FACTORS INFLUENCING THE DEVELOPMENT OF WIND POWER IN RURAL ALASKAN COMMUNITIES

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A

THESIS

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ABSTRACT

The state of Alaska is endowed with extensive and developable wind resources. The greatest areas of class seven, "superior" wind resources in the entire United States are located in Alaska. Developing these resources has the potential to play a pivotal role in reshaping Alaska's future by providing reliable, local, and stable-priced power. Despite this tremendous natural asset and the immeasurable benefits it harbors, Alaska's wind resources remain largely untapped and underutilized.

Rural Alaskan communities, classified by their remote locations, small populations, and consequent low electric demands and high electric costs, possess some of the greatest wind resources in Alaska. The challenge, however, is to overcome the current social, political, technical, economic, and environmental constraints.

This thesis aims to identify factors that contribute to and constrain the successful development of wind power projects in rural Alaska and to recommend solutions to overcome specific barriers. The findings demonstrated that the primary influencing factors included leadership, coordination at local and state levels, access to information and assistance, and local human, technical, and financial capacity. Such factors must be an integral part of planning efforts in order to advance wind power development in rural communities.

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ACRONYMS

AEA	Alaska Energy Authority
APA	Alaska Power Authority
ACEP	Alaska Center for Energy and Power
AVEC	Alaska Village Electric Cooperative
BIA	Bureau of Indian Affairs
DOE	Department of Energy
KEA	Kotzebue Electric Association
kWh	Kilowatt hour
NREL	National Renewable Energy Laboratory
PCE	Power Cost Equalization
PTC	Production Tax Credit
RPS	Renewable Portfolio Standards
SCADA	Supervisory Control and Data Acquisition
TAPS	Trans-Alaska Pipeline Systems
TDX	Tanadgusix Corporation

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CHAPTER ONE:
INTRODUCTION TO WIND POWER DEVELOPMENT IN RURAL ALASKA AND METHODOLOGY

INTRODUCTION

The wind has blown in and out of human history for thousands of years and has shaped the development of civilization. The power of the wind has caused severe erosion and dispersed airborne diseases, and has displaced countless people and destroyed homes, crops, and lives. However, from the earliest recorded sailboats over 5,000 years ago that were instrumental in development of trading, shipping, exploration and transportation, to the first windmill developed to automate the task of grinding grain and pumping water (Taylor 1999), harnessing the power of the wind has expanded our horizons. In Alaska, the wind has played a strategic role in people's lives throughout history, dictating when they hunt, recreate, and travel. Since the latter part of the twentieth century, harnessing the wind for utility-scale power generation has begun to propel Alaska and the world in a new direction.

The advantages of generating power from the wind are enormous. Wind is often an abundant local resource in many rural Alaskan communities. Wind is inexhaustible (Flowers and Kelly 2005). Wind provides stable-priced power (Poullikkas 2007). Wind is economically competitive with conventional energy sources (Weis *et al.* 2008). Because it is not imported, wind provides energy security (Asif and Muneer 2007). In many areas of the world, wind provides local tax revenue (Bolinger 2005, Del Rio and Burguillo 2008).

The state of Alaska is endowed with strong and developable wind resources. The greatest areas of class seven, "superior" wind resources in the entire United States are located in Alaska (Elliot *et al.* 1986). These areas are primarily the western and coastal regions, home to communities largely populated by rural, Alaskan Natives. In the summer of 2009, Alaska doubled its installed capacity of wind power with the completion of the 4.5 megawatt (MW) Pillar Mountain Wind Project in Kodiak. This was a significant step for the community of Kodiak. However, compared to the 29,440 MW of installed wind power capacity nationwide (AWEA 2009), Alaska has a small proportion of U.S. wind power generation and is slow to integrate wind into its electricity portfolio.

The development of the state's wind resources has the potential to play a pivotal role in reshaping Alaska's future by providing reliable, local, and stable-priced power and mitigating effects of climate change by reducing fossil fuel emissions (Szarka 2006, Mostafaeipour 2010). Compared to the challenges induced by rural Alaska's current dependence on fossil fuels, including volatile prices, an uncertain supply, and environmental concerns, the advantages of investing in wind power are numerous and promising.

Despite this tremendous natural asset and the immeasurable benefits it holds, Alaska's wind resources remain largely untapped and underutilized. In the 1980's, the state underwent steps to develop rural wind power systems, yet not a single original wind system is operational today. As with many rural Alaskan projects, minimal connection to roads and electric grids contributed to the high costs of developing and operating these systems. However, the failure of past wind projects is also attributable to poor local and state management capability, insufficient methodology for assessing project feasibility, and inadequate project coordination. Additionally, the relevant literature points to myriad factors that contribute to the failure of wind projects in other parts of rural America and the world, including the degree of public support, economic feasibility, local leadership, avian concerns, local capacity, technology advancements, and land ownership issues.

Although these obstacles are prominent, Alaska is pursuing and investing in renewable energy development once again. In response to recent spikes in oil prices that created significant economic stresses nationwide, in 2009 the Alaska legislature established new energy-related programs, including the Alaska Renewable Energy Grant Fund. This fund provides financial assistance for feasibility studies, energy resource monitoring, and renewable energy construction. In addition to efforts by the legislature, other public and private sector efforts are advancing wind technologies and conducting economic analyses with application in rural Alaska. For example, the Alaska Center for Energy and Power and the Institute for Social and Economic Research are conducting applied wind energy research in economics and technology to support the deployment of cost-effective wind-diesel hybrid technologies[1] in Alaska.

This wealth of experience and financial and technical resources found in the public and private sector make them essential to the proliferation and success of wind power development in Alaska. However, these sectors capture primarily the economic and technical factors related to wind power and overlook the social, political, and environmental variables that are often at the crux of any development project in rural Alaska. The relevant literature suggests that these factors must be an integral part of planning efforts in order to optimize and advance wind power development in rural communities. This is reinforced by the failures of the demonstration wind projects in the late 70s and 80s and the ensuing identification of predominantly social and political barriers that led to the failures. In order to avoid a repeat of these project failures, additional factors must be considered when planning for and developing wind power projects in rural Alaska.

THESIS QUESTION AND OBJECTIVE

The primary research question to be asked then is: What are the factors that contribute to and constrain the successful deployment and development of wind power projects in rural Alaska?

Through case studies, interviews, and surveys, this research examines the factors that impact wind power development in rural Alaska. These factors include coordination and interaction between local and state entities, local capacity, state policies, local leadership, confidence in technology, environmental concerns, local support of projects, structure and size of electric utility, and community population. Such factors are likely to be unique to each community. Even so, they present an important potential to identify

[1] Wind-diesel hybrid systems combine wind turbines with diesel generators to generate electricity.

and understand the thresholds that are essential for developing wind power. This research provides a crucial perspective into what is not fully understood about the successful development of wind power in rural Alaska.

This research contributes to the general knowledge of developing wind power projects in rural Alaska, based primarily on the local contexts. The purpose is explicitly to provide information that can aid rural communities in the development of wind power projects, as well as to provide recommendations to agencies and organizations working with wind power in rural Alaska in order to maximize the advancement of wind as a renewable power source.

RESEARCH CONSIDERATIONS

For decades, rural Alaska has depended primarily on diesel generators to electrify its communities. Historically, diesel generators have been the most reliable and economical option. However, in recent years, unstable and exorbitant fuel prices, climate change concerns due to burning fossil fuels, and a global movement toward renewable energy have prompted Alaskans to examine alternative fuel sources and systems. Alaska is endowed with an abundance of renewable resources such as wind; however, developing them is often hampered by social, political, environmental, economic, and technical factors.

These key factors, specifically social and political factors, are commonly overlooked and ignored by agencies and organizations that provide energy-based services and decision-makers that are determining what programs and policies are developed. The primary energy programs and policies accessed by rural Alaska—the Renewable Energy Grant Fund and Power Cost Equalization—focus mainly on economic assistance to offset high diesel costs or to develop capital projects. These programs are beneficial, but they are insufficient without a focus on the local context and the social and political factors that govern that context.

The ability to create change in the energy sector has often been informally linked to technical developments and the introduction of economic incentives (Haegemark

2001). However, to understand the overall processes of change it is not sufficient to use a paradigm that is only based on technical development or economic analysis (Scott 1995, DiMaggio and Powell 1991). The local level is, in many cases, the strategic arena that determines whether a project moves forward to be developed. Therefore, in order to advance wind power development, a new approach to changing the rural energy infrastructure is needed that places emphasis on the local context, which consists of social and political factors and interactions between the local and state levels.

As such, the infrastructure and development needs faced by rural communities can be seen as two independent resource mobilization problems (Jenkins 1983). The first problem involves "vertical linkages," that increase the community's access to resources outside of the community, including access to federal and state programs, project funding, and information about ways to solve local problems (McGranahan 1984). The second problem involves "horizontal linkages", that develop the capacity of individuals and organizations within the community to work together to pursue common projects (McGranahan 1984). Horizontal linkages frequently relate to the specific types of networks between leaders and local and state organizations where communication is facilitated in order to achieve a common goal. These networks develop over time and are commonly based on the strengths of interpersonal relationships, a sense of mutual obligations, and the sharing of information (Hofferth and Iceland 1998).

A consideration of these vertical and horizontal linkages will enable both local communities and energy agencies and organizations to do a better job developing projects, providing services, and distributing resources that are needed in order to better assist communities. This examination goes beyond the technical and economic factors that traditionally govern development projects and takes into account the socio-political characteristics that are unique to rural Alaska.

METHODOLOGY

A mixed method approach was used to pursue the research objectives. Following the literature review, the approach consists of three different components; case studies, surveys, and interviews. Each of these had a specific purpose. The case studies identified distinguishing factors that enabled a particular community to bring a wind project to fruition. The surveys sought to identify community-specific barriers. The interviews captured additional perspectives on the factors that advance or obstruct wind power projects.

Literature Review

First, a literature review was conducted to identify the primary factors that promote or obstruct wind power development in rural Alaska and rural communities throughout the United States and the developing world. The literature review consisted of an examination of government documents, academic literature, organizational reports, and different official statistics regarding the cost of electricity and project funding.

Case Studies

The case studies constitute a qualitative approach to capture the local context and complex processes of wind projects. Communities that had developed and employed utility-scale wind power systems were targeted in order to understand better the context and complexity of these projects. By focusing on rural communities that were successful, this approach provided insight into the primary factors that advanced each project, including what challenges existed and how they were overcome, who was involved in the planning, what motives drove the project, and what local and outside resources were utilized. This information clarified why certain projects were developed and provided an understanding of the contributing factors that other rural communities may need to employ in order to develop wind projects.

The three communities selected for the case studies, Kotzebue, Kasigluk, and St. Paul Island, had different utility sizes and structures (*i.e.* cooperative, public, private), as well as varying populations and geographic settings. For each case study, interviews were conducted with multiple local and regional informants, including individuals from the electric utility, local native corporation, and tribal and city government. The interviews were informal and semi-structured, usually lasting from thirty minutes to one hour. The responses of these individuals helped reconstruct the planning, development, and permitting stages for each community's wind project. Consequently, this information emphasized the thresholds and influencing factors that were instrumental in advancing the projects.

Surveys

The surveys constitute a qualitative approach toward comprehending factors that create barriers to wind power development in rural communities and better understanding why communities with a strong identified wind class either have not pursued wind development or have been unsuccessful in their attempts. The survey questions were based on information gathered during the literature review and interviews and were loosely modeled after a survey conducted by the Pembina Institute on barriers to wind energy development in remote Canadian communities. The surveys were mailed to tribal councils, city councils and electric utilities in rural communities identified by the Alaska Energy Authority as having 4-through-7 wind class but which had not yet developed their wind resource. A total of 99 communities met the research criteria and were surveyed.

Interviews

In addition to the interviews conducted for the case studies, interviews were also conducted with other electric utilities, state and federal organizations, researchers, and wind power developers, designers, and engineers. Many of these interviews were part of a larger research project on the cost of wind power and wind-diesel technological challenges being conducted by the Institute for Social and Economic Research and the Alaska Center for Energy and Power. The interview questions primarily focused on challenges to wind power development in rural Alaska and were conducted by telephone. Other interviews were conducted with individuals at the Alaska Energy Authority, Alaska Center for Energy and Power and the U.S. Fish & Wildlife Service. When possible, interviews were conducted in person; however, the majority of the interviews were conducted by telephone and were recorded by note taking. Information gathered in these interviews was used to identify additional factors from a variety of perspectives other than those captured from the local level in the survey.

Table 1.1 *Organizations interviewed*

Category	**Organization**
Utilities	Kodiak Electric Association
State & Federal Organizations	Alaska Energy Authority, U.S. Fish & Wildlife
Researchers	Alaska Center for Energy and Power, Institute for Social and Economic Research
Designers, Developers, Contractors	Sustainable Automation, Intelligent Energy Systems, Western Community Energy, STG Incorporated, D3Energy, WHPacific

THESIS STRUCTURE

Each thesis chapter is directed toward understanding different aspects of wind power development in rural Alaska. Chapter 1 provides a general overview of wind power in Alaska and details the framework and methodology used in the research. Chapter 2 begins by describing the state of wind power from a global and national perspective. The chapter outlines the study area, history of wind power in rural Alaska, Alaska energy policy, and the primary actors involved in wind power projects.

Chapter 3 details the development thresholds and barriers to wind power development in rural Alaska using surveys. This chapter also provides interview information on perceived barriers to wind power in rural Alaska from electric utilities, state and federal organizations, researchers, and wind power developers, designers, and engineers. Chapter 4 describes the contributing factors that influenced the development of wind power in three rural communities. It provides a discussion of the primary factors that enabled the projects to move forward in these communities. Chapter 5 compiles the findings from the literature review, surveys, case studies, and interviews and provides a discussion of the four primary factors that the research identified as influencing the development of wind power in rural Alaska. This closing chapter also offers a list of recommendations to be considered by the state of Alaska and rural communities and utilities as the next steps toward promoting and assisting in the development of successful wind power projects in rural Alaska.

CHAPTER TWO:
BACKGROUND AND LITERATURE REVIEW

WHAT IS WIND ENERGY?

Wind is created by temperature and pressure fluctuations as the sun warms the earth. Wind energy relates directly to the wind speed, air density, and the specific area swept by the turbine blades as the kinetic energy of the wind is transformed into mechanical energy (AWEA 2009a).

Wind systems vary greatly in size, from individual home applications that can be less than 10kW, to utility-scale turbines that can be one MW or greater. Wind is considered an intermittent resource (Swift-Hook 2010), meaning that it cannot provide a utility's base power load since the wind does not regularly blow at a constant speed. As a result, wind always requires energy storage. In most areas of the United States, wind turbines are connected to larger transmission grids, which distribute power and act as storage. However, in most areas of rural Alaska, which are not connected to an electric grid, most wind systems are integrated with the existing diesel systems that regulate the load. These systems are referred to as hybrid wind-diesel systems. In communities that have existing hydropower resources, such as in Kodiak, the wind turbines are integrated into the hydropower system.

WIND ENERGY: NATIONAL AND GLOBAL CONTEXT

The wind industry in the United States has gone through many periods of change and restructuring. Because of the 1973 OPEC oil embargo and the high electricity costs that ensued, California became the first state to develop utility-grade wind power systems (Motavalli 2005). Several states followed suit, and the U.S. wind industry continued to grow until the mid-1980s, when it reached a plateau due to the restructuring of the electric industry and the expiration of federal tax credits (AWEA 2002). However, due to technological advances, an increase in climate change concerns, and the creation of market and policy incentives from the federal production tax credits (PTCs) and state implemented renewable portfolio standards (U.S. Department of Energy 2008), the industry is on the rise once again.

Wind-generated electricity contributed over 1% of global demand for the first time in 2007 (Pryor and Barthelmie 2010). A recent report prepared by the U.S. Department of Energy found that the United States possesses affordable and accessible wind energy resources far in excess of the amount necessary to provide 20% of the U.S. electricity by 2030 (USDOE 2008). Of the renewable energy technologies applied to electricity generation, wind energy ranks second only to hydroelectric in terms of installed capacity and is experiencing rapid growth (Pryor and Barthelmie 2010).

Global wind power installation has also been on a steady climb through the last decade. Currently, there are 120,798 MW of installed wind power capacity globally (Global Wind Energy Council 2009). According to information from the American Wind Energy Association, one megawatt of wind generates approximately enough power to electrify 225 to 300 average American households. To put this in a global context, the global installed wind power capacity provides enough electricity to power between 27,179,550 and 36,239,400 American households.

In 2008, the United States passed Germany to become the number one global leader in the wind power installation (GWEC 2008). Although the United States and Europe are the leaders in installed wind power capacity, developing countries such as China are experiencing growing wind industries. In 2008, one-third of the globally installed wind capacity was developed in Asia. Additionally, third-world countries are experiencing an increase in installed micro wind turbines for individual home and building applications. With the anticipation of carbon taxes and reductions in carbon emissions, there is an ever-increasing global demand for emissions-free power, and wind power is targeted as the most promising solution.

RURAL ENERGY DEVELOPMENT: A GLOBAL OVERVIEW

Over 3 billion people in the world rely on wood, charcoal, and other biomass (i.e. plants, human and animal waste) for most of their household energy needs (Kammen

1997), primarily cooking and heating (Anderson *et al.* 1999). 1.6 billion people—a quarter of the world's population—are without electricity; the majority of these people are in rural areas of the developing world (Barnes 2007). The majority of these 1.6 billion people are the poorest of the poor. Without access to modern energy services, including electricity, it is nearly impossible to lift people out of poverty (Barnes 2007). The social and economic benefits of bringing people out of poverty and creating equitable electric services are innumerable.

Some of the greatest challenges with rural electrification are characterized by relatively low population densities, which result in an overall low demand for electricity (Barnes 2007). This low population density means that construction and operation costs must be distributed between relatively few people, resulting in higher costs for each unit of electricity consumed (Barnes 2007). The economic impact of transmission grid expansions and new technology construction can be crippling for a small community and developer.

However, electrification is a major part of the social, political, and economic transformation for rural communities (Barnes 2007). Emerging concerns in the twentieth century, such as climate change, have placed a new emphasis on rural energy services, both making the existing systems more efficient and developing new systems. Many of these improvements arose from the appropriate technology movement[2] directed by E.F. Schumacher, which focused on the design and implementation of low-tech, inexpensive tools to provide basic services, including windmills and cook stoves (Kammen and Dove 1997). These advancements have made significant improvements in living conditions in specific developing rural communities; however, there are still 1.6 billion people globally living without electricity.

On the other end of the spectrum, development has also focused on installing large centralized power systems, which require commercial fuels (Kammen and Dove 1997) and an advanced network of trained personnel to operate and maintain the systems. The latter has many parallels to rural Alaska. Like rural Alaska, many rural areas of the

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[2] Technology that is designed and implemented with specific social, political, and environmental considerations of the community or region where it is intended to be used.

world must rely on stand-alone systems to provide electricity. Connecting to a larger grid is often advantageous from a technical and economies of scale viewpoint; however, in the majority of the world's poorest nations, it is estimated that significantly less than 5 percent of rural communities are connected to national grids (Anderson *et al.* 1999).

As a result, energy development over the past several decades has installed small-scale, internal combustion engines (i.e. gasoline and diesel) to provide power for rural applications around the world (Anderson *et al.* 1999). These systems allow local people to perform basic functions such as cooking, pumping water, milling, and lighting homes (Anderson *et al.* 1999). Such systems are beneficial and have been reliable for several reasons—they are a mature technology, commercially available, available in multiple sizes, and they often have a well-established spare parts and maintenance network (Anderson *et al.* 1999). Such systems provide local people with energy services they many have not otherwise had access to. However, these systems require a constant fuel source that is not local and not stably priced and fleet of trained personnel to operate and maintain the systems.

Too often rural energy projects, particularly in developing nations, focus primarily on technology (Anderson *et al.* 1999), leaving the social and cultural appropriateness and operability of the system as an afterthought. Repeatedly, projects have been developed where the local community lacks the economic means to pay for or generate income from the project (Anderson *et al.* 1999). This commonly results from the failure of project developers and funders to become familiar with basic local conditions, such as the local capacity to operate and maintain the newly installed system.

STUDY AREA: RURAL ALASKA OVERVIEW

There are multiple meanings and definitions of rural Alaska depending on the context. The state of Alaska does not have a universal definition of "rural"; rather it is defined by each department or agency, depending on the types of services they provide. It may be defined by population, poverty level, or other standards (Logan, A., personal communication, October 9, 2008). For the purpose of this thesis, "rural" is defined as communities that have populations under 6,000 and are not connected to the Railbelt electric grid. The Railbelt electric grid is defined as the electric service area that extends from the Kenai Peninsula through Anchorage and up to Fairbanks and comprises six regulated public utilities (AEA 2009).

This research focuses on the 99 communities that meet the criteria of being rural, having a 4-through-7 wind class, and lacking a developed wind power system. The total population of the research areas is 84,709. Some communities are larger hub communities such as Bethel, Nome, Dillingham and Kodiak, yet the majority have populations of only several hundred. 61% of the residents are Alaska Natives. Some of these communities are on the road system; however, the majority are accessible only by air, barge, or by river during the summer months. Such transportation challenges and their associated costs have contributed to the prohibitively high cost of power in rural versus urban areas of the state.

According to the Institute for Social and Economic Research, in 2006 rural residents spent approximately 9.9% of their total income on energy related expenses, an increase from 6.6% in 2000 (AEA 2009). There has certainly been a further increase due to fuel price increases beginning in 2007. 89% of the communities in the study area receive the Power Cost Equalization (PCE) subsidy, which was established to equalize the higher electric costs for rural Alaska residents with the lower electric costs in urban areas. The majority of the communities in the study that do not receive PCE are eligible for the subsidy but do not receive it due to administrative and reporting problems. In 2008, rural residents in the study area paid an average of 20¢ per kWh of electricity, versus 8¢ in Anchorage and 11¢ in Juneau (Kohler 2008). The cost per kWh ranged from 13¢ to 42¢. However, the average actual cost of power before the PCE subsidy was 49¢ per kWh and ranged from 23¢ to 76¢ per kWh.

RURAL ELECTRIFICATION IN ALASKA: A BLESSING OR CURSE?

The electric condition in rural Alaska is anomalous when compared to the rest of the United State. In the 1950s, the Bureau of Indian Affairs (BIA) installed small diesel generators in their schools to provide lighting, initiating rural electrification in Alaska. Electrification also came as the result of military, cannery, logging, and mining operations (Keiser 1985). Although urban areas and large hub communities were slow to be electrified when compared to communities in the contiguous-48 states, residents in rural Alaska were the last to be electrified. During the late 1960s, the Alaska Village Electric Cooperative, which had recently been formed as a non-profit electric utility, began constructing centralized power stations in regional centers such as Bethel, Nome, and Kotzebue as part of the federal Rural Electrification Administration low-interest loan program (Keiser 1985). This occurred during the same period as the government-sponsored rural housing program began constructing pre-fabricated homes in rural communities. History would later prove that building poorly insulated homes in conjunction with diesel generators would establish a long-term reliance on diesel fuel for heating and powering rural Alaska.

The majority of rural villages did not have the necessary capital and remained without centralized power systems until the late 1970s (Keiser 1985). In 1976, Alaska developed the Alaska Power Authority (APA), which financed, constructed, and operated power projects. During the same era, the state's oil revenues were high enough to allow the state to create electrification grant and loan programs, which funded the construction of new or upgraded electric power facilities (Keiser 1985). The centralized power facilities constructed in rural villages were primarily stand-alone diesel systems, with selective mini-grids powered by diesel generators when economically and physically possible. Rural electrification efforts demonstrated the capability to electrify schools, homes, and airports and made possible amenities such as lights, freezers, and televisions (Davis 1984), yet it also established a dependence on diesel fuel that still exists.

Once diesel generators were installed, additional facilities and advanced infrastructure were needed to support the new systems. With the exception of a few electric interties[3] connecting nearby villages, the isolated power generation facilities in rural communities serviced only the immediate community, creating a need to build bulk

[3] An electric power transmission line use to connect communities and/or electric facilities with the purpose of supplying electricity.

fuel tanks and backup generators in almost every rural village. The state of Alaska invested millions into constructing local bulk-fuel storage facilities, which replaced the 55-gallon drums to store the fuel needed to operate the generators (Davis 1984). Such a large storage capacity for fuel has posed significant environmental problems and has caused the state and utilities to incur hundreds of millions of dollars in maintenance expenses since the 1970s (Colt *et al*. 2003, Duval 2004). The state also constructed standby generators to provide reliable backup in case the primary generator failed or the load increased. Not only did diesel generators create a dependence on a single, nonrenewable fuel source, but proved to be an inordinately expensive way to supply electricity for remote communities with miniscule electricity demands, despite occasional periods of low diesel prices.

During the 1970s and 1980s, the state of Alaska also invested millions to build new community facilities, including public halls, washeterias, and airports. The long-term cost of heating and electrifying the buildings was not considered at the time of construction. As a result, buildings were often over-built and energy inefficient (Keiser 1985). In the course of several decades, the federal and state government significantly increased the demand for imported fuels to maintain the new infrastructure and buildings (Keiser 1985). Unfortunately, little was done to improve underlying economic conditions in rural communities, creating a perpetual challenge to pay for and maintain the electric infrastructure and public and residential buildings. The unsustainable and inadequate quality of energy services in rural Alaska causes a domino effect. By its nature, it reduces the quality of other services and infrastructure, making them inferior to those in urban areas.

The capital costs of rural electric systems in Alaska is exorbitantly high, at times four to five times that in the Lower-48 (Kohler 2008). This is a result of over-building systems so they have the generating capacity for a least three times the size of the peak load (Kohler 2008). Such measures ensure reliability in circumstances when one generator is shut down for maintenance and another is not operating due to mechanical problems. Often federal aid has provided the majority of funding to maintain and upgrade rural Alaska's diesel infrastructure. The Denali Commission has invested more than $400 million in bulk fuel and generating facilities in the last ten years and the USDA Rural Utilities Service's High Costs of Energy Grant Program has spent approximately $100 million over the same period on infrastructure (Kohler 2008).

Additionally, the new diesel generators required that fuel be transported to rural communities. Because the majority of villages are not connected to the road system or electric grids, the diesel fuel had to be transported via barge or plane, significantly increasing the operation and maintenance costs. This absence of electric connectivity to a large grid and the road system has created challenges for rural communities to be able to take advantage of the economies of scale that are available in urban areas (Black and Veatch 2008).

ELECTRIC UTILITIES

Whereas in most parts of the United States electricity generation is separate from transmission and distribution (Moorehouse 1995), in Alaska, the majority of utilities have the responsibility for both generating and distributing power. This means that the same company owns and operates the power generation facilities and the distribution and transmission lines and infrastructure. Electric utilities are broken into four major ownership classes—investor-owned, public power owned, consumer owned rural electric cooperative, and federally-owned. The majority of the nation's power generation comes from investor-owned utilities (USDOE 2007).

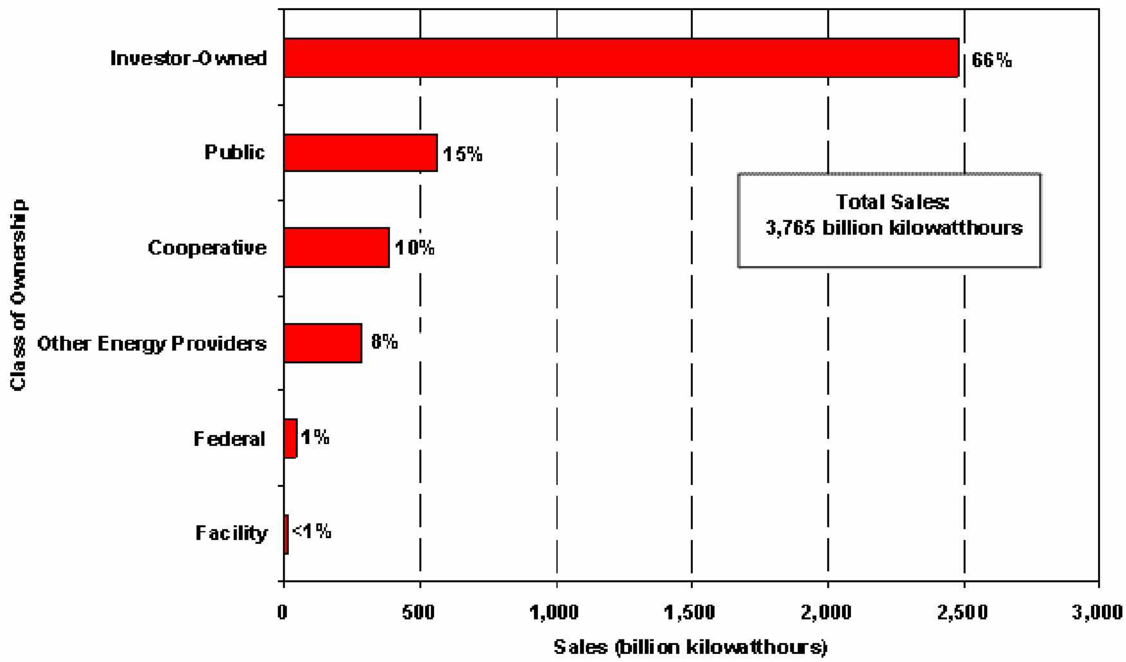


Figure 2.1 *U.S. Electric Utility Sales to Consumers by Class of Ownership, 2007*
Source: Energy Information Administration, State Electricity Profiles 2007.

