Wind Energy Site Assessment
Report Form

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Date of Consultation: 11/4/05

Time Spent: 4:00 hrs on site Mileage: 278 mi RT

Latitude: 44.5294 **Longitude:** -87.9158

Additional Expenses: NA

Name of Client: Univ. of Wisconsin at Green Bay
Contact: Dean Rodeheaver
Assistant Chancellor for Planning and Budget
University of Wisconsin-Green Bay
Cofrin Library 823
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<u>Site Address</u>
2420 Nicolet Drive, Green Bay, WI 54311
City: Green Bay
State: WI
Zip: 54311

County: Brown
Utility: WPS

Project Overview
A group of students at UWGB are interested in making the campus more sustainable. Dean Rodeheaver, the Assistant Chancellor for Planning and Budget at UW Green Bay, felt that renewable energy, specifically wind, was worth investigating for sustainability reasons and also to find out if it can cut the electricity costs for the university in the long term.

CLIENT INFORMATION

1. Why is the client interested in renewable energy?

- Clean energy/environmental concerns
- Investment in RE technology
- Reducing energy bills

2. What types of system(s) is the client interested in?

- Wind

Comments: The University already has Solar Hot Water installed for the sports center swimming pool.

3. Is the system being installed as part of a new construction, or as a retrofit?

The wind turbine would be added to the existing campus.

4. What is the client's timeline for installation? Will it be installed all at once or incrementally?

The client is just starting to evaluate their options for becoming a more sustainable campus at this time.

5. How involved is the customer willing to be with the system?

Is interested in being involved in the installation of the system.
Will take full responsibility for the maintenance of the system.
Will perform basic maintenance, but wants technical back up for problem situations.
X Wants maintenance performed by outside contractor.

Comments: It is possible to have the University maintenance staff get trained by the installer to save money on paying for outside maintenance.

6. Description of Site and Property:

A. **Are there any airports located nearby?**
The closest airport is the Straubel Airport which is over 9 miles southwest of the site and so no FAA notification is necessary.

B. Soil type and depth of bedrock:
The soil is a heavy clay and should pose no special challenge to the installation of a wind turbine foundation.

C. Electrical Service
The University has its own gas fired power plant serviced by WPS. In addition to the plant, there are 12 different meters for small loads, e.g. the Chancellor's house, the golf pro-shop (Shorewood Center), the UWGB sign, etc…

D. Electrical Usage

The main plant is billed on demand and energy-use (on/off peak). The term "demand charges" refers to when the utility records the highest reading of power (Kilowatts) demanded by the customer at one time during the entire month and charges a flat rate in $/kW for this peak "demand". Most of the utility's large customers are billed this way.

According to Paul Pinkston of Facilities Planning, for July 2004 – June 2005 at the main plant:

- 1,510,000 kwh/month - average energy usage per month
- 18,364,911 kWh. – total annual energy usage

The charges from WPS according the June 2005 bill are:

- 4.5 cents/kwh on-peak – energy-use charge.
- 2.24 cents/kwh off-peak – energy-use charge
- $8.55/kW - demand charge; $39,387 out of the total $102,922 - making up 38% of the total monthly bill
- 5.8 cents average cost/kwh paid for energy when energy-use and demand charges are combines (WPS calculated).

This 5.8 cents/kwh can be used as a ballpark estimate for comparing the cost of electricity provided by a wind system, understanding that with a wind system you are paying for 20+ years of electricity up front.

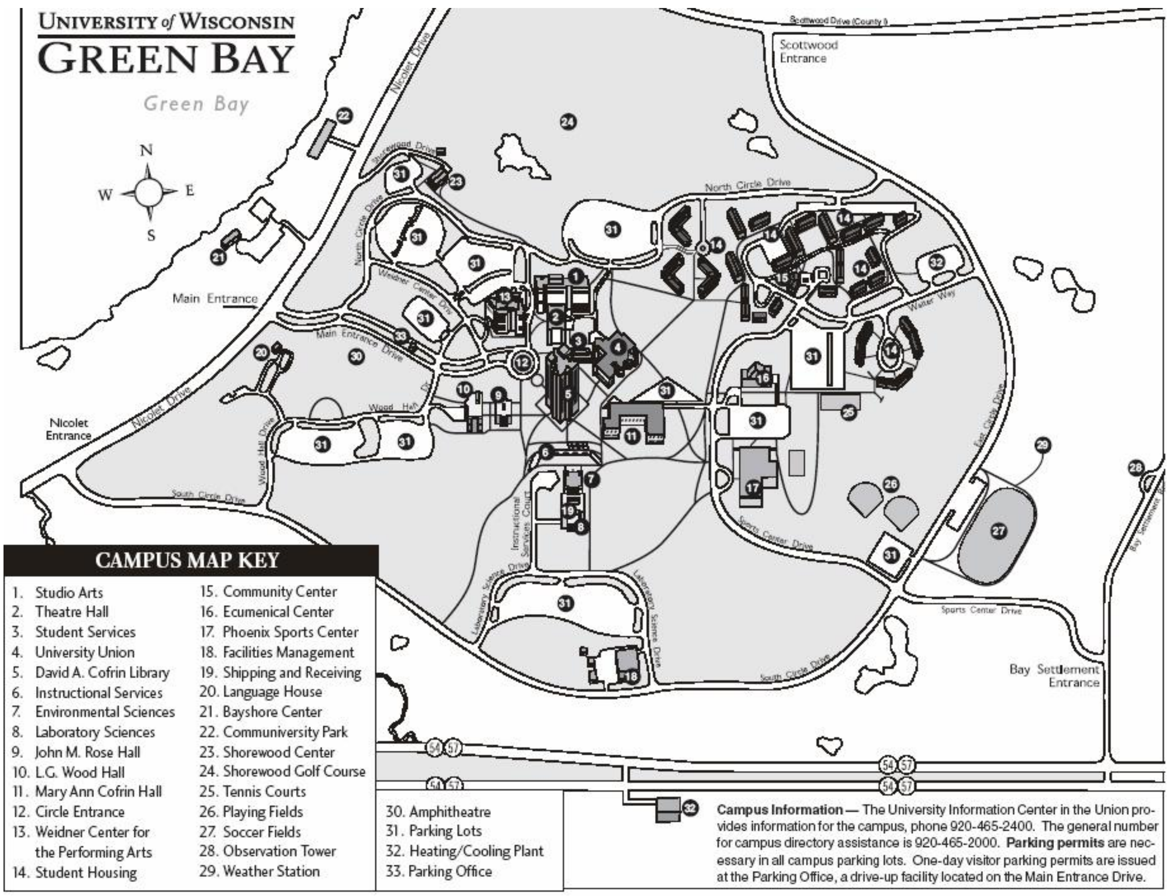
The Shorewood Center is the golf pro-shop run by UWGB and has its own meter and is billed only for energy-use, no demand charges. The average load here is 6400kwh/mo from July – December and 2306 kwh/mo from January – June. The annual use over the last year was 52,240 kWh which cost $950.42. Based on this, the average billing here is 9.2 cents/kwh. Potentially, this site could be an option for a net-zero electrical usage with a mid-size wind turbine.

