Next Steps for Wind Study

Respectfully submitted to:
Buildings and Grounds Committee

By
The Wind Feasibility Committee
Chris Bair
Gail Bonath
Peter Jacobsen
Lee Sharpe
Emily Steiver
Rick Whitney, Committee Chair

Clean. Green. Grinnell.

In January, the Wind Committee reconvened to continue the wind turbine feasibility study and address the next steps as outlined by the trustees at the November meeting. Issues addressed in this report include:

1) Review of energy consumption and conservation
2) Updated wind analysis including Wind Logics study
3) Variance or risk in economic results
4) Impact of an electric boiler on the analysis
5) Turbine availability and time considerations
6) Environmental impacts
7) Turbine siting and land availability
8) Permits and grid study
9) Utility buy-back and standby charges
10) Iowa Energy Center assistance
11) Community reception
12) Potential for research and education

The accompanying report "Overview of Energy Consumption and Conservation on Campus" provides a general overview of energy consumption and a description of major efficiency projects implemented in the last two decades.

Appendix 1 is a more detailed wind speed analysis conducted since the last report to the Board. The college contracted with WindLogics in St. Paul, Minnesota to conduct a higher resolution wind speed analysis specific to several locales determined by previous analysis to be the most appropriate positions on the landscape. This study projected a 5.5% higher average wind speed than previous studies which would result in roughly 9% more generation. Thomas Wind, the college's wind consultant, was asked to revise his economic analysis in order to reflect these higher resolution projections. The committee is happy to note that these projections have improved the economics given in the last report! His revised estimates project a simple payback period of 14.5 years and an Internal Rate of Return of 4%. Appendix 1 includes the revised analysis as well as the WindLogics study.

One specific concern is the analysis of risk involved. Mr. Wind's analysis of various uncertainties results in a range of simple payback rates from 13 to 17 years, and an internal rate of return ranging from 1.8% to 8%. One obstacle present in the current market is the huge demand for large wind turbines. A federal tax incentive which may expire in 2008 is driving a large "boom" in wind farm construction. These farms typically consist of tens to hundreds of turbines which greatly reduces the buying power of a project looking to install one or several turbines. These constraints necessitate working with less "mainstream" manufacturers which specialize in such a niche market. Utilizing smaller manufacturers does not provide a great deal of turbine history with respect to availability or operation and maintenance costs. Regarding time considerations, the following constraints arise:

1) Per Alliant Energy, the MISO (Midwest Independent System Operator) study will take 12 to 14 months to complete.
2) Per consultant, utility-scale wind turbines have a lead time of 10 to 18 months.
3) Per Alliant Energy, transformers have a lead time of 10 to 12 months.

The various permits could be sought concurrently with the MISO study. After this study is complete, turbine, transformer and other material orders could be released. Based on these estimates, erection of turbine could begin 22 to 32 months after initiating the MISO study.

Although most of the turbine configurations are economically viable, the Internal Rate of Return projections are not high enough to justify such a project from strictly an investment standpoint. Naturally, environmental considerations are an integral part of this project. If five megawatts of wind generation and an electric boiler (which would utilize excess power generated to offset natural gas usage) were installed, the college would reduce carbon dioxide emissions by 34 million pounds annually. This would offset roughly 55% of the college's current carbon dioxide emissions. Since environmental considerations are a driving force behind this effort, it is important to address any real or perceived negative environmental impacts.

Appendix 2 addresses the issue of avian mortality. This is a common concern regarding wind turbines. The factors most responsible for avian mortality are site placement, number of turbines, tower design, and blade speed. The sites considered near Grinnell are not along a major migratory route or flyway, the number of turbines installed would be relatively few, and the tower design is a closed design which does not encourage perching. Lastly, blade speeds for the newer, larger turbines are considerably slower than the older smaller turbines.

An assessment of sites appropriate for the siting of turbines yielded a number of properties which would be suitable. The college would not be restricted to just one or two options for siting. This obviously allows for a stronger negotiating position. Precedents exist for both buying and leasing land. The consultant commented, "97% of wind turbines in Iowa are on leased land. I know of one municipal utility that bought about 10 acres, and most schools put their turbines on their own land because it is usually adjacent to their school." One benefit of leasing is the annual reminder to the landowner that he/she is being compensated for any inconvenience a large turbine might cause.

Regarding permits and contracts, the committee has conferred with the consultant, Alliant Energy, and local officials regarding next steps:

1) The MISO (Midwest Independent System Operator) study is required by Alliant Energy for utility scale wind projects. This study has a not-to-exceed cost of $25,000. The purpose of this study is to model the impact on the regional power grid. Alliant requires that make, model, and number of turbines be specified, and location information be provided for this study. With that in mind, the College needs to have a specific plan in place before proceeding with the study.
2) The following will need to be obtained in order to proceed with a utility scale wind project. Once again, the College must have a specific plan in place before proceeding to obtain them.
    a) FAA clearance
    b) County building permit
    c) Alliant interconnection agreement
    d) Utility right-of-way and easement rights

On utility scale wind projects, Alliant Energy negotiates a buy-back rate contract with the owner/developer. Currently, Alliant has been negotiating this rate between 2.5 and 3.2 cents per kilowatt hour. Given that the proposed wind project will not likely affect the College's peak billing demand, no standby charges will be levied by Alliant.

Alliant Energy has offered their expertise and services to potentially negotiate with larger wind turbine manufacturers and provide complete engineering and installation services. Also, the Iowa Energy Center has a revolving loan program for renewable energy projects providing a maximum of $250,000 of interest-free funding which must be matched with a commercial loan of $250,000(maximum).

One additional consideration is community acceptance. The committee did not conduct a survey due to confidentiality issues. The committee did, however, contact Imagine Grinnell (a community enhancement organization) and City of Grinnell administrators. Both groups responded positively to the idea of such a project. Furthermore, the College has been contacted by the public school superintendent and two agricultural businesses expressing interest in wind power for their respective facilities. In general, communities in Iowa have embraced wind power, especially given that Iowa is a working landscape.

Both the new CERA wind turbine and the proposed utility scale project offer teaching and research opportunities in several disciplines. Faculty on the committee have inquired about specific metering and measured parameters regarding the CERA turbine. Advanced controls on this and future turbines will allow for data trending and analysis for use in energy research and modeling.

Appendix 1.
Additional Evaluation of Wind Generation
for
Grinnell College
by
Wind Utility Consulting
January 30, 2007
Revision 1

THOMAS A. WIND, P.E.
UTILITY CONSULTANT

January 30, 2007

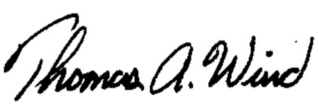
Mr. Rick Whitney
Grinnell College Facilities Management
1917 6th Ave.
Grinnell, IA 50112-1690

Dear Mr. Whitney:

Attached are some additional analyses of installing large wind turbines for your main campus in Grinnell. I have tried to address the questions and issues you have raised since the completion of my preliminary analysis in April of 2006. These additional analyses consider: 1) siting issues for the far northeastern sites, 2) both Clipper 2.5 MW and AWE 900 kW wind turbines, 3) an analysis of the excess generation sold back to Alliant, 4) the potential utilization of excess generation in an electric boiler, 5) an analysis of life extension benefits, and 6) an updated economic analysis based on the WindLogics wind speed estimates.

If you should have any questions, please don't hesitate to give me a call.

Sincerely yours,



Thomas A. Wind, PE
Wind Utility Consulting

Attachment: Additional Evaluation of Wind Generation Report

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APPENDICES

SECTION 1
OVERVIEW OF APRIL 2006 REPORT FINDINGS

Wind Utility Consulting ("Consultant") prepared a report entitled "Preliminary Evaluation of Wind Generation for Grinnell College" with some subsequent analysis as requested by Mr. Rick Whitney. The original report included a detailed wind speed map and an economic analysis of potential large wind turbine sites north and west of the main campus. The analysis included projected Alliant electric power bill savings. These savings were based on expected electricity cost increases due to inflation, higher fuel costs, and expected carbon emission mitigation costs. The analysis concluded that the higher wind speeds at the far northeastern sites justified the extra 3 miles of underground cable required to reach the site, if at least two 2.5 MW wind turbines were installed. If only one 2.5 MW turbine were installed, the closer sites would be more economical. In all cases, the economics simple payback periods are not attractive without some value placed on the environmental attributes of the wind generation. The Consultant estimated the future value of these environmental attributes will gradually increase from 0.1¢ per kWh today to 1.5¢ per kWh over 20 years. With this added value considered, the simple payback would be about 14.5 years, with an Internal Rate of Return ("IRR") of 4% on the capital investment. An analysis of various uncertainties resulted in simple paybacks ranging from 13 to 17 years, with corresponding IRRs of 1.5% to 8%.

