

City of Medford Wind Power Feasibility Study

*The McGlynn and
Andrews Middle Schools
City of Medford, MA*

July 18, 2006

**This document has been prepared
by:**



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Disclaimer

The information in this report is presented in response to the contract executed by and between Sustainable Energy Developments, Inc. and the City of Medford, MA on February 19th, 2007. The information presented herein is based on wind development best practices, commercially available information and virtual wind data provided to Sustainable Energy Developments, Inc by AWS Truewind, LLC. SED makes no guarantees, expressed or implied as to the actual outcome of the processes described in this report.

Executive Summary

Sustainable Energy Developments, Inc. has evaluated the Andrews Middle and McGlynn Schools in the City of Medford, MA for the possibility of using wind power to provide on-site electricity. The details of this analysis are presented in this report. Two potential wind turbine locations were identified between the school buildings and the Mystic River. These two sites were determined primarily by local constraints with an effort towards maintaining a minimum of a 500 feet setback from the nearest neighboring building or dwelling.

The wind resource of the proposed site was modeled using virtual Met Mast data provided by AWS Truewind, LLC and the industry standard wind modeling software Wind Atlas Analysis and Applications Program (WAsP). The virtual met mast showed that the site had an average annual wind speed of 5.13m/s (11.5mph) at a height of 35m(115ft) above the ground. The wind model showed that the wind resource did not vary greatly between the two identified sites and that either location would be suitable for the installation of a wind turbine.

The economics of the project were analyzed using two versions of the NorthWind 100kW wind turbine at each site. The analysis showed that the NW 100kW wind turbine with a 21m-rotor diameter installed on a 40m tower at the North Turbine Site would show the City of Medford the most beneficial economic returns of the four scenarios run. However, if electricity rates rise with normal inflation at 3% all scenarios would meet the City of Medford's required 12-year payback period.

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Section 1 Site Analysis

1.1 *Site Analysis Considerations*

The McGlynn and Andrews Middle Schools (Medford Schools) are centrally located in the densely populated City of Medford. Therefore it is particularly important to use prudence in choosing a turbine location so that impacts to the surrounding populations and land uses can be minimized. The criteria taken into account for siting a turbine at the Medford Schools site are:

Proximity to non-City owned buildings/dwellings – The placement of wind turbines in an urban area requires a comprehensive understanding of all factors that may limit the placement of a wind turbine. The City of Medford currently does not have a specific wind ordinance, so wind industry best practices will be used in conjunction with all applicable legal and regulatory constraints to select two possible locations. In this particular case, the turbines contemplated are two versions of the NorthWind 100kW, direct drive wind turbine. Direct drive machines are significantly quieter than the more common non-direct drive machines because they lack a gearbox, the loudest component in most wind turbines. Both of the proposed locations are more than 500 feet from any neighboring buildings and/or dwellings. Both versions of the NorthWind 100kW turbine have a maximum measured sound level of 56 dbA at 137 feet. Based on a study performed by the U.S. Environmental Protection Agency, the average measured sound level in the City of Boston was 64.45 dbA¹. Through consideration of sound levels from the EPA study and consideration of the fact that Interstate 93, an eight-lane highway, is across the river and less than 700 feet from the turbine sites, the project team can be assured that turbine-generated noise will not be an issue at the proposed locations.

Proximity to the Mystic River – In order to avoid crossing the thresholds of the MA Wetlands Protection Act (Section 131 Chapter 40) and The City of Medford's Wetland Ordinance (Chapter 87), the conservation easement that constitutes a 200-foot setback from the Mystic River will not be contemplated as potential turbine locations.

School Land Use – Potential land use conflicts posed by the school setting are of minor concern for a wind turbine. With the exception of the construction phase of the project, the wind turbine will effortlessly coexist with the sporting fields and walking paths in the area. Finalization of the exact turbine location will take into account the possibilities of future school expansions.

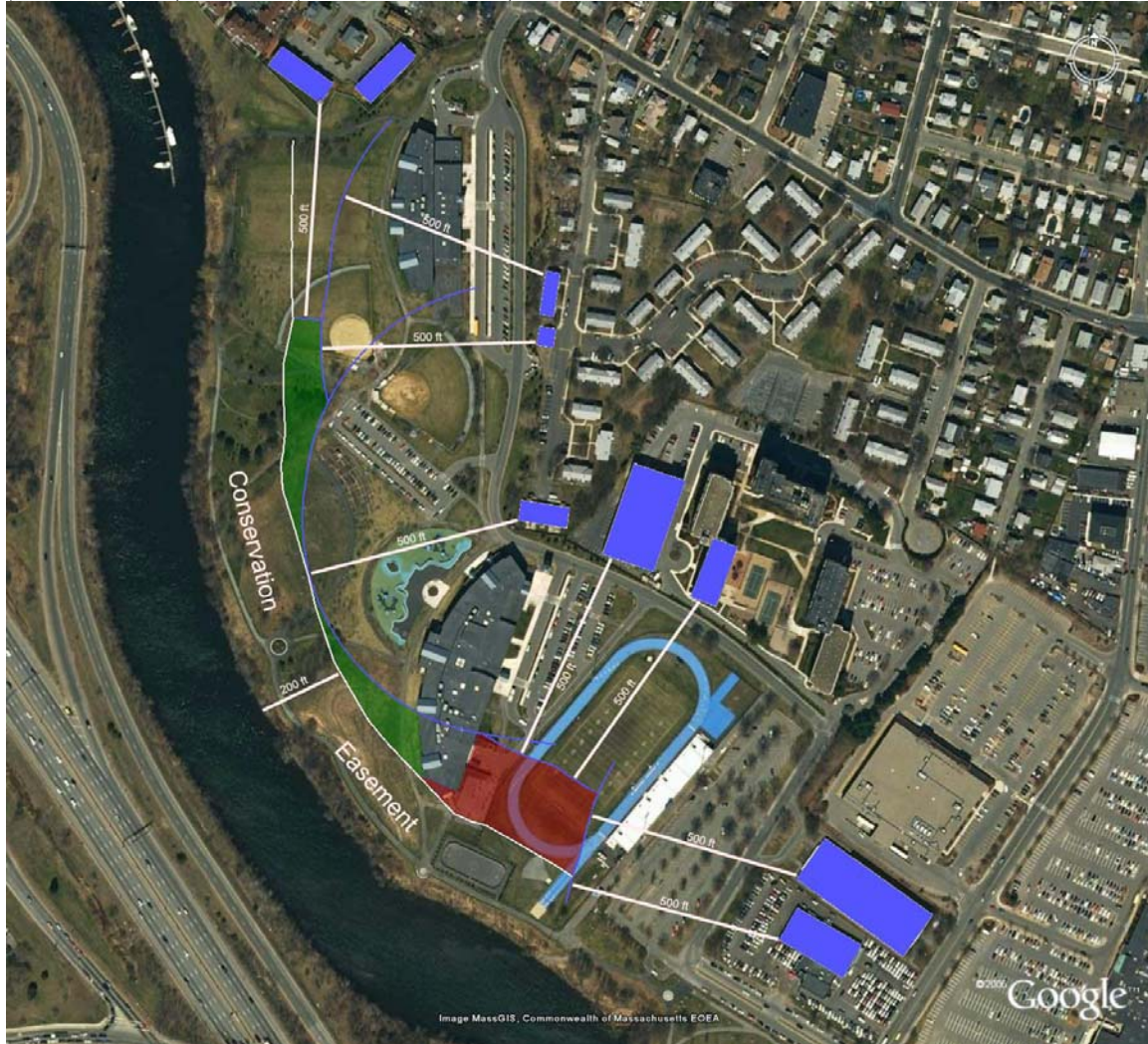
¹ U.S. Department of Environmental Protection Office of Noise Abatement and Control. "The Urban Noise Survey" EPA Report No. 55/9-77-101. August, 1977.



1.2 Site Analysis

In order to determine the appropriate locations where a wind turbine can be sited in a given area, the existing land uses must first be examined. Figure 1 is a site map utilizing a 200-foot setback from the Mystic River and a 500-foot setback from non School-owned buildings/dwellings. These setbacks were used to determine potential turbine locations.

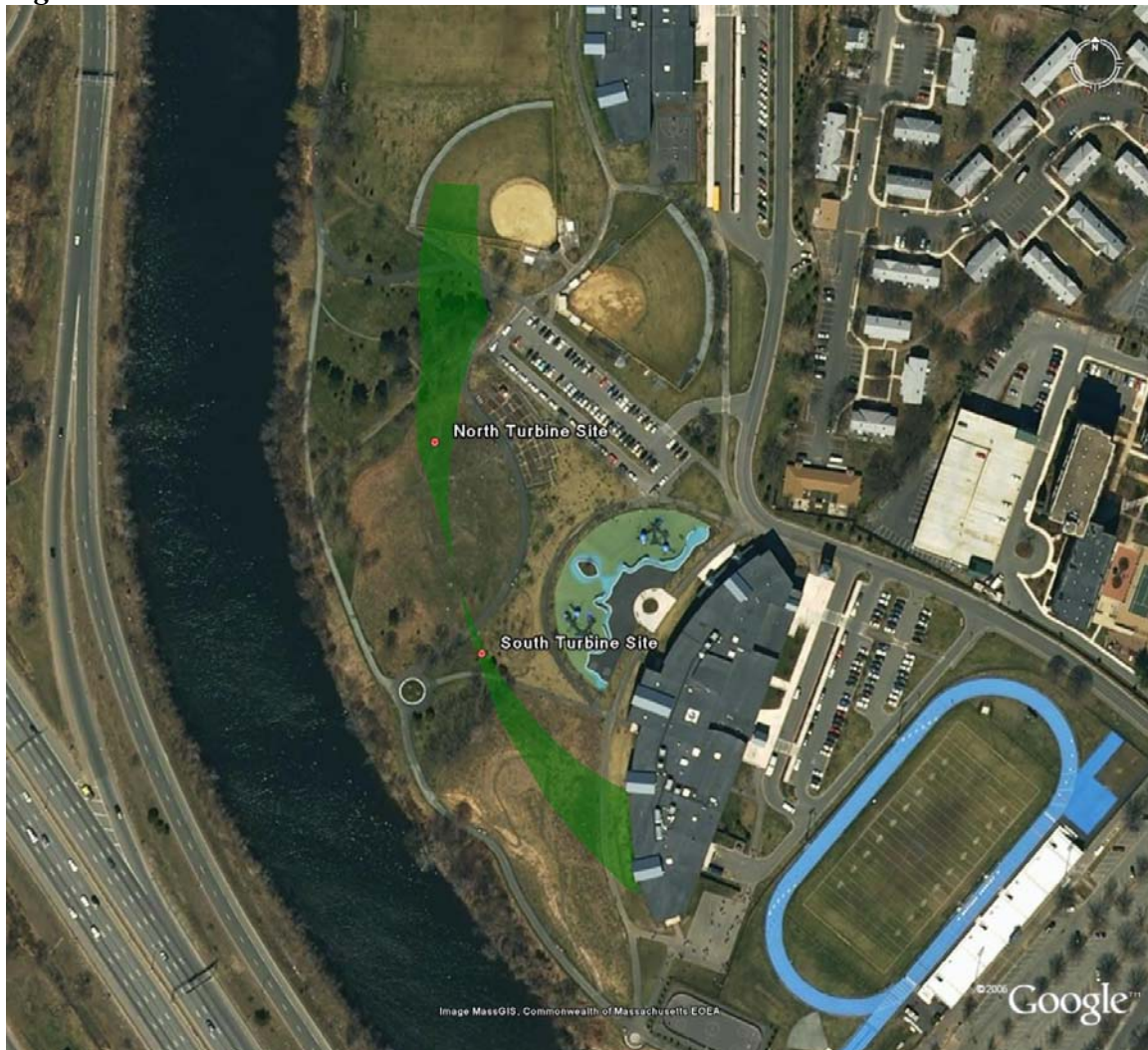
Figure 1: Potential turbine locations on the Medford Schools site highlighted in green (recommended) and red (not recommended)



The green and red areas identified in Figure 1 indicate the resulting space available to site a wind turbine. The green areas are desirable and the red area is ruled out because of the track, football field, basketball court and loading dock. The red area is also ruled out because the school buildings will significantly impact this area's wind regime, causing undesirable turbulence that should be avoided.

