

Rosebud Wind Farm

Project Development Plan

Todd County, SD

University of Colorado Boulder
Submitted to
Collegiate Wind Competition 2021



Team Members

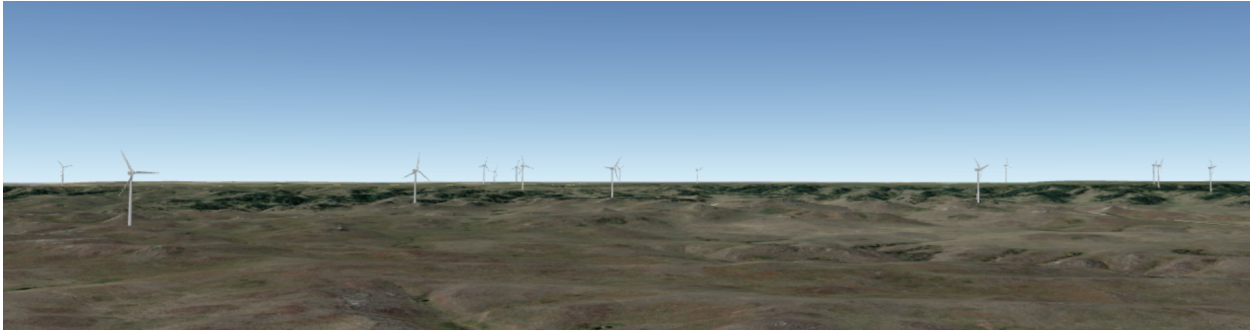
Abdoul Bah - Logistics Manager
Ioana Dumitru - CAD Engineer
David Imola - Electrical Computer Modeling Engineer
Austin Kim - Project Manager
Charlie McClung - Financial Manager
James Rizkallah - Test Engineer
Xander Sugarman - Manufacturing Engineer
Emily Zuetell - Systems Engineer

Faculty Advisor

Roark Lanning

Rosebud Wind Farm

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Executive Summary

Chinook Wind Energy of Boulder, Colorado presents the 99MW Rosebud Wind Farm in Todd County, South Dakota. Rosebud provides stellar returns on the triple bottom line of people, profit, and the planet through enabling economic growth, technical development, and clean energy to the impoverished Rosebud Indian Reservation Lakota community, while offering desirable returns through a vPPA of \$43.8/MWh with GM enabling the company to make progress on its sustainability goals. The site has been optimized for energy capture and financial metrics resulting in a wind farm with a best-of-class capacity factor of 50.48% and is capable of net energy power production of 486 GWh/yr.

Opportunity

Chinook Wind Energy has identified an opportunity to build a 100MW wind farm in western South Dakota which provides stellar returns on the triple bottom line of people, profit, and the planet. The Rosebud siting project offers a unique chance to bring a diverse set of shareholders together in a way that helps them all reach their individual goals.

Car manufacturing is a storied and influential industry and recent major announcements from manufacturers of plans to move toward electric vehicles has signaled that the electrification of the country is well underway. GM recently announced plans to become carbon neutral by 2040 and Chinook Wind Energy feels the Rosebud siting project is perfectly seated to help them achieve this goal.

We will be generating electricity in an area of the country ripe for development as well with Southwest Power Pool, the regional transmission organization we are working with, having capacity and a need for energy development (Apex). Through a virtual power purchase agreement (vPPA) the energy produced at the Rosebud site could help reduce the carbon emissions of GM. GM buys energy primarily from the MISO and ERCOT markets which have some of the most competitive wind energy prices in the US. Our vPPA price of \$43.8 / MWh is actually well above the average cost of wind energy in both of these markets but with the rising trend of vPPA prices over the last couple of years, Chinook maintains that this project has enough social and environmental benefits to convince GM that it is a worthwhile investment.

The Rosebud Indian Reservation has a unique partnership with the Oceti Sakowin Power Authority (OSPA) which makes development on reservation land more attractive than it has been in the past. OSPA has worked hard to streamline the development process on reservation lands to allay many of the financial and regulatory concerns that have prevented development in the past. They have provided a framework for developers that makes development on reservation lands comparable in price and risk to development on private lands. By partnering with them, Chinook can take advantage of their knowledge and expertise in navigating the unique regulatory nature of reservation lands and construct a wind farm that benefits both the investors and tribes. A partnership with OSPA also guarantees that the tribes are mutually invested in the success of the project and will be able to reap their fair share of financial benefits. The member tribes of OSPA are some of the poorest tribes in the nation and the impact of a project like this could secure better futures for many generations of tribal members.