The original report inspired a number of questions and ideas from the College and the Consultant performed additional analysis to address some of these questions. Based on the College's experience with its own facilities, it expected the life of the wind turbine to be longer than its design life of 20 years. The Consultant made some preliminary evaluation of what kinds of refurbishments would be needed to extend the useful life of a large wind turbine. Refurbishment cost estimates and timing were then provided to the College, which made a simple economic analysis of the benefits of life extension based on an extrapolation of the Consultant's data. This analysis suggested that the net savings increased and the IRR improved with life extension investments. For example, with no monetary value placed on the environmental attributes, the simple payback was 16.5 years with an IRR of 2.4% at the end of 20 years. With a life extension of 40 years, the simple payback was the same, but the net savings increased from $2.5 million at 20 years to $13.8 million at the end of 40 years, which improved the IRR to 5.2%.

As recommended by the Consultant, the College purchased from WindLogics in St. Paul, Minnesota, a sophisticated wind speed study of one of the far northeast sites. This study projected the average wind speed at an 80-meter hub height to be 18.0 mph, or 5.5% higher than the Consultant's original estimates. This higher wind speed estimate would result in about 9% more wind generation, which increased the IRRs and reduced the payback periods.

Due to the large demand for large wind turbines, few wind turbine manufacturers are willing to sell only one or two wind turbines for an isolated location like Grinnell. With Clipper's significant delay in production, there is no assurance that the College can purchase one or two of the Clipper wind turbines. Since the time of the original report, the Consultant has become aware of the availability of a 900 kW direct drive wind turbine from Americas Wind Energy, a small Canadian company connected to Emergya Wind Technologies, another small Dutch company that purchased the direct drive technology rights from the Lagerway bankruptcy. Due to the simplicity of its design, the turbine should have lower maintenance and refurbishment costs. A preliminary financial analysis of using this turbine showed that the economics might be comparable with the Clipper turbines for the same amount of wind generation capacity. Although the capital cost would likely be a little higher, the lower operating cost would result in about the same cost per kWh.

This study provides additional supplementary analysis of the following aspects:

1) Projections of the amount of power used and sold back to Alliant for various amounts of installed wind generation capacity
2) Analysis of using excess electricity generation in an electric boiler to offset natural gas usage
3) Additional analysis of life extension benefits
4) Additional comparative economic analysis of the Clipper 2.5 MW and AWE 900 kW wind turbines. A few other turbine models will likely be available from smaller niche manufacturers also.

SECTION 2
WIND GENERATION PROJECTIONS, POWER SALES, AND NATURAL GAS REPLACEMENT

A sophisticated computer-based analysis by WindLogics was done at one point for the far northeastern site area after the original April 2006 study. Table 1 below shows a comparison of the wind speed estimates used in the original study and those from the new WindLogics study. The higher wind speed estimates increase the annual kWh generation projections by about 9%. A non-confidential public version of the WindLogics wind speed study is shown in Appendix 1.

TABLE 1

Comparison of Original Wind Speed Study and WindLogics Study Results

	Original Estimate	WindLogics	Difference
Wind Speed at 50 Meters, in Meters per Second	6.85	7.21	5.3%
Wind Speed at 50 Meters, in Miles per Hour	15.32	16.13	5.3%
Wind Speed at 80 Meters, in Meters per Second	7.61	8.03	5.5%
Wind Speed at 80 Meters, in Miles per Hour	17.02	17.96	5.5%
Wind Shear from 50 to 80 Meters	0.225	0.229	1.9%
Approximate Increase in kWh Generation	Reference	+ 9%	+ 9%

The black ovals on the map in Figure 1 show five different ridges that each could accommodate at least three large Clipper 2.5 MW wind turbines, with generous separation resulting in array losses of only about 1%. The production differences between turbines in each of the five areas are about ± 1% from each other. For confidentiality reasons, specific wind turbine sites in each of the five areas are not shown in this report. The sites were based on ¼-mile setbacks from residences to minimize noise at residences. Less setback distance can be used if the landowner agrees to a noise easement. Setbacks from property lines can be minimal if overhang easements are obtained.

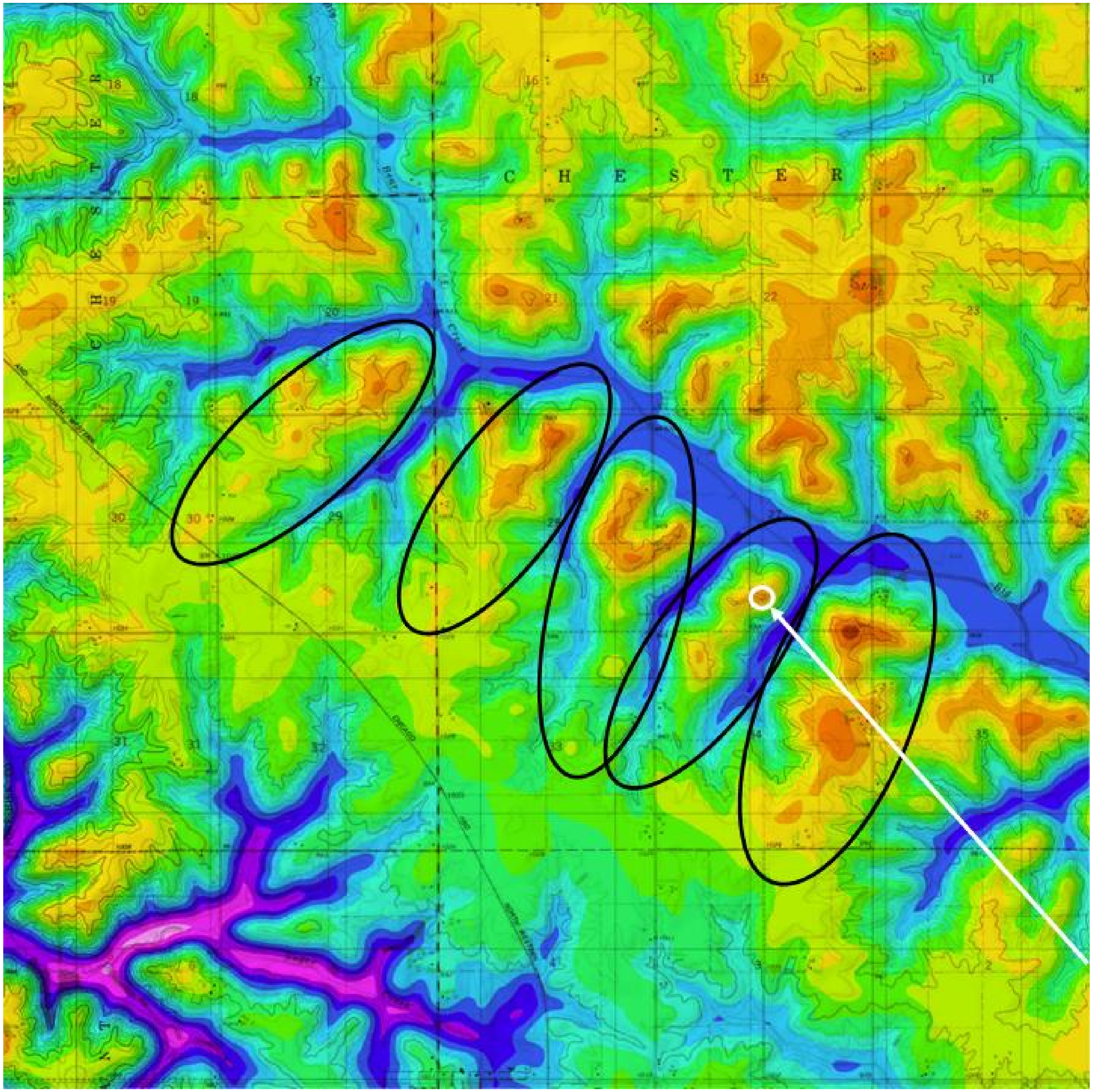
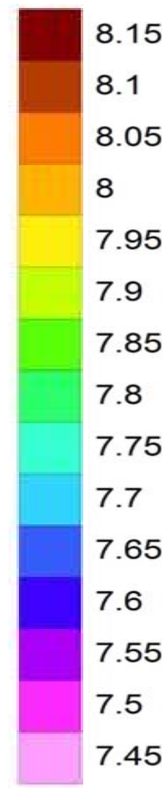


FIGURE 1
Mean Wind Speeds Northeast of Grinnell, Iowa In Meters per Second At 80 Meters Height



WindLogics Study Point
7.21 mps at 50 meters
8.03 mps at 80 meters

Projections of the mean annual kWh production were made for both the Clipper C96 2.5 MW wind turbine and the AWE Direct Wind 900 kW wind turbine at sites shown in Figure 1. These projections were compared to the annual electricity needs of the college campus. Anytime that the wind generation exceeds the campus load, part of the excess wind generation will be put into the net billing bank for later use and part must be sold to Alliant. The amount that is put into the net billing bank is the excess kWh generated over the month times the ratio of 500 kW to the wind turbine nameplate capacity. For example, if one Clipper 2.5 MW unit is installed, then 20% (500 / 2500) of any excess generation is put into the net billing bank, and 80% is sold to Alliant at some low wholesale price, of perhaps 2.5¢ per kWh. In order to estimate the amount of time that the wind turbines would be generating more power than the campus would use, a simulation was performed. The simulation used one full year of actual hourly loads from the college campus. This data spanned from September 1, 2005 through August 31, 2006. This was the most recent hourly data available from the college's billing data that could be downloaded from Alliant's web site. This hourly load data was then scaled up to match the amount of projected load on campus in 2008, which was 21,737,000 kWh. Although there was no historical hourly wind speed data from the Grinnell area, actual wind generation data for the same hours was taken from the three wind turbines at Algona, Iowa. Again, this hourly wind generation data was scaled up to match both the generating capacity and expected annual wind generation at Grinnell. The hourly loads and hourly generation were then compared to determine if wind generation exceeded the campus load. Any excess generation over the course of the hour was accumulated throughout the year to provide an estimate of how much would be allocated to the net billing bank and how much would be sold. Although this analysis is only a rough approximation of the excess generation for a specific period, it does provide some idea of how much wind generation the campus can use. Appendix 2 has 4 graphs comparing the simulated hourly wind generation with two Clipper C96 turbines at the far northeastern site and the projected hourly campus load over the course of the year 2008.