With two potential areas now identified, a turbine location must be selected. Figure 2 depicts the North and South turbine locations selected.

Figure 2: *North and South Turbine Sites*



The North Turbine Site (NTS), equidistant between the two schools, was chosen because of the ample distance from the baseball fields. The South Turbine Site (STS) was chosen to maximize the distance between the turbine and the McGlynn School. Both proposed sites are also well beyond a “fall zone” distance from the nearest school building, an issue that will be further addressed in local permitting. A “fall zone” distance is considered to be the horizontal distance from the wind turbine equal to the vertical distance from the ground to the highest point a blade tip reaches into the air. The south site is over 140% of a “fall zone” from the nearby McGlynn School building.

Section 2 WAsP Model

2.1 Wind Turbine Selection and Output Calculation Introduction

The urban nature of the project site limited turbine selection to technologies large enough to produce positive economic benefits but small enough to avoid negative impacts to the surrounding community. After exploring all of the available options, SED determined that a 100kW turbine would satisfy both of these constraints. The two wind turbines chosen for analysis are made by Vermont-based Northern Power. The first turbine is the NorthWind 100kW wind turbine with a 20-meter rotor diameter and 32-meter hub height. This turbine is available for delivery through the first quarter of 2008. The second turbine is the NorthWind 100kW wind turbine with a 21-meter rotor diameter and 40-meter hub height. This turbine is currently not in production, but will be available by the second quarter of 2008.

To determine the output of a wind turbine on the site, SED used the industry standard wind modeling software, the Wind Atlas, Analysis, and Application Program (WAsP) created by the Danish National Laboratory. The model was created by licensed user: Kevin M. Schulte, Sustainable Energy Developments, USA using WAsP version: 8.01.0069.

In order to accurately calculate the output of both machines at the Medford Schools site, the WAsP model considered:

- Virtual metrological tower data provided by AWS Truewind²
- The two locations identified in Section 1 of this study in UTM 19T
 - North Turbine Site – 327195, 4697219
 - South Turbine Site – 327214, 4697122
- A terrain map of the USGS 7.5minute Quadrangle-Medford, MA
- A roughness map for the USGS 7.5minute Quadrangle-Medford, MA
- The power curve of the NorthWind 100kW (NW100) wind turbine with a 21-meter rotor diameter and 40m hub height
- The power curve of the NorthWind 100kW (NW100) wind turbine with a 20-meter rotor diameter and a 32m hub height
- Obstacles map including the Medford Schools facilities and selected surrounding buildings/dwellings

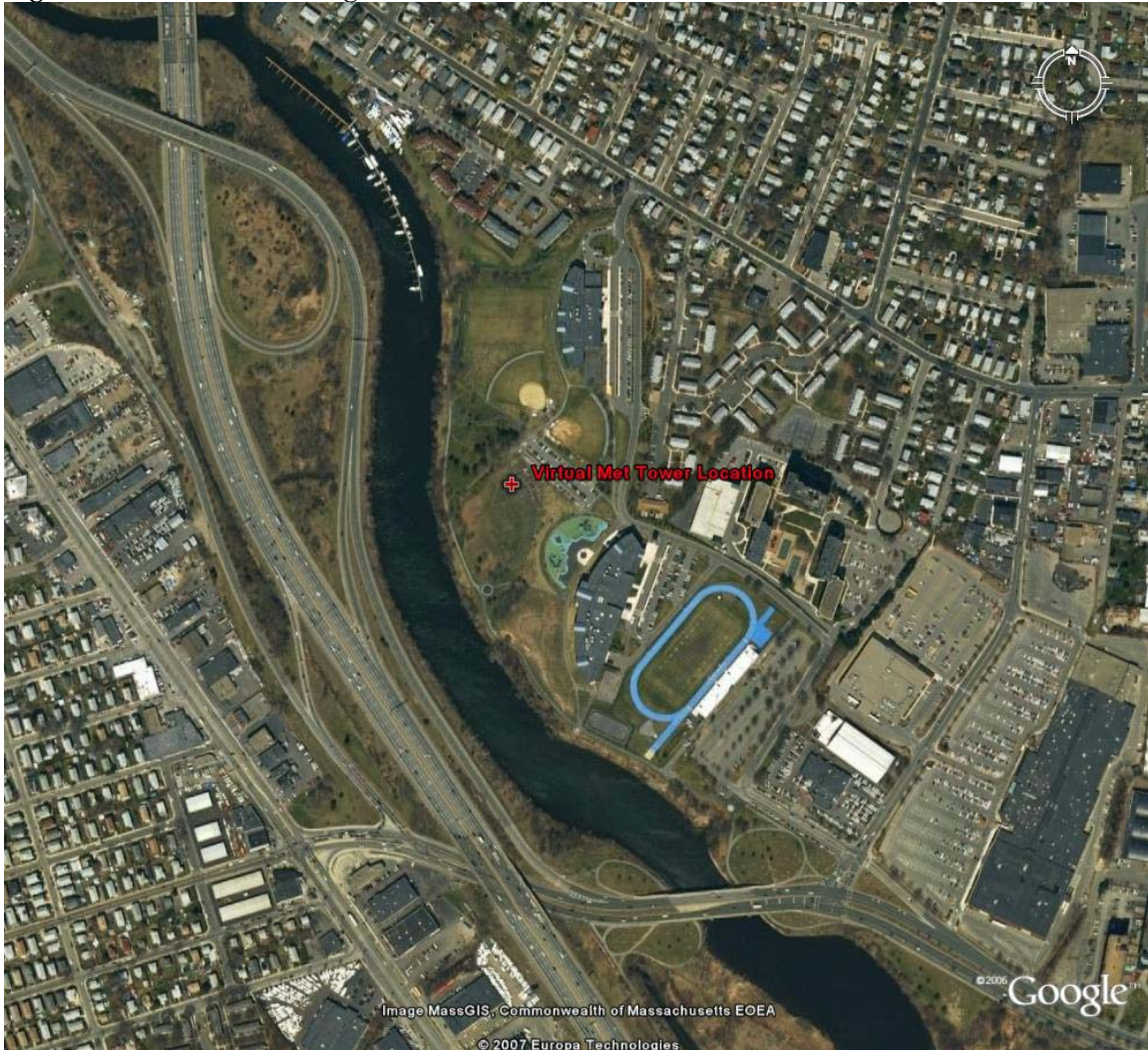
² AWS Truewind is a LLC based out of Albany, New York specializing in wind resource assessment for over 20 years.



2.2 Summary of Wind Data

SED was provided with a full year of data including hourly wind speed and directional information projected at 50 and 35 meters above ground level (a.g.l) by AWS Scientific. This virtual met data for the Medford Schools site was generated for a central location of the site shown in Figure 3.

Figure 3: *Virtual Meteorological Tower Location*



The "virtual met mast" time series was generated from the mesoscale simulation from the region-wide Southern New England wind map and the speeds were scaled to match the mean speeds from the final, high-resolution wind maps. The Southern New England wind map was validated using data from 33 stations from across the region, including tall towers and ASOS stations. The two validation points closest to the Medford, MA virtual met mast are the Boston airport and a tall tower on Thompson Island. The average bias at

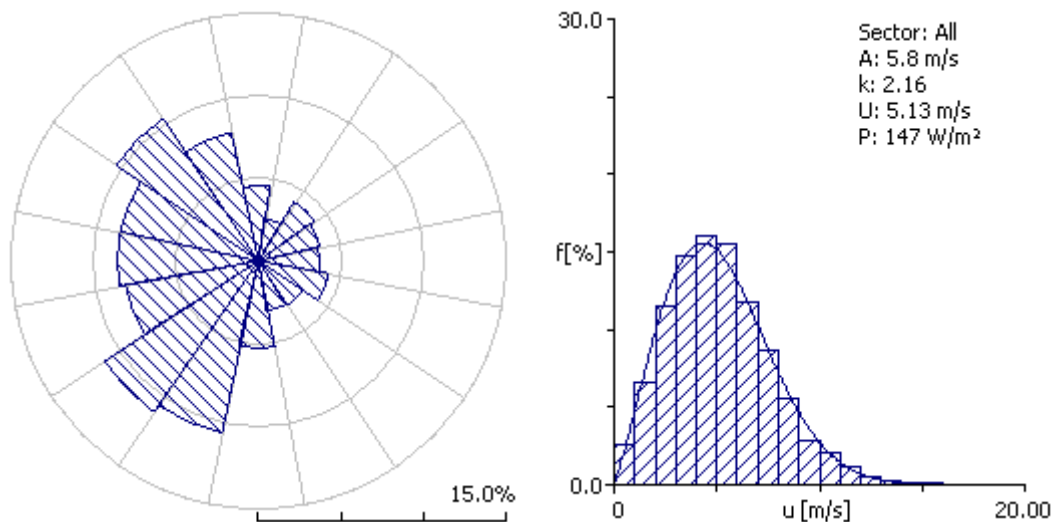
these validation points is -0.25 m/s and the standard deviation of the bias is 0.65 m/s (9%). Figure 4 is a summary of the data provided to SED.

Figure 4: Summary of Virtual Met Data

Data Source	AWS Truewind
Height	50 and 35 meters a.g.l
Location (Datum NAD 27 zone 19T)	Northing 327213
Location (Datum NAD 27 zone 19T)	Easting 4697224
Elevation	3 meters a.s.l.
Mean Wind Speed at 35 meter height	5.13 m/s

Figure 5 is the Wind Rose and Weibull Distribution for the data provided by AWS Truewind. The Wind Rose (left) describes wind direction. As depicted, the wind at the Medford Schools site is strongest from the Western sectors. The Weibull Distribution (right) is a description of the number of hours in a year the wind will be at certain wind speeds. This distribution is used in conjunction with the manufacture-supplied power curve of the wind turbine and the associated site maps to determine electrical output from a wind turbine at this site.

