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What Factors Influence Wind Perceptions

Masters of Science at Rochester Institute of Technology

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Abstract:

Over the last decade, wind power has emerged as a possible source of energy and has attracted the attention of homeowners and policy makers worldwide. Many technological hurdles have been overcome in the last few years that make this technology feasible and economical. The United States has added more wind power than any other type of electric generation in 2012. Depending on the location, wind resources have shown to have the potential to offer 20% of the nation's electricity; a single, large wind turbine has the capacity to produce enough electricity to power 350 homes. Throughout the development of wind turbines, however, energy companies have seen significant public opposition towards the tall white structures.

The purpose of this research was to measure peoples' perceptions on wind turbine development throughout their growth, from proposal to existing phase. Participants were asked an array of questions regarding their perception on economic, environmental, and social impacts of wind turbines with an online service called Amazon Mechanical Turk.

I concluded that participants were favorable towards wind turbine development and would be supportive of using the technology in their community. The responses were from residents living in the United States and required them to provide their zip code for subsequent analysis. Political affiliation and proximity to the nearest wind turbine in any phase of development (proposal, construction, existing) were also analyzed to determine if they had an effect on a person's overall perception on wind turbines and their technology. From the analysis, political affiliation was seen to be an indirect factor to understanding favorability towards wind turbines; the more liberal you are, the more supportive you will be towards renewable energy use. Proximity, however, was found to not make a significant difference throughout the analysis, suggesting that exposure to wind turbines in any stage of development does not decrease a person's favorable perception towards wind turbines. Results also showed that those who found wind technology to be reliable, are twice as likely to have an overall positive and want to implement them into their communities. Socio-economic implications were also seen within the research suggesting those who believe wind turbines will benefit their local community will be more favorable towards their development in their community.

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Chapter 1

Introduction

As we enter the twenty-first century, we as a people must start thinking about the future of our world and its environment. Within the last ten years, the Department of Energy has recognized the importance of renewable energy sources and sees them as a great solution for “diversifying income, improving environmental quality and rural economic development” (Wind Powering America, 2010). The United States government is constantly working on improving our alternative energy options by giving tax incentives to those using and researching renewable energy, as well as enforcing different Clean Energy Acts to reduce greenhouse gas emissions by specific deadlines. The American Clean Energy and Security Act requires a 17% emissions reduction of carbon dioxide, methane, and other greenhouse gasses from major U.S. sources by 2020, for example (American Clean Energy and Security Act, 2009).

Renewable Portfolio Standards, commonly known as RPS, are policies designed to reduce greenhouse gas emissions and further increase generation of electricity from renewable resources. These policies can be implemented on a state level and are used to reduce harmful emissions within a given timeframe. Not only does this standard require states to participate in generating energy from renewables, it also provides incentives for smaller companies to participate in renewable energy production. In New York, for example, the RPS requires 29% renewable energy generation by 2015 (American Wind Energy Association, 2013). This act has not only helped increase the number of wind farms throughout the state of New York but it has also given communities a chance to learn and partake in building small wind turbines. In 2013, the government decided to expand the American Recovery and Reinvestment Act (2009) for small wind turbines, allowing consumers to take 30% of the total cost of a small wind system as a tax credit (AWEA, 2013).

At the beginning stages of renewable energy technology, the government created incentive plans like the Renewable Electricity Production Tax Credit which credited back 1.5 c/kWh of electricity produced. Today, however, 2.2c/kWh is credited for electricity produced by wind power (Department of Taxation and Finance, 2012). The wind industry, in response, has brought in \$20 billion annually in private investment (AWEA, 2013).

Although wind generation may not be as cost effective as natural gas, it is still a growing technology that can help reduce greenhouse gas emissions. “Compared to natural gas, which emits between 0.6 and 2 pounds of carbon dioxide equivalent per kilowatt-hour (CO₂E/kWh), and coal, which emits between 1.4 and 3.6 CO₂E/kWh, wind only emits 0.02 to 0.04 pounds of CO₂E/kWh, solar 0.07 to 0.2, geothermal 0.1 to 0.2, and hydroelectric between 0.1 and 0.5” (IPCC,2011). Wind turbines can also be used in both large and small scale, providing the industry with a practical edge. They can be used for personal use, for example at a school, or industrial application, like at a wind farm.

Public Opposition

This growth of wind turbine construction does not have the support of all U.S. citizens. Throughout the deployment of wind farms, there has been an increase in opposition that has caused energy companies to work harder to obtain approval from the community. Some common drawbacks to wind turbines are the aesthetics: people think they are ugly and turn the landscape into something that can no longer be appreciated for its natural beauty. People also believe wind turbines produce noise that can potentially cause stress and depression to homeowners. In a study conducted in Northeastern British Columbia, a homeowner living near the Bear Mountain Windpark claimed that his blood pressure went up immediately after the turbines were installed, while his wife and daughter both began to suffer from depression (CBC News, 2012). The Journal of Noise and Health also found comparable cases while conducting a study in a small town of Maine. The researchers concluded that “roughly half of the individuals were categorized as being at risk for clinical depression- compared to only seven per cent of people living further than three kilometers away” (Nissenbaum *et al*, 2012). The research suggested that the current regulations on building wind farms are “to be insufficient to adequately protect the human population living close to them” (Nissenbaum *et al*, 2012). However, this type of distress towards wind turbines was also seen to not be “medically recognized” (Kloor, 2013). Researchers Crichton *et al*. “found that the power of suggestions can induce symptoms associated with wind turbines” (Kloor, 2013). After exposing 100 participants to either 10 minutes of infrasound and 10 minutes of sham infrasound and then presenting audiovisual information, they concluded that “psychological expectations could explain the link between wind turbine exposure and health complaints” (Crichton *et al*, 2013).

Wind turbines have also been known to kill migratory birds. Migratory birds, which are a federal trust resource managed by the U.S. Fish and Wildlife Service, travel low enough for towers, power lines and wind turbines to be a fatality (Department of Energy, 2013). “The Department of Interior strongly supports renewable energy, including wind development, but the Service wants to ensure that they are bird-,bat- and habitat friendly” (Manville, 2005). The Service estimates an annual mortality of 58,000 birds, which is relatively small, compared to other tower structures (Manville, 2005). The issue lies, however, when wind turbines are constructed around the nesting of endangered species like the Golden and Bald Eagles (Manville, 2005). It is essential for wind energy companies to be in contact with the nearest Ecological Services Field Office during the proposal phase prior to approving the build. The United States Fish and Wildlife Service have set up many user friendly resources at www.fws.gov/windenergy that discuss wind energy technology. The organization has set up a “Fact Sheet: Final Voluntary Land-Based Wind Energy Guidelines” that allows a developer to learn all necessary facts about using wind energy on their property (Fish and Wildlife Service, 2013). Engineers have also headed back to the basics of wind turbines and designed the “vertical-axis” turbine which can help reduce the number of wildlife deaths.

Public Agreement

Despite the barriers for wind deployment, the benefits allow for the technology to be seen as a competitive source for energy production. For starters, wind energy causes no harmful emissions. According to the AWEA, a “single residential-scale turbine displaces the carbon dioxide produced by 1.5 average cars” (AWEA, 2012). 100 MW of this installed capacity translates to 17,000 cars removed from the road, 12,000 homes powered with electricity, or 101,000 tons of CO₂ displaced per year (AWEA, 2012). The land the turbine is placed on can still be used for agricultural purposes, which could make wind turbines more favorable. Also, unlike coalmines, once the project has been abandoned the land can inexpensively be returned to its previous condition.

Along with no CO₂ production, wind turbines create jobs. According to AWEA, 80,000 Americans are currently employed in the wind power industry and related fields (AWEA, 2013). These jobs consist of manufacturing, project development, operation, and maintenance, all of which are skilled labor. All types of engineers are also needed for the design process such as civil, electrical, and even health and safety engineers. Not only do they create job opportunities,

they also promote education on alternative energy and wind production (James *et al*, 2013). Along with permanent jobs, wind farms also create temporary jobs which could further advance into local, technical job opportunities.

Stakeholders

There are many different organizations that are in favor of and against wind technology that are currently involved in the ongoing debate. On one end of the spectrum, we have anti-wind movements in communities that are concerned about the noise the turbines produce or the danger of losing their pristine environment, while on the other end, there are organizations that promote the technology through the use of educational programs. Both sides have established lobbying forces that argue the advantages and disadvantages. What is more important is the concern of the people. Wind technology has demonstrated to be a good option for reducing greenhouse gas emissions; it is just a matter of working with the technology and design to make them more adaptable.

This thesis explores the different factors that can have an effect on a person's perception of wind turbines and their development. By understanding these issues and looking at how they predict a person's behavior can allow for energy companies to market the technology in a way that will reduce a pushback from the community. Policymakers will also be able to take the results from this research and implement better policies for communities with wind farms.

Experimental Design

The purpose of this research is to look at what factors affect peoples' perceptions of wind turbines by looking at different factors such as environmental, economic, social, proximity, and political affiliation. With the use of an online survey mechanism, approximately 700 participants participated in a 5 minute survey called *Wind Energy Public Perception* which asked questions pertaining to wind energy and turbine development in their community. By asking the participant their permanent zip code, their proximity to the closest turbine was determined in order to measure their "level" of exposure to wind technology. A persons' proximity to a wind turbine within any of the three phases being studied (proposal, construction, and existing) could help determine if it plays into their perception on wind technology.

Three hypotheses were thus created to fully understand what factors play a role in a person's perception of wind technology:

Hypothesis 1: A person who views their political affiliation as liberal, has a more positive overall attitude towards electricity generated from a wind turbine.

Hypothesis 2: A person's proximity to a wind turbine has a negative effect on favorability of wind turbine technology.

