Holy Name Central Catholic Jr. / Sr. High School Wind Turbine Feasibility IQP

Executive Summary

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In the next few years, the rising cost of electrical energy will force Holy Name Central Catholic Jr./Sr. High School in Worcester, Massachusetts, to make some difficult financial decisions that will affect the future of the institution. From August 2004 to August 2005, the school spent $127,000 on electric energy, largely due to the base-board electric heating system. As the price per kilo-watt hour (kWh) of electricity increases, it will translate into tens of thousands of additional dollars spent on heating the building each year. To cover these added expenditures, the school's administrative board will need to decide from where the necessary funds will be drawn. Possibilities may include an increase in tuition and/or enrollment, termination of teaching positions, and cuts to extracurricular programs. While these steps may provide financial solutions in the short term, the long term implication could be as drastic as the eventual closure of Holy Name High School.

In the late 1990's and early 2000's, the school performed an exhaustive search of potential solutions to their energy crisis, including adding a computerized energy management system and the complete replacement of the current heating system. The computer control option was implemented, but the benefits were found to be insignificant. The replacement of the current system was deemed economically unreasonable because of the presence of embedded asbestos.

Last year, the Holy Name administration decided to investigate on-site generation of electricity via wind power. WPI was asked for a project team to implement the preliminary study to determine the feasibility of a wind power solution. To accomplish the goal, an engineering investigation of the following areas was performed:

- Wind potential,
- Economics,
- Interfacing with the Electrical Utility,

- Ecological and Social Impacts.

If the feasibility study came out in favor of a wind turbine installation, steps would be taken to advance the project to the next phase of implementation.

The WPI team began by researching the theory behind wind power and the installation of wind turbines. Particular areas of interest included wind patterns and the necessary requirements for electric generation, turbine design and energy conversion, site preparation and tower construction, economics and associated costs, as well as social and environmental concerns. Various methods of research were used, including visits to a recently installed wind turbine, attending an alternative energy conference, meetings with wind power consultants, and a variety of on-line sources pertaining to wind power around the world. The information gathered from the sources enabled us to (a) identify the criteria necessary to determine if wind power would be a viable solution to the problem, and (b) formulate a plan for exploring these criteria.

When considering the installation of a wind turbine, there are two predominant areas of concern:

1) The economic feasibility of installing a wind turbine.
2) Fulfillment of local, state and federal regulations regarding the construction and operation of a wind turbine.

Complete and accurate assessments of these requirements are critical in determining the overall feasibility of the project.

The economics of the project were evaluated by creating a mathematical model. The model takes in the installation costs, grants, loans, projected electricity generated by the turbine, electricity usage by Holy Name, and green-energy credit programs. The model outputs the payback period, total project cost over 20 years, yearly electricity payments, and average price

per kilo-watt-hour over a twenty year period. The projected electricity generated from the turbine is calculated using a statistical model called a Weibull distribution. In this case, a Weibull distribution shows the percentage of time a certain wind speed can be expected. The data from the Weibull distributions is then compared to the electricity usage profile of Holy Name.

Based on the mathematical model, a 600 kW wind turbine would be the best fit for Holy Name. In Figure 1, a turbine of this size would produce 60-70% of the school's electricity during the peak demand periods in the winter months.

