2010

Wind Turbine Technology: Feasibility and Application in Union Township

Brittany Mouzourakis

Honors Senior Research Project

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Dr. Tom Rohrer, Director of the Great Lakes Institute for Sustainable Systems:

Dr. Rohrer served as my Honors Research Advisor and provided me with guidance and suggestions throughout the research project.

William "Woody" Woodruff, Union Township Zoning Administrator:

Woody served as my Union Township In-Field Advisor by helping me retrieve, analyze, and archive wind turbine and anemometer data. Woody has also provided me with

necessary grant paperwork and documentation to create an accurate assessment of the wind turbine investment.

Preface

I had committed myself to studying Michigan wetland policy when I first submitted my proposal for my Honors Senior Research Project in March of 2010. This project would have been solely research-based, with little fieldwork and hands-on data collection needed to write the paper. However, after about two weeks into the fall semester, I realized my research on wetland management and policies would have had little implications for the Isabella County community. If I was going to commit myself to a semester of research, then I felt it necessary to conduct research in an area that would have serious implications for the community. With Dr. Rohrer's suggestion, I decided to take on a wind turbine project with Union Township.

I was initially hesitant to take on this project because I feared I did not have the proper science background to conduct research in the area of wind turbine technology. Despite this anxiety, I have challenged myself by confronting the technical aspects of the project, which has helped me develop key skills in problem solving and critical reasoning. Although technical, the project is interdisciplinary in nature, with special emphasis placed on weaving my finance, political science, sociological, health, and legal knowledge into one Honors Senior Research Project.

The details, implications, and conclusions of my research will be delineated further in the paper. In this preface, I wanted to convey my thankfulness to the Honors Program and Dr. Rohrer for giving me the opportunity to engage in a project that has serious policy implications for the Union Township and greater Isabella County community.

Part I

Research Topic

A. Research Focus

In January of 2010, Union Township was awarded a $67,865 Energy Efficiency and Conservation Multi-Purpose Block grant from the Federal American Recovery and Reinvestment Act of 2009. The grant provided enough funding for the purchase, installation, and construction of five wind turbines. These five wind turbines included two *Skystream* turbines, which generate energy my spinning the turbines in a pinwheel-like fashion. The other three turbines are *Windspire* turbines, which generate energy by spinning like an ~~"e~~gg-beater." The grant was awarded with the objective of determining which wind turbine design was more efficient and productive. Another objective of the grant was to inform the community of the productivity and costs associated with wind turbine technology.

My research project is primarily concerned with assessing the feasibility of wind energy in Union Township by analyzing wind and kilowatt hours output data from a *Skystream* wind turbine. On a larger scale, this research project focuses on determining whether Mid-Michigan is a viable geographic location for wind turbine investment based on average wind speeds and the amount of energy generated from the wind turbines. By using computer programs and statistical computations to determine the efficacy of wind turbines, an appropriate policy recommendation can be created for the community.

Intertwined throughout this paper is the answer to six critical questions that provide a foundation for the recommendations in this project. The answers to these questions are critical in making a determination of the feasibility and efficacy of wind turbines.

The following questions are:

1. **What is the payback period for the investment?**
2. **Is there a strong positive correlation between wind speed and kilowatt hour output?**
3. **What are the positive benefits to the environment?**
4. **Does the investment make economic sense?**
5. **What government support is available for private investment in wind turbines?**
6. **Is wind energy a better option than coal?**

B. Scope and Breadth of the Project

My research was conducted primarily through a hands-on approach that involved weekly meetings with Woody Woodruff, Zoning Administrator for Union Township, to coordinate data archiving and retrieval for the *Skystream* south turbine. Although there were two *Skystream* turbines, my research focuses on the output of the south turbine because of the continuity of data that this turbine produced. Since the north wind turbine had to be replaced on November 5, 2010, the data was disrupted and previous data became obsolete because a new turbine was being used. It was important to use the data produced by the south turbine because of the full eight weeks of data it produced without interruption, reinstallation, or replacement.

Although the data from the turbines could be manipulated in various ways to track relationships among numerous variables, such as wind gust, temperature, humidity, and precipitation to name a few, this research project focuses on the wind speed and kilowatt hours (kWh) output. The relationship between these variables two are by far the most important variable relationship, so it was important to spend the majority of the analysis focusing on this relationship.

It was necessary to do background research regarding the vast subject of United States energy policy to supplement my research. Narrowing down the expansive subject of energy policy was necessary before beginning research. The background research will focus on main fuel resources used in electricity creation and comparing that resource to wind energy through a positive and negative attributes analysis. Other focus areas for the project will include major laws, sociological, and political forces behind energy creation in the United States. As mentioned previously, this project was meant to be inter-disciplinary in nature because it reflects my inter-disciplinary undergraduate education. As an international business major with minors in legal and environmental studies, I am drawing from my diverse, educational repository developed throughout my time at Central Michigan University.

Gaining a better understanding of the political landscape surrounding these areas will provide for a meaningful and feasible policy recommendation for Union Township and the greater Isabella County community.

Part II

Background Research on Energy in the U.S.

A. Current Energy Sources

The United States is currently ranked number one in both electricity consumption and creation. The United States produces 4.11 trillion kilowatts and consumes 3.873 trillion kilowatts (CIA). Nearly one-third of the electricity produced in the United States is generated from the use of coal (DeGunther 68). Since coal makes up the largest piece of the energy ~~p~~ie," it is merits a thorough discussion.

There are four types of coal found in the Earth, but bituminous coal is the most prevalent coal found and mined in the United States. Bituminous coal has a carbon content of 45-86% and an energy content of 3.08-4.55 kilowatt hours. Coal is burned to create steam that will turn turbines, which in turn will generate rotary mechanical power. Coal is a prevalent energy source in the United States because it is cheap to burn and has a deep rooted history in American society (Nersesian, p. 82).

To formulate the policy recommendation for Union Township and the greater Isabella County community, the negative and positive aspects of coal and wind energy need to be assessed. There is no such thing as a free lunch when it comes to energy production. Each energy source, alternative energy included, has positive and negative aspects. For the purpose of this research, seven key characteristics of each energy source will be covered. These aspects

include: combustion versus non-combustion, raw materials, degree of refinement, current level of technology, pollution and environmental impacts, economics, and politics (DeGunther 22-24).

i. Arguments for Coal

Coal is an abundant source, and the United States Energy Information Administration has estimated coal reserves to last for the next 146 years, for the United States *only*, if they use 2009 consumption rates and factor in an annual 0.6% increase in coal usage per year until 2030. Nearly 94% of the coal mined in the United States is used for electricity production. Although there is a finite time constraint on coal resources, coal beats out oil, which is only projected to last for another 46-91 years depending on the rate of oil consumption (U.S. Department of Energy). Due to the vast amount of coal present in the United States, there is less of a national security risk with coal than with oil because the United States is not heavily dependent upon foreign imports of coal.

Coal is also safer than natural gas because coal does not explode. Although coal pollutes the environment, in terms of water pollution, it does not have as serious of a risk as huge oil spills, such as the BP oil spill in the summer of 2010. In terms of pure economics, coal is by far the cheapest energy source in the United States, although this is an artificial cost lowered by the U.S. government's market intervention by the use of subsidies. In 2008, the cost of bituminous coal was $51.80 per ton (U.S. Energy Information Administration). Currently, Consumer's Energy, the energy company in Union Township, charges roughly $00.112 per kilowatt hour.

ii. Arguments Against Coal

Coal is not an infinite energy source and will eventually run out, forcing society to switch to alternative energy. Coal is also a dirty pollutant that is responsible for polluting the air, water, and land. When coal burns, it emits toxic pollutants that have adverse consequences on the environment. Sulfur dioxide and particulates are emitted when coal is burned and it has been linked to the incident known as acid rain and many respiratory illnesses suffered by human beings. Nitrogen oxide is also released and causes acid rain and photochemical smog in cities. Coal also is responsible for emitting carbon dioxide, the primary greenhouse gas, into the atmosphere at catastrophic rates (U.S. Energy Information Administration). All of these pollutants can cause cardiovascular, liver, and kidney disorders in humans (DeGunther 120-122).

But perhaps most alarming, is the mercury deposited into the environment, which causes neurological and developmental damage in humans and animals. In the atmosphere, mercury is quite innocuous and poses very little threat to human beings. However, when mercury enters water, it is chemically transformed into methylmercury, which poses serious threats for humans eating fish and other organisms from the oceans and lakes. Methylmercury bio-accumulates in the fatty tissues of the fish, becoming highly toxic to those eating those organisms (U.S. Energy Information Administration). It was estimated that an annual 100,000 pounds of mercury is deposited into the atmospheres, which makes its way into the water systems (DeGunther 36).

Coal mining also has serious environmental implications, especially as it pertains to the sustainable use of the land. A common practice in U.S. mining operations is to engage in a mining technique known as mountaintop removal. Mountaintop removal is a two step process that first involves removing the top of a mountain to expose coal seams by using explosives to blow the top off of the mountain. The discarded tops of the mountain are then discarded into

–valley fills," so draglines can dig through the rock to expose the coal (U.S. Environmental Protection Agency).

