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Feasibility Study of the Arenal Volcano Wind Project

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Feasibility Study of the Arenal Volcano Wind Project

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Abstract

Empresa de Servicios Publicos de Heredia (ESPH) in Costa Rica wants to develop a wind farm to complement hydropower generation. We explored the feasibility of building a wind farm at a site in Guanacaste for ESPH by determining potential energy output, feasible turbine placement, construction feasibility, financial feasibility and the social and environmental impacts. We proposed a design with a twelve-megawatt wind farm with a payback period of five years as the most cost-effective and efficient.

Acknowledgements

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Executive Summary

Costa Rica is heavily invested in developing renewable sources of energy. In 2010, 94% of energy production in Costa Rica was renewable and a large portion of this energy is generated by hydroelectric plants (ESPH, 2010). These plants are highly effective during the rainy season between the months of March and November. However, during the dry season, between the months of December and March, the energy produced by the hydropower plants drops. To make up for this drop in hydropower production, Costa Rica relies on the energy it generates through geothermal plants, burning of fossil fuels, and wind energy. Out of these three options for energy production during the dry season, wind energy makes a perfect complement for hydro-power as the dry season is also the windiest season.

Empresa de Servicios Publicos de Heredia (ESPH) is a municipal company that provides public services such as running water, sewage, and electricity to the province of Heredia. It currently produces most of its electricity through hydroelectric plants and supplements its generation with energy purchased from ICE, the Costa Rican government's electricity broker, to meet the demand of their customers. During the dry season, however, hydropower generation diminishes, meaning ESPH has to purchase more energy from ICE. To cover more of this energy deficit and purchase less energy from ICE, ESPH has turned to wind energy. ESPH is looking to take advantage of the high wind potential available during the dry season by setting up a wind farm near Arenal, called Proyecto Eólico Volcán Arenal (PEVA).

Our goal was to provide ESPH with an assessment of the feasibility of building a wind farm on the PEVA site. Our objectives included the analysis of wind energy potential at the prospective site, power output estimation, construction feasibility, financial feasibility, and social and environmental impact assessments. This information provided ESPH with the understanding of how the different aspects of feasibility interacted and allowed them to make an informed decision in regards to the construction of the wind farm.

To assess the feasibility of the potential wind farm, we considered many factors. A major consideration is the wind behavior at the site, and the effects of turbine placement on this behavior. We also took into consideration the costs of building the wind farm, the revenue the wind power facility will generate, and any legislation involved with the operation of a wind farm. Finally, we addressed the potential social and environmental impacts of the wind farm to ensure that investing in PEVA would be a responsible choice for ESPH.

The preliminary step to determining the feasibility of PEVA involved assessing the wind potential available on the site. We obtained wind speed data from the MOVASA wind farm that neighbors the PEVA site and used it to extrapolate wind speeds for PEVA. Since the proposed site and the neighboring site are very close in proximity, it can be assumed that the wind speed's availability and behavior will be similar on both sites. We then used the extrapolated data to estimate the projected annual energy production at PEVA. Since the prediction of energy production depends on the efficiency and the power rating of a turbine, we calculated energy production relative to different turbine models offered by the top five wind turbine manufacturers in the market. We then predicted the average annual energy generation relative to each turbine power rating and wind farm sizes we found feasible for PEVA.

Once we understood the wind power generation potential at PEVA, we generated hypothetical turbine layouts corresponding to the prevailing wind direction onsite. We made these layouts for turbines of rotor diameters of 50m, 80m, and 90m to represent turbines of different power ratings, to assess the adequacy of the size of the site, and to determine feasible wind farm capacities. For each configuration, we tried to place the maximum number of turbines on PEVA taking into consideration all the space parameters to reduce shadow effect, and the layout of the land to benefit from the hill effect.

Using our turbine placement, we understood any construction issues that may occur and how it may affect the financial feasibility. The construction aspect involved determining any vegetation that may need removal, distance from the proposed site to the closest substation, and evaluating the adequacy of the access roads to the proposed site. We also researched seismological activity in the area to determine the effect it might have on the construction of the wind farm. These parameters played into the financial feasibility as well since they determine the site preparation cost. The financial feasibility also involved calculating the payback period, which takes into account the initial investment, operation and maintenance costs, and potential revenue from electricity generation.

Finally, to determine any potential impacts the wind farm might have on the surrounding area, we examined the noise generated by the wind farm, the wind farm's proximity to nearby communities, effects on the local economics of the nearby communities, and potential effects on the ecosystem that exist on the site. We used these methods to determine if PEVA was feasible for power generation.

In our results, we first determined the optimal turbine ratings that ESPH should install on PEVA corresponding to different wind farm capacities. We grouped the turbine models from the top five wind turbine manufacturers by power rating to determine the projected annual power generation relative to different power ratings. Our results demonstrate that the 1.5 MW turbines manufactured by General Electric (GE) provide the maximum average power generation at wind farm sizes of 10 MW, 15 MW, and 20 MW. Although 1.5 MW is the optimal, we still considered turbine ratings of 800 kW, 1.8 MW, 2.0 MW, and 2.3 MW for further analysis since they had the next highest power generation.

We determined the prevailing wind direction at PEVA to be from the northeast to the south-west. We used this information to determine turbine placement strategies for the previously mentioned turbine ratings. For turbines with a 50 meter rotor diameter, corresponding to turbines with an 800 kW power rating, we believe that ESPH could place 12 turbines on the site. For 80 meter rotor diameters, corresponding to 1.5 - 2.0MW turbines, we have found that the site is large enough for eight turbines. For 90 meter rotor diameters, corresponding to the largest 1.8 - 3.0MW turbines, we believe that the site can only accommodate six turbines. These size constraints limit power production and make it difficult for ESPH to reach its 20MW production goal for the site.

To facilitate the construction of the wind farm, there are a few issues ESPH would have to address. There are currently patches of bushes and trees on the PEVA site that ESPH would have to clear for construction access and for clear wind flow over the terrain. To aid ESPH with this process, we generated a map of these elevated patches, which we believe should be removed. Another factor contributing to the construction feasibility is the possibility of connecting PEVA to a substation. The closest substation to PEVA is the Corobici substation, which is located 16 kilometers south-west of PEVA. The easiest way for ESPH to build high-voltage power lines to this substation is to run them over public roads, avoiding the purchase of land. Finally, ESPH should consider evaluating the roads that lead up to PEVA. Since MOVASA has used these roads to transport their turbines with rotor diameters of 44m in the past, if ESPH were to purchase turbines with larger rotor diameters the current road conditions may not be adequate. In addition, all the turbines we have considered have a rotor diameter of 50m or higher, therefore we recommend ESPH to evaluate and improve road conditions before purchasing turbines.

We gathered the information for performing the financial analysis through ESPH and Jay Gallegos, an expert in wind energy in Costa Rica. From our conversation with Mr. Gallegos, we understood the initial cost of a wind farm to be $2.8 million/MW including turbine cost, legal fees, consultancies, and land fees. This initial cost does not include the cost of laying transmission lines, which is around $900,000 for PEVA. We performed a preliminary analysis to determine the initial costs and revenues for wind farms of size 10MW, 15 MW, and 20MW. We created cash flow tables for each turbine power rating from 800 kW to 3MW to determine the revenue the wind farm would generate over 20 years, the average lifespan of a wind farm. For a 10 MW wind farm, the total revenue can range from $45 million to $85 million, for a 15 MW wind farm, from $66 million to $111 million and for a 20 MW wind farm, from $83 million to $159 million. In addition, the payback periods for ESPH's independent investment ranged from 5 to 11 years. We determined that the wind farms with the lowest payback periods included those with the 1.5 MW turbines by GE and the 1.8 MW turbine by Vestas. Based on the turbine placement suggestions, we did a secondary financial analysis on wind farms with the feasible number of turbines of each power rating that could fit on the wind farm. We determined that a 12 MW wind farm composed of 1.5 MW turbines and a 16 MW wind farm composed of 2.0 MW turbines would provide the highest revenue for ESPH in the long run. However, the payback period for the 16 MW wind farm is around 2 years more than that of the 12 MW wind farm even though the revenue for both wind farms is about the same. Additionally, since the 16 MW wind farm has a higher power rating it would require a higher initial cost than that of the 12 MW wind farm. Therefore, we suggested the 12 MW wind farm composed of 1.5 MW turbines to be the most efficient for the PEVA site.

The social and environmental feasibility of PEVA encompassed the effects it would have on the local ecosystem and on nearby communities. We could not perform a comprehensive study of the ecology and wild life on the proposed site due to time constraints. However, as mentioned previously, we believe that the removal of patches of trees on the PEVA site would be harmful to the local ecosystem. These trees could be home to many local species of animals, including birds. However, the removal of these habitats could also lower the chances of bird fatalities from turbine strikes, as there would be fewer birds flying near the turbines. In regards to the noise produced by wind turbines, we ascertained that it would not be a nuisance as the closest communities to PEVA are at least a kilometer away. Using the sound map calculator from the

Danish Wind Industry Association we found that noise levels drop significantly outside the boundaries of the wind farm. The noise level is around 45-49 dB, within 150 meters of the boundary, around the noise level of conversational speech. Building a wind farm at PEVA would also provide benefits to nearby communities. Wind farms have proven to be very beneficial to the Tilarán area, both by providing landowners with extra income and jobs for residents. The Tilarán area is very popular for wind farming and it is likely that many laborers in this area would have skills pertaining to wind farm construction and maintenance. These workers, as well as the community at large, would benefit from the jobs created by PEVA.

According to our observations and results, we believe that PEVA site is feasible for the setup of a wind farm. The installation of a 10 – 15 MW wind farm would provide ESPH with the optimal amount of production and revenue generation. As per our results on the data provided to us, we suggested the installation of a 12 MW wind farm composed of 1.5 MW turbines that are manufactured by GE. We determined that PEVA would be feasible for construction as long as ESPH removes the patches of trees and bushes that lower power generation. The wind farm we suggested has a five year payback, which we consider financially feasible. In terms of social and environmental feasibility, we believe that any impact on the ecosystem at the PEVA site would be minimal and the noise produced will not impact any nearby communities. In addition, PEVA would provide job opportunities and a source of income for the nearby communities. While more data would provide a more accurate understanding of PEVA, we believe that PEVA is a feasible site for a wind farm.

Authorship

Pragathi Balasubramanian – Ms. Balasubramanian served as the primary researcher of wind farm financing and policies regarding energy generation, and performed the financial analysis. She also studied the environmental and social impacts of wind farming and applied this knowledge to PEVA.

Branislav Jovanovic – Mr. Jovanovic served as the primary researcher of wind dynamics and wind behavior relating to turbines. He performed the wind speed calculations and projections as well as energy production estimates. Mr. Jovanovic also generated the hypothetical turbine layouts used to asses feasibility.

James Kirk – Mr. Kirk served as the primary researcher of construction and transportation issues and how they would affect the feasibility of PEVA. He served as the primary editor of our written material and assisted Mr. Jovanovic in generating turbine layouts. Mr. Kirk also interviewed Jay Gallegos for wind farm financing information.

All team members contributed equally to this project and to understanding the feasibility of PEVA.

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Chapter 1 - Introduction

Costa Rica is heavily invested in developing renewable sources of energy. This is especially evident since in 2007, Costa Rica committed to become a carbon neutral country by 2021 (Vargas, 2007). This effort by the Costa Rican government is motivated by studies claiming that emissions of carbon dioxide are a key catalyst of climate change. In 2010, the government advanced its renewable energy agenda when President Laura Chinchilla announced her goal of making Costa Rica the first country that runs entirely on renewable sources of energy (Verdin, 2010). Additionally, the people of Costa Rica are committed to preserving natural resources since a main source of their income is from eco-tourism. Preservation of the environment is a top priority in Costa Rica, for their economy and for their way of life.

In 2010, 94% of energy production in Costa Rica was renewable and a large portion of this energy was generated by hydroelectric plants (ESPH, 2010). These plants are highly effective during the rainy season between the months of March and November. During the dry season between the months of December and March, however, the energy produced by the hydropower plants drops. While hydropower may be less effective during the dry season, Costa Rica still generates electricity through geothermal energy, fossil fuels, and wind energy. It is difficult to expand geothermal energy production since most lands with high geothermal potential are national parks. Many of these national parks are volcanoes, which tend to be geothermal hot spots. As for energy generated through fossil fuels, it is not renewable and therefore not in line with Costa Rica's interests to expand. On the other hand, wind energy has become a promising path for future energy production due to the high wind potential during the dry season.

Denmark is a prime example of a country that is heavily committed in wind energy production. In response to the 1973 oil crisis, Denmark turned to wind energy production and now generates 19% of its energy from wind farms (Walsh, 2009). Currently, Costa Rica produces less than one percent of its electricity through wind energy, however, it sees wind power as another viable option for the expansion of renewable energy production. Modern wind energy has many advantages in addition to being a renewable source of power generation. The cost of producing wind energy has decreased by at least 80% over the last 20 years, meaning that it has become more affordable to build wind turbines (D'Silva, 2010). In addition, wind is free and readily available, another reason why it has become a very promising choice for renewable energy expansion.

Empresa de Servicios Publicos de Heredia (ESPH) is a public utility company that provides public services such as running water, sewage, and electricity to the Costa Rican province of Heredia. ESPH currently produces 26 MW of Heredia's 90 MW demand, and purchases the remainder of Heredia's energy from Instituto Costarricense de Electricidad (ICE), the Costa Rican government's energy institute. ESPH currently generates electricity through three hydroelectric plants: Los Negros, Carrillos and Tacares. During the dry season, the energy produced by the hydroelectric plants decreases, meaning ESPH has to purchase more energy from ICE. ESPH would like to use wind energy to cover more of this energy deficit and, therefore, purchase less energy from ICE. Wind energy is the ideal solution for ESPH as wind farms are at their peak generation during the dry season, complementing hydroelectric power's strength in the rainy season.

Prior to this project, ESPH had been investigating building a wind farm dubbed Proyecto Eólico Volcán Arenal, or PEVA. They established goals, studied other wind farms in Costa Rica, and began investigating details about the projects such as financial information, grid connection, access roads, and environmental impact. We used this information as a basis for further research into the feasibility of building a wind farm at PEVA. To perform a full feasibility study, we must prove that it is economically viable and responsible to build the wind farm. The various factors of wind farm construction and operation were taken into account to ensure that the expenses of the farm did not outweigh the benefits ESPH will gain without having to purchase as much energy from ICE.

Our goal was to provide ESPH with an assessment of the feasibility of building a wind farm on PEVA. Our objectives included the analysis of wind data at the prospective site, power output estimation, construction feasibility, financial feasibility, and social and environmental impact assessment for the site. These objectives were achieved by collecting information from our sponsor, site visits, and wind energy experts in Costa Rica. Once we achieved these objectives, we made recommendations for wind turbine selection, wind turbine placement on the farm, and provided other information to ESPH for future use. This helped ESPH with the understanding of how the different aspects of feasibility interacted and allowed ESPH to make an informed decision in regards to the construction of the wind farms.

Chapter 2 - Background

In 2009 alone, $63 billion worth of wind turbines were installed and wind power capacity increased by 31% worldwide (World Wind Energy Association, 2010). This is evidence of how wind power generation has become a more attractive option for renewable energy in recent years. Renewable energy is a main priority for Costa Rica, since it is a very environmentally conscious country and is aware of its ample natural resources. Since wind power has become a more accessible choice for renewable energy recently, Costa Rica has directed its attention towards wind farms, and currently has about 123 MW of wind turbines installed. However, the power production on these wind farms depends highly on local weather patterns as the wind potential on these farms vary with each season. ESPH is looking to take advantage of the high wind potential available during the dry season by setting up a wind farm in Tierras Morenas, Guanacaste. When setting up a wind farm there are many aspects ESPH would have to take into consideration. One such aspect is the wind behavior in the area the wind turbines will be placed, and how it will be affected once a wind turbine is placed there. Other aspects involve the capability for the site to produce energy, the revenue the wind power generation facility will produce, available financing for building the wind farm, and any legislation involved with the set-up of the wind farm. Finally, the potential social and environmental impacts of the wind farm would also need to be addressed. This chapter will give a brief overview of how wind energy could be a viable solution to part of growing renewable energy demand, the wind dynamics that might be present at a wind power generation facility, and the ways to determine if a site is feasible for wind power generation. Definitions for italicized terms can be found in the glossary.

2.1 Renewable Energy

Electrical energy is an important element in the daily lives of people living in developed countries. As the human population grows, so does the demand for electricity. In many nations, the primary sources of electricity have been the burning of fossil fuels and nuclear fission. Since the 1970s, these sources of energy have faced growing opposition as the public has become more aware of the side effects of using them. Oil crises, global warming, and nuclear waste have all made policy makers and energy companies hesitant to invest in conventional generation to meet growing demand. Instead, they rely on the rapidly developing field of renewable energy sources to provide power cleanly and efficiently to their customers (Vogel, 2005).

The heightened interest in renewable sources of energy has led to massive proliferation of renewable energy plants as well as great leaps in the technologies related to renewable energy generation. According to a report by GBI Research, countries with emerging economies invested $65.86 billion in renewable energy sources in 2009. As Figure 2.1 demonstrates, this is a 26% growth over their 2008 investment, and GBI expects this number to continue growing. These investments are primarily from China, India, and Brazil (Peri, 2010).

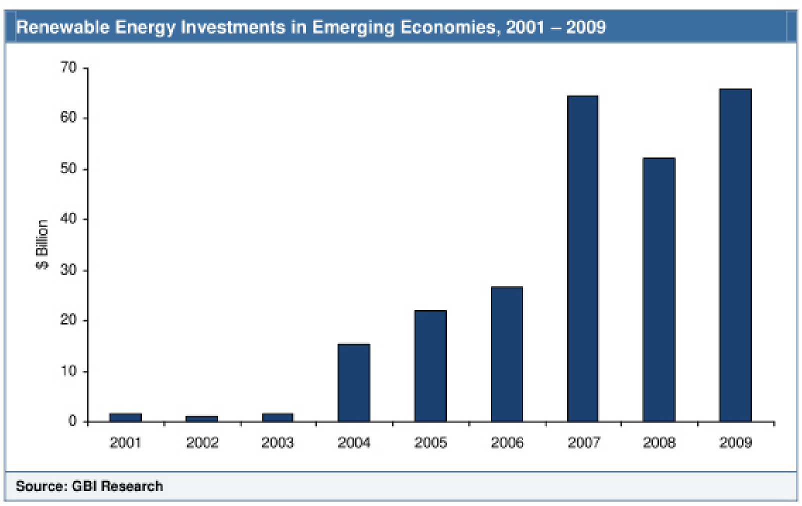

Figure 2.1 Renewable Energy Investments in Emerging Economies (Peri, 2010)

The most common forms of renewable energy are wind energy, hydroelectric energy, geothermal energy, and solar energy. Wind energy is harnessed through wind turbines, which are turned by the force of the wind and generate energy through *magnetic induction*. Hydroelectric energy harnesses the potential energy of water from lakes and rivers to spin turbines which, like wind turbines, generate electricity through magnetic induction. Geothermal electricity can be generated through many different processes, but all methods involve harnessing the energy from pressurized steam built up at the bottom of deep wells. Solar energy can either be harnessed through the use of photovoltaic cells, which are often inefficient and expensive, or through using mirrors to boil water and run the steam through a turbine. All of these forms of renewable energy have advantages and disadvantages, which make them more or less suited to certain situations (Lauber, 2005).

Costa Rica has a strong interest in developing renewable energy. In 2007, Costa Rica declared its intent to be the world's first carbon neutral country by 2021. Even before this declaration, many renewable energy projects, such as the Arenal Dam, had already been undertaken. Lake Arenal, the largest body of water in Costa Rica, is an artificial lake made to provide a reservoir for the Arenal Dam, which alone generates 70% of the nation's electricity annually (Perez, 2006). Many other hydroelectric plants make up a large part of the remainder of Costa Rica's electricity generation, but creating new hydroelectric plants has been heavily opposed by environmental groups as they are viewed as destructive to animal habitats. Geothermal plants exist in Costa Rica, but expansion in this sector is difficult as many of the best locations for geothermal plants fall in national parks and nature reserves, where development is not legal. Solar energy is not widely used in Costa Rica as the weather is often cloudy and solar energy is ineffective when the solar panels are not in direct sunlight. This leaves wind energy as the renewable energy source with the greatest potential for expansion in Costa Rica.

2.2 History of Wind Power

The power of the wind has long been utilized as a source of mechanical power and since the 1890s has become a source of electrical power as well. In the 1890s, the Danes developed the first wind turbines meant to generate electricity. Between 1890 and 1980, electric generation from wind was limited to small private turbines meant to provide power to people who would not otherwise have access to electricity (Vogel, 2005). In 1980, the first commercial wind farm that consisted of more than one turbine was built on Crotched Mountain in southern New Hampshire, USA. This wind farm consisted of 20 turbines producing 30 kW each, a very small output by today's standards.

As a result of the increased interest in wind farming after the oil crises and growing environmental awareness of the 1970s, the technology of wind farming has made considerable advances. These advances have come as a result of incentives and tax credits given by governments at all levels, especially in the United States and Europe (Vogel, 2005). Modern wind turbines are computer controlled and built from cutting-edge materials, allowing them to be bigger, more resilient, and more efficient. The technology has developed to the point that wind energy today costs only 20% of what it did in 1980 (D'Silva, 2010).

Many countries have turned to wind energy as a means of diversifying their electricity generation sources. Denmark is an excellent example of a country that has achieved enormous progress in wind energy production. In the early 1970s, 90% of Denmark's energy came from imported petroleum. In 1973, an oil crisis hit Denmark. To decrease the price of energy, the Danish government launched a program in which they covered 30% of investment costs and guaranteed loans with fixed rates for companies that promoted wind energy, such as the turbine manufacturer Vestas. Today, Danish companies control one third of the world's wind turbine market. Furthermore, Denmark has become the nation that is the most heavily invested in wind power, producing 19% of its energy from wind farming (Walsh, 2009).

Like Denmark, Costa Rica's pursuit for renewable energy has resulted in an increased interest in wind farming. There are already 123 MW of wind turbines installed in Costa Rica and they produced approximately 309 GWh of wind energy in 2009 (World Wind Energy Association, 2009). It is likely that investment in wind energy will rise due to the successful operation of these wind farms. Wind energy has become increasingly appealing in Costa Rica thanks to the decreasing costs of construction, the high priority of renewable energy, and the way that wind farming complements Costa Rica's established hydropower infrastructure.

2.3 Seasonal Weather Patterns in Costa Rica

In Costa Rica, there are two main seasons, the rainy season and the dry season. The rainy season in the Guanacaste province lasts from April to November and the dry season lasts from December to March. The rainy season is marked by very high levels of precipitation, often over ten inches per month, while in the dry season precipitation regularly falls as low as 1 inch per month. However, the national average wind speed moves as the inverse of precipitation. In the dry season, wind speeds peak around 16 meters per second while, in the rainy season, wind speeds can be as low as 6 meters per second. While these wind speeds would be higher on a potential wind farm than the national averages, their relationship with the seasons would be the same.

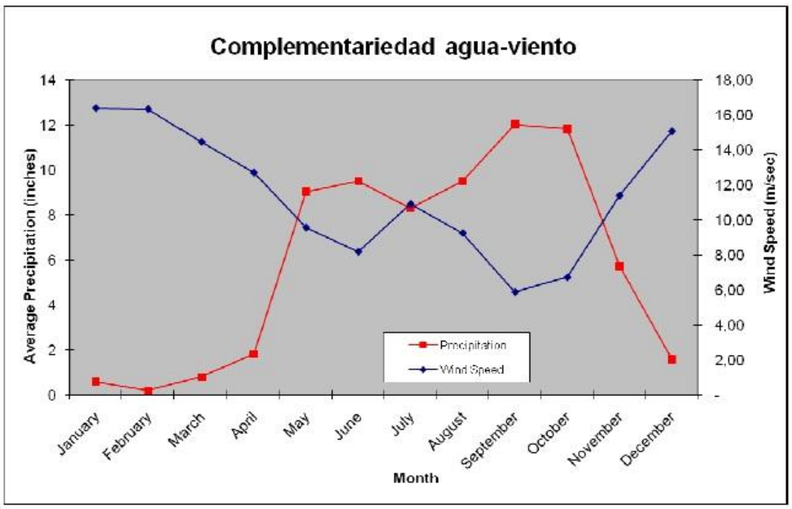

Figure 2.2 Relationship between wind speed and precipitation

As Figure 2.2 shows, this inverse relationship presents wind as a perfect seasonal complement to water in terms of electricity generation.

These seasonal changes affect power generation in Costa Rica through the availability of different renewable resources during each season. During the rainy season, Costa Rica's hydropower plants run at peak performance, while during the dry season the ability of hydropower plants to meet demand can fall. On the other hand, wind farms can be operating at their peak efficiency during the dry season. This means that wind farms and hydroelectric generation complement each other perfectly as means of generating power year-round.

Diversifying the means of power generation is of tremendous importance to a country as heavily dependent on a seasonally variable source of generation as Costa Rica. On April 19, 2007, at the end of the dry season, the entire country of Costa Rica experienced a blackout when the hydroelectric dam at Lake Arenal failed to meet demand, leading to a critical failure of the entire nation's energy distribution system. During the days that followed, Costa Rica dealt with rolling blackouts until the Arenal dam was able to meet demand again. By diversifying energy sources, specifically by investing in wind farms, Costa Rican energy providers can avoid compromising the energy grid in such a way in the future.

2.4 Wind Characteristics and Data Collection

To harness wind power to supplement hydroelectric power, wind characteristics must be understood. The primary wind characteristics we are concerned with are wind speed and direction, because they are the two main factors that determine power generation at a wind farm. There are different ways to collect data pertaining to these two characteristics. In addition, these two characteristics can vary depending on certain conditions such as shear effect and turbulence. To determine the extent to which these factors affect the power generation, they must be measured.

2.4.1 Data Collection

The two primary characteristics, wind speed and direction, must be measured and represented to determine the wind potential of a site. The wind speed is a crucial factor to power generation, as the energy contained in wind is proportional to the cube of wind speed in the direction of the blade. However, even at high wind speeds, to capture significant amounts of energy from wind there should also be a prevailing wind direction on a site. Once the prevailing wind direction is determined, it will be used for proper turbine placement to ensure that turbine arrangements are as efficient as possible.

In order to determine the predominant wind direction as well as the wind speeds at a specific site, wind data collection must be performed. The most common way to perform these measurements is to place anemometers and wind vanes on the top of *met towers* that are at or near the same height as the proposed wind turbine's hub. Towers should be uniformly distributed across the site and wind data ideally should be collected for at least a year. Data gathered using this method is usually considered highly detailed wind data.

Wind data can also be extrapolated from the wind data that has been collected from neighboring wind farms, if such data exists and is available. However, this method of data collection may lack the accuracy of on-site collection. A wind atlas can also be referenced for a general understanding of potential wind speeds and potential power generated in different parts of a country.

Simply by looking at nature we find another method of determining the predominant wind direction. When trees are subjected to strong winds predominantly in one direction, it causes a growth response called *flagging* where the tree grows in a certain direction. As shown by the tree bending in Figure 2.3, local vegetation will adapt to the prevailing wind direction by leaning in the direction the wind is blowing. Therefore, this can be very useful as an indicator of the prevailing wind direction which is critical in understanding the orientation the wind turbine layout of the site must have (Danish Wind Industry Association, 2003).

Figure 2.3 A tree experiencing flagging (Danish Wind Industry Association, 2003)

2.4.2 Effects Related to Major Wind Characteristics

An effect pertinent to wind speed is the phenomenon called the shear effect. It details how wind speed is directly affected by altitude, where the closer the wind is to the ground, the slower it is. The variation of wind speed is due to the frictional force caused by the roughness of the terrain, which opposes the direction and motion of the wind and incites turbulence. This effect is described by the wind shear equation:

$$v = v_{ref} \frac{h}{h_{ref}} \alpha$$

In this equation, v and v_{ref} are the average wind speeds at the heights h and h_{ref}. α is a shear exponent and it is dependent on terrain roughness. Determining the roughness class of a proposed site is crucial to the estimation of energy generation, since it directly affects wind speed. The roughness of a terrain is classified by roughness classes expressed in numerical values on a scale of 0 to 4 (WAsP). Smooth surfaces such as water or an open area with few wind breaks as illustrated in Figure 2.4, have low roughness, therefore they would be ranked between 0 and 1 in terms of roughness class. Landscape with a moderate number of trees and a few hills as shown in Figure 2.5, would be ranked at a roughness class of 2. If the landscape has many trees and obstacles as shown in Figure 2.6, it would make the terrain very rough, making the roughness class around 3 to 4. It would be very complex and inefficient to place a wind turbine on a site with a roughness class of 3-4. One way to determine roughness class is by using wind data analysis software such as WAsP with topographical information of the site. However, it can also be estimated by eye since it is a measure of the size and distribution of roughness elements such as trees or buildings (WAsP, 2007). An understanding of the suitability of a wind farm site requires analysis of terrain roughness to ensure that the height at which the turbine is located is not seriously affected by the roughness of the terrain (Manwell, McGowen, & Rogers, 2002).

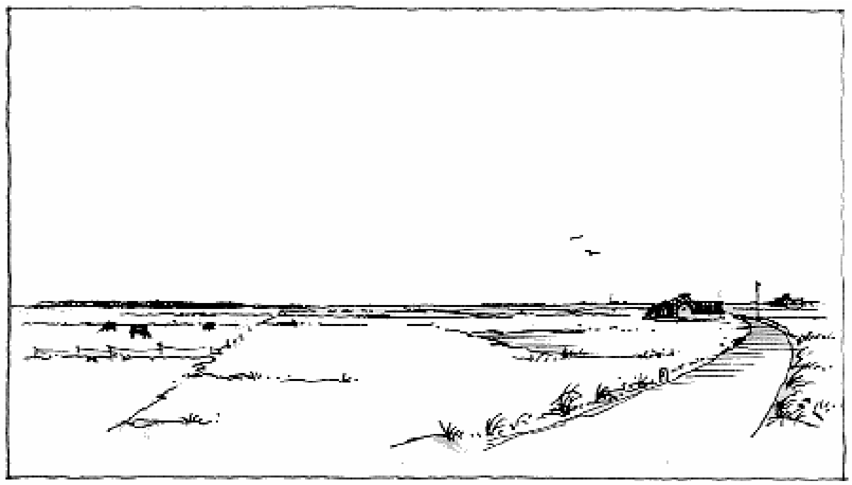

Figure 2.4 Low Roughness Class (0-1) Illustration (WAsP)

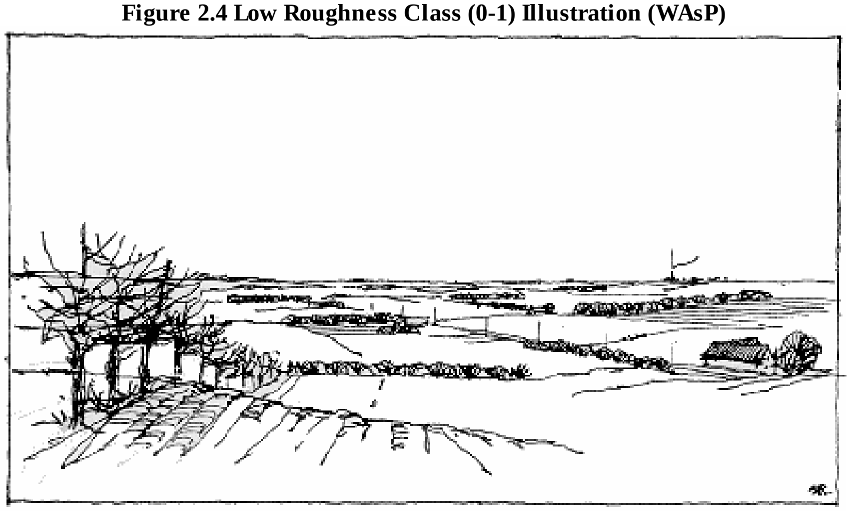

Figure 2.5 Moderate Roughness Class (2) Illustration (WAsP)

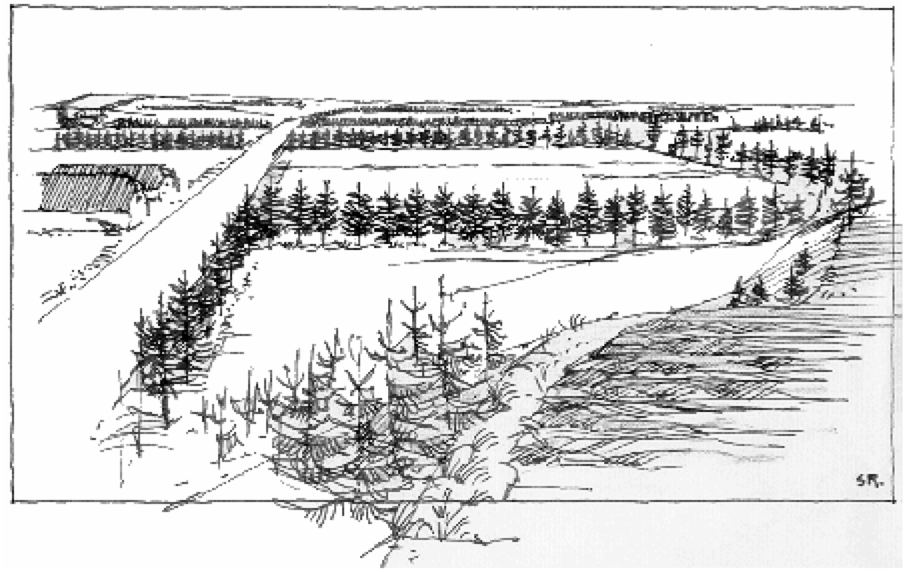

Figure 2.6 High Roughness Class (3-4) Illustration (WAsP)

Another effect related to wind speed and direction is turbulence. When both wind speed and direction change very frequently in a short period of time or over a short distance, turbulence occurs. Hailstorms and thunderstorms in particular are associated with turbulence since they contain frequent gusts of wind, which change both speed and direction. Areas with very uneven terrain surfaces, and areas behind obstacles such as buildings, similarly create turbulence (Manwell, McGowen, & Rogers, 2002). There are two ways to diminish the effects of turbulence on a potential wind farm. The first is to build a tall wind turbine tower that would stand above the more turbulent areas close to the ground. Another is to ensure that obstacles that cause turbulence are far enough from the wind turbine to not disrupt airflow to the turbine. One of the rules of thumb for choosing the proper location for wind turbines is to check that the distance between any wind obstacle and the turbine is more than five times the obstacle's height (Manwell, McGowen, & Rogers, 2002, p.13).

2.4.3 Wind Data Representations and Analysis

When working with highly detailed wind data, it is convenient to represent the prevailing wind direction in a wind rose diagram, which represents average wind speed and energy generated from different angles as indicated in Figure 2.7 (Mathur & Wagner, 2009).

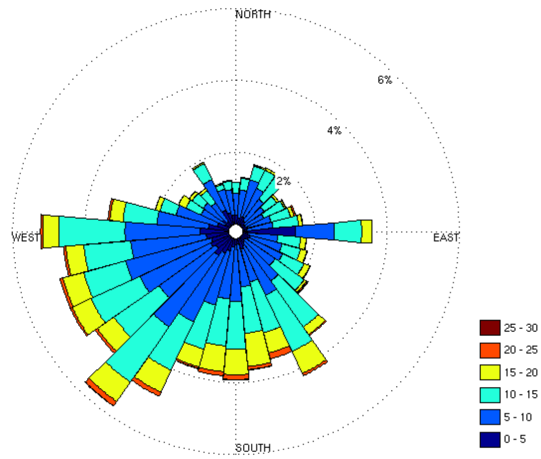

Figure 2.7 Sample wind rose diagram made in MATLAB

The wind rose is a diagram, divided into many sectors, which shows the frequency and speed of the wind in different directions. The fact that predominant wind direction can easily be recognized from the diagram allows us to apply the wind rose diagram to wind turbine placement. Similar to the wind and energy rose, turbulence rose diagrams can also be generated to depict the turbulence occurring in every direction. This data can be useful in determining turbine placement and tower height (Al-Soud, 2009).

The next customary step in analyzing wind data is the use of a probability density function. A probability density function for wind speeds on a site would give the probability of wind speed being within a certain range at a given point in time. The probability density function that is the most commonly used in wind data analysis is the Weibull distribution. It is generally used to represent probability distribution of many natural phenomena (Lun & Lam, 2000). The Weibull distribution is described by two parameters, the scale and shape values. The shape parameter describes the shape of the curve, while the scale parameter describes amplitude. These are the parameters that will be manipulated to provide a Weibull distribution fit for almost any given wind speed data. If the confidence level of a Weibull distribution is low, meaning the Weibull distribution is not an accurate representation of the data, other probability density functions can be used to express the wind behavior. Figure 2.8 illustrates two curves that are examples of the Weibull distribution.

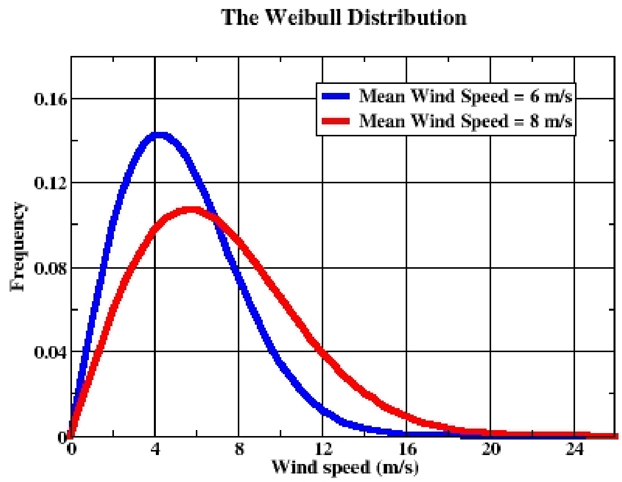

Figure 2.8 Two functions representative of Weibull distributions (Environment Canada, 2009)

To determine the probability of wind speeds on a particular site being between 4 m/s and 8 m/s, we would have to integrate the probability density function to find the area under it between these two values. If the wind speed data can be fit to a Weibull distribution, this statistical method will allow us to describe the wind data collected over a certain time period with only the shape and scale factors. Since the Weibull distribution takes into account and represents all wind speed variations, if the data can fit to a Weibull distribution, it can help us determine wind speeds available on a particular site and therefore, the estimated power output from a wind farm placed on that site.

While wind speed, direction, and shear must all be measured and analyzed to determine the suitability of a potential wind farm site, a wind farm itself has a large impact on the wind behavior in an area. To ensure the feasibility of ESPH's site, we must understand how wind turbines are affected by each other, by the site's topography, and by obstacles on site.