Table 2 below shows the projected mean annual wind generation for several different sizes of wind turbines, installed at the near-north sites and the far northeastern sites. The table also includes an estimate of the amount of wind generation that would be in excess of the net billing cap, and that would have to be sold back to Alliant at a wholesale rate. The table shows if two Clipper 2.5 MW wind turbines are installed, about 25% of the annual wind generation would have to be sold back to Alliant at the 2008 projected load levels. As the campus load increases over time, the amount sold back to Alliant would decrease. With a projected campus load of 29,200 MWh in 2015, about 14% would be sold back to Alliant.

Minor changes in Iowa's net billing law would allow more of the electricity to be banked and used at a later time. For example, the Iowa Utility Board rules on calculating how the 500 kW net billing cap is applied could be changed so that up to 500 kW of excess generation could stored in the net billing bank, rather than a prorated amount of the excess generation. This modest change alone would reduce the amount sold in 2008 from 25% down to 19.5%. Furthermore, if the cap were raised to 1 MW, the amount sold would reduce even further to 13%.

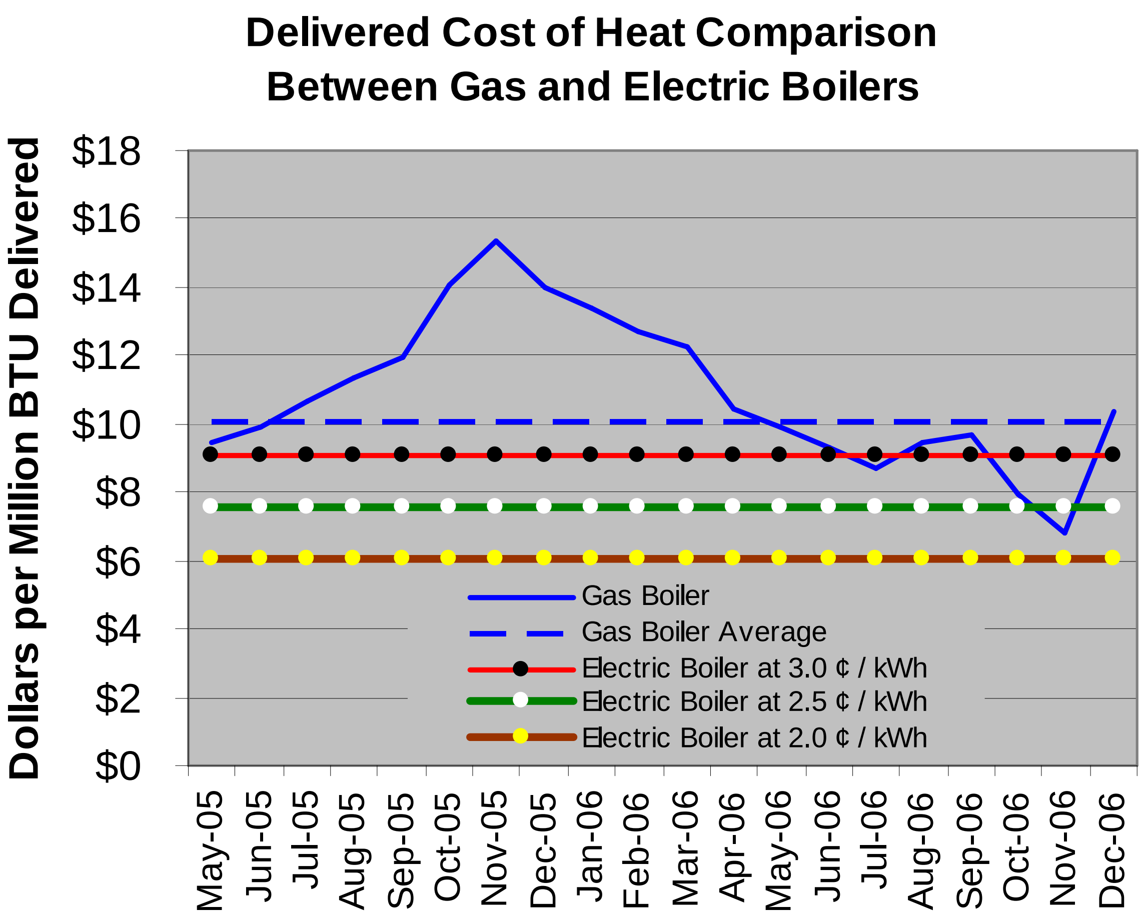
TABLE 2

Amount of Power Generated and Sold for Various Wind Turbine Options

	Annual Wind Generation	Annual Campus Load in 2008	Excess Generation to Grid	Excess to Net Billing Bank	Excess Generation Sold	Percent of Generation Sold in 2008	Percent of Generation Sold in 2015
	Mwh	Mwh	Mwh	Mwh	Mwh	%	%
Near North Sites							
1 AWE - 900 kW	2,731	21,737	0	0	0	0.0%	0.0%
2 AWE - 1,800 kW	5,458	21,737	0	0	0	0.0%	0.0%
1 Clipper - 2,500 kW	8,007	21,737	254	51	203	2.5%	0.1%
2 Clipper - 5,000 kW	15,887	21,737	4,261	426	3,835	24.1%	13.6%
Far Northeastern Sites							
1 AWE - 900 kW	2,905	21,737	0	0	0	0.0%	0.0%
2 AWE - 1,800 kW	5,761	21,737	0	0	0	0.0%	0.0%
3 AWE - 2,700 kW	8,663	21,737	419	78	341	3.9%	0.4%
4 AWE - 3,600 kW	11,503	21,737	1,612	224	1,388	12.1%	3.9%
5 AWE - 4,500 kW	14,340	21,737	3,189	354	2,835	19.8%	10.0%
6 AWE - 5,400 kW	17,049	21,737	5,068	469	4,599	27.0%	16.2%
1 Clipper - 2,500 kW	8,281	21,737	279	56	224	2.7%	0.1%
2 Clipper - 5,000 kW	16,290	21,737	4,498	450	4,048	24.9%	14.1%
3 Clipper - 7,500 kW	24,299	21,737	10,630	709	9,922	40.8%	29.8%
Note: Most of the amount shown as being sold could alternatively be used in a new electric boiler.							

The cost of wind power to the campus decreases as more wind generation is installed, especially at the far northeastern sites. The drop in cost is due in large part to the better utilization of the long underground 13 kV cables for interconnection. One way to justify additional wind generation without having to sell the excess power back to Alliant at a low wholesale rate is to install an electric boiler that would be operated during the heating season when there would be excess wind generation. The blue line in Figure 2 portrays the cost of heat delivered from the College's main gas-fired steam boilers for the past 20 months, based on an 84% thermal efficiency. With gas costing an average of $0.85 per therm over the 20-month period and a boiler efficiency of 84%, the average delivered cost of heat would be about $10 per million BTU. The red, green and brown lines show the cost of heat delivered from an electric boiler, based on a 97% thermal efficiency. Electricity priced at 3.3¢ per kWh would deliver the same price of heat as the average price of gas over the 20-month period. Therefore, if Alliant pays less than 3.3¢ per kWh, then an electric boiler will deliver lower cost heat.

