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The Future of Wind Energy for Basin Electric

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THE FUTURE OF WIND ENERGY FOR BASIN ELECTRIC

by

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TABLE OF CONTENTS

LIST OF FIGURES

Wind power could be considered one of the oldest forms of energy harnessed by man. The earliest known use of wind power was the sailboat, used as early as 5,000 B.C. Sailing technology eventually led to the development of sail-type windmills for use in food production and pumping water. (Dodge, 2002) Larger windmills, the precursor to what we now refer to as the wind turbine, began making their appearance in Denmark in the late 19th century. Several factors contributed to the growth of wind farms beyond the small turbine size used in domestic and agricultural applications; possibly the most evident were the oil embargo of the early 1970s and the energy crisis in California in the 1990s. (Dodge, 2002)

Interest in wind energy has corresponded directly with the price of fossil fuels. When the price of oil goes up, worldwide interest in wind energy also increases. Following the increased interest in wind energy was the need to quantify wind resources with advanced mapping and assessment technologies. ("History of Wind", 2005) The identification of viable and accessible wind resources provides critical information when deciding where to site a potential wind farm. North Dakota, according to the National Renewable Energy Laboratory, has been designated as #1 among all contiguous states for potential wind energy/electricity production. ("North Dakota", 2000) A 1991 study conducted by the Pacific Northwest Laboratory determined that North Dakota has the potential to produce 1.2 billion kilowatt-hours of wind-generated electricity annually—an amount that could supply 36% of the 1990 U.S. electricity consumption. (Elliott, Wendell, & Gower, 1991) However, the this seemingly simple location solution is complicated when one considers whether there is sufficient transmission capacity to export the wind energy to those population centers that need the electricity.

Wind-based electricity generating capacity has increased markedly in the United

States since 1970, although it remains a small faction of total electric capacity." ("Wind", 2004, para. 1) Since 2002, Basin Electric has been involved with wind energy and they have determined that wind energy has a place in their energy resource mix, now and in the future.

Buy or Build

Basin Electric Power Cooperative (Basin Electric) is a consumer-owned, regional cooperative headquartered in Bismarck, North Dakota. Basin Electric operates electricity-generating plants for 120 member systems in nine states, serving more than 1.8 million people. Basin Electric also has subsidiaries that provide Internet service and produce natural gas, chemicals, fertilizers, and lime. Basin Electric currently has 135 megawatts (MW) of generating capacity powered by wind; however, to meet growing energy demands of its members and contractual obligations, Basin Electric proposes to either build a 50 MW wind farm in North Dakota comprised of approximately 34 wind turbines or enter into a purchased power agreement for the 50 MW of power. This paper will address the decision-making process undertaken by Basin Electric.

One of Basin Electric's first steps is to assess the economic viability of a wind farm project. This could involve at least three key components; the first of which is to identify one or more buyers of the wind farm's output over the next 10 to 30 years of its operational lifetime. Without committed purchasers of the energy output, any further discussion of the economic viability of a wind farm project is moot.

If purchasers could be identified, the next step is to gather wind speed data at potential sites to ensure minimum criteria for a wind farm (wind resource data currently published by the U.S Department of Energy is sufficient to predict wind turbine performance.) The third step in the assessment is to determine the distance to the nearest transmission grid connection point and assess the cost of connecting to the grid. The shorter the length of the transmission line Basin Electric has to build, the lower the total cost of the wind farm project. Securing access to either public or private land is another important consideration. Compensation for land use for any wind energy development is part of the project cost. Basin Electric also needs to ensure there are adequate roads to the site (or consider the cost of building them) to allow for the delivery of the towers, turbines, and rotor blades.

The difficult decision whether to buy power from a developer or build a wind farm project may depend primarily on which option provides the least-cost delivered power. Benefits of buying renewable energy generation include the possibility of acquiring low cost power via purchase power agreements; indirect benefits from tax credits and accelerated depreciation as the owner/developer may pass on a share of these credits; and avoiding the need to devote staff resources to the construction and operation of the renewable energy generation. There is the additional benefit of reduced project risks, as the purchaser has no responsibility for project development or generation assets.

Risk

The decision to buy or build a wind farm obviously involves a certain amount of risk. The risks must be weighed against the benefits and the cooperative's willingness and ability to bear these risks. For example, buying wind generation from a developer may cost the cooperative more per kilowatt-hour than building its own wind farm, but it is less risky because the developer assumes the technical and wind resource risks. Some of the potential risks of buying power are identified below.

Buying power encounters project risk when there is a risk that the wind farm will not be available on schedule, will be over budget, or will not meet performance and reliability expectations. A cooperative without the expertise in the development of renewable energy projects would result in greater exposure to this risk.

Equipment failure is one facet of the technical risk of buying power that may result in increased power costs. An energy purchaser could avoid this risk by entering into a fixed price contract.

The delivery risk of buying power may result from more expensive "firm power" contracts reduce the risk of power shortages due to the intermittency of wind resources. An energy purchaser may opt for an "as available" (contingent) power contract as long as the purchaser has access to its own alternative cost-efficient power reserves.

Buying power also has a financial risk. A developer is financially responsible for a failed project; however, the energy purchaser would have to then seek out replacement energy generation.

On the other hand, the benefits of building and owning renewable energy generation include a greater level of control over the project and the generation assets that may allow the developer to minimize certain types of risks.

The developer may reduce the project risk of building and owning a wind farm because the developer maintains control over the construction and operation of the project and is able to control the timing of equipment maintenance and upgrades.

The price risk of building and owning a wind farm is managed when the developer maintains better control over the project's costs, the life of the equipment, and other current cost factors that impact present and future facility costs.

A developer may minimize the technical risk of building and owning a wind farm as experience gained from previous wind farm projects allows the developer to better forecast costs and select proven, high quality materials.

Additional developer benefits of building and owning involve using construction and management expertise to efficiently construct, operate and maintain the facilities it owns. A developer may also benefit from low cost power generated and sold from its own facilities. And, if the developer has used quality materials and construction practices, facility costs may be very low once the plant debt has been retired.

The build or buy decision is, at best, an exceedingly complex one. Each choice has its own set of issues that must be addressed from social, environmental, financial, and regulatory perspectives. The risk and reward aspects of the decision are not as clear-cut as one might expect since both decisions are based on a resource that is variable and certainly not very predictable.

The most likely scenario is that purchasing wind power is slightly less expensive than building and owning generation facilities. However, since the price margins are very small, changing even a few of the assumptions may produce the opposite results.

Commercial Scale Development

There are certain steps that must be taken when considering whether to build and own a wind farm. The decision, at a minimum, involves:

1. Understanding the proposed site's wind resource. The proposed site must have a minimum annual average wind speed of approximately 11–13 mph, or a wind class of 4, to even be considered a viable site. Figure 1 reflects the annual average wind resource for the United States and North Dakota is primarily a Class 4 (Good) and Class 5 (Excellent) wind resource. Figure 2 shows the wind resource map of North Dakota and the areas of good to excellent wind speeds along with the existing transmission lines. The Missouri Escarpment, running diagonally across the state southwest of Minot, reflects an estimated Class 5 wind resource, which is considered excellent. ("Wind

Resource", 2004) The proposed site at Benedict, ND is located on the Missouri Escarpment.