2.5 Wind Behavior on a Wind Farm

Wind behavior can be affected by certain phenomena, which can influence the placement of wind turbines. These effects must be taken into consideration to ensure that optimal power is produced at the site.

A type of wind behavior that is common in wind farms is the shadow effect. When wind encounters an obstacle, such as a turbine, there will be a decrease in wind speed immediately behind the obstacle. A certain distance away from that obstacle, the wind speed will return to the original speed. Therefore, if a second turbine were placed within the shadow of another turbine, the second turbine would produce less electrical energy. It is also important to consider obstacles other than wind turbines, and how they could affect power generation on a wind farm. When choosing the locations for wind turbines on a wind farm, the shadow effect will play a significant role. This effect must also be considered when evaluating the size of a wind farm, as the wind farm will have to be large enough such that turbines interfere minimally with each other. Today, it is common practice to space wind turbines perpendicular to the prevailing wind direction 3 to 5 rotor diameters from each other and, for those that are along the prevailing wind direction, 5 to 9 rotor diameters from each other (Mathur & Wagner, 2009, p.13). The spacing of turbines according to this practice would place turbines in grid form as shown in Figure 2.9.

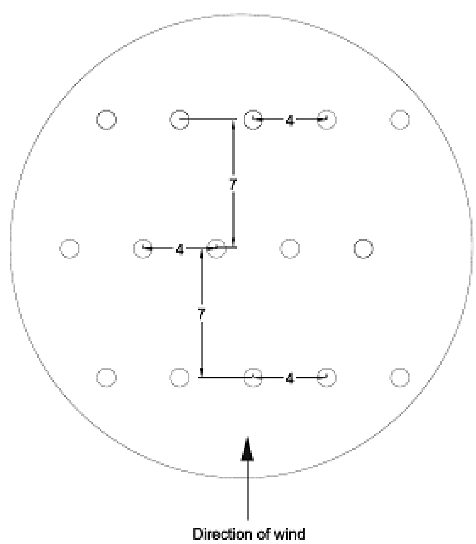

Figure 2.9 Suggested wind turbine spacing (Mathur & Wagner, 2009, p.14)

Other wind effects pertinent to turbine placement are the tunnel effect and hill effect. An example of the tunnel effect would be the change in wind flow through canyons. Wind speeds are usually higher in tunnels, making tunnels attractive for wind turbines. However, if the sides of the tunnel are uneven, they will cause turbulence, which is undesirable for wind turbines. The hill effect describes the phenomena where the wind speed is higher on the top of hills. Placing a wind turbine on hills or ridges overlooking the surrounding areas takes advantage of the hill effect. In addition, there is less interference from any obstacles that might diminish the wind speed (Mathur & Wagner, 2009). However, if the hill is too steep or has uneven terrain, there can be a significant amount of turbulence, which may nullify the advantage of higher wind speed (Danish Wind Industry Association, 2003).

These wind behaviors need to be taken into account for turbine placement and orientation when planning a wind farm. Additionally, terrain characteristics associated with these wind behaviors would allow us to assess if the proposed site would be appropriate for setting up a wind farm. Analysis of the wind information based on wind characteristics and wind behavior would aid in predicting the possible power generated by the wind turbines.

2.6 Wind Power Generation

Wind power generation is determined by the energy captured by the wind turbines. Energy enters a wind turbine system through the rotor blades. The kinetic energy from the wind is converted into the rotational kinetic energy of the blades, which is then converted to electrical energy in the wind turbine.

2.6.1 Power Generation

Wind power is proportional to the cube of the wind speed and the square of the diameter of the rotor blades. In Appendix A, we have derived the equation that represents the wind energy and wind power that is captured. Consequently, wind speed is a crucial factor for power generation and for determining the feasibility of a wind farm. Figure 2.10 illustrates the proportionality of wind power to the square of the diameter of the rotor blades and the cube of the wind speed. This information will ultimately affect the turbine choices ESPH would have to make to set up a wind farm on their proposed site (Mathur & Wagner, 2009).

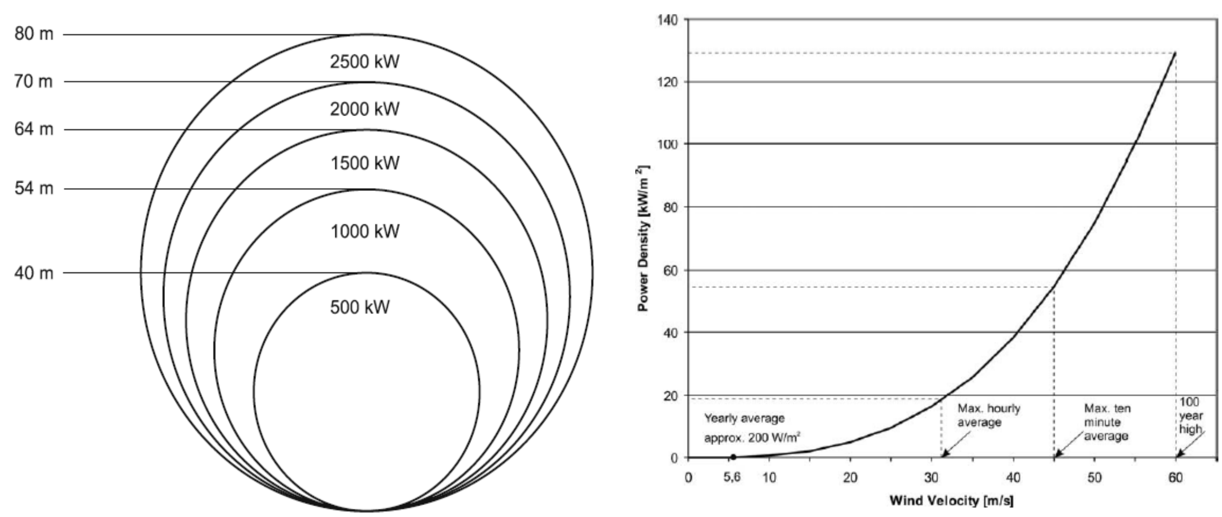

Figure 2.10 Relationship between power output, rotor diameter, and wind speed (Mathur & Wagner, 2009)

2.6.2 Turbine Components and Energy Conversion

When considering power generation it is essential to understand the components that make it possible. The main parts of a wind turbine system are the rotor blades, the gearbox, the generator, the turbine tower and the control system. Each part is described in greater detail in Appendix Z. The understanding of the wind turbine anatomy is necessary to build an efficient wind farm and for an understanding of the types of wind turbines currently available in the market.

A wind turbine will not be able to capture and convert all of the energy provided by the wind. Theoretically, the maximum wind power that can be captured by the turbine is 59.25 % as stated by *Betz's Law*. There are more power losses in the gearbox and the generator, which further limit the efficiency of the wind turbine. The equation for calculating wind power that takes into consideration these power losses is shown and explained in Appendix B (Mathur & Wagner, 2009).

2.6.3 Wind Turbine Selection

Currently there are wind turbines with power ratings ranging from 250 W to 7 MW on the market (AWEA). ESPH is looking for PEVA to have a *name-plate power rating* between 10 MW and 20 MW. When comparing turbines, there are many parameters to take into consideration to ensure that the selected turbine will produce the optimal amount of energy and will be adequate for ESPH to meet their power generation goals.

The main parameters used to compare wind turbines are: Cut-in/Cut-Out wind speed, rated speed, and rated power. These terms are visually represented on the graph shown in Figure 2.11.

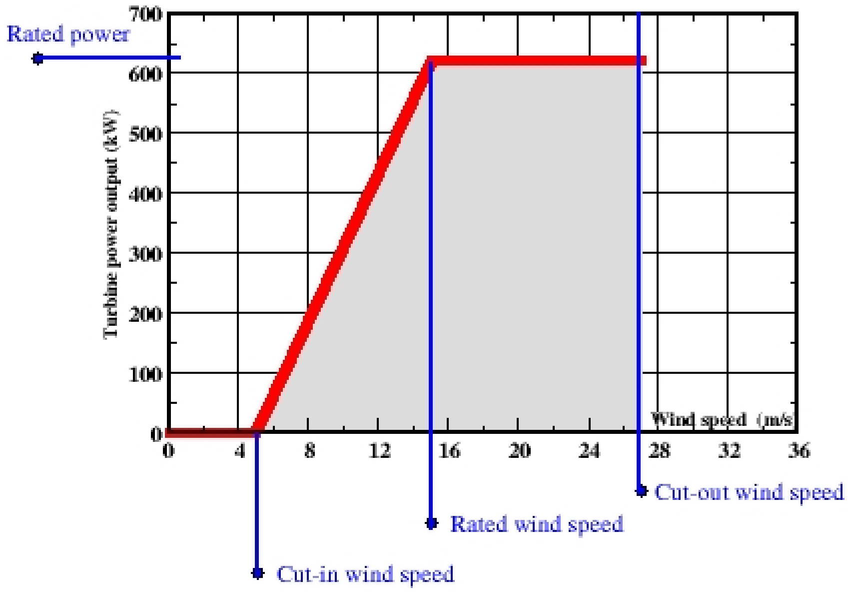

Figure 2.11 Idealized power curve for a wind turbine (Environment Canada, 2009)

Cut-In speed represents the lowest wind speed at which the wind turbine starts generating electricity. Similarly, Cut-Out speed is the highest wind speed at which the wind turbine operates before it is shut off to avoid any damage to the surroundings and the turbine itself. Rated speed is the wind speed at which the turbine is producing the rated power, which represents the power produced by a wind turbine when it is operating at optimal efficiency (Mathur & Wagner, 2009).

It is important to note that these parameters only make up a part of the information necessary for the turbine selection process. As mentioned earlier, wind turbine components and the wind speed available on site will also play into the selection process. For instance, a turbine with a higher rated power may seem to be a good option since it will produce more power at optimal efficiency. However, on a site with low wind speeds, a turbine with a higher rated power may not produce as much energy as a lower rated turbine because the turbine with a low rated capacity may be operating more efficiently at these low wind speeds (Danish Wind Industry Association, 2003).

From this research, we conclude that the wind speed and the rotor diameter are vital variables when analyzing the wind power produced by a wind turbine. Therefore performing careful wind speed analysis is vital for the feasibility study. In addition, when the wind turbine recommendations are made, it is necessary to take into consideration the wind speeds available on site, the components of the turbine and the parameters for turbine comparison.

2.7 Construction Feasibility and Financial Feasibility

Construction and financial feasibility are also important factors to consider since they determine if the construction of a wind farm and the power generation on the proposed site would return a profit after a reasonable payback period. The construction feasibility can only be determined as a consequence of the costs involved with the site preparation and turbine installation of the wind farm. Therefore, to determine the construction and financial feasibility the following factors must be examined: land conditions present on site, infrastructure necessary to facilitate the construction of the turbines, initial cost of set up, cost of maintenance of the wind farm, and the payback period for these costs.

The initial cost of setting up the wind farm includes the costs of the wind turbines, transportation of the turbines, site preparation, and turbine installation. Some sources say that, in general, the initial cost of a wind farm can be between $1,300 to $1,800 per kW of installed power. However, other factors such as local labor costs and turbine specification might cause the initial cost to lie outside this range. In addition, the taller the turbine tower, the more it will increase the initial cost (Mathur & Wagner, 2009). The cost for transportation of the wind turbines is usually included in the initial cost of the turbines. However, this cost may increase depending on the road access available to the site. Even if the site were to be remote, the transportation of a single wind turbine to the site generally should not exceed $15,000. However, since many turbines are being transported from the manufacturer to the proposed site, the transportation cost per turbine will be reduced dramatically (Danish Wind Industry Association, 2003).

The site preparation and installation phase of construction introduce many specific factors, which contribute to the initial cost. These factors include preparing the grounds for set up, laying roads for transport, and the connection to the electricity grid. Preparing the grounds includes laying reinforced concrete foundations for the construction of the wind turbines and laying access paths to the turbines on site. Once the grounds are prepared, the transportation of the turbines must be considered in case the roads to the site are not suitable for turbine transportation. Therefore laying roads to and on the site could also become a part of the initial cost. Transmission lines are another necessary factor that contributes to the initial cost, as it is required to transfer energy produced by the wind farm to a local power grid. Usually, electricity produced by wind farms cannot be directly connected to the local power grid. In this case, the wind farm might also have to purchase a transformer to convert the power from the turbines to a voltage suitable for the electricity grid the wind farm is connected to. Although it is not a necessity, the installation of a telephone connection on the wind farm may contribute to the initial cost. The telephone connection provides a way to remotely control and have constant surveillance over the turbines in the wind farm and is usually very cheap to install. These factors contribute to the set-up of the infrastructure necessary to transport and construct the wind turbines. The associated costs for this phase depends on local labor costs, soil conditions, distance to the nearest access road, cost of transporting construction equipment to the site, and the distance to the nearest electric grid connection. Taking these elements into consideration, we must consider all of these aspects when determining the cost of establishing a wind farm: cost of the wind turbines themselves, transportation of the wind turbines, site preparation and turbine installation costs (Danish Wind Industry Association, 2003).

Most wind turbine manufacturers offer services to set up the wind farm. The exact cost for these services would have to be negotiated between ESPH and the manufacturer. The companies GE[1], Vestas[2], and Gamesa[3] offer services to assist their customers with building a wind farm. GE even gives its potential customers a general estimation of $2 million per MW of wind turbines installed according to the AWEA (AWEA, 2009).

Another cost involved in feasibility is the operation and maintenance cost of the wind farm. Studies show that maintenance costs are on average 1.5 – 2% of the original cost of the turbine annually (Mathur & Wagner, 2009). This maintenance cost for the wind turbine will increase depending on the age of the turbine. During the payback period calculations, the maintenance cost would be factored in as $0.01/kWh to take in the consideration the cost increase as the turbines age. It is also important to consider the insurance cost of the wind turbines. As wind turbines wear out over time it is generally more efficient to replace parts of the turbines rather than replacing the entire turbine. The cost of parts such as the rotor blades, gearbox or the generator is about fifteen to twenty percent of the cost of a turbine. However, these expenses would have to be considered in the future. They cannot be calculated accurately

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[1] http://www.gepower.com/prod_serv/serv_for/wind_turbines/en/index.htm

[2] http://www.vestas.com/en/wind-power-plants/wind-project-planning.aspx#/vestas-univers

[3] http://www.gamesacorp.com/en/products-and-services/wind-farms/

since circumstantial factors would come into play in terms of how quickly a wind turbine would age (Mathur & Wagner, 2009).

Calculating the payback period of a wind farm is a process that takes into consideration the following variables: initial cost, operation and maintenance cost, the price at which electricity is sold, loan payback, and the power generation on the proposed site. A feasibility study performed in Brazil contains an analysis on the relationships between the different aspects of feasibility and the way they can affect the financial feasibility of the site. Through computer simulation, the authors analyzed how different layouts of the wind farm affected the *capacity factor* of the farm and, by extension, how the layouts affected the investment payback period of the farm. They aimed to achieve a layout for turbine placement that maximized profit from the farm (de Araujo Lima & Bezerra Filho, 2010). Therefore, the expected payback period can only be calculated once all other feasibility evaluations pertinent to the wind farm have been performed.

In summation, the construction and financial feasibility of a wind farm depends on site preparation, turbine installation, price of turbines, transportation of turbines, the operation and maintenance costs, and the payback period.

2.8 Wind turbines and Seismology

Costa Rica is a seismologically active country and, therefore, we must evaluate the effects that seismology might have on wind turbines. The PEVA site is located near the Arenal Volcano. Therefore, we examined seismological activities in that region and how they might affect wind turbines. Even though Arenal Volcano is the most active volcano in Costa Rica, results from seismological equipment installed there indicate that there are relatively low levels of activity (10 to 15 microearthquakes per month) (ARENAL.NET, 2006). In addition, there are many wind farms, hydroelectric power plants and geothermal power plants at the Arenal Volcano that have operated there for decades. This seems to indicate that seismology is a concern, but has not yet proven to be a threat.

To confirm this, we examined research that has been done on this topic. According to a report called *Seismic Forces for Wind Turbine Foundation*: "The shake table testing program found that there was significant amplification of the input seismic acceleration in the nacelle during all shake table tests of the turbine (Ntambakw & Rogers, 2009, p.13)." Significant amplification of the input seismic acceleration is definitely a subject of concern, but a method to reduce this is given in a study performed by Guralp Systems. According to them, changing the design of the turbine foundations so that they can take into account seismic coupling and structural stability would make turbines generate vibrations of a lower magnitude (Guralp Systems, 2006). If turbines generate smaller vibrations, that implies lower influence between earth and a tower, and vice versa. Therefore, we can assume that this method would make turbines more earthquake resistant. There are not many studies that have been done on seismological effects on wind turbines. However, one currently being executed by University of California, San Diego, will include simulated earthquakes and their influence on 24 meter wind turbines and will hopefully answer many questions in this field (Lafee, 2010).

The research that we have done on seismology and it relation to wind turbines indicates that this is a relatively new field of study; nonetheless, the methods of strengthening the foundations of the towers should be discussed with the turbine manufacturers. In addition, seismological activities in the vicinity of the Arenal Volcano have not affected other power plants in recent decades and therefore should not be a great concern for PEVA wind farm.

2.9 Social and Environmental Impacts of Wind Farming

All technological developments such as wind farms, impact those involved both voluntarily and involuntarily. Four major areas of concern are social impacts on the surrounding area, the quantity of reduction in fossil fuel emissions, impact on the ecosystem during construction, and effects on the fauna at the proposed site (Committee on Environmental Impacts of Wind Energy Projects National Research Council, 2007).

2.9.1 Social Impacts

A wind farm developer needs to take into consideration the effects on any nearby neighborhoods or communities caused by the installation of the wind farm. There are three main parts to the social impacts on surrounding communities: aesthetics of the wind facility, noise generated by the wind farm and the disturbance caused by the construction phase of the wind farm.

Aesthetics

Although some people consider wind turbines to be beautiful, others may consider them visually unpleasant (Committee on Environmental Impacts of Wind Energy Projects National Research Council, 2007). This aesthetic impact is subjective and cannot be prevented or adjusted. However, shadow flickering is an aesthetic impact that can be predicted and may be prevented or explained to surrounding communities. Shadow flickering is an effect that occurs due to the rotating blades. Depending on the time of the day and time of the year, the moving shadow of the blade might prove to be an aesthetic nuisance (AWEA, 2009). This might affect anyone living nearby who might fall under the shadow of the windmill. However, the position of the shadow, duration of the flicker and when it will occur can be calculated. Therefore, if placing the turbine in a particular spot causes its shadow to disturb any nearby communities excessively, it might be better to avoid placing that turbine in that spot. However if the shadow flicker affects any neighboring community for only a couple hours over a year, then the community can be made aware of it before the construction of the wind farm, to ensure that they consent to it. Shadow flicker is not a big problem in the United States because the sun's angle is not very low in the sky, causing the shadow of the turbine to stay short and close to the turbine. In Costa Rica, the sun's angle is even higher, further diminishing the reach of the shadow flicker. Any effect experienced in the United States is usually for a very short period, usually a couple hours over a year (AWEA, 2009). There are also methods to reduce the effects of shadow flicker after the turbine has been constructed. Trees can be planted in the way of the shadow to reduce the degree of light fluctuation. In addition, wind energy developers in the past have also considered shutting down turbines during the period of the day when the shadow flicker occurs (McMahan, 2009).

Wind farm investors should discuss these aesthetic impacts in detail with surrounding communities to confirm that they approve the implementation of the wind farm.

Noise

Another factor that nearby communities could consider as a nuisance would be the noise created by the wind turbines. Noises from wind turbines can either be produced by the interaction of the wind against the blade or the mechanical noise made by the components of the wind turbine. The noise caused by the wind interacting with the blade is the noise that is most often associated with the turbine. The mechanical noises produced by the components of a wind turbine are usually cacophonous. However utility scale turbines, such as the ones that ESPH will be using for their proposed site will be well insulated, therefore the mechanical noise will not be heard outside the turbine (Alberts, 2006).

On average, a wind turbine generates noise that can be heard 40 meters away at 50-60dB, which is around the noise level of conversational speech. Furthermore, an on-shore wind project can produce around 35-45 dB at a range of 300 meters (Committee on Environmental Impacts of Wind Energy Projects National Research Council, 2007). Figure 2.12 illustrates the comparison of the noise caused by a wind turbine to other noises.

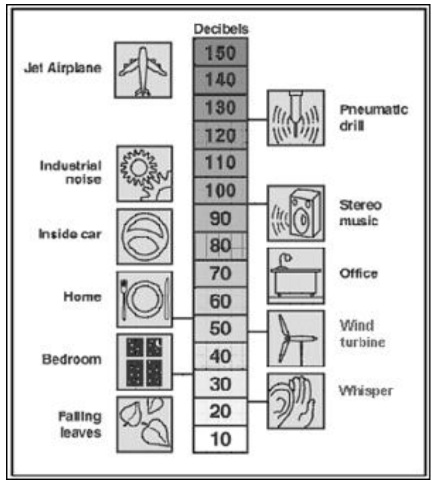

Figure 2.12 Comparison of noise levels from different sources (AWEA)

This figure illustrates that the sound made by a wind turbine is quieter than an average home but louder than a bedroom at night. The Danish Wind Industry Association mentions that the noise caused by wind turbines is a minor problem today. Generally, background noise caused by nature slowly masks the noise of the turbines, especially the noise caused by wind when it passes through trees, shrubs, leaves, etc. In addition, when the wind speeds on site are above 8 m/s the noise caused by the wind blowing would mostly block out any noise produced by the turbine. Moreover, the human ear has low sensitivity to noise made by turbines, therefore this noise would not be considered as much of a nuisance even if it was heard (Danish Wind Industry Association, 2003).

Although the noise is not considered a big issue, modern wind turbine designs are continuously exploring improved technology to further reduce the noise. An example would be the 850 kW Vestas Turbine which uses the Vestas OptiSpeed generator that takes into consideration the noise produced by turbine blades and accordingly reduces the speed of rotation of the blades to reduce noise (Vestas).

Construction

Although it is temporary, noise caused by the construction and preparation on site could also prove to be disturbing to the locals (Money, 2008). For this reason, it is important for ESPH to inform the nearby communities regarding the time period of construction to ensure that they are prepared for it.

Minor Social Impacts

There are also minor social impacts that could help the economies of neighboring communities. A few of them include land owners leasing land for wind farm use and the construction and maintenance jobs created for the wind farm. In the United States, wind farms have usually been based on private lands and seldom are they purchased. Wind project developers usually lease the land for the wind farm. If landowners for the proposed site live in the nearby communities it would definitely help the local community's economy. In terms of employment, currently, there are around half a million people employed by the wind industry worldwide (European Wind Energy Association, 2010). Therefore, installation of an additional wind farm presents the local communities with great job opportunities for skilled labor.

In summary, wind farm developers must take into consideration the mentioned social impacts when constructing a wind farm. Aesthetics, noise and construction are the main social impacts associated with the setup of a wind farm. Minor social impacts such as the boosting of local economy can be circulated among local communities as a way to gain financial and social support for the construction of the wind farm.

2.9.2 Fossil Fuel Reduction

Implementation of a wind energy system for power generation would help replace power produced by fossil fuels, which is known to release emissions harmful to the atmosphere. The maximum capacity of the wind farm ESPH is looking to establish at PEVA is 20 MW. If it were to operate at its maximum capacity all year round, it would have to operate at 20 MW output all 365 days of the year and all 24 hours of the day. Hence, we would have the following calculation:

$$Energy\ Produced\ (kWh) = 20000\ kW * 365\frac{days}{year} * 24\frac{hours}{day} \approx 1.75\ \times 10^{8}\ kWh$$

However since wind farms are known to operate at 20 – 40 % of their maximum capacity (Mathur & Wagner, 2009), we can expect the wind farm to produce about 3.5×10^7 kWh to 7.0×10^7 kWh. Since the annual electricity consumption in Costa Rica is about 8.0×10^9 kWh, the electricity produced by this wind farm would constitute to about 0.4 – 0.9% of the electricity consumed in the country (CIA, 2009). Other factors such as the seasonal usage of the wind turbines would further lower the production capacity of the wind farm. Therefore, the quantity of energy produced by this plant would not reduce fossil fuel emissions in Costa Rica by a significant amount.

2.9.3 Impact on Ecosystem

The construction period of the wind farm is bound to affect the environment since the terrain is being adapted for the use of power generation. The ecosystem will be affected due to the sudden increase of human activity in the area. In addition, site preparation could include removal of vegetation, compaction of soil, soil erosion, and changes in the hydrologic features on site. During construction, there will also be large machinery on site, which might displace animals that live in that area and result in a loss of their habitat (Erickson et al., 2001). Currently a wind energy project in Puerto Rico is not allowed to proceed for similar reasons. The site there proposed for the wind farm is currently the habitat for the endangered Puerto Rican nightjars and the endangered Puerto Rican crested toad. Habitat conservationists are protesting against the project to conserve the habitats of the endangered species, which would be displaced or could go extinct due to lack of an appropriate environment (Fry, 2010). Therefore, a careful study of the species currently living in the area, and a more open approach to conserving them must be considered.

2.9.4 Birds and Wind Farms

Since wind turbines are located at a high altitude, birds flying through the site have been reported to be killed by them. There is currently not enough information to predict the number of bird fatalities in Costa Rica, but there has been research conducted in the U.S. involving bird fatalities and the reasons behind them. Studies done in the U.S. show that wind turbines cause less than 1% of bird fatalities (AWEA, 2009). In 2003, an estimated 20,000 to 37,000 birds were killed due to wind turbines, whereas estimated bird mortality comes close to a billion per year (Committee on Environmental Impacts of Wind Energy Projects National Research Council, 2007).

A comprehensive case study was done on bird fatalities in the Alamont Pass Wind Resource Area (APWRA), a wind farm in California. This study brought to attention the ecosystem that adapted to the wind farm and its relationship to bird fatalities. The study found that cattle tended to spend a large amount of time near the base of the wind turbine. As a consequence, cow manure collects around the turbines. This manure fed grasshoppers, and this caused an accumulation of grasshoppers around the bases of the wind turbines. These grasshoppers are a common prey for the American kestrel and the burrowing owl. As evidence, they found freshly killed red-tailed hawks to contain grasshoppers. Another reason for bird fatalities at the APWRA may be because burrowing mammals also tend to live near wind turbines. The way wind farms are constructed creates many artificial vertical and lateral edges in the landscape. These edges are the preferred habitat for these mammals, which were a common prey for raptors that live around the APWRA site. Therefore, it can be surmised that the reasons for bird fatalities are not directly related to the turbine or the wind facility but rather the ecosystem that builds on that facility (Thelander, 2004).

BioResource Consultants (BRC) also researched the APWRA site in 1998 and found a set of characteristics of wind farms that caused bird fatalities. They realized that danger to birds increased with tower height, and rotor diameter. In addition, turbines on steeper slopes were more dangerous to raptors. They also found that rows of wind turbines were much safer and caused fewer bird fatalities. The BRC also proposed ways to avoid bird fatalities. Wind farm developers can allow vegetation to grow taller near the wind turbines to decrease the visibility of grasshoppers and burrowing mammals. As a consequence this will decrease the chances of birds flying near the turbine. If possible, preventing cattle from congregating under the wind turbine would reduce the development of habitat for common bird prey living around the base of the turbines. The developers could also construct benign physical structures to divert birds away from turbines. The precautionary measures mentioned above are only a few of the many measures mentioned in the study (Thelander, 2004).

The aforementioned social and environmental impacts take into consideration external effects produced by the wind farm that could affect nearby communities, ecosystems and wild life. Studying these would help ESPH decide if the benefits of the wind farm outweigh the associated negative impacts.

2.10 Government Regulations

Wind farm developers must consider legislation to understand if the regulations placed on the production and distribution of wind energy would affect the feasibility in any way. The production of energy in Costa Rica is heavily regulated by the government. ICE, a governmental organization in Costa Rica manages most of the energy production and distribution.

ESPH was established as a public utility company through Law 7789, which allows ESPH to offer services of electricity distribution, purification and distribution of drinking water, public lighting, and public sewage management system. Its jurisdiction is limited to the cantons of Heredia, San Rafael, Flores, San Pablo, San Isidro, and Santa Lucía de Barva. ESPH decided to invest in a wind farm due to extensive promotion of Law 2700 by ICE. Law 2700 allows for private investment and autonomous generation of energy. The distribution of this energy that is generated autonomously is facilitated by Law 8345, which allows for cooperatives between rural electrification organizations and municipal public service companies for national development. This will allow ESPH to connect the energy they produce autonomously through the wind farm to the Sistema Nacional Interconectado (SNI) power grid.

The government-run organization Autoridad Reguladora de Servicios Públicos (ARESEP) determines the price at which electricity is purchased by the public. The price for electricity in 2010 is set at 69 colones/kWh or $0.13/kWh for the first 200 kWh and 119 colones/kWh or $0.23/kWh for every killowatt-hour after that. ARESEP also regulates the price of the energy ESPH purchases from ICE. The purchase rates for ESPH are 0.089 $/kWh during the peak periods, the 0.046 $/kWh during off-peak periods, and 0.035 $/kWh during the nighttime. Therefore, the revenue ESPH will incur over time through electricity generation depends on the rates ARESEP will set in the future, and hence determine the payback period of the wind farm.

These regulations factor into the feasibility study in terms of calculating the payback period and establishing the rules for ESPH's capability of power generation and distribution.

2.11 Summary

The areas impacting the feasibility of a wind farm are quite diverse, requiring us to understand and recognize their interrelation. In order to evaluate the feasibility of ESPH's prospective wind farm site, PEVA, we established the following criteria.

I. The proposed wind farm site must be large enough to accommodate the required number of turbines without significant wind-damping interference between towers.
II. Suitable turbines must be readily available for purchase by the sponsor.
III. The wind farm's average wind speeds must be sufficient to meet the power demands of ESPH.
IV. The proposed wind farm must have an investment payback period deemed suitable by ESPH.
V. Suitable financing must be available to pay for the execution phase of the wind farm project.
VI. The proposed site must have suitable access roads to transport the components of the turbines.
VII. The construction of high-voltage power lines from the wind farm to a local substation must be viable.
VIII. The quality of the land must be suitable to support the construction of the turbines.
IX. The risk of damage to the wind farm from seismological activity must be deemed low enough by ESPH.
X. The placement of the proposed wind farm must not cause discomfort, through noise or other interference, to people living near the site.
XI. The construction and operation of the wind farm must comply with all applicable laws and regulations and account for any taxes and tariffs.

Chapter 3 - Methodology

ESPH needs a feasibility report to show the viability of PEVA. Energy generation, site preparation, construction, financing options, and potential social and environmental impacts determine viability. Through our analysis of these areas, we provided comprehensive feasibility reports to ESPH for PEVA.

3.1 Collection and Analysis of Existing Data

To analyze wind conditions on PEVA, we used published data for monthly average wind speeds from its neighboring wind farm, MOVASA. We did this to determine the wind behavior on the site and to estimate energy generation. Since the two sites are adjacent, we could use the data from MOVASA for analysis, as the wind potential will be similar on PEVA. However, we had to take into consideration the different terrain roughness of PEVA and the different heights at which the wind turbines at PEVA would operate. Using the wind speed data from MOVASA and the wind speed calculator[4], we determined estimates for average monthly wind speeds at different heights based on the roughness level present at the PEVA site (Danish Wind Industry Association, 2003). This calculator uses the wind shear equation to calculate the wind speed at different heights and roughness levels based on just one value of wind speed at a certain height and roughness level. For these calculations, the calculator assumes that there are no obstacles at or above the specified hub height. In addition, we assumed that there is minimal turbulence caused by the unevenness of the terrain. To determine PEVA's and MOVASA's roughness classes we examined the topography of the terrain during our site visits. By photographing the site during our visits, we compared the topography of the site to the roughness class examples provided by WAsP. Since this examination was done by eye, it was only an estimation and therefore had low accuracy.

To predict the average annual energy generation, we used the calculated estimates of monthly mean wind speeds at PEVA. We calculated the mean wind speeds at heights of 50m, 60m, 70m, and 80m since the potential turbines set up in PEVA would be at a height of 50m – 80m. Therefore, the aforementioned heights would give height specific mean wind speeds, which we could use for the calculation of energy generation depending on the potential turbines that

[4] http://www.vindselskab.dk/en/tour/wres/calculat.htm

ESPH might install on the PEVA site. We then calculated power generation with respect to the different models of wind turbines from GE, Vestas, Enercon, Gamesa, and Siemens.

To estimate the annual energy generated by a specific turbine, we consulted its power curve, which is available on product catalogs from the websites of the manufacturers. The power curve provides the value in kW of power generated by the turbine model at a certain wind speed in meters per second. With the power curve, we obtained the projected energy generated by one wind turbine at the average monthly wind speed.

Using this information, we were able to predict the total energy generated annually by a wind farm composed of a particular turbine. We assumed that ESPH required between 10-20 MW of power generation from the PEVA site. Therefore, we multiplied the power produced by one turbine over a year with the number of turbines that would be necessary to build wind farms of 10 MW, 15 MW, and 20 MW capacities. We did this to obtain the value for average projected annual energy generation at PEVA. We assumed that the turbines were never turned off and that the wind speed was at the calculated average wind speed all month long. However, this would represent values from an ideal scenario. To better approximate energy production, we calculated the ratio between the ideal energy generated on the MOVASA wind farm to the actual energy generated on MOVASA. We then used this ratio as the correction ratio for all the calculated wind speeds at PEVA and derived a set of values that represented the corrected energy generation. We expressed the calculated and the corrected values of predicted annual energy generation in tables corresponding to each wind turbine make and model in Excel files.

3.2 Site Visit Check List

We created a site checklist to help us record the information we could only collect by visiting PEVA. We used this information we collected to determine wind turbine placement and potential construction issues. This checklist helped us note the terrain and the land use of PEVA. The terrain and land use of the site gave us a general idea of the wind behavior prevalent on the wind farm. Land use information was used to determine any potential construction issues ESPH may face during the site preparation or construction phase of the wind farm (Boucher, Guerra, and Watkins, 2010).

The checklist includes:

a. Size of the site
b. Trees affected by a wind sock effect
c. Approximate distance between features such as trees, large boulders, or shacks (Pacing)
d. Proximity to neighbors and structures
e. Noise level of neighboring wind farms
f. Observed fauna on the site
g. Topography and hills
h. Land
    i. Roadways and traffic characteristics
    ii. Current uses of land
    iii. Type and density of trees (if any)
    iv. Vegetation
    v. Soil conditions – check for recent mudslides
    vi. Presence of bedrock
    vii. Drainage patterns

3.3 Turbine Selection and Placement

Based on wind characteristics available on site and the terrain information we collected, we needed to determine suitable wind turbine layouts for power generation.

To generate a layout, we first determined the wind turbines that would suit the wind speeds available on site. We researched the top five wind turbine manufacturers GE, Vestas, Enercon, Gamesa, and Siemens, to arrive at a set of turbines that ESPH could use. We listed the wind turbines in a table with their corresponding manufacturer, model, cut in/cut out speed, rated speed, and power rating. We considered the wind turbines with a power rating of up to 3 MW in our list. We chose 3 MW as the upper limit as increasing the size of the turbines much more makes turbine transportation, construction, and turbine layout considerably more challenging and expensive even though it would mean fewer turbines on site. Additionally, there have not been many turbines above this power rating that have been installed worldwide. Therefore, these turbines have not been proven as reliable as other turbine ratings because they have not been tested as widely. Turbines below 3 MW were adequate to reach ESPH's 20 MW goal for PEVA.

In addition to suggesting suitable wind turbines, we generated hypothetical wind turbine layouts for PEVA to determine that there existed a feasible turbine layout based on terrain and topographic information. As mentioned previously, we obtained terrain information from the site visits and we also obtained a topography map of the site from our sponsor. We took in to consideration the obstacles present on the site and, using the wind shade calculator,[5] we determined the distance from these obstacles at which it is feasible to place a wind turbine with minimal energy losses (Danish Wind Industry Association, 2003). Considering wind shadow effects, turbulence, areas of the site, and number of wind turbines that should be implemented, we found suitable wind turbine arrangements for the site. In addition, we took the hill and tunnel effect into account to determine places with high wind potential and would, therefore, be more efficient spots for wind turbines. We used the name-plate capacity of the hypothetical layouts to generate financial projections for specific layouts.

[5] http://www.vindselskab.dk/en/tour/wres/shelter/index.htm

3.4 Analysis of Construction Feasibility

To determine if construction on PEVA was feasible, we studied the access roads to the site, the feasibility of running high voltage lines from the site to the connection points, and current land conditions of the proposed site. We evaluated the route taken to PEVA during the site visit to determine their ability to transport wind turbine parts without damaging them. Since there is a neighboring wind farm to the proposed site, we used this as a basis for evaluating turbine transportation. To ensure the feasibility of running high voltage lines, we collected information on ESPH's planned routes from the farm to the substation, the associated costs for each connection, and any associated zoning laws. We also examined the vegetation on the site, to determine the vegetation that would have to be cleared during construction. We did this by measuring the location and height of the obstacles and determining if that could impede wind flow or hinder turbine installation. We made these evaluations using maps and topographical data provided by ESPH as well as observations noted during the site visit.

3.5 Wind Farm Financing and Payback Period

When performing the calculations for determining the payback period of the wind farm, we took into consideration the following: the initial cost, cost over time, options for financing, and revenue over time. We obtained general estimates for values such as construction, labor, and operation, and maintenance costs through the literature we have researched and from ESPH (Mathur & Wagner, 2009).

To ensure that our approach was correct and to gain more perspective on wind farm financing in Costa Rica, we contacted Mr. Jay Gallegos, CEO of MesoAmerica Energy. He had extensive knowledge of wind farm projects and the issues associated with financing these projects.

For the initial investment options, we included the loan taken and the money invested directly by ESPH. Since ESPH is interested in loans from banks in the USA, we used the prime rate as recorded by the *Wall Street Journal* since it is the base rate on corporate loans posted by at least 70% of the 10 largest U.S. banks (*The Wall Street Journal*, 2010). We determined the amount ESPH will invest independently through our talk with Mr. Gallegos, as banks require ESPH to invest a certain percentage of money into the project for which they need the loan.

The revenue over time will include the price of electricity times the estimated power generated by the wind farm. Taxes were not involved in the calculations since, as a public utility, ESPH does not have to pay taxes to produce electricity autonomously. When calculating the revenue we took into account the change in the price of electricity over time. We obtained the current price of electricity in Costa Rica through ARESEP and used estimates of the future price of electricity every year as provided to us by ESPH. We also took into consideration the expected rate of inflation with respect to the revenue.