FIGURE 2

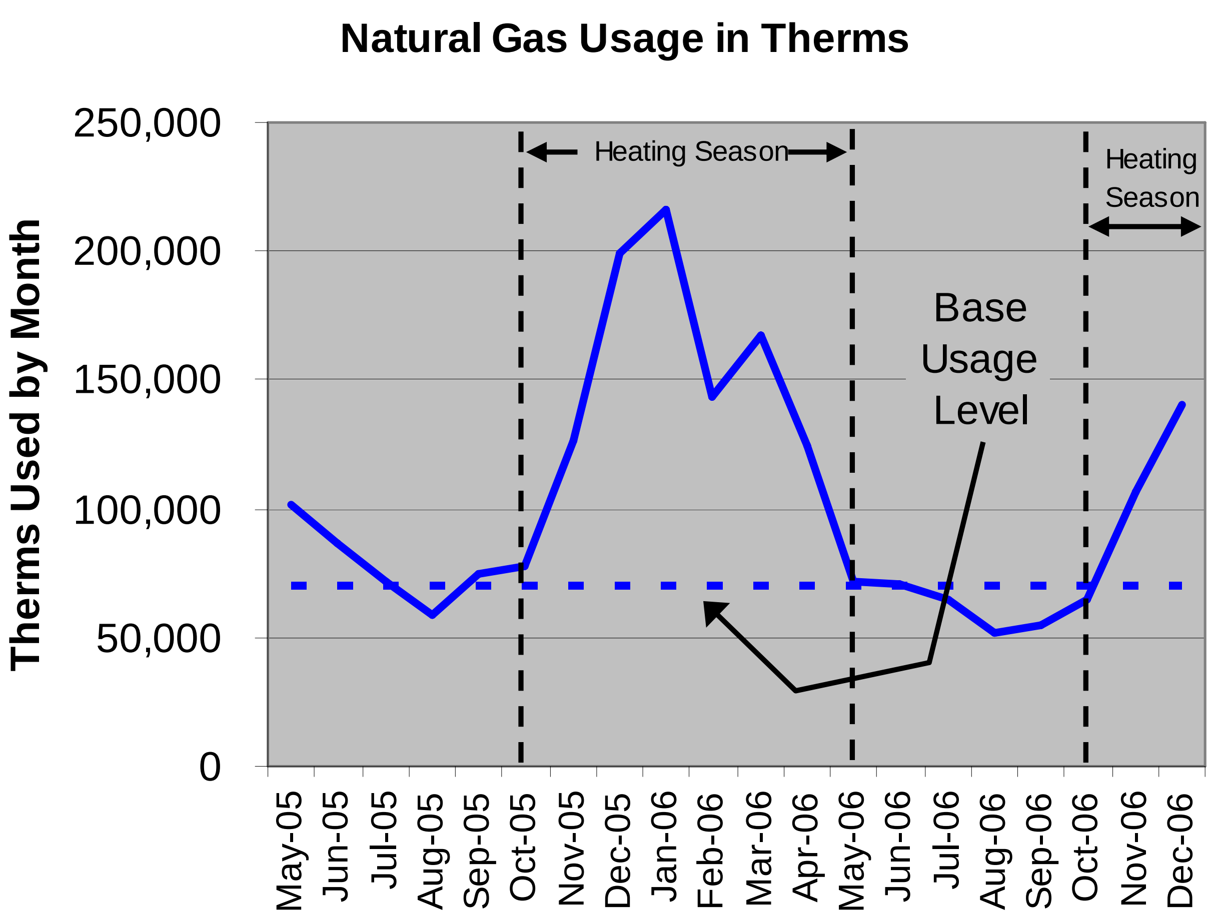


About 80 to 85% of the excess wind generation that would be sold to Alliant would be during the heating-season months of October through April. If an electric boiler were installed to better utilize the excess electricity from 5,000 kW of wind generation, and assuming the boiler could be automatically operated to utilize 90% of the excess generation that would otherwise be sold to Alliant during the heating season, the electric boiler would save 115,000 therms of gas annually.

If the average price of gas during the heating season was $1.00 per therm, the annual gas cost savings would be $115,000. If Alliant were paying 2.0¢ per kWh for the excess generation, then the college would forgo revenue of about $60,000, thereby making the net savings of only $55,000 per year. Mr. Whitney estimated the cost of a 4.2 MW electric boiler from Precision Boiler might cost about $300,000 installed. With a $55,000 annual savings, the electric boiler would have a simple payback of less than 6 years, based on natural gas costs of $1.00 per therm. Of course, if gas prices are higher or electric buyback rates are lower, the savings and payback would improve.

Based on this analysis, adding an electric boiler would likely be a cost-effective way to use excess wind generation that would otherwise be sold to Alliant at a low cost. Likewise, including an electric boiler as a part of the wind turbine project would reduce the overall payback. This is discussed in Section 4 of this report. Further investigation will be needed to determine if an electric boiler can be ramped up and down to roughly follow wind generation variations throughout the day, and how this fluctuating output will affect the existing gas-fired boilers. A specialized control scheme will also be needed to control the electric boiler, and perhaps gas-fired boiler, based on the College's real-time electric meter readings.

FIGURE 3

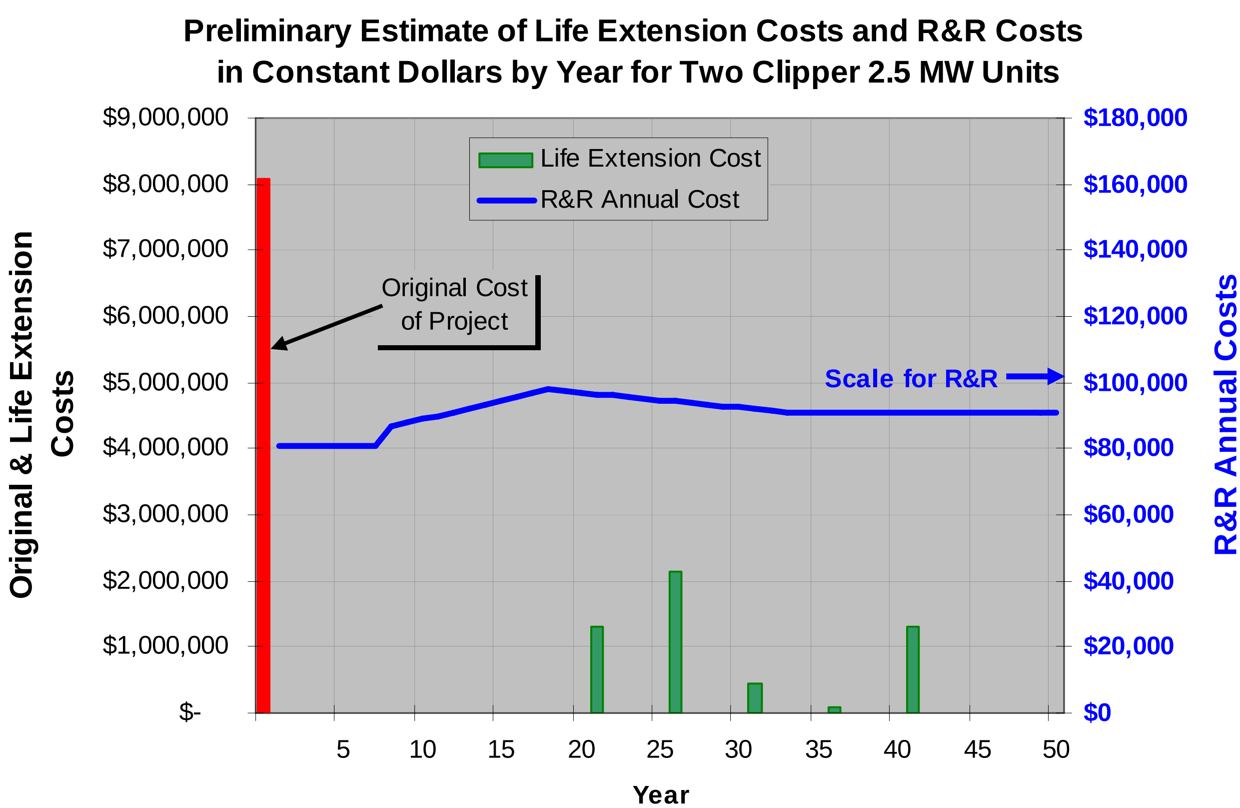


The total natural gas usage is illustrated in Figure 3. Based on this data, the total annual usage would be about 1,400,000 therms of natural gas. If the base gas usage is about 70,000 therms a month, as depicted by the dashed blue line in the graph, then the heating season usage would be the amount above the dashed line, or 575,000 therms, which is about 40% of the annual total of 1,400,000 therms. Considering the relative thermal efficiencies of natural gas and electric boilers, it takes about 25 kWh to replace 1 therm of gas usage. To replace all of the 575,000 therms of winter heating gas usage would require about 5 MW of wind generation. To replace the total current annual natural gas usage would require about 11 MW of wind generation. It would take another 6.5 MW of wind generation to replace all of the campus' electricity needs. Collectively it would require about 16.5 MW of wind generation to provide all of the campus' current energy needs. Replacing all of the electricity and natural gas needs would require a means to store energy from the wind farm for periods when the wind energy doesn't match the campus' thermal and electricity needs. Although this may be technically possible, it would be costly to build today, and not cost effective when compared to continued use of fossil fuels. Nevertheless, this example illustrates the tremendous wind energy potential that is available at Grinnell. Concerns about climate change and fossil fuel depletion will undoubtedly push advancements in storage technologies that will allow wind and solar energy to replace all of the College's fossil fuel needs.

SECTION 3
ANALYSIS OF LIFE EXTENSION BENEFITS

Conventional economic analysis of wind generation projects is based on a 20- to 25-year economic lifetime. Since the economic justification is based on achieving the desired paybacks and return levels within 10 to 15 years, the value or benefits of a longer life are not of much interest in most projects. However, if the owner does have a long-term perspective, then the value or benefits of a longer useful life should enter into the economic analysis and justification for a project. Based on the College's long-term perspective and continuous investments in its infrastructure, additional analysis was made for determining the value for future investments in the wind turbines for life extension purposes. Given expected increases in energy prices and the need for pollution-free energy sources, the value of wind generation should increase over time, since no fuel is required. Many components of a wind turbine project require minimal refurbishment to extend their lives. For example, the tower and foundation could last 50 years with very modest investments in paint, corrosion protection, and repairs. Technological advances will likely provide better methods of testing, analysis, and treatments for extending component lifetimes. Many of the better designed wind turbines installed in the mid 1980's in California are still operating today. The economics justify life extension investments if they are not too large.