Hypothesis 3: People who consider themselves to be knowledgeable of electricity generation from wind turbines will be more favorable towards them.

Through the use of STATA, a statistical software tool, multiple predictor variables were regressed to fully understand the perception of wind technology and what factors predict overall favorability. The analysis from the data obtained will help verify these hypotheses as well as reveal other important factors that may have an effect on wind turbine perception.

Chapter 2

Literature Review

There is an array of literature that discusses the barriers related to wind farm development, as well as how proximity affects resident's perception. Many studies in the UK provided empirical data that help policy makers as well as homeowners decide whether or not to build wind farms, however, there is very little literature on such issues based in the United States (Jones *et al*, 2010). Researchers Krohn and Damborg determined that the factors leading towards a positive attitude come from understanding the "benefits of wind power" while the negative attitudes are attributed to the "aspects of wind power" (Swofford *et al*, 2010). Many of the barriers affecting wind favorability can be seen as social issues, or "aspects" of the technology. Most of the research conducted has represented a positive response to wind technology environmentally and economically, however not as much socially. Social aspects, such as noise and aesthetics, have affected energy companies when trying to implement wind turbines in communities and have provided a strong pushback, despite the community knowing how beneficial the technology can be when reducing carbon dioxide emissions.

Past studies have used different methodologies, such as one on one interviews, postal surveys and opinion polls to gather data pertaining to peoples' perception of wind power, however, there has been very little work done with a statistical approach (Devine-Write, 2005).

The primary focus of this literature review is to discuss past work that will help analyze my results and further answer my hypotheses. There are many different aspects to a person's perception on renewable energy and wind turbines and those factors will also be explored.

Political Ideology

As one may expect, a person's political affiliation can have the potential to affect their perception of a new idea or technology. Trying to understand the relationship between the two will be explored in this thesis and in turn, try to answer the first hypothesis of this work: a person's political affiliation, the more liberal they believe they are, will have a positive effect on their overall attitude of wind technology. By looking at the already existing literature of how political affiliation has an effect on peoples' perceptions, one can try to understand how to better implement wind policy in the United States.

Researchers Dunlap and McCright, using 10 years of representative polling data, found that "Democrats and Liberals had greater belief in and more concern about anthropogenic climate change than Republicans and Conservatives" (Dunlap *et al*, 2008). Jost and colleagues found that people mostly engage in social cognition, where people "are motivated to perceive the world and the information they are presented in ways that accord with their existing values and ideological commitments" (Fielding *et al*, 2012).

The literature also suggests that "even when people have more information or knowledge about an issue like climate change this does not negate the effect of ideology or political affiliation on their attitudes" (Fielding *et al*, 2012). Dunlap and McCright found that "education and self-reported knowledge were positive associated with beliefs about climate science and climate change concern for Democrats and Liberals but the relationship was negative or non-existent for Republicans and Conservatives" (Dunlap *et al*, 2011). This suggests that "political conservatives may be more likely to resist the scientific evidence for climate change, primarily because they perceive climate change politics as requiring changes to social and economic systems" (Dunlap *et al*, 2011).

Although there has been no research conducted relating political ideology to a person's perception of wind turbines, the existing literature discusses the relationship with climate change, and thus, the present knowledge will be assumed to apply to this work.

Proximity

Author Patrik Devine-Wright wanted to investigate the reasons pertaining to support for local renewable energy developments. Through the use of case studies and interviews, Devine-Wright looked at two different studies conducted outside of the United States and saw a trend of negative perceptions declining over time. He also suggested that the majority of the population in the UK was in favor of local renewable projects. In one of the studies Devine-Wright analyzed, it was concluded that approval of wind turbines increased after the construction phase was complete (Wolsink, 1989). Then when looking at another Dutch wind farm, Author Paul Gipe concluded that “the level of acceptance of wind energy in a local area declines with construction and rises afterwards” (Devine-Wright, 2005). At construction phase, people may have a negative perception due to the excess noise or constant traffic; however, once the community is exposed to the turbine, there can be an increase in favorability. The community begins to accept that the turbines are now a part of the land and in turn begin to feel comfortable around them. There is also a sense of familiarity that can yield a positive impact after the turbines are operational. Devine-Wright, however, concluded that there was not enough empirical evidence to support his hypothesis and suggests that more quantitative research, using a statistical tool, to be done to fully understand the barriers (Devine-Wright, 2005).

Throughout the literature, one can see that the opposition towards wind turbines on a given resident’s land is high. NIMBY-ism, also known as “not in my back yard”, is transparently one of the biggest issues with wind farm development. NIMBY is a theory that helps explain why there is opposition towards wind farms on one’s land. According to Merriam Webster, NIMBY is the “opposition to the locating of something considered undesirable (as a prison or incinerator) in one's neighborhood”. Previous studies have shown that residents may favor wind farms in their community, as long as it is not in their "backyard" (Jones *et al*, 2010). Subsequently, while individuals claim to endorse the concept of alternative forms of energy, they are hesitant if the movement directly affects their everyday life.

Jones and Eiser (2010) and Van der Horst (2007) both agreed that NIMBYism alone is not the only prevailing factor in determining acceptance of wind farms (Groth, 2011). Jones and Eiser (2010) concluded, however, that other factors exist such as the “impact on image amenity”. They believe that the visual impact is also one of most problematic issues relating to wind farm siting (Jones *et al*, 2010). Research has shown that the aesthetics of the wind turbines, such as the size of the turbines, the color, etc. make it easier for people to have a more negative opinion.

According to a survey based in Texas, 46% of people were against wind farms because they thought they were an “unattractive feature to the landscape” (Swofford, 2009). From Swofford’s study, it was concluded that the general attitude towards wind development is favorable, however. “When asked about their attitudes prior to wind development in their community, the majority of respondents (58%) had positive attitudes” (Swofford, 2009). What is key to observe from this study, however, is that he never polled his sample on their thoughts after wind development has been constructed, and thus does not track perceptions over exposed time.

NIBYism has become a way to describe the level of support of wind turbine growth at a national and local level. “The validity of NIMBYism as a negative relation between general and local perceptions of wind energy would be demonstrated by studies indicating support for wind farms at a regional or national level, but not locally in close proximity to respondents’ place of residence” (Devine Wright, 2005). Proximity, thus, can have a major impact on favorability of wind turbine growth. Throughout the literature, researchers have seen both a positive and negative relationship between the two, however. Groth discovered that proximity to a wind turbine only partially explained Huron residents’ favorability; learning that proximity decreases positive perception. Author AM Simon, however, saw that there is a positive relationship between the two, suggesting that those who are in favor of them nationally are also supportive locally (Devine Wright, 2005). In conclusion, many researchers have disproved NIMBY as the primary factor, concluding that their data showed that if one already opposes a wind farm nationally, they are still going to oppose it locally (Wolsink, 1989).

Community Involvement

When looking at the social aspects of wind farm development, it is important to analyze the proposal phase and its impact on the community. When a company first contacts the community to discuss possible opportunities for wind development, it is crucial for the whole community to feel as if they have a say. Getting the community involved from the beginning can help with less opposition as the proposal moves forward. In 2007, Lane *et al* “conducted research in a rural community of Australia where her aim was to study how an increase in community engagement promoted interest in local environmental issues” (Lane *et al.*, 2007). She concluded that, with the help of the local community, the program developmental stages were smoother and more beneficial for all stakeholders. Groth also agreed suggesting that “by including the

community from day one, communication keeps the town involved and vested in the project because their voices are heard and concerns addressed (Groth, 2011).

Without community involvement, there could be a stronger pushback towards the wind developers and potentially reject the project. One of Groth's interviewees' thought the construction of the turbine was rushed with not enough educational programs focused towards the residents, which added uncertainty in their eyes (Groth, 2011). Another interviewee believed the energy company was holding back information and therefore brought a negative view towards wind development. "The interviewee stressed the importance that misinformation played in shaping the perception of wind energy and wind farms" (Groth, 2011).

Knowledge through Education

To move towards a more sustainable future, the generation of today's students must be trained and educated with information that can help them create new technologies. However, this knowledge must come from those who already understand and have begun the initial steps towards alternative and cheap energies. According to Heidi Hayes Jacob, "our challenge [as educators], is to match the needs of our learners to a world that is changing with great rapidity" (Jacobs, 2010). It is understood that, for wind technology to grow, there must be an increase in design and collaboration with the past to develop a better wind deployment system.

The American dependence of fossil fuels is no surprise to citizens. The industrial revolution showed generation after generation how important it is to thrive from some manufacturing system, despite what the consequences are from it. We live a world where success is the most important thing to the average citizen. These principles and ways of living did not just stem from one generation, however. We have seen ourselves increase the amount of resources we believe are necessary to survive and thus, assume are ours to take. As this kind of paradigm grows, people tend to think in terms of growth and development and less of the significant results that arise from their decisions. One can see this within our overall dependence on non-renewable technologies, such as coal and oil. The average ecological footprint has exceeded the Earth's replenishment rate of biological capacity by 20 percent (Wachernagel, 2008). What can be found interesting in this, however, is that America has a chance to change things, once again. A different path can be chosen by future generations that can learn from past experiences and move towards a cleaner world. Jacob *et al.*, authors of *Essential Education for a*

Changing World: Educating for a Sustainable Future, believe just this and acknowledge that there is a need for education in this field, stating “Most of us have not been educated to grapple effectively with our current reality.... Nor have we been educated to make the connections between our thinking, our behavior, and the results of that behavior on our current reality” (Jacobs, 2010).