The method we used to calculate the payback period is the DCF or the Discounted Cash Flow method (Pratt & Grabowski, 2008). It takes into consideration the change in the value of money over time, which is, in this case, inflation. We used the rate of inflation to calculate the current value of the future cash flows in and out of ESPH. A cash flow signifies any flow of money in and out of a business; in this case, it would be the future costs and future revenues that ESPH will incur over time. This method gave us a more accurate estimate of the payback period since it takes into consideration the inflation rate of the costs and returns in the future. However, since the calculation of the payback period is based on estimates, the future cash flow cannot be predicted with certainty. Similarly, the rate of inflation is subject to change and in this method, we are treating the rate of inflation as a constant. Therefore, calculating the payback period using the DCF method is only an estimate and can be subject to change (Pratt & Grabowski, 2008). The components of the payback period calculation can be broken down into the following variables:

Table 3.1 Financial Projection Variables

Initial cost	**Costs over time**	**Initial investment**	**Revenue**
Construction cost	Operation and maintenance cost	ESPH investment	Expected price of electricity
Cumulative wind turbine cost	Labor cost	Bank loan	Estimated power production
Legal and bank negotiation fees	Loan payments		Expected rate of inflation
Substation connection cost	Rate of inflation		

Calculating an estimated payback period provides ESPH with information on the associated costs of setting up a wind farm and the estimated returns over time for PEVA. We used this information to determine if the proposed site was financially feasible based on ESPH's priorities.

3.6 Environmental and Social Feasibility

The environmental and social feasibility of a wind farm is mainly dependent on its effect on the local ecosystem and its effect on the communities that surround it. We combined our onsite observations and any information on local fauna as observed by ESPH and the owner of the proposed site to obtain an understanding of the ecosystem present on the proposed site. However, this method does not provide us with a complete understanding of how building the wind farm will affect every aspect of the ecosystem.

In addition, an evaluation was performed to derive the noise level generated by the potential wind turbines used on the proposed site. We utilized the sound calculator[6] and the sound map calculator[7] to assess the amount of noise generation from the wind farms. We used the sound calculator to determine the specific decibel values of noise heard at different distances from a particular wind turbine. We also used the sound map calculator for a detailed visual and quantitative representation of the noise level generated by a wind farm with different layouts (Danish Wind Industry Association, 2003). These estimates, coupled with observations from the site visits, gave an understanding of wind turbine noise and the extent we expect it to affect nearby communities.

To determine the number and type of job opportunities that would result if the wind farm is constructed and in operation, we consulted ESPH on the workforce they plan to employ. Based on the required work force, we examined the availability for the specified labor in nearby towns to evaluate the extent of the effects these job opportunities would have.

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[6] http://www.vindselskab.dk/en/tour/env/db/db2calc.htm

[7] http://www.vindselskab.dk/en/tour/env/db/dbcalc.htm

3.7 Summary

The wind farm feasibility evaluation involved a detailed investigation of the available wind speeds on site, financial feasibility, construction feasibility, environmental feasibility and social feasibility. The wind farm size and power production were addressed in the wind data analysis, turbine selection and turbine placement phase. The construction feasibility of a site depended on the road access and the transmission lines to the site as well as any potential issues that ESPH could be encounter during the construction of the wind farm. The financial feasibility involved collecting information on the costs involved with the setup of a wind farm and its payback period corresponding to the power production. In summary, we assessed whether the site satisfies the criteria we established while following this methodology to create a wind farm feasibility report.

Chapter 4 – Results and Findings

Our analysis of the PEVA wind farm site yielded many important conclusions about the feasibility of the site and the issues that will be faced by ESPH in the future. We analyzed all available wind data for the site to determine whether the wind on-site was sufficient for an effective wind farm. The potential for power generation was assessed with respect to the possible different wind turbines and turbine layouts ESPH could employ to ensure that the site produced energy efficiently. We examined if the site was construction feasible, assessing if suitable access roads were present, if there existed local substations for the wind farm to connect to, and if land conditions could support wind farm construction. We performed financial analysis and projection of payback periods for different numbers and sizes of turbines to gain an understanding of what choices would yield the most revenue for ESPH. Lastly, we evaluated the noise that would be generated by the wind turbines to ensure that it would not be detrimental to the quality of life of people living nearby.

4.1 Wind Power Potential and Turbine Selection Considerations

Through our evaluations, we generated an estimate of energy production for each month on the PEVA site. Our results lack accuracy, as we did not have the detailed wind data that would come from the use of a met tower. Therefore, we used limited wind data from MOVASA, and adjusted it for the PEVA site. In addition, we generated hypothetical farm layouts to determine the maximum number of turbines ESPH could place at the site depending on turbine power rating. We used this data to generate estimates of power production for PEVA to determine if the wind was sufficient for a wind farm.

ESPH provided us with the monthly mean wind speed values of MOVASA at a height of 40 meters between 1999 and 2008. The data from MOVASA was in chart form with no numerical values, making the interpretation of the wind speed values from the graphs uncertain.

Using the provided information, we extrapolated the wind speeds on PEVA. The Danish Wind Industry Association's Wind Speed Calculator required two main variables to calculate estimated monthly mean wind speed on PEVA: the height and the site roughness class. From the information provided to us about MOVASA, we input the height to be 40 meters since the measuring instruments in MOVASA were placed on top of their turbines, which are 40 m high. We estimated the roughness class of MOVASA to be 1.0, since the site has a very flat surface and just one set of dense trees that are well maintained and well below the height of interfering with power production of the turbines. This is shown in the picture we took in Figure 4.1. For the estimated wind speed on PEVA, we used the mean wind speed values for roughness class 2.0 since the PEVA site has two dense thickets of trees onsite and has uneven terrain as illustrated in Figure 4.1.

Figure 4.1 The MOVASA site (left) and PEVA site (right)

To represent turbines of different heights that might be used on the PEVA site, we used the wind speed values from the calculator corresponding to the heights 50m, 60m, 70m, and 80m at roughness class 2.0. The tables in Appendices C and D list the recorded monthly mean wind speeds on MOVASA and the extrapolated values at the heights of 50m, 60m, 70m, and 80m later used for the estimation of energy production on PEVA. For these calculations, we assumed that there are no obstacles at or above the specified hub height. In addition, as shown by our choice of roughness class being 2.0, we assumed that there is minimal turbulence caused by the unevenness of the terrain.

A list of all turbines manufactured by GE, Vestas, Enercon, Gamesa, and Siemens was compiled with their corresponding cut-in speed, cut-out speed, rated speed, rotor diameters, hub heights, and turbine class. This information is represented in Appendix G. To estimate power generation corresponding to each turbine power rating we used the power curves of the turbine models presented in Table 4.1. These turbine models were chosen from the initial list of turbines since they had power curves that could be used more accurately for modeling.

Table 4.1 Models chosen for prediction of annual power generation on PEVA

Power Rating	Model
800 kW	E-48/800 kW (60 m)
	E-53/800 kW (60 m)
900 kW	E-44/900 kW (60 m)
1.5 MW	General Electric 1.5xle (80 m)
	General Electric 1.5sle (80 m)
1.8 MW	VESTAS V90/1.8 MW (80 m)
2.0 MW	E-82/2.0 MW (80 m)
	GAMESA G80/2 MW (60 m)
	VESTAS V80/2 MW (80 m)
	VESTAS V90/2.0 MW (80 m)
2.3 MW	E-70/2.3 MW (60 m)
	E-82/2.3 MW (80 m)
	Siemens SWT-2.3-82 VS (80 m)
3.0 MW	E-82/3 MW (80 m)

We calculated the energy generation on Excel spreadsheets by each turbine model and for wind farm sizes of 10 MW, 15 MW and 20 MW. The formula we used to calculate estimated power generation is shown in detail in Appendix E, it also shows the correction ratios corresponding to each month. Spreadsheets corresponding to energy production by turbine rating and wind farm sizes are shown in Appendices H to K.

With the corrected annual energy generation values of each turbine, we averaged the energy generation by turbine rating to determine the optimal turbine rating that should be used on the PEVA site corresponding to different wind farm capacities.

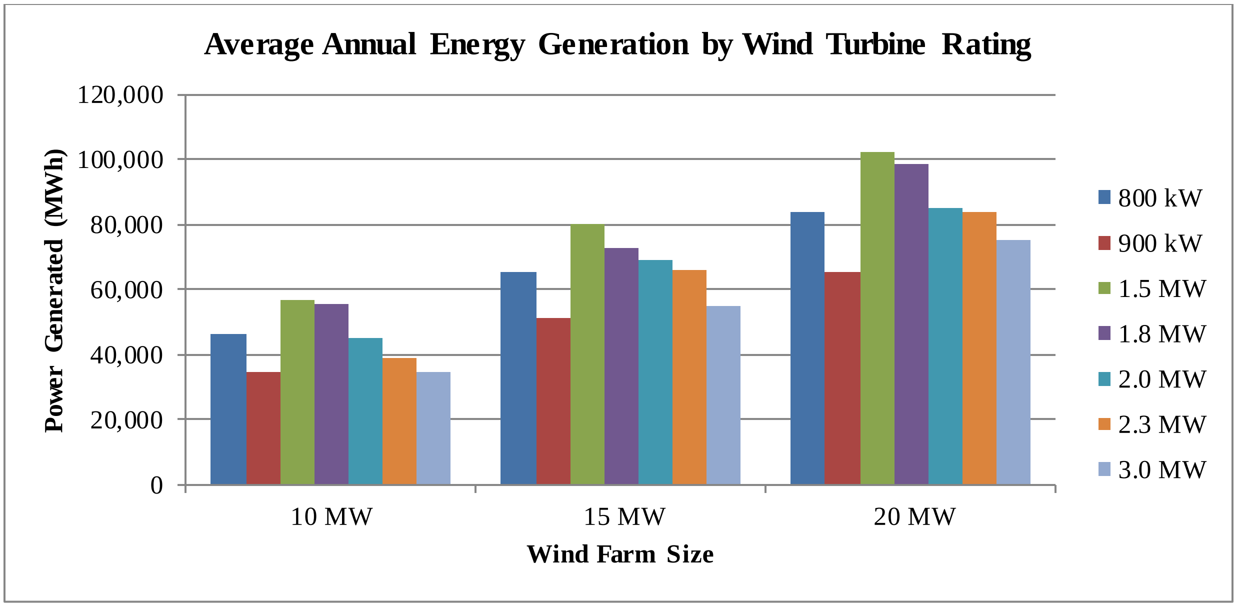

Figure 4.2 Graph of Average Annual Energy Generation by Wind Turbine Rating

Figure 4.2 illustrates, on average, turbines with a 1.5 MW power rating have the highest estimates for annual energy production for wind farm capacities of 10 MW, 15 MW, and 20 MW. This comparison was done to determine the differences in energy production by turbine rating corresponding to each wind farm. Therefore, through wind data extrapolation we have concluded that 1.5 MW rated turbines would be the best for power generation. However, other turbines will also be considered for further analysis in the wind turbine selection and placement stages.

We also measured the prevailing wind direction of the site. During our site visit to PEVA, we examined the trees on the wind farm to see if any had experienced flagging which would indicate the prevailing wind direction. We found and photographed a number of trees, all flagging in the same direction. Using a GPS compass, we determined that the direction the trees were leaning was south-west, meaning that the prevailing wind direction was from the northeast to the south-west. Figure 4.3 is a tree on the PEVA site that has experienced flagging and the compass aligned with the flagging tree, away from the wind.

Figure 4.3 PEVA flagging tree (left) and compass in the direction of flagging (right)

Since the PEVA site is only 24 hectares, we performed an analysis in which we determined how many turbines of different rotor diameters could fit, taking into consideration the prevailing wind direction, wind shadow effect and turbulences. To do this, we generated hypothetical turbine layouts using different rotor diameters to assess the adequacy of the size of the site.

First, we considered wind turbines that have 50 m rotor diameter and a power rating of 800 kW. Figure 4.4 shows our hypothetical positions on PEVA at which ESPH could place their turbines and marks areas with trees and bushes in green.

Figure 4.4 Hypothetical configuration for 50 m diameter wind turbines

In this layout, there are 12 turbines situated in four rows, which are perpendicular to the predominant wind direction. The turbine in the southeast corner is isolated and it is not a part of any row. It is placed on the top of a hill to take advantage of the hill effect. This layout uses a crosswind spacing of two rotor diameters, even though our research indicated that a spacing of three diameters is more commonly used. We chose this spacing because, when examining other wind farms in the area, we found that most of these farms used a crosswind spacing of three diameters. The circumstances that made a spacing of two diameters desirable for these farms would likely also apply to PEVA. In addition, the minimum distance between any two consecutive rows of turbines in this configuration is five rotor diameters, which is in accordance to the rule of 5-9 rotor diameters that is described in the Background section. We also took into consideration the turbulence produced by valleys and bushes. One major concern for turbulence is the very uneven valley, which is right behind the first row of turbines. Therefore, we placed turbines well behind that valley to avoid turbulence. Another concern, described later in construction feasibility, is that ESPH may have to remove most of the trees on PEVA as they are creating a wind shadow, lowering the energy production in the turbines. However, turbulence that they cause has a very small range. We ensured that all wind turbine configurations placed turbines at least 100 meters behind bushes, or at least five times the height of the bushes.

The second configuration that we generated was for turbines with 80 m rotor diameters, which correspond to 1.5 MW turbines and most of the 2 MW turbines that we have considered. The suggested turbine placement is included in the Figure 4.5.

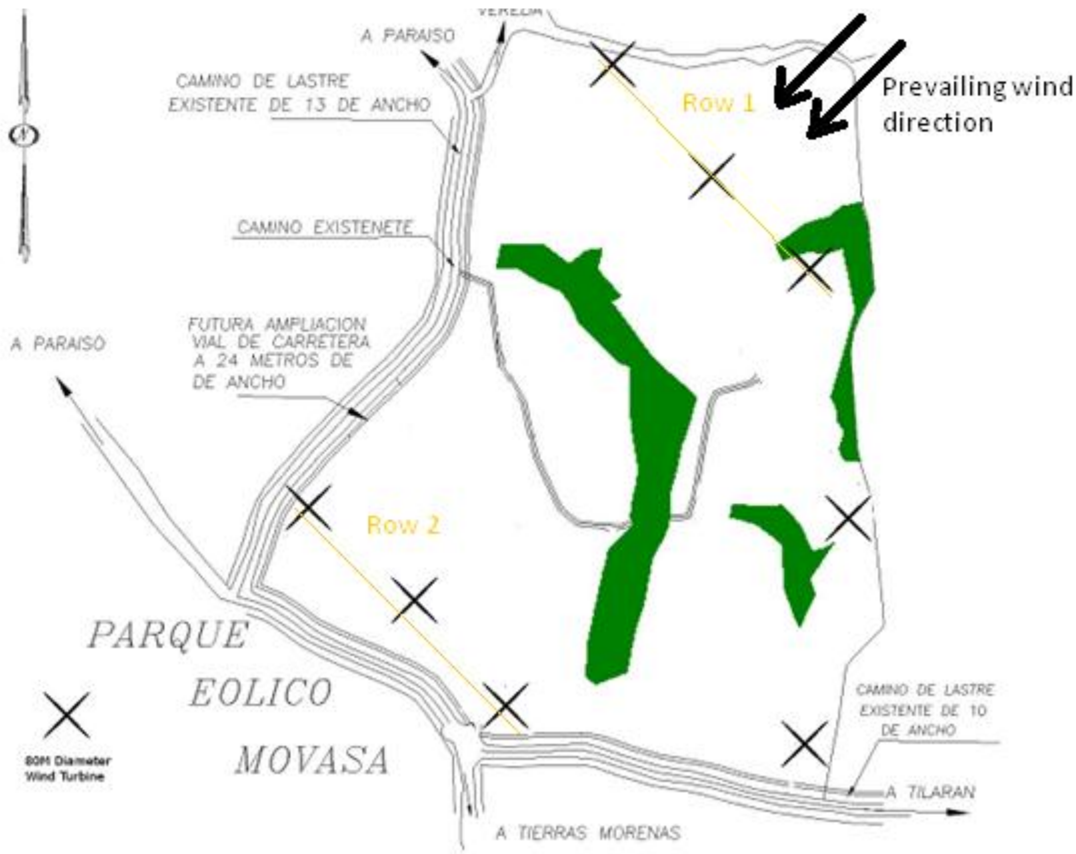

Figure 4.5 Hypothetical configuration for 80 m diameter wind turbines

Figure 4.5 shows the eight wind turbines we placed at the site. In this configuration, there are two rows and two isolated turbines to the east. Again, in this hypothetical arrangement, the distance between two turbines in a row is two rotor diameters or 160 meters. The distance between the two rows is five rotor diameters or 400 m. Due to the lack of space, we could not increase that distance and maintain the number of turbines at the site. Again, the distance between two turbines in a row was two rotor diameters or 160 meters.

Finally, we generated a configuration for 90 meter rotor diameter wind turbines that correspond mainly to 1.8 MW and 2.3 MW turbines that we considered. In Figure 4.6, we show the configuration with six turbines.

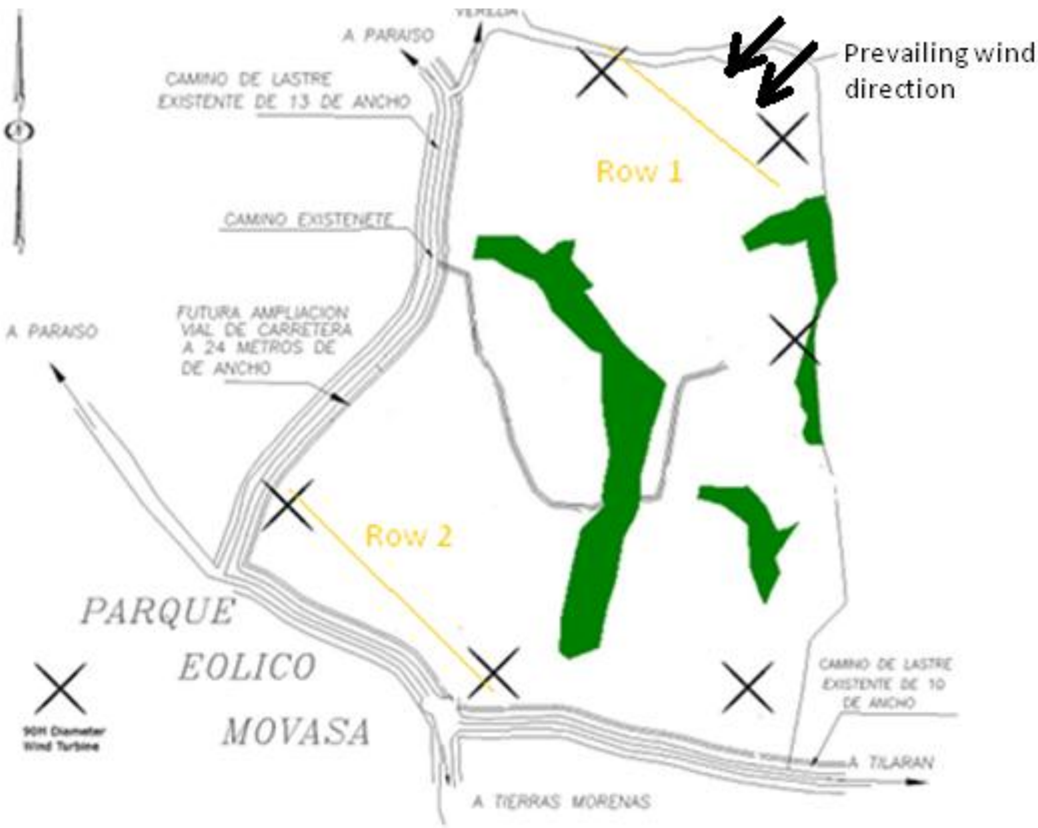

Figure 4.6 Hypothetical configuration for 90 m diameter wind turbines

In this configuration, we maintained the distance between two turbines at two rotor diameters or 180 m. We also maintained the separation between two rows as five rotor diameters or 450 meters.

For each configuration, we tried to place the maximum number of turbines on PEVA taking into considerations all the space parameters to reduce shadow effect and the layout of the land to benefit from the hill effect. However, the safer choice would be to set the difference between two rows to seven rotor diameters. If we decided to follow that option, we would have fewer turbines for each configuration and the energy production would be greatly reduced.

4.2 Construction Feasibility

Through the site visit and data analysis, we found potential obstacles to the construction of a wind farm at PEVA. The site has patches of vegetation that ESPH would have to clear for construction and for the removal of wind obstructions. We assessed the access roads to the site for their ability to transport turbine components. We also evaluated ESPH's proposed route for connecting PEVA to the nearest substation and estimated the cost of running the high-voltage lines to the substation. Together, these considerations gave us an understanding of whether it is feasible to build the PEVA wind farm.

On the PEVA site, there are patches of bushes and trees that ESPH would have to clear for construction access and for clear wind flow over the terrain. Figure 4.7 is a map of the PEVA site with patches of bushes and trees outlined in green.

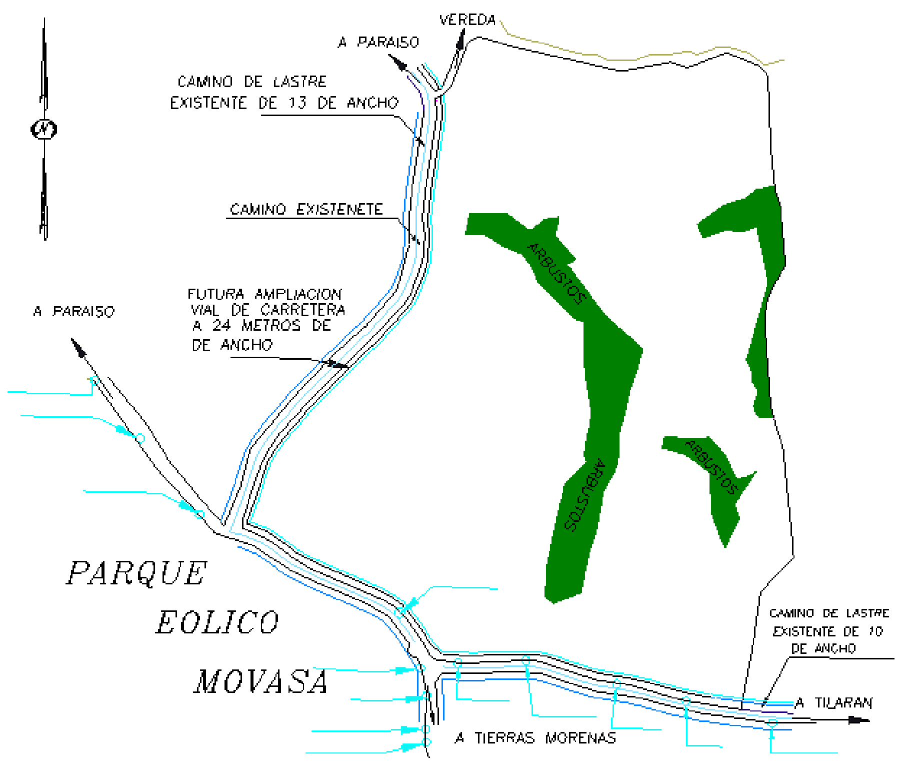

Figure 4.7 PEVA site map with bushes and trees outlined in green

We measured the tallest trees to be 25 meters tall, but the majority of bushes and trees came to 20 meters in height. Exactly which patches will have to be removed depends on the turbine layout that ESPH selects, but given the size of the patches it is almost certain that large amounts will need to be removed for turbine construction and for wind flow. Using the DWIA obstacle shadow calculator, the effect that these bushes would have on the energy produced by the wind was estimated. This calculation assumes turbine hub height of 80 and 60 meters, a distance of 240 meters between the obstacles and the turbine, a roughness class of two, an obstacle height of 20 meters, and a *porosity* of 40%, which is consistent with trees and bushes. For both, an extra 15 meters was added to the hub heights to represent the difference in terrain height between the northwestern patch of bushes and the southwestern row of turbines in our hypothetical layouts.

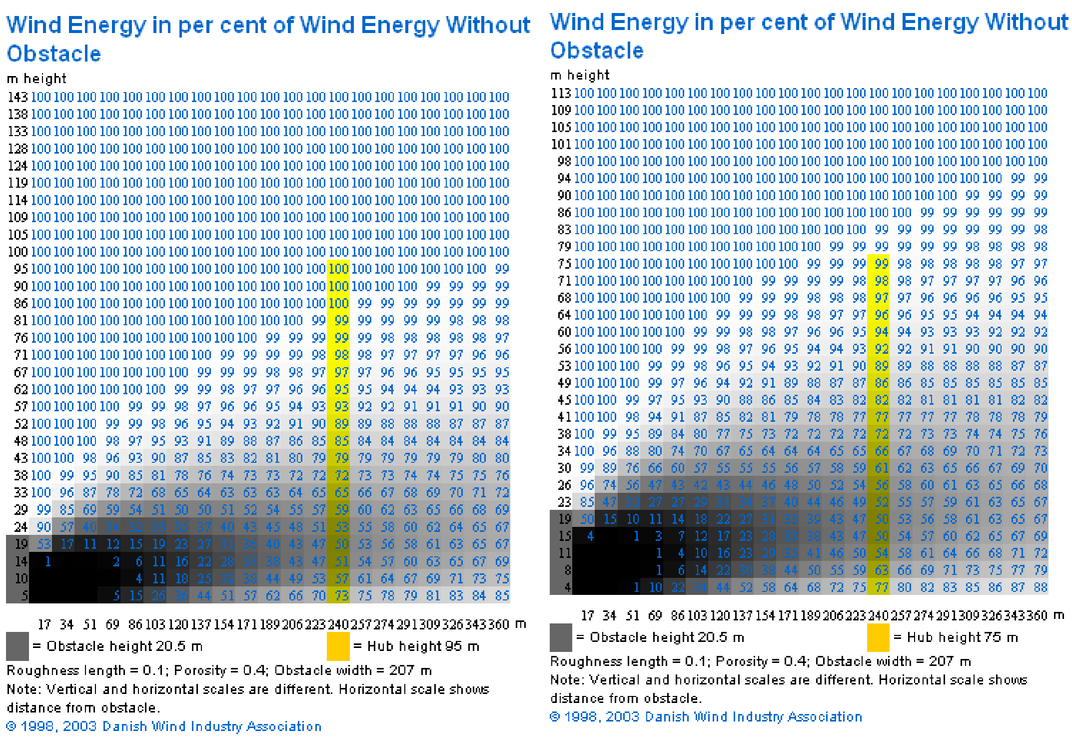

Figure 4.8 Effect of bushes and trees on wind for 60 and 80 meters hub heights

The resulting wind shadows caused by the trees and bushes are shown in Figure 4.8. While the wind energy that would be available at the hub heights is 99-100% of the energy that would be available without the obstacle, the energy drops considerably at heights below the hub height which would result in uneven loading on the turbine blades if the hubs were any lower. Assuming a 90 meter blade radius, an 80 meter tower, which is consistent with many 2 MW turbines, and a 15 meter slope between the trees and the tower, the lower tips of the blades would receive 11% less energy than the blades at the top. If the tower were level with the obstacle, though, the tips of the blades would receive 30% less energy. This would result in significantly uneven loading on the turbine. This means that, even 240 meters from the bushes, they would have a significant impact on the viability of placing turbines in their shadow if they are at the same height as the turbine base. By clearing these higher bushes and trees, ESPH would make larger sections of the site suitable for turbines. We generated a map, Figure 4.9, of these elevated trees, which we believe, should be removed colored in red.

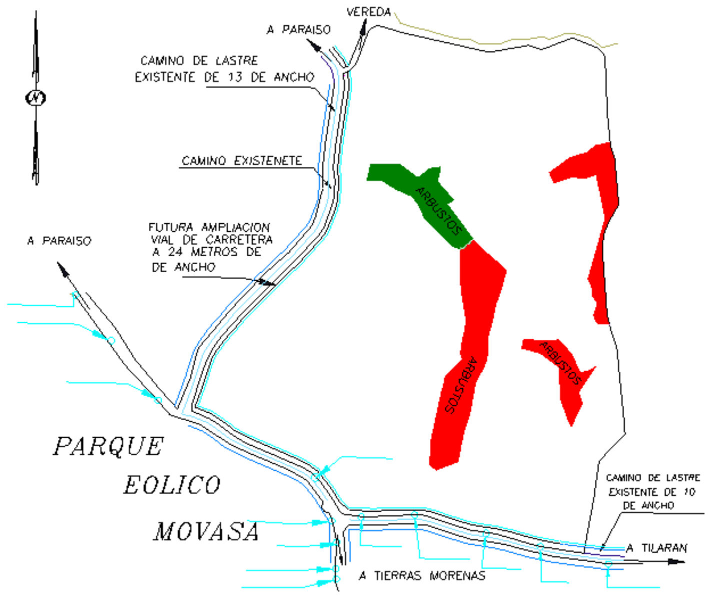

Figure 4.9 Map of PEVA with patches of trees to be cut in red

We analyzed the possibilities for connecting PEVA to a substation and the costs it would incur. The closest substation to PEVA is the Corobici substation, which is located 16 kilometers south-west of PEVA. The easiest way for ESPH to build high-voltage power lines is to run them over public roads, avoiding the purchase of land just to run power lines. To do this between PEVA and the Corobici substation means that the power lines would run for 20 kilometers. Using ESPH's estimate of power line costs at $45,000 USD per kilometer, running the high-voltage lines to Corobici substation would increase the cost of the wind farm by $900,000 USD. ESPH has said that ICE could be building a substation closer to PEVA in the future, but this is not a definite plan and ICE has not picked an exact location. We were unable to estimate how much ESPH might save by waiting for a new substation without knowing a location for the new substation.

We deemed the roads leading to PEVA to be adequate for turbine transportation as MOVASA used the same roads to deliver their turbines. MOVASA's turbines have a rotor diameter of 44 meters, meaning that the same roads could be used for delivering turbines of this size to PEVA. Due to time constraints, we were unable to collect detailed road maps and assess whether the roads would be adequate for turbines with a rotor diameter greater than 44 meters.

4.3 Financial Feasibility

The financial feasibility of PEVA depended on four main components: the initial cost, cost over time, initial investment, and revenue over time. These components were also integral in the payback period calculation since they are the main variables that determined how soon ESPH would start generating profit. In this section, information gathered on each aspect of the financial feasibility will be discussed in regards to how it affects the payback period calculations.

We used estimates for initial cost and initial investment provided to us by ESPH and by Mr. Gallegos, an expert in wind energy in Costa Rica. We also supplemented these estimates with the approximate figures in our background. Mr. Gallegos informed us that the initial cost is usually $2.8 million USD per MW installed including turbine cost, legal fees, consultancies, and land fees. However, he has seen this cost go up to $3 million USD per MW. ESPH also provided us estimates for initial costs based on neighboring wind farms; these estimates are shown in Table 4.2.

Table 4.2 Initial Cost of Wind Farms in Costa Rica

PROYECTOS EÓLICOS EN COSTA RICA						
Project	Cost of the Project (USD)	Potency (kW)	Turbines	Pot Turbine. (kW)	Anual Production (GWh)	cost/kw (USD/Kw)
Guanacaste	120.000.000	49.500	55	900	240	**2.424**
Santa Ana	50.000.000	15.300	17	850	40	**3.268**
Los Santos	32.500.000	11.250	15	750	42	**2.889**

Since the average of the initial cost per kW shown in Table 4.2 agrees with the estimate by Mr. Gallegos, we decided to use $ 2.8 million/MW as the initial cost for setting up a wind farm. The initial cost however does not include the cost of laying the transmission lines. As mentioned earlier, this cost was provided to us by ESPH to be $45,000 USD/km. The transmission line cost was a constant for all the financial analysis that was done, taking into consideration that ESPH does not wait for ICE to build a closer substation. All other costs and the initial investment depended on the size of the wind farm. The initial investment depends on the initial cost since ESPH would like the project to be financed by a 15 year bank loan and through independent investment. It is a regulation in Costa Rica that all businesses must invest at least 20% of the cost of the project for the bank to provide a loan. However, as per our talk with Mr. Gallegos, foreign banks require the independent investment to be 30% and since ESPH is looking at loans from the USA, our financial analysis assigns ESPH to finance the initial cost by

30% and the bank loan by 70%. The interest rates used for the loan in the analysis was 3.25% per annum since it is *The Wall Street Journal* Prime Rate. Since electricity production in Costa Rica has a guaranteed consumer, ICE, we believe that the interest rate offered by the bank would be low. Mr. Gallegos corroborated this during our discussion. Revenue depended on the estimated annual power production based on the turbine power rating as calculated in the wind potential section and the price of electricity. The electricity prices do not have a constant value. This is a consequence of ARESEP setting the electricity prices. According to ESPH's preliminary financial analysis, this price increases by 2.5% every year starting at the present day value of $0.1 per kWh. This value is shown in cost analysis and payback period table in Table 4.4 where the cash flow per year is calculated for 20 years, the average lifespan of a wind farm. As for costs incurred over time, ESPH provided us with the values of labor cost and rent while loan payment, rate of inflation, and operation and maintenance were calculated, and researched. Table 4.3 illustrates the list of main variables associated with the financial analysis. The figures represented in the table are the numbers associated with a 20 MW wind farm composed of 1.5 MW turbines.

Table 4.3 Example of figures associated with the main variables of financial analysis

Wind Farm Capacity: 20 MW with 1.5 MW Turbines				
Initial Investment				
	ESPH investment	$ 16,650,000		
	15 Year Loan	$ 38,850,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 54,600,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 3,313,461		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	102,000	MWh	
	Expected Rate of Inflation	10%		

As shown in Table 4.3, we used 10% as the rate of inflation used as per the preliminary financial analysis ESPH provided to us. As for the loan payment, we calculated it as a constant yearly sum based on the 15 year loan ESPH would have to take corresponding to the initial cost.

We generated similar tables for different turbines and wind farm capacities; they are shown in Appendices L through R. Once the main variables for each turbine rating and wind farm size were declared, the yearly cash flow was calculated to determine the revenue generated for each wind farm capacity by turbine rating. Table 4.4 shows the cash flow table over 5 years of a wind farm capacity of 20 MW with 800 kW turbines.

Table 4.4 Cost Analysis and Payback Period

Wind Farm Capacity: 20 MW with 800 kW Turbines Cost Analysis and Payback Period						
Year		1	2	3	4	5
Production (MWh)		84,000	84,000	84,000	84,000	84,000
Revenue						
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110
Total Revenue		8,400,000	8,610,000	8,825,250	9,045,881	9,272,028
Costs						
	O&M	840,000	840,000	840,000	840,000	840,000
	Labor	840,000	861,000	882,525	904,588	927,203
	Loan Payment	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044
	Rent	168,000	172,200	176,505	180,918	185,441
Total Cost		5,245,044	5,270,244	5,296,074	5,322,550	5,349,688
Total Cashflow		3,154,956	3,339,756	3,529,176	3,723,331	3,922,341
Discounted Cashflow		2,868,142	2,760,129	2,651,522	2,543,085	2,435,465
ESPH Initial Investment Payback	$ 17,070,000	$ 14,201,858	$ 11,441,729	$ 8,790,207	$ 6,247,122	$ 3,811,657

Initially, we did a preliminary financial analysis on turbine ratings between 800 kW to 3 MW for wind farms of sizes 10, 15, and 20 MW for an approximate estimate of revenue and payback period. Figure 4.10 shows the payback periods and the revenue each turbine rating would generate for a 10 MW wind farm over 20 years. Complete cash flow tables with different wind turbines and wind farm sizes are in Appendices L to R.

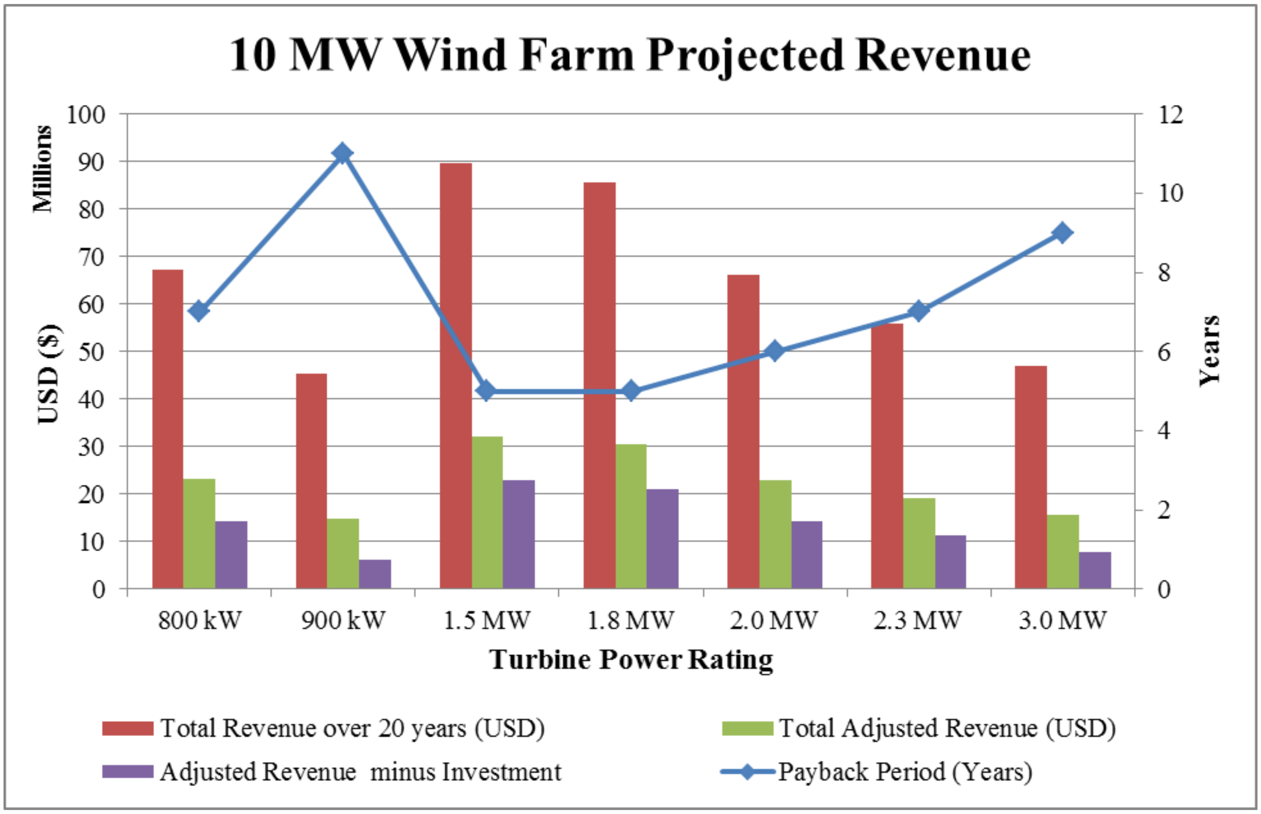

Figure 4.10 10 MW Wind Farm Projected Revenue

Figure 4.10 illustrates the projected revenue of a 10 MW wind farm corresponding to different turbines. Similar graphs can be found in Appendix S for wind farms of sizes 15 MW and 20 MW. From these graphs, we determined that the 1.5 and 1.8 MW turbines are the better choices due to their high revenues and low payback periods. In addition, we determined the potential revenue ESPH can expect to receive over the course of 20 years by wind farm size. For a 10 MW wind farm, the total revenue over time can range from \$45 million to \$85 million, for a 15 MW wind farm, from \$66 million to \$111 million and for a 20 MW wind farm, from \$83 million to \$159 million. Therefore, the higher the number of megawatts that fit on the PEVA site, the higher the power production and revenue for ESPH. In addition, the payback periods for ESPH's independent investment ranged from 5 to 11 years. The turbines with the lowest payback periods include the 1.5 MW turbines by GE and the 1.8 MW turbine by Vestas. We also found that the turbine with the highest payback period and the lowest revenue, which should not be considered for use on the site would be the 900 kW Enercon turbine.