The environmental damaged caused by mountaintop removal can be quite severe for the surround ecosystems. According to the U.S. Environmental Protection Agency, the –valley fills" surrounding the mines have increased mineral content, which include zinc sodium, selenium, and sulfate levels. The increased presence of these minerals may negatively impact fish and other organism in the valleys. Other consequences of mountaintop removal include habitat fragmentation by segmenting the forest and slow regrowth rates for forests due to compacted soil (U.S. Environmental Protection Agency).

Aside from adverse health and environmental consequences from burning coal, there are many arguments against the price of coal. Coal is very cheap on the surface level, but the layers below the surface are extremely expensive because the negative externalities are not factored into the price of coal. These externalities include government subsidies, programs, and health costs to citizens. Each year, the government provides the coal industry with over one billion dollars and has already spent $137 billion in subsidies for new coal-fired plants (Johnson 8). This brings down the cost of coal, artificially, makes it difficult for alternative energy to compete in the –free" market system.

The government also provides funds for the Federal Black Lung Program that is part of the Department of Labor. The black lung is a common name used to refer to any lung disease that has developed from prolonged exposure to breathing in coal dust. In 2009, the federal government provided $563 million to cover the healthcare costs for miners who have retired or were disabled by their development of the black lung (US Government).

Health costs associated with coal also extend to private citizens who live near coal-fired

power plants. A huge public health burden is placed on society and tax payers because of the adverse effects of particulate matter on human health. It is estimated that nearly 26,000emergency room visits and 21,850 hospital admissions are precipitated by exposure to particulate matter emitted into the air by coal-fired plants. These visits to the hospital drive up the healthcare costs for others. Productivity in industry is also affected by coal as it is estimated that 3,186,000 workdays are lost each year by coal-related health incidents (Physicians for Social Responsibility).

If the price of coal reflected the negative externalities, such as government subsidies, the Black Lung Program, health care costs, and lost productivity in the private workforce, then coal would not be as price attractive as it is today. In fact, alternative energy, if it received the same level of government financial support, would be much cheaper than $00.09 per kilowatt hour.

iii. Argument for Wind Energy

There are numerous benefits to the use of wind energy that make it a viable alternative energy technology today. It is a form of renewable energy, which means it is an infinite resource that can produce the energy for human consumption. One major benefit of wind energy is its ability to produce emissions-free energy, which means pollutants are not given off during the generation of energy. Wind turbines generate rotary mechanical energy in the same way as coal; however, instead of burning coal to produces steam that spins the turbines, wind energy blows the turbines. Since the wind in moving the turbines, pollutants are not admitted into the air as they are in the case of coal (DeGunther 191).

Wind energy is the most promising of the various options of alternative energy because wind is found everywhere, it is cost efficient, and it can be produced for less than $00.04 per

kilowatt hour. Part of the reason why wind power is deemed the energy of the future is because it involves net metering, which means that unused energy produced can be sold back to the grid. This allows the owner of a wind turbine to make a small profit by selling energy to the grid during peak demand (DeGunther 191). Tax credits are available for consumers and small businesses using wind power are also an incentive for using wind power. In February of 2009, President Obama announced the American Recovery and Re-investment Act into law, which provides a 30% tax credit off of the total cost to purchase and install a wind turbine (Skystream 3.7).

Wind turbines can also be conveniently installed by a private citizen or with help from a contractor. Wind turbines are one of the only forms of alternative energy that can be built incrementally and tied together. This means there is not a large financial commitment when investing in the technology, as opposed to photovoltaic cells. Photovoltaic cells require a onetime investment because the cells must all be connected to the grid at once (DeGunther 195).

iv. Arguments Against Wind Energy

The arguments against wind energy are not as exhaustive as the arguments against coal. One argument against this technology is mild winds. Depending on the type of wind turbine purchased, some turbines do not start spinning unless there is over 6 miles per hour of wind (DeGunther 203). This is the reason why it is critically important to take measurements of wind data using an anemometer or to retrieve data from the National Oceanic and Atmospheric Administration.

Wind turbines take up land space, are an eyesore, and emit low frequency sounds. There is some medical evidence available showing these low frequencies causing migraines, headaches,

sleep deprivation, depression, and anxiety, although this is not conclusively proven. Even so, these health effects are milder than the serious health effects caused by pollution emitted from coal-fired power plants. Another argument includes shadow flickering, which is caused by the spinning of turning blades (DeGunther 203).

The ability of wind turbines to decrease property values is a frequently cited argument against wind turbines. In a study conducted in Wisconsin, it was found that appraisers often value homes near wind turbines 17%-20% lower than the true value of the home. The authors of the study concluded this percentage based solely on visual impact and totally excluded the impact of wind noise, shadows, and motion (Easton 179).

Wind turbines are not totally emissions free. Although wind turbines produce clean energy, they still require raw materials such as fiberglass and paint to construct the turbines. Also, combustible energy is needed to create the capital equipment needed to produce the wind turbines at a large-scale pace (DeGunther 22-24).

A final argument against wind turbines is their propensity to kill bird. Large scale wind farms can kill about 5,000-6,000 birds a year. Some non-profit bird organizations are against wind farms because of this reason. However, if you compare wind farms to the amount of bird killed during one oil spill, such as the Exxon Valdez in 1989, the deaths are put into perspective. In one day, the Exxon Valdez oil spill caused over 50,000 deaths of birds in Alaska (DeGunther 201-202).

B. The Legal Environment Surrounding Alternative Energy

i. Local Union Township Ordinances

As discussed earlier, one main concern raised against wind turbines is the sound emitted from the spinning of the turbines. According to Union Township ordinances, wind energy systems are not to exceed 55 decibels, which is comparable to the sound of a running refrigerator. The ordinances also state that constructing a wind energy system has to comply with Michigan's Natural Resources and Environmental Protection Act, especially when constructing near a wetland, fragile habitat and ecosystem, and places of cultural worth. More specifically, this includes, but is not limited to: water resource protection, soil erosion, inland lakes and streams, wetlands, shorelines, Great Lakes submerged land, and sand dunes (Union Township).

To reduce the occurrence of shadow flicker, all turbines have to be painted in a matte finish to mitigate annoying reflection from the turbines. All residents who plan to construct a wind turbine must prepare a Shadow Flicker Impact Analysis to make sure the wind turbine does not cause a nuisance to neighbors and others. Also to help mitigate unsightliness of the wind turbines, writing or brand logos of any kind are not allowed on wind turbines in Union Township (Union Township).

To ensure the wind energy system will not adversely impact avian populations and the environment, an Avian and Wildlife Impact Analysis and Environmental Analysis created by a third-party expert must be submitted with the proposal to receive a permit for the wind energy system. Other necessary documentation to submit to Union Township includes: a noise modeling and analysis report, proof of liability insurance, documentation of sound pressure level, complaint resolution guide, and a decommissioning plan (Union Township). If these items are not included within the proposal, then a permit will not likely be issued.

Researching the local ordinances involved with constructing a wind turbine in Union Township provides a snapshot of the red-tape involved with beginning a wind turbine energy

system for small business or residential use. Although the paperwork, documentation, and reports comprise a long and arduous process, I do not believe the ordinances are prohibitive and overtly obstructive. To ensure the safety of the local community, wildlife, and environment, assessment reports must be conducted to ensure the wind turbines are placed in appropriate areas and do not adversely affect the community, wildlife, and environment.

ii. Federal Laws

Although there are numerous environmental statutes regulating environmental issues, the American Clean Energy and Security Act is worth discussing because it is a new piece of legislation that speaks to the importance of implementing alternative energy in American society. The American Clean Energy and Security Act passed the United States House of Representatives in June 26, 2009. Although the Act has essentially died because the Senate has not voted on the piece of legislation, it is worth researching because it may eventually be brought up in the Senate in the future (Pew Center). If this Act passes in the Senate in the future, then there will be serious implications for energy consumption and creation in the coming years.

The most pertinent part of this Act as it pertains to wind turbine research with Union Township is the Act's commitment to implementing alternative energy. This Act specifically delineates the percentage of alternative energy that must be used to produce electricity in the United States. According to the Act, the following would be mandated percentages of how much energy should be produced using alternative energyon a yearly basis:

Calendar Year	**Required Annual Percentage**
2012	6.0

2013	6.0
2014	9.5
2015	9.5
2016	13.0
2017	13.0
2018	16.5
2019	16.5
2020	20.0
2021-2039	20.0

This Act ambitiously aims to achieve 20% of energy production in the United States by utilizing alternative energy, which includes wind, solar, geothermal, renewable biomass, hydropower, and marine hydrokinetic power (Pew Center). It is estimated that wind power will grow by a factor of 15 in the next two decades and will provide enough wind to produce 6% of world electricity needs (DeGunther 195).

