-5	-4	-2	-1	0	1

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m²) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.

For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see WindPRO manual chapter 3.5.2.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curveOriginal data from Windcat, Air density: 1.225 kg/m³

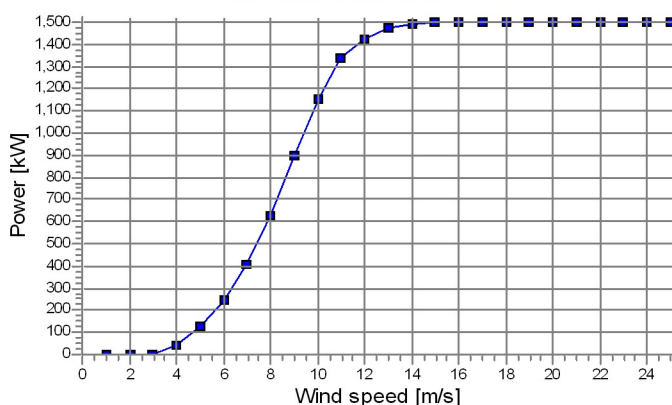
Wind speed [m/s]	Power [kW]	Ce	Ct curve
3.0	0.0	0.00	1.27
3.5	20.0	0.16	4.0
4.0	43.0	0.24	5.0
4.5	85.0	0.32	6.0
5.0	131.0	0.37	7.0
5.5	185.0	0.39	8.0
6.0	250.0	0.41	9.0
6.5	326.0	0.42	10.0
7.0	416.0	0.43	11.0
7.5	521.0	0.43	12.0
8.0	640.0	0.44	13.0
8.5	785.0	0.45	14.0
9.0	924.0	0.44	15.0
9.5	1062.0	0.43	16.0
10.0	1181.0	0.41	17.0
10.5	1283.0	0.39	18.0
11.0	1359.0	0.36	19.0
11.5	1402.0	0.32	20.0
12.0	1438.0	0.29	21.0
12.5	1463.0	0.26	22.0
13.0	1481.0	0.24	23.0
13.5	1488.0	0.21	24.0
14.0	1494.0	0.19	25.0
14.5	1500.0	0.17	
15.0	1500.0	0.16	
15.5	1500.0	0.14	
16.0	1500.0	0.13	
16.5	1500.0	0.12	
17.0	1500.0	0.11	
17.5	1500.0	0.10	
18.0	1500.0	0.09	
18.5	1500.0	0.08	
19.0	1500.0	0.08	
19.5	1500.0	0.07	
20.0	1500.0	0.07	
20.5	1500.0	0.06	
21.0	1500.0	0.06	
21.5	1500.0	0.05	
22.0	1500.0	0.05	
22.5	1500.0	0.05	
23.0	1500.0	0.04	
23.5	1500.0	0.04	
24.0	1500.0	0.04	
24.5	1500.0	0.04	
25.0	1500.0	0.03	

Power, Efficiency and energy vs. wind speed

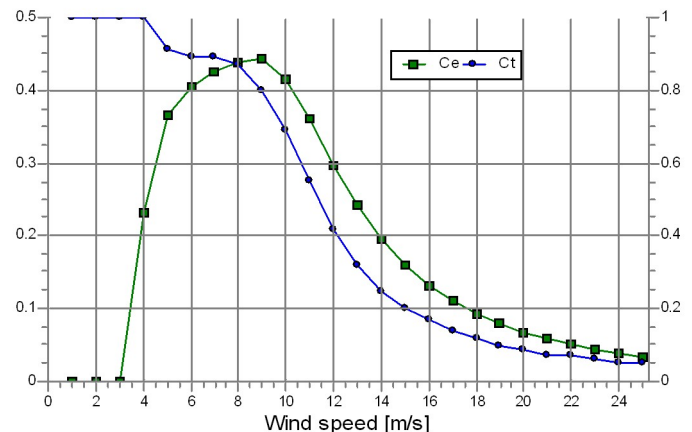
Data used in calculation, Air density: 1.195 kg/m³ New WindPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Ce	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1.0	0.0	0.00	0.50-1.50	0.0	0.0	0.0
2.0	0.0	0.00	1.50-2.50	0.0	0.0	0.0
3.0	0.0	0.00	2.50-3.50	7.5	7.5	0.2
4.0	41.4	0.23	3.50-4.50	46.7	54.2	1.2
5.0	126.9	0.36	4.50-5.50	136.1	190.4	4.4
6.0	243.3	0.40	5.50-6.50	268.3	458.6	10.5
7.0	405.1	0.42	6.50-7.50	423.8	882.4	20.2
8.0	623.4	0.44	7.50-8.50	576.0	1458.4	33.3
9.0	900.5	0.44	8.50-9.50	670.3	2128.7	48.7
10.0	1155.1	0.42	9.50-10.50	656.2	2784.9	63.7
11.0	1337.2	0.36	10.50-11.50	544.5	3329.4	76.1
12.0	1423.8	0.30	11.50-12.50	395.6	3725.0	85.1
13.0	1473.7	0.24	12.50-13.50	263.1	3988.1	91.2
14.0	1491.4	0.20	13.50-14.50	165.1	4153.3	94.9
15.0	1500.0	0.16	14.50-15.50	99.2	4252.4	97.2
16.0	1500.0	0.13	15.50-16.50	57.3	4309.8	98.5
17.0	1500.0	0.11	16.50-17.50	31.9	4341.7	99.2
18.0	1500.0	0.09	17.50-18.50	17.1	4358.8	99.6
19.0	1500.0	0.08	18.50-19.50	8.7	4367.5	99.8
20.0	1500.0	0.07	19.50-20.50	4.3	4371.8	99.9
21.0	1500.0	0.06	20.50-21.50	2.0	4373.8	100.0
22.0	1500.0	0.05	21.50-22.50	0.9	4374.7	100.0
23.0	1500.0	0.04	22.50-23.50	0.4	4375.0	100.0
24.0	1500.0	0.04	23.50-24.50	0.1	4375.2	100.0
25.0	1500.0	0.03	24.50-25.50	0.0	4375.2	100.0

Power curve
Data used in calculation



Ce and Ct curve



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PARK - Terrain

Calculation: 80m Park Calculation, Long Term Data, GE1.5 **Site Data:** A - SDO for WASP NCCI GenPC

Obstacles:

0 Obstacles used

Roughness:

Calculation uses following MAP files:

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Min X: 248,696, Max X: 275,482, Min Y: 4,709,243, Max Y: 4,734,513, Width: 26,785 m, Height: 25,270 m

Limited by a square on 40.0 km x 40.0 km around the current site

Orography:

Calculation uses following MAP files:

C:\Documents and Settings\leee.DOMAIN\My Documents\WindPRO\WindPRO Data\Projects\Gardner Feasibility Study\Height Contour Lines 6 thinned.wpo

Min X: 250,349, Max X: 266,009, Min Y: 4,710,727, Max Y: 4,727,946, Width: 15,659 m, Height: 17,218 m

Limited by a square on 10.0 km x 10.0 km around the current site

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PARK - Wind Data Analysis**Calculation:** 80m Park Calculation, Long Term Data, GE1.5**Wind data:** A - SDO for WASP NCCI GenPC; Hub height: 80.0**Site Coordinates**

UTM NAD 83 Zone: 19 East: 258,821 North: 4,718,465

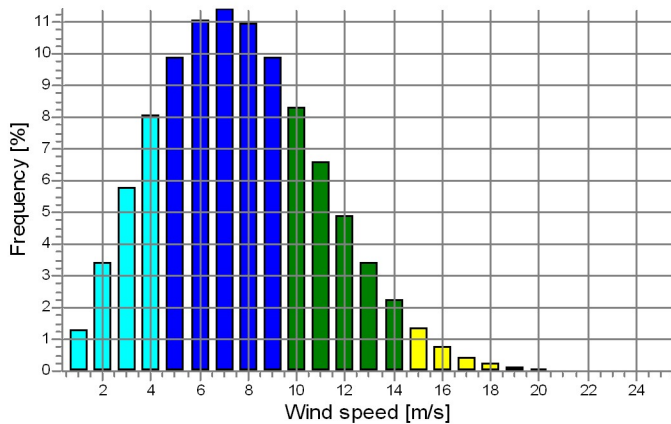
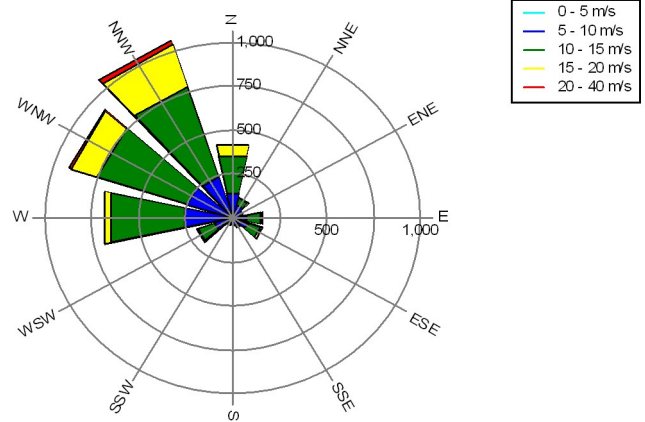
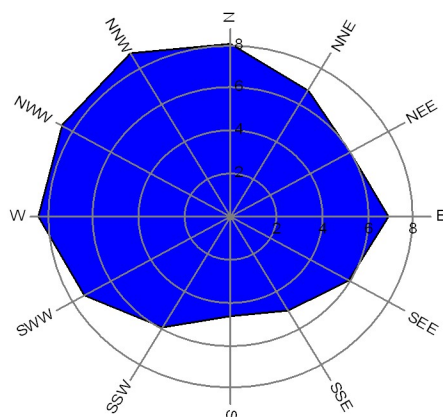
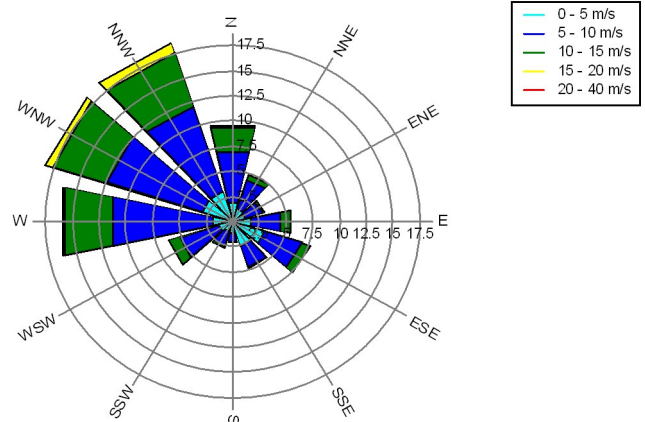
Wind data

Wind statistics

	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50

Weibull Data**Current site**

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	9.06	8.05	2.557	9.7
1 NNE	7.59	6.76	2.846	5.0
2 ENE	6.80	6.03	2.498	3.1
3 E	7.78	6.90	2.295	5.6
4 ESE	6.77	6.00	2.037	7.6
5 SSE	5.74	5.09	2.299	4.9
6 S	5.23	4.65	2.654	2.0
7 SSW	6.68	5.93	2.467	2.7
8 WSW	8.31	7.41	2.912	6.3
9 W	9.36	8.40	3.295	16.1
10 WNW	9.55	8.49	2.689	18.4
11 NNW	9.86	8.75	2.514	18.6
All	8.64	7.66	2.424	100.0

Weibull Distribution**Energy Rose (kWh/m²/year)****Mean wind speed (m/s)****Frequency (%)**

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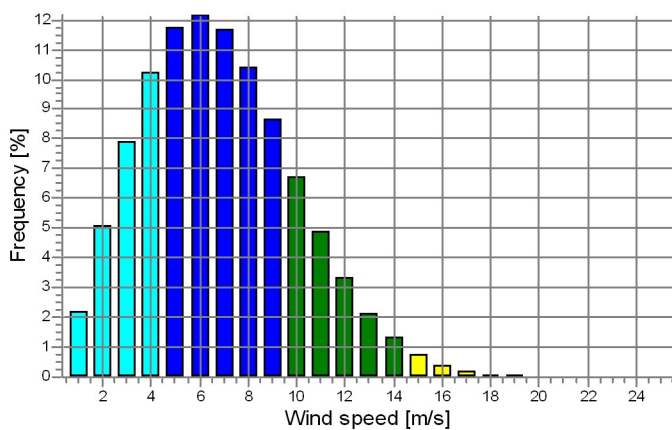
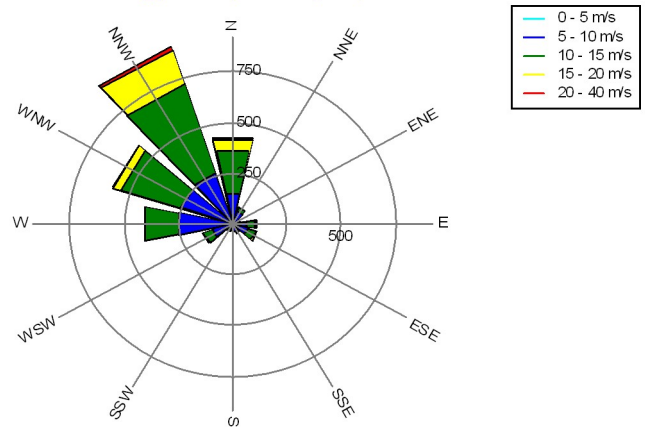
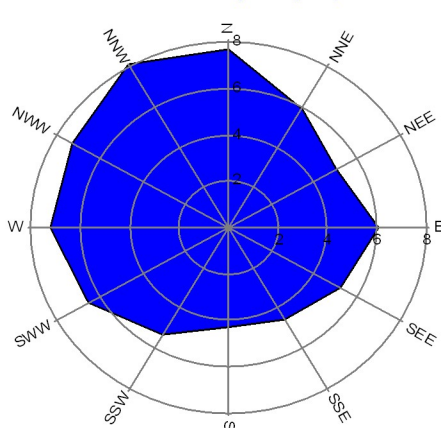
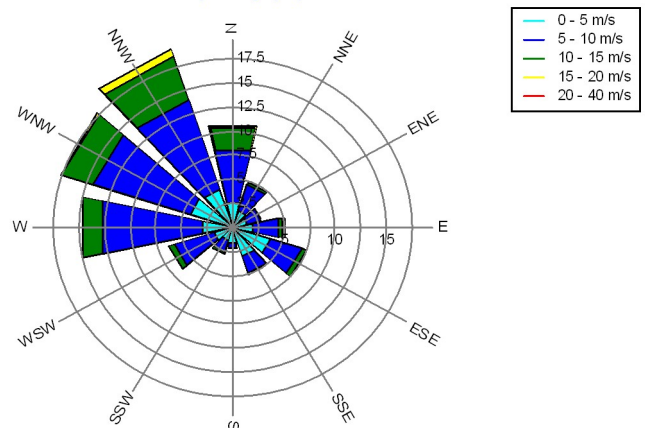
PARK - Wind Data Analysis**Calculation:** 80m Park Calculation, Long Term Data, GE1.5 **Wind data:** A - SDO for WASP NCCI GenPC; Hub height: 80.0**Site Coordinates**UTM NAD 83 Zone: 19 East: 257,978 North: 4,720,007
Gardner WTG GE1.5**Wind data**

Wind statistics

	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50

Weibull Data**Current site**

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	8.65	7.67	2.416	10.8
1 NNE	6.67	5.94	2.756	4.9
2 ENE	5.69	5.04	2.271	2.9
3 E	6.88	6.10	2.189	5.1
4 ESE	5.91	5.24	1.920	7.6
5 SSE	5.15	4.56	2.182	5.1
6 S	4.86	4.31	2.475	2.3
7 SSW	6.02	5.33	2.342	2.8
8 WSW	7.32	6.51	2.787	6.5
9 W	8.06	7.21	3.150	14.9
10 WNW	8.22	7.30	2.549	17.7
11 NNW	9.14	8.10	2.381	19.5
All	7.70	6.82	2.268	100.0

Weibull Distribution**Energy Rose (kWh/m²/year)****Mean wind speed (m/s)****Frequency (%)**

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1/5/2011 1:53 PM/2.7.468

PARK - Park power curve**Calculation:** 80m Park Calculation, Long Term Data, GE1.5

Power															
Wind speed	Free WTGs	Park WTGs	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	
[m/s]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
4.5	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
5.5	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
6.5	317	317	317	317	317	317	317	317	317	317	317	317	317	317	317
7.5	507	507	507	507	507	507	507	507	507	507	507	507	507	507	507
8.5	763	763	763	763	763	763	763	763	763	763	763	763	763	763	763
9.5	1,036	1,036	1,036	1,036	1,036	1,036	1,036	1,036	1,036	1,036	1,036	1,036	1,036	1,036	1,036
10.5	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257
11.5	1,388	1,388	1,388	1,388	1,388	1,388	1,388	1,388	1,388	1,388	1,388	1,388	1,388	1,388	1,388
12.5	1,453	1,453	1,453	1,453	1,453	1,453	1,453	1,453	1,453	1,453	1,453	1,453	1,453	1,453	1,453
13.5	1,485	1,485	1,485	1,485	1,485	1,485	1,485	1,485	1,485	1,485	1,485	1,485	1,485	1,485	1,485
14.5	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497
15.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
16.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
17.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
18.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
19.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
20.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
21.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
22.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
23.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
24.5	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
25.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description:

The park power curve is similar to a WTG power curve, meaning that when a given wind speed appears in front of the park with same speed in the entire wind farm area (before influence from the park), the output from the park can be found in the park power curve. Another way to say this: The park power curve includes array losses, but do NOT include terrain given variations in the wind speed over the park area.

Measuring a park power curve is not as simple as measuring a WTG power curve due to the fact that the park power curve depends on the wind direction and that the same wind speed normally will not appear for the entire park area at the same time (only in very flat non-complex terrain). The idea with this version of the park power curve is not to use it for validation based on measurements. This would require at least 2 measurement masts at two sides of the park, unless only a few direction sectors should be tested, AND non complex terrain (normally only useable off shore). Another park power curve version for complex terrain is available in WindPRO.

The park power curve can be used for:

1. Forecast systems, based on more rough (approximated) wind data, the park power curve would be an efficient way to make the connection from wind speed (and direction) to power.
2. Construction of duration curves, telling how often a given power output will appear, the park power curve can be used together with the average wind distribution for the Wind farm area in hub height. The average wind distribution can eventually be obtained based on the Weibull parameters for each WTG position. These are found at print menu: >Result to file< in the >Park result< which can be saved to file or copied to clipboard and pasted in Excel.
3. Calculation of wind energy index based on the PARK production (see below).
4. Estimation of the expected PARK production for an existing wind farm based on wind measurements at minimum 2 measurement masts at two sides of wind farm. The masts must be used for obtaining the free wind speed. The free wind speed is used in the simulation of expected energy production with the PARK power curve. This procedure will only work suitable in non complex terrains. For complex terrain another park power curve calculation is available in WindPRO (PPV-model).

Note:

From the >Result to file< the >Wind Speeds Inside Wind farm< is also available. These can (e.g. via Excel) be used for extracting the wake induced reductions in measured wind speed.

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PARK - RIX calculation**Calculation:** 80m Park Calculation, Long Term Data, GE1.5**Assumptions**

Radius for calculation	3,500 m
Directional step	5 °
Steepness threshold	40.0 % / 22 °
Directional weight	Frequency distributed
Height contours used	HCLs

Reference sites**Terrain UTM NAD83 Zone: 19**

East	North	Z [m]	Name of wind distribution	Type	Reference site RIX [%]
A 258,821	4,718,465	369.6	SDO for WAsP NCCI GenPC	WAsP (WAsP 10 for Windows RVEA0151 1, 6, 0, 0)	0.2

WTG sites**UTM NAD83 Zone: 19**

Terrain	East	North	Z [m]	Reference site RIX [%]	WTG RIX [%]	Delta RIX (WTG site - Reference site) [%]
1 A	UTM NAD83 Zone: 19 257,978	4,720,007	367.1	0.2	0.1	-0.1

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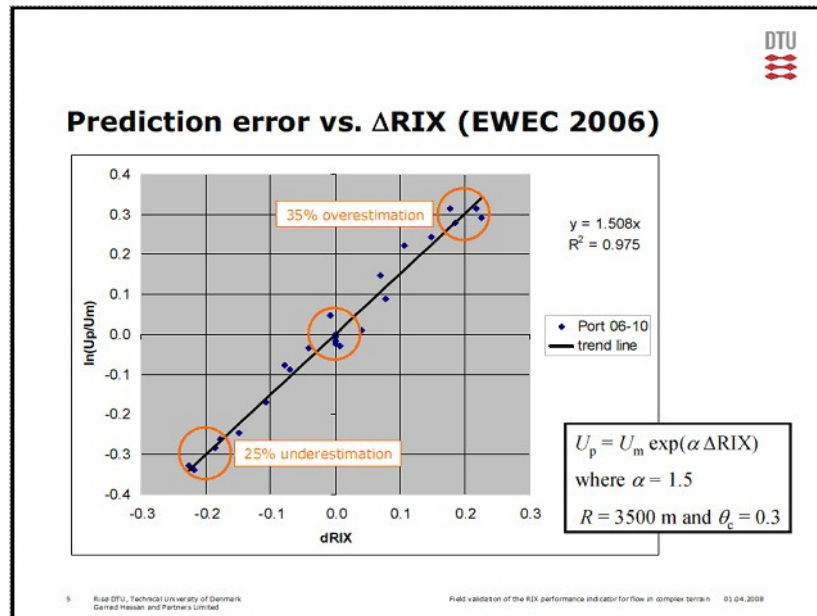
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PARK - RIX calculation

Calculation: 80m Park Calculation, Long Term Data, GE1.5

Latest research /Risø/ show that the threshold in RIX calculation typically work best with 40% (new default), and that delta Rix within +/- 5% should not give corrections. Cross predictions based on more mast can fine tune the threshold, see Cross predictor tool in WindPRO Meteo Analyzer. In WindPRO LOSS&&UNCERTAINTY module, RIX correction can be calculated automatically as a bias based on most recent recommended correction formulas, which can be found in EWEC2006 && 08 papers on Rix from Risø, see extract below:

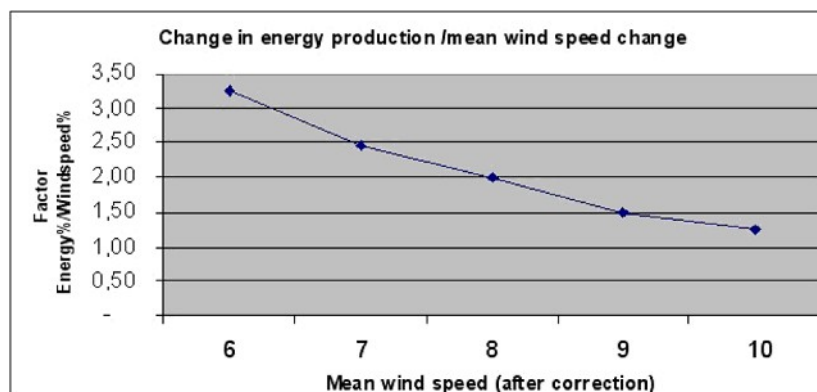


The main conclusion based on use of the RIX method is that if both reference site (measurement mast) and predicted site (WTG) are equally rugged (Delta RIX < 5%), very small calculation errors are expected.

If reference site (measurement mast) is very rugged, e.g. RIX = 0.2 and predicted site (WTG) are less rugged (e.g. RIX = 0), Delta RIX will be -0.2 and according to the graph, 30% too low wind speed prediction at WTG site could be expected. This could lead to around 60%*) too low calculated energy production.

If the reference site is less rugged, e.g. RIX = 0, and the predicted site (WTG) are very rugged (e.g. RIX = 0.2), Delta RIX will be +0.2, and according to the graph, 30% too high wind speed prediction at WTG site could be expected. This could lead to around 60%*) too high calculated energy production.

*) Doubling of energy prediction error based on mean wind speed error is a rough conversion, which holds for wind speeds around 8 m/s. At 6-7 m/s tripling is more right, while only 1.5 factors should be used for 9 m/s, see graph below based on a typical WTG.



Source: EWEC06 paper:

IMPROVING WASP PREDICTIONS IN (TOO) COMPLEX TERRAIN

Niels G. Møller, Anthony J. Bowen and Ioannis Antoniou

WindPRO is developed by EMD International A/S, Niels Jernesvej 10, DK-9220 Ålborg Ø, Tlf. +45 96 35 44 44, Fax +45 96 35 44 46, e-mail: windpro@emd.dk

Wind Energy Department, Risø National Laboratory

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Calculated:

1/5/2011 1:53 PM/2.7.468

PARK - Time varying AEP**Calculation:** 80m Park Calculation, Long Term Data, GE1.5

Windfarm: 1.5 MW based on 1 turbines of type GE WIND ENERGY GE 1.5sle 1500 77.0 !O!.

Calculated mean yield per month and hour [MWh]. The result includes wake losses but no other losses.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%

Hour/Month [MWh]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	19	20	23	16	15	17	11	11	15	15	18	13	192
1	19	20	24	17	14	17	11	12	14	14	17	15	194
2	17	20	25	16	15	15	10	11	11	15	19	15	190
3	18	21	25	16	15	13	11	11	11	16	19	15	193
4	19	21	24	15	16	13	11	11	13	17	16	13	189
5	19	22	23	15	13	11	9	11	14	15	18	13	184
6	22	22	23	14	10	9	8	8	12	13	19	13	175
7	22	22	21	15	12	9	6	8	10	11	18	13	167
8	19	23	22	15	12	8	7	8	9	10	17	13	164
9	19	24	21	18	12	10	8	8	11	10	17	13	172
10	20	25	23	20	12	10	11	7	9	13	18	14	183
11	21	26	24	19	12	11	11	7	10	12	17	16	187
12	21	27	26	19	13	13	11	9	10	13	16	16	195
13	19	26	25	21	14	12	11	8	11	14	15	17	193
14	18	26	26	19	14	13	11	9	11	16	13	17	191
15	16	24	27	19	16	14	10	9	10	13	12	14	186
16	16	23	27	18	14	13	10	9	8	12	11	14	175
17	15	20	25	18	13	12	8	7	8	14	12	14	164
18	18	18	23	17	11	9	7	6	11	15	13	14	163
19	20	21	26	16	13	9	7	9	13	16	14	14	178
20	19	21	24	16	13	12	9	9	14	17	15	14	182
21	19	19	24	16	15	13	9	9	13	17	15	13	183
22	18	20	23	17	16	14	10	11	13	16	16	13	187
23	17	20	23	17	14	17	10	12	14	16	16	13	188
Grand Total	450	533	577	410	322	294	229	222	276	338	383	341	4,375

Hour/Month [MW]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	0.6	0.7	0.7	0.5	0.5	0.6	0.3	0.4	0.5	0.5	0.6	0.4	0.5
1	0.6	0.7	0.8	0.6	0.5	0.6	0.4	0.4	0.5	0.5	0.6	0.5	0.5
2	0.6	0.7	0.8	0.5	0.5	0.5	0.3	0.4	0.4	0.5	0.6	0.5	0.5
3	0.6	0.8	0.8	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.5	0.5
4	0.6	0.8	0.8	0.5	0.5	0.4	0.3	0.3	0.4	0.5	0.5	0.4	0.5
5	0.6	0.8	0.8	0.5	0.4	0.4	0.3	0.4	0.5	0.5	0.6	0.4	0.5
6	0.7	0.8	0.8	0.5	0.3	0.3	0.3	0.3	0.4	0.4	0.6	0.4	0.5
7	0.7	0.8	0.7	0.5	0.4	0.3	0.2	0.3	0.3	0.3	0.6	0.4	0.5
8	0.6	0.8	0.7	0.5	0.4	0.3	0.2	0.3	0.3	0.3	0.6	0.4	0.4
9	0.6	0.9	0.7	0.6	0.4	0.3	0.3	0.3	0.4	0.3	0.6	0.4	0.5
10	0.7	0.9	0.7	0.7	0.4	0.3	0.4	0.2	0.3	0.4	0.6	0.5	0.5
11	0.7	0.9	0.8	0.6	0.4	0.4	0.4	0.2	0.3	0.4	0.6	0.5	0.5
12	0.7	1.0	0.8	0.6	0.4	0.4	0.4	0.3	0.3	0.4	0.5	0.5	0.5
13	0.6	0.9	0.8	0.7	0.4	0.4	0.4	0.3	0.4	0.4	0.5	0.6	0.5
14	0.6	0.9	0.8	0.6	0.5	0.4	0.3	0.3	0.4	0.5	0.4	0.5	0.5
15	0.5	0.9	0.9	0.6	0.5	0.5	0.3	0.3	0.3	0.4	0.4	0.5	0.5
16	0.5	0.8	0.9	0.6	0.5	0.4	0.3	0.3	0.3	0.4	0.4	0.5	0.5
17	0.5	0.7	0.8	0.6	0.4	0.4	0.3	0.2	0.3	0.4	0.4	0.5	0.5
18	0.6	0.7	0.8	0.6	0.3	0.3	0.2	0.2	0.4	0.5	0.4	0.4	0.4
19	0.7	0.8	0.8	0.5	0.4	0.3	0.2	0.3	0.4	0.5	0.5	0.5	0.5
20	0.6	0.7	0.8	0.5	0.4	0.4	0.3	0.3	0.5	0.5	0.5	0.4	0.5
21	0.6	0.7	0.8	0.5	0.5	0.4	0.3	0.3	0.4	0.5	0.5	0.4	0.5
22	0.6	0.7	0.7	0.6	0.5	0.5	0.3	0.4	0.4	0.5	0.5	0.4	0.5
23	0.5	0.7	0.7	0.6	0.5	0.6	0.3	0.4	0.5	0.5	0.5	0.4	0.5
Grand Total	0.6	0.8	0.8	0.6	0.4	0.4	0.3	0.3	0.4	0.5	0.5	0.5	0.5

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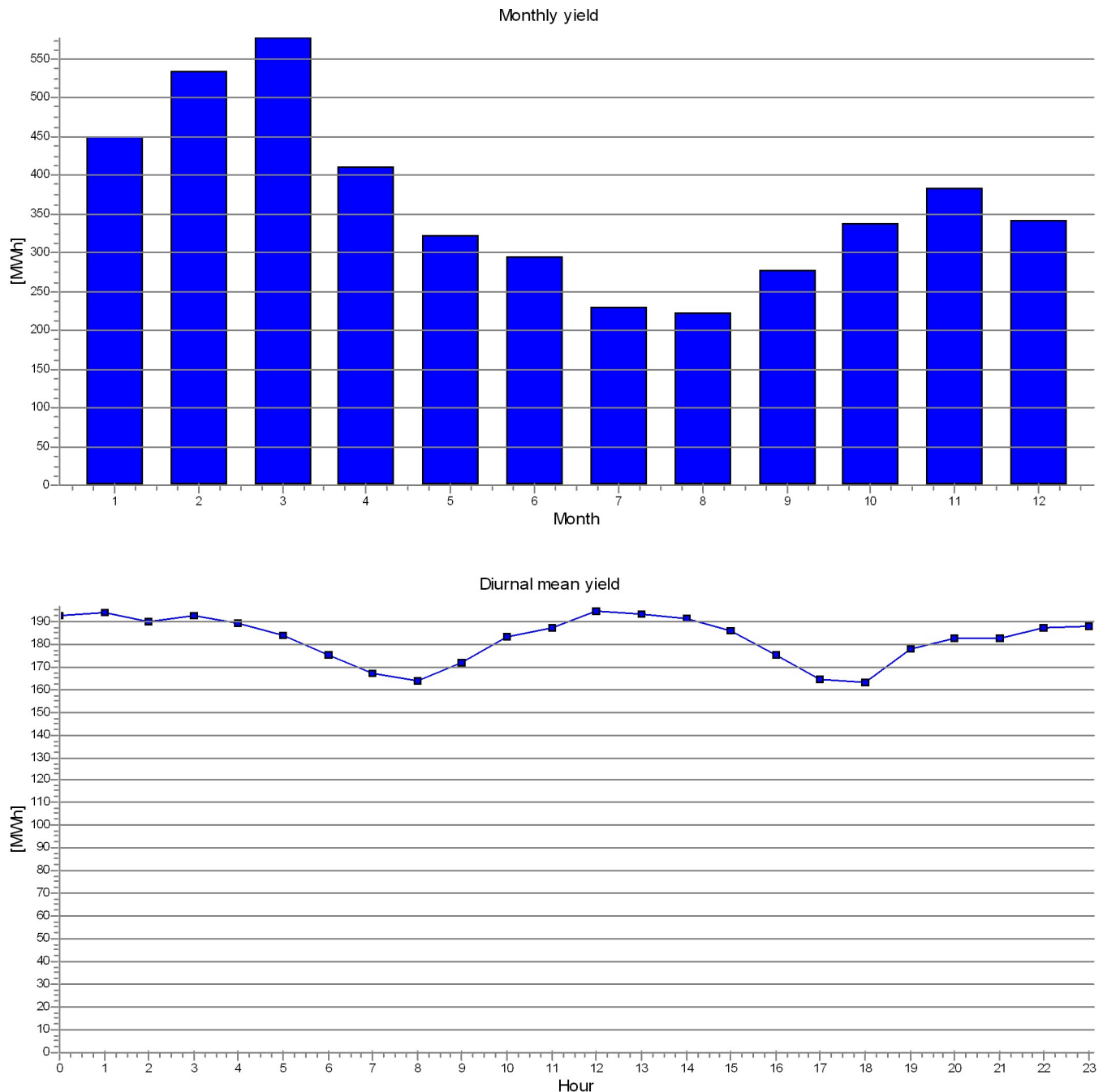
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PARK - Time varying AEP**Calculation:** 80m Park Calculation, Long Term Data, GE1.5

Windfarm: 1.5 MW based on 1 turbines of type GE WIND ENERGY GE 1.5sle 1500 77.0 !O!.

Calculated mean yield per month and hour [MWh]. The result includes wake losses but no other losses.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%



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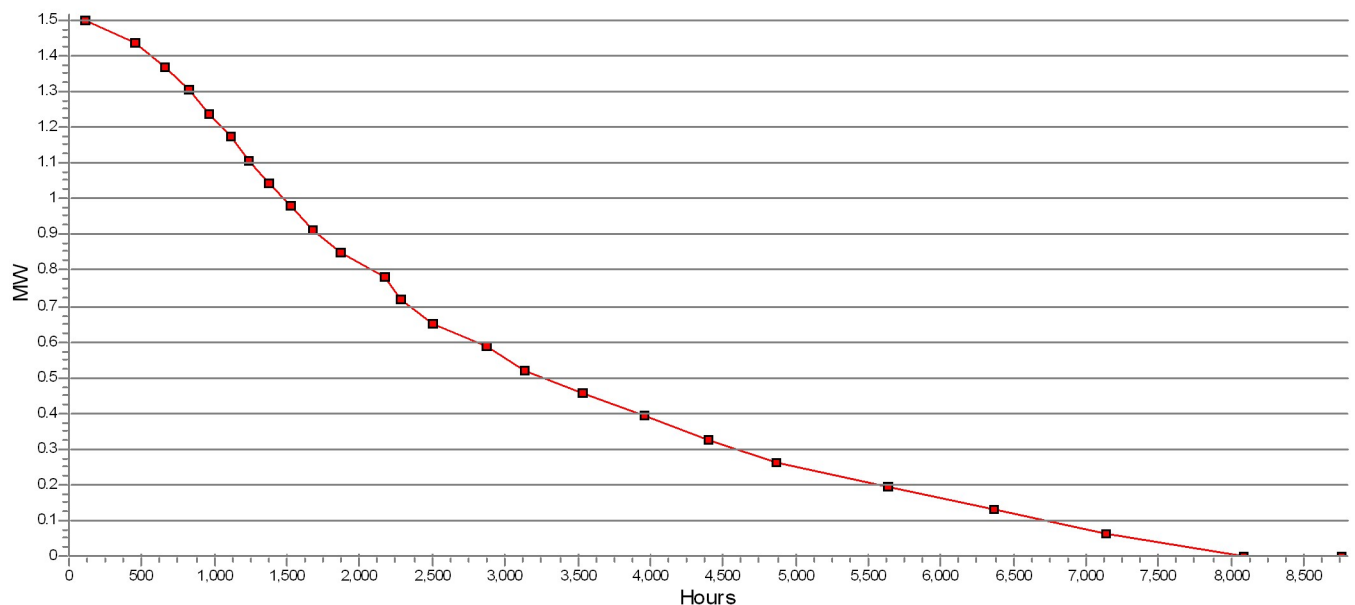
PARK - Time varying AEP**Calculation:** 80m Park Calculation, Long Term Data, GE1.5

Windfarm: 1.5 MW based on 1 turbines of type GE WIND ENERGY GE 1.5sle 1500 77.0 !O!.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%

Hours	Hours [%]	Hours accumulated	Rated power [MW]	Rated power (MW/WTG)
113	1.3	113	1.5	1.5
338	3.9	451	1.4 - 1.5	1.4 - 1.5
202	2.3	654	1.4 - 1.4	1.4 - 1.4
174	2.0	827	1.3 - 1.4	1.3 - 1.4
130	1.5	957	1.2 - 1.3	1.2 - 1.3
158	1.8	1116	1.2 - 1.2	1.2 - 1.2
123	1.4	1239	1.1 - 1.2	1.1 - 1.2
140	1.6	1379	1.0 - 1.1	1.0 - 1.1
149	1.7	1527	1.0 - 1.0	1.0 - 1.0
157	1.8	1684	0.9 - 1.0	0.9 - 1.0
181	2.1	1865	0.8 - 0.9	0.8 - 0.9
305	3.5	2170	0.8 - 0.8	0.8 - 0.8
111	1.3	2281	0.7 - 0.8	0.7 - 0.8
225	2.6	2505	0.7 - 0.7	0.7 - 0.7
372	4.2	2877	0.6 - 0.7	0.6 - 0.7
258	2.9	3135	0.5 - 0.6	0.5 - 0.6
405	4.6	3540	0.5 - 0.5	0.5 - 0.5
423	4.8	3962	0.4 - 0.5	0.4 - 0.5
443	5.1	4405	0.3 - 0.4	0.3 - 0.4
457	5.2	4863	0.3 - 0.3	0.3 - 0.3
772	8.8	5634	0.2 - 0.3	0.2 - 0.3
735	8.4	6369	0.1 - 0.2	0.1 - 0.2
767	8.8	7136	0.1 - 0.1	0.1 - 0.1
955	10.9	8090	0.0 - 0.1	0.0 - 0.1
670	7.6	8760	0.0	0.0

Duration curve 1.5 MW WindFarm



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PARK - Main Result**Calculation:** Park Calculation, Long Term Data, PW 900**Wake Model**

N.O. Jensen (RISØ/EMD)

Calculation Settings

Air density calculation mode Individual per WTG
 Result for WTG at hub altitude 1.196 kg/m³
 Air density relative to standard 97.6 %
 Hub altitude above sea level (asl) 438.1 m
 Annual mean temperature at hub alt. 6.5 °C
 Pressure at WTGs 959.8 hPa

Wake Model Parameters

From angle	To angle	Terrain type	Wake Decay Constant
[°]	[°]		
-180.0	180.0	Very closed farmland	0.100

Wake calculation settings

Angle [°]			Wind speed [m/s]		
start	end	step	start	end	step
0.5	360.0	1.0	0.5	30.5	1.0

Wind data

Wind statistics	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50



Scale 1:40,000

New WTG

Site Data

WASP version WASP 10 for Windows RVEA0151 1, 6, 0, 0**Key results for height 71.0 m above ground level****Terrain UTM NAD83 Zone: 19**

East	North	Name of wind distribution	Type	Wind energy [kWh/m²]	Mean wind speed [m/s]	Equivalent roughness
A 258,821	4,718,465	SDO for WASP NCCI GenPC	WASP (WASP 10 for Windows RVEA0151 1, 6, 0, 0)	3,579	7.5	2.1

Calculated Annual Energy for Wind Farm

WTG combination	Result PARK [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Specific results ^{a)}			Mean wind speed @ hub height [m/s]
				Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	
Wind farm	2,287.8	2,287.8	100.0	29.0	2,287.8	2,542	6.5

^{a)} Based on wake reduced results, but no other losses included**Calculated Annual Energy for each of 1 new WTGs with total 0.9 MW rated power**

WTG type			Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Displacement height [m]	Power curve		Annual Energy Park			
Terrain	Valid	Manufact.						Creator	Name	Result [MWh]	Efficiency [%]	Capacity factor [%]	Mean wind speed [m/s]
1 A	Yes	PowerWind	PowerWind 56-900	900	56.0	71.0	23.0	EMD	Level 0 - Measured - 24.03.2009	2,287.8	100.0	29.0	6.52

Annual Energy results do not include any losses apart from wake losses. For expected NET AEP (expected sold production), see report Loss & Uncertainty.

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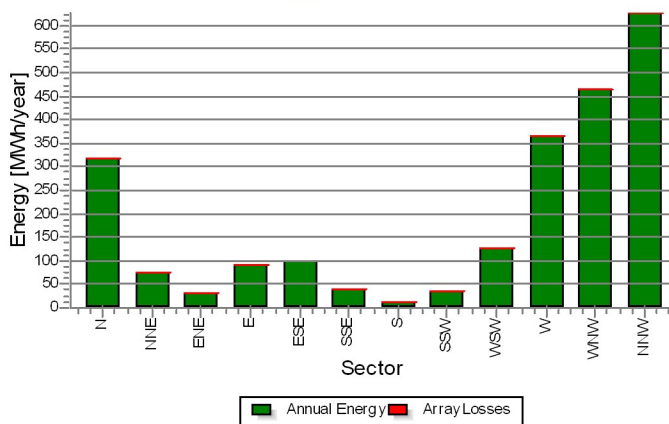
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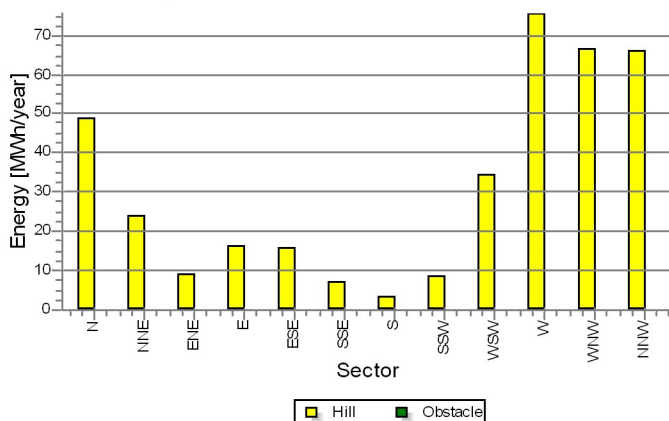
PARK - Production Analysis**Calculation:** Park Calculation, Long Term Data, PW 900WTG: All WTGs, Air density 1.196 kg/m³**Directional Analysis**

Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	268.6	52.0	21.6	74.9	83.1	32.9	10.2	26.0	94.5	290.7	396.4	561.6	1,912.5
+Increase due to hills	[MWh]	48.8	23.7	9.1	16.2	15.9	7.3	3.4	8.6	34.3	75.5	66.7	65.8	375.3
Resulting energy	[MWh]	317.3	75.7	30.7	91.1	99.1	40.2	13.6	34.6	128.8	366.2	463.1	627.4	2,287.8
Specific energy	[kWh/m ²]													929
Specific energy	[kWh/kW]													2,542
Increase due to hills	[%]	18.2	45.7	42.2	21.6	19.2	22.2	33.4	32.9	36.2	26.0	16.8	11.7	19.62
Utilization	[%]	34.9	42.5	41.6	39.2	39.3	41.2	40.2	41.7	41.8	41.8	37.8	32.4	36.9
Operational	[Hours/year]	901	410	241	420	626	419	189	234	542	1,236	1,460	1,609	8,286
Full Load Equivalent	[Hours/year]	353	84	34	101	110	45	15	38	143	407	515	697	2,542

Energy vs. sector



Impact of hills and obstacles vs. sector



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PARK - Power Curve Analysis

Calculation: Park Calculation, Long Term Data, PW 900WTG: 1 - PowerWind PowerWind 56 900 56.0 !O! Level 0 - Measured - 24.03.2009, Hub height: 71.0 m

Name: Level 0 - Measured - 24.03.2009

Source: DEWI

Source/Date	Created by	Created	Edited	Stop wind speed	Power control	CT curve type
3/24/2009	EMD	1/15/2010	3/16/2010	[m/s] 25.0	Pitch	User defined

HP curve comparison - Note: For standard air density and weibull k parameter = 2

Vmean	[m/s]	5	6	7	8	9	10
HP value	[MWh]	1,138	1,842	2,567	3,270	3,859	4,383
PowerWind PowerWind 56 900 56.0 !O! Level 0 - Measured - 24.03.2009	[MWh]	1,264	1,999	2,742	3,424	4,014	4,498
Check value	[%]	-10	-8	-6	-4	-4	-3

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m²) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.

