Siting and Project Development Report

2021 Collegiate Wind Competition

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Executive Summary

California Polytechnic State University's Wind Power Club has prepared the following report for the Project Development Contest of the 2021 U.S. Department of Energy Collegiate Wind Competition. This report details a site design and plan to develop and eventually decommission a 100-MW wind farm in Butte County, which is situated in the western half of South Dakota. Furthermore, the team has performed a financial analysis over the 20-year life expectancy of the project. In total, this project is projected to cost around $231,804,050 and will result in a total revenue of $557,000,000. Lastly, the team predicts the project to have produced 5,120 GWh of electricity over that same lifetime.

Table of Contents

1. Site Description

The chosen site for the 100-MW wind farm is in the northeastern portion of Butte County in Western South Dakota (Figure 1) and will span across 6 square miles of space. The location is centered around the latitude-longitude coordinates of 44.8553, -103.1282. This site was selected over others due to its good wind resource potential, optimal soil quality for large structures, nearby access to grid infrastructure such as high-voltage transmission lines, high impact on local socioeconomics, and high average wind speeds. Close proximity to a larger population within the city of Belle Fourche (pop. 5,702) provides a place to find people interested in learning to be technicians and employees (United States Census Bureau, 2021).

Figure 1. State context view of final site location (red pushpin) within Butte County, South Dakota.

1.1. Brief Site Description

To choose the ideal project site as shown in *Figure 2*, the team started by compiling data on the following categories: wind speed/ class, topography, transmission lines, existing roads, land uses, sensitive habitats, and endangered/ threatened species. After initial research, multiple areas of interest within three counties

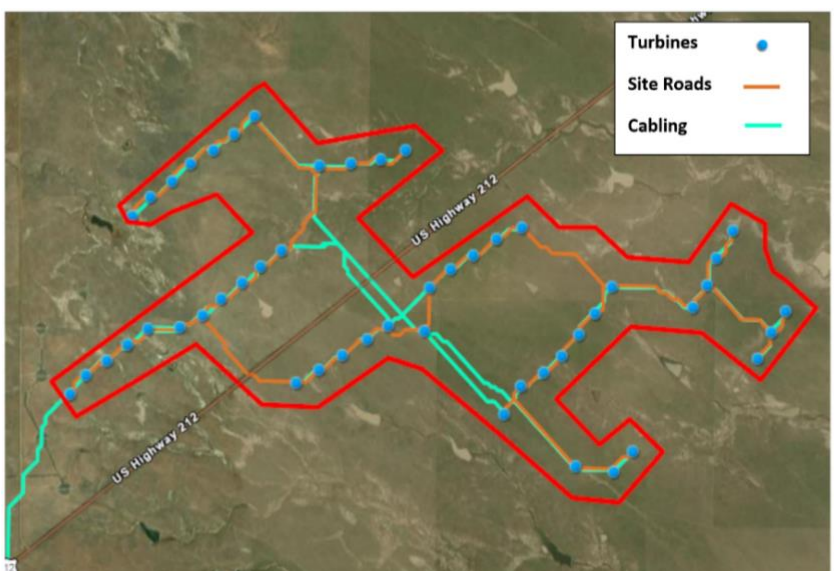

Figure 2. This map shows the delineation of the projected site boundary, turbine placement, site roads, and cabling lines for the project located in the northeast portion of Butte County, SD.

in western South Dakota were selected for further research through GIS analysis. GIS software was used to develop a map of South Dakota that showed the best counties for wind farm development based on the initial research with a focus on the topographical data, developed and protected land and a rough wind class. Using GIS, the most viable counties for wind farm development were narrowed down to Butte County, Harding County and Fall River County.

With the potential options narrowed down, more extensive and specific research was done on each individual site. Factors taken into consideration included existing infrastructure, soil stability, and socioeconomic considerations. Harding County was rejected due to its complete lack of usable electrical infrastructure, as the substations were too far from the high wind areas. Fall River County was rejected due to poor soil quality (USDA, 2021), and development there would incur prohibitively high costs in the creation of support roads capable of dealing with the loads associated with turbine construction. Butte County was picked as the final site due to adequate soil conditions and existing electrical infrastructure, average wind speeds around 8m/s, as reflected in *Figure 3*, and proximity to the town of Belle Fourche which provides potential a workforce.