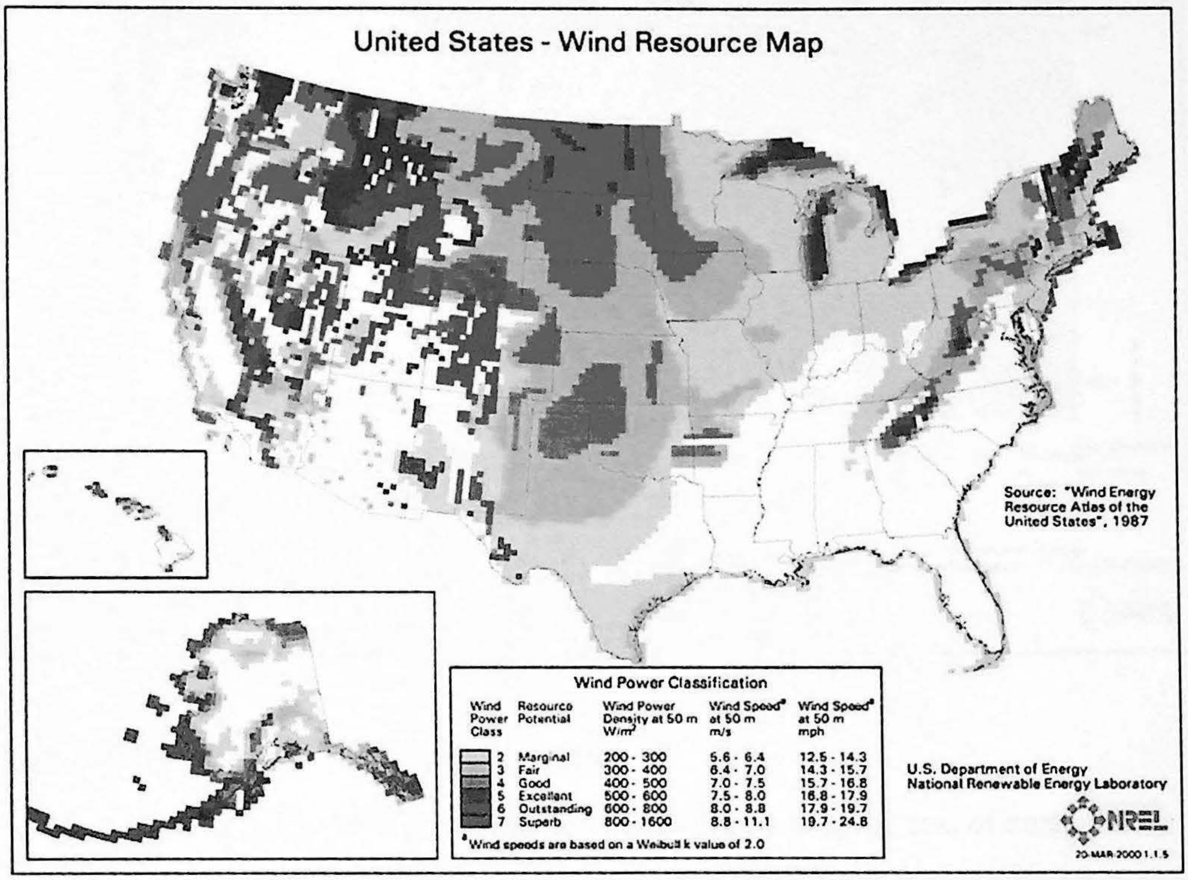


Figure 1: Wind Resource Map of the U.S.

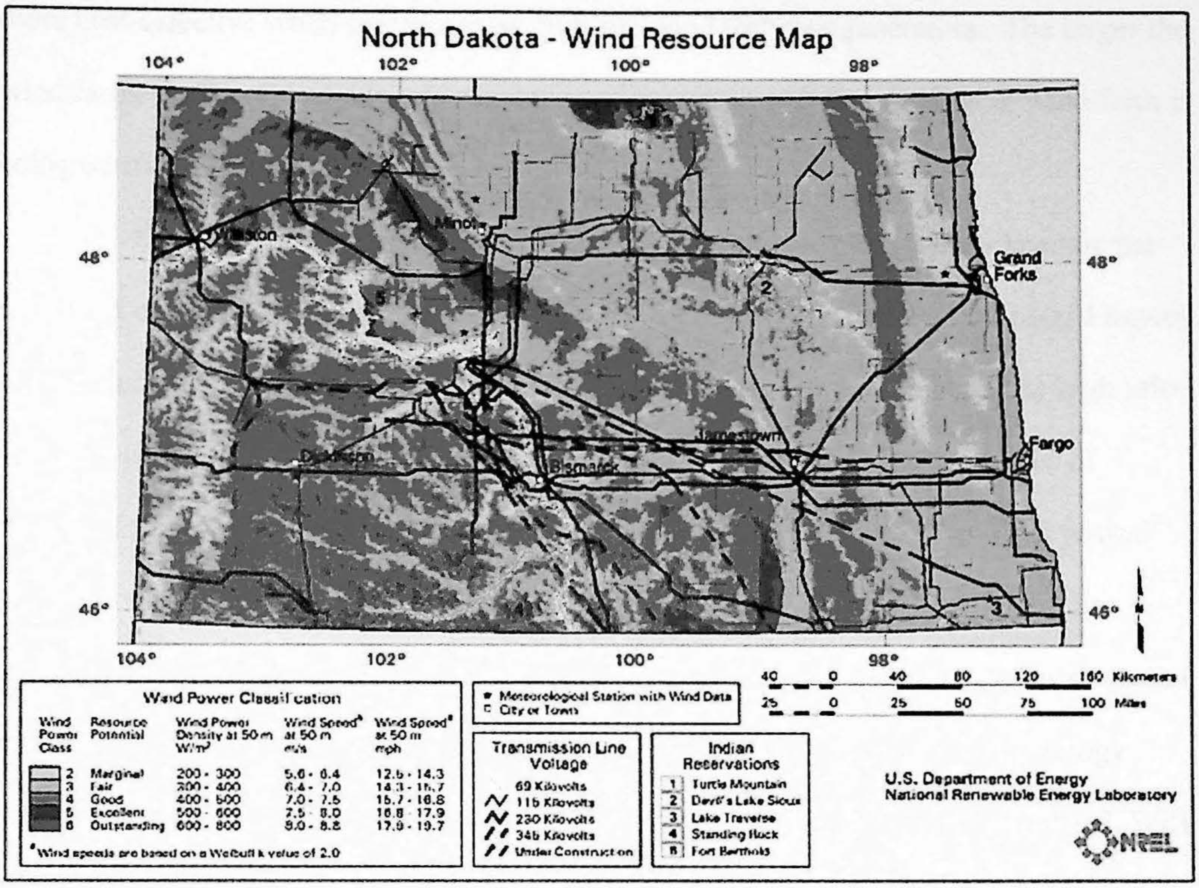


Figure 2: North Dakota Wind Resource Map

2. Proximity to existing transmission lines. Minimizing the cost of transmission infrastructure is critical in keeping costs down when building a wind farm. When possible, access and availability to existing transmission lines is a primary consideration in site selection. It should also be noted that not only is proximity important but also vital that there be no transmission constraints on the grid.

3. Acquire access to facility site and roads leading to the facility. Landowners will expect to be compensated for any wind farm development on their land. Lease agreements, maintenance equipment, and the development of roads for heavy industrial equipment will need to be discussed with all parties involved.

4. Take advantage of economies of scale. Development costs of wind farms are

more cost-effective when spread across multiple wind turbines/generators. The larger the wind farm, the more cost-advantageous the entire project will be. A 50 MW wind farm is being considered for this project.

5. Secure commitments for the wind farm output. Wind energy has become the most cost competitive renewable energy option on the market. Finding committed buyers of the wind energy ensures the continued financial viability of the project. The high price volatility of natural gas has caused somewhat of a shift towards cheaper sources of energy. Environmental requirements are also increasing the demand for "green power" (also known as environmentally friendly) and shifting energy buyers to wind energy.

6. Address siting and project feasibility issues. There are numerous questions that must be answered relating to the feasibility of a proposed facility site. Is the geology suitable for development? Will the wind turbines affect wildlife or local air traffic? Will noise or aesthetics be an issue with the local community? All of these potential issues must be addressed before proceeding with construction.

7. Understand wind farm economics. The choice of the turbine rotors' length, the size of the turbine generators, and the height of the towers are all factors in the facility's productivity and electricity cost. Understanding and taking advantage of local, state, and federal incentives could reduce the overall cost of the project and make it a more favorable investment.

8. Navigate the zoning and permitting process. Both social and environmental factors can make the task of siting the facility a virtual nightmare. Consultants and appropriate legal counsel familiar with the local issues may help smooth the permitting process.

9. Investigate wind turbine manufacturers. Some wind turbines are designed to

function more efficiently at lower wind speeds while others are more efficient at higher speeds. Comparing the performance of potential turbine manufacturers' products and talking with existing customers may prove helpful in the decision-making process.

