Engineering Management
Field Project

Residential Wind Power

By

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An EMGT Field Project report submitted to the Engineering Management Program
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Acronyms and/or Abbreviations

EIA – U.S. Energy Information Administration

AWEA – American Wind Energy Association

PCEC – Platte Clay Electric Cooperative

OPEC - Organization of the Petroleum Exporting Countries

HELOC - home equity line of credit

kwh/mth – kilowatt hours per month

ROI – Return on Investment

OECD - Organization for Economic Cooperation and Development

Acknowledgements

Special thanks to Russ Denney at Platte Clay Electric for providing insight into a local Electrical Cooperative and their policies surrounding residential wind power. Denney was vital to providing information that led to many topics within this report.

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Also, a thank you is warranted to Zach Taylor at LouCo Industries in Smithville, MO. Taylor provided multiple conversations and documentation in which the technology was discussed at length. Different applications of the products were discussed along with financial considerations, tax advisement, zoning regulations, and power company implications.

A special thanks to the engineering experts that contributed to this paper including Herb Tuttle, John Conard, Kyle Hart, and Shad Brouillette.

1. Introduction

1.1 Purpose of this Field Project

This research study will explore the use of residential wind power and associated engineering and environmental issues. There is various wind power generating devices available to the consumer. The study will discuss the dependencies of human lifestyles on the production of power and the impacts on daily lives. The information presented will give the reader a better understanding of the process of selecting an alternative energy source, while considering the positive and negative environmental impacts of the usage of wind power.

The research will also explore the considerations for investing in residential wind power. Research will be presented examining the financing availability for installing a wind turbine system. Also, findings of federal tax benefits available for installing a wind turbine system will be presented.

Much consideration will be given to the potential location of the installation of the residential wind turbine system. Information will be presented on installation, maintenance, cost analysis, and the future of power generation within the United States. Also discussed is the rising cost of energy and the political ramifications of dependency on foreign countries for power generation.

Finally, the usage of residential wind power in a crisis situation will be explored. The review of this material will give the reader a better understanding of all the benefits and drawbacks of a residential wind power system, the future of wind power generation, and whether or not investment consideration is right for their situation.

1.2 Nature of Problem

In today's world, electric power is vital to everything. Without power, modern society is quickly vaulted back in time. Lifestyles are very dependent upon something that is invisible and that is taken for granted. Today, the slightest inconvenience of a power outage due to a storm as short lived as a couple of hours, impacts many lives.

Very few people in the United States go through half of their day without some dependency on a power source. It could be power generation by oil, electrical power, natural gas, or even solar power. Dependencies go unrecognized, un-thought of, or more typically ignored and left to the experts. Much press is given to any type of oil crisis that raises crude oil prices hampering the price at the pump or commodity production and transportation. Many people do not even take the time to think about the impact to daily life that power and changes within the market play on their lives. When one wakes up in the morning it is often to an alarm clock powered by a municipal, investor-owned or area electrical cooperative. Hot showers are often heated by an electric source, natural gas or propane source. Then people unplug their rechargeable battery powered cell phones and flip on their electrical coffee makers while grabbing

nourishment from an electric powered refrigerator. Very little consideration is given to the power burnt to harvest the coffee and bake the bread consumed.

People convene their daily lives generally through a transportation source. Many leave lights powered up on their way out the door. Almost no consideration is given to the amount of fuel needed to fire up the car. Some people will leave it running for 10-20 minutes to cool or heat the car. Often, the only attention consumers give energy is when the quick station pump rolls $3-$5 per gallon racking up a $50 to $100 bill. No consideration is generally given to the electrical power source of the station, the heat in the winter time, etc. The most thought given is when the check is written for the fuel bill.

The media gives a lot of attention to the significant speculation within the oil industry. There is also attention given to power outages due to crisis, natural events, political posturing on energy dependence, etc. More recently there is intense media coverage of nuclear power generation and the potential drawbacks in the case of catastrophe.

According to Linda Dorman with the U.S. Energy Information Administration, ‘world marketed energy consumptions grows by 53 percent from 2008 to 2035’ (Dorman, 2011). This is a significant increase in energy consumption across the world that will need new sources to supply power. Figure 1 below illustrates the expected growing demand that will be put on power infrastructure in the future. This will require new sources of energy in the future which will preferably be clean solutions.

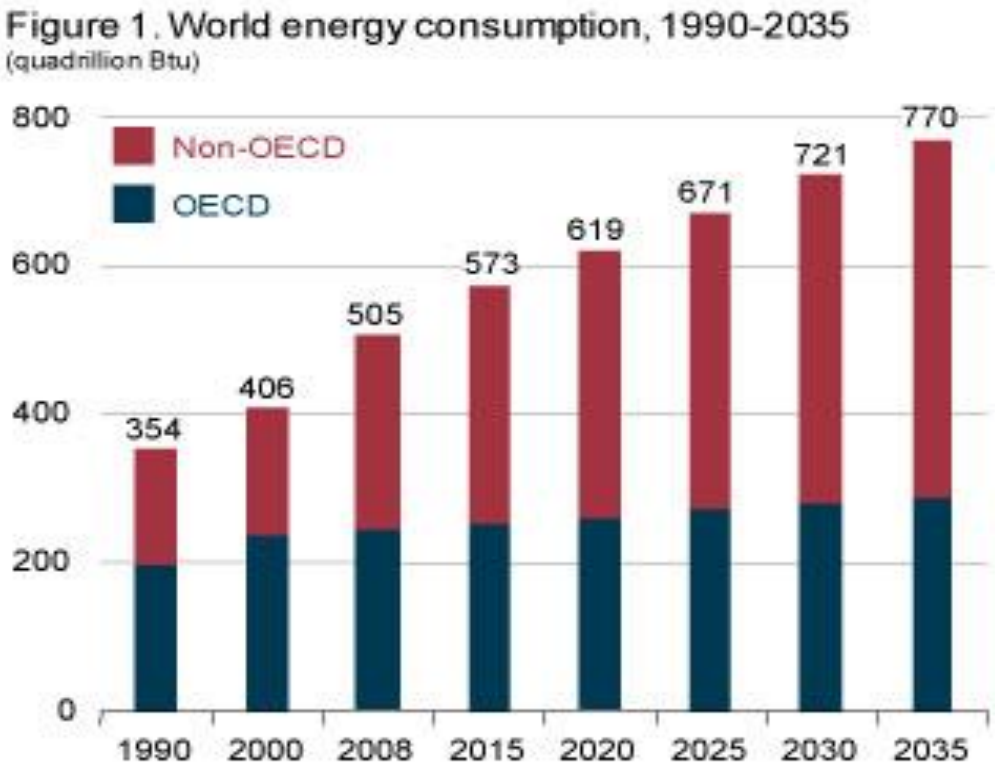

Figure 1 World energy consumption *EIA, 2011*

All this leads back to one thing – 'dependency'. The American society is a dependent one. The United States is dependent on foreign oil to build infrastructure, produce food, travel, heat/cool, etc. Citizens of the United States are dependent on the government to keep the electrical power grid up and running and oil prices down to a sustainable level. Very little consideration is given to how fragile the American society is and how vulnerable that way of life is given these dependencies. This paper proposes just one potential solution to help alleviate the dependency. Residential wind power is not a solution, but a small stepping stone to consider in breaking the chain of dependencies.