Part III

Union Township Wind Turbine Project

A. Research Objectives

The majority of my research was conducted at Union Township Hall with Woody Woodruff, the Zoning Administrator in Union Township. As the recipient of a $67,865 Energy Efficiency and Conservation Multi-Purpose Block grant from the Federal American Recovery and Reinvestment Act of 2009, Union Township is responsible for collecting data to gain a better understanding of wind energy. As stated in their grant request:

> "The major goal of this energy project is to move the township further along in its quest to become a greener, more sustainable community. By demonstrating the viability of residential wind in moderate wind areas like Central Michigan, the township hopes to encourage its citizens and businesses to invest in systems that can provide jobs here and in other parts of the state. A secondary goal is to provide on the ground reliable data for community residents about potential payback times for their alternative energy investments."

I was primarily in charge of taking the data from the system and using it to draw conclusions and make a policy recommendation. I was also an intermediary between the project

and Dr. Rohrer, who wrote letters of support for Union Township when they were applying for the Energy Efficiency and Conservation Multi-Purpose Block grant. As a member of the Central Michigan University (CMU) Campus Sustainability Advisory Committee, I will be able to share the conclusions of my research with CMU. In parallel with Union Township's goal, I hope to provide reliable data for CMU to use when determining whether or not to invest in alternative energy on campus.

By assessing the feasibility of wind turbine technology in Union Township, I hope to gain a holistic view of the political, legal, and economic system that has its fabric woven deeply within the local community. This project will tie together my knowledge accumulated through my international business major and environmental and legal studies minor, in one comprehensive research project. I believe I will gain a realistic understanding of the difficulty a lawmaker has in either choosing economically or environmentally viable policies. I hope to use the insights gained from this project to create a balanced policy recommendation that I will deliver to Union Township.

Dr. Rohrer had initially wanted me to compare the two types of wind turbines against one another to determine which technology produced more energy. However, delays in construction halted the progress of the project and made this objective impossible for me to achieve in the fall semester. The *Skystream* turbines were installed on October 6, 2010, which has provided me with over eight weeks of data. However, the *Windspire* turbines were installed during the week of November 22, 2010, and the proper software has not been installed to begin collecting kilowatt hours output data.

Thus, the main objective of my research project is to use the data collected from the south turbine to formulate conclusions and a policy recommendation for the Isabella County

community to use in determining whether or not they should invest in this technology for their home or business. A secondary objective of the project is to present my research at SRCEE, CMU's Posters at the Capitol, and at various environmental conferences throughout the spring semester of 2011.

B. Project Specifics

My research involves the study of only the *Skystream* turbines because of the delay in construction for the *Windspire* turbines. The *Skystream* 3.7 wind turbine is made for a small business or for private citizens. The cut-in speed, the speed at which wind turbine begins to produce power, is rated at 8 mph. This is an important specification to know about the wind turbine because it indicates the necessary wind speed needed to produce power. Although power is produced starting at 8 mph, the website suggests at least 10 mph average wind speed, with 12 mph being the ideal wind speed. The wind turbine has three blades, weighs 205 pounds, and can survive in winds up to 140 mph. There is a five-year warranty on the *Skystream* turbines and a *Skyview* wireless monitoring system hooks up to computers and allows for the archiving and collection of data (Skystream 3.7). Figure 1.1 shows an enhanced view of the wind turbines:

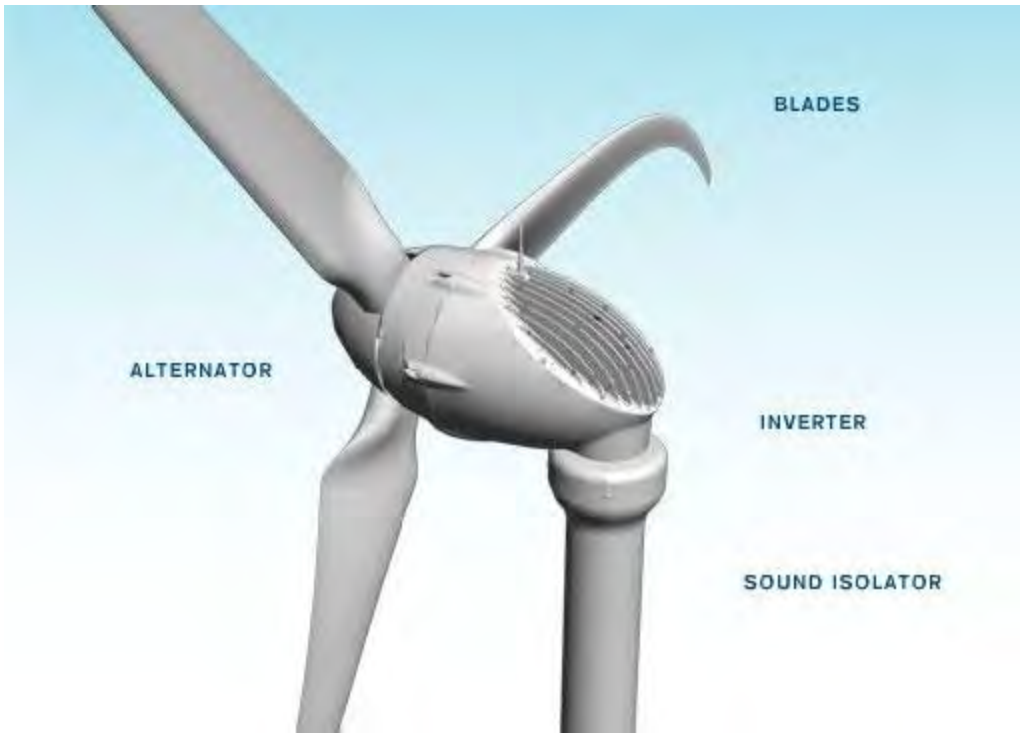

Figure 1.1

Source: Skystream 3.7. –Skystream Up Close."
http://www.skystreamenergy.com/skystream-info/skystreamupclose.php

The wind turbines produce energy for the owner of a *Skystream* turbine by pivoting to find wind and generating kinetic energy by spinning the wind turbines. When the wind turbine is installed, it gets plugged in directly to a home owner's electric meter. When the wind is below the cut-in rate of 8 mph, energy used in the household will come from the fossil-fuel burning electric company. However, when the wind does blow over 8 mph, then the wind energy is used to offset the traditional amount of fossil-fuel generated electricity. When the *Skystream* turbines produce more energy than the household needs, then the meter spins backwards creating a credit that can be used in the future (Skystream 3.7). Figure 2 shows how the *Skystream* turbines work:

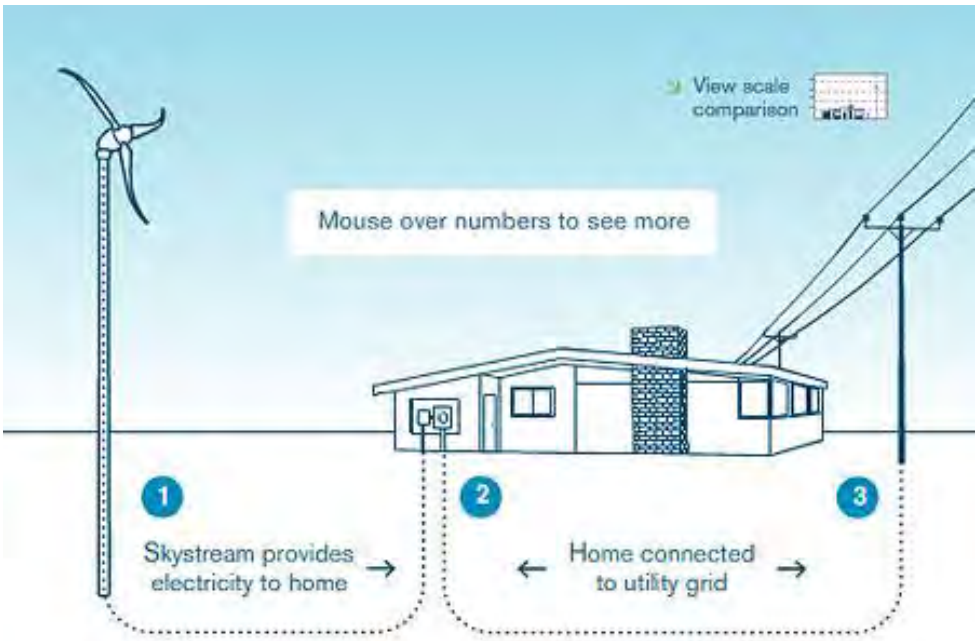

Figure 2

Source: Skystream. ―How it Works.‖ http://www.skystreamenergy.com/how-it-works/

The *Skystream* Company has already created power curves and other statistical models to help estimate the amount of energy the turbines will produce. These graphs will play a useful role in my conclusions because of my lack of data for the months of December through September. I will be using these models and graphs to help estimate a yearly savings cost, which in turn will allow me to calculate the payback period for this alternative energy investment. Figure 3 and 4 represent the statistical models:

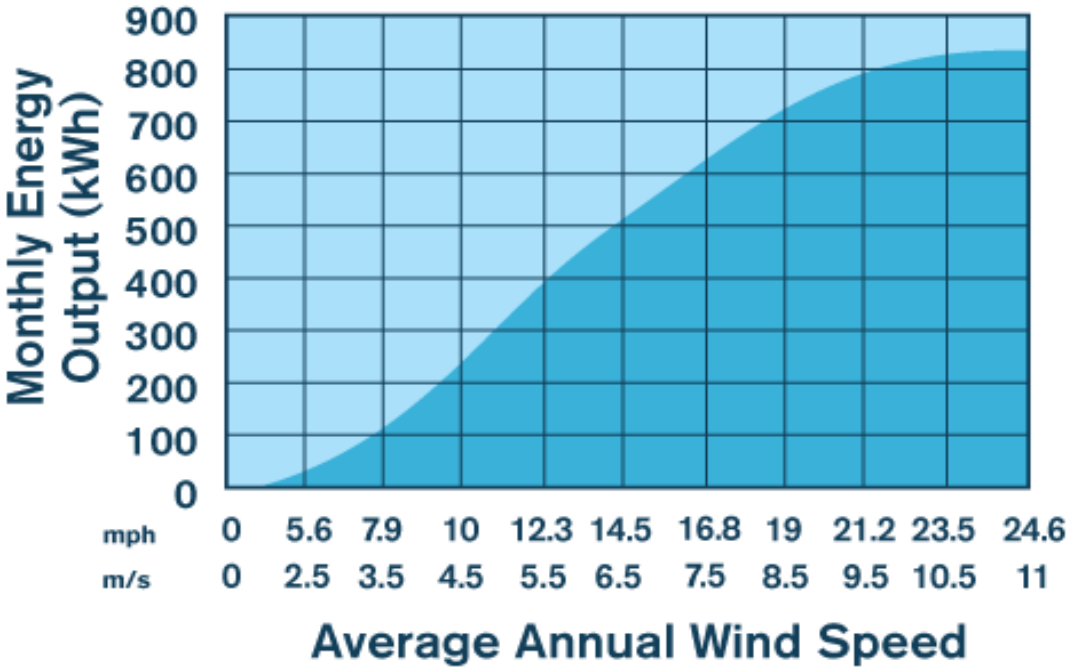

Figure 3

Source: Husker Wind Power. ~~–~~Skystream 3.7 Energy Curve."
http://huskerwindpower.com/wp-content/uploads/2009/09/SkystreamEnergyCurve.png

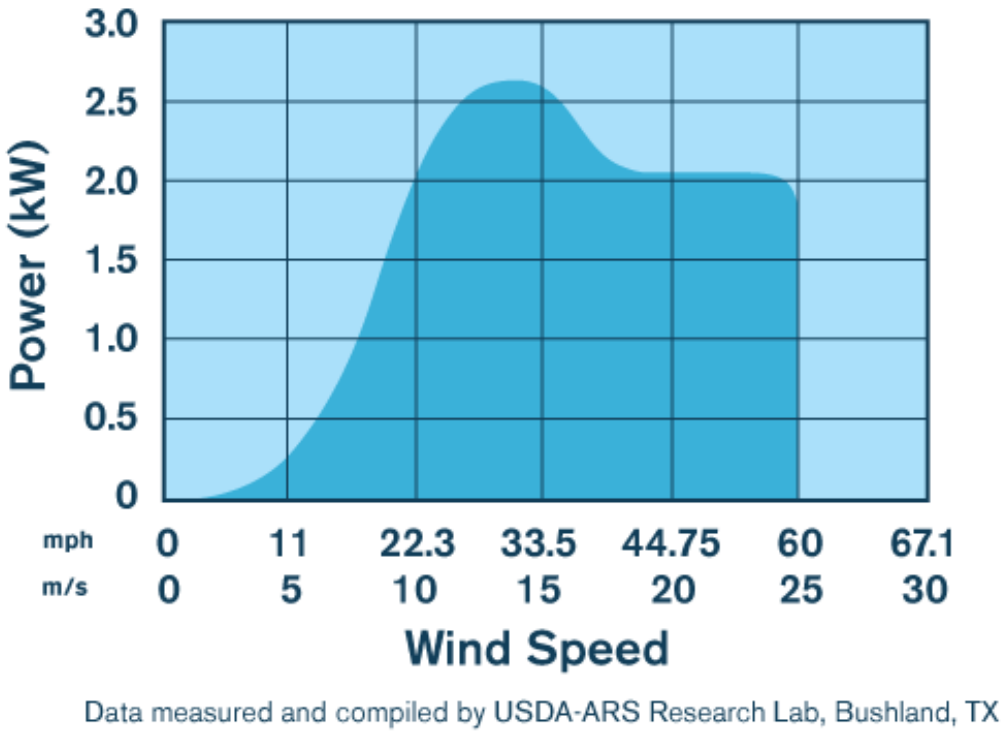

Figure 4

Source: Husker Wind Power. –Skystream 3.7 Power Curve."
http://huskerwindpower.com/wp-content/uploads/2009/09/SkystreamPowerCurve.png

Two different computer systems were used to measure the performance of the wind turbines and the wind measurements. To monitor the performance of the wind turbines we used the *Skyview* software that came with the wind turbines. This software calculated daily kilowatt hour creation and keep a running tab on how much the wind turbine was offsetting Union Township's carbon footprint. A simple weather station program was used to monitor and collect the wind speed data.

The manufacturers of the *Skystream* boast about the wind turbines' super quiet features, which make the product more attractive in residential neighborhoods. Although there are not many complaints raised against wind energy in comparison to coal, the largest concern voiced by

the populace is the noise level emitted from wind turbines when they are spinning. Figure 5 is a graph representing the decibel level emitted from the *Skystream* turbine.

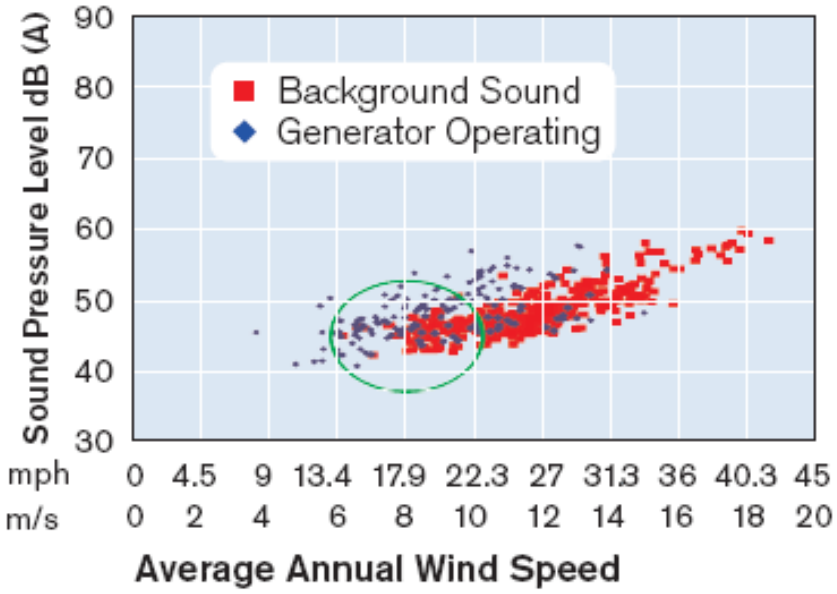

Figure 5

Source: Noonan, Liam. ―Decibel Levels.‖ http://www.segen.co.uk/images/noisereport.gif

C. Research Methods

To complete this project I have engaged in two different types of research acquisition. The first way I acquired research was through a hands-on and in-field approach. I stayed informed and retrieved data for the project by attending weekly meetings with Woody Woodruff since September of 2010. At our weekly meetings, Woody and I would log into the software to retrieve anemometer, kilowatt output, carbon footprint, and cost savings data. Both Woody and I were new to using the different computer programs to set parameters for data archiving and creation; however, we learned throughout the semester by researching the manual and using trial and error methods.

Each week, as I received the previous week's wind and kilowatt output data, I would log the information into a running excel sheet. To create power curve graphs, a graph that places kilowatt (kWh) hours on the y-axis and miles per hour (mph) on the x-axis, I needed to match daily kWh output to the average wind speed for that same day. Although using average daily wind speed is not the most accurate measure to use due to periods of the day with low and high wind speed, it provided an adequate basis for me to make assumptions upon. I have collected eight weeks of complete data, which runs from October 7, 2010—when the south wind turbine was installed—to December 2, 2010.

An excel spreadsheet was also used to keep a running total of the amount of money saved every day since the installation of the south wind turbine. I calculated aggregate savings using the standard price of $00.112 per kWh by using a formulated spreadsheet with pre-set formulas. This cost savings spreadsheet will be discussed further in the paper because it provided me with a strong foundation in calculating the payback period and in formulating my policy recommendation for Union Township.

The second research method used in this project was standard research conducted using sources from the CMU library. Such sources included books, scholarly journals, magazines, and administrative agencies. This conventional type of research was mostly conducted to enhance my understanding of energy production and the politics behind energy sources.

D. Research Findings

i. Relationship Between mph and kWh

A rudimentary science background gives one the intuitive understanding of the physics behind energy-generation of wind turbines. The more wind a location has, the more electricity

the turbine can generate. Accordingly, the assumption that slow and steady winds all day, as opposed to sporadic high winds, is the preferable method of producing electricity is also intuitive logic. The graph below, figure 6, shows the kWh of each individual day gridded against the average wind speed for that specific day in miles per hour from the time period of October 07, 2010 to December 02, 2010. The x and y coordinates for this graph can be found in the appendix at the end of the paper.