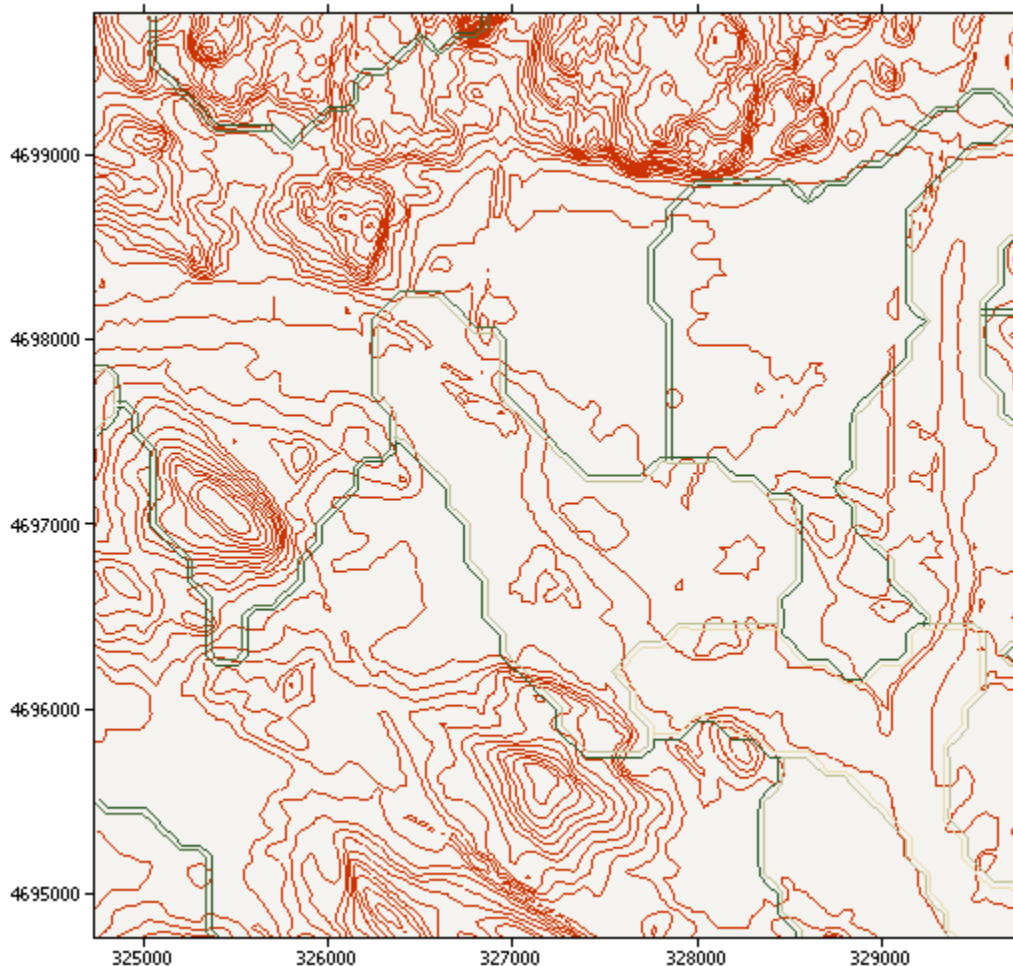
Figure 5: Wind Rose (Left) and Weibull Distribution (Right)



2.3 Terrain and Roughness Maps

WAsP uses terrain and roughness maps to accurately determine the way the wind flows over the identified site. These maps are also input into the model in order to calculate the local site effects. The terrain map is a topographical representation of the area using 10-foot contour lines. The roughness map is a representation of the surface roughness and/or ground cover in the surrounding area based on the WAsP roughness classification system. The site was modeled using a 2500m square around the Medford Schools campus as a subset of the 7.5-minute USGS Quadrangle for Medford, MA. The terrain map comes directly from the US Geographic Survey and the roughness map used in this model was obtained from AWS Truewind. Figure 6 is a representation of both the terrain and roughness maps for the site and surrounding area. The terrain map contours are red and the double green lines represent the roughness classifications.

Figure 6: *Terrain and roughness map for the site and surrounding area*



2.4 Wind Turbine Power Curve

In order for the model to work properly it is important for WAsP to have an accurate power curve for the turbines being considered for the project. The power curve indicates how much power the turbine will produce at each wind speed bin. For this model SED used the power curve for the NorthWind 100kW wind turbine with a 21-meter rotor diameter and 40m-hub height and the NorthWind 100kW wind turbine with a 20-meter rotor diameter and 32m-hub height. Northern Power provided the technical specifications needed for these calculations. Figures 7 and 8 show the power curve information for both turbines as they appear in WAsP's turbine editor.

Figure 7: Power curve information for the NorthWind 100kW wind turbine with a 20-meter rotor and 32 meter hub height

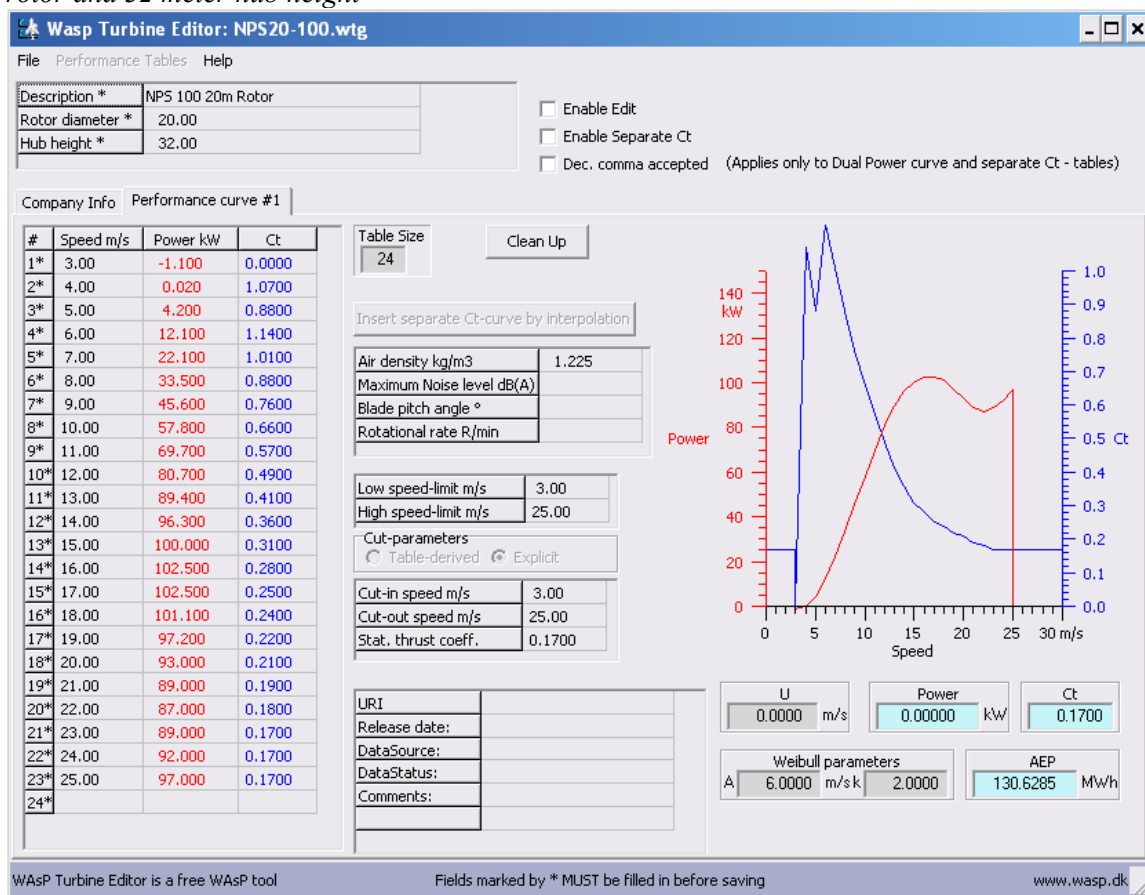
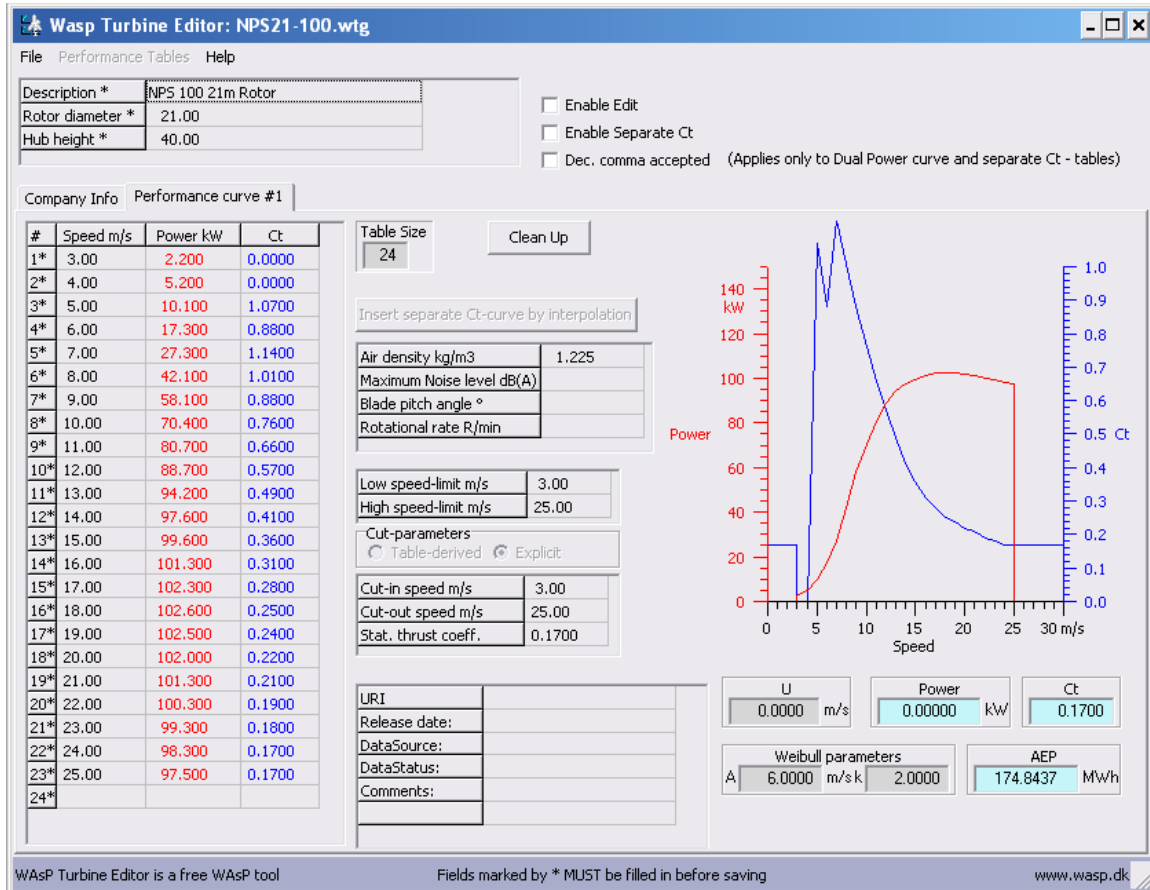