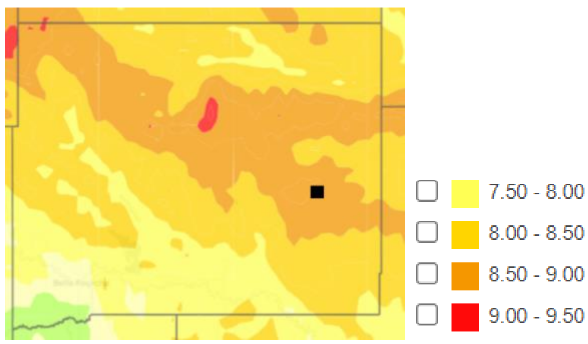

Figure 3. Map of wind speed data at 100m height in Butte Cunty, SD.

Willow Creek wind farm, a recently constructed wind farm in Butte County, was used as a guide for many of the decisions that were made for the proposed wind farm in Butte County. Perhaps most importantly, the Willow Creek wind farm had already constructed infrastructure as part of their project, including (as noted above) a new collector substation and transmission lines (DOE, 2016). The proposed project would be able to utilize these resources as well, lowering development costs for new infrastructure. The Willow Creek project is about 10 miles from the proposed site. In addition to tangible benefits, the project development reports made by the Willow Creek wind farm team were useful in the research and planning of the wind farm proposed in this report.

1.2. Turbine Selection

The turbine selection process consisted of researching a variety of different models, narrowing down the selection based on necessary characteristics, and preforming model-specific research. Initial research was performed using an online wind turbine database, where models were examined and selected based on certain factors—power curve, output, and rotor speed and diameter. After this initial research, the team decided to pursue an approach consisting of numerous smaller turbines in contrast to fewer, yet more powerful turbines. Specifically, the turbines used would be rated in the 1.5-2MW range and with a 100m hub height. This choice was made because after running the site and different turbine models through the System Advisor Model (SAM), it was discovered that the use of multiple 1.5MW turbines resulted in the highest capacity factor, maximizing energy output compared to other possibilities, such as a handful of larger nameplate turbines generating the same amount of power. After comparing several different smaller turbines, the Vestas V90-2.0MW model was the best model in terms of power output, size, and cost. The V90-2.0MW has a rotor diameter of 90m rotor diameter, a hub height of 100m, and a rated power of 2MW.

1.3. Permitting

The team believes that an ideal location has been found for a 100-MW wind farm, given the regional restrictions from the Collegiate Wind Competition. However, even after taking environmental considerations into account, additional permits may be required for the realization of the project. After carefully reviewing the potential impacts the project may have and reviewing permits that were acquired by the Willow Creek Windfarm, the following permits were deemed necessary for the construction of the proposed project. The necessary permits and legislation to keep in mind are as listed below:

- A construction permit granted by the South Dakota Public Utilities Commission is necessary for the installation of the farm.
- The construction of this project requires the acquirement of the General Permit for Storm Water Discharges Associated with Construction Activities issued by the SDDENR. For acquisition, the permit requires for the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP), which would incorporate best management practices to control erosion and sedimentation that may result from this project.
- A Conditional Use Permit would be required to assure that the project is compatible with adjacent land uses.
- A Section 404 permit and consultation with the US Army Corps of Engineers is necessary for development to occur around wetlands.
- The project developer needs to be wary of the Migratory Bird Treaty Act (MBTA) and take measures to avoid and minimize impact on avian species listed under the MBTA. The MBTA does not provide permits for the incidental take of its protected species.
- The Bald and Golden Eagle Protection Act specifically protects against the taking of any Bald or Golden Eagles. There is a Guidance that the US FWS released in 2013 that interprets and clarifies permit requirements in the regulations and provides recommendations to avoid and reduce impacts on these bird species whilst constructing and operating land-based wind energy.
- The federal Endangered Species Act and the South Dakota Endangered Species Act both work to protect against taking or harming of any federally or state listed species. However, if listed species are identified to occur within the boundaries of the project, the developer may need to file for a Safe Harbors Agreement that would protect the project from the incidental taking of species during the construction portion of the project. This may require coordination and consultation with the US FWS and state wildlife agencies.
- Oversize/ Overweight Load Permits (9 total) may need to be acquired for the transportation of construction materials and turbine parts to the project site.
- A National Pollutant Discharge Elimination Systems (NPDES) permit may be needed if a waste management plan shall address solid and liquid waste generated at the site is in compliance with SWAA requirements.