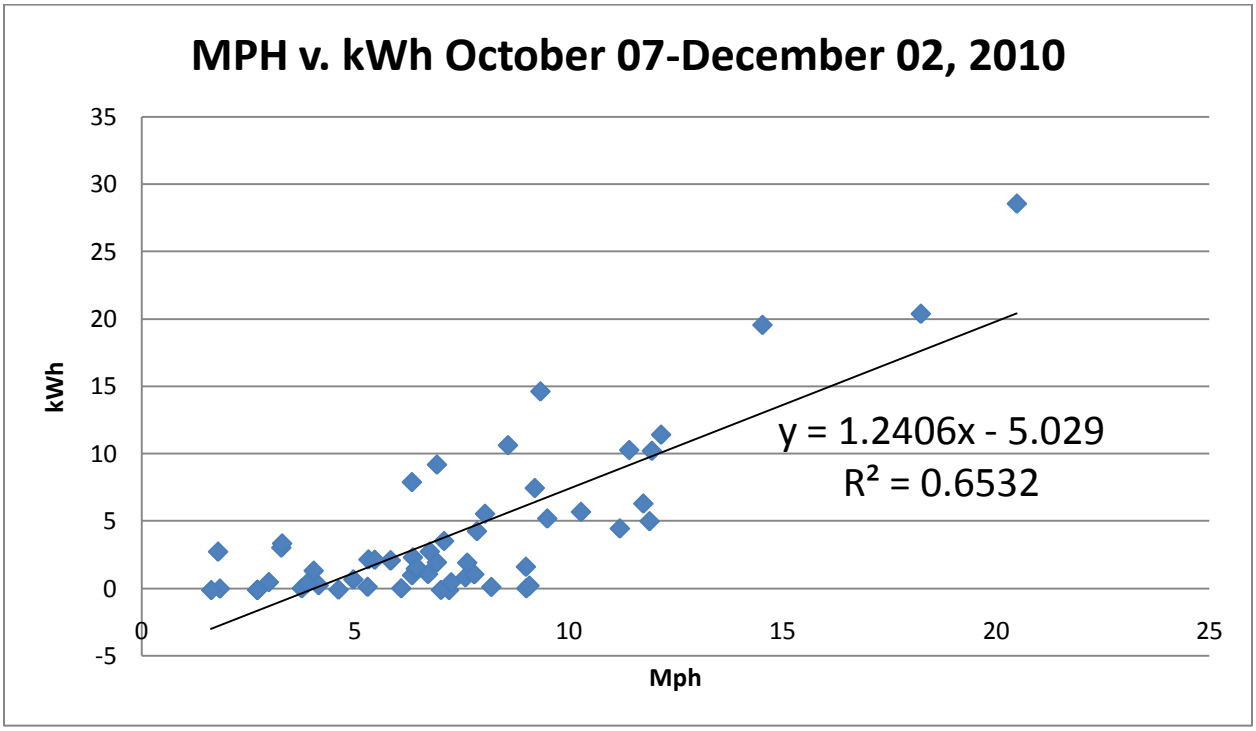

Figure 6

There is a positive correlation between the two variables, which as previously mentioned makes intuitive sense. The correlation coefficient is .808, which indicates a strong level of positive correlation between the two variables mph and kWh. Thus, the data does show that the higher the wind speed, the more kWh should be produced.

However, there are some data points on the graph with large mph and low kWh and vice versa. The reason for these variations is the volatility in wind speed and the persistent blowing

of the wind. However, these variations are explained using the statistical concept of r-squared. According to our r-squared value, 65.32% of the variance in the data set is explained by the linear regression produced by the line of best fit. Although the goal of statistics is to get the r-squared value as close to –1" as possible, because that would indicate the linear regression model was a perfect model for the data, .6532 is strong statistically. Most statisticians agree that an r-squared value over .50 is adequate in research (Duke University).

According to our linear regression model, r-squared value, and correlation coefficient, wind and kilowatt output are positively correlated and their variance can be explained by using a linear regression model. By using a line of best fit, I produced an equation that can explain variance in 65.32% of the data points. This equation is y=1.2406x-5.029, where x represents the mph variable.

It would be difficult to graph all 56 days of the study with hourly wind speed and kilowatt output. However, I felt it necessary to select a day and track kilowatt output hourly against the measured wind speed at that specific hour. Although the results of doing this corroborate the aforementioned results, it is nonetheless interesting to note. The graphs below are a measurement of wind speed and kilowatt output every hour on November 25, 2010. I thought it would be important to graph the two variables separately so that I could compare the two against one another. It is evident that when wind speed peaks, so does kilowatt output. When the wind speed falls below the cut-in speed of 8 mph, the kWh output plummets significantly below zero. The concept of negative energy seems odd; however, there is a threshold amount of electricity needed to archive data. If the wind does not blow, then the turbine pulls from its battery sources, and thus loses energy. This is why a negative value exists.

Figure 7 and 8:

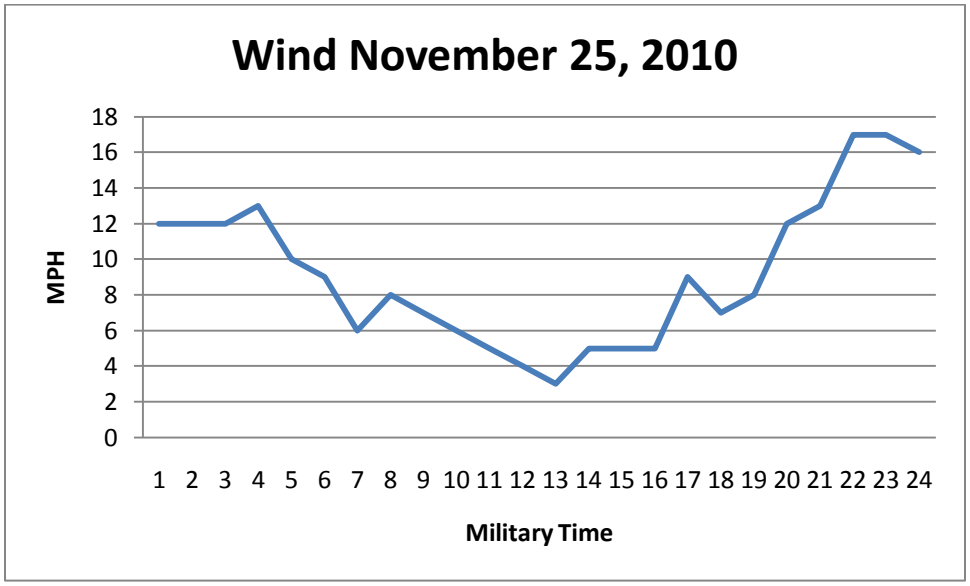

Figure 7

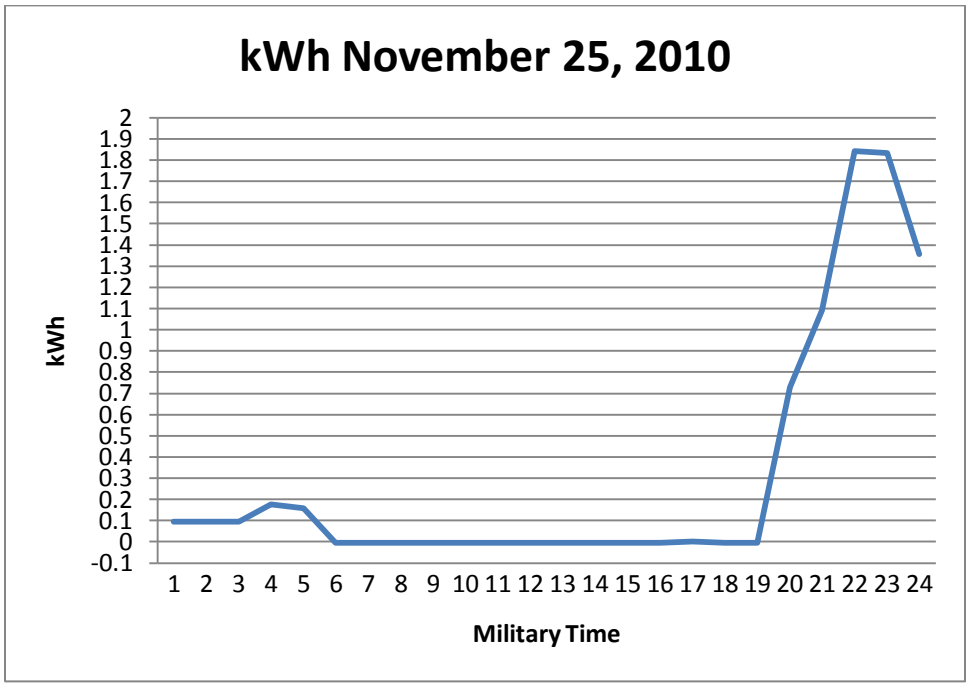

Figure 8

ii. Payback Period of the Wind Turbine Investment

In 2009, the cost of electricity in Union Township was $00.112/ kWh (Union Township). For the purposes of this project, I will be using this price of electricity to calculate the payback period in years for this wind turbine investment. Since the beginning of the project on October 7, 2010, the south wind turbine has produced 233.90 kilowatts. Although this is complete data for the months of October and November, the project is missing data for December through September. The best way to calculate the payback period on this investment would be to log the total number of kilowatt hours produced per year and use those kilowatt hours to calculate a yearly savings rate.