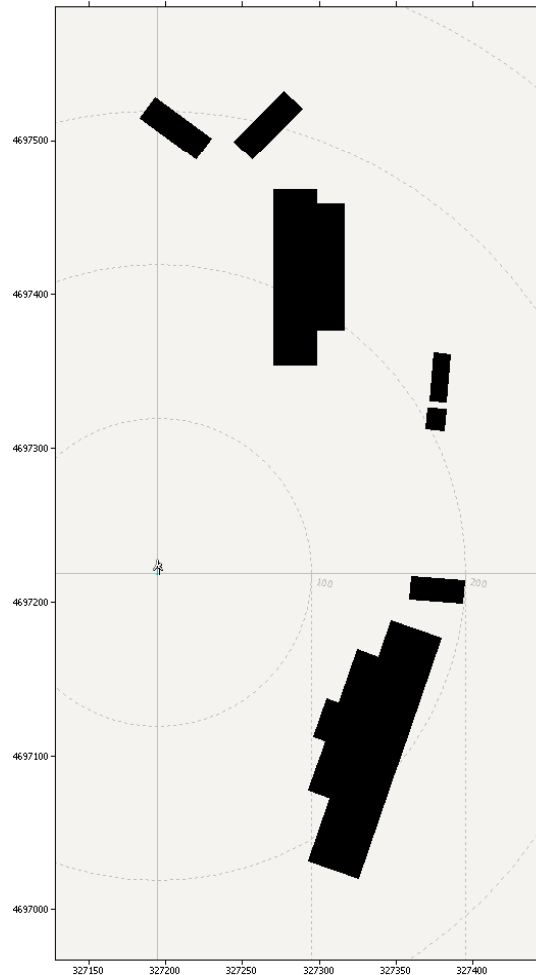
Figure 8: Power curve information for the NW 100 wind turbine with a 21-meter rotor and 40-meter tower



2.5 Obstacle Map

All obstacles in close proximity of the site have potential to impact the calculated electrical output of the wind turbine. SED measured and input all buildings within or barely beyond the 500-foot setback of the anticipated turbine sites into WAsP. The wind regime at this site is made up of heavy westerly components, so the buildings to the east of the project site are of little concern in building the obstacle model. It should also be noted that the buildings are taken into account by the AWS roughness classifications. Measurements and coordinates were obtained for the seven identified buildings around the site so these obstacles could be modeled in WAsP. For buildings that were not perfect rectangles, the most accurate rectangular representation of the buildings was used. Figure 9 is a visual representation of the obstacle map including the northern proposed turbine location as a frame of reference.

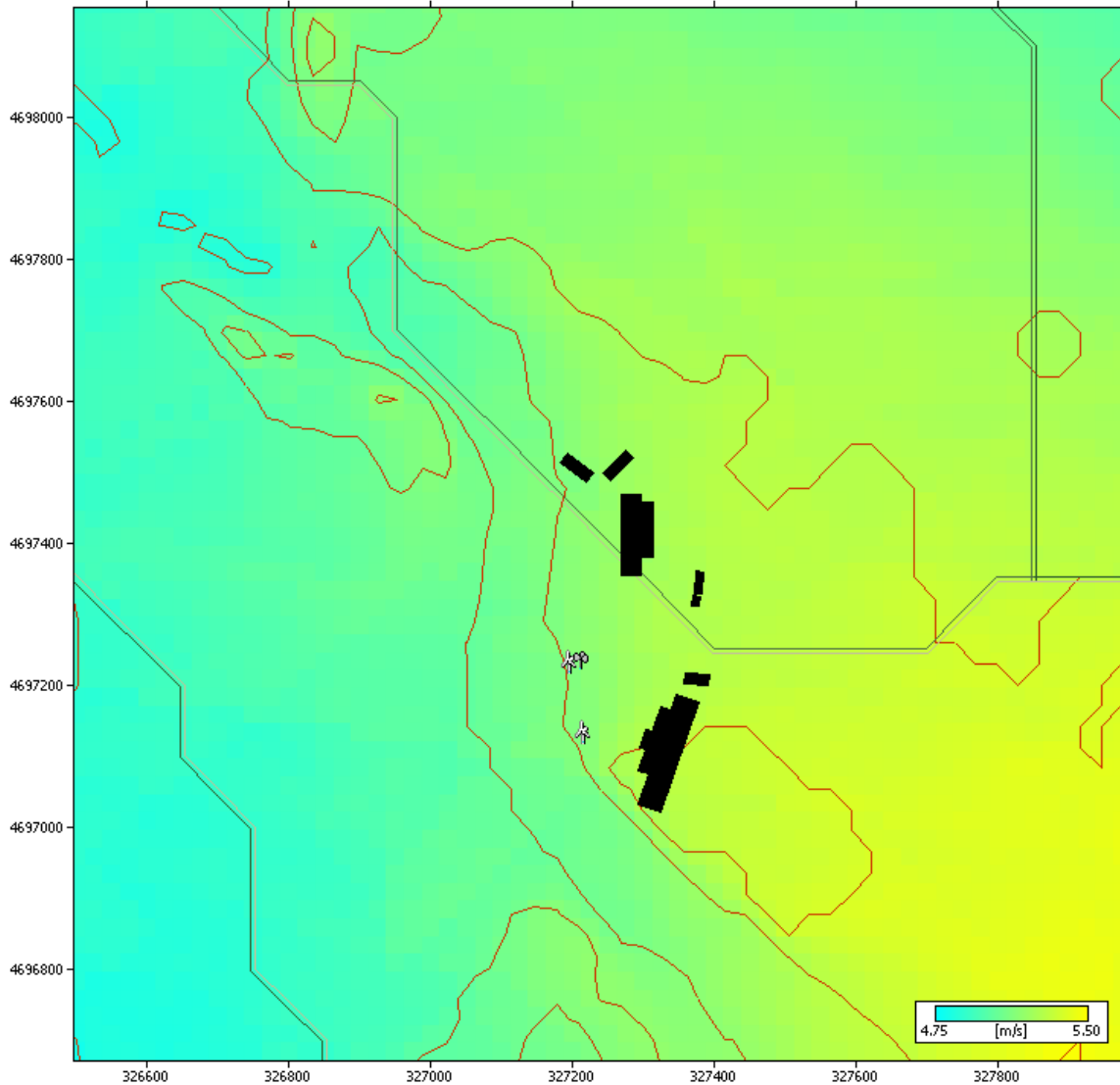
Figure 9: Obstacle map including North Turbine Site



2.6 Resource Grid

Once the model is constructed, a resource grid is made to provide a visual representation of the site. Figure 10 is the resource grid for the average annual wind speed across the depicted area.

Figure 10: Mean Wind Speed Resource Grid for the site including wind turbine and virtual meteorological tower locations



Note in Figure 10 how the annual energy production increases slightly as the elevation rises towards the southwest. This is known as a speedup effect that is caused by the wind power density increasing as the prevailing westerly winds rise up this small slope. Given

the slight variations in wind resource across the area of potential turbine locations, micro-sitting would not produce a significant increase in energy production.

2.7 Summary of Model Results

Once completed, the model was run with both versions of the NorthWind turbine at both locations identified. Figure 11 is a summary of the results for all four of the model runs.

Figure 11: Site location, Turbine, Annual Energy Output (AEO), Mean Wind Speed, Mean Power Density and Latitude and Longitude

Model Run	Site Loc.	Turbine	AEO (kW-hr)	Mean Wind Speed	Mean Power Density	Latt, Long (UTM 19T)
1	South	NW-20	111,656	5.12 m/s	147 W/m ²	327214, 4697122
2	North	NW-20	110,744	5.10 m/s	146 W/m ²	327195, 4697219
3	South	NW-21	170,700	5.35 m/s	164 W/m ²	327214, 4697122
4	North	NW-21	167,607	5.31 m/s	160 W/m ²	327195, 4697219

It is clear from this summary that the 21-meter rotor version of the NorthWind turbine produces significantly more energy over the course of a year. This is no surprise since it is typical for turbines with larger rotors and higher hub heights to harness more wind energy. The South Turbine Site also produced slightly more power than the North Turbine Site, but it should be noted that the difference between the two sites of 1-2% is statistically insignificant.

2.8 Detailed Model Results

The detailed reports from WAsP include site impacts on the turbine's production. The site effects given by WAsP are as follows:

- Angle [°] is the wind sector
- Or.Spd [%] A description of the increase in wind speed in each sector from the measurement location based on terrain changes
- Or.Tur [°] A description of the turbulence in each sector based on terrain changes measured in degrees from horizontal
- Obs.Spd [%] A description of the % change in wind speed as a result of obstacles near the turbine location
- Rgh.Spd [%] A description of the % change in wind speed as a result of roughness (ground cover)
- Wake [%] Sector wise percentage loss in wind turbine output based on the wake effect of other wind turbines
- Rix [%] The ruggedness index is a measure of how complex the terrain surrounding the turbine location is measured concentrically outward from the base of the turbine in 30m intervals



Figure 12: Model Run 1 - NorthWind 100kW Wind Turbine with a 20-Meter Rotor Diameter and 32m Hub Height at the South Turbine Site

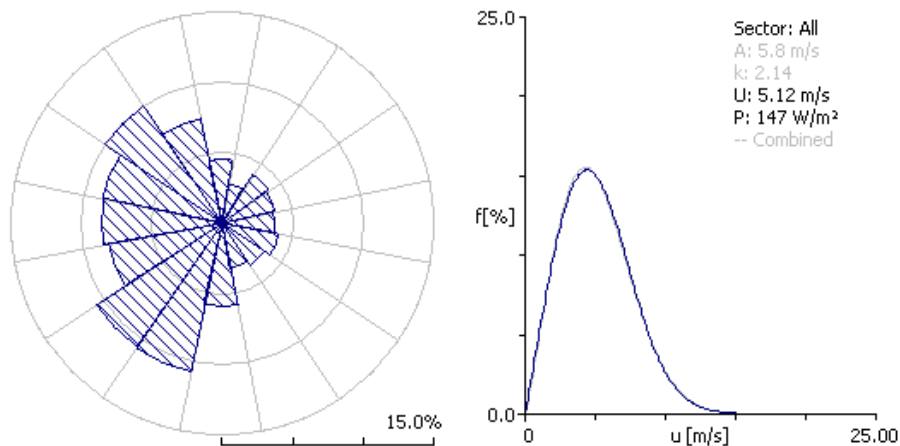
Site Effects

Sector	Angle [°]	Or.Spdx [%]	Or.Tur [%]	Obs.Spdx [%]	Rgh.Spdx [%]	Rix [%]
1	0	-2.64	-0.1	-3.56	0.00	0.5
2	23	-2.56	0.1	-2.90	0.00	0.4
3	45	-2.31	0.2	-0.35	-5.87	0.0
4	68	-1.79	0.2	-1.26	-0.78	0.0
5	90	-1.53	0.0	-1.04	-2.28	0.0
6	113	-1.58	0.0	-0.88	-2.13	0.0
7	135	-1.59	0.0	-0.82	0.67	0.0
8	158	-2.16	-0.2	-0.02	10.76	0.0
9	180	-2.69	-0.1	0.00	13.64	0.0
10	203	-2.75	0.2	0.00	8.56	0.0
11	225	-2.24	0.3	0.00	0.00	0.0
12	248	-1.97	0.3	0.00	0.55	0.0
13	270	-1.62	0.1	0.00	0.00	0.0
14	293	-1.64	-0.1	0.00	2.37	0.0
15	315	-1.89	-0.2	0.00	9.52	0.0
16	338	-2.47	-0.3	-0.09	12.67	0.0