Site Description

After conducting an alternatives analysis of 9 sites with adequate wind resources in Western South Dakota, according to the NREL Wind Prospector (*The Wind Prospector*), the Rosebud Wind Farm sites was selected for:

- Physical Characteristics: wind resource, topography, land cover
- Infrastructure: Access to transmission lines and roads
- Environment: Proximity to critical habitats and water resources
- Community: Proximity to towns and households, general acceptance of wind farms

Ultimately, Chinook selected a 7500 acre site in the rolling hills of western Todd County on the Rosebud Indian Reservation as the ideal location for the new wind farm development. The site offers consistent wind speeds of 8.5-9.5 m/s (Wind Integration National Dataset Toolkit), acceptable topography with hillslopes <math><10^\circ</math>, easy access to a 115kV transmission line owned by Lacreek Electrical Assn, Inc., and easy transportation access via US-18. The land is federally owned by the Bureau of Indian Affairs and there are no critical habitats on the site (The Wind Prospector).

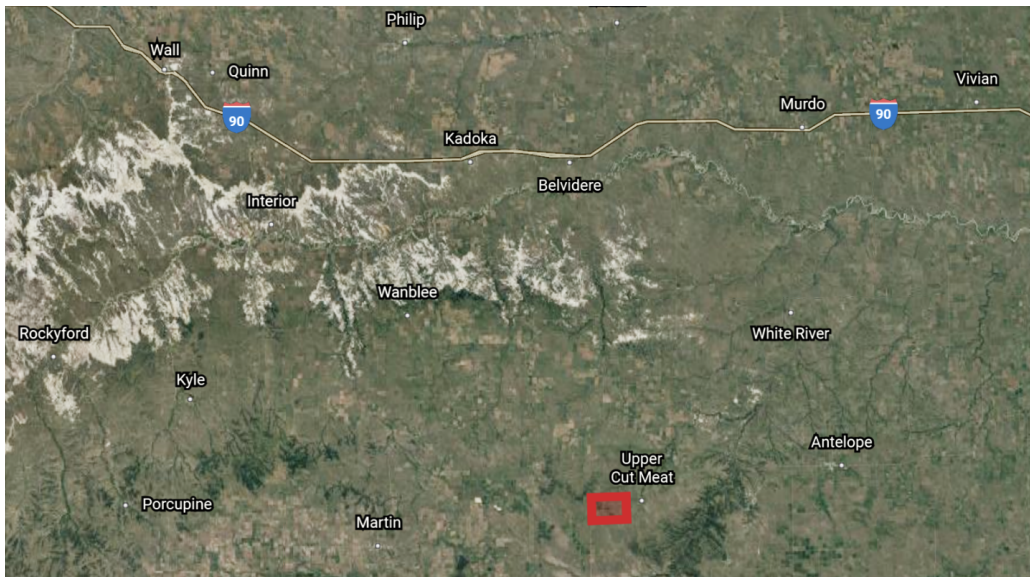


Figure 1. Map of Chinook’s Rosebud Wind Farm in Todd County, SD

The chosen site is located in Southwestern South Dakota in Todd county near the city of Upper Cut Meat, south of I-90. Additional to the previously stated factors, Chinook aims to be a positive contributor to support climate justice to communities that normally would not have access to clean energy and that may be impoverished. This site provides an opportunity to reinvest in the community and achieve the goal of climate justice. **Table 2.** examines the county’s demographics compared to South Dakota’s demographics that gives Chinook an idea of how climate justice can be utilized to give a community more access to clean energy. The median household income is lower and the persons in poverty percentage is higher than the state’s average (“United States Census Bureau QuickFacts”).

Table 2. Select demographics for Todd County vs the South Dakota average demographics in 2019.

	Population	Median Household Income	Population per square mile	Persons in Poverty
Todd County	10,177	\$24,000	6.9	43.4%
South Dakota Average	N/A	\$58,275	10.7	11.9%

The Chinook Site is completely inside the Rosebud Indian Reservation, so communication with tribal land councils to reduce cultural and environmental impacts is essential. South Dakota’s native tribes have been encouraging more clean energy projects on tribal land, so the overall perception of wind farms is positive. The Oceti Sakowin Power Authority (OSPA) collaborates with tribes and developers to form agreements of these wind farm sites on tribal land. A recent OSPA project in the Oglala Lakota county, within the Pine Ridge and Cheyenne River Indian Reservation, partnered with Apex Clean Energy and the Rosebud Sioux Tribe to develop one of the largest clean energy projects on tribal land of 500 MW. OSPA does this by offering positive community factors creating jobs in construction and maintenance and using revenue to provide more opportunities to tribes that suffer from poverty (Jossi). Furthermore, the revenue from *Chinook’s* project would help fund infrastructure and social programs of the Rosebud Reservation while supplying clean energy to the area. *Chinook* is confident in partnering with OSPA to help communicate with the Rosebud Sioux Tribe and offer an economic, environmental, and social benefit to the surrounding community.