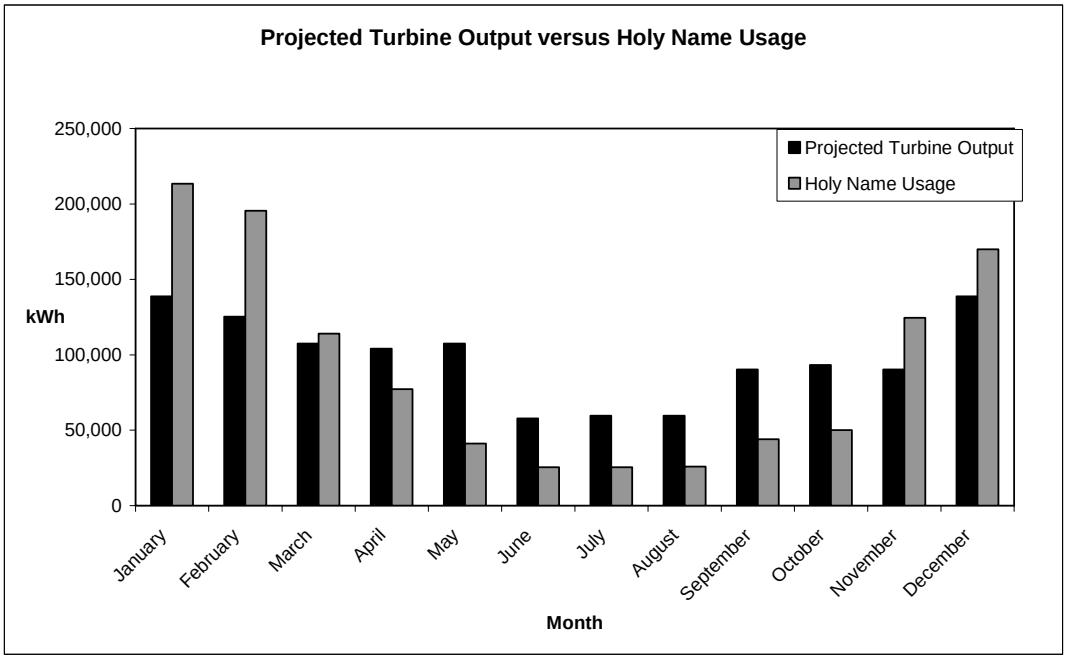


Figure 1: Projected Turbine Output versus Holy Name Usage

Given an installation cost of $1.4 million for the turbine, plus operating costs, minus the amount of money received from grants and renewable energy certificates, the result obtained from the model would be a payback period of 5 to 7 years. Over a 20 year period, the school would pay as little as $0.011/kWh for their electricity.

The initial weather data used in the Weibull distribution was taken from an online wind-mapping site. Concern regarding the accuracy of the online information led to the need to gather measurements of average wind speed and direction at Holy Name. With the permission of the Headmaster, Mrs. Mary Riordan, a guyed, welded steel tower was constructed and installed atop an old smokestack on the school. Mounted to this tower is an anemometer that measures wind speed and direction every ten minutes and stores the readings on a computer inside the school. The data is downloaded on a weekly basis and imported into excel where it can be extrapolated to the heights appropriate for wind turbines. The anemometer has been gathering data since Mid-December, 2005 and the results obtained thus far confirm the validity of the average wind speeds available online.

The investigation of the legal requirements regarding the installation began by researching the primary areas of concern at the local, state and federal levels. From the research, the necessary steps to gain approval for the construction of a wind turbine were identified. These steps included:

1) The application for a building permit from the local government,
2) The request for a grid-interconnection assessment from the respective power company,
3) An obstruction evaluation performed by the Federal Aviation Administration (FAA).

Having identified these steps, more information was gathered by interviewing individuals who have put up wind turbines and dealt with building permits, grid-interconnection studies, and FAA studies. One such resource was Brother Joseph Byron from the Portsmouth Abbey School in Portsmouth, RI.

From the information gathered via these sources, our team was able to narrow down the possible locations for a turbine. To determine the appropriate location, a thorough assessment of

the terrain and property at the school was performed. Using topographical maps, site survey information and aerial photographs, the zoning regulations regarding set-backs from property lines, line-of-sight considerations with adjacent property, noise pollution, and site access for construction vehicles were studied. The survey also took into account the interconnection of the turbine into the existing power network, encouraging a location close to an existing power line in order to minimize the need for additional wiring. Figure 2 is an aerial photo of Holy Name's property. The x near the center of the photo is the most suitable area for the school to install their turbine.