Since this data is missing, I will be using wind data from the National Oceanic and Atmospheric Administration (NOAA). NOAA archives the average monthly wind speed in various cities in each state. The closest city NOAA has data for is Lansing. I will be using the Lansing data to make estimates of the kilowatt output produced during the months of December through October. Although this is not entirely accurate, I believe it will provide an adequate estimation of the payback period because the geography and climate of Lansing and Union Township and very similar.

The following, figure 9, is a chart that uses the accurate data I collected from October and November and the estimated data from NOAA to come up with a yearly kilowatt hours output figure that will be used to calculate the payback period. I took the average wind speed from NOAA for each month and used the *Skystream* power curve in figure 3 to estimate the kilowatt output.

Month	**kWh Output (*denotes NOAA data)**

January	11.7 mph. About 300 kWh
February	10.9 mph. About 260 kWh
March	11.2 mph. About 290 kWh
April	11.1 mph. About 285 kWh
May	9.9 mph. About 245 kWh
June	8.8 mph. About 150 kWh
July	8.0 mph. About 110 kWh
August	7.5 mph. About 90 kWh
September	8.2 mph. About 190 kWh
October	86.55 kilowatts
November	147.35 kilowatts
December	11 mph. About 280 kWh
TOTAL:	2433.9 kWh/year

Figure 9

To calculate the payback period, I need to multiple 2433.9 kWh by the current price per kWh of electricity. However, the price of a kilowatt hour of energy today will not be the same price throughout the entire life of the wind turbine. According to the United States Energy Information Administration, the cost of electricity will continue to rise as the government is cutting coal subsidies from the budget because there is not enough money due to the economic climate. By averaging the increases and decreases of electricity costs from 2000-2009 in figure 11, I will be using an annual growth rate of 3.479%. The chart, figure 10, shows cost savings each year reflecting a 3.479% increase in the cost per kilowatt hour (U.S. Energy Information

Administration). Twenty years of cost savings are calculated because the life of the wind turbine is twenty years.

Year	Savings
1	(2433.9 kWh x $0.112/kWh)= $272.60
2	(2433.9 kWh x [0.112*1.03479])= $282.08
3	(2433.9 kWh x [0.1158*1.03479])= $291.89
4	(2433.9 kWh x [0.1199*1.03479])= $302.05
5	(2433.9 kWh x [0.1241*1.03479])= $312.56
6	(2433.9 kWh x [0.1284*1.03479])= $323.43
7	(2433.9 kWh x [0.1329*1.03479])= $334.68
8	(2433.9 kWh x [0.1375*1.03479])= $346.33
9	(2433.9 kWh x [0.1423*1.03479])= $358.38
10	(2433.9 kWh x [0.1472*1.03479])= $370.84
11	(2433.9 kWh x [0.1524*1.03479])= $383.75
12	(2433.9 kWh x [0.1577*1.03479])= $397.10
13	(2433.9 kWh x [0.1632*1.03479])= $410.91
14	(2433.9 kWh x [0.1688*1.03479])= $425.21
15	(2433.9 kWh x [0.1747*1.03479])= $440.00
16	(2433.9 kWh x [0.1808*1.03479])= $455.31
17	(2433.9 kWh x [0.1871*1.03479])= $471.15
18	(2433.9 kWh x [0.1936*1.03479])= $487.53

19	(2433.9 kWh x [0.2003*1.03479])= $504.50
20	(2433.9 kWh x [0.2073*1.03479])= $522.05
TOTAL SAVINGS over 20 years:	$7,690.54

Figure 10

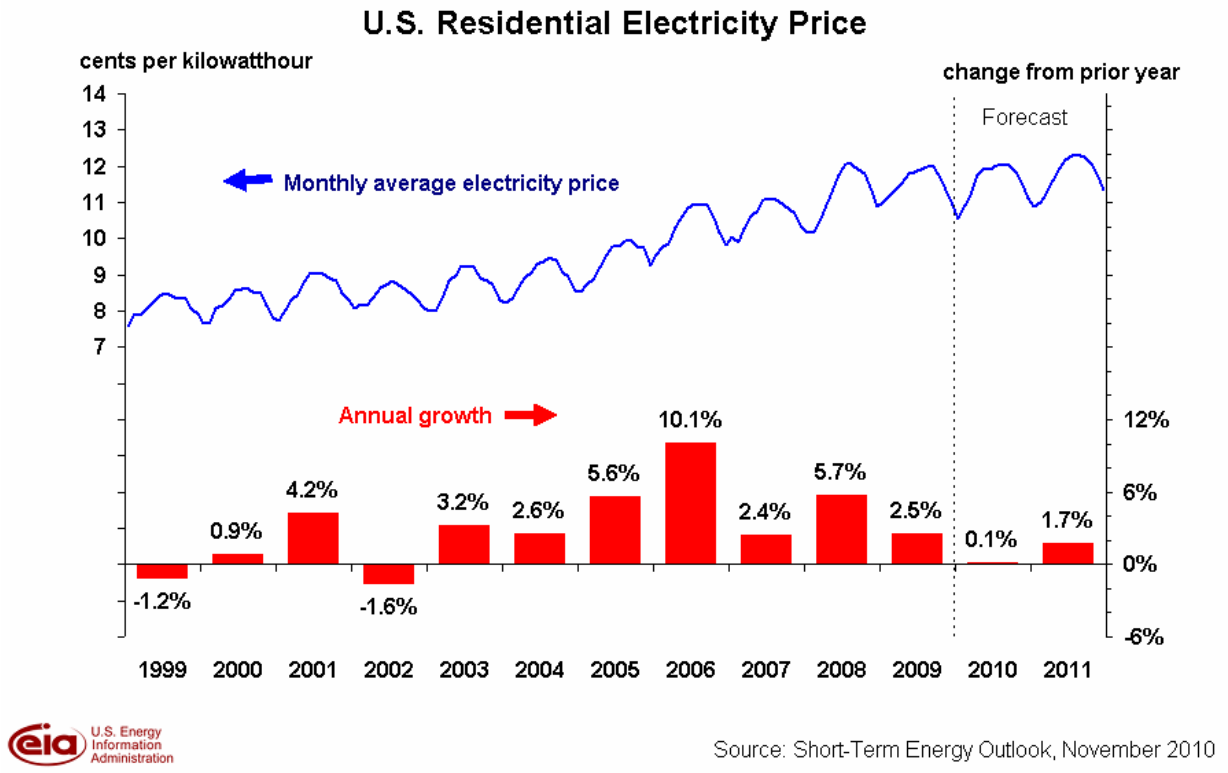

Figure 11

Source: U.S. Energy Information Administration. ―U.S. Residential Electricity Price.‖ http://www.eia.doe.gov/steo/gifs/Fig23.gif

To calculate the payback period, I must first identify the costs associated with purchasing a wind turbine energy system. The following are expenses delineated in the Union Township budget in the grant proposal:

- $6,000 for 1 wind turbine
- $1,000 for windmill installation
- $500 for windmill site preparation
- $2000 for net metering equipment
- 1,250 for Electrical Hook-ups
- $500 for Wind Energy System permit

TOTAL Cost: $11,250

Since Union Township received $67,865 in grant funding from the United States government, they did not seek tax credits to offset the price of the wind turbine project. However, for the purposes of my research, I believe it is important to factor in the tax credits because this grant was applied for in hopes ~~to~~ provide…reliable data for community residents about potential payback times for their alternative energy investments" (Union Township).

The first tax credit that must be factored into the cost of the wind turbine is the American Recovery and Re-investment Act of 2009, also known as the stimulus bill, which was signed into law by President Obama in 2009. This Act amended the ~~c~~ost caps" that were present in the 2008 tax credit guidelines. This new change allows consumers and small business owners to take a tax credit of 30% off of the installed cost of the wind turbine. The tax credit works by calculating 30% of the installation bill and deducting that value from year-end taxes owed to the government for up to two years. This federal stimulus bill can also be used in combination with state alternative energy incentives program (Skystream 3.7).

The state of Michigan also provide the renewable energy rebates, which will reimburse residential and small commercial businesses with either $10,000 or 25% off of the cost of a wind turbine system, whichever price is cheaper. Knowing these tax liabilities will allow me to calculate the payback period of investing in a wind turbine as a residential or small commercial business community member (Skystream 3.7).

