

Wind Power for Williams College: A Feasibility Study



Figure 1. Wind turbines at the Searsburg, VT wind farm.

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Executive Summary

This report addresses the feasibility of developing a wind project on land owned by Williams College. It examines a range of various issues related to such a project. The idea for a wind farm on College property dates to the late 1970s when Reed Zars '77 first proposed putting wind turbines on the Berlin Pass. While Reed Zars' proposal and future studies focused on Berlin Pass, this report also examines the possibility of using land in Hopkins Memorial Forest (HMF). Further research during the course of this project leads to the conclusion that Berlin Pass is a better site for wind turbines than HMF (Figure E1). Berlin Pass is closer to usable roads, closer to utility grid interconnection, and does not have the land use issues of HMF. In addition, a project on Berlin Pass will allow all the wind turbines to be placed in the same state which would not necessarily be the case with a multi-turbine project in HMF.

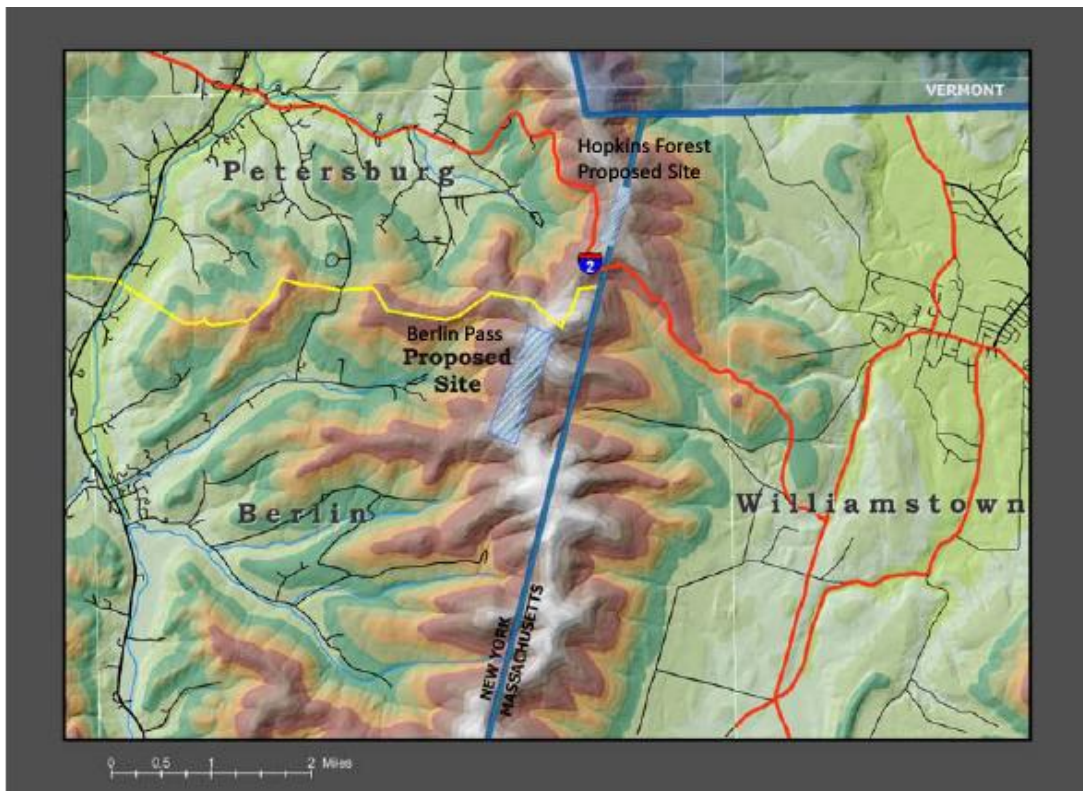


Figure E1. Locations of the two potential sites on property owned by the College.

The environmental impact of a project on Berlin Pass is expected to be minimal. Less than two acres of Berlin Pass will be directly impacted by construction activities. No wildlife migratory corridors will be impacted and there will be minimal disruption of wetlands. Noise produced by the turbines will not be above background noise levels for the vast majority of nearby residents. Based on similar projects' experiences, avian deaths are expected to be extremely limited. Finally, the Taconic Crest hiking trail will need to be slightly rerouted to avoid any potential ice throw injury liability.

Analysis of wind data from the Taconic Crest demonstrates very favorable wind conditions. The average wind speeds at 30, 40, and 50 meters are 4.98 m/s, 5.92 m/s, and 7.13

m/s respectively based on four and a half years of data collected in ten minute increments. Estimated wind speeds at 80 and 100 meters are 7.83 m/s and 8.16 m/s respectively. The average wind direction is 284.5 degrees (west-northwest). Estimated annual power production per turbine ranges from approximately 6 to 10 GWh depending on the brand, capacity, and size of the wind turbine. Based on an annual desired total production of 17 to 22 GWh to meet the College's entire electricity draw from the electrical grid, approximately three wind turbines would be needed. The estimated total cost for a three turbine project of Vestas 1.8 MW turbines is approximately \$17,000,000. Depending on various factors such as incentives, ownership structure, and cost of electricity, payback on a three turbine project could be in the five to ten year range with an internal rate of return of approximately 15% and a net present value of about \$6.9 million.

The next step for this project is finding a professional developer to do a more complete feasibility study. That study should address interconnection standards, road construction to Berlin Pass, full economic and environmental impact analysis, and other engineering challenges. Once that study is completed and the College decides to move forward with the project, permitting in Berlin and Williamstown could be pursued.

Introduction

In 2007, Williams College adopted a goal to reduce greenhouse gas emissions by 10% below the College's 1990-1991 levels by 2020.¹ Some of this reduction can be achieved by conservation efforts and efficiency improvements already underway. However, to fully achieve this goal will require the use of some sort of renewable, clean energy source. While there are many options for clean energy, wind energy stands out as a logical choice given the ample wind present on the mountaintops surrounding Williamstown. In light of the clean nature of wind energy, this report explores the possibility of using large scale wind turbines on Williams College property to reduce the College's dependency on fossil fuels by providing enough electricity to offset the College's annual electricity consumption from the grid.

Based on class work I did for my Renewable Energy and Sustainable Campus Geosciences class, I determined that constructing a wind turbine on campus is not practical given the prevailing wind conditions in the Purple Valley. Even small scale wind turbines constructed on campus buildings will not produce much more than 7,000 kWh per turbine per year in the best case scenarios. The average yearly wind speed of 3.2 m/s at 15 meters above the Science Center roofline is simply too low to support significant levels of electricity production.² Approximately 3,150 building mounted small turbines would be needed to supply the 22,000,000 kWh of electricity purchased each year.³ As such, in this report I explore other College owned property that could host large wind turbines capable of producing in the multi-megawatt range.

Harvesting wind energy is not a new idea at Williams College. Reed Zars '77 first proposed the idea of putting wind turbines on the Berlin Pass in the fall of 1976. His initial vision evolved through a thesis completed by Thomas Black '81. Black eventually arranged for the installation of a 100 foot (approximately 30 meters) tower with anemometers on Berlin Pass to conduct a fifteen month feasibility study. Based on the data collected from this tower, Black concluded that the Berlin Pass location was a good candidate for wind energy, with an estimated twenty year payback based on the wind turbines of the era. However, no action was taken by the school based on his recommendations.

The cost of installing and operating wind turbines has dropped considerably since Black's time. As a result, a group of students led by Nick Hiza '02 reopened the investigation into wind power for the College. Over the course of a year and a half, this group of students focused on evaluating Berlin Pass as the site for several large scale wind turbines that could provide a significant portion of the College's power. Pro forma financial analysis suggested payback in the four to eight year range for a multi-unit wind farm.

Despite the attractive economics outlined by Hiza's group, again no further significant action was taken toward developing the site. Hiza's proposal was also met with some opposition from the residents of Berlin, NY. The town of Berlin contains the land on which Hiza suggested the College construct several wind turbines. When Hiza proposed installing a meteorological tower on the Berlin Pass site, the town of Berlin called for a full environmental impact analysis evaluating the impact as if the College were installing a wind farm rather than a simple 50 meter measuring tower.⁴

¹ Schapiro, Morton. *Letters from the President and Trustees*. Presented 24 January 2007.

² Augenbraun, JJ. *Small Scale Wind Turbines at Williams College*. Final report for Geosciences 206. 19 May 2009.

³ *Energy Use*. http://www.williams.edu/resources/sustainability/energy_use.php.

⁴ Information on the history of student work exploring wind energy at Berlin Pass gathered from Hiza et al (May 2003). *The Berlin Wind Project: An Interim Report on Project Feasibility and Potential Environmental Impact*, p. 58-63.

In the year following Hiza's report, the College installed a 50 meter meteorological tower in Hopkins Memorial Forest. The location (42.72824 N, 73.27106 W at an elevation of 716 meters)⁵ of the tower provides a good proxy for the wind conditions of many sites along the Taconic Crest including Berlin Pass (Figures 2 and 3). This tower has been taking wind speed measurements at heights of 30, 40, and 50 meters since October 2004 in ten minute increments. With the exception of some icing events, the tower has been reliably recording data with an approximately 90% collection rate.⁶

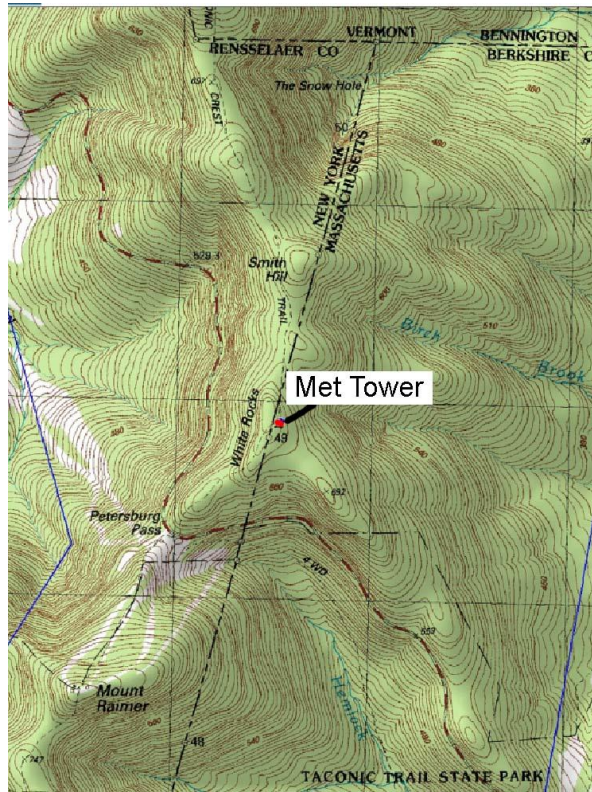


Figure 2. Location of meteorological tower in Hopkins Memorial Forest.