10. Secure qualified technicians to meet O&M needs. Wind turbines are becoming more efficient in their design and performance; however, reliability is obviously a major factor in the wind farm's success. Professionals familiar with the operation and maintenance of specific wind turbines will prove to be invaluable in both the short run and the long run. ("10 Steps in", n.d.)

Cost of Capital

There are three methods commonly used to calculate the cost of a wind energy project; they are installed capital cost, specific capital cost, and total cost of energy.

The first measure, installed capital cost, includes all planning, equipment purchase and delivery, construction, and installation costs for a complete wind system that is ready to generate and deliver electricity. The primary cost component is the capital cost for the wind generator. Costs would also include establishing the electrical power connections from each of the wind turbines to the substation, the cost of the substation itself, and any other supporting infrastructure. The supporting infrastructure may include buildings for operations and maintenance, spare parts inventory, and diagnostic equipment. Costs associated with negotiating land access and transmission access agreements would also be included in the installed capital cost.

The next measure, specific capital cost, combines the installed capital cost with the site's potential annual energy production and calculates the cost of generating one kilowatt-hour per year.

The life-cycle cost of wind energy, the third measure of wind energy cost, incorporates all elements of cost, including the installed capital cost, the cost of capital (calculated to be the installed capital cost over the assumed 20-30 year lifetime of the wind farm), the installation's lifetime operations and maintenance (O&M) costs, and the cost of major turbine overhauls and turbine subsystem replacements.

The O&M costs are incurred over the lifetime of the wind farm and include maintenance and service, insurance, and any applicable taxes. One rule of thumb estimate for annual operating costs is 2% to 3% of the initial system cost; while another estimate is based on the energy production of the system and is equivalent to one to two cents per kilowatt-hour of output. ("Wind Energy", 2006)

"Actual costs will vary depending on the size of the installation, the difficulty of construction, the sophistication of the equipment and supporting infrastructure, and the cost of capital." ("Wind Energy", 1997, para. 10) However, it is generally understood that renewable energy technologies are more capital-intensive than fossil fuel technologies.

Wind Resource

Wind energy assessments identify adequate wind resources. Annual and seasonal wind power measurements or assessments are taken preferably over a time span of at least two years with the sensors at different tower heights and facing multiple directions. The assessments include classifying wind power based on three factors: the abundance and quality of wind data at a particular site, the complexity of the terrain or topography, and the geographical variability of the wind resource. Specifying a wind power class depends on these three factors and defines the degree of certainty or certainty rating of the wind resource. The assignment of a certainty rating requires subjective evaluation of the interaction of the factors involved. The certainty ratings for the wind resource assessment are defined based on certain conditions and are classified as Rating 1 through Rating 4.

Rating 1 is the lowest degree of certainty and is assigned to those areas where no data may exist in the vicinity of the site; the terrain is highly complex; and the wind resource may be subject to a high degree of variability due to various meteorological and topographical indicators around and at the site. Any combination of these conditions may exist in a Rating 1 area.

Rating 2 is considered a low-intermediate degree of certainty and is assigned where either little or no data exist at or near the site and the complexity of the terrain is low; therefore, the wind resource may not differ substantially from nearby sites with data available. Or, there is limited data at or near the site but the terrain is highly complex or the wind resource variability is large.

Rating 3 is considered a high-intermediate degree of certainty and is assigned to an area where either there are limited wind resource data at or near the site, the terrain is not too complex and the small variability of the wind resource suggests little difference from nearby sites with wind resource or, significant wind data exist in moderately complex terrain and/or where the wind resource is moderately variable.

The final rating, Rating 4, is the highest degree of certainty where significant wind resource data exist, the surrounding terrain is not complex and the wind resource variability is low; therefore, certainty of the wind resource can be confidently applied to other sites in the surrounding area. (Voelker, 1979) Figure 1 reflects the certainty rating estimates of wind resources in the contiguous United States. There are definite ratings in the 3 and 4 category in North Dakota which indicates that the wind resource data for North Dakota is reliable. ("Map: Certainty", n.d.)

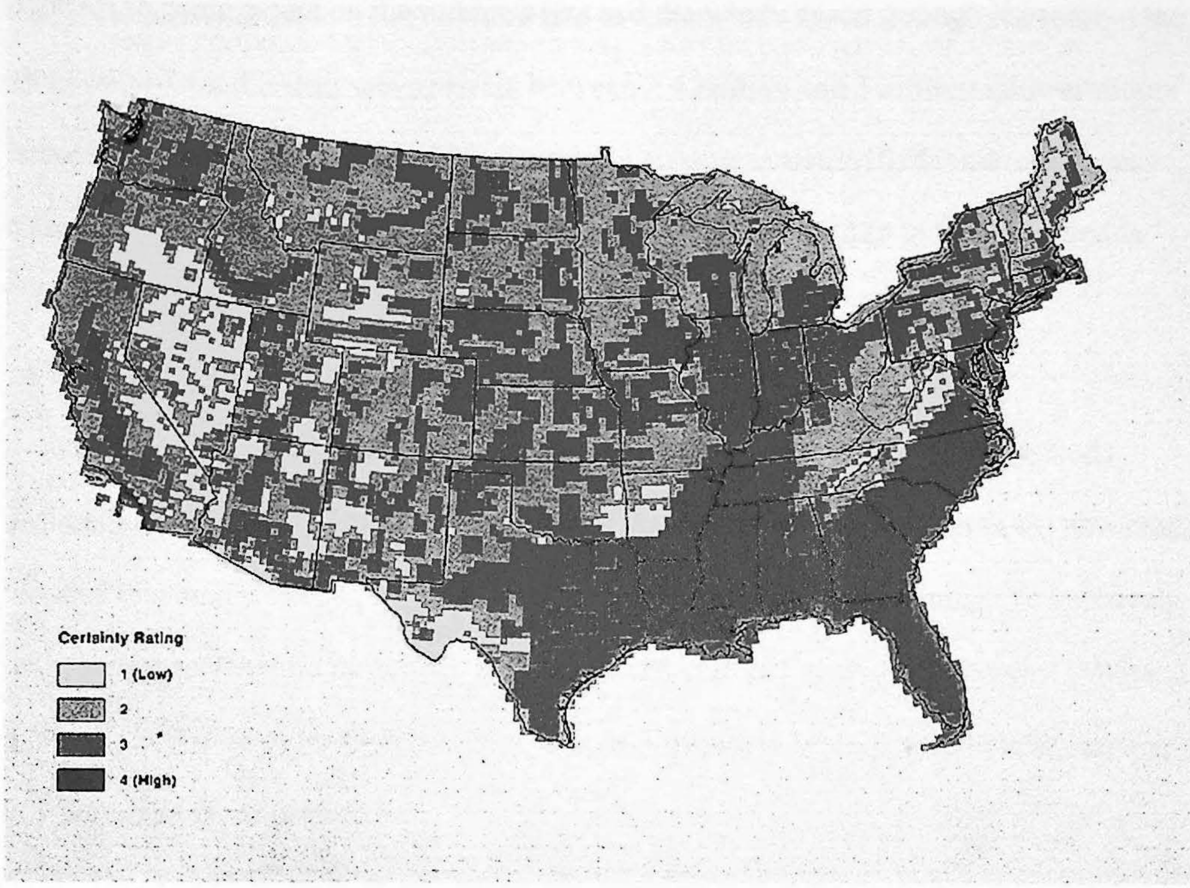


Figure 3: U.S. Wind Resource Certainty Rating Estimates

Sizing a Wind Farm Project

It has been proven that a large wind farm is more economical than a small one, simply based on economies of scale. Assuming identical wind turbine sizes and the same average wind speed and availability, you would potentially realize a 40% decrease in the cost of electricity per kilowatt-hour with a 51-MW wind farm versus a 3-MW wind farm. In essence, your transaction costs and O&M costs are spread over more kilowatt-hours with a larger project and you benefit from the efficiencies of managing a larger wind farm. ("The Economics", 2002)

The electricity generated from this facility will be measured in kilowatts or, more conveniently, in megawatts (MW, 1,000 kilowatts.) The output of the wind turbine depends to some extent on the turbine's size and the wind's speed through the rotor. One megawatt of wind energy can generate between 2.4 million and 3 million kilowatt-hours annually and, since the average U.S. household consumes about 10,000 kilowatt-hours each year, a megawatt of wind generates enough electricity for 225 to 300 households. ("How Many Homes", 2006)

Siting a Wind Farm Project

The criticality of the proper site for a wind farm cannot be overemphasized. Typically, it may take 18 months to two years to complete a 50MW wind farm; however, most of this time is needed for measuring the wind resource and obtaining site approvals and permits as the wind farm itself can actually be built in less than six months. ("What is a Wind", 2006) In order for a potential wind energy site to be considered viable, certain key factors must be present.