2. **Financial Analysis**

2.1. Net Annual Energy Production

The team drew the anticipated net annual energy production from the software OpenWind software and found the estimated production to be 353.78GWh. After inputting necessary parameters into the SAM modeling software, the team found the proposed wind farm to be capable of generating a gross annual energy of 297,000,000 kWh.

2.2. Land Leases

Generally, the cost of renting the land is calculated by taking 3-5% of the wind farm's gross earnings with a minimum rent, which can range from $3,000 to $8,000 per turbine, and depends on the productivity of the wind farm as well as the demand for the energy. Some wind farms pay $4,500 to $6,000 per MW and increase each year due to demand. For larger turbines like the one selected, the estimated cost per turbine will be about $6,500 per turbine per year. This number was found by comparing the prices of similar sized farms in the Midwest. This would total to about $325,000 per year.

2.3. Capital Costs

To calculate figures for the wind farm's balance of system, values from the final wind farm layout on OpenWind were then translated to NREL's JEDI Wind Model. The inputs are as listed below, and the results gathered from JEDI are displayed in Table 1. These parameters are: a total construction time of 9 months, 1 access road with a width of 33 feet and a length of 23467 meters for supplying material, an interconnect distance of 38.4 miles, and an interconnect voltage of 115kV.

Although the JEDI Wind Model was able to provide sufficient cost estimates for most of the items listed in *Table 1*, there were several items that were not provided due to the locality of the cost: substations, surveying, construction insurance, title insurance, and lease payments during construction. To account for the missing values, the team did extensive research on past wind farm projects located both nationally and specifically in South Dakota with also discussion of these potential costs with industry professionals. After considering parameters, the team selected conservative estimates based on current industry and national averages.

Table 1. Capital cost breakdown estimates of proposed wind farm.

Item	**Cost ($)**	**$/kW**
Site Preparation*	$18,600,000	186.6
Turbines (includes blades and towers)	$142,000,000	1420.0
Foundations	$9,590,000	95.9
Electrical Hardware	$6,390,000	63.9
Electric Collection System and Transmission Lines	$9,460,000	94.6
Substation	$4,090,000	40.9
Wind Farm Control and Monitoring Equipment	$490,000	4.9
Operation and Maintenance Facilities and Equipment	$436,000	4.4
Shipping	$8,950,000	89.5
Resource Assessment	$1,300,000	13.0
Surveying	$4,240,000	42.4
Legal Counsel	$528,000	5.3
Project Management	$5,340,000	53.4
Permits	$2,050,000	20.5
Construction Insurance	$820,000	8.2
Title Insurance	$50	0.01
Lease Payments During Construction (Assumes 1 year)	$400,000	4.0
Engineering Services	$9,360,000	93.6
Sales and Use Tax	$7,760,000	77.6
TOTAL INITIAL CAPITAL COST	**$231,804,050**	**2318.41**

*Site preparation – exact cost of building the haul roads, based on the LF of haul road

2.4. Operating Expenses

The Cal Poly team has calculated the potential operation expenses for the proposed wind farm through the JEDI and SAM software and has organized the results in *Table 2*. Due to exposure to environmental conditions and to curtailment losses, the productivity and functionality of turbines are expected to decrease over time. As a result, regular maintenance on turbines may be initially required two to three times a year and with the frequency of required maintenance increasing as the turbines age. Due to this projected increase in required maintenance during the wind farms later years, operation expenses are also projected to increase over time.