Due to the large number of communities in the Alaska and the distance separating them, there are over 150 electric utilities servicing Alaskan communities. Consumer-owned electric cooperatives (predominantly AVEC) and public-power companies that are community and local government-owned produce the majority of electricity generation in rural Alaska.

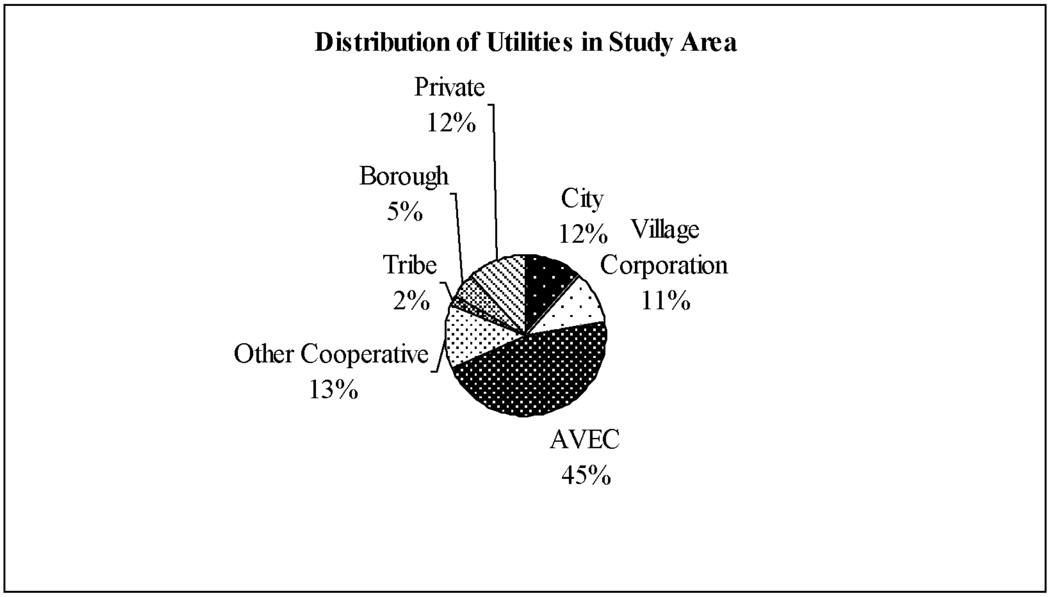


Figure 2.2 *Distribution of Utility Ownership in the 99 communities study area.*

PAST AND PRESENT WIND PROJECTS IN ALASKA

The first barrel of oil began flowing through the Trans-Alaska Pipeline Systems (TAPS) in 1977, generating unprecedented wealth in the state. The state decided to invest the majority of this revenue in the Permanent Fund[4] but it also invested portions of the oil wealth in infrastructure development (Goldsmith 2001). Most notably, the state sponsored mega-energy projects, including the Four Dam Pool and Bradley Lake hydro projects, and the Railbelt Intertie[5]. Although rural communities were not the primary focus of infrastructure development, the state did make small investments in rural wind power systems in the late 1970s and 1980s.

As of January 1984, the state had installed 140 wind generators across rural Alaska, predominantly in southwestern and south-central communities (Konkel 1984). Most of the wind generators were Jacobs brand turbines and had a capacity of 1 to 4 kWh, though 20 generators had over a 10 kWh capacity (Konkel 1984). Approximately

[4] A constitutionally established Fund created to invest at least 25 percent of all mineral lease rentals, royalties, and royalty sales proceeds received by the state. The Fund's annual earning are split mainly between the state operating expenses and the Permanent Fund Dividend, an annual payout to residents of Alaska,

[5] Transmission lines connecting six regulated electric utilities that extend from Fairbanks to Anchorage and the Kenai Peninsula.

two-thirds of the wind power systems had battery storage; the other one-third were integrated into the existing mini-grids and diesel generators. (Foster 2004).

The investment in wind power systems promised to help wean rural Alaska off its dependence on imported oil. However, as of the early 1990s, not a single wind demonstration project remained in operation. The initial analysis of why these projects failed pointed to several factors. For one, the technology of the early wind turbines was immature and not suited to handle the arctic and subarctic environments where they were installed. The State adopted the traditional approach to rural energy development, which was simply to focus on the installation of a new technology and the percentage of communities electrified by this technology (Anderson *et al.* 1999). Such an approach was void of community-specific social and political considerations. Coupled with a lack of long-term financing due to expired federal tax incentives, limited to no operator training (Keiser 1985), and poor planning (Davis 1984), the projects were destined to fail. The world experienced a decline in oil prices in the mid-80s, and many rural villages reverted to diesel generators, which were familiar and reliable to operate and maintain.

In hindsight, it was not a solitary factor that led to the failure of rural wind projects but rather myriad variables, some of which still have not been addressed in the recent attempts to develop wind resources. In addition to the technical and financial challenges, the lack of administrative capacity, program management, and coordination between entities contributed to the failures. In 1984, the Special Assistant to the Commissioner of Commerce and Economic Development offered several reasons why alternative energy projects failed, including:

1) "State agencies did not develop strong management capabilities;
2) State agencies lacked a methodology for assessing the technical and financial feasibility of projects;
3) Coordination among state agencies was often lacking;
4) Features of alternative technologies were often poorly matched with a useful rural application (Keiser 1985)."

The review of the history of power development in Alaska indicates that there was minimal strategy at the state or local level, creating scattered and uncoordinated development efforts and projects. What physically remains today from the initial surge of Alaska's wind power investments is the scattered frame of over a hundred wind turbines across Alaska. This history of development projects in rural Alaska—where projects were designed and inefficiently managed by outside agencies—has created a stigma against the wind industry for almost two decades.

Since the late 90s, Alaska has once again seen investment and growth in its wind industry, largely through energy policies, technology advancement, and the increasing competitive edge of wind energy as diesel cost continues to rise. To avoid the cost escalation inevitable with diesel fuel, utilities began to reinvest in wind power. In 1997, Kotzebue Electric Association (KEA), a consumer owned nonprofit electric cooperative, emerged as the state's new leader in the wind industry with the construction of three 66-kW turbines. As of 2008, KEA had 17 turbines installed; they represent the first megawatt of wind power in Alaska.

In the years that followed KEA's wind investment, AVEC and Tanadgusix Corporation (TDX) followed suit and installed wind turbines in several rural communities, including Kasigluk, St. Paul, Wales, Selawik, and Toksook Bay. Additionally, the state made varying efforts to promote and pursue wind development. It developed the Alaska wind energy atlas and created the anemometer loan program, which supplied meteorological "met" towers, data logging equipment, and technical support to utilities and communities for collecting data need to gauge local wind resources (AEA, 2009). However, it was not until global oil prices drastically increased in 2008 that there was a real resurgence of interest. At that point, the state began to invest seriously in alternative power systems.

Since the initial investment in wind turbines in the early 1980s, several variables have changed. The cost of installing wind power systems has declined due to technology advancements and the increased cost of diesel fuel, making wind more affordable and competitive with diesel generators. In 2004, the state of Alaska created the Rural Energy

Plan, which acknowledged that roughly 32 rural communities "present attractive opportunities for wind resource development, with reconnaissance benefit/cost ratios ranging from 1.0 up to 1.7[6]." It further stated that these communities have a potential net economic benefit sufficient to justify developing the resources (Foster 2004). Another 17 communities were identified as having potentially developable wind resources with reconnaissance benefit/cost ratios ranging from 0.85 to 1.0 (Foster 2004).

The state supported the findings of economic feasibility and invested $350 million in renewable energy projects with the development of the Renewable Energy Grant Fund in 2008. Both 2008 and 2009 saw significant increases in the installed capacity of wind power in the state. From the 200kW systems installed in Savoonga to the 4.5 MW systems installed in Kodiak, which doubled Alaska's installed capacity of wind power, wind is on the rise once again in Alaska. As of September 2009, the American Wind Energy Association reported that Alaska has 7.82 MW of installed wind capacity, making Alaska thirty-fourth in the nation for installed capacity.

[6] Anything over a one is deemed economically viable to develop

***Table 2.1** Installed wind capacity and projects in Alaska, 1997-2009*

Location	**Installed Capacity**	**Operator**	**Year online**
Kodiak	4.5 MW	Kodiak Electric Association	2009
Nome	1.17 MW	Bering Straits Native Corp. and Sitnasuak	2008
Kotzebue	1.14 MW	Kotzebue Electric Association	1997, 1999, 2002, 2006
St. Paul Island	675 kW	Tanadgusix Corporation (TDX)	1999, 2006
Unalakleet	600 kW	Unalakleet Valley Electric Cooperative	2009/2010
Kongiganak	475 kW	Alaska Village Electric Cooperative	2009
Toksook Bay	400 kW	Alaska Village Electric Cooperative	2005
Chevak	400 kW	Alaska Village Electric Cooperative	2009
Gambell	300 kW	Alaska Village Electric Cooperative	2009
Hooper Bay	300 kW	Alaska Village Electric Cooperative	2008
Kasigluk	300 kW	Alaska Village Electric Cooperative	2006
Selawik	260 kW	Kotzebue Electric Association	2004
Perryville	240 kW	Native Village of Perryville	2009
Tin City	225 kW	Tanadgusix Corp	2008
Mekoryuk	200 kW	Alaska Village Electric Cooperative	2009
Savoonga	200 kW	Alaska Village Electric Cooperative	2008
Wales	120 kW	Alaska Village Electric Cooperative	2000
Delta	100 kW	Alaska Environmental Power	2009
Port Heiden/ Pilot Point	20 kW	Sustainable Energy Commission of the Alaska Peninsula	2003
Healy	10 kW	Alaska Environmental Power	2008
Shaktoolik	4.8 kW	Shaktoolik Native Corporation	2008

ENERGY POLICY: A NATIONAL AND STATE CONTEXT

The principal impetus of the recent growth in renewable energy development throughout the nation is policy. The majority of renewable energy policies have a multi-faceted objective, including removing market barriers, diversifying state and national energy portfolios, improving human and environmental health, securing long-term energy supplies, and provide new energy development opportunities (Renewable Energy Policy Network for the 21 Century 2009).

The federal government has a different focus than state-level energy policies. Federally, the majority of renewable energy incentives take the form of tax credits and low interest loans. The Production Tax Credit (PTC), the primary federal incentive driving the wind industry, supports the production of electricity from qualifying renewable energy facilities. The credit currently provides a 2.1¢ per kWh benefit for the first ten years a renewable energy facility is in operation (Union of Concerned Scientists 2009). The PTC has been critical to the growth of the wind sector; however, it is approved only for short-term durations and is continually subject to reauthorization by Congress, making it difficult for developers to invest in and plan for future projects. The federal Energy Policy Act of 2005 offered "Clean Renewable Energy Bonds", (CREBs) which are equivalent to an interest-free loan used to finance qualified energy projects (National Rural Electric Cooperative Association 2009). In contrast to the PTC, which is available to private developers and investor-owned utilities, CREBs are available only to public power companies and cooperatives. The other main federal loan program is the USDA Rural Energy Generation Loan that provides low interest loans for rural businesses, public power distributors, and cooperatives to provide renewable power to rural customers.

Despite selective federal policies and programs, states have taken the leading role of incentivizing and promoting renewable energy. Growth in renewable energy sectors is strongest in states where the policy-makers have established favorable conditions for renewable development, (*e.g.*, Iowa, Minnesota, and Texas). This is largely because states have experienced immediate and tangible benefits from local development of renewable energy. This included economic growth through property taxes on landowners, price stability for consumers, diversification of the state's energy portfolio, and an effective hedge against fossil fuel price volatility and the much anticipated carbon tax.

A states' role in energy development is often to foster an enabling political environment, develop regulations, and promote programs. Such actions may take the form of legislation, standards, codes, targets, financing, training and policies (Anderson et al. 1999). Such policies include Renewable Portfolio Standards (RPS), System Benefit Funds (SBF), tax incentives, and net metering. RPSs have largely driven utility-scale wind development on the state level. They require electricity providers to derive a minimum percentage of their power from renewable energy sources by a certain date (USDOE 2008). As of May 2009, 29 states have RPSs (DSIRE 2009). The SBF is created from fees paid by electricity consumers. The revenue is reinvested in energy efficiency measures, renewable energy development, and low-income assistance. The majority of states have some form of personal, corporate, sales, or property tax incentives that provide impetus for investing in renewable energy projects. Additionally, net-metering is an important incentive offered in over 35 states (DSIRE 2009). It enables consumer investment in renewable energy generation, thus offsetting their consumption and enabling them to sell excess power to utilities at a retail price.

ENERGY POLICY IN ALASKA

Compared to other states that have implemented Renewable Portfolio Standards (33 states), property taxes incentives (32 states), and sales tax incentives for renewable energy (26 states), Alaska has been slow to respond to the rise in and need for a state-level renewable energy policy. Historically, the majority of Alaska energy policies have been directed at subsidizing and equalizing energy costs rather than investing in stable, renewable, and local energy resources and infrastructure. For rural Alaskans, the Power Cost Equalization (PCE) has had the most significant impact and provided the greatest relief to high electric prices. PCE was implemented in 1980 at a time of state surplus and with the intent to provide rate relief for rural communities. Because these communities are generally not connected to the road system and therefore subject to high costs of diesel fuel and transporting fuel, they do not receive the lower rates enjoyed by urban communities and those connected to hydropower (AEA 2007). The PCE subsidy has drastically reduced the costs of electricity for residents and public entities. However, it has done little to improve the underlying condition of rural communities and economies. Additionally, the combined electricity costs borne by both consumers and the state PCE program do not account for a large proportion of the real costs of the electric system, due to additional funding from government grants, mostly for infrastructure (Colt et al. 2003). Like many subsidies, they are difficult to eliminate once implemented and rural Alaska has clearly grown dependent on the PCE.

Despite the imperfections, 2008 and 2009 were landmark years for energy policy in Alaska. Not only did the Alaska legislature designate $300 million for weatherization, but it allocated $300 million over five years for renewable energy projects with the creation of the Renewable Energy Grant Program. The program provides assistance for feasibility studies, energy resource monitoring, and renewable energy construction. In the first two rounds of funding, the program has already invested $125 million in over 107 projects, ranging from a utility-scale wind farm in Nome to a biomass assessment in McGrath.

The state has created several energy plans over the past three decades, including the Rural Energy Plan in 2004. None of the plans has been thoroughly implemented and they all lack a comprehensive state policy to guide them. In 2009, the Alaska Energy Authority completed *Alaska Energy: A First Step Towards Energy Independence*. The document contains two main sections - a narrative and a technology screening tool developed to allow each community to review locally available energy resources and determine the least cost energy options (AEA 2009). As such, this document is a tool for communities and the state to conduct preliminary resource assessments and a vehicle to discuss the future of energy development and use in Alaska. However, the document is not written into law and is not an official plan adopted by the legislature, creating uncertainty whether it too will be another state energy document left unimplemented.

The monumental creation of the Renewable Energy Grant program ensures that Alaska is moving forward, yet many of the state's efforts are not coordinated with one another and there no comprehensive policy to direct the state's action. The current policies have eased the economic restraints associated with renewable energy development and have designated funds for researching emerging technologies to ease the technological barriers. However, they fail to address many of the crucial sociopolitical barriers that stand in the way of moving wind development forward in rural Alaska. Additionally, the newer policies coexist with older policies such as the PCE, yet they have fundamentally opposing objectives. The perpetuation of the PCE program creates state-sponsored disincentives for implementing renewable energy systems by continuing a diesel subsidy, whereas the Renewable Energy Grant Fund's very purpose is to promote and economically support the deployment of renewable energy. As such, the creation of comprehensive statewide energy policies will play a determinant role in the future direction of Alaska.

MAIN ACTORS/STAKEHOLDERS

Central to the analyses of wind power development thresholds, barriers, and drivers in rural Alaska is an understanding of the actors and their role in the decision-making process at both policy and planning levels. Although a project may be small scale, the siting and planning decisions affect a multitude of other stakeholders (Wustenhagen et al. 2007) and decisions must therefore be supported by multiple stakeholders. In order to bridge the gaps between technical, economic, social, political, and environmental barriers, it is essential for cross-scale participatory efforts to be carried out between all stakeholder groups. An analysis by Beirele and Cayford in 2002 identified essential factors for public participation in environmental decision-making: engaging stakeholders, the responsiveness of the lead agency, motivation of the participants, quality of deliberation, and the degree of the participants' control over the process (Beirele and Cayford 2002).

The following information identifies the primary actors and stakeholders and their role in wind energy development in Alaska.

Federal, State and Local Government

The role of the federal, state, and local government is of vital importance for the deployment of wind power. Government involvement occurs at almost every stage, including planning, permitting, and financing. Through the development of policy and market incentives, programs, and technical assistance, the governments have the capacity to endorse, stall, or thwart the development of wind projects. In regards to rural wind development, the federal and state governments are primarily involved in policies or programs that either regulate, offer incentives to, or assist in funding renewable energy projects (Weis *et al.* 2008). Local governments are often involved in coordinating projects, local participation, and permitting.

Local Community

For purposes of this research, the local community is limited to city and tribal governments, residents, local organizations, and village corporations. Local governments have the responsibility of working directly with residents and being liaisons between different levels of government and their community. As a result, local governments are often important in the implementation and enforcement of energy policies and programs (REN21 2009). Residents and local organizations may participate in the planning process and influence the outcome of a wind project; their acceptance or resistance often directly determines whether wind projects are implemented (Jobert *et al.* 2007). Local communities may be involved throughout all stages of development in wind projects, or they may be involved in distinct stages such as strategic planning or site selection. They may form coalitions or networks to either promote or reject a project, and they can participate through various channels, including public comment, community meetings and local decision-making. Due to their extensive landholding in the vicinity of local villages in rural Alaska, village corporations are often involved in site selection and land leasing for wind projects.

Electric Utility

Electric utilities are the generators, owners, distributors, and at times developers of wind projects in Alaska, and they play an important role throughout all stages of developing a project. The utility's role depends on the project and the size of the utility, but it may involve project oversight, funding, siting, technical assistance, construction, power generation, power distribution, and the maintenance and operation of projects.

Private Sector (Developers, Contractors, Manufacturers)

Developers and contractors are the companies involved in designing, constructing, financing, and sometime operating wind–diesel projects. The manufacturers are involved in designing and developing equipment, including turbines, blades, and integration equipment such as software and remote controllers. They have played a significant role in seeing projects to completion and designing equipment for the Alaska environment; recently under the Renewable Energy Grant Fund, they have applied for and financed projects.

Researchers

Researchers include academics, research consultants, and the scientific community at large. Regarding wind power development, they are often responsible for creating a new knowledge base by testing new technologies, conducting feasibility assessments and wind analyses, and establishing the legitimacy of problems and successes of wind power in rural Alaska. Researchers may also help disseminate information, provide technical assistance, and advocate for policy revisions that encourage the deployment of wind systems.

Nonprofit and Advocacy Organizations

Nonprofit and advocacy organizations refer to a wide range of entities that have varying interests and roles in wind power development. Both function as pressure groups and often raise awareness of specific issues (Betsill and Corell 2008). Such activities may include advocating for or against certain projects and policies, raising environmental issues, launching campaigns and initiatives, and introducing new legislation. Both groups are of strategic importance and can exert a significant influence over the future of wind power in Alaska.

CHAPTER THREE:
THRESHOLDS AND BARRIERS TO WIND POWER DEVELOPMENT IN RURAL ALASKA

THRESHOLDS TO WIND POWER DEVELOPMENT

Various thresholds must be met in order to develop wind power in rural Alaska. Every factor contributes, but no single factor in itself is sufficient for implementation (Agterbosch *et al.* 2009). By the same token, it is impossible to pinpoint one single variable as the primary barrier to or facilitator of wind development in rural Alaska. Social, political, technical, economic, and environmental factors interact with and influence one another and must be examined collectively. Consequently, solutions must address all of these elements at some level. Certain common obstacles in rural communities include complex logistics, small economies of scale, limited local administrative and operator capacity, project coordination, challenging environmental conditions, remoteness, and limited number of turbines suitable for small village level loads. However, wind power policies and programs typically have tended to address energy supply, technology, and economics rather than the societal and complex procedural issues at the crux of developing sustainable projects (Szarka 2006).

Certain development thresholds and barriers are common to wind projects in any location, while others are more specific to wind-diesel applications in rural Alaska. In rural Alaska, turbines are rarely connected to a larger electric grid and are most often stand-alone wind-diesel systems, for which there are limited turbine manufacturers that can meet the need of small, 100 to 500 kWh loads. Additionally, in rural Alaska the temporal and spatial scale and scope of projects often involve a different set of considerations than projects in urban areas of Alaska and the United States. This chapter explains development thresholds identified in the literature and explores the connection between those documented and the results of the surveys. Although it alludes to technical, economic, and environmental factors, it focuses primarily on the social and political barriers.

Social Thresholds

Social context is important. On a national level, it is a variable that frequently affects whether wind power is accepted or rejected, yet its importance in planning and developing policy is underemphasized. Recent research on renewable energy in developing nations suggests that one of the major misconceptions that have impeded sustainable development in rural communities is that successful development outcomes are essentially technological rather than sociological in nature (Kammen 1999). This misconception has been confirmed historically in development projects in rural Alaska and will remain an impediment if emphasis is not redirected toward addressing social issues.

Wind farms typically consist of dozens to hundreds of turbines scattered across the landscape, as well as transmission lines, access roads, and sub-stations. In the United States, one of the greatest obstacles to wind development has been the lack of community acceptance and support. This commonly arises from aesthetic and noise factors, including the "not in my backyard" (NIMBY) syndrome, where people and communities resist or oppose development near their community. Such dissent often stems from lack of public participation in the planning process and a deficiency in public awareness (Agterbosch *et al.* 2009) that goes beyond "information campaigns" (Szarka 2006). As a result, turbines have been constructed in undesirable locations for local communities, or even abandoned. However, other research argues that NIMBY is an over-simplification of individual and community motives (Bell *et al.* 2005, Wolsink 2000). Additionally, community acceptance is known to have a time dimension (Wustenhagen *et al.* 2007). It requires sustained efforts and communication by planners and developers and varies depending on the planning stage and level of involvement.

There is a threshold of local human capacity to develop, manage, administer, and maintain wind systems that is needed before a wind system can be developed. In Alaska, such responsibilities often fall on the local utility, tribe, or city government in communities that have small populations and limited resources. Faced with responsibility for providing multiple services and organizing numerous projects in their communities, these local entities encounter challenges due to limitation of staff, frequent turn over, and incomplete information regarding specific projects. Such local capacity issues have not yet been documented adequately for rural electricity projects in Alaska (AEA 2009) and, therefore, have not been thoroughly addressed.

It is usually these smaller and at times poorly organized communities that are overlooked and do not reap the benefits of energy programs (Keiser 1985). Contributing factors are a lack of communication and coordination between state agencies and local organizations, a lack of local knowledge about existing funding and technical assistance resources, and a lack of an intimate understanding on the part of supervising agencies regarding issues faced by rural communities. Building local-state relations through trust and coordination (Agterbosch *et al.* 2009) is a path to overcoming such social barriers.

Training issues—having sufficient staff and adequate training for that staff—is another development threshold that impacts the ability to maintain projects in rural Alaska (Keiser 1985). Most rural communities have modest local resources and require outside training and assistance to maintain their systems (Foster 2004). However, such assistance is often prohibitively costly or not readily available. In fact, there continue to be problems in the operation and maintenance of diesel generators in rural Alaska even though training for diesel technologies is far more readily available than training for wind power (Keiser 1985).

Rural wind projects are almost always are initiated by an individual. Therefore, leaders must have the vision to recognize the possibilities of projects and use their influence to gather support and move projects forward. Community development theory suggests that leaders in the more viable communities are likely to repeat their efforts at developing projects over a period of time (Fendley and Christenson 1989), giving leaders numerous opportunities to work together and build projects. The success of energy projects hinges on these key relationships and the local leaders' abilities to leverage these networks to their full capacity.

Political Thresholds

The integration of economic, environmental, technical, and social concerns into policy-making is a trademark of the sustainability concept, but this approach has only informed energy policy to a limited extent (Szarka 2006). Understanding this hurdle and developing a new policy paradigm that focuses beyond electric production capacity is critical to designing a policy more hospitable to wind power development in rural Alaska.

The complex regulatory framework (*i.e.,* permitting procedures, regulations, and enforcement) that governs the planning and permitting of renewable energy projects is built of interdependent conditions that create bottlenecks in projects (Agterbosch *et al.* 2009). Project delays due to permitting on state lands and receiving clearance from the Federal Aviation Administration are just two examples. For small communities with limited human resources, navigating this complex regulatory process frequently delays or even halts projects.

Scattered decision-making at the local and state levels result in limited coordination and lack of communication during the course of a project. Additionally, the fragmentation of interests between entities such as communities and developers, and a limited knowledge base on the part of agencies regarding rural issues, further impede the chances of a project's success. These conditions can be counteracted through open communication between various stakeholders, capacity building of local stakeholders, and collaboration driven by a shared interest (Agterbosch *et al.* 2009). However, this is seldom the case. Decision-makers need to recognize the efficacy of renewable energy in the policy arena in order to create an environment that effectively fosters the growth of the wind industry and the development of wind-diesel projects across rural Alaska.

A recent analysis of rural energy development in China identified multiple barriers to the successful development of biomass projects. The inability of government agencies to recognize and integrate local-contextual details and to learn from past mistakes, most notably the need for accountability, is a primary reason that projects failed (Young *et al.* 2007). Such agencies exercised insufficient oversight of the projects by immediately turning them over to local administrations that were already struggling, ultimately contributing to the collapse of projects (Young *et al.* 2007). The explanations of why rural energy development projects in China failed mirror the political reasoning behind the failure of past wind projects in Alaska. Alaska's past failures were also a result of technical wind turbine challenges and the political component is parallel.

Technical Thresholds

Due to remoteness and low electricity demands, the majority of rural Alaskan communities are not connected to the electric grid and are unlikely to be connected in the future. Therefore, stand-alone power systems, primarily diesel generators, are currently the only feasible way to provide electricity to these communities. To compete with the existing diesel systems, wind power project planning, construction, and operation will have to overcome several technical barriers.

In most parts of the United States and in the Railbelt in Alaska, electricity is managed in the electric grid. However, the majority of rural Alaskan communities are not grid-connected and transmission lines are often uneconomical, creating a demand for energy storage solutions. Because wind is an intermittent resource, it requires storage or integration with another energy source such as a diesel generator to regulate the fluctuations (AEA 2009). For rural Alaska, battery storage is a potential solution but, as a costly and immature technology, it poses a major technical barrier to developing reliable and economic wind systems (Davis 1984). Additionally, a 1984 Department of Commerce and economic Development report on wind systems identified the need for a facility to test turbines and batteries and suggested consolidating technical knowledge regarding wind generator technology specific to arctic and sub-arctic climates.

This idea has been somewhat realized with the development of the Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks in 2008. ACEP, together with the Alaska Energy Authority and the National Renewable Energy Laboratory, is creating a wind-diesel application center (WiDAC) that analyzes technology options, tests state-of-the-art hardware and control software, and provides technical assistance to wind–diesel stakeholders (ACEP 2009). WiDAC is a step in the right direction, yet it is still a ways from having the financial and human resources, as well as the facilities, to provide adequate wind technology services at a statewide level.

Physical conditions in Alaska, including permafrost, ice, strong winds, and low temperatures, create significant technical and logistical hurdles for projects and affect the reliability and performance of turbines (ACEP 2009). Seasonal conditions and temperatures, including warming trends, affect the transportation of equipment (Kohler 2008).

Once the appropriate technology is secured, the human factor comes into play. The success of utilizing such technologies largely depends on operation and maintenance (Keiser 1985). In rural communities, having local operators and responsive technical support are factors that must be considered when constructing, operating, and maintaining wind-diesel systems. Past wind projects have experienced extensive downtime when the turbines were inoperable due to mechanical problems (AEA 2009). In addition, there is a vast discrepancy between technical services in urban and rural areas. For example, while urban areas have ready access to spare parts, limited inventory in rural areas routinely results in inefficient generation or even complete shut down. These basic technical circumstances end up creating major financial and operational barriers.