1.3 Methodology of Investigation

While considering methods of investigation for writing this report, much consideration was given to the power needed to produce this consolidated information. Volunteering in the field during installation of one of these devices was vital to the understanding of the device. A few fictional novels referenced drove the author to consider many ‘what if’ scenarios that helped shape this report. Non-fiction books also played a role in providing information through investigation.

Over the course of many months, attention was paid to several news articles and media stories that referenced power dependencies shaping this report. The political landscape and policies of Washington DC had an impact on how this report was written. Speeches by politicians and news publication opinions drive a desire to move away from dependencies on a power infrastructure that has several single points of failure. All of the attention given to green energy resources speaks to the importance of alternative energy sources such as residential wind power. Reducing dependencies on susceptible power grids through residential wind power is an extremely important avenue to a green future.

Another method of investigation included discussions with service providers of residential wind power devices. Information provided by manufactures of various devices and their capabilities proved vital. Interviews with these installation experts as well as contacts within local power cooperatives provided input and opinion. All of these items helped produce results important to the reader and consumers of electricity.

2. Literature Review

2.1 Introduction to the Researched Materials

Energy is a topic that dominates our lives and how one lives in today's world. Residential electrical power is instrumental to how people enjoy their personal lives. Electrical power is consumed at increasing levels year after year. As our country becomes increasingly populated, additional homes are built each year. Builders and consumers alike are looking for more efficient ways to reduce energy consumption. Concurrently, consumers are continuing to increase utilization of products that drive the need for more energy. Residential wind power research is the proposed alternative avenue to provide or supplement the need for energy in an economical manner.

Many of the trends published about residential wind power are in support of the 'Green' initiative. There are also publications on the concerns associated with the United States power grid and the vulnerabilities thereof. Most of what is published has been found to be from a pro-'Green' perspective. The pro-'Green' bias in the majority of the available research materials brought caution to the study to be observed in this research.

The ‘Green’ initiative itself is a welcome idea in American society. Wind power is an alternative that has been proven to provide energy in a very clean form. Because wind power is a relatively new form of energy, the longevity of the data supporting or refuting its benefit is not yet available. Also, because residential wind power is in its infancy stages, the technology is not as mature as other methods of energy production.

Cost is a very important factor to investing in the residential wind power technology. The high cost of energy has driven the marketplace to look for alternative sources of energy for the homestead. The cost of energy has risen year after year. The consumption of energy has also increased in the majority of households due to the modern conveniences that most households enjoy today. Any alternative should be analyzed against the costs of the current energy provider. Most of the materials available on residential wind power do not do a thorough analysis of the comparative costs. Rather, comparative analysis is a gap that is missing in most of the research materials available.

The desire for American households to use abundant energy is at the core of the success of capitalism. American households are built upon the philosophy of ‘work hard, play hard’. This requires energy. While the environment should always be a huge consideration, any alternative to existing energy consumption should be evaluated on capitalistic values. New energy products, such as wind power, must be a cost effective solution to the problem of producing abundant clean energy. If it

is not cost effective, people will not and should not use it. Once an alternative is developed, such as wind power, consumers will use it abundantly.

In the literature research it became imperative to characterize the main themes found. The purpose for each piece of literature researched has fallen into one of three categories:

1. Power in case of crisis
2. Green energy initiative
3. Reducing energy consumption

It should be noted that it was very difficult to find detailed literature clearly showing the cost effectiveness of the alternative of residential wind power. Most of the literature research reviewed is redundantly driving home the point of cleaner energy and reducing energy consumption. Because of this redundant bias of most publications available, some literature is not included in the scope of this literature review.

2.2 The Research

A major contributor in the desire to research this topic was driven from a fictional novel that gave a disastrous view into the electrical energy dependence of American society. The novel “One Second After” by William Forstchen was an eye opening

fictional novel that explored a ‘what if’ scenario that exposed the fragile nature of US citizens’ dependency on the electrical power grid in the United States. (Forstchen, 2009)

Forstchen explores a scenario of crisis in which the United States is attacked on multiple coasts by an Electronic Magnetic Pulse (EMP) device that takes out most electro-mechanical devices including the United States power grid. The novel explores all the dependencies on power in the United States. Soon following the outage there is a shortage in food. There is a rationing of medical supplies. The characters in the novel include a family in which one of the children is an insulin dependent diabetic. The novel explores how the lifestyles retreat quickly to a pre-19th century level. This book inspires the preparation for crisis and the need to reduce energy dependency. The author invokes a need for preparedness for crisis into the reader.

There are many news articles (see reference section) that add information to the viability of a residential wind power solution as a way to reduce consumer dependency. In the research for this project it was found that there is a wide range of belief in the viability of wind power as a solution in the future. Many of those authors have offered opinions and there have been many facts presented as well.

The research has found that articles and publications presented by the American Wind Energy Association (AWEA) to be very useful. These articles can be found at

renewableenergyworld.com. The AWEA has a lot of useful information on alternative energy sources. The AWEA produces many case studies in which there is abundant wind power to incorporate as a source to the US power grid. It is a conclusion of the AWEA that wind power is a viable, clean alternative to existing power plants in the future. The AWEA has an objective of communicating this opportunity to the consumer by providing information on the viability of wind power.

Positive information on the wind power solution is readily available to a seeking consumer. Ian Woofenden provides a lot of information on where consumers can get their first blush view into the industry in his book “Wind Power for Dummies”. Woofenden provides guidance for installing and maintaining a wind power device at your home. This book gives you as step by step guide and all the considerations to determine if residential wind power is right for a specific consumer. (Woofenden, 2009)

This book covers multiple areas such as basic understanding of the concepts of using wind power. It also goes into detail on how to find a good contractor to do the installation. There is information provided on how to tie into the existing power grid and potentially sell power back to the local power company. Woofenden also gets into the costs and financing of a wind power solution along with local zoning considerations. The author is very biased towards wind power for the future and does not discuss the long term pay back that proves the solution financially viable. (Woofenden, 2009)

There are examples of individuals who have dedicated considerable effort into reducing home power consumption. One 'Green fanatic', Jim Martin, discusses how "over the past 15 years my family has been living 100% off the grid with only solar power and wind generator" (Martin, 2011). Martin discusses multiple techniques for living a more 'Green' lifestyle. Martin leverages multiple methods for reducing power consumption reduction such as better insulation, solar power, wind power, battery, etc. Martin fails to provide a cost analysis on what was spent on his green initiative in comparison to leveraging the existing power grid.

After reviewing some of the high level articles published, the author spent time researching the environment and capabilities of wind power. Evelyn Royer discusses harnessing wind power for multiple applications in EcoHome (Royer, 2011). Royer introduces the SkyStream product and its application at homes in rural Texas. The article also emphasizes tax incentives and the application of wind turbines as the future of mainstream power production. Royer briefly discusses the regions of the US that are better suited for wind power. Once again there was not a real cost comparison between wind power and existing methods of power production.

Reviewing the products for residential use the author found one manufacturer that dominates the market. The SkyStream system by Southwest Wind Power served as a great source on products and services available (2011). Southwest Wind Power is

a viable company that has managed to become profitable installing residential and small business wind power products. The website and documentation readily available by the company serves as very good information on the viability of wind power.