Figure 3. The 50 meter meteorological tower.

Since power produced from the wind is a cubic function of wind speed, using as small measurement increments as possible is important to accurately calculate the power production of a wind turbine.⁷ In Hiza's case they did not have access to the four and half years of detailed wind data now available. This current report will provide a more detailed analysis of the wind energy available based on this data and on the power curves of the latest wind turbines from Vestas and GE. This report will also examine the various issues associated with developing a wind farm as well as discussing the ideal location for such a turbine on property owned by the College.

⁵ Location provided through personal communication with Jay Racela, Technical Assistant for the Center for Environmental Studies.

⁶ Of the 243,706 wind speed readings during the measurement period, only 24,573 needed to be corrected.

⁷ For more information on the importance of using small measurement increments see the Danish Wind Industry Association's explanation of the average bottle fallacy: <http://www.windpower.org/en/tour/wres/bottle.htm>

Potential Sites

Overview

Ideal wind sites have several important characteristics. First, for wind turbines to be effective they require consistent high wind speeds. Since wind speeds generally increase with altitude, the higher the proposed site, the better the winds for generating electricity. In addition, a site with few nearby obstructions such as taller surrounding mountains or large buildings is desired. Furthermore, the ideal site should have the potential for road and power line accessibility. Moreover, a site should be chosen that minimizes the engineering challenges associated with constructing roads and power lines to the wind turbine site. A site should also be chosen that will allow for the least wetland, wildlife, and general environmental disruption by construction activities as possible. Finally, permitting requirements should be considered in the selection of a site. Since permitting for a wind turbine currently falls under the responsibility of the affected town, regulations can vary widely from one site to another depending on town location.

Off campus, property owned by the College meeting at least the altitude criteria includes Hopkins Memorial Forest (HMF) and parts of the Berlin Pass area (Figure 4). Both HMF and Berlin Pass have relatively high altitudes (approximately 700 meters for both sites) compared to their surroundings. The College could always consider purchasing additional land at other local sites, but most other sites would have to deal with many of the same issues as HMF and Berlin Pass sites outlined in the following sections.

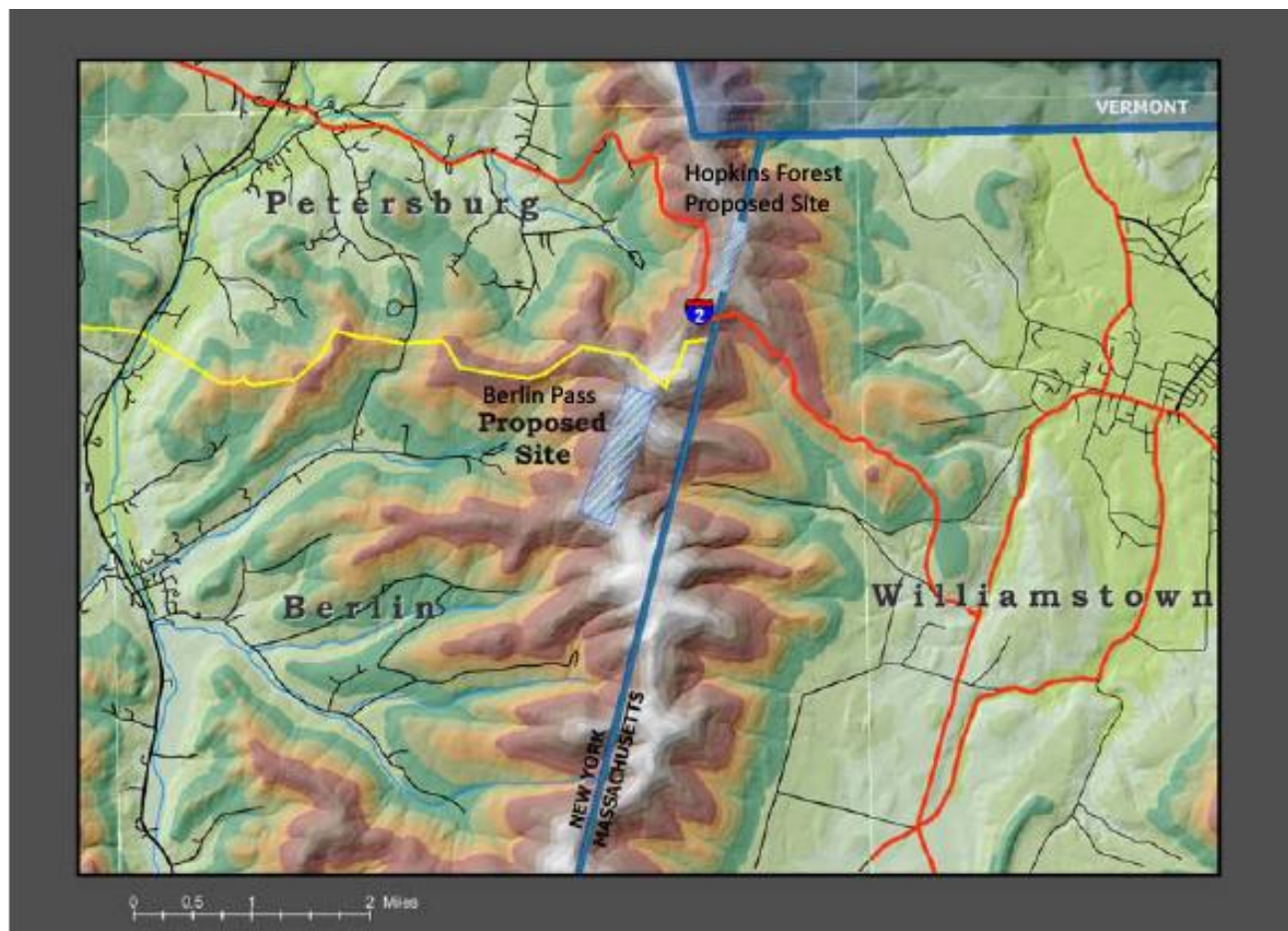


Figure 4. Locations of the two potential sites on property owned by the College.

Property Descriptions

Hopkins Memorial Forest consists of approximately 2,600 acres spread over northwestern Massachusetts and adjoining pieces of Vermont and New York (Figure 5). Most of the land contained in HMF was consolidated between 1887 and 1910 by Colonel Amos Lawrence Hopkins. In 1935, Williams College deeded the land to the United States Forest Service to be used as an experimental research facility. The land was returned to the College in 1968. Since then the College has continued to use the forest for research and educational purposes.⁸

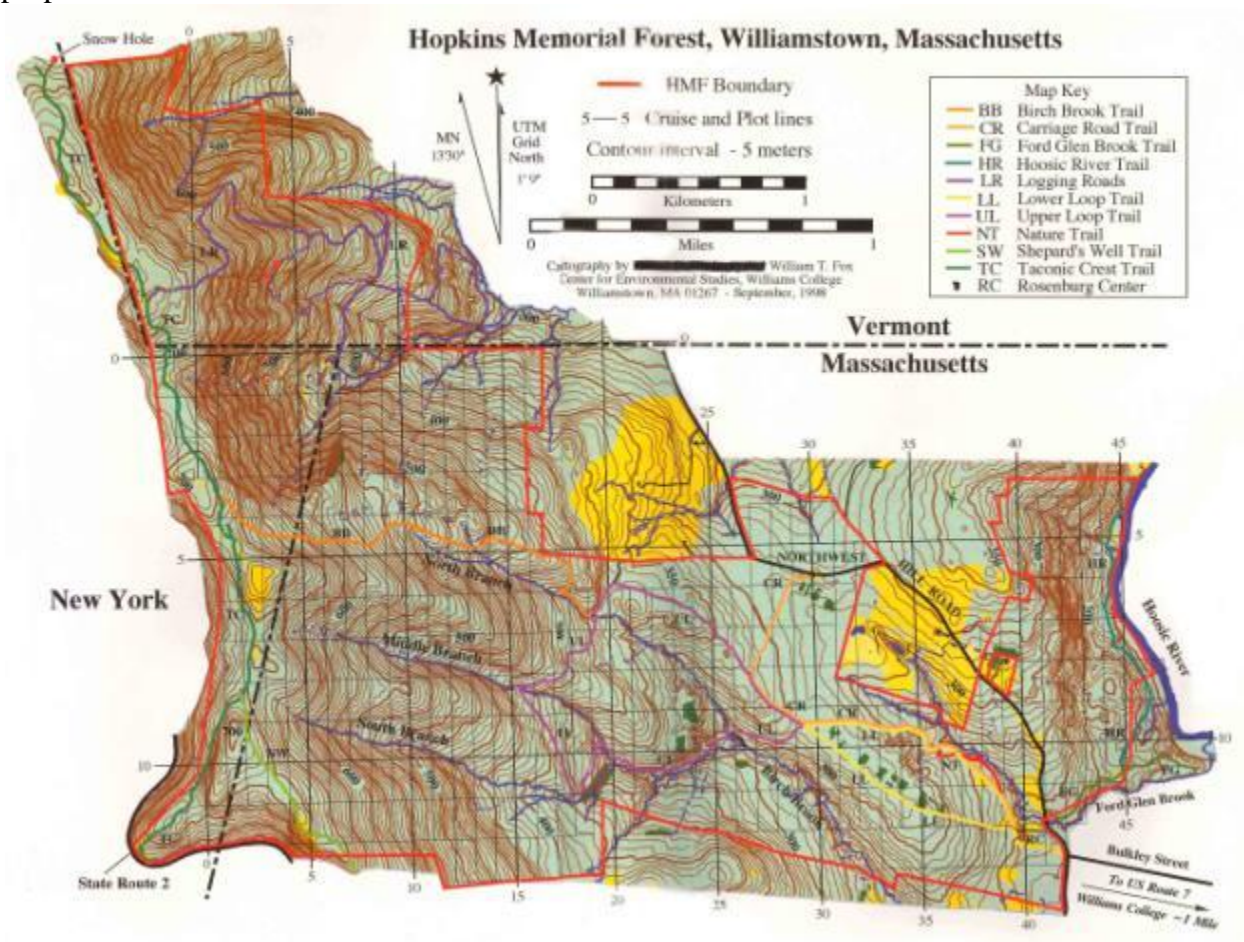


Figure 5. Detailed map of Hopkins Memorial Forest boundaries and hiking trails.