The WPS load summary for July 2004 – June 2005, and the bill for the month of June 2005 can be found at the end of this report.

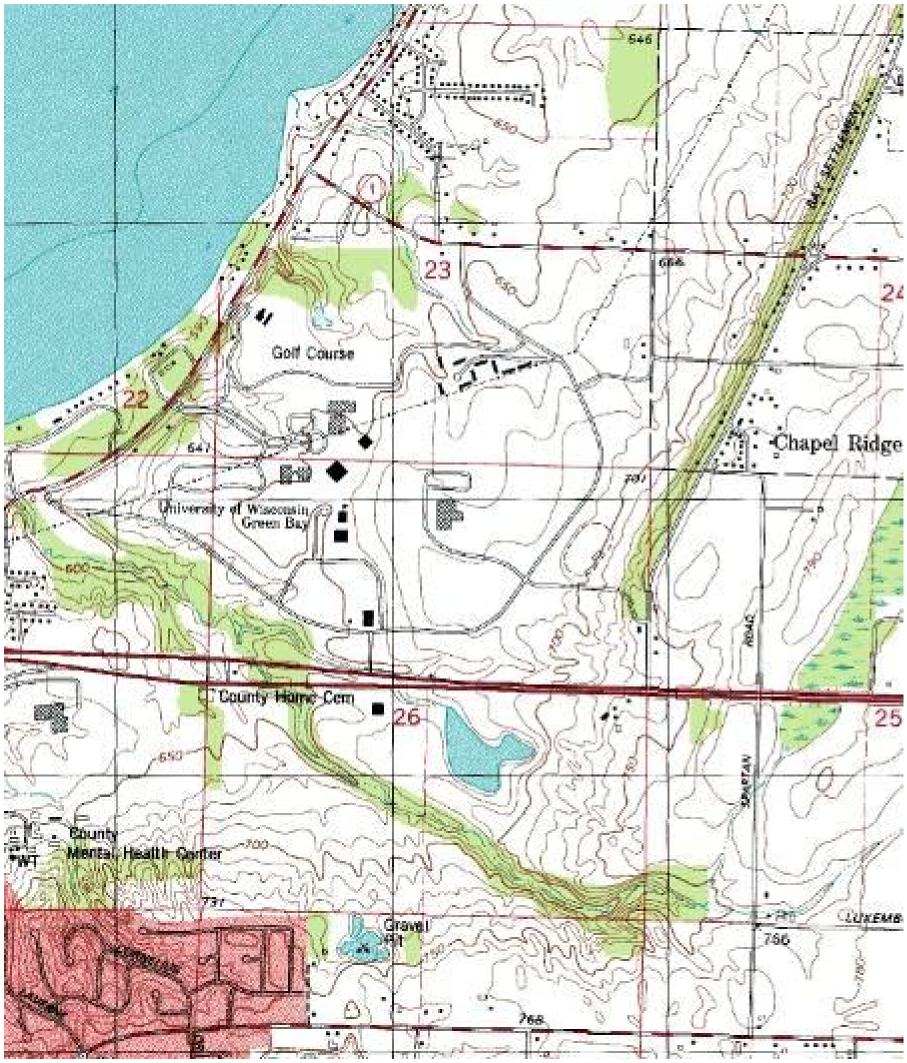
E. Physical Description of site and property:

The UWGB campus is an area of approximately 1 square mile, sitting at the southern most part of Green Bay (the bay not the city), about 0.1 miles southeast of the water. (See map of the campus below.) It is fairly densely occupied by classroom and housing buildings, many parking areas, and fields for recreational sports. There is also a golf course in the northern most part of the campus. The remaining areas are heavily wooded with hardwoods including maples, oaks and poplars, and evergreens. Most of the immediate area surrounding the campus is protected Arboretum land owned by the state. To the southeast lies a ridge which is part of the Niagra Escarpment; a raised land formation created by glaciers running from Dodge County northeast up through the Fond du Lac, Brown, and Door Counties. The Niagra Escarpment is considered the best location for siting wind turbines in the state.

The center of the campus contains most of the school buildings, the tallest being the David Cofrin Library, which is 126’ at the highest point. To the northeast and east are all the housing units which are approximately 45’ high.



The campus is fairly level with elevations ranging from 640’ – 670’. To the north and west the elevation drops off to the bay at around 580’. The Niagra Escarpment ridge runs from the southwest to northeast just southeast of campus. From the center of campus to the east the elevation rises to 780’ within half a mile and to the south it rises to 750’ within a mile up to the ridge of the escarpment. See the topographical map below and the 360 degree photographs taken from the top of the David Cofrin Library to get a feeling for the landscape of the area.



Topo Map of UWGB area from 1980

A 360 degree view of campus taken from the top of the Cofrin Library (120')


South


Southwest

A 360 degree view of campus taken from the top of the Cofrin Library (120')

West

Northwest

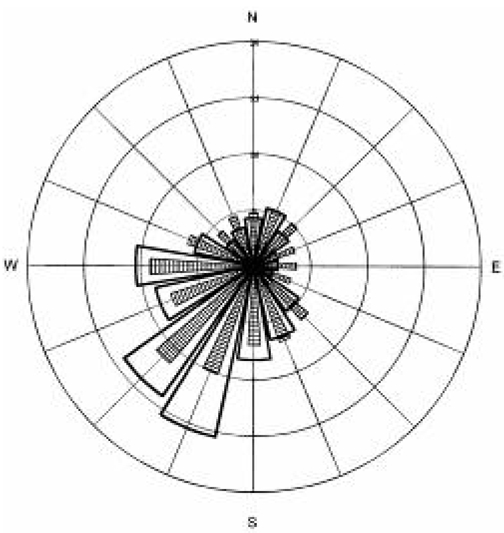
North

Northeast

East

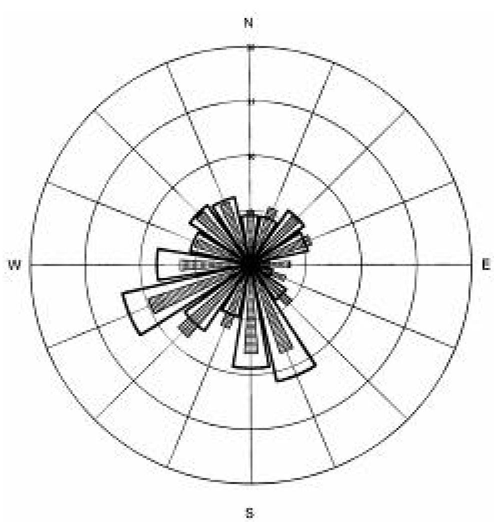
Southeast

Prevailing wind direction winter versus summer:
When siting a turbine, it is important to know what kind of wind resource is available. From 1997- 2001 a study called the Wind Resource Assessment Program (WRAP) was conducted in Wisconsin by a consortium of utilities. The purpose of the study was to measure the wind resource in the state based on 14 monitoring stations. The wind speed and wind direction were recorded at 60 meters (197') above ground level at all stations for 3 years. The report, released in January 2002, resulted in a "wind map" of Wisconsin. The wind map provides estimates for average annual wind speeds (at 197') for all areas of the state. This map can be found at the Focus on Energy website www.focusonenergy.org and is attached at the end of this report. A diagram illustrating the prevailing wind directions was also created for each station. This is called a **wind rose.** The wind roses for the two stations closest to Green Bay are shown below. It can be seen that the prevailing winds in this area come from the west, southwest, south and southeast. The location of these monitoring stations can be seen on the map in Figure 1 below. Note: The wind rose from station #405 is less representative of Green Bay and so the southeast winds will be given less weight.