- $10,750 (the price without the cost of the permit) x 30% from the stimulus package = Cost savings of $3,225
- $10,750 x 25% from Michigan's incentives = Cost savings of $2687.50

Total cost after tax incentives and rebates: $5,337.50 (includes the cost of a permit)

By referring back to figure 10, the payback period of a $5,337.50 wind turbine investment would take 15 years and two months. After the 15 years and two months, the rest of the life of investment would be pure cost savings on electricity. According to the calculated chart, this would equal a pure cost savings of $2,353.04. By dividing $2,353.04 by the initial investment of $5,337.50, I have calculated a return on investment of 44%. This is a strong indication that investing in wind turbines is a prudent decision. The only downside to investing in wind turbines is the lack of liquidity that has to be given up today to receive future benefits at a later date. Residents lacking liquidity may find it difficult to purchase a wind energy system without engaging in some type of monthly payment system.

In addition to the payback period, I have been keeping an excel sheet that has been calculated the current savings to date. Since the installation of the south turbine on October 07, 2010, the wind tubine has generated 233.90 kWh, which has translated into a cost savings of $26.20. The excel spreadsheet will be included in the appendix at the end of the paper for further reference.

iii. Carbon Footprint

Since the installation of the south wind turbine on October 07, 2010, the wind turbine has saved 239 pounds of carbon dioxide from entering the atmosphere by generating 233.90 kilowatt hours. This is because the 233.90 kWh generated from the turbine was clean and emissions-free,

as opposed to 233.90 kWh produced at a coal-fired power plant. The north turbine, although not studied greatly in my research, has saved 115.9 pounds of carbon dioxide from entering into the atmosphere. The north turbine has, in aggregate, produced 113.7 kWh through wind technology. By dividing the amount of carbon dioxide that was offset by the turbine by the total energy produced by the turbine, a factor has been created that we can use to estimate future carbon footprint savings. When the turbines produce 1 kWh, it offsets 1.02 pounds of carbon dioxide.

By investing in the wind turbine technology for 20 years, we will be saving approximately 49,651.56 pounds of carbon dioxides from entering the atmosphere. This will definitely help reduce the speed of global warming and will help keep the air pollutant free. This clean air in turn, will hopefully decrease the incidence of coal-related health problems such as liver, lung, respiratory, and cardiovascular illnesses because particulate matter, volatile organic compounds, and mercury are not entering the atmosphere through the energy creation process of the wind turbine.

iii. Viability

Wind turbines are both economically and environmentally viable alternative energy sources to coal-fired power plants. The data I have collected points to both environmental and economic savings. Environmentally speaking, investing in wind turbines can help mitigate emitted carbon dioxide, sulfur dioxide, and mercury that end up in the atmosphere. Economically speaking, the wind turbines have a real economic incentive with a return on invest of 44%, which is a better investment in stock and capital markets these days.

Although wind turbine technology makes logical sense in terms of economics and environmental health, there are some recommendations I would make to private investors in

wind turbine technology. Investing in a wind turbine with a lower cut-in speed would be an even more economically and environmentally viable wind turbine investment. With a cut-in speed of 6 or 7 mph, more energy would be produced with less wind needed. According to NOAA, the Mid-Michigan region receives a yearly mph of 9.9., so a wind turbine with a lower cut-in speed would make more sense in the region because of the lack of pervasive winds.

The *Skystream* was created and tested based on the assumption of an average wind speed of 12 mph. However, as previously mentioned, Mid-Michigan does not come close to averaging 12 mph monthly. Although investing in a *Skystream* turbine is a profitable endeavor, a wind turbine with a lower cut-in speed would provide the investor with the ease of a shorter payback period. With a lower cut-in speed, the investor may be able to payback their investment within 10 years, as opposed to the calculated 15 years for a Skystream turbine with the tax and rebate incentives.

E. Research Biases and Errors

Any researcher has inherent biases which should be candidly stated and expressed to the reader. As an environmental studies minor, I have already formed a very strong opinion about the necessity of switching to alternative energy. I have been a participant in the Power Shift Conference, in which I advocated for the passage of the American Clean Energy and Security in Congress. While on this conference, I participated in a demonstration in front of Washington D.C.'s largest coal plants. Additionally, I have orchestrated a local response at a DEQ air permit hearing in Bay City Michigan. The purpose of this hearing was to determine whether or not eight new proposed coal plants should be allowed air permit hearings. It is not a secret that I am opposed to the usage of coal and other combustible fossil fuels.

The excel data of mph, kilowatt output, and offset carbon dioxide are correct in so far as the weather station and *Skyview* computer systems were accurate. All data was retrieved from those systems, so no manipulation of data could occur. The only area of bias and error that may be present in my research is the calculation of payback period. There are numerous ways to calculate payback period, depending on what a researcher uses as the base cost. I chose to primarily focus on the costs listed in the grant proposal and discount them based on the two tax and reimbursement incentive programs for alternative energy. When determining the average price increase of coal, I used a non-biased source, the United States Energy Information Administration, to created a weighted average coal increase based on the previous ten years of coal increase or decrease data. In all circumstance, I have tried to remain objective and present the facts and the data I have collected in an unbiased way.

Part IV

Policy Recommendation for Union Township

A. Issues

1. What should Union Township do to promote energy sustainability?

2. What level of government intervention is necessary to promote sustainable and alternative energy?

3. What laws should change to help promote sustainability through private investment of alternative energy?

4. What actions need to be taken on a sociological level to shift to a culture of sustainability?

B. Recommendations

1. What should Union Township do to promote energy sustainability?

Union Township should aggressively engage in a public relations and marketing campaign to teach residents about the environmental, economical, and sociological benefits of engaging in sustainable energy practices. Union Township and the greater Isabella County community are rural areas, so I believe the best way to promote a sustainability initiative is through a ~~–l~~ead-by-example" method. Union Township's wind turbine project is a strong first step in promoting this sustainable culture.

2. What level of government intervention is necessary to promote sustainable and alternative energy?

A local tax incentive is needed to boost the level of private investment in wind technology. Although there is a federal and state tax and reimbursement incentive program, a local tax credit would also entice local citizens to privately invest in the technology. Also, with an unemployment rate of 7.1%, Union Township should look into tax cuts for businesses involved in alternative energy businesses, also known as –green jobs" (United States Census). Green businesses are beginning to catch on, so it is important for Union Township to have the –green" business –friendly infrastructure in place. With the proper tax structure in place, Union Township and the greater Isabella County community will be an attractive place for businesses to locate. Of course, the surge of new businesses will provide more employment opportunities for people in the Mid-Michigan region, which will help mitigate the unemployment rate.

3. What laws should change to help promote sustainability through private investment of alternative energy?

Upon reviewing the ordinances in Union Township, I would recommend increasing the sound pressure level from 55 decibels to 60 decibels. 55 decibels is comparable to the sound a running refrigerator makes, which is not an egregiously loud sound. By increasing the decibel level, more wind turbines will meet Union Township's ordinances, which will give private citizens more opportunities to shop the market for the best priced and most efficient wind turbine.

Union Township should also decrease the cost of purchasing a permit to have an onsite wind energy system on private property. As budgeted in the grant proposal, a permit costs $500, which is an expensive price to pay considering the other expenses included in the wind turbine project. Decreasing the cost of this permit will entice more private citizens and small business owners to invest in this technology.

4. What actions need to be taken on a sociological level to shift to a culture of sustainability?

Shifting to a sustainable culture is a sociological shift that involves fighting frictional forces in the community, such as ignorance, apathy, and traditions. Union Township must begin to implement an actionable agenda that will serve as a model to the citizens. The wind turbine project was a proactive first step in setting an appropriate example for the community to follow; however, more needs to be done to educate the community about these options. Through the use of community outreach programs, weekly updates on the wind turbines, and seminars held in the K-12 schools, Union Township will perpetuate the education needed to empower residents to invest in alternative energy and other sustainable practices.

C. Rationale for the Recommendations

1. Union Township is responsible for the well-being of their citizens. Promoting alternative energy options to residents is in the best interest of the people because it can save the owner of the wind turbines money over the life of the investment, which in the case of Union Township's investment is twenty years.

In addition to Union Township's duty to promote the well-being of the community, Union Township is also bound by the requirements of their grant proposal to provide citizens with the research necessary to determine whether wind turbine technology is a feasible investment. I have recommended Union Township use a "lead-by-example" strategy to spur interest in wind turbine energy technology. However, more dialogue must occur between the findings of the Union Township wind turbine project and the residents of the community. Although my findings show this is a viable investment with an outstanding return on investment

of 44%, many community members are unaware of these numbers. Furthermore, this is a sustainable practice that since its inception has saved over 300 pounds of carbon dioxide from entering into the atmosphere to continue contributing to global climate change.

To educate the community about the economical and environmental benefits of alternative energy, Union Township needs to engage the community members by creating a stronger link between media sources, such as The Morning Sun, which is the primary newspaper in the Mid-Michigan region. Additionally, Union Township may want to explore sending digital newsletters to update the residents on the progress of the wind turbine project. Finally, creating a specific section on the Union Township website that would be dedicated solely to informing the populace of the progress made in the project would be beneficial. By reaching out to the community through various conduits, Union Township will be successful in taking the first steps necessary in supporting a sustainable culture in the community.

2. A tax incentive is a sure way to attract more residents to consider investing in wind energy technology. Although the federal and state alternative energy programs decrease the cost of investing in this technology, I believe a tax incentive, either in a credit or reimbursement form, needs to be offered at the local level to convince community members to invest. Another tax break is needed because the 15 year repayment period may cause many investors to be weary of the investment because it requires a heavy, front-loaded investment. Liquidity is a restraining factor to most investors. Since the cost saving will not be realized until the 16^{th} year, this may dissuade investment.