Southwest is very up front on the costs and the expectations of their products. Southwest also provides videos to teach the consumer how the product works and what exactly to expect from installation, maintenance and costs associated. Southwest has multiple business partners throughout the US that performs installation of their products. The website also does an equitable job of providing cost information and information on tax incentives. Overall, the company and their documentation present very legitimate and honest facts. The one item you cannot find is an overall breakdown in costs in comparison to existing power suppliers.

Chris Webb with the AWEA discusses the market around wind power in an article the AWEA published in March 2011. Webb focuses on the advancements in residential wind energy over the last several years and touches on what to expect in the future. Webb also points to the SkyStream product as an industry leader. Webb's information focuses more on the marketplace and the companies that will be manufacturing wind turbines in the future and the ones that have had success in the past. Webb's literature points to the growing market for residential wind power and gives hope for a stronger manufacturing capability that will hopefully advance the technology and drive the initial costs of the devices down. This would give hope for

a financially viable product in the future, but falls short of producing evidence of a modern cost effective product (Webb, 2011).

Home use wind power technology has been advancing over the last several years. Jennifer Claerr offers additional analysis of products and services available for the home in her extensive article ‘Small Wind Turbines for the Home’ (Claerr, 2011). The literature provided by Claerr readily presents that residential wind power is not right for every situation. The article discusses considerations that should factor into making the investment in wind power. The cost of installing a wind turbine is briefly discussed in the article without a lot of comparative background information.

There are a few not so positive reviews on wind power production. In addition to the aforementioned authors’ work, Eric Bibler provides a good first blush look in a New York Times article on wind turbines (Bibler, 2011). Bibler discusses facts around wind energy and debunks several fallacies. Bibler points out many issues with wind power as an alternative to the existing power grid. His article also chastises many publications that provide half-truths to the viability of wind power. Bibler describes wind power as ‘unreliable, and unpredictable’.

2.1 Research Conclusion

The articles aforementioned suggest insight into the viability of wind power in comparison to traditional methods of power production for a home residence. The

AWEA provides great insight into the current state of wind power as an alternative solution to existing power plants. Southwest wind power is a great company that is working to advance the technology of residential wind power. There are many publications and books available on the viability of residential wind power. For every negative publication on wind power, one can find at least 10 positive articles. There is an abundance of information available on the topic to persuade the market to invest in residential wind power.

Research has concluded that there are very few publications on the limitations of residential wind power. Eric Bibler does an excellent job of pointing out some of these limitations in his article (Bibler, 2011). The passion of the 'Green Initiative' and the universally accepted notion of limiting power consumption have driven the unbalanced availability of all encompassing information available. The bottom line is that any investment needs to be evaluated for viability, both financially and environmentally.

Excessive energy consumption contributing to environmental consequences and dependency factors are the key drivers to finding an alternative solution to power production. An environmentally friendly, home based solution with limited dependencies is just what the market needs. The key problem with home based solutions is the amount of energy that is actually produced for the amount of money invested.

Research has shown that there is not readily available clear research on the cost viability of residential wind power. Although, costs and incentives are generally discussed, there is not a clear comparison against existing home power solutions. The drive to have cleaner energy and reduce consumption by 'less than clean' methods (such as nuclear and coal burning power plants) has muddied the viability of new solutions such as residential wind power. The bottom line is that once an alternative energy resource is available to produce power in a cleaner, more effective way than existing methods, the market will explode with demand.

3. Wind Power in the Midwestern US

3.1 Commercial Wind Power Farms

If a person were to drive through rural Iowa one would recognize huge space-aged windmills that generate power to the power grid of the United States. These are huge devices that stretch across the plains as far as the eye can see. From afar, one would not recognize the massive size of these devices.

Figure 2 Wind Generators in Iowa – 1 *AWEA, 2008*

Figure 3 Wind Generators in Iowa -2 *AWEA, 2009*

The massive sizes of these non-residential devices devour the landscape of the area. They symbolize the vision of a futuristic place and time. Concerns about climate change and air quality have driven the United States to consider alternative power sources. Figures 1 and 2 illustrate an example of these commercial power sources. Iowa is not the only state with wind power farms. Several other states produce power through wind (Figure 4, Table 1).

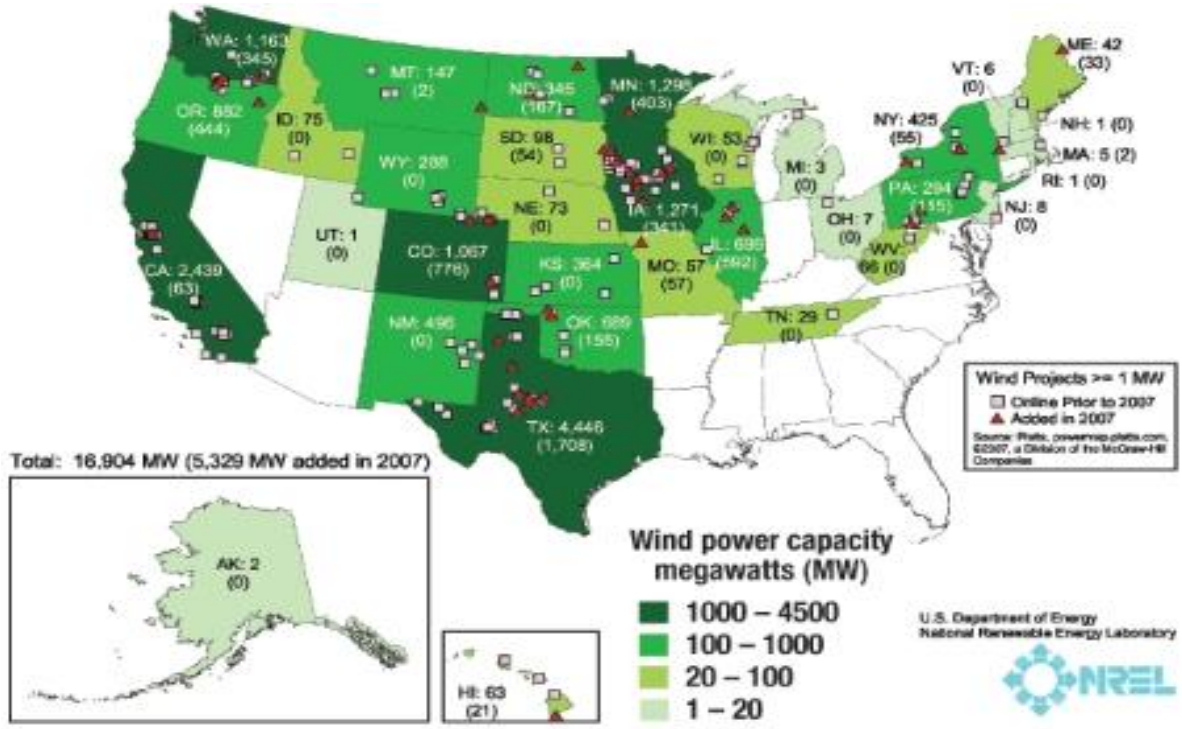

Figure 4 - State Wind Power Capacity (AWEA, 2007)