In 1992, Education for Sustainability agreed to move towards sustainability by “leveraging changes in K-12 school systems to prepare young people for the shift towards a sustainable future” (The Cloud Institute, 1995). One of Cloud Institute’s vision is, thus, to create a learning environment where children can learn about sustainability and thus providing a paradigm shift: “for creating new functional pathways” in young people (The Natural Strategy, 2012). This educational philosophy allows students to learn by understanding that “long-term change” is necessary and that “to us, sustainability and reservation are the names for the desired conditions we are educating for” (The Natural Strategy, 2012).

Arthur L. Costa and Bena Kallick, discuss the difficulties that come with changing a curriculum that has been untouched for over 25 years. They identified 16 vital habits which are necessary for success in school, work, and life, such as “thinking flexibly”, where the goal is to look at a problem in a different way and to be able to generate alternatives and consider other options (Jacobs, 2010).

Many authors and futurists have begun discussing this concept of “The Habits of Mind”, which discusses, in detail, the behaviors a program should “integrate into a curriculum, instruction, and assessment” that should be continually practiced, modified, and refined (Jacobs, 2010). From this paradigm comes metacognition, which helps explain the development of “our ability to know what we know and what we don't know”, thus allowing us to look at people’s own perceptions of anything (Jacobs, 2010). This paradigm will allow for a smoother transition for supporting renewable energy. Therefore, by changing the way students think, to think about different alternatives to a problem and consciously choosing their “own steps and strategies during the act of problem solving” can reflect on a more sustainable community and increase the future outcomes of applications (Jacobs, 2010).

In Illinois, there is a local school that is partially powered by wind turbines allowing students to learn about green energy, in a class setting as well as in reality. Small steps like this go a long way to a young student’s mind. Although this can be considered to be a bigger step

than most schools or even businesses/organizations, other schools can learn from them and see what type of curriculum they provide and go from there. Understanding the past and how we went from the Industrial Revolution to where we are today is important; it is also important, however, how we as Americans adapted to change. Learning about the past allows for students to be more open minded about what possibilities are available for future technologies. The future is about breaking away from the ordinary, so that more efficient and effective innovations can be created.

To fully understand if residents' perceptions are affected by their perceived knowledge will depend on their education before and after the wind farms are running. The process throughout that development, however, is also interesting; education should be occurring through town meetings, the energy companies building the turbines, and an overall interest in what's being added into a community should increase education.

Chapter 3

Survey Methodology

Amazon Mechanical Turk, commonly known as MTurk or AMT, is a crowdsourcing internet marketplace that allows participants (known as workers) to perform tasks on computers that require human intelligence to complete. To become a participant, one must sign up through the website and can then begin performing "human intelligence tasks", also known as HIT's, for a reward. Both workers and requestors are anonymous; however, the worker has a unique ID provided by Amazon. A website of this nature can help researchers of all calibers to perform research in a cheap and quick manner. Although the website is fairly new, began in 2005, and has its setbacks, it has been proven to be a competitive method for performing survey-based research. Paolacci *et al* conducted research on AMT and found no difference in the magnitude of effects obtained through the site and using traditional subject pools (Paolacci *et al*, 2010). The question regarding validity and generalizability can become important, however. By conducting a classical experiment using three different sources: MTurk, a traditional subject pool at a university, and through the use of an online discussion board, the results provided evidence suggesting that AMT is a reliable methodology (Paolacci *et al*, 2010). The surveys from all three sources resulted in very similar data, with MTurk having a lower non-response rate. Overall, the

results from this small study suggest that Mechanical Turk holds validity and can be used in parallel to other methodologies (Paolacci *et al*, 2010).

Another study was conducted to describe and evaluate Amazon Mechanical Turk's contributions to research in social sciences. Michal Buhrmester and his colleagues concluded that AMT "has the necessary elements to successfully complete a research project from start to finish" (Buhrmester *et al*, 2011). The demographic characteristics also suggest that "AMT participants are at least as diverse and more representative of non- college populations than those of typical Internet and traditional samples" (Buhrmester et al, 2011). Finally, the researchers concluded that the quality of data provided by MTurk "met or exceeded the psychometric standards associated with published research" (Buhrmester et al, 2011).

A third study was conducted using AMT to replicate classical behaviors and results such as the Stroop task. The Stroop Effect is the ability to quickly perceive words without effectively processing the true meaning of the word. A common test of this effect is to have a set of words (blue, green, yellow) displayed in a color different from the color it actually means. This type of experiment was replicated on Amazon Turk as a task and given to workers to pair colors like red, green, blue, and yellow with their respective English words, thus comparing their reaction times. Results from this study, conducted by 60 mechanical turk workers, were compared to a replicated study of the classic Stroop Effect (which used a more common, traditional methodology). The average reaction time was 859 milliseconds which was consistent with the traditional 809 ms results conducted by Logan & Zbrodoff. From this comparison, along with other experiments conducted using similar neuropsychology effects, the researchers concluded that experiments done on AMT should be considered as a valid methodology for cognitive research (Crump *et al*, 2013). "We believe AMT is a revolutionary tool for conducting experiments, [and has the] potential to transform behavioral research" (Crump *et al*, 2013).

By understanding Amazon Turk's potential as a methodology is essential. For this type of research, the importance to obtain a large amount of data in a cheap and quick manner was pertinent.

As the researcher, commonly known as the "requester", you can provide a small reward to the worker for completing the survey. This reward can be "as low as \$0.01 and rarely exceeds \$1.00" (Paolacci *et al*, 2010). As the requester, one also has the option to reward good work with bonuses and push poor quality work by refusing payment. This type of system requires the

requester to “accept” or “deny” the task completed by the worker within a week, before Amazon “accepts” it automatically, allowing for a quick response return and making sure the survey is working properly. The requester can choose to deny a HIT if the worker didn’t answer all the questions, for example.

Study Area

By using this online source (Amazon Mechanical Turk), the survey instrument, “*Wind Energy Public Perception Survey*”, was developed to allow participants to answer an array of questions regarding wind turbine perceptions. Based off of their zip codes and proximity to a turbine, I determined in what phase of wind deployment the community was in and therefore, fully measured the change in perception of those living with wind technology.

I provided workers with a \$0.25 wage and obtained 712 participants. The analysis of the participants’ proximity to the nearest wind turbine in proposal phase, construction phase and existing phase was also essential for this research. From this, three additional subgroups could be measured to understand even better, how perception changes over time due to participant’s location to a wind turbine.

The survey included 4-7 questions regarding three major impacts that can change resident’s perception on wind technology: environmental, economic, and social. The first question in the survey was the location the respondent resided in, in terms of a five digit zip code. To conclude the introduction part of the survey, three additional questions were asked to determine the level of the participant’s perceived knowledge and their overall attitude towards wind turbines. The purpose of asking these questions were for an understanding of how educated the respondent was in terms of wind development in their part of the community. The majority of the questions were measured on a five point Likert scale from “Very Negative to Very Positive”, “Strongly Disagree to Strongly Agree” and from “Unaware to Very Knowledgeable”. The last three questions pertained to the respondent’s sex, age and political affiliation. The full survey can be found in the Appendix, under *Wind Energy Public Perception Survey*. Table 1 shows the survey questions along with their abbreviated form which will be used throughout the analysis of data for easier demonstration. A third section is presented in the table explaining what type of impact the question will explain.

Table 1: *Wind Energy Public Perception Survey* questions along with abbreviated form and type of impact

	Question	Abbreviated Form	Type of Impact
1	What is your zip code?	Zip code	Overall
2	How knowledgeable do you consider yourself about electricity generation from wind turbines	Knowledge	Overall
3	I learned about electricity generation from wind in school, work, or town meeting	Learn	Overall
4	What is your overall attitude towards electricity generation from wind turbines?	Overall Attitude	Overall
5	Protecting the environment is important to me	Protecting	Environmental
6	I am concerned about global climate changes	Concerned	Environmental
7	I believe we should use more renewable energy (solar, wind, biofuels, etc.) to fulfill the U.S. energy demand	Use More	Environmental
8	I believe wind is a reliable source of energy	Reliable	Environmental
9	I am supportive of building wind turbines in my community	Supportive	Environmental
10	Wind turbine use to generate electricity creates a disturbing noise	Noise	Environmental/Social
11	Wind Turbines are a danger to wildlife	Danger	Environmental/Social
12	Renewable energy will help the national economy	National Economy	Economic
13	Having a wind turbine in my community will help my community's economy	Community Economy	Economic
14	Wind farms result in increased tourism	Tourism	Economic
15	Wind farms will create jobs	Jobs	Economic
16	I think wind turbines are an attractive feature of the landscape	Attractive	Social
17	Having a wind turbine in my community will positively impact my life	LifeImpact	Social
18	The advantages to having wind turbines in my community will outweigh the disadvantages	ProCon	Social
19	What is the proximity of your residence to a wind turbine?	Proximity	Overall
20	What is your age?	Age	Overall
21	Are you Male/Female?	Gender	Overall
22	Generally speaking, I consider myself to be politically...	Political	Overall

The survey was developed using a variety of questions from a previous study conducted in Texas on *Social Perceptions of Wind Energy* (Swofford, 2009). The format from the pilot study was changed to a Likert Scale and reduced in question size to increase response rate and better fit this research. There are three main parts to the survey: environmental, economic and social. Each section has multiple questions pertaining to the participants' perception of wind energy, wind turbines and how they affect their lives and communities in different aspects such as tourism, aesthetics and disturbances.

A pilot study was also implemented prior to making the HIT available. This pilot study was given to an array of peers ranging from college students to professors. The pilot study was successful in the sense that the wording of certain questions was confusing to some as well as some of the terminology used. Some of the questions also did not provide adequate response answers because some participants didn't feel they knew enough to answer the question due to educational purposes. For questions of this nature, such as, "I believe wind is a reliable source of energy", a sixth option of "Not Applicable" or "Unaware" was added to the Likert Scale so that the participant could complete the survey with the understanding of each question being asked. Along with the multiple choice questions, there were open ended questions after each section allowing the participant to elaborate on any key issues regarding wind energy.