FIGURE 4

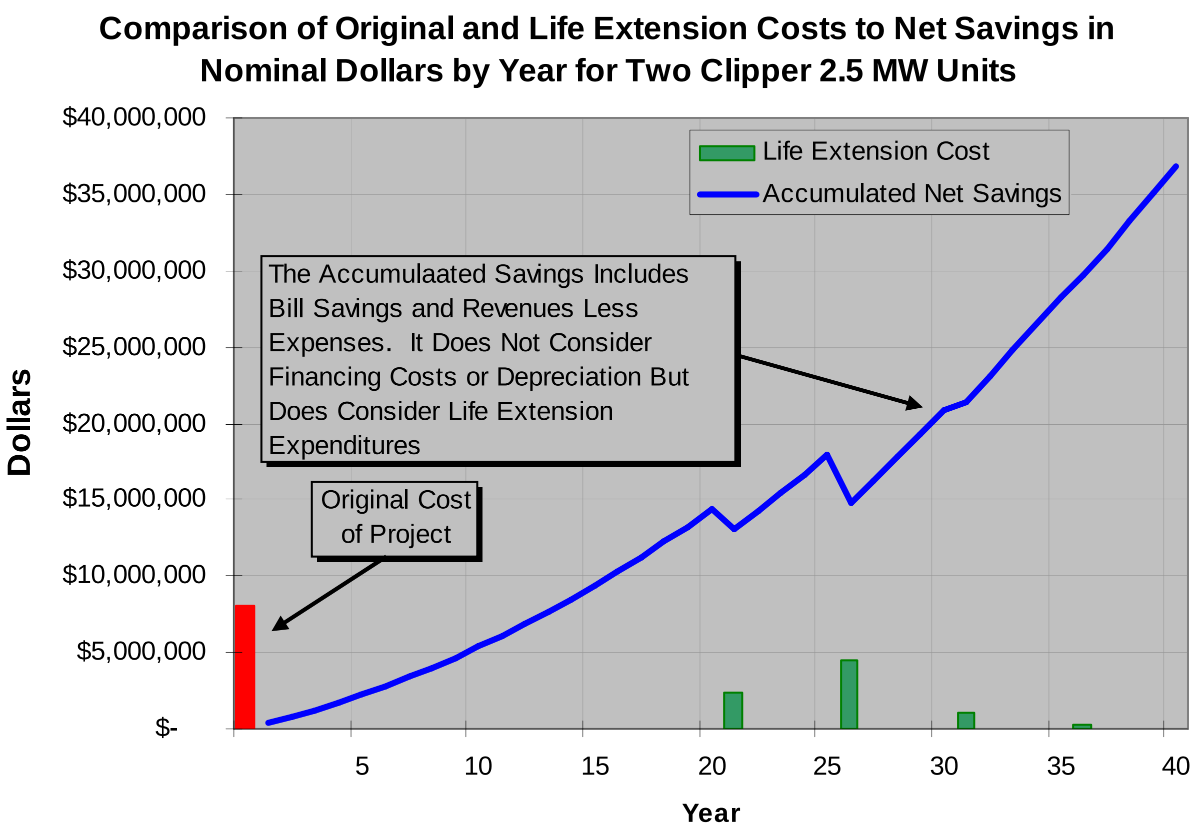


Based on a long-term perspective and the ever continuing need for more energy, conceptual cost estimates were made for the cost of extending the life of a wind turbine to 50 years, which is double the typical expected lifetime. Figure 4 depicts the total original project cost to the College for two Clipper 2.5 MW wind turbines at the far northeastern site. The red bar shows the original cost while the green bars show the major life extension refurbishment costs that occur at various points in the future, depending upon the component. The blue line shows the extraordinary Repair and Replacement ("R&R") costs above normal maintenance expenses. These R&R costs cover gearbox repairs, generator repairs, and repair and replacement for items that normally wear out. All of the costs shown in Figure 4 are in constant or inflation-adjusted real dollars, which excludes any effects of inflation. By showing all expenditures in constant dollars, the graph compares the true costs more accurately. It should be noted that these cost estimates are very rough, since little is now known about these long-term costs for large wind turbines.

As Figure 4 shows, the life-extension refurbishment costs in the green bars are modest, total about 66% of the original cost, and are spread out over a 30-year period. Therefore, an investment of 66% of the original cost doubles the amount of energy produced. Therein lies the value of these life extension benefits.

Figure 5 compares the original capital and life-extension costs to the accumulated net savings from installing two Clipper units at the far northeastern site. This graph shows the costs in nominal dollars rather than inflation adjusted dollars as used in Figure 4 above. The accumulated savings exceed the capital costs after 13.5 years (simple payback period). Even after deducting the life- extension costs, the accumulated net savings still exceed the original capital cost several times over during a 40-year period. The Internal Rate of Return ("IRR") for this particular scenario is 6.3% at the end of 20 years, and 7.9% at the end of 40 years. Adding an electric boiler to this scenario only marginally improves the payback with two wind turbines.

FIGURE 5



SECTION 4
ECONOMIC ANALYSIS OF WIND GENERATION OPTIONS

An economic analysis was made for eight different scenarios of wind generation options. This includes two models of wind turbines (the Clipper 2.5 MW and AWE 900 kW) units. A critical factor in this analysis is the electric power bill savings. The power cost savings per kW has been increased since the original April 2006 report, due to higher than expected electricity prices from Alliant. Furthermore, a Democratic Party controlled Congress has already proposed a number of bills addressing climate change, which would add to the price of electricity from fossil fuels. Collectively, these two factors are projected to result in a 20-year compounded escalation rate of 4.6% in the cost per kWh saved in the College's electric power bills. Compared to the previous study's 3.4%, the resulting higher estimate of power bill savings has greatly improved the economics of wind generation.

Table 3 shows the annual wind generation, percentage of electric energy needs provided by the wind generation, and the amount sold back to Alliant at an initial price of 2.1¢ per kWh. The table also includes the projected capital costs, simple paybacks, and Internal Rate of Returns ("IRR") for a number of different scenarios. Another measure shown is the average operating cost of the wind generation in cents per kWh. This measure excludes any fixed financing costs. It should be noted that there is some uncertainty in the wind speed estimates, which are the most important factor in the entire analysis. Also, wind turbine prices have increased significantly over the past two years. Therefore, wind turbine prices may be higher than projected in this analysis.

The results in the table suggest the simple payback for most of the options range from 13 to 14.5 years. These simple paybacks translate into IRRs of 4% to 6% over a 20-year period. Adding an electric boiler marginally improves the IRR by about 0.5%. This is based on gas savings starting at $1.00 per therm and escalating 3% per year.

It is a little surprising that even with three Clipper 2.5 MW wind turbines providing 7.5 MW of power, they only provide about 59% of the campus' needs. The balance must be sold back to the utility or potentially used in an electric boiler. Iowa's 500 kW cap on net billing allowed about 7% of the wind power to be banked for later use.

It should be noted that there are potentially four wind turbine suppliers that may bid on this project. In addition to Clipper and AWE, Fuhrlaender and Vensys may also be available. All but Clipper are smaller manufacturers specializing in the niche markets like this.

It appears that most of the wind turbine options are economically viable, however, the IRR's are not very high. If the College receives a bequest for the wind generation project, then the simple payback and IRR would improve if the bequest was not counted as part of the capital cost. Table 4 compares the IRRs for the same eight scenarios shown in Table 3 with and without a $1,000,000 bequest. The bequest increases the IRR for the lower cost projects the most since the bequest is a larger part of the cost. For two Clipper turbines, the IRRs go up by about 1.5% at 20 years and the simple payback improves from 13.5 years to 12.2 years.