UNITED STATES WIND POWER RANKINGS: THE TOP 20 STATES

Incremental capacity (2007, MW)		Cumulative capacity (end of 2007, MW)		Estimated percentage of in-state generation	
Texas	1708	Texas	4446	Minnesota	7.5%
Colorado	776	California	2439	Iowa	7.5%
Illinois	592	Minnesota	1298	Colorado	6.1%
Oregon	444	Iowa	1271	South Dakota	6.0%
Minnesota	403	Washington	1183	Oregon	4.4%
Washington	345	Colorado	1087	New Mexico	4.0%
Iowa	341	Oregon	882	North Dakota	3.8%
North Dakota	167	Illinois	699	Oklahoma	3.0%
Oklahoma	155	Oklahoma	689	Texas	3.0%
Pennsylvania	115	New Mexico	496	Washington	2.8%
California	63	New York	425	California	2.8%
Missouri	57	Kansas	364	Kansas	2.3%
New York	55	North Dakota	345	Hawaii	2.3%
South Dakota	54	Pennsylvania	294	Montana	1.9%
Maine	33	Wyoming	288	Wyoming	1.7%
Hawaii	21	Montana	147	Idaho	1.5%
Massachusetts	2	South Dakota	98	Illinois	0.8%
Montana	2	Idaho	75	Maine	0.8%
		Nebraska	73	New York	0.7%
		West Virginia	68	Nebraska	0.7%
Rest of US	0	Rest of US	277	Rest of US	0.05%
TOTAL	**5329**	**TOTAL**	**16,904**	**TOTAL**	**1.1%**

Source: AWEA project database, EIA, Berkeley Lab estimates

Table 1 - United States Wind Power Rankings (AWEA, 2007)

Wind Power is becoming an increasing part of everyday life. Commercial wind power farms are contributing more to the power grid all the time. Wind power is definitely a driving contributor to a clean air future.

However, there are environmental concerns with wind power that engineers are encountering. First, residents of the area are often concerned about the impact to the landscape by these massive wind generators. Many people do not like the way the wind generators dominate the landscape. They fight the visual effects and the potential impact to property values. Modern towers are extremely tall and can range from 200 to 400 feet from tip to rotor. These towers are installed in locations that are most visible to catch as much wind as possible to generate maximum power.

The huge wind generators have an impact on local wildlife as well. Geese often fly into the rotors creating many deaths. According to the National Wind Watch Organization, other birds and bats are also impacted depending on the location of the devices. It is common now that an engineer must plan for a study on the local and migratory wildlife to assess the impact on that wildlife. Insects are also in consideration for being negatively impacted by these commercial wind farms (Craighansford). Although very few studies have been done to this point, Craighansford points out that honey bees are potentially impacted by the constant vibrations of the large turbines. Noise pollution has been another concern identified for the large wind turbine farms.

These environmental factors have been isolated to large wind farms. There have been very few environmental factors mentioned above that are of concern for residential wind turbines.

3.2 Residential Wind Power Solutions

The main purpose of this paper is to apply the implementation of a wind power solution at a small-scale local level. Many considerations should be given when investigating purchasing a residential wind power solution. How does the local power provider account for power pushed back to the grid? Is there a good location to install a wind turbine system? What are the zoning regulations for installation? Is wind power the best solution? What are the other alternatives? All of these questions are addressed through the research.

The Technology

As the industry evolves, there are many manufacturers addressing residential wind power. One product that is very prevalent, and a pioneer within the industry, is SkyStream 3.7 produced by Southwest Wind Power. (skystream.com, 2011) This product can range in price based on installation and size of the tower on which the wind turbine is mounted. This device has sold more to date that any other product. It is also rated number one in the industry by Timothy Hurst with CleanTechnica.com. (Hurst, 2008) Details on pricing considerations will be discussed in later sections of this publication.

Arguably the most critical determining factor is the amount of wind in the location of installation. Wind issues can somewhat be adjusted by the size of the tower to alleviate any wind blockage. Yet, some areas just do not provide much wind to make a device worth the installation. There are wind maps available online for research provided by many private and government agencies. Figure 5 below gives a view of average wind power estimates across the United States.

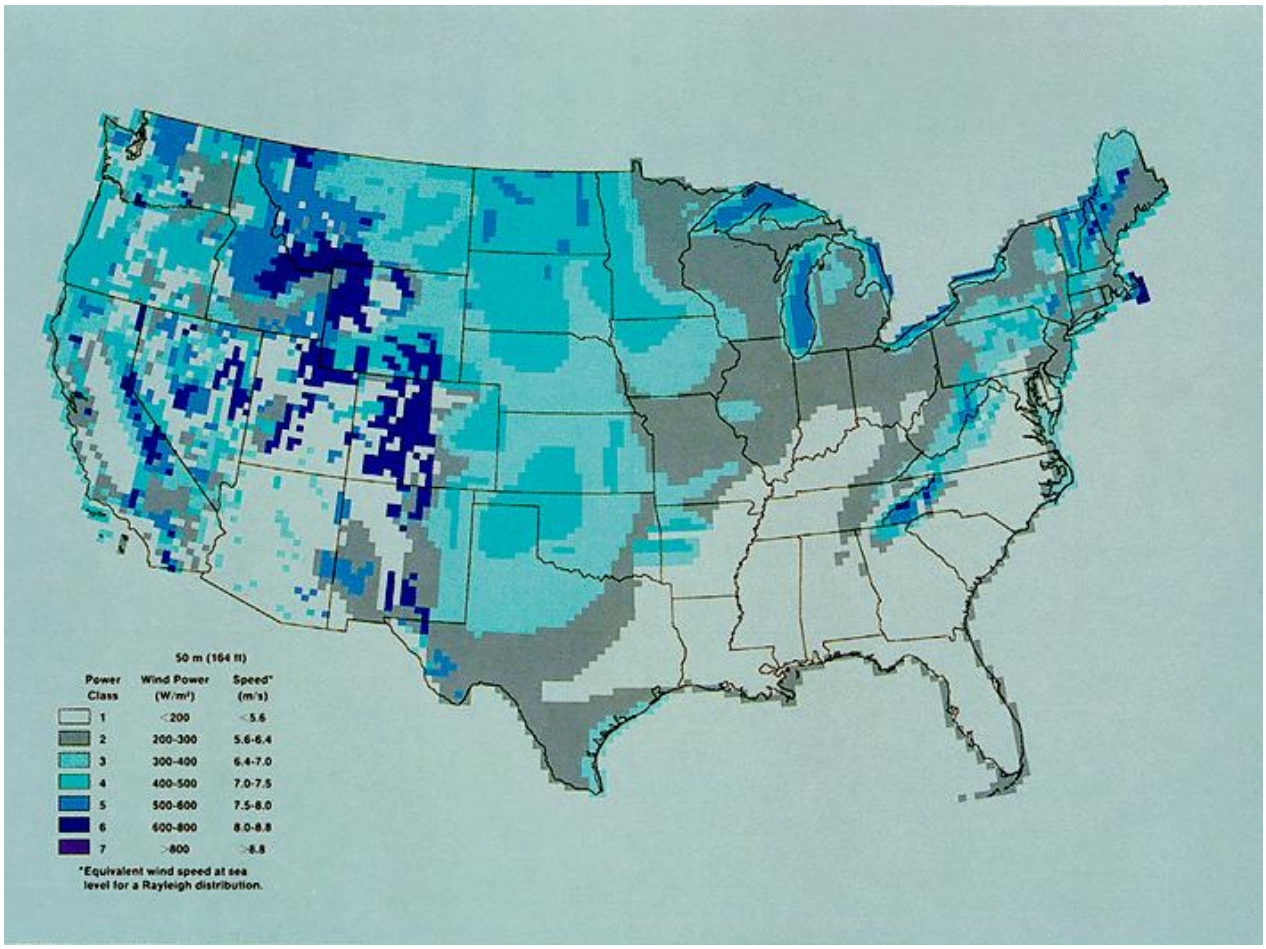

Figure 5 - Annual average wind resource estimates in the contiguous United States (http://rredc.nrel.gov, 2011)

There are a few key items to consider when determining if wind turbine power is a good investment. First, it must be determined if zoning regulations will allow the device in the planned location. Many installers of the product have information about zoning restrictions in the desired location. Most installers will work with the zoning officials to make this determination.