1. The site must be an attractive wind resource. Having enough wind is not enough; the wind must also have the right characteristics. Those characteristics include wind data that has been measured at multiple locations and heights for at least one year and preferably two years, wind direction and wind shear data, and terrain roughness assessments to measure turbulence from trees and buildings.

2. Landowner and community support are needed for a successful project. When identifying a prospective wind farm site, identifying landowners and community leaders is very important. Land lease arrangements with the landowner "host" grant the developer access to the property for wind measurements, road construction, installation of electrical lines, and, ultimately, for construction and operation of a wind farm. Communication with the local community helps to build support for and an understanding of the project's environmental, tax, and employment benefits.

3. Permitting requirements are specific to each wind farm project. The permitting process provides an opportunity for the community and the developer to open lines of communication that are invaluable to the success of the project. The particular characteristics, location, and technical details of the wind farm project are discussed in accordance with the permitting process.

4. The wind site must be compatible with the potential site uses. Farmland is ideally suited simply because it is sparsely populated and the added revenue to the landowner is sufficiently compensated for the small amount of land taken out of production by the wind towers/generators. Higher elevation sites such as ridgelines with little public use can also be excellent site choices.

5. A nearby transmission line is critical to keep project costs down. The transmission line must also have the capacity to handle the power output of the wind farm. Power lines and substations can be costly and time consuming to permit and build. A wind site meeting every other criterion may be deemed infeasible due to the cost and/or difficulty of interconnecting to the transmission grid.

6. Adequate road access to the wind farm site is essential for the delivery of materials and maintenance personnel. Roads must be able to accommodate heavy industrial equipment during construction and operations. Obviously, existing roads are ideal; however, if no roads exist, new road construction costs must be carefully considered for their potential negative impacts on the project economics.

7. Aviation hazards must be avoided due to the height of the turbines and the area the wind farm encompasses. Tower heights of new wind turbines reach upwards of 300 feet and require Federal Aviation lighting and notification of construction.

8. A favorable wholesale electricity market is critical. The success of a

commercial scale wind farm ultimately hinges on the commitment of buyers of wind energy. The cost and financial risk associated with the plant's operation are directly influenced by the ability to secure purchase power contracts, rules governing interconnection to the power grid, and the integration, balancing, and scheduling requirements of the grid. ("Siting Considerations", 2005)

Ratings and Factors

Turbines are used in nearly all electrical generating technologies, and wind power is no different. The blades — or rotors — of a wind turbine are similar to airplane blades. Strong, steady winds cause the blades, some as long as 130 feet, to rotate a turbine. The rotating motion of magnets in the turbines causes an electric field that can generate a flow of electrical current. The output of a typical wind turbine depends on the turbine's size (power rating) and the wind resource. The power rating of wind turbines currently being manufactured range in size from 250 watts to 5 megawatts.

Power rating is one thing but capacity factor is the critical productivity measurement of a wind turbine. A turbine's power rating is the amount of power that the turbine would have produced if it operated at maximum output 100% of the time; also known as the nameplate rating. The capacity factor, on the other hand, is the actual amount of power produced over a given time period divided by the nameplate rating. Since the wind doesn't blow steadily at all times, modern utility-scale wind turbines operate only 65% to 90% of the time; therefore, a capacity factor of 25% to 40% is more common.

It is important to note that an economical turbine design is the determining factor when considering reliability and efficiency. A large rotor and small generator may run at full capacity with a 60% - 80% capacity factor but produce only a small amount of electricity. Therefore, a large generator has the potential to provide the most electricity per capital dollar invested with the acceptance that the capacity factor will most likely be lower. ("What is "Capacity", 2006)

Another 'factor' to consider is the wind turbine's availability factor, which is a measure of the reliability of the mechanical aspects of the turbine. The availability factor is a measurement of the time that a plant is in service and ready to generate (not out of service for maintenance or repairs.) Reported as a percentage, the availability factor or availability of modern wind turbines is more than 98% due primarily to decades of constant engineering refinements. ("What is "Availability"", 2006)

Obviously, projecting wind turbine performance and efficiency is dependent on one crucial element: wind speed. As a general rule, an annual average wind speed greater than thirteen miles per hour (equivalent to six meters per second) is required for utility-scale wind farms. A site with an average wind speed of 12 miles per hour theoretically generates approximately 33% more electricity than a site averaging 11 miles per hour because the power available in the wind is proportional to the cube of its speed. This means that doubling the wind speed increases the power available by a factor of eight. An important aspect of wind speed is that what seems like a small difference in wind speed (for example, 11 miles per hour versus 12 miles per hour), can mean a large difference in the available energy and electricity produced which has a direct impact on the cost of the electricity generated. ("Wind Energy", 2002)

Financial Benefits

There are a number of federal tax incentives and financial 'vehicles' that are available to owners of wind farm projects. Important for financing wind projects, the Production Tax Credit (PTC), originally enacted as part of the Energy Policy Act of

1992, currently provides a credit of 1.9-cent per kilowatt-hour (kWh) of electricity produced by the wind farm. This credit is adjusted (increased) each year by the official rate of inflation from the previous year and is available for the first ten years of operation of the equipment. The credit is available to new renewable energy facilities placed into commercial service after enactment of the law, and prior to the latest deadline, December 31, 2007. ("Federal Production", 2006) For the purposes of this study, we assume the wind farm will be in operation in 2007 and will be able to take advantage of the Production Tax Credit.

"An unintended, though key, benefit of the PTC is that it now provides substantial incentive for wind turbine manufacturers to improve the efficiency and reliability of their equipment since the PTC is credited for electric power actually produced and transmitted." (Maloy, 2003, para. 4) If the equipment proves to be unavailable for long periods of time or is plagued with high O&M costs, that turbine and/or manufacturer may be eliminated from wind project plans. Competition between manufacturers has intensified with parts and labor warranties and turbine availability guarantees being packaged with higher quality equipment. (Maloy, 2003)