TABLE 3

Results of Economic Analysis for Various Wind Generation Options and Sites															
					Percentage of Wind Generation Sold to Alliant					Internal Rate of Return					
										No Electric Boiler			With Electric Boiler	
#	Scenario	Wind Gen. Capacity	Mean Annual Wind Generation	% of Campus Electricity Provided by Turbines	No Electric Boiler	With Electric Boiler	Total Capital Cost	20 Year Level-ized Oper-ating Cost	Simple Pay-back	At 10 Years	At 20 Years	Life Exten. At 40 Years	At 10 Years	At 20 Years
		kW	Mwh	%	%	%	Mil. $	¢ / kWh	Years	%	%	%	%	%
	Near North Sites													
1	One AWE Turbine, North Site	900	2,731	10.2%	0.0%		$2.1	1.37	15.9	-9.2%	2.8%	5.9%		
2	One Clipper Turbine, North Site	2,500	8,007	29.4%	1.6%		$4.3	1.86	13.2	-5.6%	5.3%	7.8%		
3	Two Clipper Turbines, North Sites	5,000	15,887	47.8%	19.3%	1.9%	$8.0	1.79	13.6	-6.4%	5.0%	7.8%	-5.5%	5.4%
	Far Northeastern Sites													
4	Two Clipper Turbines	5,000	16,290	48.7%	19.8%	2.0%	$8.1	1.76	13.5	-6.2%	5.2%	7.9%	-5.2%	5.6%
5	Three Clipper Turbines	7,500	24,299	58.5%	35.5%	3.5%	$11.7	1.72	14.6	-7.8%	4.1%	7.3%	-5.2%	5.5%
6	Four AWE Turbines	3,600	11,503	39.2%	8.6%	0.9%	$6.9	1.15	13.3	-5.9%	5.3%	7.8%	-6.0%	5.1%
7	Six AWE Turbines	5,400	17,049	49.6%	22.1%	2.2%	$9.9	1.12	13.8	-6.8%	4.8%	7.6%	-5.7%	5.3%
8	Eight AWE Turbines	7,200	22,608	56.4%	33.2%	3.3%	$12.8	1.10	14.4	-7.7%	4.2%	7.2%	-5.7%	5.3%

Notes:

Since campus electric loads are growing, the percentages of wind generated electricity that are used by the campus or sold are averages for the first 10 years of operation. The "Total Capital Cost" does not include an electric boiler.

by about 3% compared to the previous study. No monetary value was placed on the environmental attributes of wind energy in this additional analysis.

If a $1,000,000 bequest is received for the project, the IRRs go up by about 1.5% at 20 years and the simple payback improves by about 3 years for wind projects in the 5,000 kW size range.

This study also considered a smaller 900 kW direct drive wind turbine as an alternative to the much larger 2.5 MW Clipper turbines. Even though the initial cost per kW is higher for the smaller turbines, the overall payback and IRRs are comparable for the same amount of wind generation, because of their simpler design and lower long-term maintenance costs. Therefore, installing these smaller wind turbines appears to be economically competitive with the larger wind turbines. Even though it is unlikely that any large wind turbine company will sell one or two wind turbines to the College, due to the high demand for wind turbines now, there are at least two other smaller niche manufacturers that are willing to provide wind turbines. Therefore, the College will likely have some options if it decides to proceed with the wind project.

As in any planning study, there is always some uncertainty in the findings. Most of the uncertainty in this study is associated with the accuracy of the wind speed estimates and the amount of future escalation in electricity costs. This level of uncertainty might result in paybacks being up to 4 years longer than shown in this study.

In conclusion, an investment in wind generation will likely have a simple payback of about 14 years with a 20-year IRR of about 5%.

Thomas A. Wind
Wind Utility Consulting
January 30, 2007

APPENDIX 1

WindLogics Wind Speed Study

for One of the Far Northeastern Sites

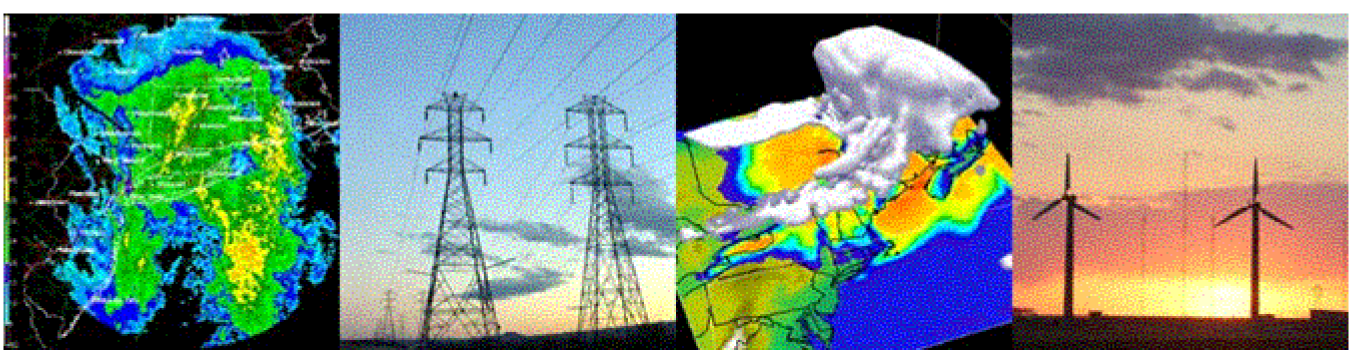
WindLogics®

Wind Utility Consulting

Grinnell College

Wind Resource Analysis

August 11, 2006



Wind Utility Consulting Summary Report
Grinnell College

Executive Summary

1. INTRODUCTION

Wind Utility Consulting engaged WindLogics to analyze the detailed wind characteristics of the Grinnell College site. The objective of this study is to provide an analysis of the overall wind regime, including a long-term estimation of the wind resource at 50 and 80 m above ground level (AGL), for one virtual tower located on the Grinnell College site (see Table 1). The site is located about 5 km northeast of the city of Grinnell in Poweshiek County, Iowa.

Tower	Latitude	Longitude	Elevation
	(WGS 84)	(WGS 84)	(in meters)
Tower 1	N 41.7928	W 92.6983	301

Table 1: Virtual Tower Location

2. SUMMARY OF RESULTS

2.1 Annual Wind Speed

At the virtual tower location, the annual average wind speed at 50 m above ground level (AGL) is 7.21 m/s. The annual average wind speed at 80 m AGL is 8.03 m/s.

2.2 Seasonal Characteristics

We typically see decreased wind speeds during the summer months and increased wind speeds during the transitional and cooler months. Table 2 displays the average seasonal wind speeds for each analysis height at the virtual tower location.

Tower	50 m AGL		80 m AGL	
	Oct - May	Jun - Sep	Oct - May	Jun - Sep
Tower 1	7.83	5.97	8.67	6.75

Table 2: Average Seasonal Wind Speed Values (in m/s) at the Virtual Tower Location

2.3 Meteorological Overview

The location and strength of the jet stream and related tracks of synoptic-scale weather systems dominate the meteorology of the Upper Midwest (i.e., low and high pressure systems). During the winter and transitional seasons, the Grinnell College site is influenced by transient and developing synoptic-scale weather systems associated with the cool/cold season jet stream position. These systems establish the pressure gradients that drive low-level winds. In the summer, the jet stream weakens and moves north, resulting in generally weaker synoptic systems and weaker winds.

NORMALIZED MONTHLY AND ANNUAL AVERAGE WIND SPEED VALUES

Normalized Monthly and Annual Wind Speed Averages (in m/s)
Grinnell College - Tower 1 – 50 m

Month	m/s
January	8.36
February	7.73
March	8.41
April	7.76
May	7.53
June	6.47
July	5.45
August	5.49
September	6.48
October	7.50
November	7.76
December	7.62
Annual Average	7.21

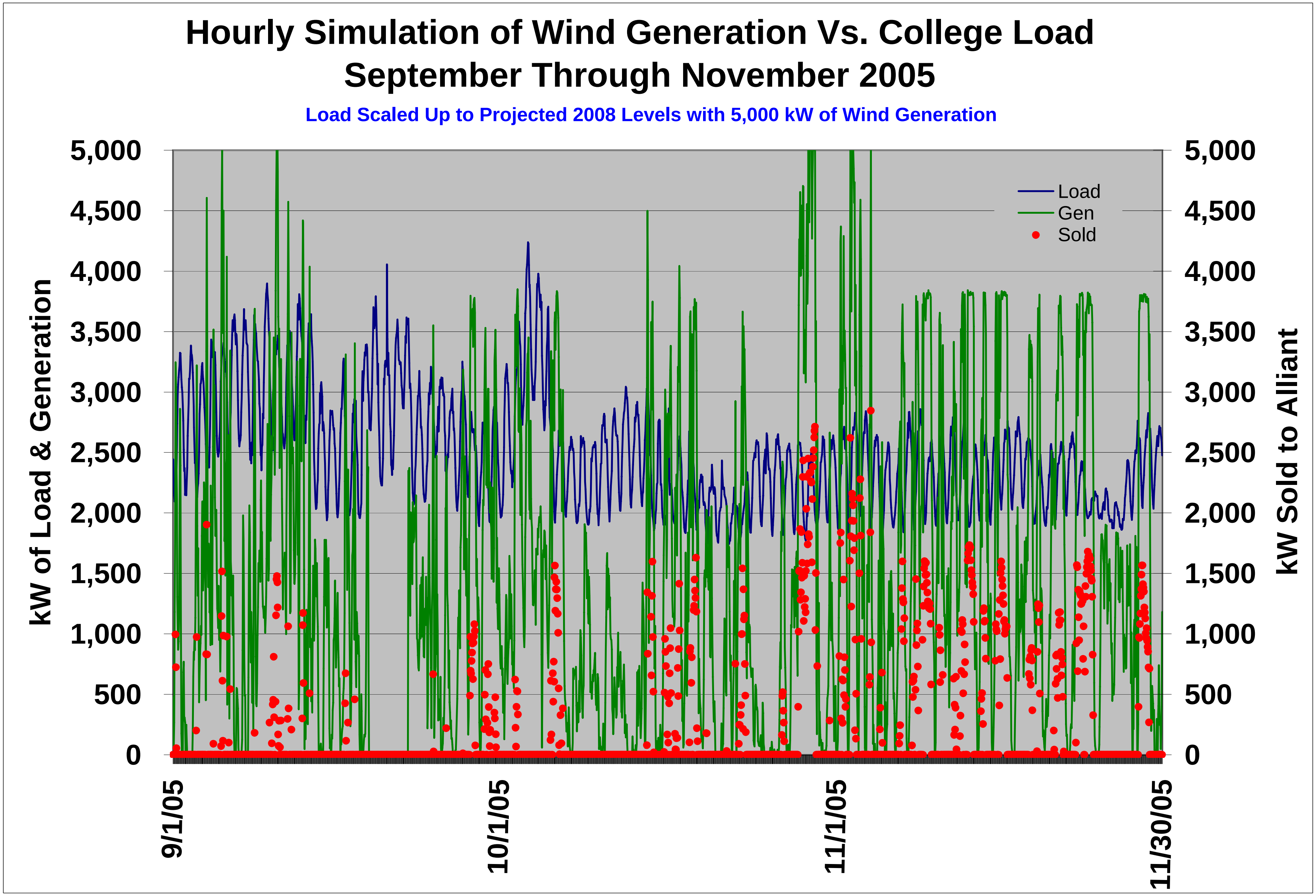
Normalized Monthly and Annual Wind Speed Averages (in m/s)
Grinnell College - Tower 1 – 80 m