Economic Thresholds

Economics play a major role in the development and long-term success of wind projects. Rural Alaska is automatically at a disadvantage due to the high costs associated with supplying electricity to meet its low electric demands, as well as the prohibitive costs of building additional transmission lines to connect rural communities (Brown and Escobar 2007). This is true in many rural areas of the world where low population densities result in high capital, operation, and maintenance costs for electric utilities (Fluitman 1983). There are also disproportionately high expenses associated with equipment, operation, distribution, and maintenance of systems in rural Alaska. Combined, these result in significant costs to rural utilities and can be financially debilitating. However, because the infrastructure for diesel systems already exists and is cheaper than capitalizing on alternative systems, the choice is too often business-as-usual.

Sparse, scattered population in rural Alaska necessarily means that communities and utilities cannot take advantage of economies of scale. Additionally, there is commonly a maximum price that rural communities are either willing or able to pay for electricity. If the amount is less than the amount required to develop, operate, and maintain a wind system, then the project either cannot be developed or must be subsidized (Anderson *et al.* 1999). However, this does not negate the benefits. Investments in renewable energy over the long-term can provide stable costs that are not necessarily subject to the vagaries of fossil fuel supply and demand.

It is uncontestable that Alaska's oil reserves are declining and that, consequently, so is the state's oil revenue. The days when the state had bottomless coffers to invest generously in civic projects have passed; available oil revenue will continue to decline, and competition for funds will increase. The ability of rural communities and utilities to obtain project financing through state loans and grants will become increasingly difficult, magnifying the current challenges for rural utilities. Additionally, as state oil revenue declines and the global price of fossil fuels increases, price forecasts will become more and more unpredictable. This poses an impediment to rural wind development because financing a wind project requires a projection of the break-even point, which is based on the forecast cost of oil.

Environmental Thresholds

On the national level, environmental concerns are among the most commonly litigated issues associated with the development of wind projects (Brown and Escobar 2007). Because of the likelihood of contact between birds and wind turbine blades, the most common environmental and biological concerns surrounding wind power projects are the potential impacts on avian populations. In Alaska, high wind areas and significant populations of migratory birds, including endangered and threatened bird species, intersect in the same coastal areas and river deltas.

The two major laws that govern avian impacts from wind turbines are the Migratory Bird Treaty Act (MBTA) and the Endangered Species Act (ESA). Both acts prohibit the "take"[7] of the species that they protect. Consequently, the taking of any migratory bird or endangered species constitutes a violation of the Acts in question, with the exception of takings indicated in an ESA incidental take permit. To date, there have been no prosecutions under the MBTA arising from wind turbines. This is true even at California's Altamont Pass, which has four thousand wind turbines in a concentrated area. No environmental assessment or community participation went into the development of this area, and the result has been the world's largest concentration of wind turbine-related avian deaths. Thousands of raptors and migratory birds have died since the turbines were installed in the 1970s (McKinsey 2008). The minimal enforcement of past violations suggests that the U.S. Fish & Wildlife Service will be cautious when prosecuting the taking of birds resulting from wind turbine collisions, particularly if developers take necessary and recommended precautions. However, wildlife impacts are anticipated to be significant obstacles for wind development due to rapid growth in the industry and the increased focus on cumulative effects of avian mortality. The uncertainty apparent in the selective enforcement of the MBTA is potentially one of the greatest risks for developers (McKinsey 2008).

Numerous studies document bird deaths following collisions with wind turbines, meteorological towers, and guy wires, as well as from habitat loss and fragmentation due to the physical presence of turbines, roads, and electric lines. In Alaska, there is limited available data on avian impacts from wind projects. Several federal agencies and multiple states have established guidelines and recommendations to mitigate and avoid impacts to protected birds. Under both the MBTA and ESA, the USFWS cannot absolve individuals or developers from liability for following voluntary guidelines or recommendations. However, court cases and a history of limited enforcement suggest

[7] Defined under the ESA as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct (Bean 1997)." The MBTA interprets "take" as the prohibition of killing, possession, transportation, and importation of migratory birds, eggs, parts, and the nests. A major different between the MBTA and ESA is that the MBTA does not issue "accidental" or "incidental" takes, where as the ESA does.

that the USFWS has exercised discretion toward those who have made concerted good faith efforts to minimize the take of protected birds.

Summary of Thresholds

Based on the literature review above, there are multiple social, political, technical, economic, and environmental thresholds that need to be met in order to overcome barriers to wind development in rural Alaska. The ability to meet some or all of these thresholds creates favorable conditions and gives a community or entity the advantage to overcome obstacles that otherwise would have hindered or stopped the development process.

***Table 3.1** Summary of thresholds for wind power development*

Social	• Community acceptance, support, and participation • Aesthetic and noise factors, NIMBY • Local capacity to develop, manage, and maintain wind systems • Leadership / project champion • Access to information • Ability to learn from past mistakes
Political	• Ability to navigate complex regulatory frameworks • Decision-making coordination at the local and state levels • Integration of local-context • Methodology for assessing project feasibility and tracking problems • Local and state-level accountability • Access to technical assistance
Technical	• Turbine performance and reliability • Logistical coordination (i.e. transportation, scheduling, equipment) • Resource assessment
Economic	• Ability to take advantage of economies of scale • Method for analyzing wind economics
Environmental	• Documentation of environmental impacts • Avian Issues: migratory, endangered and threatened species

SURVEY OF BARRIERS TO WIND POWER DEVELOPMENT

The underlying original research for this paper relied in part on a quantitative survey approach. It focused on the barriers in rural communities that either have not pursued wind development or have been unsuccessful in their attempts. Studying such factors not only provided insight into certain hindrances to projects, but it also opened the door to broader possible solutions. The surveys were used to capture the perspective of the primary decision-making entities in communities identified by the Alaska Energy Authority as having a 4-through-7 wind class but that had not yet developed their wind resource. There were several compelling reasons that a survey approach was preferable to other methods. Surveys are relatively inexpensive, allowing the researcher to cover larger sample sizes than case studies alone. They provide a standardized approach. They ensure that the same categories of data are collected from various respondents. Because of the uniformity in response choices, they can be interpreted comparatively. Commonalities and difference are thus easier to pinpoint. However, surveys also have shortcomings. Because the response choices are limited and predefined, they provide little context or individual nuance. They also restrict the participant's ability to address controversial or unfamiliar questions.

Survey Development

Mail-out surveys were used to reach the greatest number of communities. Due to limited resources and funding, surveys were sent only to tribal councils, city councils, and electric utilities but not to individual community residents. As the primary service providers and decision-making entities in the community, these three entities were the most suitable to respond based on the subject matter. They have their finger on the pulse of the community, are knowledgeable on the issues, have survived the trials and errors of past development projects, and have the benefit of hindsight.

The survey questions were based on information gathered during the literature review and interviews and designed to capture trends in perspectives specific to rural Alaska. In particular, many of the questions were modeled after a survey conducted by the Pembina Institute on barriers to wind energy development in remote Canadian communities, which found that capital, operation, and maintenance costs were identified by manufacturers, researchers, developers, and government as the most significant barriers (Weis *et al.* 2008).

The rural Alaska survey was broken into three sections (see Appendix 1). The first section focused on background information. It asked general questions about both the individual respondent and the respondent's organization. The second section, the bulk of the survey, focused on the organization's experience with wind power development based on economic, social, political, technical, and environmental variables. The respondents were asked to designate how specific statements best represented their organization's perspective on rural wind power development, basing their responses on personal knowledge of the organization's understanding of wind power. They ranked their responses on scales ranging, for example, from *very feasible* to *not feasible* or from *very qualified* to *not qualified*. The intention was that the respondents represent the position of the organization, not their personal opinions. The third section asked respondents to prioritize what their organization considered to be the major barriers to wind development in their community. They ranked different barriers from one to ten, with one as the most important barrier and ten as the least important barrier. A blank space for "others" enabled the respondent to add a barrier that was not already listed. Many respondents did not answer section three as intended, perhaps because the instructions were either difficult to understand or could have been interpreted in multiple ways. As a result, the improper responses had to be discarded, decreasing the overall response rate for section three. Another component of section three was two open-ended questions to enable comments about additional resources and overall experience with wind development.

Once the survey was formulated, sample surveys were distributed to select individuals in order to test the readability and ease of understanding. Based on this feedback, changes were made to increase the clarity of the questions. The surveys were then reviewed and approved by the Institutional Review Board (IRB) at the University of Alaska Fairbanks to ensure integrity and the rights of research participants.

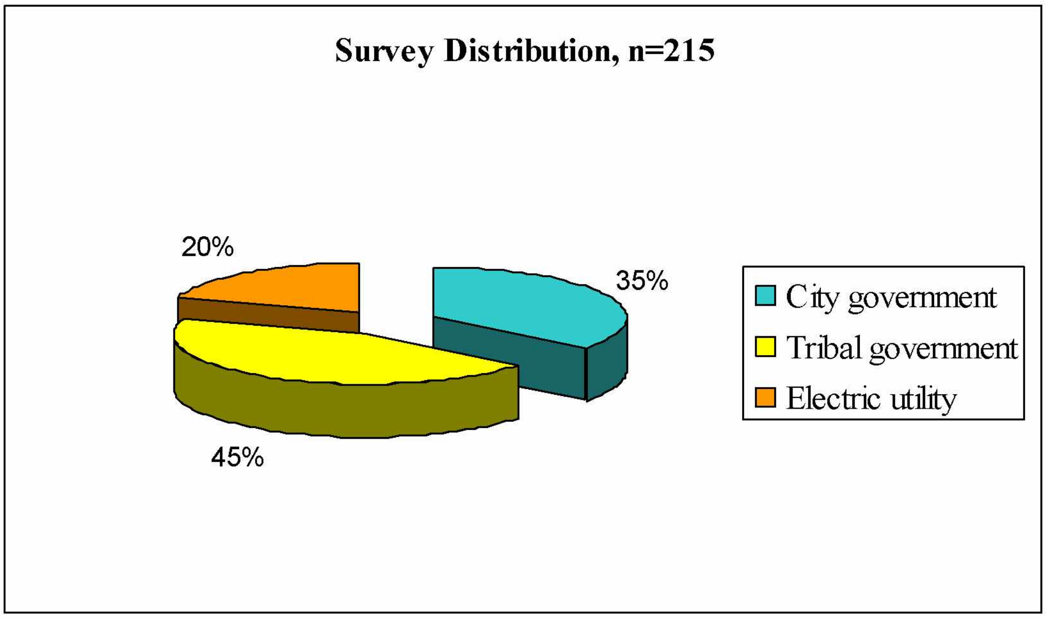
Under the parameters of the thesis, rural communities targeted by the survey were those with populations under 6,000 and not connected to the Railbelt electric grid. The Alaska Energy Authority identified 115 communities with a 4-through-7 wind class, but only 99 met the additional research criteria of being rural and lacking a developed wind power system. Prior to mailing the surveys, phone calls were made to confirm respondents contact information and to notify tribes, cities, and utilities to expect the survey. To ensure that the survey was received by the most knowledgeable representatives of the entities, they were addressed to the tribal administrator for a tribal government, the city mayor for a city government, and the utility manager for an electric utility. For the majority of the questions, respondents were asked to respond based on the perspective of the organization in which they were employed. The possibility that respondent's were influenced by personal biases is acknowledged.

Additionally, in compliance with the IRB, a participant consent form was attached to the survey to explain the purpose and voluntary nature of the research, to assure the respondent's of confidentiality, and to obtain the signatures of respondents who chose to participate in the survey. Also included was a self-addressed stamped envelope. Four slightly different versions of the surveys were mailed. They were customized according to the organization to which they were distributed: tribal councils, city councils, individual electric utilities, and electric utilities that provide services to more than one community.

Of the 99 focus communities, several did not have a city or tribal government, so the number of surveys mailed to each community varied. Additionally, certain electric utilities such as the Alaska Village Electric Cooperative provided services to multiple targeted communities. Even when a utility provided electric services to multiple communities, a single survey was sent to that utility. For example, the Alaska Village Electric Cooperative (AVEC) is the electric utility for 42 communities in this study. Although each existing tribal and city government in each community received a separate survey, only one survey was sent to AVEC; they provided responses based on their collective perspective for all of the communities that they service.

Response Rate and Methods of Analysis

A total of 215 surveys were distributed to city governments, tribal governments, and electric utilities. After the first mailing, 10% of the surveys were returned. In order to improve the response rate, a reminder postcard was mailed to each non-responding organization two weeks after the first mailing. Approximately two weeks later, organizations who still had not responded received a second survey. After the second survey mailing, 26% of the surveys were returned. A third survey mailing occurred approximately two weeks later. After the final mailing, a total of 78 completed surveys were received, resulting in a 36% response rate.



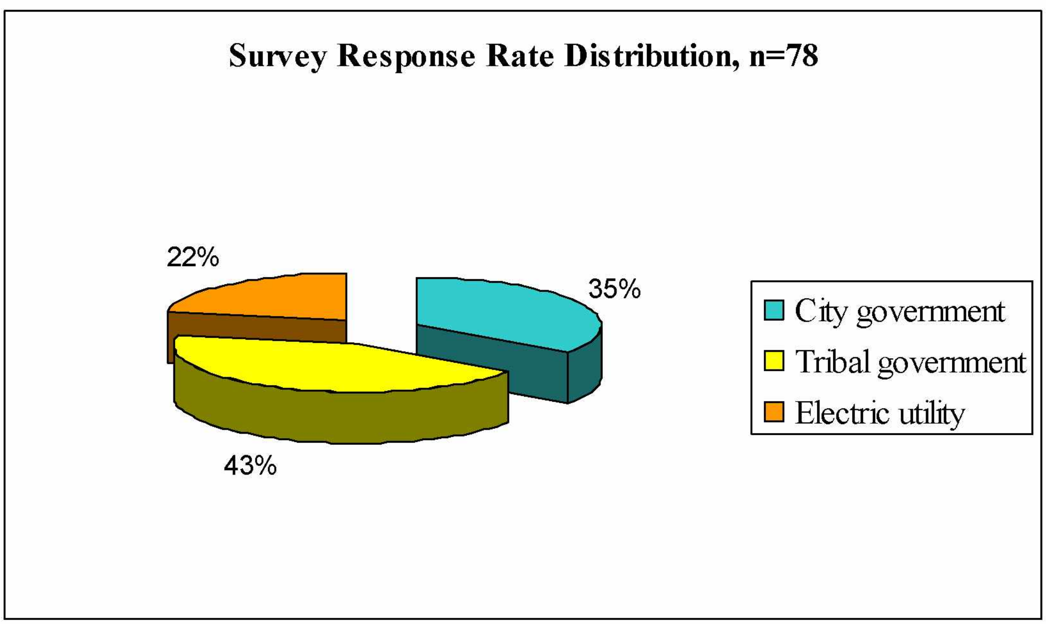


Figure 3.1 *Comparison of the survey distribution and survey response rate distribution.*

Statistics Package for Social Science (SPSS) and Microsoft Excel were used in the statistical analysis to evaluate the frequency and percentage of response rates. These programs were also used to establish correlations among multiple variables. For example, correlations between the utility structure and certain response rates. Additionally, written comments to open-ended questions were examined and incorporated into the discussion.

SURVEY RESULTS

Background Information

The first section focused on background information about the individual respondents and organization. The questions zeroed in on the respondents position at the organization, personal perspective on wind power, and the electric utility ownership.

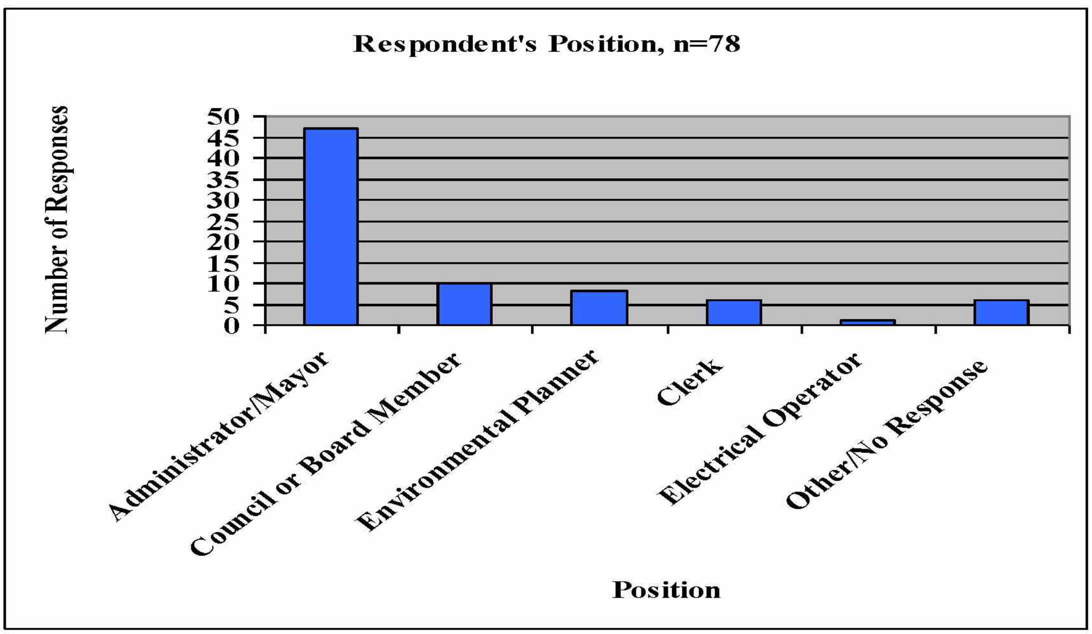


Figure 3.2 *Response to the question: Please indicate your position at the organization.*

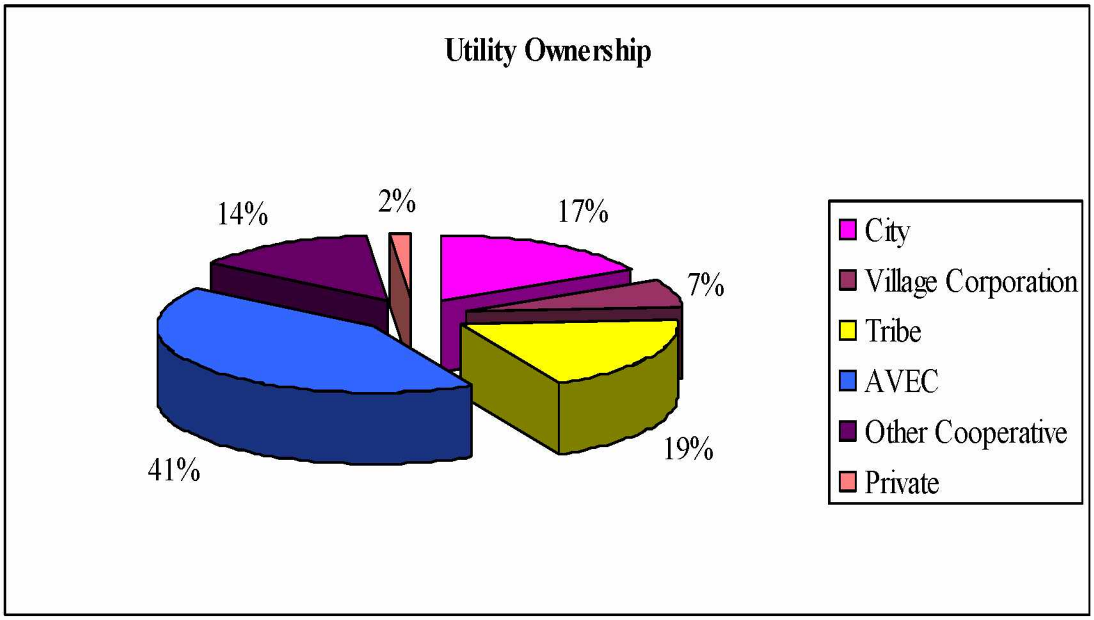


Figure 3.3 *Utility ownership of survey responding communities.*

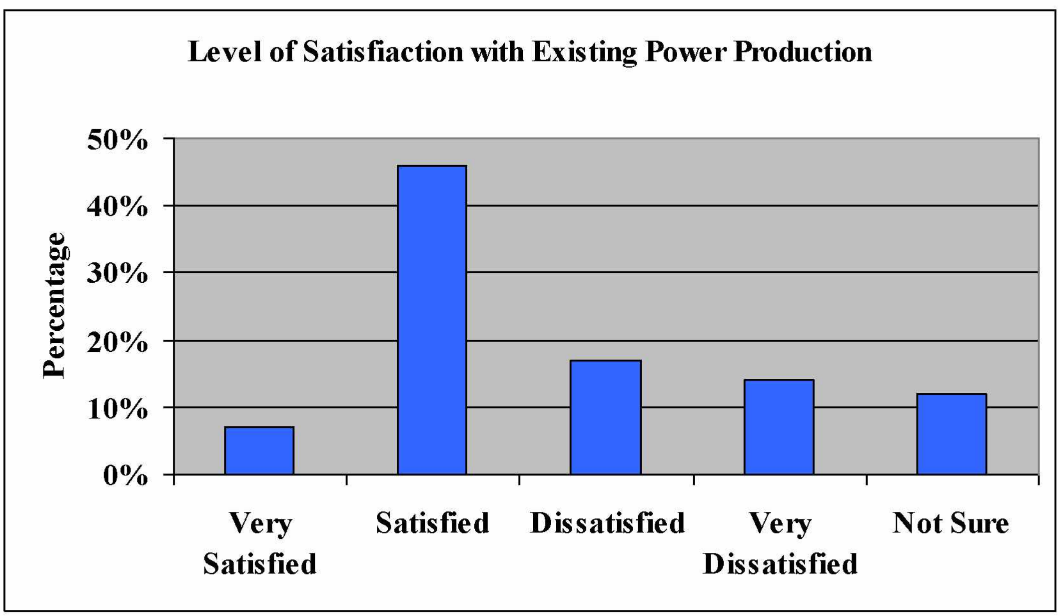


Figure 3.4 *Response to the question: How satisfied is your organization with how electricity is produced in your community?*

77% of the surveys were completed by people in decision-making positions, including tribal and city administrators, city mayors, tribal and city council members, and utility board members. Such respondents have a greater level of knowledge of community issues and ability to respond on behalf of the organization, increasing the reliability of the responses. When asked whether the respondents considered themselves advocates of wind power in their community, 73% responded *yes* and 17% responded *no*. This indicates a high degree of interest among local decisions-makers to develop wind power in their local community. Although the surveys were not equally distributed among utility structures, all ownership configurations were represented in the survey.

Level of Local Acceptance and Support

Factors influencing community acceptance and support are increasingly recognized as key contributing variables for understanding why certain projects are developed and others are not. However, social acceptance as part of energy planning has been largely neglected (Wustenhagen *et al.* 2007). Community support can take multiple forms, including advocating for projects, participating in the planning process, and staying informed. Three survey questions addressed factors of local acceptance and support in order to quantify whether such factors are of significant importance in rural communities in Alaska. Respondents were asked to rank the level of support and impact on a scale based on the perspective of their organizations.

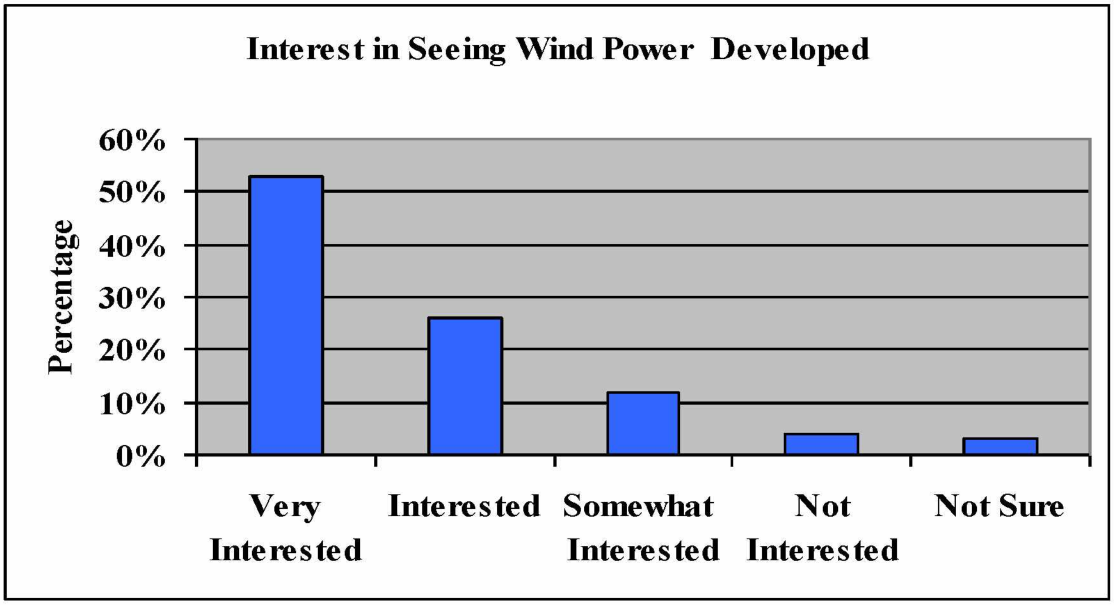


Figure 3.5 *Response to the question: Is your organization interested in seeing wind power developed in your community?*

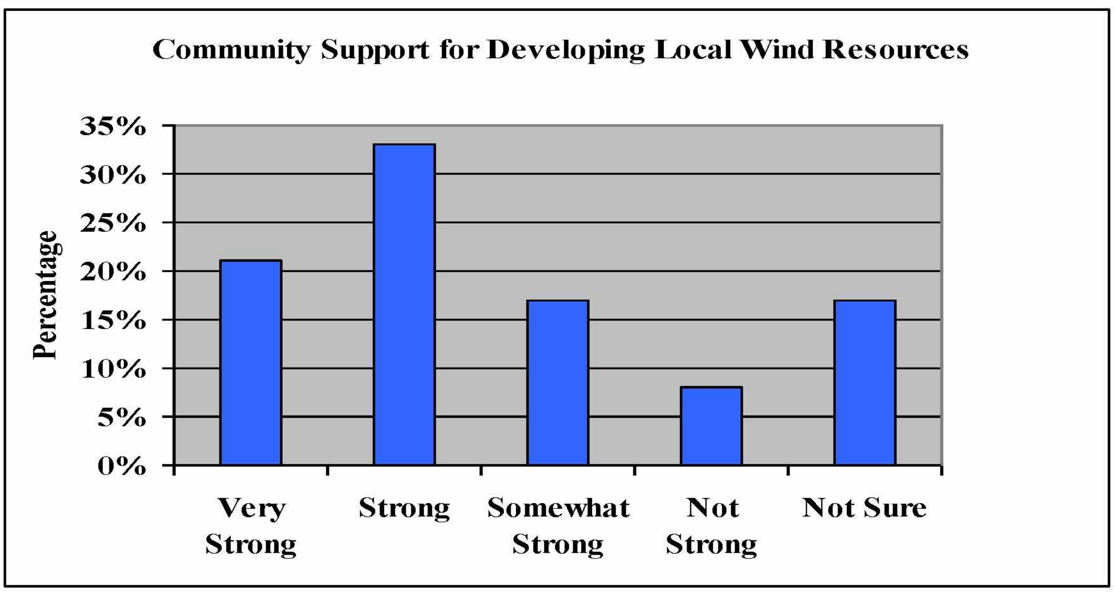


Figure 3.5 *Response to the question: How strong is the support within your community for developing wind power?*

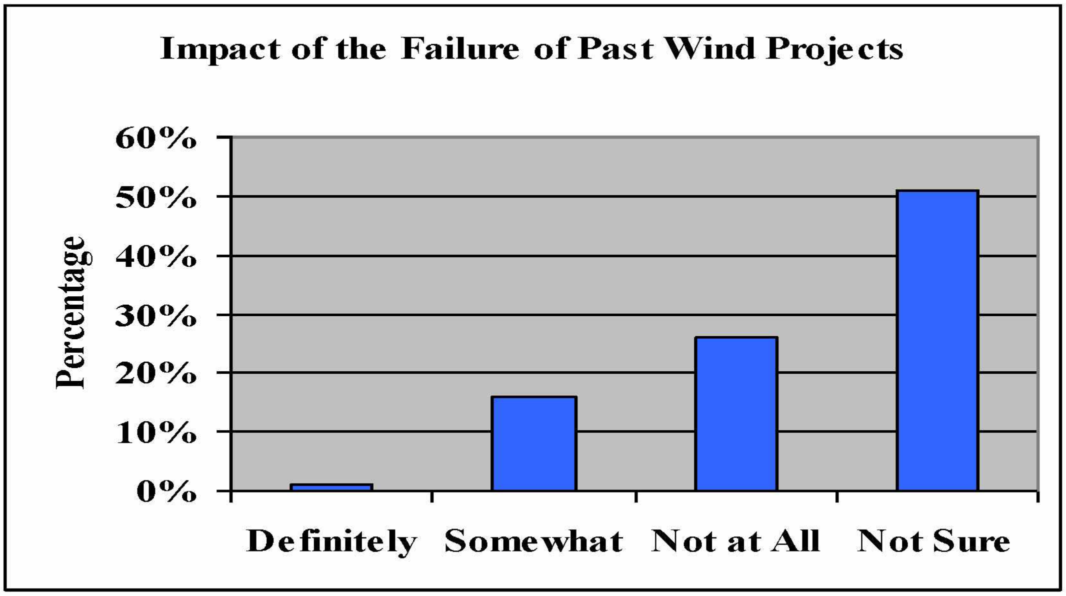


Figure 3.7 *Response to the question: Have past failures of rural wind projects affected the organization's perception of wind power's reliability?*

When asked whether their organization was interested in seeing wind power developed in their community, 91% of respondents indicated that that their organization had varying degrees of interest in seeing wind power developed, whereas 4% marked they were *not interested*. All of the 4% that responded *not interested* noted that they have other alternative power options such as hydro that they would prefer to develop ahead of wind. Similarly, 71% of respondents replied that support within their community for wind power development was either *very strong, strong*, or *somewhat strong*. Only 8% of respondents stated that the organization was *not interested* in wind power development, largely due to having local alternative sources of power. Whereas community opposition is noted as a prominent barrier to development in other parts of the country due to aesthetic and environment factors, the low rate of participants that replied *not interested* demonstrates that it is not perceived by local authorities to be a significant barrier in rural Alaska. This may be a result of communities recognizing the magnitude of benefits from wind power, including local employment and reliable, stable power prices, particularly after rural Alaska experienced such a dramatic increase in the cost of power during 2008. However, this difference in response between Alaska and the rest of the U.S. may reflect the fact that this research surveyed community leaders and utilities, whereas community opposition in the literature is likely based on surveys answered by the general public.