This **wind rose** graph illustrates the percent time and percent energy in each direction sector. The wide, outlined bars represent the percent of total energy and the narrower, shaded bars illustrate the percent of total time in each of the sixteen direction sectors. (Wind rose from Wisconsin Wind Resource Assessment Program (WRAP) 2002 report).

Wind Rose Site 410



Wind Rose Site 405 Sturgeon Bay

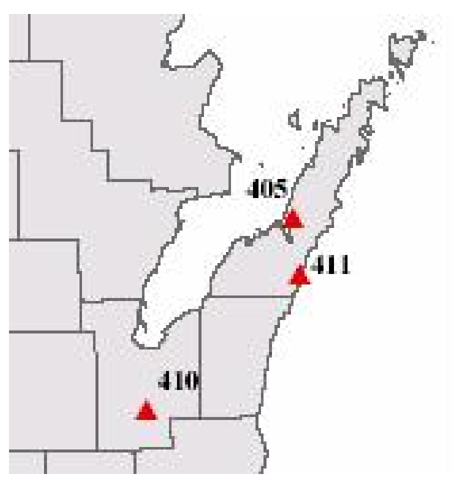


Fig. 1
Map of stations used in WRAP study

7. Description of Potential Wind System
A. Tower Choices

There are three main types of towers that can be used for small residential size wind systems, 20KW and under:

- Free-standing towers which have no guy wires. The advantage of the freestanding tower is its small footprint (about 12'-15' square), which is good for tight spaces. Of the small wind systems this tower is generally the most expensive because it contains the most steel and weighs more than the other types. It is also the most visible on the landscape because of all this steel. This type of tower requires climbing the tower for maintenance.

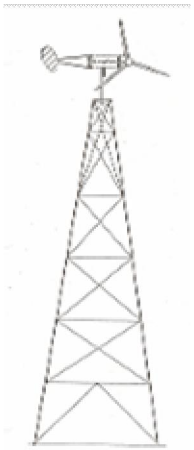
- Guyed Lattice towers which typically have three sets of guy wires. The stationary guyed lattice tower is usually the least expensive type of tower. The guy wires holding up this tower have a footprint of around 30'- 40' square. This type of tower requires climbing the tower for maintenance.

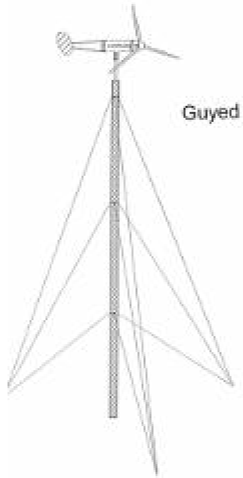
- Tilt-up towers which have four sets of guy wires. These towers are usually only slightly more expensive than guyed lattice towers. The advantage of the tilt-up tower is that maintenance can be performed without climbing the tower. The tilt-up has the largest footprint(around 50' square) of the tower types due to the four sets of guy wires, and it also requires relatively flat terrain for the length of the tower in at least one direction from the base of the tower, in order to lower the tower to the ground.

On guyed towers the guy wires are virtually invisible when viewed from a distance.

For smaller commercial wind systems, 20KW to 90KW, a free-standing tower is used and will provide the strength necessary to handle not only the weight of the turbine, but also the torque as the winds push on the rotor.

For large commercial turbines, 100KW and up, the monopole towers are the only type of tower usually used. These are the large tubular towers you see on commercial wind farms. All the electronics for the tower are located inside the base of the tower, and the tower is climbed on the inside for maintenance. These towers have a footprint of around 20' – 30' square.





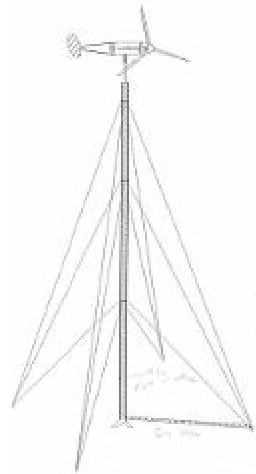


Photo credit: American Wind Energy Association - AWEA

Freestanding **Guyed Lattice** **Guyed Tilt-Up** **Monopole**

B. Potential Sites for Wind System:

The turbine should be located where it can intercept the most wind, based on the prevailing wind directions and the locations of the highest obstructions. The more wind the more electricity. Obstructions, such as buildings and tall trees disrupt the flow of the wind and create turbulence. This not only slows the wind, reducing the amount of energy that can be extracted, but also creates a harsher environment for the wind turbine especially the rotor blades, and this may shorten the life of the system. To reduce the effect of turbulence, the turbine should be sited farther away from the obstructions and/or on a higher tower where the turbine and the blades can be above the turbulence. According to the wind roses mentioned previously, at this UWGB site the prevailing wind directions are from the west, southwest, south, and slightly southeast. Because there are significant obstructions in the form of buildings and tall trees on campus, it would be best to site the turbine where these obstructions do not block the wind from these directions.

Possible turbine locations:

1) On the south side of the sports center is a flat grassy area which has fairly good exposure to the prevailing wind directions. This location is south of all the main campus buildings although there are some tall trees in the vicinity. Currently this area is used for recreational sports, but if a free standing tower is used and placed just off the field, the 20 ft square area required by the turbine may not be too much of a hindrance. The turbine could potentially be wired to serve the Sports Center.

2) The second location would be just south of site 1, across Sports Center Drive in the clear area near South Circle drive, just west of the marshy area. This has all the advantages of site 1 except that the turbine is farther away from any buildings to which it can send the electricity it generates; meaning a longer wire run and increased cost.

Both these sites have good exposure to the prevailing winds and are among the highest elevations on the campus at 675'. The following photos are taken from Site #1, but they are also representative of the landscape for site 2 which is only 400yd. to the south.

It should be noted that there is a new building, on the order of 55' in height, is slated to go in just north of site #2 and east of site #1. The height of the tower should be such that this is not an issue since the surrounding trees are taller than 55' making them the critical obstructions.

3) A possible third site is up in a parking lot by the Shorewood Center, the golf course pro-shop, on the north side of campus. This location is at an elevation of around 640' on top of a ridge running southwest to northeast on this section of campus (see the topo above). Because it is northwest of all the main buildings, and northwest of the other 2 higher sites, this site can still take advantage of the prevailing winds from the west and south, and would also have much better exposure to winds coming off the bay from the north and northwest. This site also has the issue of being surrounded by mature hardwoods, so a tall enough tower is needed to make sure that the rotor of the turbine is free from turbulence. (More on tower heights later in the report.) An advantage of this site is that the Shorewood Center has its own electrical meter, billed at 9.2 cents/kwh, and the turbine could be wired in here and dedicated to this building. The following photos for Site 3 are taken from the circular parking lot just east of North Circle Drive.