For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see WindPRO manual chapter 3.5.2.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curve

Original data from Windcat, Air density: 1.225 kg/m³

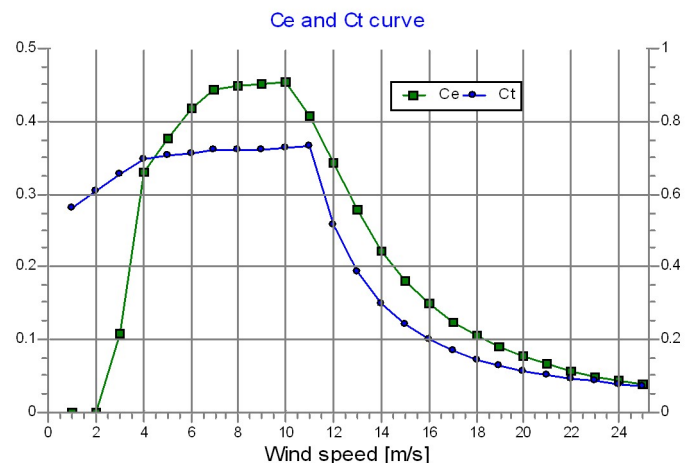
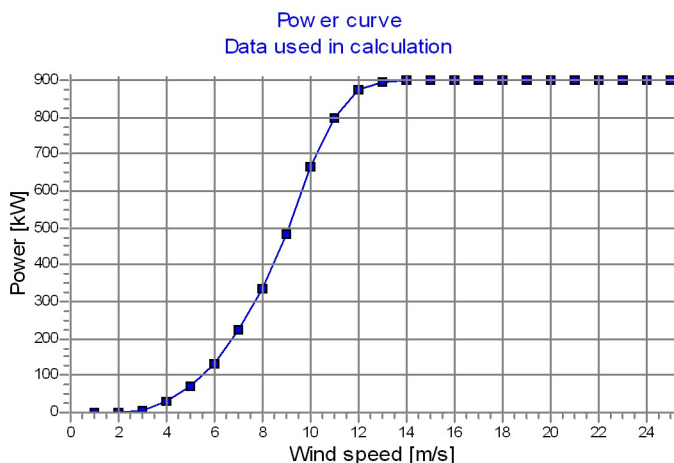
Wind speed Power Ce Wind speed Ct curve

[m/s]	[kW]		[m/s]	
3.0	5.0	0.12	3.0	0.65
4.0	32.0	0.33	4.0	0.70
5.0	71.0	0.38	5.0	0.70
6.0	136.0	0.42	6.0	0.71
7.0	230.0	0.44	7.0	0.72
8.0	345.0	0.45	8.0	0.72
9.0	497.0	0.45	9.0	0.72
10.0	687.0	0.46	10.0	0.73
11.0	815.0	0.41	11.0	0.73
12.0	886.0	0.34	12.0	0.52
13.0	900.0	0.27	13.0	0.38
14.0	900.0	0.22	14.0	0.30
15.0	900.0	0.18	15.0	0.24
16.0	900.0	0.15	16.0	0.20
17.0	900.0	0.12	17.0	0.17
18.0	900.0	0.10	18.0	0.15
19.0	900.0	0.09	19.0	0.13
20.0	900.0	0.07	20.0	0.12
21.0	900.0	0.06	21.0	0.10
22.0	900.0	0.06	22.0	0.09
23.0	900.0	0.05	23.0	0.09
24.0	900.0	0.04	24.0	0.08
25.0	900.0	0.04	25.0	0.07

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1.196 kg/m³ New WindPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed	Power	Ce	Interval	Energy	Acc. Energy	Relative
[m/s]	[kW]		[m/s]	[MWh]	[MWh]	[%]
1.0	0.0	0.00	0.50-1.50	0.0	0.0	0.0
2.0	0.0	0.00	1.50-2.50	0.0	0.0	0.0
3.0	4.3	0.11	2.50-3.50	7.8	7.8	0.3
4.0	31.1	0.33	3.50-4.50	34.0	41.8	1.8
5.0	69.4	0.38	4.50-5.50	82.4	124.2	5.4
6.0	132.8	0.42	5.50-6.50	152.9	277.0	12.1
7.0	224.5	0.44	6.50-7.50	232.8	509.9	22.3
8.0	337.3	0.45	7.50-8.50	300.3	810.1	35.4
9.0	484.6	0.45	8.50-9.50	339.8	1,149.9	50.3
10.0	667.0	0.45	9.50-10.50	335.6	1,485.6	64.9
11.0	797.3	0.41	10.50-11.50	281.9	1,767.4	77.3
12.0	873.7	0.34	11.50-12.50	204.1	1,971.5	86.2
13.0	897.3	0.28	12.50-13.50	132.8	2,104.4	92.0
14.0	900.0	0.22	13.50-14.50	80.7	2,185.0	95.5
15.0	900.0	0.18	14.50-15.50	47.1	2,232.1	97.6
16.0	900.0	0.15	15.50-16.50	26.6	2,258.8	98.7
17.0	900.0	0.12	16.50-17.50	14.5	2,273.2	99.4
18.0	900.0	0.10	17.50-18.50	7.6	2,280.8	99.7
19.0	900.0	0.09	18.50-19.50	3.8	2,284.6	99.9
20.0	900.0	0.08	19.50-20.50	1.8	2,286.4	99.9
21.0	900.0	0.07	20.50-21.50	0.8	2,287.2	100.0
22.0	900.0	0.06	21.50-22.50	0.4	2,287.6	100.0
23.0	900.0	0.05	22.50-23.50	0.1	2,287.7	100.0
24.0	900.0	0.04	23.50-24.50	0.1	2,287.8	100.0
25.0	900.0	0.04	24.50-25.50	0.0	2,287.8	100.0



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PARK - Terrain

Calculation: Park Calculation, Long Term Data, PW 900 **Site Data:** A - SDO for WAsP NCCI GenPC

Obstacles:

0 Obstacles used

Roughness:

Calculation uses following MAP files:

C:\...leee.DOMAIN\My Documents\WindPRO\WindPRO Data\Projects\Gardner Feasibility Study\ROUGHNESSLINE_Gardner Resource Assessment_2.wpo

Min X: 248,696, Max X: 275,482, Min Y: 4,709,243, Max Y: 4,734,513, Width: 26,785 m, Height: 25,270 m

Limited by a square on 40.0 km x 40.0 km around the current site

Orography:

Calculation uses following MAP files:

C:\Documents and Settings\leee.DOMAIN\My Documents\WindPRO\WindPRO Data\Projects\Gardner Feasibility Study\Height Contour Lines 6 thinned.wpo

Min X: 250,349, Max X: 266,009, Min Y: 4,710,727, Max Y: 4,727,946, Width: 15,659 m, Height: 17,218 m

Limited by a square on 10.0 km x 10.0 km around the current site

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PARK - Wind Data Analysis**Calculation:** Park Calculation, Long Term Data, PW 900Wind data: A - SDO for WASP NCCI GenPC; Hub height: 71.0**Site Coordinates**

UTM NAD 83 Zone: 19 East: 258,821 North: 4,718,465

Wind data

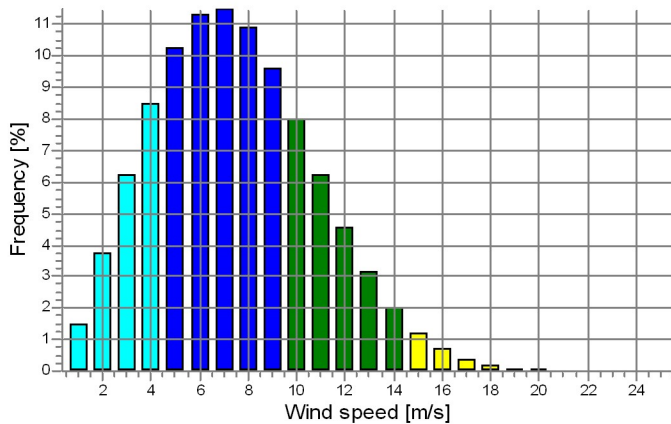
Wind statistics

	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50

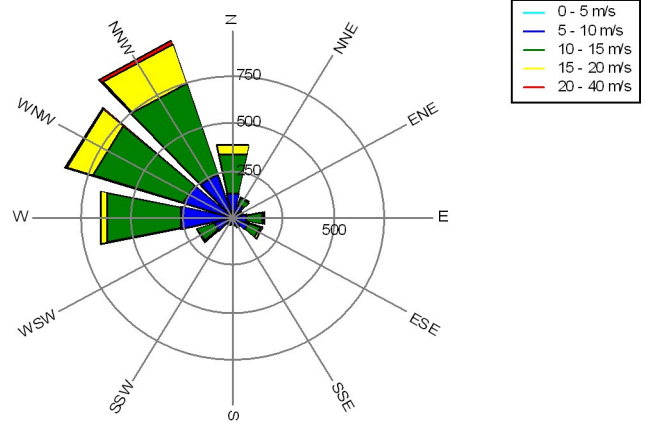
Weibull Data**Current site**

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	8.82	7.83	2.510	9.7
1 NNE	7.42	6.60	2.783	5.0
2 ENE	6.65	5.90	2.455	3.1
3 E	7.63	6.76	2.248	5.6
4 ESE	6.62	5.86	1.998	7.6
5 SSE	5.58	4.94	2.256	4.8
6 S	5.09	4.52	2.604	2.0
7 SSW	6.51	5.77	2.416	2.7
8 WSW	8.14	7.25	2.854	6.3
9 W	9.18	8.22	3.225	16.2
10 WNW	9.35	8.31	2.635	18.4
11 NNW	9.60	8.51	2.467	18.5
All	8.44	7.48	2.385	100.0

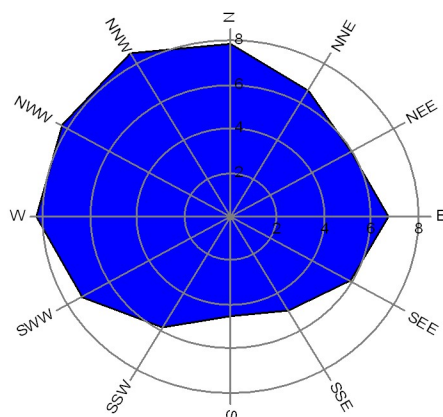
Weibull Distribution



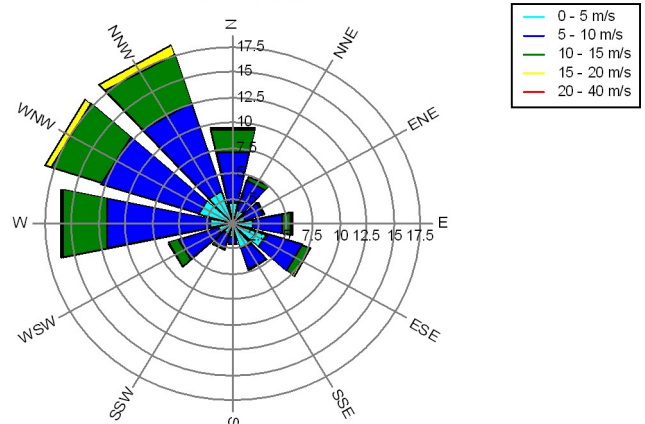
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



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PARK - Wind Data Analysis**Calculation:** Park Calculation, Long Term Data, PW 900Wind data: A - SDO for WASP NCCI GenPC; Hub height: 71.0**Site Coordinates**

UTM NAD 83 Zone: 19 East: 257,978 North: 4,720,007

PowerWind 900

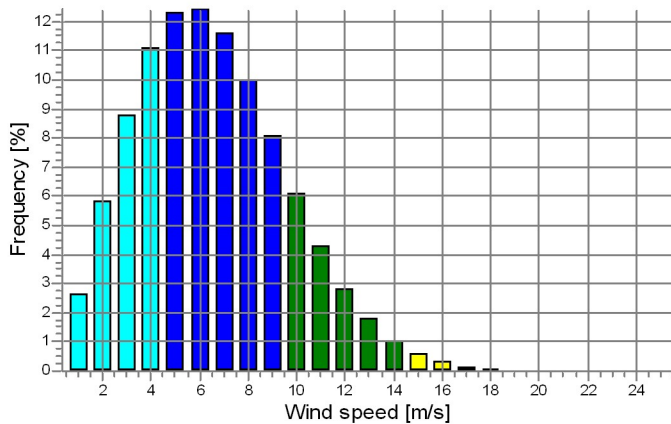
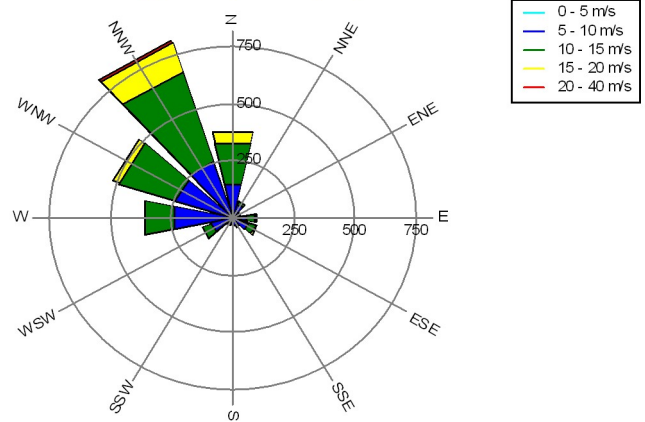
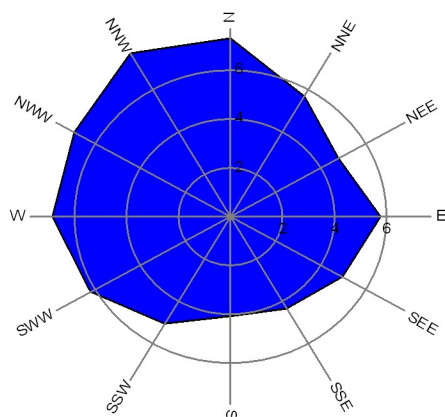
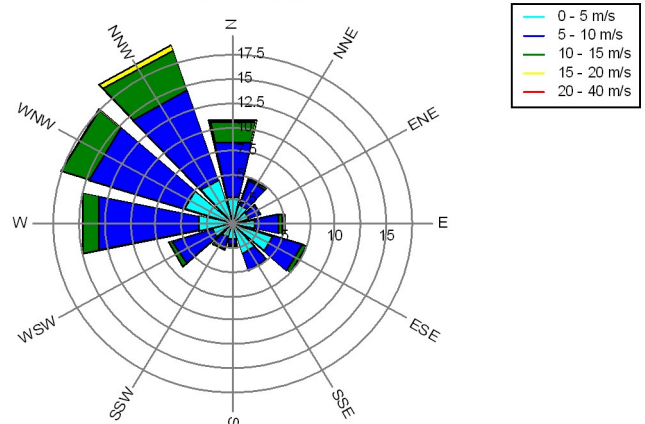
Wind data

Wind statistics

	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50

Weibull Data**Current site**

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	8.26	7.32	2.350	10.9
1 NNE	6.42	5.70	2.678	4.9
2 ENE	5.45	4.83	2.205	2.9
3 E	6.58	5.82	2.127	5.1
4 ESE	5.65	5.01	1.865	7.6
5 SSE	4.92	4.36	2.123	5.1
6 S	4.66	4.13	2.404	2.3
7 SSW	5.78	5.12	2.275	2.8
8 WSW	7.03	6.25	2.713	6.5
9 W	7.72	6.90	3.061	14.9
10 WNW	7.86	6.98	2.479	17.6
11 NNW	8.72	7.73	2.314	19.4
All	7.36	6.52	2.217	100.0

Weibull Distribution**Energy Rose (kWh/m²/year)****Mean wind speed (m/s)****Frequency (%)**

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PARK - Park power curve**Calculation:** Park Calculation, Long Term Data, PW 900

Power															
Wind speed	Free WTGs	Park WTGs	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	
[m/s]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3.5	18	18	18	18	18	18	18	18	18	18	18	18	18	18	
4.5	50	50	50	50	50	50	50	50	50	50	50	50	50	50	
5.5	100	101	101	101	101	101	101	101	101	101	101	101	101	101	
6.5	178	178	178	178	178	178	178	178	178	178	178	178	178	178	
7.5	280	280	280	280	280	280	280	280	280	280	280	280	280	280	
8.5	409	410	410	410	410	410	410	410	410	410	410	410	410	410	
9.5	574	574	574	574	574	574	574	574	574	574	574	574	574	574	
10.5	735	735	735	735	735	735	735	735	735	735	735	735	735	735	
11.5	839	839	839	839	839	839	839	839	839	839	839	839	839	839	
12.5	890	890	890	890	890	890	890	890	890	890	890	890	890	890	
13.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
14.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
15.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
16.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
17.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
18.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
19.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
20.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
21.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
22.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
23.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
24.5	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
25.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
26.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
27.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
28.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Description:

The park power curve is similar to a WTG power curve, meaning that when a given wind speed appears in front of the park with same speed in the entire wind farm area (before influence from the park), the output from the park can be found in the park power curve. Another way to say this: The park power curve includes array losses, but do NOT include terrain given variations in the wind speed over the park area.

Measuring a park power curve is not as simple as measuring a WTG power curve due to the fact that the park power curve depends on the wind direction and that the same wind speed normally will not appear for the entire park area at the same time (only in very flat non-complex terrain). The idea with this version of the park power curve is not to use it for validation based on measurements. This would require at least 2 measurement masts at two sides of the park, unless only a few direction sectors should be tested, AND non complex terrain (normally only useable off shore). Another park power curve version for complex terrain is available in WindPRO.

The park power curve can be used for:

1. Forecast systems, based on more rough (approximated) wind data, the park power curve would be an efficient way to make the connection from wind speed (and direction) to power.
2. Construction of duration curves, telling how often a given power output will appear, the park power curve can be used together with the average wind distribution for the Wind farm area in hub height. The average wind distribution can eventually be obtained based on the Weibull parameters for each WTG position. These are found at print menu: >Result to file< in the >Park result< which can be saved to file or copied to clipboard and pasted in Excel.
3. Calculation of wind energy index based on the PARK production (see below).
4. Estimation of the expected PARK production for an existing wind farm based on wind measurements at minimum 2 measurement masts at two sides of wind farm. The masts must be used for obtaining the free wind speed. The free wind speed is used in the simulation of expected energy production with the PARK power curve. This procedure will only work suitable in non complex terrains. For complex terrain another park power curve calculation is available in WindPRO (PPV-model).

Note:

From the >Result to file< the >Wind Speeds Inside Wind farm< is also available. These can (e.g. via Excel) be used for extracting the wake induced reductions in measured wind speed.

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PARK - RIX calculation**Calculation:** Park Calculation, Long Term Data, PW 900**Assumptions**

Radius for calculation 3,500 m
 Directional step 5 °
 Steepness threshold 40.0 % / 22 °
 Directional weight Frequency distributed
 Height contours used HCLs

Reference sites**Terrain UTM NAD83 Zone: 19**

East	North	Z [m]	Name of wind distribution	Type	Reference site RIX [%]
A 258,821	4,718,465	369.6	SDO for WAsP NCCI GenPC	WAsP (WAsP 10 for Windows RVEA0151 1, 6, 0, 0)	0.2

WTG sites**UTM NAD83 Zone: 19**

Terrain	East	North	Z [m]	Reference site RIX [%]	WTG RIX [%]	Delta RIX (WTG site - Reference site) [%]
1 A	UTM NAD83 Zone: 19 257,978	4,720,007	367.1	0.2	0.1	-0.1

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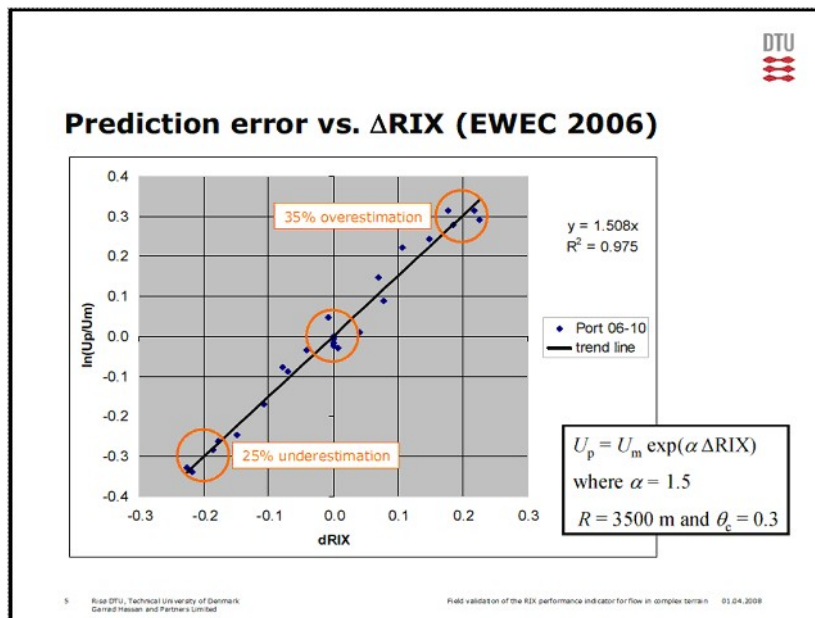
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PARK - RIX calculation

Calculation: Park Calculation, Long Term Data, PW 900

Latest research /Risø/ show that the threshold in RIX calculation typically work best with 40% (new default), and that delta Rix within +/- 5% should not give corrections. Cross predictions based on more mast can fine tune the threshold, see Cross predictor tool in WindPRO Meteo Analyzer. In WindPRO LOSS&&UNCERTAINTY module, RIX correction can be calculated automatically as a bias based on most recent recommended correction formulas, which can be found in EWEC2006 && 08 papers on Rix from Risø, see extract below:

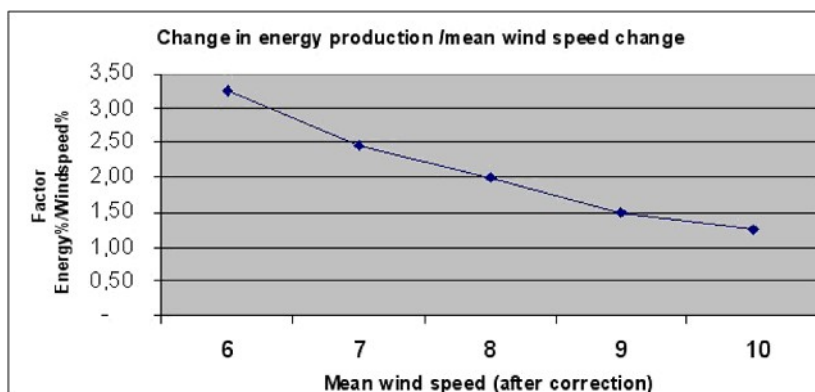


The main conclusion based on use of the RIX method is that if both reference site (measurement mast) and predicted site (WTG) are equally rugged (Delta RIX < 5%), very small calculation errors are expected.

If reference site (measurement mast) is very rugged, e.g. RIX = 0.2 and predicted site (WTG) are less rugged (e.g. RIX = 0), Delta RIX will be -0.2 and according to the graph, 30% too low wind speed prediction at WTG site could be expected. This could lead to around 60%*) too low calculated energy production.

If the reference site is less rugged, e.g. RIX = 0, and the predicted site (WTG) are very rugged (e.g. RIX = 0.2), Delta RIX will be +0.2, and according to the graph, 30% too high wind speed prediction at WTG site could be expected. This could lead to around 60%*) too high calculated energy production.

*) Doubling of energy prediction error based on mean wind speed error is a rough conversion, which holds for wind speeds around 8 m/s. At 6-7 m/s tripling is more right, while only 1.5 factors should be used for 9 m/s, see graph below based on a typical WTG.



Source: EWEC06 paper:

IMPROVING WASP PREDICTIONS IN (TOO) COMPLEX TERRAIN

Niels G. Møller, Anthony J. Bowen and Ioannis Antoniou

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Wind Energy Department, Risø National Laboratory

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PARK - Time varying AEP**Calculation:** Park Calculation, Long Term Data, PW 900

Windfarm: 0.9 MW based on 1 turbines of type PowerWind PowerWind 56 900 56.0 !O!.

Calculated mean yield per month and hour [MWh]. The result includes wake losses but no other losses.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%

Hour/Month [MWh]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	10	11	12	9	7	8	5	5	7	8	10	7	100
1	10	11	13	9	7	8	5	6	7	7	9	8	100
2	9	11	13	8	8	7	5	5	6	8	10	8	98
3	9	12	13	9	8	7	5	6	6	9	10	8	100
4	10	11	13	8	8	7	5	5	7	9	8	7	97
5	10	12	12	8	7	6	5	5	7	8	9	6	94
6	11	12	12	7	5	4	4	4	6	7	10	7	90
7	12	12	11	8	6	4	3	4	5	5	9	7	87
8	9	13	12	8	6	4	3	4	5	5	9	7	86
9	10	14	12	9	6	5	4	4	5	5	9	7	91
10	11	15	13	10	6	5	6	4	5	7	9	8	97
11	11	15	13	10	6	6	6	4	5	6	9	9	100
12	11	16	14	10	7	6	6	4	5	7	9	9	104
13	10	15	14	11	7	6	6	4	6	7	8	10	103
14	9	14	15	10	7	6	5	4	5	8	7	9	102
15	8	13	15	11	8	7	5	5	5	7	6	8	99
16	8	13	15	10	7	6	5	5	4	7	6	8	92
17	7	11	13	10	6	6	4	4	4	7	6	8	86
18	9	10	13	9	5	5	3	3	5	8	7	7	85
19	10	12	14	9	6	4	4	4	6	8	7	8	93
20	10	11	13	9	7	6	4	4	7	9	8	7	95
21	10	11	13	9	7	6	5	5	6	9	8	7	96
22	10	11	12	9	8	7	5	5	7	8	9	7	98
23	9	11	12	9	7	8	5	6	7	8	8	7	97
Grand Total	233	296	312	218	163	145	113	111	138	177	201	182	2,288

Hour/Month [MW]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	0.3	0.4	0.4	0.3	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.2	0.3
1	0.3	0.4	0.4	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3
2	0.3	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
3	0.3	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.3
4	0.3	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.3
5	0.3	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3
6	0.4	0.4	0.4	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.2
7	0.4	0.4	0.4	0.3	0.2	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.2
8	0.3	0.5	0.4	0.3	0.2	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.2
9	0.3	0.5	0.4	0.3	0.2	0.2	0.1	0.1	0.2	0.2	0.3	0.2	0.3
10	0.3	0.5	0.4	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.3	0.3	0.3
11	0.4	0.5	0.4	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.3	0.3	0.3
12	0.3	0.6	0.5	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.3	0.3	0.3
13	0.3	0.5	0.4	0.4	0.2	0.2	0.2	0.1	0.2	0.2	0.3	0.3	0.3
14	0.3	0.5	0.5	0.3	0.2	0.2	0.2	0.1	0.2	0.3	0.2	0.3	0.3
15	0.3	0.5	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3
16	0.3	0.5	0.5	0.3	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.3
17	0.2	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2
18	0.3	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2
19	0.3	0.4	0.5	0.3	0.2	0.1	0.1	0.1	0.2	0.3	0.2	0.2	0.3
20	0.3	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.2	0.3	0.3	0.2	0.3
21	0.3	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.2	0.3	0.3	0.2	0.3
22	0.3	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.3
23	0.3	0.4	0.4	0.3	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.2	0.3
Grand Total	0.3	0.4	0.4	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.3	0.2	0.3

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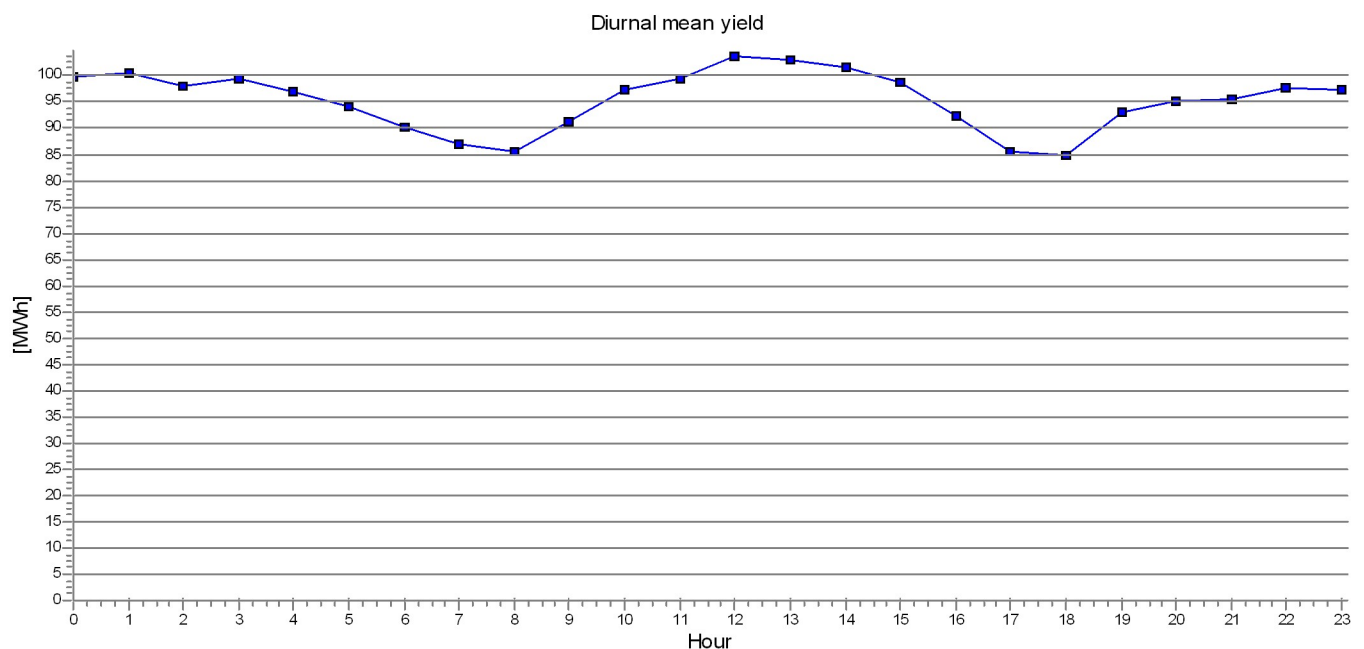
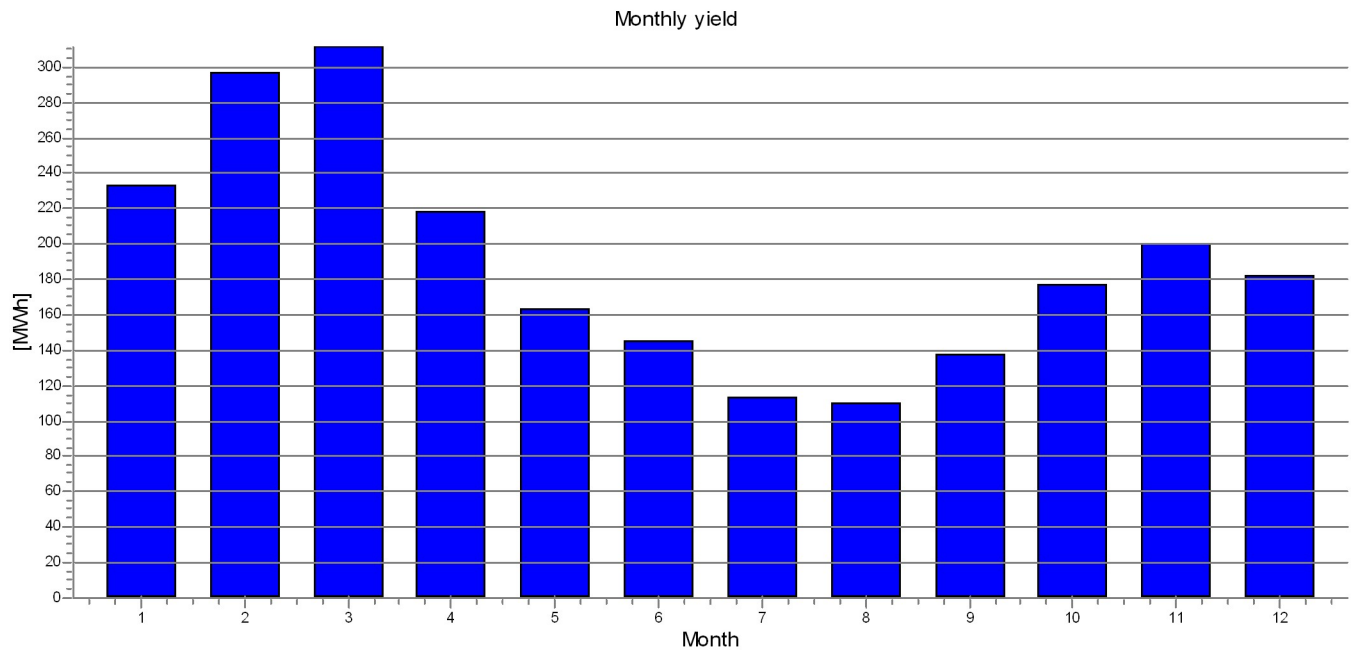
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PARK - Time varying AEP**Calculation:** Park Calculation, Long Term Data, PW 900

Windfarm: 0.9 MW based on 1 turbines of type PowerWind PowerWind 56 900 56.0 !O!.

Calculated mean yield per month and hour [MWh]. The result includes wake losses but no other losses.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%



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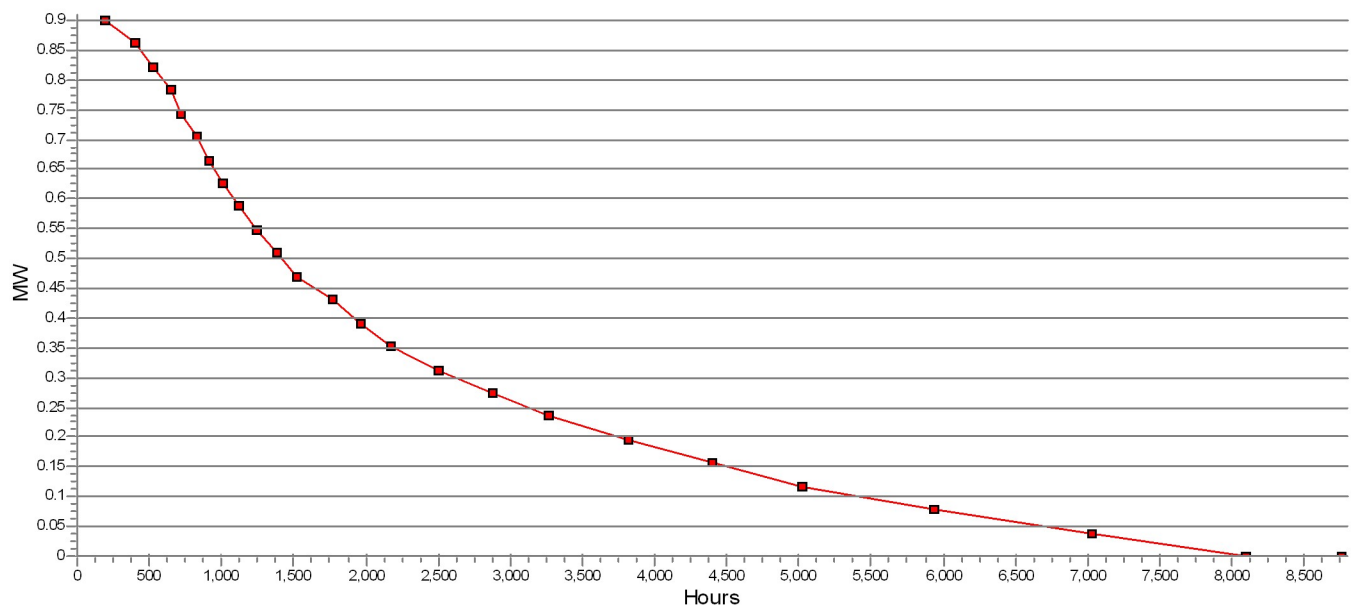
PARK - Time varying AEP**Calculation:** Park Calculation, Long Term Data, PW 900

Windfarm: 0.9 MW based on 1 turbines of type PowerWind PowerWind 56 900 56.0 !O!.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%

Hours	Hours [%]	Hours accumulated	Rated power [MW]	Rated power (MW/WTG)
197	2.3	197	0.9	0.9
206	2.4	404	0.9 - 0.9	0.9 - 0.9
126	1.4	529	0.8 - 0.9	0.8 - 0.9
124	1.4	654	0.8 - 0.8	0.8 - 0.8
63	0.7	716	0.7 - 0.8	0.7 - 0.8
111	1.3	827	0.7 - 0.7	0.7 - 0.7
87	1.0	914	0.7 - 0.7	0.7 - 0.7
95	1.1	1009	0.6 - 0.7	0.6 - 0.7
107	1.2	1116	0.6 - 0.6	0.6 - 0.6
123	1.4	1239	0.5 - 0.6	0.5 - 0.6
140	1.6	1378	0.5 - 0.5	0.5 - 0.5
149	1.7	1527	0.5 - 0.5	0.5 - 0.5
245	2.8	1772	0.4 - 0.5	0.4 - 0.5
189	2.2	1960	0.4 - 0.4	0.4 - 0.4
210	2.4	2170	0.4 - 0.4	0.4 - 0.4
336	3.8	2505	0.3 - 0.4	0.3 - 0.4
372	4.2	2877	0.3 - 0.3	0.3 - 0.3
396	4.5	3273	0.2 - 0.3	0.2 - 0.3
552	6.3	3824	0.2 - 0.2	0.2 - 0.2
581	6.6	4405	0.2 - 0.2	0.2 - 0.2
615	7.0	5020	0.1 - 0.2	0.1 - 0.2
913	10.4	5933	0.1 - 0.1	0.1 - 0.1
1093	12.5	7026	0.0 - 0.1	0.0 - 0.1
1065	12.2	8091	0.0 - 0.0	0.0 - 0.0
669	7.6	8760	0.0	0.0

Duration curve 0.9 MW WindFarm



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PARK - Main Result**Calculation:** Park Calculation, Long Term Data, 2 PW 900**Wake Model**

N.O. Jensen (RISØ/EMD)

Calculation Settings

Air density calculation mode Individual per WTG
 Result for WTG at hub altitude 1.196 kg/m³ to 1.196 kg/m³
 Air density relative to standard 97.6 %
 Hub altitude above sea level (asl) 437.0 m to 437.7 m
 Annual mean temperature at hub alt. 6.5 °C to 6.5 °C
 Pressure at WTGs 959.9 hPa to 959.9 hPa

Wake Model Parameters

From angle [°]	To angle [°]	Terrain type	Wake Decay Constant
-180.0	180.0	Very closed farmland	0.100

Wake calculation settings

Angle [°]			Wind speed [m/s]		
start	end	step	start	end	step
0.5	360.0	1.0	0.5	30.5	1.0

Wind data

Wind statistics	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50



Scale 1:40,000

New WTG

Site Data

WASP version WASP 10 for Windows RVEA0151 1, 6, 0, 0**Key results for height 71.0 m above ground level****Terrain UTM NAD83 Zone: 19**

East	North	Name of wind distribution	Type	Wind energy [kWh/m²]	Mean wind speed [m/s]	Equivalent roughness
A 258,821	4,718,465	SDO for WASP NCCI GenPC	WASP (WASP 10 for Windows RVEA0151 1, 6, 0, 0)	3,579	7.5	2.1

Calculated Annual Energy for Wind Farm

WTG combination	Result PARK [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Specific results ^{a)}			Mean wind speed @ hub height [m/s]
				Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	
Wind farm	4,412.8	4,569.9	96.6	28.0	2,206.4	2,452	6.5

^{a)} Based on wake reduced results, but no other losses included**Calculated Annual Energy for each of 2 new WTGs with total 1.8 MW rated power**

WTG type	Terrain	Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Displacement height [m]	Power curve Creator	Name	Annual Energy Park			
											Result [MWh]	Efficiency [%]	Capacity factor [%]	Mean wind speed [m/s]
1 A	Yes	PowerWind	PowerWind 56-900	900	56.0	71.0	23.0	EMD	Level 0 - Measured - 24.03.2009	2,214.1	97.0	28.1	6.51	
2 A	Yes	PowerWind	PowerWind 56-900	900	56.0	71.0	23.0	EMD	Level 0 - Measured - 24.03.2009	2,198.8	96.1	27.9	6.52	

Annual Energy results do not include any losses apart from wake losses. For expected NET AEP (expected sold production), see report Loss & Uncertainty.

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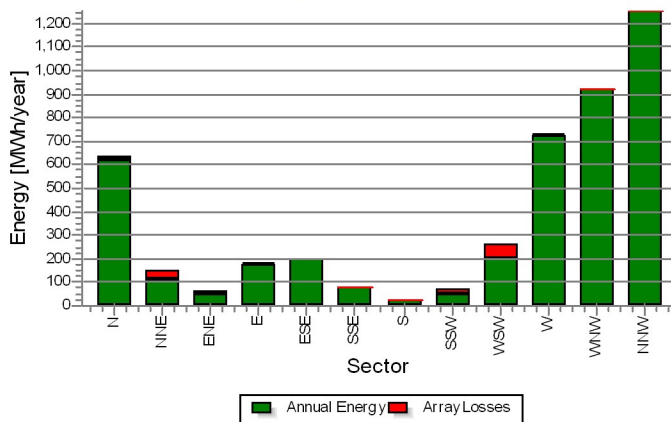
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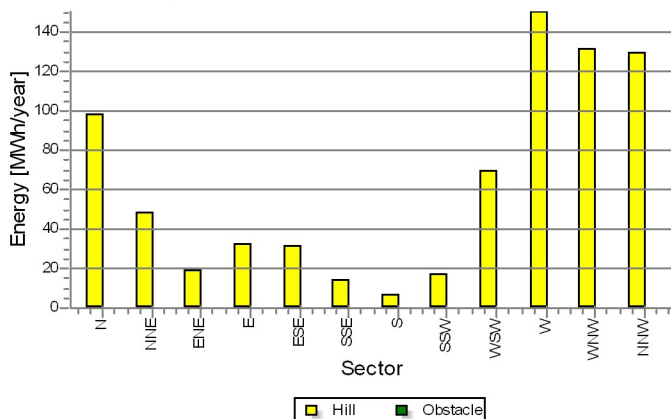
PARK - Production Analysis**Calculation:** Park Calculation, Long Term Data, 2 PW 900WTG: All WTGs, Air density 1.196 kg/m³**Directional Analysis**

Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	535.3	104.4	43.7	148.4	165.8	65.8	20.5	52.2	189.6	581.3	792.5	1,124.5	3,823.7
+Increase due to hills	[MWh]	97.8	48.2	18.5	32.0	31.4	14.5	6.9	17.3	69.2	150.2	130.7	129.6	746.2
-Decrease due to array losses	[MWh]	13.4	37.5	14.2	2.9	0.0	0.0	1.0	17.9	57.9	12.3	0.0	0.0	157.1
Resulting energy	[MWh]	619.7	115.0	48.0	177.5	197.2	80.2	26.4	51.6	200.9	719.1	923.2	1,254.1	4,412.8
Specific energy	[kWh/m ²]													896
Specific energy	[kWh/kW]													2,452
Increase due to hills	[%]	18.3	46.2	42.4	21.6	19.0	22.0	33.6	33.1	36.5	25.8	16.5	11.5	19.52
Decrease due to array losses	[%]	2.1	24.6	22.8	1.6	0.0	0.0	3.7	25.8	22.4	1.7	0.0	0.0	3.44
Utilization	[%]	34.2	32.1	32.1	38.6	39.3	41.2	38.8	31.0	32.5	41.1	37.8	32.4	35.6
Operational	[Hours/year]	901	411	241	420	625	419	190	234	543	1,235	1,457	1,607	8,284
Full Load Equivalent	[Hours/year]	344	64	27	99	110	45	15	29	112	400	513	697	2,452

Energy vs. sector



Impact of hills and obstacles vs. sector



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PARK - Power Curve Analysis

Calculation: Park Calculation, Long Term Data, 2 PW 900WTG: 1 - PowerWind PowerWind 56 900 56.0 !O! Level 0 - Measured - 24.03.2009, Hub height: 71.0 m

Name: Level 0 - Measured - 24.03.2009

Source: DEWI

Source/Date	Created by	Created	Edited	Stop wind speed	Power control	CT curve type
3/24/2009	EMD	1/15/2010	3/16/2010	[m/s] 25.0	Pitch	User defined

HP curve comparison - Note: For standard air density and weibull k parameter = 2

Vmean	[m/s]	5	6	7	8	9	10
HP value	[MWh]	1,138	1,842	2,567	3,270	3,859	4,383
PowerWind PowerWind 56 900 56.0 !O! Level 0 - Measured - 24.03.2009	[MWh]	1,264	1,999	2,742	3,424	4,014	4,498
Check value	[%]	-10	-8	-6	-4	-4	-3

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m²) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.