Although the ridge running through the western part of HMF appears to be an attractive site for wind turbines, there are several major drawbacks. First, some turbines would have to be constructed in New York and some in Massachusetts. This would effectively double the number of permits required for the project. In addition, the ridge is narrower than the proposed ridge in Berlin Pass which could potentially limit the number of turbines that could be constructed on the site. Furthermore, the nearest electrical grid interconnection is a minimum of 3,000 meters from the site and unlike with the Berlin Pass site there are not even old jeep access roads to the site.⁹

⁸ Hopkins Memorial Forest: History. <http://www.williams.edu/CES/hopkins/history/historyhome.htm>.

⁹ Personal communication with Professor David Dethier of Williams College Geosciences Department.

The largest problem with the HMF site is an obstacle dating back to 1935 when the U.S. Forest Service took over management of the land: the permanent plot system. The permanent plot system allowed for the inventorying of all major growth in the forest. Since 1935, the plots have been resurveyed several times and detailed records have been kept on the forest. These records form the basis for one of the best long-term databases of “unmanaged” deciduous forests in the world. Since these plots cover approximately 95% of the HMF land, including much of the ridge, installing wind turbines in HMF would be extremely disruptive to research dating back to 1935.¹⁰

The likelihood of getting approval to disrupt these plots is quite slim. The combination of the permanent plot systems and long distances to a usable road and electrical grid interconnection make HMF a very poor site for building wind turbines. As such, I will not further consider HMF as a potential site for wind turbines throughout the rest of this report. Instead, I will focus on the second, and more promising, possibility of Berlin Pass.

The Berlin Pass site consists of approximately 400 acres straddling the Massachusetts-New York state line (Figure 6). Most of the property is in New York, specifically in the town of Berlin. The land on the Massachusetts side is in Williamstown. The part in Williamstown encompasses some of the land the College ski team used for practice during the 1950s and 1960s. The College received most of the land in this parcel in 1972 through alumni gifts. This site has the added benefit of the potential for higher wind speeds due to the funneling effect of the Green Hollow ridgelines that extend to the west into New York (Figure 7).¹¹

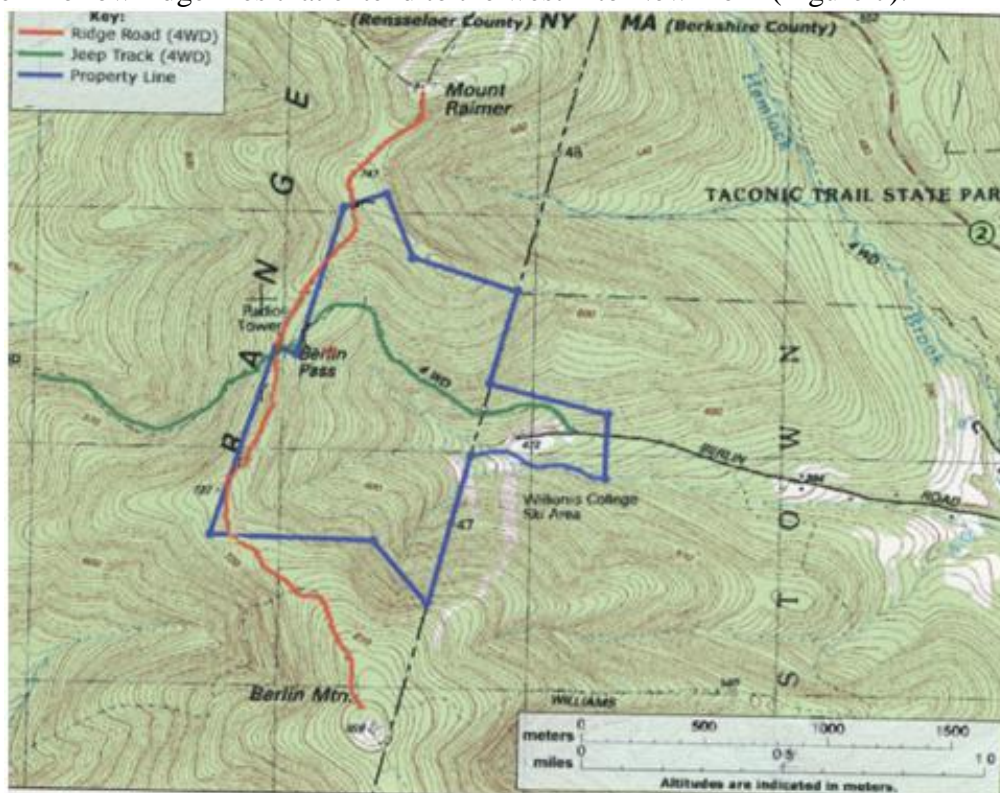


Figure 6. Detailed map of the Berlin Pass site.

¹⁰ HMF Permanent Plot System. <http://oit.williams.edu/hmfplot/methodology.php?which=plotsystem>.

¹¹ Hiza et al. *The Berlin Wind Project*, p. 9-11.

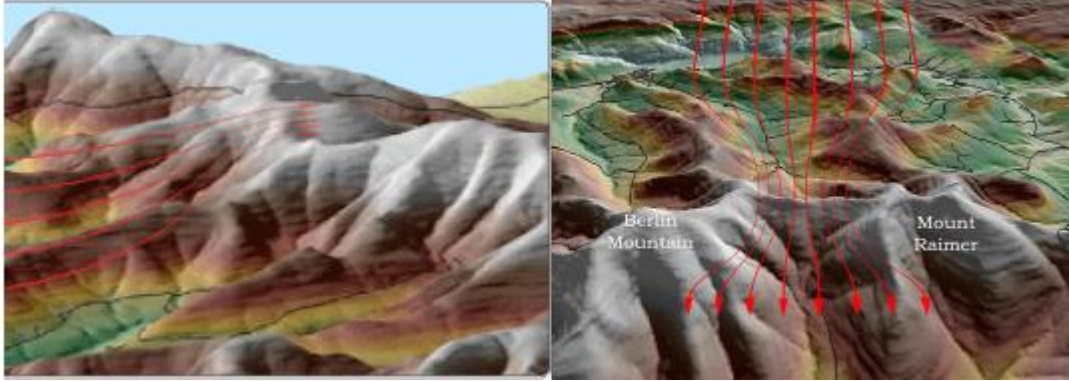


Figure 7. Projected effect of Green Hollow ridgelines on wind patterns.

Berlin Pass contains similar terrain to HMF, but there is more room on the New York side of the border to install wind turbines. In fact, Hiza's group found that there was actually room to install approximately seven wind turbines on the property in Berlin.¹² Therefore, we can eliminate the issue of having to permit turbines in two states. In addition, Berlin Pass has not been the site of ongoing environmental research. Berlin Pass is also not as pristine as HMF due to its history as a ski area and the presence of several jeep/ATV tracks. Overall, a wind project has more potential for success on Berlin Pass than in HMF.

Road Access

Major construction would need to be undertaken to build a road from the nearest existing access road to the proposed site. However, there is already a fairly well maintained and relatively well compacted dirt road (Berlin Road) that runs from Route 2 to the base of the old College Ski Area. This road runs to within 1,400 meters of the proposed site. An unmaintained jeep track runs the remaining distance to the turbine site (blue line in Figure 10). However, this track has fallen into disrepair with numerous washouts and fallen trees (Figures 8 and 9).



Figure 8. Jeep track.



Figure 9. Damage to jeep track.

¹² Hiza et al. *The Berlin Wind Project*, p. 15-16.

According to the Petricca Construction Company, this jeep track could be feasibly repaired to support both maintenance vehicles and transport vehicles for all wind turbine components.¹³ Although this is the most obvious route, there are two other potential paths for roads to the site. The first alternate route involves extending Green Hollow Road in Berlin (red line in Figure 10). This would require constructing a road of at least 2,000 meters in length (or upgrading the existing unmaintained jeep track). However, the College does not own land all the way to the end of the existing Green Hollow Road and would have to obtain land easements in Berlin to construct the road.

The other alternative route would again involve repairing/upgrading another jeep track of approximately 2,000 meters from where Route 2 crosses Petersburg Pass (yellow line in Figure 10). Again, this road would pass through land the College does not own. A further complication comes from the possibility that this road may have to traverse two states, adding to the number of permits required. Overall, the jeep track from the old ski area appears to be the most suitable path to the turbine site. It has the added benefit of being constructed entirely on College property unlike extending Green Hollow Road or the dirt road from Petersburg Pass. Further analysis by an engineer is necessary to determine the best route for such a road.