Photos from Site #1 (also representative for Site #2)


South


Southwest


West

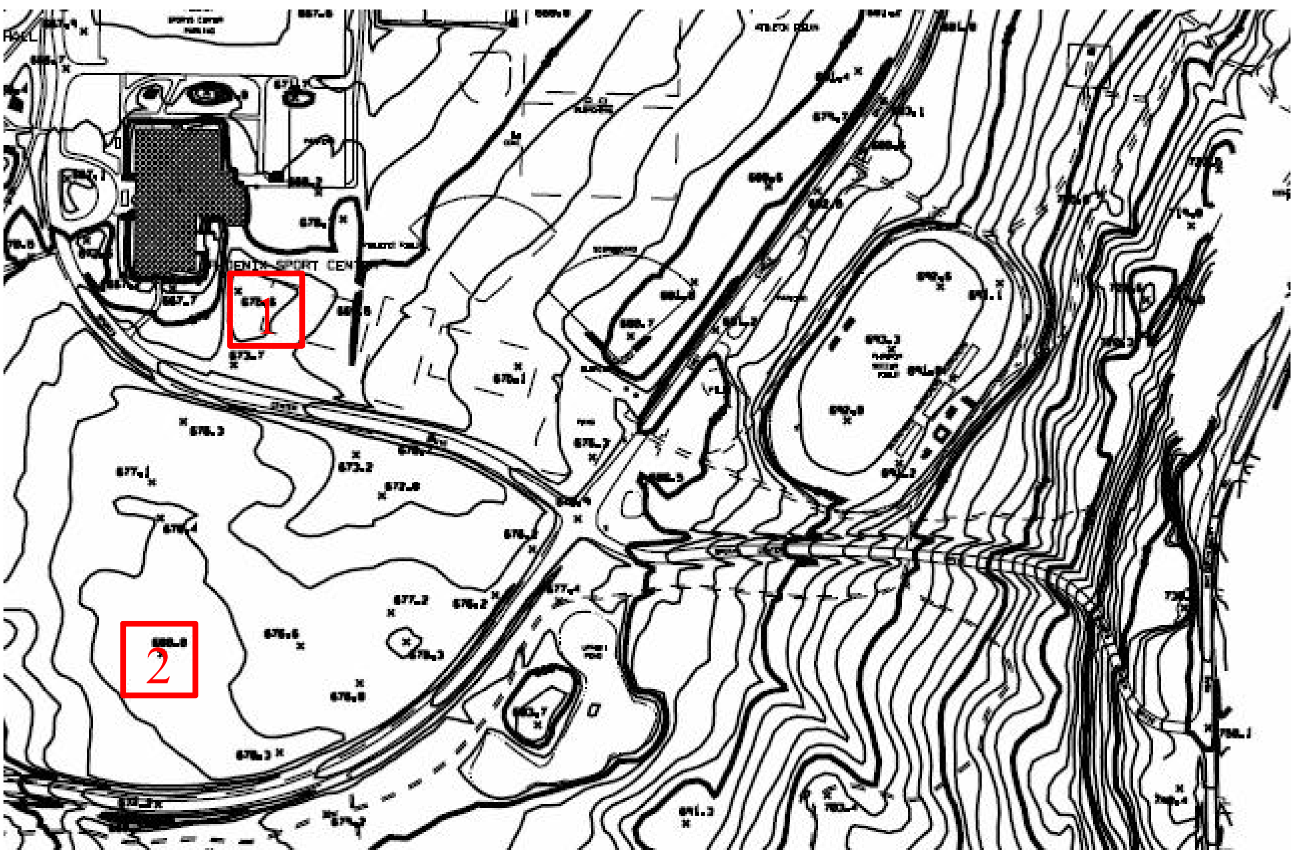

Northwest


North


Northeast

East

Southeast



Close up topos for Site 1 and Site 2 (gradations of 2')