For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see WindPRO manual chapter 3.5.2.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curve

Original data from Windcat, Air density: 1.225 kg/m³

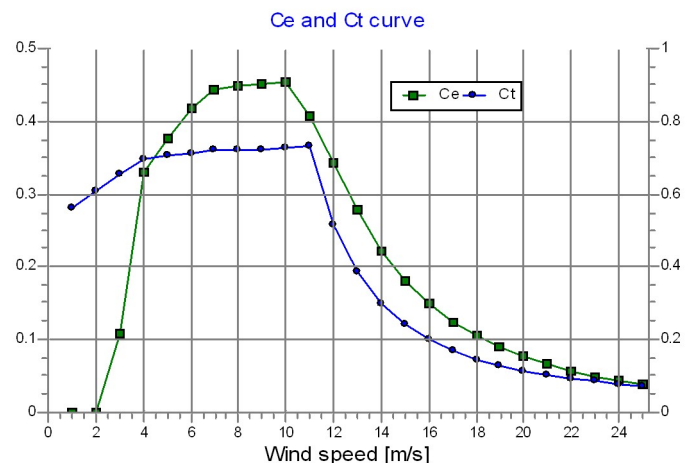
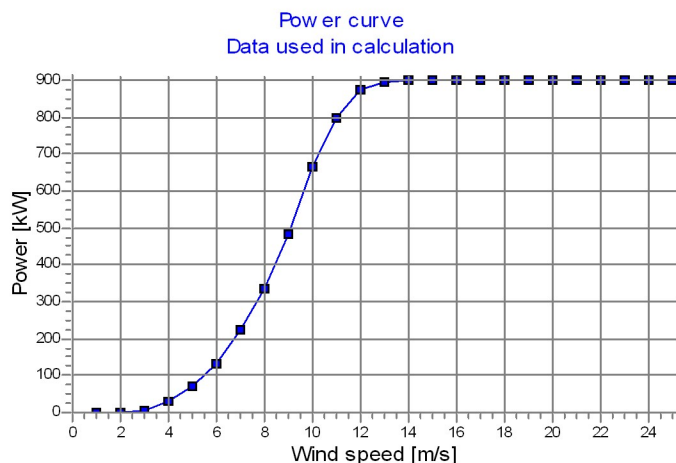
Wind speed Power Ce Wind speed Ct curve

[m/s]	[kW]		[m/s]	
3.0	5.0	0.12	3.0	0.65
4.0	32.0	0.33	4.0	0.70
5.0	71.0	0.38	5.0	0.70
6.0	136.0	0.42	6.0	0.71
7.0	230.0	0.44	7.0	0.72
8.0	345.0	0.45	8.0	0.72
9.0	497.0	0.45	9.0	0.72
10.0	687.0	0.46	10.0	0.73
11.0	815.0	0.41	11.0	0.73
12.0	886.0	0.34	12.0	0.52
13.0	900.0	0.27	13.0	0.38
14.0	900.0	0.22	14.0	0.30
15.0	900.0	0.18	15.0	0.24
16.0	900.0	0.15	16.0	0.20
17.0	900.0	0.12	17.0	0.17
18.0	900.0	0.10	18.0	0.15
19.0	900.0	0.09	19.0	0.13
20.0	900.0	0.07	20.0	0.12
21.0	900.0	0.06	21.0	0.10
22.0	900.0	0.06	22.0	0.09
23.0	900.0	0.05	23.0	0.09
24.0	900.0	0.04	24.0	0.08
25.0	900.0	0.04	25.0	0.07

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1.196 kg/m³ New WindPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed	Power	Ce	Interval	Energy	Acc. Energy	Relative
[m/s]	[kW]		[m/s]	[MWh]	[MWh]	[%]
1.0	0.0	0.00	0.50-1.50	0.0	0.0	0.0
2.0	0.0	0.00	1.50-2.50	0.0	0.0	0.0
3.0	4.3	0.11	2.50-3.50	7.6	7.6	0.3
4.0	31.1	0.33	3.50-4.50	33.1	40.6	1.8
5.0	69.4	0.38	4.50-5.50	80.1	120.7	5.5
6.0	132.8	0.42	5.50-6.50	148.5	269.2	12.2
7.0	224.5	0.44	6.50-7.50	225.9	495.1	22.4
8.0	337.3	0.45	7.50-8.50	290.9	786.0	35.5
9.0	484.6	0.45	8.50-9.50	328.7	1,114.7	50.3
10.0	667.0	0.45	9.50-10.50	324.3	1,439.0	65.0
11.0	797.3	0.41	10.50-11.50	272.2	1,711.3	77.3
12.0	873.7	0.34	11.50-12.50	197.1	1,908.4	86.2
13.0	897.3	0.28	12.50-13.50	128.4	2,036.8	92.0
14.0	900.0	0.22	13.50-14.50	78.0	2,114.8	95.5
15.0	900.0	0.18	14.50-15.50	45.6	2,160.4	97.6
16.0	900.0	0.15	15.50-16.50	25.7	2,186.1	98.7
17.0	900.0	0.12	16.50-17.50	14.0	2,200.1	99.4
18.0	900.0	0.10	17.50-18.50	7.3	2,207.3	99.7
19.0	900.0	0.09	18.50-19.50	3.6	2,211.0	99.9
20.0	900.0	0.08	19.50-20.50	1.7	2,212.7	99.9
21.0	900.0	0.07	20.50-21.50	0.8	2,213.5	100.0
22.0	900.0	0.06	21.50-22.50	0.3	2,213.8	100.0
23.0	900.0	0.05	22.50-23.50	0.1	2,214.0	100.0
24.0	900.0	0.04	23.50-24.50	0.1	2,214.0	100.0
25.0	900.0	0.04	24.50-25.50	0.0	2,214.1	100.0



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PARK - Terrain

Calculation: Park Calculation, Long Term Data, 2 PW 900 **Site Data:** A - SDO for WAsP NCCI GenPC

Obstacles:

0 Obstacles used

Roughness:

Calculation uses following MAP files:

C:\...eeee.DOMAIN\My Documents\WindPRO\WindPRO Data\Projects\Gardner Feasibility Study\ROUGHNESSLINE_Gardner Resource Assessment_2.wpo

Min X: 248,696, Max X: 275,482, Min Y: 4,709,243, Max Y: 4,734,513, Width: 26,785 m, Height: 25,270 m

Limited by a square on 40.0 km x 40.0 km around the current site

Orography:

Calculation uses following MAP files:

C:\Documents and Settings\eeee.DOMAIN\My Documents\WindPRO\WindPRO Data\Projects\Gardner Feasibility Study\Height Contour Lines 6 thinned.wpo

Min X: 250,349, Max X: 266,009, Min Y: 4,710,727, Max Y: 4,727,946, Width: 15,659 m, Height: 17,218 m

Limited by a square on 10.0 km x 10.0 km around the current site

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PARK - Wind Data Analysis**Calculation:** Park Calculation, Long Term Data, 2 PW 900 **Wind data:** A - SDO for WASP NCCI GenPC; Hub height: 71.0**Site Coordinates**

UTM NAD 83 Zone: 19 East: 258,821 North: 4,718,465

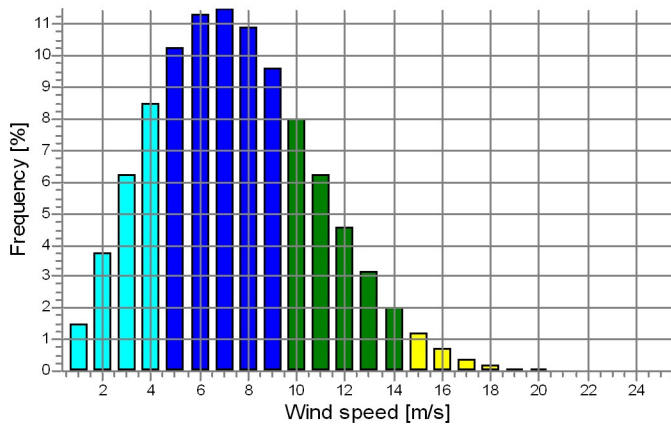
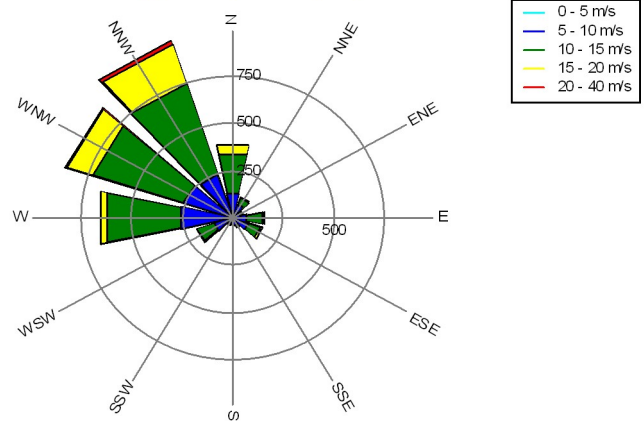
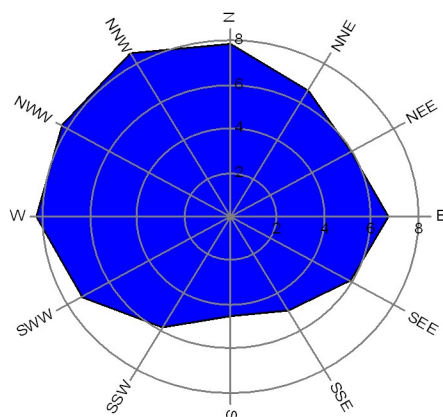
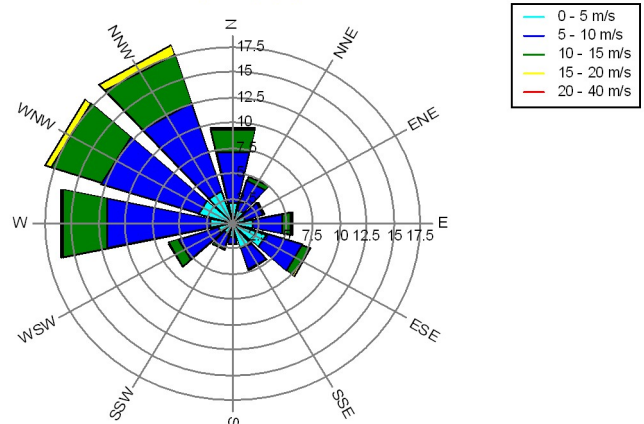
Wind data

Wind statistics

	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50

Weibull Data**Current site**

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	8.82	7.83	2.510	9.7
1 NNE	7.42	6.60	2.783	5.0
2 ENE	6.65	5.90	2.455	3.1
3 E	7.63	6.76	2.248	5.6
4 ESE	6.62	5.86	1.998	7.6
5 SSE	5.58	4.94	2.256	4.8
6 S	5.09	4.52	2.604	2.0
7 SSW	6.51	5.77	2.416	2.7
8 WSW	8.14	7.25	2.854	6.3
9 W	9.18	8.22	3.225	16.2
10 WNW	9.35	8.31	2.635	18.4
11 NNW	9.60	8.51	2.467	18.5
All	8.44	7.48	2.385	100.0

Weibull Distribution**Energy Rose (kWh/m²/year)****Mean wind speed (m/s)****Frequency (%)**

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PARK - Wind Data Analysis**Calculation:** Park Calculation, Long Term Data, 2 PW 900Wind data: A - SDO for WASP NCCI GenPC; Hub height: 71.0**Site Coordinates**

UTM NAD 83 Zone: 19 East: 257,971 North: 4,719,958

PowerWind PowerWind 56 900 56.0 !O! hub: 71.0 m (2)

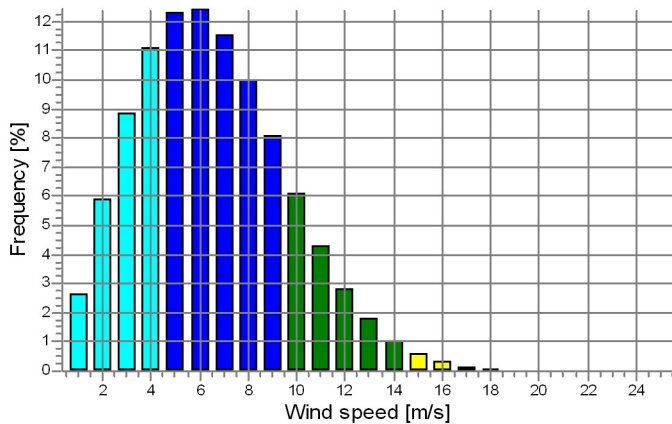
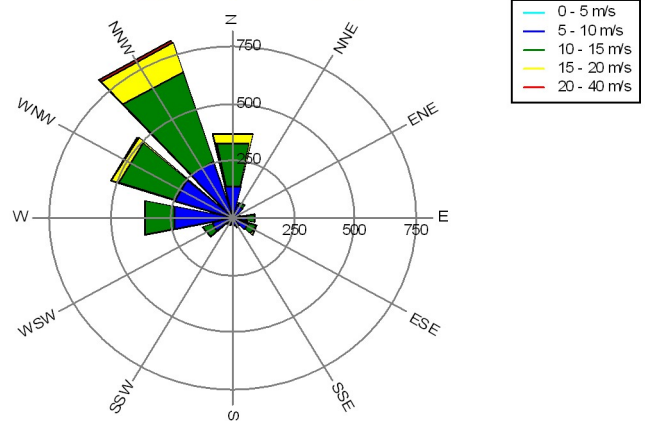
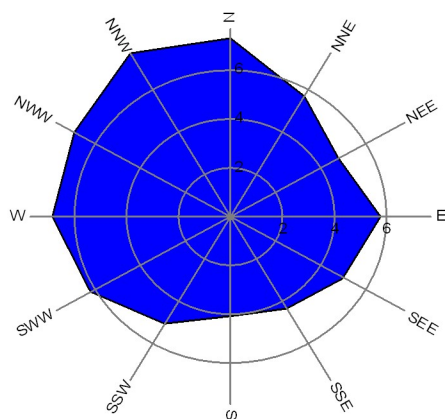
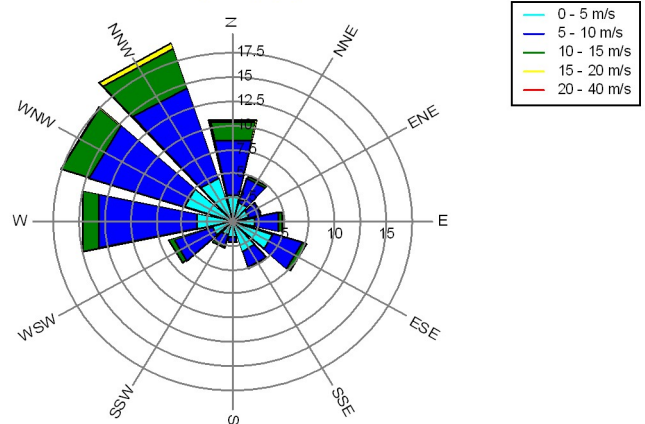
Wind data

Wind statistics

	Distance [km]	Weight [%]
NCCI 49-1 Wind Index MCP NCAR.GenPC.wws	0	50
NCCI 49-2 Wind Index MCP NCAR.GenPC.wws	0	50

Weibull Data**Current site**

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	8.24	7.31	2.350	10.8
1 NNE	6.38	5.67	2.693	4.9
2 ENE	5.43	4.81	2.213	2.9
3 E	6.52	5.78	2.131	5.1
4 ESE	5.65	5.02	1.865	7.6
5 SSE	4.94	4.37	2.123	5.1
6 S	4.65	4.13	2.408	2.3
7 SSW	5.76	5.10	2.279	2.8
8 WSW	6.99	6.22	2.709	6.5
9 W	7.70	6.88	3.061	14.9
10 WNW	7.88	6.99	2.479	17.7
11 NNW	8.72	7.72	2.314	19.5
All	7.35	6.51	2.213	100.0

Weibull Distribution**Energy Rose (kWh/m²/year)****Mean wind speed (m/s)****Frequency (%)**

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PARK - Park power curve**Calculation:** Park Calculation, Long Term Data, 2 PW 900

Power															
Wind speed	Free WTGs	Park WTGs	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	
[m/s]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3.5	35	32	34	20	21	34	35	35	34	20	21	34	35	35	
4.5	100	94	96	70	73	98	100	100	96	70	73	98	100	100	
5.5	201	190	194	146	151	197	201	201	194	146	151	197	201	201	
6.5	355	337	343	259	267	348	356	356	343	259	267	348	356	356	
7.5	560	532	542	413	426	549	561	561	542	413	426	549	561	561	
8.5	819	778	793	610	629	803	819	819	793	610	629	803	819	819	
9.5	1,147	1,092	1,112	858	884	1,126	1,149	1,149	1,112	858	884	1,126	1,149	1,149	
10.5	1,470	1,405	1,437	1,119	1,154	1,452	1,471	1,471	1,437	1,119	1,154	1,452	1,471	1,471	
11.5	1,678	1,633	1,661	1,417	1,451	1,669	1,679	1,679	1,661	1,417	1,451	1,669	1,679	1,679	
12.5	1,781	1,765	1,777	1,687	1,701	1,779	1,781	1,781	1,777	1,687	1,701	1,779	1,781	1,781	
13.5	1,800	1,798	1,800	1,785	1,788	1,800	1,800	1,800	1,800	1,785	1,788	1,800	1,800	1,800	
14.5	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	
15.5	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	
16.5	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	
17.5	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	
18.5	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	
19.5	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	
20.5	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	
21.5	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	
22.5	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	
23.5	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	
24.5	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	
25.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
26.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
27.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
28.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Description:

The park power curve is similar to a WTG power curve, meaning that when a given wind speed appears in front of the park with same speed in the entire wind farm area (before influence from the park), the output from the park can be found in the park power curve. Another way to say this: The park power curve includes array losses, but do NOT include terrain given variations in the wind speed over the park area.

Measuring a park power curve is not as simple as measuring a WTG power curve due to the fact that the park power curve depends on the wind direction and that the same wind speed normally will not appear for the entire park area at the same time (only in very flat non-complex terrain). The idea with this version of the park power curve is not to use it for validation based on measurements. This would require at least 2 measurement masts at two sides of the park, unless only a few direction sectors should be tested, AND non complex terrain (normally only useable off shore). Another park power curve version for complex terrain is available in WindPRO.

The park power curve can be used for:

1. Forecast systems, based on more rough (approximated) wind data, the park power curve would be an efficient way to make the connection from wind speed (and direction) to power.
2. Construction of duration curves, telling how often a given power output will appear, the park power curve can be used together with the average wind distribution for the Wind farm area in hub height. The average wind distribution can eventually be obtained based on the Weibull parameters for each WTG position. These are found at print menu: >Result to file< in the >Park result< which can be saved to file or copied to clipboard and pasted in Excel.
3. Calculation of wind energy index based on the PARK production (see below).
4. Estimation of the expected PARK production for an existing wind farm based on wind measurements at minimum 2 measurement masts at two sides of wind farm. The masts must be used for obtaining the free wind speed. The free wind speed is used in the simulation of expected energy production with the PARK power curve. This procedure will only work suitable in non complex terrains. For complex terrain another park power curve calculation is available in WindPRO (PPV-model).

Note:

From the >Result to file< the >Wind Speeds Inside Wind farm< is also available. These can (e.g. via Excel) be used for extracting the wake induced reductions in measured wind speed.

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PARK - RIX calculation**Calculation:** Park Calculation, Long Term Data, 2 PW 900**Assumptions**

Radius for calculation 3,500 m
 Directional step 5 °
 Steepness threshold 40.0 % / 22 °
 Directional weight Frequency distributed
 Height contours used HCLs

Reference sites**Terrain UTM NAD83 Zone: 19**

East	North	Z	Name of wind distribution	Type	Reference site RIX
		[m]			[%]
A 258,821	4,718,465	369.6	SDO for WAsP NCCI GenPC	WAsP (WAsP 10 for Windows RVEA0151 1, 6, 0, 0)	0.2

WTG sites**UTM NAD83 Zone: 19**

Terrain	East	North	Z	Reference site RIX	WTG RIX	Delta RIX (WTG site - Reference site)
	UTM NAD83 Zone: 19		[m]	[%]	[%]	[%]
1 A	257,971	4,719,958	366.7	0.2	0.1	-0.1
2 A	258,030	4,720,020	366.0	0.2	0.1	-0.1

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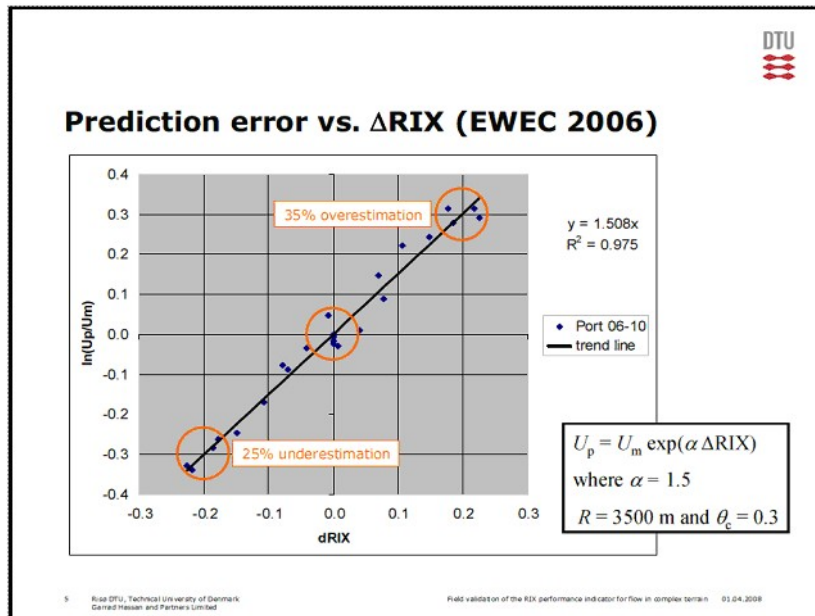
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PARK - RIX calculation

Calculation: Park Calculation, Long Term Data, 2 PW 900

Latest research /Risø/ show that the threshold in RIX calculation typically work best with 40% (new default), and that delta Rix within +/- 5% should not give corrections. Cross predictions based on more mast can fine tune the threshold, see Cross predictor tool in WindPRO Meteo Analyzer. In WindPRO LOSS&&UNCERTAINTY module, RIX correction can be calculated automatically as a bias based on most recent recommended correction formulas, which can be found in EWEC2006 && 08 papers on Rix from Risø, see extract below:

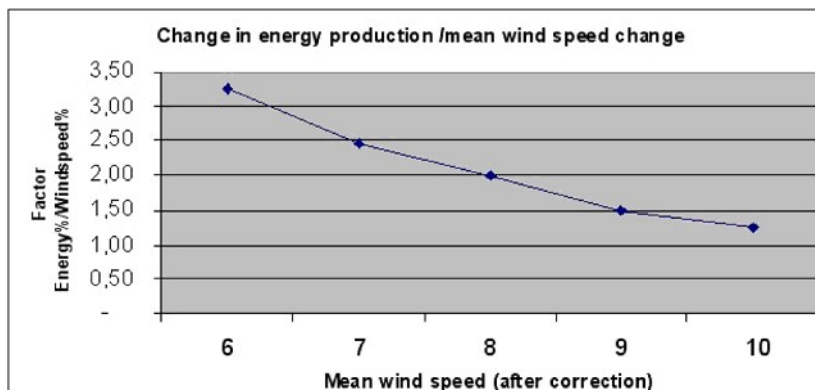


The main conclusion based on use of the RIX method is that if both reference site (measurement mast) and predicted site (WTG) are equally rugged (Delta RIX < 5%), very small calculation errors are expected.

If reference site (measurement mast) is very rugged, e.g. RIX = 0.2 and predicted site (WTG) are less rugged (e.g. RIX = 0), Delta RIX will be -0.2 and according to the graph, 30% too low wind speed prediction at WTG site could be expected. This could lead to around 60%*) too low calculated energy production.

If the reference site is less rugged, e.g. RIX = 0, and the predicted site (WTG) are very rugged (e.g. RIX = 0.2), Delta RIX will be +0.2, and according to the graph, 30% too high wind speed prediction at WTG site could be expected. This could lead to around 60%*) too high calculated energy production.

*) Doubling of energy prediction error based on mean wind speed error is a rough conversion, which holds for wind speeds around 8 m/s. At 6-7 m/s tripling is more right, while only 1.5 factors should be used for 9 m/s, see graph below based on a typical WTG.



Source: EWEC06 paper:

IMPROVING WASP PREDICTIONS IN (TOO) COMPLEX TERRAIN

Niels G. Møller, Anthony J. Bowen and Ioannis Antoniou

WindPRO is developed by EMD International A/S, Niels Jernesvej 10, DK-9220 Ålborg Ø, Tlf. +45 96 35 44 44, Fax +45 96 35 44 46, e-mail: windpro@emd.dk

Wind Energy Department, Risø National Laboratory

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PARK - Time varying AEP**Calculation:** Park Calculation, Long Term Data, 2 PW 900

Windfarm: 1.8 MW based on 2 turbines of type PowerWind PowerWind 56 900 56.0 !O!.

Calculated mean yield per month and hour [MWh]. The result includes wake losses but no other losses.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%

Hour/Month [MWh]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	19	22	24	17	14	16	10	10	14	16	19	13	193
1	19	21	25	18	14	16	10	11	14	14	18	16	195
2	17	22	25	16	14	14	10	10	11	15	19	16	190
3	18	23	25	16	15	13	10	11	11	17	19	15	193
4	19	23	25	15	15	13	10	10	13	17	16	13	188
5	20	24	24	15	13	11	9	10	13	15	17	12	182
6	22	24	24	14	10	8	8	8	12	13	18	13	174
7	22	24	22	15	11	9	6	8	10	10	17	13	167
8	18	25	23	15	11	8	6	8	9	10	17	14	164
9	19	27	23	18	11	10	8	8	10	10	17	14	175
10	21	29	25	20	12	10	10	7	9	13	18	15	188
11	21	29	26	20	12	11	11	7	10	12	18	17	193
12	21	31	28	20	14	12	10	9	9	13	16	17	201
13	19	29	27	21	13	12	11	8	11	14	15	19	199
14	18	29	28	20	14	12	10	9	10	15	13	19	196
15	16	27	29	20	16	13	9	9	10	13	12	16	191
16	15	25	29	19	14	12	9	9	7	13	11	15	177
17	14	21	26	19	12	11	7	7	7	14	11	15	164
18	18	20	25	17	10	9	6	6	10	14	13	15	163
19	19	23	28	16	11	8	7	8	12	16	13	15	178
20	19	23	25	17	12	11	8	8	13	17	15	14	182
21	19	21	25	17	14	12	8	8	12	17	16	13	183
22	19	22	24	18	15	13	9	10	13	16	16	13	188
23	17	22	23	18	13	16	9	11	14	16	15	14	187
Grand Total	449	585	607	419	310	282	212	209	263	340	379	356	4,413

Hour/Month [MW]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	0.6	0.8	0.8	0.6	0.5	0.5	0.3	0.3	0.5	0.5	0.6	0.4	0.5
1	0.6	0.8	0.8	0.6	0.4	0.5	0.3	0.3	0.5	0.5	0.6	0.5	0.5
2	0.6	0.8	0.8	0.5	0.5	0.5	0.3	0.3	0.4	0.5	0.6	0.5	0.5
3	0.6	0.8	0.8	0.5	0.5	0.4	0.3	0.3	0.4	0.5	0.6	0.5	0.5
4	0.6	0.8	0.8	0.5	0.5	0.4	0.3	0.3	0.4	0.6	0.5	0.4	0.5
5	0.6	0.9	0.8	0.5	0.4	0.4	0.3	0.3	0.4	0.5	0.6	0.4	0.5
6	0.7	0.9	0.8	0.5	0.3	0.3	0.2	0.3	0.4	0.4	0.6	0.4	0.5
7	0.7	0.9	0.7	0.5	0.4	0.3	0.2	0.3	0.3	0.3	0.6	0.4	0.5
8	0.6	0.9	0.7	0.5	0.4	0.3	0.2	0.2	0.3	0.3	0.6	0.5	0.5
9	0.6	1.0	0.7	0.6	0.4	0.3	0.3	0.3	0.3	0.3	0.6	0.5	0.5
10	0.7	1.0	0.8	0.7	0.4	0.3	0.3	0.2	0.3	0.4	0.6	0.5	0.5
11	0.7	1.0	0.8	0.7	0.4	0.4	0.3	0.2	0.3	0.4	0.6	0.5	0.5
12	0.7	1.1	0.9	0.7	0.4	0.4	0.3	0.3	0.3	0.4	0.5	0.6	0.6
13	0.6	1.0	0.9	0.7	0.4	0.4	0.3	0.3	0.4	0.4	0.5	0.6	0.5
14	0.6	1.0	0.9	0.7	0.5	0.4	0.3	0.3	0.3	0.5	0.4	0.6	0.5
15	0.5	1.0	0.9	0.7	0.5	0.4	0.3	0.3	0.3	0.4	0.4	0.5	0.5
16	0.5	0.9	0.9	0.6	0.5	0.4	0.3	0.3	0.2	0.4	0.4	0.5	0.5
17	0.5	0.7	0.8	0.6	0.4	0.4	0.2	0.2	0.2	0.4	0.4	0.5	0.4
18	0.6	0.7	0.8	0.6	0.3	0.3	0.2	0.2	0.3	0.5	0.4	0.5	0.4
19	0.6	0.8	0.9	0.5	0.4	0.3	0.2	0.3	0.4	0.5	0.4	0.5	0.5
20	0.6	0.8	0.8	0.6	0.4	0.4	0.2	0.3	0.4	0.5	0.5	0.5	0.5
21	0.6	0.8	0.8	0.6	0.4	0.4	0.3	0.3	0.4	0.6	0.5	0.4	0.5
22	0.6	0.8	0.8	0.6	0.5	0.4	0.3	0.3	0.4	0.5	0.5	0.4	0.5
23	0.5	0.8	0.7	0.6	0.4	0.5	0.3	0.3	0.5	0.5	0.5	0.4	0.5
Grand Total	0.6	0.9	0.8	0.6	0.4	0.4	0.3	0.3	0.4	0.5	0.5	0.5	0.5

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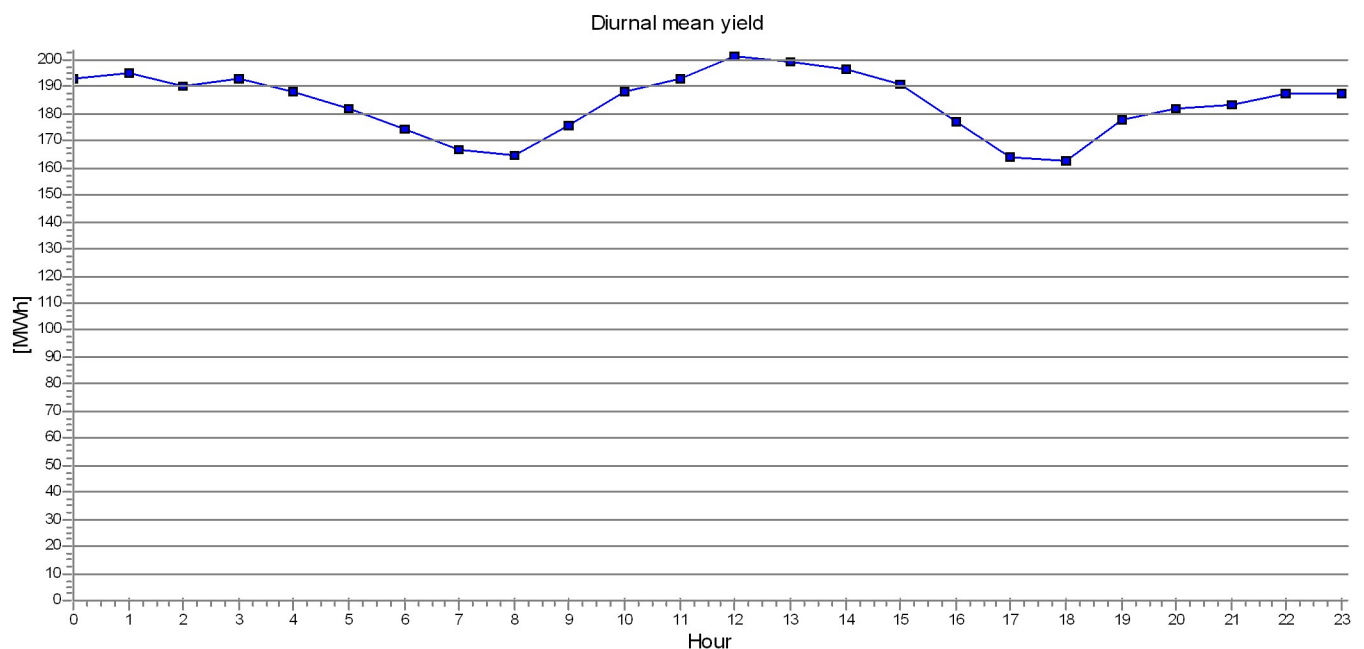
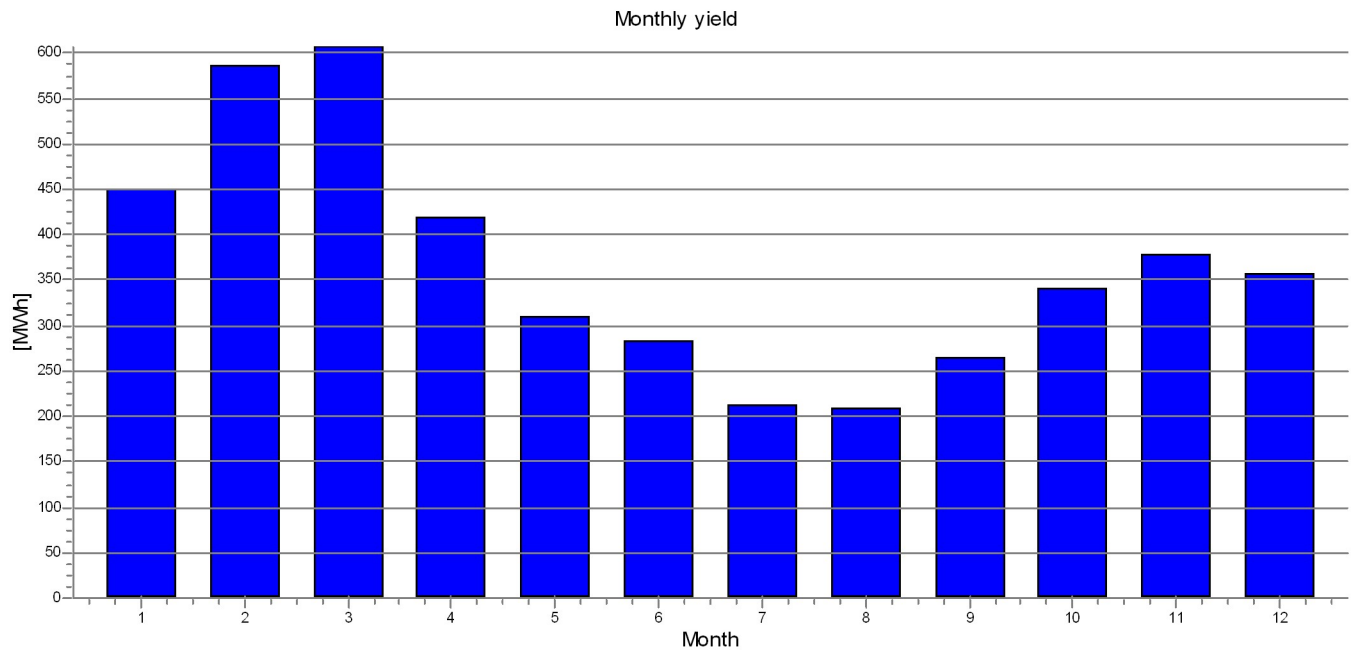
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PARK - Time varying AEP**Calculation:** Park Calculation, Long Term Data, 2 PW 900

Windfarm: 1.8 MW based on 2 turbines of type PowerWind PowerWind 56 900 56.0 !O!.

Calculated mean yield per month and hour [MWh]. The result includes wake losses but no other losses.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%



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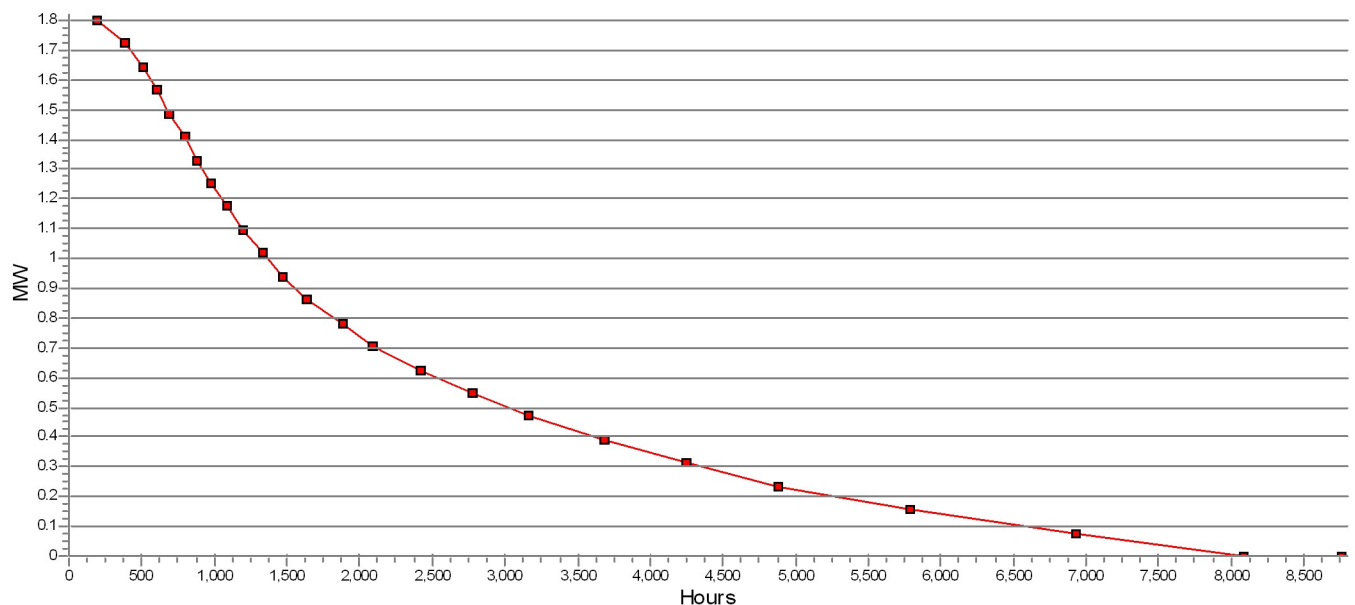
PARK - Time varying AEP**Calculation:** Park Calculation, Long Term Data, 2 PW 900

Windfarm: 1.8 MW based on 2 turbines of type PowerWind PowerWind 56 900 56.0 !O!.

Used wind distribution: . 1/22/2007 - 1/21/2008 (365 days), 10 minutes, 100%

Hours	Hours [%]	Hours accumulated	Rated power [MW]	Rated power (MW/WTG)
191	2.2	191	1.8	0.9
201	2.3	392	1.7 - 1.8	0.9 - 0.9
120	1.4	512	1.6 - 1.7	0.8 - 0.9
89	1.0	601	1.6 - 1.6	0.8 - 0.8
92	1.0	692	1.5 - 1.6	0.7 - 0.8
104	1.2	796	1.4 - 1.5	0.7 - 0.7
86	1.0	882	1.3 - 1.4	0.7 - 0.7
92	1.0	974	1.3 - 1.3	0.6 - 0.7
106	1.2	1080	1.2 - 1.3	0.6 - 0.6
121	1.4	1201	1.1 - 1.2	0.5 - 0.6
132	1.5	1333	1.0 - 1.1	0.5 - 0.5
143	1.6	1475	0.9 - 1.0	0.5 - 0.5
157	1.8	1632	0.9 - 0.9	0.4 - 0.5
254	2.9	1886	0.8 - 0.9	0.4 - 0.4
210	2.4	2096	0.7 - 0.8	0.4 - 0.4
331	3.8	2427	0.6 - 0.7	0.3 - 0.4
351	4.0	2777	0.5 - 0.6	0.3 - 0.3
380	4.3	3158	0.5 - 0.5	0.2 - 0.3
529	6.0	3686	0.4 - 0.5	0.2 - 0.2
556	6.3	4243	0.3 - 0.4	0.2 - 0.2
640	7.3	4882	0.2 - 0.3	0.1 - 0.2
902	10.3	5784	0.2 - 0.2	0.1 - 0.1
1145	13.1	6929	0.1 - 0.2	0.0 - 0.1
1162	13.3	8091	0.0 - 0.1	0.0 - 0.0
669	7.6	8760	0.0	0.0

Duration curve 1.8 MW WindFarm



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Loss&Uncertainty - Main result**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC**Main data for PARK**

PARK calculation 2.7.468: 80m Park Calculation, Long Term Data,

Count	1
Rated power	1.6 MW
Mean wind speed	6.8 m/s at hub height
Sensitivity	1.9 %AEP / %Mean Wind Speed
Expected lifetime	20 Years

RESULTS

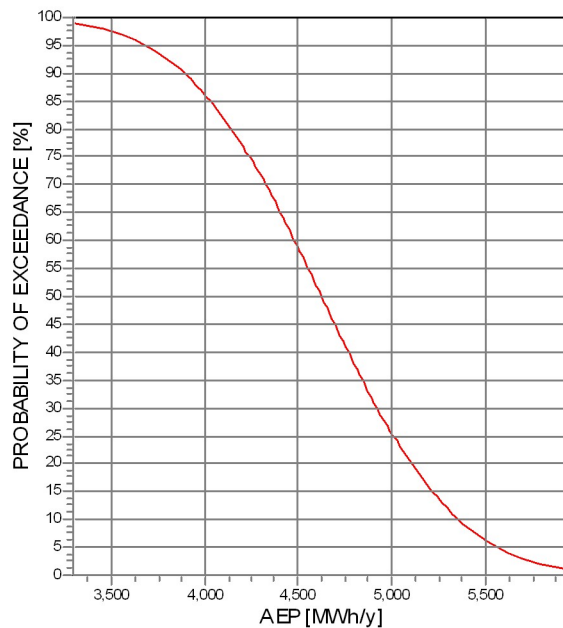
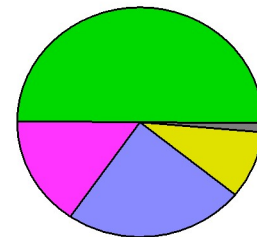
		P50	P84	P90
NET AEP	[MWh/y]	4,624	4,058	3,895
Capacity factor	[%]	32.0	28.1	26.9
Full load hours	[h/y]	2,802	2,460	2,361



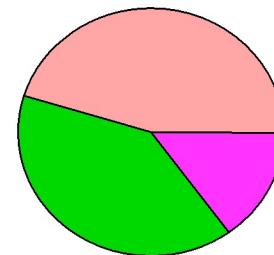
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Result details

	P50	Uncertainty
GROSS AEP *)	5,033 MWh/y	12.3 %
Bias correction	0 MWh/y	0.0 %
Loss correction	-409 MWh/y	-8.1 %
Wake loss	0.0 %	
Other losses	-8.1 %	
NET AEP	4,624 MWh/y	12.3 %

**Loss: 8.1 %**

1. Wake effects	0.0 %	2. Availability	4.2 %
3. Turbine performance	1.3 %	4. Electrical	2.0 %
5. Environmental	0.8 %	6. Curtailment	0.1 %
7. Other	0.0 %		

Uncertainty: 12.3 %

A. Wind data	8.9 %	B. Wind model	7.9 %
C. Power conversion	3.0 %	D. BIAS	0.0 %
E. LOSS	0.0 %		

*) Calculated Annual Energy Production before any bias or loss corrections

Assumptions: Uncertainty and percentiles (PXX values) are calculated for the expected lifetime

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Loss&Uncertainty - Assumptions and results**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC**ASSUMPTIONS**

LOSS		Method *)	Loss [%]	Loss [MWh/y]	Std dev**) [%]	Comment
1.	Wake effects					
	Wake effects, all WTGs	Calculation	0.0	0	0.0	
2.	Availability					
	Turbine availability	Estimate	3.0	151	0.0	Downtime due to turbine service
	Balance of plant (Substation)	Estimate	0.2	10	0.0	Substation Maintenance
	Grid availability	Estimate	1.0	50	0.0	Grid unavailable, external circumstance
3.	Turbine performance					
	High wind hysteresis	Calculation	1.3	65	0.0	Required restart after high-wind cut-out
4.	Electrical					
	Electrical losses	Estimate	2.0	101	0.0	Transformer and line losses
5.	Environmental					
	Performance degradation due to icing	Estimate	0.8	40	0.0	Ice accumulation on blades
6.	Curtailment					
	Grid curtailment and ramp-rate	Estimate	0.1	5	0.0	Power outage during low wind (requires restart)
7.	Other					No input
	LOSS, total		8.1	409	0.0	
UNCERTAINTY		Method *)	Std dev, wind speed [%]	Std dev, AEP [%]	Comment	
A.	Wind data					
	Wind measurement/Wind data	Estimate	2.5	4.9	Average Std. dev of wind speed over 12 sectors. Calculated in MCP	
	Long term correction	Estimate	3.0	5.8	Typical value for mid-quality reference data	
	Year-to-year variability	Estimate	9.9	19.2	Variability of long term data. Calculated in MCP	
	Future climate	Estimate	1.0	1.9	Typical value for low climate uncertainty	
	Other wind related					
B.	Wind model					
	Vertical extrapolation	Calculation	3.1	6.0	Recommended incremental value for complex terrain	
	Horizontal extrapolation	Calculation	2.6	5.1	Recommended incremental value for complex terrain	
	Other wind model related					
C.	Power conversion					
	Power curve uncertainty	Estimate		3.0	Typical value for manufacturers power curve	
	Metering uncertainty					
	Other AEP related uncertainties					
D.	BIAS, total uncertainty			0.0		
E.	LOSS, total uncertainty			0.0		
	UNCERTAINTY, total (1y average)			22.4		
	UNCERTAINTY, total (20y average)			12.3		

VARIABILITY

Years	Variability (std dev)	Total std dev
1	19.25	22.4
5	8.61	14.4
10	6.09	13.0
20	4.30	12.3

Comment

Wind measurement/Wind data

Average Std. dev of wind speed over 12 sectors. Calculated in MCP

Long term correction

Typical value for mid-quality reference data

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Loss&Uncertainty - Assumptions and results**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC

Year-to-year variability

Variability of long term data. Calculated in MCP

Future climate

Typical value for low climate uncertainty

Vertical extrapolation

Recommended incremental value for complex terrain

Horizontal extrapolation

Recommended incremental value for complex terrain

Power curve uncertainty

Typical value for manufacturers power curve

Turbine availability

Downtime due to turbine service

Balance of plant (Substation)

Substation Maintenance

Grid availability

Grid unavailable, external circumstance

High wind hysteresis

Required restart after high-wind cut-out

Electrical losses

Transformer and line losses

Performance degradation due to icing

Ice accumulation on blades

Grid curtailment and ramp-rate

Power outage during low wind (requires restart)

RESULTS**AEP versus exceedance level / time horizon**

PXX	1 y	5 y	10 y	20 y
[%]	[MWh/y]	[MWh/y]	[MWh/y]	[MWh/y]
50	4,624	4,624	4,624	4,624
75	3,924	4,175	4,217	4,240
84	3,592	3,962	4,025	4,058
90	3,294	3,771	3,852	3,895
95	2,918	3,530	3,633	3,688

*) Calculation means that a calculation method available in the WindPRO software is used. This still typically involve a user judgement and user data where the quality of those decides the accuracy. If calculation method is used, the values will often be different from turbine to turbine, here the average is shown, but at page "WTG results" the individual turbine results are shown.

**) For totals the std dev refers to the full AEP, otherwise std dev refers to the bias or loss component which is a fraction of the total AEP.

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Loss&Uncertainty - WTG results**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC**Main data for PARK**

PARK calculation 2.7.468: 80m Park Calculation, Long Term Data, V82 GenPC

Count 1
 Rated power 1.6 MW
 Mean wind speed 6.8 m/s at hub height
 Sensitivity 1.9 %AEP / %Mean Wind Speed
 Expected lifetime 20 Years



Scale: 25,000

Expected AEP per WTG including bias, loss and uncertainty evaluation

Description	Calculated GROSS*) [MWh/y]	Bias [%]	Loss [%]	Unc. [%]	20 years averaging		
					P50 [MWh/y]	P84 [MWh/y]	P90 [MWh/y]
1 VESTAS V82-1650/900 1650-900 82.0 !O! hub: 80.0 m (1)	5,032.8	0.0	8.1	12.3	4,623.9	4,058.2	3,894.9
PARK	5,032.8	0.0	8.1	12.3	4,623.9	4,058.2	3,894.9

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Loss&Uncertainty - Vertical extrapolation**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC**Vertical extrapolation uncertainty**

WTG	Uncertainty input elevation difference [%/10m]	Uncertainty input height difference [%/10m]	Measure elevation [m a.s.l.]	Measure height [m a.g.l.]	Delta elevation [m]	Delta height [m]	Result (std dev AEP) [%]
Gardner WTG Vestas	1.00	1.00	369.0	49.0	-1.9	31.0	6.0

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Loss&Uncertainty - Horizontal extrapolation**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC**Horizontal extrapolation uncertainty**

WTG	Uncertainty input, distance [%/km]	Lower threshold value [km]	Upper threshold value [km]	Distance [km]	Result (std dev AEP) [%]
Gardner WTG Vestas	1.50	0.0	0.0	1.7	5.1

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Loss&Uncertainty - High wind hysteresis, Main**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC

Shown losses is the energy content below powercurve cut-out where the WTG is stopped.
All losses are scaled to represent a year if the data series used is longer or shorter.

Summary

WTG	Cut out events/year	Hysteris loss [MWh/y]	Percent of AEP [%]	
Gardner WTG Vestas	55	65	1.29	
TOTAL	55	65	1.29	
AVERAGE	55	65		

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Loss&Uncertainty - High wind hysteresis, Detail**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC

Shown losses is the energy content below powercurve cut-out where the WTG is stopped.

Note that all hysteresis losses in MWh are calculated for the full time series. The losses in per cent in the Main report are scaled to represent one year if the length of the data series deviates from a year.

WTG: VESTAS V82-1650/900 1650-900 82.0 !O! hub: 80.0 m (1) in layer: Vestas

Cut out time	Cut in time	Total duration [min]	Duration below PC cut out [min]	Hysteris loss [MWh]
2/5/2007 10:36	2/5/2007 11:28	53	53	1.44
2/5/2007 12:49	2/5/2007 13:10	21	21	0.58
2/5/2007 13:13	2/5/2007 13:35	21	21	0.59
2/5/2007 13:46	2/5/2007 14:39	52	52	1.44
2/5/2007 14:50	2/5/2007 16:16	86	84	2.32
2/8/2007 13:59	2/8/2007 14:10	12	12	0.32
2/14/2007 22:25	2/14/2007 22:37	12	12	0.33
2/15/2007 00:06	2/15/2007 01:17	71	71	1.94
2/15/2007 01:58	2/15/2007 02:17	19	19	0.53
2/15/2007 05:37	2/15/2007 05:49	13	13	0.35
2/15/2007 07:39	2/15/2007 09:00	80	80	2.21
2/15/2007 09:09	2/15/2007 09:19	10	10	0.28
2/15/2007 09:25	2/15/2007 12:34	189	189	5.20
2/15/2007 12:47	2/15/2007 13:57	70	70	1.92
2/15/2007 14:08	2/15/2007 14:18	10	10	0.28
2/15/2007 14:48	2/15/2007 15:38	50	50	1.38
2/15/2007 16:17	2/15/2007 18:14	118	92	2.53
2/15/2007 18:43	2/15/2007 18:56	13	13	0.36
2/16/2007 09:39	2/16/2007 09:49	10	10	0.28
2/16/2007 10:45	2/16/2007 12:00	76	76	2.08
2/16/2007 12:06	2/16/2007 13:23	77	77	2.11
2/16/2007 16:06	2/16/2007 16:19	12	12	0.34
2/19/2007 05:12	2/19/2007 05:29	17	17	0.46
2/19/2007 10:19	2/19/2007 10:29	10	10	0.28
2/23/2007 12:49	2/23/2007 13:15	26	26	0.72
2/23/2007 19:25	2/23/2007 19:49	24	24	0.66
2/23/2007 21:32	2/24/2007 00:16	165	165	4.53
2/24/2007 01:27	2/24/2007 01:38	11	11	0.30
3/5/2007 15:27	3/5/2007 15:37	10	10	0.28
3/5/2007 16:42	3/5/2007 18:06	83	83	2.29
3/6/2007 02:56	3/6/2007 03:13	16	16	0.45
3/6/2007 03:36	3/6/2007 04:28	52	52	1.42
3/6/2007 05:36	3/6/2007 05:49	13	13	0.36
3/6/2007 09:20	3/6/2007 09:35	15	15	0.40
3/6/2007 10:26	3/6/2007 11:50	84	73	2.01
3/6/2007 11:56	3/6/2007 13:30	94	94	2.58
3/6/2007 13:41	3/6/2007 14:46	65	65	1.78
3/6/2007 14:57	3/6/2007 15:09	13	13	0.35
3/8/2007 14:14	3/8/2007 15:03	49	49	1.34
3/16/2007 23:47	3/17/2007 00:05	18	18	0.50
4/16/2007 02:03	4/16/2007 02:20	16	16	0.44
4/16/2007 02:48	4/16/2007 03:08	20	20	0.54
4/16/2007 04:02	4/16/2007 06:37	155	155	4.26
7/6/2007 13:47	7/6/2007 13:58	11	11	0.31
9/8/2007 15:46	9/8/2007 15:56	10	10	0.28
10/23/2007 12:16	10/23/2007 12:49	33	33	0.90
10/24/2007 06:46	10/24/2007 07:19	33	33	0.90
11/16/2007 14:16	11/16/2007 14:26	11	11	0.29
11/30/2007 00:28	11/30/2007 00:57	29	29	0.81
12/1/2007 09:32	12/1/2007 10:20	48	48	1.31
12/1/2007 10:24	12/1/2007 10:53	29	29	0.81

To be continued on next page...