Calculating a precise cost for operation and maintenance is difficult because each wind farm faces differing construction and environmental stresses. However, it has been made known in a study on aging wind farms that the rate of failure is highest both during the turbines' initial deployment and towards the end of their operating lifetime (>10 years). In total, turbines generally lose an output of about 12% over their 20-year lifetime, a rate of 0.6% per year [Green and Staffell, 2014]. For this project, no degradation rates were set in the SAM software. However, in a more realistic analysis the team could set a degradation percent rate per year which would then affect the annual energy output per year. However, it was best to run the simulation under the most ideal case because the degradation rate was unknown.

Table 2. Operation expenses breakdown of proposed wind farm

Item	Cost ($)	$/kW/yr
Operations and Maintenance Costs (preventative maintenance, corrective maintenance, spare parts)	$4,800,000	0.24
Land Lease Costs	$325,000	0.017
Annual Property Tax	$733,000	0.037
Asset Management	$6,110,000	0.31
Operational Insurance	$122,000	0.006
TOTAL ANNUAL OPERATING EXPENSES	**$12,090,000**	**0.61**

2.5. Market Conditions

The location of the proposed wind farm is within the region that the Southern Power Pool (SPP) operates. SPP is a Regional Transmission Organization (RTOs) running under a regulated retail market. The neighboring Willow Creek wind farm's power is sold to the SPP Market (South Dakota Public Utilities Commission). This project would emulate a tariff with SPP that was used by Willow Creek. The team plans to connect the farm to the same transmission and interconnection facilities. With the electrical infrastructure already set in place, SPP would be able to handle any predicted curtailment or potential congestion.

The proposed farm should be appealing to SPP because it can fill in demand during select parts of the years that electricity will need to replace natural gas. With "more than thirty cities in California have now enacted measures limiting or prohibiting natural gas in new homes" (Davis, 2021), households switching from gas heating to electric heating will continue to become more common. The population of states within the SPP will likely continue to make this switch due to increasing gas prices outlined in *Table 3* and potential state mandates. SPP's current energy production is 22.7% by natural gas (SPP, 2021). The proposed wind farm would provide an alternative clean energy source that can support an accelerated electricity demand.

Table 3. LCOE comparison of various utility-scale generation facilities (IEA).

Source	Gas	Oil	Nuclear	Solar	Wind (onshore)	Proposed Wind Farm
Median LCOE USD / MWh	$71	$88	$69	$56	$50	$50

Figure 4 illustrates the energy consumption of the SPP and how over the years, it has increased during the colder months of October to January. Through the SAM modeling software, *Figure 5* outlines the monthly energy capability of the proposed farm. The farm can support increased energy consumption within the colder months of December and January that the SPP may face. The RTO would spend less with the proposed electricity prices being cheaper than from coal. It is important to note that the levelized costs of energy (LCOE) given in *Table 3* do not include subsidies in the cost, which results in natural gas showing as more expensive than wind.

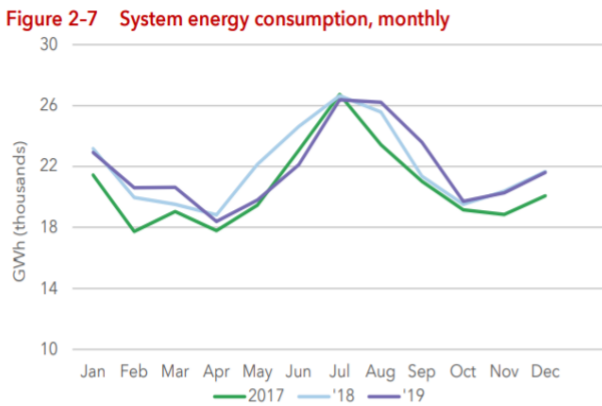

Figure 4. System energy consumption, monthly (Market Monitoring Unit, 2020)

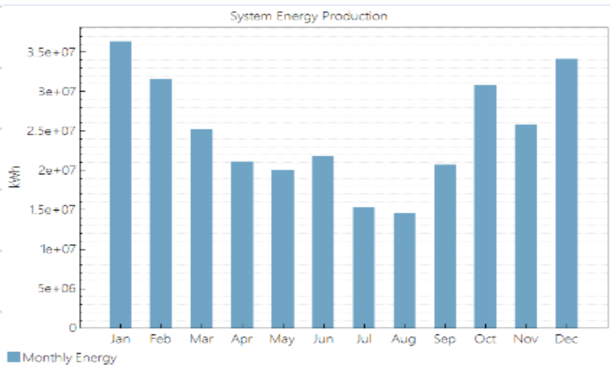

Figure 5. System energy production in kWh, monthly created through SAM.