The all-sector RIX (ruggedness index) for the site is 0.1%

Predicted Wind Climate

-	Total	Wind with maximum power density
Mean wind speed	5.12 m/s	7.86 m/s
Mean power density	147 W/m ²	23 W/m ²



Results

Site	Location [m]	Turbine	Height [m]	Net AEP [MWh]	Wake loss [%]
Turbine site 1	(327214.0,4697122.0)	NPS 100 20m Rotor	32	111.656	0.0

The combined (omni-directional) Weibull distribution predicts a gross Annual Energy Production (AEP) of 111.659 MWh and the emergent distribution (sum of sectors) predicts a gross AEP of 111.656 MWh. (The difference is 0.0%)

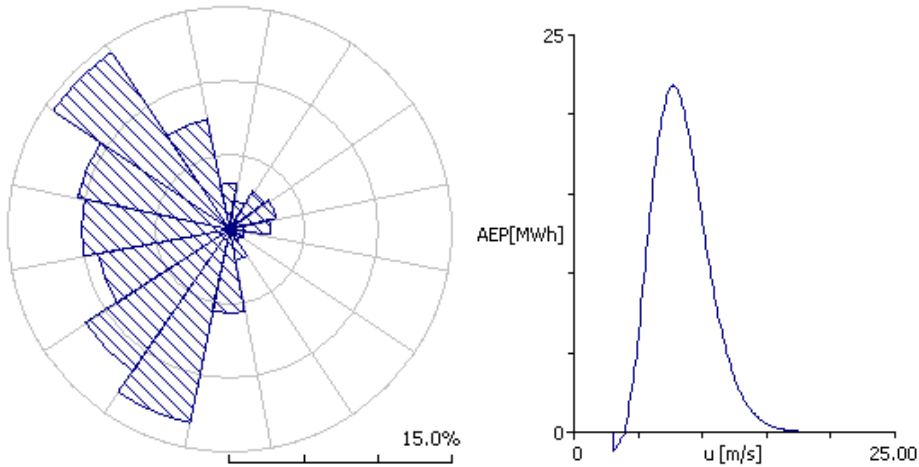


Figure 13: Model Run 2 - NorthWind 100kW Wind Turbine with a 20-Meter Rotor Diameter and 32m Hub Height at the North Turbine Site

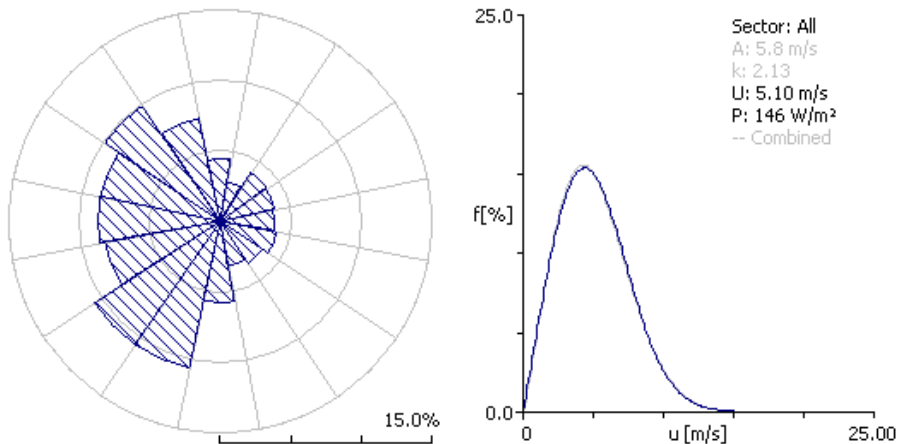
Site Effects

Sector	Angle [°]	Or.Spdl [%]	Or.Tur [°]	Obs.Spdl [%]	Rgh.Spdl [%]	Rix [%]
1	0	-3.36	0.0	-2.53	0.00	0.5
2	23	-3.04	0.4	-4.30	0.00	0.3
3	45	-2.31	0.6	-1.12	-6.15	0.0
4	68	-1.51	0.4	-0.27	-6.94	0.0
5	90	-1.06	0.0	-0.40	-2.97	0.0
6	113	-1.31	-0.3	-2.26	-1.33	0.0
7	135	-1.72	-0.4	-2.98	-0.14	0.0
8	158	-2.69	-0.4	-0.92	11.09	0.0
9	180	-3.36	0.0	0.00	13.55	0.0
10	203	-3.21	0.5	0.00	9.59	0.0
11	225	-2.35	0.6	0.00	-0.56	0.0
12	248	-1.61	0.5	0.00	1.16	0.0
13	270	-1.14	0.0	0.00	0.00	0.0
14	293	-1.35	-0.4	0.00	3.14	0.0
15	315	-2.07	-0.6	0.00	10.13	0.0
16	338	-3.09	-0.5	0.00	13.03	0.0

The all-sector RIX (ruggedness index) for the site is 0.1%

Predicted Wind Climate

-	Total	Wind with maximum power density
Mean wind speed	5.10 m/s	7.85 m/s
Mean power density	146 W/m ²	22 W/m ²



Results

Site	Location [m]	Turbine	Height [m]	Net AEP [MWh]	Wake loss [%]
Turbine site 2	(327195.0,4697219.0)	NPS 100 20m Rotor	32	110.744	0.0

The combined (omni-directional) Weibull distribution predicts a gross AEP of 110.694 MWh and the emergent (sum of sectors) distribution predicts a gross AEP of 110.744 MWh. (The difference is 0.05%)

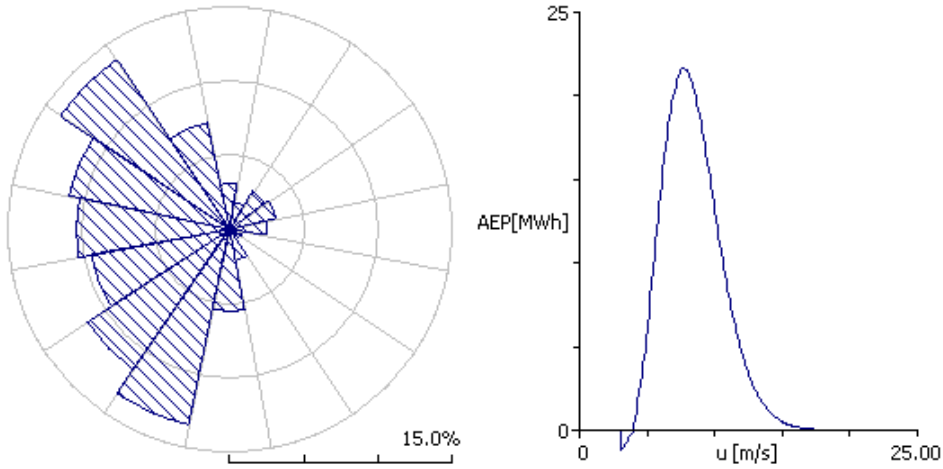


Figure 14: Model Run 3 - NorthWind 100kW Wind Turbine with a 21-Meter Rotor Diameter and 40m Hub Height at the South Turbine Site

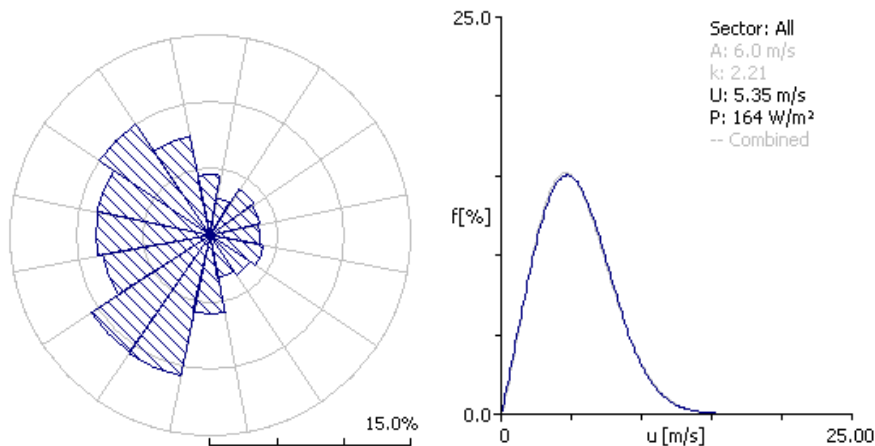
Site Effects

Sector	Angle [°]	Or.Spdl [%]	Or.Tur [°]	Obs.Spdl [%]	Rgh.Spdl [%]	Rix [%]
1	0	-2.43	-0.1	-1.58	0.00	0.5
2	23	-2.39	0.1	-1.12	0.00	0.4
3	45	-2.12	0.3	-0.08	-4.90	0.0
4	68	-1.59	0.2	-0.19	-1.99	0.0
5	90	-1.29	0.0	-0.11	-2.61	0.0
6	113	-1.31	-0.1	-0.09	-2.37	0.0
7	135	-1.37	-0.1	-0.11	0.12	0.0
8	158	-1.95	-0.2	0.00	7.40	0.0
9	180	-2.47	-0.1	0.00	9.31	0.0
10	203	-2.54	0.2	0.00	2.89	0.0
11	225	-2.06	0.3	0.00	0.00	0.0
12	248	-1.73	0.4	0.00	0.00	0.0
13	270	-1.36	0.1	0.00	0.00	0.0
14	293	-1.35	-0.1	0.00	0.00	0.0
15	315	-1.62	-0.3	0.00	6.44	0.0
16	338	-2.20	-0.3	-0.04	9.50	0.0

The all-sector RIX (ruggedness index) for the site is 0.1%

Predicted Wind Climate

-	Total	Wind with maximum power density
Mean wind speed	5.35 m/s	8.10 m/s
Mean power density	164 W/m ²	25 W/m ²



Results

Site	Location [m]	Turbine	Height [m]	Net AEP [MWh]	Wake loss [%]
Turbine site 1	(327214.0,4697122.0)	NPS 100 21m Rotor	40	170.700	0.0

The combined (omni-directional) Weibull distribution predicts a gross AEP of 170.783 MWh and the emergent (sum of sectors) distribution predicts a gross AEP of 170.700 MWh. (The difference is 0.05%)

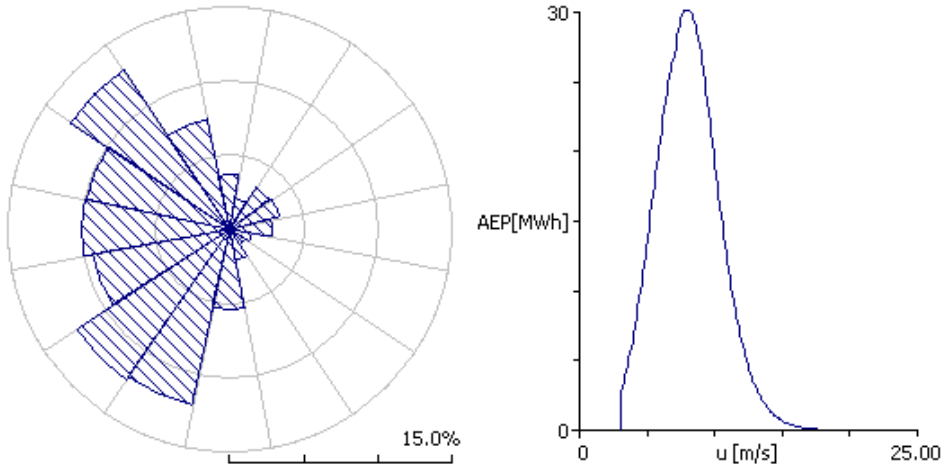


Figure 15: Model Run 4 - NorthWind 100kW Wind Turbine with a 21-Meter Rotor Diameter and 40m Hub Height at the North Turbine Site