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Loss&Uncertainty - High wind hysteresis, Detail**Calculation:** 80m Park Calculation, Long Term Data, V82 GenPC*...continued from previous page*

Cut out time	Cut in time	Total duration [min]	Duration below PC cut out [min]	Hysteris loss [MWh]
12/3/2007 21:12	12/3/2007 22:00	48	48	1.31
12/3/2007 22:04	12/3/2007 22:33	29	29	0.81
1/9/2008 13:38	1/9/2008 13:48	10	10	0.28
1/9/2008 21:23	1/9/2008 22:49	85	82	2.24

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Loss&Uncertainty - Main result**Calculation:** Park Calculation, Long Term Data, FL 1500**Main data for PARK**

PARK calculation 2.7.468: Park Calculation, Long Term Data, FL

Count

1

Rated power 1.5 MW

Mean wind speed 6.3 m/s at hub height

Sensitivity 2.3 %AEP / %Mean Wind Speed

Expected lifetime 20 Years

RESULTS

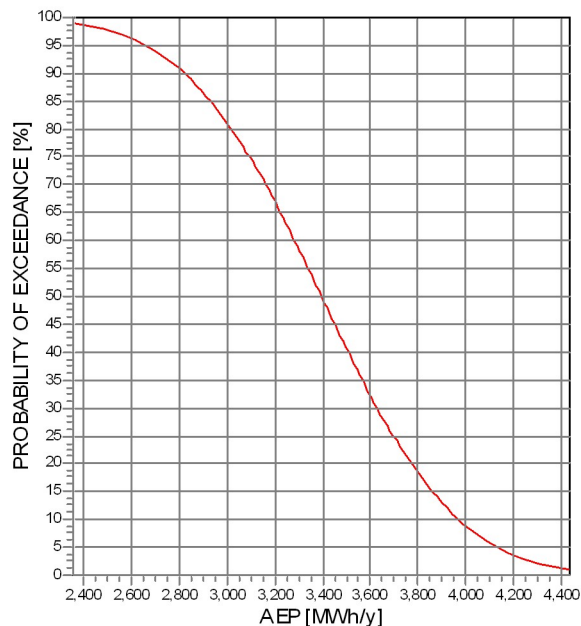
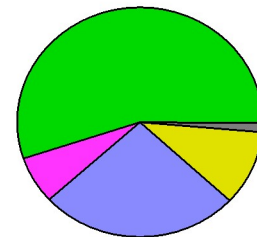
		P50	P84	P90
NET AEP	[MWh/y]	3,395	2,951	2,823
Capacity factor	[%]	25.8	22.5	21.5
Full load hours	[h/y]	2,264	1,967	1,882



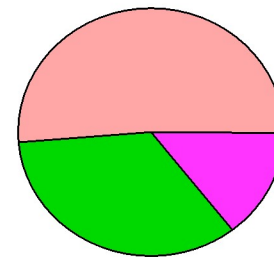
Scale: 25,000

Result details

	P50	Uncertainty
GROSS AEP *)	3,666 MWh/y	13.2 %
Bias correction	0 MWh/y	0.0 %
Loss correction	-271 MWh/y	-7.4 %
Wake loss	0.0 %	
Other losses	-7.4 %	
NET AEP	3,395 MWh/y	13.2 %

**Loss: 7.4 %**

1. Wake effects	0.0 %	2. Availability	4.2 %
3. Turbine performance	0.5 %	4. Electrical	2.0 %
5. Environmental	0.8 %	6. Curtailment	0.1 %
7. Other	0.0 %		

Uncertainty: 13.2 %

A. Wind data	10.6 %	B. Wind model	7.1 %
C. Power conversion	3.0 %	D. BIAS	0.0 %
E. LOSS	0.0 %		

*) Calculated Annual Energy Production before any bias or loss corrections

Assumptions: Uncertainty and percentiles (PXX values) are calculated for the expected lifetime

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Loss&Uncertainty - Assumptions and results**Calculation:** Park Calculation, Long Term Data, FL 1500**ASSUMPTIONS**

LOSS		Method *)	Loss [%]	Loss [MWh/y]	Std dev**) [%]	Comment
1.	Wake effects					
	Wake effects, all WTGs	Calculation	0.0	0	0.0	
2.	Availability					
	Turbine availability	Estimate	3.0	110	0.0	Downtime due to turbine service
	Balance of plant (Substation)	Estimate	0.2	7	0.0	Substation Maintenance
	Grid availability	Estimate	1.0	37	0.0	Grid unavailable, external circumstance
3.	Turbine performance					
	High wind hysteresis	Calculation	0.5	18	0.0	Required restart after high-wind cut-out
4.	Electrical					
	Electrical losses	Estimate	2.0	73	0.0	Transformer and line losses
5.	Environmental					
	Performance degradation due to icing	Estimate	0.8	29	0.0	Ice accumulation on blades
6.	Curtailment					
	Grid curtailment and ramp-rate	Estimate	0.1	4	0.0	Power outage during low wind (requires restart)
7.	Other					No input
	LOSS, total		7.4	271	0.0	
UNCERTAINTY		Method *)	Std dev, wind speed [%]	Std dev, AEP [%]	Comment	
A.	Wind data					
	Wind measurement/Wind data	Estimate	2.5	5.8	Average Std. dev of wind speed over 12 sectors. Calculated in MCP	
	Long term correction	Estimate	3.0	6.9	Typical value for mid-quality reference data	
	Year-to-year variability	Estimate	9.9	22.9	Variability of long term data. Calculated in MCP	
	Future climate	Estimate	1.0	2.3	Typical value for low climate uncertainty	
	Other wind related					
B.	Wind model					
	Vertical extrapolation	Calculation	1.6	3.7	Recommended incremental value for complex terrain	
	Horizontal extrapolation	Calculation	2.6	6.1	Recommended incremental value for complex terrain	
	Other wind model related					
C.	Power conversion					
	Power curve uncertainty	Estimate		3.0	Typical value for manufacturer power curve	
	Metering uncertainty					
	Other AEP related uncertainties					
D.	BIAS, total uncertainty			0.0		
E.	LOSS, total uncertainty			0.0		
	UNCERTAINTY, total (1y average)			25.9		
	UNCERTAINTY, total (20y average)			13.2		

VARIABILITY

Years	Variability (std dev)	Total std dev
1	22.88	25.9
5	10.23	15.9
10	7.23	14.1
20	5.12	13.2

Comment

Wind measurement/Wind data

Average Std. dev of wind speed over 12 sectors. Calculated in MCP

Long term correction

Typical value for mid-quality reference data

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Loss&Uncertainty - Assumptions and results**Calculation:** Park Calculation, Long Term Data, FL 1500

Year-to-year variability

Variability of long term data. Calculated in MCP

Future climate

Typical value for low climate uncertainty

Vertical extrapolation

Recommended incremental value for complex terrain

Horizontal extrapolation

Recommended incremental value for complex terrain

Power curve uncertainty

Typical value for manufacturer power curve

Turbine availability

Downtime due to turbine service

Balance of plant (Substation)

Substation Maintenance

Grid availability

Grid unavailable, external circumstance

High wind hysteresis

Required restart after high-wind cut-out

Electrical losses

Transformer and line losses

Performance degradation due to icing

Ice accumulation on blades

Grid curtailment and ramp-rate

Power outage during low wind (requires restart)

RESULTS**AEP versus exceedance level / time horizon**

PXX	1 y	5 y	10 y	20 y
[%]	[MWh/y]	[MWh/y]	[MWh/y]	[MWh/y]
50	3,395	3,395	3,395	3,395
75	2,802	3,032	3,072	3,094
84	2,521	2,860	2,919	2,951
90	2,269	2,705	2,781	2,823
95	1,949	2,510	2,607	2,661

*) Calculation means that a calculation method available in the WindPRO software is used. This still typically involve a user judgement and user data where the quality of those decides the accuracy. If calculation method is used, the values will often be different from turbine to turbine, here the average is shown, but at page "WTG results" the individual turbine results are shown.

**) For totals the std dev refers to the full AEP, otherwise std dev refers to the bias or loss component which is a fraction of the total AEP.

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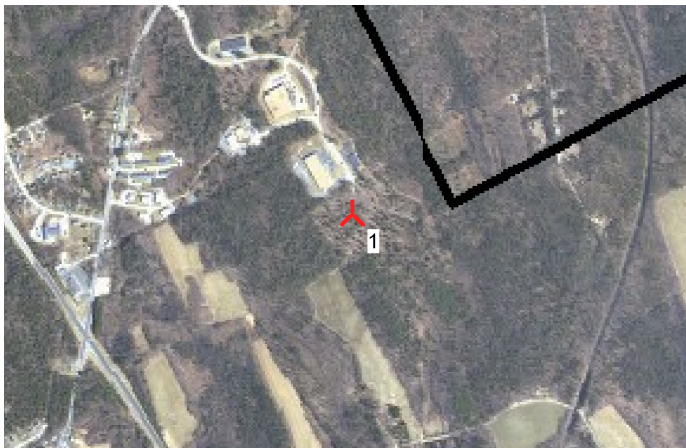
Loss&Uncertainty - WTG results

Calculation: Park Calculation, Long Term Data, FL 1500

Main data for PARK

PARK calculation 2.7.468: Park Calculation, Long Term Data, FL 1500

Count 1
 Rated power 1.5 MW
 Mean wind speed 6.3 m/s at hub height
 Sensitivity 2.3 %AEP / %Mean Wind Speed
 Expected lifetime 20 Years



Scale: 25,000

Expected AEP per WTG including bias, loss and uncertainty evaluation

Description	User label	Calculated GROSS*) [MWh/y]	Bias [%]	Loss [%]	20 years averaging			
					Unc. [%]	P50 [MWh/y]	P84 [MWh/y]	P90 [MWh/y]
1 FUHLRLÄNDER FL 1500-77 1500 77.0 !-! hub: 65.0 m (6)	FL 1500	3,666.2	0.0	7.4	13.2	3,395.4	2,951.1	2,822.9
PARK		3,666.2	0.0	7.4	13.2	3,395.4	2,951.1	2,822.9

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Loss&Uncertainty - Vertical extrapolation**Calculation:** Park Calculation, Long Term Data, FL 1500**Vertical extrapolation uncertainty**

WTG	Uncertainty input elevation difference [%/10m]	Uncertainty input height difference [%/10m]	Measure elevation [m a.s.l.]	Measure height [m a.g.l.]	Delta elevation [m]	Delta height [m]	Result (std dev AEP) [%]
FL 1500	1.00	1.00	369.6	49.0	-2.5	16.0	3.7

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Loss&Uncertainty - Horizontal extrapolation

Calculation: Park Calculation, Long Term Data, FL 1500

Horizontal extrapolation uncertainty

WTG	Uncertainty input, distance [%/km]	Lower threshold value [km]	Upper threshold value [km]	Distance [km]	Result (std dev AEP) [%]
FL 1500	1.50	0.0	0.0	1.8	6.1

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Loss&Uncertainty - High wind hysteresis, Main**Calculation:** Park Calculation, Long Term Data, FL 1500

Shown losses is the energy content below powercurve cut-out where the WTG is stopped.
All losses are scaled to represent a year if the data series used is longer or shorter.

Summary

WTG	Cut out events/year	Hysteris loss [MWh/y]	Percent of AEP [%]
FL 1500	27	18	0.50
TOTAL	27	18	0.50
AVERAGE	27	18	

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Loss&Uncertainty - High wind hysteresis, Detail**Calculation:** Park Calculation, Long Term Data, FL 1500

Shown losses is the energy content below powercurve cut-out where the WTG is stopped.

Note that all hysteresis losses in MWh are calculated for the full time series. The losses in per cent in the Main report are scaled to represent one year if the length of the data series deviates from a year.

WTG: FUHRLÄNDER FL 1500-77 1500 77.0 !-! hub: 65.0 m (6) in layer: FL 1500

Cut out time	Cut in time	Total duration [min]	Duration below PC cut out [min]	Hysteris loss [MWh]
2/5/2007 13:16	2/5/2007 13:32	15	15	0.38
2/5/2007 13:49	2/5/2007 14:35	46	46	1.14
2/5/2007 14:57	2/5/2007 15:49	52	52	1.30
2/5/2007 15:56	2/5/2007 16:12	16	16	0.40
2/15/2007 07:49	2/15/2007 08:56	66	66	1.65
2/15/2007 10:23	2/15/2007 11:07	44	44	1.09
2/15/2007 13:28	2/15/2007 13:43	16	16	0.39
2/15/2007 16:27	2/15/2007 17:23	56	56	1.41
2/16/2007 12:38	2/16/2007 12:50	12	12	0.30
2/16/2007 16:09	2/16/2007 16:19	10	10	0.25
2/23/2007 19:34	2/23/2007 19:46	13	13	0.32
2/23/2007 22:56	2/23/2007 23:23	27	27	0.69
3/5/2007 16:49	3/5/2007 17:03	14	14	0.35
3/6/2007 04:19	3/6/2007 04:29	10	10	0.25
3/6/2007 10:32	3/6/2007 11:05	34	34	0.84
3/6/2007 11:39	3/6/2007 11:49	10	10	0.25
3/6/2007 12:04	3/6/2007 12:30	26	26	0.65
3/6/2007 12:47	3/6/2007 13:25	38	38	0.95
3/6/2007 13:51	3/6/2007 14:41	49	49	1.23
3/8/2007 14:17	3/8/2007 14:34	16	16	0.41
7/6/2007 13:48	7/6/2007 13:58	10	10	0.25
9/8/2007 15:48	9/8/2007 15:58	10	10	0.25
12/1/2007 09:36	12/1/2007 10:16	40	40	1.00
12/1/2007 10:27	12/1/2007 10:39	12	12	0.30
12/3/2007 21:16	12/3/2007 21:56	40	40	1.00
12/3/2007 22:07	12/3/2007 22:19	12	12	0.30
1/9/2008 22:05	1/9/2008 22:45	40	40	0.99

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Loss&Uncertainty - Main result**Calculation:** 80m Park Calculation, Long Term Data, GE1.5**Main data for PARK**

PARK calculation 2.7.468: 80m Park Calculation, Long Term Data

Count 1
 Rated power 1.5 MW
 Mean wind speed 6.8 m/s at hub height
 Sensitivity 2.0 %AEP / %Mean Wind Speed
 Expected lifetime 20 Years

RESULTS

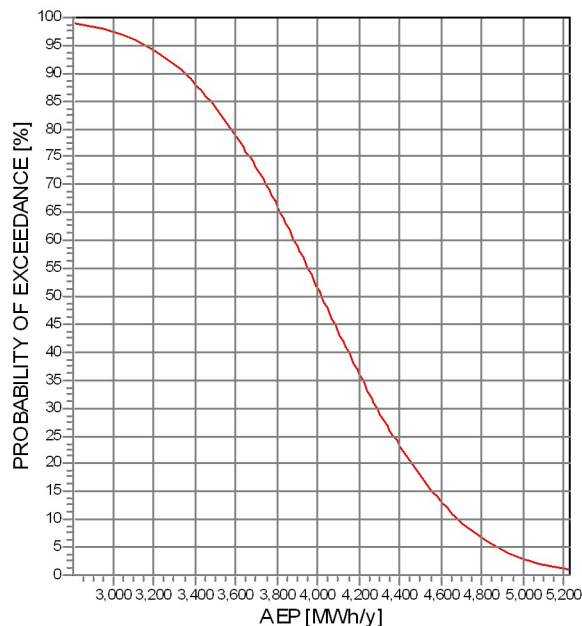
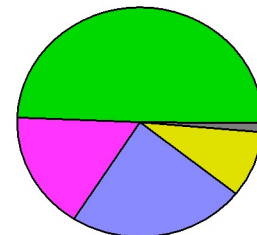
		P50	P84	P90
NET AEP	[MWh/y]	4,016	3,500	3,351
Capacity factor	[%]	30.6	26.6	25.5
Full load hours	[h/y]	2,678	2,333	2,234



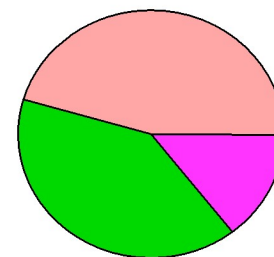
Scale: 25,000

Result details

	P50	Uncertainty
GROSS AEP *)	4,375 MWh/y	12.9 %
Bias correction	0 MWh/y	0.0 %
Loss correction	-359 MWh/y	-8.2 %
Wake loss	0.0 %	
Other losses	-8.2 %	
NET AEP	4,016 MWh/y	12.9 %

**Loss: 8.2 %**

1. Wake effects	0.0 %	2. Availability	4.2 %
3. Turbine performance	1.4 %	4. Electrical	2.0 %
5. Environmental	0.8 %	6. Curtailment	0.1 %
7. Other	0.0 %		

Uncertainty: 12.9 %

A. Wind data	9.4 %	B. Wind model	8.3 %
C. Power conversion	3.0 %	D. BIAS	0.0 %
E. LOSS	0.0 %		

*) Calculated Annual Energy Production before any bias or loss corrections

Assumptions: Uncertainty and percentiles (PXX values) are calculated for the expected lifetime

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Loss&Uncertainty - Assumptions and results**Calculation:** 80m Park Calculation, Long Term Data, GE1.5**ASSUMPTIONS**

LOSS		Method *)	Loss [%]	Loss [MWh/y]	Std dev**) [%]	Comment
1.	Wake effects					
	Wake effects, all WTGs	Calculation	0.0	0	0.0	
2.	Availability					
	Turbine availability	Estimate	3.0	131	0.0	Downtime due to turbine service
	Balance of plant (Substation)	Estimate	0.2	9	0.0	Substation Maintenance
	Grid availability	Estimate	1.0	44	0.0	Grid unavailable, external circumstance
3.	Turbine performance					
	High wind hysteresis	Calculation	1.4	60	0.0	Required restart after high-wind cut-out
4.	Electrical					
	Electrical losses	Estimate	2.0	88	0.0	Transformer and line losses
5.	Environmental					
	Performance degradation due to icing	Estimate	0.8	35	0.0	Ice accumulation on blades
6.	Curtailment					
	Grid curtailment and ramp-rate	Estimate	0.1	4	0.0	Power outage during low wind (requires restart)
7.	Other					No input
	LOSS, total		8.2	359	0.0	
UNCERTAINTY		Method *)	Std dev, wind speed [%]	Std dev, AEP [%]	Comment	
A.	Wind data					
	Wind measurement/Wind data	Estimate	2.5	5.1	Average Std. dev of wind speed over 12 sectors. Calculated in MCP	
	Long term correction	Estimate	3.0	6.1	Typical value for mid-quality reference data	
	Year-to-year variability	Estimate	9.9	20.3	Variability of long term data. Calculated in MCP	
	Future climate	Estimate	1.0	2.0	Typical value for low climate uncertainty	
	Other wind related					
B.	Wind model					
	Vertical extrapolation	Calculation	3.1	6.4	Recommended incremental value for complex terrain	
	Horizontal extrapolation	Calculation	2.6	5.4	Recommended incremental value for complex terrain	
	Other wind model related					
C.	Power conversion					
	Power curve uncertainty	Estimate		3.0	Typical value for manufacturers power curve	
	Metering uncertainty					
	Other AEP related uncertainties					
D.	BIAS, total uncertainty			0.0		
E.	LOSS, total uncertainty			0.0		
	UNCERTAINTY, total (1y average)			23.6		
	UNCERTAINTY, total (20y average)			12.9		

VARIABILITY

Years	Variability (std dev)	Total std dev
1	20.27	23.6
5	9.06	15.1
10	6.41	13.7
20	4.53	12.9

Comment

Wind measurement/Wind data

Average Std. dev of wind speed over 12 sectors. Calculated in MCP

Long term correction

Typical value for mid-quality reference data

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Loss&Uncertainty - Assumptions and results**Calculation:** 80m Park Calculation, Long Term Data, GE1.5

Year-to-year variability

Variability of long term data. Calculated in MCP

Future climate

Typical value for low climate uncertainty

Vertical extrapolation

Recommended incremental value for complex terrain

Horizontal extrapolation

Recommended incremental value for complex terrain

Power curve uncertainty

Typical value for manufacturers power curve

Turbine availability

Downtime due to turbine service

Balance of plant (Substation)

Substation Maintenance

Grid availability

Grid unavailable, external circumstance

High wind hysteresis

Required restart after high-wind cut-out

Electrical losses

Transformer and line losses

Performance degradation due to icing

Ice accumulation on blades

Grid curtailment and ramp-rate

Power outage during low wind (requires restart)

RESULTS**AEP versus exceedance level / time horizon**

PXX	1 y	5 y	10 y	20 y
[%]	[MWh/y]	[MWh/y]	[MWh/y]	[MWh/y]
50	4,016	4,016	4,016	4,016
75	3,377	3,606	3,645	3,666
84	3,073	3,412	3,469	3,500
90	2,801	3,238	3,311	3,351
95	2,456	3,017	3,111	3,162

*) Calculation means that a calculation method available in the WindPRO software is used. This still typically involve a user judgement and user data where the quality of those decides the accuracy. If calculation method is used, the values will often be different from turbine to turbine, here the average is shown, but at page "WTG results" the individual turbine results are shown.

**) For totals the std dev refers to the full AEP, otherwise std dev refers to the bias or loss component which is a fraction of the total AEP.

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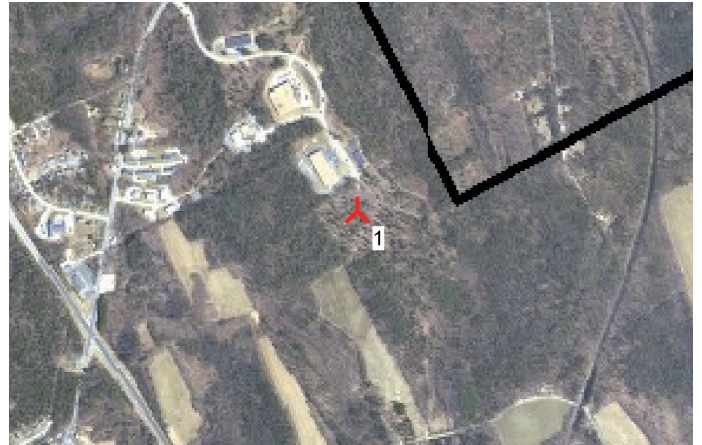
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Loss&Uncertainty - WTG results**Calculation:** 80m Park Calculation, Long Term Data, GE1.5**Main data for PARK**

PARK calculation 2.7.468: 80m Park Calculation, Long Term Data, GE1.5

Count 1
 Rated power 1.5 MW
 Mean wind speed 6.8 m/s at hub height
 Sensitivity 2.0 %AEP / %Mean Wind Speed
 Expected lifetime 20 Years



Scale: 25,000

Expected AEP per WTG including bias, loss and uncertainty evaluation

Description	Calculated GROSS*) [MWh/y]	Bias [%]	Loss [%]	20 years averaging			P90 [MWh/y]
				Unc. [%]	P50 [MWh/y]	P84 [MWh/y]	
1 GE WIND ENERGY GE 1.5sle 1500 77.0 !O! hub: 80.0 m (4)	4,375.2	0.0	8.2	12.9	4,016.3	3,499.7	3,350.5
PARK	4,375.2	0.0	8.2	12.9	4,016.3	3,499.7	3,350.5

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Loss&Uncertainty - Vertical extrapolation**Calculation:** 80m Park Calculation, Long Term Data, GE1.5**Vertical extrapolation uncertainty**

WTG	Uncertainty input elevation difference [%/10m]	Uncertainty input height difference [%/10m]	Measure elevation [m a.s.l.]	Measure height [m a.g.l.]	Delta elevation [m]	Delta height [m]	Result (std dev AEP) [%]
Gardner WTG GE1.5	1.00	1.00	369.6	49.0	-2.5	31.0	6.4

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Loss&Uncertainty - Horizontal extrapolation**Calculation:** 80m Park Calculation, Long Term Data, GE1.5**Horizontal extrapolation uncertainty**

WTG	Uncertainty input, distance [%/km]	Lower threshold value [km]	Upper threshold value [km]	Distance [km]	Result (std dev AEP) [%]
Gardner WTG GE1.5	1.50	0.0	0.0	1.8	5.4

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Loss&Uncertainty - High wind hysteresis, Main**Calculation:** 80m Park Calculation, Long Term Data, GE1.5

Shown losses is the energy content below powercurve cut-out where the WTG is stopped.
 All losses are scaled to represent a year if the data series used is longer or shorter.

Summary

WTG	Cut out events/year	Hysteris loss [MWh/y]	Percent of AEP [%]
Gardner WTG GE1.5	55	60	1.37
TOTAL	55	60	1.37
AVERAGE	55	60	

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Loss&Uncertainty - High wind hysteresis, Detail**Calculation:** 80m Park Calculation, Long Term Data, GE1.5

Shown losses is the energy content below powercurve cut-out where the WTG is stopped.

Note that all hysteresis losses in MWh are calculated for the full time series. The losses in per cent in the Main report are scaled to represent one year if the length of the data series deviates from a year.

WTG: GE WIND ENERGY GE 1.5sle 1500 77.0 !O! hub: 80.0 m (4) in layer: GE 1.5 WTG

Cut out time	Cut in time	Total duration [min]	Duration below PC cut out [min]	Hysteris loss [MWh]
2/5/2007 10:36	2/5/2007 11:28	53	53	1.31
2/5/2007 12:49	2/5/2007 13:10	21	21	0.53
2/5/2007 13:13	2/5/2007 13:35	21	21	0.54
2/5/2007 13:46	2/5/2007 14:39	52	52	1.31
2/5/2007 14:50	2/5/2007 16:16	86	86	2.15
2/8/2007 13:59	2/8/2007 14:10	12	12	0.29
2/14/2007 22:25	2/14/2007 22:37	12	12	0.30
2/15/2007 00:06	2/15/2007 01:17	71	71	1.77
2/15/2007 01:58	2/15/2007 02:17	19	19	0.48
2/15/2007 05:37	2/15/2007 05:49	13	13	0.32
2/15/2007 07:39	2/15/2007 09:00	80	80	2.01
2/15/2007 09:09	2/15/2007 09:19	10	10	0.25
2/15/2007 09:25	2/15/2007 12:34	189	189	4.73
2/15/2007 12:47	2/15/2007 13:57	70	70	1.75
2/15/2007 14:08	2/15/2007 14:18	10	10	0.25
2/15/2007 14:48	2/15/2007 15:38	50	50	1.25
2/15/2007 16:17	2/15/2007 18:14	118	118	2.94
2/15/2007 18:43	2/15/2007 18:56	13	13	0.33
2/16/2007 09:39	2/16/2007 09:49	10	10	0.25
2/16/2007 10:45	2/16/2007 12:00	76	76	1.89
2/16/2007 12:06	2/16/2007 13:23	77	77	1.92
2/16/2007 16:06	2/16/2007 16:19	12	12	0.31
2/19/2007 05:12	2/19/2007 05:29	17	17	0.42
2/19/2007 10:19	2/19/2007 10:29	10	10	0.25
2/23/2007 12:49	2/23/2007 13:15	26	26	0.65
2/23/2007 19:25	2/23/2007 19:49	24	24	0.60
2/23/2007 21:32	2/24/2007 00:16	165	165	4.12
2/24/2007 01:27	2/24/2007 01:38	11	11	0.27
3/5/2007 15:27	3/5/2007 15:37	10	10	0.25
3/5/2007 16:42	3/5/2007 18:06	83	83	2.08
3/6/2007 02:56	3/6/2007 03:13	16	16	0.41
3/6/2007 03:36	3/6/2007 04:28	52	52	1.29
3/6/2007 05:36	3/6/2007 05:49	13	13	0.33
3/6/2007 09:20	3/6/2007 09:35	15	15	0.36
3/6/2007 10:26	3/6/2007 11:50	84	84	2.09
3/6/2007 11:56	3/6/2007 13:30	94	94	2.35
3/6/2007 13:41	3/6/2007 14:46	65	65	1.62
3/6/2007 14:57	3/6/2007 15:09	13	13	0.31
3/8/2007 14:14	3/8/2007 15:03	49	49	1.22
3/16/2007 23:47	3/17/2007 00:05	18	18	0.46
4/16/2007 02:03	4/16/2007 02:20	16	16	0.40
4/16/2007 02:48	4/16/2007 03:08	20	20	0.49
4/16/2007 04:02	4/16/2007 06:37	155	155	3.87
7/6/2007 13:47	7/6/2007 13:58	11	11	0.28
9/8/2007 15:46	9/8/2007 15:56	10	10	0.25
10/23/2007 12:16	10/23/2007 12:49	33	33	0.82
10/24/2007 06:46	10/24/2007 07:19	33	33	0.82
11/16/2007 14:16	11/16/2007 14:26	11	11	0.27
11/30/2007 00:28	11/30/2007 00:57	29	29	0.73
12/1/2007 09:32	12/1/2007 10:20	48	48	1.19
12/1/2007 10:24	12/1/2007 10:53	29	29	0.74

To be continued on next page...

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Loss&Uncertainty - High wind hysteresis, Detail**Calculation:** 80m Park Calculation, Long Term Data, GE1.5*...continued from previous page*

Cut out time	Cut in time	Total duration [min]	Duration below PC cut out [min]	Hysteris loss [MWh]
12/3/2007 21:12	12/3/2007 22:00	48	48	1.19
12/3/2007 22:04	12/3/2007 22:33	29	29	0.74
1/9/2008 13:38	1/9/2008 13:48	10	10	0.25
1/9/2008 21:23	1/9/2008 22:49	85	85	2.13

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Loss&Uncertainty - Main result**Calculation:** Park Calculation, Long Term Data, PW 900**Main data for PARK**

PARK calculation 2.7.468: Park Calculation, Long Term Data, PV

Count 1
 Rated power 0.9 MW
 Mean wind speed 6.5 m/s at hub height
 Sensitivity 2.2 %AEP / %Mean Wind Speed
 Expected lifetime 20 Years

RESULTS

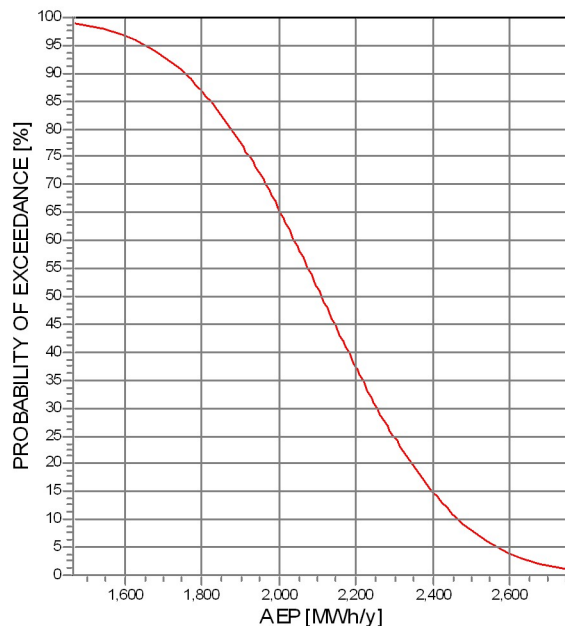
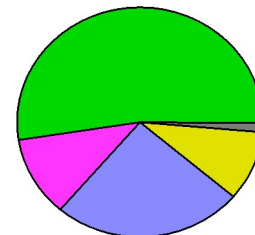
		P50	P84	P90
NET AEP	[MWh/y]	2,110	1,834	1,754
Capacity factor	[%]	26.8	23.3	22.3
Full load hours	[h/y]	2,345	2,038	1,949



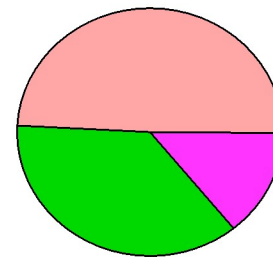
Scale: 25,000

Result details

	P50	Uncertainty
GROSS AEP *)	2,288 MWh/y	13.2 %
Bias correction	0 MWh/y	0.0 %
Loss correction	-177 MWh/y	-7.8 %
Wake loss	0.0 %	
Other losses	-7.8 %	
NET AEP	2,110 MWh/y	13.2 %

**Loss: 7.8 %**

1. Wake effects	0.0 %	2. Availability	4.2 %
3. Turbine performance	0.9 %	4. Electrical	2.0 %
5. Environmental	0.8 %	6. Curtailment	0.1 %
7. Other	0.0 %		

Uncertainty: 13.2 %

A. Wind data	10.3 %	B. Wind model	7.7 %
C. Power conversion	3.0 %	D. BIAS	0.0 %
E. LOSS	0.0 %		

*) Calculated Annual Energy Production before any bias or loss corrections

Assumptions: Uncertainty and percentiles (PXX values) are calculated for the expected lifetime

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Loss&Uncertainty - Assumptions and results**Calculation:** Park Calculation, Long Term Data, PW 900**ASSUMPTIONS**

LOSS		Method *)	Loss [%]	Loss [MWh/y]	Std dev**) [%]	Comment
1.	Wake effects					
	Wake effects, all WTGs	Calculation	0.0	0	0.0	
2.	Availability					
	Turbine availability	Estimate	3.0	69	0.0	Downtime due to turbine service
	Balance of plant (Substation)	Estimate	0.2	5	0.0	Substation Maintenance
	Grid availability	Estimate	1.0	23	0.0	Grid unavailable, external circumstance
3.	Turbine performance					
	High wind hysteresis	Calculation	0.9	21	0.0	Required restart after high-wind cut-out
4.	Electrical					
	Electrical losses	Estimate	2.0	46	0.0	Transformer and line losses
5.	Environmental					
	Performance degradation due to icing	Estimate	0.8	18	0.0	Ice accumulation on blades
6.	Curtailment					
	Grid curtailment and ramp-rate	Estimate	0.1	2	0.0	Power outage during low wind (requires restart)
7.	Other					No input
	LOSS, total		7.8	177	0.0	
UNCERTAINTY		Method *)	Std dev, wind speed [%]	Std dev, AEP [%]	Comment	
A.	Wind data					
	Wind measurement/Wind data	Estimate	2.5	5.6	Average Std. dev of wind speed over 12 sectors. Calculated in MCP	
	Long term correction	Estimate	3.0	6.7	Typical value for mid-quality long-term data	
	Year-to-year variability	Estimate	9.9	22.1	Variability of long term data. Calculated in MCP	
	Future climate	Estimate	1.0	2.2	Typical value for moderate climate uncertainty	
	Other wind related					
B.	Wind model					
	Vertical extrapolation	Calculation	2.2	4.9	Recommended incremental value for complex terrain	
	Horizontal extrapolation	Calculation	2.6	5.9	Recommended incremental value for complex terrain	
	Other wind model related					
C.	Power conversion					
	Power curve uncertainty	Estimate		3.0	Typical Value for manufacturers power curve	
	Metering uncertainty					
	Other AEP related uncertainties					
D.	BIAS, total uncertainty			0.0		
E.	LOSS, total uncertainty			0.0		
	UNCERTAINTY, total (1y average)			25.2		
	UNCERTAINTY, total (20y average)			13.2		

VARIABILITY

Years	Variability (std dev)	Total std dev
1	22.08	25.2
5	9.88	15.7
10	6.98	14.1
20	4.94	13.2

Comment

Wind measurement/Wind data

Average Std. dev of wind speed over 12 sectors. Calculated in MCP

Long term correction

Typical value for mid-quality long-term data

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Loss&Uncertainty - Assumptions and results**Calculation:** Park Calculation, Long Term Data, PW 900

Year-to-year variability

Variability of long term data. Calculated in MCP

Future climate

Typical value for moderate climate uncertainty

Vertical extrapolation

Recommended incremental value for complex terrain

Horizontal extrapolation

Recommended incremental value for complex terrain

Power curve uncertainty

Typical Value for manufacturers power curve

Turbine availability

Downtime due to turbine service

Balance of plant (Substation)

Substation Maintenance

Grid availability

Grid unavailable, external circumstance

High wind hysteresis

Required restart after high-wind cut-out

Electrical losses

Transformer and line losses

Performance degradation due to icing

Ice accumulation on blades

Grid curtailment and ramp-rate

Power outage during low wind (requires restart)

RESULTS**AEP versus exceedance level / time horizon**

PXX	1 y	5 y	10 y	20 y
[%]	[MWh/y]	[MWh/y]	[MWh/y]	[MWh/y]
50	2,110	2,110	2,110	2,110
75	1,751	1,887	1,910	1,923
84	1,581	1,781	1,815	1,834
90	1,428	1,686	1,730	1,754
95	1,235	1,566	1,622	1,653

*) Calculation means that a calculation method available in the WindPRO software is used. This still typically involve a user judgement and user data where the quality of those decides the accuracy. If calculation method is used, the values will often be different from turbine to turbine, here the average is shown, but at page "WTG results" the individual turbine results are shown.

**) For totals the std dev refers to the full AEP, otherwise std dev refers to the bias or loss component which is a fraction of the total AEP.

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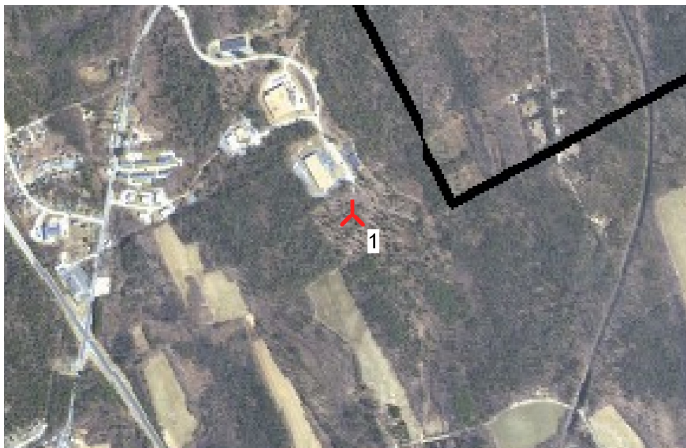
Loss&Uncertainty - WTG results

Calculation: Park Calculation, Long Term Data, PW 900

Main data for PARK

PARK calculation 2.7.468: Park Calculation, Long Term Data, PW 900

Count 1
 Rated power 0.9 MW
 Mean wind speed 6.5 m/s at hub height
 Sensitivity 2.2 %AEP / %Mean Wind Speed
 Expected lifetime 20 Years



Scale: 25,000

Expected AEP per WTG including bias, loss and uncertainty evaluation

Description	Calculated GROSS*) [MWh/y]	Bias [%]	Loss [%]	20 years averaging			
				Unc. [%]	P50 [MWh/y]	P84 [MWh/y]	P90 [MWh/y]
1 PowerWind PowerWind 56 900 56.0 !O! hub: 71.0 m (5)	2,287.8	0.0	7.8	13.2	2,110.3	1,834.1	1,754.4
PARK	2,287.8	0.0	7.8	13.2	2,110.3	1,834.1	1,754.4

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Loss&Uncertainty - Vertical extrapolation**Calculation:** Park Calculation, Long Term Data, PW 900**Vertical extrapolation uncertainty**

WTG	Uncertainty input elevation difference [%/10m]	Uncertainty input height difference [%/10m]	Measure elevation [m a.s.l.]	Measure height [m a.g.l.]	Delta elevation [m]	Delta height [m]	Result (std dev AEP) [%]
PowerWind 900	1.00	1.00	369.6	49.0	-2.5	22.0	4.9

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Loss&Uncertainty - Horizontal extrapolation**Calculation:** Park Calculation, Long Term Data, PW 900**Horizontal extrapolation uncertainty**

WTG	Uncertainty input, distance [%/km]	Lower threshold value [km]	Upper threshold value [km]	Distance [km]	Result (std dev AEP) [%]
PowerWind 900	1.50	0.0	0.0	1.8	5.9

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Loss&Uncertainty - High wind hysteresis, Main**Calculation:** Park Calculation, Long Term Data, PW 900

Shown losses is the energy content below powercurve cut-out where the WTG is stopped.
All losses are scaled to represent a year if the data series used is longer or shorter.

Summary

WTG	Cut out events/year	Hysteris loss [MWh/y]	Percent of AEP [%]
PowerWind 900	35	21	0.90
TOTAL	35	21	0.90
AVERAGE	35	21	

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Loss&Uncertainty - High wind hysteresis, Detail**Calculation:** Park Calculation, Long Term Data, PW 900

Shown losses is the energy content below powercurve cut-out where the WTG is stopped.

Note that all hysteresis losses in MWh are calculated for the full time series. The losses in per cent in the Main report are scaled to represent one year if the length of the data series deviates from a year.

WTG: PowerWind PowerWind 56 900 56.0 !O! hub: 71.0 m (5) in layer: Single PowerWind

Cut out time	Cut in time	Total duration [min]	Duration below PC cut out [min]	Hysteris loss [MWh]
2/5/2007 12:58	2/5/2007 13:08	10	10	0.15
2/5/2007 13:15	2/5/2007 13:33	18	18	0.27
2/5/2007 13:48	2/5/2007 14:36	48	48	0.73
2/5/2007 14:54	2/5/2007 16:14	80	80	1.20
2/15/2007 00:18	2/15/2007 01:13	55	55	0.83
2/15/2007 05:39	2/15/2007 05:49	10	10	0.15
2/15/2007 07:45	2/15/2007 08:57	72	72	1.08
2/15/2007 09:28	2/15/2007 12:32	184	184	2.76
2/15/2007 12:49	2/15/2007 13:48	59	59	0.89
2/15/2007 16:23	2/15/2007 17:27	63	63	0.95
2/15/2007 18:49	2/15/2007 18:59	10	10	0.15
2/16/2007 10:56	2/16/2007 11:36	40	40	0.61
2/16/2007 12:34	2/16/2007 12:55	21	21	0.31
2/16/2007 16:08	2/16/2007 16:18	10	10	0.15
2/23/2007 12:56	2/23/2007 13:12	16	16	0.24
2/23/2007 19:31	2/23/2007 19:47	16	16	0.25
2/23/2007 22:08	2/23/2007 22:29	20	20	0.30
2/23/2007 22:48	2/23/2007 23:27	39	39	0.58
3/5/2007 16:46	3/5/2007 17:39	53	53	0.79
3/6/2007 03:39	3/6/2007 04:25	46	46	0.69
3/6/2007 10:29	3/6/2007 11:09	40	40	0.60
3/6/2007 11:36	3/6/2007 11:47	11	11	0.17
3/6/2007 12:00	3/6/2007 13:27	87	87	1.31
3/6/2007 13:48	3/6/2007 14:43	55	55	0.83
3/6/2007 14:59	3/6/2007 15:09	10	10	0.15
3/8/2007 14:16	3/8/2007 14:37	21	21	0.31
4/16/2007 04:07	4/16/2007 05:32	85	85	1.27
7/6/2007 13:47	7/6/2007 13:59	11	11	0.17
9/8/2007 15:47	9/8/2007 15:57	10	10	0.15
12/1/2007 09:35	12/1/2007 10:18	43	43	0.65
12/1/2007 10:26	12/1/2007 10:39	14	14	0.20
12/3/2007 21:15	12/3/2007 21:58	43	43	0.65
12/3/2007 22:06	12/3/2007 22:19	14	14	0.20
1/9/2008 13:39	1/9/2008 13:49	10	10	0.15
1/9/2008 22:04	1/9/2008 22:47	43	43	0.64

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Loss&Uncertainty - Main result**Calculation:** Park Calculation, Long Term Data, 2 PW 900**Main data for PARK**

PARK calculation 2.7.468: Park Calculation, Long Term Data, 2 PW 900

Count 2
 Rated power 1.8 MW
 Mean wind speed 6.5 m/s at hub height
 Sensitivity 2.2 %AEP / %Mean Wind Speed
 Expected lifetime 20 Years

RESULTS

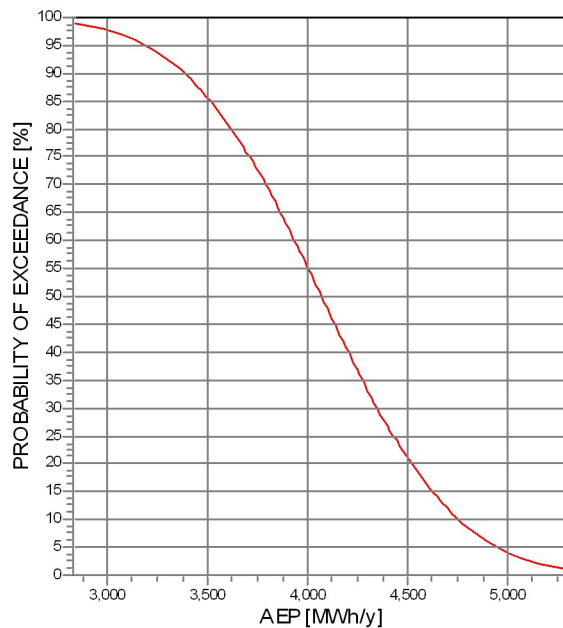
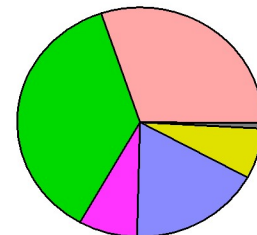
		P50	P84	P90
NET AEP	[MWh/y]	4,071	3,539	3,386
Capacity factor	[%]	25.8	22.4	21.5
Full load hours	[h/y]	2,261	1,966	1,881



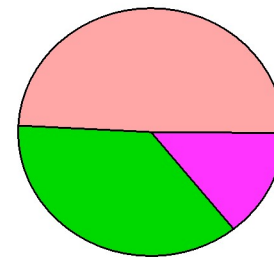
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Result details

	P50	Uncertainty
GROSS AEP *)	4,570 MWh/y	13.1 %
Bias correction	0 MWh/y	0.0 %
Loss correction	-499 MWh/y	-10.9 %
Wake loss	-3.4 %	
Other losses	-7.8 %	
NET AEP	4,071 MWh/y	13.1 %

**Loss: 10.9 %**

1. Wake effects	3.4 %	2. Availability	4.2 %
3. Turbine performance	0.9 %	4. Electrical	2.0 %
5. Environmental	0.8 %	6. Curtailment	0.1 %
7. Other	0.0 %		

Uncertainty: 13.1 %

A. Wind data	10.3 %	B. Wind model	7.6 %
C. Power conversion	3.0 %	D. BIAS	0.0 %
E. LOSS	0.0 %		

*) Calculated Annual Energy Production before any bias or loss corrections

Assumptions: Uncertainty and percentiles (PXX values) are calculated for the expected lifetime

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Loss&Uncertainty - Assumptions and results**Calculation:** Park Calculation, Long Term Data, 2 PW 900**ASSUMPTIONS**

LOSS		Method *)	Loss [%]	Loss [MWh/y]	Std dev**) [%]	Comment
1.	Wake effects					
	Wake effects, all WTGs	Calculation	3.4	157	0.0	
2.	Availability					
	Turbine availability	Estimate	3.0	137	0.0	Downtime due to turbine service
	Balance of plant (Substation)	Estimate	0.2	9	0.0	Substation Maintenance
	Grid availability	Estimate	1.0	46	0.0	Grid unavailable, external circumstance
3.	Turbine performance					
	High wind hysteresis	Calculation	0.9	41	0.0	Required restart after high-wind cut-out
4.	Electrical					
	Electrical losses	Estimate	2.0	91	0.0	Transformer and line losses
5.	Environmental					
	Performance degradation due to icing	Estimate	0.8	37	0.0	Ice accumulation on blades
6.	Curtailment					
	Grid curtailment and ramp-rate	Estimate	0.1	5	0.0	Power outage during low wind (requires restart)
7.	Other					No input
	LOSS, total		10.9	499	0.0	
UNCERTAINTY		Method *)	Std dev, wind speed [%]	Std dev, AEP [%]	Comment	
A.	Wind data					
	Wind measurement/Wind data	Estimate	2.5	5.6	Average Std. dev of wind speed over 12 sectors. Calculated in MCP	
	Long term correction	Estimate	3.0	6.7	Typical value for mid-quality reference data	
	Year-to-year variability	Estimate	9.9	22.1	Variability of long term data. Calculated in MCP	
	Future climate	Estimate	1.0	2.2	Typical value for low climate uncertainty	
	Other wind related					
B.	Wind model					
	Vertical extrapolation	Calculation	2.2	5.0	Recommended incremental value for complex terrain	
	Horizontal extrapolation	Calculation	2.6	5.8	Recommended incremental value for complex terrain	
	Other wind model related					
C.	Power conversion					
	Power curve uncertainty	Estimate		3.0	Typical value for manufacturers power curve	
	Metering uncertainty					
	Other AEP related uncertainties					
D.	BIAS, total uncertainty			0.0		
E.	LOSS, total uncertainty			0.0		
	UNCERTAINTY, total (1y average)			25.2		
	UNCERTAINTY, total (20y average)			13.1		

VARIABILITY

Years	Variability (std dev)	Total std dev
1	22.08	25.2
5	9.88	15.7
10	6.98	14.0
20	4.94	13.1

Comment

Wind measurement/Wind data

Average Std. dev of wind speed over 12 sectors. Calculated in MCP

Long term correction

Typical value for mid-quality reference data

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Loss&Uncertainty - Assumptions and results**Calculation:** Park Calculation, Long Term Data, 2 PW 900

Year-to-year variability

Variability of long term data. Calculated in MCP

Future climate

Typical value for low climate uncertainty

Vertical extrapolation

Recommended incremental value for complex terrain

Horizontal extrapolation

Recommended incremental value for complex terrain

Power curve uncertainty

Typical value for manufacturers power curve

Turbine availability

Downtime due to turbine service

Balance of plant (Substation)

Substation Maintenance

Grid availability

Grid unavailable, external circumstance

High wind hysteresis

Required restart after high-wind cut-out

Electrical losses

Transformer and line losses

Performance degradation due to icing

Ice accumulation on blades

Grid curtailment and ramp-rate

Power outage during low wind (requires restart)

RESULTS**AEP versus exceedance level / time horizon**

PXX	1 y	5 y	10 y	20 y
[%]	[MWh/y]	[MWh/y]	[MWh/y]	[MWh/y]
50	4,071	4,071	4,071	4,071
75	3,378	3,640	3,685	3,710
84	3,050	3,436	3,503	3,539
90	2,755	3,253	3,339	3,386
95	2,382	3,021	3,131	3,191

*) Calculation means that a calculation method available in the WindPRO software is used. This still typically involve a user judgement and user data where the quality of those decides the accuracy. If calculation method is used, the values will often be different from turbine to turbine, here the average is shown, but at page "WTG results" the individual turbine results are shown.