To fully understand the scope of MTurk, two waves of the survey were available online. The first "batch" went live on April 5, 2013 which allowed 400 "workers" to participate in the survey for a reward of \$0.25. The first batch was completed within four days. Initially, this data was analyzed and processed using MATLAB. The second wave of the survey was available online on April 16, 2013. This survey was open to 1,000 workers, however only 317 workers completed the task. After obtaining all of the data (n=717) responses, a thorough analysis was completed, using only the responses from those who gave "accurate" zip codes. Since the worker's participation was anonymous, for the purposes of this research, only zip codes that were considered to be delivery points by the U.S. Postal Service were used.

Chapter 4

Data Analysis

The following section presents results from the survey questionnaire regarding participants' perception of wind turbines in the United States. Through the use of Amazon

Mechanical Turk, 712 surveys were completed. Three surveys were discarded due to incorrect answers and format issues. The final number of surveys accepted was 709. These were analyzed using STATA, a data analysis and statistical program, and a five-point Likert Scale was used for scaling the responses. The scaling ranged from “Strongly Disagree” to “Strongly Agree”, “Unaware” to “Very Knowledgeable”, and “Very Negative” to “Very Positive”. To better understand the data, the range was further simplified by lumping together “Strongly Disagree” and “Disagree” into “Disagree”, “Strongly Agree” and “Agree” into “Agree” and “Neutral” as the middle ground. The resulting analysis of all completed surveys will be presented in the following section.

Amazon Mechanical Turk allows “workers” to complete tasks (surveys) online for a small reward. These tasks are commonly used by businesses seeking to outsource the tasks, for example: paying workers to view and classify images that would better a business’s marketing plan. However, “social scientists have increasingly become interested in crowdsourcing as a viable alternative to traditional methods of participant recruitment” (Paolacci *et al*, 2010). Since Mechanical Turk has shown to be a reliable and efficient way to understand a demographic in an inexpensive way, we decided to keep it as part of the methodology. Amazon reports that the system has about 200,000 workers registered in over 100 countries with an interesting range of demographics: 45-55% Male to Female Ratio, about 40% between the ages of 18-24, 22% between the ages of 25-30 and 19% between the ages of 31-40 years of age. Also 42% of the workers hold a Bachelor’s degree while 21% claimed to have “some college” and a median annual reported income between \$20,000-\$30,000. These demographics, according to the research conducted, “reveal a significantly highly educated population, though one with low levels of employment and income” (Ross *et al*, 2009). Karen Fort *et al*. claims that “only 80% of the tasks available are being performed by 3,000 to 9,000 workers. This suggests that only 1% of registered workers are completing surveys, which is in accord with the “90-9-1” rule valid in the Internet culture” (Fort *et. al*). Our own experience has produced similar representation throughout the participants. For example the Male to Female Ratio was 61%-39%, ranging from ages of 18-75. The current Male to Female demographics of the United States suggests a more equal representation, however: 49%-51%. The age demographics obtained from Amazon Turk suggest a much younger group of people while the US demographics suggest those aged between

18-24 only represent 6.7% of the entire population, while 25-34 represent 14.2%, and ages 35-44 represent 16%.(US Census Bureau).

Table 2: Age Demographics: Responses from *Wind Energy Public Perception Survey*

Age Demographics	% (n=712)
18-24	35.6
25-34	39.8
35-44	12.2
45+	12.4

A question of political affiliation was also asked during the survey ranging from “Very Conservative” to “Very Liberal”. Amazon Turk users have a strong Liberal representation, while Conservatives only hold 15% of the demographics. However, when comparing these results to the national population, Conservatives represent about 42% of the population, Moderates at 36%, and Liberals only representing 22% (Saad, 2011).

Table 3: Political Demographics: Responses from *Wind Energy Public Perception Survey*

Political Demographics	% (n=711)
Very Conservative	4.2
Somewhat Conservative	12.2
Moderate	24.9
Somewhat Liberal	38.9
Very Liberal	19.8

From this information, one can see that the majority of Amazon Turk users are to be young, politically liberal, computer users. It is important to note that this information may be seen as a diverse group of internet-based users, however, it cannot be concluded that it is a good representation of the United States, as a whole.

Through the use of STATA, a statistical program, the results from each participant’s survey was easily transferable to obtain relationships between the different factors that affect perception: proximity, environmental, economic and social. Logistic Regression allowed for analysis of what variables were important in predicting perceptions and was thus used. The goal of logistic regression is to statistically find the best model that describes the relationship between dependent and independent variables (Olmacher *et al*, 2003). In this research, we found 17 independent variables and 3 dependent variables. Many of the variables were seen as both a predictor and predicted variable. A predictor variable, commonly known as an independent

variable, is any variable that explains the effect on the predicted variable, also known as the dependent variable. Variable “Support”, for example, is seen as both a predictor and predicted variable due to what is being explored in this research. Some of the variables used also have repetitive characteristics, for example “supportive” and “overall attitude”. When running a regression on what factors affect overall attitude towards renewable energy, variables such as “supportive” and “use more” are dependent on that predicted variable; if you are to be more supportive of a wind turbine in your community, you are more likely to have a positive overall attitude and would more likely be in favor of the technology. Thus, to improve the regression analysis, variables of this nature were dropped from the regression. Table 5 and 6 represents the description of all the variables used and whether they were seen as predictor or predicted variables.

Table 4: Description of Predictor Variables

Variable Name	Description
Attractive	I find wind turbines to be an attractive feature of the landscape
Community Economy	Having a wind turbine in my community will benefit me economically
Concerned	I am concerned about global climate change
Danger	Wind Turbines are a danger to wildlife
Jobs	Wind farms will create jobs
Knowledge	How knowledgeable do you consider yourself about electricity generation from wind turbines
Learn	I learned about electricity generation from wind in school, work, or town meeting
LifeImpact	Having a wind turbine in my community will positively impact my life
National Economy	Renewable energy will help the national economy
Noise	Wind turbines create a disturbing noise
Political	What is your political affiliation
ProCon	The advantages of wind turbines outweigh the disadvantages
Protecting	Protecting the environment is important to me
Proximity	What is the proximity of your resident to a wind turbine?
Reliable	Wind turbines are a reliable source of energy
Tourism	Wind turbines create tourism in my community

Table 5: Description of Predicted Variables

Overall Attitude	What is your overall attitude towards electricity generation from wind turbines?
------------------	--

Supportive	I am supportive of wind turbines in my community
Use More	I believe we should use more renewable energy (wind, solar) to fulfill the U.S. energy demand

Throughout the regressions, many of the variables were seen to be highly correlated, suggesting multicollinearity. Multicollinearity occurs when your predicted variables are fairly similar, thus, when running the regression, it becomes more and more difficult to determine which predicted variable is actually producing the effect on the Y variable, or predictor variable. When running a simple linear regression with one X variable, the standard error was very low; however, by adding more X variables to the model, you are invariably adding more error, increasing the size of your standard error. In short, “adding extraneous variables to a model tends to reduce the precision of all your estimates” (Chen *et al*, 2003). For example, when running a regression model in order to determine the relationships between X variables and “Supportive”, it was necessary to drop variables like “Use More” and “Overall Attitude” from the model. By dropping these variables from the regression, it allowed for other relationships to show up within the model. For variables like these, it was assumed that the more supportive you are of a wind turbine, the more positive your overall attitude is towards it and the more likely you are to believe we should use more renewable energy. Since these relationships were already obvious, dropping them out of the regression would produce better relationships between other variables by masking the relationships that are already obvious.

All of the regressions are run in terms of Odds Ratios (OR). OR is a measure of association between an exposure and an outcome. The OR is commonly used as a relative measure for risk, telling us how much more likely it is that someone who is exposed to the factor under study will develop a certain outcome as compared to someone who is not exposed. Thus, to measure peoples’ perceptions of wind turbines due to exposure, an array of ordered logistic models were analyzed to determine what key relationships form from the dependent (political affiliation, supportive, use more) and independent (attractive, noise, economic) variables.

Proportional Odds are a way to present probabilities and thus was used throughout this paper. If the odds of something are less than 1, it means it is less likely to be the outcome; if the odds are equal to 1, exposure does not affect odds of the outcome, and if the odds are above 1, then the outcome is more likely. For example, an OR of 2 means that an outcome is 2 times more likely to occur. When the logistic regression is calculated, the regression coefficient is the

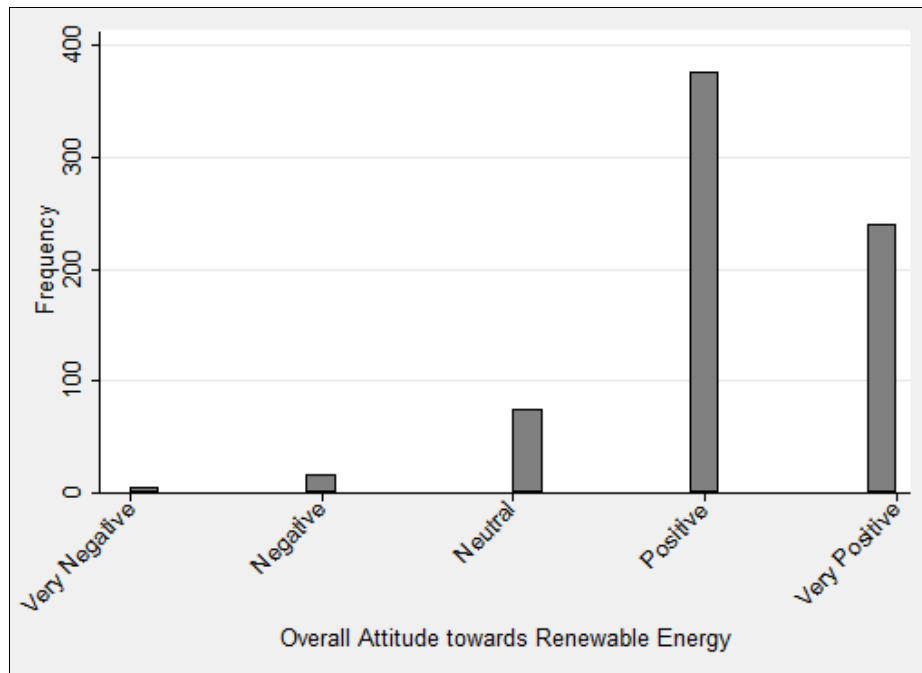
estimated increase in the log odds of the outcome per unit increase in the value of exposure (Szumilas, 2010). Through the use of OR, the strength of a relationship can be analyzed by looking at the relative value of these variables: the greater the value, the stronger the correlation.