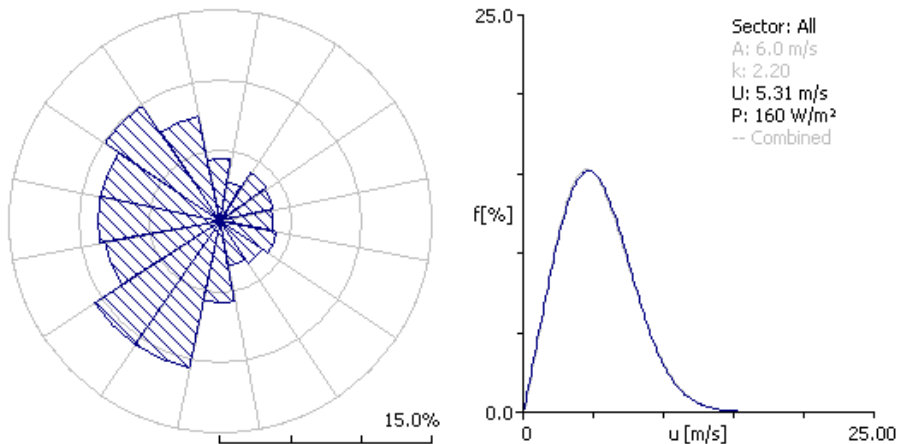
Site Effects

Sector	Angle [°]	Or.Spdl [%]	Or.Tur [°]	Obs.Spdl [%]	Rgh.Spdl [%]	Rix [%]
1	0	-3.02	0.0	-0.95	0.00	0.5
2	23	-2.75	0.4	-1.32	0.00	0.3
3	45	-2.09	0.5	-0.27	-5.14	0.0
4	68	-1.36	0.4	-0.05	-5.29	0.0
5	90	-0.94	0.0	-0.08	-3.46	0.0
6	113	-1.14	-0.3	-0.44	-1.78	0.0
7	135	-1.54	-0.4	-0.64	0.00	0.0
8	158	-2.42	-0.4	-0.23	7.84	0.0
9	180	-3.02	0.0	0.00	9.13	0.0
10	203	-2.89	0.4	0.00	4.19	0.0
11	225	-2.13	0.6	0.00	-4.27	0.0
12	248	-1.44	0.5	0.00	0.00	0.0
13	270	-1.01	0.0	0.00	0.00	0.0
14	293	-1.18	-0.3	0.00	0.46	0.0
15	315	-1.82	-0.5	0.00	6.71	0.0
16	338	-2.74	-0.5	0.00	9.18	0.0

The all-sector RIX (ruggedness index) for the site is 0.1%

Predicted Wind Climate

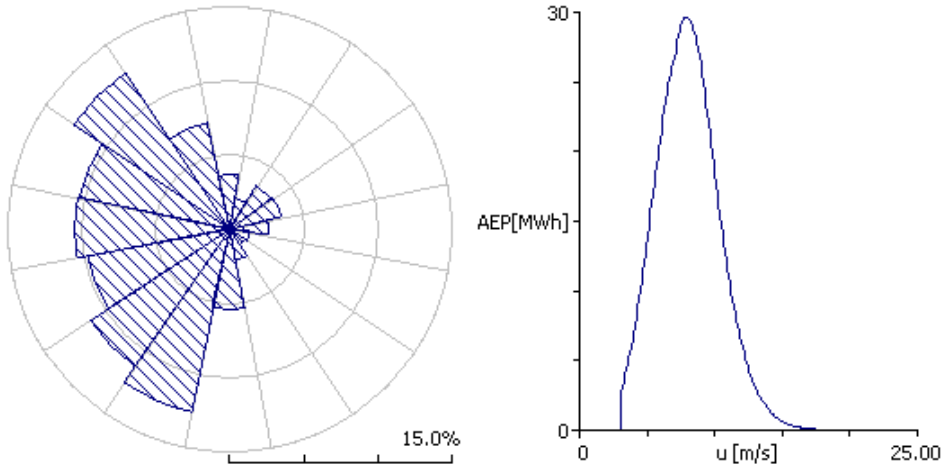
-	Total	Wind with maximum power density
Mean wind speed	5.31 m/s	8.05 m/s
Mean power density	160 W/m ²	25 W/m ²



Results

Site	Location [m]	Turbine	Height [m]	Net AEP [MWh]	Wake loss [%]
Turbine site 2	(327195.0,4697219.0)	NPS 100 21m Rotor	40	167.607	0.0

The combined (omni-directional) Weibull distribution predicts a gross AEP of 167.797 MWh and the emergent (sum of sectors) distribution predicts a gross AEP of 167.607 MWh. (The difference is 0.11%)



Section 3 Economic Analysis

3.1 Cost Model

The capital costs and life cycle costs for a wind energy generating facility have been compiled based on best practices and SED's experience with other projects in the U.S. Figure 15 breaks the capital costs for the construction of this project into three main categories and shows the "all-in" cost for a project located at the Medford Schools site.

3.1.1 Life Cycle Costs – Maintenance and Insurance

In order to quantify maintenance issues for this project, SED assigned a budgetary figure of \$0.015 per kilo-watt-hour of electricity produced by the wind turbine. This budgeting for maintenance will allow the project to adequately account for routine and scheduled maintenance activities as well as to prepare for the potential of major replacements. This cost, as well as the estimated downtime due to wind turbine maintenance, was determined through examination of the wind turbine's operating history, experience in the wind industry and discussions with wind turbine maintenance experts. The estimated budgetary figures for maintenance that is built into the financial models for the wind turbines examined can be found in Figure 15. The figures below represent the first year of operation and are scheduled to inflate at 3% annually.

Figure 16: Annual Maintenance Budgets

Wind Turbine	Annual Maintenance Budget (Year 1)
NW 100kW 20m Rotor 32m HH	\$1,725
NW 100kW 21m Rotor 40m HH	\$2,280

Most wind turbine insurance providers premium for coverage of a wind turbines is \$10,000/MW. The Medford Schools Project is 100kW and will likely have an insurance cost of \$1,000 in the first year of operation. This figure is scheduled to inflate at 3% annually.

3.1.2 Project Management

SED recommends the employment of a project manager with wind power expertise and specifically on-site wind power experience in order to successfully complete the Medford Schools Wind Project. SED is well suited to fill this role and as project manager would be responsible for all aspects of the design and construction of the project as an agent of the City of Medford. The project manager should be tasked with management and oversight of all civil and electrical engineering, project permitting and regulatory



approvals. The project manager should also be capable of assisting the City with project finance.

Where applicable, the project manager, will guide city officials to procure services throughout the design and construction process. By acting as the project manager on behalf of the City of Medford SED would provide the City with a streamlined and cost effective wind energy installation.

3.1.3 Design and Construction Costs

Figure 1 provides a detailed capital cost estimate for the project from this date forward. This estimate does not include any reduction in the project cost as a result of the Massachusetts Technology Collaborative's Large On-Site Renewable Solicitation. SED is currently in the process of procuring a grant through this program on behalf of the City of Medford.

The design phase of the project will consist of five main tasks: turbine procurement; electrical engineering; civil engineering; project permitting; and project finance. The construction phase will include foundation installation, the installation of the electrical infrastructure, as well as the final erection and completion of the wind turbine.

The costs for these services are estimated below and will be further quantified during the design phase of the project. Included in this cost estimate is the SMARTVIEW software that can be used to integrate the wind turbine as an educational tool in the School Curriculum.

3.1.4 Wind Turbine Commissioning

In order to ensure the proper operation and installation of the NorthWind 100kW wind turbine manufacturer trained technicians should be hired to commission the wind turbine both during the mechanical installation process and upon completion of the installation to ensure proper electrical connections. The use of trained technicians will ensure that the warranty will remain in place for a full two years.



Figure 17: Cost Estimates for Design and Construction of the Medford Schools Wind Project



**SUSTAINABLE ENERGY
DEVELOPMENTS INC.**

6304 Furnace Rd.
Ontario, NY 14519
Ph: (315)-524-9010
Fx: (315)-524-9046

**Design and
Construction
Quotation**

Client: City of Medford - Schools
Wind Turbine Northwind 100kW
Rotor Diameter: 20m
Hub Height: 32m
Location: Medford, MA
Date: 2/15/2007
Expiration: 8/15/2007

Item	Model#	Cost	Qty.	Total
Equipment from Turbine Manufacturer:				
100kW Wind Turbine	NW 100 20m Rotor	\$287,000	1	\$287,000
Power Controller	Included		1	
30m Tower		\$40,000	1	\$40,000.0
NPS Technicians/Commisioning	Included	\$15,420	1	\$15,420
SMARTVIEW		\$8,000	1	\$8,000
	Total from Turbine Manufacturer			\$350,420
Foundation Materials:				
Concrete*				\$12,500
Rebar cages				\$5,000
Forming				\$2,500
Foundation Bolts				\$2,500
*Assumes 100yds of concrete				
	Total foundation materials			\$22,500
Electical Materials:				
Transformer				\$8,500
Metering				\$2,000
Disconnect switch				\$2,000
Wire & conduit				\$5,000
Misc.				\$1,500
*assumes 300-400 ft. wire run				
	Total electrical materials			\$19,000
Labor:				
Foundation				\$3,360
Electrical				\$3,360
Assembly				\$1,120
Erection				\$2,240
Crane				\$8,000
Engineering - Electrical				\$7,500
Engineering - Civil				\$7,500
Permitting				\$2,500
SED Project Management				\$22,500
	Total Labor			\$58,080
	Total			\$450,000



3.2 *Economic Analysis*

SED employed the lifecycle maintenance figures, design, construction and capital cost estimates and the annual energy outputs calculated in the wind resource analysis in order to perform a cash flow analysis of each potential wind turbine and site scenario. In addition to the assumptions detailed elsewhere in this report the following assumptions will be applied to the cash flow analysis:

- The two wind turbines that were examined were a 100kW turbine on a 32-meter tower with a 20-meter rotor diameter and a 100kW turbine on a 40-meter tower with a 21-meter rotor diameter
- The project will be awarded a \$250,000 grant for design and construction from the MTC LORI solicitation
- Unlevered return was used as if City of Medford paid for the total installed cost of the turbine upfront
- Total installed cost for the project is estimated at \$450,000 (\$200,000 after MTC grant money is included)
- The facility's annual electric load/usage is 1,708,800 kilo-Watt-hours
- The cost for electricity at the facility is 0.14 \$/kWh excluding any demand charges
- Insurance, operations and maintenance costs inflate at 3% annually
- The project will be able to sell Renewable Energy Credits at \$0.03/kWh for a period of ten years

A summary of the cash flow analysis for the two wind turbines at the two potential locations is provided as Figure 2-1 (Turbine Site 1) and Figure 2-2 (Turbine Site 2). The output page of the cash flow model for each potential wind turbine with a 3% rate of electricity cost inflation is attached as Appendix A. In general, the economic analysis concludes that the wind speed at Turbine Site 1 is slightly higher than the wind regime at Turbine Site 2 and the 100kW turbine on a 40-meter tower with a 21-meter rotor diameter will produce over 50% more electricity than the 100kW turbine on a 32-meter tower with a 20-meter rotor diameter. The 100kW wind turbine with the larger rotor diameter will produce more electricity because of the larger swept area from which it can gather energy, especially when considering that it can be installed on a taller tower that provides access to a stronger, less-turbulent wind regime.