**) For totals the std dev refers to the full AEP, otherwise std dev refers to the bias or loss component which is a fraction of the total AEP.

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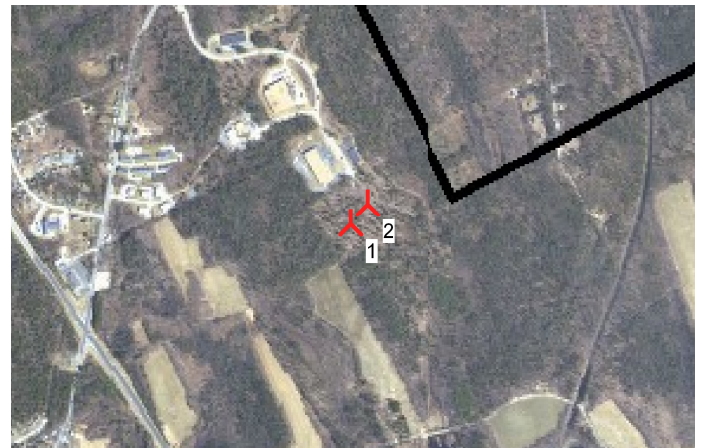
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Loss&Uncertainty - WTG results**Calculation:** Park Calculation, Long Term Data, 2 PW 900**Main data for PARK**

PARK calculation 2.7.468: Park Calculation, Long Term Data, 2 PW 900

Count 2
 Rated power 1.8 MW
 Mean wind speed 6.5 m/s at hub height
 Sensitivity 2.2 %AEP / %Mean Wind Speed
 Expected lifetime 20 Years



Scale: 25,000

Expected AEP per WTG including bias, loss and uncertainty evaluation

Description	Calculated GROSS*) [MWh/y]	Bias [%]	Loss [%]	20 years averaging			
				Unc. [%]	P50 [MWh/y]	P84 [MWh/y]	P90 [MWh/y]
1 PowerWind PowerWind 56 900 56.0 !O! hub: 71.0 m (2)	2,282.0	0.0	10.5	13.1	2,042.3	1,775.6	1,698.6
2 PowerWind PowerWind 56 900 56.0 !O! hub: 71.0 m (3)	2,287.9	0.0	11.3	13.2	2,028.2	1,763.4	1,686.9
PARK	4,569.9	0.0	10.9	13.1	4,070.5	3,539.0	3,385.6

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4736

Ellen Ebner / eeebner@tighebond.com

Calculated:

1/5/2011 2:01 PM/2.7.468

Loss&Uncertainty - Vertical extrapolation**Calculation:** Park Calculation, Long Term Data, 2 PW 900**Vertical extrapolation uncertainty**

WTG

		Uncertainty input elevation difference [%/10m]	Uncertainty input height difference [%/10m]	Measure elevation [m a.s.l.]	Measure height [m a.g.l.]	Delta elevation [m]	Delta height [m]	Result (std dev AEP) [%]
PowerWind	PowerWind 56 900 56.0 !O! hub: 71.0 m (2)	1.00	1.00	369.6	49.0	-2.9	22.0	5.0
PowerWind	PowerWind 56 900 56.0 !O! hub: 71.0 m (3)	1.00	1.00	369.6	49.0	-3.6	22.0	5.0

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Loss&Uncertainty - Horizontal extrapolation

Calculation: Park Calculation, Long Term Data, 2 PW 900

Horizontal extrapolation uncertainty

WTG

		Uncertainty input, distance [%/km]	Lower threshold value [km]	Upper threshold value [km]	Distance [km]	Result (std dev AEP) [%]	
PowerWind	PowerWind 56 900 56.0 !O! hub: 71.0 m (2)	1.50	0.0	0.0	1.7		5.7
PowerWind	PowerWind 56 900 56.0 !O! hub: 71.0 m (3)	1.50	0.0	0.0	1.7		5.8

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Calculated:

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Loss&Uncertainty - High wind hysteresis, Main**Calculation:** Park Calculation, Long Term Data, 2 PW 900

Shown losses is the energy content below powercurve cut-out where the WTG is stopped.

All losses are scaled to represent a year if the data series used is longer or shorter.

Summary

WTG

	Cut out events/year	Hysteris loss [MWh/y]	Percent of AEP [%]
PowerWind PowerWind 56 900 56.0 !O! hub: 71.0 m (2)	35	20	0.89
PowerWind PowerWind 56 900 56.0 !O! hub: 71.0 m (3)	35	21	0.90
TOTAL	70	41	0.90
AVERAGE	35	20	

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Calculated:

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Loss&Uncertainty - High wind hysteresis, Detail**Calculation:** Park Calculation, Long Term Data, 2 PW 900

Shown losses is the energy content below powercurve cut-out where the WTG is stopped.

Note that all hysteresis losses in MWh are calculated for the full time series. The losses in per cent in the Main report are scaled to represent one year if the length of the data series deviates from a year.

WTG: PowerWind PowerWind 56 900 56.0 !O! hub: 71.0 m (2) in layer: PowerWind 900

Cut out time	Cut in time	Total duration [min]	Duration below PC cut out [min]	Hysteris loss [MWh]
2/5/2007 12:58	2/5/2007 13:08	10	10	0.15
2/5/2007 13:15	2/5/2007 13:33	18	18	0.27
2/5/2007 13:48	2/5/2007 14:36	48	48	0.73
2/5/2007 14:54	2/5/2007 16:14	80	80	1.19
2/15/2007 00:18	2/15/2007 01:13	55	55	0.82
2/15/2007 05:39	2/15/2007 05:49	10	10	0.15
2/15/2007 07:45	2/15/2007 08:57	72	72	1.08
2/15/2007 09:28	2/15/2007 12:32	184	184	2.76
2/15/2007 12:49	2/15/2007 13:48	59	59	0.88
2/15/2007 16:23	2/15/2007 17:26	63	63	0.95
2/15/2007 18:49	2/15/2007 18:59	10	10	0.15
2/16/2007 10:56	2/16/2007 11:36	40	40	0.60
2/16/2007 12:34	2/16/2007 12:54	20	20	0.30
2/16/2007 16:08	2/16/2007 16:18	10	10	0.15
2/23/2007 12:56	2/23/2007 13:12	15	15	0.23
2/23/2007 19:31	2/23/2007 19:47	16	16	0.24
2/23/2007 22:09	2/23/2007 22:28	20	20	0.30
2/23/2007 22:49	2/23/2007 23:27	39	39	0.58
3/5/2007 16:46	3/5/2007 17:39	52	52	0.79
3/6/2007 03:39	3/6/2007 04:25	46	46	0.68
3/6/2007 10:29	3/6/2007 11:09	40	40	0.60
3/6/2007 11:36	3/6/2007 11:47	11	11	0.17
3/6/2007 12:00	3/6/2007 13:27	87	87	1.30
3/6/2007 13:48	3/6/2007 14:43	55	55	0.82
3/6/2007 14:59	3/6/2007 15:09	10	10	0.15
3/8/2007 14:16	3/8/2007 14:37	20	20	0.31
4/16/2007 04:08	4/16/2007 05:32	84	84	1.27
7/6/2007 13:48	7/6/2007 13:59	11	11	0.17
9/8/2007 15:47	9/8/2007 15:57	10	10	0.15
12/1/2007 09:35	12/1/2007 10:18	43	43	0.65
12/1/2007 10:26	12/1/2007 10:39	14	14	0.20
12/3/2007 21:15	12/3/2007 21:58	43	43	0.65
12/3/2007 22:06	12/3/2007 22:19	14	14	0.20
1/9/2008 13:39	1/9/2008 13:49	10	10	0.15
1/9/2008 22:04	1/9/2008 22:46	43	43	0.64

WTG: PowerWind PowerWind 56 900 56.0 !O! hub: 71.0 m (3) in layer: PowerWind 900

Cut out time	Cut in time	Total duration [min]	Duration below PC cut out [min]	Hysteris loss [MWh]
2/5/2007 12:58	2/5/2007 13:08	10	10	0.15
2/5/2007 13:15	2/5/2007 13:33	18	18	0.27
2/5/2007 13:48	2/5/2007 14:36	48	48	0.73
2/5/2007 14:54	2/5/2007 16:14	80	80	1.20
2/15/2007 00:18	2/15/2007 01:13	55	55	0.83
2/15/2007 05:39	2/15/2007 05:49	10	10	0.15
2/15/2007 07:45	2/15/2007 08:57	72	72	1.08
2/15/2007 09:28	2/15/2007 12:32	184	184	2.76
2/15/2007 12:49	2/15/2007 13:48	59	59	0.89
2/15/2007 16:23	2/15/2007 17:26	63	63	0.95
2/15/2007 18:49	2/15/2007 18:59	10	10	0.15
2/16/2007 10:56	2/16/2007 11:36	40	40	0.61

To be continued on next page...

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Loss&Uncertainty - High wind hysteresis, Detail**Calculation:** Park Calculation, Long Term Data, 2 PW 900

...continued from previous page

Cut out time	Cut in time	Total duration [min]	Duration below PC cut out [min]	Hysteresis loss [MWh]
2/16/2007 12:34	2/16/2007 12:55	21	21	0.31
2/16/2007 16:08	2/16/2007 16:18	10	10	0.15
2/23/2007 12:56	2/23/2007 13:12	16	16	0.24
2/23/2007 19:31	2/23/2007 19:47	16	16	0.25
2/23/2007 22:08	2/23/2007 22:29	20	20	0.30
2/23/2007 22:48	2/23/2007 23:27	39	39	0.58
3/5/2007 16:46	3/5/2007 17:39	53	53	0.79
3/6/2007 03:39	3/6/2007 04:25	46	46	0.68
3/6/2007 10:29	3/6/2007 11:09	40	40	0.60
3/6/2007 11:36	3/6/2007 11:47	11	11	0.17
3/6/2007 12:00	3/6/2007 13:27	87	87	1.31
3/6/2007 13:48	3/6/2007 14:43	55	55	0.82
3/6/2007 14:59	3/6/2007 15:09	10	10	0.15
3/8/2007 14:16	3/8/2007 14:37	21	21	0.31
4/16/2007 04:07	4/16/2007 05:32	85	85	1.27
7/6/2007 13:47	7/6/2007 13:59	11	11	0.17
9/8/2007 15:47	9/8/2007 15:57	10	10	0.15
12/1/2007 09:35	12/1/2007 10:18	43	43	0.65
12/1/2007 10:26	12/1/2007 10:39	14	14	0.20
12/3/2007 21:15	12/3/2007 21:58	43	43	0.65
12/3/2007 22:06	12/3/2007 22:19	14	14	0.20
1/9/2008 13:39	1/9/2008 13:49	10	10	0.15
1/9/2008 22:04	1/9/2008 22:47	43	43	0.64

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Calculated:

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SHADOW - Main Result**Calculation: Worst Case Flicker Vestas****Assumptions for shadow calculations**

Maximum distance for influence

Calculate only when more than 20 % of sun is covered by the blade

Please look in WTG table

Minimum sun height over horizon for influence

3 °

Day step for calculation

1 days

Time step for calculation

1 minutes

Sunshine probability S (Average daily sunshine hours) [PORTLAND]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.33	5.56	5.86	7.36	7.36	8.60	8.76	9.21	6.67	6.36	4.57	4.07

Operational hours are calculated from WTGs in calculation and wind distribution:

SDO for WAsP NCCCI GenPC

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
910	410	241	421	633	425	191	235	543	1,240	1,473	1,631	8,352

Idle start wind speed: Cut in wind speed from power curve

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values.

A WTG will be visible if it is visible from any part of the receiver window. The

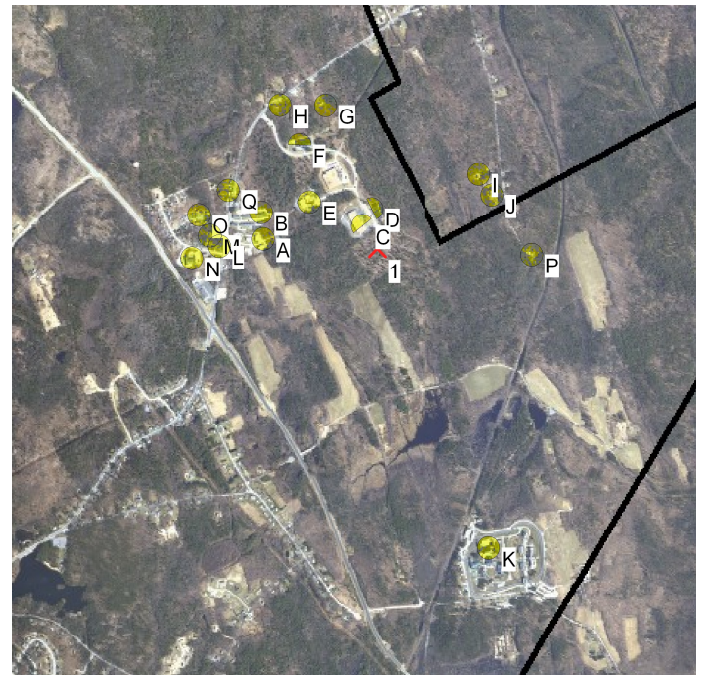
ZVI calculation is based on the following assumptions:

Height contours used: HCLs

Obstacles used in calculation

Eye height: 1.5 m

Grid resolution: 10 m



Scale 1:40,000

New WTG

Shadow receptor

WTGs

UTM NAD83 Zone: 19				WTG type			Shadow data				
East	North	Z	Row	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Calculation distance	RPM
		[m]	data/Description				[kW]	[m]	[m]	[m]	[RPM]
1	257,978	4,720,007	367.1	No	VESTAS	V82-1650/900-1,650/900	1,650	82.0	80.0	1,046	14.4

Shadow receptor-Input

UTM NAD83 Zone: 19										
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
A	Shadow Receptor Condo 1	257,374	4,720,079	373.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
B	Shadow Receptor Condo 2	257,367	4,720,220	372.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
C	Shadow Receptor Industry 1	257,902	4,720,129	366.3	1.0	1.0	1.0	-38.4	90.0	Fixed direction
D	Shadow Receptor Industry 2	257,954	4,720,217	359.7	1.0	1.0	1.0	63.6	90.0	Fixed direction
E	Shadow Receptor Industry 3	257,624	4,720,265	369.0	1.0	1.0	1.0	-15.0	90.0	"Green house mode"
F	Shadow Receptor Industry 4	257,584	4,720,573	365.9	1.0	1.0	1.0	1.1	90.0	Fixed direction
G	Shadow Receptor Residence 1	257,730	4,720,774	358.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
H	Shadow Receptor Residence 2	257,488	4,720,785	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
I	Shadow Receptor Residence 3	258,527	4,720,382	340.9	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
J	Shadow Receptor Residence 4	258,596	4,720,268	340.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
K	Shadow Receptor Residence 5	258,511	4,718,398	351.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
L	Shadow Receptor Residence 6	257,139	4,720,048	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
M	Shadow Receptor Residence 7	257,092	4,720,106	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
N	Shadow Receptor Commercial 1	256,992	4,719,991	372.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
O	Shadow Receptor Residential	257,037	4,720,218	369.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

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SHADOW - Main Result**Calculation: Worst Case Flicker Vestas**

...continued from previous page

UTM NAD83 Zone: 19										
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
P	Shadow Receptor Residence 8	258,795	4,719,948	331.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
Q	Shadow Receptor Residence 9	257,198	4,720,343	373.6	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case			Shadow, expected values	
		Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow hours per year [h/year]	
A	Shadow Receptor Condo 1	16:14	40	0:31	5:55	
B	Shadow Receptor Condo 2	15:06	39	0:30	5:55	
C	Shadow Receptor Industry 1	283:49	181	1:59	95:20	
D	Shadow Receptor Industry 2	118:59	93	1:31	32:15	
E	Shadow Receptor Industry 3	46:53	82	0:45	17:10	
F	Shadow Receptor Industry 4	0:00	0	0:00	0:00	
G	Shadow Receptor Residence 1	0:00	0	0:00	0:00	
H	Shadow Receptor Residence 2	0:00	0	0:00	0:00	
I	Shadow Receptor Residence 3	24:04	63	0:30	6:56	
J	Shadow Receptor Residence 4	14:55	40	0:29	4:58	
K	Shadow Receptor Residence 5	0:00	0	0:00	0:00	
L	Shadow Receptor Residence 6	8:04	29	0:23	2:56	
M	Shadow Receptor Residence 7	6:52	26	0:21	2:29	
N	Shadow Receptor Commercial 1	5:18	26	0:18	1:58	
O	Shadow Receptor Residential	5:40	25	0:20	2:09	
P	Shadow Receptor Residence 8	9:20	30	0:24	3:38	
Q	Shadow Receptor Residence 9	8:32	32	0:23	3:23	

Total amount of flickering on the shadow receptors caused by each WTG

No.	Name	Worst case [h/year]	Expected [h/year]
1	Gardner WTG Vestas	547:13	179:14

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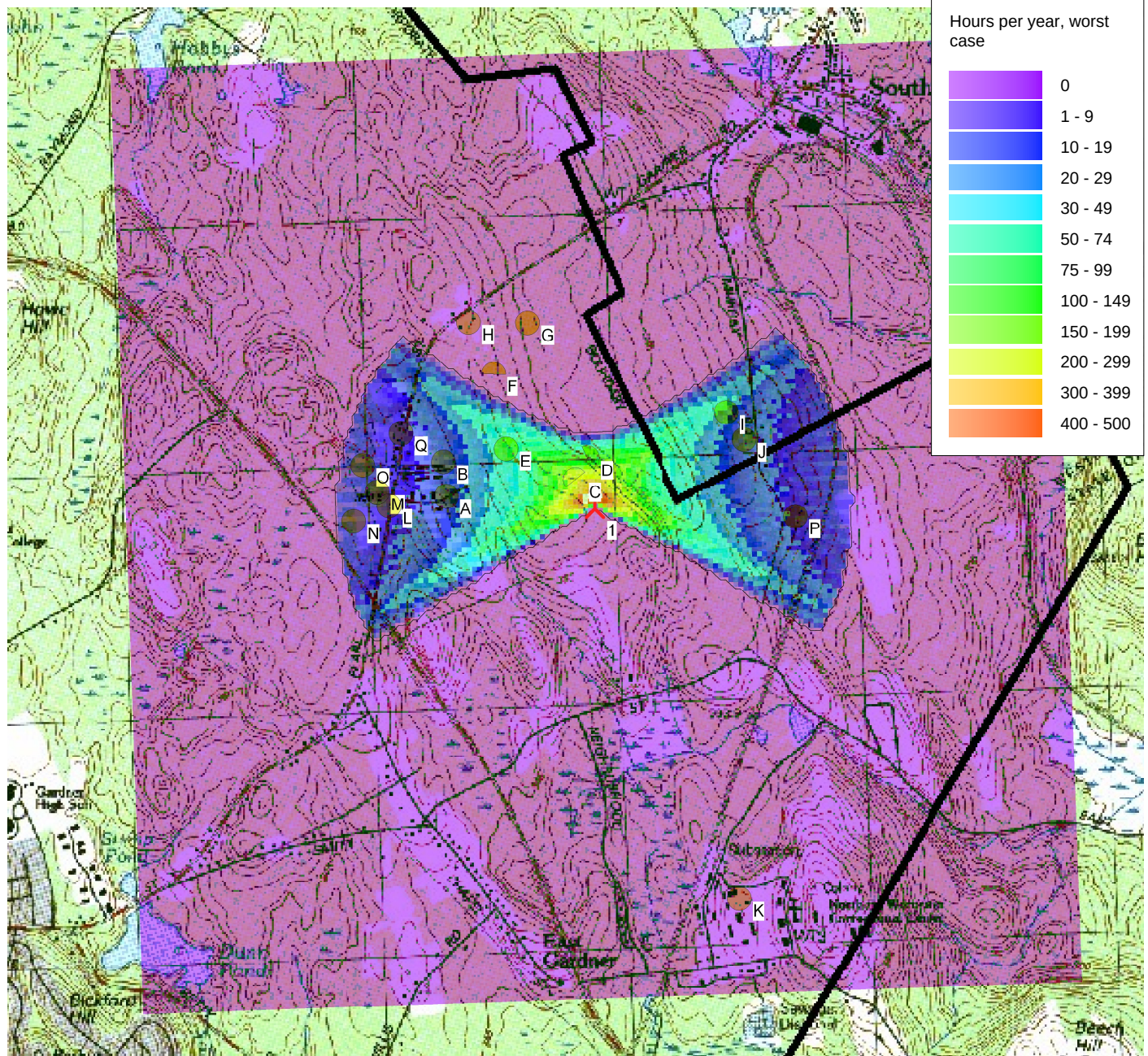
Ellen Ebner / eebner@tighebond.com

Calculated:

9/12/2010 1:29 PM/2.7.468

SHADOW - Map

Calculation: Worst Case Flicker Vestas



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Calculated:

10/12/2010 5:58 PM/2.7.468

SHADOW - Main Result**Calculation: Worst Case Flicker FL 1500****Assumptions for shadow calculations**

Maximum distance for influence

Calculate only when more than 20 % of sun is covered by the blade

Please look in WTG table

Minimum sun height over horizon for influence

3 °

Day step for calculation

1 days

Time step for calculation

1 minutes

Sunshine probability S (Average daily sunshine hours) [PORTLAND]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.33	5.56	5.86	7.36	7.36	8.60	8.76	9.21	6.67	6.36	4.57	4.07

Operational hours are calculated from WTGs in calculation and wind distribution:

SDO for WAsP NCCI GenPC

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
827	373	218	379	567	382	174	214	496	1,116	1,320	1,466	7,532

Idle start wind speed: Cut in wind speed from power curve

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values.

A WTG will be visible if it is visible from any part of the receiver window. The

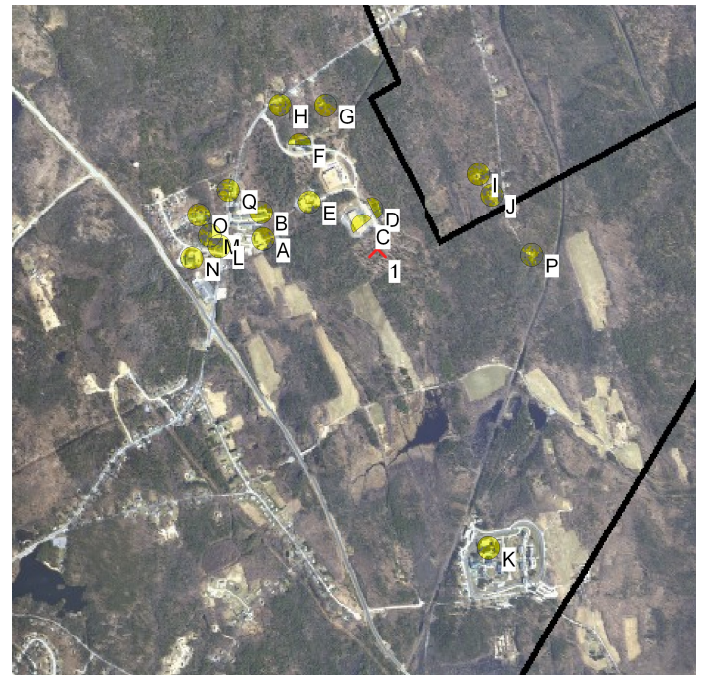
ZVI calculation is based on the following assumptions:

Height contours used: HCLs

Obstacles used in calculation

Eye height: 1.5 m

Grid resolution: 10 m



Scale 1:40,000

New WTG

Shadow receptor

WTGs

UTM NAD83 Zone: 19				WTG type						Shadow data		
East	North	Z	Row	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Calculation distance	RPM	
		[m]	data/Description				[kW]	[m]	[m]	[m]	[RPM]	
UTM NAD83 Zone: 19												
1	257,978	4,720,007	367.1	Yes	FUHLRLÄNDER	FL 1500-77-1,500	1,500	77.0	65.0	2,000	17.4	

Shadow receptor-Input

UTM NAD83 Zone: 19												
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode		
				[m]	[m]	[m]	[m]	[°]	[°]			
A	Shadow Receptor Condo 1	257,374	4,720,079	373.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"		
B	Shadow Receptor Condo 2	257,367	4,720,220	372.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"		
C	Shadow Receptor Industry 1	257,902	4,720,129	366.3	1.0	1.0	1.0	-38.4	90.0	Fixed direction		
D	Shadow Receptor Industry 2	257,954	4,720,217	359.7	1.0	1.0	1.0	63.6	90.0	Fixed direction		
E	Shadow Receptor Industry 3	257,624	4,720,265	369.0	1.0	1.0	1.0	-15.0	90.0	"Green house mode"		
F	Shadow Receptor Industry 4	257,584	4,720,573	365.9	1.0	1.0	1.0	1.1	90.0	Fixed direction		
G	Shadow Receptor Residence 1	257,730	4,720,774	358.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"		
H	Shadow Receptor Residence 2	257,488	4,720,785	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"		
I	Shadow Receptor Residence 3	258,527	4,720,382	340.9	1.0	1.0	1.0	-180.0	90.0	"Green house mode"		
J	Shadow Receptor Residence 4	258,596	4,720,268	340.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"		
K	Shadow Receptor Residence 5	258,511	4,718,398	351.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"		
L	Shadow Receptor Residence 6	257,139	4,720,048	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"		
M	Shadow Receptor Residence 7	257,092	4,720,106	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"		
N	Shadow Receptor Commercial 1	256,992	4,719,991	372.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"		
O	Shadow Receptor Residential	257,037	4,720,218	369.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"		

To be continued on next page...

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SHADOW - Main Result**Calculation: Worst Case Flicker FL 1500**

...continued from previous page

UTM NAD83 Zone: 19										
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
P	Shadow Receptor Residence 8	258,795	4,719,948	331.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
Q	Shadow Receptor Residence 9	257,198	4,720,343	373.6	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case			Shadow, expected values	
		Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow hours per year [h/year]	
A	Shadow Receptor Condo 1	12:46	38	0:29	4:11	
B	Shadow Receptor Condo 2	11:52	37	0:28	4:12	
C	Shadow Receptor Industry 1	274:04	160	1:59	82:08	
D	Shadow Receptor Industry 2	68:39	67	1:17	16:33	
E	Shadow Receptor Industry 3	51:00	103	0:43	16:34	
F	Shadow Receptor Industry 4	0:00	0	0:00	0:00	
G	Shadow Receptor Residence 1	0:00	0	0:00	0:00	
H	Shadow Receptor Residence 2	0:00	0	0:00	0:00	
I	Shadow Receptor Residence 3	25:44	75	0:28	6:40	
J	Shadow Receptor Residence 4	13:44	40	0:27	4:04	
K	Shadow Receptor Residence 5	0:00	0	0:00	0:00	
L	Shadow Receptor Residence 6	6:00	27	0:20	1:57	
M	Shadow Receptor Residence 7	4:57	24	0:18	1:37	
N	Shadow Receptor Commercial 1	3:27	22	0:14	1:09	
O	Shadow Receptor Residential	3:58	23	0:16	1:21	
P	Shadow Receptor Residence 8	8:17	30	0:22	2:51	
Q	Shadow Receptor Residence 9	6:02	29	0:19	2:09	

Total amount of flickering on the shadow receptors caused by each WTG

No.	Name	Worst case [h/year]	Expected [h/year]
1	FL 1500	480:38	142:13

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1/5/2011 2:18 PM / 3

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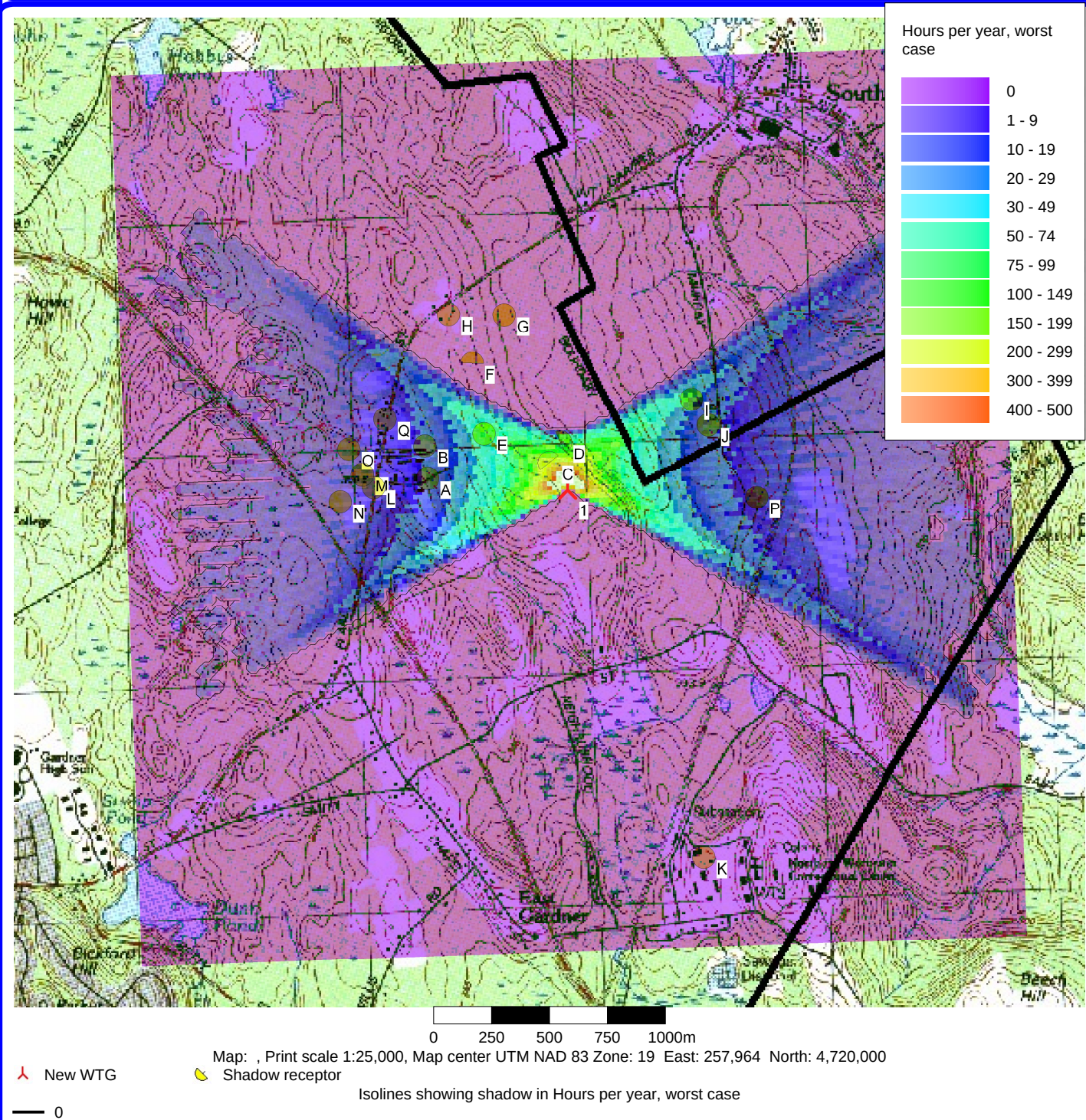
Ellen Ebner / eebner@tighebond.com

Calculated:

10/12/2010 5:58 PM/2.7.468

SHADOW - Map

Calculation: Worst Case Flicker FL 1500



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Calculated:

10/6/2010 11:51 AM/2.7.468

SHADOW - Main Result**Calculation: Worst Case Flicker GE1.5****Assumptions for shadow calculations**

Maximum distance for influence

Calculate only when more than 20 % of sun is covered by the blade

Please look in WTG table

Minimum sun height over horizon for influence

3 °

Day step for calculation

1 days

Time step for calculation

1 minutes

Sunshine probability S (Average daily sunshine hours) [PORTLAND]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.33	5.56	5.86	7.36	7.36	8.60	8.76	9.21	6.67	6.36	4.57	4.07

Operational hours are calculated from WTGs in calculation and wind distribution:

SDO for WAsP NCCI GenPC

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
848	381	224	392	589	396	178	219	505	1,155	1,372	1,519	7,777

Idle start wind speed: Cut in wind speed from power curve

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values.

A WTG will be visible if it is visible from any part of the receiver window. The

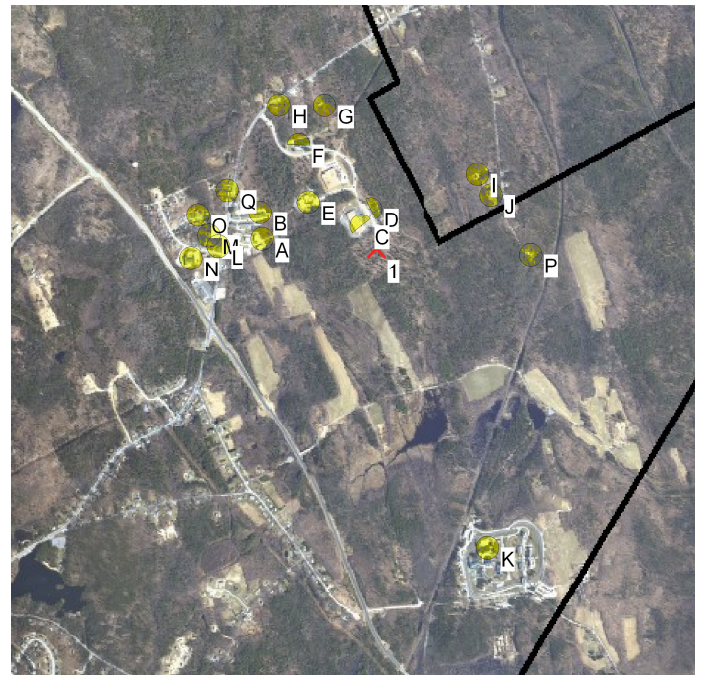
ZVI calculation is based on the following assumptions:

Height contours used: HCLs

Obstacles used in calculation

Eye height: 1.5 m

Grid resolution: 10 m



Scale 1:40,000

New WTG

Shadow receptor

WTGs**UTM NAD83 Zone: 19**

	East	North	Z	Row data/Description	WTG type		Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Shadow data	
					Valid	Manufact.					Calculation distance [m]	RPM [RPM]
1	257,978	4,720,007	367.1		Yes	GE WIND ENERGY	GE 1.5sle-1,500	1,500	77.0	80.0	2,000	20.0

Shadow receptor-Input

No.	Name	UTM NAD83 Zone: 19			Width [m]	Height [m]	Height a.g.l. [m]	Degrees from south cw [°]	Slope of window [°]	Direction mode
		East	North	Z						
A	Shadow Receptor Condo 1	257,374	4,720,079	373.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
B	Shadow Receptor Condo 2	257,367	4,720,220	372.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
C	Shadow Receptor Industry 1	257,902	4,720,129	366.3	1.0	1.0	1.0	-38.4	90.0	Fixed direction
D	Shadow Receptor Industry 2	257,954	4,720,217	359.7	1.0	1.0	1.0	63.6	90.0	Fixed direction
E	Shadow Receptor Industry 3	257,624	4,720,265	369.0	1.0	1.0	1.0	-15.0	90.0	"Green house mode"
F	Shadow Receptor Industry 4	257,584	4,720,573	365.9	1.0	1.0	1.0	1.1	90.0	Fixed direction
G	Shadow Receptor Residence 1	257,730	4,720,774	358.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
H	Shadow Receptor Residence 2	257,488	4,720,785	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
I	Shadow Receptor Residence 3	258,527	4,720,382	340.9	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
J	Shadow Receptor Residence 4	258,596	4,720,268	340.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
K	Shadow Receptor Residence 5	258,511	4,718,398	351.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
L	Shadow Receptor Residence 6	257,139	4,720,048	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
M	Shadow Receptor Residence 7	257,092	4,720,106	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
N	Shadow Receptor Commercial 1	256,992	4,719,991	372.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
O	Shadow Receptor Residential	257,037	4,720,218	369.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

To be continued on next page...

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Calculated:

10/6/2010 11:51 AM/2.7.468

SHADOW - Main Result**Calculation: Worst Case Flicker GE1.5**

...continued from previous page

No.	Name	UTM NAD83 Zone: 19				Height a.g.l. [m]	Degrees from south cw [°]	Slope of window [°]	Direction mode
		East	North	Z	Width				
				[m]	[m]	[m]			
P	Shadow Receptor Residence 8	258,795	4,719,948	331.5	1.0	1.0	-180.0	90.0	"Green house mode"
Q	Shadow Receptor Residence 9	257,198	4,720,343	373.6	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case			Shadow, expected values	
		Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow hours per year [h/year]	
A	Shadow Receptor Condo 1	14:14	36	0:29	4:50	
B	Shadow Receptor Condo 2	13:23	37	0:28	4:53	
C	Shadow Receptor Industry 1	253:14	178	1:51	79:21	
D	Shadow Receptor Industry 2	107:21	89	1:25	27:05	
E	Shadow Receptor Industry 3	40:47	77	0:42	13:54	
F	Shadow Receptor Industry 4	0:00	0	0:00	0:00	
G	Shadow Receptor Residence 1	0:00	0	0:00	0:00	
H	Shadow Receptor Residence 2	0:00	0	0:00	0:00	
I	Shadow Receptor Residence 3	21:10	60	0:28	5:41	
J	Shadow Receptor Residence 4	13:14	38	0:27	4:07	
K	Shadow Receptor Residence 5	0:00	0	0:00	0:00	
L	Shadow Receptor Residence 6	7:26	28	0:22	2:31	
M	Shadow Receptor Residence 7	6:21	26	0:20	2:09	
N	Shadow Receptor Commercial 1	4:42	23	0:18	1:37	
O	Shadow Receptor Residential	5:09	24	0:18	1:49	
P	Shadow Receptor Residence 8	8:22	30	0:22	3:01	
Q	Shadow Receptor Residence 9	7:43	31	0:22	2:51	

Total amount of flickering on the shadow receptors caused by each WTG

No.	Name	Worst case Expected	
		[h/year]	[h/year]
1	Gardner WTG GE1.5	492:11	150:08

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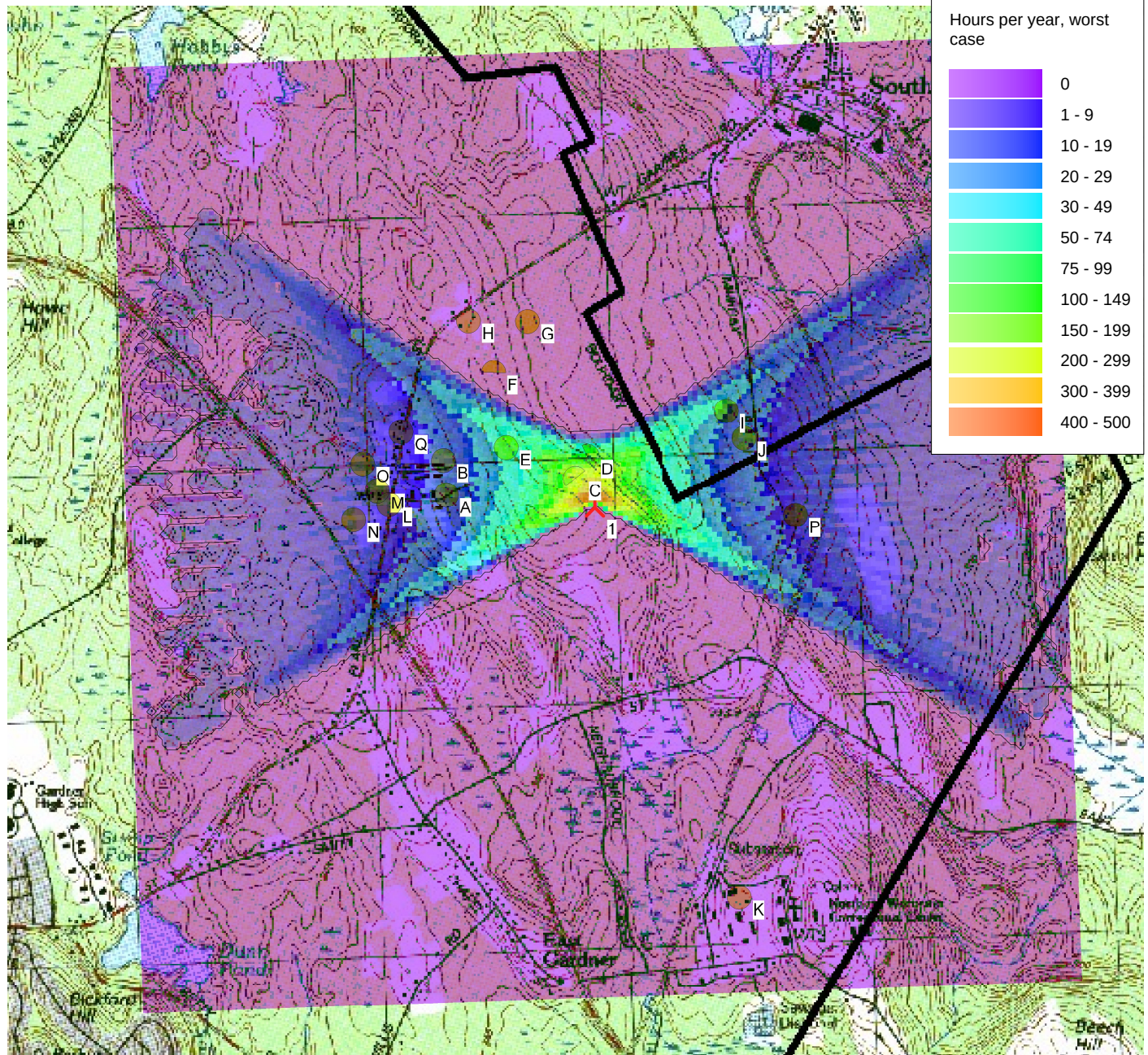
Ellen Ebner / eebner@tighebond.com

Calculated:

10/6/2010 11:51 AM/2.7.468

SHADOW - Map

Calculation: Worst Case Flicker GE1.5



0 250 500 750 1000m

Map: , Print scale 1:25,000, Map center UTM NAD 83 Zone: 19 East: 257,964 North: 4,720,000

New WTG

Shadow receptor

Isolines showing shadow in Hours per year, worst case

0

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Calculated:

10/6/2010 12:12 PM/2.7.468

SHADOW - Main Result**Calculation: Worst Case Flicker PW56****Assumptions for shadow calculations**

Maximum distance for influence

Calculate only when more than 20 % of sun is covered by the blade

Please look in WTG table

Minimum sun height over horizon for influence

3 °

Day step for calculation

1 days

Time step for calculation

1 minutes

Sunshine probability S (Average daily sunshine hours) [PORTLAND]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.33	5.56	5.86	7.36	7.36	8.60	8.76	9.21	6.67	6.36	4.57	4.07

Operational hours are calculated from WTGs in calculation and wind distribution:

SDO for WAsP NCCI GenPC

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
906	408	239	417	625	421	191	234	542	1,228	1,455	1,614	8,281

Idle start wind speed: Cut in wind speed from power curve

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values.