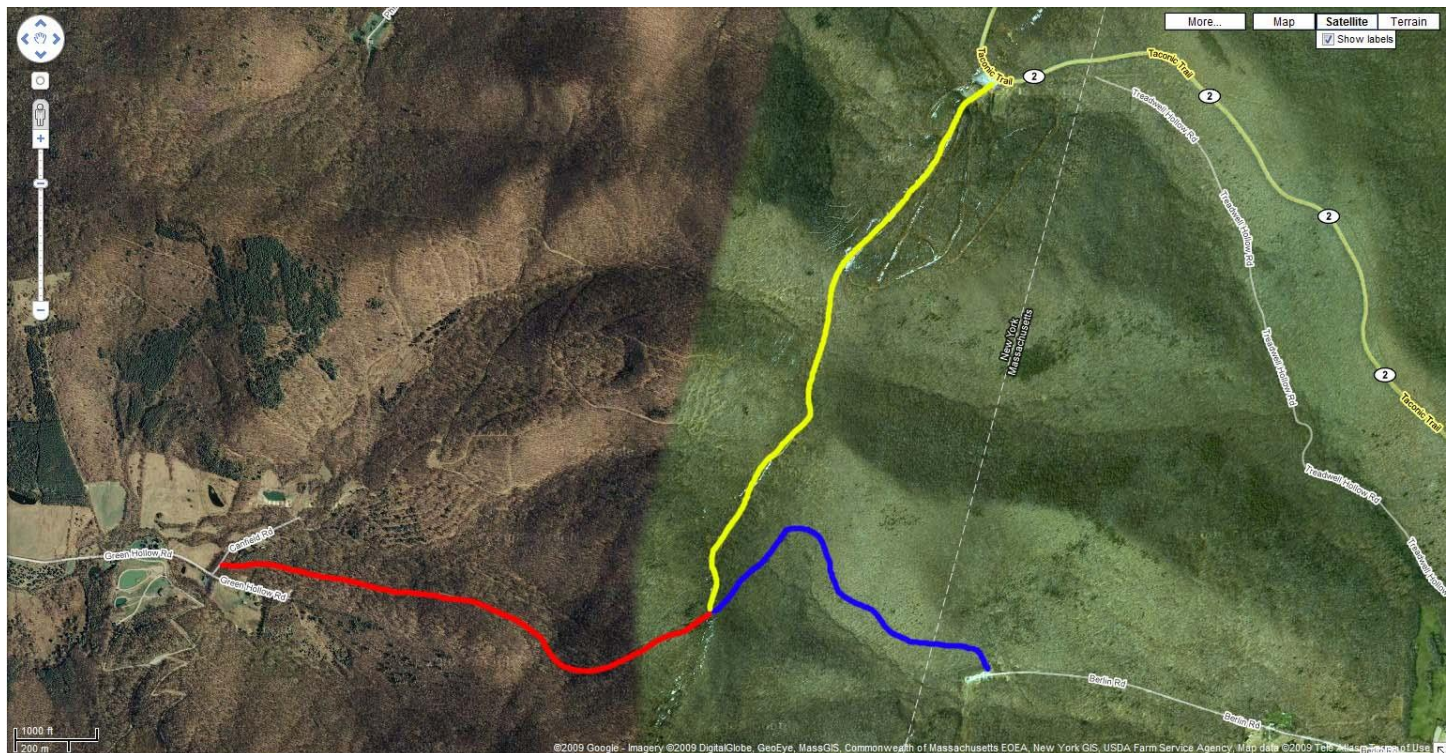


Figure 10. Three potential paths for roads to the proposed site.

¹³ According to a proposal obtained from Petricca Construction Company by Hiza.

Grid Interconnection

A utility grid interconnection is essential for transmitting the power produced by the wind turbines. There are two potential points of interconnection for this project. Power lines could be strung from the site to the termination of power lines on Green Hollow Road. Taking a direct route, these power lines would run for a minimum of 1,600 meters. Only part of these power lines would be on College property. Special easements would have to be obtained from private property owners in Berlin to allow for these power lines. If these power lines were constructed, the turbines would interconnect with New York State Electric and Gas (NYSEG) which operates the electrical grid in Berlin, NY. NYSEG provides detailed interconnection requirements in its Bulletin 86-01: Requirements for Independent Power Producers of Electricity.¹⁴ These requirements specify strict standards for quality of electricity generated and the level of equipment used.

The other possible site for interconnection is with the end of National Grid's power lines on Berlin Road in Williamstown. The power lines on Berlin Road terminate at the last house on that road which is approximately 1,000 meters from the end of Berlin Road. Therefore, power lines from the Massachusetts side of the site would have to run for a minimum of 1,800 meters. While this is longer than for power lines from Berlin, the entire length of the power line could be constructed alongside an existing road or on College property. This would minimize the challenge of constructing power lines on private property. In addition, the power lines in Williamstown have recently been upgraded making them more likely to be able to handle the power produced by the wind turbines.¹⁵ National Grid has similar regulations as NYSEG for interconnection standards.

In either case, Williams College would be responsible for all costs associated with the interconnection study and construction of the power lines. An interconnection study is necessary to determine if the NYSEG or National Grid power lines can support the added load of a wind turbine farm.¹⁶ The study might find that power lines have to be upgraded beyond the initial interconnection point to safely transport the electricity. In addition, it will not be feasible to connect the wind turbines "behind" the meter at the College's heating plant (where grid electricity enters the campus' distribution system). For liability reasons, National Grid will not allow anyone else to string power lines on the company's poles.¹⁷ While connecting "behind" the meter would increase the value of the transmitted electricity by essentially running the electricity meter backwards, the added costs of building an independent transmission system would not make financial sense.

Permitting and Zoning Considerations

There are three main permitting considerations for this project: the turbines, the power lines, and the road. The proposed site is in a rural use district of Berlin, NY. Berlin does not have town by-laws, but it does have land use regulations. The land use regulations place a maximum height restriction of 10.7 meters (35 feet) on structures built in rural use districts.¹⁸

¹⁴ Available at <http://www.nyseg.com/SuppliersAndPartners/interconnectioninfo.html>.

¹⁵ Personal communication with Joanne DeRose, Representative of National Grid.

¹⁶ Personal communication with Alex Kuriakose, Senior Engineer for Distributed Generation Services at National Grid.

¹⁷ Personal communication with Joanne DeRose, Representative of National Grid.

¹⁸ Berlin Town Board. *Town of Berlin: Land Use Regulations*, 1988, p. 9.

Since a wind turbine would exceed the maximum height for a rural use district, a special permit would need to be obtained from the town of Berlin. The Town of Berlin Zoning Board of Appeals would need to issue this permit pursuant to Article VIII of the Town of Berlin: Land Use Regulations. Included in this section of the regulations is a clause that allows for the zoning board to reject an application for purely aesthetic reasons.¹⁹ Previous attempts to install just a meteorological tower were met with resistance and the demand for a full environmental impact analysis of the type required for installing wind turbines. In addition, several letters from residents of Berlin were sent to the College administration opposing the idea of a wind farm on Berlin Pass. This reaction by town members indicates that there may be resistance to a plan for College turbines on the ridge. However, the political climate of the town may have changed since representatives of the College last approached the town in 2003. As such, the completion of a full environmental impact analysis along with visual simulations may convince the Zoning Board of Appeals to allow the issuance of a special permit for this project.

In addition to obtaining a special use permit from the Town of Berlin, a wind farm needs to obtain clearance from the Federal Aviation Administration (FAA). The FAA requires that a Notice of Proposed Construction be filed for any structure over 61 meters (200 feet). The FAA will then determine if there is a potential for interference with air traffic or radar systems. Based on the FAA approval of the Hoosac Wind Project (a distance of about 10 kilometers from the Harriman-North Adams Airport), it is likely that the FAA would approve wind turbines on Berlin Pass which is a distance of approximately 9 kilometers from the same airport.²⁰ Wind turbines need to be lit in accordance with FAA regulations. This means placing lights on the outermost wind turbines and having another light every 800 meters within the wind farm.²¹ These regulations mean that a College wind farm would most likely need two or three lights depending on the total number of wind turbines.

Unlike the construction of the actual wind turbines, road and power line construction will likely have to deal with the regulations of both Williamstown and Berlin (if we build the road and power lines from the Williamstown side). At the least, we will have to follow Berlin's regulations for these construction activities. In Berlin and Williamstown, road construction appears to be allowed on private property as an incidental or accessory use for the property. In at least Williamstown (and likely Berlin), we will need to conduct a site survey to determine the environmental impact. Depending on the presence of waterways and certain species, special permits may need to be filed with the proper conservation agencies.²² In Berlin, power lines are granted a special height exception allowing them to be constructed to a height of 30.5 meters (100 feet). In Williamstown, power lines may be constructed to a height of 10.7 meters (35 feet). In certain situations, a special use permit may be obtained in Williamstown to increase the maximum height of structures to 13.7 meters (45 feet).²³ Even under the more stringent Williamstown regulations, the power lines should not exceed the maximum allowed heights.

Overall, the main challenge with the permitting process will be obtaining the approval of the Berlin Zoning Board of Appeals for a special use permit. Tactfully approaching the town government will be important for securing this permit. The absence of any wetlands on the site

¹⁹ See pages 12-14 of Hiza's feasibility study for a more complete outline of the procedure for obtaining a special permit from the Zoning Board of Appeals.

²⁰ *Airspace Issues in Wind Turbine Siting*. http://www.masstech.org/renewableenergy/MTC_FAA.pdf.

²¹ *Development of Obstruction Lighting Standards for Wind Turbine Farms*.
<http://www.airtech.tc.faa.gov/safety/Downloads/TN05-50.pdf>.

²² Personal communication with Jason Moran, Project Manager for Williams College Facilities Department.

²³ See Town of Berlin: Land Use Regulations (page 7) and Code of Williamstown.

allows the College to avoid dealing with any of the special variance issues associated with wetlands.²⁴

Environmental Impact

I will briefly summarize the environmental impact of wind turbines on Berlin Pass in this report.²⁵ There are usually four major areas of environmental consideration with wind turbine projects: noise, avian risk, ice throw danger, and ecological impact. There are two sources of noise from wind turbines, mechanical noise and aerodynamic noise. Mechanical noise (noise from metal components moving in the turbine's gearbox) has been greatly reduced. Through a combination of specially designed gearboxes, blades that minimize vibrations, and sound insulation, manufacturers have largely eliminated mechanical noise, and it is no longer considered a major source of noise.²⁶ Aerodynamic noise is still a minor concern, but modern turbines minimize this source of noise through careful blade design and low rotational speed of rotors. This noise comes from the wind hitting the blades just as noise comes from leaves rustling in the wind.²⁷

Modern turbines emit approximately 100 dB(A) of noise. This level of noise quickly drops as you increase the distance from the turbine. At a distance of 170 meters (560 feet) from the turbine, noise is in the 40-44 dB(A) range. This is about the same level of noise as in a quiet office.

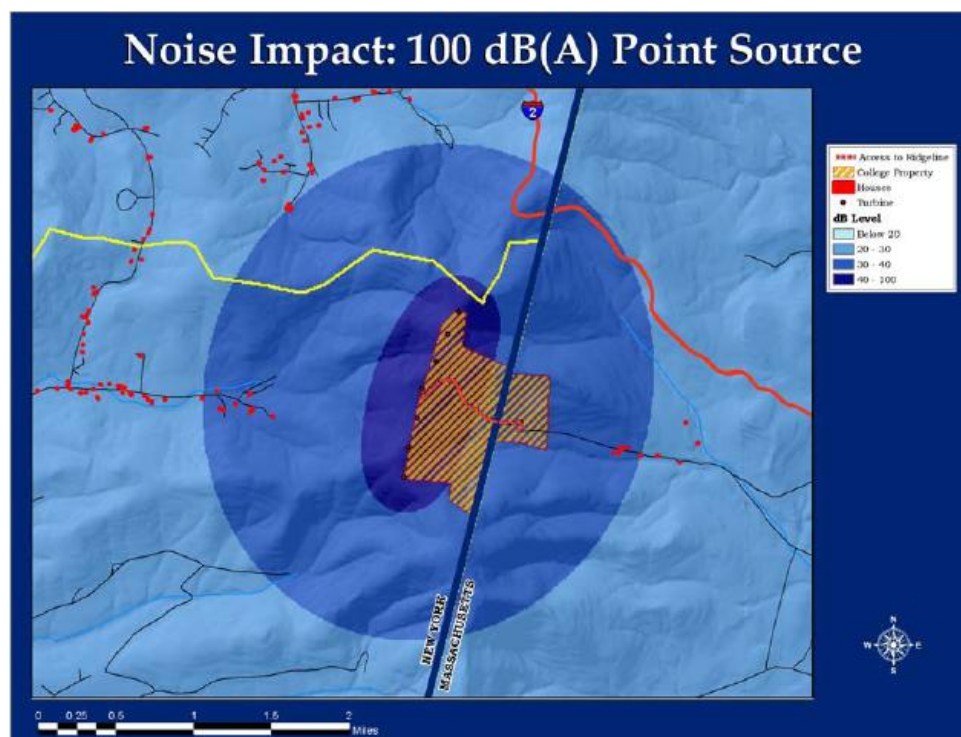


Figure 11. Noise impact of wind turbines on Berlin Pass. This graphic was created based on the assumption of seven wind turbines, so actual noise levels of a three turbine project would be even less. Darkest blue represents 40+ dB(A). Next lighter shade of blue represents 30-40 dB(A) and lightest blue represents less than 30 dB(A).