In an interview with a local installer, an installer of Southwest Wind Products, zoning regulations were discussed in great detail. The installers of Southwest Wind Products (such as SkyStream) are required by the parent company to be very knowledgeable of

existing zoning regulations. The installers and the parent company take complete responsibility of complying with the zoning laws and explain in detail any intricacies of each installation. Contact information of the local zoning office is provided for the customer to insure the proper procedures are being followed.

Southwest Wind Power and the local installer were gracious enough to provide references to me of existing customers on the condition of anonymity of any publication of findings. There are actually several installations already completed near Kansas City, MO. Research surveyed 7 installation sites, 5 of which were provided by Southwest Wind Power partners. The other 2 were visual locations witnessed within the Kansas City area.

Consistent findings at each of the locations surveyed were rural homes valued at $250K+. Overall, the consumers surveyed were generally happy with their investment. All individuals were very insistent that preserving the environment was their main motivation for leveraging residential wind power. Secondarily was the potential to use the device in a time of crisis. Interestingly enough, only 2 of the 7 were equipped with battery backup that would actually allow for efficient usage in time of crises.

None of the consumers surveyed could provide tracking for the cost effectiveness of the device. The average amount that the users suggested that was saved was approximately 20% reduction in their energy consumption. These individuals all hinted

at the fact that savings would not recoup their investment for some time. Most pointed at the 15-20 year break-even point.

This long payback period also does not account for the time value of money, which would make the break-even point even further out from installation. It was the general consensus of the interviewed individuals that money was not the main factor in their investment decision, rather the environment took priority. This was an astonishing finding. Although, it is great that this sample of clientele had the means to invest in wind power, financially there was not a strong case for doing so. One would even question if the extremely small reduction in power consumption was worth the investment costs.

Figures 5 and 6 below provide a visual view of one of the industry's most popular devices (SkyStream). Figure 6 gives a view of the main components of the SkyStream product. Note that the material used is very simplistic, yet built to last. Figure 7 displays the expected scenery of a device in a typical location.

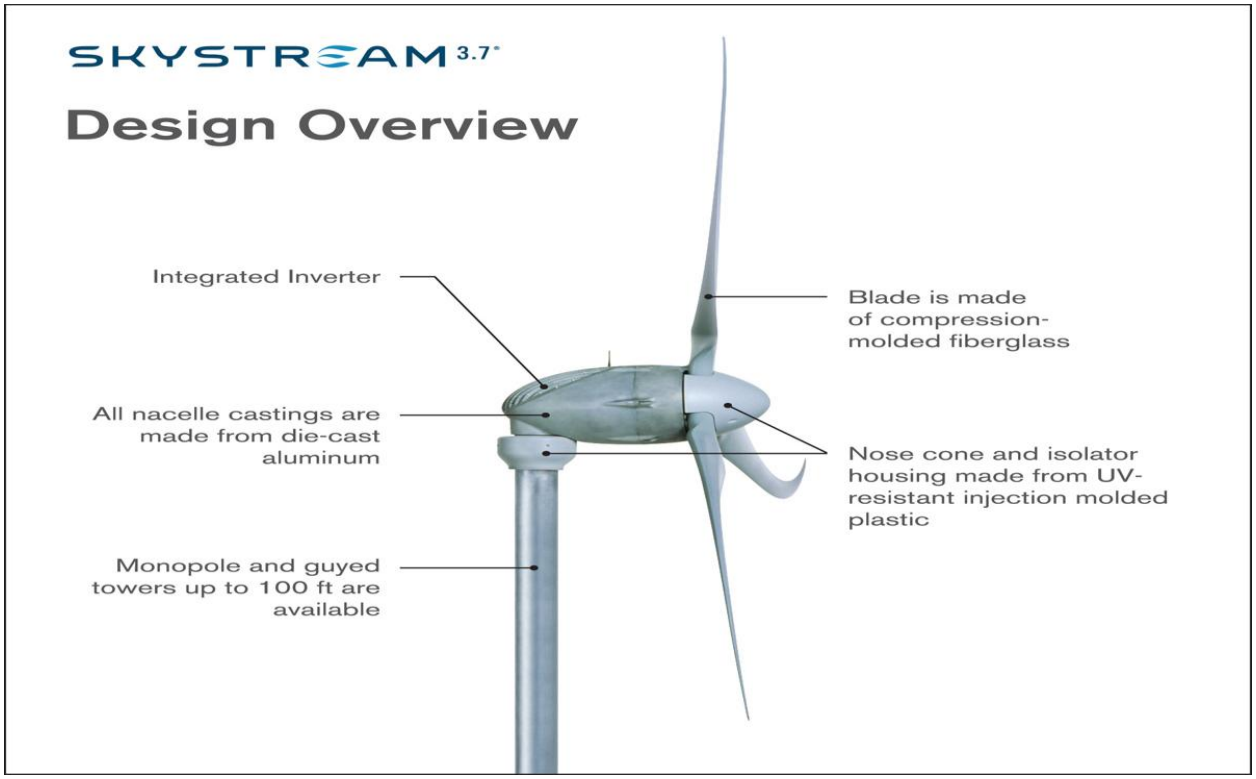

Figure 6 - SkyStream Design Overview (Skystream.com, 2011)

Figure 7 - SkyStream in Action (Skystream.com, 2011)

The wind maps, size, and view will give a consumer insight on the viability of their location for a wind turbine. With the amount of investment involved, detailed attention should be paid to the anticipated power production by the wind turbine. There are devices that can be placed in the desired location that can measure average wind speed over a period of time. Many of the installation experts will explore multiple solutions for green power production with the homeowner.

Functioning of Residential Wind Generators

The device operates by driving an electric generator by air currents passing through the blades on the tower. The faster the turbine turns the more energy produced. The power produced is directly sent to the main power line of the residence. The power replaces or supplements the existing power supply from the local power grid. Figure 8 below does not include the ability to store any power in a battery backup. If there is additional power produced by SkyStream, it will be sent back to the electric grid provided the local generating company is setup to receive distributed energy. More often the product will just slow the turning of the home's meter on the existing electric grid.

There are multiple products and price ranges of products that are available. This effort focused on the SkyStream 3.7 because the market share and costs associated with this product makes it the most popular in the residential industry.