Overview of Results

Overall Attitude

At the beginning of the survey, participants were asked what their overall attitude was towards electricity generated by wind, to better access peoples' perceptions on the matter. Out of 709 participants, 86% had a positive attitude towards this type of renewable energy. Below (Figure 1) is a histogram representing the overall attitude participants had towards wind energy generation.

Figure 1: Histogram of participant's overall attitude towards renewable energy



Environmental, Economic and Social Issues

The first section of the survey consisted of several questions regarding attitudes toward environmental issues. From these questions, 88% of the participants found that protecting the environment was an important issue to them, 79% were concerned about global climate changes, while 9% disagreed with the statement. When asked if they believe we should use more

renewable energy to fulfill America's energy demand, 93% participants agreed. The overall environmental attitude towards renewable energy growth is, thus, positive.

The participants were then asked whether or not they thought electricity generated from wind turbines was "reliable", and the majority agreed (78%). There was also a 78% positive response when choosing to have a wind turbine in their community while only 6% disagreed with this statement. The growth of wind farms in the United States depends on the level of support from local communities. It is thus important to note that more than three quarters of the participants are favorable towards wind turbines in their community.

The general economic attitude towards renewable energy and wind power was also largely positive. The majority of the respondents believe renewable energy will help the national economy (84%). When asked if having a wind turbine in their community would help their local economy, 65% agreed that it would. Although it is not as high as for the national economy, the perception that wind turbines will help economically, is still largely positive.

As one can see, most people find renewable energy and wind turbines a positive addition to our energy-intensive society. Their general perception towards these structures are largely positive, however, once one looks at the social attitude, the perception begins to turn negative. Four questions regarding the social impacts of wind turbines were asked and analyzed

When asked whether wind turbines are an attractive feature of the landscape, 41% of the participants agreed, while 33% were neutral. When asked if they believe a wind turbine in their community will provide a positive impact in their lives, 50% agreed. A larger portion of the participants, however, believe that the advantages of having a wind turbine in their community will outweigh the disadvantages.

Although the results were positive, the responses were not as strongly positive in relation to their beliefs on the environmental and economic impacts. However, overall, people's support is high for renewable energy and wind turbines; there could be other factors that are affecting the reasons why communities choose to not build them. It can thus be considered to be more of an issue at the local level (Warren *et al*, 2005). This can also be the reason why wind planning and siting processes face significant challenges as well (Wolsink, 2007).

Regression Analysis

To better help policy makers, the understanding of what factors can affect the growth of wind development is quite important. To test my hypotheses, regressions were run to see the

different relationships between the predictor and predicted variables. In Table 7, the predictor variables are presented down the column, with the predicted variables on the top row. If the predictor variable met the removal criterion (if it was not making a statistically significant contribution to how well the model predicts the outcome variable [less than 90% confidence interval]) it was removed from the model (Field, 2009). After this was completed, the remaining variable was then assessed to determine its contribution to the outcome of the predicted variable. In the tables below, all predictor variables represented were statistically significant, with a confidence interval of 90% and a P-test of less than 0.100. The odd ratios with three asterisks were statistically significant at a 99% confidence interval.

Table 6: Comparisons between the three main predictor variables and predicted variables in terms of Odds Ratios.

	A	B	C
	What is your overall attitude towards electricity generated from a wind turbine	I am supportive of wind turbines in my community	I believe we should use more renewable energy to fulfill the U.S. energy demand
	“Overall Attitude”	“Supportive”	“Use More”
Attractive	1.16	1.62***	0.93
Community Economy	1.92***	3.90***	1.25
Concerned	1.09	1.24**	1.50***
Danger	1.03	0.92**	0.84**
Jobs	1.26**	1.04*	0.98
Knowledge	1.43***	1.03	1.60***
Learn	0.72**	1.30	1.18
National Economy	1.26*	0.92	2.84***
Noise	0.95	1.02	1.21**
Political	1.20*	1.15*	1.50***
Protecting	1.60***	1.27*	2.11***
Proximity	1.67**	0.83	1.09
Reliable	2.05***	2.01***	1.80***
Tourism	0.89	0.97	1.24**

*Significant at 90%, **Significant at 95%, *** Significant at 99%

By looking at Table 7 column A, it can be seen that “political” was not as statistically significant as some of the other variables (OR 1.20, 90% CI) despite knowing that a person’s political affiliation can have an effect on their beliefs. This can also be seen with the predicted variable “proximity”, with an OR of 1.67 at 95% CI. Understanding whether or not “political affiliation” and “proximity” can change a person’s perception of wind turbines will allow for

better policy implementation by targeting specific areas of wind turbine development. Assuming both of these variables should have a stronger correlation to “overall attitude”, multiple single regressions were done to understand if the relationship was valid, without controlling for the other variables, as done in the regression above. Both if these will be further explored within *Hypothesis 1 and 2*.

Hypothesis 1

Hypothesis 1 suggests that a person, who views their political affiliation as liberal, has a more positive overall attitude towards electricity generated from a wind turbine. To study this hypothesis, a regression was completed to determine if there was a relationship between “political affiliation” and favorability of wind turbines. Initially, by looking at Table 7, there is not a strong correlation between political affiliation and two out of the three predicted variables. The regression does suggest that those who consider themselves to be more liberal are more likely to want to use more wind turbines in their community, however. Since previous literature suggested that political beliefs should affect perception, I decided to look at the relationships more closely. I ran a single regression between “overall attitude” and “political”. From the single regression, the OR was 1.70 with a confidence interval of 99%, demonstrating a strong positive relationship between political affiliation and overall attitude; the more liberal you are, the more likely you are to have a positive overall attitude towards wind generation, almost by double.

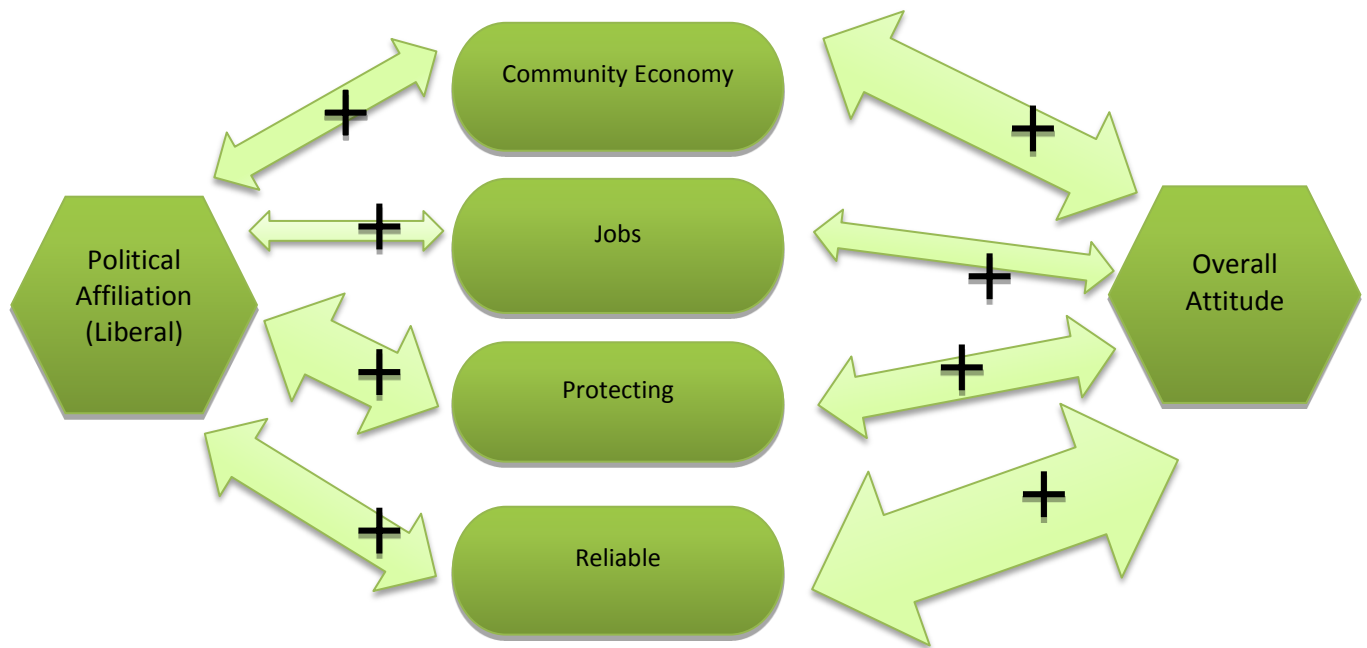
Since "overall attitude" and "political" were correlated, we took the analysis a step further and determined what variables were affected by political affiliation, thus affecting people's overall attitude. By using the same statistical method, I looked at how political affiliation affects participants' favorability of wind turbines. Table 8 represents the different intermediate variables that had a statistically significant correlation to political affiliation. These regressions were run individually between “political” and the intermediate variable. From Table 8, one can see all the variables that indirectly affect overall attitude on wind turbine growth through their political affiliation. A simpler way of looking at what factors affect overall attitude through political affiliation can be seen in Figure 11. This flow chart shows the factors that were statistically significant from Table 7 and Table 8. The positive and negative signs on the chart depict either a positive or negative correlation between the two variables.