²⁴ Hiza et al. *The Berlin Wind Project*, p. 10.

²⁵ See Chapter 4, starting on p. 22, of Hiza's feasibility study for a more complete analysis of environmental impact.

²⁶ *Low Mechanical Noise*. <http://www.windpower.org/en/tour/design/quietma.htm>.

²⁷ *Low Aerodynamic Noise*. <http://www.windpower.org/en/tour/design/quietae.htm>.

Beyond approximately 260 meters (850 feet) sound drops to 35-39 dB(A). This level is equivalent to a whispered conversation. Beyond approximately 475 meters (1560 feet), wind turbine noise is below 35 dB(A) which is essentially masked by the background noise of the environment.²⁸ Based on these numbers, very few residents will experience any increase in background noise due to the installation of turbines on the ridge. The closest houses will experience the barely audible noise level of about 35 dB(A) (Figure 11).

Risk to avian population is expected to be minor in an environment like Berlin Pass. Studies performed at a wind turbine in Denmark show that birds will alter their paths by a few hundred meters to avoid wind turbines. Studies from Canada show that migratory birds will also alter their paths around wind turbines.²⁹ In addition, local empirical evidence supportw the low risk to birds. The Searsburg, Vermont wind farm has been operating for almost twelve years and has recorded only two bird fatalities.³⁰ That site operates ten wind turbines which would imply a bird fatality rate of one per sixty years of wind turbine operation.

In a cold environment like Berlin Pass, blade icing should be considered. However, based on years of observations at the Searsburg project, ice is rarely thrown from the turbines. The rotation of the rotor generally keeps ice formation at a minimum. When ice does form it tends to melt and eventually drop off the blade rather than being thrown large distances.³¹ Despite the relative safety, General Electric Energy recommends a setback distance from any hiking trails of approximately 180 meters (600 feet) to avoid any potential ice throw danger. The Taconic Crest trail runs through the proposed site. As such, it may be necessary to reroute the trail around the wind turbines to avoid any potential liability issues.³²

Any development in a wilderness environment disturbs the natural ecology and all efforts should be made to protect the natural environment. It is expected that ecological impacts at the site would be minimal as the site contains no endangered species or sensitive habitats such as wetlands. In addition, according to previous student research, wind turbine construction and operation would not impact wildlife migratory corridors through the site. Less than 1% or approximately 2 acres of the total College property on Berlin Pass would be impacted by construction activities. This estimate includes road construction from the Williamstown side as well as the foundations for the wind turbines. Parts of this site have already been disturbed from previous use as a ski area, which means the site is no longer as pristine as other sites in the Berkshires.³³ Overall, it is expected that any negative environmental impacts of building wind turbines on Berlin Pass would be outweighed by the benefits of generating clean, renewable wind energy.

²⁸ *Sound from Turbines*. <http://www.windpower.org/en/tour/env/sound.htm#minor>.

²⁹ *Birds and Wind Turbines*. <http://www.windpower.org/en/tour/env/birds.htm>.

³⁰ Personal communication with Martha Staskus, Vermont Environmental Research Associates.

³¹ Ibid.

³² For a full discussion of rerouting the trail, see pages 27-30 of Hiza's feasibility study. Total cost of rerouting the trail would be approximately \$14,000 adjusted for inflation by CPI Inflation Calculator.

³³ Canada et al. *Report on the Feasibility of a Wind Power Project on the Berlin Pass*, p. 12.

Wind Analysis

Overview

In order for any wind project to be economically viable, sufficient wind resources are required. Four and a half years of ten minute wind speed data collected from the Taconic Crest strongly support the presence of sufficient winds to make any project along the ridgeline financially successful. In this section I will explain how I estimated wind speeds at the typical hub heights of commercial wind turbines as well as provide power production estimates of possible turbines for the site.

Methodology

I obtained wind data from the meteorological tower in HMF spanning from November 11, 2004 to June 30, 2009. With help from Chris Warren and Amy Johns, I developed a Perl script to scan through the data and note any missing data (Appendix A). After running this script, I corrected for missing data, representing about 10% of the total data set (Appendix B).

I used a wind shear formula to estimate wind speeds at typical wind turbine hub heights:

$$v = v_{ref} * \ln (z / z_o) / \ln (z_{ref} / z_o) \quad (1)$$

Where: v is the wind speed estimate at a height z meters above ground level.

v_{ref} is the known wind speed at a known height z_{ref} and z_o is the roughness length in the current wind direction.^{34,35}

For the Berlin Pass site, I used a roughness length of 0.40 meters based on the definition of rough and uneven terrain provided in the Danish Wind Industry Association's reference manual.³⁶ With this formula, I estimated wind speeds (based on the average of both 50 meter anemometers on the meteorological tower) at the typical turbine heights of 67, 70, 80, 95, 100, and 105 meters (Appendix C). These are the heights of the various Vestas and GE wind turbines used to produce power production estimates later in this section.³⁷

³⁴ *Roughness and Wind Shear*. <http://www.windpower.org/en/tour/wres/shear.htm>.

³⁵ This method for estimating wind speeds was found to be the most accurate by Sam Arons in his thesis.

³⁶ This is a conservative roughness length, the true roughness length is more likely 0.80 meters or greater. This would slightly increase wind speed estimates, but I will work with the 0.40 meter length to provide more conservative estimates throughout this report.

³⁷ Gamesa and Siemens were also contacted but neither company deals with wind projects on such a small scale.

Summary of Wind Speeds and Direction

As expected, overall wind speeds increased with height above the ground. Wind speeds were lowest at the 30 meter anemometer and highest at the 50 meter anemometer. For the measurement period, the 50 meter anemometers recorded an average wind speed of 7.13 m/s (Table 1 and Figure 12).

Table 1. Average wind speeds at various heights. Note that the 30, 40, and 50 meter averages are empirical while the other averages are estimated based on Equation 1.

Height	Average Wind Speed
30 m	4.98 m/s
40 m	5.92 m/s
50 m	7.13 m/s
67 m	7.57 m/s
70 m	7.63 m/s
80 m	7.83 m/s
95 m	8.08 m/s
100 m	8.16 m/s
105 m	8.23 m/s

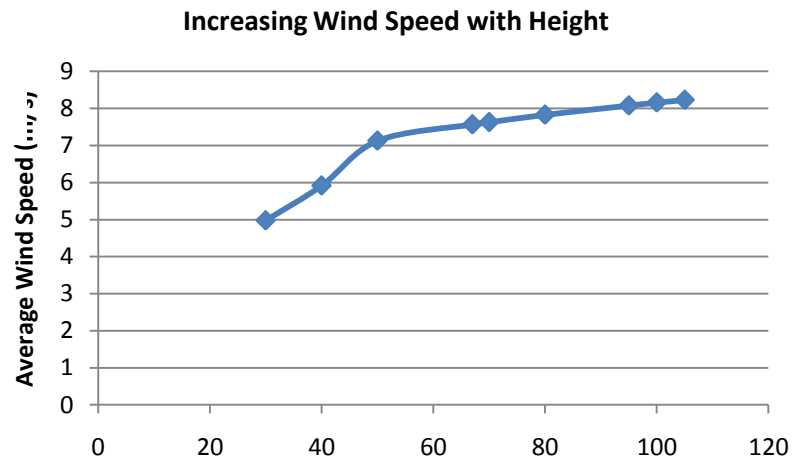


Figure 12. Graph of increasing wind speed with heights. Because I used a conservative roughness length, it is likely wind speeds would be higher than indicated above 50 meters.

Most of the wind passing over the Taconic Crest came from the northwest and west-northwest direction with an average direction of 284.5 degree (Figure 13). This direction is corroborated by wind measurements at the Searsburg wind farm and other measuring stations in the surrounding area.

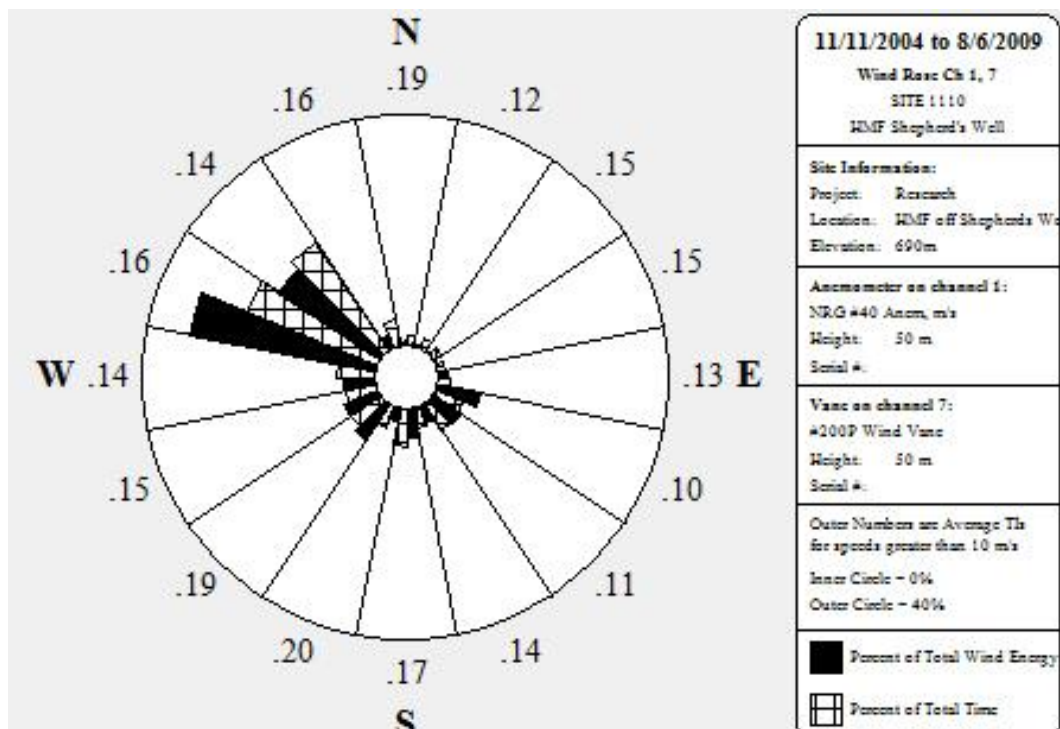


Figure 13. Wind rose for measurements from the meteorological tower at 50 meters.