Month	m/s
January	9.20
February	8.54
March	9.21
April	8.51
May	8.27
June	7.23
July	6.20
August	6.26
September	7.31
October	8.42
November	8.67
December	8.57
Annual Average	8.03

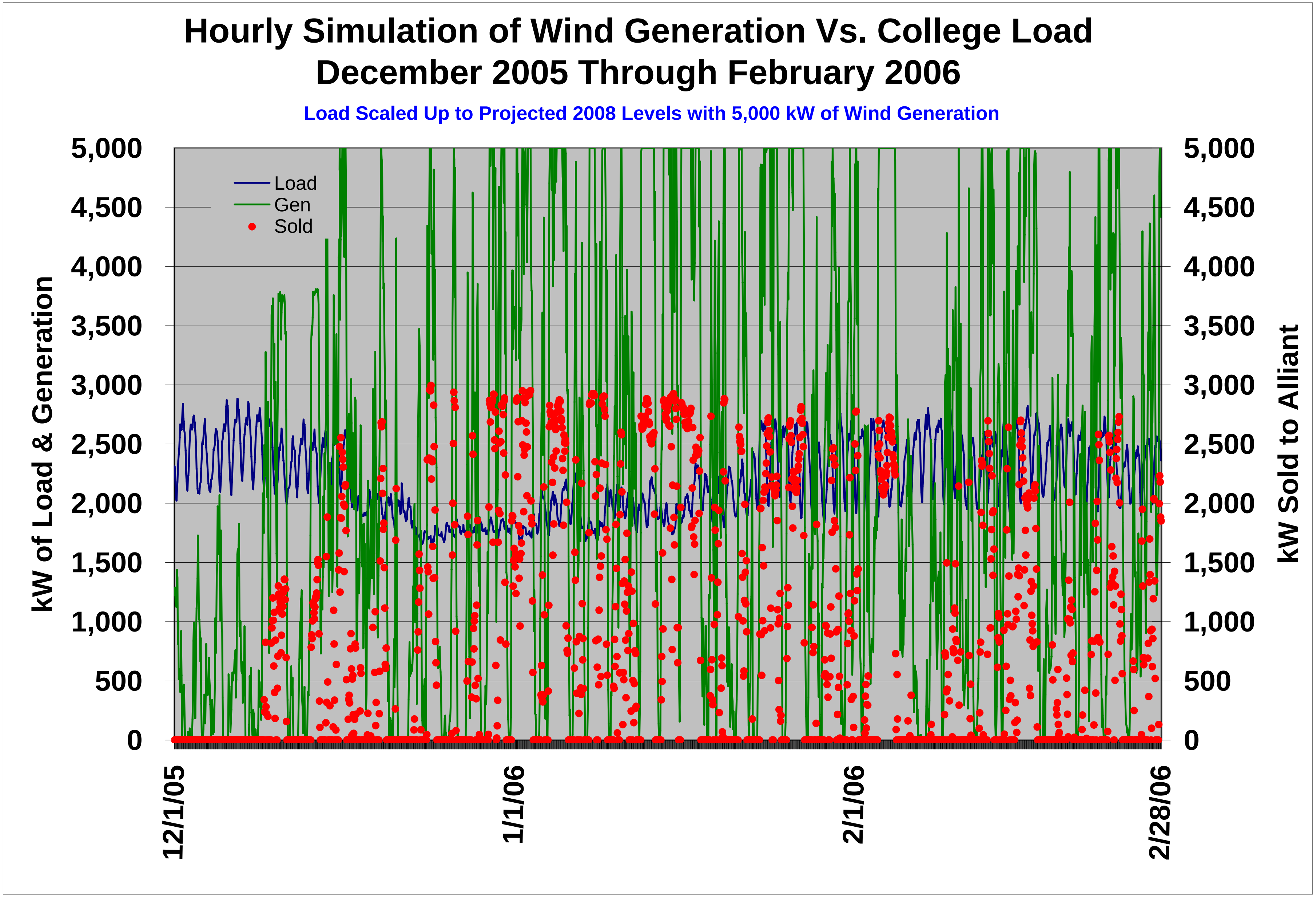
Mean quantities normalized to long-term average.
Data distributions representative of modeled year.

APPENDIX 2

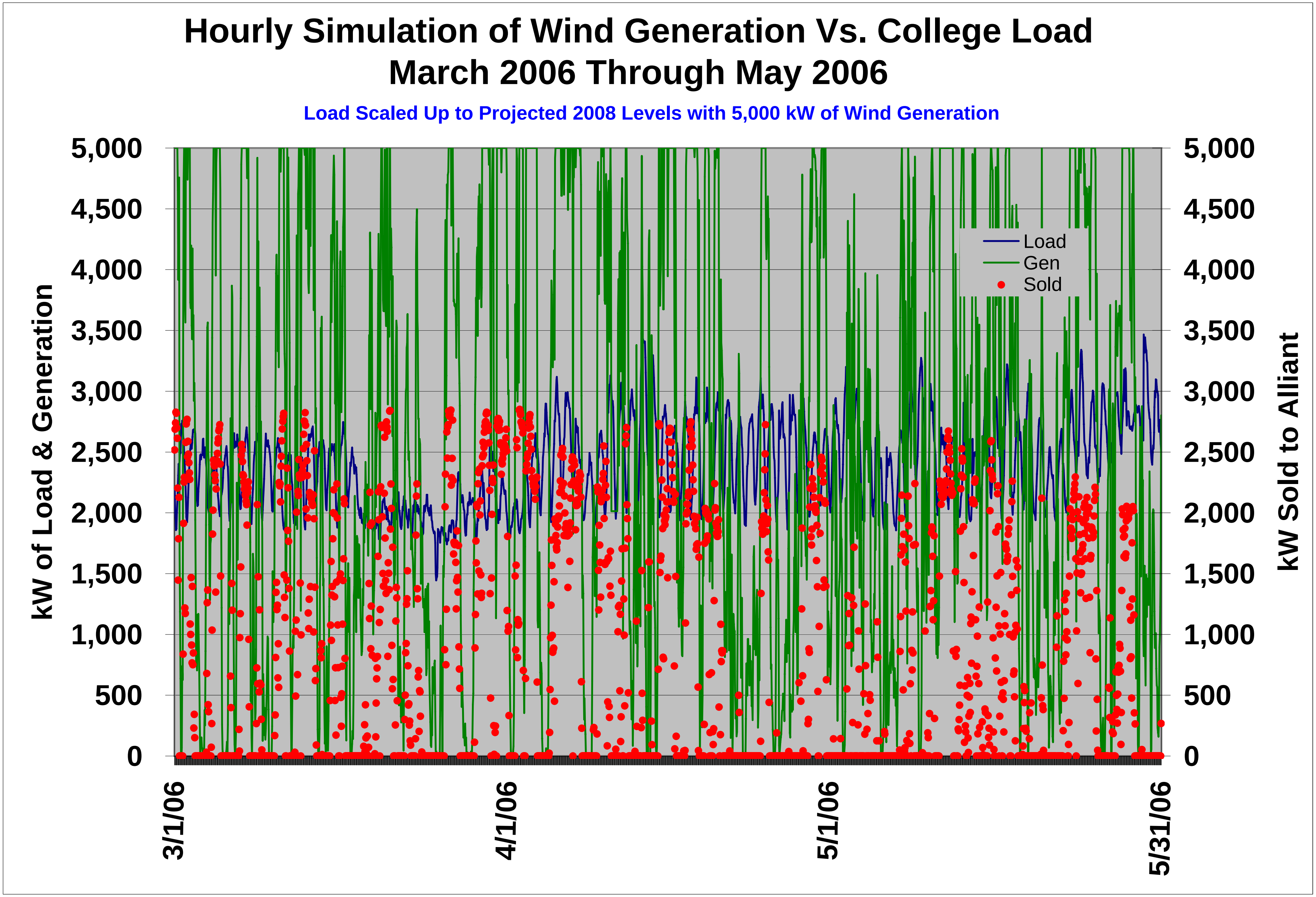
This Appendix Includes Four Graphs Showing an Hourly Simulation of 5000 kW of Clipper Wind Generation at the Far Northeastern Site and the Projected 2008 Grinnell College Campus Load