A WTG will be visible if it is visible from any part of the receiver window. The

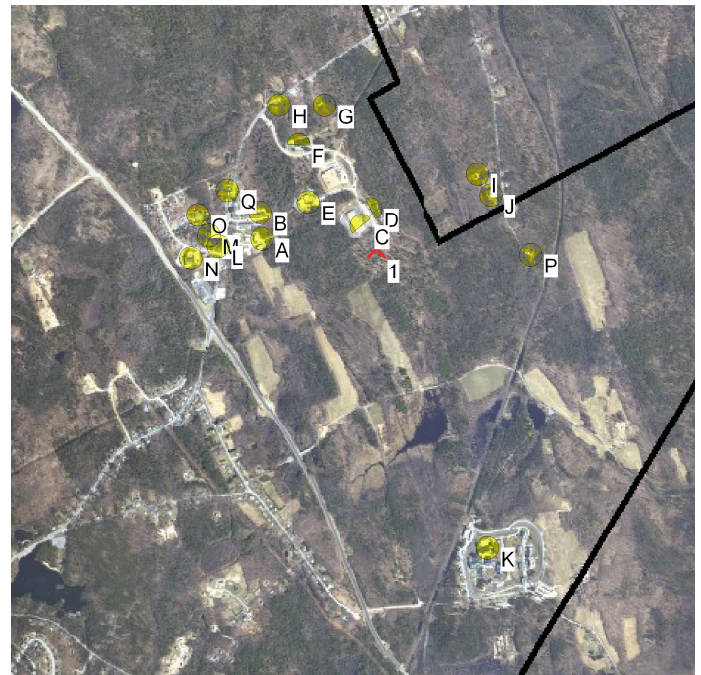
ZVI calculation is based on the following assumptions:

Height contours used: HCLs

Obstacles used in calculation

Eye height: 1.5 m

Grid resolution: 10 m



Scale 1:40,000

New WTG

Shadow receptor

WTGs

UTM NAD83 Zone: 19				WTG type				Shadow data			
East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Calculation distance [m]	RPM [RPM]
UTM NAD83 Zone: 19		[m]									
1	257,978	4,720,007	367.1	Yes	PowerWind	PowerWind 56-900	900	56.0	71.0	1,142	0.0

Shadow receptor-Input

UTM NAD83 Zone: 19										
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
A	Shadow Receptor Condo 1	257,374	4,720,079	373.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
B	Shadow Receptor Condo 2	257,367	4,720,220	372.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
C	Shadow Receptor Industry 1	257,902	4,720,129	366.3	1.0	1.0	1.0	-38.4	90.0	Fixed direction
D	Shadow Receptor Industry 2	257,954	4,720,217	359.7	1.0	1.0	1.0	63.6	90.0	Fixed direction
E	Shadow Receptor Industry 3	257,624	4,720,265	369.0	1.0	1.0	1.0	-15.0	90.0	"Green house mode"
F	Shadow Receptor Industry 4	257,584	4,720,573	365.9	1.0	1.0	1.0	1.1	90.0	Fixed direction
G	Shadow Receptor Residence 1	257,730	4,720,774	358.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
H	Shadow Receptor Residence 2	257,488	4,720,785	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
I	Shadow Receptor Residence 3	258,527	4,720,382	340.9	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
J	Shadow Receptor Residence 4	258,596	4,720,268	340.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
K	Shadow Receptor Residence 5	258,511	4,718,398	351.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
L	Shadow Receptor Residence 6	257,139	4,720,048	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
M	Shadow Receptor Residence 7	257,092	4,720,106	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
N	Shadow Receptor Commercial 1	256,992	4,719,991	372.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
O	Shadow Receptor Residential	257,037	4,720,218	369.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

To be continued on next page...

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10/6/2010 12:12 PM/2.7.468

SHADOW - Main Result**Calculation: Worst Case Flicker PW56**

...continued from previous page

UTM NAD83 Zone: 19										
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
P	Shadow Receptor Residence 8	258,795	4,719,948	331.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
Q	Shadow Receptor Residence 9	257,198	4,720,343	373.6	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case			Shadow, expected values	
		Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow hours per year [h/year]	
A	Shadow Receptor Condo 1	7:31	26	0:22	2:42	
B	Shadow Receptor Condo 2	7:11	28	0:21	2:48	
C	Shadow Receptor Industry 1	159:27	150	1:24	52:58	
D	Shadow Receptor Industry 2	42:55	57	0:55	11:16	
E	Shadow Receptor Industry 3	22:56	58	0:31	8:14	
F	Shadow Receptor Industry 4	0:00	0	0:00	0:00	
G	Shadow Receptor Residence 1	0:00	0	0:00	0:00	
H	Shadow Receptor Residence 2	0:00	0	0:00	0:00	
I	Shadow Receptor Residence 3	11:52	44	0:21	3:24	
J	Shadow Receptor Residence 4	7:14	28	0:20	2:24	
K	Shadow Receptor Residence 5	0:00	0	0:00	0:00	
L	Shadow Receptor Residence 6	3:53	20	0:16	1:23	
M	Shadow Receptor Residence 7	3:19	18	0:15	1:11	
N	Shadow Receptor Commercial 1	2:23	18	0:12	0:52	
O	Shadow Receptor Residential	2:42	18	0:14	1:01	
P	Shadow Receptor Residence 8	4:29	22	0:16	1:41	
Q	Shadow Receptor Residence 9	4:03	22	0:16	1:36	

Total amount of flickering on the shadow receptors caused by each WTG

No.	Name	Worst case [h/year]	Expected [h/year]
1	PowerWind 900	276:52	90:30

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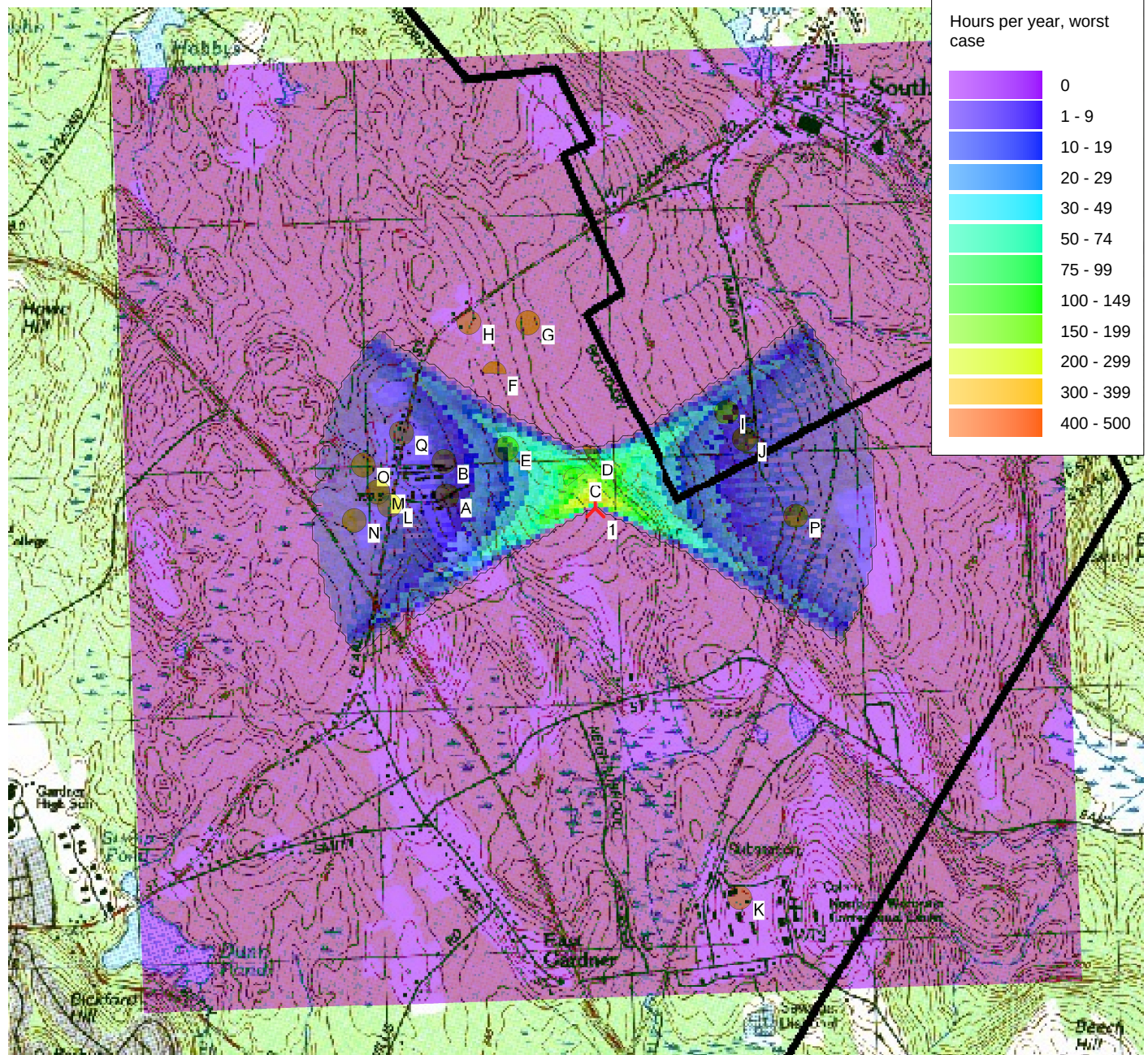
Ellen Ebner / eebner@tighebond.com

Calculated:

10/6/2010 12:12 PM/2.7.468

SHADOW - Map

Calculation: Worst Case Flicker PW56



0 250 500 750 1000m

Map: , Print scale 1:25,000, Map center UTM NAD 83 Zone: 19 East: 257,964 North: 4,720,000

New WTG

Shadow receptor

Isolines showing shadow in Hours per year, worst case

0

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Calculated:

10/6/2010 12:17 PM/2.7.468

SHADOW - Main Result**Calculation: Worst Case Flicker 2PW56****Assumptions for shadow calculations**

Maximum distance for influence

Calculate only when more than 20 % of sun is covered by the blade

Please look in WTG table

Minimum sun height over horizon for influence

3 °

Day step for calculation

1 days

Time step for calculation

1 minutes

Sunshine probability S (Average daily sunshine hours) [PORTLAND]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.33	5.56	5.86	7.36	7.36	8.60	8.76	9.21	6.67	6.36	4.57	4.07

Operational hours are calculated from WTGs in calculation and wind distribution:

SDO for WAsP NCCI GenPC

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
907	409	240	417	625	420	191	234	543	1,227	1,453	1,612	8,281

Idle start wind speed: Cut in wind speed from power curve

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values.

A WTG will be visible if it is visible from any part of the receiver window. The

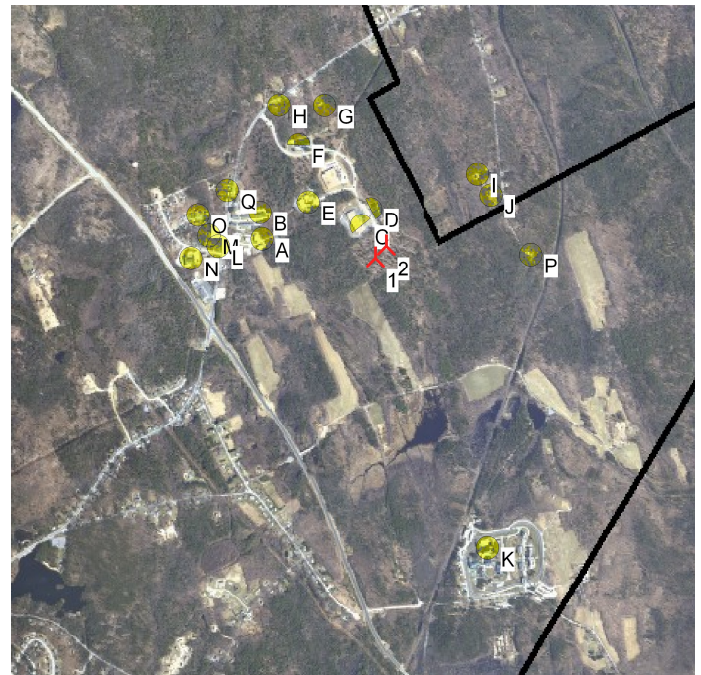
ZVI calculation is based on the following assumptions:

Height contours used: HCLs

Obstacles used in calculation

Eye height: 1.5 m

Grid resolution: 10 m



Scale 1:40,000

New WTG

Shadow receptor

WTGs

UTM NAD83 Zone: 19				WTG type				Shadow data			
East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Calculation distance [m]	RPM
UTM NAD83 Zone: 19			[m]								[RPM]
1	257,971	4,719,958	366.7	Yes	PowerWind	PowerWind 56-900	900	56.0	71.0	1,142	0.0
2	258,030	4,720,020	366.0	Yes	PowerWind	PowerWind 56-900	900	56.0	71.0	1,142	0.0

Shadow receptor-Input

UTM NAD83 Zone: 19											
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode	
				[m]	[m]	[m]	[m]	[°]	[°]		
A	Shadow Receptor Condo 1	257,374	4,720,079	373.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"	
B	Shadow Receptor Condo 2	257,367	4,720,220	372.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"	
C	Shadow Receptor Industry 1	257,902	4,720,129	366.3	1.0	1.0	1.0	-38.4	90.0	Fixed direction	
D	Shadow Receptor Industry 2	257,954	4,720,217	359.7	1.0	1.0	1.0	63.6	90.0	Fixed direction	
E	Shadow Receptor Industry 3	257,624	4,720,265	369.0	1.0	1.0	1.0	-15.0	90.0	"Green house mode"	
F	Shadow Receptor Industry 4	257,584	4,720,573	365.9	1.0	1.0	1.0	1.1	90.0	Fixed direction	
G	Shadow Receptor Residence 1	257,730	4,720,774	358.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"	
H	Shadow Receptor Residence 2	257,488	4,720,785	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"	
I	Shadow Receptor Residence 3	258,527	4,720,382	340.9	1.0	1.0	1.0	-180.0	90.0	"Green house mode"	
J	Shadow Receptor Residence 4	258,596	4,720,268	340.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"	
K	Shadow Receptor Residence 5	258,511	4,718,398	351.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"	
L	Shadow Receptor Residence 6	257,139	4,720,048	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"	
M	Shadow Receptor Residence 7	257,092	4,720,106	369.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"	
N	Shadow Receptor Commercial 1	256,992	4,719,991	372.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"	

To be continued on next page...

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Calculated:

10/6/2010 12:17 PM/2.7.468

SHADOW - Main Result**Calculation: Worst Case Flicker 2PW56**

...continued from previous page

UTM NAD83 Zone: 19										
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
O	Shadow Receptor Residential	257,037	4,720,218	369.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
P	Shadow Receptor Residence 8	258,795	4,719,948	331.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
Q	Shadow Receptor Residence 9	257,198	4,720,343	373.6	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case			Shadow, expected values	
		Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow hours per year [h/year]	
A	Shadow Receptor Condo 1	14:14	48	0:23	5:12	
B	Shadow Receptor Condo 2	13:37	51	0:20	5:18	
C	Shadow Receptor Industry 1	190:36	173	1:24	62:56	
D	Shadow Receptor Industry 2	60:14	81	0:54	17:34	
E	Shadow Receptor Industry 3	49:34	117	0:30	17:21	
F	Shadow Receptor Industry 4	0:00	0	0:00	0:00	
G	Shadow Receptor Residence 1	0:00	0	0:00	0:00	
H	Shadow Receptor Residence 2	0:00	0	0:00	0:00	
I	Shadow Receptor Residence 3	24:11	79	0:23	6:36	
J	Shadow Receptor Residence 4	13:26	45	0:23	4:16	
K	Shadow Receptor Residence 5	0:00	0	0:00	0:00	
L	Shadow Receptor Residence 6	7:12	36	0:16	2:35	
M	Shadow Receptor Residence 7	6:03	34	0:15	2:12	
N	Shadow Receptor Commercial 1	4:11	28	0:13	1:30	
O	Shadow Receptor Residential	4:49	32	0:13	1:49	
P	Shadow Receptor Residence 8	9:22	42	0:17	3:32	
Q	Shadow Receptor Residence 9	7:31	43	0:16	2:51	

Total amount of flickering on the shadow receptors caused by each WTG

No.	Name		Worst case [h/year]	Expected [h/year]
1	PowerWind PowerWind 56 900 56.0 !O! hub: 71.0 m (2)		190:41	60:20
2	PowerWind PowerWind 56 900 56.0 !O! hub: 71.0 m (3)		220:13	74:52

Project:

Gardner Resource Assessment

Printed/Page

1/5/2011 2:22 PM / 3

Licensed user:

Tighe & Bond, Inc.

53 Southampton Road

US-01085 Westfield, MA

4736

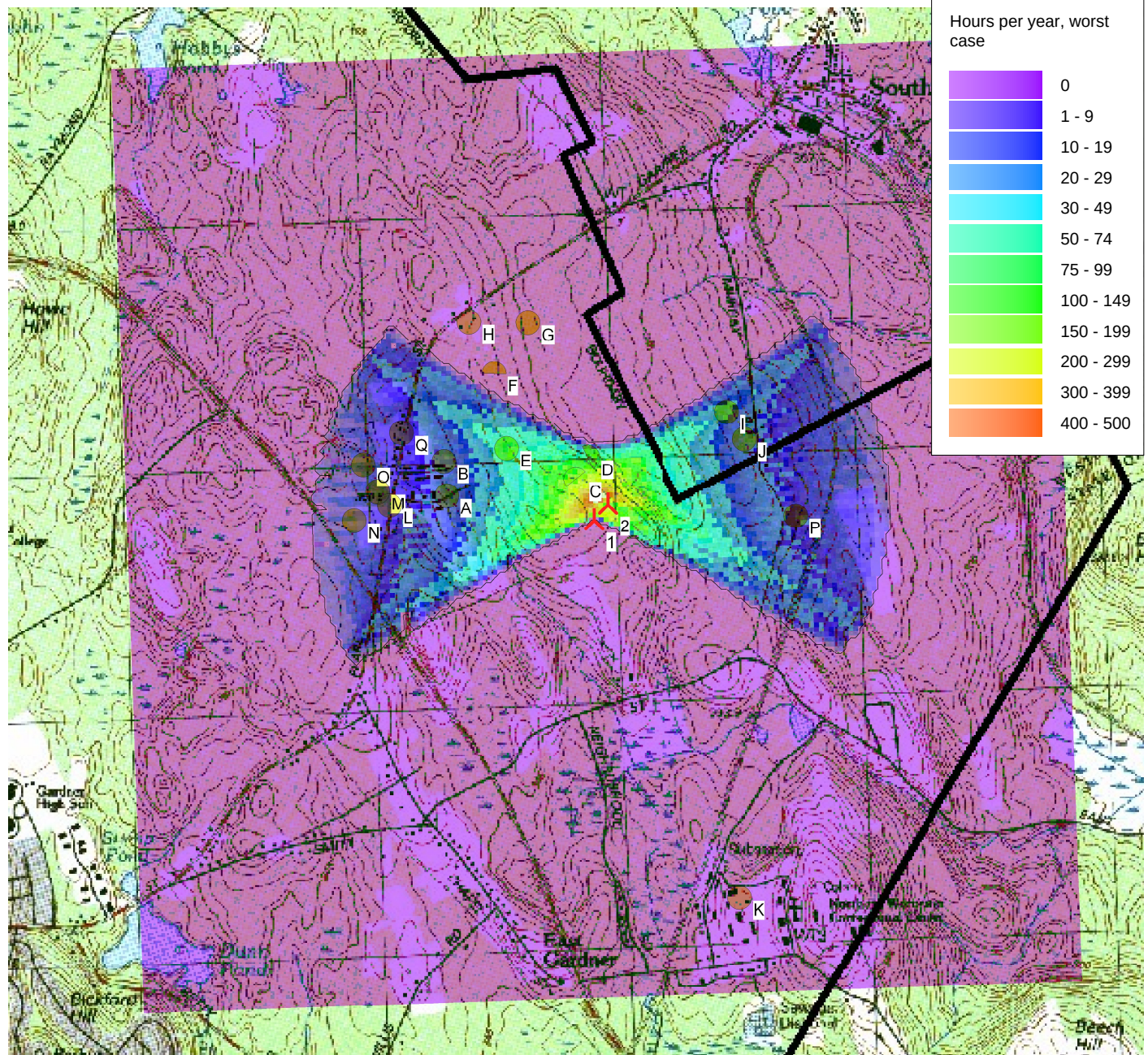
Ellen Ebner / eebner@tighebond.com

Calculated:

10/6/2010 12:17 PM/2.7.468

SHADOW - Map

Calculation: Worst Case Flicker 2PW56



0 250 500 750 1000m

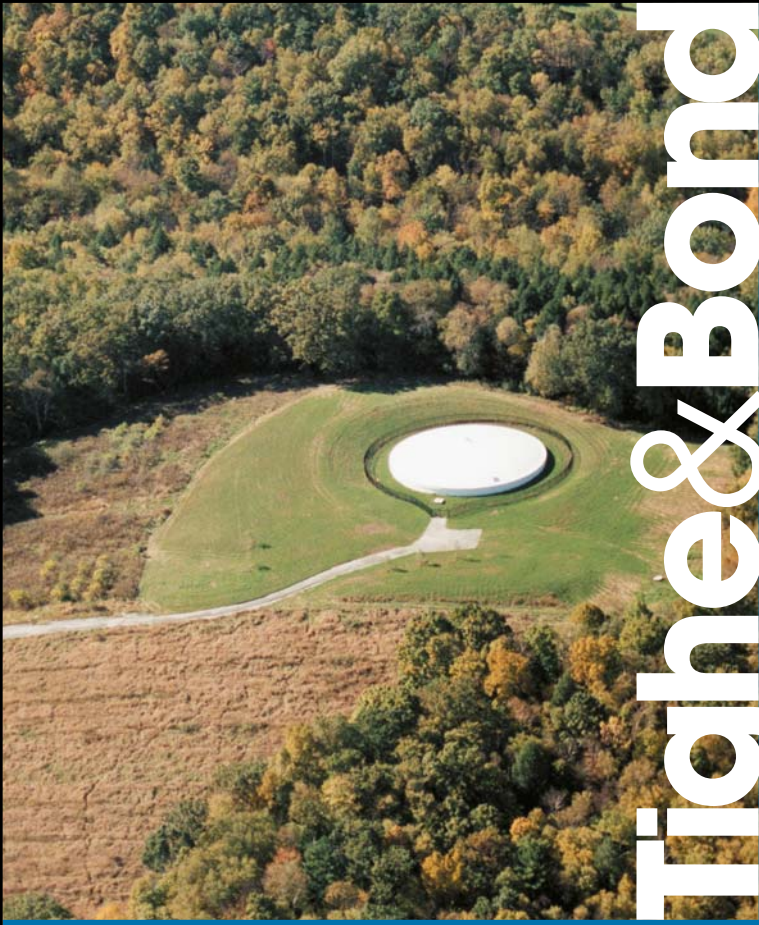
Map: , Print scale 1:25,000, Map center UTM NAD 83 Zone: 19 East: 257,964 North: 4,720,000

New WTG

Shadow receptor

Isolines showing shadow in Hours per year, worst case

0



Tighe & Bond

VESTAS V82 1650 82.0 !O!

File C:\Documents and Settings\lee.DOMAIN\My Documents\WindPRO\WTG Data\VESTAS V82 1650 82.0 !O!.wtg

Company	VESTAS	50Hz :78m hub height (India only)
Type/Version	V82	60Hz: 70m and 80m hub height available
Rated power	1,650.0 kW	
Secondary generator	0.0 kW	
Rotor diameter	82.0 m	
Tower	Tubular	
Grid connection	50/60 Hz	

Origin country	DK
Blade type	AL40/LM40
Generator type	One generator
Rpm, rated power	14.4 rpm
Rpm, initial	0.0 rpm
Hub height(s)	78.0; 70.0; 80.0 m
Maximum blade width	3.08 m
Blade width for 90% radius	0.00 m
Valid	Yes
Creator	EMD
Created	11/21/2008 13:09
Edited	11/21/2008 13:09

**Power curve:** Level 0 --- 11-2004

Source Manufacturer

Source date	Creator	Created	Edited	Default	Stop windSpeed	Air density	Tip angle	Power control	CT curve type
11/30/2004 00:00	EMD	7/31/2003 13:27	11/21/2008 13:22	Yes	[m/s] 20.0	[kg/m3] 1.225	[°] 0.0	Active stall	User defined

Power-curve based on item no: TSD 4000256-01 EN dated 2004-10-07.

Ct curve may 2008

Power curve

Wind speed [m/s]	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00
Power [kW]	28.00	144.00	309.00	511.00	758.00	1,017.00	1,285.00	1,504.00	1,637.00	1,650.00	1,650.00	1,650.00	1,650.00	1,650.00	1,650.00
Ce	0.135	0.356	0.442	0.461	0.458	0.431	0.397	0.349	0.293	0.232	0.186	0.151	0.125	0.104	0.087

Wind speed [m/s]	19.00	20.00
Power [kW]	1,650.00	1,650.00
Ce	0.074	0.064

Ct curve

Wind speed [m/s]	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00
Ct	0.99	0.95	0.93	0.84	0.77	0.70	0.64	0.58	0.51	0.44	0.38	0.33	0.30	0.27	0.25	0.23	0.22

HP curve comparison

Vmean [m/s]	5	6	7	8	9	10
HP value [MWh]	2,405	3,788	5,194	6,528	7,624	8,607

Level 0 --- 11-2004 [MWh]	2,543	3,956	5,327	6,524	7,467	8,129
Check value [%]	-5	-4	-3	0	2	6

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m²) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.

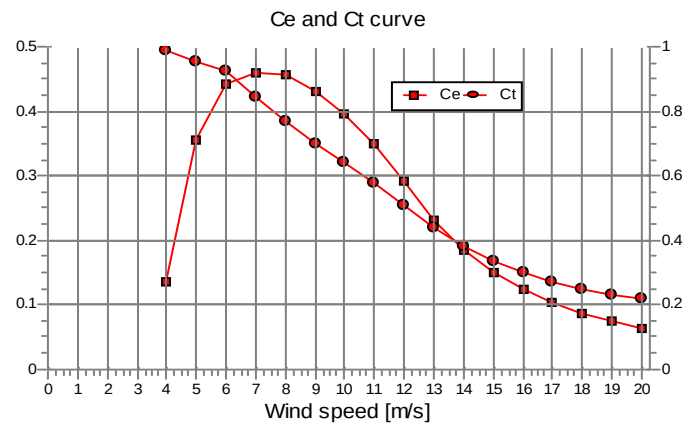
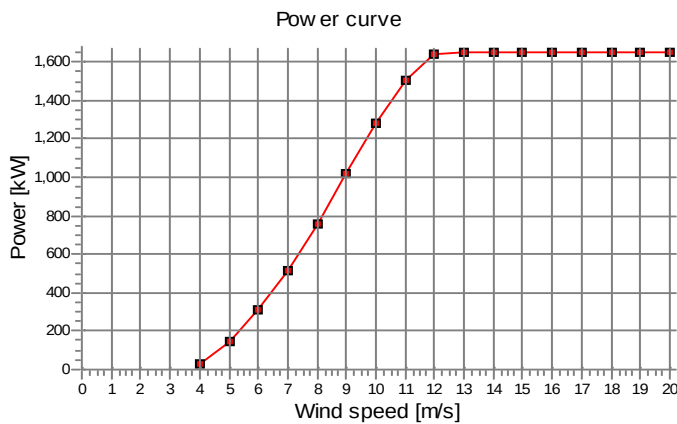
For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see WindPRO manual chapter 3.5.2.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", Jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

VESTAS V82 1650 82.0 !O!

File C:\Documents and Settings\lee.DOMAIN\My Documents\WindPRO\WTG Data\VESTAS V82 1650 82.0 !O!.wtg

**Noise:** Level 0 - - 05-2008

Source Manufacturer

Source date	Creator	Created	Edited	Default
5/31/2008 13:33	EMD	12/17/2004 15:18	11/25/2008 11:45	No

Hub height [m]	Wind speed [m/s]	Lwa.ref [dB(A)]	Wind speed dependency [dB(A)/m/s]	Pure tones
70.0	95%	103.3		
	3.0	101.1	1.0	No
	4.0	100.9	1.0	No
	5.0	101.1	1.0	No
	6.0	101.3	1.0	No
	7.0	101.9	1.0	No
	8.0	102.9	1.0	No
	95%	103.3	1.0	No
78.0	3.0	101.1	1.0	No
	4.0	101.4	1.0	No
	5.0	101.6	1.0	No
	6.0	101.8	1.0	No
	7.0	102.2	1.0	No
	8.0	103.2	1.0	No
	95%	103.3	1.0	No
	3.0	101.1	1.0	No
80.0	4.0	101.4	1.0	No
	5.0	101.6	1.0	No
	6.0	101.8	1.0	No
	7.0	102.2	1.0	No
	8.0	103.2	1.0	No
	95%	103.3	1.0	No
	3.0	101.1	1.0	No
	4.0	101.4	1.0	No

Verification Report: WTSE03007B2

Visual dataName
Source

Source date	Creator	Created	Edited	Default
12/30/1899 00:00	EMD	5/23/2001 11:29	11/21/2008 13:28	Yes

Tower

Height [m]	Bottom diameter [m]	Top diameter [m]
64.0	4.2	2.3

VESTAS V82 1650 82.0 !O!

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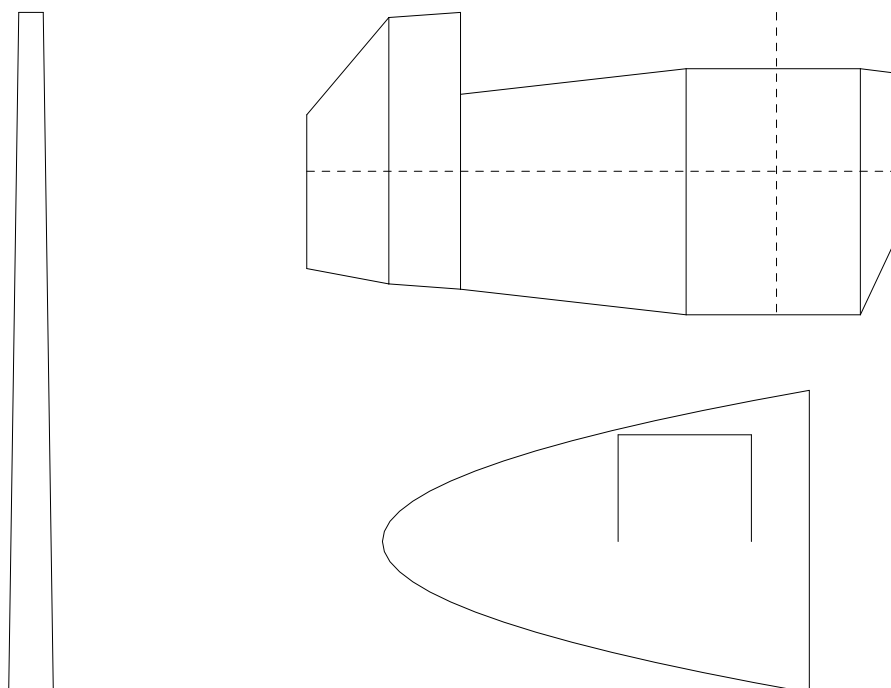
Cabin

Distance cabin front (rotor) to tower center: 21 %

Shape	Height front [m]	Height back [m]	Width front [m]	Width back [m]	Length bottom [m]	Length top [m]	Front offset [m]	Rear offset [m]
Box	2.60	1.50	1.80	1.60	0.80	0.80	0.20	-0.20
Box	2.70	2.60	1.90	1.80	0.70	0.70	0.20	0.20
Box	2.40	1.90	2.00	1.90	2.20	2.20	-0.20	-0.20
Box	2.40	2.40	2.00	2.00	1.70	1.70	-0.20	-0.20
Box	1.50	2.40	2.00	2.00	0.40	0.40	0.20	-0.20

Rotor and hub

Number of blades	3
Blade position (center to cabin)	0.70 m
Chord max	3.00 m
Rotor position relative to tower	Up wind
Hub length (cabin to spinner tip)	2.40 m
Spinner length (0 = no spinner)	2.40 m
Hub diameter (2xradius from hub center to blade root)	1.20 m
Spinner max diameter	1.70 m
Shaft radius	0.40 m
Hub tilt angle	5.0 °
Blade cone angle	0.0 °



FUHLRLÄNDER FL 1500-77 1500 77.0 !-!

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Company FUHLRLÄNDER
 Type/Version FL 1500-77
 Rated power 1,500.0 kW
 Secondary generator 0.0 kW
 Rotor diameter 77.0 m
 Tower Other - unknown
 Grid connection 50/60 Hz

Origin country DE
 Blade type LM 37.5/NOI 37.5
 Generator type One generator
 Rpm, rated power 17.4 rpm
 Rpm, initial 9.7 rpm
 Hub height(s) 65.0; 80.0; 100.0 m
 Maximum blade width 0.00 m
 Blade width for 90% radius 0.00 m
 Valid Yes
 Creator EMD
 Created 10/20/2004 15:34
 Edited 10/20/2004 15:34

**Power curve:** Level 0 - - - 07-2004

Source Manufacturer

Source date	Creator	Created	Edited	Default	Stop windSpeed	Air density	Tip angle	Power control	CT curve type
					[m/s]	[kg/m3]	[°]		
7/29/2004 00:00	EMD	8/11/2003 14:09	11/28/2005 11:05	Yes	25.0	1.225	0.0	Pitch	Standard pitch

theoretical PC

Power curve

Wind speed [m/s]	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
Power [kW]	0.00	36.90	122.20	233.00	389.10	597.10	861.80	1,166.00	1,495.40	1,500.20	1,500.20	1,500.20	1,500.20	1,500.20	1,500.20
Ce	0.000	0.202	0.343	0.378	0.398	0.409	0.414	0.409	0.394	0.304	0.239	0.192	0.156	0.128	0.107

Wind speed [m/s]	18.00	19.00	20.00
Power [kW]	1,500.20	1,500.20	1,500.20
Ce	0.090	0.077	0.066

Ct curve

Wind speed [m/s]	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
Ct	0.10	0.10	0.10	0.80	0.82	0.84	0.79	0.72	0.66	0.59	0.53	0.46	0.40	0.33	0.28	0.23	0.20	0.16	0.13	0.12	0.12	0.11	0.11	0.10

HP curve comparison

Vmean [m/s]	5	6	7	8	9	10
HP value [MWh]	2,126	3,366	4,628	5,833	6,826	7,716
Level 0 - - - 07-2004 [MWh]	2,141	3,414	4,686	5,842	6,833	7,638
Check value [%]	-1	-1	-1	0	0	1

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m²) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.

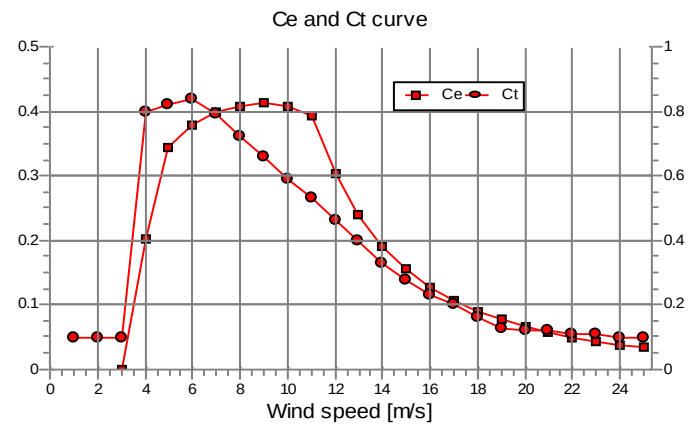
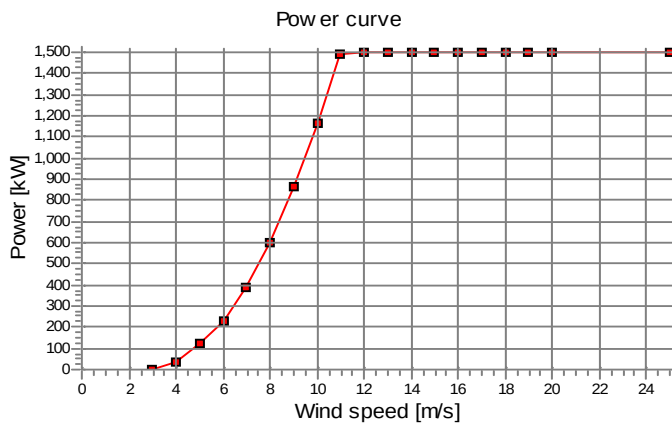
For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see WindPRO manual chapter 3.5.2.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

FUHLÄNDER FL 1500-77 1500 77.0 !-!

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**Noise:** Level 0 - - 06-2003

Source MANUFACTURER

Source date	Creator	Created	Edited	Default
11/28/2005 13:33	EMD	11/28/2005 11:06	11/28/2005 11:08	No

Hub height	Wind speed	Lwa.ref	Wind speed dependency	Pure tones
[m]	[m/s]	[dB(A)]	[dB(A)/m/s]	
All	8.0	102.0	1.0	No

102 dB(A) Measured Noise 20.06.03, IBAS Ing.- Bayreuth
Report: 03.2452/1

GE WIND ENERGY GE 1.5sle 1500 77.0 !O!

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Company GE WIND ENERGY Alternative Hub height of 61.4, 70, 85 and 100 m only
 Type/Version GE 1.5sle available for the 50 Hz model.
 Rated power 1,500.0 kW Final confirmation of data by manufacturer is pending
 Secondary generator 0.0 kW
 Rotor diameter 77.0 m
 Tower Tubular
 Grid connection 50/60 Hz

Origin country US
 Blade type LM 37, GE 37
 Generator type Variable
 Rpm, rated power 20.0 rpm
 Rpm, initial 10.0 rpm
 Hub height(s) 80.0; 61.4; 64.7; 70.0; 85.0; 96.0; 100.0 m
 Maximum blade width 0.00 m
 Blade width for 90% radius 0.00 m
 Valid Yes
 Creator EMD
 Created 1/12/2005 11:47
 Edited 1/12/2005 11:47

**Power curve:** Level 0 - Calculated - 10%<TI<15% - 2006

Source Manufacturer

Source date	Creator	Created	Edited	Default	Stop windSpeed	Air density	Tip angle	Power control	CT curve type
					[m/s]	[kg/m3]	[°]		
12/31/2006 00:00	EMD	11/21/2000 11:50	1/10/2007 10:16	Yes	25.0	1.225	0.0	Pitch	User defined

Based on GE document 1.5sl_sle_PCD_allComp_XXXXXXX.ENxx.03.pdf. Special adapted power curves for air densities 1.02-1.20 kg/m³ available from manufacturer.
 When using this PC, WindPRO's standard algorithm for air density adaptation will be used.

Power curve

Wind speed	[m/s]	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00
Power	[kW]	0.00	20.00	43.00	83.00	131.00	185.00	250.00	326.00	416.00	521.00	640.00	785.00	924.00	1,062.00	1,181.00
Ce		0.000	0.164	0.236	0.319	0.367	0.390	0.406	0.416	0.425	0.433	0.438	0.448	0.444	0.434	0.414

Wind speed	[m/s]	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50
Power	[kW]	1,283.00	1,359.00	1,402.00	1,436.00	1,463.00	1,481.00	1,488.00	1,494.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00
Ce		0.389	0.358	0.323	0.291	0.263	0.236	0.212	0.191	0.173	0.156	0.141	0.128	0.117	0.107	0.098

Wind speed	[m/s]	18.00	18.50	19.00	19.50	20.00	20.50	21.00	21.50	22.00	22.50	23.00	23.50	24.00	24.50	25.00
Power	[kW]	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00
Ce		0.090	0.083	0.077	0.071	0.066	0.061	0.057	0.053	0.049	0.046	0.043	0.041	0.038	0.036	0.034

Ct curve

Wind speed	[m/s]	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00
Ct		1.27	1.03	0.91	0.89	0.89	0.87	0.80	0.69	0.55	0.42	0.32	0.25	0.20	0.17	0.14	0.12	0.10	0.09	0.07	0.07	0.06	0.05	0.05

Power curve: Level 0 - Calculated - TI<10% - 2006

Source Manufacturer

Source date	Creator	Created	Edited	Default	Stop windSpeed	Air density	Tip angle	Power control	CT curve type
					[m/s]	[kg/m3]	[°]		
12/31/2006 00:00	EMD	11/21/2000 11:50	1/10/2007 10:16	No	25.0	1.225	0.0	Pitch	User defined

Based on GE document 1.5sl_sle_PCD_allComp_XXXXXXX.ENxx.03.pdf. Special adapted power curves for air densities 1.02-1.20 kg/m³ available from manufacturer.
 When using this PC, WindPRO's standard algorithm for air density adaptation will be used.

Power curve

Wind speed	[m/s]	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00
Power	[kW]	0.00	20.00	43.00	83.00	131.00	185.00	250.00	326.00	416.00	521.00	640.00	785.00	924.00	1,079.00	1,209.00
Ce		0.000	0.164	0.236	0.319	0.367	0.390	0.406	0.416	0.425	0.433	0.438	0.448	0.444	0.441	0.424

Wind speed	[m/s]	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50
Power	[kW]	1,314.00	1,393.00	1,440.00	1,473.00	1,486.00	1,495.00	1,498.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00
Ce		0.398	0.367	0.332	0.299	0.267	0.239	0.213	0.192	0.173	0.156	0.141	0.128	0.117	0.107	0.098

GE WIND ENERGY GE 1.5sle 1500 77.0 !O!

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Wind speed [m/s]	18.00	18.50	19.00	19.50	20.00	20.50	21.00	21.50	22.00	22.50	23.00	23.50	24.00	24.50	25.00
Power [kW]	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00
Ce	0.090	0.083	0.077	0.071	0.066	0.061	0.057	0.053	0.049	0.046	0.043	0.041	0.038	0.036	0.034

Ct curve

Wind speed [m/s]	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00
Ct	1.27	1.03	0.91	0.89	0.89	0.87	0.80	0.69	0.55	0.42	0.32	0.25	0.20	0.17	0.14	0.12	0.10	0.09	0.07	0.07	0.06	0.05	0.05

Power curve: Level 0 - Calculated - 15%<TI<20% - 2006

Source Manufacturer

Source date Creator Created Edited Default Stop windSpeed Air density Tip angle Power control CT curve type

12/31/2006 00:00 EMD 11/21/2000 11:50 1/10/2007 10:16 No [m/s] 25.0 [kg/m3] 1.225 [°] 0.0 Pitch User defined

Based on GE document 1.5sl_sle_PCD_allComp_XXXXXXX.ENxx.03.pdf. Special adapted power curves for air densities 1.02-1.20 kg/m³ available from manufacturer. When using this PC, WindPRO's standard algorithm for air density adaptation will be used.

Power curve

Wind speed [m/s]	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00
Power [kW]	0.00	20.00	43.00	83.00	131.00	185.00	250.00	326.00	416.00	521.00	640.00	785.00	924.00	1,029.00	1,133.00
Ce	0.000	0.164	0.236	0.319	0.367	0.390	0.406	0.416	0.425	0.433	0.438	0.448	0.444	0.421	0.397

Wind speed [m/s]	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50
Power [kW]	1,209.00	1,285.00	1,334.00	1,383.00	1,412.00	1,441.00	1,456.00	1,471.00	1,479.00	1,487.00	1,490.00	1,494.00	1,496.00	1,498.00	1,500.00
Ce	0.366	0.338	0.308	0.281	0.253	0.230	0.207	0.188	0.170	0.154	0.140	0.128	0.117	0.107	0.098

Wind speed [m/s]	18.00	18.50	19.00	19.50	20.00	20.50	21.00	21.50	22.00	22.50	23.00	23.50	24.00	24.50	25.00
Power [kW]	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00
Ce	0.090	0.083	0.077	0.071	0.066	0.061	0.057	0.053	0.049	0.046	0.043	0.041	0.038	0.036	0.034

Ct curve

Wind speed [m/s]	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00
Ct	1.27	1.03	0.91	0.89	0.89	0.87	0.80	0.69	0.55	0.42	0.32	0.25	0.20	0.17	0.14	0.12	0.10	0.09	0.07	0.07	0.06	0.05	0.05

HP curve comparison

Vmean	[m/s]	5	6	7	8	9	10
HP value	[MWh]	2,126	3,366	4,628	5,833	6,826	7,716

Level 0 - Calculated - 10%<TI<15% - 2006 [MWh] 2,230 3,492 4,738 5,867 6,837 7,627

Check value [%] -5 -4 -2 -1 0 1

Level 0 - Calculated - TI<10% - 2006 [MWh] 2,245 3,523 4,785 5,926 6,901 7,693

Check value [%] -5 -4 -3 -2 -1 0

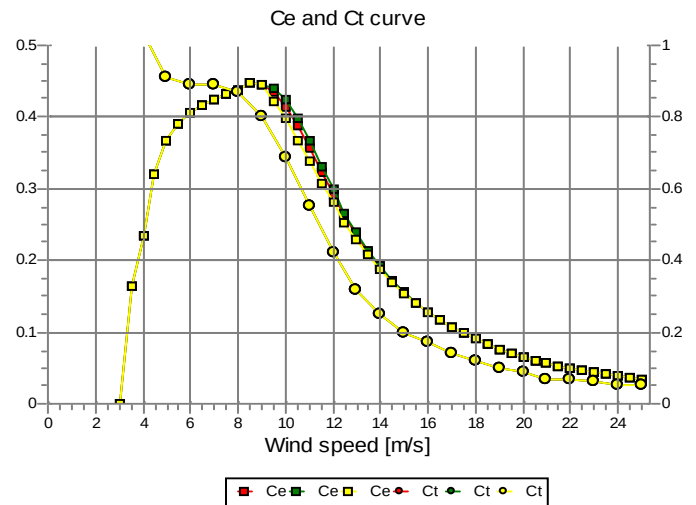
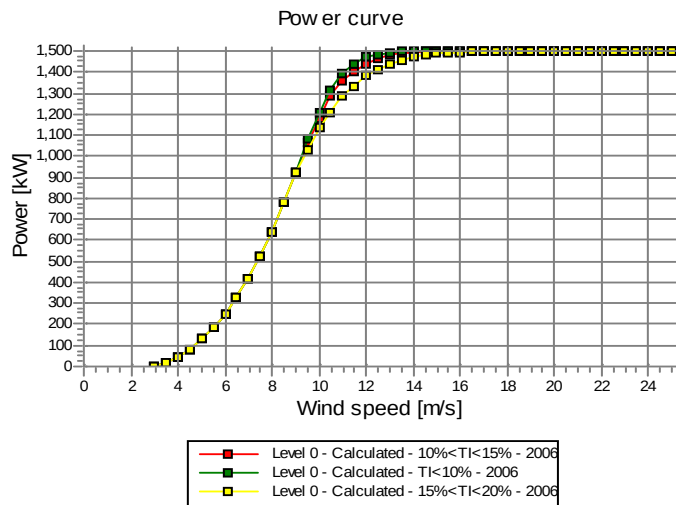
Level 0 - Calculated - 15%<TI<20% - 2006 [MWh] 2,203 3,431 4,644 5,750 6,705 7,490

Check value [%] -3 -2 0 1 2 3

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m²) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses. For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see WindPRO manual chapter 3.5.2. The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003. Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

GE WIND ENERGY GE 1.5sle 1500 77.0 !O!

File C:\Documents and Settings\eee.DOMAIN\My Documents\WindPRO\WTG Data\GE WIND ENERGY GE 1.5sle 1500 77.0 !O!.wtg

**Noise:** Level 0 - Standard operation - 01-2005

Source Manufacturer

Source date	Creator	Created	Edited	Default
1/7/2005 13:33	EMD	1/25/2005 14:02	6/27/2005 11:37	No

Hub height	Wind speed	Lwa.ref	Wind speed dependency	Pure tones
[m]	[m/s]	[dB(A)]	[dB(A)/m/s]	
All	8.0	104.0	1.0	No

+/- 2dB per IEC 61400-14 CDV

PowerWind PowerWind 56 900 56.0 !O!