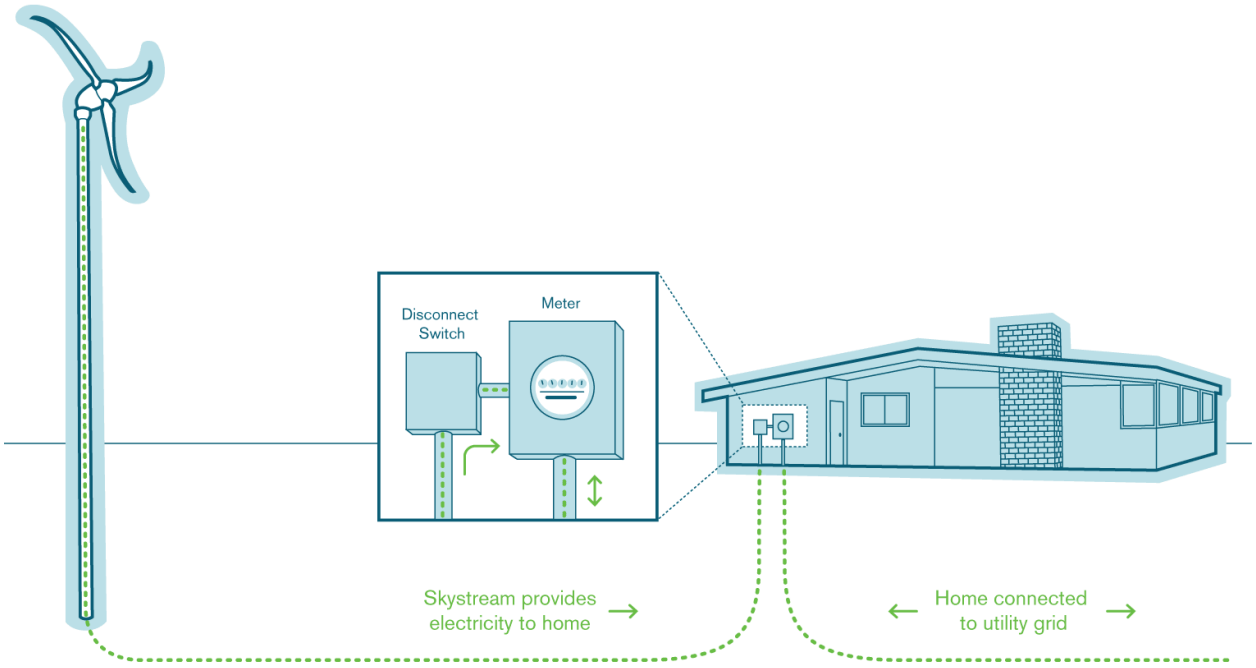

Figure 8 - How SkyStream works (Skystream.com, 2011)

SkyStream 3.7 Specifications	
Energy Potential	Up to 400 kWh/month*
Rated Capacity	2.4 kW
Weight	205 lbs (93 kg)
Rotor Diameter	12 ft (3.72 m) Swept Area: 115.7 ft² (10.87 m²)
Type	Downwind rotor with stall-regulation control
Direction of Rotation	Clockwise looking upwind
Blade Material	Fiberglass reinforced composite
Number of Blades	3
Rated Speed	50-325 rpm
Tip Speed	213 ft/sec. (66 m/s)
Alternator	Slotless permanent magnet brushless
Yaw Control	Passive
Grid Feeding	Southwest Windpower inverter 120/240 VAC 50-60 Hz
Braking System	Electronic stall regulation with redundant relay switch control
Cut-in Wind Speed (power production starts)	8 mph (3.5 m/s)
Rated Wind Speed	29 mph (13 m/s)
User Control	Wireless 2-way interface remote system
Survival Wind Speed	140 mph (63 m/s)

Table 2 - SkyStream 3.7 Specifications (Skystream.com, 2011)

**Based on preliminary data measured at 12 mph average annual wind speeds. Actual output will vary based on site conditions & tower heights.*

Technical Details

Table 2 displays technical specifications of the SkyStream 3.7 product. As you can see, this product is expected to produce up to 400 kWh/month. The height of the system is variable to get the maximum wind power. The unit is made of reinforced fiberglass composite, aluminum and plastic. The entire unit weighs approximately 200 lbs. The unit itself will survive winds up to 140 mph before potential damage. The user can control the unit by way of a 2 way wireless radio interface.

Installation and Maintenance

The installation of a residential wind turbine is generally completed by an installation expert. The determination of the best possible location is made by the installer. There are multiple sizes of towers that are available to the consumer. Each tower height is considered to get the most possible wind through the system and to comply with local zoning laws. In some cases a roof top system is also a possibility.

Wind turbines such as the SkyStream 2.4 KW require almost no maintenance. There are few moving parts and sealed bearings provide longevity according to the manufacturer. Standard systems carry a warranty of 5 years, yet the term of life for the unit should easily exceed that warranty. A is advised to occasionally check the unit from the ground for any noise. There should also be no vibration coming from the

product. The consumer can also visually inspect the device to determine if the blades are turning with the wind.

Most products in this line also provide software that will monitor the output of the device. A user can monitor the usage to determine the actual value of the system, as well as any operational problems or maintenance requirements.

Location of Installation

Wind maps can be found through a dealer or research online. There are devices that may also be purchased to closely measure average wind speed over a period of time. This can be used to calculate the effectiveness of a device and any seasonal variations in the wind direction and speed. Again, zoning laws will need to be considered when determining the location on a given property.

Environmental Impacts

Small turbine systems used in residential location have little impact on the local wildlife. It is possible that a small bird could be hindered by the device. This should be considered when installing the device along with the device height. The blades on most standard systems have a 6 foot radius and 115 square feet in swept area. Studies completed have shown that initially wildlife is not a major issue with the SkyStream

device. This is more of a consideration for large wind turbine farms that have multiple units covering a much larger ‘swept area’ over a landscape.

Another environmental impact to consider is visibility on the landscape. Often zoning laws take into account this potential impact. There are a low percentage of people that may consider the devices ‘eye sores’. Some people do not like the appearance of the product on the landscape. In some areas local zoning laws are being revised to deal with wind turbine devices. Most of the devices are positively looked upon due to the environmental advantages. Yet, each location has its own zoning laws that must be observed and accounted for.

The most important environmental impact is the ability to produce power off of the earth’s natural resource that is most always there and available. Wind is a great source of power. It is extremely clean and efficient. Using this natural resource can take the stress off of the already strained electrical grid. Reduction in the amount of coal and nuclear generated power provides a positive impact to the environment. Any source of energy that can eliminate side effects such as storing nuclear waste and putting any type of pollutant into the air is a positive step in the right direction.

The overall relief to the strain on the grid by using residential wind power will likely only make a small impact. Many family homes are not well suited for wind power. Owners of the prime locations may not necessarily have the money to invest. Also, the return on investment has not proven an immediate driver to increase demand for the turbine.

Yet, as green minded consumers, society should continue to look for small ways to help the environment. Every small contribution helps. There is no smoking gun alleviating the pressure on the grid. Most power sources today have a 'side effect' associated with it. Wind power has one of the cleanest, sustaining usages with the least amount of side effects.

3.3 An Investment in Residential Wind Power

Consumers must look into all options available when investigating a residential wind power solution. There are many options to save on power within a home. Conscious power usage is a great place to start. So, when considering investment options, one should first do a self check on their practices within their home.