Site #3 Shorewood Golf Center Area


South


Southwest

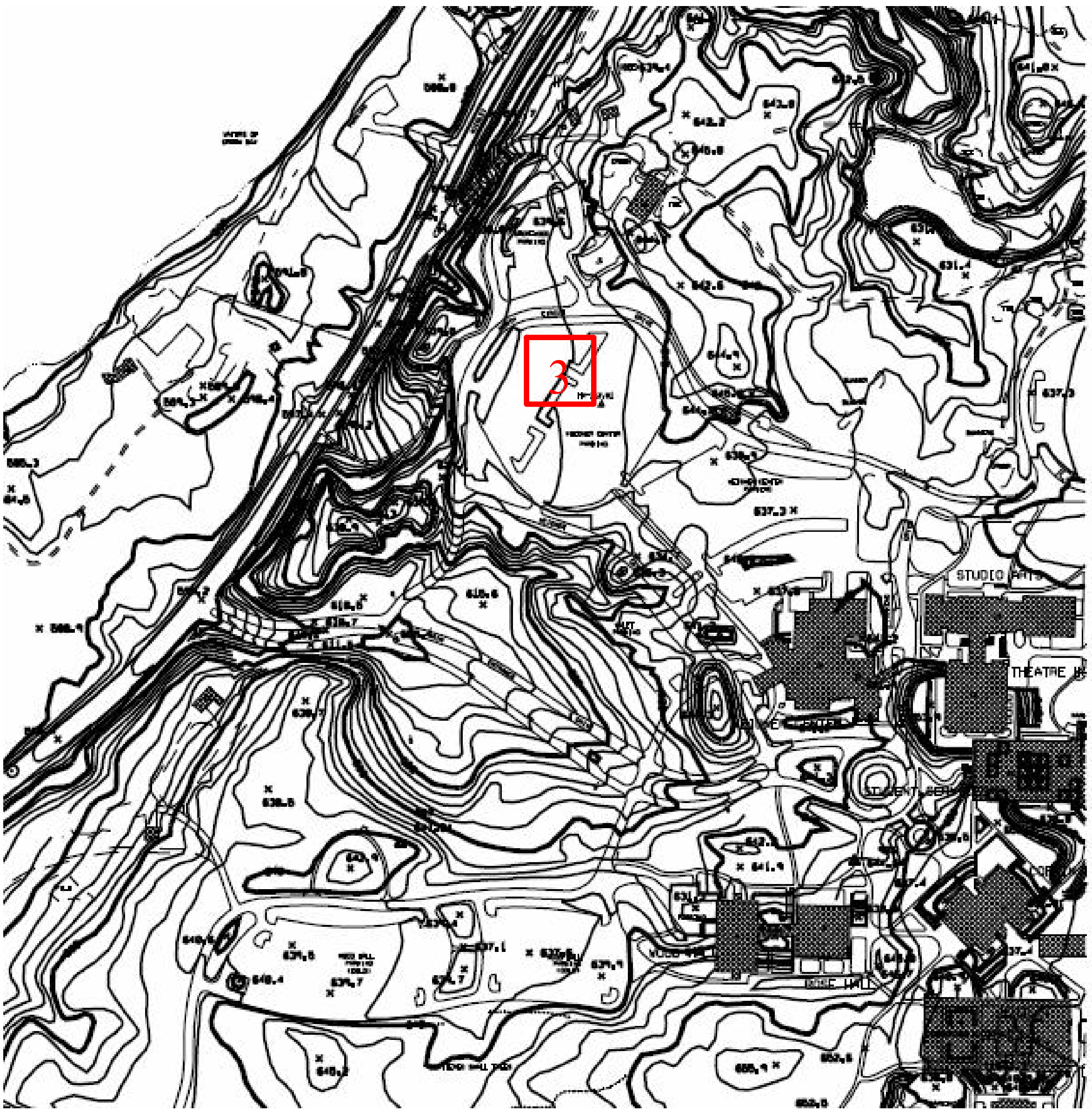

West


Northwest


North


Northeast

East **Southeast**



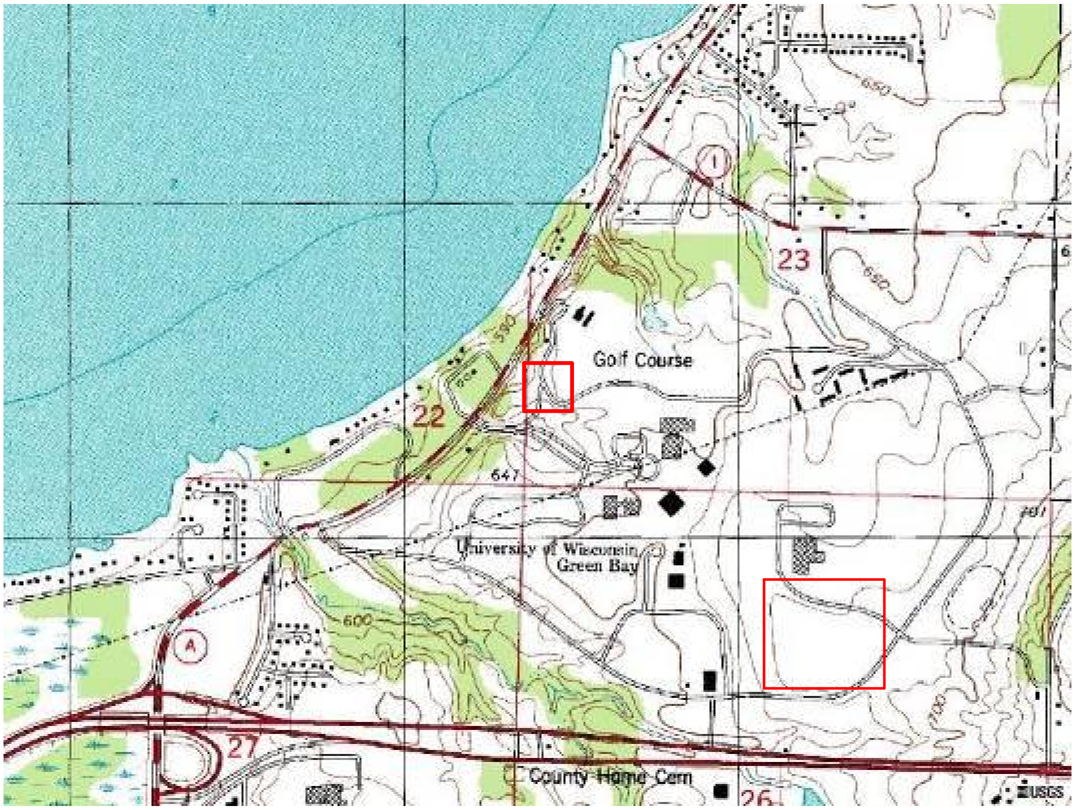
Close up topos for Site 3 (gradations of 2')

Aerial Photos of UWGB Campus

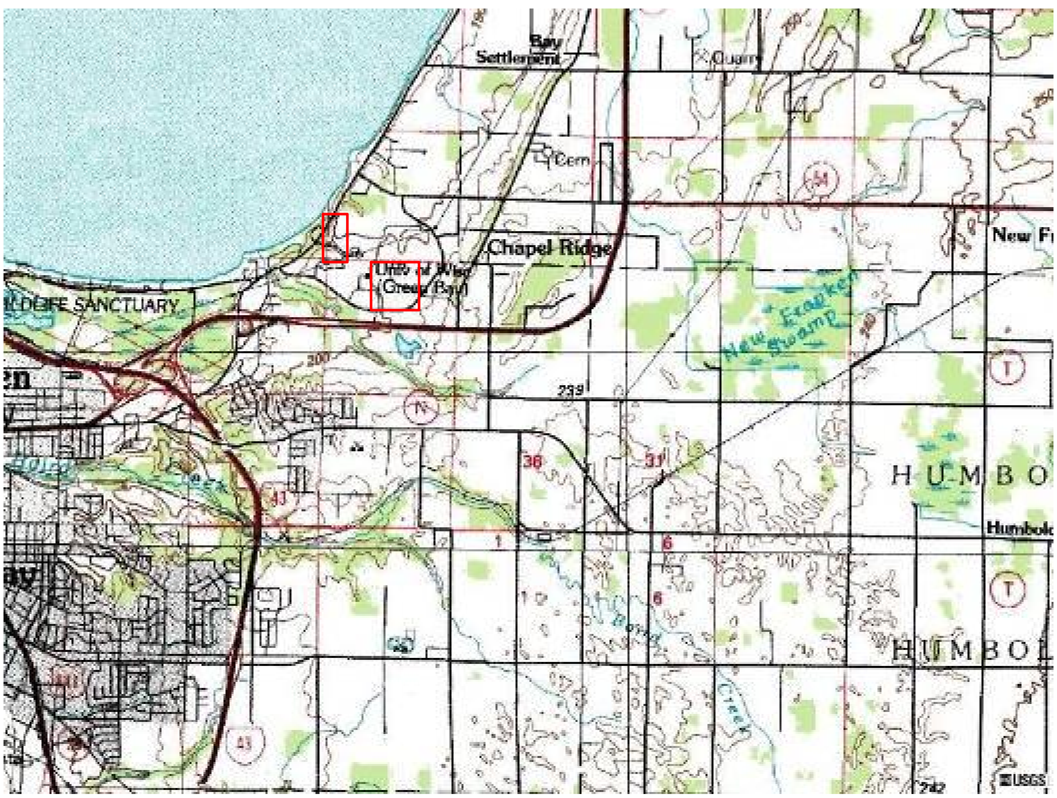
Scale 1" = 400 yds   Potential sites marked with stars.