However, if a tax break were offered to decrease the initial investment, then the payback period would be sooner than 15 years, which would entice private investment. Financing of the

tax break will be the largest restraining force on this recommendation because all communities are feeling the budget deficit. A viable option for the township to pursue is working with Consumers Energy to provided financial incentives for residents to invest in wind technology. A deal could be created in which Consumers Energy subsidizes part of the cost of a small-scale wind turbine in exchange for private citizen's excess kWh generates to be applied to the grid for Consumers Energy to sell to other homes. This would allow for a synergistic contractual agreement between the two parties.

3. The rationale behind advocating for the increase in decibel level is both made on a common sense and economic claim. 55 decibels is comparable to the sound of a running refrigerator, which leads me to believe that the claim regarding wind turbines being a nuisance and disturbance of the peace is unsubstantiated. The decibel argument against wind turbines seems to be an unnecessary obstruction to progress.

On purely economic terms, I believe residents will have more options when determining whether to invest in wind turbine technology if the decibel ceiling was increased by 5 decibels. If more wind turbine options are able to enter the pool of technologies considered because the ceiling was raised, then residents will have the economic power of the free market system to make an informed decision. As an example, using the old ordinances, some less expensive turbines may have been excluded from consideration because of the ceiling on the decibel level. However, if the ceiling were raised, cheaper turbines that operate at slightly louder levels may convince residents to invest in the technology.

4. The rationale behind Union Township holding community outreach programs, weekly updates on the wind turbines, and seminars held in the K-12 schools, is quite simple: the more exposure one receives, the more knowledgeable one becomes. The key to fostering a sustainable culture involves using education and programming to challenge the status quo of energy understanding in the community. The main issue obstructing the progress of alternative energy investment in most residents in the township is apathy and lack of knowledge in the area of energy policy and technology. A prescribed action plan needs to be developed to adequately provide the necessary background information and knowledge necessary to make an informed decision on wind turbine technology.

Community outreach programs are an important tool to use with community members because it helps build rapport between local government and its people. Although news sources and online media are an effective way to communicate with the community, many people learn better by hands-on and tactile methods. Programs inviting community members to observe the wind turbines and to do construction demonstrations may be useful for many residents. Conducting ―how-to" and ―do-it-yourself" workshops involving the purchase, construction, and installation of the wind energy system will also spur interest in this technology. Many citizens are afraid to invest in a new technology, so introducing these programs will lessen the anxiety felt by a community member.

Since the youth of today is the future of tomorrow, it is imperative to provide educational opportunities to children and young adults in K-12 schools about the importance of sustainability. A viable option to bring environmental education in the classroom is to work with the School Board to place sustainability educational requirements into the curriculum. Additionally, Union

Township should present its research and findings to young adults and children so they can learn at a young age that alternative energy is a feasible technology in the Mid-Michigan region.

Closing Thoughts

I was fortunate to work on the Union Township wind turbine project this past semester. The project started as a requirement for the Honors Program but turned into a sincere and genuine passion for alternative energy. I had been passionate about alternative energy before I started collecting and analyzing research, but I did not have a strong background in the technical, legal, political, and economical framework that surrounds energy policy. This project has strengthened my understanding of wind turbines and alternative energy as a whole.

I enjoyed working on this project because it drew on my interdisciplinary background. I pulled all of my undergraduate knowledge together to incorporate my finance, statistics, business principles, economics, politics, and legal understanding into one comprehensive project. Throughout conducting this research I have strived to challenge my technical understanding of the physics, scientific, and chemical processes that are involved in using the power of wind to create mechanical energy. I also feel the project has strengthened my problem solving and critical thinking skills.

When I graduate from Central Michigan University, I plan to go to law school to become an environmental lawyer. Although it is not a prerequisite, having an adequate background in science, economics, and finance will make you a more prepared and informed environmental lawyer. This research project has also helped me develop more diligent research habits, which is a skill valued in law school. More than anything, I am more knowledgeable about alternative energy and feel I could freely converse about the positive and negative attributes of current United States energy production.

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Part V

Appendix

South Skystream Turbine: Total Savings to Date

Reading Date/Time	Total Output Reading (KW)	Period (Hrs)	KW Produced This Period	Utility $/KW	$ Saved	Avg KW/Hr This Period	Monthly Use (KW) From Bill	Bill Period	Total Saved
10/7/10 0:00	0.00	0:00:00	0.00	$0.11		0.0			$0.00
10/29/2010 9:28	104.80	537:28:00	104.80	$0.11	$11.74	4.7			$11.74
10/30/2010 14:25	112.50	28:57:00	7.70	$0.11	$0.86	6.4			$12.60
11/2/2010 14:40	118.60	72:15:00	6.10	$0.11	$0.68	2.0			$13.28
11/3/2010 8:45	118.50	18:05:00	-0.10	$0.11	-$0.01	-0.1			$13.27
11/4/2010 8:38	120.20	23:53:00	1.70	$0.11	$0.19	1.7			$13.46
11/5/10 9:10	126.50	24:32:00	6.30	$0.11	$0.71	6.2			$14.17
11/8/10 9:11	130.50	72:01:00	4.00	$0.11	$0.45	1.3			$14.62
11/9/10 8:35	130.30	23:24:00	-0.20	$0.11	-$0.02	-0.2			$14.59
11/10/10 8:35	130.20	24:00:00	-0.10	$0.11	-$0.01	-0.1			$14.58
11/11/10 8:35	130.20	24:00:00	0.00	$0.11	$0.00	0.0			$14.58
11/15/10 8:35	137.90	96:00:00	7.70	$0.11	$0.86	1.9			$15.44
11/16/10 8:35	138.90	24:00:00	1.00	$0.11	$0.11	1.0			$15.56
11/17/10 8:35	141.30	24:00:00	2.40	$0.11	$0.27	2.4			$15.83
11/18/10 14:55	144.30	30:20:00	3.00	$0.11	$0.34	2.4			$16.16
11/19/10 12:03	145.50	21:08:00	1.20	$0.11	$0.13	1.4			$16.30
11/23/10 12:15	169.60	96:12:00	24.10	$0.11	$2.70	6.0			$19.00
11/26/10 11:25	196.10	71:10:00	26.50	$0.11	$2.97	8.9			$21.96
11/29/10 9:05	217.10	69:40:00	21.00	$0.11	$2.35	7.2			$24.32
12/2/10 15:48	233.80	78:43:00	16.70	$0.11	$1.87	5.1			$26.19
12/3/10 9:25	233.90	17:37:00	0.10	$0.11	$0.01	0.1			$26.20

X and Y Variables for the mph v. kWh Graph

Date	Average mph	kWh
7-Oct-10	6.08	0
8-Oct-10	9.01	0
9-Oct-10	7.083333333	3.51
10-Oct-10	2.979166667	0.46
11-Oct-10	4.145833333	0.23
12-Oct-10	1.833333333	-0.02
13-Oct-10	3.75	0
14-Oct-10	6.333333333	0.97
15-Oct-10	5.833333333	2.06
16-Oct-10	6.916666667	1.93
17-Oct-10	6.354166667	2.3
18-Oct-10	3.270833333	3.02
19-Oct-10	9.083333333	0.2
20-Oct-10	11.89583333	4.98
21-Oct-10	6.916666667	9.18
22-Oct-10	7.854166667	4.24
23-Oct-10	5.3125	2.14
24-Oct-10	3.87	0.35
25-Oct-10	4.03	1.31
26-Oct-10	5.83	2.08
27-Oct-10	9.34	14.61
28-Oct-10	20.5	28.54
29-Oct-10	8.58	10.62
30-Oct-10	11.2	4.44
31-Oct-10	6.33	7.88
1-Nov-10	1.79	2.72
2-Nov-10	1.63	-0.13

3-Nov-10	7.2	-0.13
4-Nov-10	9	1.6
5-Nov-10	10.29	5.67
6-Nov-10	3.29	3.33
7-Nov-10	6.42	1.46
8-Nov-10	2.71	-0.12
9-Nov-10	7.01	-0.12
10-Nov-10	2.71	-0.12
11-Nov-10	2.71	-0.12
12-Nov-10	4.958	0.66
13-Nov-10	7.583	0.82
14-Nov-10	11.75	6.29
15-Nov-10	7.792	1.04
16-Nov-10	6.458	1.52
17-Nov-10	6.75	2.73
18-Nov-10	5.458	2.12
19-Nov-10	8.042	5.53
20-Nov-10	6.708	1.06
21-Nov-10	7.25	0.45
22-Nov-10	9.5	5.18
23-Nov-10	14.54	19.54
24-Nov-10	7.625	1.9
25-Nov-10	9.208	7.44
26-Nov-10	18.25	20.37
27-Nov-10	11.42	10.26
28-Nov-10	5.292	0.11
29-Nov-10	4.611	-0.1
11/30/2010	12.167	11.4
12/1/2010	11.95	10.2
12/2/2010	8.19	0.1