Table 7: Summary of the variables that “political affiliation” predicts

Intermediate Variable	Odds Ratio	Std Error	P> z
Attractive	1.47***	0.099	0.000
Community Economy	1.51***	0.105	0.000
Concerned	2.35***	0.177	0.000
Danger	0.84***	0.054	0.006
Jobs	1.43***	0.100	0.000
Noise	0.83***	0.052	0.004
Protecting	1.66***	0.121	0.000
Reliable	1.56***	0.109	0.000

*Significant at 90%, **Significant at 95%, *** Significant at 99%

Figure 2: Flow chart of how “political affiliation” can predict “overall attitude” through various intermediate variables. The width of the arrow indicates the strength of the relationship.



Hypothesis 2

To further validate *Hypothesis 2*, three different phases of wind turbine development were analyzed: proposed, construction, and built. Each participant was asked for their five digit zip code at the beginning of the survey. They were also asked what their proximity was to the nearest wind turbine. Since proximity was assumed to play an important role, an initial “zip code” question was asked to all participants. By obtaining their zip code, I could then determine their proximity to the nearest wind turbine during proposal, construction, or existing phase;

however, I needed two more data sets that already existed: the latitude/longitude of every wind turbine in any of the three phases, and the latitude/longitude of all existing zip codes in the U.S.

The Federal Aviation Association, commonly known as the FAA, has all the required information for a wind turbine to be constructed. Since a wind turbines' height can affect aviation, any proposed wind turbine must be approved by the FAA. This data is open to the public and can be obtained through their website (Federal Aviation Administration). Through the use of the FAA document obtained, a set of all proposed, currently under construction and already existing wind turbines was accessibly available. The most up to date (2013) data file has the latitude and longitude of every turbine proposed to be built in the United States. By using this, I was able to combine databases (zip codes and FAA) and determine the shortest distance from every participant's zip code and the nearest wind turbine going through any of the three phases: proposed, construction, built.

The Latitude and Longitude of every zip code in the United States was also obtained. When downloaded (April 2013), the US Postal Service had updated the database with the most up to date 5 digit zip codes. The US Postal Service provides all zip code latitude and longitudes in degree form, however. To obtain the exact distance between two latitude and longitude points, the equation below can be used.

Exact Distance in Miles

$$\begin{aligned} &= 3958.75 \\ &\quad * \arccos[(\sin(P * Lat_1) * \sin(P * Lat_2) + \cos(P * Lat_1) * \cos(P * Lat_2) \\ &\quad * \cos(P(Lon_2 - Lon_1)))] \end{aligned}$$

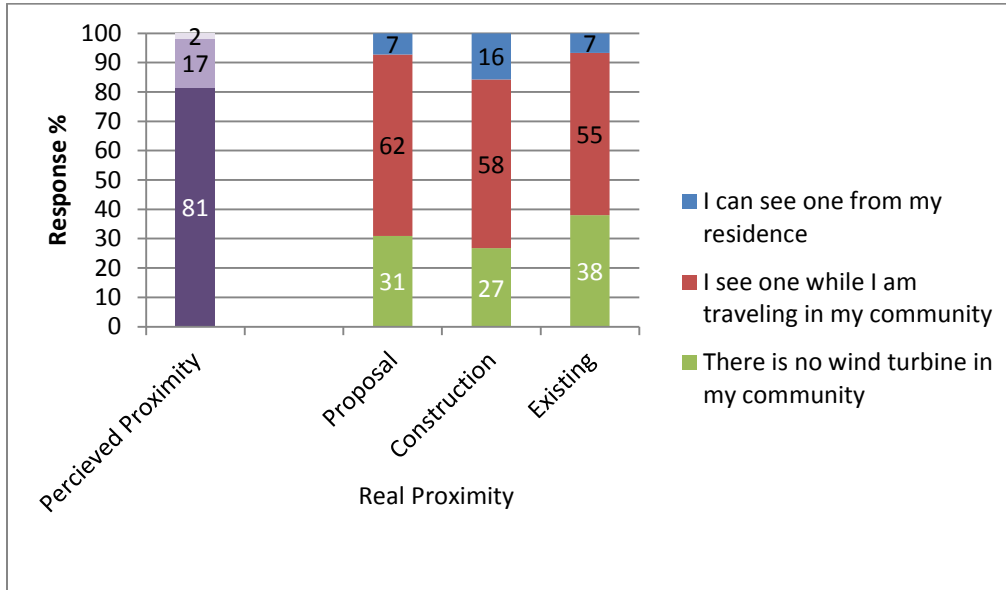
Where P is $\pi/180$ and Lat_1 , Lat_2 , Lon_1 and Lon_2 are the latitude and longitude of any two data points. Since the database holds the latitude and longitude in degrees, the "P" constant variable will convert the data points to radians so that the above equation can be used. Given that the Earth is shaped as a sphere, spherical geometry and trigonometric math functions must be implemented. This equation thus provides the exact distance from any two points, in miles.

To determine the distance between each participant and the nearest wind turbine, MATLAB was used to calculate the shortest distance. Once each distance, in miles, was measured between each participant and each wind turbine in proposal, construction, and already existing, the smallest distance was obtained, thus providing me with the closest proximity a person is to any wind turbine in the United States. The distance used, however, is based on the

latitude and longitude of the center of the zip code and can “range in size from a single building to a delivery zone spanning hundreds of square miles”, thus giving the analysis some variability (Grubestic,2008). Choosing a different methodology, such as sending postal surveys to specific towns under study, could provide more accurate results.

The results from the initial survey questions showed that 81% of the responses said there was no turbines in their community, while 17% saw them while traveling in their community. With their five digit zip code, it was possible to estimate the distance to any wind turbine under proposal phase, construction phase, or already existing to try to find correlations with their perceptions. Every zip code provided was then compared to the zip code database obtained by the U.S. Postal Service to fully understand the participant’s “knowledge” on wind turbines, based on their proximity. By asking what the participants’ proximity was in two different ways (zip code and “proximity to nearest wind turbine”), it was possible to distinguish between the participants’ “perceived knowledge” and their real distance from the nearest wind turbine in any developmental stage. Figure 6 represents this distinction: “Proximity” is the participant’s response to the question of how far away they are from a wind turbine, while the other three variables are the true percentages of those participants living nearest to a wind turbine in any of the developmental stages (Proposal, Construction, Existing). From the figure, one can see that the majority of participants (81%) believe they live nowhere near a wind turbine, thus not affecting them, however, after some zip code analysis, one can see that that is not the case. Most of the participants actually live between 20-100 miles from a wind turbine in any deployment stage. Analytically, out of the 81% of the participants who suggested they did not live anywhere near a wind turbine, 27-38% live in a community where a wind turbine can be seen from their residence; 55-65% live near a wind turbine (proposal, construction, or existing) that can be seen while traveling throughout the town; and 7-16% of the participants do not actually have a wind turbine in their community. These statistics, however, are dependent on the zip codes provided by the USPS and are subject to change, depending on the magnitude of their current zip code. These data points are also objective and thus can be interpreted differently, depending on how the participant characterizes “community” and their perceived distance from a turbine structure.

Figure 3: Representation of Perceived Proximity compared to Real Proximity (in all three phases)



When looking at the relationship between “proximity” and “supportive” in Table 7, there was no significant relationship. However, it is reasonable to imagine that proximity does have an effect on some perceptions towards wind turbines. With this in mind, I decided to complete more analysis on these variables. When running a single X variable regression between “supportive” and “proximity”, “proximity” showed a negative correlation, with an OR of 0.73 at 95% CI. This suggested that the closer a participant lived to a wind turbine (perceived proximity), the more likely they were to be supportive of a wind turbine in their community. Like “political affiliation”, multiple single regressions were completed to look at what predictor variables correlated most with “proximity”. Five variables turned to be significant with a 99% confidence interval, one variable at 95% confidence interval, and one at 90% confidence (Table 9).