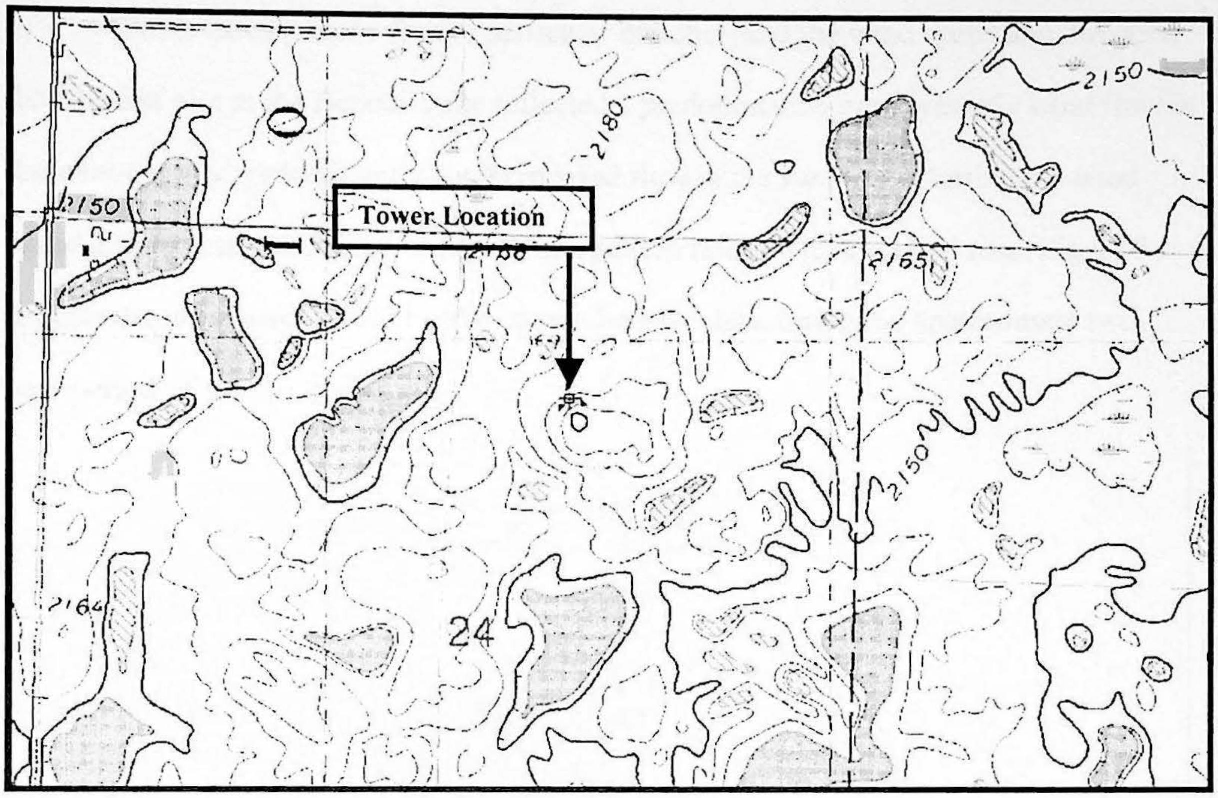
The Renewable Energy Production Incentive (REPI) is another financial incentive made available through the federal government. The REPI provides incentive payments based on the electricity produced and sold by new qualifying renewable energy generation facilities. These qualifying facilities are eligible for payments of 1.5 cents per kilowatt-hour (adjusted for inflation) for the first ten-year period of operation. ("Renewable Energy", 2006) The REPI differs from the PTC in that the REPI is subject to the annual Federal appropriations process; therefore, the REPI payments are hardly guaranteed. A developer may take advantage of either the PTC or the REPI; therefore, for the purposes of this study, we will be using the PTC's financial incentive.

The economic impact is another benefit of wind energy that is measurable by the states, counties, and cities in which (or near where) the wind farm exists. There are direct economic expenditures by the on-site contractors and local manufacturing. Indirect economic impacts are felt in the local banks, local services, and by the spending of people directly and indirectly employed by the project.

A common and basic way of evaluating the economic feasibility of a wind farm investment is by calculating its payback period or break-even point. The payback period is the number of years it takes to recover the wind farm investment's initial cost. The initial cost includes all expenses incurred to evaluate, buy materials, and build a wind farm up to the point of initial power generation.

Proposed Site

Location of the proposed wind farm is located on the Missouri Escarpment (elevation: 2,200 feet) approximately 4.2 miles north-northwest of Benedict, North Dakota (Township: 151 N; Range: 82 W; Section 35). The land around the site is primarily comprised of cultivated fields with several small ponds and lakes in the surrounding area. Wind monitoring data had been collected on this site for a little over three years, from October 1994 through December 1997. Figure 4 reflects the comprehensive wind resource data from this reporting period. ("Map: Wind Resource", n.d.)



Summary Wind Data:	33 ft. AGL[a]	82 ft. AGL	131 ft. AGL
Mean Wind Speed	13.9 mph	16.3 mph	18.3 mph
Maximum, 60-Min. Mean Wind Speed	61.8 mph at 131 ft. AGL – 04/06/97 3:00 a.m.		
Estimated Wind Power Class	Class 5 (508 W/m2 at 131 ft AGL)		
a Above Ground Level			

Figure 4: Benedict ND Wind Monitoring Site (Comprehensive Report)

Turbines operate best in areas where wind speeds are 16 mph to 20 mph at a height of 50 meters (112 feet). The Benedict site data reflect a mean wind speed of 18.3 miles per hour at a tower height of 131 feet above ground level over the three-year period. The wind resource data collected at the Benedict site was collected at three different sensor heights (33 feet, 82 feet, and 131 feet.) The data recovery rates at 33 feet, 82 feet, and 131 feet were 51 percent, 74 percent, and 75 percent, respectively. Based on this data, the estimated wind power class at this site would be at least a Class 5, which is considered Excellent according to the National Renewable Energy Laboratory, U.S. Department of Energy.

Winds usually come from a particular direction and the wind speed and direction distribution plot at the Benedict site reflected a predominantly northwesterly wind flow in the winter and a predominantly southern wind flow in the summer. Plotting the wind speed and direction distribution results in a pattern referred to as a wind rose. Figure 5 reflects the wind rose pattern for the comprehensive data during the approximate two-year period of data gathering.

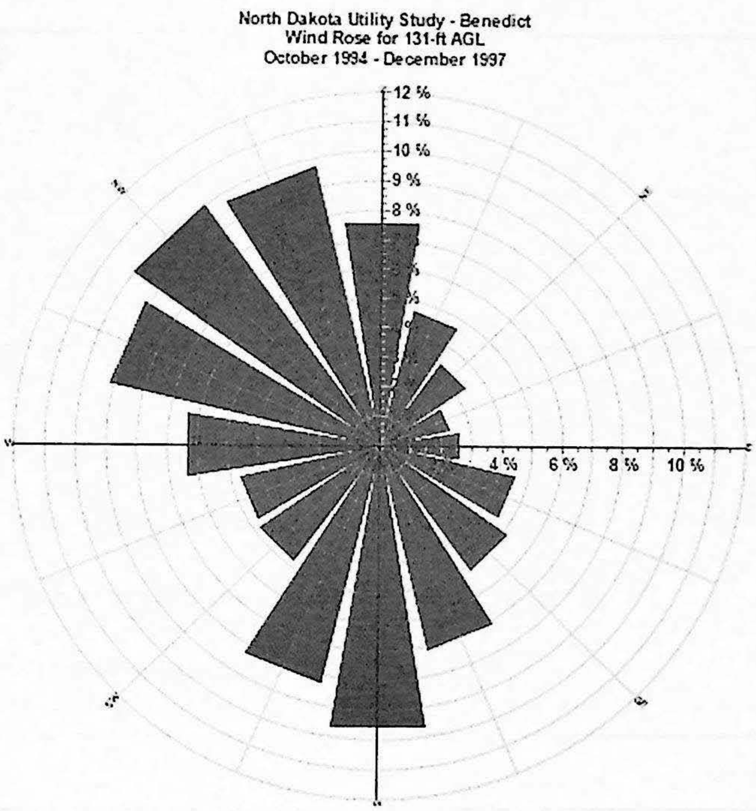


Figure 5: Benedict ND Wind Rose Pattern

Wind turbines are usually mounted on towers from 100 feet to 300 feet tall because wind speed (and wind energy) increases with height. The proposed wind turbines used for this wind farm project are the GE 1.5 MW Series Wind Turbines with recommended tower/hub height of 80 meters (262.5 feet.) Since the wind monitoring data was collected at 131 feet, one can extrapolate the average wind speed at the hub height of 262 feet based on the 1/7 power law. The one-seventh power law states that the speed and power available in wind increases with increasing elevation. Therefore, at the GE Wind Turbine hub height of 262 feet, Figure 6 reflects the calculation whereby the average wind speed increases to 20.21 mph or an increase of approximately 10.4 percent.

Wind Speed at Hub Height of 262 feet (GE 1.5 MW Wind Turbine)
$\frac{V}{V_0} = (\frac{H}{H_0})^{\alpha}$
$V = (\frac{H}{H_0})^{\alpha} V_0$
Where: V_0 is the average wind speed at the original height (18.3 mph) V is the average wind speed at the new height H_0 is the original monitoring height (131 feet) H is the new hub height (262.5 feet)
$V = (262.5 \div 131)^{1/7} \times 18.3$
$V = 1.1044 \times 18.3$
V = 20.2103 mph (estimated average wind speed at new hub height)

Figure 6: Calculation of Wind Speed at GE Turbine Hub Height

Analysis and Conclusion

A spreadsheet was developed to determine the financial impact of building and owning a 50 MW wind farm. In developing this spreadsheet, particular attention was paid to avoid proprietary information while still presenting a representative financial model. Figure 8 reflects the model input data and financial assumptions that were used in the calculation of the project's cash flow.