File C:\Documents and Settings\lee.DOMAIN\My Documents\WindPRO\WTG Data\PowerWind PowerWind 56 900 56.0 !O!.wtg

Company PowerWind
 Type/Version PowerWind 56
 Rated power 900.0 kW
 Secondary generator 0.0 kW
 Rotor diameter 56.0 m
 Tower Tubular
 Grid connection 50/60 Hz

Origin country DE
 Blade type C27
 Generator type One generator
 Rpm, rated power 0.0 rpm
 Rpm, initial 0.0 rpm
 Hub height(s) 71.0; 59.0 m
 Maximum blade width 2.50 m
 Blade width for 90% radius 0.86 m
 Valid Yes
 Creator EMD
 Created 1/15/2010 13:42
 Edited 1/15/2010 13:42

**Power curve:** Level 0 - Measured - 24.03.2009

Source DEWI

Source date	Creator	Created	Edited	Default	Stop windSpeed	Air density	Tip angle	Power control	CT curve type
					[m/s]	[kg/m3]	[°]		
3/24/2009 12:49	EMD	1/15/2010 13:49	3/16/2010 10:57	Yes	25.0	1.225	0.0	Pitch	User defined

Power curve

Wind speed [m/s]	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
Power [kW]	5.00	32.00	71.00	136.00	230.00	345.00	497.00	687.00	815.00	886.00	900.00	900.00	900.00	900.00	900.00
Ce	0.123	0.331	0.377	0.417	0.444	0.447	0.452	0.455	0.406	0.340	0.272	0.217	0.177	0.146	0.121

Wind speed [m/s]	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00
Power [kW]	900.00	900.00	900.00	900.00	900.00	900.00	900.00	900.00
Ce	0.102	0.087	0.075	0.064	0.056	0.049	0.043	0.038

Ct curve

Wind speed [m/s]	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00
Ct	0.65	0.70	0.70	0.71	0.72	0.72	0.72	0.73	0.73	0.52	0.38	0.30	0.24	0.20	0.17	0.15	0.13	0.12	0.10	0.09	0.09	0.08	0.07

HP curve comparison

Vmean [m/s]	5	6	7	8	9	10
HP value [MWh]	1,138	1,842	2,567	3,270	3,859	4,383
Level 0 - Measured - 24.03.2009 [MWh]	1,264	1,999	2,742	3,424	4,014	4,498
Check value [%]	-10	-8	-6	-4	-4	-3

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m^2) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.

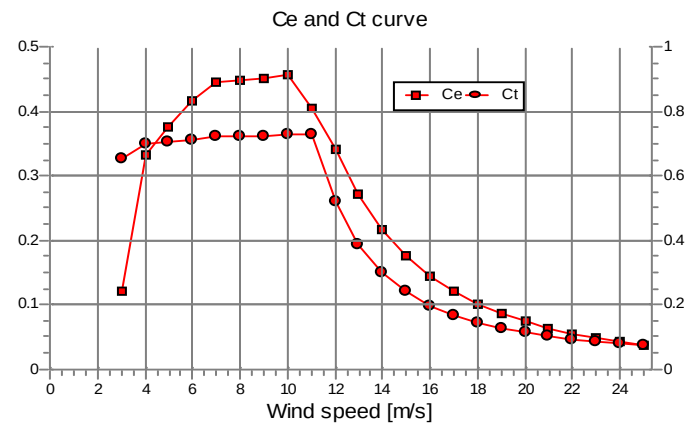
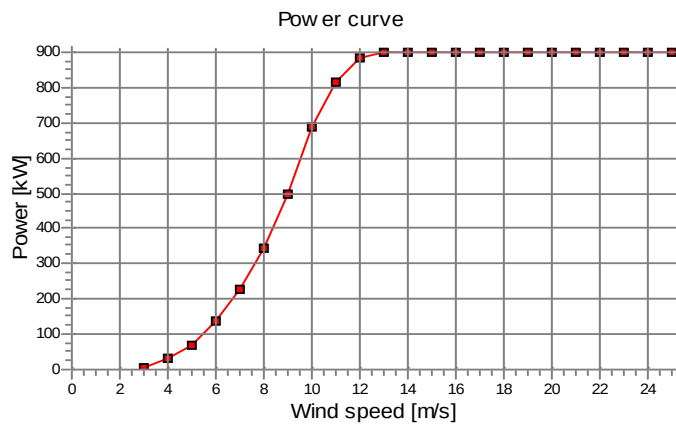
For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see WindPRO manual chapter 3.5.2.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

PowerWind PowerWind 56 900 56.0 !O!

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Tighe & Bond

MEMORANDUM OF UNDERSTANDING

This Memorandum Of Understanding is entered into as of the 5th day of November 2009 by and between the Gardner Redevelopment Authority, a public body politic and corporate created under MGL 121B having a usual office at 115 Pleasant Street, Gardner, MA ("the GRA") and the City of Gardner, a municipality with offices at 95 Pleasant Street, Gardner, MA ("the City").

Recitals

1. The City and the GRA both seek to pursue in partnership ("the City/GRA partnership") green energy initiatives including installation of a wind turbine on property owned by the GRA in the Summit Industrial Park, located at (insert address), ("the site")
2. A Preliminary Survey of a Potential Wind Project Site in the City of Gardner, Massachusetts was completed on October 16, 2009, by DNV Global Energy Concepts, Inc., ("the Preliminary Survey") on behalf of the City for the Massachusetts Technology Collaborative ("MTC"). A copy of the Preliminary Survey is attached hereto as Exhibit "A". The Preliminary Survey concluded that the site in the Summit Industrial Park can technically accommodate one sub-MW or MW-scale turbine and recommends that the City initiate a detailed feasibility study.
3. The City/GRA partnership intends to apply for a grant to conduct the feasibility study for in-depth technical and economic feasibility analyses from the Massachusetts Technology Collaborative Commonwealth Wind Incentive Program at the site in the Summit Industrial Park.

Agreement

Now, therefore, in consideration of the promises made by each party to the other, the City and the GRA agree as follows:

1. Ground Lease by the GRA. The GRA will lease to the City a sufficient portion of the property containing the site identified in the Preliminary Survey of a Potential Wind Project Site in the City of Gardner dated October 16, 2009 to accommodate a wind turbine of a size to be specified in the in-depth feasibility analysis and to be further identified in one or more proposals for projects submitted to MTC from time to time for a period of at least 25 years.
2. Obligation of the City. The City will pay the GRA an amount annually equal to one-half of the net revenue resulting from the operation of the wind turbine including the value of any net excess electricity generated and credited towards the City's utility bill.

3. Installation and Operation. The City will pay, in the City's discretion, all costs associated with investigations, studies, permitting, construction and operation of the wind turbine.
4. Cooperation. The GRA and the City agree to share all documents and information relative to the investigations, studies, permitting, construction and operation of the wind turbine.
5. Term and Termination.
 - a) The effective start date of performance shall be the date the City has been awarded financial support or funding under any of MTC's programs or initiatives.
 - b) The City may terminate this Agreement if the in-depth feasibility analysis determines the site cannot technically accommodate one sub-MW or MW-scale turbine, or if a fatal flaw is identified during the feasibility, design or construction phase, or in the event of loss of availability of sufficient funds for the purposes of this Agreement, or in the event of an unforeseen public emergency or other change in law or circumstance mandating City action inconsistent with performing its obligations under this Agreement.
6. Notices. All notices and directions to any party shall be in writing and shall be deemed given when delivered by hand if a receipt is obtained thereof, or when deposited in the United States Mail, and if delivered by mail, shall be mailed by certified or registered mail, return receipt requested, postage paid in all cases and shall be delivered as follows: (a) to the GRA: Chairman, Gardner Redevelopment Authority, 115 Pleasant Street, Gardner, MA 01440 and (b) to the City: Mayor, City Hall, 95 Pleasant Street, Gardner, MA 01440.

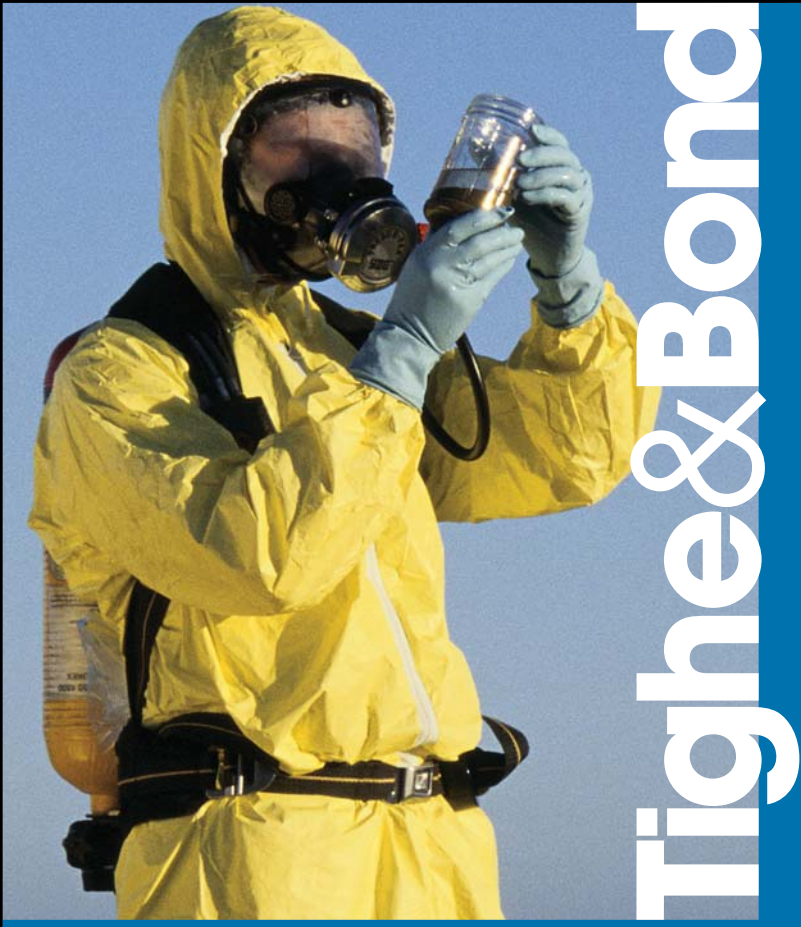
GARDNER REDEVELOPMENT AUTHORITY

By: Edward Lepkowski
Edward Lepkowski, Chairman

10/6/09
Date

CITY OF GARDNER
By: Mark Hawke
Mark Hawke, Mayor

11/6/09
Date



Tighe & Bond



Federal Aviation Administration
Air Traffic Airspace Branch, ASW-520
2601 Meacham Blvd.
Fort Worth, TX 76137-0520

Aeronautical Study No.
2009-WTE-4273-OE

Issued Date: 07/16/2009

Robert Hubbard
Gardner Redevelopment Authority
115 Pleasant Street
Room 201
Gardner, MA 01440

**** DETERMINATION OF NO HAZARD TO AIR NAVIGATION ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

Structure:	Wind Turbine Summit Wind Turbine
Location:	Gardner, MA
Latitude:	42-35-40.06N NAD 83
Longitude:	71-57-00.03W
Heights:	397 feet above ground level (AGL) 1602 feet above mean sea level (AMSL)

This aeronautical study revealed that the structure does not exceed obstruction standards and would not be a hazard to air navigation provided the following condition(s), if any, is(are) met:

As a condition to this Determination, the structure is marked and/or lighted in accordance with FAA Advisory circular 70/7460-1 K Change 2, Obstruction Marking and Lighting, white paint/synchronized red lights - Chapters 4,12&13(Turbines).

It is required that FAA Form 7460-2, Notice of Actual Construction or Alteration, be completed and returned to this office any time the project is abandoned or:

- ☐ At least 10 days prior to start of construction (7460-2, Part I)
☒ Within 5 days after the construction reaches its greatest height (7460-2, Part II)

This determination expires on 07/16/2011 unless:

- (a) extended, revised or terminated by the issuing office.
- (b) the construction is subject to the licensing authority of the Federal Communications Commission (FCC) and an application for a construction permit has been filed, as required by the FCC, within 6 months of the date of this determination. In such case, the determination expires on the date prescribed by the FCC for completion of construction, or the date the FCC denies the application.

NOTE: REQUEST FOR EXTENSION OF THE EFFECTIVE PERIOD OF THIS DETERMINATION MUST BE POSTMARKED OR DELIVERED TO THIS OFFICE AT LEAST 15 DAYS PRIOR TO THE EXPIRATION DATE.

Additional wind turbines or met towers proposed in the future may cause a cumulative effect on the national airspace system. This determination is based, in part, on the foregoing description which includes specific coordinates and heights . Any changes in coordinates will void this determination. Any future construction or alteration requires separate notice to the FAA.

This determination does include temporary construction equipment such as cranes, derricks, etc., which may be used during actual construction of the structure. However, this equipment shall not exceed the overall heights as indicated above. Equipment which has a height greater than the studied structure requires separate notice to the FAA.

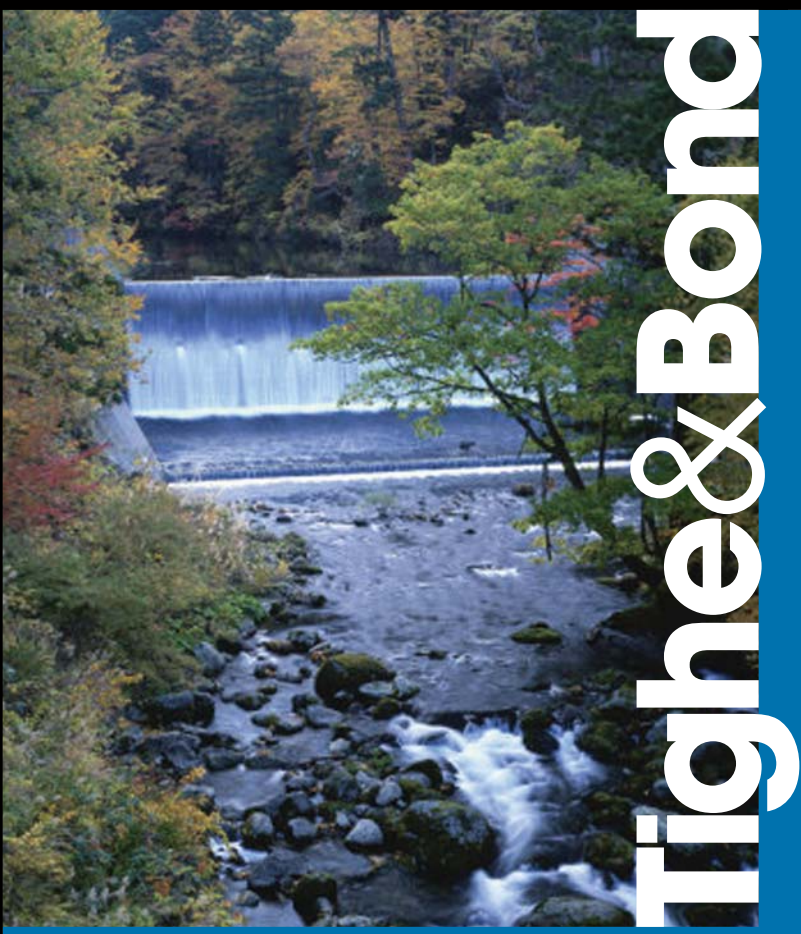
This determination concerns the effect of this structure on the safe and efficient use of navigable airspace by aircraft and does not relieve the sponsor of compliance responsibilities relating to any law, ordinance, or regulation of any Federal, State, or local government body.

If we can be of further assistance, please contact our office at (404) 305-7081. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2009-WTE-4273-OE.

Signature Control No: 629538-116436056

(DNE -WT)

Michael Blaich
Specialist



United States WatchList of Birds of Conservation Concern

The U.S. WatchList** reflects a comprehensive analysis of all the bird species in the United States, and identifies those in greatest need of immediate conservation attention. The list builds on data from Partners in Flight (PIF), the latest research from the bird conservation community, and data from the Christmas Bird Count and Breeding Bird Survey.

Identifying and spotlighting the species at greatest risk is the first step in building the public policies, funding support, conservation initiatives, and public commitment needed to save them. The U.S. WatchList lays the groundwork for an “industry standard” to guide conservation priorities among conservation organizations and government agencies.

Red List: Highest Continental Concern

Mottled Duck
Steller's Eider (*Threatened*)
Spectacled Eider (*Threatened*)
Gunnison Sage-Grouse
Sooty Grouse
Greater Prairie-Chicken
 (*“Atwater's” ssp. Endangered*)
Lesser Prairie-Chicken
Bermuda Petrel (*Endangered*)
Black-capped Petrel
Pink-footed Shearwater
Black-vented Shearwater
Ashy Storm-Petrel
Black Storm-Petrel
Least Storm-Petrel
Magnificent Frigatebird
Reddish Egret
California Condor (*Endangered*)
Yellow Rail
Black Rail
Whooping Crane (*Endangered*)
Piping Plover (*Endangered*)
Mountain Plover
Eskimo Curlew (*Endangered*)
Rock Sandpiper
Buff-breasted Sandpiper
Ivory Gull
Least Tern (*“California” and “Interior”*
 ssp. Endangered)
Kittlitz's Murrelet
Xantus's Murrelet
Craveri's Murrelet
White-crowned Pigeon
Green Parakeet



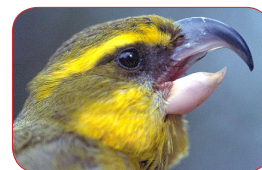
Spotted Owl: Tom Kogut/USDA Forest Service

Thick-billed Parrot
Red-crowned Parrot
Spotted Owl (*N., MX ssp. Threatened*)
Lewis's Woodpecker
Red-cockaded Woodpecker (*Endangered*)
Gilded Flicker
Ivory-billed Woodpecker (*Endangered*)
Bell's Vireo (*“Least” ssp. Endangered*)
Black-capped Vireo (*Endangered*)
Florida Scrub-Jay (*Endangered*)
Bicknell's Thrush
Bendire's Thrasher
Bachman's Warbler (*Endangered*)
Golden-winged Warbler
Golden-cheeked Warbler (*Endangered*)
Kirtland's Warbler (*Endangered*)
Bachman's Sparrow
Black-chinned Sparrow
Baird's Sparrow
Henslow's Sparrow
Saltmarsh Sharp-tailed Sparrow
Seaside Sparrow (*“Cape Sable”*
 ssp. Endangered)
Tricolored Blackbird

Red List: Hawaii

Hawaiian Duck
Hawaiian Goose
Laysan Duck
Laysan Albatross*
Black-footed Albatross*
Short-tailed Albatross (*Endangered*)*
Newell's Shearwater
Hawaiian Petrel
Band-rumped Storm-Petrel*
Tristram's Storm-Petrel
Hawaiian Hawk
Hawaiian Coot
Hawaiian Crow ('Alala)
Elepaio
Millerbird
Kamoa
Olomao
Omao
Puaiohi
Laysan Finch
Nihoa Finch
Ou
Palila
Maui Parrotbill
Oahu Amakihi
Kauai Amakihi
Anianiau
Nukupuu
Akiapolaau
Akikiki
Hawaii Creeper
Oahu Alauahio
Maui Alauahio
Akekee
Akepa
Iiwi
Akohekohe
Poouli

*also on continental lists



Maui Parrotbill: Eric VanderWerf

United States WatchList of Birds of Conservation Concern

Yellow List: Declining or Rare Continental Species

Emperor Goose
Trumpeter Swan
Greater Sage-Grouse
Mountain Quail
Scaled Quail
Montezuma Quail
Yellow-billed Loon
Clark's Grebe
Cory's Shearwater
Greater Shearwater
Buller's Shearwater
Sooty Shearwater
Manx Shearwater
Audubon's Shearwater
Masked Booby
Red-faced Cormorant
Swallow-tailed Kite
Swainson's Hawk
Clapper Rail
King Rail
American Golden-Plover
Snowy Plover (*"Western" ssp. Threatened*)
Wilson's Plover
Wandering Tattler
Bristle-thighed Curlew
Long-billed Curlew
Hudsonian Godwit
Bar-tailed Godwit
Marbled Godwit
Black Turnstone
Surfbird
Red Knot
Sanderling
Semipalmated Sandpiper
Western Sandpiper
White-rumped Sandpiper
Stilt Sandpiper
Heermann's Gull
Thayer's Gull

Iceland Gull
Yellow-footed Gull
Red-legged Kittiwake
Ross's Gull
Gull-billed Tern
Elegant Tern
Roseate Tern (*NE pops. Endangered, remainder Threatened*)
Aleutian Tern
Bridled Tern
Black Skimmer
Razorbill
Marbled Murrelet (*WA, OR, CA pops Threatened*)
Ancient Murrelet
Whiskered Auklet
Mangrove Cuckoo
Flammulated Owl
Elf Owl
Short-eared Owl
Antillean Nighthawk
Black Swift
Blue-throated Hummingbird
Costa's Hummingbird
Calliope Hummingbird
Allen's Hummingbird
Elegant Trogon
Red-headed Woodpecker
Williamson's Sapsucker
Nuttall's Woodpecker
Arizona Woodpecker
White-headed Woodpecker
Olive-sided Flycatcher
Willow Flycatcher (*SW ssp. Endangered*)
Thick-billed Kingbird
Gray Vireo
Island Scrub-Jay
Pinyon Jay
Yellow-billed Magpie
Mexican Chickadee

Oak Titmouse
California Gnatcatcher (*Threatened*)
Wood Thrush
Varied Thrush
Wrentit
California Thrasher
Leconte's Thrasher
Sprague's Pipit
Blue-winged Warbler
Virginia's Warbler
Colima Warbler
Lucy's Warbler
Bay-breasted Warbler
Hermit Warbler
Grace's Warbler
Prairie Warbler
Cerulean Warbler
Prothonotary Warbler
Swainson's Warbler
Kentucky Warbler
Canada Warbler
Red-faced Warbler
Abert's Towhee
Rufous-winged Sparrow
Five-striped Sparrow
Brewer's Sparrow
Sage Sparrow
Lark Bunting
Le Conte's Sparrow
Nelson's Sharp-tailed Sparrow
Smith's Longspur
Chestnut-collared Longspur
McKay's Bunting
Varied Bunting
Painted Bunting
Rusty Blackbird
Audubon's Oriole
Black Rosy-Finch
Brown-capped Rosy-Finch
Lawrence's Goldfinch



Red-legged Kittiwake: Glen Tepke



Blue-winged Warbler: Peter LaTourrette



Lark Bunting: Bill Schmoker



North American
BBA Explorer



Massachusetts 2007-2011

[HOME](#)

Results by Block



[BBA HOME](#)

[MA2007 BBA](#)

[Home](#)

[Methods](#)

[Block Maps](#)

[Species Info](#)

[Results](#)

[-by Species](#)

[-by Block](#)

[-by Region](#)

[All Species Summary](#)

Draft Results Summary for 0401/ Fitchburg - 01 (Worcester)

All results DRAFT until final review / publication.

[select another block](#)

SUMMARY:

97 total species: 32 CO, 47 PR, 18 PO, (plus 2 OB)

27 species in MA1974

Results last updated: 11 Oct 2010

[view missing species](#)

Species List

Species	Best Evidence	Other details	MA1974
Canada Goose	● CO PY		
Wood Duck	● CO PY		
Mallard	● CO PY		
Hooded Merganser	● CO FL		
Ruffed Grouse	● CO DD		
Wild Turkey	● PR S		
Common Loon	● CO PY		
Double-crested Cormorant	○ OB O		
American Bittern	● PR P		
Great Blue Heron	● CO NY		
Green Heron	● PR P		
Turkey Vulture	○ OB O		
Cooper's Hawk	⊗ PO X		
Broad-winged Hawk	● PR A		
Virginia Rail	● PR P		
Killdeer	● CO DD		
American Woodcock	● PR C		
Rock Pigeon	⊗ PO X		
Mourning Dove	● PR S		● CO
Black-billed Cuckoo	⊗ PO X		
Great Horned Owl	⊗ PO X		
Barred Owl	● PR S		
Chimney Swift	● PR P		⊗ PO
Ruby-throated Hummingbird	⊗ PO X		
Belted Kingfisher	⊗ PO X		
Red-bellied Woodpecker	⊗ PO X		
Downy Woodpecker	● PR S		
Hairy Woodpecker	⊗ PO X		
Northern Flicker (Yellow-shafted Flicker)	● PR S		
Pileated Woodpecker	● PR S		
Eastern Wood-Pewee	● PR S		
Alder Flycatcher	● PR S		
Willow Flycatcher	● PR S		

Least Flycatcher	● PR S		
Eastern Phoebe	● PR S		● PR
Great Crested Flycatcher	● PR S		● PR
Eastern Kingbird	● CO CF		
Blue-headed Vireo	● PR A		
Warbling Vireo	● PR S		
Red-eyed Vireo	● PR S		● PR
Blue Jay	● PR S		⊗ PO
American Crow	● CO FL		● CO
Common Raven	⊗ PO X		
Tree Swallow	● CO FY		● CO
Bank Swallow	⊗ PO X		
Barn Swallow	● PR A		● CO
Black-capped Chickadee	● CO FL		⊗ PO
Tufted Titmouse	● PR S		
Red-breasted Nuthatch	● CO FY		
White-breasted Nuthatch	● CO FL		
Brown Creeper	● PR S		
Carolina Wren	⊗ PO X		
House Wren	● CO FY		● CO
Winter Wren	⊗ PO X		
Sedge Wren	● PR S		
Marsh Wren	⊗ PO X		
Veery	● PR S		
Hermit Thrush	● CO FL		
Wood Thrush	● PR S		
American Robin	● CO CF		● CO
Gray Catbird	● CO CF		● CO
Northern Mockingbird	● CO FL		
European Starling	● CO CF		● CO
Cedar Waxwing	● CO ON		
Nashville Warbler	● PR P		
Yellow Warbler	● CO FL		● PR
Chestnut-sided Warbler	● PR S		
Magnolia Warbler	⊗ PO X		
Black-throated Blue Warbler	● PR S		
Yellow-rumped Warbler (Myrtle Warbler)	● PR S		
Black-throated Green Warbler	● PR S		● PR
Blackburnian Warbler	⊗ PO X		
Pine Warbler	● CO CN		
Black-and-white Warbler	● PR S		
American Redstart	● PR S		● PR
Ovenbird	● PR S		
Northern Waterthrush	● PR S		
Common Yellowthroat	● CO CF		● PR
Canada Warbler	● PR S		
Scarlet Tanager	● PR S		

Eastern Towhee	PR S		
Chipping Sparrow	CO CF		CO
Savannah Sparrow	PO X		
Song Sparrow	CO CF		PR
Swamp Sparrow	PR S		PR
White-throated Sparrow	PR S		
Northern Cardinal	PR S		
Rose-breasted Grosbeak	PR S		
Indigo Bunting	PR S		
Bobolink	CO CF		CO
Red-winged Blackbird	CO CF		CO
Eastern Meadowlark			PR
Common Grackle	CO CF		CO
Brown-headed Cowbird	PO X		PO
Baltimore Oriole	CO FY		
Purple Finch	PR S		
House Finch	CO CN		
American Goldfinch	CO CN		
Evening Grosbeak	PO X		
House Sparrow	PR S		CO

(select a Quad first)

Arrangement of blocks:

01	04	07	10
02	05	08	11
03	06	09	12

OR block code:

'Quad' is used here for topographic quads or other larger units containing survey blocks.

Back to [Massachusetts 2007-2011](#) | [Results Menu](#)

Related topics: [Results for Worcester County](#)

Help & Hints for atlases in progress

- Only *reviewed* data are shown in public results.
- This page may show no results (0 species) for the current atlas, but have lots of results from a previous atlas.
- For atlas participants, the Block Sightings Detail Report may be more useful and includes all species, even those not finalized or reviewed.

[Patuxent Wildlife Research Center](#), part of the [U.S. Geological Survey \(USGS\)](#), and [National Biological Information Infrastructure](#) provide the BBA (Breeding Bird Atlas) Explorer in cooperation with the atlas project sponsors.

[U.S. Department of the Interior](#) || [U.S. Geological Survey](#) || [Patuxent Wildlife Research Center](#) Laurel, MD, USA 20708-4038

This site is: <http://www.pwrc.usgs.gov/bba>

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Contact: mwimer@usgs.gov

Last updated: Site - December 2008; Content - various, depending on atlas.

Page generated on: 12-Oct-2010

Massachusetts Breeding Bird Atlas II (2007-2011)

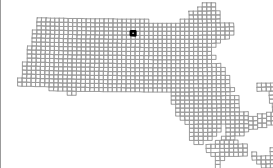
Block: 0401
Fitchburg - 01



Map Key

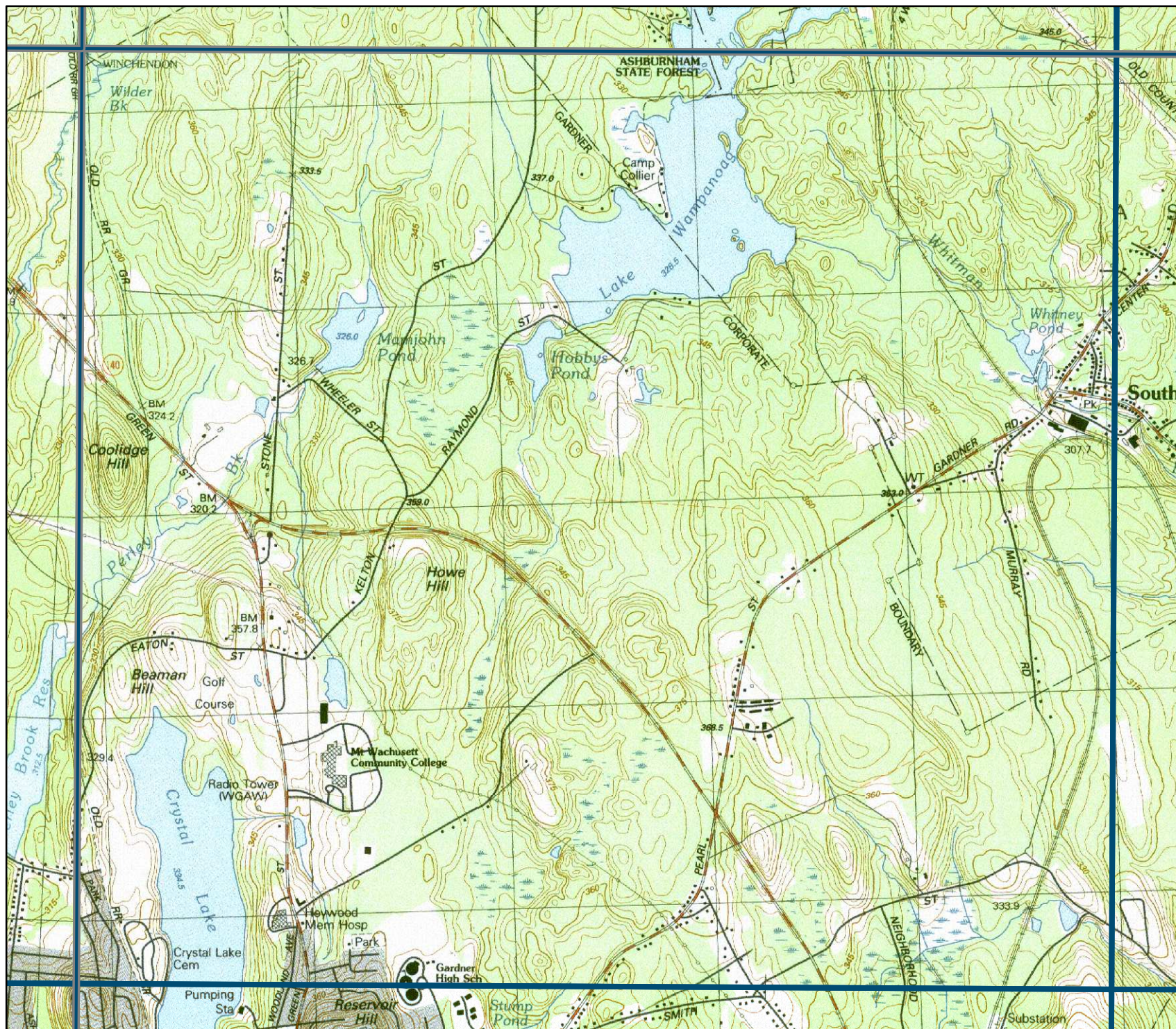
-  Atlas block border
-  Topo border
-  County line

Block locator



0163	0166	0173	0176
0394		0404	
0395	0402	0405	

Date generated:
Mar 05, 2008



More info: <http://www.massaudubon.org/birdatlas/bba2> | To print a map: <http://www.pwrc.usgs.gov/bba>
Topographic data from Office of Geographic and Environmental Information (MassGIS),
Commonwealth of Massachusetts, Executive Office of Energy and Environmental Affairs

0 0.25 0.5 1 Mile

Massachusetts Cultural Resource Information System

MACRIS

MACRIS Search Results

Search Criteria: Town(s): Gardner; Resource Type(s): Area, Building, Burial Ground, Object, Structure;

Inv. No.	Property Name	Street	Town	Year
GAR.A	West Gardner Square Historic District		Gardner	
GAR.B	Heywood - Wakefield Company Complex		Gardner	
GAR.C	Whitney Tavern		Gardner	
GAR.D	Gardner Uptown Historic District		Gardner	
GAR.E	Diners of Massachusetts		Gardner	
GAR.912	Betty's Spring	Betty Spring Rd	Gardner	1951
GAR.913	Betty Spring Road Bridge	Betty Spring Rd	Gardner	1919
GAR.920	Shoddy Mill Bridge	Bridge St	Gardner	1937
GAR.94	Bailey, Dr. House	39 Broadway	Gardner	1855
GAR.95	Massachusetts Turnpike Toll House	52 Broadway	Gardner	1805
GAR.47	East Schoolhouse No. 6, Old	11 Carter Rd	Gardner	1789
GAR.246	Stevens Block	Central St	Gardner	1890
GAR.253	Carbone Block	Central St	Gardner	1900
GAR.266		Central St	Gardner	
GAR.267	Vezine Realty Building	Central St	Gardner	
GAR.268	Heritage Park Fun Center	Central St	Gardner	1920
GAR.922	Heywood - Town Hall Monument	Central St	Gardner	1965
GAR.2	First Congregational Church	5 Central St	Gardner	1878
GAR.110	Syndicate Block	28 Central St	Gardner	1895
GAR.29	Heywood, Charles House	41 Central St	Gardner	1886
GAR.111	Gardner Masonic Lodge	48 Central St	Gardner	1920
GAR.30	Heywood - Derby House	52 Central St	Gardner	1860
GAR.31	Conant, Charles House	55 Central St	Gardner	1825
GAR.32	Heywood, Henry House	100 Central St	Gardner	1869
GAR.33	Heywood, Seth House	117 Central St	Gardner	1869
GAR.108	Former U. S. Post Office - Gardner Center Branch	144 Central St	Gardner	1899

Inv. No.	Property Name	Street	Town	Year
GAR.210	Heywood - Wakefield Company Complex Office Bldg	206 Central St	Gardner	1907
GAR.274	Heywood - Wakefield Company Complex Wood Shop	206 Central St	Gardner	1880
GAR.275	Heywood - Wakefield Company Complex Finishing Dept	206 Central St	Gardner	1880
GAR.276	Heywood - Wakefield Company Complex Power Plant	206 Central St	Gardner	1880
GAR.277	Heywood - Wakefield Company Complex Warehouse	206 Central St	Gardner	1880
GAR.265	Horrigan Cleaners	263 Central St	Gardner	1886
GAR.264	Featherstone Apartments	275 Central St	Gardner	1895
GAR.258	Central Luncheonette	280 Central St	Gardner	1885
GAR.257	Richard, A. J. Building	287 Central St	Gardner	1894
GAR.259	Central Pub Building	294-302 Central St	Gardner	1890
GAR.245	Green Block	301 Central St	Gardner	1898
GAR.216	Gardner News Building	309 Central St	Gardner	1906
GAR.48	Payson, Joseph House	48 Chapel St	Gardner	1760
GAR.58	Smith, F. W. Silver Company	60 Chestnut St	Gardner	1888
GAR.217	Brooks, Harvey House	82 Chestnut St	Gardner	1875
GAR.59	Mason, Warren E. House	107 Chestnut St	Gardner	1865
GAR.60	Watkins, Edward G. House	141 Chestnut St	Gardner	1890
GAR.229	Stanley's Motor Sales Showroom	31 City Hall Ave	Gardner	1924
GAR.219	Kane, Mary E. Building	175 Connors St	Gardner	1901
GAR.62	Sacred Heart Roman Catholic Church	Cross St	Gardner	1893
GAR.218	Bryant, John M. House	20 Cross St	Gardner	1871
GAR.61	Bryant, John M. House	22 Cross St	Gardner	1868
GAR.211	Saint Paul's Episcopal Church	79 Cross St	Gardner	1909
GAR.74	Jackson, Abel House	49 Dyer St	Gardner	1780
GAR.93	South Gardner Hotel	8 East Broadway	Gardner	1804
GAR.96		68 East Broadway	Gardner	1855
GAR.105	Maynard, Joseph House	203 East Broadway	Gardner	1828
GAR.106	Greenwood, Jonathan House	378 East Broadway	Gardner	1800
GAR.43	Howe, Ebenezer House	Eaton St	Gardner	1773
GAR.44	Bacon, Joseph House	Eaton St	Gardner	1772
GAR.42	Howe - Goodman House	9 Eaton St	Gardner	1780
GAR.908	Hope Lodge of Masons Marker	Elm St	Gardner	1914
GAR.923	Higgins, William H. Monument	Elm St	Gardner	1989
GAR.22	Heywood, Levi House	13 Elm St	Gardner	1845

Inv. No.	Property Name	Street	Town	Year
GAR.112	Gardner American Legion Hall	22 Elm St	Gardner	1980
GAR.23	Bush, C. W. House	23 Elm St	Gardner	1845
GAR.24	Bancroft, Amasa House	37 Elm St	Gardner	1845
GAR.114		44 Elm St	Gardner	1795
GAR.25	Edgell, John - Temple Double House	45 Elm St	Gardner	1856
GAR.115		52 Elm St	Gardner	1795
GAR.206	Elm Street Fire Station	58 Elm St	Gardner	1897
GAR.116	Carlton, Louis E. House	61 Elm St	Gardner	1902
GAR.205	Gardner First Unitarian Church	66 Elm St	Gardner	1887
GAR.117	Smith, Roger R. House	75 Elm St	Gardner	1940
GAR.118	Turner, Marden H. House	85 Elm St	Gardner	1922
GAR.204	Sawin, Levi - Pearson, Chester House	88 Elm St	Gardner	1899
GAR.119	Siebert, Otto W. House	93 Elm St	Gardner	1915
GAR.26	Edgell, John D. House	98 Elm St	Gardner	1880
GAR.207	Glazier, Thomas E. - Boyles House	105 Elm St	Gardner	1878
GAR.120	Bent, Leslie C. House	129 Elm St	Gardner	1895
GAR.214	Gardner High School, Old	130 Elm St	Gardner	1898
GAR.924	Hitchcock Chair Monument	130 Elm St	Gardner	1980
GAR.121	Favor - Dunn House	137 Elm St	Gardner	1915
GAR.122		147 Elm St	Gardner	1860
GAR.123		153 Elm St	Gardner	1940
GAR.124		159 Elm St	Gardner	1820
GAR.126	Gardner High School - Elm Street School	160 Elm St	Gardner	1926
GAR.125	Moore, Cornelius House	163 Elm St	Gardner	1875
GAR.127	Bresnihan - Mulcahey House	177 Elm St	Gardner	1860
GAR.27	First Minister's House	186 Elm St	Gardner	1792
GAR.208	Blouin, Joseph House	308 Elm St	Gardner	1912
GAR.209	Bent, Charles O. House	394 Elm St	Gardner	1885
GAR.128	Alexander, E. House	7 Glazier St	Gardner	1860
GAR.65		27 Graham St	Gardner	1901
GAR.255		29 Graham St	Gardner	1900
GAR.800	Burying Ground, Old	Green St	Gardner	1785
GAR.129		7 Green St	Gardner	1959
GAR.3	Prescott, Jonathan House	15 Green St	Gardner	1790
GAR.4	Collier, David R. House	21 Green St	Gardner	1903
GAR.5	Howe, Volney W. House	27 Green St	Gardner	1878
GAR.6	Smith, Asa House	37 Green St	Gardner	1837
GAR.278	Richardson Double House	45-49 Green St	Gardner	1896

Inv. No.	Property Name	Street	Town	Year
GAR.7	Second Evangelical Congregational Church	55-57 Green St	Gardner	1855
GAR.8	Alger, J. L. House	74 Green St	Gardner	1854
GAR.38	Central House	94 Green St	Gardner	1860
GAR.39	Rugg, Benjamin House	111 Green St	Gardner	1885
GAR.40	Lamson, W. H. House	129 Green St	Gardner	1855
GAR.97		13 High St	Gardner	1855
GAR.98	First Baptist Church	14 High St	Gardner	1833
GAR.99	Chaney, Lorenzo House	25 High St	Gardner	1835
GAR.100	Eaton, Eliezer House	46 High St	Gardner	1855
GAR.101	Eaton, Benjamin House	64 High St	Gardner	1855
GAR.102	Metcalfe, John House	165 High St	Gardner	1855
GAR.103	Wright House	247-249 High St	Gardner	1832
GAR.104	Greenwood, Jonathan House	310 High St	Gardner	1785
GAR.78	Hill, Asa House	Hill St	Gardner	1785
GAR.54	Bancroft, Jonathan Jr. House	Hosley Rd	Gardner	1810
GAR.45	Kelton House	126 Kelton St	Gardner	1828
GAR.911	Jackson, Elisha Tablet	Kendall St	Gardner	1935
GAR.81	Sawin, John House	21 Kendall St	Gardner	1850
GAR.212	Lake Street Fire Station	2 Lake St	Gardner	1884
GAR.28	Holland, Joseph House	20 Lennon St	Gardner	1768
GAR.919	B & M Railroad Bridge #26.52	Logan St	Gardner	1930
GAR.37	Lynde, William S. House	69 Lynde St	Gardner	1769
GAR.72	Edgell, Bush and Company	Main St	Gardner	1844
GAR.248	Goodnow Pearson Store No. 3	Main St	Gardner	1910
GAR.249	Greenwood, T. T.	Main St	Gardner	1903
GAR.250	Goodnow Pearson Store No. 1	Main St	Gardner	1907
GAR.252	Dunn, John A. Chair Factory	Main St	Gardner	1915
GAR.260	Pandiscio Realty Building	Main St	Gardner	1960
GAR.263	Opticians Building	Main St	Gardner	1915
GAR.261	A. R. Block	38 Main St	Gardner	1915
GAR.262	Music Shop Building	42 Main St	Gardner	1907
GAR.279	Miss Toy Town Diner - Blue Moon Diner	102 Main St	Gardner	1949
GAR.918	Mill Street Bridge over Baker Brook	Mill St	Gardner	1930
GAR.66		59 Nichols St	Gardner	1903
GAR.67		100 Nichols St	Gardner	1903
GAR.68	Our Lady of the Holy Rosary Roman Catholic Church	135 Nichols St	Gardner	1915
GAR.909	Soldiers Civil War Monument	Park St	Gardner	1885

Inv. No.	Property Name	Street	Town	Year
GAR.34		7 Park St	Gardner	1855
GAR.35	Fairbank, W. L. House	17 Park St	Gardner	1855
GAR.36	Hill, Harrison G. O. House	23 Park St	Gardner	1855
GAR.1	Greenwood Memorial Pool and Bath House	69 Park St	Gardner	1914
GAR.64	Bankcroft, Jonathan	156 Park St	Gardner	1772
GAR.238	Ryan Brothers Block	Parker St	Gardner	1895
GAR.236	Michelman Block	20-24 Parker St	Gardner	1924
GAR.215	Gardner Savings Bank	29 Parker St	Gardner	1909
GAR.237	Orpheum Theatre Block	32-40 Parker St	Gardner	1913
GAR.243	Gardner Realty Corporation Building	33-47 Parker St	Gardner	1926
GAR.239	Rose Clothing Store Building	50 Parker St	Gardner	1915
GAR.240	Robichaud Block	60-72 Parker St	Gardner	1915
GAR.256	Rome Block	63 Parker St	Gardner	1905
GAR.241	Levine Block	74-78 Parker St	Gardner	1935
GAR.107	Partridge, Jabez House	81 Partridge St	Gardner	1780
GAR.921	Whitney Tavern Recreational Area	11 Patriots Rd	Gardner	
GAR.130		12 Pearl St	Gardner	1953
GAR.11	Heywood, Levi Memorial Library	28 Pearl St	Gardner	1885
GAR.131	Colby House	48 Pearl St	Gardner	1880
GAR.202	Colby, Dr. Edwin House	54 Pearl St	Gardner	1895
GAR.12	Cowee, Joel House	68 Pearl St	Gardner	1820
GAR.13	Gates, Francis House	87 Pearl St	Gardner	1865
GAR.14	Parker, Dr. David House	99 Pearl St	Gardner	1867
GAR.15	Barker, Joseph House	100 Pearl St	Gardner	1855
GAR.132	Dunn, George A. House	114 Pearl St	Gardner	1900
GAR.133		117 Pearl St	Gardner	1950
GAR.134	Whittemore, F. S. House	124 Pearl St	Gardner	1886
GAR.16	Whitney, Charles House	125 Pearl St	Gardner	1878
GAR.17	Danforth, Theodore W. House	131 Pearl St	Gardner	1878
GAR.135	Alexander - Chafee House	132-134 Pearl St	Gardner	1850
GAR.136	Greenwood, Herbert House	144 Pearl St	Gardner	1886
GAR.137	Monroe, A. House	145 Pearl St	Gardner	1870
GAR.138	Dunn, J. P. House	152 Pearl St	Gardner	1880
GAR.19	Comee, James M. House	162 Pearl St	Gardner	1815
GAR.18	Gates, Nancy House	163 Pearl St	Gardner	1855
GAR.20	Wood, L. House	173 Pearl St	Gardner	1800
GAR.139	Hunting, Gilson W. House	181 Pearl St	Gardner	1860
GAR.203	Heywood, Benjamin House	204 Pearl St	Gardner	1800

Inv. No.	Property Name	Street	Town	Year
GAR.51	Brown, Jonathan House	747 Pearl St	Gardner	1791
GAR.52	Brown, Jonathan House	793 Pearl St	Gardner	1791
GAR.53	White, John House	872 Pearl St	Gardner	1768
GAR.269	Store Building	Pine St	Gardner	1920
GAR.270		Pine St	Gardner	1930
GAR.272		Pine St	Gardner	1910
GAR.273		Pine St	Gardner	1855
GAR.254	Wood, H. - Priest, J. G. House	93 Pine St	Gardner	1865
GAR.271		93R Pine St	Gardner	1900
GAR.227	Gardner City Hall and Auditorium	Pleasant St	Gardner	1938
GAR.230	Colonial Hotel	Pleasant St	Gardner	1923
GAR.251	Rosenberg Block	Pleasant St	Gardner	1899
GAR.901	World War I Memorial	Pleasant St	Gardner	1939
GAR.902	World War II Memorial	Pleasant St	Gardner	1951
GAR.903	Firefighters Memorial	Pleasant St	Gardner	1972
GAR.904	Ten Commandments Monument	Pleasant St	Gardner	1955
GAR.905	Vietnam War Memorial	Pleasant St	Gardner	1973
GAR.906	Korean War Memorial	Pleasant St	Gardner	1961
GAR.907	Polish - American Veterans Monument	Pleasant St	Gardner	1955
GAR.109	Garbose Building	3 Pleasant St	Gardner	1883
GAR.235	Riordan Block	7-13 Pleasant St	Gardner	1924
GAR.234	Davis' Brick Block	17 Pleasant St	Gardner	1892
GAR.233	First National Bank	25-27 Pleasant St	Gardner	1923
GAR.232	J. C. Penney Store	29 Pleasant St	Gardner	1925
GAR.231	Gardner Cooperative Bank	33 Pleasant St	Gardner	1927
GAR.228	U. S. Post Office - Gardner Branch	69 Pleasant St	Gardner	1936
GAR.226	Gardner Court House and Police Department	115 Pleasant St	Gardner	1928
GAR.69		133 Pleasant St	Gardner	1912
GAR.70	Congregation Ohave Shalom Synagogue	152 Pleasant St	Gardner	1912
GAR.71	Saint Joseph's Roman Catholic Church	358 Pleasant St	Gardner	1913
GAR.200	Howe, Ezekiel House	Raymond St	Gardner	1810
GAR.915	Route 2 Bridge	Route 2	Gardner	1961
GAR.916	Route 2 Bridge	Route 2	Gardner	1961
GAR.917	Route 2 Bridge	Route 2	Gardner	1961
GAR.55		39 School St	Gardner	1869
GAR.57	Temple, Asa House	60 School St	Gardner	1886
GAR.56	Morse, C. W. House	65 School St	Gardner	1858
GAR.49	Gates, A. House	250 Smith St	Gardner	1840