From the findings in the initial financial comparison, we found that turbines of power rating 800 kW, 1.5 MW, 1.8 MW, 2 MW and 2.3 MW had the highest revenue. Based on the turbine placement suggestions in the previous section, we did a financial analysis on wind farms with the number of turbines of each power rating that could fit on the wind farm. As shown in Figure 4.11, the 12 MW and 16 MW wind farms would provide the highest revenue for ESPH on the long run. However, the payback period for the 16 MW wind farm is around 2 years more than that of the 12 MW wind farm even though the revenue over 20 years for both wind farms is about the same. Additionally, since the 16 MW wind farm has a higher power rating it would require a higher initial cost than that of the 12 MW wind farm. Therefore, we consider the 12 MW wind farm made of 1.5 MW turbines from GE to be the most efficient and cost-effective choice for ESPH.

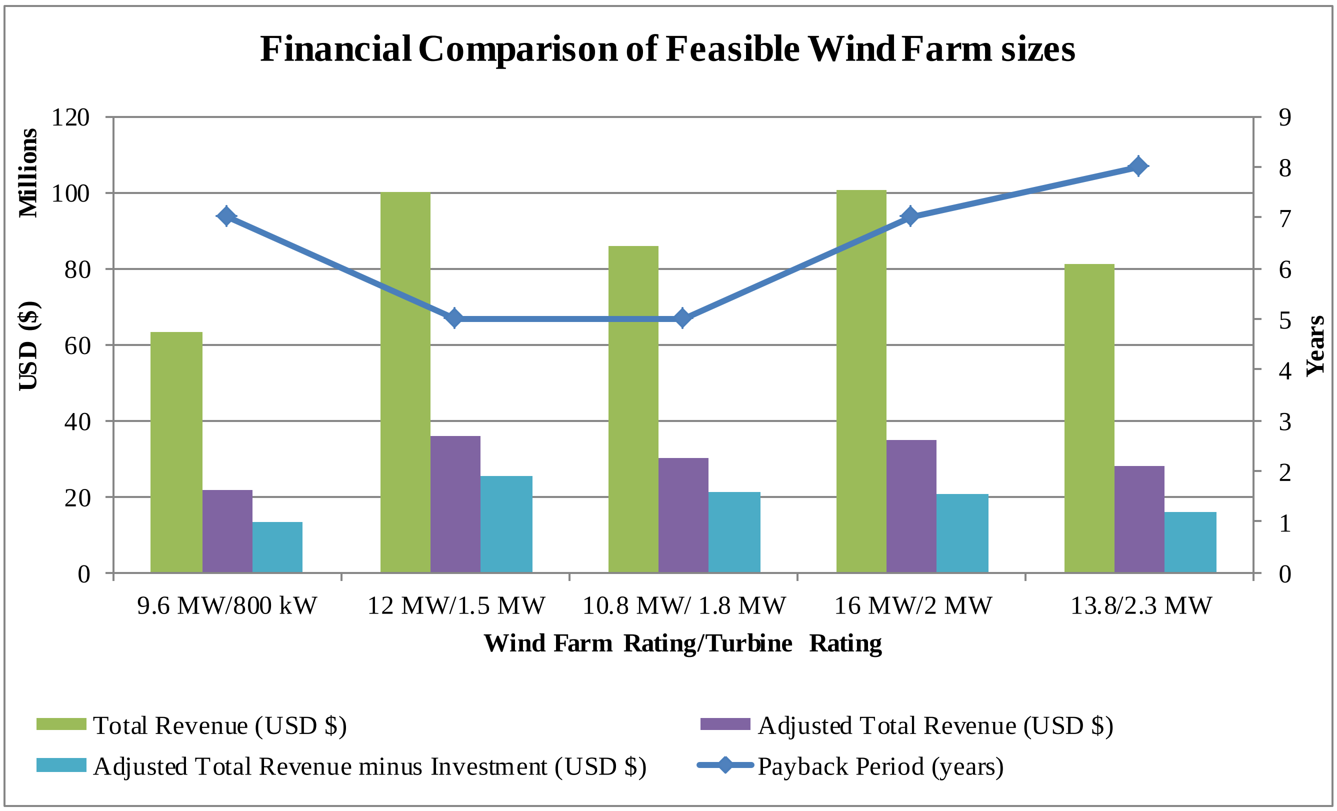

Figure 4.11 Financial Comparison of Feasible Turbines and Wind Farm sizes

4.4 Social and Environmental Feasibility

Social and environmental feasibility encompasses the effects of the wind farm on the local ecosystem and any possible effects on nearby communities. We could not perform a comprehensive study of the ecology and wild life on the proposed site due to time constraints. However, we did collect general information on the vegetation and wildlife we observed during our site visits. Vegetation on the site included three patches of trees, grass and bushes. In addition, we observed cows and vultures at the site. Figure 4.12 shows some of the wildlife and vegetation at the site.

Figure 4.12 Wildlife and vegetation at PEVA

In the construction feasibility, we discussed that ESPH may have to cut some of the trees and bushes in order to reduce wind shadow effects and turbulence. This could affect the habitat of any animals, primarily birds, which live in these trees. While the destruction of habitats could be harmful to bird populations, we believe that the removal of these habitats could lower the number of bird fatalities from turbine strikes, as there would be fewer birds flying near the turbines. In addition, clearing these trees would open more land for cattle grazing which is currently the primary function of the land. Choosing turbine layouts with smaller numbers of larger turbines would also benefit grazing cattle, as the turbines would have a lesser impact on the land as a whole. However, these cattle may exhibit behavior similar to the ones described in the case study at the APWRA as mentioned in section 2.9.4 of the background. This may lead to the chain reaction that causes bird fatalities as we have described in the background. On the other hand, the area of PEVA is 24 hectares while the area of APWRA is about 75,000 hectares. Therefore, due to PEVA's small area, the bird fatalities that may occur as a consequence would be a minor concern.

We have determined that the noise produced by a wind farm at PEVA would not be a serious issue as the closest communities to PEVA were at least a kilometer away. The only neighboring building that we have found in that area belongs to the MOVASA wind farm. To ensure noise from our wind farm would not disturb these communities, we used the sound map calculator from the Danish Wind Industry Association to determine the noise level that turbines would produce at the PEVA site. Figure 4.13 shows the noise generated by two potential farm layouts: one with 80 meter diameter turbines and one with 50 meter diameter turbines.

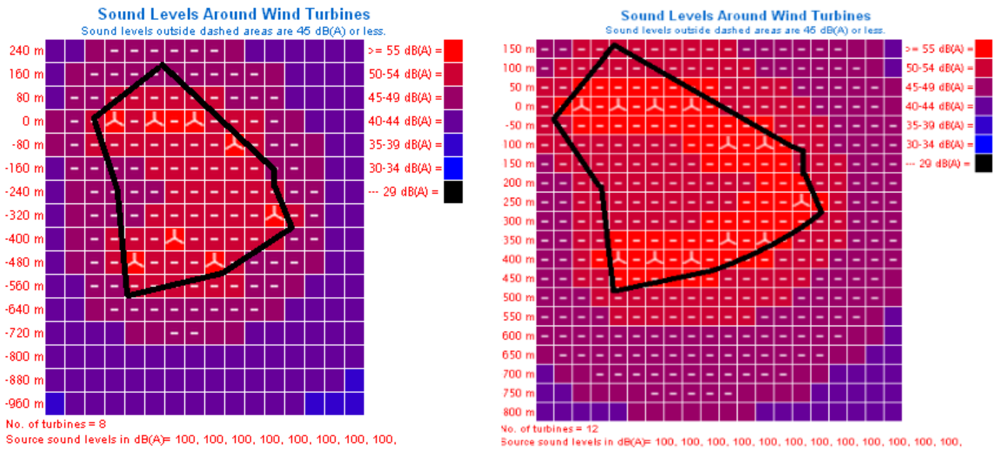

Figure 4.13 Sound maps of hypothetical PEVA layouts of 80 meter (left) and 50 meter turbines (right)

These maps show idealized configurations of turbines with the boundaries of PEVA in black. Due to the different turbine sizes, the scales of each map are different. These results show that noise levels drop significantly outside the boundaries of the wind farm, to 49-45 dB within 150 meters of the boundary, and would have minimal impact on any nearby communities.

Wind farms have proven to be very beneficial to the Tilarán area, both by providing landowners with extra income and by providing jobs for residents. ESPH has estimated that building a wind farm would provide work for 100 people during construction and 15 full-time maintenance staff while in operation. While these jobs would primarily be skilled labor, the Tilarán area is very popular for wind farming, so it is likely that many laborers in this area would already have skills pertaining to wind farm construction and maintenance. These workers, as well as the community at large, would benefit from the jobs created by the PEVA wind farm just as they have benefited from other wind farms. Wind farming has become iconic of prosperity in the Tilarán area, making its way in to street murals such as the one shown in Figure 4.14.

Figure 4.14 Street mural depicting a wind farm in Tilarán, Guanacaste

Chapter 5 - Conclusions and Recommendations

Once we had collected all available data and made our projections as to the energy outputs and finances of PEVA, we were able to make conclusions as to the feasibility of the PEVA wind farm as well as recommendations for what ESPH should do from here.

5.1 PEVA Feasibility

Through our evaluations, we found that the PEVA site is a feasible location for a wind farm. While a 20 MW farm could physically be built on the site, the turbines would have to be placed very close together, introducing considerable wind-damping interference between turbines and decreasing the efficiency of the individual turbines. The PEVA site has wind conditions well suited for a wind farm, but the site is not large enough to support a wind farm with a 20 MW capacity. The size of the site is more suited for a 10-15 MW wind farm.

Most payback periods for PEVA respective to wind turbines, range between five and eight years and are excellent for a wind project. Our findings show that PEVA should have a payback period in this window with any farm size between 10 and 15 MW with a broad range of turbine choices. These payback periods are very short and we attribute them to the high wind speeds on site and the high generation potential of modern wind turbines. The cost of connecting PEVA to the nearest substation is considerable. It is not so large, though, that ESPH should wait for ICE to build a closer substation, especially considering that there is no guarantee ICE will do so.

Transportation of wind turbines to the site would be an issue if the turbines selected have a diameter greater than 44 meters. If the turbines are 44 meters or smaller, the installation of the neighboring MOVASA wind farm has already proven road access adequate. Once ESPH has decided on a turbine size, ESPH will have to evaluate the access roads to the site for the chosen blade length if the turbines have a diameter greater than 44 meters. While all the turbines we evaluated had diameters of 50 meters or above, there may be smaller turbines available from other manufacturers. We do not believe that ESPH should limit themselves to turbines smaller than 44 meters as we have found that many larger turbines could be better suited to the site from our wind and financial analysis.

Sound and its effects on nearby communities are negligible for the PEVA site as the only nearby buildings are those belonging to the MOVASA wind farm. The site is far enough removed from the communities of Tilarán and Tierras Morenas that there would be no harmful effects on the community from the noise of the wind turbines. Building these wind farms will definitely provide benefits to nearby communities since they provide a demand for skilled laborers and provide a source of revenue for landowners whose lands have high wind potential. The city nearest to PEVA has demonstrated just this since the town of Tilarán has flourished under the development of nearby wind farms.

While PEVA might not be able to support the generation capacity ESPH had originally envisioned, it is still a feasible site for a wind farm. Through our analysis, we believe that a 12 MW wind farm made of 1.5 MW GE turbines would be the most efficient for ESPH to install, due to the high revenue and short five year payback period. However, on a more general scale, we believe that ESPH can build a 10 to 15 MW wind farm on the site with an expected payback period of 5 to 6 years. This would provide considerable benefit to ESPH by complementing their hydropower generation with up to 80 GWh yearly, generating revenue, and decreasing their reliance on energy from ICE.

5.2 Recommendations

Our primary recommendation for ESPH is the need for the collection of more site-specific data, specifically detailed information on wind speeds for more accurate estimates of power production. These estimates would contribute to a better financial feasibility analysis especially once ESPH has determined the cost quotations by different turbine manufacturers to build the wind farm.

Since most of our uncertainties come from the fact that we did not receive highly detailed wind data for PEVA, we recommend the installation of met towers that would collect all the information needed for an accurate estimate of the available wind potential. ESPH is already planning this, and has contracted Campbell Scientific to collect the data. The data should be collected on PEVA for at least a year. This way, monthly wind potential can be analyzed to determine the energy produced during the wet and dry seasons. In addition, banks require this detailed wind data before they invest in a site to ensure that it is a suitable wind farm site. ESPH will need to have comprehensive wind data to ensure that their projects are feasible and persuasive to banks.

Once the wind speed variations throughout the year are recorded, we recommend that ESPH represent the frequencies of each wind speed by fitting the given wind data to a Weibull distribution or another probability density function. The Weibull distribution encompasses many different probability density functions such as the Rayleigh distribution. It is very flexible and is widely used to provide a close approximation to the probabilistic behavior of many natural phenomena. It has been used in recent years for wind energy applications to give an accurate fit for experimental data (Lam & Lun, 2000). This method is widely used because the shape and scale parameters allow us to describe and predict future wind potential on the site (Danish Wind Industry Association, 2003). Using MATLAB or wind analysis software such as WAsP, they should perform a non-linear least squares curve fit to a Weibull distribution to determine the shape and scale parameters of the corresponding curve equation. They should also use this software to determine that the Weibull distribution is an accurate representation of their data. While the Weibull distribution can represent almost all naturally occurring wind behavior, they might want to use a different probability density function that is a better fit. WAsP and MATLAB can both perform curve fit confidence checks, using r-square and sum of squares due to error fits or other statistical methods (MathWorks, 2010). Since the wind speeds in Costa Rica differ significantly throughout the year, they should derive these parameters as well as mean wind speeds on a monthly scale. The prediction of future wind potential will provide an accurate estimate of future energy generation.

ESPH can then determine corresponding power outputs for different turbines based on wind conditions available on site with the wind turbine power calculator[8]. They would need to input measured values of the monthly mean wind speeds, the Weibull distribution parameters, and the roughness class into this calculator. This calculator would provide them with information on power input, power output, energy output, and capacity factor information corresponding to each wind turbine (Danish Wind Industry Association, 2003). From this information, ESPH can deduce the wind turbines most suitable for PEVA and the energy generated by a wind farm composed of these turbines.

With more detailed wind data, ESPH should perform a more accurate financial analysis for the site once better estimates of energy production can be determined. We recommend that ESPH use the Excel files we have given them to derive the pay back periods specific to the quotes they gather from different turbine manufacturers. Our findings through these spreadsheets can be found in Appendices L through R. These files will allow them to determine the production capacities relative to each turbine model, compare it to the initial price tag, and derive the payback period relative to each manufacturer.

For the construction of the wind farm, we recommend that ESPH re-evaluate the access roads leading to the site to ensure that they are adequate for whichever turbine diameter they select. We believe that ESPH's best options for turbines are well above the size used on the MOVASA site and, therefore, ESPH will have to ensure that it is possible to transport the turbine blades to PEVA.

The construction phase is when ESPH will also have an opportunity to protect their wind turbines from seismic activity, and we recommend that ESPH discuss all options for seismic accommodations with the turbine manufacturers and any construction firms involved in the project. While we believe that seismic activity does not significantly influence the feasibility of this wind project, it is crucial that ESPH understands all of their options moving forward.

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[8] http://www.vindselskab.dk/en/tour/wres/pow/index.htm

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Glossary

Betz's Law: A theory that states that the maximum power coefficient is 0.5925, or 59.25% efficiency

Capacity factor: The ratio, expressed in percent, of the actual output of a power plant over a period of time and its output if it had operated at its full name-plate power rating the entire time.

Drag force: Opposing force that acts on the rotor blades by the wind

Fictitious force: A force that does not come from the interaction of objects within a frame of reference but rather from the acceleration of the frame of reference as a whole.

Flagging: A phenomenon where trees and other vegetation in a high-wind area lean in the area's predominant wind direction.

Lift force: force that acts on the rotor blades that is provided by the motor in the wind turbine

Magnetic induction: A physical phenomenon where a changing magnetic field produces electric voltage in a coil. This principle used in wind turbines to generate electricity.

Met towers: Short for meteorological tower, met towers are erected with anemometers to collect wind data at a point over a long period of time.

Name-plate power rating: The ideal power rating of a power plant, in watts. Power plants, especially wind farms, rarely generate their name-plate power rating as it is the maximum output.

Pay-back period: The time between the beginning of wind farm operation and when the wind farm has recouped its initial investment.

Porosity: The ratio between open space within an object and the total volume of the object. In wind, it is related to how much interference objects such as trees have on wind.

Rose diagram: A circular graph that expresses magnitude as a function of angle. Wind roses, for example, show average wind speed in every direction from a central point.

Shadow effect: The decrease in wind speed in the area behind a wind turbine.

Shadow flickering: The flickering of light experience by anyone standing in the shadow of a turbine's blades.

Stator: The non-moving component of a generator, usually a coil, on which voltage is induced by changes in the magnetic field.

Tip speed ratio: The ratio between the speed of the tip of the blade and the wind speed

Transformer: Electric installation which changes the voltage, frequency and/or phase of transmitted electric power.

Weibull distribution: A probability density function commonly used as a flexible representation of the probability of a certain wind speed available at a given location as well as many other natural phenomena.

Appendix A – Wind Power Derivation

The following will provide some physics background in order to derive the power of the wind.

Wind power can be expressed as change of wind energy per unit time, as shown below.

$$P = \frac{\Delta E}{\Delta t}$$

Wind energy is in the form of kinetic energy, hence the change in kinetic energy can be expressed as:

$$\Delta E = \frac{\Delta m v^2}{2}$$

Here, Δm represents the change of wind mass over a certain period of time and v is the wind speed. Furthermore, change in mass is the product of change in volume and specific density of the air:

$$\Delta m = \Delta V \rho_a$$

Therefore, the expression for the change in kinetic energy becomes:

$$\Delta E = \frac{\Delta V \rho_a v^2}{2}$$

Change in volume can be represented as the product of area being swept by the rotor blades and change in length. Furthermore, the change in length is the product of wind speed and time.

$$\Delta V = \Delta l A$$

$$\Delta l = \Delta t v$$

$$\Delta V = \Delta t A v$$

Finally, if we substitute the change in volume with the change in wind energy we get:

$$\Delta E = \frac{\Delta t A \rho_a v^3}{2}$$

Since we derived the expression for the change in wind energy, the power produced by a certain turbine can be expressed as:

$$P = \frac{\Delta E}{\Delta t} = \frac{1}{2} A \rho_a v^3$$

In this final equation we have 3 extremely important variables, A being the area that is being swept by the rotor blades, ρ_a is the specific density of air and v is the wind speed. It is essential to examine the factors that could possibly affect the aforementioned variables to optimize the power produced by a turbine. The specific density of air ρ_a is dependent upon temperature and altitude. For instance, at 0□ and at sea level, the specific density would be $1.293\ kg/m^3$ however at 15□ it would be $1.225\ kg/m^3$. There is a minor difference between these two values, hence, the specific density of air does not play an important role in determining the wind power (Hermann-Josef Wagner, 2009). The area being swept by the rotors blades is another variable to consider. The area swept by the blades, A, is proportional to the square of the diameter of the circle, d.

$$A = \frac{\pi d^2}{4}$$

"Number of studies were undertaken to determine the "optimum" size of rotor blades (Molly et al. 1993) by balancing the costs of manufacture, installation and operation of various size of wind turbine against the revenue generated. Results indicated that diameters should be 35 to 60 m" (Burton, Sharpe, Jenkins, & Bossanyi, 2001). Wind power is also proportional to the cube of wind speed. Consequently, we can state that wind speed is crucial in determining wind power and in choosing an appropriate location for a wind farm.

In conclusion, the area being swept by the rotor blades and the wind speed available on site will determine the power that can be produced by an individual wind turbine.

Appendix B – Turbine Power Generation & Efficiency

Considering all limitations in transferring the wind power in a wind turbine, the power that is delivered to the electric grid is approximately:

$$P = \frac{1}{2} A\rho_a v^3 c_p \eta_g \eta_e$$

The previously undefined variables in this equation are: $c_p = 0.5925$ the power coefficient - the percentage of wind power captured by the blades, η_g - the gearbox efficiency, and η_e - the electric generator efficiency (Manwell, McGowen, & Rogers, 2002).

Appendix C – MOVASA Recorded Monthly Mean Wind Speeds 1999 - 2007

MOVASA Recorded Mean Wind Speeds

Year	Wind speeds (m/s) January	February	March	April	May	June	July	August	September	October	November	December	Annual mean wind speeds
1999							6.4	5.5	2.7	4.2	7.2	11.6	
2000	14.2	15.6	12.5	12.8	7.1	7.2	7.2	7.5	3.1	7.9	7.9	11.7	9.6
2001		18.1	11.0	15.3	6.2	9.6	8.3	7.7	4.6	5.7	10.0	9.6	
2002	13.2	14.9	15.4	14.3	10.1	5.4							
2003	15.7	11.9	9.2	6.3	5.1	2.0	4.5	4.2	3.8	2.0	4.0	11.7	6.7
2004	12.8	13.8	16.2	10.4	8.0	6.3	5.3	6.5	2.6	3.7	8.2	11.6	8.8
2005	15.1	11.8	7.7	9.9	5.4	2.5	4.5	5.5	5.2	3.5	7.9	8.0	7.3
2006	12.1	13.8	14.2	10.2	6.2	5.0	6.3	6.3	5.6	5.9	9.0	11.7	8.9
2007	18.8	12.6	14.1	7.7	6.4	5.3	7.2	3.9	4.0	3.4	9.8	9.6	8.6
Mean	14.6	14.1	12.5	10.9	6.8	5.4	6.2	5.9	4.0	4.5	8.0	10.7	
Variance	4.4	3.9	8.0	8.5	2.3	5.2	1.6	1.7	1.1	3.0	3.1	1.8	
St. Deviation	2.1	2.0	2.8	2.9	1.5	2.3	1.3	1.3	1.1	1.7	1.8	1.3	

Appendix D – MOVASA Mean Wind Speeds and PEVA Mean Wind Speeds

Mean Wind Speeds on MOVASA and PEVA

Sites:	MOVASA Actual Mean Wind Speed (m/s)	PEVA Calculated Mean Wind Speed (m/s)			
Months\Height	**40 m**	**50 m**	**60 m**	**70 m**	**80 m**
January	14.6	13.8	14.2	14.5	14.8
February	14.1	13.3	13.7	14.0	14.3
March	12.5	11.9	12.2	12.5	12.8
April	10.9	10.3	10.6	10.9	11.1
May	6.8	6.5	6.6	6.8	6.9
June	5.4	5.1	5.3	5.4	5.5
July	6.2	5.9	6.1	6.2	6.3
August	5.9	5.6	5.7	5.9	6.0
September	4.0	3.7	3.9	3.9	4.0
October	4.5	4.3	4.4	4.5	4.6
November	8.0	7.6	7.8	8.0	8.2
December	10.7	10.1	10.4	10.7	10.9

Appendix E –MOVASA Calculated versus Actual Production

	MOVASA (40 m) Production Vestas NM44/750 kW (MWh)			
Months	**Power generation per mean speed (kW)**	**Calculated**	**Actual**	**Correction Ratio (Actual/Calculated)**
January	728	17325	10753	0.621
February	713	15332	10354	0.675
March	591	14082	11275	0.801
April	429	9889	9494	0.960
May	96	2293	4875	2.126
June	37	855	3369	3.940
July	72	1726	4444	2.575
August	59	1416	4613	3.258
September	1	32	1625	50.781
October	3	67	2306	34.418
November	188	4330	5388	1.244
December	417	9937	6314	0.635
Annual production		**77284**	**74810**	

We derived the calculated energy per month using the following formula.

$$E_{month} = P_1 * N * D * 24 * \left(\frac{1}{1000}\right) * k$$

In this formula, P_1 represents the power produced at the monthly mean wind speed as derived from the power curve of a specific turbine. The variable N is the number of wind turbines on the wind farm and D is the number of days in a month. In addition, the number 24 represents the number of hours in a day and 1/1000 is the conversion factor from kWh to MWh. Finally, k is the corrected value that is the ratio between the actual production at MOVASA wind farm and its calculated production.

Cells that are highlighted in yellow represent the production of the months where wind speeds are very low, sometimes below cut-in wind speed. Therefore, the formula above will give results that are inaccurate. Since the calculated energy production will be small compared to other months and to the annual production, we decided to set the production values for the months of September and October to be the same as the values from MOVASA. This way, we decreased the error made if we had used the calculated and corrected value instead.

Appendix F – Turbines Required for different Wind Farm Sizes

Power Rating (MW)	Turbines needed (10 MW)	Turbines needed (15 MW)	Turbines needed (20 MW)
0.80	13	19	25
0.85	12	18	24
0.90	11	17	22
1.32	8	11	15
1.50	7	10	13
1.65	6	9	12
1.80	6	8	11
2.00	5	8	10
2.30	4	7	9
2.50	4	6	8
3.00	3	5	7
3.60	3	4	6
4.50	2	3	4
7.50	1	2	3

Appendix G – All Turbines from Gamesa, Enercon, Vestas, GE, and Siemens

Turbines in the Market

	Model	Rated Power	Cut In Speed (m/s)	Cut Out Speed (m/s)	Rated Speed (m/s)	Rotor Diameter (m)	Turbine Height (m)	Turbine Class	Wind Zone	Turbines Installed	No.
Gamesa	**Made AE-52-800 KW**	800 kW				52	50	IA			1
	Made AE-56-800 KW	800 kW				56	60	IIA			2
	Made AE-59-800 KW	800 kW				59	60	IIIA			3
	Gamesa G58-850 kW	850 kW	3	21-23	12	58	44/55/65/74*	IIA/IIIB	WZII	8,400	4
	Gamesa G52-850 KW	850 kW	4	28	13	52	44//55/65	IA			5
	Made AE-61-1320 KW	1.32 MW	4	25	16	61	55	IA			6
	Gamesa G80-2.0 MW	2.0 MW	4	25	14	80	60/67/78/100~	IA	WZII/WZIII		7
	Gamesa G87-2.0 MW	2.0 MW	4	25	12	87	67/78/100	IIA	WZII		8
	Gamesa G90-2.0 MW IIA	2.0 MW	4	21-25	12	90	67/78/100	IIA/IIIA			9
	Gamesa G97-2.0 MW IIIA	2.0 MW	4	21-25	11	97	78/90/115*	IIIA			10
	Gamesa G128-4.5 MW	4.5 MW				128	120	IIA	WZII		11
Enercon	**E-33/330 kW**	330 kW	3	28~34	13	33.4	37/44/49/50	IA/IIA	WZIII		12
	E-48/800 kW	800 kW	3	28~34	14	48	50/60/75/76	IIA	WZIII		13
	E-53/800 kW	800 kW	2	28~34	13	52.9	60/73/75	IIA	WZII		14
	E-44/900 kW	900 kW	3	28~34	17	44	45/55/65	IA			15
	E-82/2 MW	2.0 MW	2	28~34	13	82	78/85/98/108/138	IIA	WZIII		16
	E-70/2.3 MW	2.3 MW	2	28~34	16	71	57/64/85/98/113	IA/IIA	WZIII		17
	E-82/2.3 MW	2.3 MW	2	28~34	14	82	78/85/98/108/138	IIA	WZ III		18
	E-82/3 MW	3.0 MW	2	28~34	17	82	78/85/98/108/138	IA/IIA			19
	E-101/3 MW	3.0 MW	2	28~34	13	101	99/135	IIA	WZ III		20
	E-126/7.5 MW	7.5 MW	3	28~34	17	127	135	IA	WZ III		21
Vestas	**V52-850 kW**	850 kW	4	25	16	52	44/49/55/65/74	IA/IIA			22
	V60-850 kW	850 kW	3.5	>20	13	60		IIB			23
	V82-1.65 MW	1.65 MW	3.5	20	13	82	**50Hz, 230V** - 78 **60Hz, 110V** - 70/80	IIA			24
	V90-1.8 MW	1.8 MW	4	25	12	90	**50Hz** - 80/95/105 **60Hz** - 80/95	IIA			25
	V100-1.8 MW	1.8 MW	3	20	12	100	80/95	IIIA			26
	V80-2.0 MW	2.0 MW	4	25	16	80	67/80	IA			27
	V90-2.0 MW	2.0 MW	4	25	12	90	80/95/105/125	IIIA			28
	V90-3.0 MW	3.0 MW	3.5	25	15	90	65/75/80/90/105	IA IIA-105m tower			29
	V112-3.0 MW	3.0 MW	3	25	12	112	84/94/119	IIA IIIA- 119m tower			30

	Model	Rated Power	Cut In Speed (m/s)	Cut Out Speed (m/s)	Rated Speed (m/s)	Rotor Diameter (m)	Turbine Height (m)	Turbine Class	Wind Zone	Turbines Installed	No.
GE	**1.5sle**	1.5 MW	3.5	25	14	72	65/80	IIA		12,000	31
	1.5xle	1.5 MW	3.5	20	11.5	82.5	80	IIIB			32
	2.5 MW	2.5 MW	3	25	12.5	100	75/85/100	IIIA/IIB			33
Siemens	**SWT-2.3-82**	2.3 MW	3-5	25	13-14	82.4	80	IA			34
	SWT-2.3-93	2.3 MW	4	25	13-14	93	80				35
	SWT-2.3-101	2.3 MW	3-4	25	12-13	101	80				36
	SWT-3.0-101	3.0 MW	3	25	12-13	101	80	IA			37
	SWT-3.6-120	3.6 MW	3-5	25	12-13	120	90				38
	SWT-3.6-107	3.6 MW	3-5	25	13-14	107	80				39

Legend	
*	towers currently in design for this height
~	Available for sites with a certain wind class
21-25	turbine starts generating less than optimal power at these cut out speeds
28~34	cut off speeds depend on site and turbulence

Appendix H – Projected Annual Energy Production for a 10 MW Wind Farm

H.1 Projected Annual Energy Production for Enercon Turbines

			Annual Energy Production Forecast for Enercon Turbines Wind Farm Capacity: 10 MW			
	E-48/800 kW (60 m) Production (MWh)			E-53/800 kW (60 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected
January	810	7834	4862	810	7834	4862
February	805	7032	4749	810	7076	4779
March	760	7351	5885	790	7641	6118
April	620	5803	5571	700	6552	6290
May	155	1499	3187	183	1770	3763
June	75	702	2766	90	842	3319
July	110	1064	2739	141	1364	3511
August	90	870	2836	120	1161	3781
September	20	187	1625	34	318	1625
October	40	387	2306	62	600	2306
November	250	2340	2912	310	2902	3611
December	620	5997	3810	695	6722	4271
Annual production		**41067**	**43250**		**44782**	**48237**

	E-70/2.3 MW (60 m) Production (MWh)			E-82/2.3 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	2250	6696	4156	2350	6994	4341
February	2180	5860	3957	2350	6317	4266
March	1930	5744	4599	2220	6607	5290
April	1400	4032	3871	1900	5472	5253
May	350	1042	2214	515	1533	3258
June	150	432	1702	250	720	2837
July	245	729	1877	380	1131	2912
August	210	625	2036	321	955	3112
September	46	132	1625	82	236	1625
October	85	253	2306	135	402	2306
November	590	1699	2114	840	2419	3010
December	1400	4166	2647	1835	5461	3470
Annual production		**31410**	**33106**		**38246**	**41680**

	E-44/900 kW (60 m) Production (MWh)			E-82/2.0 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	860	7038	4368	2050	7626	4733
February	830	6135	4143	2050	6888	4652
March	730	5974	4783	2050	7626	6106
April	540	4277	4106	1820	6552	6290
May	130	1064	2262	510	1897	4034
June	63	499	1966	255	918	3617
July	98	802	2065	470	1748	4502
August	83	679	2213	321	1194	3890
September	16	127	1625	82	295	1625
October	32	262	2306	140	521	2306
November	215	1703	2119	850	3060	3808
December	520	4256	2704	1750	6510	4136
Annual production		**32816**	**34661**		**44836**	**49699**

	E-70/2.3 MW (60 m) Production (MWh)			E-82/2.3 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	2250	6696	4156	2350	6994	4341
February	2180	5860	3957	2350	6317	4266
March	1930	5744	4599	2220	6607	5290
April	1400	4032	3871	1900	5472	5253
May	350	1042	2214	515	1533	3258
June	150	432	1702	250	720	2837
July	245	729	1877	380	1131	2912
August	210	625	2036	321	955	3112
September	46	132	1625	82	236	1625
October	85	253	2306	135	402	2306
November	590	1699	2114	840	2419	3010
December	1400	4166	2647	1835	5461	3470
Annual production		**31410**	**33106**		**38246**	**41680**

	E-82/3 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected
January	2820	6294	3907
February	2750	5544	3744
March	2400	5357	4289
April	2050	4428	4251
May	522	1165	2477
June	250	540	2128
July	410	915	2356
August	321	716	2334
September	82	177	1625
October	140	312	2306
November	850	1836	2285
December	1880	4196	2666
Annual production		**31481**	**34368**

H.2 Projected Annual Energy Production for Other Turbines

	Annual Energy Production Forecast for Other Turbines Wind Farm Capacity: 10 MW					
	GAMESA G80/2 MW (60 m) Production (MWh)			General Electric 1.5xle/1.5 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected
January	2000	7440	4618	1500	7812	4849
February	1900	6384	4311	1500	7056	4765
March	1800	6696	5361	1500	7812	6255
April	1300	4680	4493	1500	7560	7258
May	300	1116	2373	550	2864	6090
June	150	540	2128	300	1512	5958
July	250	930	2395	430	2239	5766
August	220	818	2666	400	2083	6787
September	0	0	1625	150	756	1625
October	50	186	2306	210	1094	2306
November	500	1800	2240	890	4486	5582
December	1100	4092	2600	1450	7552	4798
Annual Production		**34682**	**37115**		**52826**	**62038**

	General Electric 1.5sle/1.5 MW (80 m) Production (MWh)			VESTAS V80/2 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	1500	7812	4849	1996	7425	4609
February	1500	7056	4765	1994	6700	4525
March	1500	7812	6255	1900	7068	5659
April	1400	7056	6774	1600	5760	5530
May	400	2083	4429	430	1600	3401
June	190	958	3773	210	756	2979
July	340	1771	4559	300	1116	2873
August	250	1302	4242	261	971	3163
September	50	252	1625	44.1	159	1625
October	90	469	2306	100	372	2306
November	550	2772	3449	700	2520	3136
December	1410	7343	4666	1550	5766	3664
Annual Production		**46686**	**51692**		**40212**	**43469**

	VESTAS V90/1.8 MW (80 m) Production (MWh)			VESTAS V90/2.0 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected
January	1800	8035	4987	2000	7440	4618
February	1800	7258	4901	2000	6720	4538
March	1780	7946	6362	1980	7366	5897
April	1610	6955	6677	1650	5940	5703
May	500	2232	4745	500	1860	3954
June	300	1296	5107	300	1080	4256
July	405	1808	4655	405	1507	3879
August	330	1473	4799	330	1228	3999
September	20	86	1625	20	72	1625
October	110	491	2306	110	409	2306
November	795	3434	4274	795	2862	3561
December	1770	7901	5020	1770	6584	4184
Annual Production		**48916**	**55459**		**43067**	**48520**

	Siemens SWT-2.3-82 VS/2.3 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	2300	6845	4248
February	2300	6182	4175
March	2200	6547	5242
April	1980	5702	5475
May	500	1488	3164
June	285	821	3234
July	420	1250	3218
August	400	1190	3878
September	10	29	1625
October	40	119	2306
November	950	2736	3405
December	1800	5357	3404
Annual Production		**38267**	**43373**

H.3 Projected Average Energy Production by Turbine Power Rating

Calculated Annual Power Production by Power Rating - 10 MW				
Power Rating	**Model**	**Annual Power Generation**	**Avg. Annual Power Generation**	**Variance (±)**
800 kW	E-48/800 kW (60 m)	43,250	**46,000**	2500
	E-53/800 kW (60 m)	48,237		
900 kW	E-44/900 kW (60 m)	34,661	**35,000**	
1.5 MW	General Electric 1.5xle (80 m)	62,038	**57,000**	5,200
	General Electric 1.5sle (80 m)	51,692		
1.8 MW	VESTAS V90/1.8 MW (80 m)	55,459	**55,000**	
2.0 MW	E-82/2.0 MW (80 m)	49,699	**45,000**	6,000
	GAMESA G80/2 MW (60 m)	37,115		
	VESTAS V80/2 MW (80 m)	43,469		
	VESTAS V90/2.0 MW (80 m)	48,520		
2.3 MW	E-70/2.3 MW (60 m)	33,106	**39,000**	5,000
	E-82/2.3 MW (80 m)	41,680		
	Siemens SWT-2.3-82 VS (80 m)	43,373		
3.0 MW	E-82/3 MW (80 m)	34,368	**34,000**	

Appendix I - Projected Annual Energy Production for a 15 MW Wind Farm

I.1 Projected Annual Energy Production for Enercon Turbines

			Annual Energy Production Forecast for Enercon Turbines Wind Farm Capacity: 15 MW			
	E-48/800 kW (60 m) Production (MWh)			E-53/800 kW (60 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	810	11450	7107	810	11450	7107
February	805	10278	6941	810	10342	6984
March	760	10743	8602	790	11167	8941
April	620	8482	8143	700	9576	9194
May	155	2191	4658	183	2587	5500
June	75	1026	4043	90	1231	4851
July	110	1555	4004	141	1993	5132
August	90	1272	4145	120	1696	5526
September	20	274	1625	34	465	1625
October	40	565	2306	62	876	2306
November	250	3420	4256	310	4241	5277
December	620	8764	5569	695	9825	6243
Annual production		**60021**	**61397**		**65450**	**68686**