When questioned if past failures of rural wind projects affected an organization's perception of wind power reliability, 1% responded *definitely*, 26% responded *not at all*, and 51% responded *not sure*. Although there was a long-standing stigma against wind power after the mass failure of projects in the 80s, the 51% *not sure* and 26% *not at all* response rates suggest that past failures no longer discourage people from the potential of wind development. Additionally, the high *not sure* response rate may signify that project failures in the 80s are either forgotten or have become such a distant memory that there is no longer a stigma associated with them. The pendulum has swung and there is a window of opportunity to take advantage of this receptiveness to change.

Commitment of Leadership

For the purpose of this survey, leadership refers to the individuals who strongly support a project and propel it forward. Such leadership can take the form of formal leaders who are appointed to their positions, such as tribal and city administrators and council members, or informal members from the community. Two survey questions were directed toward the significance of and commitment of local leadership in development of wind resources. Respondents were asked to rank these factors from the perspective of their organizations.

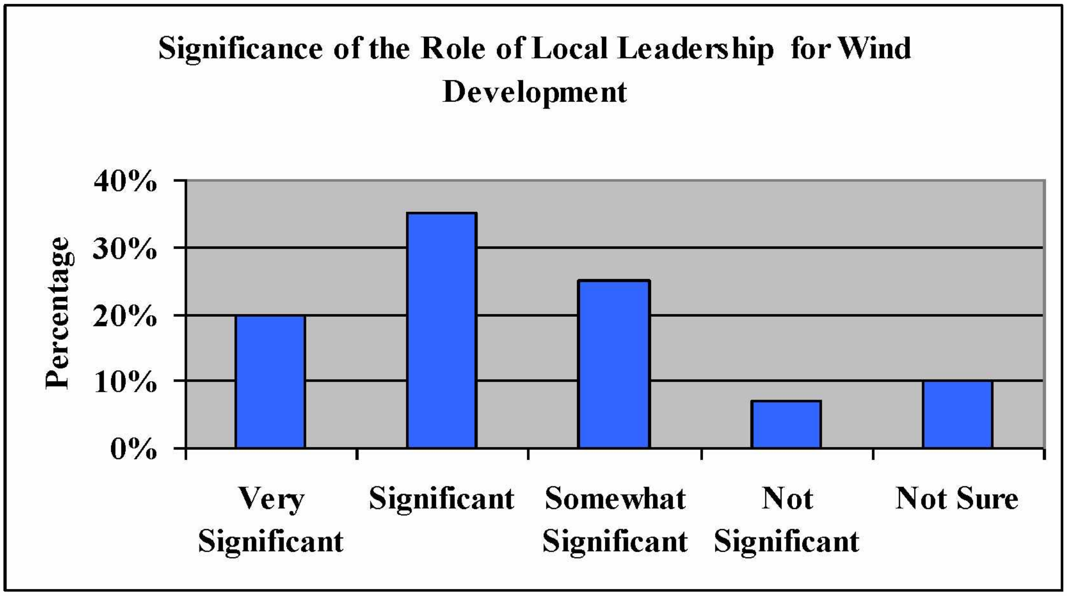


Figure 3.8 *Response to the question: How significant is the role of local leadership (i.e. someone who strongly supports the project) for wind power development in your community?*

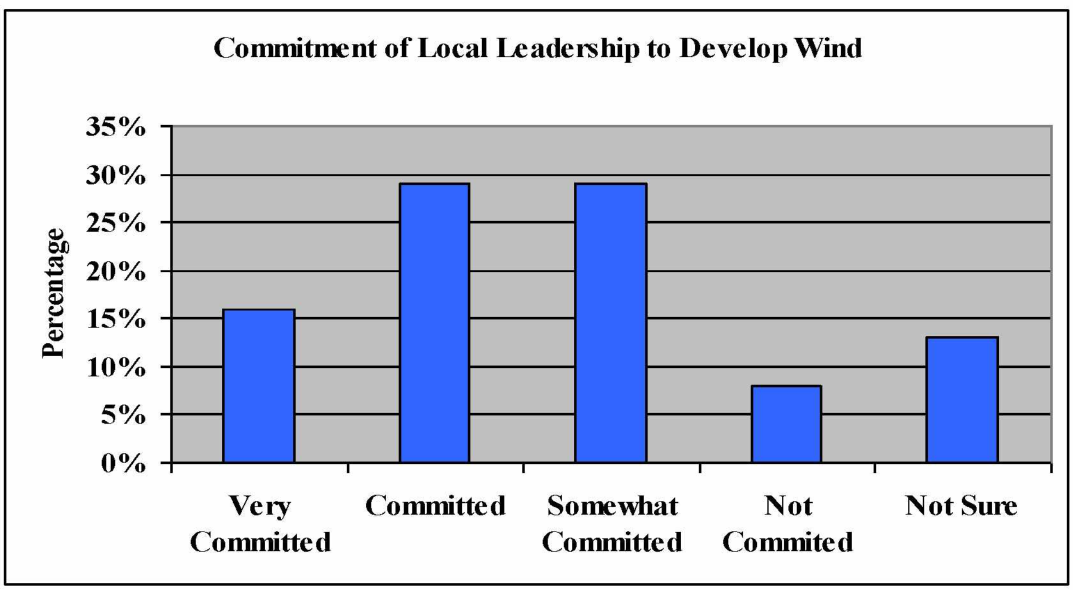


Figure 3.9 *Response to the question: How committed is your community's current leadership to develop wind power?*

80% of respondents replied that local leadership played either a *very significant*, *significant,* or *somewhat significant* role in the development of wind power in communities, whereas 7% replied that leadership was not a significant factor. Similarly, 74% of respondents replied that local leadership was either *very committed, committed,* or *somewhat committed* to developing wind power, whereas 8% replied that leadership was *not committed.* These results indicate that the participating organizations view local leadership as playing a principal role in the development of wind power. However, such results may be influenced by the fact that 77 percent of the surveys were answered by community leaders in decision-making positions, which may influence their opinion that leadership is important.

Such results emphasize the value and interest in having a level of local control rather than relying solely on outside agencies to design and manage projects. They also highlight the need for local communities and state agencies to help cultivate local leadership capability if project development is to occur from within the local community. However, demands on local leaders are often sizeable in small communities. They wear many hats and as a result are often spread thin. All this responsibility can overwhelm leaders, resulting in high turnovers that can delay or stop a project.

Level of Local Coordination

Three questions were directed toward the level of coordination and cooperation among local organizations when developing wind resources. Respondents were asked to rank the level of coordination and conflicting opinions on a scale based on the perspective of their organizations.

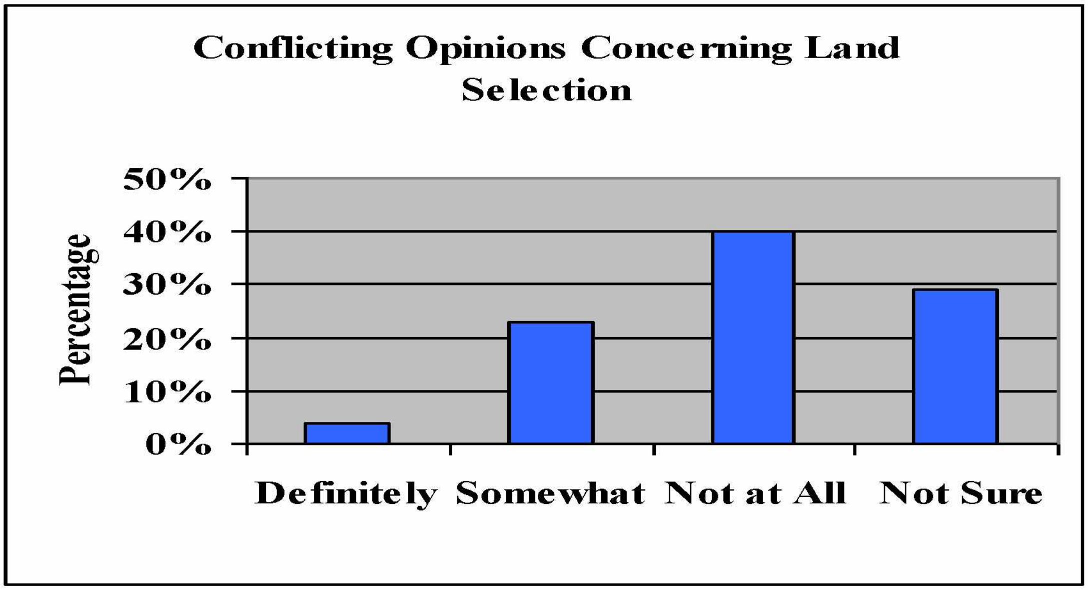


Figure 3.10 *Response to the question: Are there conflicts over the specific parcel of land to use to develop a wind farm?*

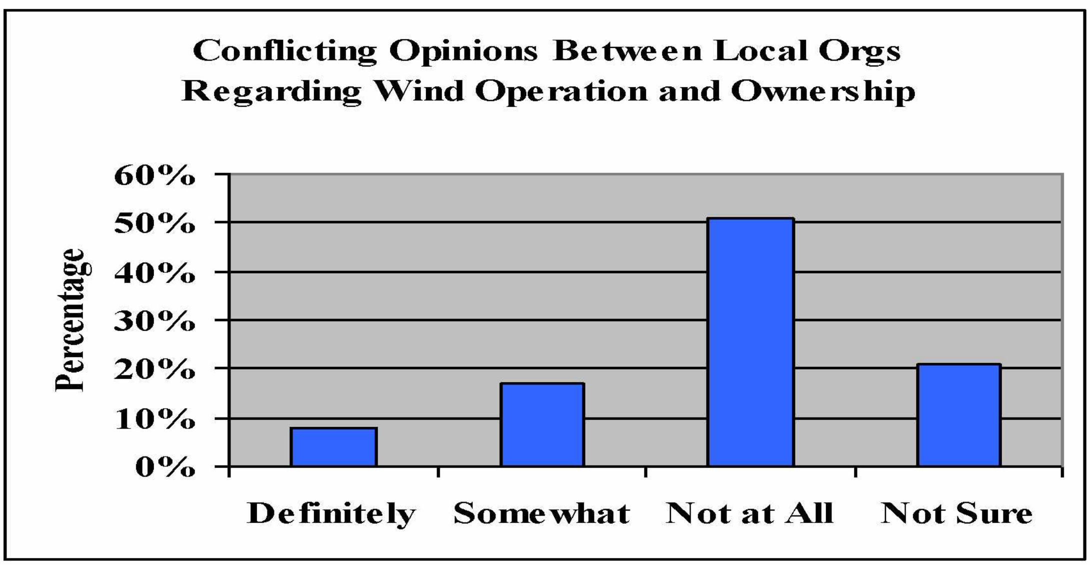


Figure 3.11 *Response to the question: Do local entities (i.e. utility, Tribal government, city government, etc.) have conflicting opinions regarding ownership and operation of a wind farm?*

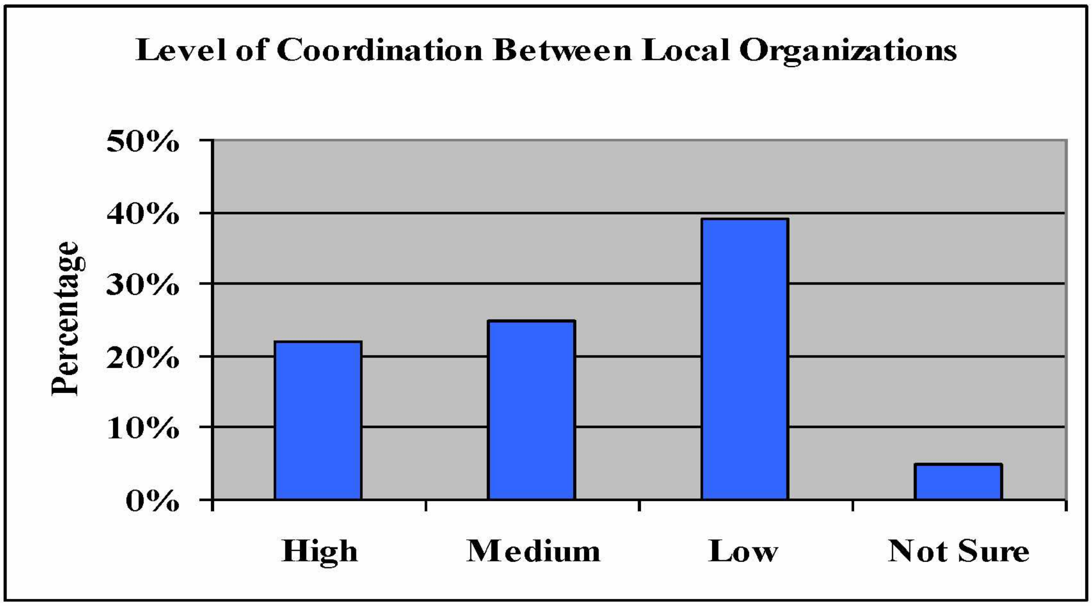


Figure 3.12 *Response to the question: What level of coordination is there between local organizations (i.e. utility, city, Tribe) when considering and planning for wind power development?*

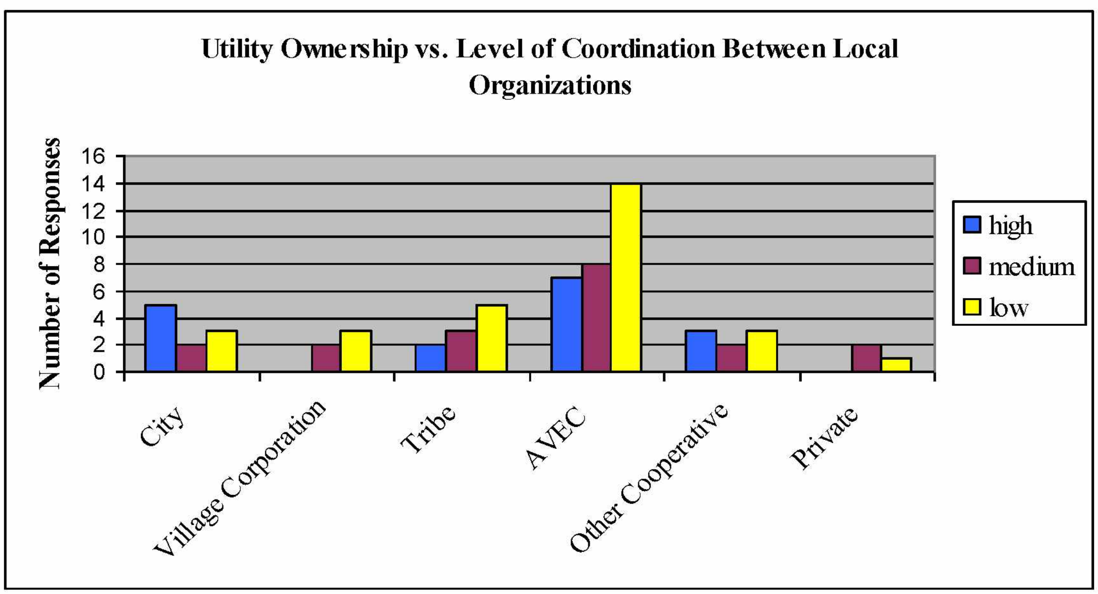


Figure 3.13 *Utility Ownership as compared to responses to the question: What level of coordination is there between local organizations (i.e. utility, city, Tribe) when considering and planning for wind power development?*

27% replied *definitely* or *somewhat* when asked if there were conflicting opinions regarding site selection for the turbines, whereas 40% replied *not at all*. Similarly, 25% chose *definitely* or *somewhat* when asked if local entities had conflicting opinions regarding ownership and operation, whereas 51% said *not at all*. Although a portion of respondents acknowledged some degree of conflict, the majority indicated that it was not an issue. However, when asked about the level of coordination among entities when planning for projects, 22% replied *high*, 25% replied *medium*, and 39% replied *low*. Despite the minimal conflicting opinions regarding wind power project ownership, operation, and site selection, there appears to be a relatively low level of coordination among local organizations (*i.e.*, electric utility, city, and tribe) when it comes to planning for wind power projects. Lower populations and limited resources make it critical for smaller communities to combine resources in order to move projects forward. Different organizations may be eligible for different funding sources, have different familiarity with the regulatory process, and maintain different connections with state and federal agencies. Without coordination, a large complex project such as installing wind turbines can quickly become an unattainable goal for a single entity to pursue.

This analysis established that the level of coordination between local entities was the lowest in communities serviced by AVEC. Multiple respondents added explanatory comments stating that their local tribal and city governments had pursued and/or applied for funding to install wind turbines even though AVEC was their utility provider. These communities were interested in tribal or city ownership of turbines and the potential to sell power to AVEC even though AVEC owned the existing power plant and transmission infrastructure. In cases where a local entity had applied for funding through the Renewable Energy Grant Fund, no funding was awarded; also, in certain cases funding was awarded to AVEC when they applied independently. Such examples demonstrate a lack of coordination among entities that have a mutual interest in establishing wind power in their communities.

Level of Local Capacity and Access to Information

Local human capacity to develop, manage, administer, and maintain wind power systems is an ongoing barrier to energy development projects in rural Alaska (AEA, 2009). Such barriers often reflect a lack of local knowledge regarding funding and technical assistance resources, a lack of qualified personnel, and limited economic resources. Eight questions relate to the local capacity of planning for and developing local wind power projects. Respondents were asked to rank their answers on a scale based on the perspective of their organizations.

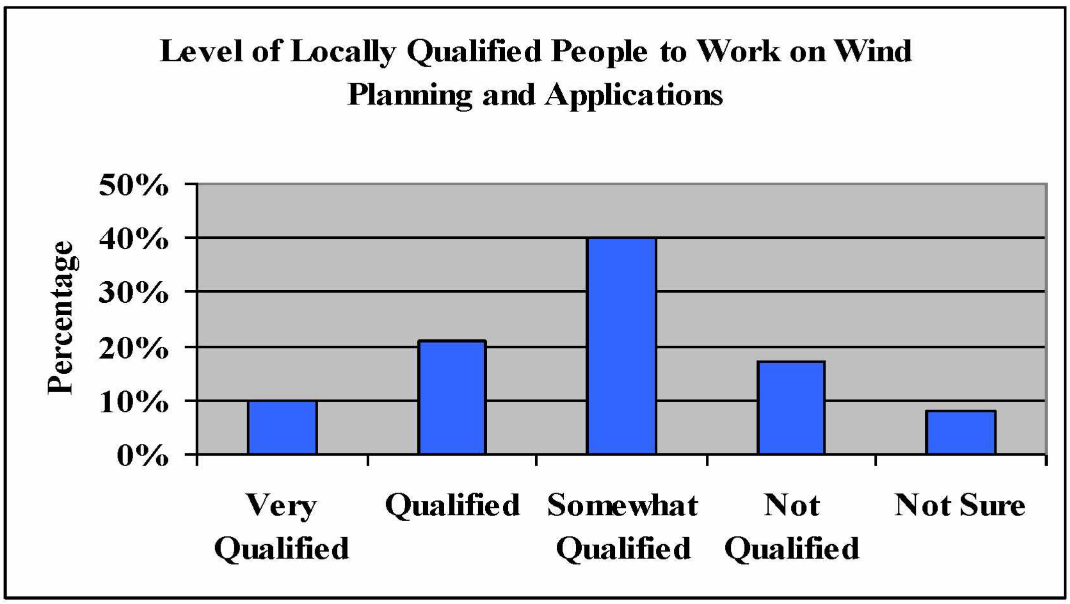


Figure 3.14 *Response to the question: How qualified are local staff to work on wind power planning and applying for grants?*

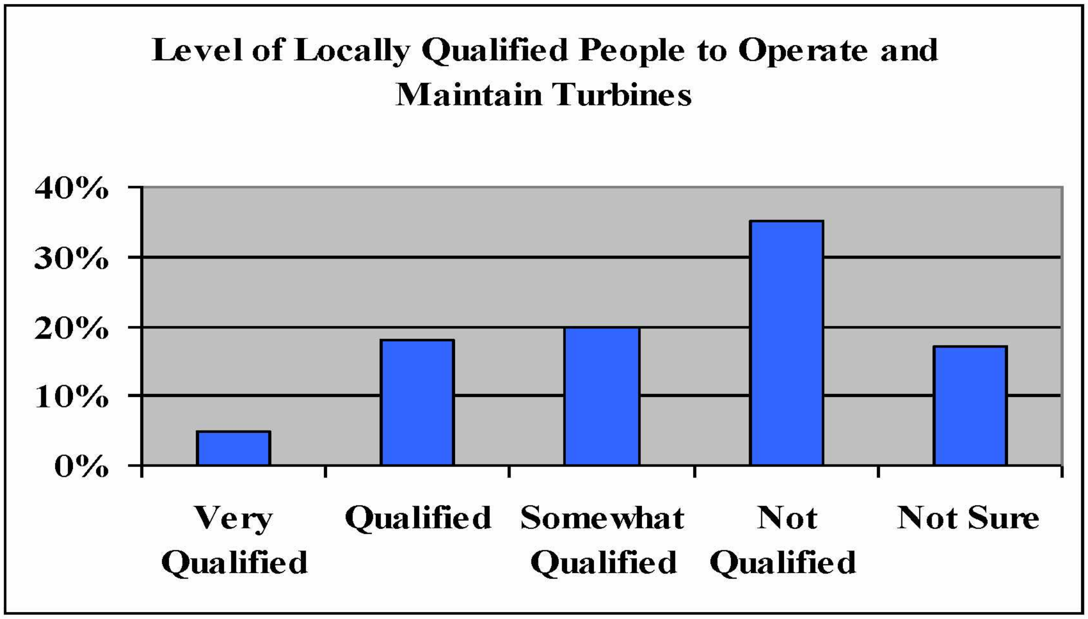


Figure 3.15 *Response to the question: How qualified are employees at your electric utility to operate and maintain wind turbines?*

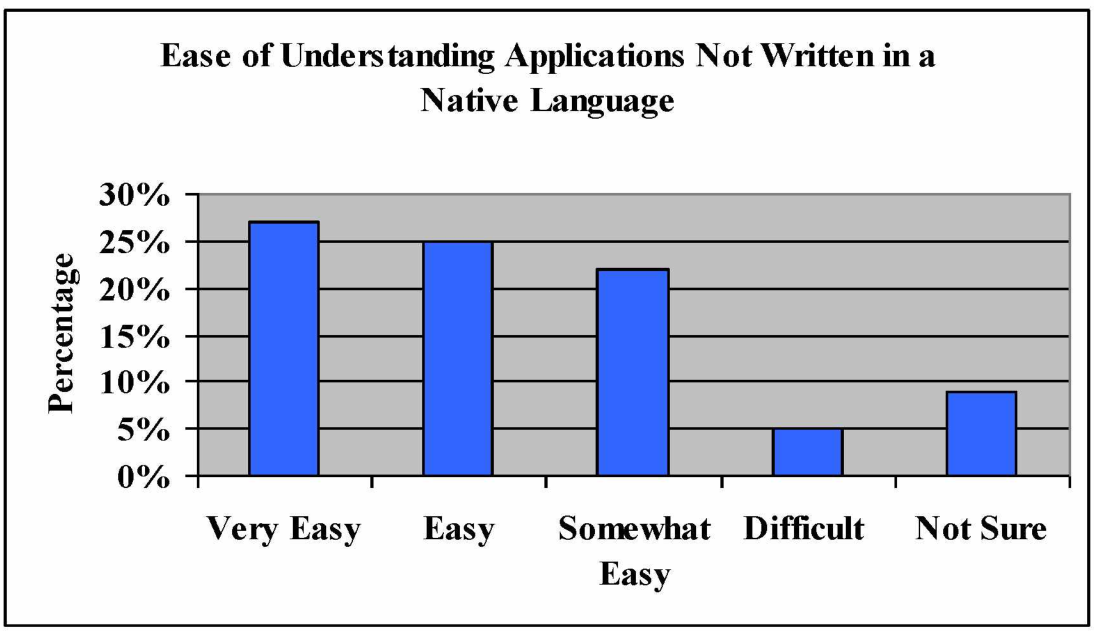


Figure3.16 *Response to the question: How easy is it to understand funding and project applications that are not written in your Native language?*

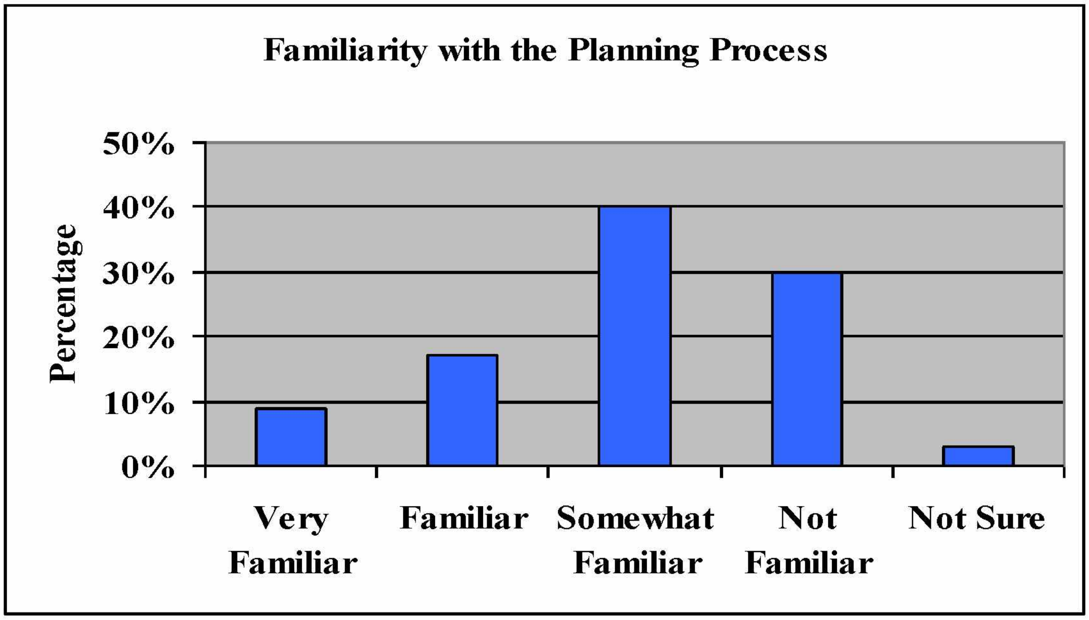


Figure 3.17 *Response to the question: How familiar is your organization with the planning and development process for wind development?*