2.6. Tax Incentives

There are several federal and state incentives that have increased the feasibility and profitability of wind farm projects; perhaps the most significant, the Production Tax Credit (PTC), generates $0.018 per kWh of electricity generated over a 10-year period (US Department of Energy, 2020). This credit can start being earned either in the year of the project construction, or the year in which 5% of the total capital cost for the project has been spent and construction has begun. New to 2021, a $0.013 per kWh increase in the PTC (EIA, 2021) will be appealing to investors.

There are two state tax incentives specific to South Dakota that help spur wind farm construction. The Large Commercial Wind and Solar Alternative Taxes, a property tax incentive for commercial wind farms, was established in 2007 and capitulates that wind farms built after March 31st, 2015, pay an annual tax of $0.00045kWh of the electricity produced (NC Clean Energy Technology Center, 2021). This annual tax occurs in place of other real and personal property taxes levied by the state, counties, municipalities and other groups that could have a stake in wind farm construction. Another state incentive is the Renewable Energy Facility Sales and Use Tax Reimbursement, a sales tax incentive, launched on April 1st, 2013, which provides reinvestment payments to renewable energy projects that cost more than $20,000,000 (NC Clean Energy Technology Center, 2021). The reinvestment payments are up to 100% of the South Dakota sales and utilize taxes paid on project costs.

3. **Finance Plan**

Wind energy projects have increased in scope and scale over the past several years. Investment in wind energy projects now average $13,600,000,000 in the United States alone, and the average cost of a 100MW wind farm is $165,000,000 (Schwabe, Feldman, et al., 2017). It is more imperative than ever for firms to create flexible and strong finance plans that generate profit in a smooth and orderly manner with benefits for both developers and outside investors. The proposed wind farm implements a leveraged partnership flip with debt finance plan.

3.1. Tax and Sponsor Equity

The tax equity plan can be separated into two major timeframes, the pre-flip and the post-flip. Under each phase a third-party tax investor and the developer will share the tax benefits and project cash for the operational wind farm. In the pre-flip phase of the plan, the tax investor receives 98% of the tax benefit and project cash, while the developers receive only 2%. This plan also incorporates the share of equity to be 98% for investors and 2% for developers. Once the wind farm generates enough power (and thus profit) to reach the target internal rate of return (IRR), the project reaches the "flip year." After this flip year, the post-flip phase begins. In the post-flip phase, the benefits switch to the developer, with the tax benefit share for the developer becoming 90% and only 10% for the share for the tax investor. The estimated after-tax cash flows are shown in *Figure 6.*

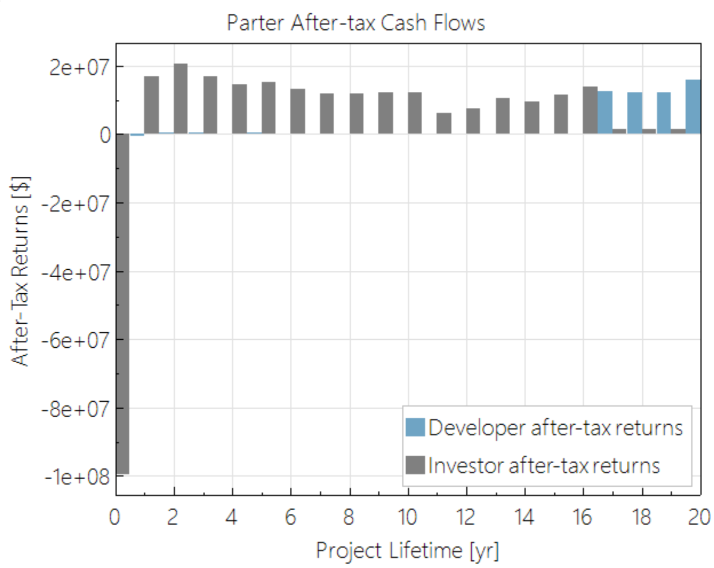

Figure 6. Graph of after-tax cash flows.