Inv. No.	Property Name	Street	Town	Year
GAR.88		19 South Main St	Gardner	1855
GAR.914	Union Street Bridge	Union St	Gardner	1900
GAR.89	Jackson, Isaac House	20 Union St	Gardner	1842
GAR.90		21 Union St	Gardner	1855
GAR.91	Lovewell, Charles House	24 Union St	Gardner	1855
GAR.92	Brooks, Ivers House	81-83 Union St	Gardner	1853
GAR.87	Pierce, Sylvester K. House	4 West Broadway	Gardner	1875
GAR.224	Gates, Marcius - Gates, Samuel House	23 West Broadway	Gardner	1853
GAR.223	Moore, John Milton House	29 West Broadway	Gardner	1860
GAR.86	Bent, Roderic L. House	30 West Broadway	Gardner	1870
GAR.222	Stevens, S. W. A. - Hogan, William House	39 West Broadway	Gardner	1850
GAR.85	Travers, George M. House	78 West Broadway	Gardner	1838
GAR.84	Bickford House	88 West Broadway	Gardner	1838
GAR.83		91 West Broadway	Gardner	1855
GAR.80	Jackson, Sullivan House	207 West Broadway	Gardner	1790
GAR.21	Massachusetts Army National Guard Armory	323 West Broadway	Gardner	1956
GAR.73	Hinds, Abijah Brickyard	758 West Broadway	Gardner	1830
GAR.201	Conant, Ball and Company Factory	60 West Lynde St	Gardner	1855
GAR.900	Spanish - American War Monument	West St	Gardner	1915
GAR.63		549 West St	Gardner	1826
GAR.75		261 Whitney St	Gardner	1855
GAR.76	Eager, Jonathan House	262 Whitney St	Gardner	1790
GAR.77	Whitney, Joshua House	264 Whitney St	Gardner	1774
GAR.50	Willis Farm, Old	168 Willis Rd	Gardner	1855
GAR.221	Bent, G. Leslie - Stone, A. J. House	17 Winter St	Gardner	1890
GAR.220	Joslin, Benjamin T. House	47 Winter St	Gardner	1866
GAR.79	Bent, S. and Brothers Inc.	85 Winter St	Gardner	1870
GAR.910	Gardner Town Common, Old	Woodland Ave	Gardner	1785
GAR.113	Heywood, Harriet G. House	16 Woodland Ave	Gardner	1909
GAR.10	Burrage, Charles - Wilder House	34 Woodland Ave	Gardner	1890
GAR.213	Stratton, Herbert S. House	74 Woodland Ave	Gardner	1886
GAR.9	Osgood, Charles House	79 Woodland Ave	Gardner	1886

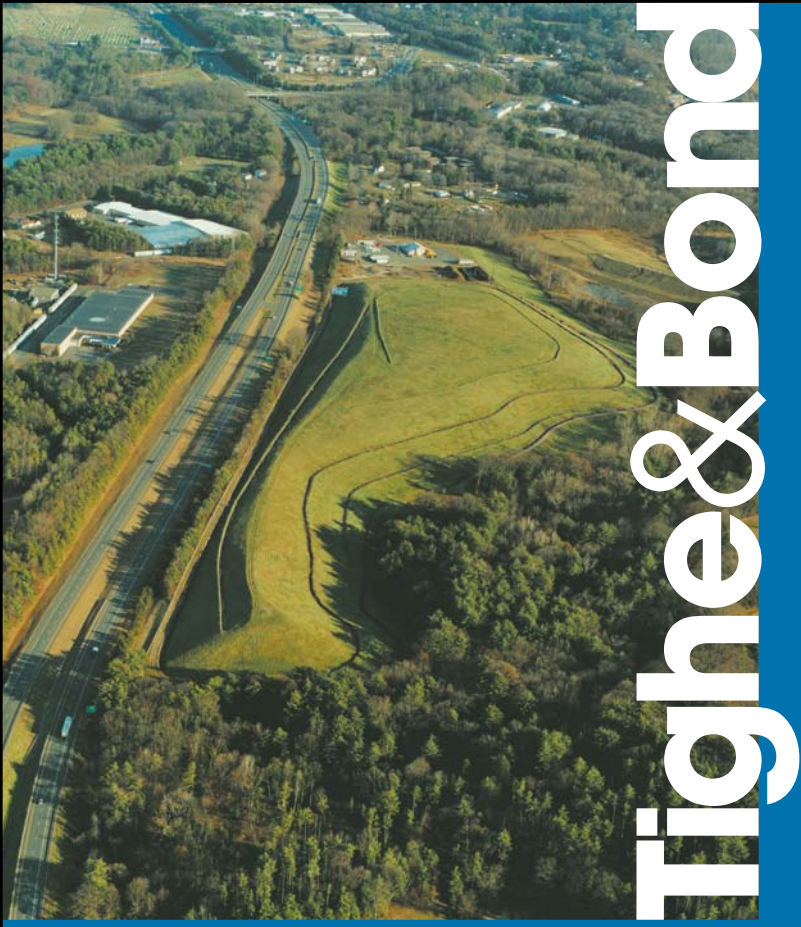


TABLE 5-3
Gardner Wind Turbine Financial Analysis: Inputs & Outputs (USD)

Project Summary	
Project Summary:	
Project	Garnder Wind Turbine
Location	Gardner, MA
Operation Commencement	12/31/12
Operation Duration	30 years
System & Installation Summary:	
Turbine	Vestas V82
System Capacity (MW-ac)	1.650
Annual Capacity Factor (20-yr Average P50)	32.0%
Cost Assumptions	
Equipment Costs:	
Turbine	\$2,900,000
Electrical Equipment	\$65,000
Other	\$--
Equipment Price	\$2,965,000
Sales Tax	\$--
Total Equipment Cost	\$2,965,000
Development Costs¹:	
Engineering Design	\$444,800
Permitting	\$--
Construction	\$593,000
Site Preparation	\$--
Foundation	\$--
Installation	\$--
Commissioning/Startup	\$--
Development Costs (General)	\$148,250
Total Development Cost	\$1,186,050
Transaction Costs:	
Land Purchase	--
Title Insurance	\$8,900
Legal Transactions	\$20,000
Builder's Risk (Erection) Insurance	\$4,500
Dev Security Deposit	\$--
Total Transaction Costs	\$33,400
Financing Costs:	
Equity Placement	--
Debt Placement	--
Other Financing Fees	--
Total Financing Cost	\$--
Total Project Costs:	
Equipment Cost	\$2,965,000
Development & Transaction Costs	\$1,219,450
Construction Interest	\$--
Financing Cost	\$--
Utility Interconnection Cost	\$--
Utility Interconnection Upgrade Payment	\$--
Credit for Power Sales pre COD	\$--
TOTAL PROJECT COSTS	\$4,184,500

¹ Includes contingency for National Grid interconnection study. Costs may vary

Revenue Assumptions	
Average Annual Production (kWhs)	4,625,280
Initial Bid Price (\$ / kWh)	\$0.1440
TOD adjustment factor	1.000
Initial TOD Adjusted Price (\$ / kWh)	\$0.1440
Annual Price escalation	2.5%
REC Value (Y1-10, \$/MWh)	\$40
REC Value (Y11-30, \$/MWh)	\$30
Annual Output Degradation	--%
Utility Interconnection Upgrade Payment	
Terms	5 years
Rate	7.5%
Line Loss & Other Losses	--%
Estimated CO2 Emission Credit	\$--
Operating Assumptions	
	Annual Cost \$
Annual O&M	\$60,000
O&M Escalation	3.0%
General Property Insurance	\$5,100
Insurance Escalation	3.0%
Business Interruption Insurance	\$8,400
Insurance Escalation	3.0%
Management	\$17,100
Management Escalation	3.0%
Property Tax	--
Land Rental Payment	--
Land Rental Escalation	0%
Tax Assumptions	
No Tax Liability	
Tax Incentives	
ITC (30% of project costs)	\$--
% ITC not Depreciable	--%
Tax Depreciable Basis	\$--
Tax Rates:	
Federal Tax Rate	--%
State Tax Rate	--%
State Sales Tax	--%
State Incentives:	
State Tax Credit	\$--
Commonwealth Wind	\$400,000
Tax Depreciable Basis	\$--
Years Depreciable	1 years
Federal Funding	
Federal Grant	\$250,000
Financing Assumptions	
Construction Interest	\$--
IRR Leverage Effect	x0.65
Debt Sizing (% Long Term)	
Long Term Debt	\$3,757,600
Rate	4.0%
Term	20 years
Letters of Credit	\$--
Rate	--%
Term	0 years

Project Indicators	
leveraged:	
IRR	13.3%
NPV (Discount 6%)	\$4,342,600
Payback Period (Discount 6%)	7.3
Unleveraged:	
IRR	20.4%
NPV (Discount 6%)	\$7,466,100
Payback Period (Discount 6%)	4.6
Sensitivity Anaysis	
leveraged	
Project Cost at -20%	\$3,347,600
NPV (Discount 6%)	\$5,882,000
Payback Period (Discount 6%)	5.3
Project Cost at +20%	
NPV (Discount 6%)	\$5,021,400
Payback Period (Discount 6%)	\$2,858,400
	13.0
AEP at P90 CF (kWh)	26.90%
NPV (Discount 6%)	3,888,126
Payback Period (Discount 6%)	\$2,614,900
	12.0
AEP at +20% (kWh)	5,550,336
NPV (Discount 6%)	\$6,572,600
Payback Period (Discount 6%)	6.1
Other Assumptions	
Amortization of Financing Fees (\$/yr):	
Debt Financing Fee (leveraged Scenario)	\$--
Equity Financing Fee (leveraged Scenario)	\$--
Equity Financing Fee (Unleveraged Scenario)	\$--
Initial Equity Investment (Unleveraged Scenario):	
Equity Investment	\$3,619,200
Equity Fees	\$--
Total Equity Investment	\$3,619,200
Fund Allocation (leveraged):	
Total Project Cost	\$4,184,500
Cash Reserves for O&M & Repair Work	84,700
Working Capital	\$--
Federal Grant	(250,000)
State Grant	(400,000)
Federal Investment Tax Credit	--
Funds Required	\$3,619,200
Debt Service Account	138,400
TOTAL FUNDS REQUIRED	\$3,757,600
Fund Source (leveraged):	
Equity	\$--
Debt	\$3,757,600
Total Funds	\$3,757,600
Summary Financial Metrics (leveraged):	
% Equity	--%
% Debt	100%
Last Updated: 12/17/2010	

TABLE 5-3
Gardner Wind Turbine Financial Analysis: Inputs & Outputs (USD)

Project Summary	
<u>Project Summary:</u>	
Project	Garnder Wind Turbine
Location	Gardner, MA
Operation Commencement	12/31/12
Operation Duration	30 years
<u>System & Installation Summary:</u>	
Turbine	Furhlander FL1500
System Capacity (MW-ac)	1.500
Annual Capacity Factor (20-yr Average P50)	25.8%
Cost Assumptions	
<u>Equipment Costs:</u>	
Turbine	\$2,750,000
Electrical Equipment	\$65,000
Other	\$--
Equipment Price	\$2,815,000
Sales Tax	\$--
Total Equipment Cost	\$2,815,000
<u>Development Costs¹:</u>	
Engineering Design	\$422,300
Permitting	\$--
Construction	\$563,000
Site Preparation	\$--
Foundation	\$--
Installation	\$--
Commissioning/Startup	\$--
Development Costs (General)	\$140,750
Total Development Cost	\$1,126,050
<u>Transaction Costs:</u>	
Land Purchase	--
Title Insurance	\$8,500
Legal Transactions	\$20,000
Builder's Risk (Erection) Insurance	\$4,300
Dev Security Deposit	\$--
Total Transaction Costs	\$32,800
<u>Financing Costs:</u>	
Equity Placement	--
Debt Placement	--
Other Financing Fees	--
Total Financing Cost	\$--
<u>Total Project Costs:</u>	
Equipment Cost	\$2,815,000
Development & Transaction Costs	\$1,158,850
Construction Interest	\$--
Financing Cost	\$--
Utility Interconnection Cost	\$--
Utility Interconnection Upgrade Payment	\$--
Credit for Power Sales pre COD	\$--
TOTAL PROJECT COSTS	\$3,973,900

¹ Includes contingency for National Grid interconnection study. Costs may vary

Revenue Assumptions		
Average Annual Production (kWhs)	3,390,120	
Initial Bid Price (\$ / kWh)	\$0.1440	
TOD adjustment factor	1.000	
Initial TOD Adjusted Price (\$ / kWh)	\$0.1440	
Annual Price escalation	2.5%	
REC Value (Y1-10, \$/MWh)	\$40	
REC Value (Y11-30, \$/MWh)	\$30	
Annual Output Degradation	--%	
Utility Interconnection Upgrade Payment		
Terms	5 years	
Rate	7.5%	
Line Loss & Other Losses	--%	
Estimated CO2 Emission Credit	\$--	
Operating Assumptions		
	Annual Cost \$	
Annual O&M	\$60,000	
O&M Escalation	3.0%	
General Property Insurance	\$4,800	
Insurance Escalation	3.0%	
Business Interruption Insurance	\$7,900	
Insurance Escalation	3.0%	
Management	\$12,500	
Management Escalation	3.0%	
Property Tax	--	
Land Rental Payment	--	
Land Rental Escalation	0%	
Tax Assumptions		
No Tax Liability		
Tax Incentives		
ITC (30% of project costs)	\$--	
% ITC not Depreciable	--%	
Tax Depreciable Basis	\$--	
Tax Rates:		
Federal Tax Rate	--%	
State Tax Rate	--%	
State Sales Tax	--%	
State Incentives:		
State Tax Credit	\$--	
Commonwealth Wind	\$400,000	
Tax Depreciable Basis	\$--	
Years Depreciable	1 years	
Federal Funding		
Federal Grant	\$250,000	
Financing Assumptions		
Construction Interest	\$--	
IRR Leverage Effect	x0.58	
Debt Sizing (% Long Term)		
Long Term Debt	\$3,516,900	
Rate	4.0%	
Term	20 years	
Letters of Credit	\$--	
Rate	--%	
Term	0 years	

Project Indicators		
leveraged:		
IRR		9.4%
NPV (Discount 6%)		\$1,805,500
Payback Period (Discount 6%)		12.2
Unleveraged:		
IRR		16.1%
NPV (Discount 6%)		\$4,728,900
Payback Period (Discount 6%)		6.2
Sensitivity Anaysis		leveraged
Project Cost at -20%		\$3,179,080
NPV (Discount 6%)		\$3,241,197
Payback Period (Discount 6%)		8.1
Project Cost at +20%		\$4,768,620
NPV (Discount 6%)		\$369,730
Payback Period (Discount 6%)		32.6
AEP at P90 CF (kWh)		21.50%
NPV (Discount 6%)		2,825,100
Payback Period (Discount 6%)		\$463,799
AEP at +20% (kWh)		28.3
NPV (Discount 6%)		4,068,144
Payback Period (Discount 6%)		\$3,415,963
Other Assumptions		9.6
Amortization of Financing Fees (\$/yr):		
Debt Financing Fee (leveraged Scenario)		\$--
Equity Financing Fee (leveraged Scenario)		\$--
Equity Financing Fee (Unleveraged Scenario)		\$--
Initial Equity Investment (Unleveraged Scenario):		
Equity Investment		\$3,387,400
Equity Fees		\$--
Total Equity Investment		\$3,387,400
Fund Allocation (leveraged):		
Total Project Cost		\$3,973,900
Cash Reserves for O&M & Repair Work		63,500
Working Capital		\$--
Federal Grant		(250,000)
State Grant		(400,000)
Federal Investment Tax Credit		--
Funds Required		\$3,387,400
Debt Service Account		129,500
TOTAL FUNDS REQUIRED		\$3,516,900
Fund Source (leveraged):		
Equity		\$--
Debt		\$3,516,900
Total Funds		\$3,516,900
Summary Financial Metrics (leveraged):		
% Equity		--%
% Debt		100%
Last Updated:		12/17/2010

TABLE 5-3
Gardner Wind Turbine Financial Analysis: Inputs & Outputs (USD)

Project Summary	
Project Summary:	
Project	Garnder Wind Turbine
Location	Gardner, MA
Operation Commencement	12/31/12
Operation Duration	30 years
System & Installation Summary:	
Turbine	GE1.5
System Capacity (MW-ac)	1.500
Annual Capacity Factor (20-yr Average P50)	30.6%

Cost Assumptions	
Equipment Costs:	
Turbine	\$2,850,000
Electrical Equipment	\$65,000
Other	\$--
Equipment Price	\$2,915,000
Sales Tax	\$--
Total Equipment Cost	\$2,915,000
Development Costs¹:	
Engineering Design	\$437,300
Permitting	\$--
Construction	\$583,000
Site Preparation	\$--
Foundation	\$--
Installation	\$--
Commissioning/Startup	\$--
Development Costs (General)	\$145,750
Total Development Cost	\$1,166,050

Transaction Costs:	
Land Purchase	--
Title Insurance	\$8,800
Legal Transactions	\$20,000
Builder's Risk (Erection) Insurance	\$4,400
Dev Security Deposit	\$--
Total Transaction Costs	\$33,200

Financing Costs:	
Equity Placement	--
Debt Placement	--
Other Financing Fees	--
Total Financing Cost	\$--

Total Project Costs:	
Equipment Cost	\$2,915,000
Development & Transaction Costs	\$1,199,250
Construction Interest	\$--
Financing Cost	\$--
Utility Interconnection Cost	\$--
Utility Interconnection Upgrade Payment	\$--
Credit for Power Sales pre COD	\$--
TOTAL PROJECT COSTS	\$4,114,300

Revenue Assumptions	
Average Annual Production (kWhs)	4,020,840
Initial Bid Price (\$ / kWh)	\$0.1440
TOD adjustment factor	1.000
Initial TOD Adjusted Price (\$ / kWh)	\$0.1440
Annual Price escalation	2.5%
REC Value (Y1-10, \$/MWh)	\$40
REC Value (Y11-30, \$/MWh)	\$30
Annual Output Degradation	--%
Utility Interconnection Upgrade Payment	
Terms	5 years
Rate	7.5%
Line Loss & Other Losses	--%
Estimated CO2 Emission Credit	\$--

Operating Assumptions	
	Annual Cost \$
Annual O&M	\$60,000
O&M Escalation	3.0%
General Property Insurance	\$5,000
Insurance Escalation	3.0%
Business Interruption Insurance	\$8,200
Insurance Escalation	3.0%
Management	\$14,800
Management Escalation	3.0%
Property Tax	--
Land Rental Payment	--
Land Rental Escalation	0%

Tax Assumptions	
No Tax Liability	
Tax Incentives	
ITC (30% of project costs)	\$--
% ITC not Depreciable	--%
Tax Depreciable Basis	\$--
Tax Rates:	
Federal Tax Rate	--%
State Tax Rate	--%
State Sales Tax	--%

State Incentives:	
State Tax Credit	\$--
Commonwealth Wind	\$400,000
Tax Depreciable Basis	\$--
Years Depreciable	1 years

Federal Funding	
Federal Grant	\$250,000

Financing Assumptions	
Construction Interest	\$--
IRR Leverage Effect	x0.62
Debt Sizing (% Long Term)	
Long Term Debt	\$3,674,000
Rate	4.0%
Term	20 years
Letters of Credit	\$--
Rate	--%
Term	0 years

Project Indicators	
leveraged:	
IRR	11.3%
NPV (Discount 6%)	\$3,040,700
Payback Period (Discount 6%)	9.2
Unleveraged:	
IRR	18.2%
NPV (Discount 6%)	\$6,094,800
Payback Period (Discount 6%)	5.3

Sensitivity Anaysis	
leveraged	
Project Cost at -20%	
NPV (Discount 6%)	\$4,527,300
Payback Period (Discount 6%)	6.5
Project Cost at +20%	
NPV (Discount 6%)	\$4,937,100
NPV (Discount 6%)	\$1,554,500
Payback Period (Discount 6%)	18.5
AEP at P90 CF (kWh)	
25.50%	3,350,700
NPV (Discount 6%)	\$1,447,900
Payback Period (Discount 6%)	17.1
AEP at +20% (kWh)	
	4,825,008
NPV (Discount 6%)	\$4,950,200
Payback Period (Discount 6%)	7.5

Other Assumptions	
Amortization of Financing Fees (\$/yr):	
Debt Financing Fee (leveraged Scenario)	\$--
Equity Financing Fee (leveraged Scenario)	\$--
Equity Financing Fee (Unleveraged Scenario)	\$--

Initial Equity Investment (Unleveraged Scenario):	
Equity Investment	\$3,538,700
Equity Fees	\$--
Total Equity Investment	\$3,538,700

Fund Allocation (leveraged):	
Total Project Cost	\$4,114,300
Cash Reserves for O&M & Repair Work	74,400
Working Capital	\$--
Federal Grant	(250,000)
State Grant	(400,000)
Federal Investment Tax Credit	--
Funds Required	\$3,538,700
Debt Service Account	135,300
TOTAL FUNDS REQUIRED	\$3,674,000

Fund Source (leveraged):	
Equity	\$--
Debt	\$3,674,000
Total Funds	\$3,674,000

Summary Financial Metrics (leveraged):	
% Equity	--%
% Debt	100%
Last Updated: 12/17/2010	

¹ Includes contingency for National Grid interconnection study. Costs may vary

TABLE 5-3
Gardner Wind Turbine Financial Analysis: Inputs & Outputs (USD)

Project Summary	
Project Summary:	
Project	Garnder Wind Turbine
Location	Gardner, MA
Operation Commencement	12/31/12
Operation Duration	30 years
System & Installation Summary:	
Turbine	PowerWind 56
System Capacity (MW-ac)	0.900
Annual Capacity Factor (20-yr Average P50)	26.8%

Cost Assumptions	
Equipment Costs:	
Turbine	\$2,100,000
Electrical Equipment	\$65,000
Other	\$--
Equipment Price	\$2,165,000
Sales Tax	\$--
Total Equipment Cost	\$2,165,000
Development Costs¹:	
Engineering Design	\$324,800
Permitting	\$--
Construction	\$433,000
Site Preparation	\$--
Foundation	\$--
Installation	\$--
Commissioning/Startup	\$--
Development Costs (General)	\$108,250
Total Development Cost	\$866,050

Transaction Costs:	
Land Purchase	--
Title Insurance	\$6,500
Legal Transactions	\$20,000
Builder's Risk (Erection) Insurance	\$3,300
Dev Security Deposit	\$--
Total Transaction Costs	\$29,800

Financing Costs:	
Equity Placement	--
Debt Placement	--
Other Financing Fees	--
Total Financing Cost	\$--

Total Project Costs:	
Equipment Cost	\$2,165,000
Development & Transaction Costs	\$895,850
Construction Interest	\$--
Financing Cost	\$--
Utility Interconnection Cost	\$--
Utility Interconnection Upgrade Payment	\$--
Credit for Power Sales pre COD	\$--
TOTAL PROJECT COSTS	\$3,060,900

¹ Includes contingency for National Grid interconnection study. Costs may vary

Revenue Assumptions	
Average Annual Production (kWhs)	2,112,912
Initial Bid Price (\$ / kWh)	\$0.1440
TOD adjustment factor	1.000
Initial TOD Adjusted Price (\$ / kWh)	\$0.1440
Annual Price escalation	2.5%
REC Value (Y1-10, \$/MWh)	\$40
REC Value (Y11-30, \$/MWh)	\$30
Annual Output Degradation	--%
Utility Interconnection Upgrade Payment	
Terms	5 years
Rate	7.5%
Line Loss & Other Losses	--%
Estimated CO2 Emission Credit	\$--

Operating Assumptions	
	Annual Cost \$
Annual O&M	\$60,000
O&M Escalation	3.0%
General Property Insurance	\$3,700
Insurance Escalation	3.0%
Business Interruption Insurance	\$6,100
Insurance Escalation	3.0%
Management	\$7,800
Management Escalation	3.0%
Property Tax	--
Land Rental Payment	--
Land Rental Escalation	0%

Tax Assumptions	
No Tax Liability	
Tax Incentives	
ITC (30% of project costs)	\$--
% ITC not Depreciable	--%
Tax Depreciable Basis	\$--
Tax Rates:	
Federal Tax Rate	--%
State Tax Rate	--%
State Sales Tax	--%

State Incentives:	
State Tax Credit	\$--
Commonwealth Wind	\$400,000
Tax Depreciable Basis	\$--
Years Depreciable	1 years

Federal Funding	
Federal Grant	\$250,000

Financing Assumptions	
Construction Interest	\$--
IRR Leverage Effect	x0.52
Debt Sizing (% Long Term)	
Long Term Debt	\$2,545,100
Rate	4.0%
Term	20 years
Letters of Credit	\$--
Rate	--%
Term	0 years

Project Indicators	
leveraged:	
IRR	7.3%
NPV (Discount 6%)	\$476,400
Payback Period (Discount 6%)	18.8
Unleveraged:	
IRR	13.9%
NPV (Discount 6%)	\$2,592,000
Payback Period (Discount 6%)	7.5

Sensitivity Anaysis	
leveraged	
Project Cost at -20%	
NPV (Discount 6%)	\$1,582,300
Payback Period (Discount 6%)	10.7
Project Cost at +20%	
NPV (Discount 6%)	\$3,673,020
Payback Period (Discount 6%)	(\$629,492)
	N/A
AEP at P90 CF (kWh)	
22.30%	1,758,132
NPV (Discount 6%)	(\$366,567)
Payback Period (Discount 6%)	N/A
AEP at +20% (kWh)	
	2,535,494
NPV (Discount 6%)	\$1,479,153
Payback Period (Discount 6%)	13.6

Other Assumptions	
Amortization of Financing Fees (\$/yr):	
Debt Financing Fee (leveraged Scenario)	\$--
Equity Financing Fee (leveraged Scenario)	\$--
Equity Financing Fee (Unleveraged Scenario)	\$--

Initial Equity Investment (Unleveraged Scenario):	
Equity Investment	\$2,451,400
Equity Fees	\$--
Total Equity Investment	\$2,451,400

Fund Allocation (leveraged):	
Total Project Cost	\$3,060,900
Cash Reserves for O&M & Repair Work	40,500
Working Capital	\$--
Federal Grant	(250,000)
State Grant	(400,000)
Federal Investment Tax Credit	--
Funds Required	\$2,451,400
Debt Service Account	93,700
TOTAL FUNDS REQUIRED	\$2,545,100

Fund Source (leveraged):	
Equity	\$--
Debt	\$2,545,100
Total Funds	\$2,545,100

Summary Financial Metrics (leveraged):	
% Equity	--%
% Debt	100%
Last Updated: 12/17/2010	

TABLE 5-3
Gardner Wind Turbine Financial Analysis: Inputs & Outputs (USD)

Project Summary	
Project Summary:	
Project	Garnder Wind Turbine
Location	Gardner, MA
Operation Commencement	12/31/12
Operation Duration	30 years
System & Installation Summary:	
Turbine	2 x Powerwind 56
System Capacity (MW-ac)	1.800
Annual Capacity Factor (20-yr Average P50)	25.8%

Cost Assumptions	
Equipment Costs:	
Turbine	\$4,100,000
Electrical Equipment	\$110,000
Other	\$--
Equipment Price	\$4,210,000
Sales Tax	\$--
Total Equipment Cost	\$4,210,000
Development Costs¹:	
Engineering Design	\$631,500
Permitting	\$--
Construction	\$842,000
Site Preparation	\$--
Foundation	\$--
Installation	\$--
Commissioning/Startup	\$--
Development Costs (General)	\$210,500
Total Development Cost	\$1,684,000

Transaction Costs:	
Land Purchase	--
Title Insurance	\$12,700
Legal Transactions	\$20,000
Builder's Risk (Erection) Insurance	\$6,400
Dev Security Deposit	\$--
Total Transaction Costs	\$39,100

Financing Costs:	
Equity Placement	--
Debt Placement	--
Other Financing Fees	--
Total Financing Cost	\$--

Total Project Costs:	
Equipment Cost	\$4,210,000
Development & Transaction Costs	\$1,723,100
Construction Interest	\$--
Financing Cost	\$--
Utility Interconnection Cost	\$--
Utility Interconnection Upgrade Payment	\$--
Credit for Power Sales pre COD	\$--
TOTAL PROJECT COSTS	\$5,933,100

Revenue Assumptions	
Average Annual Production (kWhs)	4,068,144
Initial Bid Price (\$ / kWh)	\$0.1440
TOD adjustment factor	1.000
Initial TOD Adjusted Price (\$ / kWh)	\$0.1440
Annual Price escalation	2.5%
REC Value (Y1-10, \$/MWh)	\$40
REC Value (Y11-30, \$/MWh)	\$30
Annual Output Degradation	--%
Utility Interconnection Upgrade Payment	
Terms	5 years
Rate	7.5%
Line Loss & Other Losses	--%
Estimated CO2 Emission Credit	\$--

Operating Assumptions	
	Annual Cost \$
Annual O&M	\$60,000
O&M Escalation	3.0%
General Property Insurance	\$7,200
Insurance Escalation	3.0%
Business Interruption Insurance	\$11,800
Insurance Escalation	3.0%
Management	\$15,000
Management Escalation	3.0%
Property Tax	--
Land Rental Payment	--
Land Rental Escalation	0%

Tax Assumptions	
No Tax Liability	
Tax Incentives	
ITC (30% of project costs)	\$--
% ITC not Depreciable	--%
Tax Depreciable Basis	\$--
Tax Rates:	
Federal Tax Rate	--%
State Tax Rate	--%
State Sales Tax	--%

State Incentives:	
State Tax Credit	\$--
Commonwealth Wind	\$400,000
Tax Depreciable Basis	\$--
Years Depreciable	1 years

Federal Funding	
Federal Grant	\$250,000

Financing Assumptions	
Construction Interest	\$--
IRR Leverage Effect	x0.47
Debt Sizing (% Long Term)	
Long Term Debt	\$5,566,100
Rate	4.0%
Term	20 years
Letters of Credit	\$--
Rate	--%
Term	0 years

Project Indicators	
leveraged:	
IRR	5.7%
NPV (Discount 6%)	(\$243,500)
Payback Period (Discount 6%)	32.6
Unleveraged:	
IRR	12.2%
NPV (Discount 6%)	\$4,383,500
Payback Period (Discount 6%)	8.8

Sensitivity Anaysis	
leveraged	
Project Cost at -20%	\$4,746,480
NPV (Discount 6%)	\$1,900,063
Payback Period (Discount 6%)	16.1
Project Cost at +20%	
NPV (Discount 6%)	(\$2,387,062)
Payback Period (Discount 6%)	N/A
AEP at P90 CF (kWh)	
21.50%	3,390,120
NPV (Discount 6%)	(\$1,853,864)
Payback Period (Discount 6%)	N/A
AEP at +20% (kWh)	
	4,881,773
NPV (Discount 6%)	\$1,689,085
Payback Period (Discount 6%)	19.8

Other Assumptions	
Amortization of Financing Fees (\$/yr):	
Debt Financing Fee (leveraged Scenario)	\$--
Equity Financing Fee (leveraged Scenario)	\$--
Equity Financing Fee (Unleveraged Scenario)	\$--

Initial Equity Investment (Unleveraged Scenario):	
Equity Investment	\$5,361,200
Equity Fees	\$--
Total Equity Investment	\$5,361,200

Fund Allocation (leveraged):	
Total Project Cost	\$5,933,100
Cash Reserves for O&M & Repair Work	78,100
Working Capital	\$--
Federal Grant	(250,000)
State Grant	(400,000)
Federal Investment Tax Credit	--
Funds Required	\$5,361,200
Debt Service Account	204,900
TOTAL FUNDS REQUIRED	\$5,566,100

Fund Source (leveraged):	
Equity	\$--
Debt	\$5,566,100
Total Funds	\$5,566,100

Summary Financial Metrics (leveraged):	
% Equity	--%
% Debt	100%
Last Updated:	12/17/2010

¹ Includes contingency for National Grid interconnection study. Costs may vary

Tighe & Bond

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City of Gardner, Summit Industrial Park Wind Feasibility Study - Long Term Data

TO: Peter McPhee, Leigh Cameron – Massachusetts Clean Energy Center
FROM: Ellen Ebner, Briony Angus, Fran Hoey
COPY: Rob Hubbard, City of Gardner
DATE: April 15, 2011

This memorandum presents a summary of work performed by Tighe & Bond in response to questions from the Massachusetts Clean Energy Center (MassCEC) regarding the long term data used in the City of Gardner Summit Industrial Park Wind Feasibility Study, submitted in January 2011. The questions were related to the Measure Correlate Predict (MCP) process and specifically the effect of using the National Center for Atmospheric Research (NCAR)/National Centers for Environmental Prediction (NCEP) Reanalysis long-term, 30 year data set on energy prediction results. It was observed that the NCAR/NCEP Reanalysis data set used in the feasibility study displayed a “shift” in the average wind speed observed around the year 2000. The most recent ten years of data has a lower average wind speed than the overall dataset. MassCEC suggested that it may be appropriate to use only the most recent ten years of data in calculations, as a method to correct for the change in average wind speed, citing that the change may be a bias in the data. MassCEC’s concern is that the use of the higher wind speeds in the data set prior to 2000 would cause the wind energy prediction to be higher than it should be.

Tighe & Bond agreed to evaluate the impact of using an artificially truncated dataset (i.e. only the most recent 10 years of data) on the estimates of energy production in the Feasibility Study, and this memorandum outlines the results of that exercise. This memorandum also provides a summary of the process used to calculate estimates of annual energy production (AEP) because it is our belief that the data has been taken out of context in previous discussions and, furthermore, that we need to include consideration for the overall process as well as a review of some WindPRO-specific guidelines that may not have been clearly discussed up to this time.

The following sections will first recount the overall WindPRO process that Tighe & Bond used to determine AEP in an effort to put the long term data in proper context. The memorandum also includes a summary of research and discussions with industry experts regarding the shift in the data in the most recent ten years and whether this shift represents an actual bias, and the statistical validity of using a 10-year data set for this analysis. The results of the modeling exercise requested by MassCEC are also summarized.

WindPRO Process Review

To put the long term data discussion in proper context, we present a brief review of the process followed in the Wind Resource Assessment section (Section 1) of the Feasibility Study. Specifically, we would like to clarify the role of the “7.7 m/s” wind speed that appears in the MCP analysis section of the report. Due to the use of off-site measured data from the North Central Correctional Institution (NCCI), and the decision to take the resource analysis through the entire WindPRO and WAsP calculation process in order to include a bankable loss and uncertainty analysis, the relationship of this number to the annual energy production (AEP) calculation is not as simple as would be expected based on similar size projects. There are several steps between the MCP analysis and the energy calculations

that are not required by projects that do not need to conduct horizontal extrapolation (i.e. extrapolating data from an off-site location) and a detailed loss and uncertainty analysis.

The WindPRO resource assessment process used for the Summit Industrial Park Feasibility Study was as follows. The sections noted in the bulleted list below correspond to the sections of the Tighe & Bond Feasibility Study report.

1. **Input the data from the NCCI met tower location** into WindPro (Section 1.1)
2. Create a **measurement location wind statistic** by removing surface roughness and obstacle effects at the NCCI site (Section 1.2)
3. Create a **long-term corrected data series** using MCP and Wind Index to adjust the wind statistic to better match long-term meteorological trends for the area (Section 1.3)
4. Create a **measurement location wind statistic profile**. As noted in bullet #2 above, the measurement location wind statistic is the wind speed at the met tower location once roughness and obstacle effects are removed. The measurement location wind statistic profile provides some basic indicators of wind resources based on the measurement location wind statistic. The profile provides the wind statistic average wind speed at 80m at the met tower location after long term correlation (Section 1.4); this is where the 7.7 m/s wind speed is found in the Feasibility Study text.
5. Create a **turbine location wind resource profile**. The met tower wind statistic is extrapolated over the terrain to the proposed turbine location and turned back into a resource profile, which means the effects of surface roughness and obstacles specific to the turbine location are reintroduced. The resource maps (Figures 1-6 and 1-7) illustrate the resulting wind speeds, which are less than 7.7 m/s. An average wind speed was not calculated at the exact turbine location at this step. Note that the topography has also had some influence, causing wind speeds to remain relatively high during the extrapolation due to the hill on which the Industrial Park is located (Section 1.5)
6. Determine the **average annual wind speed** (80m). This is the final hub height average wind speed for the turbine location including the effects of topography, surface roughness, obstacles, and displacement height. The displacement height, which is added to account for tree cover, is why the average annual wind speed dropped from about 7.4 m/s on the resource maps to 6.8 m/s (Section 1.5, subsection below Figure 1-7). Given the extremely tall tree cover in the turbine area, this was anticipated
7. Conduct **energy calculations**. 6.8 m/s is the wind speed that was carried through the WindPro calculations to determine AEP.

Long Term Data Validity

The validity of the long-term data used in the Feasibility Study is important and therefore, Tighe & Bond has continued to explore the questions surrounding the observed “shift” in average wind speed with the help of WindPRO related literature, other industry experts, and a representative of National Oceanic and Atmospheric Administration/Earth Systems Research Laboratory Physical Sciences Division (NOAA/ESRL PSD).

It is our opinion that the entire 30-year data set is appropriate to use for long term data correlation. Furthermore, we strongly believe that the validity of the future wind speed predictions is enhanced through the use of a larger data set (i.e. validity is reduced by use

of an artificially truncated data set). We were not able to identify any external factors that would account for the shift observed in the data, indicating that there is no bias and the shift is most likely part of the climatological trend. Furthermore, the correlation of measured data to long term data is very good, indicating that the NCAR/NCEP Reanalysis data is a good data source for the site. We do not believe that it is good modeling practice to use just the ten years of most recent data for the long term correlation because of the shift, because no bias has been identified and more data is generally better to minimize uncertainty.

Trial Analysis

The WindPRO analysis was completed using the most recent ten years of long term data as requested by MassCEC. Use of this data alone resulted in a decrease in AEP, causing the P50 capacity factor to decrease from 32 to 25% for the largest turbine. The year to year variability included in the uncertainty analysis as the standard deviation of the wind speed decreased by approximately 2.7%. The adjusted MCP results were run through all the calculations and the final results are within the sensitivity analysis included in the Feasibility Study. In the Feasibility Study sensitivity analysis we showed that the payback period ranges between 5.3 and 13 years for the largest turbine. Using only ten years of long term data and holding other variables the same, the payback period is 12 years. Tighe & Bond presented to the City that the project payback period would be between 7 to 15 years.

Discussion

While we concur that it may be more conservative, we do not believe that it is statistically valid to arbitrarily eliminate 20 years of the 30 year data set, as it cannot be established that the shift in the last ten years represents an actual bias. We are uncomfortable cutting the dataset to ten years or using another “bias” correction technique.

A bias is a known issue with the data (e.g., a sensor that is always higher than others by a fixed value or a problem with compilation of the data). We have reviewed the NCAR/NCEP Reanalysis data list of known issues and found nothing related to a wind speed “shift” circa 2000. We have also been in contact with the data representative of NOAA/ESRL PSD who confirmed that there are no known biases in the data related to this “shift.” We were referred to the National Weather Service Climate Prediction Center (NWSCPC) website and various literature. Upon review of those resources, no known errors were found for that time period.

Published NCAR/NCEP Reanalysis literature was reviewed specifically for possible causes or precedence of this apparent “climate” shift. The point of the Reanalysis (as opposed to the original NCAR/NCEP analysis) was to create a climate data set that was not affected by changes in the assimilation model over time. All of the historic data was processed through the same model and therefore, changes in the model are not the cause of the data-shift.

While changes in technology (i.e., notably the addition of satellite data and aircraft data) have been known to cause a “climate” shift, this shift is very predictable. The shift occurs circa 1980 in data from geographic locations where there had not been a good density of measurement sources prior to the addition of satellite and aircraft data. Impact of the addition of this technology was shown to be insignificant in the Northern Hemisphere mid-latitudes where data has historically been plentiful. Other than the 1980 “climate” shift and one other known “climate” shift around 1957, data shifts are generally attributed to climatological oscillations.

WindPRO literature confirms that ten year meteorological fluctuations happen and are common when looking at very long term climate records. The conclusion is that ten years is not necessarily an accurate representation of the climate. Discussion with WindPRO industry experts also confirmed that ten years is too limited a data set for use in long term data correlation due to climate oscillations. Generally, a 1 to 3% uncertainty on future climate variations is included in the uncertainty analysis to account for long term oscillations. We had previously included a 1% value because we used a full 30 years of data, which is considered to be an appropriate data set for this purpose. We believe, that given the current concern, it would be reasonable to change this to 3%. Another recommendation received is to use 50 years of data in Wind Index, as opposed to 10 to 30 years.

Tighe & Bond does have access to data dating back to 1948 and the majority of the data looks more similar to the years 1980 to 2000 than 2000 to 2010. The average wind speed from 1957 to 2010 is 6.23 m/s at 42m agl. Average wind speed from 1980 to 2010 is 6.13 m/s at 42m agl. Average wind speed from 2001 to 2010 is 5.26 m/s at 42m agl.

It is very difficult to predict the type of climate oscillation being observed and to some extent; the entire industry will always be improving in this regard. Tighe & Bond cannot say whether the next ten years will look like the last ten or the last 50, but we are comfortable that the prediction methods we use are up-to-date and consistent with those recommended for use with the WindPRO software.

Precedence

As in any industry, precedence is important. In the absence of being able to define a bias, some correction may be acceptable if there was significant precedence.

We understand that there may be temptation to compare the Summit Industrial Park project to the projects at Mount Wachusett Community College (MWCC) and the North Central Correctional Institute (NCCI). Tighe & Bond does not believe that a direct comparison is appropriate because our study represents a completely different level of analysis than was conducted for those projects, as MassCEC now requires a higher level of analysis than in previous funding blocks. Among the major factors that differ: we used WindPRO and WAsP for the entire analysis, our measured data was not on-site, and we performed a detailed uncertainty analysis. In addition, topography and site factors at MWCC and NCCI are completely different. These two studies both have very little detail on long term data:

- NCCI used only five years of “long term” data from Mt. Tom in Holyoke, MA to normalize their wind speeds. As a result of this exercise, average wind speeds increased by 7%. NCCI used Wind Farmer for the correlation, but did not perform an uncertainty analysis.
- MWCC used Logan Airport data. The College made a 2% adjustment to the data based on the long term data set from Logan.

Conclusion

Tighe & Bond cautions against changing the study to use ten year data without significant consideration and explanation. Without the identification of a known bias, we cannot correct for it properly or presume a method for doing so. We can only adjust the uncertainty in the analysis. An extensive loss and uncertainty analysis has been completed as well as a sensitivity analysis using the P90 AEP and +/- 20% of the AEP and project costs

to protect the project from unexpected deviations. These measures tested the viability of the project under both negative and positive circumstances based on our best estimate of the AEP and cost.

Using only the most recent ten years of data will make a more “conservative” AEP at the cost of accuracy. Ultimately, a loss of accuracy could cause the City to formulate their turbine size and power-sales plan incorrectly. While it is possible this may happen regardless of the path taken, we need to be sure that our analysis was based on our best knowledge of the site and climate, and on best modeling practices. We are not comfortable making an assumption about whether the long term climate oscillations will continue downward in the future, and statistically we believe the best method for a healthy level of conservatism is to use more data.

We look forward to discussing this matter with MassCEC, and to your approval of the Feasibility Study such that the City's chances of obtaining further funding for design and construction are not negatively impacted. We truly believe that this project has undergone a much higher level of analysis compared to many projects that have previously received additional funding from MassCEC, and are comfortable that the analysis conducted in the Feasibility Study and in the exercise summarized in this memorandum indicate that the project is technically and economically viable.

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Robert Hubbard
Director
Department of Community Development & Planning
City of Gardner
115 Pleasant Street
Gardner, MA 01440

April 25, 2011

Re: City of Gardner, Summit Industrial Park Wind Feasibility Study – Long Term Data

Dear Mr. Hubbard,

I am writing to follow up on Tighe & Bond's Memorandum dated April 15, 2011 regarding the long-term data used in the City of Gardner, Summit Industrial Park Wind Feasibility Study. In order to promote responsibly-sited wind projects in the Commonwealth, MassCEC's role is twofold: to provide financial support for wind projects in the state and to serve as a resource for our grantees, which includes serving as a third-party reviewer for studies performed under MassCEC grants. While MassCEC does not provide technical analysis, it is our standard practice to provide additional review of technical studies and to identify questions or issues for grantees so that they can be better prepared to make important decisions regarding their wind project.

This letter is intended to clarify our intent in asking Tighe & Bond to prepare an alternative analysis of expected long-term project energy production. MassCEC is writing to ensure that the City understands the following:

1. The long-term (30-year) dataset for the potential turbine site is unusual in that, when only the most recent 10 years are used for correlation, a significantly lower wind speed is estimated;
2. If accurate, this lower wind speed estimate results in a large reduction in the turbine's predicted electricity output because electricity production is highly dependent on wind speed.

MassCEC identified the 30-year long term data set used in the City of Gardner Feasibility Study as a concern since the sudden and persistent decline in wind speeds after year 2000 is unusual. We are not aware of similar inconsistencies in other regional datasets. MassCEC requires correlation of one-year onsite wind monitoring data with several years of long term data in all MassCEC-funded Feasibility Studies because uncertainty is reduced with correlation to more years of data. However, MassCEC's intent in requesting the alternative 10-year analysis in this case was to quantify the potential difference in energy production between using the most recent 10 years of data versus the 30-year long-term data that could potentially be flawed.

While correlating to additional years of long-term data does improve the confidence interval, the improvement from 10 years to 30 years statistically results in only a small improvement. The change in energy production estimates obtained from these two different calculations is, however, significant. Correlating to the full 30 years predicts a 32% capacity factor for the turbine, which would be considered excellent. Using the 10 year data, however, would predict a substantially lower capacity factor of 25%. This represents a 21.9% reduction in expected electricity production.

We appreciate Tighe & Bond's efforts in responding to our concerns, conducting the analysis for the 10 year correlation, and preparing the Memorandum. Many of our improvements to the Feasibility Study process over the past several years are intended to help quantify the uncertainties inherent in wind energy projects, so that grantees are best prepared to make informed decisions. MassCEC believes that taking a conservative approach to such analyses is important since small changes in wind speeds can have significant impacts on project economics.

In summary, we believe the reduced capacity factor from the more conservative 10 year correlation to be an important sensitivity analysis for the City to consider in their project planning.

Please feel free to contact me at 617-315-9313 if you have any questions or would like to discuss further.

Sincerely,



Andrew Brydges
Program Director
Massachusetts Clean Energy Center

CC: Briony Angus, Tighe & Bond
Ellen Ebner, Tighe & Bond
Fran Hoey, Tighe & Bond