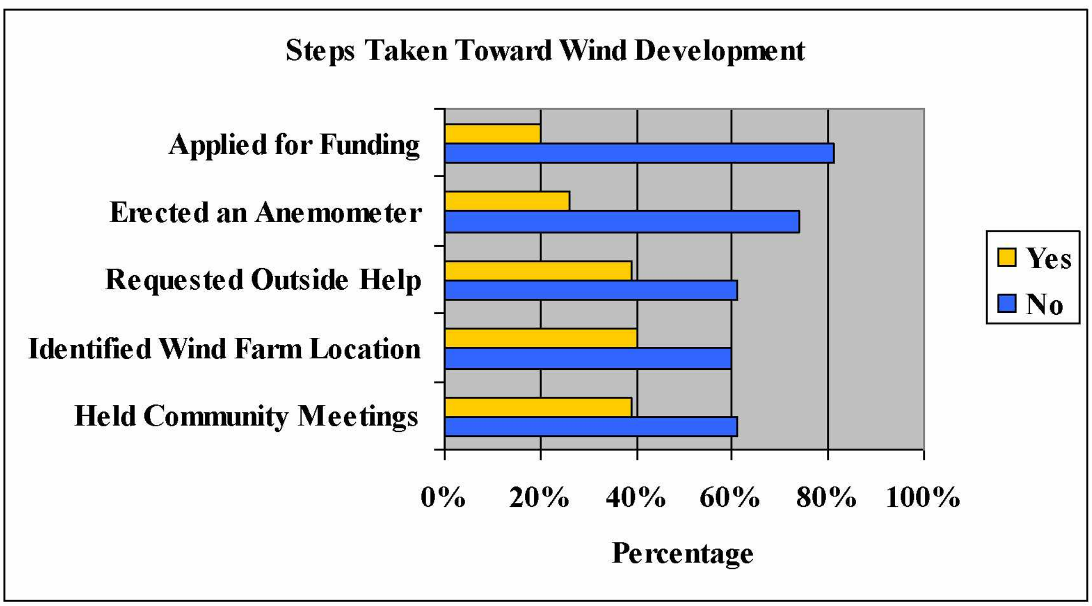


Figure 3.18 *Response to the question: Has your community, electric utility, city government, or Tribal government taken any of the following steps?*

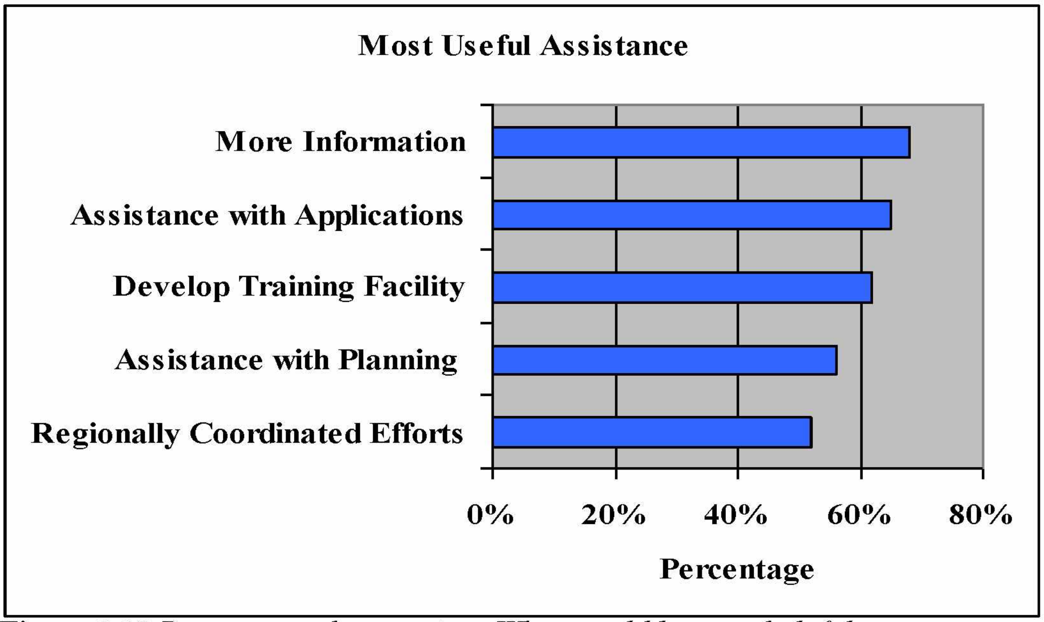


Figure 3.19 *Response to the question: What would be most helpful to your community when planning for wind development?*

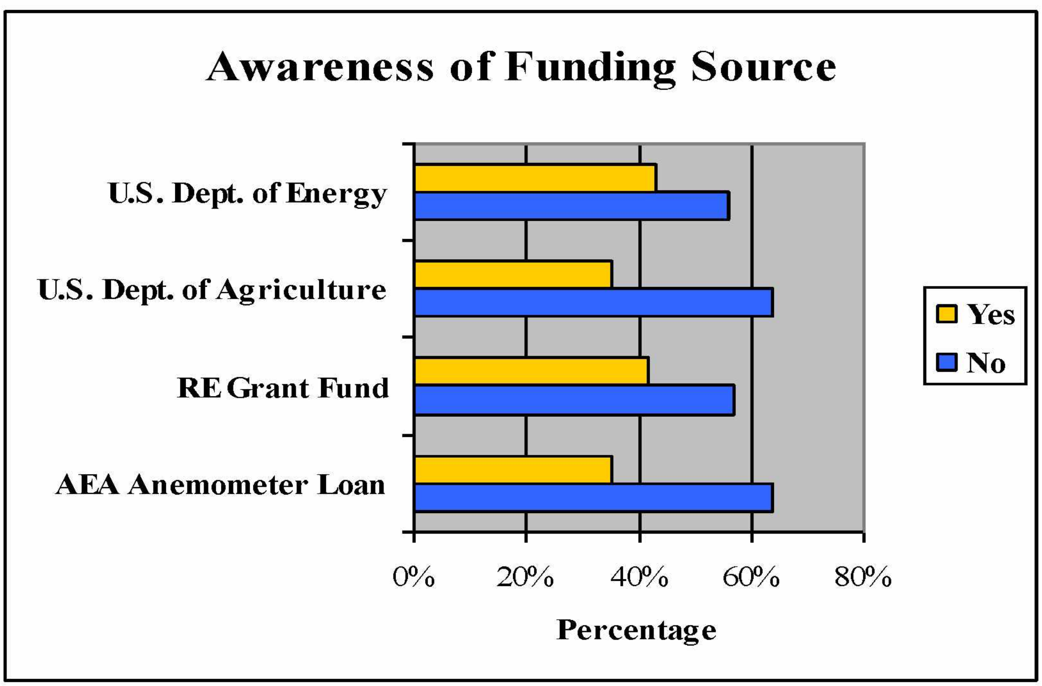


Figure 3.20 *Response to the question: Is the electric utility aware of the following programs and funding options?*

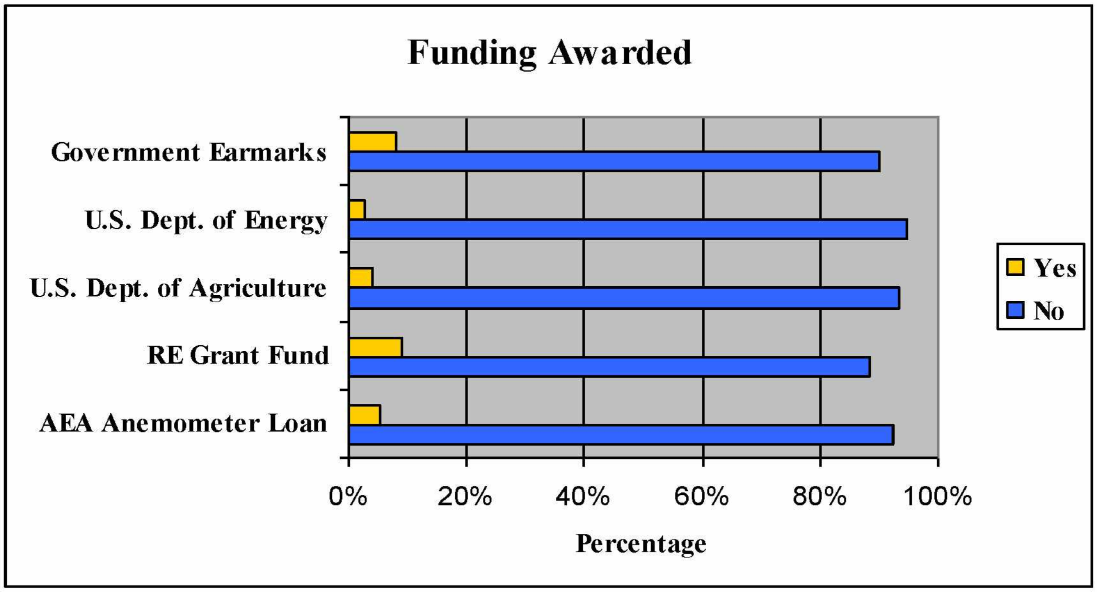


Figure3.21 *Response to the question: Has your community received funding from any of the following programs and funding options?*

During interviews with manufacturers and developers (see Section 3.4), the majority pointed to a lack of locally qualified staff as a major barrier to developing projects. However, 71% of survey respondents indicated that local staff were either *very qualified*, *qualified* or *somewhat qualified* to work on wind power planning and grant applications and only 17% responded that local staff were *not qualified*. However, only 23% marked that local personnel were *qualified* to operate and maintain turbines, whereas 35% marked that they were *not qualified*. These results confirm that local organizations have more confidence in the ability of local personnel to coordinate planning and application efforts than in their ability to operate and maintain a wind power system. In small communities, the tribal and city governments are typically responsible and involved at varying levels in planning efforts and therefore have a respectable level of experience with grant writing and planning. However, because the vast majority of communities rely on diesel-generated power, they have no training in operating and maintaining wind turbines.

Although there is a degree of confidence in local personnel's ability to plan for a wind project, the survey responses indicated that 30% were *not familiar* with the planning process. These results demonstrate an assurance in the capabilities of local staff, yet it also indicates a disconnect between the state and local communities due to minimal information making it to the local level.

The majority of communities surveyed have taken at least one step in the process of developing wind resources in their communities. The most common steps taken were 1) identifying a wind farm location, 2) requesting outside help, and 3) holding community meetings. The results reveal some level of initiative and interest from the community. However, they beg the question of what more is needed to move projects from initial planning to implementation. It is obvious that local entities in communities with small populations are at a disadvantage due to having modest local resources and reliance outside assistance that is often costly and not readily available. These smaller, poorly organized communities have been routinely overlooked and have not reaped the benefits of energy programs. Increased local capacity is needed for development to occur at the community level and cannot be orchestrated solely from the outside. However, increased participation and outreach from state agencies is essential to increase local-state coordination, build trust with local communities, and provide communities with the resource they need to advance projects.

Survey results reflect that 79% of respondents characterized their organization as either *very interested* or *interested* in developing wind power in their community; however, only 26% of communities actually had an anemometer erected at some point, which is a mandatory step to receive state or federal funding for wind projects. Additionally, only 35% of organizations acknowledged they were aware of the anemometer loan program. Such results point to a shortcoming in disseminating energy information to rural communities. The wind coordinator at the Alaska Energy Authority admitted that the AEA does not conduct outreach on the anemometer loan program due to limited staff and resources. Instead, they wait for communities to contact them. Furthermore, only 5% of communities have actually received the anemometer loan. The majority of the anemometers were erected by the Federal Aviation Administration (FAA) at airports rather than secured through local organizations. There is an apparent disconnect between the availability of this resource and the number of communities taking advantage if it, further demonstrating a divide between the state and local level.

Interestingly, when asked what would be the most useful to a community when planning for wind development, the least frequent response was regionally coordinated efforts. To some degree, all rural Alaskan communities network on a regional level, whether providing health services, making tribally based regional decisions through the regional non-profits, or addressing subsistence issues. Regional coordination among tribes is a necessity. When it comes to energy services, the state has periodically considered a regional approach, as demonstrated through the production of numerous plans linked to regional energy service centers and the formation of regional electric cooperatives. However, it is evident that many rural communities prefer that their electric services remain community-owned and operated and do not want to consolidate at the regional level. There is a tension between these competing interests. Such a mindset is inherently problematic when trying to take advantage of at economies of scale. However, community-based projects have inherent benefits that are not invalidated by limited economies of scale, such as local job creation, reduced dependence on outside fuel sources, and a movement toward creating more sustainable communities.

State-Level Political Barriers

Political barriers commonly arise from a lack of communication and coordination among agencies and local organizations, local difficulty navigating regulatory and planning processes, and misdirected focus from state agencies regarding issues faced by rural communities. However, building local-state relationships through trust and coordination (Agterbosch *et al.* 2009) is a viable solution to overcoming such social barriers. Two questions address political barriers related to planning for and developing local wind power projects. Respondents were asked to rank their replies on a scale based on the perspective of their organizations.

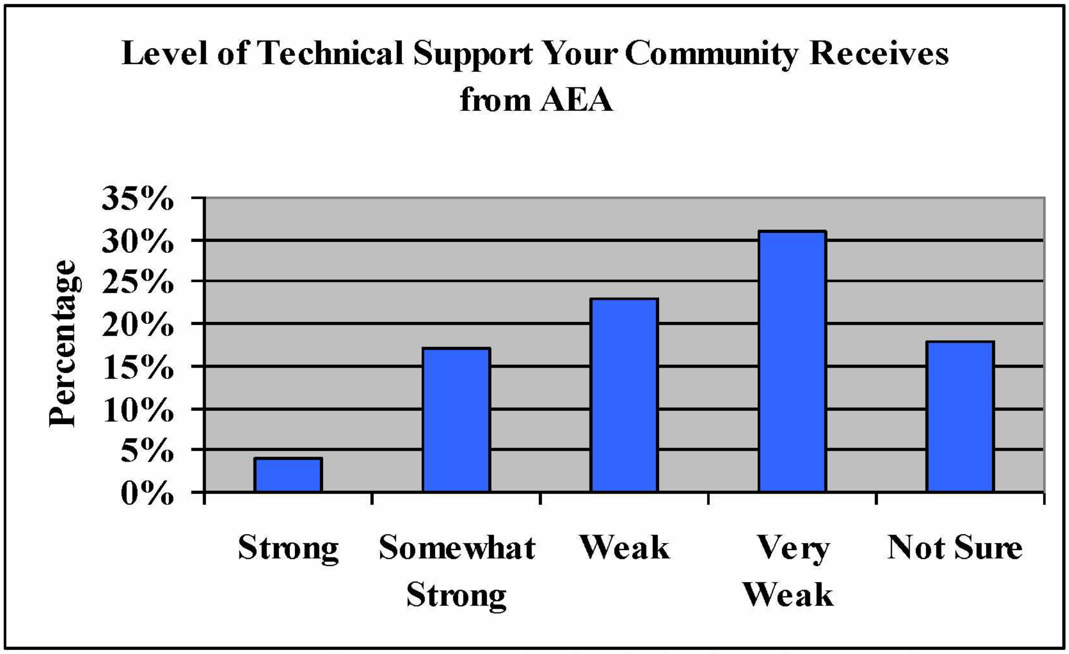


Figure 3.22 *Response to the question: What level of technical support (i.e. grant writing, planning) has the electric utility received for rural wind development from the Alaska Energy Authority?*

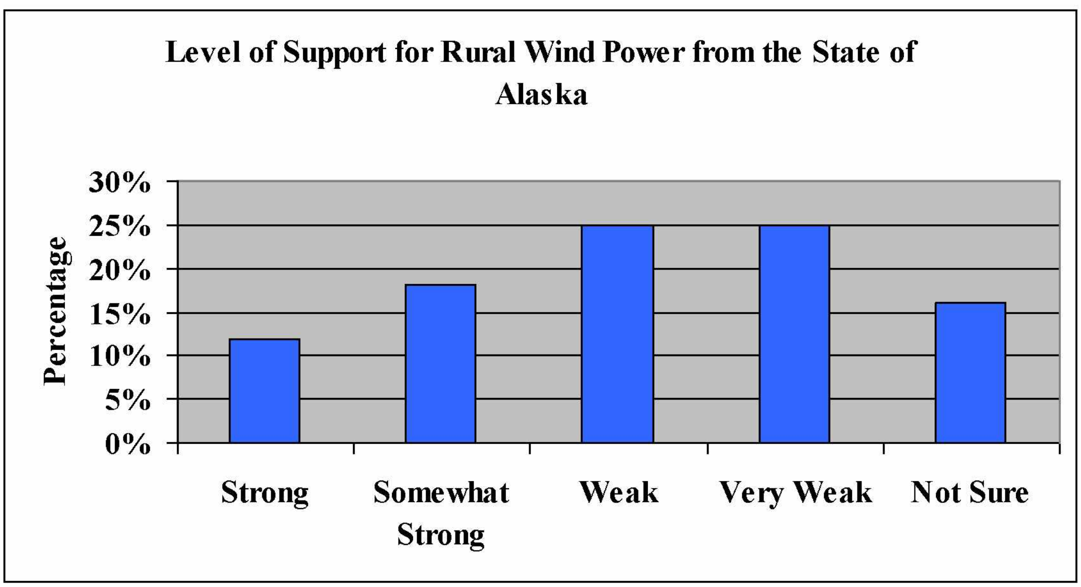


Figure 3.23 *Response to the question: What level of political and financial support does the electric utility feel the state offers for rural wind power development?*

In Alaska, the primary energy agency is the Alaska Energy Authority, which assists in the development of reliable and efficient energy systems throughout Alaska and aims to reduce the cost of electricity for residential customers and community facilities (AEA 2009).

54% of respondents said they received *very weak* or *weak* technical support from the AEA, 4% reported *strong* suppor*t*, and 17% reported *somewhat strong* support. Similarly, 50% replied that the state offers *weak* or *very weak* political and financial support for rural wind power, 12% stated *strong*, and 18% state *somewhat strong*. In spite of several state-based program and funding opportunities, these results demonstrate that many rural communities feel they received inadequate assistance from the state to support their energy efforts.

The primary state energy, decision-making, and permitting agencies are located on the road system or in major urban centers. Not only are rural communities physically disconnected from the electric grid and road system, but they are also disconnected from direct access and involvement with state energy programs and decision-making. Such physical distances increase the barriers to building relationships and to keeping informed and up to date on programs, policies, and funding options. In contrast, utilities that are based in urban centers or participate on statewide boards are more likely to establish working relationships with state agencies and decision-makers. Essentially, every step rural communities must take toward energy planning and services must be accomplished long distance; as a result, it is significantly more difficult and requires considerably more resources than the same process for urban areas. This is compounded by the difficulty of having a presence at the capital. Smaller communities lack the financial and human resources to travel to Juneau during legislative sessions to either lobby or rally for issues and funding that affect rural community energy services.

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Economic Considerations

Economics play a major role in the development and long-term success of a wind project. However, rural Alaska is automatically at a disadvantage due to the low electric demands and prohibitively high costs associated with supplying electricity to meet these demands. Two questions relate to economics, and respondents were asked to rank their responses on a scale based on the perspective of their organizations.

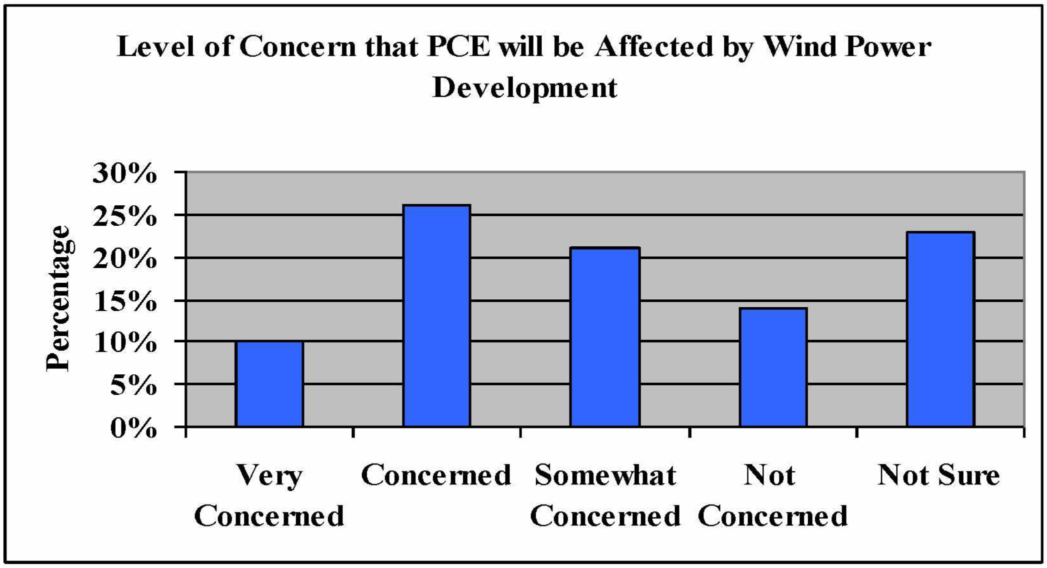

Figure 3.24 *Response to the question: How concerned is the electric utility that your Power Cost Equalization subsidy will be affected if wind power is developed?*

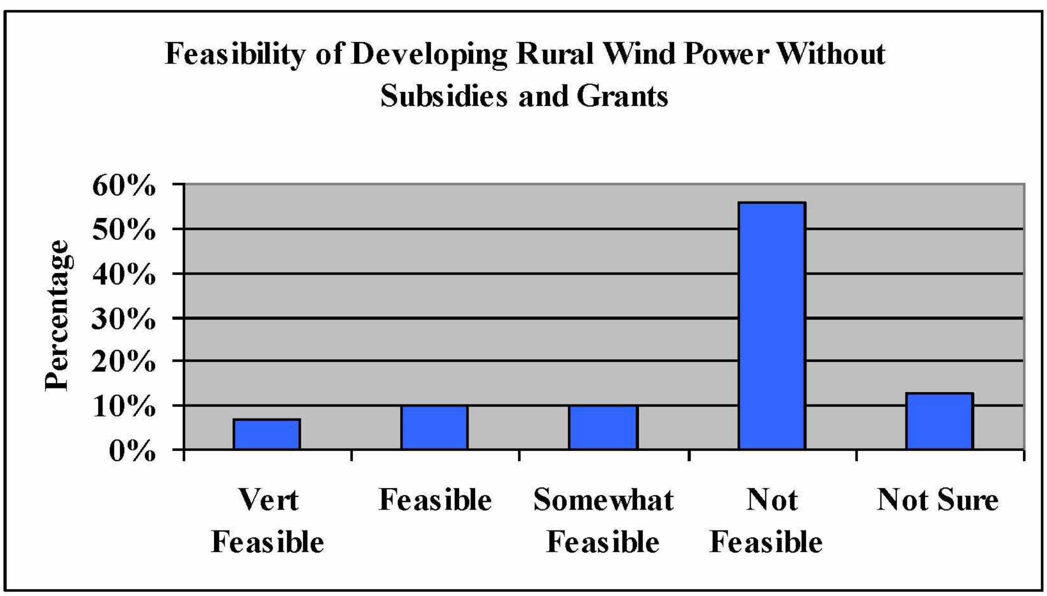

Figure 3.25 *Response to the question: How financially feasible would it be to develop wind power in your community without state subsidies and grants?*

For rural Alaskans, the Power Cost Equalization (PCE) legislation has had the most significant impact and provided the greatest relief of any option since it was implemented in 1980. 57% of survey respondents expressed some level of concern that the PCE subsidy would be affected if they develop wind power in their communities. The PCE does not explicitly incentivize wind power or other forms of renewable energy. According to AEA, electric rates are affected only if wind generation reduces a utility's costs. Although this is not expected in the near future due to the economics of rural wind investments, wind power promises to reduce fuel consumption by as much as 30% (Alaska Democrats 2008), potentially cutting the cost and affecting PCE. Despite the relief PCE offers communities, there are recurring debates as to whether PCE encourages dependence on diesel generated power and whether the program should be perpetuated.

27% of respondents expressed a belief in some level of feasibility of financing wind projects without state subsidies and grants, whereas 56% do not believe it would be feasible. The case study on the TDX wind project on St. Paul Island is a testament that it is possible to develop rural projects without state or federal assistance. However, the majority of rural utilities and organizations lack the financial resources and means to develop a project without such assistance. Furthermore, many of these communities lack the capacity to meet criteria to apply for specific funding sources, automatically reducing the likelihood of advancing wind projects.

Importance of Environmental and Cultural Protection

Two questions related to the importance of protecting bird and cultural sites. Respondents were asked to rank their responses on a scale based on the perspective of their organizations.

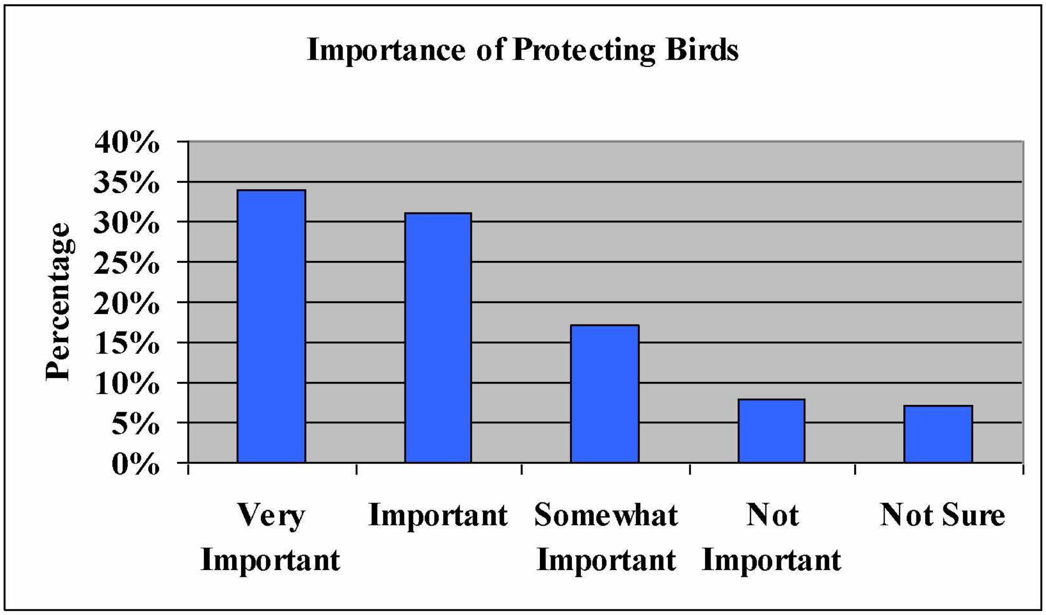

Figure 3.26 *Response to the question: How important is it to protect birds if wind turbines are installed?*

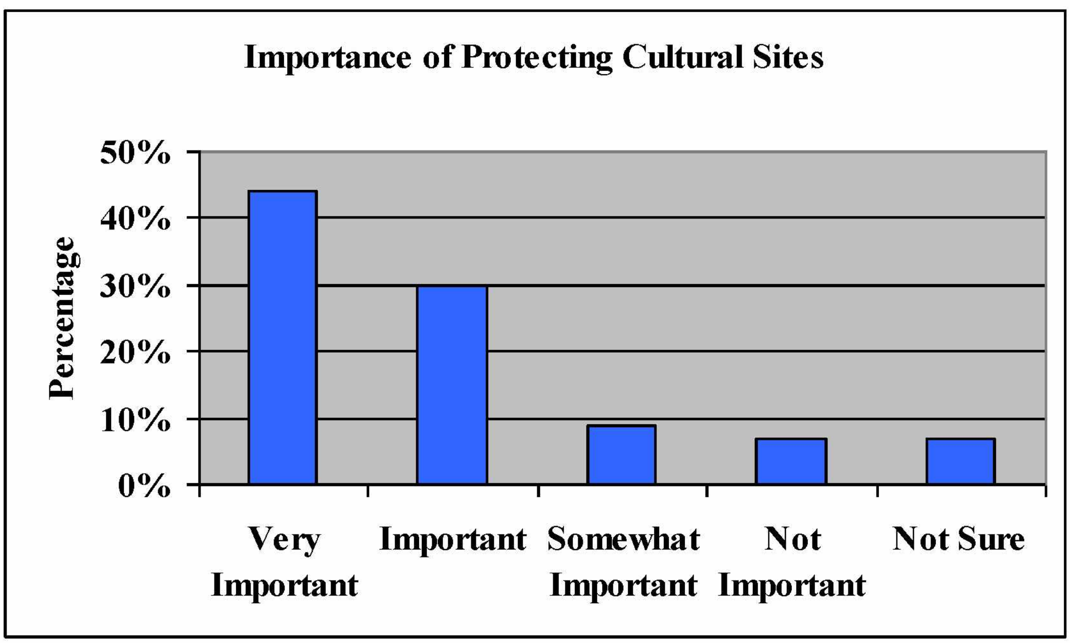

Figure 3.27 *Response to the question: How important is it to protect cultural sites when considering where to develop wind power?*

82% of respondents answered that protecting birds if wind turbines are installed is either *very important, important*, or *somewhat important*; 8% stated that it was *not important*. Similarly, 83% stated that protecting cultural sites is either *very important, important,* or *somewhat important*; while 7% stated that it was *not important*. Clearly, communities hold a high degree of concern about these issues of wildlife protection and cultural preservation. These are evidently factors that will need to be taken into consideration during the planning stage, but it does not make them impassable barriers that cannot be remedied. Additionally, community interest in protecting birds is apparent through the number of communities that are conducting their own bird monitoring at existing and potential wind farm sites. Although this is not yet written into USFWS guidelines and regulations, communities have deemed it important enough to do on their own, despite additional economic costs.