Efficiently consuming power is the key consideration prior to making an investment. Generating power cleanly and efficiently is great. Yet, making the most of the power upon usage is vital. High efficiency heating and cooling is often a good investment as well. In some cases, it can bring a better return on investment. Other items to consider are investments in the appropriate siding, roofing, insulation and other materials used in the construction of one's home. In interviews with safety inspector at Platte Clay Electrical Cooperative (PCEC), many of these considerations are better options for solutions than alternative power sources. Denney says, "Often a home is losing 30% of its heating and cooling through older, inefficient windows." (Denney, 2011) This is roughly equivalent to the amount of power produced by the aforementioned SkyStream system.

Most power companies offer a home inspection that assists in power usage. Often power companies or heating and cooling contractors will offer a free of charge 'blow test'. The blow test will determine air leaks and inefficient insulation within the home. Many of these lower cost solutions should first be implemented by a savvy home owner. Once all of these items are implemented, then a home owner could look into power generation.

Rising Costs of Energy

The rising cost of energy should be a concern to everyone in the United States. The cost of fuel for a car is making many people reconsider their energy consumption. The market should also be a concern to consumers. The United States has a tremendous amount of dependency on foreign oil. With the lack of drilling in the United States over the last few decades, the US imports most of its oil. The United States is 1st in the world in oil importing. China is a distant but increasing second. This dependency is often funding many terrorist friendly nations throughout the rest of the world. The lack of oil production in the US is a fine balancing act between economic, environmental and national security.

The economic ball that is being juggled has a huge impact on daily life. It is a simple case of supply and demand. With the reduced supply of oil and natural gas that could be produced by US companies, the higher the demand and price for consumption of

these resources. Setting the price tag and supply and demand aside, the lack of producing at home in the United States has an impact on job creation. The more this production occurs within the United States, more jobs are created which has a reciprocal positive impact on the economy.

The economic ramifications must be carefully balanced with the environment impacts. Oil drilling had been relatively safe for several years. The most recent BP oil spill in the gulf has brought up even more concerns with potential environmental impacts. The actual drilling of crude oil is one potential hazard to the environment. Another consideration must be given to the side effects of air pollution. Gas and diesel engines generate gases that are not 'green friendly'. Therefore a constant political battle is waged between the impacts of producing more oil versus the economic balance of day-to-day green lifestyles.

If all the economic and environmental battles were not enough, forethought must be given to any dollars paid for importing crude energy. Often the countries that are producing the most oil, and OPEC itself, are suspect to having direct ties with terrorist groups. The last thing the United States should do is forego production in the United States only to improve economies of foreign countries which harbor terrorists.

Another recently identified alternative energy source driving energy costs is the production of ethanol. The use of ethanol by vehicles has been pushed upon society over the last ten years. Unfortunately, this has not proven to be a good alternative to

crude oil. Ethanol is mostly supported by Midwest corn growth. This has reduced the amount of exported corn and raised the price of corn. This has resulted in starvation in different parts of the world and the increased price in commodities. Not only that, but the amount of energy used to run diesel machinery to harvest the raw materials (corn) all but completely eliminates the benefit of energy savings through ethanol production.

Nuclear power plants have also been a huge consideration in the power industry. Nuclear energy has become safer over the last several years. Initially there was a huge concern for safety surrounding nuclear power plants. That concern had subsided greatly over the last several years but has peaked again due to the tsunami in Japan which caused at least a partial meltdown of the Fukushima Dai-ichi nuclear power plant. Coal has always been a suspect power due to the contaminants released into the air. Coal also uses diesel power to transport. Another item to consider is the lives of the people who work in coal mining communities and the danger of the work itself.

Overall, the rising cost of energy is felt throughout all walks of life. Whether it is through the production of oil to fuel vehicles, nuclear power from power plants, or coal burning; the cost is constantly rising. Low energy costs correlates directly with pricing and economic stability. Therefore, wind, as an alternative fuel source should be explored.

Tax Benefits of Residential Wind Power

The government has instituted many tax benefits for those who seek ‘green’ solutions. The US government has provided a ‘Cash for Clunkers’ program to get fuel-inefficient vehicles off the road. Incentives for energy saving solutions such as high efficiency heating and cooling units, windows and doors, etc. have been commonplace in the market.

More recently, the Federal government has offered tax benefits for installing residential wind power devices. For most standard devices similar to the SkyStream system discussed, there is a 30% tax credit for taking advantage of this solution. This initial incentive is from the federal government. There are also some states that have jumped on the bandwagon to help support the production of wind power within their borders by way of tax incentives. For example, Iowa is giving a cash back credit of $.25 - $.75 per kWh x turbine's estimated first year output. With the SkyStream product averaging 300 kWh per month, the cash back savings is $900-$2700 per year.

Financing Availability of Residential Wind Power Solutions

There are multiple financing avenues a homeowner can work through. Most installers have bank financing offered through the selling process. Financing on these devices is very reasonable with the current federal interest rate. Many individuals can leverage a HELOC (home equity line of credit) for this work. This allows users to leverage tax advantages of a home equity loan and gain favorable interest rates.

3.4 Residential Wind Power in Crisis Scenarios

Many of the lower cost solutions discussed in this article in relation to wind power do very little to help in a crisis situation. The SkyStream turbine only works to supplement a power grid. Battery backup systems, while available, are substantially more expensive. Forstchen points out the vulnerabilities that this nation faces in the event of a prolonged power outage in his novel (2009). Individuals should be more prepared to deal with power outage potentials in a crisis.

Overall, through research, today's wind power solution does not provide a viable backup to prolonged power outages. It is more of a solution to supplement the existing grid and reduce energy usage by unclean methods. Further exploration would need to be done to prepare for a crisis similar to the Forstchen novel.

4. Analysis/Interpretation of Data

Data has been collected around the value of wind turbine devices as an alternative energy source in the United States. Wind turbine devices are becoming more prevalent on a large scale for business use and even home use. This document focuses purely on residential use and the impact to the environment.

4.1 Compilation/combination of data

Wind turbine dealers have sold almost 100,000 residential units since 1980. In 2009 the turbine market swelled 15% despite the economic slump, according to the American Wind Energy Association (AWEA). The market boom, buoyed by growing interest in alternative energy, is a direct result of federal tax credits worth 30% of wind-harvesting costs (Royer, 2011).

Given a determination that a desired location will produce an average wind speed of at least 11mph, the financial analysis below should be considered. A lower cost residential system discussed above was the SkyStream system.