By looking at the chart below (Figure 12), policy analysts as well as engineers can see how people perceive wind turbines and what issues could arise when making decisions for their family or community. By understanding how a person’s proximity to the nearest wind turbine can play in their perception, will also help improve implementation of deployment. In this chart, one can see all the factors that can affect someone’s level of support towards wind turbine development. For example, the farther away a participant lives from a wind turbine in any developmental stage, the less likely they are to believe wind turbines are economy boosters for their community (OR 0.63, 99% CI). All of the intermediate variables in Table 9 were affected by proximity, which in turn affected the participant’s support for a wind turbine in their

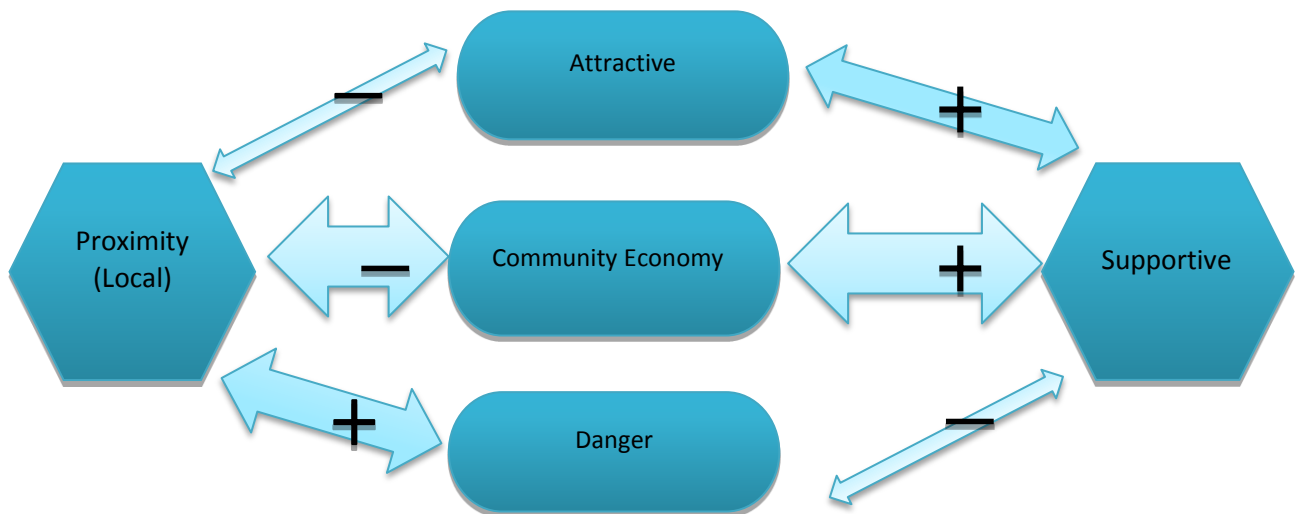
community. Thus, by looking at what factors affect a persons’ decision to choose wind power based on proximity, policy makers can make appropriate decisions on policies implemented involving wind power generation.

Table 8: Summary of the variables that “proximity” predicts

Intermediate Variable	Odds Ratio	Std Error	P> z
Attractive	0.76*	0.110	0.074
Community Economy	0.63***	0.100	0.004
Danger	1.48***	0.223	0.006
Knowledge	0.58***	0.089	0.000
Learn	1.42**	0.239	0.039
Noise	1.78***	0.276	0.000

*Significant at 90%, **Significant at 95%, *** Significant at 99%

Figure 4: Flow chart of how “proximity” can predict “supportive” through various intermediate variables. The width of the arrow indicates the strength of the relationship.

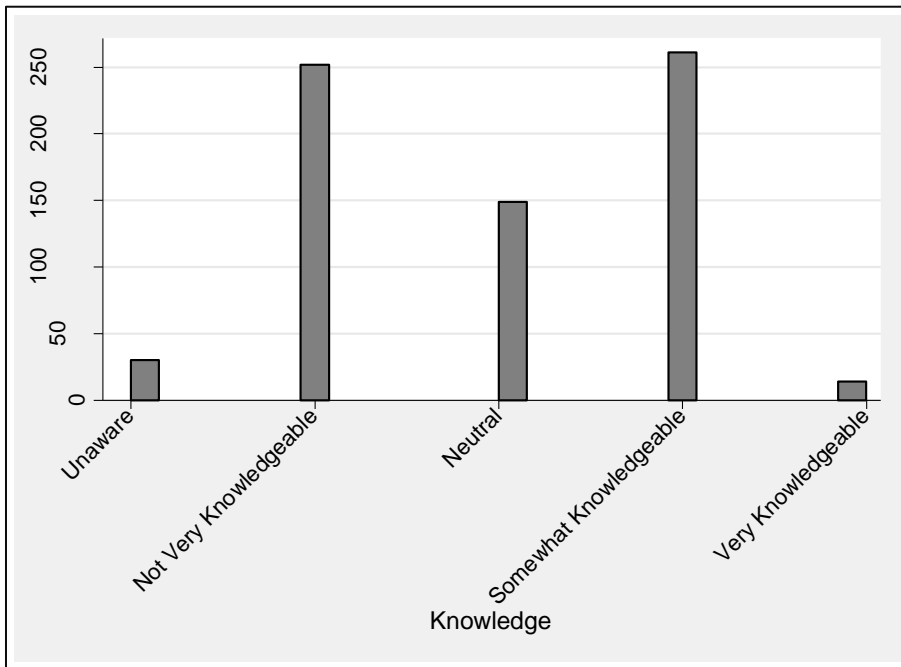


Hypothesis 3

Participants were also asked to answer a question about how knowledgeable they are on wind generation. Most policy makers assume there is a positive relationship between improving knowledge and enhancing positive attitude (Wolsink, 1989). Wolsink suggests that, despite educational advancements, the person’s perception may not even be affected by their level of knowledge. Figure 2 gives us some insight on this theory. In this graph, one can see that almost

the same number of people considered themselves to be knowledgeable and not very knowledgeable.

Figure 5: Histogram of participants' perceived knowledge of wind generation



It is also important to understand where and how people learn about wind generated electricity, thus a True/False question was asked covering whether or not the participant had learned about wind energy in school, work or at a town meeting. Out of 709 workers, 49% claimed to have learned about wind energy in school, work or a town meeting. By looking at Figure 2 and comparing it to these results, one can assume the people who find themselves to be “Unaware” and “Not Very Knowledgeable”, would benefit from learning about wind technology through resources such as at school, work, or a town meeting. Researcher Phillip Converse once argued this notion that the public, when asked difficult questions, respond to questions in a very meaningless manner (Hanson, 2012). When looking at the science of voting, Converse (1964) observed that a “significant minority of citizens (sometimes as much as one- third) either cannot or will not locate themselves on a single bipolar dimension”, suggesting that they choose the “neutral” option out of pure ignorance (Blasius *et al*, 2001). By looking at Figure 2, Converse’s theory could explain those participants who voted “Unaware” and “Neutral” as well as “Not Very Knowledgeable” have the potential to learn more about wind generation and make a better

conclusion. Blaius *et al* also suggested that “respondents with insufficient information or insufficient knowledge ...might prefer to mask their lack of an opinion” (Blaius *et al*, 2001). That percentage of people, thus, may benefit more from government educational programs and policies.

Chapter 5

Discussion

Throughout the analysis process, many predicted variables were seen to be statistically significant. Logistic Regression, along with Odd Ratios, allowed for a statistical analysis of a range of variables to better understand which were more likely to predict an outcome and thus help prove my three hypotheses. It was important to understand what factors affect a participants’ perception of wind turbines and what influences must be observed in order for better policies on renewable energy to be implemented. To verify our three hypotheses, the results from Chapter 4 will be analyzed to determine the validity of the hypothesis in question. Each hypothesis will be discussed as well as any additional, interesting results that require attention from the regression results (Table 7).

Hypothesis 1

Political Affiliation was seen to be statistically significant with only one variable out of the three: “Use More”. The regression suggests that those who find themselves to be politically liberal, are more likely to want to use renewable energy in to fulfill the U.S. energy demand, with an OR of 1.5. Although the variable “political” was not as statistically significant with “overall attitude” and “supportive” as it was with “use more”, it did hint that there was some correlation. By running a regression with just one X and Y variable, one can see a statistically significant relationship between the two, without factoring in other variables (as done with multiple predicted variable regressions). Figure 11 represents this type of correlation between variables. On the left tier, the predicted variable has an arrow to the middle tier, which represents either a positive or negative relationship. Through regression analysis, we know the left tier variable predicts the middle tier variables. We also know the right tier variable is affected by the left tier variable, because of the variables on the middle tier. The arrows are double headed because the relationship can be predicted either way; from middle tier to right or vice versa.

Figure 11 suggests that political affiliation does affect overall attitude indirectly through the many factors which are predicted by political affiliation, suggesting that *Hypothesis 1* is indeed valid. Consistent with the previous literature, those who identify as politically liberal are more likely to be supportive of wind technology and have a positive overall attitude of them.

Hypothesis 2

This method was also done for variable “proximity” to measure *Hypothesis 2*. It became apparent that it was also true that proximity and level of support towards a wind turbine were also correlated, through the use of single variable regression. Unlike previous studies, proximity did not change from construction phase to existing phase; however, it was shown to not worsen due to turbine exposure. Figure 12, however, represents the relationship between proximity and level of support affected by the factors in the middle tier. Without the intermediate factors, there is no relationship between the two. Proximity does play an important role when looking at favorability, but the relationship only relates when you look at how the many different factors affect supportiveness. The data, thus, suggests that proximity does not worsen due to perception, and proves that *Hypothesis 2* is in fact, not valid.

Hypothesis 3

It was no surprise that the variable “knowledge” also produced a strong correlation with “overall attitude”, with the likelihood that someone who thought they were knowledgeable on wind turbine electricity generation was more likely to have a positive overall attitude towards wind turbines, by almost double. In conclusion, the analysis provided evidence that “knowledge” is a strong predictor variable and thus does predict a positive response to favorability, proving, proving *Hypothesis 3*.

Reliability

From the regression, the strongest correlation to “overall attitude” was “reliability”, suggesting that if a participant was to find wind turbine technology reliable, then they would be more likely to have a positive overall attitude towards wind generation by double. “Reliability” was also seen to be the only variable that was significant throughout all three regressions, suggesting that Americans would be more interested in supporting and using renewable energy if they found it to be a dependable source of energy.