Technical Considerations

Certain technical factors regarding rural energy services include turbine technology, availability of heavy equipment, power source reliability, the wind site specification, and distance from existing roads and power infrastructure. Three questions related to confidence in technology, availability of heavy equipment and wind farm locations. Respondents were asked to rank their answers on a scale based on the perspective of their organizations.

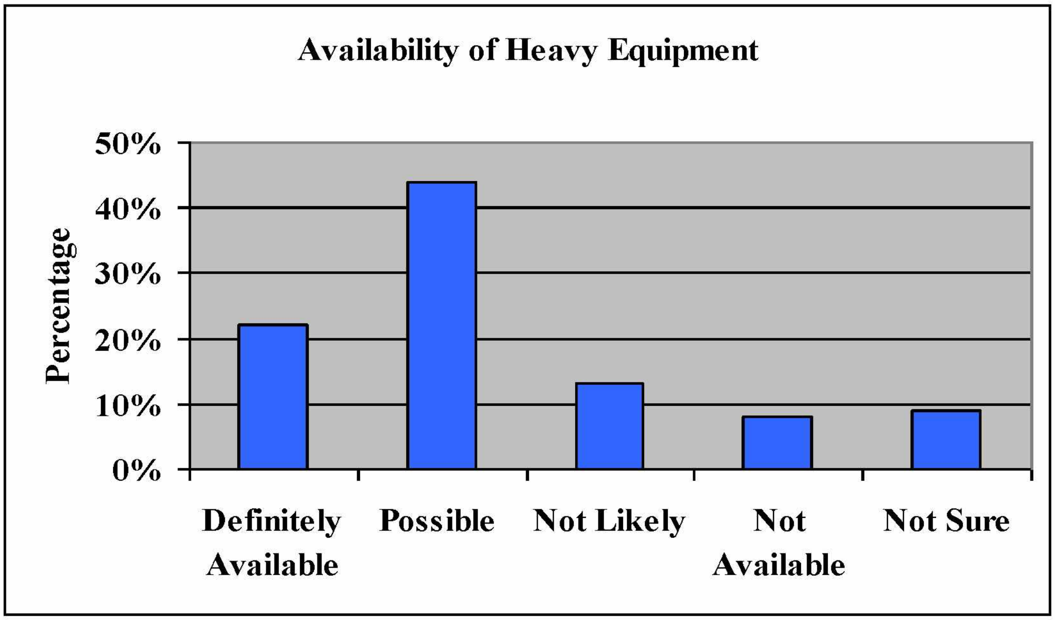

Figure 3.28 *Response to the question: Would heavy equipment be available if your community decided to install and operate a wind farm?*

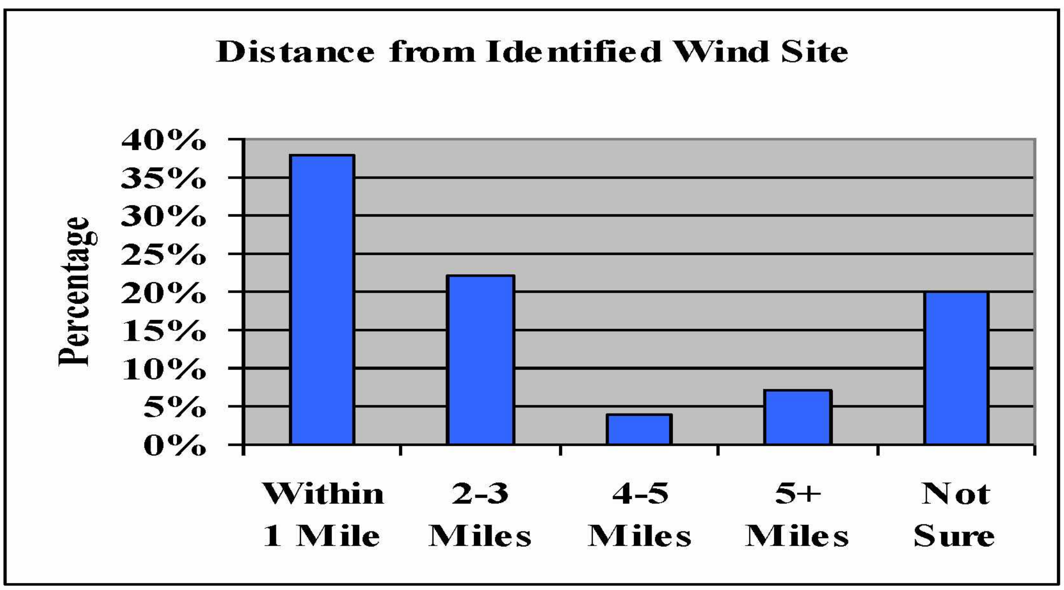

Figure 3.29 *Response to the question: If your community has selected a wind farm location, how close is it to existing electric lines and infrastructure?*

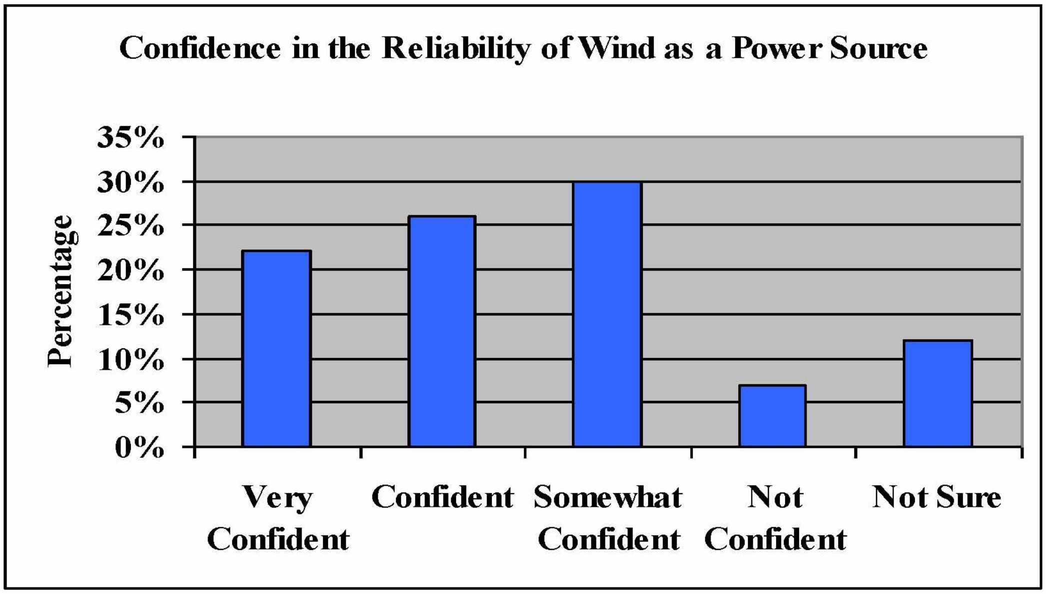

Figure 3.30 *Response to the question: How confident is the electric utility in the reliability of wind turbines as a power source?*

Interviews with manufacturers and developers (See section 3.4) revealed that, while heavy equipment availability is not an insurmountable obstacle to projects, it is rarely readily available and can cause significant delays and price increases. Contrary to their interview responses, in the survey, 66% of communities expressed the position that heavy equipment would be either *definitely available* or *possibly available* were wind projects to be developed in their communities. Only 21% replied that it was either *not likely* or *not available*. These survey responses are inconsistent with the reality of development logistics in rural communities. The challenge of acquiring heavy equipment in rural communities is ever present. The response inconsistency may be due to ambiguity in the survey question that did not differentiate between the heavy equipment to install wind turbines and equipment needed to maintain wind turbines, which is more readily available in rural communities.

78% of respondents expressed varying degrees of confidence in the reliability of wind turbines as a power source; 7% responded *not confident*. Despite the intermittence wind as an intermittent resource and the technical challenges associated with it in rural arctic environments, the majority of respondents are confident in the benefits using wind in their communities. Although it is uncertain whether the responses are based on technical information, individual perceptions, or anecdotal hearsay, clearly, the majority of respondents indicated no substantial concerns over the reliability of wind.

The economics of a project tells us that the farther the distance from existing power infrastructure, the more expensive the wind power project. 38% of communities have identified wind sites within one mile of existing electric lines and infrastructure, and 22% have located sites within two to three miles. This close vicinity reduces the technical and economic challenges associated with turbine implementation, operation, and maintenance.

BARRIERS IDENTIFIED BY THE WIND SECTOR

Scope of Interviews

In addition to the interviews conducted for the case studies, interviews were also conducted with numerous individuals working in fields related to the wind industry, including other electric utilities, state and federal organizations, researchers, and wind power developers, designers, and engineers. Information gathered in these interviews was used to identify additional factors, or confirm already identified factors, that create barriers to wind power development in rural communities from perspectives other than those captured in the local level in the survey.

The majority of these interviews were part of a larger research project on the cost of wind power and wind-diesel technical challenges conducted by the Institute for Social and Economic Research and the Alaska Center for Energy and Power. The interviewees were individuals from the following organizations: Sustainable Automation, Intelligent Energy Systems, Western Community Energy, STG Incorporated, D3Energy, Kodiak Electric Association, and WHPacific. The interview questions primarily focused on challenges and potential solutions to wind power development in rural Alaska from the perspective of wind power developers, designers, and engineers working with rural wind projects. These interviews provided an on-the-ground perspective of the challenges faced when coordinating projects in rural Alaska, contributing to the overall picture of wind power development. The interviews were all conducted by telephone.

Additional interviews were conducted with individuals at the Alaska Energy Authority, Alaska Center for Energy and Power, and the U.S. Fish & Wildlife Service. The interview questions also focused on challenges and potential barriers to wind power development in rural Alaska, yet from the perspective of the state energy agency, an energy research institute, and a permitting agency. These perspectives both broadened and deepened an understanding of the scope and magnitude of barriers to wind power development in rural Alaska. All of these interviews were conducted in person in Fairbanks and Anchorage and were recorded by note taking.

The results of the interviews can be broken into four categories: regulatory, local capacity, political, and economic.

Regulatory Barriers

Developers and engineers stated that the Alaska's land lease process was unnecessarily complex and drawn out, causing further project delays. It was suggested that these delays partly resulted from the fact that state land leases for wind turbines are relatively new and the process is not refined. However, the interviewee also noted that state bureaucratic processes often cause needless delays that could be alleviated with more attention to the process.

Multiple developers identified permitting as a major cause for delays in wind power projects. Due to the lengthy and at times convoluted permitting process involved with many permitting agencies such as the Federal Aviation Administration and U.S. Fish and Wildlife Service (USFWS), project timeframes are extended, resulting in increased project costs and the need for additional staff. In addition to this difficult permitting process, avian studies recommended by the USFWS have also driven up the overall project cost. Although many communities have a vested interested in protecting local avian populations, the interviews alluded to the fact that many developers are conducting extensive avian studies as a precautionary measure to avoid potential penalties from the

USFWS. However, the USFWS expressed grave concern about its lack of enforcement and the potential for great avian losses from wind turbines since the majority of wind projects are erected in western Alaska, the nesting ground for multiple endangered and threatened avian species.

Both the Migratory Bird Treaty Act (MBTA) and the Endangered Species Act (ESA) prohibit the "take" of the species that they protect. This very stipulation regarding "take" renders the Acts to be a significant obstacle to wind energy development, particularly in the case of the MBTA since it is so expansive in scope. However, the minimal enforcement of past violations suggests that the USFWS will be cautious when prosecuting bird takings resulting from wind turbine collisions, particularly if developers take necessary and recommended precautions. (McKinsey 2008).

The USFWS has developed an Interim Guidance on Avoiding and Minimizing Wildlife Impacts from Wind Turbines with the intent to assist USFWS staff in providing technical assistance and establishing guiding principles to communities and developers that are considering wind power development. The guidelines are voluntary and therefore have no legal authority. However, the guidelines state, "while the Act has no provision for allowing the unauthorized take, it must be recognized that some birds may be killed at structures such as wind turbines even if all reasonable measures to avoid it are implemented (US Fish & Wildlife Service 2003)." It is also worth noting that the introduction in the Interim Guidance states that the Department of the Interior strongly encourages the pursuit and development of renewable energy source, while acknowledging the potential harm to wildlife (USFWS 2003). In many ways this statement reinforces the discordances within the Act and between federal policies, yet it also provides acknowledgment that the Department of Interior is committed to finding solutions to mitigate avian and wind turbine problems.

Barriers to Building and Utilizing Local Capacity

Almost every interviewee acknowledged that limited local capacity in terms of management, technical, and logistical coordination capacities were underlying barriers

for the majority of rural energy projects. Local management was identified as often insufficient when completing tasks in a timely manner and coordinating transportation and onsite logistics. Interviewees also pointed to a lack of locally qualified technicians as a major barrier to the ongoing operation and maintenance of wind projects.
Operators often have inadequate tools and equipment to maintain turbines and the local utilities have limited financial resources to support the project. Additionally, multiple project developers remarked that local operators rarely have enough operational hours to receive their journeyman card. Consequently, technicians are hired from outside of the community to do maintenance work, dramatically increasing the project costs. Overall, limited and unqualified staff at the managerial and operator level constitute a significant challenge for developing projects in rural communities.

Political Barriers

Multiple interviewees pointed to the lack of a comprehensive energy plan for Alaska as a hindrance to long-term growth in Alaska's wind industry. This includes a lack of clear goals and a limited long-term financial commitment and support from the state. As a result, projects are often developed in spurts with limited long-term commitment or operation and maintenance plans. Although Alaska recently instated the Renewable Energy Grant Fund, engineers and developers remarked that the distribution of these funds are poorly coordinated. Projects are selected on a case-by-case basis where projects in the same sub-region are funded several years apart, limiting the level of coordination and increasing the overall project costs.

An interviewee recommended aggregating projects that are in geographically similar areas in order to make development and maintenance more financially viable. Increased project coordination and an overall vision for energy development in Alaska would greatly help alleviate these challenges and project shortcomings.

Economic Barriers

The primary economic barrier identified in the interviews was difficulty creating economies of scale for installation, construction, financial management, and the operation and maintenance of wind projects. In a sense, limited economies of scale are inseparable from any development project in rural Alaska due to the increase cost of transportation and infrastructure limitations. However, this is magnified by poor project coordination and limited planning on a regional level.

Discussion of Barriers Identified by the Wind Sector

Although the individuals interviewed work primarily in a technical capacity with wind power, the majority of factors they identified were social, political, and economic in nature. An interviewee stated that "technical and physical aspects of projects are straight forward, it's the social aspects that create the great challenges." This is not to say that technical problems are not an issue. Individuals discussed the need for future research in technical areas to focus on problems such as icing, energy storage, and complex high penetration systems. However, most responses related to social, political, and economic barriers.

Specifically, individuals stated that perceived hurdles such as limited construction cranes and a limited construction season are not nearly as great of hurdles as coordinating projects with rural communities that have limited managerial and technical capacities, as well as navigating the complex and timely permitting process associated with wind projects. Several interviewees recommended that the state increase its outreach efforts and provide more information on wind planning, permitting, and funding to rural communities. It was also recommended to consolidate energy information statewide, including lessons learned from installed projects and case studies. Such a clearinghouse of information would be more accessible to rural communities and potentially lend itself to be more efficient for the state to operate and manage.

Overall, these interviews mirrored many of the concerns identified in the surveys, including limited support from the state and specific local capacity barriers. However, they brought a new perspective to these challenges, as well as identified new ones, such as the importance of coordinating planning efforts in geographically similar areas and the need for a comprehensive state energy plan and goals.

CHAPTER FOUR:
CONTRIBUTING FACTORS TO RURAL WIND POWER DEVELOPMENT: CASE STUDIES ON EXISTING WIND-DIESEL POWER PROJECTS IN KOTZEBUE, ST. PAUL ISLAND AND KASIGLUK

CASE STUDY OVERVIEW

Researcher Robert K. Yin defines case study research as an empirical inquiry that investigates a contemporary phenomenon, 1) within its real-life context, 2) when the boundaries between phenomenon and context are not clearly evident, and 3) in which multiple sources of evidence are used (Yin 1984). The quintessential characteristic of such case studies is that they allow the researcher to move toward a more holistic understanding of complex issues in social situations and systems (Feagin *et al.* 1990). In general, the case studies in my research re-construct the planning and development process, as well as the interactions between individuals, organizations, and communities, for three different rural wind power projects, carving out the different strategies that enabled each project to be seen to fruition.

A frequent criticism of the case study method is that it depends on a single or few cases, ultimately rendering it incapable of justifying a generalized conclusion (Hamel *et al.* 1993). Although this method tends to examine fewer cases as opposed to other research methods, it provides an in depth and contextual analysis that cannot be obtained through any other setting or method.

Because the purpose of this research is to understand the contextual setting and complex social processes involved in developing wind projects in rural communities, a case study method is appropriate. Case studies were conducted in three different rural communities in Alaska—St. Paul Island, Kotzebue, and Kasigluk. All three communities were selected because they overcame a combination of barriers and reached the threshold required to develop a wind power project in their community. They also represented a diverse class of geographic regions, populations, and utility structures and sizes. Specifically, the case studies were conducted in a large hub community serviced by an individual electric cooperative (Kotzebue), a small community serviced by a large electric cooperative (Kasigluk), and a small community serviced by a local village corporation-owned utility (Saint Paul).

Data gathered through the case studies was primarily qualitative, using semi-structured, open-ended interviews (Yin 1993) and review of documents and literature. For each case study, interviews were conducted with multiple local and regional informants, including city officers and staff, tribal council members and administrators, utility managers, community planners, regional native corporations, village corporations, and borough officials. Most often it is the local utility that spearheads energy projects; however, other local and regional entities are usually involved at some level with site selection, permitting, and garnering community support. Individuals and entities were selected for interviews based on their involvement in the project and their role as decision-making entities in the community.

The interviews were informal and semi-structured, usually lasting from thirty minutes to one hour. Interviews for the St. Paul case study were conducted in Anchorage at the Tanadgusix Corporation (TDX) office, as well as over the phone. Interviews for the Kotzebue case studies were conducted primarily onsite in Kotzebue. Interviews for the Kasigluk case study were conducted in Anchorage at the Alaska Village Electric Cooperative office, as well as over the phone. The responses of these individuals helped reconstruct the planning, development, and permitting stages for each community's wind project. Consequently, this information emphasized both the barriers as well as the factors instrumental in advancing the projects.

The documentation and literature came primarily from the National Renewable Energy Laboratory, Department of Energy, and utility and village corporations, and provided background information for the case studies. Organizational reports, statistics from Alaska's Power Cost Equalization program, and evaluations of projects by various entities were examined for each project. The case studies focused on factors that were indentified in the literature review and background research.

KOTZEBUE CASE STUDY

Community Description

The community of Kotzebue, Alaska, is located in northwestern Alaska on a three-mile spit at the end of the Baldwin Peninsula in Kotzebue Sound. The population of Kotzebue is 3,146. The community's primary inhabitants are Inupiat Eskimo who have occupied the site for over 600 years (Alaska Division of Community and Regional Affairs 2008). Like most rural communities in Alaska, Kotzebue is only accessible by sea, river, or air. Due to its size and location at the confluence of three river drainages, Kotzebue is the transfer point between ocean and inland shipping and has become the transportation and economic hub for other villages in the northwest region since the turn of the century. The local economy has a strong public sector that is directly or indirectly connected to government employment, including the Northwest Arctic Borough, the city, Maniilaq Association, and the school district (Alaska Division of Community and Regional Affairs 2008). Additionally, Kotzebue has a growing private sector that is largely dependent on mineral exploration and commercial fishing.

According to the Alaska Division of Commerce, the unemployment rate in Kotzebue during the 2000 U.S. Census was 9.8 percent, although 36.78 percent of all adults were not in the work force. The median household income was $57,163 and per capita income was $18,289; 13 percent of residents were living below the poverty level. As a comparison, during the 2000 U.S. Census the medium household income in Anchorage was $55,546 and per capita income was $25,287. The income between Kotzebue and Anchorage were relatively similar; however, the cost of living (i.e. electricity, water and sewage, services, etc.) in Kotzebue is significantly higher than in Anchorage, creating greater separation between people's disposable income. Seven percent of Anchorage residents were living below the poverty level as compared to 13 percent in Kotzebue.

Energy Infrastructure

Originally, electricity was provided to Kotzebue homes and businesses by small, privately owned generators (Kotzebue Electric Association 2009). However, in the early 1950s, a small group of local residents began pursuing electrification and eventually received a loan from the Rural Electrification Administration (Reeves, B., personal communication, July 31, 2009). As a result, a consumer owned nonprofit electric cooperative, the Kotzebue Electric Association (KEA), was formed. In 1954, KEA began installing diesel generators and constructing a mini-grid, becoming the primary residential and commercial power supplier in Kotzebue. By the winter of 1956, sixty-five customers/members were connected to the new electric grid (KEA 2009) and it has expanded ever since.

KEA is comprised of a nine-member locally elected utility board that approves all local projects through resolutions. Every electric customer in Kotzebue is a member of the cooperative and has the right to vote for utility board members. Since inception, KEA has expanded its services and grown as a utility. The original plant has been upgraded, new generators have come on line to serve an increasing demand for energy, and KEA has pursued new and renewable forms of power generation. Presently, the average load for the community is approximately 2.5 MW and minimum 700 kW. The diesel power plant has an installed capacity of 11 MW (Baring-Gould and Dabo 2009). KEA consumes approximately 1.4 million gallons of diesel fuel annually with an average efficiency of 14 kWh per gallon (NREL 2009).

Table 4.1 *Power generation comparison between Kotzebue, Kasigluk, and Anchorage in 2008*

	Kotzebue	**Kasigluk**	**Anchorage**
Population	3,126	578	284,994
Installed capacity (kW)	20,390	2,357	994,342
Diesel Consumption (gallons)	1,423,571	154,079	N/A
Total kWh generated (diesel)	20,915,914	2,106,177	N/A
Total kWh generated (wind)	874,900	593,660	N/A
Residential electric rate (cents per kWh)	16.90*	15.84*	10.65

* Residential electric rate after PCE subsidy

Kotzebue Wind Farm: Planning and Development

The first wind turbines arrived in Kotzebue in 1979 through the efforts of the state of Alaska. Turbines were installed at the Chukchi Campus and the city manager's office; however, neither produced a kW of power, and the turbine at the city manager's office blew apart in a blizzard (Reeves, B., personal communication, July 31, 2009). Despite wind power's rocky start in Kotzebue, it would resurface as a viable power option for the local utility over a decade and a half later.

Although fuel prices were relatively low and stable during the early 90s, KEA foresaw diminishing support from the state legislature for the PCE program (Reeves, B. personal communication, July 31, 2009) and was determined to find solutions that would be reliable and affordable into the future. It was evident that biomass and river hydro power were not options due to the lack of resources; however, it was clear that Kotzebue had constant and strong winds, which were strongest during the winter months when electric demands were highest. As a result, KEA took the first steps toward investing in wind power in 1992 with the installation of an anemometer to monitor the local wind resource. KEA and the state shared the costs of installing the meteorological tower in 1992. KEA selected a site near town that was flat tundra, which was accessible and allowed the wind to blow unobstructed across the landscape. The anemometer data revealed a 4-5 wind class, which is rated as "good" for power development (Szymoniak 2006) and an average wind speed of 13.5 mph (KEA 2009a). Once the wind class was confirmed, KEA received a grant from the National Rural Electric Cooperative Association (NRCA) to conduct a power quality study from 1993 and 1994 (Reeves, B., personal communication, July 31, 2009).

After the power quality was confirmed, KEA began taking the next steps to develop a community wind project. In 1994, the KEA board committed and invested $250,000 to the project; this was matched by funds from the state of Alaska. Only partial funding was available for the foundation studies. KEA had to get creative and utilize existing local resources to help offset some of the costs. Fortunately, they were able to obtain excess piling left over from the construction of the regional hospital's foundation (Reeves, B., personal communication, July 31, 2009). KEA was able to avoid an expensive land purchase when the local village corporation, Kikiktagruk Inupiat Corporation, recognized the benefits of wind power and supported the project by entering into a lease with KEA for the wind farm site (Keith, K., personal communication, July 30, 2009). KEA indicated that the regional native corporation, Manillaq, and the local community were also supportive of the project.

With funding commitments from the state and utility, the needed studies completed, and support from the local community and organizations, the next step was to find a manufacturer with expertise in making turbines suited for the arctic environment. This had been a significant shortcoming of the wind turbines installed in Kotzebue in 1979. After much difficulty, the Atlantic Orient Canada (AOC) company became interested in the project. They had both the necessary level of expertise and the desired credibility with federal funding agencies (Reeves, B., personal communication, July 31, 2009). KEA purchased their first turbines in 1995, three AOC 15/50 50 kW rated turbines. Due to manufacturing and barge delays, the turbines arrived in Kotzebue in 1996 and were not commissioned until 1997.

Kotzebue wind farm has grown dramatically with the addition and diversification of turbines[8] in 1999, 2002, and 2006 and currently provides 1.17 MW of power to the community. The majority of these turbines were funded by state and federal grants. Kotzebue system is considered to be low-medium penetration, based on the overall generating capacity of the turbines. In Kotzebue, the turbines contribute to the overall power generation and offsets the use of diesel fuel. Since the initial installation, the DOE has come on board and invested money for Kotzebue to participate in the Turbine Verification Program, which monitors and documents the operation, maintenance, and performance of the wind turbines in arctic environments (Keith, K., personal communication, July 30, 2009). KEA's goal is to provide 4MW of power, with excess electricity and battery storage capacity; they are well on their way to meeting this goal.

Influencing Factors of Wind Power Development in Kotzebue

KEA entered into the wind project with the goals of reducing diesel consumption and the cost of electricity, developing a cost effective arctic foundation, developing a safety and training program for wind systems, documenting operations and maintenance costs, and testing turbines designed for arctic conditions and making adaptations as necessary (Reeves, B. personal communication, July 31, 2009, KEA 2009). Ten years after the installation of the first turbines, KEA has demonstrated the ability to achieve most of these goals and operate effectively and efficiently in a remote arctic environment. The primary factors contributing to this success are KEA's human technical capacity, leadership, and commitment. KEA had shown a commitment to make wind power work. Both the state-sponsored wind power projects during the late 70's and early 80's and KEA's wind project had available funding from the state. The risk of developing wind projects was the same. What was different was the commitment from the utility, support from the local community, and overall capacity for the project. Additionally, the technology was more advanced in the 90s and, although few, there were more companies equipped to work with Alaska-sized turbines, environment, and needs.

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[8] KEA currently has 15 AOC turbines, 1 Northwind turbine and 1 Vestas turbine (KEA 2009a).

If not for the commitment and cooperation of KEA's long-time general manager and the board, a project of this scale in rural Alaska could never have been developed. It took five years from the initial planning phase to the commissioning of the first wind turbines. During that time, countless roadblocks emerged: primarily finding appropriate turbines and an experienced manufacturer, and logistics coordination with transportation and equipment. Since then, KEA has confronted many additional challenges such as integrating the new wind system with the diesel plant and working through the hurdles of maintaining equipment in a remote arctic environment. However, the manager, board, locally trained technicians, and community have all demonstrated a commitment to the project's success that has enabled it to work through these numerous challenges.

It must be stated that, without a doubt, the overall project champion was the long-term utility manager. Not only was the manager dedicated, but he was actively involved with multiple state and federal power organizations, including being the President of the Alaska Power Association (APA), a Board member of the Utility Wind Interest Group, and a member of the Cooperative Research Council of the National Rural Electric Cooperative Association. Through his active participation and the connection he formed with agencies, he has magnified the capacity of the utility to remain up to date, informed, and involved.

Another influential factor was the significant support KEA received from the manufacturers. Although the turbines experienced several electrical and mechanical problems early on, the manufacturers were committed to finding technical solutions. Additionally, the manufacturers provided onsite training until the local technicians had the confidence and skills to conduct the turbine operation and maintenance work independently. Economically, KEA secured grants for the vast majority of the project, helping to level the economic playing field with diesel.

Not only was Kotzebue the first community to develop a utility-scale wind farm in Alaska, but it also has contributed significantly to the knowledge of wind operations in remote arctic environments; numerous communities have benefited as a result. A major advantage of the wind farm is that KEA could integrate power generated from the wind, the most viable local power source, into the local grid. Not only did this diversify the power source, it reduced the amount and cost of diesel fuel consumed. Combined, Kotzebue's turbines generate approximately 5-7% of the community's electricity, representing approximately 90,000 gallons of diesel fuel annually (KEA 2009a). Based on the 2008 PCE data, this amounts to over $230,000 in fuel savings (KEA 2009a).