1" = .8 miles

Topographical Maps of Site



1" = .3 mi 1980



1" = 1.3 mi 1980

C. Recommended minimum tower height based on site:

The general rule for determining tower heights is to position the lowest point of the turbine rotor at least 30' above the highest obstruction within 500 feet (trees, buildings, etc…) or the prevailing tree line. This is to ensure that the turbine is clear of any turbulence which, as discussed above, affects wind generator output and possibly the life of the system. In the case of sites 1 and 2 above, which are essentially the same, just 400 yards apart, we would look mainly at the obstructions in the prevailing wind directions of West and South. As you can see from the 360 photos of site one, the main obstructions in these directions are the trees. All these trees are hardwoods and, based on the other trees on campus, will grow to be about 75' at their mature height. Therefore, we must use this future tree height of 75' as the tallest obstruction in the prevailing wind directions. Note that this is 20' taller than the expected height of 55' for the future building planned in this area. To compute the minimum tower height acceptable with these conditions we add the 30 foot rule of thumb for clearing turbulence to the 75' tree height and the blade length of the turbine rotor (assuming a Vestas V15-35 for now; more on turbines later) to get:

Minimum Tower Height = 75' (highest obstacle) + 30' (rule of thumb) + 25' (blade length)
= 130ft

Towers are usually available in 20 foot sections so the minimum tower heights calculated above would be rounded up accordingly to 140 feet. The taller the tower is, the higher the wind speed, the less turbulence, and the higher the energy output for any given turbine, so going to an even higher tower should also be considered.

Site #3 above also has the hardwood trees as the highest obstruction and so the minimum tower height for this site would also be 140'.

D. Wind resource estimate:

How well the wind turbine performs is based on the speed and the frequency of the wind intercepted by the turbine; a continuous high-speed wind being the best condition. Knowing the average annual wind speed at a specific site will enable us to determine how various turbines will perform at this site.

The wind speed at the UWGB site in Green Bay, taken from the wind speed estimates on the Wisconsin wind map, is 14.1 mph at 60 meters (197 ft). However, this wind map is not the only determining factor since it has limited accuracy. Based on other wind site assessments done in the Green Bay area, combined with the fact that the UWGB campus is just northeast of and below the Niagra Escarpment and just east of the city of Green Bay both of which will slow down the wind, the estimated wind speed at UWGB must be adjusted downwards. Instead of the 14.1 mph, this report will use 12.7 mph.

Wind speed increases with increasing height above ground, so we must do some calculations to extrapolate this wind speed of 12.7 mph taken at 197', down to our 140' tower height.

We use the following equation (ref. *The Wind Power Book* by Jack Park):

$V = (H/H_0)^{\alpha} V_0$ where:

V = the wind speed at the desired height (the tower height)
Vo = 12.7 mph - the wind speed at the original height (from the map and adjusted downward)
H = 140' - the tower height/ turbine hub height
Ho = 197' - the original height that the original wind speed was measured
α = the wind shear coefficient

The wind shear coefficient is variable used to adjust for the type of ground clutter at a site. The α used for this site will be set at 0.28 ("Mostly wooded country/or small towns and suburbs"). Using the above equation we get:

V = Wind Speed at Hub Height = 11.5 mph average annual wind speed at 140 ft.

This is the wind speed that will be used to calculate the average annual energy output of some potential wind turbine choices (assuming tower is 140ft).

E. Turbine possibilities:

UWGB is just beginning to research their options when it comes to wind, so below is a range of turbine options including the energy outputs and installed costs. These turbines are representative of the range of sizes available from a residential size turbine (Bergey XL-S 10KW), a small business-size turbine (Vestas V-15-35kW and V17-90KW), up to a small commercial size (Vestas V47-90KW which is the same type of turbines as the ones that can be seen at the WPS wind farm in Kewaunee County and off Hwy 41 in Byron, WI). These specific turbine choices are used to give UWGB an idea of what each of these sized turbines can do and for what cost. The final turbine selection would be dependent on turbine availability and potential cost increases, which is information that an installer would have.

The Bergey turbine is a reliable residential size machine that could be used as a learning tool for the university, at the same time generating some electricity for a location like the Shorewood Center. Also, this turbine can take advantage of "net metering". This means that when the turbine is generating more electricity than the building needs at that moment, the electrical meter at the building simply runs backward, thus the utility is "paying" you retail rates for the power. In Wisconsin, net metering is limited to a maximum of 20kW rated power for renewable energy sources connected to the grid.

The Vestas V15-35 is a significantly larger turbine, with twice the blade length of the Bergey, a gear box, and more complicated electronics. These turbines were first installed in the California wind farms in the 1980's and have been completely remanufactured by Energy Maintenance Service (EMS) in South Dakota, making them a good value. They are currently the most popular turbine choice for small businesses and technical colleges.

The Vestas V-17 is slightly bigger in size than the V-15 and produces about double the power. Reconditioned versions of the machine may be available from suppliers, such as Halus Power Systems of San Jose, CA. There are none of these installed in Wisconsin as of today.

The Vestas V47-660 is the size of turbine that wind farms were using about 6+ years ago. They are very large turbines on very tall towers (80 meters) and they produce significantly more power than the 3 turbines above.

All 3 of the **Vestas** turbines are over the Wisconsin 20KW limit for net-metering, so any excess electricity would be sold to the utility at a "buy back rate", which for WPS is currently 4.3 cents/kwh.

As the turbines blades get longer, the towers must get taller according to the equation for minimum tower heights used previously. Because the tower is taller, the hub of the turbine is higher in the air, and the wind speed increases proportionately to this hub height. These taller tower heights and the increased wind speeds are shown in the table below. These are the figures that will be used to make the energy output calculations for these turbines.

Turbine	Rated Output	Rotor Diameter (m/ft)	Tower Height	Wind Speed at Hub Height
Bergey XL-S 10kW	10 KW	7m (22')	140'	11.5 mph
EMS Vestas V15-35	35 kW	15m (50')	140'	11.5 mph
Vestas V17 – 90	90 kW	17m (56.6')	160'	11.8 mph
Vestas V47 – 660	660 kW	47m (156.6')	80m (265')	13.8 mph

F. Energy Outputs

The estimated outputs in the table below were calculated by using a "Wind Turbine Estimated Energy Output Calculator", which is an Excel spreadsheet developed by Seventh Generation Energy Systems, Inc., and provided to wind site assessors by Focus on Energy. This program takes into account factors such as: the elevation of the site, the air density, the wind speed(from the table above), the probability of the distribution of wind speeds the site is likely to get, rotor swept area, the tower height(also from the table), and the manufacturers' power curve for the turbine. The energy output calculated is also de-rated by 20% to account for turbulence and other losses.

The estimated monthly and annual energy outputs that could be expected:

Turbine	Est. Monthly Energy Output (kWh)	Est. Annual Energy Output (kWh)
Bergey XL-S 10kw	900 kwh/mo	10,900 kwh/yr
EMS Vestas V15-35kw	4,600 kwh/mo	55,500 kwh/yr
EMS Vestas V17-90kw	8,000 kwh/mo	95,000 kwh/yr
EMS Vestas V47-660kw	93,000 kwh/mo	1,100,000 kwh/yr

The wind speeds and turbine output values presented here should be taken as rough estimates, and should in no way be interpreted as a guarantee of the average wind speed or the average output of a particular wind turbine at your site.

G. System Cost

The estimated installed system costs are listed below, assuming no grant money or incentives.