	E-44/900 kW (60 m) Production (MWh)			E-82/2.0 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected
January	860	10877	6751	2050	12202	7573
February	830	9482	6403	2050	11021	7443
March	730	9233	7393	2050	12202	9769
April	540	6610	6346	1820	10483	10064
May	130	1644	3496	510	3036	6454
June	63	771	3038	255	1469	5788
July	98	1240	3191	470	2797	7203
August	83	1050	3420	321	1911	6224
September	16	196	1625	82	472	1625
October	32	405	2306	140	833	2306
November	215	2632	3275	850	4896	6092
December	520	6577	4179	1750	10416	6618
Annual production		**50716**	**51423**		**71737**	**77159**

	E-70/2.3 MW (60 m) Production (MWh)			E-82/2.3 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	2250	11718	7273	2350	12239	7596
February	2180	10255	6925	2350	11054	7465
March	1930	10051	8048	2220	11562	9257
April	1400	7056	6774	1900	9576	9194
May	350	1823	3875	515	2682	5702
June	150	756	2979	250	1260	4965
July	245	1276	3285	380	1979	5096
August	210	1094	3563	321	1672	5446
September	46	232	1625	82	413	1625
October	85	443	2306	135	703	2306
November	590	2974	3700	840	4234	5268
December	1400	7291	4633	1835	9557	6072
Annual production		**54968**	**54987**		**66931**	**69992**

	E-82/3 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	2820	10490	6511
February	2750	9240	6240
March	2400	8928	7148
April	2050	7380	7085
May	522	1942	4128
June	250	900	3546
July	410	1525	3927
August	321	1194	3890
September	82	295	1625
October	140	521	2306
November	850	3060	3808
December	1880	6994	4444
Annual production		**52469**	**54659**

I.2 Projected Annual Energy Production for Other Turbines

			Annual Energy Production Forecast for Other Turbines Wind Farm Capacity: 15 MW			
	GAMESA G80/2 MW (60 m) Production (MWh)			General Electric 1.5xle/1.5 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	2000	11904	7388	1500	11160	6927
February	1900	10214	6898	1500	10080	6807
March	1800	10714	8578	1500	11160	8935
April	1300	7488	7189	1500	10800	10369
May	300	1786	3796	550	4092	8700
June	150	864	3404	300	2160	8511
July	250	1488	3831	430	3199	8237
August	220	1309	4266	400	2976	9695
September	0	0	1625	150	1080	1625
October	50	298	2306	210	1562	2306
November	500	2880	3584	890	6408	7974
December	1100	6547	4160	1450	10788	6855
Annual Production		**55492**	**57026**		**75466**	**86940**

	General Electric 1.5sle/1.5 MW (80 m) Production (MWh)			VESTAS V80/2 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	1500	11160	6927	1996	11880	7374
February	1500	10080	6807	1994	10720	7239
March	1500	11160	8935	1900	11309	9055
April	1400	10080	9677	1600	9216	8848
May	400	2976	6327	430	2559	5441
June	190	1368	5390	210	1210	4766
July	340	2530	6513	300	1786	4597
August	250	1860	6059	261	1553	5061
September	50	360	1625	44.1	254	1625
October	90	670	2306	100	595	2306
November	550	3960	4928	700	4032	5017
December	1410	10490	6666	1550	9226	5862
Annual Production		**66694**	**72161**		**64340**	**67191**

	VESTAS V90/1.8 MW (80 m) Production (MWh)			VESTAS V90/2.0 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	1800	10714	6650	2000	11904	7388
February	1800	9677	6535	2000	10752	7261
March	1780	10595	8483	1980	11785	9436
April	1610	9274	8903	1650	9504	9124
May	500	2976	6327	500	2976	6327
June	300	1728	6809	300	1728	6809
July	405	2411	6207	405	2411	6207
August	330	1964	6399	330	1964	6399
September	20	115	1625	20	115	1625
October	110	655	2306	110	655	2306
November	795	4579	5698	795	4579	5698
December	1770	10535	6694	1770	10535	6694
Annual Production		**65221**	**72635**		**68908**	**75274**

	Siemens SWT-2.3-82 VS/2.3 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected
January	2300	11978	7435
February	2300	10819	7306
March	2200	11458	9174
April	1980	9979	9581
May	500	2604	5536
June	285	1436	5660
July	420	2187	5632
August	400	2083	6787
September	10	50	1625
October	40	208	2306
November	950	4788	5958
December	1800	9374	5957
Annual Production		**66966**	**72955**

I.3 Projected Average Energy Production by Turbine Power Rating

Calculated Annual Power Production by Power Rating - 15 MW				
Power Rating	**Model**	**Annual Power Generation**	**Avg. Annual Power Generation**	**Variance (±)**
800 kW	E-48/800 kW (60 m)	61,397	**65,000**	3600
	E-53/800 kW (60 m)	68,686		
900 kW	E-44/900 kW (60 m)	51,423	**51,000**	
1.5 MW	General Electric 1.5xle (80 m)	86,940	**80,000**	7,400
	General Electric 1.5sle (80 m)	72,161		
1.8 MW	VESTAS V90/1.8 MW (80 m)	72,635	**73,000**	
2.0 MW	E-82/2.0 MW (80 m)	77,159	**69,000**	10,000
	GAMESA G80/2 MW (60 m)	57,026		
	VESTAS V80/2 MW (80 m)	67,191		
	VESTAS V90/2.0 MW (80 m)	75,274		
2.3 MW	E-70/2.3 MW (60 m)	54,987	**66,000**	9,000
	E-82/2.3 MW (80 m)	69,992		
	Siemens SWT-2.3-82 VS (80 m)	72,955		
3.0 MW	E-82/3 MW (80 m)	54,659	**55,000**	

Appendix J - Projected Annual Energy Production for a 20 MW Wind Farm

J.1 Projected Annual Energy Production for Enercon Turbines

			Annual Energy Production Forecast for Enercon Turbines Wind Farm Capacity: 20 MW			
	E-48/800 kW (60 m) Production (MWh)			E-53/800 kW (60 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected
January	810	15066	9351	810	15066	9351
February	805	13524	9133	810	13608	9190
March	760	14136	11318	790	14694	11765
April	620	11160	10714	700	12600	12097
May	155	2883	6129	183	3404	7237
June	75	1350	5319	90	1620	6383
July	110	2046	5268	141	2623	6753
August	90	1674	5454	120	2232	7271
September	20	360	1625	34	612	1625
October	40	744	2306	62	1153	2306
November	250	4500	5600	310	5580	6943
December	620	11532	7327	695	12927	8214
Annual production		**78975**	**79545**		**86119**	**89134**

	E-44/900 kW (60 m) Production (MWh)			E-82/2.0 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected
January	860	14076	8737	2050	15252	9466
February	830	12271	8287	2050	13776	9303
March	730	11949	9567	2050	15252	12212
April	540	8554	8212	1820	13104	12581
May	130	2128	4524	510	3794	8067
June	63	998	3932	255	1836	7234
July	98	1604	4130	470	3497	9003
August	83	1359	4426	321	2388	7780
September	16	253	1625	82	590	1625
October	32	524	2306	140	1042	2306
November	215	3406	4238	850	6120	7615
December	520	8511	5408	1750	13020	8273
Annual production		**65632**	**65391**		**89671**	**95466**

	E-70/2.3 MW (60 m) Production (MWh)			E-82/2.3 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected
January	2250	15066	9351	2350	15736	9767
February	2180	13185	8904	2350	14213	9598
March	1930	12923	10347	2220	14865	11902
April	1400	9072	8710	1900	12312	11820
May	350	2344	4983	515	3448	7332
June	150	972	3830	250	1620	6383
July	245	1641	4224	380	2544	6551
August	210	1406	4581	321	2149	7002
September	46	298	1625	82	531	1625
October	85	569	2306	135	904	2306
November	590	3823	4757	840	5443	6773
December	1400	9374	5957	1835	12287	7807
Annual production		**70673**	**69574**		**86054**	**88867**

	E-82/3 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected
January	2820	14687	9115
February	2750	12936	8736
March	2400	12499	10008
April	2050	10332	9919
May	522	2719	5780
June	250	1260	4965
July	410	2135	5498
August	321	1672	5446
September	82	413	1625
October	140	729	2306
November	850	4284	5331
December	1880	9791	6221
Annual production		**73457**	**74950**

J.2 Projected Annual Energy Production for Other Turbines

			Annual Energy Production Forecast for Other Turbines Wind Farm Capacity: 20 MW			
	GAMESA G80/2 MW (60 m) Production (MWh)			General Electric 1.5xle/1.5 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected
January	2000	14880	9235	1500	14508	9005
February	1900	12768	8622	1500	13104	8849
March	1800	13392	10723	1500	14508	11616
April	1300	9360	8986	1500	14040	13479
May	300	2232	4745	550	5320	11310
June	150	1080	4256	300	2808	11065
July	250	1860	4789	430	4159	10708
August	220	1637	5332	400	3869	12604
September	0	0	1625	150	1404	1625
October	50	372	2306	210	2031	2306
November	500	3600	4480	890	8330	10366
December	1100	8184	5200	1450	14024	8911
Annual Production		**69365**	**70300**		**98105**	**111843**

	General Electric 1.5sle/1.5 MW (80 m) Production (MWh)			VESTAS V80/2 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected
January	1500	14508	9005	1996	14850	9217
February	1500	13104	8849	1994	13400	9049
March	1500	14508	11616	1900	14136	11318
April	1400	13104	12581	1600	11520	11060
May	400	3869	8225	430	3199	6802
June	190	1778	7008	210	1512	5958
July	340	3288	8467	300	2232	5747
August	250	2418	7877	261	1942	6326
September	50	468	1625	44.1	318	1625
October	90	870	2306	100	744	2306
November	550	5148	6406	700	5040	6271
December	1410	13638	8665	1550	11532	7327
Annual Production		**86702**	**92630**		**80424**	**83006**

	VESTAS V90/1.8 MW (80 m) Production (MWh)			VESTAS V90/2.0 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	1800	14731	9143	2000	14880	9235
February	1800	13306	8986	2000	13440	9076
March	1780	14568	11664	1980	14731	11795
April	1610	12751	12242	1650	11880	11405
May	500	4092	8700	500	3720	7909
June	300	2376	9362	300	2160	8511
July	405	3315	8534	405	3013	7758
August	330	2701	8798	330	2455	7998
September	20	158	1625	20	144	1625
October	110	900	2306	110	818	2306
November	795	6296	7835	795	5724	7123
December	1770	14486	9204	1770	13169	8367
Annual Production		**89679**	**98399**		**86135**	**93110**

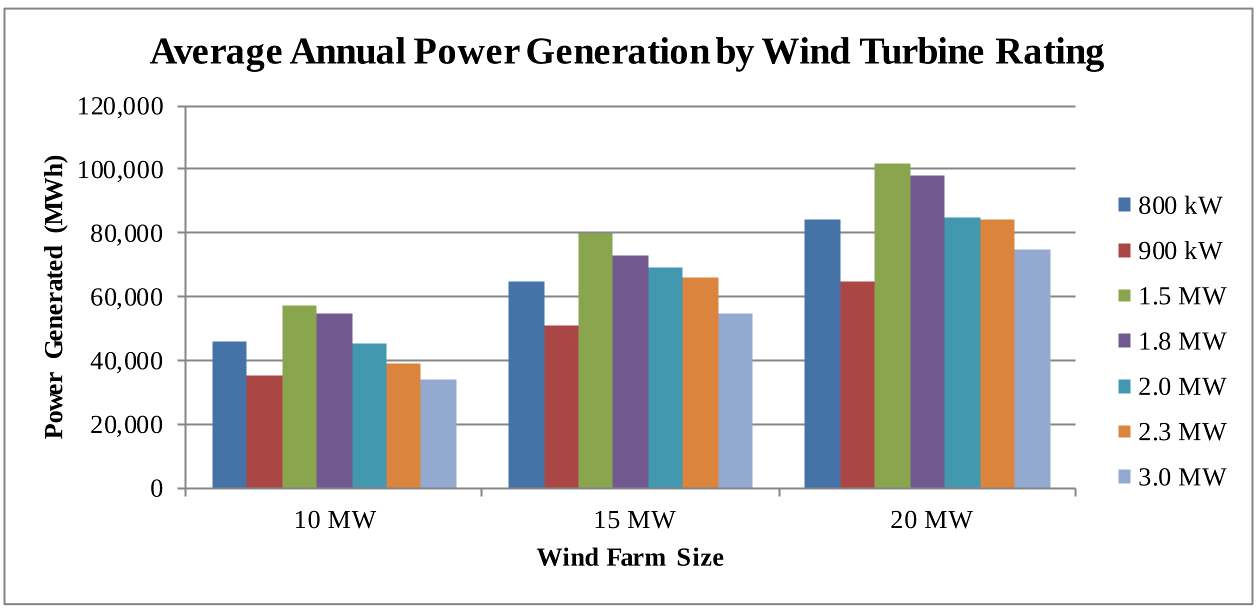
	Siemens SWT-2.3-82 VS/2.3 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	2300	15401	9559
February	2300	13910	9394
March	2200	14731	11795
April	1980	12830	12318
May	500	3348	7118
June	285	1847	7277
July	420	2812	7241
August	400	2678	8726
September	10	65	1625
October	40	268	2306
November	950	6156	7660
December	1800	12053	7658
Annual Production		**86100**	**92677**

J.3 Projected Average Energy Production by Turbine Power Rating

Calculated Annual Power Production by Power Rating - 20 MW				
Power Rating	**Model**	**Annual Power Generation**	**Avg. Annual Power Generation**	**Variance (±)**
800 kW	E-48/800 kW (60 m)	79,545	**84,000**	4800
	E-53/800 kW (60 m)	89,134		
900 kW	E-44/900 kW (60 m)	65,391	**65,000**	
1.5 MW	General Electric 1.5xle (80 m)	111,843	**102,000**	9,600
	General Electric 1.5sle (80 m)	92,630		
1.8 MW	VESTAS V90/1.8 MW (80 m)	98,399	**98,000**	
2.0 MW	E-82/2.0 MW (80 m)	95,466	**85,000**	13,000
	GAMESA G80/2 MW (60 m)	70,300		
	VESTAS V80/2 MW (80 m)	83,006		
	VESTAS V90/2.0 MW (80 m)	93,110		
2.3 MW	E-70/2.3 MW (60 m)	69,574	**84,000**	12,000
	E-82/2.3 MW (80 m)	88,867		
	Siemens SWT-2.3-82 VS (80 m)	92,677		
3.0 MW	E-82/3 MW (80 m)	74,950	**75,000**	

Appendix K – Projected Annual Power Generation by Wind Farm Size

		Average Annual Power Generation by Wind Farm Rating (MWh)		
		10 MW	**15 MW**	**20 MW**
Power Rating	**800 kW**	46,000	65,000	84,000
	900 kW	35,000	51,000	65,000
	1.5 MW	57,000	80,000	102,000
	1.8 MW	55,000	73,000	98,000
	2.0 MW	45,000	69,000	85,000
	2.3 MW	39,000	66,000	84,000
	3.0 MW	34,000	55,000	75,000



Appendix L – Financial Analysis of 800 kW Turbines

L.1 800 kW Turbines on a 10 MW Wind Farm

Wind Farm Capacity: 10 MW with 800 kW Turbines					
Initial Investment					
	ESPH investment	$	9,006,000		
	15 Year Loan	$	21,014,000	Interest Rate:	0.0325
Initial Cost					
	Construction				
	Wind Turbine Cost	$	29,120,000		
	Legal Fees				
	Transmission Line	$	900,000		
Costs Over Time					
	Operation and Maintenance		0.01	$/kWh	
	Labor Cost		10%	of revenue	
	Loan Payment	$	1,792,254		
	Rate of Inflation		10%		
	Rent		2%	of revenue	
Revenue					
	Expected Price of Electricity		Varies by Year		
	Estimated Production of Proposed Site		46,000	MWh	
	Expected Rate of Inflation		10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 21,014,000			
1		$ 682,955	$ 1,109,299	$ 1,792,254
2	$ 19,904,701	$ 646,903	$ 1,145,351	$ 1,792,254
3	$ 18,759,349	$ 609,679	$ 1,182,575	$ 1,792,254
4	$ 17,576,774	$ 571,245	$ 1,221,009	$ 1,792,254
5	$ 16,355,765	$ 531,562	$ 1,260,692	$ 1,792,254
6	$ 15,095,073	$ 490,590	$ 1,301,664	$ 1,792,254
7	$ 13,793,409	$ 448,286	$ 1,343,968	$ 1,792,254
8	$ 12,449,440	$ 404,607	$ 1,387,647	$ 1,792,254
9	$ 11,061,793	$ 359,508	$ 1,432,746	$ 1,792,254
10	$ 9,629,047	$ 312,944	$ 1,479,310	$ 1,792,254
11	$ 8,149,737	$ 264,866	$ 1,527,388	$ 1,792,254
12	$ 6,622,349	$ 215,226	$ 1,577,028	$ 1,792,254
13	$ 5,045,321	$ 163,973	$ 1,628,281	$ 1,792,254
14	$ 3,417,040	$ 111,054	$ 1,681,200	$ 1,792,254
15	$ 1,735,839	$ 56,415	$ 1,735,839	$ 1,792,254
Total		$ 5,869,813	$ 21,014,000	$ 26,883,813

Wind Farm Capacity: 10 MW with 800 kW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000
Revenue										
Price of Electricity (per kWh)		0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		4,600,000	4,715,000	4,832,875	4,953,697	5,077,539	5,204,478	5,334,590	5,467,954	5,604,653
Costs										
O&M		460,000	460,000	460,000	460,000	460,000	460,000	460,000	460,000	460,000
Labor		460,000	471,500	483,288	495,370	507,754	520,448	533,459	546,795	560,465
Loan Payment		1,792,254	1,792,254	1,792,254	1,792,254	1,792,254	1,792,254	1,792,254	1,792,254	1,792,254
Rent		92,000	94,300	96,658	99,074	101,551	104,090	106,692	109,359	112,093
Total Cost		2,804,254	2,818,054	2,832,199	2,846,698	2,861,559	2,876,792	2,892,405	2,908,409	2,924,813
Total Cashflow		1,795,746	1,896,946	2,000,676	2,106,999	2,215,980	2,327,686	2,442,185	2,559,546	2,679,841
Discounted Cashflow		1,632,496	1,567,724	1,503,137	1,439,109	1,375,949	1,313,918	1,253,227	1,194,047	1,136,514
ESPH Initial Investment Payback	$ 9,006,000	$ 7,373,504	$ 5,805,780	$ 4,302,643	$ 2,863,534	$ 1,487,585	$ 173,666			

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		5,744,770	5,888,389	6,035,599	6,186,489	6,341,151	6,499,680	6,662,172	6,828,726	6,999,444	7,174,430	7,353,791
Costs												
	O&M	460,000	460,000	460,000	460,000	460,000	460,000	460,000	460,000	460,000	460,000	460,000
	Labor	574,477	588,839	603,560	618,649	634,115	649,968	666,217	682,873	699,944	717,443	735,379
	Loan Payment	1,792,254	1,792,254	1,792,254	1,792,254	1,792,254	1,792,254					
	Rent	114,895	117,768	120,712	123,730	126,823	129,994	133,243	136,575	139,989	143,489	147,076
Total Cost		2,941,627	2,958,861	2,976,526	2,994,633	3,013,192	3,032,216	1,259,461	1,279,447	1,299,933	1,320,932	1,342,455
Total Cashflow		2,803,143	2,929,528	3,059,073	3,191,856	3,327,958	3,467,464	5,402,711	5,549,279	5,699,511	5,853,498	6,011,336
Discounted Cashflow		1,080,733	1,026,782	974,715	924,567	876,355	830,083	1,175,787	1,097,895	1,025,107	957,094	893,547

Total 20 Year Cashflow	$ 67,320,961
Total 20 Year Discounted Cashflow	$ 23,278,787

L.2 800 kW Turbines on a 15 MW Wind Farm

Wind Farm Capacity: 15 MW with 800 kW Turbines					
Initial Investment					
	ESPH investment	$ 13,038,000			
	15 Year Loan	$ 30,422,000	Interest Rate:	0.0325	
Initial Cost					
	Construction				
	Wind Turbine Cost	$ 42,560,000			
	Legal Fees				
	Transmission Line	$ 900,000			
Costs Over Time					
	Operation and Maintenance	0.01	$/kWh		
	Labor Cost	10%	of revenue		
	Loan Payment	$ 2,594,649			
	Rate of Inflation	10%			
	Rent	2%	of revenue		
Revenue					
	Expected Price of Electricity	Varies by Year			
	Estimated Production of Proposed Site	65,000	MWh		
	Expected Rate of Inflation	10%			

Year	Loan Payment Balance	Interest	Amount Paid on Principal	Annual Payment
0	$ 30,422,000			
1		$ 988,715	$ 1,605,934	$ 2,594,649
2	$ 28,816,066	$ 936,522	$ 1,658,127	$ 2,594,649
3	$ 27,157,939	$ 882,633	$ 1,712,016	$ 2,594,649
4	$ 25,445,923	$ 826,992	$ 1,767,657	$ 2,594,649
5	$ 23,678,266	$ 769,544	$ 1,825,106	$ 2,594,649
6	$ 21,853,160	$ 710,228	$ 1,884,421	$ 2,594,649
7	$ 19,968,739	$ 648,984	$ 1,945,665	$ 2,594,649
8	$ 18,023,074	$ 585,750	$ 2,008,899	$ 2,594,649
9	$ 16,014,175	$ 520,461	$ 2,074,188	$ 2,594,649
10	$ 13,939,986	$ 453,050	$ 2,141,600	$ 2,594,649
11	$ 11,798,386	$ 383,448	$ 2,211,202	$ 2,594,649
12	$ 9,587,185	$ 311,584	$ 2,283,066	$ 2,594,649
13	$ 7,304,119	$ 237,384	$ 2,357,265	$ 2,594,649
14	$ 4,946,854	$ 160,773	$ 2,433,876	$ 2,594,649
15	$ 2,512,977	$ 81,672	$ 2,512,977	$ 2,594,649
Total		$ 8,497,738	$ 30,422,000	$ 38,919,738

Wind Farm Capacity: 15 MW with 800 kW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		6,500,000	6,662,500	6,829,063	6,999,789	7,174,784	7,354,153	7,538,007	7,726,457	7,919,619
Costs										
	O&M	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000
	Labor	650,000	666,250	682,906	699,979	717,478	735,415	753,801	772,646	791,962
	Loan Payment	2,594,649	2,594,649	2,594,649	2,594,649	2,594,649	2,594,649	2,594,649	2,594,649	2,594,649
	Rent	130,000	133,250	136,581	139,996	143,496	147,083	150,760	154,529	158,392
Total Cost		4,024,649	4,044,149	4,064,137	4,084,624	4,105,623	4,127,148	4,149,210	4,171,824	4,195,003
Total Cashflow		2,475,351	2,618,351	2,764,926	2,915,165	3,069,161	3,227,006	3,388,797	3,554,633	3,724,615
Discounted Cashflow		2,250,319	2,163,926	2,077,330	1,991,097	1,905,707	1,821,561	1,738,989	1,658,263	1,579,601

ESPH Initial Investment Payback	$ 13,038,000	$ 10,787,681	$ 8,623,755	$ 6,546,425	$ 4,555,328	$ 2,649,621	$ 828,060			

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		8,117,609	8,320,550	8,528,563	8,741,777	8,960,322	9,184,330	9,413,938	9,649,287	9,890,519	10,137,782	10,391,226
Costs												
	O&M	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000
	Labor	811,761	832,055	852,856	874,178	896,032	918,433	941,394	964,929	989,052	1,013,778	1,039,123
	Loan Payment	2,594,649	2,594,649	2,594,649	2,594,649	2,594,649	2,594,649					
	Rent	162,352	166,411	170,571	174,836	179,206	183,687	188,279	192,986	197,810	202,756	207,825
Total Cost		4,218,762	4,243,115	4,268,077	4,293,662	4,319,888	4,346,769	1,779,673	1,807,914	1,836,862	1,866,534	1,896,947
Total Cashflow		3,898,847	4,077,434	4,260,487	4,448,115	4,640,434	4,837,561	7,634,266	7,841,372	8,053,656	8,271,248	8,494,279
Discounted Cashflow		1,503,174	1,429,116	1,357,522	1,288,460	1,221,971	1,158,074	1,661,439	1,551,374	1,448,521	1,352,415	1,262,620

Total 20 Year Cashflow	$ 94,195,704
Total 20 Year Discounted Cashflow	$ 32,421,479

L.3 800 kW Turbines on a 20 MW Wind Farm

Wind Farm Capacity: 20 MW with 800 kW Turbines				
Initial Investment				
	ESPH investment	$ 17,070,000		
	15 Year Loan	$ 39,830,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 56,000,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 3,397,044		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	84,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 39,830,000			
1		$ 1,294,475	$ 2,102,569	$ 3,397,044
2	$ 37,727,431	$ 1,226,142	$ 2,170,903	$ 3,397,044
3	$ 35,556,528	$ 1,155,587	$ 2,241,457	$ 3,397,044
4	$ 33,315,071	$ 1,082,740	$ 2,314,304	$ 3,397,044
5	$ 31,000,767	$ 1,007,525	$ 2,389,519	$ 3,397,044
6	$ 28,611,248	$ 929,866	$ 2,467,179	$ 3,397,044
7	$ 26,144,069	$ 849,682	$ 2,547,362	$ 3,397,044
8	$ 23,596,707	$ 766,893	$ 2,630,151	$ 3,397,044
9	$ 20,966,556	$ 681,413	$ 2,715,631	$ 3,397,044
10	$ 18,250,925	$ 593,155	$ 2,803,889	$ 3,397,044
11	$ 15,447,036	$ 502,029	$ 2,895,015	$ 3,397,044
12	$ 12,552,021	$ 407,941	$ 2,989,103	$ 3,397,044
13	$ 9,562,917	$ 310,795	$ 3,086,249	$ 3,397,044
14	$ 6,476,668	$ 210,492	$ 3,186,552	$ 3,397,044
15	$ 3,290,115	$ 106,929	$ 3,290,115	$ 3,397,044
Total		$ 11,125,662	$ 39,830,000	$ 50,955,662

Wind Farm Capacity: 20 MW with 800 kW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		8,400,000	8,610,000	8,825,250	9,045,881	9,272,028	9,503,829	9,741,425	9,984,960	10,234,584
Costs										
	O&M	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000
	Labor	840,000	861,000	882,525	904,588	927,203	950,383	974,142	998,496	1,023,458
	Loan Payment	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044
	Rent	168,000	172,200	176,505	180,918	185,441	190,077	194,828	199,699	204,692
Total Cost		5,245,044	5,270,244	5,296,074	5,322,550	5,349,688	5,377,504	5,406,015	5,435,239	5,465,194
Total Cashflow		3,154,956	3,339,756	3,529,176	3,723,331	3,922,341	4,126,325	4,335,410	4,549,721	4,769,390
Discounted Cashflow		2,868,142	2,760,129	2,651,522	2,543,085	2,435,465	2,329,203	2,224,751	2,122,478	2,022,687
ESPH Initial Investment Payback	$ 17,070,000	$ 14,201,858	$ 11,441,729	$ 8,790,207	$ 6,247,122	$ 3,811,657	$ 1,482,454			

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		10,490,449	10,752,710	11,021,528	11,297,066	11,579,493	11,868,980	12,165,705	12,469,847	12,781,593	13,101,133	13,428,662
Costs												
	O&M	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000
	Labor	1,049,045	1,075,271	1,102,153	1,129,707	1,157,949	1,186,898	1,216,570	1,246,985	1,278,159	1,310,113	1,342,866
	Loan Payment	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044					
	Rent	209,809	215,054	220,431	225,941	231,590	237,380	243,314	249,397	255,632	262,023	268,573
Total Cost		5,495,898	5,527,369	5,559,627	5,592,692	5,626,583	5,661,322	2,299,885	2,336,382	2,373,791	2,412,136	2,451,439
Total Cashflow		4,994,551	5,225,341	5,461,900	5,704,374	5,952,910	6,207,658	9,865,820	10,133,466	10,407,802	10,688,997	10,977,222
Discounted Cashflow		1,925,616	1,831,450	1,740,330	1,652,354	1,567,587	1,486,064	2,147,090	2,004,852	1,871,935	1,747,736	1,631,694

Total 20 Year Cashflow	$ 121,070,447
Total 20 Year Discounted Cashflow	$ 41,564,170

Appendix M – Financial Analysis of 900 kW Turbines

M.1 900 kW Turbines on a 10 MW Wind Farm

Wind Farm Capacity: 10 MW with 900 kW Turbines					
Initial Investment					
	ESPH investment	$ 8,586,000			
	15 Year Loan	$ 20,034,000		Interest Rate:	0.0325
Initial Cost					
	Construction				
	Wind Turbine Cost	$ 27,720,000			
	Legal Fees				
	Transmission Line	$ 900,000			
Costs Over Time					
	Operation and Maintenance	0.01	$/kWh		
	Labor Cost	10%	of revenue		
	Loan Payment	$ 1,708,671			
	Rate of Inflation	10%			
	Rent	2%	of revenue		
Revenue					
	Expected Price of Electricity	Varies by Year			
	Estimated Production of Proposed Site	35,000	MWh		
	Expected Rate of Inflation	10%			

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 20,034,000			
1		$ 651,105	$ 1,057,566	$ 1,708,671
2	$ 18,976,434	$ 616,734	$ 1,091,937	$ 1,708,671
3	$ 17,884,496	$ 581,246	$ 1,127,425	$ 1,708,671
4	$ 16,757,071	$ 544,605	$ 1,164,067	$ 1,708,671
5	$ 15,593,004	$ 506,773	$ 1,201,899	$ 1,708,671
6	$ 14,391,106	$ 467,711	$ 1,240,960	$ 1,708,671
7	$ 13,150,145	$ 427,380	$ 1,281,292	$ 1,708,671
8	$ 11,868,853	$ 385,738	$ 1,322,934	$ 1,708,671
9	$ 10,545,920	$ 342,742	$ 1,365,929	$ 1,708,671
10	$ 9,179,991	$ 298,350	$ 1,410,322	$ 1,708,671
11	$ 7,769,669	$ 252,514	$ 1,456,157	$ 1,708,671
12	$ 6,313,512	$ 205,189	$ 1,503,482	$ 1,708,671
13	$ 4,810,030	$ 156,326	$ 1,552,345	$ 1,708,671
14	$ 3,257,684	$ 105,875	$ 1,602,797	$ 1,708,671
15	$ 1,654,888	$ 53,784	$ 1,654,888	$ 1,708,671
Total		$ 5,596,071	$ 20,034,000	$ 25,630,071

Wind Farm Capacity: 10 MW with 900 kW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		3,500,000	3,587,500	3,677,188	3,769,117	3,863,345	3,959,929	4,058,927	4,160,400	4,264,410
Costs										
	O&M	350,000	350,000	350,000	350,000	350,000	350,000	350,000	350,000	350,000
	Labor	350,000	358,750	367,719	376,912	386,335	395,993	405,893	416,040	426,441
	Loan Payment	1,708,671	1,708,671	1,708,671	1,708,671	1,708,671	1,708,671	1,708,671	1,708,671	1,708,671
	Rent	70,000	71,750	73,544	75,382	77,267	79,199	81,179	83,208	85,288
Total Cost		2,478,671	2,489,171	2,499,934	2,510,965	2,522,273	2,533,863	2,545,743	2,557,919	2,570,401
Total Cashflow		1,021,329	1,098,329	1,177,254	1,258,152	1,341,072	1,426,066	1,513,184	1,602,481	1,694,010
Discounted Cashflow		928,481	907,710	884,488	859,335	832,700	804,977	776,503	747,569	718,425
ESPH Initial Investment Payback	$ 8,586,000	$ 7,657,519	$ 6,749,810	$ 5,865,322	$ 5,005,987	$ 4,173,287	$ 3,368,310	$ 2,591,807	$ 1,844,238	$ 1,125,813

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		4,371,020	4,480,296	4,592,303	4,707,111	4,824,789	4,945,408	5,069,044	5,195,770	5,325,664	5,458,806	5,595,276
Costs												
	O&M	350,000	350,000	350,000	350,000	350,000	350,000	350,000	350,000	350,000	350,000	350,000
	Labor	437,102	448,030	459,230	470,711	482,479	494,541	506,904	519,577	532,566	545,881	559,528
	Loan Payment	1,708,671	1,708,671	1,708,671	1,708,671	1,708,671	1,708,671					
	Rent	87,420	89,606	91,846	94,142	96,496	98,908	101,381	103,915	106,513	109,176	111,906
Total Cost		2,583,194	2,596,307	2,609,748	2,623,525	2,637,646	2,652,120	958,285	973,492	989,080	1,005,057	1,021,433
Total Cashflow		1,787,827	1,883,989	1,982,556	2,083,586	2,187,143	2,293,288	4,110,758	4,222,277	4,336,584	4,453,749	4,573,843
Discounted Cashflow		689,285	660,327	631,703	603,541	575,943	548,995	894,621	835,355	779,973	728,224	679,873
ESPH Initial Investment Payback		$ 436,528										

Total 20 Year Cashflow	$ 46,047,474
Total 20 Year Discounted Cashflow	$ 15,088,025

M.2 900 kW Turbines on a 15 MW Wind Farm

Wind Farm Capacity: 15 MW with 900 kW Turbines

Initial Investment				
	ESPH investment	$ 13,122,000		
	15 Year Loan	$ 30,618,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 42,840,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 2,611,366		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	51,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 30,618,000			
1		$ 995,085	$ 1,616,281	$ 2,611,366
2	$ 29,001,719	$ 942,556	$ 1,668,810	$ 2,611,366
3	$ 27,332,909	$ 888,320	$ 1,723,046	$ 2,611,366
4	$ 25,609,863	$ 832,321	$ 1,779,045	$ 2,611,366
5	$ 23,830,818	$ 774,502	$ 1,836,864	$ 2,611,366
6	$ 21,993,954	$ 714,804	$ 1,896,562	$ 2,611,366
7	$ 20,097,392	$ 653,165	$ 1,958,201	$ 2,611,366
8	$ 18,139,191	$ 589,524	$ 2,021,842	$ 2,611,366
9	$ 16,117,349	$ 523,814	$ 2,087,552	$ 2,611,366
10	$ 14,029,797	$ 455,968	$ 2,155,397	$ 2,611,366
11	$ 11,874,400	$ 385,918	$ 2,225,448	$ 2,611,366
12	$ 9,648,952	$ 313,591	$ 2,297,775	$ 2,611,366
13	$ 7,351,177	$ 238,913	$ 2,372,452	$ 2,611,366
14	$ 4,978,725	$ 161,809	$ 2,449,557	$ 2,611,366
15	$ 2,529,168	$ 82,198	$ 2,529,168	$ 2,611,366
Total		$ 8,552,486	$ 30,618,000	$ 39,170,486

Wind Farm Capacity: 15 MW with 900 kW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		51,000	51,000	51,000	51,000	51,000	51,000	51,000	51,000	51,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		5,100,000	5,227,500	5,358,188	5,492,142	5,629,446	5,770,182	5,914,436	6,062,297	6,213,855
Costs										
	O&M	510,000	510,000	510,000	510,000	510,000	510,000	510,000	510,000	510,000
	Labor	510,000	522,750	535,819	549,214	562,945	577,018	591,444	606,230	621,385
	Loan Payment	2,611,366	2,611,366	2,611,366	2,611,366	2,611,366	2,611,366	2,611,366	2,611,366	2,611,366
	Rent	102,000	104,550	107,164	109,843	112,589	115,404	118,289	121,246	124,277
Total Cost		3,733,366	3,748,666	3,764,348	3,780,423	3,796,899	3,813,788	3,831,098	3,848,841	3,867,028
Total Cashflow		1,366,634	1,478,834	1,593,839	1,711,719	1,832,547	1,956,394	2,083,338	2,213,456	2,346,826
Discounted Cashflow		1,242,395	1,222,177	1,197,475	1,169,127	1,137,867	1,104,334	1,069,082	1,032,594	995,284
ESPH Initial Investment Payback	$ 13,122,000	$ 11,879,605	$ 10,657,428	$ 9,459,953	$ 8,290,826	$ 7,152,959	$ 6,048,625	$ 4,979,543	$ 3,946,949	$ 2,951,666

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		51,000	51,000	51,000	51,000	51,000	51,000	51,000	51,000	51,000	51,000	51,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		6,369,201	6,528,431	6,691,642	6,858,933	7,030,406	7,206,166	7,386,321	7,570,979	7,760,253	7,954,259	8,153,116
Costs												
	O&M	510,000	510,000	510,000	510,000	510,000	510,000	510,000	510,000	510,000	510,000	510,000
	Labor	636,920	652,843	669,164	685,893	703,041	720,617	738,632	757,098	776,025	795,426	815,312
	Loan Payment	2,611,366	2,611,366	2,611,366	2,611,366	2,611,366	2,611,366					
	Rent	127,384	130,569	133,833	137,179	140,608	144,123	147,726	151,420	155,205	159,085	163,062
Total Cost		3,885,670	3,904,777	3,924,363	3,944,438	3,965,014	3,986,106	1,396,358	1,418,517	1,441,230	1,464,511	1,488,374
Total Cashflow		2,483,531	2,623,654	2,767,279	2,914,495	3,065,392	3,220,061	5,989,962	6,152,461	6,319,023	6,489,748	6,664,742
Discounted Cashflow		957,509	919,575	881,740	844,225	807,213	770,857	1,303,590	1,217,232	1,136,532	1,061,126	990,671
ESPH Initial Investment Payback		$ 1,994,157	$ 1,074,582	$ 192,842								

Total 20 Year Cashflow	$ 65,273,937
Total 20 Year Discounted Cashflow	$ 21,060,605

M.3 900 kW Turbines on a 20 MW Wind Farm

Wind Farm Capacity: 20 MW with 900 kW Turbines				
Initial Investment				
	ESPH investment	$ 16,902,000		
	15 Year Loan	$ 39,438,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 55,440,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 3,363,611		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	65,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 39,438,000			
1		$ 1,281,735	$ 2,081,876	$ 3,363,611
2	$ 37,356,124	$ 1,214,074	$ 2,149,537	$ 3,363,611
3	$ 35,206,587	$ 1,144,214	$ 2,219,397	$ 3,363,611
4	$ 32,987,190	$ 1,072,084	$ 2,291,527	$ 3,363,611
5	$ 30,695,663	$ 997,609	$ 2,366,002	$ 3,363,611
6	$ 28,329,661	$ 920,714	$ 2,442,897	$ 3,363,611
7	$ 25,886,764	$ 841,320	$ 2,522,291	$ 3,363,611
8	$ 23,364,473	$ 759,345	$ 2,604,266	$ 3,363,611
9	$ 20,760,207	$ 674,707	$ 2,688,904	$ 3,363,611
10	$ 18,071,303	$ 587,317	$ 2,776,294	$ 3,363,611
11	$ 15,295,009	$ 497,088	$ 2,866,523	$ 3,363,611
12	$ 12,428,486	$ 403,926	$ 2,959,685	$ 3,363,611
13	$ 9,468,801	$ 307,736	$ 3,055,875	$ 3,363,611
14	$ 6,412,926	$ 208,420	$ 3,155,191	$ 3,363,611
15	$ 3,257,735	$ 105,876	$ 3,257,735	$ 3,363,611
Total		$ 11,016,165	$ 39,438,000	$ 50,454,165