One of the greatest positives of Kotzebue's wind project is its testament that wind power does technically work in a rural, arctic environment. Such assurance has contributed immeasurably to the general pool of knowledge and helped answer countless questions related to the integration of wind with diesel systems in rural Alaska. Such knowledge is being utilized by rural communities currently pursuing wind power. Basically, Kotzebue has served as a remote, onsite research facility for wind power in the arctic. As a result, KEA has been able to improve turbine design and make the necessary adaptations to the system in an on-site environment.

Although on some level Kotzebue relies on outside assistance from manufacturers and engineers, local experience and skills are being cultivated. Kotzebue hires all local technicians to operate and maintain the turbines and provides continual onsite training. Additionally, the wind farm has served as a classroom for other utilities and technicians, and KEA has hosted anemometer workshops and training for turbine operators and maintenance tower climbers (Reeves, B., personal communication, July 31, 2009).

KEA identified remote monitoring as a crucial component to the success of their wind farm. The Supervisory Control and Data Acquisition (SCADA) remote monitoring system provides information about the electrical characteristics of the engines, fuel levels, system metering and controls for the wind system (KEA 2009a). Despite periodic challenges with SCADA, the remote monitoring has increased the efficiency, generated economic and fuel savings, and provided better fuel economy, maintenance, and trouble shooting (Keith, K., personal communication, July 30 2009). KEA estimated that the utility had a 5% savings just from using remote monitoring.

In 2002, the Community Service Network of the National Rural Electric Cooperative Association awarded KEA the Community Service Network Award in recognition of the community and utility's innovative work. KEA also received awards from the National Rural Electric Cooperative Association for Research and Development Achievement Wind Energy and from the American Wind Energy Association for utility leadership. Additionally, KEA has developed a middle school teacher/student guide on wind energy that has been approved for use by the Northwest Arctic Borough School District Curriculum Committee (KEA 2009a) and is currently being used in the region's schools.

Setbacks and Challenges

Due to the harsh arctic climate, new technology, and learning curve for technicians, KEA experienced early growing pains. The Kotzebue wind farm experienced numerous electrical and technical challenges, although none of them were insurmountable. Early on, KEA faced technical challenges related to integrating the new wind technology with the conventional diesel power plant. Problems also included difficulties with the SCADA system communication, manufacturing problems such as stress fractures in the bolts, and failures with the generators. Many of these problems resulted from exposure to the arctic environment; however, many are also attributable to unanticipated problems with new technologies. Additionally, KEA encountered significant time delays due to the complex logistics of developing projects in rural Alaska, most notably delays in transporting turbines and equipment by barge.

Like all communities in rural Alaska, Kotzebue is faced with the challenge of finding the most feasible alternative to diesel fuel. Wind can help answer part of the rural energy question, but it is intermittent and can create system stability issues. Kotzebue's low-medium penetration systems currently offset about 5-7% of the diesel fuel. Although they anticipate to more than double the wind capacity, this still leaves the community with a significant dependence on diesel fuel. Even if they were to increase the system's penetration, there are still questions related to operating and maintaining high penetration systems in remote communities. Batteries are an option being pursued that would, through energy storage, supply a more reliable source of power. However, batteries are currently prohibitively expensive, especially without grant funding, though this may change in the future.

Development projects are already at an economic disadvantage due to limited economies of scale and increased transportation costs. Rural utilities have so many loans for annual bulk fuel purchases that it is difficult to secure loans for capital projects, such as wind farms. Although grant funding is available, it often involves cost-sharing, which is difficult for small utilities to come up with. Furthermore, the utility takes a significant financial risk by investing its own money into large capital projects; however, it is also a gamble if they do nothing at all. When asked about economic savings of the wind project, KEA responded that it is hard to determine whether the cost of energy is reduced due to difficulties factoring in grant savings.

KEA identified operator resistance to working with and being responsible for new technologies as one of the biggest problems faced by smaller communities when developing and maintaining projects. They addressed the fact that local operators are often solely responsible for providing reliable power services to residents and do not want the potential burden of learning an entire new technology, having something go wrong, and being held responsible. They pointed to the fact that projects naturally develop differently in different places based on local expertise, utility size, and structure, and level of local support and coordination (Reeves, B., personal communication, July 31, 2009).

Finally, KEA stated that avian concerns will be a major factor in the future. The area around Kotzebue is seasonally populated with species of spectacled eiders and stellar eiders, both of which are considered endangered. Although not required, KEA has been voluntarily monitoring their wind site since 1997 and has not documented any bird fatalities. The USFWS does not provide clear guidelines and requirements for protecting birds from wind turbines through measures such as bird diverters and radars. However, such measures are likely to be required in the future and will be a significant cost to the local utility, which already is at a financial disadvantage (Reeves, B., personal communication, July 31, 2009).

ST. PAUL ISLAND CASE STUDY

Community Description

The community of St. Paul is located on the southern tip of St. Paul Island, the largest of the five Bering Sea Pribilof Islands. St. Paul is primarily inhabited by Aleut and Eskimo (ADCRA 2009) and is accessible solely by sea or air. In the late eighteenth century, numerous Russian trading companies established bases on the Pribilof Islands to take advantage of the lucrative fur seal resources. The commercial fur seal industry fell under federal control after statehood (Corbett and Swibold 2000) and dominated the economy of the Pribilof Islands until 1983 when Congress passed the Fur Seal Act Amendment. This Act ended government control of the commercial fur seal industry and turned over the responsibility for managing the industry and providing local services to the community (ADCRA 2009). At this point, the federal government provided $12 million to St. Paul to help diversify the local economy. The commercial fur seal harvest on St. Paul Island officially ceased in 1985.

Since the fur seal industry dissolved, the economy on St. Paul Island has become heavily dependent on city and tribal government employment, crab and halibut commercial fishing and processing, and marine support services (ADCRA 2009). However, the halibut and crab fisheries have suffered a declined over the past decade, forcing the community to seek alternative sources of revenue and stability. The population decreased from 763 in 1990 to 450 in 2008, largely attributable to the steady decline in the fisheries and the increasing cost of living (ADCRA 2009).

According to the Alaska Division of Commerce, the unemployment rate in St. Paul during the 2000 U.S. Census was 15 percent, although 41.5 percent of all adults were not in the work force. The median household income was $50,750 and the per capita income was $18,408; 12 percent of residents were living below the poverty level.

Energy Infrastructure

Household electricity on St. Paul Island is currently provided by St. Paul Electric Municipal Utility, which is owned and operated by the city of St. Paul. A new $3 million diesel power plant came online in 2000 and has a 3470 kW generating capacity (ADCRA 2009). The utility manages the power plant and the local grid. A small wind turbine provides power and hot water to the tribal office but is not connected to the local power grid.

St. Paul Wind Farm: Planning and Development

Tanadgusix Corporation (TDX) is the St. Paul Alaska Native village corporation created under the Alaska Native Claims Settlement Act (ANCSA) of 1971. ANCSA was established with the intent of resolving Native land claims and stimulating economic growth throughout Alaska. In the years that followed, the TDX Corporation purchased and developed several subsidiary companies, which provided services to the commercial, industrial, and public sectors (Institute for Social and Economic Research 2008). In turn, the profits from these investments provided a revenue to TDX and its shareholders

Around the same time the halibut and crab fisheries were experiencing troubles, TDX and the community of St. Paul were faced with other major challenges—cost of transportation, cost of labor, and cost of energy (Philemenoff, R., personal communication, November 21, 2008). TDX owned multiple local assets, including a 100,000 square foot industrial seafood processing building (POSS Camp) and airport facility with offices, repair equipment, and storage facilities (USDOE 2004), all of which accrued significant energy costs. The POSS Camp alone had an average load of 60 to 125 kW and almost year-round space heating needs (USDOE 2004). From the perspective of the TDX, there was little they could do to reduce the cost of labor and transportation, but they saw promise in reducing the cost of power.

During a work visit to Palm Springs, California, the TDX CEO was first introduced to wind power. He returned to St. Paul committed to harnessing the power of St. Paul's wind, which was classified as class seven (Philemenoff, R., personal communication, November 21, 2008). Well positioned due to successful investments, in 1998 the CEO encouraged the TDX Board of Directors to pursue the development of wind power (ISER 2008) to offset the electric and heating costs of the TDX owned buildings. Although the electric utility was owned by the city of St. Paul, TDX acted alone in the project without any collaboration with the utility. In the beginning, TDX pursued grants to fund the wind project. However, they were unable to secure funding from the state of Alaska or the federal government and the unfamiliarity of wind projects in rural Alaska created major obstacles for securing outside grant funding (Philemenoff, R., personal communication, November 21, 2008). In the end, the TDX Board of Directors committed to paying for the entire project with corporate funds, confident that the investment would pay off in the long-run.

The project was an enormous undertaking, notably since the only other wind turbines installed in Alaska were in Kotzebue, which were operated by the local utility, were federally funded, and were a low penetration system. TDX was investing in a local system as well, yet it was built solely through private funding, using high penetration technology; both approaches were new to Alaska. TDX chose a high penetration system[9] to maximize the power of the wind and to improve the efficiency of the existing diesel generators; however, the system required significant technical innovation and modifications of the diesel controls (USDOE 2004). Nonetheless, TDX was determined to prove that it could successfully fund a wind project privately and that it could reduce both the cost of electricity and dependence on diesel.

The planning phase required the commitment of numerous people across different sectors. Participants included TDX staff and Board of Directors, an attorney to handle regulatory issues, a project manager, and experts to conduct feasibility studies. During the 1999 construction phase and the 2006 expansion phase, five to seven people were employed on the project, including two full-time local employees to operate and maintain the wind system (ISER 2008) and three employees from Northern Power, the turbine manufacturer. Additionally, in 2003, ten local workers were trained to operate and maintain the wind turbines (Philemenoff, R., personal communication, November 21, 2008). TDX could not have hired and contracted this many people without the assets and

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[9] High penetration are systems in which the average wind power generated can approach or even exceed the average load, where as low penetration wind-diesel systems have an output averages no more than about 15% of the load.

successes of prior investments and the expertise to determine what personnel were needed to develop a project.

By 1999, a 225 kW stand-alone wind-diesel system that produced heat and power was completed and operating on St. Paul Island. TDX had successfully built the first Native owned and operated hybrid wind-diesel system in Alaska using solely private funding. Due to this success, TDX created the subsidiary TDX Power, Inc., to serve as an electric power production and distribution company. To date, TDX Power, particularly the wind power generation sector, has become the corporation's most profitable business venture (ISER 2008). Within its first two years, the system experienced two major mechanical failures when the gearbox malfunctioned due to inadequate design for extreme arctic temperatures. However, the problem was addressed by the manufacturer and the wind farm continued to operate successfully. Northern Power installed a remote monitoring system, SCADA, that enabled the system to be monitored and controlled from off-site locations via telecommunications links (USDOE 2004). TDX recouped the wind farm investment in eight years (Philemenoff, R., personal communication, November 21, 2008).

As of 2008, the high penetration system enabled TDX to generate electricity for 12 cents per kilowatt hour (kWh), compared to 49 cents per kWh for diesel-powered electricity through the St. Paul Electric Municipal Utility (ISER 2008). TDX saw firsthand the financial benefits of installing wind power for their corporation and was interested in expanding the system to include electricity generation to the community of St. Paul. In 2006, TDX received a grant from the DOE, which allowed TDX to expand the wind farm and install two additional turbines. These turbines enabled the TDX wind farm to produce 700,000 kW of electricity annually with a 36% capacity factor due to the high penetration system. TDX intended to connect the two newest turbines to the existing St. Paul Island electric grid to provide residential power; however, a detailed working agreement between TDX and the St. Paul Electric Municipal Utility was not in place prior to construction.

As of August 2009, the two turbines were sitting idle as a result of complications surrounding integration with the existing utility grid because a dispute arose between the utility and TDX. TDX was interested in purchasing the St. Paul Electric Municipal Utility and proposed to buy the diesel power plant from the City of St. Paul and integrate it with the TDX wind farm. As a result, TDX contracted an independent study to examine the option of buying the utility. However, the City of St. Paul claimed the study was flawed and that the report did not appropriately reflect the value of the existing diesel plant (Philemenoff, R., personal communication, November 21, 2008). Unfortunately, internal political struggles between the two entities have kept the residents of St. Paul from benefitting from the reduced cost of electricity that TDX experiences from using wind power. TDX and the utility have been unable to reach an agreement regarding the terms and price, and the city is currently unwilling to sell.

Influencing Factors of Wind Power Development in St. Paul

Leadership and vision were fundamental to developing St. Paul's wind farm. Numerous people were involved in promoting the concept and advancing the project, yet wind power is unlikely to have been developed without the efforts of two particular individuals. The TDX Chairman and CEO, who is a long-time TDX employee, advocated for wind power from conception through the commissioning phase. Not only did he plant the seed with the Board of Directors after seeing wind farms in California and envisioning the benefits for TDX and St. Paul, but he also led the charge throughout every stage of the project. His long-standing commitment to the success of the company and the projects they invest in is exemplified through his role in both the ongoing operation in St. Paul's wind farm and the expansion of TDX's wind services to other communities. In addition to the CEO, TDX recruited the Chairman of the nationwide Electric Power Supply Association (EPSA) to advise TDX throughout the project. With years of engineering experience in Alaska coupled with his technical expertise, the EPSA Chairman provided guidance on wind turbine design, construction, and operation throughout the project. Without the guidance, commitment, and leadership from these two individuals, the TDX wind project would not have been possible. Together, with the help of many people along the way, they built the wind farm from the ground up.

It must be noted that much of TDX's success stemmed from their financial assets. TDX had made successful investments in the past that provided the financial means to develop a wind project when outside funding was not available. As of 2008, TDX Power held assets in excess of $10 million and had sales of $7 million that year alone (ISER 2008). For many rural village corporations, this volume of income is not an option. Yet due to these successful investments, TDX also had the financial advantage to hire experts to assist the project. This included the Chairman of the EPSA, as well as an attorney, project manager, and multiple operators and employees from the turbine manufacturers.

The TDX Board of Directors had invested millions into the wind project and was committed to guaranteeing the project's success and recouping their money. Without the Board's financial support and commitment, the project would have remained an innovative idea that never got off the ground. As a result of having a financial stake in the outcome, they gave the project the constant attention it needed. Contemplating TDX's success, the Chairman of EPSA has questioned whether the same level of commitment would exist for projects that were grant funded without a financial investment from local entities.

In his interview, the TDX CEO attributed the success of the project to the "commitment, constant attention, and follow through" of the corporation and those working on the project (Philemenoff, R., personal communication, November 21, 2008). These variables, along with leadership and financial assets, were the backbone of the TDX wind project. Without these variables working in synergy, the project in all likelihood would never have made it off the ground.

TDX considered the most significant benefit from the wind farm to be the reduction in cost of electrifying and heating the industrial commercial seafood processing facilities. Based on the cost of power in 2008, TDX estimates that the wind system eliminates $200,000 per year in electric charges (ISER 2008). Consequently, these cost savings translate to profit for the TDX shareholders. Another significant benefit reaped by the local community is the addition and security of wind turbine operator jobs. In 2003, TDX trained ten people to operate and maintain the turbines (Philemenoff, R., personal communication, November 21, 2008). It took years of trial and error and training from the turbine manufacturers, but TDX boasts a highly trained, reliable, and local work force.

Due to their success and expertise in high penetration systems, TDX Power was formed in 1999 and now serves as a resource to other communities that are interested in developing wind-diesel systems and those that are in the process of installing them. They have been asked to teach other communities about wind power, as well as train local operators. In addition, TDX Power has expanded their services and successfully developed wind-diesel to other communities, including Sand Point and Tin City. With more and more high penetration systems being pursued through the Renewable Energy Grant Fund, TDX will continue to provide expertise and valuable experience to communities that are new to wind power.

Setbacks and Challenges

The St. Paul wind project was a major feat for TDX and wind power in Alaska as a whole, yet it faced major challenges and setbacks, some that were overcome and some that are still a hindrance. Early on, technology was a limiting factor. Not only did few manufacturers focus on small and midsized turbines suitable for Alaska, but very few were high penetration systems. In the first two years St. Paul's system was operational, the wind system experienced two major mechanical breakdowns due to gearbox failure from inadequate design systems for cold temperatures (ISER 2008).

However, according to the TDX CEO, technology was only half the problem—the other half is the human factor in the form of human resources, human nature, and politics (ISER 2008). Although TDX overcame personnel challenges, it took many years to bring staff online so that they could properly and efficiently operate and maintain the wind system. This also required an extended period of technical support from the manufacturer while local operators gained familiarity with the equipment and controls, (USDOE 2004); this was both costly and time intensive.

Since the wind farm's inception, TDX had sought to provide wind-generated power to the households in St. Paul; however, they are presently unable to achieve this due to conflict between TDX and the electric utility. TDX made an offer to the City of St. Paul to purchase the diesel power plant and integrate it with the TDX wind farm, but the city was not interested in selling for the proposed price. TDX viewed this as a calamity as the residents continue to pay three times the cost of the TDX wind-generated power and the two newly installed turbines are sitting idle. However, for the City of St. Paul, continuing to operate the electric utility means a continued source of revenue for the city to maintain its basic operations, however small it might be. Whereas the city once relied on tax revenue from the halibut and crab industry to maintain its services, it grew to rely heavily on the revenue from the local utility. Such discord has generated much tension between these local organizations and individuals in the community.

KASIGLUK CASE STUDY

Community Description

Kasigluk is located on the Johnson River in the Yukon-Kuskokwim River Delta region in western Alaska, 26 miles northwest of Bethel. The community comprises Old and New Kasigluk and has the combined population of 578. The community is inhabited primarily by Yup'ik Eskimos (ADCRA 2009). Similar to St. Paul and Kotzebue, Kasigluk is accessible only by sea, river, or air. The local economy is driven by employment through the school, commercial fishing, and local tribal and city governments.

According to the Alaska Division of Commerce, the unemployment rate in Kasigluk during the 2000 U.S. Census was 21 percent, although 54 percent of all adults were not in the work force. The median household income was $31,500, and per capita income was $7,194; 23 percent of residents were living below the poverty level.

Energy Infrastructure

The electric utility is owned and operated by the Alaska Village Electric Cooperative, a non-profit electric utility servicing 53 communities throughout the Interior and western Alaska. AVEC is financed primarily by loans from the Rural Utilities Service, United States Department of Agriculture, and financial assistance received from the federally-funded Denali Commission (Alaska Village Electric Cooperative 2009). AVEC has been operating since 1968 and owns and operates over 500 fuel tanks, 160 diesel generators, and 48 power plants across Alaska (Northern Power 2009). In Kasigluk, the utility operates a combined wind-diesel power plant that has a total generating capacity of 1,624 kW and an average electrical consumption of 2,705,005kWh. The current cost of electricity in Kasigluk is 47 cents before PCE and 19 cents after PCE (AEA 2009a). Kasigluk has a class 4-5 wind resource and has three Northwind 100 100-KW wind turbines installed with a generating capacity of 300 kW.

Kasigluk Wind Farm: Planning and Development

The priority of the wind power system in Kasigluk was somewhat secondary to other work that needed to be completed on the community's power generation system. The diesel power plant serviced both Kasigluk and the nearby community of Nunapitchuk. Due to boggy and shifting ground at the old tank farm in Akula Heights and deteriorating power line foundations, AVEC needed to relocate the facilities and rebuild three miles of transmission lines between the communities (Petrie, B., personal communication, July 2008a). During the planning phase for these changes, AVEC considered the possibility of piggybacking a wind energy project with the other work. Not only had the delivered cost of fuel to AVEC communities been rising since 2002, but 77% of the diesel fuel used in AVEC communities was consumed in villages with a wind class of four or greater (Petrie 2008). Kasigluk had an identified 4-5 wind class and an average wind speed of 15 mph. AVEC became interested in installing three Northwind 100 turbines with a combined 300 kW generating capacity, representing the first field deployment of these turbines in Alaska (NREL 2009).

The planning phase for the wind project and power system upgrade work began in 2002 and involved AVEC, Kasigluk Traditional Council, Kasigluk Incorporation (local Native corporation), and funding partners. All involved parties were supportive of the project and interested in both upgrading the old power system and bringing new wind turbines online. During the process, AVEC developed a business plan that included considerations such as the life of the turbines, gallons of diesel displaced, cost per kWh, and whether the turbines had a payback time of less than 20 years.

Unlike TDX, AVEC was a non-profit cooperative and did not have the financial assets to fund the wind project privately. However, they were able to contribute 10 percent of the overall project funding. The additional 90 percent came from the Rural Utility Service and the Denali Commission through a USDA Rural Development High Energy Cost Grant Program, which helps coordinate the upgrading of bulk fuel and electric utility facilities in rural Alaska. The overall project cost was $16.8 million (Petrie, B., personal communication, July 2008a).

AVEC worked closely with Kasigluk Incorporated to lease the land for the wind project site. With AVEC's decades of experience working in arctic and subarctic environments, AVEC served as the foundation engineer for the wind turbines. Due to the magnitude of work relocating the fuel tanks, rebuilding transmission lines, and building the wind farm, the overall project took four years and the turbines were officially on-line and producing electricity in 2006. The current power system provides electricity to Kasigluk, Old Kasigluk, and Nunapitchuk. The result was an amalgamated project that involved relocating and constructing a new tank farm in Kasigluk, rebuilding transmission lines between Nunapitchuk and Kasigluk, and erecting 3 wind turbines at Akula Heights that provide power 94% of the time.

The specific design of the Northwind 100kw turbines assisted in reducing the frequency and amount of maintenance and operation. Additionally, a SCADA system was installed to provide remote monitoring of the system by both AVEC and Northern Power Systems. This allowed the turbines to be started and stopped remotely. In addition to SCADA, Kasigluk had 2-3 on-site operators that monitored the wind-diesel system through the use of SCADA up to four times a day (NREL 2009). Scheduled maintenance occurred on the turbines every six months under a service agreement between AVEC and the manufacturer.

According to AVEC, since commissioning in July 2006 through April 2008, Kasigluk's wind turbines provided about 23% of all electricity used in Kasigluk and Nunapitchuk, which displaced nearly 65,400 gallons of diesel fuel. In 2007 alone, diesel worth $72,000 was displaced by wind (at 2008 fuel prices, this would amount to $150,000). The turbines are expected to produce approximately 600,000 kWh per year, although this varies from year to year (Petrie, B., personal communication, July 2008a).

Influencing Factors of Wind Power Development in Kasigluk

While AVEC does not anticipate that wind power systems will replace diesel as the primary power source in rural communities, they do foresee wind power as a viable option to offset diesel consumption in many of their communities. "Diesel is very reliable, but it's also very costly, and the cost of storing it is also an item because we also have to build these fuel facilities that are capable of storing the entire year's supply. Wind can help us extend the life of our fuel storage facilities and lower the cost for power generation—that's the main thing we're looking at," said Brent Petrie, AVEC project manager (Talend 2006). It is largely these financial incentives that accelerated the Kasigluk wind project and continue to drive other AVEC wind projects.

Aside from the economics of reducing diesel importation and consumption, accessible financing greatly influenced the ability of the project to move beyond the visioning phase. AVEC knew that in order to ensure success the project not only needed adequate capital funding but also needed to secure sufficient funding for the ongoing operation and maintenance costs in order to reduce significant periods of down time of the turbines. This would help establish that the demonstration project was worth replicating in other rural communities.

The next impetus for getting the project underway was the determination of the AVEC project manager. The project did not emerge from the community; rather it arose from the project manager's personal interest in wind and expertise on rural power generation. His background enabled him to envision combining an upgrade project with a wind-diesel integration project. As the project champion from the visioning phase through construction, he continues to play a vital role in the oversight of the project's operation and maintenance. He championed and pioneered the integration of the Northwind 100 turbines in remote rural communities. Backing the project manager was an organization built of dozens of Anchorage-based staff and village-based operators at each of AVEC's 48 power plants. The AVEC staff included primarily engineers, project managers, and administration. AVEC also had the means to hire attorneys and contract individuals for various feasibility studies due to their organization's size and human and financial resources. Each wind project had a team of engineers and managers with technical expertise and experience to design a project, walk through the permitting process, coordinate logistics, find financing, install the turbines, and train operators. Although wind projects are new, AVEC has coordinated diesel power projects for over 40 years.

There were technical factors in place that advanced the project. Given the remote locations of the turbines and limited onsite technical staff, monitoring the power system often could have posed a challenge to AVEC. However, the advancement of the SCADA system, which allowed AVEC to monitor and control the wind turbines and diesel generators from offsite, reduced the operation and maintenance costs and provided assurance that the project would operate more dependably and be maintained adequately. Without this technology, AVEC would have had to allocate more staff and spend more money and could not have guaranteed that the systems would be maintained properly.

The combined factors of leadership, organizational capacity, financing, and technology advancements were positive variables that led to the development of Kasigluk's wind project.

AVEC pioneered the integration of the Northwind 100s in Kasigluk, which since then have been installed in numerous AVEC communities and other villages in Alaska, including Hooper Bay, Toksook Bay, and Savoonga . Locating adequately sized and appropriate turbines for small arctic communities promoted wind advancement all across rural Alaska, and AVEC is responsible for spearheading such efforts. It has been a major learning curve, but the benefits have paid off.

The major benefits from the project are reductions in the costs of electricity and diesel fuel consumption. Although the savings equate to significant direct savings to the consumers, they have limited the utility's expenditures and proven that wind-diesel systems can cut costs and reduce fuel consumption, leading to their advancement in other communities.

AVEC has come a long way in providing on-site training for its operators so there are typically 2-3 trained wind-diesel operators in each community with a hybrid system. Such training necessitated working with the turbine manufactures, Alaska Vocational Technical Center, and AVEC staff and required significant time and resources. AVEC still relies heavily on the SCADA systems, but neither the SCADA or wind-diesel system could exist in a remote community without constant attention from skilled and trained operators.

As a result of Kasligluk's success, AVEC has since been able to find funding and install wind turbines in Wales, Selawik, Toksook Bay, Kasigluk, Gambell, Savoonga, Hooper Bay and Chevak. In addition, other communities who have witnessed AVEC's success have pursued wind development. AVEC has received multiple awards for their efforts and advancements in the wind field, including the Wind Cooperative of the Year Award from the U.S. Department of Energy's Wind Powering America Program in 2007.

Setbacks and Challenges

Although the Kasigluk project was a major feat, it also faced significant hurdles. Very few concerns emerged from the communities of Kasigluk and Nunapitchuk throughout the permitting process; however, it was the permitting process that created the greatest setbacks and hindrance for AVEC. Issues arose primarily from conditions placed on the project through the National Environmental Policy Act process and federal permitting agencies, including the Federal Aviation Administration, Army Corps of

Engineers, and United States Fish and Wildlife Service (Petrie, B., personal communication, July 2008a). These conditions, requiring siting and avian monitoring, resulted in additional work, project delays, and increased project costs. Fortunately, AVEC had adequate human capacity and expertise to work through this process, whereas such roadblocks could have halted projects with smaller utilities.

Another major challenge arose from the complex logistics of constructing a project in remote Alaska. In the words of the project manager, "planning and logistics can make or break a project" (Talend 2006). The project site was located on permafrost and glacial silt laid by the Yukon-Kuskokwim River Delta, creating unstable soils for construction, particularly for turbine foundations. Because the foundation was critical, AVEC invested significant time and money into engineering and constructing a technically sound foundation. Additionally, coordinating equipment shipments and crane rentals added significant time and money to the project; this is not an impediment in other parts of the state and country. In order to make the project financially feasible, AVEC had to carefully coordinate a quick turnaround time for the crane and equipment rentals and often tried to coordinate equipment rentals with other nearby projects in order to cut down on costs. However, at times such logistics were overwhelming for the larger cooperative, suggesting they would be even greater setbacks for smaller utilities that lack experience coordinating large projects.

AVEC also points to the maintenance of the turbines and wind-diesel system as a major challenge in an environment with such high winds, frigid temperatures, and limited personnel. AVEC has invested aggressively in training multiple operators in a single community. However, employee retention and proper training has remained an ongoing problem.

Another major challenge the project manager identified for future projects in rural Alaska was how to conduct adequate wind resource assessments. These assessments estimate how much wind energy is available at potential sites. Such estimates of the available energy not only ensure that projects are not placed in poor wind areas (Petrie 2008) but also can make or break the economics of a wind project. The project manager believes the current tools used to assess wind resources are inadequate and pose a risk that projects might be developed in unsuitable areas and with unrealistic expectations. He also noted that since the Renewable Energy Grant Fund was implemented in 2008, the number of interested developers, many of whom are from out of state, has dramatically increased and there are more entities competing for funds. Additionally, he noted that some developers who have little Alaska-specific knowledge of rural conditions and project development are trying to influence communities to develop projects, even in situations where it is not cost effective.

COMMON INFLUENCING FACTORS AMONG KOTZEBUE, ST. PAUL ISLAND, AND KASIGLUK

The three case studies offer insight into the local context of wind projects and the primary factors that advanced their development. All three cases are considered successful for many reasons, yet they all reflect specific challenges to implementing wind power in rural communities.