Turbine	Installed Cost of System	FOE Reward Factor	Cash Back Reward or Implementation Grant	Total Installed Cost
Bergey XL-S 10 KW on a 140' freestanding tower	$64,000	NA	NA	$64,000
EMS Vestas 15-35kw on a 140' freestanding tower	$115,000	NA	NA	$115,000
Vestas V17-90 on a 160' free standing tower	$125,000	NA	NA	$125,000
Vestas V47 – 660kW on an 80meter monopole	$900,000	NA	NA	$900,000

Note that these costs, based on costs at the end of 2004, are estimates only; an installer will be able to give actual installation costs. A list of full-service installers is provided with this report.

H. Economics

Because UWGB is a state institution, it is not eligible for Focus on Energy grants or loans. Also, the federal production tax credit is not applicable. So the following cost analysis assumes UWGB is paying for the entire system.

The following table assumes that the Bergey turbine would be grid connected to the Shorewood Center and be net metered at the current rate of 9.2 cents/kwh.

Turbine	Installed Cost of System	Est. Annual Energy Output (kWh)	Saved Energy Cost/year	Simple Payback
Bergey XL-S 10 KW on a 140' freestanding tower	$64,000	10,900 kwh/yr	$1000 assuming at Shorewood $.092/kwh net metering	64 yrs

While economic payback of this turbine, at these wind speeds does not appear to warrant consideration, the university might consider the marquee value of such a turbine displaying UWGBs concern for the environment is a significant factor. McAllister College in St. Paul installed a Bergey XL-S funded completely by the senior class as their gift to the college.

In the following cost analysis the first 2 columns assume that the Vestas V15-35 is grid tied at the Shorewood Center, but is not net-metered (since it is over the 20 KW limit). The line showing **Wind Percent of Facility Energy Use** is thus the percentage of use only of the Shorewood facility. The **Energy Bill Savings** calculation is based on a savings of 9.2 cents/kwh that the Shorewood facility is charged by the utility, and that any excess power is bought by WPS for 4.3 cents/kwh (the current average buy-back rate). This is really a best case scenario since the winds will not always blowing when the center needs power. The third column shows the payback when selling 50% of the power back to the utility at the 4.3 cents/kwh and using 50% at the site offsetting 9.2cents/kwh. Also note that the Shorewood center has no Demand billing charges.

The first column uses the downwardly adjusted wind speed and the second column uses the wind speed based on the wind map alone. It can be seen how important the wind speed is in determining the economic feasibility of installing a turbine; a 1.3 mph increase in the wind speed changes the payback time by 5 years! The last column showing if 50% of the power is sold back to the utility, clearly demonstrates that it pays to use all the power generated by the turbine at the site and not sell any back to the utility at the lower buy-back rate. (turbine is not net-metered).

	Vestas V15-35 12.7mph wind speed at 197' Using all power	**Vestas V15-35 14.1 mph wind speed at 197' Using all power**	**Vestas V15-35 Wind Speed 12.7mph Selling 50% Power**
Capacity (kW)	35	35	35
Voltage	240	240	240
Phase	1	1	1
Rotor Diameter (m)	15	15	15
Tower Type	Freestanding Lattice	Freestanding Lattice	Freestanding Lattice
Tower Height (m/ft)	43/140	43/140	43/140
Total Structure Height (ft)	165	165	165
Wind Speed at Hub Height (mph)	**11.5**	**12.8**	**11.5**
Average Output Power (kW)	5.6	8.0	5.6
Annual Energy Output (kWh)	55,500	70,500	55,500
Monthly Energy Output (KWh)	4,600	5,900	4,600
Wind Percent of Facility Energy Use	**106%**	**135%**	**213%**
Estimated Capacity Factor	18%	23%	18%
Installed Capital Cost ($)	$115,000	$115,000	$115,000
Installed Cost ($/kW) based on rated KW	$3,286	$3,286	$3,286
Annual Carrying Charge ($/yr) – over 10yrs	$11,500	$11,500	$11,500
Production Cost - ($/kWh) over 10 yrs	$0.21	$0.16	$0.21
O&M - $ per turbine per year (1% of installed cost)	$1,150	$1,150	$1,150
Total Cost of Energy ($/kWh) incl. OM	**$0.23**	**$0.18**	**$0.23**
FOE Rebate Level	$0.00	$0.00	$0.00
Max FOE Rebate	$0	$0	$0
Net Cost After Rebate	$115,000	$115,000	$115,000
Revenue from Excess Power Sales	$141	$785	$1,264
Energy Cost Saved by Generation	$4,807	$4,807	$2,404
Annual Savings – (energy cost savings + revenue) – O&M	$3,798	$4,442	$2,518
Simple Payback (yrs) – Cost of System/Annual Savings	30.3	25.9	45.7

The two larger Vestas turbines (V17-90 and V47-660) are assumed to be part of the main plants' generation and their energy percentage is that of the total electrical usage of UWGB; the 18,000,000 kwh/year. The energy savings is computed at a rate of 3.5 cents/kwh which is a weighted average of the on-peak and off-peak energy of use billing: 44% off-peak (.0224 cents/kwh) and 56% on peak (.04554 cents/kwh) = 3.5 cents/kwh (this is a generalization based on the one bill I have for 06/05).

The **revenue from excess power sales** is based on the 4.3 cents avoided cost that WPS would pay for any excess generation. The demand charges would still remain, since it can't be assumed that the wind would be blowing when the peak demand occurs. Unfortunately, this type of billing with demand charges (which make up more than 1/3rd of the electrical bill) make it impossible for any intermittent resource (wind or solar) to eliminate this huge cost burden. If the utility simply charged for energy use at a higher rate, renewable energy systems would be much more economically appealing. This can be seen in the second column for each turbine where the electricity rate is set at 5.8 cents/kwh. The utility computed this as the average cost/kwh on the bill for June of 2005 when combining the energy-use and demand charges and dividing by total kwh used.

	Vestas V17-90 using energy rate 3.5 cents/kwh and existing demand charges	**Vestas V17-90 using energy rate 5.8 cents/kwh without demand charges**
Capacity (kW)	90	90
Voltage	480	480
Phase	3	3
Rotor Diameter (m)	17	17
Tower Type	Freestanding Lattice	Freestanding Lattice
Tower Height (m/ft)	48/160	40/160
Total Structure Height (ft)	188	188
Wind Speed at Hub Height (mph)	11.8	**11.8**
Average Output Power (kW)	11	11
Annual Energy Output (kWh)	95,200	95,200
Monthly Energy Output (KWh)	7,900	7,900
Wind Percent of Facility Energy Use	**1%**	**0%**
Estimated Capacity Factor	12%	12%
Installed Capital Cost ($)	$125,000	$125,000
Installed Cost ($/kW) based on rated KW	$1,389	$1,389
Annual Carrying Charge ($/yr) – over 10yrs	$12,500	$12,500
Production Cost - ($/kWh) over 10 yrs	$0.13	$0.13
O&M - $ per turbine per year (1% of installed cost)	$1,250	$1,250
Total Cost of Energy ($/kWh) incl. OM	**$0.14**	**$0.14**
FOE Rebate Level	$0.00	$0.00
Max FOE Rebate	$0	$0
Net Cost After Rebate	$125,000	$125,000
Revenue from Excess Power Sales	$0	$0
Energy Bill Savings	$3,333	$5,523
Annual Savings – (energy bill savings + revenue) – O&M	$2,083	$4,273
Simple Payback (yrs) – Cost of System/Annual Savings	60.0	29.3