Wind Farm Capacity: 20 MW with 900 kW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		6,500,000	6,662,500	6,829,063	6,999,789	7,174,784	7,354,153	7,538,007	7,726,457	7,919,619
Costs										
	O&M	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000
	Labor	650,000	666,250	682,906	699,979	717,478	735,415	753,801	772,646	791,962
	Loan Payment	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611
	Rent	130,000	133,250	136,581	139,996	143,496	147,083	150,760	154,529	158,392
Total Cost		4,793,611	4,813,111	4,833,099	4,853,586	4,874,585	4,896,109	4,918,172	4,940,786	4,963,965
Total Cashflow		1,706,389	1,849,389	1,995,964	2,146,203	2,300,199	2,458,044	2,619,835	2,785,672	2,955,654
Discounted Cashflow		1,551,263	1,528,421	1,499,597	1,465,886	1,428,242	1,387,502	1,344,390	1,299,536	1,253,486

ESPH Initial Investment Payback	$ 16,902,000	$ 15,350,737	$ 13,822,317	$ 12,322,719	$ 10,856,834	$ 9,428,591	$ 8,041,089	$ 6,696,700	$ 5,397,163	$ 4,143,678

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		8,117,609	8,320,550	8,528,563	8,741,777	8,960,322	9,184,330	9,413,938	9,649,287	9,890,519	10,137,782	10,391,226
Costs												
	O&M	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000
	Labor	811,761	832,055	852,856	874,178	896,032	918,433	941,394	964,929	989,052	1,013,778	1,039,123
	Loan Payment	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611					
	Rent	162,352	166,411	170,571	174,836	179,206	183,687	188,279	192,986	197,810	202,756	207,825
Total Cost		4,987,724	5,012,077	5,037,039	5,062,624	5,088,850	5,115,731	1,779,673	1,807,914	1,836,862	1,866,534	1,896,947
Total Cashflow		3,129,885	3,308,473	3,491,525	3,679,153	3,871,472	4,068,599	7,634,266	7,841,372	8,053,656	8,271,248	8,494,279
Discounted Cashflow		1,206,706	1,159,599	1,112,507	1,065,720	1,019,480	973,990	1,661,439	1,551,374	1,448,521	1,352,415	1,262,620
ESPH Initial Investment Payback		$ 2,936,971	$ 1,777,372	$ 664,865								

Total 20 Year Cashflow	$ 82,661,276
Total 20 Year Discounted Cashflow	$ 26,572,694

Appendix N - Financial Analysis of 1.5 MW Turbines

N.1 1.5 MW Turbines on a 10 MW Wind Farm

Wind Farm Capacity: 10 MW with 1.5 MW Turbines					
Initial Investment					
	ESPH investment	$ 9,090,000			
	15 Year Loan	$ 21,210,000	Interest Rate:	0.0325	
Initial Cost					
	Construction				
	Wind Turbine Cost	$ 29,400,000			
	Legal Fees				
	Transmission Line	$ 900,000			
Costs Over Time					
	Operation and Maintenance	0.01	$/kWh		
	Labor Cost	10%	of revenue		
	Loan Payment	$ 1,808,971			
	Rate of Inflation	10%			
	Rent	2%	of revenue		
Revenue					
	Expected Price of Electricity	Varies by Year			
	Estimated Production of Proposed Site	57,000	MWh		
	Expected Rate of Inflation	10%			

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 21,210,000			
1		$ 689,325	$ 1,119,646	$ 1,808,971
2	$ 20,090,354	$ 652,937	$ 1,156,034	$ 1,808,971
3	$ 18,934,320	$ 615,365	$ 1,193,605	$ 1,808,971
4	$ 17,740,715	$ 576,573	$ 1,232,398	$ 1,808,971
5	$ 16,508,317	$ 536,520	$ 1,272,450	$ 1,808,971
6	$ 15,235,867	$ 495,166	$ 1,313,805	$ 1,808,971
7	$ 13,922,061	$ 452,467	$ 1,356,504	$ 1,808,971
8	$ 12,565,558	$ 408,381	$ 1,400,590	$ 1,808,971
9	$ 11,164,968	$ 362,861	$ 1,446,109	$ 1,808,971
10	$ 9,718,858	$ 315,863	$ 1,493,108	$ 1,808,971
11	$ 8,225,750	$ 267,337	$ 1,541,634	$ 1,808,971
12	$ 6,684,116	$ 217,234	$ 1,591,737	$ 1,808,971
13	$ 5,092,379	$ 165,502	$ 1,643,468	$ 1,808,971
14	$ 3,448,911	$ 112,090	$ 1,696,881	$ 1,808,971
15	$ 1,752,030	$ 56,941	$ 1,752,030	$ 1,808,971
Total		$ 27,134,562	$ 21,210,000	$ 27,134,562

Wind Farm Capacity: 10 MW with 1.5 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		5,700,000	5,842,500	5,988,563	6,138,277	6,291,733	6,449,027	6,610,252	6,775,509	6,944,897
Costs										
	O&M	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000
	Labor	570,000	584,250	598,856	613,828	629,173	644,903	661,025	677,551	694,490
	Loan Payment	1,808,971	1,808,971	1,808,971	1,808,971	1,808,971	1,808,971	1,808,971	1,808,971	1,808,971
	Rent	114,000	116,850	119,771	122,766	125,835	128,981	132,205	135,510	138,898
Total Cost		3,062,971	3,080,071	3,097,598	3,115,564	3,133,979	3,152,854	3,172,201	3,192,032	3,212,358
Total Cashflow		2,637,029	2,762,429	2,890,964	3,022,713	3,157,755	3,296,173	3,438,051	3,583,477	3,732,538
Discounted Cashflow		2,397,299	2,282,999	2,172,024	2,064,553	1,960,717	1,860,604	1,764,264	1,671,718	1,582,961

ESPH Initial Investment Payback	$ 9,090,000	$ 6,692,701	$ 4,409,701	$ 2,237,677	$ 173,124

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		7,118,519	7,296,482	7,478,894	7,665,866	7,857,513	8,053,951	8,255,300	8,461,682	8,673,224	8,890,055	9,112,306
Costs												
	O&M	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000
	Labor	711,852	729,648	747,889	766,587	785,751	805,395	825,530	846,168	867,322	889,005	911,231
	Loan Payment	1,808,971	1,808,971	1,808,971	1,808,971	1,808,971	1,808,971					
	Rent	142,370	145,930	149,578	153,317	157,150	161,079	165,106	169,234	173,464	177,801	182,246
Total Cost		3,233,193	3,254,549	3,276,438	3,298,875	3,321,872	3,345,445	1,560,636	1,585,402	1,610,787	1,636,807	1,663,477
Total Cashflow		3,885,326	4,041,933	4,202,456	4,366,992	4,535,641	4,708,506	6,694,664	6,876,280	7,062,437	7,253,248	7,448,829
Discounted Cashflow		1,497,961	1,416,673	1,339,032	1,264,962	1,194,376	1,127,179	1,456,954	1,360,435	1,270,241	1,185,964	1,107,221

Total 20 Year Cashflow	$ 89,597,441
Total 20 Year Discounted Cashflow	$ 31,978,139

N.2 1.5 MW Turbines on a 15 MW Wind Farm

Wind Farm Capacity: 15 MW with 1.5 MW Turbines				
Initial Investment				
	ESPH investment	$ 12,870,000		
	15 Year Loan	$ 30,030,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 42,000,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 2,561,216		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	80,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 30,030,000			
1		$ 975,975	$ 1,585,241	$ 2,561,216
2	$ 28,444,759	$ 924,455	$ 1,636,761	$ 2,561,216
3	$ 26,807,998	$ 871,260	$ 1,689,956	$ 2,561,216
4	$ 25,118,041	$ 816,336	$ 1,744,880	$ 2,561,216
5	$ 23,373,162	$ 759,628	$ 1,801,588	$ 2,561,216
6	$ 21,571,573	$ 701,076	$ 1,860,140	$ 2,561,216
7	$ 19,711,434	$ 640,622	$ 1,920,594	$ 2,561,216
8	$ 17,790,839	$ 578,202	$ 1,983,014	$ 2,561,216
9	$ 15,807,825	$ 513,754	$ 2,047,462	$ 2,561,216
10	$ 13,760,364	$ 447,212	$ 2,114,004	$ 2,561,216
11	$ 11,646,359	$ 378,507	$ 2,182,709	$ 2,561,216
12	$ 9,463,650	$ 307,569	$ 2,253,647	$ 2,561,216
13	$ 7,210,003	$ 234,325	$ 2,326,891	$ 2,561,216
14	$ 4,883,112	$ 158,701	$ 2,402,515	$ 2,561,216
15	$ 2,480,597	$ 80,619	$ 2,480,597	$ 2,561,216
Total		$ 8,388,241	$ 30,030,000	$ 38,418,241

Wind Farm Capacity: 15 MW with 1.5 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		8,000,000	8,200,000	8,405,000	8,615,125	8,830,503	9,051,266	9,277,547	9,509,486	9,747,223
Costs										
	O&M	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
	Labor	800,000	820,000	840,500	861,513	883,050	905,127	927,755	950,949	974,722
	Loan Payment	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216
	Rent	160,000	164,000	168,100	172,303	176,610	181,025	185,551	190,190	194,944
Total Cost		4,321,216	4,345,216	4,369,816	4,395,031	4,420,876	4,447,368	4,474,522	4,502,354	4,530,883
Total Cashflow		3,678,784	3,854,784	4,035,184	4,220,094	4,409,627	4,603,898	4,803,026	5,007,132	5,216,340
Discounted Cashflow		3,344,349	3,185,772	3,031,693	2,882,381	2,738,031	2,598,780	2,464,712	2,335,864	2,212,238

ESPH Initial Investment Payback					
	$ 12,870,000	$ 9,525,651	$ 6,339,879	$ 3,308,186	$ 425,805

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		9,990,904	10,240,676	10,496,693	10,759,111	11,028,088	11,303,791	11,586,385	11,876,045	12,172,946	12,477,270	12,789,201
Costs												
	O&M	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
	Labor	999,090	1,024,068	1,049,669	1,075,911	1,102,809	1,130,379	1,158,639	1,187,604	1,217,295	1,247,727	1,278,920
	Loan Payment	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216					
	Rent	199,818	204,814	209,934	215,182	220,562	226,076	231,728	237,521	243,459	249,545	255,784
Total Cost		4,560,124	4,590,097	4,620,819	4,652,309	4,684,587	4,717,671	2,190,366	2,225,125	2,260,754	2,297,272	2,334,704
Total Cashflow		5,430,779	5,650,579	5,875,874	6,106,801	6,343,502	6,586,120	9,396,019	9,650,920	9,912,193	10,179,997	10,454,497
Discounted Cashflow		2,093,801	1,980,494	1,872,235	1,768,923	1,670,442	1,576,665	2,044,848	1,909,383	1,782,795	1,664,511	1,553,994

Total 20 Year Cashflow	$ 125,416,149
Total 20 Year Discounted Cashflow	$ 44,711,909

N.3 1.5 MW Turbines on a 20 MW Wind Farm

Wind Farm Capacity: 20 MW with 1.5 MW Turbines				
Initial Investment				
	ESPH investment	$ 16,650,000		
	15 Year Loan	$ 38,850,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 54,600,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 3,313,461		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	102,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 38,850,000			
1		$ 1,262,625	$ 2,050,836	$ 3,313,461
2	$ 36,799,164	$ 1,195,973	$ 2,117,489	$ 3,313,461
3	$ 34,681,675	$ 1,127,154	$ 2,186,307	$ 3,313,461
4	$ 32,495,368	$ 1,056,099	$ 2,257,362	$ 3,313,461
5	$ 30,238,006	$ 982,735	$ 2,330,726	$ 3,313,461
6	$ 27,907,280	$ 906,987	$ 2,406,475	$ 3,313,461
7	$ 25,500,806	$ 828,776	$ 2,484,685	$ 3,313,461
8	$ 23,016,120	$ 748,024	$ 2,565,437	$ 3,313,461
9	$ 20,450,683	$ 664,647	$ 2,648,814	$ 3,313,461
10	$ 17,801,869	$ 578,561	$ 2,734,901	$ 3,313,461
11	$ 15,066,968	$ 489,676	$ 2,823,785	$ 3,313,461
12	$ 12,243,184	$ 397,903	$ 2,915,558	$ 3,313,461
13	$ 9,327,626	$ 303,148	$ 3,010,313	$ 3,313,461
14	$ 6,317,312	$ 205,313	$ 3,108,149	$ 3,313,461
15	$ 3,209,164	$ 104,298	$ 3,209,164	$ 3,313,461
Total		$ 10,851,920	$ 38,850,000	$ 49,701,920

Wind Farm Capacity: 20 MW with 1.5 MW Turbines
Cost Analysis and Payback Period

Year	1	2	3	4	5	6	7	8	9
Production (MWh)	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000
Revenue									
Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue	10,200,000	10,455,000	10,716,375	10,984,284	11,258,891	11,540,364	11,828,873	12,124,595	12,427,710
Costs									
O&M	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000
Labor	1,020,000	1,045,500	1,071,638	1,098,428	1,125,889	1,154,036	1,182,887	1,212,459	1,242,771
Loan Payment	3,313,461	3,313,461	3,313,461	3,313,461	3,313,461	3,313,461	3,313,461	3,313,461	3,313,461
Rent	204,000	209,100	214,328	219,686	225,178	230,807	236,577	242,492	248,554
Total Cost	5,557,461	5,588,061	5,619,426	5,651,575	5,684,528	5,718,305	5,752,926	5,788,413	5,824,786
Total Cashflow	4,642,539	4,866,939	5,096,949	5,332,709	5,574,363	5,822,059	6,075,947	6,336,182	6,602,923
Discounted Cashflow	4,220,490	4,022,263	3,829,413	3,642,312	3,461,241	3,286,400	3,117,921	2,955,876	2,800,284

ESPH Initial Investment Payback					
	$ 16,650,000	$ 12,429,510	$ 8,407,247	$ 4,577,834	$ 935,522

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		12,738,402	13,056,862	13,383,284	13,717,866	14,060,813	14,412,333	14,772,641	15,141,957	15,520,506	15,908,519	16,306,232
Costs												
	O&M	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000
	Labor	1,273,840	1,305,686	1,338,328	1,371,787	1,406,081	1,441,233	1,477,264	1,514,196	1,552,051	1,590,852	1,630,623
	Loan Payment	3,313,461	3,313,461	3,313,461	3,313,461	3,313,461	3,313,461					
	Rent	254,768	261,137	267,666	274,357	281,216	288,247	295,453	302,839	310,410	318,170	326,125
Total Cost		5,862,070	5,900,285	5,939,455	5,979,605	6,020,759	6,062,941	2,792,717	2,837,035	2,882,461	2,929,022	2,976,748
Total Cashflow		6,876,333	7,156,578	7,443,829	7,738,261	8,040,054	8,349,392	11,979,924	12,304,922	12,638,046	12,979,497	13,329,484
Discounted Cashflow		2,651,124	2,508,337	2,371,833	2,241,499	2,117,197	1,998,778	2,607,181	2,434,463	2,273,064	2,122,251	1,981,343

Total 20 Year Cashflow	$ 159,186,927
Total 20 Year Discounted Cashflow	$ 56,643,270

Appendix O - Financial Analysis of 1.8 MW Turbines

O.1 1.8 MW Turbines on a 10 MW Wind Farm

Wind Farm Capacity: 10 MW with 1.8 MW Turbines					
Initial Investment					
	ESPH investment	$ 9,342,000			
	15 Year Loan	$ 21,798,000		Interest Rate:	0.0325
Initial Cost					
	Construction				
	Wind Turbine Cost	$ 30,240,000			
	Legal Fees				
	Transmission Line	$ 900,000			
Costs Over Time					
	Operation and Maintenance	0.01	$/kWh		
	Labor Cost	10%	of revenue		
	Loan Payment	$ 1,859,120			
	Rate of Inflation	10%			
	Rent	2%	of revenue		
Revenue					
	Expected Price of Electricity	Varies by Year			
	Estimated Production of Proposed Site	55,000	MWh		
	Expected Rate of Inflation	10%			

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 21,798,000			
1		$ 708,435	$ 1,150,685	$ 1,859,120
2	$ 20,647,315	$ 671,038	$ 1,188,083	$ 1,859,120
3	$ 19,459,232	$ 632,425	$ 1,226,695	$ 1,859,120
4	$ 18,232,536	$ 592,557	$ 1,266,563	$ 1,859,120
5	$ 16,965,973	$ 551,394	$ 1,307,726	$ 1,859,120
6	$ 15,658,247	$ 508,893	$ 1,350,227	$ 1,859,120
7	$ 14,308,020	$ 465,011	$ 1,394,110	$ 1,859,120
8	$ 12,913,910	$ 419,702	$ 1,439,418	$ 1,859,120
9	$ 11,474,491	$ 372,921	$ 1,486,199	$ 1,859,120
10	$ 9,988,292	$ 324,619	$ 1,534,501	$ 1,859,120
11	$ 8,453,791	$ 274,748	$ 1,584,372	$ 1,859,120
12	$ 6,869,419	$ 223,256	$ 1,635,864	$ 1,859,120
13	$ 5,233,554	$ 170,091	$ 1,689,030	$ 1,859,120
14	$ 3,544,524	$ 115,197	$ 1,743,923	$ 1,859,120
15	$ 1,800,601	$ 58,520	$ 1,800,601	$ 1,859,120
Total		$ 6,088,807	$ 21,798,000	$ 27,886,807

Wind Farm Capacity: 10 MW with 1.8 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		5,500,000	5,637,500	5,778,438	5,922,898	6,070,971	6,222,745	6,378,314	6,537,772	6,701,216
Costs										
	O&M	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000
	Labor	550,000	563,750	577,844	592,290	607,097	622,275	637,831	653,777	670,122
	Loan Payment	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120
	Rent	110,000	112,750	115,569	118,458	121,419	124,455	127,566	130,755	134,024
Total Cost		3,069,120	3,085,620	3,102,533	3,119,868	3,137,637	3,155,850	3,174,518	3,193,653	3,213,266
Total Cashflow		2,430,880	2,551,880	2,675,905	2,803,030	2,933,334	3,066,895	3,203,796	3,344,119	3,487,950
Discounted Cashflow		2,209,890	2,108,991	2,010,447	1,914,507	1,821,370	1,731,182	1,644,054	1,560,056	1,479,231

ESPH Initial Investment Payback	$ 9,342,000	$ 7,132,110	$ 5,023,118	$ 3,012,671	$ 1,098,164

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		6,868,746	7,040,465	7,216,477	7,396,889	7,581,811	7,771,356	7,965,640	8,164,781	8,368,900	8,578,123	8,792,576
Costs												
	O&M	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000
	Labor	686,875	704,046	721,648	739,689	758,181	777,136	796,564	816,478	836,890	857,812	879,258
	Loan Payment	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120					
	Rent	137,375	140,809	144,330	147,938	151,636	155,427	159,313	163,296	167,378	171,562	175,852
Total Cost		3,233,370	3,253,976	3,275,098	3,296,747	3,318,938	3,341,683	1,505,877	1,529,774	1,554,268	1,579,375	1,605,109
Total Cashflow		3,635,376	3,786,489	3,941,379	4,100,141	4,262,873	4,429,673	6,459,763	6,635,007	6,814,632	6,998,748	7,187,467
Discounted Cashflow		1,401,595	1,327,141	1,255,845	1,187,665	1,122,548	1,060,428	1,405,833	1,312,701	1,225,672	1,144,351	1,068,371

Total 20 Year Cashflow	$ 84,749,336
Total 20 Year Discounted Cashflow	$ 29,991,878

O.2 1.8 MW Turbines on a 15 MW Wind Farm

Wind Farm Capacity: 15 MW with 1.8 MW Turbines				
Initial Investment				
	ESPH investment	$ 12,366,000		
	15 Year Loan	$ 28,854,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 40,320,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 2,460,917		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	73,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 28,854,000			
1		$ 937,755	$ 1,523,162	$ 2,460,917
2	$ 27,330,838	$ 888,252	$ 1,572,664	$ 2,460,917
3	$ 25,758,174	$ 837,141	$ 1,623,776	$ 2,460,917
4	$ 24,134,398	$ 784,368	$ 1,676,549	$ 2,460,917
5	$ 22,457,849	$ 729,880	$ 1,731,037	$ 2,460,917
6	$ 20,726,813	$ 673,621	$ 1,787,295	$ 2,460,917
7	$ 18,939,517	$ 615,534	$ 1,845,382	$ 2,460,917
8	$ 17,094,135	$ 555,559	$ 1,905,357	$ 2,460,917
9	$ 15,188,778	$ 493,635	$ 1,967,281	$ 2,460,917
10	$ 13,221,496	$ 429,699	$ 2,031,218	$ 2,460,917
11	$ 11,190,278	$ 363,684	$ 2,097,233	$ 2,460,917
12	$ 9,093,045	$ 295,524	$ 2,165,393	$ 2,460,917
13	$ 6,927,653	$ 225,149	$ 2,235,768	$ 2,460,917
14	$ 4,691,885	$ 152,486	$ 2,308,430	$ 2,460,917
15	$ 2,383,454	$ 77,462	$ 2,383,454	$ 2,460,917
Total		$ 8,059,750	$ 28,854,000	$ 36,913,750

Wind Farm Capacity: 15 MW with 1.8 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		7,300,000	7,482,500	7,669,563	7,861,302	8,057,834	8,259,280	8,465,762	8,677,406	8,894,341
Costs										
	O&M	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000
	Labor	730,000	748,250	766,956	786,130	805,783	825,928	846,576	867,741	889,434
	Loan Payment	2,460,917	2,460,917	2,460,917	2,460,917	2,460,917	2,460,917	2,460,917	2,460,917	2,460,917
	Rent	146,000	149,650	153,391	157,226	161,157	165,186	169,315	173,548	177,887
Total Cost		4,066,917	4,088,817	4,111,264	4,134,273	4,157,857	4,182,030	4,206,808	4,232,205	4,258,238
Total Cashflow		3,233,083	3,393,683	3,558,298	3,727,029	3,899,977	4,077,250	4,258,954	4,445,201	4,636,104
Discounted Cashflow		2,939,167	2,804,697	2,673,402	2,545,611	2,421,579	2,301,501	2,185,517	2,073,719	1,966,160
ESPH Initial Investment Payback	$ 12,366,000	$ 9,426,833	$ 6,622,136	$ 3,948,734	$ 1,403,123					

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		9,116,700	9,344,617	9,578,233	9,817,688	10,063,131	10,314,709	10,572,577	10,836,891	11,107,813	11,385,509	11,670,146
Costs												
	O&M	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000
	Labor	911,670	934,462	957,823	981,769	1,006,313	1,031,471	1,057,258	1,083,689	1,110,781	1,138,551	1,167,015
	Loan Payment	2,460,917	2,460,917	2,460,917	2,460,917	2,460,917	2,460,917					
	Rent	182,334	186,892	191,565	196,354	201,263	206,294	211,452	216,738	222,156	227,710	233,403
Total Cost		4,284,921	4,312,271	4,340,305	4,369,039	4,398,492	4,428,682	1,998,709	2,030,427	2,062,938	2,096,261	2,130,418
Total Cashflow		4,831,779	5,032,346	5,237,928	5,448,649	5,664,638	5,886,027	8,573,867	8,806,464	9,044,876	9,289,248	9,539,729
Discounted Cashflow		1,862,860	1,763,807	1,668,965	1,578,280	1,491,676	1,409,068	1,865,923	1,742,312	1,626,800	1,518,866	1,418,020

Total 20 Year Cashflow	$ 112,585,130
Total 20 Year Discounted Cashflow	$ 39,857,931

O.3 1.8 MW Turbines on a 20 MW Wind Farm

Wind Farm Capacity: 20 MW with 1.8 MW Turbines					
Initial Investment					
	ESPH investment	$ 16,902,000			
	15 Year Loan	$ 39,438,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 55,440,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 3,363,611		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	98,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 39,438,000			
1		$ 1,281,735	$ 2,081,876	$ 3,363,611
2	$ 37,356,124	$ 1,214,074	$ 2,149,537	$ 3,363,611
3	$ 35,206,587	$ 1,144,214	$ 2,219,397	$ 3,363,611
4	$ 32,987,190	$ 1,072,084	$ 2,291,527	$ 3,363,611
5	$ 30,695,663	$ 997,609	$ 2,366,002	$ 3,363,611
6	$ 28,329,661	$ 920,714	$ 2,442,897	$ 3,363,611
7	$ 25,886,764	$ 841,320	$ 2,522,291	$ 3,363,611
8	$ 23,364,473	$ 759,345	$ 2,604,266	$ 3,363,611
9	$ 20,760,207	$ 674,707	$ 2,688,904	$ 3,363,611
10	$ 18,071,303	$ 587,317	$ 2,776,294	$ 3,363,611
11	$ 15,295,009	$ 497,088	$ 2,866,523	$ 3,363,611
12	$ 12,428,486	$ 403,926	$ 2,959,685	$ 3,363,611
13	$ 9,468,801	$ 307,736	$ 3,055,875	$ 3,363,611
14	$ 6,412,926	$ 208,420	$ 3,155,191	$ 3,363,611
15	$ 3,257,735	$ 105,876	$ 3,257,735	$ 3,363,611
Total		$ 11,016,165	$ 39,438,000	$ 50,454,165

Wind Farm Capacity: 20 MW with 1.8 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		98,399	98,399	98,399	98,399	98,399	98,399	98,399	98,399	98,399
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		9,839,900	10,085,898	10,338,045	10,596,496	10,861,408	11,132,944	11,411,267	11,696,549	11,988,963
Costs										
	O&M	983,990	983,990	983,990	983,990	983,990	983,990	983,990	983,990	983,990
	Labor	983,990	1,008,590	1,033,804	1,059,650	1,086,141	1,113,294	1,141,127	1,169,655	1,198,896
	Loan Payment	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611
	Rent	196,798	201,718	206,761	211,930	217,228	222,659	228,225	233,931	239,779
Total Cost		5,528,389	5,557,909	5,588,166	5,619,181	5,650,970	5,683,554	5,716,953	5,751,187	5,786,277
Total Cashflow		4,311,511	4,527,989	4,749,879	4,977,316	5,210,438	5,449,389	5,694,314	5,945,362	6,202,686
Discounted Cashflow		3,919,555	3,742,139	3,568,654	3,399,573	3,235,272	3,076,038	2,922,084	2,773,555	2,630,544

ESPH Initial Investment Payback					
	$ 16,902,000	$ 12,982,445	$ 9,240,305	$ 5,671,651	$ 2,272,078

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		98,399	98,399	98,399	98,399	98,399	98,399	98,399	98,399	98,399	98,399	98,399
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		12,288,687	12,595,904	12,910,802	13,233,572	13,564,411	13,903,521	14,251,109	14,607,387	14,972,572	15,346,886	15,730,558
Costs												
	O&M	983,990	983,990	983,990	983,990	983,990	983,990	983,990	983,990	983,990	983,990	983,990
	Labor	1,228,869	1,259,590	1,291,080	1,323,357	1,356,441	1,390,352	1,425,111	1,460,739	1,497,257	1,534,689	1,573,056
	Loan Payment	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611	3,363,611					
	Rent	245,774	251,918	258,216	264,671	271,288	278,070	285,022	292,148	299,451	306,938	314,611
Total Cost		5,822,243	5,859,109	5,896,897	5,935,630	5,975,330	6,016,024	2,694,123	2,736,876	2,780,699	2,825,616	2,871,657
Total Cashflow		6,466,443	6,736,794	7,013,904	7,297,942	7,589,081	7,887,498	11,556,986	11,870,510	12,191,873	12,521,270	12,858,901
Discounted Cashflow		2,493,094	2,361,205	2,234,846	2,113,954	1,998,442	1,888,204	2,515,137	2,348,517	2,192,816	2,047,328	1,911,394

Total 20 Year Cashflow	$ 151,060,086
Total 20 Year Discounted Cashflow	$ 53,372,353

Appendix P - Financial Analysis of 2.0 MW Turbines

P.1 2.0 MW Turbines on a 10 MW Wind Farm

Wind Farm Capacity: 10 MW with 2.0 MW Turbines				
Initial Investment				
	ESPH investment	$ 8,670,000		
	15 Year Loan	$ 20,230,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 28,000,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 1,725,388		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	45,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 20,230,000			
1		$ 657,475	$ 1,067,913	$ 1,725,388
2	$ 19,162,087	$ 622,768	$ 1,102,620	$ 1,725,388
3	$ 18,059,467	$ 586,933	$ 1,138,455	$ 1,725,388
4	$ 16,921,012	$ 549,933	$ 1,175,455	$ 1,725,388
5	$ 15,745,557	$ 511,731	$ 1,213,657	$ 1,725,388
6	$ 14,531,899	$ 472,287	$ 1,253,101	$ 1,725,388
7	$ 13,278,798	$ 431,561	$ 1,293,827	$ 1,725,388
8	$ 11,984,971	$ 389,512	$ 1,335,876	$ 1,725,388
9	$ 10,649,094	$ 346,096	$ 1,379,292	$ 1,725,388
10	$ 9,269,802	$ 301,269	$ 1,424,119	$ 1,725,388
11	$ 7,845,683	$ 254,985	$ 1,470,403	$ 1,725,388
12	$ 6,375,279	$ 207,197	$ 1,518,191	$ 1,725,388
13	$ 4,857,088	$ 157,855	$ 1,567,533	$ 1,725,388
14	$ 3,289,555	$ 106,911	$ 1,618,477	$ 1,725,388
15	$ 1,671,078	$ 54,310	$ 1,671,078	$ 1,725,388
Total		$ 5,650,820	$ 20,230,000	$ 25,880,820

Wind Farm Capacity: 10 MW with 2.0 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		4,500,000	4,612,500	4,727,813	4,846,008	4,967,158	5,091,337	5,218,620	5,349,086	5,482,813
Costs										
	O&M	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000
	Labor	450,000	461,250	472,781	484,601	496,716	509,134	521,862	534,909	548,281
	Loan Payment	1,725,388	1,725,388	1,725,388	1,725,388	1,725,388	1,725,388	1,725,388	1,725,388	1,725,388
	Rent	90,000	92,250	94,556	96,920	99,343	101,827	104,372	106,982	109,656
Total Cost		2,715,388	2,728,888	2,742,725	2,756,909	2,771,447	2,786,348	2,801,622	2,817,278	2,833,326
Total Cashflow		1,784,612	1,883,612	1,985,087	2,089,099	2,195,711	2,304,989	2,416,998	2,531,808	2,649,488
Discounted Cashflow		1,622,375	1,556,704	1,491,425	1,426,883	1,363,364	1,301,106	1,240,302	1,181,107	1,123,641
ESPH Initial Investment Payback	$ 8,670,000	$ 7,047,625	$ 5,490,921	$ 3,999,496	$ 2,572,613	$ 1,209,250				

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		5,619,883	5,760,380	5,904,390	6,052,000	6,203,300	6,358,382	6,517,342	6,680,275	6,847,282	7,018,464	7,193,926
Costs												
	O&M	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000
	Labor	561,988	576,038	590,439	605,200	620,330	635,838	651,734	668,028	684,728	701,846	719,393
	Loan Payment	1,725,388	1,725,388	1,725,388	1,725,388	1,725,388	1,725,388					
	Rent	112,398	115,208	118,088	121,040	124,066	127,168	130,347	133,606	136,946	140,369	143,879
Total Cost		2,849,774	2,866,634	2,883,915	2,901,628	2,919,784	2,938,394	1,232,081	1,251,633	1,271,674	1,292,216	1,313,271
Total Cashflow		2,770,109	2,893,747	3,020,475	3,150,372	3,283,516	3,419,988	5,285,261	5,428,642	5,575,608	5,726,249	5,880,655
Discounted Cashflow		1,067,997	1,014,241	962,416	912,550	864,652	818,718	1,150,227	1,074,028	1,002,822	936,287	874,122

Total 20 Year Cashflow	$ 66,276,025
Total 20 Year Discounted Cashflow	$ 22,984,968

P.2 2.0 MW Turbines on a 15 MW Wind Farm

Wind Farm Capacity: 15 MW with 2.0 MW Turbines					
Initial Investment					
	ESPH investment	$ 13,710,000			
	15 Year Loan	$ 31,990,000	Interest Rate:	0.0325	
Initial Cost					
	Construction				
	Wind Turbine Cost	$ 44,800,000			
	Legal Fees				
	Transmission Line	$ 900,000			
Costs Over Time					
	Operation and Maintenance	0.01	$/kWh		
	Labor Cost	10%	of revenue		
	Loan Payment	$ 2,728,382			
	Rate of Inflation	10%			
	Rent	2%	of revenue		
Revenue					
	Expected Price of Electricity	Varies by Year			
	Estimated Production of Proposed Site	69,000	MWh		
	Expected Rate of Inflation	10%			

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 31,990,000			
1		$ 1,039,675	$ 1,688,707	$ 2,728,382
2	$ 30,301,293	$ 984,792	$ 1,743,590	$ 2,728,382
3	$ 28,557,704	$ 928,125	$ 1,800,256	$ 2,728,382
4	$ 26,757,447	$ 869,617	$ 1,858,765	$ 2,728,382
5	$ 24,898,683	$ 809,207	$ 1,919,174	$ 2,728,382
6	$ 22,979,508	$ 746,834	$ 1,981,548	$ 2,728,382
7	$ 20,997,961	$ 682,434	$ 2,045,948	$ 2,728,382
8	$ 18,952,013	$ 615,940	$ 2,112,441	$ 2,728,382
9	$ 16,839,571	$ 547,286	$ 2,181,096	$ 2,728,382
10	$ 14,658,476	$ 476,400	$ 2,251,981	$ 2,728,382
11	$ 12,406,495	$ 403,211	$ 2,325,171	$ 2,728,382
12	$ 10,081,324	$ 327,643	$ 2,400,739	$ 2,728,382
13	$ 7,680,585	$ 249,619	$ 2,478,763	$ 2,728,382
14	$ 5,201,823	$ 169,059	$ 2,559,322	$ 2,728,382
15	$ 2,642,500	$ 85,881	$ 2,642,500	$ 2,728,382
Total		$ 8,935,725	$ 31,990,000	$ 40,925,725

Wind Farm Capacity: 15 MW with 2.0 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		6,900,000	7,072,500	7,249,313	7,430,545	7,616,309	7,806,717	8,001,885	8,201,932	8,406,980
Costs										
	O&M	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000
	Labor	690,000	707,250	724,931	743,055	761,631	780,672	800,188	820,193	840,698
	Loan Payment	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382
	Rent	138,000	141,450	144,986	148,611	152,326	156,134	160,038	164,039	168,140
Total Cost		4,246,382	4,267,082	4,288,299	4,310,047	4,332,339	4,355,188	4,378,608	4,402,613	4,427,219
Total Cashflow		2,653,618	2,805,418	2,961,013	3,120,498	3,283,970	3,451,529	3,623,277	3,799,318	3,979,761
Discounted Cashflow		2,412,380	2,318,528	2,224,653	2,131,342	2,039,087	1,948,298	1,859,314	1,772,410	1,687,807

ESPH Initial Investment Payback	$ 13,710,000	$ 11,297,620	$ 8,979,092	$ 6,754,439	$ 4,623,097	$ 2,584,010	$ 635,711

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		8,617,154	8,832,583	9,053,398	9,279,733	9,511,726	9,749,519	9,993,257	10,243,089	10,499,166	10,761,645	11,030,686
Costs												
	O&M	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000
	Labor	861,715	883,258	905,340	927,973	951,173	974,952	999,326	1,024,309	1,049,917	1,076,165	1,103,069
	Loan Payment	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382					
	Rent	172,343	176,652	181,068	185,595	190,235	194,990	199,865	204,862	209,983	215,233	220,614
Total Cost		4,452,440	4,478,292	4,504,789	4,531,950	4,559,789	4,588,324	1,889,191	1,919,171	1,949,900	1,981,397	2,013,682
Total Cashflow		4,164,714	4,354,292	4,548,609	4,747,783	4,951,937	5,161,195	8,104,066	8,323,918	8,549,266	8,780,248	9,017,004
Discounted Cashflow		1,605,678	1,526,153	1,449,327	1,375,264	1,304,000	1,235,549	1,763,681	1,646,843	1,537,661	1,435,641	1,340,320

Total 20 Year Cashflow	$ 100,381,436
Total 20 Year Discounted Cashflow	$ 34,613,935

P.3 2.0 MW Turbines on a 20 MW Wind Farm

Wind Farm Capacity: 20 MW with 2.0 MW Turbines				
Initial Investment				
	ESPH investment	$ 17,070,000		
	15 Year Loan	$ 39,830,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 56,000,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 3,397,044		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	85,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 39,830,000			
1		$ 1,294,475	$ 2,102,569	$ 3,397,044
2	$ 37,727,431	$ 1,226,142	$ 2,170,903	$ 3,397,044
3	$ 35,556,528	$ 1,155,587	$ 2,241,457	$ 3,397,044
4	$ 33,315,071	$ 1,082,740	$ 2,314,304	$ 3,397,044
5	$ 31,000,767	$ 1,007,525	$ 2,389,519	$ 3,397,044
6	$ 28,611,248	$ 929,866	$ 2,467,179	$ 3,397,044
7	$ 26,144,069	$ 849,682	$ 2,547,362	$ 3,397,044
8	$ 23,596,707	$ 766,893	$ 2,630,151	$ 3,397,044
9	$ 20,966,556	$ 681,413	$ 2,715,631	$ 3,397,044
10	$ 18,250,925	$ 593,155	$ 2,803,889	$ 3,397,044
11	$ 15,447,036	$ 502,029	$ 2,895,015	$ 3,397,044
12	$ 12,552,021	$ 407,941	$ 2,989,103	$ 3,397,044
13	$ 9,562,917	$ 310,795	$ 3,086,249	$ 3,397,044
14	$ 6,476,668	$ 210,492	$ 3,186,552	$ 3,397,044
15	$ 3,290,115	$ 106,929	$ 3,290,115	$ 3,397,044
Total		$ 11,125,662	$ 39,830,000	$ 50,955,662