First, a relatively conservative capacity factor of 38% was used as an average; though, a capacity factor of 40% or greater could be experienced during particularly windy weeks or months. According to S. Stengel of Florida Power & Light, a range of $1.3 million to $1.7 million is a generally accepted capital cost figure per 1-MW turbine. (personal communication, March 15, 2006) We used an average figure of $1.5 million per MW for the capital cost of the turbine. We have also assumed a $1 million cost to connect to the transmission grid; therefore, the total project cost for a 50 MW wind farm is $76 million. It was assumed that 60% of the project would be financed for a loan period of 20 years at a conservative interest rate of 6%. According to S. Cerkoney, it is possible that financing from the Rural Utilities Service (which is part of the US Department of Agriculture and was formerly the Rural Electrification Administration) may be lower than the 6% interest rate used in this model but it may only be a quarter percent lower (personal communication, DATE, 2006).

The assumed total marginal tax rate of 38% is made up of a federal tax rate of 35% and a 3% state tax rate. The Internal Revenue Service allows a renewable energy tax incentive in the form of the Modified Accelerated Cost-Recovery System (MACRS). Under this system, businesses installing eligible renewable energy technologies put into service after 1986 may recover their investments through depreciation deductions over a period of five years. The MACRS depreciation rates for the 5-year recovery period for this project are 20.00%, 32.00%, 19.20%, 11.52%, 11.52%, and 5.76%. ("IRS Publication", n.d.) A salvage value of 5% of the original project cost at the end of the 20-

year loan period was also assumed.

An annual inflation rate of 3.39% was assumed in this model, which corresponds with the average inflation rate in the United States from 1913 through 2005. ("Annual Inflation", n.d.) Annual fixed O&M costs were assumed to be $20,000 per MW and annual variable O&M costs were assumed to be $1.00 per MW-hour for this project. Insurance costs for this project were assumed to be 1% of the cost of the wind farm and lease payments to the landowner were assumed to be $2,500 per MW per year.

Accounting for the local property tax for the wind farm project was more complicated. As each political subdivision in the state has its own mill levy, an average rural mill levy of 325 mills was assumed for local property taxes. According to D. J. Boehm, to calculate a representative local property tax for this model one takes the true and full value of the project multiplied times the assessed value (which is 50%) multiplied times the taxable value (which is 1.5%) multiplied times the mill levy and divide this figure by 1000 (personal communication, DATE , 2006). Therefore, for this model, we assumed a local property tax value of 0.2438% of the total project cost for the 20-year life of for this wind farm.

Purchased power contract pricing information is not widely available. Figure 7 is a chart reflecting the results of a study conducted by Lawrence Berkeley National Laboratory whereby data was compiled reflecting actual contract pricing and that data was plotted against the expected capacity factor of the wind farm project. (Wiser & Bolinger, 2005) Based on this information, we assumed a purchase power contract price of $30 per MW-hour (based on the 38% capacity factor) with an escalation factor of 1.5% for the life of the project.

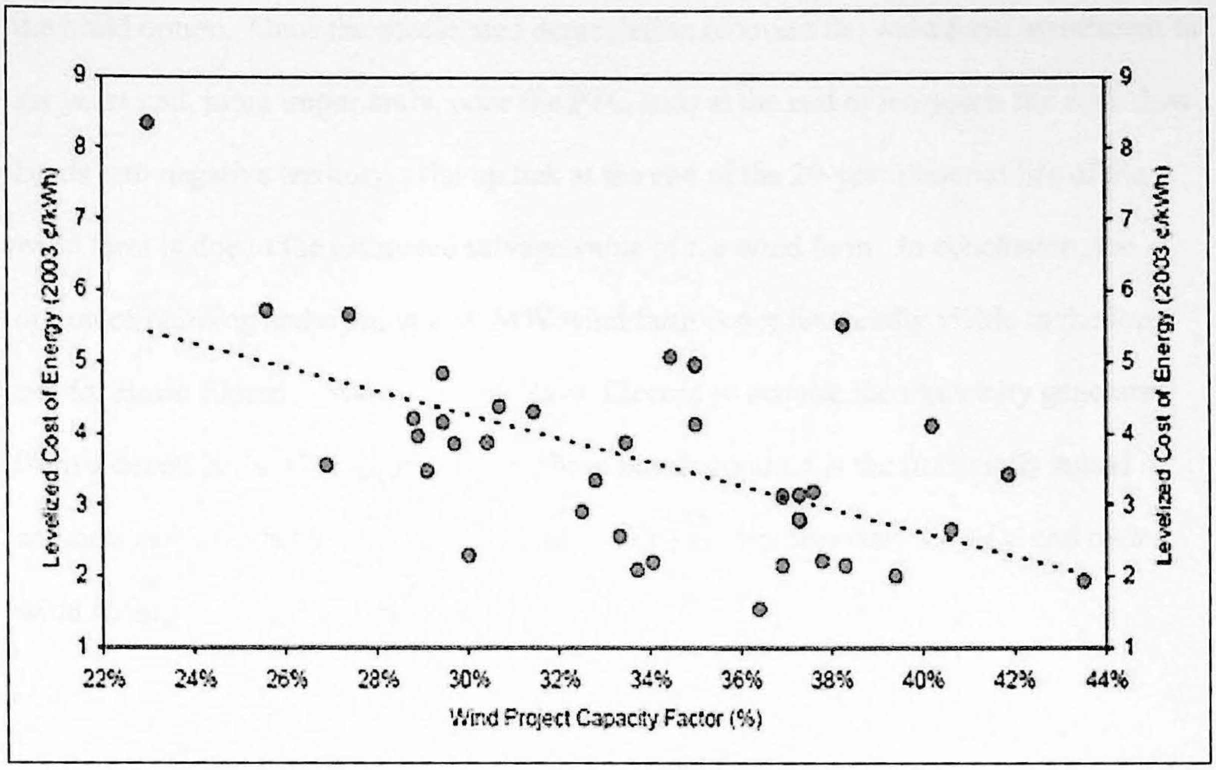


Figure 7: Purchased Power Contract Pricing (¢/kWh) based on Capacity Factor

Figures 9 and 10 reflect the revenues, expenses, cash flows, and internal rates of return for the wind farm build option. The spreadsheet has been split onto two pages for readability purposes, years 2007 through 2016 in Figure 9 and years 2017 through 2026 in Figure 10.

One of the key factors of the build option is the benefit provided by the MACRS accelerated depreciation rates. In essence, the total wind farm investment can be recovered in six years using depreciation charges to offset income tax liabilities. Another key factor of the build option is the Production Tax Credit (PTC), which is reflected as \$0.019 times the net energy (MW per year) delivered. The PTC is adjusted for inflation each year and provides a substantial benefit of almost \$37 million to the cash flow over the ten years it is allowed.

However, looking at the cash flow plotted out in Figure 11 tells the real story of the build option. Once the accelerated depreciation recovers the wind farm investment in six years and, more importantly, once the PTC ends at the end of ten years, the cash flow heads into negative territory. The up tick at the end of the 20-year material life of the wind farm is due to the estimated salvage value of the wind farm. In conclusion, the option of building and owning a 50 MW wind farm is not financially viable in the long run for Basin Electric. A decision by Basin Electric to acquire the electricity generated from a developer's wind farm via a purchase power contract is the financially sound solution as it avoids the huge financial asset commitment necessary to build and own a wind facility.