Community Economy

A second regression was run to determine what factors affected people's support towards building wind turbines in their community. The strongest predictor variable was "community economy", which represented a participant who believed building a wind turbine in their community would benefit them locally. This relationship suggested that those who agreed were four times more likely to be supportive of a wind turbine in their community. Helping Americans understand all the benefits of wind turbine growth in their community can have a major impact on their decisions when choosing an alternative energy source. Knowing that wind farms will help your community economically, through job openings, tax incentives, etc., can potentially change a town members' perspective on the structures.

Conclusion

In summary, *Hypothesis 1 and 3* were proven to be correct, while, while *Hypothesis 2* was incorrect, through the use of Multiple Logistic Regression. From the analysis, however, I found two other important predictor variables that can predict overall favorability towards wind turbine development: Reliability and Community Economy. From the analysis, it is suggestive that those who find wind technology to be a reliable source of energy will also be more favorable of them and want to implement them in their communities. If they are aware of the local benefit they can produce, will also provide a stronger perception of them and thus will be implemented more often. Energy companies as well as policy analysts should promote these benefits when attending a town meeting, representing how efficient, effective, and beneficial building a wind farm in their community can be.

Chapter 6

Policy Implications

The importance of finding alternate ways to produce energy efficiently and effectively as natural gas and coal is a task that every individual should participate in. As of 2010, renewable energy provided 10% of electricity generation nationwide, with a fifth of that coming from wind power (Global Energy Center, 2013). Coal and natural gas are resources that have limited quantities; renewable energy, however, "has the potential to generate power for as long as the necessary equipment continues to function" (GEC, 2013).

Some of the benefits to building wind farms in a community is the growth in temporary and permanent jobs. Job creation also brings improvement in the local economy. According to Noble Power, wind parks create hundreds of jobs during construction phase as well as well-paying operations and maintenance jobs. There is also tax revenue from the wind parks that flow out to schools, the town, and the county. The wind is free and there is no need to purchase fuel, therefore, the energy produced is kept locally. Once the wind turbines are built, people can still grow crops around the turbine and use the excess land to benefit themselves and the community. It was thus, no surprise, that “community economy” and “overall attitude” had a strong positive correlation. From the survey results, participants believed that wind turbines were beneficial for the local economy and were more likely to have a positive overall attitude towards and be supportive of their growth. Thus, it may be beneficial for energy companies to promote local economic benefits when providing information to a community. This socio-economic influence can be recognized in Congress so that better benefits for local stakeholders can guide the renewable energy policies.

However, not everyone enjoys wind turbines. Not In My Backyard is a theory that explains how people may like and appreciate wind technology, just not in their community or backyard. Many scholars have tried to prove that this theory played a major effect on communities and their perception of wind turbines. From my results, I saw that people who considered themselves to be knowledgeable of wind turbines did have a positive perception of them and were interested in using more renewable energy, however, were not as supportive when looking to implement them in their community. This perception was linked to a person’s perceived knowledge, which may be affected by an array of other factors and has the potential to change with more informative programs. To reduce pushback, I recommend implementing better educational programs for Americans, locally and nationally, to better understand the benefits of renewable energy and the technology designed to apply it. Additionally, it would be beneficial for policy makers to put in place a set of regulations for energy companies to follow that would involve placement of the turbine to a given home, so that the local community does not use noise, death in migratory birds, and aesthetics as an excuse.

Another common obstacle towards wind turbine development is that people are skeptical as to whether or not the technology is reliable. From the regression above (Table 7), a strong correlation suggested that those who found the technology to be reliable were more likely to

have a positive overall attitude, be more supportive of its technology, and want to use them in their communities. To help the development of wind turbines, it would be most beneficial for the energy sector to implement wind turbines in areas that will produce the most electricity consistently. Choosing the right location, such as far from homes, rural, high wind speeds, would also reduce the number of noise complaints, ensuring an easier implementation process for all stakeholders involved.

Understanding the policy cycle and how programs get implemented in Congress is extremely important when looking at renewable energies. The groups involved as well as the lobbyists make an impact on the incentives created as well as subsidies that allow for wind technology to flourish around the country. The use of production tax credits, for example, are ways that the government can help Americans with making their homes and businesses better equipped for the future. However, they will not be able to do this for ever. For renewables to flourish, the market should start a transition from oil, ensuring a plan for electricity production for the future. Since wind energy policy comes from the state level, it is up to that state to make state grant programs as well as renewable portfolio standards.

Proximity has also been seen to be a barrier of wind turbine growth. Throughout the literature, researchers have found both positive and negative correlations to the home's proximity to a wind turbine. Groth found that proximity decreases positive perception, while Anderson *et al* found no link between distance and negative perception (Devine Wright, 2005). From this research, however, we concluded that proximity did not worsen over time. There is no definitive way to determine if distance will help increase wind turbine growth or not, however. This factor of favorability will depend on the community, on a case by case level.

Overall, there has been a positive public perception on wind turbine development: environmentally, economically, and socially. Throughout this research, it has been seen that the majority of people are in favor of wind generation and would like to see more of them in their communities. This relationship is seen more with participants who considered themselves politically liberal as well.

Renewable energy is growing every day in the United States. The government has taken many steps to help the environment and reduce greenhouse gas emissions. What needs to occur now is a policy intervention. If we want to see a cleaner world, educational programs must be put into place to teach old and new generations about these new technologies and their benefits to

our environment. The transition may be a slow process, however, still necessary. There must also be a more effective understanding of what barriers lie within people's perceptions of wind turbines. This can also be "cured" with educational programs as well as incentive programs from the government. It is up to the engineers to reduce the disadvantages and make the technology more reliable as well as the government and other energy sources to reduce the cost of energy and make it more competitive. At first, these technologies will be costly, as they require infrastructure transitions and market interest; however, with some initial help from the government, renewable energy prices can be competitive. The United States should begin implementing alternative energy into the education system along with the scientific world so that we can transition toward a cleaner energy- dependent future.

Recommendations

Although the use of Amazon Mechanical Turk provided a quick and cheap manner to obtain results pertaining to this research, I found the tool to not be as representative as other methodologies. Most of the participants are politically liberal and between the ages of 17 to 35. For this type of demographic, it was still interesting to see how this current generation views renewable energy.

The online crowdsourcing has one flaw that could use some attention. At the beginning of my research, I wanted to understand how perception of wind turbines change throughout a given state. Although ATurk allows you to make "Qualifications" which allow only certain users to take the survey, depending on whether or not they passed preliminary questions, I found it hard to obtain participants who passed that Qualification Test. This suggests to me that the people participating in Amazon Turk are interested in taking surveys that do not require an additional qualification test.

Appendix A

The following is the survey questionnaire used for research purposes

Wind Energy Public Perception Survey

The goal of this research survey conducted by the Rochester Institute of Technology is to assess the public's perception and its change through time on power generated by wind turbines. This survey will assist in developing a broader and clearer understanding of key issues regarding wind farms deployment including public perception, environmental and visual impact concerns. We acknowledge that this survey does not cover all issues related to wind energy, and encourage concerned participants to elaborate on their responses in the provided short response areas.

Your participation is strictly voluntary. Your consent to participate in the research will be recognized by completing this survey. Your survey response will be strictly confidential and will only be used for research purposes. The responses will be grouped together with other survey responses from the same geographical region and your individual responses will not be revealed. The survey consists of 20 questions that will take you approximately 10-15 minutes to complete. Each participant will be asked for their five digit zip code to group the responses for research purposes. If you choose to not complete the survey, there will be no penalty. We greatly appreciate your participation in this research study. If you have any questions, you may contact the researcher, Tatiana Stein, at Tes1196@rit.edu or Heather Foti, Human Subjects Research Director, at hmfsrcs@rit.edu

What is your five digit zip code? _____

How knowledgeable do you consider yourself about electricity generation from wind turbines?

- Unaware
- Not Very Knowledgeable
- Neutral
- Somewhat Knowledgeable
- Very Knowledgeable

I learned about electricity generation from wind in school, work, or town meeting

- True
- False
- Not Applicable

What is your overall attitude towards electricity generation from wind turbines?

- Very Negative
- Negative
- Neutral
- Positive
- Very Positive

Please provide any additional comments about your overall knowledge and attitude towards wind energy

Environmental Attitudes:

Protecting the environment is important to me

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree

I am concerned about global climate changes

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree

I believe we should use more renewable energy (solar, wind, biofuels, etc) to fulfill the U.S. energy demand

- Strongly Disagree
- Somewhat Disagree
- Neutral

- Somewhat Agree
- Strongly Agree

I believe wind is a reliable source of energy

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree
- Unaware

I am supportive of building wind turbines in my community

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree

Wind turbine use to generate electricity create a disturbing noise

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree
- Unaware

Wind Turbines are a danger to wildlife

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree
- Unaware

Please provide any additional comments about wind energy and the environment

Economic Attitude

Renewable energy will help the national economy

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree

Having a wind turbine in my community will help my community's economy

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree

Wind farms result in increased tourism

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree
- Unaware

Wind farms will create jobs

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree

Unaware

Please provide any additional comments about wind energy and the economy

Social Attitude

I think wind turbines are an attractive feature of the landscape

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree

Having a wind turbine in my community will positively impact my life

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree

The advantages to having wind turbines in my community outweigh the disadvantages

- Strongly Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Strongly Agree

What is the proximity of your residence to a wind turbine?

- I can see one from my residence
- I see one when I am traveling in my community
- There is no a turbine in my community

Please provide any additional comments about wind energy and social impacts

What is your age?

- 18-24
- 25-34
- 35-44
- 45-54
- 55-65
- 65-74
- 75-older

Are you?

- Male
- Female

Generally speaking, I consider myself to be politically

- Very Conservative
- Somewhat Conservative
- Moderate
- Somewhat Liberal
- Very Liberal

Please feel free to provide any additional comments you feel are important that have not been addressed in this survey

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