All three projects pioneered the way for the advancement of wind technology in remote Alaska environments and provided confirmation that such technology is feasible. Kotzebue Electric Association reintroduced the concept of wind as a power option for rural Alaska, Tanadgusix Corporation proved that high penetration systems are possible in remote communities, and the Alaska Village Electric Cooperative demonstrated that Northwind 100 systems are an appropriate technology to operate and maintain in the bush. Prior to these projects, the ghosts of past failed wind projects left in question the viability of wind power in rural Alaska. However, all three of these projects demonstrated that the technology is both mature enough and accessible for rural applications. This is not to say that technological implementation was problem free. All three case studies demonstrated many challenges both mechanical and electrical in nature, including generator problems, stress fractures in bolts, and equipment defects. These challenges did not block the projects, but they created major hurdles that were costly and created delays at multiple stages.

Additionally, technological advances such as SCADA and the option of rotating wind technicians between communities mean it is not necessary to have all of the technical expertise at the local level. In the case of AVEC, Kasigluk has trained onsite local technicians, yet they also have trained engineers and technicians that work among all of their villages when larger technical problems arise. Similarly, Kotzebue has onsite technicians, but they also have contracted engineers that consult with KEA and travel to Kotzebue when needed. These findings confirm that smaller village level utilities can develop wind power projects on their own, but it is inevitable that they will need outside support for larger technical challenges and must have the financial means to access this support.

Financing also played a major role in all projects included in the three case studies. TDX had the advantage of financial assets derived from successful previous investments. For KEA and AVEC, grants covered the majority of capital expenses, making it economically feasible for them to develop the projects. Although these three utilities relied on different funding sources, all were successful in securing the requisite funding at a time when wind power was not as widely accepted and supported in Alaska as it is today. As a result of their financing success, ultimately all of the utilities were able to significantly offset diesel consumption and generated cost savings. Such a decrease in electric costs and diesel consumption provides price stability and acts as a hedge against volatile fuel prices, which have adversely affected rural Alaska over the past several years.

Coupled with technological and financial achievements, the three electric utilities demonstrated significant strength in organizational capacity and human capital. All three utilities entered into the projects with the advantage of mature organizational capacity and with project development, managerial, and technical experience. Additionally, all three utilities had relatively more personnel and greater years in business than many other rural utilities or power developers, potentially influencing the organization’s ability to develop projects. Combined, this experience allowed the utilities to navigate the planning, development, and permitting processes, as well as ongoing operation and maintenance. These utilities not only navigated the process but also had the perseverance to work through challenges and move their projects forward. For example, the failure of TDX to find public and outside funding was a financial setback, but the Board's determination and financial means led them to commit their own funds to advance the project. Similarly, the complications that AVEC experienced during the permitting process were a hurdle, but not insurmountable due to AVEC's qualified personnel and experience permitting other power projects. Without these resources, it is implausible that the projects would have been developed so successfully, or perhaps at all.

Of all of the human capacity variables, leadership is the one that shone through the strongest in all three case studies. Without a project champion, the projects would never have advanced beyond the visioning phase. All were initiated by individuals who recognized the possibility and benefits of wind power and were driven to lower or stabilize the price of power, consequently creating more sustainable and financially stable communities and utilities. Recognizing that none of these projects could have been executed without support from the Board, community, and/or funding agencies, the project leaders took it upon themselves to provide assurance that the project would benefit their community and entity. Such leadership kept each project afloat and advancing.

It must also be noted that two out of the three developers, AVEC and TDX, are located in Anchorage, the center for the state energy agency (Alaska Energy Authority), funding agencies, and other energy related organizations. Such positioning makes technical assistance and funding agencies more accessible and fosters greater opportunities to build working relationships with such agencies. As the wind diesel coordinator at AEA observed, they did not have the financial and personnel capabilities of doing much outreach; communities and utilities must know what resources are available in order to access them. The physical location of AVEC and TDX immediately put them at a greater advantage. Although KEA is based in Kotzebue, the utility manager was actively involved with multiple state and federal power organizations, including being the President of the Alaska Power Association (APA), a Board member of the

Utility Wind Interest Group, and a member of the Cooperative Research Council of the National Rural Electric Cooperative Association. Such positioning and connections are undoubtedly assets to KEA and the power projects they develop.

This case study research strives to establish findings that are generalizable beyond the immediate case studies. Although each case is unique, many of the circumstances and issues are common across rural Alaska. As such, the findings provide insight and guidance to other rural communities as they pursue wind power development.

CHAPTER FIVE:
CONCLUSION AND DISCUSSION

Supplying electricity to any community across Alaska comes with challenges, yet nowhere is it as formidable as in remote, rural communities. Challenges include limited or non-existent transmission lines and access roads, exorbitant fuel costs, artificially low fossil fuel costs due to subsidies, logistical complications, and inadequate infrastructure. Interests regarding rural energy services have oscillated over the years as fuel prices have surged and declined and alternative power sources have risen and fallen from the public and state's attention. It is primarily these factors, fuel prices and public attention to energy, that have been the greatest drivers for changing rural Alaska's diesel-dependent power systems.

In many ways, the introduction of small-scale diesel generators stimulated monumental progress in living conditions in the bush by establishing a constant source of power using a reliable, mature, and commercially available technology with a well-established technical assistance and maintenance network. These systems have provided local communities with services and capabilities they would not otherwise have had access to. However, because diesel generated electric systems require a constant fuel sources that is neither locally available or stable-priced, they are not a panacea for the energy needs of rural communities

The funding and promotion of alternative sources of power has come and gone in Alaska over the past several decades. In the late 1970s and early 1980s, the state's installation of over 140 wind generators across rural Alaska held the promise to alleviate some of the local stresses resulting from dependence on diesel; however, not a single wind turbine was operational as of the early 1990s. The initial analysis of why these projects failed pointed to several factors: immature technology, lack of community-specific considerations, lack of long-term financing due to expired federal tax incentives, limited to no operator training, poor planning, lack of methodology for assessing the technical and financial feasibility, inadequate coordination among state agencies, and a decrease in the price of oil in the mid-80s.

It took nearly two decades, but wind power made a return to Alaska communities in 1997 with the construction of a 150 kW system in Kotzebue. Wind power has continued to grow as an alternative energy source ever since. The case studies pinpoint variables that contributed to the successful development of wind projects in selected communities; however, the transition to wind in Alaska is also constrained by myriad factors—social, political, environmental, economic, and technical. Evaluating the factors that contribute to and create constraints to wind power development in rural Alaska offers insight for understanding both what it takes to develop successful wind power projects and which variables need to be addressed in order to move more communities in the direction of wind energy. Better understanding these factors and development thresholds not only helps avoid failure of future wind projects similar to the 70s and 80s disasters, but it provides guidance for communities in the initial stages of pursuing wind power, as well as for agencies and organizations that provide technical and financial assistance. Although many relevant factors came to light in the case studies, surveys and literature reviews, this research identified four primary factors that influence the development of wind power in rural communities. The factors are leadership, networks, local capacity, and information access and dissemination.

INFLUENCING FACTORS FOR DEVELOPMENT

Leadership/Project Champion

The three case studies conducted found that each of the wind power projects was developed largely due to the dedication of a single key individual. These project champions consisted of the utility manager from Kotzebue Electric Association, the project manager from the Alaska Village Electric Association, and the village corporation chairman of Tanadgusix Corporation. Through their commitment to minimize the dependence on diesel fuel for electricity and decrease the cost of power, these individuals provided the impetus to embrace the possibilities of wind power projects and used their influence to garner support and propel the projects forward.

In hindsight, the success of these projects hinged on the project champions' commitment and ability to leverage local and outside networks and resources to their full capacities. They initiated planning and development strategies at the local level and coordinated efforts that linked appropriate organizations and key individuals to the local project, thus contributing significantly to the development of the projects. This included identifying and securing outside funding, coordinating with local entities for land lease and assistance, building networks with technical expertise, and connecting to agencies that promoted and featured their projects.

This is not to say that the projects would never have been developed were it not for these individual leaders. These projects may have been developed at a later point in time or could have proceeded with the leadership of another individual. However, it is irrefutable that the projects that exist today in Kotzebue, St. Paul, and Kasigluk would not be what they are or have developed within the same scope and timeframe without the three project leaders as catalyst.

Furthermore, the case studies demonstrate that, although project leaders and champions often arise at the local level, they do not necessarily come from the local community. The KEA and TDX project leader emerged from the local level—the electric utility and the local village corporation. These leaders worked for local entities and were invested in the community as well as the success of their organizations; both of these factors were influential in promoting wind power. However, for the Kasigluk project, the project champion was from the electric cooperative, based in Anchorage, Alaska. Although this individual was not from or based in the community, he was part of an organization that had a vested interest in the local community, as well as in reducing the costs and dependence on diesel fuel for the electric cooperative.

Further supporting the importance of leadership to project success, 80% of survey respondents noted that leadership played either a *very significant, significant,* or *somewhat significant* role in the development of wind projects. Although these responses were from communities that have not yet developed their wind resource, their responses indicate that they understand the importance of local leadership as a catalyst for advancing wind projects, and perhaps all development projects.

Local, Regional and Statewide Networks

Due to the physical distance from the state's urban areas (which are where the majority of state, funding, and decision-making agencies are located) and limited resources, it is critical for rural communities to establish networks to assist in the development of major projects. Networks are needed both within the local community and between the local community and outside organizations at the state and federal levels. These networks provide information and assistance from the planning process through the operation and maintenance of a project. The failed projects in the 70s and 80s each reveal that it is one thing to construct a project, but it is quite another challenge to amass an adequate network of individuals, organizations, and agencies at local and state levels resilient enough to maintain the project.

The case studies demonstrate that a development strategy requires a multi-faceted commitment from and between networks comprised of community organizations and agencies and organizations that provide energy services. TDX is a rare example of a project that was developed with minimal outside assistance due to adequate financial assets. However, the AVEC and KEA case studies demonstrate that for lesser endowed communities, accessing the proper organizations, agencies, and programs is a viable way to develop a wind project.

The literature consulted for this research emphasizes the importance of project coordination at the local level; however, it was surprising that not all of the case studies entities demonstrated extensive local coordination. KEA is an example that accessed significant local resources to support its wind project. However, AVEC reported minimal interaction with the local community and organizations while developing its project. St. Paul was a private project so it was not essential for TDX to interact with the local community in order to move the project forward. TDX did attempt to work with the local utility, with minimal effect. Ultimately, the project was developed with little partnership between local organizations. This does not necessarily signify that local coordination and involvement are insignificant. This may be explained by the extensive resources within and available to KEA, TDX, AVEC and their capacity to develop projects on their own, minimizing their need to rely on the local level for support and assistance.

Numerous small, rural communities benefit from local coordination and collaboration in order to work efficiently and effectively. When asked about the level of coordination among entities during the project-planning phase, 22% of the survey respondents replied *high*, 25% replied *medium*, and 39% replied *low*. A low level of coordination is a disadvantage to smaller communities for numerous reasons. Different organizations may be eligible for different funding sources, have different familiarity with the regulatory process, and maintain different connections with state and federal agencies. Without local coordination in concert with local-state coordination, pursuing a goal as extensive and complex project such as installing wind turbines can quickly become unattainable for a single entity or community.

Additionally, the survey responses indicated that 30% of respondents were *not familiar* with the planning process, indicating a disconnect to state agencies that provide information and assistance at the local level. Such a lack of connection has untold impact on certain communities' inability to develop a wind project despite their access to a viable wind resource. This verifies the value of increased collaboration between the local and state levels, and also signifies the need for local entities to work together to overcome the inadequacies of services provided by the state. It also suggests that larger entities that represent numerous communities like ACEP may be particularly effective in promoting and installing wind-power projects across rural regions.

Interestingly, when the survey asked for the most useful consideration for a community when planning for wind development, the least frequent response was regionally coordinated efforts. To some degree, all rural Alaskan communities network on a regional level; such regional coordination among tribes has become a necessity. However, it is evident that many rural communities prefer that their electric services remain community-owned and operated and do not want to consolidate at the regional level, exacerbating the problem of rural communities not taking advantage of economies of scale. However, although these results may reflect a resistance to utility consolidation, they do not necessarily imply opposition to coordinated planning efforts and information sharing.

Local Capacity: Human, Technical, and Financial

The development of local capacity is not only beneficial to the advancement of wind power projects; it may be of great significance to the continuance and advancement of rural communities themselves. Many rural communities are struggling to maintain basic functions and provide basic services in the face of increasing social, political, and economic stresses. Many do not have the means to maintain existing projects and infrastructure, much less have the capacity develop innovative new projects such as wind power. In Alaska, local capacity to develop, manage, administer, fund, and maintain wind power systems often falls on local entities in communities with small populations and limited resources and this is an ongoing barrier to wind power development.

The case studies reinforce the importance of capacity. KEA, TDX, and AVEC all had the human and technical capacity to coordinate efforts between their entity and relevant state and federal agencies. They had the knowledge to acquire funding and technical assistance resources. They had established working relationships with funding, technical assistance, and/or industry organizations. Additionally, TDX had the internal financial resources to develop a project without outside assistance Whereas most rural communities have modest local resources and require outside training and assistance to maintain their systems, the communities in the case studies were somewhat exceptional due to their extensive human, technical, and in the case of TDX, financial resources. For example, in the Kasigluk case study AVEC indentified the permitting process as the greatest impediment to the development of the wind power project. Despite this challenge, the electric cooperative had adequate numbers of sufficiently qualified staff to dedicate to navigating this process and working with the necessary agencies.

The case studies further demonstrate the complexities of developing projects and coordinating logistics in rural Alaska. All of the projects experienced setbacks for one reason or another—permitting, transportation logistics, technical difficulties—yet they had the human capacity, in terms of the quantity and qualifications of their staff, and adaptability to continue with the project. However, the majority of small, rural communities often do not have enough qualified staff or the financial means to overcome such an obstacle, creating significant shortcomings that drastically slow or halt a project.

Access to Information and Information Dissemination

The communities that have benefited from state energy programs and assistance have largely been those that actively sought information and assistance to develop their wind resource. However, even for those communities, there was no clear process to seek such aid. The labyrinth of state agencies, federal permitting agencies, research institutes, and energy-related organizations can be prohibitive to identifying the appropriate organization to contact and finding the needed information.

These case studies reveal that KEA, AVEC, and TDX were all able to connect to the appropriate information needed to develop their projects. In part, this was achieved through established networks with energy organizations and agencies, which provided the needed information. This was also accomplished by having adequate staff or contracted employees dedicated to finding information on specific issues, including funding, technical issues, the permitting process, and transportation logistics.

However, for communities that are not actively seeking information, it is unlikely that the information will find them. They are therefore less likely to stay informed and up-to-date. For example, although the survey results reflect that 79% of respondents characterized their organization as either *very interested* or *interested* in developing wind power in their community, only 35% acknowledged that they were actually aware of the anemometer loan program. Recording a year's worth of anemometer data is required in order to pursue state funding for wind power projects. Such results suggest a shortcoming at the state level in disseminating energy information to rural communities.

The wind coordinator at the Alaska Energy Authority acknowledged that the AEA does not conduct outreach for the anemometer loan program due to limited staff and resources.

Instead, the AEA waits for communities to take the initiative and contact them. This two-part problem—limited information reaching communities and the state energy agency being too understaffed and underfunded to adequately conduct the extensive outreach—creates a major hindrance to a community's ability to consider and develop projects. There is a major discrepancy between the availability of energy resources and the number of communities taking advantages of the resources, further demonstrating a divide between the state and local levels.

Additionally, the literature and interviews suggest that wind power development and permitting will experience changes in the future, including the potential tightening and enforcement of regulations related to avian monitoring and mortality. Without the dissemination of adequate information, it will be increasingly difficult to enforce such changes or educate people about them.

RECOMMENDATIONS

In order to encourage long-term wind diesel developments, it is essential to address existing barriers so that effective measures can be taken to foster the success of wind power projects in rural Alaska. The majority of individuals surveyed indicated that their communities have taken at least one step in the process of developing wind resources in their communities. The most common steps taken were 1) identifying a wind farm location, 2) requesting outside help, and 3) holding community meetings. The results reveal some level of initiative and interest from many communities. However, they beg the question of what more is needed to move projects from initial planning to implementation. The barriers identified in the survey, along with the literature review and contributing factors identified in the case studies, helped generate recommendations for what may be considered for the next steps toward promoting and assisting in the development of successful wind power projects in rural Alaska. The recommendations follow:

RECOMMENDATIONS FOR STATE OF ALASKA

1) Develop comprehensive statewide energy plan and policy.

Without a clearly defined statewide energy policy and plan there is no explicit pathway to transition to wind power systems in more rural communities, not to mention to guide all energy planning and development statewide. A statewide energy policy would provide set goals and guidance on the direction the state should move regarding energy infrastructure. The statewide energy plan would more clearly pave the way for how to meet these goals, including providing financial and training plans and programs to expand local capacities to develop and maintain wind power infrastructure.

2) Increase coordination between the local and state level.

Increased coordination and the formation of networks between the local and state levels will benefit both parties. At the state level, it will help ensure that state funded projects are on the right path and that critical resources—human, technical, and financial—are in place to facilitate a project's success. Such coordination can be increased through improved outreach efforts, planning meetings, educational forums, and more frequent communication between state agencies and the local community. In order to meet this goal and level of coordination, it would require an increase in staff and financial resources from the state.

3) Increase the dissemination and exchange of information between state entities and rural communities.

Increasing a community's access to information will increase their knowledge of wind power and the resources that are available to assist them in their development efforts. This would involve increasing the state's capacity to conduct outreach, service more communities, and approach communities directly rather than presuming information will eventually make it to the right parties. This may involve consolidating services or creating a clearinghouse so that communities can contact one central organization for information on the technical, funding, and permitting aspects of wind power. Such measures would improve the dissemination of information and keep communities informed and up-to-date.

4) Increase the availability of technical assistance to rural communities.
Due to the newness of both wind technology and the development process in rural Alaska, there is a need for technical assistance during the planning, permitting, development, and construction phases of wind power projects. Such assistance would increase the capacity of local entities not only to develop wind projects but also to develop and maintain other infrastructure projects in their community. This would necessitate increased political support for wind power and a commitment from the state to increase its services and the number of communities it serves, as well as to establish a mechanism to better track and follow-up on projects. Concerning permitting issues, increased technical assistance would support communities through the complex permitting processes and address current regulatory issues such as avian concerns by directing resources toward studying wind turbine impacts on avian populations.

RECOMMENDATIONS FOR COMMUNITIES

1) Promote indigenous and local leadership and administrative capacities.
There is no clear method to promoting and fostering leadership among individuals in rural communities. However, many regional native corporations already offer indigenous leadership programs, which may serve as a model for increasing leadership programs at state universities or even at the local level.

2) Encourage and provide regional coordination and information sharing.
The Alaska Energy Authority identified 115 communities in Alaska that have a 4-through-7 wind class. Many communities within the same region, such as in southwestern Alaska, will be pursuing wind power projects and undergoing a common process. In many ways (including health care and tribal services), rural communities already coordinate on a regional level. Increased regional coordination for energy

planning and development would promote information sharing help minimize the duplicated of efforts, such as navigating the permitting process and identifying funding sources. It would allow communities to coordinate project logistics and scheduling, ultimately reducing the overall project cost. Additionally, it would provide communities with access to a greater breadth of knowledge, allow communities to share their challenges and success stories and thus learn from each other's experiences, and potentially provide a greater sense of cohesion.

3) Increase coordination between the local and state level.

Increased coordination and the formation of networks between the local and state levels will benefit both parties. At the local level, it will increase a community's access to information needed to develop a wind project. It will also provide the support networks necessary to navigate different stages of development, including permitting, logistics, and operation and maintenance. This increased coordination can be achieved through increased communication between state agencies and local communities, planning meetings, educational forums, the involvement of more local utilities on state-wide energy committees and organizations, and the increased dissemination of information.

CLOSING

There is no standard solution for rural wind power projects. The case studies are clear examples that each project is unique in its challenges and methods of overcoming them. However, this research reveals that there are common development thresholds that, if addressed, can more effectively lead to the advancement of wind power projects in rural Alaska. Addressing these thresholds will require commitment and participation from both the local and state levels through enhanced coordination, increased dissemination and sharing of information, encouraging the development of local leadership, and increased capacity of local organizations to plan for and develop projects.

Though not a small task, none of these factors—social, political, technical, economic, or environmental—require starting from scratch. The framework exists for overcoming many of the identified barriers and transitioning toward an increased capacity for wind power development across rural Alaska. This goal is achievable with an increased level of attention, commitment, and funding.

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APPENDIX

WIND ENERGY SURVEY

Barriers to Wind Energy Development in Rural Alaska Communities

Community Name:____

Directions: Please answer the survey questions to the best of your ability and return the survey in the self addressed envelop when completed. There are not right or wrong answers. Any information obtained about you will be kept strictly confidential and your identity will remain anonymous. If you have any questions please contact Jill Maynard at 907-750-1365 or fsjem13@uaf.edu. **Your participation is greatly appreciated!**

I. Background Information

Please indicate your position at the electric utility. Please check the box that applies:
☐ Manager ☐ Operator ☐ Other________________________

How many years have you been in this position?
____

Do you personally consider yourself an advocate of wind power for your community?
☐ Yes ☐ No

Who owns and operates the electric utility in your community? Please check just one box.
☐ City government ☐ Village Corporation ☐ Tribal government ☐ Other __________

How satisfied is the electric utility with how electricity is produced in your community? Please check just one box. ☐ Very Satisfied ☐ Satisfied ☐ Dissatisfied ☐Very dissatisfied ☐Not sure

Is the electric utility interested in seeing wind power developed in your community? Please check just one box.
☐ Very Interested ☐ Interested ☐ Somewhat Interested ☐Not Interested ☐ Not sure

If the electric utility is not interested in wind, are they interested in developing any other resources? Please check all that apply.
☐ Geothermal ☐ Coal ☐ Natural gas ☐ Solar ☐ Hydro

How familiar is the electric utility with the planning and development process for wind development? Please check just one box.
☐ Very familiar ☐ Familiar ☐ Somewhat familiar ☐ Not familiar ☐Not sure

Has your community, electric utility, city government or Tribal government taken any of the following steps? Please check all that apply.

- ☐ Held community meetings regarding wind development
- ☐ Identified a location to put up a wind turbine
- ☐ Requested help from organizations and agencies outside of your community
- ☐ Put up an anemometer (used to measure the wind speed in a specific location)
- ☐ Applied for funding for wind feasibility studies or capital projects

Is the electric utility aware of the following programs and funding options? Please check all that apply.

- ☐ Alaska Energy Authority Anemometer Loan Program
- ☐ Alaska Renewable Energy Grant Fund (new in 2008)
- ☐ USDA Rural Development grant
- ☐ Department of Energy—Tribal Energy Program

Has your community received funding from any of the following programs and funding options? Please check all that apply.

- ☐ Alaska Energy Authority Anemometer Loan Program
- ☐ Alaska Renewable Energy Grant Fund (new in 2008)
- ☐ USDA Rural Development grant
- ☐ Department of Energy—Tribal Energy Program
- ☐ Government earmarks
- ☐ Other (please list) ____
- ☐ Don't know

Did your community apply for the Renewable Energy Grant Fund this year? ☐ Yes ☐ No

If not, please explain why:

____

____

II. Community Experience with Wind Energy Development

Please describe how the following statements represent the electric utility perspective on wind power development. Please base your response on your knowledge of the electric utility's position/understanding of wind power. These questions are designed to better understand the barriers to wind development in your community. Please check just ONE box.

State government involvement

a. What level of political and financial support does the electric utility feel the state offers for rural wind power development?

☐ Strong ☐ Somewhat strong ☐ Weak ☐ Very weak ☐ Not sure

b. What level of technical support (i.e. grant writing, planning) has the electric utility received for rural wind development from the Alaska Energy Authority?
☐ Strong ☐ Somewhat strong ☐ Weak ☐ Very weak ☐ Not sure

Coordination among local organizations
a. What level of coordination is there between local organizations (i.e. utility, city, Tribe) when considering and planning for wind power development?
☐ High ☐ Medium ☐ Low ☐ Not sure

Economics
a. How financially feasible would it be to develop wind power in your community without state subsidies and grants?
☐ Very feasible ☐ Feasible ☐ Somewhat Feasible ☐ Not feasible ☐ Not sure

b. How financial feasible would it be for your community or utility to pay off loans in order to develop wind power?
☐ Very feasible ☐ Feasible ☐ Somewhat feasible ☐ Not feasible ☐ Not sure

Local capacity
a. How qualified are employees at your electric utility to operate and maintain wind turbines?
☐ Very qualified ☐ Qualified ☐ Somewhat qualified ☐ Not qualified ☐ Not sure

b. Is there sufficient staff to develop a project?
☐ Yes ☐ No ☐ Not sure

c. How easy is it to understand funding and project applications that are not written in your Native language?
☐ Very easy ☐ Easy ☐ Somewhat difficult ☐ Difficult ☐ Not sure

d. How qualified are local staff to work on wind power planning and applying for grants?
☐ Very qualified ☐ Qualified ☐ Somewhat qualified ☐ Not qualified ☐Not sure

e. How significant is the role of local leadership (i.e. someone who strongly supports the project) for wind power development in your community?
☐ Very significant ☐ Significant ☐ Somewhat ☐ Not significant ☐ Not sure

f. How committed is your community's current leadership to develop wind power?
☐ Very committed ☐ Committed ☐ Somewhat committed ☐ Not committed ☐ Not sure

Confidence in technology
a. How confident is the electric utility in the reliability of wind turbines as a power source?

☐ Very confident ☐ Confident ☐ Somewhat confident ☐ Not confident ☐ Not sure

Power Cost Equalization

a. How concerned is the electric utility that your Power Cost Equalization subsidy will be affected if wind power is developed?

☐ Very concerned ☐ Concerned ☐ Somewhat concerned ☐ Not concerned ☐ Not sure

Local acceptance and support

a. To what extent are local people concerned about the visibility and noise of wind turbines?

☐ Very concerned ☐ Concerned ☐ Somewhat concerned ☐ Not concerned ☐ Not sure

b. How strong is the support within your community for developing wind power?

☐ Very strong ☐ Strong ☐ Somewhat strong ☐ Not strong ☐ Not sure

c. How important is it to protect cultural sites when considering where to develop wind power?

☐ Very important ☐ Important ☐ Somewhat important ☐ Not important ☐ Not sure

Environmental/biological issues

a. How important is it to protect birds if wind turbines are installed?

☐ Very important ☐ Important ☐ Somewhat important ☐ Not important ☐ Not sure

Complex Logistics

a. Would heavy equipment be available if your community decided to install and operate a wind farm?

☐ Definitely ☐ Possible ☐ Not Likely ☐ No ☐ Not sure

d. If your community has selected a wind farm location, how close is it to existing electric lines and infrastructure?

☐ Within 1 mile ☐ 2-3 miles ☐ 4-5 miles ☐ Greater than 5 miles ☐ Not sure

Failure of past projects

a. Have past failures of rural wind projects affected the electric utility's perception of wind power's reliability?

☐ Definitely ☐ Somewhat ☐ Not at all ☐ Not sure

Land ownership and use issues

a. Do local entities (i.e. utility, Tribal government, city government, etc) have conflicting opinions regarding ownership and operation of a wind farm?

☐ Definitely ☐ Some conflicts ☐ No conflicts ☐Not sure

b. Are there conflicts over the specific parcel of land to use to develop a wind farm?

☐ Definitely ☐ Some conflicts ☐ No conflicts ☐ Not sure

III. Ranking Barriers to Wind Development in Your Community

As a representative of the electric utility, please rank what the electric utility considers to be the barriers to developing wind energy in your community. 1= most important barrier, 10=least important barrier, please rank each barrier from 1 to 10.

Barrier	Rank barriers (1= most important, 10 = least important)	Comments
Government Involvement (e.g. financial and technical support)		
Local politics/coordination among local organizations		
Economics /Capital costs		
Local acceptance & land issues (e.g. land ownership, land use, community support)		
Confidence in technology		
Power Cost Equalization		
Local capacity (e.g. leadership, expertise)		
Biological issues (e.g. birds, noise, soil quality)		
Complex logistics (e.g. access to equipment)		
Fear due to failure of past projects		
Others:		

What would be most helpful to your community when planning for wind development? Please check all that apply.

- ☐ More information on wind energy and funding opportunities
- ☐ Help with funding application
- ☐ Help with community planning
- ☐ Regionally coordinated efforts
- ☐ Developing an operators training facility

Please describe what additional types of resources would be most helpful to help your community develop a wind power project?

Please describe your overall experience with wind energy development. Please write in the space below.

If you have questions please contact me at 907-750-1365 or fsjem@uaf.edu. Thank you so much for your participation!

Jill Maynard