The flip year calculated through SAM modeling is at the 16th year of the project operation, as shown in Figure 6. The target IRR for the remainder of the project will be about 12%. These values were simulated through different parametric models in SAM with the aim of determining the greatest net present value (NPV) and the smallest levelized cost of Energy (LCOE). Under this analysis, the NPV for the tax investor over the project life is expected to be $17,029,200, and the NPV for the developer will be $14,289,713.

3.2. Long-term Debt

Long term debt is necessary for project financing and can be financed using a common high cost scenario (Schwabe et al., 2017). This scenario was selected because the target IRR was set at 12%. Following the recommended cost scenario, the debt percentage for this project was set at 35% for a debt period of 15 years, and an annual interest rate of 5%. Placing these values into the financial models, the team calculated a levelized PPA price and cost of energy values, which are listed in *Table 4.*

Table 4. Levelized PPA Price and COE Comparison

Levelized PPA Price (nominal)	7.51 ¢/kWh
Levelized PPA Price (real)	6.15 ¢/kWh
Levelized COE (nominal)	6.48 ¢/kWh
Levelized COE (real)	5.30 ¢/kWh

The more the PPA price exceeds the COE, the larger the revenue surplus is created resulting in increased profit for the project. Both the nominal and real LCOEs are lower than the PPA prices, so the project is expected to make a profit. If the revenue surplus exceeds the tariff rate from SPP, the project should have no problem paying off long-term debt.

3.3. Income Tax

The state of South Dakota has no income tax; however, Federal and sales taxes apply to this project. The Federal income tax is 21%/year, while the sales tax is 4.5% of total direct cost. These taxes must be factored into the financial analysis of the proposed wind farm project.

3.4. Depreciation

The team employed the 5 year Modified Accelerated Cost Recovery System (MACRS) method to determine depreciation deductions for federal income because that is the primary method allowed in the US. The proposed project has access to this tax benefit due to the structure of the finance plan and use of debt. Using calculations from the SAM models, the depreciation schedule from the first year to the sixth is: 20%, 32%, 19.2%, 11.5%, 11.5%, 5.76%.

4. Risk Management Plan

All projects inherently have risk associated with them which can adversely affect the successful and timely outcome of the project. These risks are best understood using large amounts of data and experience from developers, owners, and operators of similar wind energy projects. The risk management plan for a project is used to identify risks, analyze their impacts, and then plan risk mitigation strategies and response measures in advance (Rolik, 2017). There are many ways to categorize and prioritize these risks; however, the team decided to make 6 categories which cover the major anticipated issues with that this project might face. These categories of risk types have several detailed sub-risks which are shown in *Appendix 1* below.

Each type of risk will require specific project and situation-dependent actions to mitigate the impact of the risk on the overall success of the project. The main goal of a risk management plan is to reduce the uncertainty of the project so that investors and project owners can have confidence that the endeavor will be successful. The team has compiled some common risk response measures to reduce the uncertainty of the project.

Risks can be addressed in two major ways: by mitigating measures which aid in preventing the risk from happening, or by response measures which are used to correct the root causes of the issue after it has happened. *Appendix 1* below delineates some of the major mitigation and response measures which can be taken to minimize the risk type as much as possible. Each risk type listed can impact the project cost, the project schedule, or in some cases both. It should be noted that these consequences are listed on the table to summarize the impacts of the risk type in general, not the individual risks within that category. It is important to understand that the risk levels of a project are constantly changing over the project's lifetime, although it is generally true that the possibility of risk decreases as the project bears completion (Rolik, 2017).

4.1. Risk Assessment

The final information listed in *Appendix 1* is the probability of occurrence of that type of risk, along with a short description of the value ascribed. Some risks, such as social pushback to the project, are challenging to assess statistically because community ideals can vary drastically from different locations. Uncertainty propagates when combining each risk type, so the reduction of all probabilities of occurrence is crucial to move forward with this project.