	Vestas V47-660 using 3.5 cents/kwh and existing demand charges	Vestas V47-660 using energy use rate 5.8 cents/kwh without demand charges
Capacity (kW)	660	660
Voltage		
Phase		
Rotor Diameter (m)	47	47
Tower Type	Monopole	Monopole
Tower Height (m/ft)	80/265	80
Total Structure Height (ft)	339	339
Wind Speed at Hub Height (mph)	**13.8**	**13.8**
Average Output Power (kW)	128	128
Annual Energy Output (kWh)	1,118,029	1,118,029
Monthly Energy Output (KWh)	93,169	93,169
Wind Percent of Facility Energy Use	**6%**	**6%**
Estimated Capacity Factor	19%	19%
Installed Capital Cost ($)	$900,000	$900,000
Installed Cost ($/kW) based on rated KW	$1,364	$1,364
Annual Carrying Charge ($/yr) – over 10yrs	$90,000	$90,000
Production Cost - ($/kWh) over 10 yrs	$0.08	$0.08
O&M - $ per turbine per year (1% of installed cost)	$9,000	$9,000
Total Cost of Energy ($/kWh) incl. OM	**$0.09**	**$0.09**
FOE Rebate Level	$0.00	$0.00
Max FOE Rebate	$0	$0
Net Cost After Rebate	$900,000	$900,000
Revenue from Excess Power Sales	$0	$0
Energy Bill Savings	$39,131	$64,846
Annual Savings – (energy bill savings + revenue) – O&M	$33,131	$55,846
Simple Payback (yrs) – Cost of System/Annual Savings	28.4	16.1

Simple payback includes an annual maintenance cost equal to 1% of the installed wind system cost, but excludes cost of capital, inflation, and utility rate increases.

From the outcome of columns 1 and 2 for the V15-35 it can be seen how crucial wind speed is to the turbine output and to the economic payback. The only way to know the wind speed for certain is to put up a metering tower at the site and monitor it for a year or more. If a large capital outlay is being considered, metering is well worth the delay and the cost of metering (around $8000)

From the tables for the V17 and V47 one sees that another crucial ingredient is the rate in $/kwh charged for the energy that is now being replaced by the turbine generation. Just increasing the rate from 3.5 cent/kwh to 5.8 cents/kwh decreases payback time by 12 years! If there is excess generation by the turbine, the buy-back rate also has a big impact on payback time.

One can see the advantages as turbine size increases for customers billed with demand charges.

Turbines

Bergey XL-S

Vestas V15-35 (V17-90 is very similar 3' longer blades)

Vestas V47-660 Byron

8. Follow Up

A. Energy efficiency is always a cheaper option than installing more capacity. The UWGB has been working on energy efficiency for some time, and will continue to do so. If there has not been a professional energy audit of the school buildings and the housing units, I would highly recommend it. Issues such as heating an entire floor of a building when one teacher wants to come in and work on a Saturday may have solutions.

B. If UWGB would like to continue to research the possibilities of wind energy on a large scale, based on the shorter payback, the best option would be to set up a metering tower for one or more years at one of the suggested sites to make sure the wind resource is worthy of such an investment. The cost of setting up and monitoring one of these towers for 1 year is in the ballpark of $8,000 - $10,000. Some of the Full Service Wind Installers listed at the end of this report can provide this service. These same installers can help with zoning issues, and give the latest information on costs and availability of turbines. Mick Sagrillo can also be used as a resource on any other wind issues.

C. Consult with all the concerned parties at the university to determine if the project makes financial sense at the current rates, or if it may make sense down the road when electrical rates increase by 30%? 50%? Buy-back rates will also continue to increase making the project more cost effective. Is it possible to negotiate with the utility to get around the demand charges and pay a higher energy-use charge? This would have a major effect on the feasibility of renewable energy projects.

D. Talk to WPS and find out if the buy back rates for excess generation can be higher than the 4.3 cents/kwh used in this report. Dennis Derricks is the renewable energy contact at WPS. He can be reached at 920-433-5734. He is also the one to talk to for permitting or grid inter-tie agreements.

E. Go look at some of the suggested turbines to see what effect they would have physically on the campus. A Vestas V15-65 (same size as the V15-35) can be seen at Lakeshore Tech in Cleveland, WI.. And the Vestas V47-660 can be seen at the WPS wind farm in Kewaunee County as well as along Hwy 41 in Byron WI..

F. Check with county and local building and zoning offices to make sure that there are no local ordinances or other problems with installing a wind turbine and tower, and find out the permitting process (installer will advise on this). The university should also begin to inform the neighbors that may be affected by the turbine, to educate them on wind systems in general, and to meet with the local zoning authorities. This will help to avoid problems keep the door open for continued communication with local authorities to identify and address any building permit or zoning issues. You can also contact Mick Sagrillo for help with zoning issues msagrillo@itol.com .

G. Look for financial grants to help offset some of the cost of this project. Is the senior class interested in a gift of a Bergey turbine to the university?

H. One of the main reasons for having a wind site assessment was the interest of the students in having a more sustainable campus. Among ideas I heard discussed during my visit were 1) limiting on campus driving; e.g. unnecessary driving from class to class when already on campus. This would also reduce the need for more parking areas; 2) Local produce in the cafeteria. 3) Encouraging students to use Compact Florescent Lights (CFLs) in their dorm rooms. This can reduce lighting costs by 75%. These are ideas to be encouraged among the staff and students.

I. The University may want to consider more solar hot water panels which have a more favorable payback, perhaps for the housing units. Solar PV panels would have similar payback times to those for wind, unless the university can take advantage of some of the new federal incentives.

9. Educational Resources

- Focus on Energy web site (www.focusonenergy.org) great for lots of information on Renewable Energy.
- Home Power Magazine/Website (www.homepower.com) – Case studies and stories of renewable energy installations around the country.
- Midwest Renewable Energy Association (www.the-mrea.org) – Hands-on workshops in Wind, PV, Solar Hot water, and more.
- American Wind Energy Association www.awea.com
- Turbine manufacturer's web sites: Performance ratings, turbine and tower prices, informative articles.
  www.Bergey.com for Bergey XL-S
  www.Energyms.com for the EMS Vestas V15
  www.halus.com for Vestas V15s and Vestas V17's

10. Materials Included in Site Assessment Report:

1. Aerial Photos of Property for wind site.
2. Digital pictures in all compass directions for proposed sites.
3. Topographical Maps of the Surrounding Area.
4. Wind Rose graphs from nearest monitored site(s)
5. Photos of types of turbines.
6. Websites for more information including for Focus on Energy.
7. Turbine outputs and costs.
8. Basic economic analysis.

11. Materials Enclosed with Site Assessment Report:

1. Wisconsin Wind Map
2. Table of small wind system installation costs
3. Full service wind installer list
4. Electrical load history.