Estimated Power Production

After estimating wind speeds at the proper heights, I binned the data for each height according to the intervals specified in the manufacturers' power curves.³⁸ For Vestas, binning was in 1.0 m/s intervals and for GE binning was in 0.50 m/s intervals. Cut-in and cut-out speeds were factored into the calculations. I then applied the power curves for various turbines supplied by Vestas and GE. Vestas has a selection of 1.65, 1.8, 2.0, and 3.0 MW turbines and GE has a selection of 1.5 and 2.5 MW turbines available (Appendix C). GE's power curves account for different air densities while Vestas do not.³⁹ Estimated yearly power production numbers were very promising even when using a conservative roughness length (Tables 2 and 3).

Table 2. Estimated annual power production for Vestas turbines.

Turbine Capacity	Hub Height	Rotor Diameter	Yearly Energy Production
1.65 MW	70 m	82 m	6.19 GWh
1.65 MW	80 m	82 m	6.43 GWh
1.8 MW	80 m	90 m	7.44 GWh
1.8 MW	95 m	90 m	7.78 GWh
1.8 MW	80 m	100 m	8.19 GWh
1.8 MW	95 m	100 m	8.50 GWh
2.0 MW	67 m	80 m	6.33 GWh
2.0 MW	80 m	80 m	6.73 GWh
3.0 MW	80 m	90 m	9.23 GWh
3.0 MW	105 m	90 m	10.09 GWh

Table 3. Estimated annual power production for GE turbines.

Turbine Capacity	Hub Height	Rotor Diameter	Yearly Energy Production
1.5 MW SLE	65 m	77 m	5.14 GWh
1.5 MW SLE	80 m	77 m	5.51 GWh
1.5 MW SL	65 m	77 m	5.12 GWh
1.5 MW SL	80 m	77 m	5.47 GWh
1.5 MW XLE	80 m	82.5 m	6.12 GWh
2.5 MW XL	75 m	100 m	8.95 GWh
2.5 MW XL	85 m	100 m	9.32 GWh
2.5 MW XL	100 m	100 m	9.75 GWh

In the fiscal year 2008, the College used 27,368,364 kWh of electricity. Of that amount, 5,686,933 kWh were generated at the cogeneration plant on campus.⁴⁰ Assuming that the College would like to generate sufficient electricity to power the campus, the production of the wind project should be on the order of 17,000,000 to 22,000,000 kWh (17 to 22 GWh) annually depending upon the effects of conservation projects on campus.⁴¹ Therefore, approximately three

³⁸ Vestas power curves are restricted under an NDA and were obtained from Andrew Ragland. To review the terms of the NDA please contact Jeff Jones. GE power curves are not restricted under an NDA, but GE has requested we do not publicly disclose the curves. GE power curves were provided by Matt Perkins.

³⁹ I used a yearly average of 1.15kg/m³, based on Sam Arons' calculations for his thesis.

⁴⁰ *Energy Use*. http://www.williams.edu/resources/sustainability/energy_use.php.

⁴¹ Personal communication with Stephanie Boyd, Director of the Zilkha Center at Williams College.

wind turbines would be required to satisfy this demand. When picking a wind turbine, more than just the total electricity production must be considered. For example, a wind turbine should be selected that best matches the wind speed regimes, updraft characteristics, and turbulence patterns of the site. As a result, the actual number of turbines required may be more or less than three.

Production of electricity from wind is generally highest in the winter which is when the College generates the highest amounts of its own electricity. The Taconic Crest experiences higher average monthly wind speeds in the winter months which corresponds to higher electricity production (Figure 14). The main meter electricity use monitors the total electricity drawn from the electrical grid by the College (Figure 15). The discrepancies in these graphs' peaks mean that while the project will generate the amount of electricity the College uses in a year, the generation profile will not necessarily match up with when the electricity is used. However, on an annual basis the project should result in the College's net electricity draw from the electrical grid being essentially zero.

Average Wind Speed at 50 m

Figure 14. Average wind speed patterns over the course of the year at 50 meters. Data compiled for June 1, 2008 to June 1, 2009.

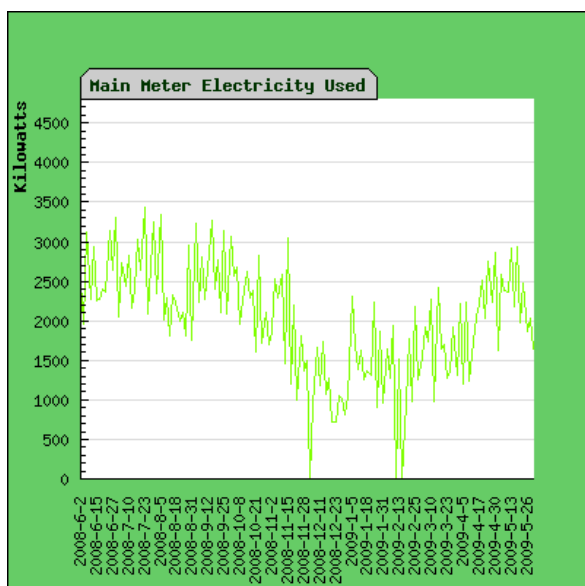
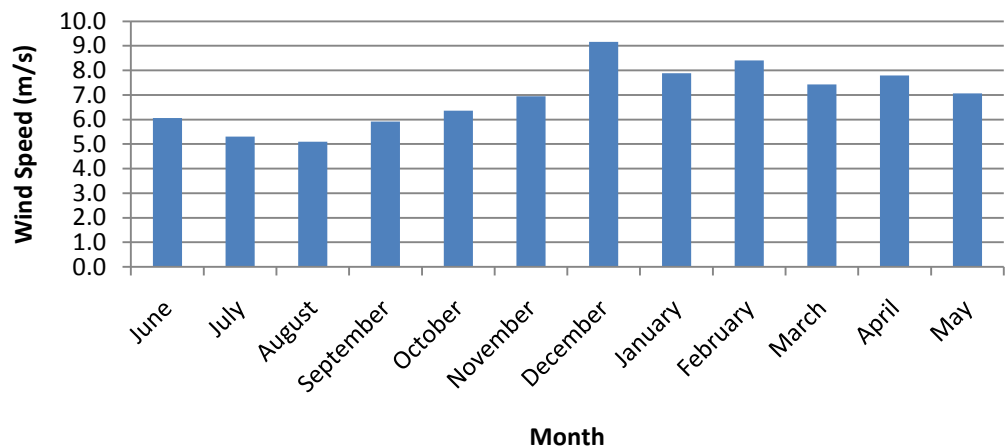


Figure 15. College electricity use from the grid for June 1, 2008 to June 1, 2009.

Cost Analysis

Incentives Available

There are several forms of incentives available for large scale wind projects. However, the dual state nature of this project complicates the application process and reduces eligibility for some of the state awarded incentives. I will give a brief overview of the applicable available incentives in both states. In Massachusetts, the Massachusetts Technology Collaborative offers up to \$400,000 grants for feasibility, design and construction of private wind turbine projects.⁴² In addition, the Mass Energy Consumers Alliance offers to buy renewable energy credits at \$.03/kWh for wind projects in Massachusetts.⁴³ Furthermore, the Massachusetts Department of Energy Resources allows businesses to deduct from net income, for state excise tax purposes, any expenses incurred in the installation of a wind turbine. Any system that qualifies for this deduction is also exempt from taxation under the tangible property measure of Massachusetts's corporate excise tax.⁴⁴ However, all these incentives require that the project be constructed in Massachusetts, disqualifying a project on Berlin Pass.

In New York, the New York State Energy Research and Development Authority (NYSERDA) offers grants to clean energy projects of up to 50% of a project's cost, with a maximum of \$200,000 per project. The Berlin Pass project would likely qualify for this grant.⁴⁵ In addition, this project would qualify for property tax exemption (which records indicate the College does pay on the Berlin property) in New York. This tax exemption is a local option exemption meaning the host town can opt-out of the exemption. However, Berlin is among the towns that has not decided to opt-out as of yet.⁴⁶

At the federal level, there is the Renewable Energy Production Tax Credit (PTC) that provides a tax credit of \$.021/kWh (adjusted for inflation annually) for the first ten years of service for wind energy. Unless this credit is renewed, to qualify a project needs to be in-service by December 31, 2012.⁴⁷ Since the College does not pay taxes, the PTC would not be directly beneficial to the College. In addition, the College could potentially qualify for the Renewable Energy Production Incentive (REPI). REPI provides a payment of \$.021/kWh (adjusted for inflation annually) for the first ten years of service as long as the project is in service before October 1, 2016.⁴⁸ Clean Renewable Energy Bonds (CREBs) may be issued at a 0% interest rate (bondholder receives federal tax credits instead of interest from the borrower) to help finance a wind project. This 0% interest rate means the borrower only has to pay back the principal of the bond allowing the borrower to obtain money at a lower rate than normally available.⁴⁹

Cost Estimates

Costs presented here are very preliminary and meant to provide an order of magnitude understanding of the proposed project. I based the following estimates on a combination of personal communication with Matt Perkins, a GE Energy representative, and information provided by Hiza's pro forma financial reports. I have tried to make cost estimates as

⁴² http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MA82F&re=1&ee=1.

⁴³ http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MA10F&re=1&ee=1.

⁴⁴ [dsireusa.org/incentives/incentive.cfm?Incentive_Code=MA03F&state=MA&CurrentPageID=1&RE=1&EE=1](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MA03F&state=MA&CurrentPageID=1&RE=1&EE=1).