	B	C	D	E	F	G	H	I
1	**ASSUMPTIONS**							
2	TOTAL NAMEPLATE RATING OF WIND FARM					**50.0**	MW ANNUALLY	
3	CAPACITY FACTOR					**38.0%**	ANNUALLY	
4	TOTAL COST OF WIND FARM			**$1,500,000**	per MW	$75,000,000	PROJECT COST	
5	COST TO CONNECT TO GRID					**$1,000,000**	CONNECT TO GRID	
6			TOTAL COST OF WIND FARM			$76,000,000	TOTAL PROJECT COST	
7	PERCENT OF PROJECT TO BE FINANCED					**60%**	PERCENT FINANCED	
8	DOLLAR AMOUNT OF FINANCED PROJECT					$45,600,000	AMOUNT FINANCED	
9	BALANCE NEEDED UPFRONT AS EQUITY CAPITAL					$30,400,000	EQUITY NEEDED	
10	INTEREST RATE FOR FINANCED AMOUNT					6.0%	ANNUAL INT RATE	
11	DISCOUNT RATE					6.0%	ANNUAL INT RATE	
12	FEDERAL TAX RATE					35.0%		
13	STATE TAX RATE					3.0%		
14	TOTAL MARGINAL TAX RATE					38.0%	TOTAL	
15	FINANCING TERM					20	YEARS	
16	COST OF ANNUAL AMORTIZATION					$3,975,616		
17	DEPRECIATION LIFE ACCORDING TO IRS					MACRS* 5	YEARS	
18	MACRS DEPRECIATION SCHEDULE (20%; 32%; 19.2%; 11.52%; 11.52%; 5.76%)							
19	INFLATION RATE					3.39%	ANNUALLY	
20								
21	ANNUAL OPERATIONS & MAINTENANCE COSTS							
22		FIXED O&M COSTS				$20,000	PER MW	
23		VARIABLE O&M COSTS				$1.00	PER MWh	
24								
25	COST OF INSURANCE FOR WIND FARM					1.00%	ANNUALLY	
26	LEASE PAYMENTS FOR LAND WIND FARM OCCUPIES					$2,500	PER MW	
27	LOCAL PROPERTY TAX					0.2438%	OF TOTAL PROJECT COST	
28	SALVAGE VALUE AT END OF 20 YEARS			5.0%	OF ORIG. COST	$3,800,000		
29								
30	ESCALATION PERCENT OF PURCH. POWER AGREEMENT					1.50%	ANNUALLY	

Figure 8: Benedict ND Wind Farm (Assumptions)

YEAR		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Period		0	1	2	3	4	5	6	7	8	9
MAXIMUM MW CONNECTED TO GRID		50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
NET ENERGY DELIVERED (MW per YEAR)		166,440	166,440	166,440	166,440	166,440	166,440	166,440	166,440	166,440	166,440
CONTRACTED PURCHASE POWER AGREEMENT RATE ($/MWh)		**$30.00**	**$30.45**	**$30.91**	**$31.37**	**$31.84**	**$32.32**	**$32.80**	**$33.30**	**$33.79**	**$34.30**
ANNUAL REVENUE											
REVENUE FROM PURCHASE POWER AGREEMENT ($/YEAR)		$4,993,200	$5,068,098	$5,144,119	$5,221,281	$5,299,600	$5,379,094	$5,459,781	$5,541,678	$5,624,803	$5,709,175
MATERIAL SALVAGE VALUE (END OF MATERIAL LIFE)											
TOTAL REVENUE		**$4,993,200**	**$5,068,098**	**$5,144,119**	**$5,221,281**	**$5,299,600**	**$5,379,094**	**$5,459,781**	**$5,541,678**	**$5,624,803**	**$5,709,175**
OPERATING EXPENSES											
ANNUAL O&M COSTS		$1,166,440	$1,205,982	$1,246,865	$1,289,134	$1,332,835	$1,378,019	$1,424,733	$1,473,032	$1,522,968	$1,574,596
ANNUAL LEASE COSTS FOR LAND		$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000
LOCAL PROPERTY TAX		$185,250	$185,250	$185,250	$185,250	$185,250	$185,250	$185,250	$185,250	$185,250	$185,250
INSURANCE ON WIND FARM		$760,000	$760,000	$760,000	$760,000	$760,000	$760,000	$760,000	$760,000	$760,000	$760,000
OPERATING EXPENSE SUBTOTAL		$2,236,690	$2,276,232	$2,317,115	$2,359,384	$2,403,085	$2,448,269	$2,494,983	$2,543,282	$2,593,218	$2,644,846
FIXED EXPENSES											
INTEREST ON WIND FARM DEBT		$2,736,000	$2,661,623	$2,582,783	$2,499,214	$2,410,629	$2,316,730	$2,217,197	$2,111,692	$1,999,857	$1,881,311
DEPRECIATION (MACRS 5)		$15,200,000	$24,320,000	$14,592,000	$8,755,200	$8,755,200	$4,377,600				
FIXED EXPENSES SUBTOTAL		$17,936,000	$26,981,623	$17,174,783	$11,254,414	$11,165,829	$6,694,330	$2,217,197	$2,111,692	$1,999,857	$1,881,311
MACRS DEPRECIATION SCHEDULE		**20.00%**	**32.00%**	**19.20%**	**11.52%**	**11.52%**	**5.76%**				
TOTAL PRE-TAX EXPENSES		$20,172,690	$29,257,855	$19,491,899	$13,613,797	$13,568,915	$9,142,599	$4,712,181	$4,654,974	$4,593,074	$4,526,157
PRE-TAX NET INCOME (LOSS)		($15,179,490)	($24,189,757)	($14,347,779)	($8,392,516)	($8,269,314)	($3,763,504)	$747,600	$886,704	$1,031,729	$1,183,018
INCOME TAX BENEFIT (EXPENSE)		$5,768,206	$9,192,108	$5,452,156	$3,189,156	$3,142,339	$1,430,132	($284,088)	($336,947)	($392,057)	($449,547)
AFTER TAX NET INCOME (LOSS)		($9,411,284)	($14,997,650)	($8,895,623)	($5,203,360)	($5,126,975)	($2,333,373)	$463,512	$549,756	$639,672	$733,471
CASH FLOW											
AFTER TAX NET INCOME (LOSS)		($9,411,284)	($14,997,650)	($8,895,623)	($5,203,360)	($5,126,975)	($2,333,373)	$463,512	$549,756	$639,672	$733,471
DEPRECIATION		$15,200,000	$24,320,000	$14,592,000	$8,755,200	$8,755,200	$4,377,600	$0	$0	$0	$0
PRODUCTION TAX CREDIT	**$0.019**		$3,162,360	$3,269,564	$3,380,402	$3,494,998	$3,613,478	$3,735,975	$3,862,625	$3,993,568	$4,128,950
INTEREST PAYMENT ON LOAN PRINCIPAL		($1,239,616)	($1,313,993)	($1,392,832)	($1,476,402)	($1,564,986)	($1,658,886)	($1,758,419)	($1,863,924)	($1,975,759)	($2,094,305)
ANNUAL CASH FLOW	**Equity** ($30,400,000)	$4,549,100	$11,170,718	$7,573,109	$5,455,840	$5,558,237	$3,998,820	$2,441,069	$2,548,457	$2,657,480	$2,768,116
INTERNAL RATE OF RETURN OF WIND FARM PROJECT			-31.4%	-11.6%	-2.2%	4.3%	7.7%	9.2%	10.6%	11 7%	12.6%

Figure 9: Benedict ND Wind Farm (Cash Flow 2007-2014)