As can be seen from the cashflow analysis summary, the 100kW turbine on a 40-meter tower with a 21-meter rotor diameter at Turbine Site 1 shows the quickest and highest return on investment and shortest payback term, independent of the rate of electricity rate inflation. However, the difference between the two sites' wind regimes and resulting turbine electrical output is minimal and a wind turbine at either site would produce economic returns sufficient to satisfy the City's stated economic thresholds.



Figure 1: Cash flow Summaries at North Turbine Site

Wind Turbine	NW 100kW 21m Rotor 40m Tower (2008)	NW 100kW 20m Rotor 32m Tower (2007)
Wind Turbine Rated Capacity (kW)	100kW	100kW
Annual Energy Production (kWh/yr)	170,700	111,656
Internal Rate of Return (25 Years)		
0% Energy Escalation	10.9%	5.4%
3% Energy Escalation	14.2%	8.9%
5% Energy Escalation	16.3%	11.1%
8% Energy Escalation	19.4%	14.2%
Payback Period (years)		
0% Energy Escalation	8	14
3% Energy Escalation	8	12
5% Energy Escalation	7	11
8% Energy Escalation	7	10

Figure 19: Cash flow Summaries at South Turbine Site

Wind Turbine	NW 100kW 21m Rotor 40m Tower (2008)	NW 100kW 20m Rotor 32m Tower (2007)
Wind Turbine Rated Capacity (kW)	100kW	100kW
Annual Energy Production (kWh/yr)	167,607	110,744
Internal Rate of Return (25 Years)		
0% Energy Escalation	10.6%	5.3%
3% Energy Escalation	13.9%	8.8%
5% Energy Escalation	16.0%	11.0%
8% Energy Escalation	19.1%	14.1%
Payback Period (years)		
0% Energy Escalation	9	14
3% Energy Escalation	8	12
5% Energy Escalation	8	11
8% Energy Escalation	7	10



Appendix A: Cash flow model assuming 3% electricity inflation

NW 100kW 32m Hub Height 21m Rotor

Prepared for: **Medford Schools**
Date: **2/22/2007**

South Site - Medford Schools

Assumptions (Inputs)

Project Size (MW):	0.1
Total Installed Cost (\$):	\$213,921
Allocation to Business (%):	0
Annual Energy Output (kWh):	111,656
PPA Value (\$/kWh):	\$0.1400
PPA Escalator (%):	3
Energy Value at Facility (\$/kWh)	0.14
Percent to Grid (%)	0
Energy Value to Grid (\$/kWh)	0.07
Green Tag or REC Value (\$/kWh):	\$0.0300
Length of Green Tag Contract (Years)	10
Green Tag Ownership (%)	100
Loan Downpayment (%):	100
Down Payment (\$):	\$213,921
Amount of Loan (\$):	\$0
Interest Rate (%):	0
Loan Term (Years):	0
Month Installed:	0
Net State and Federal Tax Rate (%):	0
PTC Value (\$/kWh):	0
PTC Inflation (%)	3
O & M Cost (\$/kWh):	\$0.015
O & M Inflation Rate (%):	3
Insurance Cost (\$/MW)	10000
Insurance Inflation Rate (%)	3

Results

Loan Payments

Monthly Payment (\$):	#NUM!
Value of Interest Deduction (\$):	#NUM!
Net Monthly Payment (\$):	#NUM!

Ave. Monthly Savings on Bill

Year 1 (\$):	\$1,303
Year 10 (\$):	\$1,751
Year 20 (\$):	\$2,353
Year 25 (\$):	\$3,162

Annual Cash Flow Model

Year	Net Energy	REC Sales	O&M Costs	Insurance Costs	Annual Cash Flow	Total Cash Flow
0					(\$213,921)	(\$213,921)
1	\$15,632	\$3,350	(\$1,675)	(\$1,000)	\$16,307	(\$197,614)
2	\$16,101	\$3,350	(\$1,725)	(\$1,030)	\$16,695	(\$180,919)
3	\$16,584	\$3,350	(\$1,777)	(\$1,061)	\$17,096	(\$163,823)
4	\$17,081	\$3,350	(\$1,830)	(\$1,093)	\$17,508	(\$146,315)
5	\$17,594	\$3,350	(\$1,885)	(\$1,126)	\$17,933	(\$128,382)
6	\$18,122	\$3,350	(\$1,942)	(\$1,159)	\$18,370	(\$110,012)
7	\$18,665	\$3,350	(\$2,000)	(\$1,194)	\$18,821	(\$91,191)
8	\$19,225	\$3,350	(\$2,060)	(\$1,230)	\$19,285	(\$71,906)
9	\$19,802	\$3,350	(\$2,122)	(\$1,267)	\$19,763	(\$52,142)
10	\$20,396	\$3,350	(\$2,185)	(\$1,305)	\$20,256	(\$31,887)
11	\$21,008	\$0	(\$2,251)	(\$1,344)	\$17,413	(\$14,474)
12	\$21,638	\$0	(\$2,318)	(\$1,384)	\$17,936	\$3,462
13	\$22,287	\$0	(\$2,388)	(\$1,426)	\$18,474	\$21,936
14	\$22,956	\$0	(\$2,460)	(\$1,469)	\$19,028	\$40,963
15	\$23,645	\$0	(\$2,533)	(\$1,513)	\$19,599	\$60,562
16	\$24,354	\$0	(\$2,609)	(\$1,558)	\$20,187	\$80,749
17	\$25,085	\$0	(\$2,688)	(\$1,605)	\$20,792	\$101,541
18	\$25,837	\$0	(\$2,768)	(\$1,653)	\$21,416	\$122,957
19	\$26,612	\$0	(\$2,851)	(\$1,702)	\$22,058	\$145,015
20	\$27,411	\$0	(\$2,937)	(\$1,754)	\$22,720	\$167,735
21	\$28,233	\$0	(\$3,025)	(\$1,806)	\$23,402	\$191,137
22	\$29,080	\$0	(\$3,116)	(\$1,860)	\$24,104	\$215,241
23	\$29,952	\$0	(\$3,209)	(\$1,916)	\$24,827	\$240,068
24	\$30,851	\$0	(\$3,305)	(\$1,974)	\$25,572	\$265,640
25	\$31,776	\$0	(\$3,405)	(\$2,033)	\$26,339	\$291,978
26	\$32,730	\$0	(\$3,507)	(\$2,094)	\$27,129	\$319,108
27	\$33,711	\$0	(\$3,612)	(\$2,157)	\$27,943	\$347,051
28	\$34,723	\$0	(\$3,720)	(\$2,221)	\$28,781	\$375,832
29	\$35,765	\$0	(\$3,832)	(\$2,288)	\$29,645	\$405,476
30	\$36,837	\$0	(\$3,947)	(\$2,357)	\$30,534	\$436,010

Blue shading indicates a column that shows a tax value not a cash transaction
Mid year Convention used for depreciation

Internal Rate of Return

Years 1 - 25: 8.2%

Payback Period

12 Years

NW 100kW 32m Hub Height 21m Rotor

Prepared for: **Medford Schools**
Date: **2/22/2007**

North Site - Medford Schools

Assumptions (Inputs)

Project Size (MW):	0.1
Total Installed Cost (\$):	\$213,921
Allocation to Business (%):	0
Annual Energy Output (kWh):	110,744
PPA Value (\$/kWh):	\$0.1400
PPA Escalator (%):	3
Energy Value at Facility (\$/kWh)	0.14
Percent to Grid (%):	0
Energy Value to Grid (\$/kWh)	0.07
Green Tag or REC Value (\$/kWh):	\$0.0300
Length of Green Tag Contract (Years)	10
Green Tag Ownership (%)	100
Loan Downpayment (%):	100
Down Payment (\$):	\$213,921
Amount of Loan (\$):	\$0
Interest Rate (%):	0
Loan Term (Years):	0
Month Installed:	0
Net State and Federal Tax Rate (%):	0
PTC Value (\$/kWh):	0
PTC Inflation (%)	3
O & M Cost (\$/kWh):	\$0.015
O & M Inflation Rate (%):	3
Insurance Cost (\$/MW)	10000
Insurance Inflation Rate (%)	3

Results

Loan Payments

Monthly Payment (\$):	#NUM!
Value of Interest Deduction (\$):	#NUM!
Net Monthly Payment (\$):	#NUM!

Ave. Monthly Savings on Bill

Year 1 (\$):	\$1,292
Year 10 (\$):	\$1,736
Year 20 (\$):	\$2,334
Year 25 (\$):	\$3,136

Annual Cash Flow Model

Year	Net Energy	REC Sales	O&M Costs	Insurance Costs	Annual Cash Flow	Total Cash Flow
0					(\$213,921)	(\$213,921)
1	\$15,504	\$3,322	(\$1,661)	(\$1,000)	\$16,165	(\$197,756)
2	\$15,969	\$3,322	(\$1,711)	(\$1,030)	\$16,551	(\$181,205)
3	\$16,448	\$3,322	(\$1,762)	(\$1,061)	\$16,947	(\$164,258)
4	\$16,942	\$3,322	(\$1,815)	(\$1,093)	\$17,356	(\$146,901)
5	\$17,450	\$3,322	(\$1,870)	(\$1,126)	\$17,777	(\$129,124)
6	\$17,974	\$3,322	(\$1,926)	(\$1,159)	\$18,211	(\$110,913)
7	\$18,513	\$3,322	(\$1,984)	(\$1,194)	\$18,658	(\$92,256)
8	\$19,068	\$3,322	(\$2,043)	(\$1,230)	\$19,118	(\$73,138)
9	\$19,640	\$3,322	(\$2,104)	(\$1,267)	\$19,591	(\$53,547)
10	\$20,229	\$3,322	(\$2,167)	(\$1,305)	\$20,080	(\$33,467)
11	\$20,836	\$0	(\$2,232)	(\$1,344)	\$17,260	(\$16,207)
12	\$21,461	\$0	(\$2,299)	(\$1,384)	\$17,778	\$1,570
13	\$22,105	\$0	(\$2,368)	(\$1,426)	\$18,311	\$19,881
14	\$22,768	\$0	(\$2,439)	(\$1,469)	\$18,860	\$38,742
15	\$23,451	\$0	(\$2,513)	(\$1,513)	\$19,426	\$58,168
16	\$24,155	\$0	(\$2,588)	(\$1,558)	\$20,009	\$78,177
17	\$24,880	\$0	(\$2,666)	(\$1,605)	\$20,609	\$98,786
18	\$25,626	\$0	(\$2,746)	(\$1,653)	\$21,228	\$120,014
19	\$26,395	\$0	(\$2,828)	(\$1,702)	\$21,864	\$141,878
20	\$27,187	\$0	(\$2,913)	(\$1,754)	\$22,520	\$164,398
21	\$28,002	\$0	(\$3,000)	(\$1,806)	\$23,196	\$187,594
22	\$28,842	\$0	(\$3,090)	(\$1,860)	\$23,892	\$211,486
23	\$29,708	\$0	(\$3,183)	(\$1,916)	\$24,609	\$236,095
24	\$30,599	\$0	(\$3,278)	(\$1,974)	\$25,347	\$261,441
25	\$31,517	\$0	(\$3,377)	(\$2,033)	\$26,107	\$287,549
26	\$32,462	\$0	(\$3,478)	(\$2,094)	\$26,890	\$314,439
27	\$33,436	\$0	(\$3,582)	(\$2,157)	\$27,697	\$342,136
28	\$34,439	\$0	(\$3,690)	(\$2,221)	\$28,528	\$370,664
29	\$35,472	\$0	(\$3,801)	(\$2,288)	\$29,384	\$400,048
30	\$36,537	\$0	(\$3,915)	(\$2,357)	\$30,265	\$430,313