⁴⁵ http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY40F&re=1&ee=1.

⁴⁶ http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY07F&re=1&ee=1.

⁴⁷ http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F&re=1&ee=1.

⁴⁸ http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US33F&re=1&ee=1.

⁴⁹ http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US45F&re=1&ee=1.

conservative as possible so that true costs will likely be less than what is presented in this report (Table 4).

Table 4. Estimated costs associated with project of three 1.8 MW Vestas turbines.

Component	Cost
Turbines (5.2 MW total)	\$2,000,000 per MW X 5.2 = \$10,400,000
Installation	\$2,000,000
Project management/contingencies	\$1,800,000
Road Improvement/Construction	\$1,000,000
Legal and public relations	\$1,000,000
Transmission Line Construction	\$700,000
Permitting and Site Survey	\$50,000
Interconnection Study	\$25,000
Easements and Trails	\$25,000
<i>Total</i>	<i>\$17,00,000</i>

Financial Analysis

The estimates included in this report will address both the situation of the College funding the project itself and the possibility of using an outside investor/developer to fund the project. I have tried to make the estimates as conservative as possible so actual returns will probably be better than predicted. I based this analysis on a project of three 1.8 MW Vestas turbines at an 80 meter hub height with 90 meter diameter rotor. Although such a turbine is expected to produce 7.44 GWh per year, I used a figure of 7.22 GWh per year to account for the 97-98% availability factor (available to produce electricity) of the turbines. Furthermore, I assumed a maintenance and operations cost of approximately \$75,000 per turbine per year.

I also assumed we would not be receiving “behind” the meter pricing on electricity produced. This means the College does not get the electricity for free because we will still have to pay approximately \$.04/kWh for transmission and distribution of electricity to campus for electricity generated at Berlin Pass. In the case of our cogenerated electricity, we do not have to pay National Grid anything for that electricity because it is generated on campus “behind” the meter. For the price of electricity, I used last year’s average of \$.12/kWh. This estimate essentially assumes there is no net cost of electricity. In other words, we are selling and buying electricity at the same price. In addition, I adjusted all future revenues and expenses associated with the project by the long term (1913-2007) United States average inflation rate of 3.42%.⁵⁰ Finally, I assumed a 25 year life span of the project. I summarized the financial information in Table 5.

⁵⁰ *Inflation by Decade.* <http://www.inflationdata.com/inflation/Inflation/DecadeInflation.asp>.

Table 5. Financial analysis for a project of three 1.8 MW Vestas turbines.

Owner	Simple Payback	Net Present Value (at 10%)	Internal Rate of Return
College	8.6 years	\$3,988,756	13%
College (selling RECs)	6.4 years	\$11,043,603	18%
Developer	7.0 years	\$6,880,847	15%
Developer (selling RECs)	5.5 years	\$13,935,695	20%

Regardless of who funds the projects and what incentives the project qualifies for, increasing the capacity or height of the turbines for the project will further enhance the economic viability of the project. Also, even though the College will probably not sell the Renewable Energy Credits (RECs) associated with this project, they can be valued at approximately \$.03/kWh. RECs are essentially the “greenness” of the electricity. The College cannot sell the project’s RECs and then claim the project is helping us achieve our goal of lowering greenhouse gas emissions. Selling the project’s RECs would allow some other entity to claim the reduction in greenhouse gas emission associated with this project.

Alternative Ownership/Funding Structures

There are several other types of ownership structures for a project of this scale. First, the College could solicit alumni to help fund the project. This method has the potential to raise more money than seeking loans from banks. In addition, it may provide more favorable terms for the College than private investors would provide. The College could also engage private investors for the project. This would allow the investors to take advantage of certain tax credits that the College otherwise could not. Under certain agreements known as the “flip” ownership structure, private investors own the project to take advantage of tax benefits and then ownership eventually switches to the College once the tax breaks are exhausted. Finally, the College could allow an outside firm to develop and market the project. This method allows for the College to be almost entirely hands-off while still benefiting from receiving clean energy to power the College.⁵¹

⁵¹ *Community Wind Development*. April 2006.

Conclusion

In conclusion, the Berlin Pass is the ideal College-owned property on which to develop a wind farm. The Pass has consistent high wind speeds and relatively easy access to roads and major transmission lines. The economics of even the most conservative scenarios are financially attractive. In all likelihood, the project would pay for itself within five to ten years of completion and quite possibly faster than that. Once the administration decides to proceed on this project, I would recommend retaining a developer to help with the engineering and permitting associated with the project as well as do a more thorough feasibility study (Appendix D and E).

The biggest foreseeable obstacles will be obtaining permitting in the town of Berlin, transporting the parts of the turbine to the Berlin Pass, and interconnecting with the grid. However, with the proper incentives the permitting issue can likely be overcome. Similarly, the transportation and interconnection issues will be surmountable with the proper engineering experience. I would recommend moving forward with this project as soon as possible. Completion of this project will go a long way toward achieving the College's greenhouse gas emission reduction goals.

Acknowledgements

This project was supported by my summer internship through the Zilkha Center for Environmental Initiatives. I would like to thank Stephanie Boyd, Amy Johns, David Dethier, and Jay Racela for their help and advice throughout the summer. In addition, I am grateful for the help of Jeff Jones, Mimi Roy, and Jason Moran for additional advice and information throughout the summer. Also, I would like to thank Matt Perkins at GE Energy and Andrew Ragland at Vestas for providing me with information about their companies' wind turbines. Finally, I would like to give a special thanks to Nick Hiza (and all the previous students who have worked on the Berlin Pass Wind Project) for his suggestions and comments as well as his initial work on the Berlin Wind Feasibility Study in 2003.

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Image Credits

Figure 1:

Image provided by JJ Augenbraun, Summer Intern at the Zilkha Center.

Figure E1:

Base image obtained from Hiza, Nicholas et al. *The Berlin Wind Project: An Interim Report on Project Feasibility and Potential Environmental Impact*. 11 May 2003. Additional editing of Hopkins Memorial Forest proposed site by JJ Augenbraun.

Figure 2:

Image provided by Jay Racela, Technical Assistant for the Center for Environmental Studies.

Figure 3: Image provided by JJ Augenbraun.

Figure 4: See Figure E1.

Figure 5:

“HMF Map.” HMF Permanent Plot System. Williams College. 9 August 2009.
<<http://oit.williams.edu/hmfplot/image/hmfmap.jpg>>.

Figures 6 and 7:

Hiza, Nicholas et al. *The Berlin Wind Project: An Interim Report on Project Feasibility and Potential Environmental Impact*. 11 May 2003.

Figures 8 and 9:

Images provided by JJ Augenbraun

Figure 10:

Base image obtained from Google Maps. 16 August 2009. Additional editing by JJ Augenbraun.

Figure 11:

Image obtained from Hiza, Nicholas et al. *The Berlin Wind Project: An Interim Report on Project Feasibility and Potential Environmental Impact*. 11 May 2003.

Figure 12:

Graph prepared by JJ Augenbraun.

Figure 13:

Image provided by Jay Racela.

Figure 14:

Graph prepared by JJ Augenbraun

Figure 15:

Graph taken from Sustainability at Williams website. < http://www.williams.edu/resources/sustainability/campus_electricity_trends/electricity_trends_advanced.php>.

Appendix A: Perl Script for Detecting Missing Data

```
#!/usr/bin/perl
# by JJ Augenbraun
use strict;
use Time::Local;

open(FILEIN, "VariousHeightsData.txt")           #input file
    or die("could not open file: $!\n");
open(FILEOUT, ">MissingData.txt")                 #output file
    or die("could not write file: $!\n");

my $line;
my $chan1; #50 m (1)
my $chan2; #50 m (2)
my $missingCounter; #number of missing cells in a row
my $firstMissingDate; #first missing date in a set of missing dates
my $previousTimeStamp; #previous date and time

while($line = <FILEIN>) {
    my @token = split /\t/, $line; #splits the line by tab delimiters
    my $dateString = $token[0]; #stores the date string 6/13/2005 11:30
    $chan1 = $token[1];          #stores 50 m channel 1 data in string
    $chan2 = $token[2];          #stores 50 m channel 2 data in string
    my $temperature = $token[5]; #stores temperature data in string

    if(($chan1 <= 0.4) or ($chan2 <= 0.4)) {
        if($firstMissingDate eq("")) {
            $firstMissingDate = $dateString;
        }

        $missingCounter++;
    } else {
        if($firstMissingDate ne("")) {
            print FILEOUT "$firstMissingDate,$missingCounter\n";
            $firstMissingDate = "";
            $missingCounter = 0;
        }
    }
}

$dateString =~ /\(d{1,2})\/(d{1,2})\/(d{4})s(d{1,2}):(\d{2})/;

my $month = $1-1;
my $day = $2;
my $year = $3;
my $hour = $4;
my $minute = $5;
```



```

my $currentTimeStamp = timelocal(0, $minute, $hour, $day, $month, $year);
if($previousTimeStamp) {
    my $difference = ($currentTimeStamp - $previousTimeStamp)/600;
    if($difference > 1) {

        print FILEOUT "$dateString,$difference\n";
    }
}
$previousTimeStamp = $currentTimeStamp;
}

close(FILEIN);
close(FILEOUT);
exit;

```

Appendix B: Procedure for Correcting Missing Wind Data

- when one 50 meter channel is missing data, copy in data from other 50 meter channel
- when both channels are missing data, average data cells before and after the missing chunk in the amount equal to the missing chunk for each channel (only if 144 or less cells are missing)
- when more than 144 cells are missing data, try to fill in with data from same time in other years by averaging the data from the other three years for that time period
- fill in large chunks with other year's data before filling in smaller chunks reliant on the data missing in the larger chunks
- when 50 meter wind speed is less than 30 meter wind speed and temperature is below freezing, use 30 meter or 40 meter data

Appendix C: GE and Vestas Wind Turbines⁵²

GE 1.5 MW turbines:

http://www.gepower.com/prod_serv/products/wind_turbines/en/15mw/specs.htm

- 65 and 80 m hub heights for 1.5 MW SLE
- 3.5 m/s cut in speed and 25 m/s cut out speed
- 77 m diameter rotor

- 65 and 80 m hub height for 1.5 MW SL
- 3.5 m/s cut in speed and 20 m/s cut out speed
- 77 m diameter rotor

- 80 m hub height for 1.5 MW XLE
- 3.5 m/s cut in speed and 20 m/s cut out speed
- 82.5 m diameter rotor