In particular, standard O&M costs, such as regular maintenance, may be considered low risk because the cost of goods and services are expected to follow the economy in general (Morthorst & Awerbuch, 2009). Due to pitch misalignment, icing, leading edge erosion, and other factors, the performance of a wind turbine will still have a small amount of uncertainty in the overall performance. According to the team's research, it is generally a consensus within industry to accept a bias within 1% for total energy production due to these types of errors, so the team assumed an additional performance uncertainty factor of about 1% (Damiani, 2018). Performance uncertainty should be minimized, so a cold weather package for the winter conditions of this area will be included as a simple way to improve technology performance and reduce downtime.

The SAM model for the selected site outputs predicted loss factors due to turbine performance, environmental degradation and exposure, and curtailment due to the loading, permitting, or grid demands. The curtailment losses are predicted to be the lowest, around 2.5%, and are mostly attributed to permitting factors such as bird or bat death prevention. Both the turbine performance losses and environmental degradation losses are each predicted to amount to around 4.5% of the lifetime energy production.

4.2. Management and Mitigation Measures

Turbine performance loss predictions can be improved over the lifetime of the project as more years of operating data come in, while environmental losses can be mitigated through leading edge erosion coatings, icing prevention technologies, and related technologies. While these approaches may not fully eliminate all types of risks associate with a large utility-scale wind energy project, they will help improve the project economics and overall reliability and success of the project.

The major high-risk category assessed by the team is that of wind data uncertainty. The team was only able to access a few years of wind data, none of which was directly at the turbine sites or from met towers of the correct height. The data is thus extrapolated, and although this provides a reasonable starting point, more accurate data collection is necessary to reduce the uncertainty of the annual energy production. Most of the risk categories assessed were considered "moderate" or "low" due to their limited impact on the overall project construction schedule or on the project cost. Risks assessed as moderate include environmental conditions, operations & maintenance, and construction risks. These are mostly managed through extensive planning and scheduling, but in some cases, require flexibility of the project owner such as in cases of extreme wind conditions or changes in component lead times during construction. The low-risk categories are obviously of least concern, however, still require mitigation measures and response plans to best optimize the project. These low-risk categories include permitting delays, social pushback, and business interruptions. These are each considered low risk because they have little likelihood of fully stopping the project, and even in the event they do cause issues, they will mostly be addressed prior to the project being fully installed.

The most effective way to manage risk is to utilize project insurance for the aspects where the developer has some say, such as business interruption, construction, and O&M categories of risks (Gatzert & Kosub, 2016). Although some insurance may seem redundant, this is one of the most widely used industry methods to mitigate risks outside of the project owner's control.

5. Conclusions and Recommendations

It is important to note that this site plan should be considered preliminary since there have been no direct interactions with the community at the location and no PPAs or permits have been discussed or approved. To further iterate this proposal, the team would need to install met towers to collect accurate wind data for a year or more, as well as have direct discussions and interactions with the local communities and potential landowners and financial lenders. To optimize and finalize turbine locations, road and crane pad designs, and annual power output, the team would require more data on wind speed and turbulence, expected PPA pricing, and loan rates to refine the financing and overall costs of the farm. The team would also suggest evaluating the project design for re-powering the turbines at end of life rather than a full decommissioning.

In summary, the team has determined that the best location for the 100 MW wind farm of the given Western South Dakota region is in the Northeastern corner of Butte County, off Highway 212, using Vestas V90-2.0MW turbines. Given the current evaluations, the project is expected to make a profit for both investors and developers and would benefit the local community by providing jobs and additional income to boost the regional economy. This site could have even more long-term economic benefit by repowering the turbines at their end of life, however this requires further financial analysis and incorporates a large amount of uncertainty due to unknown market conditions 20 years from now. One of the major benefits of this location is that the proposed location is close to the recently built Willow Creek Wind farm, which has added brand new electrical and transmission infrastructure which can be expanded and utilized rather than building new infrastructure for this project from scratch.

The financial analysis and risk management plans were developed to reduce uncertainty in the project and to verify the validity of this project going forward. These plans and assessments should be further expanded alongside the finalized site design were this project to continue to real development. Overall, the team recommends this site to a project owner due to its excellent wind resource, minimal environmental impacts, proximity to necessary infrastructure, and financial viability.