		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
YEAR		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Period		10	11	12	13	14	15	16	17	18	19
MAXIMUM MW CONNECTED TO GRID		50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
NET ENERGY DELIVERED (MW per YEAR)		166,440	166,440	166,440	166,440	166,440	166,440	166,440	166,440	166,440	166,440
CONTRACTED PURCHASE POWER AGREEMENT RATE ($/MWh)		$34.82	$35.34	$35.87	$36.41	$36.95	$37.51	$38.07	$38.64	$39.22	$39.81
ANNUAL REVENUE											
REVENUE FROM PURCHASE POWER AGREEMENT ($/YEAR)		$5,794,812	$5,881,735	$5,969,961	$6,059,510	$6,150,403	$6,242,659	$6,336,299	$6,431,343	$6,527,813	$6,625,730
MATERIAL SALVAGE VALUE (END OF MATERIAL LIFE)											$3,800,000
TOTAL REVENUE		$5,794,812	$5,881,735	$5,969,961	$6,059,510	$6,150,403	$6,242,659	$6,336,299	$6,431,343	$6,527,813	$10,425,730
OPERATING EXPENSES											
ANNUAL O&M COSTS		$1,627,975	$1,683,163	$1,740,223	$1,799,216	$1,860,210	$1,923,271	$1,988,470	$2,055,879	$2,125,573	$2,197,630
ANNUAL LEASE COSTS FOR LAND		$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000
LOCAL PROPERTY TAX		$185,250	$185,250	$185,250	$185,250	$185,250	$185,250	$185,250	$185,250	$185,250	$185,250
INSURANCE ON WIND FARM		$760,000	$760,000	$760,000	$760,000	$760,000	$760,000	$760,000	$760,000	$760,000	$760,000
OPERATING EXPENSE SUBTOTAL		$2,698,225	$2,753,413	$2,810,473	$2,869,466	$2,930,460	$2,993,521	$3,058,720	$3,126,129	$3,195,823	$3,267,880
FIXED EXPENSES											
INTEREST ON WIND FARM DEBT		$1,755,653	$1,622,455	$1,481,265	$1,331,604	$1,172,964	$1,004,804	$826,556	$637,612	$437,332	$225,035
DEPRECIATION (MACRS 5)											
FIXED EXPENSES SUBTOTAL		$1,755,653	$1,622,455	$1,481,265	$1,331,604	$1,172,964	$1,004,804	$826,556	$637,612	$437,332	$225,035
MACRS DEPRECIATION SCHEDULE											
TOTAL PRE-TAX EXPENSES		$4,453,878	$4,375,868	$4,291,738	$4,201,070	$4,103,423	$3,998,325	$3,885,275	$3,763,741	$3,633,155	$3,492,915
PRE-TAX NET INCOME (LOSS)		$1,340,935	$1,505,866	$1,678,223	$1,858,440	$2,046,980	$2,244,334	$2,451,023	$2,667,602	$2,894,658	$6,932,816
INCOME TAX BENEFIT (EXPENSE)		($509,555)	($572,229)	($637,725)	($706,207)	($777,852)	($852,847)	($931,389)	($1,013,689)	($1,099,970)	($2,634,470)
AFTER TAX NET INCOME (LOSS)		$831,379	$933,637	$1,040,498	$1,152,233	$1,269,127	$1,391,487	$1,519,634	$1,653,913	$1,794,688	$4,298,346
CASH FLOW											
AFTER TAX NET INCOME (LOSS)		$831,379	$933,637	$1,040,498	$1,152,233	$1,269,127	$1,391,487	$1,519,634	$1,653,913	$1,794,688	$4,298,346
DEPRECIATION		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
PRODUCTION TAX CREDIT	$0.019	$4,268,921									
INTEREST PAYMENT ON LOAN PRINCIPAL		($2,219,963)	($2,353,161)	($2,494,351)	($2,644,012)	($2,802,652)	($2,970,811)	($3,149,060)	($3,338,004)	($3,538,284)	($3,750,581)
ANNUAL CASH FLOW	Equity ($30,400,000)	$2,880,337	($1,419,524)	($1,453,852)	($1,491,779)	($1,533,525)	($1,579,325)	($1,629,426)	($1,684,090)	($1,743,596)	$547,765
INTERNAL RATE OF RETURN OF WIND FARM PROJECT		13.3%	13.0%	12.7%	12.4%	12.1%	11.9%	11.6%	11.3%	11.0%	11.1%

Figure 10: Benedict ND Wind Farm (Cash Flow 2015-2026)

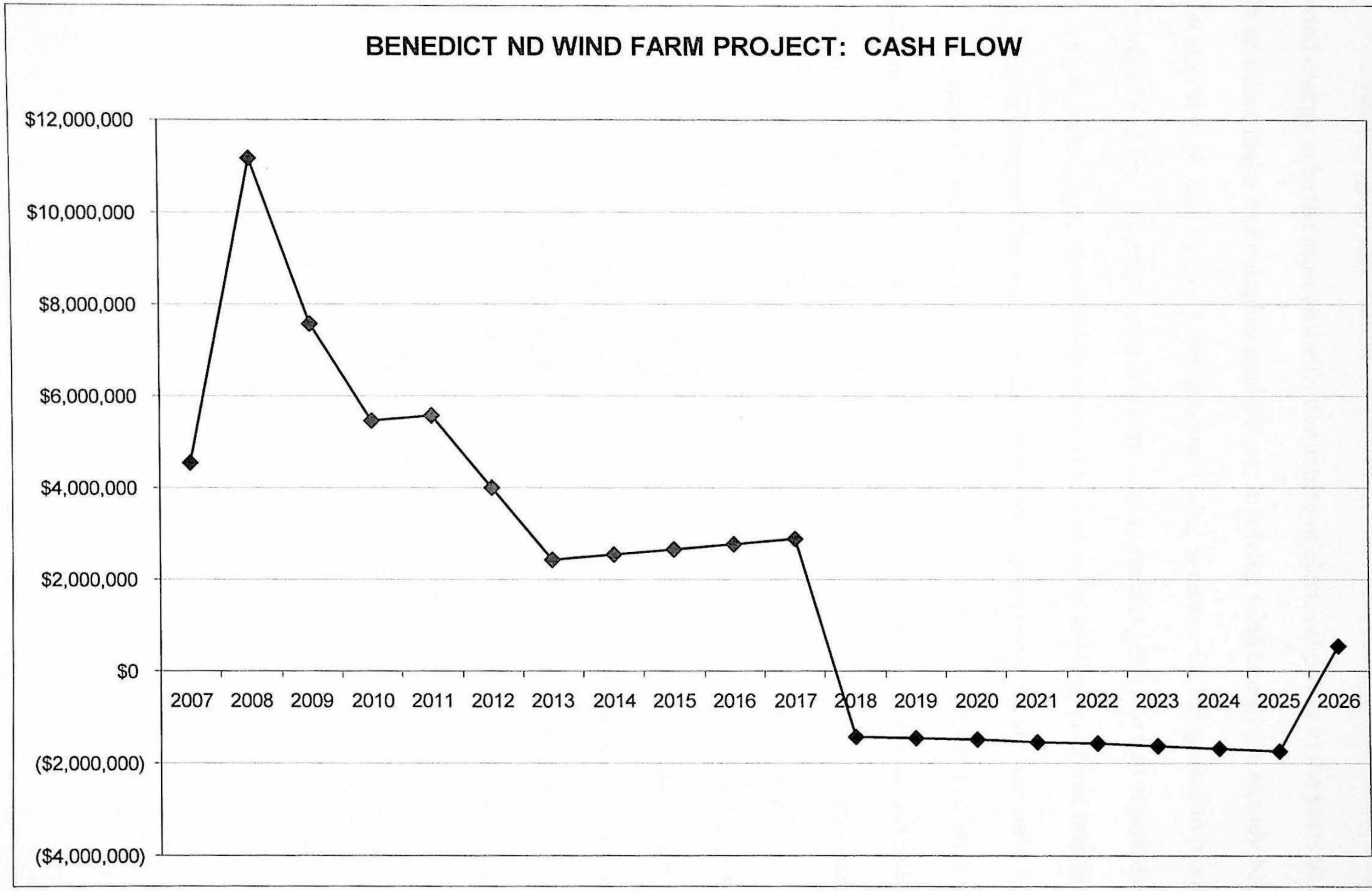


Figure 11: Benedict ND Wind Farm Project (Cash Flow Chart)

The Future of Wind Energy

Technological innovations, refinements, and improvements will continue to push wind energy to be the most cost effective source of electrical power in the years to come. In addition, major technological applications involving wind energy are already being developed in North Dakota. Electricity from wind generators is being used to produce hydrogen fuel by powering an electrolyzer—a commercial generator that separates the hydrogen and oxygen contained in water. The hydrogen will then be stored and used either as a transportation fuel or as firm (non-intermittent) power from fuel cells.

Benefits are numerous: revitalization of rural economies, creation of jobs, promotion of cost-effective energy production, improvement of energy sustainability, reduction of air pollution, no waste storage requirements, and support of agriculture.

"Wind is popular because it is a domestic source of abundant, cheap, inexhaustible, widely distributed, climate-benign, and clean energy—attributes not matched by any other energy source." (Brown, 2003, para. 5) It is anticipated that wind energy will always be a part of Basin Electric's resource mix as it provides a hedge against the volatility of natural gas prices; however, it is financially more effective today for Basin Electric to purchase the power from wind energy than to build and own its own wind farm facilities.

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