GE 2.5 MW turbines:

http://www.gepower.com/prod_serv/products/wind_turbines/en/2xmw/index.htm

- 75, 85, and 100 m hub heights for 2.5 MW XL
- 3.5 m/s cut in speed and 25 m/s cut out speed
- 100 m diameter rotor

Vestas 1.65 MW turbines:

<http://www.vestas.com/en/wind-power-solutions/wind-turbines/1.65-mw.aspx>

- 70 and 80 m hub heights for 1.65 MW V82
- 3.5 m/s cut in speed and 20 m/s cut out speed
- 82 m diameter rotor

Vestas 1.8 and 2.0 MW turbines:

<http://www.vestas.com/en/wind-power-solutions/wind-turbines/2.0-mw.aspx>

- 80 and 95 m hub heights for 1.8 MW V90
- 4 m/s cut in speed and 25 m/s cut out speed
- 90 m diameter rotor

- 80 and 95 m hub heights for 1.8 MW V100
- 4 m/s cut in speed and 20 m/s cut out speed
- 100 m diameter rotor

- 67 and 80 m hub heights for 2.0 MW V80
- 4 m/s cut in speed and 25 m/s cut out speed
- 80 m diameter rotor

Vestas 3.0 MW turbines:

<http://www.vestas.com/en/wind-power-solutions/wind-turbines/3.0-mw.aspx>

- 80 and 105 m hub heights for 3.0 M V90
- 4 m/s cut in speed and 25 m/s cut out speed
- 90 m diameter rotor

⁵² Information on wind turbines obtained from GE (http://www.gepower.com/prod_serv/products/wind_turbines/en/index.htm) and Vestas (<http://www.vestas.com/en/wind-power-solutions/wind-turbines.aspx>).

Appendix D: List of Potential Developers

Aeronautica Windpower

Website: <http://aeronauticawind.com/aw/index.html>

Contact Information: info@aeronauticawind.com

800.360.0132

Location: Plymouth, MA

Services: Wind study, permitting/engineering, installation, service, financing

Ownership: Flexible options

Turbines: Manufacture their own or can use outside vendor

EOS Ventures

Website: <http://www.eos-ventures.com/>

Contact Information: info@eos-ventures.com

413-738-7007

Location: Hancock, MA

Services: design, installation, commissioning

Ownership: Engineering, procurement, and construction (EPC), Power Purchase Agreement, flip model

Turbines: Do not manufacture the turbines

Northern Power Systems

Website: <http://www.northernpower.com/index.php>

Contact Information: 877-90-NORTH or 802.461.2955

Location: Barre, VT

Services: Installation and servicing

Turbines: Manufacture their own

First Wind

Website: <http://www.firstwind.com/index.cfm>

Contact Information: contact@firstwind.com

617-964-3340

Location: Newton, MA

Services: Development, ownership, and operation of wind farms

Vermont Environmental Research Associates

Website: <http://www.northeastwind.com/>

Contact Information: vera@northeastwind.com

802-244-7522

Note: Martha Staskus gives tours at Searsburg, her email is marthas@northeastwind.com

Location: Waterbury Center, VT

Services: Project management, wind resource assessment, environmental assessment, economic analysis, public outreach

Mortenson

Website: <http://www.mortenson.com/>

Contact Information: web.admin@mortenson.com

763-522-2100

Location: Minneapolis, MN

Services: Development, design, construction, and project management

Wanzek

Website: <http://www.wanzek.com/>

Contact Information: constructors@wanzek.com

701-282-6171

Location: Fargo, ND

Services: EPC, BOP, general construction services, plant maintenance services

Blattner Energy

Website: <http://www.blattnerenergy.com/>

Contact Information: http://www.blattnerenergy.com/contact_us.php

320-356-7351

Location: Avon, MN

Services: EPC

RMT – Fowler Ridge

Website: <http://www.rmtinc.com/public/index.html>

Contact Information: info@rmtinc.com

608-831-4444

Location: Madison, WI

Services: EPC

Patriot Renewables

Website: <http://www.patriotrenewables.com/index.html>

Contact Information: info@patriotrenewables.com

617-890-0600

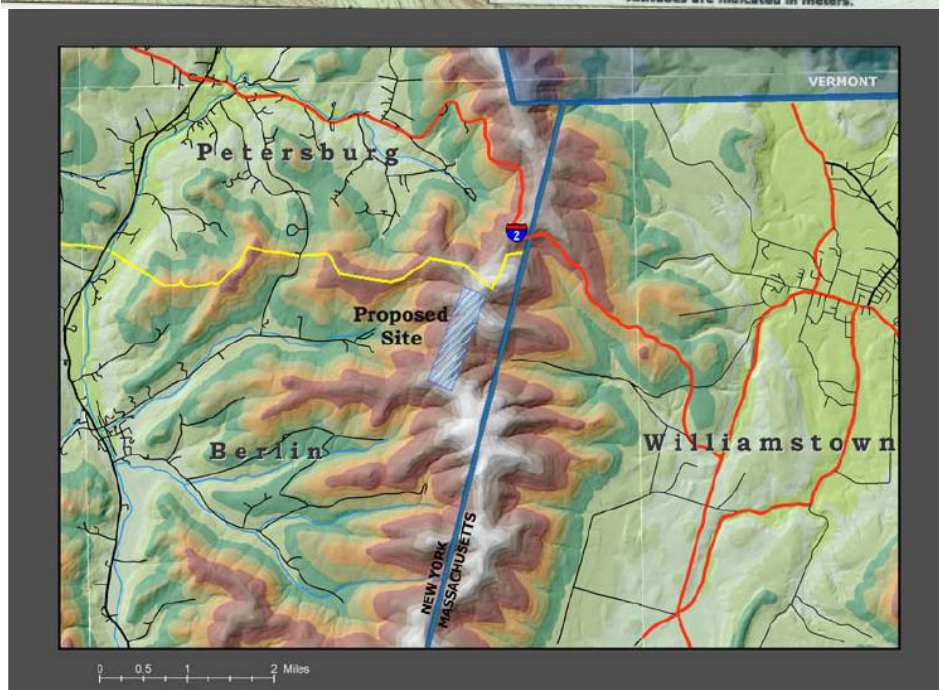
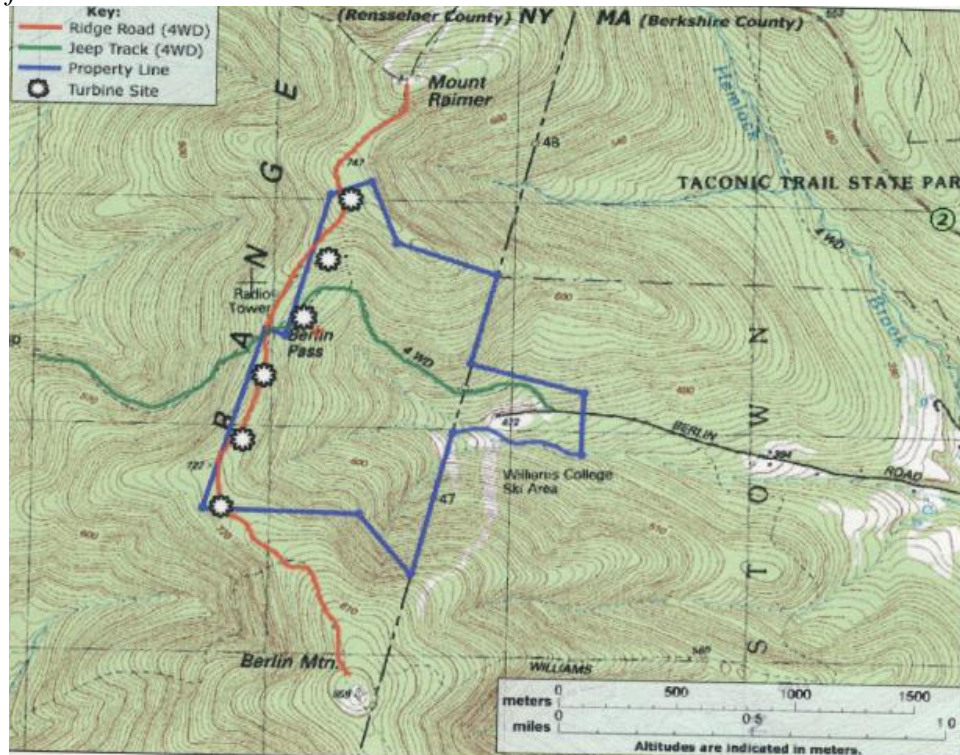
Location: Quincy, MA

Services: Developer, owner, and operator

Note: Affiliate of Jay Cashman, Inc.

Appendix E: Project Information for Potential Developers

Overview of Site:



GPS Location of Met Tower: 42.72824 N, 73.27106 W elev. 716 m

GPS Location of middle of proposed wind site: 42.70620335 N, 73.28935715 W elev. 686 m

Description/current land use

- college owned land located on Berlin Pass, between Berlin Mountain and Mount Raimer
- 400 acres of steep forested land in a rough rectangular shape
 - approximately 5000 feet east to west and 7000 feet north to south
- highest point is 856 m, some of the land extends into MA, but none of the proposed site

Estimated Distance to Power Distribution/Substation



- 3.25 miles to Route 7 power lines
- about 7.5 miles to Williams College Heating Plant
- maybe closer high voltage lines on NY site, haven't fully explored this possibility

Average cost per kWh

- 12 cents a kWh

College Annual Electricity Use:

- 27,368,364 kWh total, 5,686,933 kWh generated in our cogeneration plant

Desired Annual Production of Project:

- 17,000,000 to 22,000,000 kWh

More Information about College's Energy Use:

<http://www.williams.edu/resources/sustainability/index.php>

Land Restrictions

- land closest to site on MA side is part of an upland conservation zone

Community Opposition/Support for Wind Energy Projects

- according to a survey done in 2002, 87% of local population expressed strong or very strong support for the Berlin Wind Project

Current Zoning of Property

- Rural Use District in NY
- wind turbines would be in excess of height restrictions for rural use of 35'
- special permit required

Wetlands

- according to 2003 Berlin Wind Feasibility Study, no wetlands have been recognized along the ridgetop of this site

Endangered Species Habitat

- also according to 2003 Berlin Wind Feasibility Study, no endangered species living in site area

Berlin Town Wind Energy Bylaw

- none, Land Use Regulations exist from 1988
- previous attempt in 2003-2004 to erect a meteorological tower on site was blocked by Town Zoning Board, political climate most likely has changed

Berlin Town Wind Energy Committee

- none