Wind Farm Capacity: 20 MW with 2.0 MW Turbines
Cost Analysis and Payback Period

		1	2	3	4	5	6	7	8	9
Year		1	2	3	4	5	6	7	8	9
Production (MWh)		85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		8,500,000	8,712,500	8,930,313	9,153,570	9,382,410	9,616,970	9,857,394	10,103,829	10,356,425
Costs										
	O&M	850,000	850,000	850,000	850,000	850,000	850,000	850,000	850,000	850,000
	Labor	850,000	871,250	893,031	915,357	938,241	961,697	985,739	1,010,383	1,035,642
	Loan Payment	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044
	Rent	170,000	174,250	178,606	183,071	187,648	192,339	197,148	202,077	207,128
Total Cost		5,267,044	5,292,544	5,318,682	5,345,473	5,372,933	5,401,081	5,429,931	5,459,504	5,489,815
Total Cashflow		3,232,956	3,419,956	3,611,631	3,808,098	4,009,476	4,215,889	4,427,463	4,644,325	4,866,610
Discounted Cashflow		2,939,051	2,826,410	2,713,472	2,600,982	2,489,569	2,379,760	2,271,988	2,166,612	2,063,918
ESPH Initial Investment Payback	$ 17,070,000	$ 14,130,949	$ 11,304,539	$ 8,591,068	$ 5,990,086	$ 3,500,516	$ 1,120,757			

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		10,615,335	10,880,719	11,152,737	11,431,555	11,717,344	12,010,277	12,310,534	12,618,298	12,933,755	13,257,099	13,588,527
Costs												
	O&M	850,000	850,000	850,000	850,000	850,000	850,000	850,000	850,000	850,000	850,000	850,000
	Labor	1,061,534	1,088,072	1,115,274	1,143,156	1,171,734	1,201,028	1,231,053	1,261,830	1,293,376	1,325,710	1,358,853
	Loan Payment	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044	3,397,044					
	Rent	212,307	217,614	223,055	228,631	234,347	240,206	246,211	252,366	258,675	265,142	271,771
Total Cost		5,520,884	5,552,730	5,585,373	5,618,831	5,653,125	5,688,277	2,327,264	2,364,196	2,402,051	2,440,852	2,480,623
Total Cashflow		5,094,451	5,327,988	5,567,364	5,812,724	6,064,218	6,322,000	9,983,270	10,254,102	10,531,705	10,816,247	11,107,903
Discounted Cashflow		1,964,131	1,867,427	1,773,934	1,683,739	1,596,898	1,513,437	2,172,650	2,028,719	1,894,220	1,768,543	1,651,119

Total 20 Year Cashflow	$ 123,118,377
Total 20 Year Discounted Cashflow	$ 42,366,579

Appendix Q - Financial Analysis of 2.3 MW Turbines

Q.1 2.3 MW Turbines on a 10 MW Wind Farm

Wind Farm Capacity: 10 MW with 2.3 MW Turbines				
Initial Investment				
	ESPH investment	$ 7,998,000		
	15 Year Loan	$ 18,662,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 25,760,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 1,591,655		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	39,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 18,662,000			
1		$ 606,515	$ 985,140	$ 1,591,655
2	$ 17,676,860	$ 574,498	$ 1,017,158	$ 1,591,655
3	$ 16,659,702	$ 541,440	$ 1,050,215	$ 1,591,655
4	$ 15,609,487	$ 507,308	$ 1,084,347	$ 1,591,655
5	$ 14,525,140	$ 472,067	$ 1,119,588	$ 1,591,655
6	$ 13,405,551	$ 435,680	$ 1,155,975	$ 1,591,655
7	$ 12,249,576	$ 398,111	$ 1,193,544	$ 1,591,655
8	$ 11,056,032	$ 359,321	$ 1,232,334	$ 1,591,655
9	$ 9,823,697	$ 319,270	$ 1,272,385	$ 1,591,655
10	$ 8,551,312	$ 277,918	$ 1,313,738	$ 1,591,655
11	$ 7,237,574	$ 235,221	$ 1,356,434	$ 1,591,655
12	$ 5,881,140	$ 191,137	$ 1,400,518	$ 1,591,655
13	$ 4,480,622	$ 145,620	$ 1,446,035	$ 1,591,655
14	$ 3,034,586	$ 98,624	$ 1,493,031	$ 1,591,655
15	$ 1,541,555	$ 50,101	$ 1,541,555	$ 1,591,655
Total		$ 5,212,832	$ 18,662,000	$ 23,874,832

Wind Farm Capacity: 10 MW with 2.3 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		3,900,000	3,997,500	4,097,438	4,199,873	4,304,870	4,412,492	4,522,804	4,635,874	4,751,771
Costs										
	O&M	390,000	390,000	390,000	390,000	390,000	390,000	390,000	390,000	390,000
	Labor	390,000	399,750	409,744	419,987	430,487	441,249	452,280	463,587	475,177
	Loan Payment	1,591,655	1,591,655	1,591,655	1,591,655	1,591,655	1,591,655	1,591,655	1,591,655	1,591,655
	Rent	78,000	79,950	81,949	83,997	86,097	88,250	90,456	92,717	95,035
Total Cost		2,449,655	2,461,355	2,473,348	2,485,640	2,498,240	2,511,155	2,524,392	2,537,960	2,551,868
Total Cashflow		1,450,345	1,536,145	1,624,090	1,714,233	1,806,630	1,901,338	1,998,412	2,097,914	2,199,903
Discounted Cashflow		1,318,495	1,269,541	1,220,202	1,170,844	1,121,775	1,073,255	1,025,502	978,692	932,974

ESPH Initial Investment Payback									
	$ 7,998,000	$ 6,679,505	$ 5,409,964	$ 4,189,762	$ 3,018,917	$ 1,897,142	$ 823,886		

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		4,870,566	4,992,330	5,117,138	5,245,066	5,376,193	5,510,598	5,648,363	5,789,572	5,934,311	6,082,669	6,234,736
Costs												
	O&M	390,000	390,000	390,000	390,000	390,000	390,000	390,000	390,000	390,000	390,000	390,000
	Labor	487,057	499,233	511,714	524,507	537,619	551,060	564,836	578,957	593,431	608,267	623,474
	Loan Payment	1,591,655	1,591,655	1,591,655	1,591,655	1,591,655	1,591,655					
	Rent	97,411	99,847	102,343	104,901	107,524	110,212	112,967	115,791	118,686	121,653	124,695
Total Cost		2,566,123	2,580,735	2,595,712	2,611,063	2,626,799	2,642,927	1,067,804	1,084,749	1,102,117	1,119,920	1,138,168
Total Cashflow		2,304,442	2,411,595	2,521,426	2,634,003	2,749,394	2,867,671	4,580,559	4,704,823	4,832,194	4,962,749	5,096,567
Discounted Cashflow		888,462	845,249	803,404	762,977	724,001	686,498	996,863	930,824	869,113	811,449	757,572

Total 20 Year Cashflow	$ 55,994,433
Total 20 Year Discounted Cashflow	$ 19,187,694

Q.2 2.3 MW Turbines on a 15 MW Wind Farm

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Wind Farm Capacity: 15 MW with 2.3 MW Turbines				
Initial Investment				
	ESPH investment	$ 13,794,000		
	15 Year Loan	$ 32,186,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 45,080,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 2,745,098		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	66,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 32,186,000			
1		$ 1,046,045	$ 1,699,053	$ 2,745,098
2	$ 30,486,947	$ 990,826	$ 1,754,272	$ 2,745,098
3	$ 28,732,674	$ 933,812	$ 1,811,286	$ 2,745,098
4	$ 26,921,388	$ 874,945	$ 1,870,153	$ 2,745,098
5	$ 25,051,235	$ 814,165	$ 1,930,933	$ 2,745,098
6	$ 23,120,302	$ 751,410	$ 1,993,688	$ 2,745,098
7	$ 21,126,613	$ 686,615	$ 2,058,483	$ 2,745,098
8	$ 19,068,130	$ 619,714	$ 2,125,384	$ 2,745,098
9	$ 16,942,746	$ 550,639	$ 2,194,459	$ 2,745,098
10	$ 14,748,287	$ 479,319	$ 2,265,779	$ 2,745,098
11	$ 12,482,508	$ 405,682	$ 2,339,417	$ 2,745,098
12	$ 10,143,092	$ 329,650	$ 2,415,448	$ 2,745,098
13	$ 7,727,644	$ 251,148	$ 2,493,950	$ 2,745,098
14	$ 5,233,694	$ 170,095	$ 2,575,003	$ 2,745,098
15	$ 2,658,691	$ 86,407	$ 2,658,691	$ 2,745,098
Total		$ 8,990,473	$ 32,186,000	$ 41,176,473

Wind Farm Capacity: 15 MW with 2.3 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		6,600,000	6,765,000	6,934,125	7,107,478	7,285,165	7,467,294	7,653,977	7,845,326	8,041,459
Costs										
	O&M	660,000	660,000	660,000	660,000	660,000	660,000	660,000	660,000	660,000
	Labor	660,000	676,500	693,413	710,748	728,517	746,729	765,398	784,533	804,146
	Loan Payment	2,745,098	2,745,098	2,745,098	2,745,098	2,745,098	2,745,098	2,745,098	2,745,098	2,745,098
	Rent	132,000	135,300	138,683	142,150	145,703	149,346	153,080	156,907	160,829
Total Cost		4,197,098	4,216,898	4,237,193	4,257,996	4,279,318	4,301,174	4,323,575	4,346,537	4,370,073
Total Cashflow		2,402,902	2,548,102	2,696,932	2,849,483	3,005,847	3,166,121	3,330,401	3,498,789	3,671,386
Discounted Cashflow		2,184,456	2,105,869	2,026,245	1,946,235	1,866,395	1,787,193	1,709,022	1,632,211	1,557,026
ESPH Initial Investment Payback	$ 13,794,000	$ 11,609,544	$ 9,503,675	$ 7,477,430	$ 5,531,195	$ 3,664,800	$ 1,877,608	$ 168,585		

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		8,242,496	8,448,558	8,659,772	8,876,266	9,098,173	9,325,627	9,558,768	9,797,737	10,042,681	10,293,748	10,551,091
Costs												
	O&M	660,000	660,000	660,000	660,000	660,000	660,000	660,000	660,000	660,000	660,000	660,000
	Labor	824,250	844,856	865,977	887,627	909,817	932,563	955,877	979,774	1,004,268	1,029,375	1,055,109
	Loan Payment	2,745,098	2,745,098	2,745,098	2,745,098	2,745,098	2,745,098					
	Rent	164,850	168,971	173,195	177,525	181,963	186,513	191,175	195,955	200,854	205,875	211,022
Total Cost		4,394,198	4,418,925	4,444,271	4,470,250	4,496,879	4,524,173	1,807,052	1,835,728	1,865,122	1,895,250	1,926,131
Total Cashflow		3,848,298	4,029,633	4,215,501	4,406,016	4,601,294	4,801,454	7,751,716	7,962,009	8,177,559	8,398,498	8,624,960
Discounted Cashflow		1,483,685	1,412,362	1,343,189	1,276,266	1,211,664	1,149,430	1,686,999	1,575,241	1,470,806	1,373,222	1,282,045

Total 20 Year Cashflow	$ 93,986,898
Total 20 Year Discounted Cashflow	$ 32,079,560

Q.3 2.3 MW Turbines on a 20 MW Wind Farm

Wind Farm Capacity: 20 MW with 2.3 MW Turbines				
Initial Investment				
	ESPH investment	$ 17,658,000		
	15 Year Loan	$ 41,202,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 57,960,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 3,514,060		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	84,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 41,202,000			
1		$ 1,339,065	$ 2,174,995	$ 3,514,060
2	$ 39,027,005	$ 1,268,378	$ 2,245,682	$ 3,514,060
3	$ 36,781,323	$ 1,195,393	$ 2,318,667	$ 3,514,060
4	$ 34,462,655	$ 1,120,036	$ 2,394,024	$ 3,514,060
5	$ 32,068,632	$ 1,042,231	$ 2,471,830	$ 3,514,060
6	$ 29,596,802	$ 961,896	$ 2,552,164	$ 3,514,060
7	$ 27,044,638	$ 878,951	$ 2,635,109	$ 3,514,060
8	$ 24,409,529	$ 793,310	$ 2,720,750	$ 3,514,060
9	$ 21,688,778	$ 704,885	$ 2,809,175	$ 3,514,060
10	$ 18,879,604	$ 613,587	$ 2,900,473	$ 3,514,060
11	$ 15,979,131	$ 519,322	$ 2,994,738	$ 3,514,060
12	$ 12,984,392	$ 421,993	$ 3,092,067	$ 3,514,060
13	$ 9,892,325	$ 321,501	$ 3,192,559	$ 3,514,060
14	$ 6,699,766	$ 217,742	$ 3,296,318	$ 3,514,060
15	$ 3,403,448	$ 110,612	$ 3,403,448	$ 3,514,060
Total		$ 11,508,901	$ 41,202,000	$ 52,710,901

Wind Farm Capacity: 20 MW with 2.3 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		8,400,000	8,610,000	8,825,250	9,045,881	9,272,028	9,503,829	9,741,425	9,984,960	10,234,584
Costs										
	O&M	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000
	Labor	840,000	861,000	882,525	904,588	927,203	950,383	974,142	998,496	1,023,458
	Loan Payment	3,514,060	3,514,060	3,514,060	3,514,060	3,514,060	3,514,060	3,514,060	3,514,060	3,514,060
	Rent	168,000	172,200	176,505	180,918	185,441	190,077	194,828	199,699	204,692
Total Cost		5,362,060	5,387,260	5,413,090	5,439,566	5,466,703	5,494,520	5,523,031	5,552,255	5,582,210
Total Cashflow		3,037,940	3,222,740	3,412,160	3,606,315	3,805,325	4,009,309	4,218,394	4,432,705	4,652,374
Discounted Cashflow		2,761,764	2,663,421	2,563,606	2,463,162	2,362,807	2,263,151	2,164,703	2,067,890	1,973,061
ESPH Initial Investment Payback	$ 17,658,000	$ 14,896,236	$ 12,232,815	$ 9,669,209	$ 7,206,047	$ 4,843,239	$ 2,580,089	$ 415,386		

Year	10	11	12	13	14	15	16	17	18	19	20
Production (MWh)	84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000	84,000
Revenue											
Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue	10,490,449	10,752,710	11,021,528	11,297,066	11,579,493	11,868,980	12,165,705	12,469,847	12,781,593	13,101,133	13,428,662
Costs											
O&M	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000	840,000
Labor	1,049,045	1,075,271	1,102,153	1,129,707	1,157,949	1,186,898	1,216,570	1,246,985	1,278,159	1,310,113	1,342,866
Loan Payment	3,514,060	3,514,060	3,514,060	3,514,060	3,514,060	3,514,060					
Rent	209,809	215,054	220,431	225,941	231,590	237,380	243,314	249,397	255,632	262,023	268,573
Total Cost	5,612,914	5,644,385	5,676,643	5,709,708	5,743,599	5,778,338	2,299,885	2,336,382	2,373,791	2,412,136	2,451,439
Total Cashflow	4,877,535	5,108,325	5,344,885	5,587,358	5,835,894	6,090,642	9,865,820	10,133,466	10,407,802	10,688,997	10,977,222
Discounted Cashflow	1,880,501	1,790,437	1,703,045	1,618,459	1,536,773	1,458,051	2,147,090	2,004,852	1,871,935	1,747,736	1,631,694

Total 20 Year Cashflow	$ 119,315,208
Total 20 Year Discounted Cashflow	$ 40,674,138

Appendix R - Financial Analysis of 3.0 MW Turbines

R.1 3.0 MW Turbines on a 10 MW Wind Farm

Wind Farm Capacity: 10 MW with 3.0 MW Turbines

Initial Investment					
	ESPH investment	$	7,830,000		
	15 Year Loan	$	18,270,000	Interest Rate:	0.0325
Initial Cost					
	Construction				
	Wind Turbine Cost	$	25,200,000		
	Legal Fees				
	Transmission Line	$	900,000		
Costs Over Time					
	Operation and Maintenance		0.01	$/kWh	
	Labor Cost		10%	of revenue	
	Loan Payment	$	1,558,222		
	Rate of Inflation		10%		
	Rent		2%	of revenue	
Revenue					
	Expected Price of Electricity		Varies by Year		
	Estimated Production of Proposed Site		34,000	MWh	
	Expected Rate of Inflation		10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 18,270,000			
1		$ 593,775	$ 964,447	$ 1,558,222
2	$ 17,305,553	$ 562,430	$ 995,792	$ 1,558,222
3	$ 16,309,761	$ 530,067	$ 1,028,155	$ 1,558,222
4	$ 15,281,606	$ 496,652	$ 1,061,570	$ 1,558,222
5	$ 14,220,035	$ 462,151	$ 1,096,071	$ 1,558,222
6	$ 13,123,964	$ 426,529	$ 1,131,694	$ 1,558,222
7	$ 11,992,271	$ 389,749	$ 1,168,474	$ 1,558,222
8	$ 10,823,797	$ 351,773	$ 1,206,449	$ 1,558,222
9	$ 9,617,348	$ 312,564	$ 1,245,659	$ 1,558,222
10	$ 8,371,690	$ 272,080	$ 1,286,142	$ 1,558,222
11	$ 7,085,547	$ 230,280	$ 1,327,942	$ 1,558,222
12	$ 5,757,605	$ 187,122	$ 1,371,100	$ 1,558,222
13	$ 4,386,505	$ 142,561	$ 1,415,661	$ 1,558,222
14	$ 2,970,844	$ 96,552	$ 1,461,670	$ 1,558,222
15	$ 1,509,174	$ 49,048	$ 1,509,174	$ 1,558,222
Total		$ 5,103,335	$ 18,270,000	$ 23,373,335

Wind Farm Capacity: 10 MW with 3.0 MW Turbines
Cost Analysis and Payback Period

Year	1	2	3	4	5	6	7	8	9
Production (MWh)	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000
Revenue									
Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue	3,400,000	3,485,000	3,572,125	3,661,428	3,752,964	3,846,788	3,942,958	4,041,532	4,142,570
Costs									
O&M	340,000	340,000	340,000	340,000	340,000	340,000	340,000	340,000	340,000
Labor	340,000	348,500	357,213	366,143	375,296	384,679	394,296	404,153	414,257
Loan Payment	1,558,222	1,558,222	1,558,222	1,558,222	1,558,222	1,558,222	1,558,222	1,558,222	1,558,222
Rent	68,000	69,700	71,443	73,229	75,059	76,936	78,859	80,831	82,851
Total Cost	2,306,222	2,316,422	2,326,877	2,337,594	2,348,578	2,359,837	2,371,377	2,383,206	2,395,331
Total Cashflow	1,093,778	1,168,578	1,245,248	1,323,834	1,404,386	1,486,951	1,571,580	1,658,325	1,747,239
Discounted Cashflow	994,343	965,767	935,573	904,197	872,013	839,345	806,469	773,621	741,000

ESPH Initial Investment Payback										
	$ 7,830,000	$ 6,835,657	$ 5,869,890	$ 4,934,317	$ 4,030,120	$ 3,158,107	$ 2,318,762	$ 1,512,293	$ 738,672	

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		4,246,134	4,352,287	4,461,095	4,572,622	4,686,938	4,804,111	4,924,214	5,047,319	5,173,502	5,302,840	5,435,411
Costs												
	O&M	340,000	340,000	340,000	340,000	340,000	340,000	340,000	340,000	340,000	340,000	340,000
	Labor	424,613	435,229	446,109	457,262	468,694	480,411	492,421	504,732	517,350	530,284	543,541
	Loan Payment	1,558,222	1,558,222	1,558,222	1,558,222	1,558,222	1,558,222					
	Rent	84,923	87,046	89,222	91,452	93,739	96,082	98,484	100,946	103,470	106,057	108,708
Total Cost		2,407,758	2,420,497	2,433,554	2,446,937	2,460,655	2,474,716	930,906	945,678	960,820	976,341	992,249
Total Cashflow		1,838,376	1,931,791	2,027,541	2,125,685	2,226,283	2,329,395	3,993,308	4,101,641	4,212,682	4,326,499	4,443,161
Discounted Cashflow		708,773	677,081	646,037	615,735	586,250	557,639	869,060	811,488	757,688	707,417	660,448

Total 20 Year Cashflow	$ 46,256,280
Total 20 Year Discounted Cashflow	$ 15,429,944

R.2 3.0 MW Turbines on a 15 MW Wind Farm

Wind Farm Capacity: 15 MW with 3.0 MW Turbines				
Initial Investment				
	ESPH investment	$ 12,870,000		
	15 Year Loan	$ 30,030,000	Interest Rate:	0.0325
Initial Cost				
	Construction	$ 42,000,000		
	Wind Turbine Cost			
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 2,561,216		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	55,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 30,030,000			
1		$ 975,975	$ 1,585,241	$ 2,561,216
2	$ 28,444,759	$ 924,455	$ 1,636,761	$ 2,561,216
3	$ 26,807,998	$ 871,260	$ 1,689,956	$ 2,561,216
4	$ 25,118,041	$ 816,336	$ 1,744,880	$ 2,561,216
5	$ 23,373,162	$ 759,628	$ 1,801,588	$ 2,561,216
6	$ 21,571,573	$ 701,076	$ 1,860,140	$ 2,561,216
7	$ 19,711,434	$ 640,622	$ 1,920,594	$ 2,561,216
8	$ 17,790,839	$ 578,202	$ 1,983,014	$ 2,561,216
9	$ 15,807,825	$ 513,754	$ 2,047,462	$ 2,561,216
10	$ 13,760,364	$ 447,212	$ 2,114,004	$ 2,561,216
11	$ 11,646,359	$ 378,507	$ 2,182,709	$ 2,561,216
12	$ 9,463,650	$ 307,569	$ 2,253,647	$ 2,561,216
13	$ 7,210,003	$ 234,325	$ 2,326,891	$ 2,561,216
14	$ 4,883,112	$ 158,701	$ 2,402,515	$ 2,561,216
15	$ 2,480,597	$ 80,619	$ 2,480,597	$ 2,561,216
Total		$ 8,388,241	$ 30,030,000	$ 38,418,241

Wind Farm Capacity: 15 MW with 3.0 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000
Revenue										
Price of Electricity (per kWh)		0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		5,500,000	5,637,500	5,778,438	5,922,898	6,070,971	6,222,745	6,378,314	6,537,772	6,701,216
Costs										
O&M		550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000
Labor		550,000	563,750	577,844	592,290	607,097	622,275	637,831	653,777	670,122
Loan Payment		2,561,216	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216
Rent		110,000	112,750	115,569	118,458	121,419	124,455	127,566	130,755	134,024
Total Cost		3,771,216	3,787,716	3,804,629	3,821,964	3,839,733	3,857,945	3,876,614	3,895,749	3,915,362
Total Cashflow		1,728,784	1,849,784	1,973,809	2,100,935	2,231,238	2,364,800	2,501,700	2,642,023	2,785,854
Discounted Cashflow		1,571,622	1,528,747	1,482,952	1,434,967	1,385,423	1,334,868	1,283,768	1,232,523	1,181,474
ESPH Initial Investment Payback	$ 12,870,000	$ 11,298,378	$ 9,769,631	$ 8,286,679	$ 6,851,713	$ 5,466,289	$ 4,131,421	$ 2,847,654	$ 1,615,131	$ 433,656

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		6,868,746	7,040,465	7,216,477	7,396,889	7,581,811	7,771,356	7,965,640	8,164,781	8,368,900	8,578,123	8,792,576
Costs												
	O&M	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000
	Labor	686,875	704,046	721,648	739,689	758,181	777,136	796,564	816,478	836,890	857,812	879,258
	Loan Payment	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216	2,561,216					
	Rent	137,375	140,809	144,330	147,938	151,636	155,427	159,313	163,296	167,378	171,562	175,852
Total Cost		3,935,466	3,956,072	3,977,193	3,998,843	4,021,033	4,043,779	1,505,877	1,529,774	1,554,268	1,579,375	1,605,109
Total Cashflow		2,933,281	3,084,393	3,239,283	3,398,046	3,560,777	3,727,577	6,459,763	6,635,007	6,814,632	6,998,748	7,187,467
Discounted Cashflow		1,130,907	1,081,061	1,032,136	984,293	937,664	892,352	1,405,833	1,312,701	1,225,672	1,144,351	1,068,371

Total 20 Year Cashflow	$ 74,217,902
Total 20 Year Discounted Cashflow	$ 24,651,683

R.3 3.0 MW Turbines on a 20 MW Wind Farm

Wind Farm Capacity: 20 MW with 3.0 MW Turbines				
Initial Investment				
	ESPH investment	$ 17,910,000		
	15 Year Loan	$ 41,790,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 58,800,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 3,564,210		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	75,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 41,790,000			
1		$ 1,358,175	$ 2,206,035	$ 3,564,210
2	$ 39,583,965	$ 1,286,479	$ 2,277,731	$ 3,564,210
3	$ 37,306,234	$ 1,212,453	$ 2,351,757	$ 3,564,210
4	$ 34,954,477	$ 1,136,021	$ 2,428,189	$ 3,564,210
5	$ 32,526,288	$ 1,057,104	$ 2,507,105	$ 3,564,210
6	$ 30,019,183	$ 975,623	$ 2,588,586	$ 3,564,210
7	$ 27,430,596	$ 891,494	$ 2,672,715	$ 3,564,210
8	$ 24,757,881	$ 804,631	$ 2,759,579	$ 3,564,210
9	$ 21,998,302	$ 714,945	$ 2,849,265	$ 3,564,210
10	$ 19,149,037	$ 622,344	$ 2,941,866	$ 3,564,210
11	$ 16,207,171	$ 526,733	$ 3,037,477	$ 3,564,210
12	$ 13,169,695	$ 428,015	$ 3,136,195	$ 3,564,210
13	$ 10,033,500	$ 326,089	$ 3,238,121	$ 3,564,210
14	$ 6,795,379	$ 220,850	$ 3,343,360	$ 3,564,210
15	$ 3,452,019	$ 112,191	$ 3,452,019	$ 3,564,210
Total		$ 11,673,146	$ 41,790,000	$ 53,463,146

Wind Farm Capacity: 20 MW with 3.0 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		7,500,000	7,687,500	7,879,688	8,076,680	8,278,597	8,485,562	8,697,701	8,915,143	9,138,022
Costs										
	O&M	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000
	Labor	750,000	768,750	787,969	807,668	827,860	848,556	869,770	891,514	913,802
	Loan Payment	3,564,210	3,564,210	3,564,210	3,564,210	3,564,210	3,564,210	3,564,210	3,564,210	3,564,210
	Rent	150,000	153,750	157,594	161,534	165,572	169,711	173,954	178,303	182,760
Total Cost		5,214,210	5,236,710	5,259,772	5,283,411	5,307,641	5,332,477	5,357,934	5,384,027	5,410,772
Total Cashflow		2,285,790	2,450,790	2,619,915	2,793,268	2,970,955	3,153,084	3,339,767	3,531,116	3,727,249
Discounted Cashflow		2,077,991	2,025,446	1,968,381	1,907,840	1,844,730	1,779,834	1,713,828	1,647,292	1,580,718
ESPH Initial Investment Payback	$ 17,910,000	$ 15,832,009	$ 13,806,562	$ 11,838,181	$ 9,930,341	$ 8,085,612	$ 6,305,778	$ 4,591,949	$ 2,944,658	$ 1,363,940

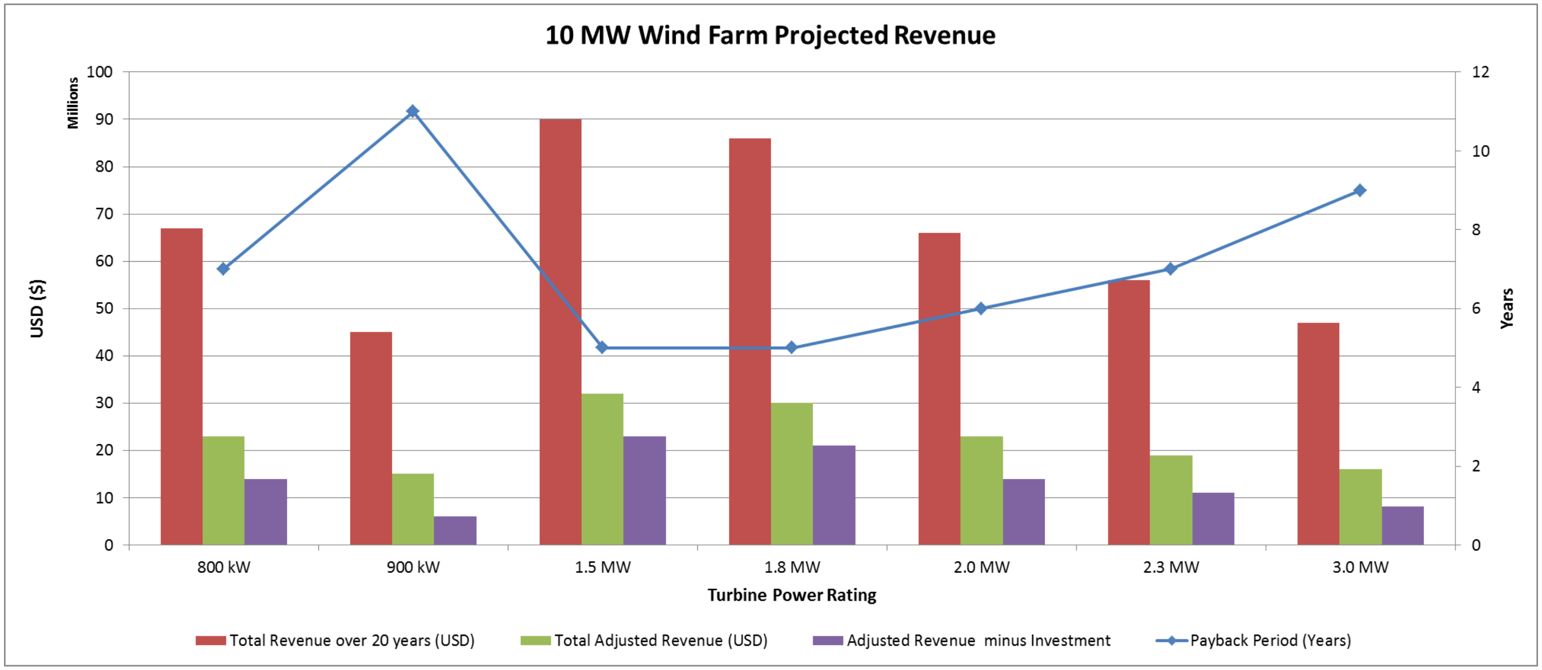
Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		9,366,472	9,600,634	9,840,650	10,086,666	10,338,833	10,597,304	10,862,236	11,133,792	11,412,137	11,697,440	11,989,876
Costs												
	O&M	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000
	Labor	936,647	960,063	984,065	1,008,667	1,033,883	1,059,730	1,086,224	1,113,379	1,141,214	1,169,744	1,198,988
	Loan Payment	3,564,210	3,564,210	3,564,210	3,564,210	3,564,210	3,564,210					
	Rent	187,329	192,013	196,813	201,733	206,777	211,946	217,245	222,676	228,243	233,949	239,798
Total Cost		5,438,186	5,466,286	5,495,088	5,524,610	5,554,870	5,585,886	2,053,468	2,086,055	2,119,456	2,153,693	2,188,785
Total Cashflow		3,928,286	4,134,348	4,345,562	4,562,056	4,783,963	5,011,417	8,808,768	9,047,737	9,292,681	9,543,748	9,801,091
Discounted Cashflow		1,514,524	1,449,064	1,384,630	1,321,465	1,259,767	1,199,693	1,917,045	1,790,047	1,671,370	1,560,479	1,456,870

Total 20 Year Cashflow	$ 100,131,594
Total 20 Year Discounted Cashflow	$ 33,071,014

Appendix S – Summary of the Wind Farm Projected Revenue

S.1 10 MW Wind Farm Projected Revenue

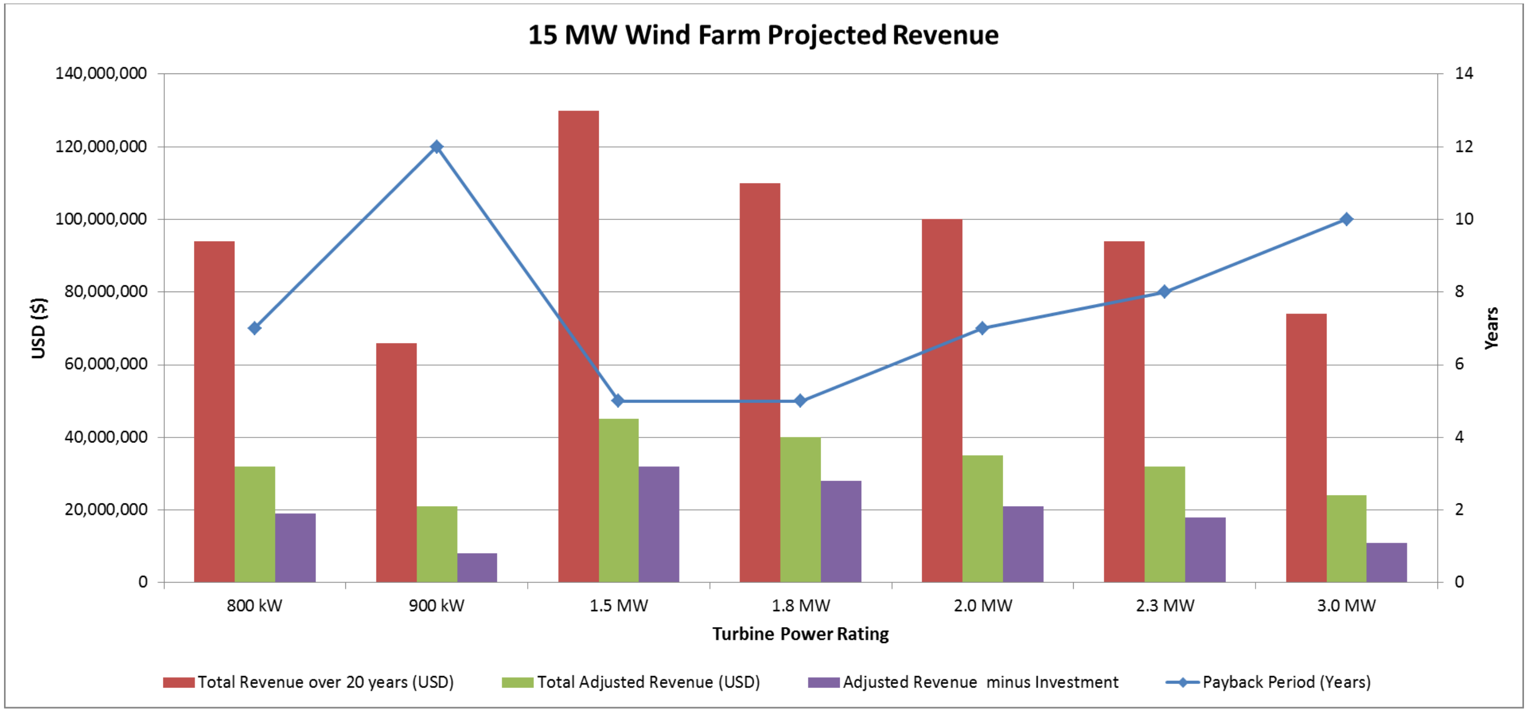
	10 MW Wind Farm Projected Revenue Comparison						
	800 kW	900 kW	1.5 MW	1.8 MW	2.0 MW	2.3 MW	3.0 MW
Payback Period (Years)	7	11	5	5	6	7	9
Total Revenue over 20 years (USD)	67,000,000	45,000,000	90,000,000	86,000,000	66,000,000	56,000,000	47,000,000
Total Adjusted Revenue (USD)	23,000,000	15,000,000	32,000,000	30,000,000	23,000,000	19,000,000	16,000,000
Adjusted Revenue minus Investment	14,000,000	6,000,000	23,000,000	21,000,000	14,000,000	11,000,000	8,200,000



S.2 15 MW Wind Farm Projected Revenue

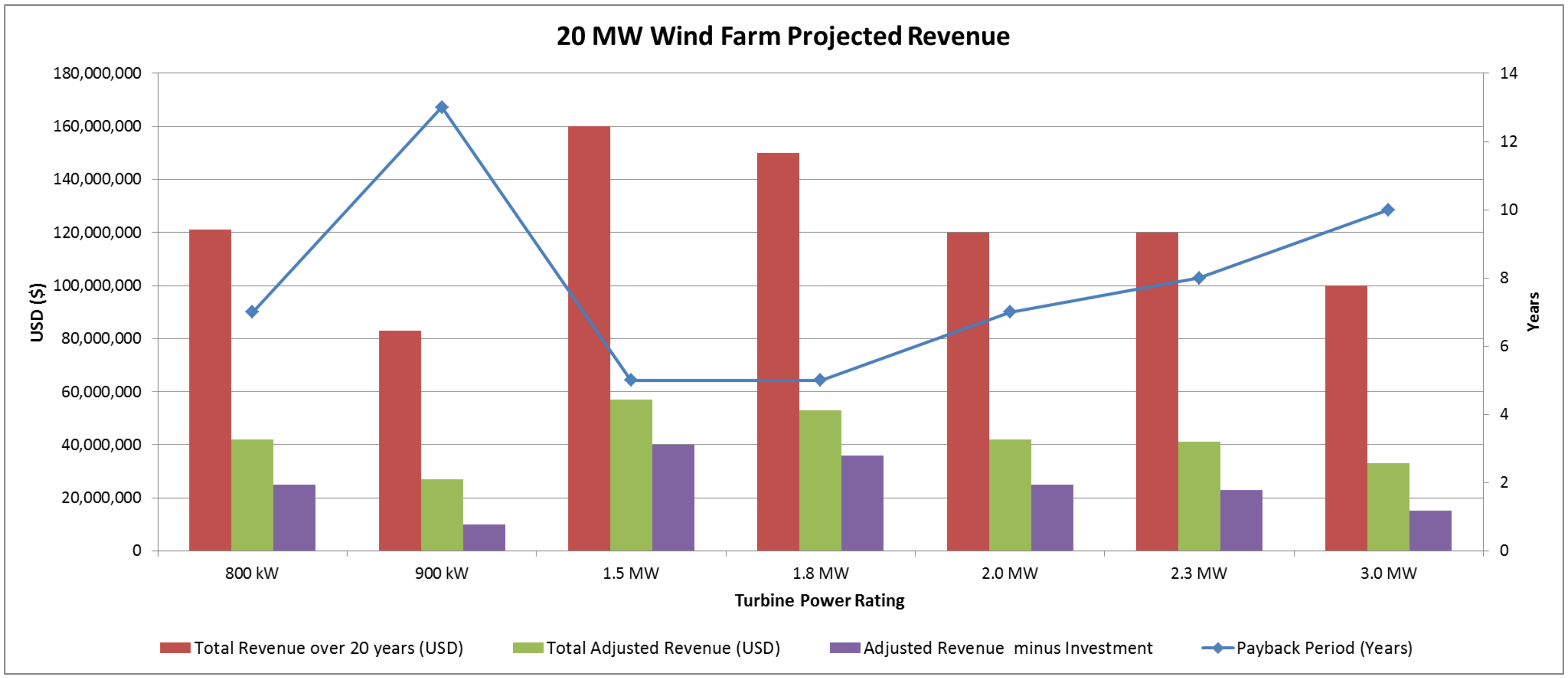
15 MW Wind Farm Projected Revenue Comparison