SkyStream 2.4 KW

*** Average Energy Produced - 300 kwh/mth*

*** Average cost of kwh in US* $0.12

SkyStream 2.4 KW	
Average 11mph wind speed	
Price	$17,000.00
Fed. Tax Credit- (30%)	$5,100.00
Net Cost	$11,900.00
Average US kwh	$0.12
Energy Produced- 300 kwh/mth	$36.00
Return on Investment (per year)	**3.6%**
Break Even - Years	27.55

Based on original investment of $11,900

Future Value of initial investment at 4%, based on Break Even year **$35,055.19**

Proven 6 KW

*** Average Energy Produced - 1000 kwh/mth*

Proven 6 KW	
Average 12 mph wind speed	
Price	$59,000.00
Fed. Tax Credit- (30%)	$17,700.00
Net Cost	$41,300.00
Average US kwh	$0.12
Energy Produced- 1000 kwh/mth	$120.00
Return on Investment (per year)	**3.5%**
Break Even - Years	28.68

Based on original investment of $41,300

Future Value of initial investment at 4%, based on Break Even year **$127,196.65**

Bergey 10 KW

*** Average Energy Produced - 1300 kwh/mth*

Bergey 10 KW	
Average 12 mph wind speed	
Price	$65,000.00
Fed. Tax Credit- (30%)	$19,500.00
Net Cost	$45,500.00
Average US kwh	$0.12
Energy Produced- 1300 kwh/mth	$120.00
Return on Investment (per year)	**3.2%**
Break Even - Years	31.60

Based on original investment of $45,500

Future Value of initial investment at 4%, based on Break Even year **$157,114.98**

4.2. Statistics and Analysis

Of the home owners surveyed, all went with the lower cost SkyStream system. The initial costs for this system are more reasonable. The findings led to the fact that most dealers do a good job in determining the value of the system in advance. Between the dealers and the savvy consumers researched, most knew details on their investment and its consequences.

Most users do a thorough job of researching their investment. Five of seven consumers analyzed, installed the product with a new house construction. In these seven cases all were energy conscious in the development of their home. Most of the market consumers for these devices are higher end homes with monthly energy consumption averaging 1500-2000 kwh/mth. With the SkyStream system, most consumers were getting average wind speeds between 11-15 mph. Therefore the average energy outputs of these systems are 350 kwh/mth. This accounts for 17-23% of the home's energy use on average.

With the smaller system being the most likely purchase for home owners, the unit eventually pays for itself. As shown above, under average circumstances, it takes 27 years to pay for the SkyStream product. This is not taking into account the time value of money. More importantly, this is a step in the right direction towards a clean energy solution for the environment.

4.3 Rejection of specific data

It was a rare occasion to find an individual actually ‘selling’ power back to the power grid. Some advertisements actually make this a selling point and it is basically false. The products available to consumers today will never replace the local power grid. Systems that are available today will only supplement grid power. The higher end systems will supplement a larger share of a house’s energy needs. Unfortunately, the costs of these systems are not currently viable when investigating the return on investment (ROI).

The costs of these systems must greatly decrease in order to become attractive to more consumers. They will not replace the existing power grid. The battery backup technology is not advanced enough at this time to warrant investment in most situations. The battery is usually not capable of sustaining a household in the event of wind speeds less than 11 mph.

4.4 Gap Analysis

More research should be completed on products for the future and the costs associated. One of the biggest providers (Southwest Wind Power) does not have much information for public use on how the costs of these solutions will reduce over time. Units appear to be greatly over-priced when considering the cost of raw materials required in production.

To make an informed investment decision, the consumer should close this gap by investigating the trends for the price of installing these systems. Currently, it is on a downward spiral. If some of the higher end solutions were available in the less than $20K range, the market would likely soar. Unfortunately, with only a few manufacturers of these devices, costs remain high while technology and market competition stalls.

All this has a huge role to play on the impact to the environment. Until there are producers creating these solutions in a low cost way, it is likely only 'green' extremists will invest in these devices. The ROI just doesn't make fiscal sense. At the rate these devices are being installed due to the current technology and price, the residential systems make an extremely small impact on power consumption. Again, every little bit helps the environment.

Summary

Energy is a topic on everyone's mind in today's society. This research is a view of one small facet of energy production and the instigating factors that drive society to look towards alternative energy sources. Energy is a hot topic on network newscasts almost daily over the last few years. This has driven many consumers to start looking into reducing their consumption of expensive energy or potentially leverage products to produce their own.

Residential wind power devices are one of many energy generation solutions beginning to become more prevalent in the marketplace today. This document explores the need

for energy generation solutions. It also explores the options in wind power generation. More importantly, the environmental impacts of energy generation in respects to wind power are discussed.

The cost viability of self-generation of energy through wind power is an interesting topic throughout the market today. Many consumers are becoming more and more energy conscious with the increasing cost of energy. Another driving factor is the sheer growth of the ‘green’ movement in today’s society.

The environment is a huge driving factor in the way companies do business today. Many champion the ‘green’ effort in everyday business. Others lag way behind. Consumers are leveraging products that attach to the green movement. Wind power generation is one of these alternatives for the future. There are several different environmental impacts to consider with wind energy generation. Wind power is a clean, viable, eco-friendly resource that companies and consumers could capitalize on in the near future.

Conclusion

The results of this study were extremely powerful in understanding the energy challenges the United States faces in the upcoming years. The US has huge energy concerns that the people and the government need to take head on. Policy must take into account a fine balance of environmental and economical impacts of energy consumption.

Residential wind power is only one small facet of that huge challenge. There are many sources of power production out there for residential consumers. More important than power generation, it is the author's finding that conservative power consumption should first be implemented. US citizens should invest in technology that removes dependencies from foreign power sources.

Government regulation should only provide incentives to improve the technologies available to its people. Strict guidelines should be enforced to ensure the appropriate level of risk to the environment. Yet, with that said, companies should be encouraged to produce energy and energy saving/generating solutions to consumers at a competitive market price. If companies cannot be profitable doing this in a capitalistic society, it will never happen. In the near term, policies should allow industry to open the dams on energy production. Concurrently, regulation should require a percentage of profits to go towards research of clean energy production. Policy should reward those in the industry who develop these techniques.

Residential wind power has only a small niche in today's market. It is approaching the tipping point to where it may become a viable product. The costs need to decrease or the benefits need to increase. It simply does not produce enough power to counter the current price in the products available today. The risk versus reward will continue to keep most consumers away from these products as an alternative energy producing solution.

Those who purchase the product today are more likely doing it for environmental reasons rather than cost efficiency. With the long break-even period in the area of 17 years, it just is not a great investment at this time. The only countering argument to purchasing the wind power solution is the small positive effect is has on the environment.

There are multiple other devices that are entering the market which will become more prevalent in the upcoming years. Along with wind power, solar power is a reasonable alternative. Above all, this research has driven a need to focus on limiting consumption rather than self generation.

Keep in mind everyone needs to do their part. Whether it is through reduced consumption or clean, self generation; the environment must always be a strong consideration factor in energy usage. All citizens of the world should be considerate of the environment left behind for future generations.

Suggestions for Additional Work

Additional work would be beneficial into the area of zoning restrictions for wind power. This focus would have to be specific to a location of the author's choice. The cost / benefit analysis is key to rather or not consumers are willing to invest in this 'green' market. Zoning regulations are vital to this effort.

Because most of the solutions discussed by the author are to supplement the existing electrical grid, in addition to zoning, how the local power supply company accommodates the consumer is also very vital. Some electrical providers offer different rates for power pushed back to the grid. Most utility companies subtract out operating costs of the grid. Detailed analysis on how providers work with consumers on this issue is a big part of the cost / benefit analysis that could be investigated further.

There are many new devices available for research that provided information on the green effort. Some of these technologies, including solar power, would have served residential solutions in a way that wind power cannot. Other devices could potentially be solutions for assisting the environment where wind power is not a legitimate solution. Depending on the location of the device, zoning, etc., there are many different options that should be explored. The costs of other devices had a large range and differentiated greatly from the wind turbines.

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