Appendix 1. Risk Analysis

Risk Category	Occurrence Probability	Impacts	Associated Risks	Mitigations
Wind Data Uncertainty	High	Cost	**2.4% uncertainty from Openwind data output of final site.** • Overestimates of wind resource due to no use of met towers – could lead to underperformance of power production • Higher loading due to gusts that are not measured • High uncertainty in data due to short number of years of data use – data may be for outlier set of years • More change in wind behavior expected as climate change continues	1. Decrease uncertainty by installing more met towers and increasing data collection times. 2. Use extreme wind speeds of locally recorded long-term data for severe weather event loading.
Environmental Conditions	Moderate	Cost	**4.5% uncertainty from SAM data output of final site** - Extreme weather (wind, cold, snow, etc) may hinder the function of the wind farm and result in temporary shutdown - Environmental degradation of blades and equipment may decrease the performance of the windfarm	1. Upgrade and install winter package to each turbine if icing losses make this financially necessary.
Operations & Maintenance	Moderate	Both	**Major component failures occur at a rate of 3-10% annually (Ozturk, Samet, et al.).** • Damage or failure of components – more common in unproven technologies • Unforeseen rise in prices for spare parts and supplies used for maintenance – rise in cost of operation • Damage to turbines or access roads from severe weather events (i.e. lightning, tornadoes, persistent ice, earthquakes)	1. Have spares of major components on site to reduce downtime from transport. 2. Implement condition monitoring systems to catch issues before components fail (Gatzert & Kosub, 2016). 3. Transfer risks to 3rd party by hiring an O&M company to do all operations and maintenance work. 4. Insurance to cover cost of major component failures.
Permitting Delays or Issues	Low	Schedule	**No major issues in South Dakota found.** - Delays in Federal, State, or local permit approvals	1. Permit reviewing agencies must evaluate the permit proposal within the Period of Limitations.

Risk Category	Occurrence Probability	Impacts	Associated Risks	Mitigations
			- Unforeseen increase in property prices or taxes – makes leasing and development more expensive (Rynne, Flowers, et al, 2011) - Missed application deadlines	2. The USFWS must evaluate each Tier of the proposal within 60 days of submittal, otherwise the developer may continue to the next phase (US Fish & Wildlife Service, 2020). 3. Mitigation: Submit permits very early in the process.
Construction	Moderate	Both	**Construction delays can collectively account for up to 36% of project delays (Gatzert & Kosub, 2016).** • Weather delays for construction - may need to wait to transport heavy equipment on dirt/gravel roads, and/or require heaters to cure concrete in colder months • Material delivery delays creating bottleneck in construction • Multiple noise concerns associated with construction, activities must be done concurrently to reduce length of work and noise disruption • Project interference caused from existing cultural sites/trails	1. Monitor site conditions prior to construction to time construction around seasonal conditions. 2. Account for very high lead times in material and component delivery.
Social Pushback	Low	Schedule	**Visual impact was not a major social concern according to assessment done for Willow Creek Windfarm (U.S. Department of Energy Western Area Power Administration).** - Local community opposes the wind farm being built in town hall meetings etc. - Lack of landowners willing to lease land to build turbines on - Theft of materials or equipment	1. Involve local community early in the design process - invitations for public comment advertised through newspaper and radio (U.S. Department of Energy Western Area Power Administration, 2016). 2. Make as many contracts as possible for construction/operations with local companies.
Business Interruption	Low	Cost	**In local market "Natural gas resources tend to have higher prices as a result of congestion, while coal and wind resources tend to have dramatically lower prices" (Market Monitoring Unit).**	1. Sign long term PPA's to ensure stability in price of power. 2. Improve power and weather forecasting techniques.

Risk Category	Occurrence Probability	Impacts	Associated Risks	Mitigations
			• Oversupply of power leads to requirement to curtail power production • Damage to grid or unsafe wind speeds leading to loss of revenue • Price of power volatility • Legal action towards project will interfere with project schedule	3. Ensure cost margin of project can account for major impacts on the grid and still make a profit overall.

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