	800 kW	900 kW	1.5 MW	1.8 MW	2.0 MW	2.3 MW	3.0 MW
Payback Period (Years)	7	12	5	5	7	8	10
Total Revenue over 20 years (USD)	94,000,000	66,000,000	130,000,000	110,000,000	100,000,000	94,000,000	74,000,000
Total Adjusted Revenue (USD)	32,000,000	21,000,000	45,000,000	40,000,000	35,000,000	32,000,000	24,000,000
Adjusted Revenue minus Investment	19,000,000	8,000,000	32,000,000	28,000,000	21,000,000	18,000,000	11,000,000



S.3 20 MW Wind Farm Projected Revenue

20 MW Wind Farm Projected Revenue Comparison	800 kW	900 kW	1.5 MW	1.8 MW	2.0 MW	2.3 MW	3.0 MW
Payback Period (Years)	7	13	5	5	7	8	10
Total Revenue over 20 years (USD)	121,000,000	83,000,000	160,000,000	150,000,000	120,000,000	120,000,000	100,000,000
Total Adjusted Revenue (USD)	42,000,000	27,000,000	57,000,000	53,000,000	42,000,000	41,000,000	33,000,000
Adjusted Revenue minus Investment	25,000,000	10,000,000	40,000,000	36,000,000	25,000,000	23,000,000	15,000,000



Appendix T - Analysis of Feasible 9.6 MW Wind Farm

T.1 Projected Annual Energy Production

	Annual Energy Production Forecast for 800 kW Enercon Turbines Wind Farm Capacity: 9.6 MW					
	E-48/800 kW (60 m) Production (MWh)			E-53/800 kW (60 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected
January	810	7232	4488	810	7232	4488
February	805	6492	4384	810	6532	4411
March	760	6785	5433	790	7053	5647
April	620	5357	5143	700	6048	5806
May	155	1384	2942	183	1634	3474
June	75	648	2553	90	778	3064
July	110	982	2529	141	1259	3241
August	90	804	2618	120	1071	3490
September	20	173	1625	34	294	1625
October	40	357	2306	62	554	2306
November	250	2160	2688	310	2678	3333
December	620	5535	3517	695	6205	3943
Annual production		**37908**	**40226**		**41337**	**44829**

Average 800 kW Calculated Production at 9.6 MW Wind Farm				
Power Rating	Model	Annual Power Generation	Avg. Annual Power Generation	Variance (±)
800 kW	E-48/800 kW (60 m)	40,226	**43,000**	2300
	E-53/800 kW (60 m)	44,829		

T.2 Projected Revenue

Wind Farm Capacity: 9.6 MW with 800 kW Turbines				
Initial Investment				
	ESPH investment	$ 8,334,000		
	15 Year Loan	$ 19,446,000	Interest Rate:	0.0325
Initial Cost				
	Construction	$ 26,880,000		
	Wind Turbine Cost			
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 1,658,522		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	43,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 19,446,000			
1		$ 631,995	$ 1,026,527	$ 1,658,522
2	$ 18,419,473	$ 598,633	$ 1,059,889	$ 1,658,522
3	$ 17,359,584	$ 564,186	$ 1,094,335	$ 1,658,522
4	$ 16,265,249	$ 528,621	$ 1,129,901	$ 1,658,522
5	$ 15,135,348	$ 491,899	$ 1,166,623	$ 1,658,522
6	$ 13,968,725	$ 453,984	$ 1,204,538	$ 1,658,522
7	$ 12,764,187	$ 414,836	$ 1,243,686	$ 1,658,522
8	$ 11,520,501	$ 374,416	$ 1,284,105	$ 1,658,522
9	$ 10,236,396	$ 332,683	$ 1,325,839	$ 1,658,522
10	$ 8,910,557	$ 289,593	$ 1,368,929	$ 1,658,522
11	$ 7,541,628	$ 245,103	$ 1,413,419	$ 1,658,522
12	$ 6,128,210	$ 199,167	$ 1,459,355	$ 1,658,522
13	$ 4,668,855	$ 151,738	$ 1,506,784	$ 1,658,522
14	$ 3,162,071	$ 102,767	$ 1,555,754	$ 1,658,522
15	$ 1,606,316	$ 52,205	$ 1,606,316	$ 1,658,522
Total		$ 5,431,826	$ 19,446,000	$ 24,877,826

Wind Farm Capacity: 9.6 MW with 800 kW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		43,000	43,000	43,000	43,000	43,000	43,000	43,000	43,000	43,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		4,300,000	4,407,500	4,517,688	4,630,630	4,746,395	4,865,055	4,986,682	5,111,349	5,239,132
Costs										
	O&M	430,000	430,000	430,000	430,000	430,000	430,000	430,000	430,000	430,000
	Labor	430,000	440,750	451,769	463,063	474,640	486,506	498,668	511,135	523,913
	Loan Payment	1,658,522	1,658,522	1,658,522	1,658,522	1,658,522	1,658,522	1,658,522	1,658,522	1,658,522
	Rent	86,000	88,150	90,354	92,613	94,928	97,301	99,734	102,227	104,783
Total Cost		2,604,522	2,617,422	2,630,644	2,644,197	2,658,089	2,672,328	2,686,924	2,701,884	2,717,218
Total Cashflow		1,695,478	1,790,078	1,887,043	1,986,432	2,088,306	2,192,727	2,299,758	2,409,465	2,521,915
Discounted Cashflow		1,541,344	1,479,404	1,417,764	1,356,760	1,296,674	1,237,737	1,180,140	1,124,033	1,069,538
ESPH Initial Investment Payback	$ 8,334,000	$ 6,792,656	$ 5,313,253	$ 3,895,489	$ 2,538,729	$ 1,242,055	$ 4,318			

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		43,000	43,000	43,000	43,000	43,000	43,000	43,000	43,000	43,000	43,000	43,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		5,370,111	5,504,364	5,641,973	5,783,022	5,927,597	6,075,787	6,227,682	6,383,374	6,542,959	6,706,532	6,874,196
Costs												
	O&M	430,000	430,000	430,000	430,000	430,000	430,000	430,000	430,000	430,000	430,000	430,000
	Labor	537,011	550,436	564,197	578,302	592,760	607,579	622,768	638,337	654,296	670,653	687,420
	Loan Payment	1,658,522	1,658,522	1,658,522	1,658,522	1,658,522	1,658,522					
	Rent	107,402	110,087	112,839	115,660	118,552	121,516	124,554	127,667	130,859	134,131	137,484
Total Cost		2,732,935	2,749,045	2,765,558	2,782,484	2,799,833	2,817,616	1,177,322	1,196,005	1,215,155	1,234,784	1,254,903
Total Cashflow		2,637,176	2,755,318	2,876,414	3,000,538	3,127,764	3,258,171	5,050,360	5,187,369	5,327,804	5,471,749	5,619,292
Discounted Cashflow		1,016,745	965,722	916,514	869,149	823,638	779,980	1,099,106	1,026,293	958,252	894,675	835,272

Total 20 Year Cashflow	$ 63,183,159
Total 20 Year Discounted Cashflow	$ 21,888,740

Appendix U - Analysis of Feasible 12 MW Wind Farm

U.1 Projected Annual Energy Production

	Annual Energy Production Forecast for 1.5 MW Turbines Wind Farm Capacity: 12 MW					
	General Electric 1.5xle/1.5 MW (80 m) Production (MWh)			General Electric 1.5sle/1.5 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	1500	8928	5541	1500	8928	5541
February	1500	8064	5446	1500	8064	5446
March	1500	8928	7148	1500	8928	7148
April	1500	8640	8295	1400	8064	7742
May	550	3274	6960	400	2381	5062
June	300	1728	6809	190	1094	4312
July	430	2559	6590	340	2024	5210
August	400	2381	7756	250	1488	4848
September	150	864	1625	50	288	1625
October	210	1250	2306	90	536	2306
November	890	5126	6379	550	3168	3942
December	1450	8630	5484	1410	8392	5333
Annual Production		**60372**	**70339**		**53355**	**58515**

Average 1.5 MW Calculated Production at 12 MW Wind Farm				
1.5 MW	General Electric 1.5xle (80 m)	70,339	**64,000**	5,900
	General Electric 1.5sle (80 m)	58,515		

U.2 Projected Revenue

Wind Farm Capacity: 12 MW with 1.5 MW Turbines				
Initial Investment				
	ESPH investment	$ 10,350,000		
	15 Year Loan	$ 24,150,000	Interest Rate:	0.0325
Initial Cost				
	Construction	$ 33,600,000		
	Wind Turbine Cost			
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 2,059,719		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	64,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 24,150,000			
1		$ 784,875	$ 1,274,844	$ 2,059,719
2	$ 22,875,156	$ 743,443	$ 1,316,277	$ 2,059,719
3	$ 21,558,879	$ 700,664	$ 1,359,056	$ 2,059,719
4	$ 20,199,824	$ 656,494	$ 1,403,225	$ 2,059,719
5	$ 18,796,599	$ 610,889	$ 1,448,830	$ 2,059,719
6	$ 17,347,769	$ 563,802	$ 1,495,917	$ 2,059,719
7	$ 15,851,852	$ 515,185	$ 1,544,534	$ 2,059,719
8	$ 14,307,318	$ 464,988	$ 1,594,731	$ 2,059,719
9	$ 12,712,587	$ 413,159	$ 1,646,560	$ 2,059,719
10	$ 11,066,027	$ 359,646	$ 1,700,073	$ 2,059,719
11	$ 9,365,953	$ 304,393	$ 1,755,326	$ 2,059,719
12	$ 7,610,628	$ 247,345	$ 1,812,374	$ 2,059,719
13	$ 5,798,254	$ 188,443	$ 1,871,276	$ 2,059,719
14	$ 3,926,978	$ 127,627	$ 1,932,092	$ 2,059,719
15	$ 1,994,885	$ 64,834	$ 1,994,885	$ 2,059,719
Total		$ 6,745,788	$ 24,150,000	$ 30,895,788

Wind Farm Capacity: 12 MW with 1.5 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		6,400,000	6,560,000	6,724,000	6,892,100	7,064,403	7,241,013	7,422,038	7,607,589	7,797,779
Costs										
	O&M	640,000	640,000	640,000	640,000	640,000	640,000	640,000	640,000	640,000
	Labor	640,000	656,000	672,400	689,210	706,440	724,101	742,204	760,759	779,778
	Loan Payment	2,059,719	2,059,719	2,059,719	2,059,719	2,059,719	2,059,719	2,059,719	2,059,719	2,059,719
	Rent	128,000	131,200	134,480	137,842	141,288	144,820	148,441	152,152	155,956
Total Cost		3,467,719	3,486,919	3,506,599	3,526,771	3,547,447	3,568,641	3,590,364	3,612,630	3,635,453
Total Cashflow		2,932,281	3,073,081	3,217,401	3,365,329	3,516,955	3,672,372	3,831,674	3,994,959	4,162,326
Discounted Cashflow		2,665,710	2,539,736	2,417,281	2,298,565	2,183,752	2,072,958	1,966,255	1,863,678	1,765,233
ESPH Initial Investment Payback	$ 10,350,000	$ 7,684,290	$ 5,144,554	$ 2,727,273	$ 428,708					

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		7,992,723	8,192,541	8,397,355	8,607,288	8,822,471	9,043,032	9,269,108	9,500,836	9,738,357	9,981,816	10,231,361
Costs												
	O&M	640,000	640,000	640,000	640,000	640,000	640,000	640,000	640,000	640,000	640,000	640,000
	Labor	799,272	819,254	839,735	860,729	882,247	904,303	926,911	950,084	973,836	998,182	1,023,136
	Loan Payment	2,059,719	2,059,719	2,059,719	2,059,719	2,059,719	2,059,719					
	Rent	159,854	163,851	167,947	172,146	176,449	180,861	185,382	190,017	194,767	199,636	204,627
Total Cost		3,658,846	3,682,824	3,707,402	3,732,594	3,758,416	3,784,883	1,752,293	1,780,100	1,808,603	1,837,818	1,867,763
Total Cashflow		4,333,877	4,509,717	4,689,953	4,874,695	5,064,055	5,258,149	7,516,815	7,720,736	7,929,754	8,143,998	8,363,598
Discounted Cashflow		1,670,897	1,580,628	1,494,364	1,412,025	1,333,524	1,258,759	1,635,878	1,527,506	1,426,236	1,331,609	1,243,196

Total 20 Year Cashflow	$ 100,171,724
Total 20 Year Discounted Cashflow	$ 35,687,789

Appendix V - Analysis of Feasible 10.8 MW Wind Farm

V.1 Projected Annual Energy Production

Annual Energy Production Forecast for 1.8 MW Turbine Wind Farm Capacity: 10.8 MW			
	VESTAS V90/1.8 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	1800	8035	4987
February	1800	7258	4901
March	1780	7946	6362
April	1610	6955	6677
May	500	2232	4745
June	300	1296	5107
July	405	1808	4655
August	330	1473	4799
September	20	86	1625
October	110	491	2306
November	795	3434	4274
December	1770	7901	5020

Average 1.8 MW Calculated Production at 10.8 MW Wind Farm				
Power Rating	**Model**	**Annual Power Generation**	**Avg. Annual Power Generation**	**Variance (±)**
1.8 MW	VESTAS V90/1.8 MW (80 m)	55,459	**55,000**	

V.2 Projected Revenue

Wind Farm Capacity: 10.8 MW with 1.8 MW Turbines				
Initial Investment				
	ESPH investment	$ 9,342,000		
	15 Year Loan	$ 21,798,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 30,240,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 1,859,120		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	55,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 21,798,000			
1		$ 708,435	$ 1,150,685	$ 1,859,120
2	$ 20,647,315	$ 671,038	$ 1,188,083	$ 1,859,120
3	$ 19,459,232	$ 632,425	$ 1,226,695	$ 1,859,120
4	$ 18,232,536	$ 592,557	$ 1,266,563	$ 1,859,120
5	$ 16,965,973	$ 551,394	$ 1,307,726	$ 1,859,120
6	$ 15,658,247	$ 508,893	$ 1,350,227	$ 1,859,120
7	$ 14,308,020	$ 465,011	$ 1,394,110	$ 1,859,120
8	$ 12,913,910	$ 419,702	$ 1,439,418	$ 1,859,120
9	$ 11,474,491	$ 372,921	$ 1,486,199	$ 1,859,120
10	$ 9,988,292	$ 324,619	$ 1,534,501	$ 1,859,120
11	$ 8,453,791	$ 274,748	$ 1,584,372	$ 1,859,120
12	$ 6,869,419	$ 223,256	$ 1,635,864	$ 1,859,120
13	$ 5,233,554	$ 170,091	$ 1,689,030	$ 1,859,120
14	$ 3,544,524	$ 115,197	$ 1,743,923	$ 1,859,120
15	$ 1,800,601	$ 58,520	$ 1,800,601	$ 1,859,120
Total		$ 6,088,807	$ 21,798,000	$ 27,886,807

Wind Farm Capacity: 10.8 MW with 1.8 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		5,500,000	5,637,500	5,778,438	5,922,898	6,070,971	6,222,745	6,378,314	6,537,772	6,701,216
Costs										
	O&M	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000
	Labor	550,000	563,750	577,844	592,290	607,097	622,275	637,831	653,777	670,122
	Loan Payment	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120
	Rent	110,000	112,750	115,569	118,458	121,419	124,455	127,566	130,755	134,024
Total Cost		3,069,120	3,085,620	3,102,533	3,119,868	3,137,637	3,155,850	3,174,518	3,193,653	3,213,266
Total Cashflow		2,430,880	2,551,880	2,675,905	2,803,030	2,933,334	3,066,895	3,203,796	3,344,119	3,487,950
Discounted Cashflow		2,209,890	2,108,991	2,010,447	1,914,507	1,821,370	1,731,182	1,644,054	1,560,056	1,479,231

ESPH Initial Investment Payback	$ 9,342,000	$ 7,132,110	$ 5,023,118	$ 3,012,671	$ 1,098,164

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		6,868,746	7,040,465	7,216,477	7,396,889	7,581,811	7,771,356	7,965,640	8,164,781	8,368,900	8,578,123	8,792,576
Costs												
	O&M	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000	550,000
	Labor	686,875	704,046	721,648	739,689	758,181	777,136	796,564	816,478	836,890	857,812	879,258
	Loan Payment	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120	1,859,120					
	Rent	137,375	140,809	144,330	147,938	151,636	155,427	159,313	163,296	167,378	171,562	175,852
Total Cost		3,233,370	3,253,976	3,275,098	3,296,747	3,318,938	3,341,683	1,505,877	1,529,774	1,554,268	1,579,375	1,605,109
Total Cashflow		3,635,376	3,786,489	3,941,379	4,100,141	4,262,873	4,429,673	6,459,763	6,635,007	6,814,632	6,998,748	7,187,467
Discounted Cashflow		1,401,595	1,327,141	1,255,845	1,187,665	1,122,548	1,060,428	1,405,833	1,312,701	1,225,672	1,144,351	1,068,371

Total 20 Year Cashflow	$ 84,749,336
Total 20 Year Discounted Cashflow	$ 29,991,878

Appendix W - Analysis of Feasible 16 MW Wind Farm

W.1 Projected Annual Energy Production

Annual Energy Production Forecast for 2.0 MW Turbines
Wind Farm Capacity: 16 MW

	GAMESA G80/2 MW (60 m) Production (MWh)			VESTAS V80/2 MW (80 m) Production (MWh)			VESTAS V90/2.0 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected	Power generation per mean speed (kW)	Calculated	Corrected
January	2000	11904	7388	1996	11880	7374	2000	11904	7388
February	1900	10214	6898	1994	10720	7239	2000	10752	7261
March	1800	10714	8578	1900	11309	9055	1980	11785	9436
April	1300	7488	7189	1600	9216	8848	1650	9504	9124
May	300	1786	3796	430	2559	5441	500	2976	6327
June	150	864	3404	210	1210	4766	300	1728	6809
July	250	1488	3831	300	1786	4597	405	2411	6207
August	220	1309	4266	261	1553	5061	330	1964	6399
September	0	0	1625	44.1	254	1625	20	115	1625
October	50	298	2306	100	595	2306	110	655	2306
November	500	2880	3584	700	4032	5017	795	4579	5698
December	1100	6547	4160	1550	9226	5862	1770	10535	6694
Annual Production		55492	57026		64340	67191		68908	75274

Annual Energy Production Forecast for 2 MW Enercon Turbine
Wind Farm Capacity: 16 MW

	E-82/2.0 MW (80 m) Production (MWh)		
Months	Power generation per mean speed (kW)	Calculated	Corrected
January	2050	12202	7573
February	2050	11021	7443
March	2050	12202	9769
April	1820	10483	10064
May	510	3036	6454
June	255	1469	5788
July	470	2797	7203
August	321	1911	6224
September	82	472	1625
October	140	833	2306
November	850	4896	6092
December	1750	10416	6618
Annual production		71737	77159

Average 2.0 MW Calculated Production at 16 MW Wind Farm

Power Rating	Model	Annual Power Generation	Avg. Annual Power Generation	Variance (±)
2.0 MW	E-82/2.0 MW (80 m)	77,159	69,000	10,000
	GAMESA G80/2 MW (60 m)	57,026		
	VESTAS V80/2 MW (80 m)	67,191		
	VESTAS V90/2.0 MW (80 m)	75,274		

W.2 Projected Revenue

Wind Farm Capacity: 16 MW with 2.0 MW Turbines				
Initial Investment				
	ESPH investment	$ 13,710,000		
	15 Year Loan	$ 31,990,000	Interest Rate:	0.0325
Initial Cost				
	Construction			
	Wind Turbine Cost	$ 44,800,000		
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 2,728,382		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	69,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 31,990,000			
1		$ 1,039,675	$ 1,688,707	$ 2,728,382
2	$ 30,301,293	$ 984,792	$ 1,743,590	$ 2,728,382
3	$ 28,557,704	$ 928,125	$ 1,800,256	$ 2,728,382
4	$ 26,757,447	$ 869,617	$ 1,858,765	$ 2,728,382
5	$ 24,898,683	$ 809,207	$ 1,919,174	$ 2,728,382
6	$ 22,979,508	$ 746,834	$ 1,981,548	$ 2,728,382
7	$ 20,997,961	$ 682,434	$ 2,045,948	$ 2,728,382
8	$ 18,952,013	$ 615,940	$ 2,112,441	$ 2,728,382
9	$ 16,839,571	$ 547,286	$ 2,181,096	$ 2,728,382
10	$ 14,658,476	$ 476,400	$ 2,251,981	$ 2,728,382
11	$ 12,406,495	$ 403,211	$ 2,325,171	$ 2,728,382
12	$ 10,081,324	$ 327,643	$ 2,400,739	$ 2,728,382
13	$ 7,680,585	$ 249,619	$ 2,478,763	$ 2,728,382
14	$ 5,201,823	$ 169,059	$ 2,559,322	$ 2,728,382
15	$ 2,642,500	$ 85,881	$ 2,642,500	$ 2,728,382
Total		$ 8,935,725	$ 31,990,000	$ 40,925,725

Wind Farm Capacity: 16 MW with 2.0 MW Turbines
Cost Analysis and Payback Period

Year		1	2	3	4	5	6	7	8	9
Production (MWh)		69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		6,900,000	7,072,500	7,249,313	7,430,545	7,616,309	7,806,717	8,001,885	8,201,932	8,406,980
Costs										
	O&M	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000
	Labor	690,000	707,250	724,931	743,055	761,631	780,672	800,188	820,193	840,698
	Loan Payment	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382
	Rent	138,000	141,450	144,986	148,611	152,326	156,134	160,038	164,039	168,140
Total Cost		4,246,382	4,267,082	4,288,299	4,310,047	4,332,339	4,355,188	4,378,608	4,402,613	4,427,219
Total Cashflow		2,653,618	2,805,418	2,961,013	3,120,498	3,283,970	3,451,529	3,623,277	3,799,318	3,979,761
Discounted Cashflow		2,412,380	2,318,528	2,224,653	2,131,342	2,039,087	1,948,298	1,859,314	1,772,410	1,687,807
ESPH Initial Investment Payback	$ 13,710,000	$ 11,297,620	$ 8,979,092	$ 6,754,439	$ 4,623,097	$ 2,584,010	$ 635,711			

Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		8,617,154	8,832,583	9,053,398	9,279,733	9,511,726	9,749,519	9,993,257	10,243,089	10,499,166	10,761,645	11,030,686
Costs												
	O&M	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000	690,000
	Labor	861,715	883,258	905,340	927,973	951,173	974,952	999,326	1,024,309	1,049,917	1,076,165	1,103,069
	Loan Payment	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382	2,728,382					
	Rent	172,343	176,652	181,068	185,595	190,235	194,990	199,865	204,862	209,983	215,233	220,614
Total Cost		4,452,440	4,478,292	4,504,789	4,531,950	4,559,789	4,588,324	1,889,191	1,919,171	1,949,900	1,981,397	2,013,682
Total Cashflow		4,164,714	4,354,292	4,548,609	4,747,783	4,951,937	5,161,195	8,104,066	8,323,918	8,549,266	8,780,248	9,017,004
Discounted Cashflow		1,605,678	1,526,153	1,449,327	1,375,264	1,304,000	1,235,549	1,763,681	1,646,843	1,537,661	1,435,641	1,340,320

Total 20 Year Cashflow	$ 100,381,436
Total 20 Year Discounted Cashflow	$ 34,613,935

Appendix X - Analysis of Feasible 9.6 MW Wind Farm

X.1 Projected Annual Energy Production

	Annual Energy Production Forecast for 2.3 MW Enercon Turbines Wind Farm Capacity: 13.8 MW					
	E-70/2.3 MW (60 m) Production (MWh)			E-82/2.3 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	2250	10044	6234	2350	10490	6511
February	2180	8790	5936	2350	9475	6399
March	1930	8616	6898	2220	9910	7935
April	1400	6048	5806	1900	8208	7880
May	350	1562	3322	515	2299	4888
June	150	648	2553	250	1080	4256
July	245	1094	2816	380	1696	4368
August	210	937	3054	321	1433	4668
September	46	199	1625	82	354	1625
October	85	379	2306	135	603	2306
November	590	2549	3172	840	3629	4515
December	1400	6250	3971	1835	8191	5205
Annual production		**47115**	**47693**		**57369**	**60555**

	Annual Energy Production Forecast for Other 2.3 MW Turbine Wind Farm Capacity: 13.8 MW		
	Siemens SWT-2.3-82 VS/2.3 MW (80 m) Production (MWh)		
Months	**Power generation per mean speed (kW)**	**Calculated**	**Corrected**
January	2300	10267	6372
February	2300	9274	6263
March	2200	9821	7863
April	1980	8554	8212
May	500	2232	4745
June	285	1231	4851
July	420	1875	4827
August	400	1786	5817
September	10	43	1625
October	40	179	2306
November	950	4104	5107
December	1800	8035	5106
Annual Production		**57400**	**63095**

Average 2.3 MW Calculated Production at 13.8 MW Wind Farm				
Power Rating	**Model**	**Annual Power Generation**	**Avg. Annual Power Generation**	**Variance (±)**
2.3 MW	E-70/2.3 MW (60 m)	47,693	**57,000**	8,000
	E-82/2.3 MW (80 m)	60,555		
	Siemens SWT-2.3-82 VS (80 m)	63,095		

X.2 Projected Revenue

Wind Farm Capacity: 13.8 MW with 2.3 MW Turbines				
Initial Investment				
	ESPH investment	$ 11,862,000		
	15 Year Loan	$ 27,678,000	Interest Rate:	0.0325
Initial Cost				
	Construction	$ 38,640,000		
	Wind Turbine Cost			
	Legal Fees			
	Transmission Line	$ 900,000		
Costs Over Time				
	Operation and Maintenance	0.01	$/kWh	
	Labor Cost	10%	of revenue	
	Loan Payment	$ 2,360,617		
	Rate of Inflation	10%		
	Rent	2%	of revenue	
Revenue				
	Expected Price of Electricity	Varies by Year		
	Estimated Production of Proposed Site	57,000	MWh	
	Expected Rate of Inflation	10%		

	Loan Payment			
Year	**Balance**	**Interest**	**Amount Paid on Principal**	**Annual Payment**
0	$ 27,678,000			
1		$ 899,535	$ 1,461,082	$ 2,360,617
2	$ 26,216,918	$ 852,050	$ 1,508,567	$ 2,360,617
3	$ 24,708,350	$ 803,021	$ 1,557,596	$ 2,360,617
4	$ 23,150,754	$ 752,400	$ 1,608,218	$ 2,360,617
5	$ 21,542,536	$ 700,132	$ 1,660,485	$ 2,360,617
6	$ 19,882,052	$ 646,167	$ 1,714,451	$ 2,360,617
7	$ 18,167,601	$ 590,447	$ 1,770,170	$ 2,360,617
8	$ 16,397,431	$ 532,916	$ 1,827,701	$ 2,360,617
9	$ 14,569,730	$ 473,516	$ 1,887,101	$ 2,360,617
10	$ 12,682,629	$ 412,185	$ 1,948,432	$ 2,360,617
11	$ 10,734,197	$ 348,861	$ 2,011,756	$ 2,360,617
12	$ 8,722,441	$ 283,479	$ 2,077,138	$ 2,360,617
13	$ 6,645,303	$ 215,972	$ 2,144,645	$ 2,360,617
14	$ 4,500,658	$ 146,271	$ 2,214,346	$ 2,360,617
15	$ 2,286,312	$ 74,305	$ 2,286,312	$ 2,360,617
Total		$ 7,731,260	$ 27,678,000	$ 35,409,260

Wind Farm Capacity: 13.8 MW with 2.3 MW Turbines
Cost Analysis and Payback Period

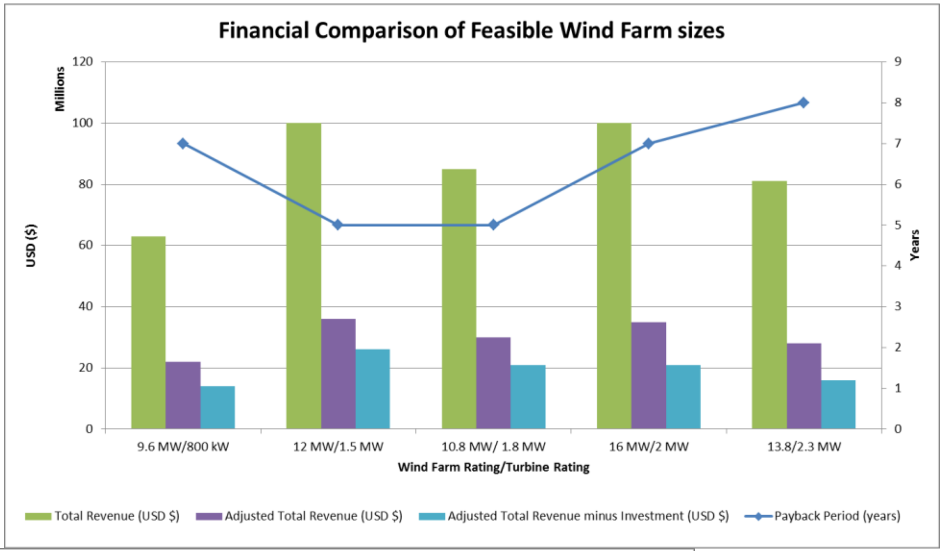
Year		1	2	3	4	5	6	7	8	9
Production (MWh)		57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000
Revenue										
	Price of Electricity (per kWh)	0.100	0.103	0.105	0.108	0.110	0.113	0.116	0.119	0.122
Total Revenue		5,700,000	5,842,500	5,988,563	6,138,277	6,291,733	6,449,027	6,610,252	6,775,509	6,944,897
Costs										
	O&M	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000
	Labor	570,000	584,250	598,856	613,828	629,173	644,903	661,025	677,551	694,490
	Loan Payment	2,360,617	2,360,617	2,360,617	2,360,617	2,360,617	2,360,617	2,360,617	2,360,617	2,360,617
	Rent	114,000	116,850	119,771	122,766	125,835	128,981	132,205	135,510	138,898
Total Cost		3,614,617	3,631,717	3,649,245	3,667,210	3,685,625	3,704,501	3,723,848	3,743,678	3,764,005
Total Cashflow		2,085,383	2,210,783	2,339,318	2,471,066	2,606,108	2,744,526	2,886,405	3,031,830	3,180,892
Discounted Cashflow		1,895,802	1,827,093	1,757,564	1,687,771	1,618,188	1,549,214	1,481,182	1,414,371	1,349,009
ESPH Initial Investment Payback	$ 11,862,000	$ 9,966,198	$ 8,139,104	$ 6,381,540	$ 4,693,769	$ 3,075,581	$ 1,526,367	$ 45,185		

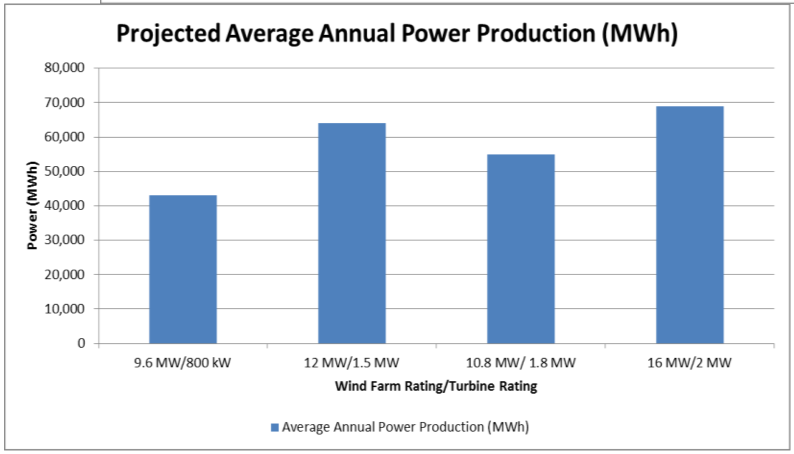
Year		10	11	12	13	14	15	16	17	18	19	20
Production (MWh)		57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000	57,000
Revenue												
	Price of Electricity (per kWh)	0.125	0.128	0.131	0.134	0.138	0.141	0.145	0.148	0.152	0.156	0.160
Total Revenue		7,118,519	7,296,482	7,478,894	7,665,866	7,857,513	8,053,951	8,255,300	8,461,682	8,673,224	8,890,055	9,112,306
Costs												
	O&M	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000
	Labor	711,852	729,648	747,889	766,587	785,751	805,395	825,530	846,168	867,322	889,005	911,231
	Loan Payment	2,360,617	2,360,617	2,360,617	2,360,617	2,360,617	2,360,617					
	Rent	142,370	145,930	149,578	153,317	157,150	161,079	165,106	169,234	173,464	177,801	182,246
Total Cost		3,784,840	3,806,195	3,828,085	3,850,521	3,873,519	3,897,091	1,560,636	1,585,402	1,610,787	1,636,807	1,663,477
Total Cashflow		3,333,679	3,490,287	3,650,809	3,815,345	3,983,994	4,156,859	6,694,664	6,876,280	7,062,437	7,253,248	7,448,829
Discounted Cashflow		1,285,278	1,223,324	1,163,260	1,105,170	1,049,110	995,119	1,456,954	1,360,435	1,270,241	1,185,964	1,107,221

Total 20 Year Cashflow	$ 81,322,743
Total 20 Year Discounted Cashflow	$ 27,782,271

Appendix Y – Summary of Feasible Wind Farms

	Feasible Wind Farm Power Rating/Turbine Power Rating Comparison				
	9.6 MW/800 kW	12 MW/1.5 MW	10.8 MW/ 1.8 MW	16 MW/2 MW	13.8/2.3 MW
Average Annual Power Production (MWh)	43,000	64,000	55,000	69,000	57,000
Payback Period (years)	7	5	5	7	8
Total Revenue (USD $)	63,000,000	100,000,000	85,000,000	100,000,000	81,000,000
Adjusted Total Revenue (USD $)	22,000,000	36,000,000	30,000,000	35,000,000	28,000,000
Adjusted Total Revenue minus Investment (USD $)	14,000,000	26,000,000	21,000,000	21,000,000	16,000,000


Financial Comparison of Feasible Wind Farm sizes
Millions
USD ($)
Years
120
100
80
60
40
20
0
9
8
7
6
5
4
3
2
1
0
9.6 MW/800 kW
12 MW/1.5 MW
10.8 MW/ 1.8 MW
16 MW/2 MW
13.8/2.3 MW
Wind Farm Rating/Turbine Rating
Total Revenue (USD $)
Adjusted Total Revenue (USD $)
Adjusted Total Revenue minus Investment (USD $)
Payback Period (years)


Projected Average Annual Power Production (MWh)
Power (MWh)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
9.6 MW/800 kW
12 MW/1.5 MW
10.8 MW/ 1.8 MW
16 MW/2 MW
Wind Farm Rating/Turbine Rating
Average Annual Power Production (MWh)

Appendix Z – Anatomy of a Wind Turbine

There are five main components in wind turbines: the rotor blades, gearbox, generator, control system and tower. A detailed diagram of the turbine components is shown in the figure below.

The blades are the components that convert kinetic energy from the wind to the kinetic energy of the rotor that is used for generating power. Wind turbines usually come with 3 blades because there is no need for a counterweight, which is usually used to stabilize the system. Wind turbine blades can weigh up to 7 tons (Grande, 2009). The weight of the blades should be taken into consideration since it is important that the blades are not too heavy and are aerodynamic enough to be able to withstand different wind speeds and different weather considerations (Vaughn Nelson, 2009).

The generator of the turbine is the transducer that performs the conversion from kinetic energy to electrical energy. Magnets within the generator housing are rotated by the shaft. Due to the change of magnetic field in the generator housing as the magnets rotate, an induced voltage appears on a stator - which is usually a static coil that is connected to electric circuits (Mathur & Wagner, 2009). This is how electricity is produced in a turbine.

The gearbox is another very important component. It is placed between the main shaft that turns slowly with the rotor blades, and the secondary shaft, which turns very fast at around 1000 to 1500 revolutions per minute. The secondary shaft leads to the generator. The gearbox's main purpose is to increase the rotational speed of the secondary shaft. If the turbine did not have a gearbox, then the generator would be rotating at the same speed as the blades. This would mean that the turbine would need more magnets in the generator to create the same amount of electrical energy as a turbine with a gearbox. In the current wind turbine market, there are models available that don't have a gearbox. Although turbines with gearboxes often end up aging more quickly, those without them are expensive due to the costs of magnetic poles (Mathur & Wagner, 2009).

It is important that the wind farm delivers a voltage that can be transferred to the local electricity grid with the same phase shift and frequency. Synchronous generators sometimes have additional networks that convert voltages of various frequencies into the one that the electric grid uses. When the voltage being produced by the wind farm is too large, it will not be connected directly to the electricity grid of smaller communities, since they would need electricity at a low voltage. Through the use of a transformer, the voltage from the grid can be lowered in order to meet the demand of local communities (Manwell, McGowen, & Rogers, 2002).

When the wind speeds are very high and the generated power is higher than the rated power of a turbine, the wind turbine will break down. There are two ways to ensure that very high wind speeds will not destroy a wind turbine. One of the common solutions is to have a turbine that can vary the pitch angle of the blades. Pitch angle is the angle at which the blades meet the wind. That angle is constant between all the blades. When the wind speeds begin to be high enough that there is a possibility of damage to the turbine, the pitch angle will be increased, causing the wind turbine to generate less power and prevent the turbine from being damaged. If under all pitch angles, the generated power is higher than rated power, then wind turbine should be turned off. There are special brakes inside the turbine that can stop the rotor blades. The control system of the turbine is what sets the pitch angle according to wind speed, and decides whether to apply the brakes (Vaughn Nelson, 2009).

Finally, the tower is the part of a wind turbine on which other components are placed, including the blades, gearbox and generator. As mentioned previously, height determines wind speed; therefore, usually the greater the tower height, the higher the wind speed (Mathur & Wagner, 2009).