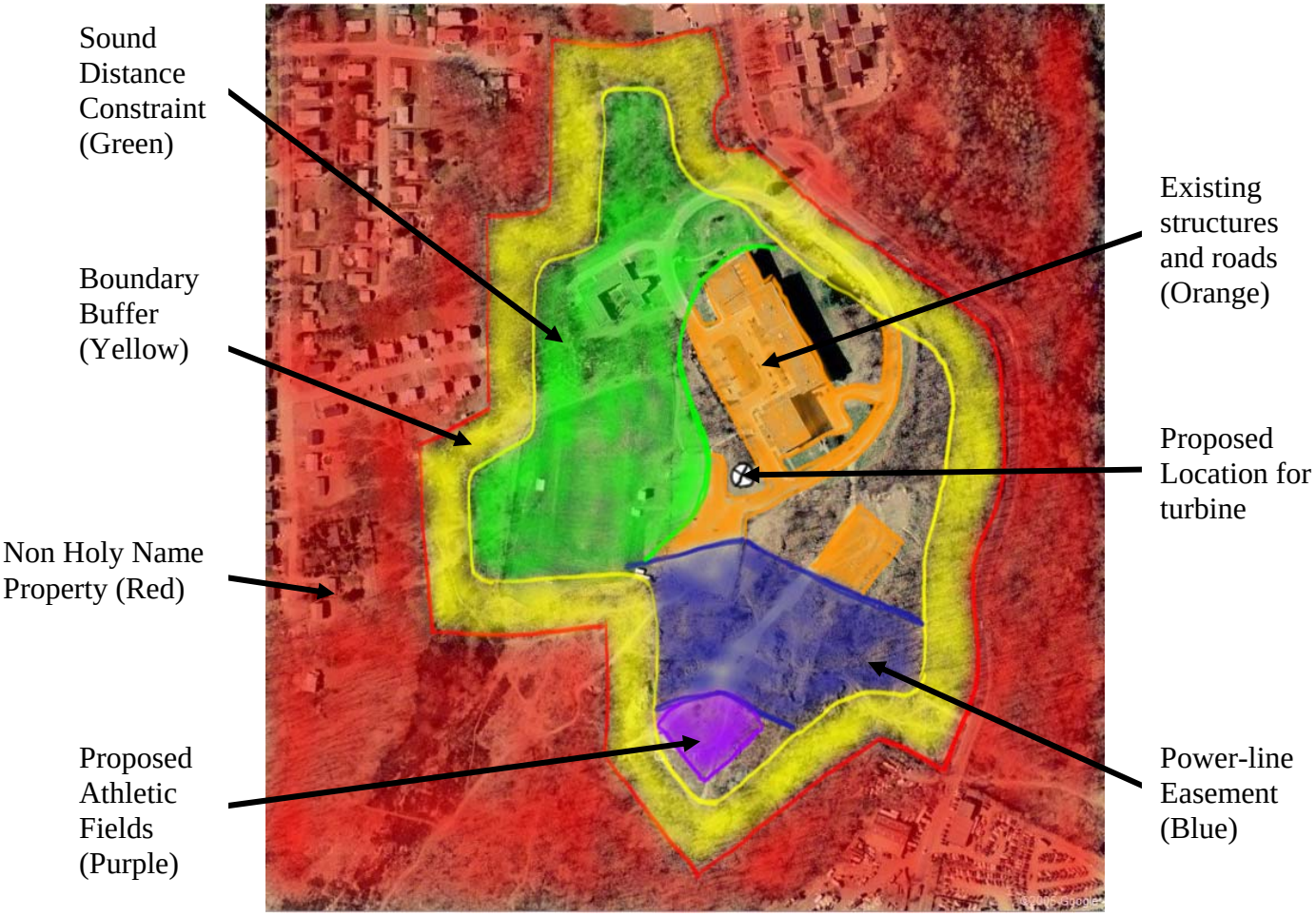


Figure 2: Aerial photo depicting the most viable area of property for a wind turbine

In addition to the land area assessment, the process for gaining approval from the FAA was researched. After participating in a conference call with a representative from the FAA, it was our responsibility to file obstruction evaluations for three specific sites on the school's property. The coordinates of these three locations, along with the necessary information regarding the specific turbines that were selected, was submitted electronically on the FAA website.

It was determined that the installation of a 600kW wind turbine at Holy Name is feasible. The conclusion was reached based upon the following information:

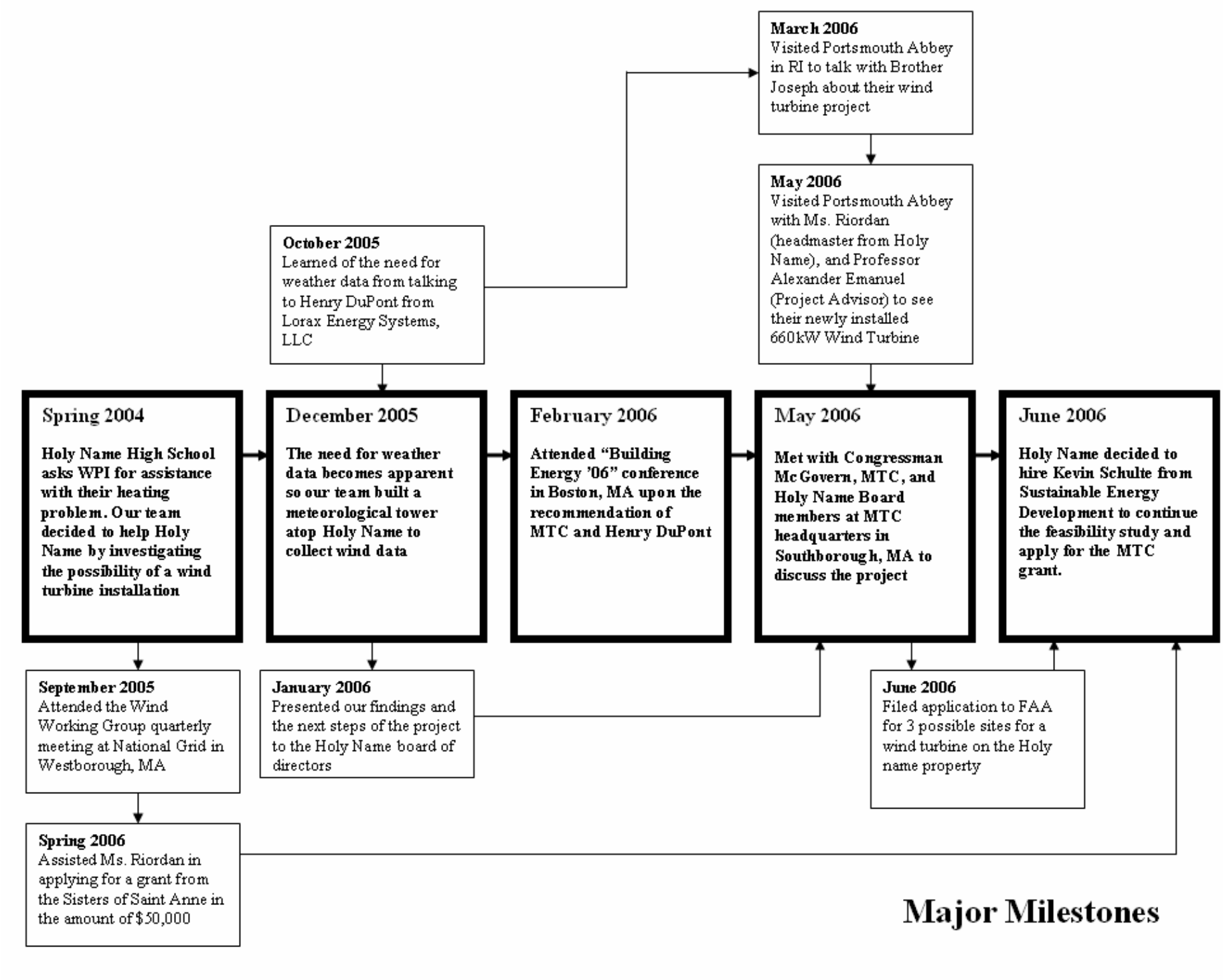
1) The school's demand for electricity,
2) Experimental verification for the availability of sufficient wind speeds on site,
3) The favorable economics.

The recommendation is for the school to install a 600 kW turbine atop a 50 meter (approx. 164 ft) tower. Such a turbine would produce 60-70% of the school's electricity during the peak demand periods in the winter months. The turbine will pay for itself in as little as 5 to 7 years. If the school does not install a wind turbine, they will be faced with a estimated $4.5 million electricity bill after 20 years. By installing a wind turbine, over a 20 year period, Holy Name will spend only $300,000 on electricity and the turbine. Furthermore, a list has been compiled of suggested installation sites on Holy Name's property where a wind turbine could be erected.

As energy prices are predicted to increase annually, Holy Name is in desperate need of a viable solution to the problem that they are faced with. The installation of a wind turbine on their property would dramatically reduce the annual cost of heating their buildings with electricity. The savings would enable the school to improve the education offered to its students

in several ways, including increased academic opportunities, and the latest technology being implemented into the classroom.

Beyond the benefits to the school, a wind turbine in Worcester, MA would serve as a landmark of change. As we march onward into the next century, we are already faced with an impending energy crisis. The implementation of wind power and other renewable sources of energy are extremely important if we as a society are intent upon maintaining our everyday lives as we know them.


March 2006
Visited Portsmouth Abbey in RI to talk with Brother Joseph about their wind turbine project
May 2006
Visited Portsmouth Abbey with Ms. Riordan (headmaster from Holy Name), and Professor Alexander Emanuel (Project Advisor) to see their newly installed 660kW Wind Turbine
October 2005
Learned of the need for weather data from talking to Henry DuPont from Lorax Energy Systems, LLC
Spring 2004
Holy Name High School asks WPI for assistance with their heating problem. Our team decided to help Holy Name by investigating the possibility of a wind turbine installation
December 2005
The need for weather data becomes apparent so our team built a meteorological tower atop Holy Name to collect wind data
February 2006
Attended "Building Energy '06" conference in Boston, MA upon the recommendation of MTC and Henry DuPont
May 2006
Met with Congressman Mc Govern, MTC, and Holy Name Board members at MTC headquarters in Southborough, MA to discuss the project
June 2006
Holy Name decided to hire Kevin Schulte from Sustainable Energy Development to continue the feasibility study and apply for the MTC grant.
September 2005
Attended the Wind Working Group quarterly meeting at National Grid in Westborough, MA
January 2006
Presented our findings and the next steps of the project to the Holy Name board of directors
June 2006
Filed application to FAA for 3 possible sites for a wind turbine on the Holy name property
Spring 2006
Assisted Ms. Riordan in applying for a grant from the Sisters of Saint Anne in the amount of $50,000
Major Milestones