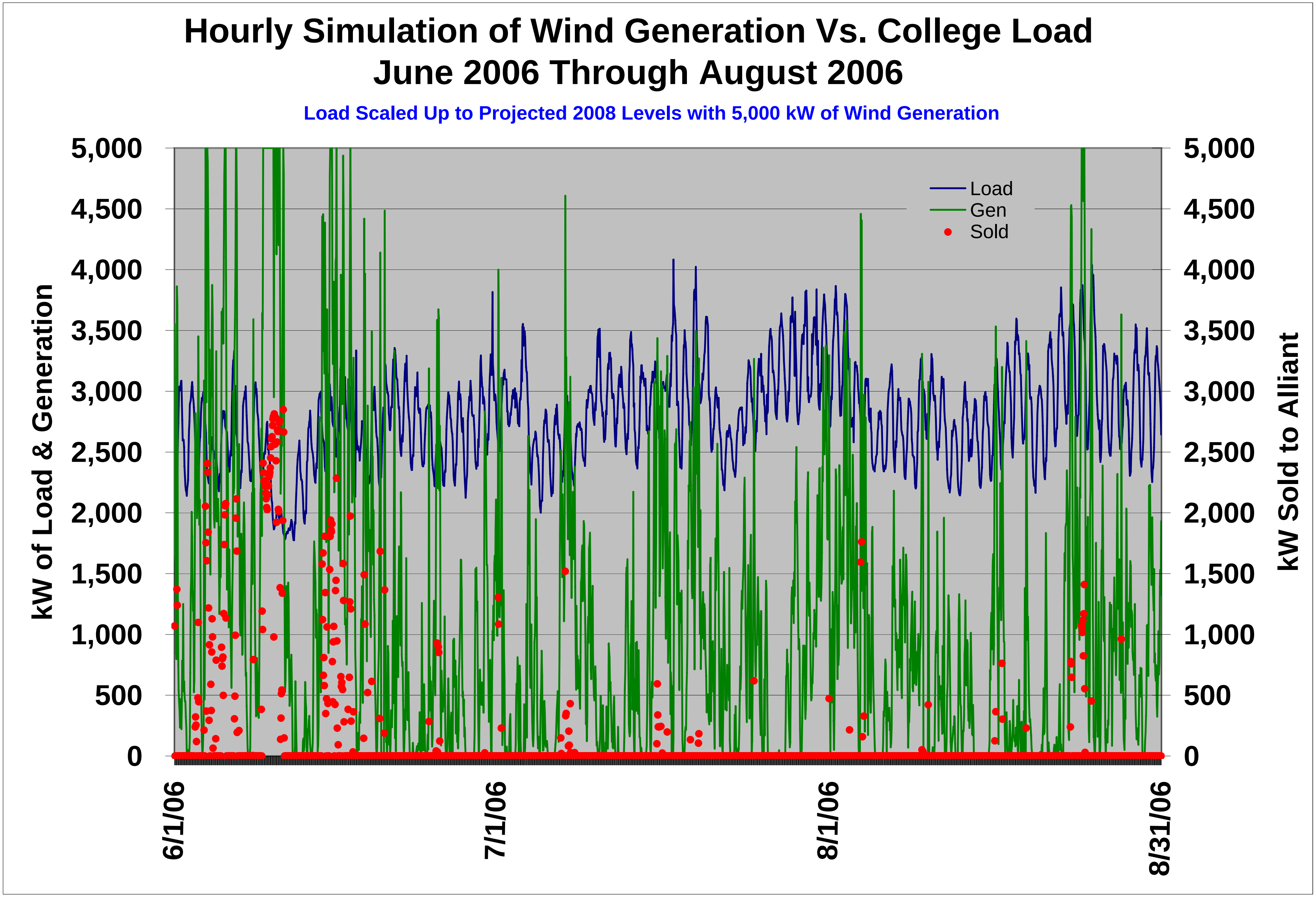


Hourly Simulation of Wind Generation Vs. College Load
September Through November 2005
Load Scaled Up to Projected 2008 Levels with 5,000 kW of Wind Generation
kW of Load & Generation
kW Sold to Alliant
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Load
Gen
Sold
9/1/05
10/1/05
11/1/05
11/30/05



Hourly Simulation of Wind Generation Vs. College Load
December 2005 Through February 2006
Load Scaled Up to Projected 2008 Levels with 5,000 kW of Wind Generation
Load
Gen
Sold
kW of Load & Generation
kW Sold to Alliant
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
12/1/05
1/1/06
2/1/06
2/28/06


Hourly Simulation of Wind Generation Vs. College Load
March 2006 Through May 2006
Load Scaled Up to Projected 2008 Levels with 5,000 kW of Wind Generation
kW of Load & Generation
kW Sold to Alliant
Load
Gen
Sold
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
3/1/06
4/1/06
5/1/06
5/31/06



Hourly Simulation of Wind Generation Vs. College Load
June 2006 Through August 2006
Load Scaled Up to Projected 2008 Levels with 5,000 kW of Wind Generation
kW of Load & Generation
kW Sold to Alliant
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Load
Gen
Sold
6/1/06
7/1/06
8/1/06
8/31/06

Appendix 2. Summary of Issues Regarding Bird Deaths and Wind Turbines

Possible adverse impacts on bird populations, is a common concern regarding the installation of wind turbines. The main concern is death due to collisions, and a secondary concern is the degradation of the habitat in which the turbines are constructed. Site specific characteristics, such as location relative to a migratory route or high quality habitat, are the predominant indicators of a detrimental impact on bird populations. Infrastructure characteristics, such as guy-wires or lattice based towers, should also be considered.

Two of the largest causes of bird mortality are loss of habitat and collisions with man-made objects. Loss of high quality habitat is critically important, and placement of turbines should avoid high quality areas. Since wind turbines are a source for collision, it is important to understand the frequency of collisions at existing wind "farms" and how those situations may relate to a site near Grinnell.

<u>Research</u>

The National Wind Coordinating Committee conducted an analysis of all available research focused on avian mortality due to wind turbines. They found that the avian mortality per turbine, per year was 1.83 excluding the state of California. Studies conducted in the Midwest agree with the national numbers. The University of Wisconsin-Green Bay studied 31 turbine sites operating in Kewaunee County and found an even lower mortality rate of 1.29 birds per turbine per year.

<u>Infrastructure Considerations</u>

Although the impacts from collision appear to be low, several infrastructure considerations would ensure the impacts are minimized. First of all, fewer, larger turbines are preferred over numerous small machines. Secondly, the towers should not be lit at night. This either attracts or confuses birds which migrate at night. Thirdly, the tower should not be a "lattice" tower; rather it should be a solid unit. A lattice tower provides opportunities for perching. Additionally, the use of guy-wires should be minimized or eliminated as they provide a collision hazard. Lastly, transmission lines should be placed underground. Transmission lines present two distinct hazards. Large winged bird species can potentially contact two "hot" wires simultaneously, resulting in electrocution. They also provide a collision hazard.

<u>Site Considerations</u>

Proper placement of wind turbines is the best way to minimize adverse effects on bird populations. The site chosen should not be along a major migration corridor. In Iowa the major routes of migration are via the large river corridors, the Mississippi, the Missouri, and to a lesser extent, interior systems such as the Des Moines, Iowa and Cedar rivers. The site should also avoid fragmenting or degrading a high quality habitat.

<u>Grinnell College's Situation</u>

Overall changes in wind turbine technology are eliminating many of the aforementioned concerns. Fewer, larger turbines with slower moving blades have a much smaller impact than numerous smaller turbines with faster moving blades. The turbines suggested in the feasibility study are two relatively large 2.5 MW turbines, with a solid tower, and no guy-wires.

The proposed sites appear to be very acceptable sites from an avian impact perspective. Grinnell is essentially located on a ridge dividing the Iowa and Des Moines River systems, so the sites are not situated along a river corridor migration route. As far as habitat is concerned, the sites are located either in areas currently in row crop agriculture, overgrazed pasture, or are enrolled in the Conservation Reserve Program. The areas located in CRP are predominantly vegetated with a monoculture of stunted Smooth Brome. Construction at any of the areas would not be impacting high quality habitat.

Sources

Effects of Wind Turbines on Birds and Bats in Northeast Wisconsin; Robert W. Howe, William Evans, and Amy T. Wolf; November, 2002.

Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States; National Wind Coordinating Committee; West, Inc.; August, 2001

Wind Power and Birds: A Wisconsin Bird Conservation Initiative “White Paper”
W. Mueller, N. Cutright, S. Diehl, K. Etter Hale, J. Trick