Blue shading indicates a column that shows a tax value not a cash transaction
Mid year Convention used for depreciation

Internal Rate of Return

Years 1 - 25: 8.1%

Payback Period

12 Years

NW 100kW 40m Hub Height 21m Rotor

Prepared for: **Medford Schools**
Date: **2/22/2007**

South Site - Medford Schools

Assumptions (Inputs)

Project Size (MW):	0.1
Total Installed Cost (\$):	\$213,921
Allocation to Business (%):	0
Annual Energy Output (kWh):	170,700
PPA Value (\$/kWh):	\$0.1400
PPA Escalator (%):	3
Energy Value at Facility (\$/kWh)	0.14
Percent to Grid (%)	0
Energy Value to Grid (\$/kWh)	0.07
Green Tag or REC Value (\$/kWh):	\$0.0300
Length of Green Tag Contract (Years)	10
Green Tag Ownership (%)	100
Loan Downpayment (%):	100
Down Payment (\$):	\$213,921
Amount of Loan (\$):	\$0
Interest Rate (%):	0
Loan Term (Years):	0
Month Installed:	0
Net State and Federal Tax Rate (%):	0
PTC Value (\$/kWh):	0
PTC Inflation (%)	3
O & M Cost (\$/kWh):	\$0.015
O & M Inflation Rate (%):	3
Insurance Cost (\$/MW)	10000
Insurance Inflation Rate (%)	3

Results

Loan Payments

Monthly Payment (\$):	#NUM!
Value of Interest Deduction (\$):	#NUM!
Net Monthly Payment (\$):	#NUM!

Ave. Monthly Savings on Bill

Year 1 (\$):	\$1,992
Year 10 (\$):	\$2,676
Year 20 (\$):	\$3,597
Year 25 (\$):	\$4,834

Annual Cash Flow Model

Year	Net Energy	REC Sales	O&M Costs	Insurance Costs	Annual Cash Flow	Total Cash Flow
0					(\$213,921)	(\$213,921)
1	\$23,898	\$5,121	(\$2,561)	(\$1,000)	\$25,459	(\$188,463)
2	\$24,615	\$5,121	(\$2,637)	(\$1,030)	\$26,069	(\$162,394)
3	\$25,353	\$5,121	(\$2,716)	(\$1,061)	\$26,697	(\$135,697)
4	\$26,114	\$5,121	(\$2,798)	(\$1,093)	\$27,344	(\$108,352)
5	\$26,897	\$5,121	(\$2,882)	(\$1,126)	\$28,011	(\$80,341)
6	\$27,704	\$5,121	(\$2,968)	(\$1,159)	\$28,698	(\$51,644)
7	\$28,535	\$5,121	(\$3,057)	(\$1,194)	\$29,405	(\$22,239)
8	\$29,392	\$5,121	(\$3,149)	(\$1,230)	\$30,134	\$7,895
9	\$30,273	\$5,121	(\$3,244)	(\$1,267)	\$30,884	\$38,779
10	\$31,181	\$5,121	(\$3,341)	(\$1,305)	\$31,657	\$70,436
11	\$32,117	\$0	(\$3,441)	(\$1,344)	\$27,332	\$97,768
12	\$33,080	\$0	(\$3,544)	(\$1,384)	\$28,152	\$125,919
13	\$34,073	\$0	(\$3,651)	(\$1,426)	\$28,996	\$154,916
14	\$35,095	\$0	(\$3,760)	(\$1,469)	\$29,866	\$184,782
15	\$36,148	\$0	(\$3,873)	(\$1,513)	\$30,762	\$215,544
16	\$37,232	\$0	(\$3,989)	(\$1,558)	\$31,685	\$247,230
17	\$38,349	\$0	(\$4,109)	(\$1,605)	\$32,636	\$279,865
18	\$39,500	\$0	(\$4,232)	(\$1,653)	\$33,615	\$313,480
19	\$40,685	\$0	(\$4,359)	(\$1,702)	\$34,623	\$348,103
20	\$41,905	\$0	(\$4,490)	(\$1,754)	\$35,662	\$383,765
21	\$43,162	\$0	(\$4,625)	(\$1,806)	\$36,732	\$420,497
22	\$44,457	\$0	(\$4,763)	(\$1,860)	\$37,834	\$458,331
23	\$45,791	\$0	(\$4,906)	(\$1,916)	\$38,969	\$497,300
24	\$47,165	\$0	(\$5,053)	(\$1,974)	\$40,138	\$537,437
25	\$48,580	\$0	(\$5,205)	(\$2,033)	\$41,342	\$578,779
26	\$50,037	\$0	(\$5,361)	(\$2,094)	\$42,582	\$621,361
27	\$51,538	\$0	(\$5,522)	(\$2,157)	\$43,860	\$665,221
28	\$53,084	\$0	(\$5,688)	(\$2,221)	\$45,175	\$710,397
29	\$54,677	\$0	(\$5,858)	(\$2,288)	\$46,531	\$756,927
30	\$56,317	\$0	(\$6,034)	(\$2,357)	\$47,927	\$804,854

Blue shading indicates a column that shows a tax value not a cash transaction
Mid year Convention used for depreciation

Internal Rate of Return		Payback Period
Years 1 - 25:	13.3%	8 Years

NW 100kW 40m Hub Height 21m Rotor

Prepared for: **Medford Schools**
Date: **2/22/2007**

North Site - Medford Schools

Assumptions (Inputs)

Project Size (MW):	0.1
Total Installed Cost (\$):	\$213,921
Allocation to Business (%):	0
Annual Energy Output (kWh):	167,607
PPA Value (\$/kWh):	\$0.1400
PPA Escalator (%):	3
Energy Value at Facility (\$/kWh)	0.14
Percent to Grid (%)	0
Energy Value to Grid (\$/kWh)	0.07
Green Tag or REC Value (\$/kWh):	\$0.0300
Length of Green Tag Contract (Years)	10
Green Tag Ownership (%)	100
Loan Downpayment (%):	100
Down Payment (\$):	\$213,921
Amount of Loan (\$):	\$0
Interest Rate (%):	0
Loan Term (Years):	0
Month Installed:	0
Net State and Federal Tax Rate (%):	0
PTC Value (\$/kWh):	0
PTC Inflation (%)	3
O & M Cost (\$/kWh):	\$0.015
O & M Inflation Rate (%):	3
Insurance Cost (\$/MW)	10000
Insurance Inflation Rate (%)	3

Results

Loan Payments

Monthly Payment (\$):	#NUM!
Value of Interest Deduction (\$):	#NUM!
Net Monthly Payment (\$):	#NUM!

Ave. Monthly Savings on Bill

Year 1 (\$):	\$1,955
Year 10 (\$):	\$2,628
Year 20 (\$):	\$3,532
Year 25 (\$):	\$4,746

Annual Cash Flow Model

Year	Net Energy	REC Sales	O&M Costs	Insurance Costs	Annual Cash Flow	Total Cash Flow
0					(\$213,921)	(\$213,921)
1	\$23,465	\$5,028	(\$2,514)	(\$1,000)	\$24,979	(\$188,942)
2	\$24,169	\$5,028	(\$2,590)	(\$1,030)	\$25,578	(\$163,364)
3	\$24,894	\$5,028	(\$2,667)	(\$1,061)	\$26,194	(\$137,170)
4	\$25,641	\$5,028	(\$2,747)	(\$1,093)	\$26,829	(\$110,341)
5	\$26,410	\$5,028	(\$2,830)	(\$1,126)	\$27,483	(\$82,858)
6	\$27,202	\$5,028	(\$2,915)	(\$1,159)	\$28,157	(\$54,701)
7	\$28,018	\$5,028	(\$3,002)	(\$1,194)	\$28,851	(\$25,851)
8	\$28,859	\$5,028	(\$3,092)	(\$1,230)	\$29,565	\$3,715
9	\$29,725	\$5,028	(\$3,185)	(\$1,267)	\$30,301	\$34,016
10	\$30,616	\$5,028	(\$3,280)	(\$1,305)	\$31,060	\$65,076
11	\$31,535	\$0	(\$3,379)	(\$1,344)	\$26,812	\$91,888
12	\$32,481	\$0	(\$3,480)	(\$1,384)	\$27,617	\$119,505
13	\$33,455	\$0	(\$3,585)	(\$1,426)	\$28,445	\$147,950
14	\$34,459	\$0	(\$3,692)	(\$1,469)	\$29,299	\$177,248
15	\$35,493	\$0	(\$3,803)	(\$1,513)	\$30,177	\$207,426
16	\$36,558	\$0	(\$3,917)	(\$1,558)	\$31,083	\$238,509
17	\$37,654	\$0	(\$4,034)	(\$1,605)	\$32,015	\$270,524
18	\$38,784	\$0	(\$4,155)	(\$1,653)	\$32,976	\$303,500
19	\$39,948	\$0	(\$4,280)	(\$1,702)	\$33,965	\$337,465
20	\$41,146	\$0	(\$4,408)	(\$1,754)	\$34,984	\$372,449
21	\$42,380	\$0	(\$4,541)	(\$1,806)	\$36,033	\$408,482
22	\$43,652	\$0	(\$4,677)	(\$1,860)	\$37,115	\$445,597
23	\$44,961	\$0	(\$4,817)	(\$1,916)	\$38,228	\$483,825
24	\$46,310	\$0	(\$4,962)	(\$1,974)	\$39,375	\$523,199
25	\$47,699	\$0	(\$5,111)	(\$2,033)	\$40,556	\$563,755
26	\$49,130	\$0	(\$5,264)	(\$2,094)	\$41,773	\$605,528
27	\$50,604	\$0	(\$5,422)	(\$2,157)	\$43,026	\$648,554
28	\$52,123	\$0	(\$5,585)	(\$2,221)	\$44,317	\$692,871
29	\$53,686	\$0	(\$5,752)	(\$2,288)	\$45,646	\$738,517
30	\$55,297	\$0	(\$5,925)	(\$2,357)	\$47,016	\$785,532

Blue shading indicates a column that shows a tax value not a cash transaction
Mid year Convention used for depreciation

Internal Rate of Return		Payback Period
Years 1 - 25:	13.0%	8 Years