Environmental Factors

A baseline environmental assessment of Todd County, SD and the project site was conducted using a collection of environmental reports from governmental agencies to verify compatibility with the proposed project and identify key environmental concerns that require mitigation. **Table 1.** details this assessment. Western Todd County has no critical habitats and all endangered or threatened bird and bat species at risk from wind turbines are listed as only ‘possible occurrence’ in the area by the U.S. Fish and Wildlife Services. Furthermore, the project area covers exclusively grasslands and no productive agricultural or grazing land. Shallow wells and large aquifers ensure sufficient water access for construction activities and minimize risk of surface-water contamination from construction and operation activities.

Table 1. Baseline Environment Assessment of Todd County, SD

		Description	Source
Physical	Topography	3,150 ft elevation, Rolling hills, gullies, drainages flowing to the northeast	US Geological Survey
	Natural Hazards	Rosebud, SD has a very low risk of earthquake compared to the national average. The risk of tornadoes is medium, but half the risk of South Dakota on average. From 1950-2010, Rosebud experienced 338 instances of thunderstorm winds, 761 instances of hail, 25 floods, and 2 wildfires	USA Natural Disasters and Weather Extremes
	Air	No recorded days with PM2.5 pollution above regulatory standard	CDC, National Environment Public Health Tracking Network
	Water	Shallow wells in Ogallala(17 million acre-ft), Arikaree(50 million acre-ft), White River aquifers supply water with low concentrations of dissolved solids, but have recorded high concentrations of nitrates and arsenic	US Geological Survey
	Soil	Sandy soils, mostly sand hills in project area with limited farming	USDA Soil Conservation Service
	Climate	Subhumid, hot summers, cold winters	U.S. Department of the Interior, Bureau of Indian Affairs
	Noise		

Biological	Birds	Whooping Crane (Possible Occurrence, Endangered), Rufa Red Knot (Possible Occurrence, Threatened)	U.S. Fish and Wildlife Services South dakota Listed Species by County
	Bats	Northern Long-eared bat (Possible Occurrence, Threatened)	
	Mammals/Insects	Black-footed ferret (Known Occurrence, Experimental), American Burying Beetle (Known Occurrence, Endangered)	
	Flora	Western Prairie Fringed Orchid (Possible Occurrence, Threatened)	
	Vegetation	Native grasses with trees on bottom lands and along Little White River	Todd County Conservation District
Socio-Economic and Cultural	Land Use	Project Site: Undeveloped grassland Todd County: 13% cropland (Alfalfa, oats, corn, wheat)	Multi-Resolution Land-Characteristics Consortium
	Access to Basic Services	64% of households have Internet Access, inconsistent data on Electricity, clean water, sewerage, transportation access	City-Data
	Cultural Heritage	Rosebud Sioux Tribe, roots going back 2,000 years, home to Sinte Gleska University is a four-year tribal university, sever social, economic, health adversities	American Communities Project
	Jobs/Employment	Per-capita income is third poorest in the U.S. , 43.4% of population in poverty	American Community Survey 5-Year Estimates
	Nearby Communities	Parmelee (14.3 miles), St. Francis (20 miles), Rosebud (22 miles)	Google Maps

Turbine Selection

An appropriate turbine was selected according to the IEC wind class of the site. The high winds (8.82-9.39 m/s) at the site required a Class 1 turbine. As turbulence data was not available in the WIND dataset, we opted for a Class 1A turbine that could withstand worst case scenario turbulence expected for the hilly terrain. A higher power turbine was selected to minimize the potential wake interactions from nearby turbines and reduce construction and operation costs by reducing the number of turbines. Due to limitations in the OpenWind licensing available to the Chinook, note that simulations are run with the older model Gamesa 128 4.5 MW. The final turbine model selected for the site is the SG 5.0-132, specified at a flexible power rating of 4.5MW.

Table 3. SG 5.0-132 Specifications

Power Rating	4.5 MW
Wind Class	IEC IA
Tower Height	90 m
Generator Frequency	50 Hz/60 Hz
Gearbox	3 stages

Site Layout



Figure 2. Rosebud Site Layout including turbines (numbered), relevant buildings (teal), 115kv transmission line (red), and existing roads including US-18.

The final site consists of 22 4.5MW SG 5.0-132 turbines. The goal of the site layout was to maximize energy capture and minimize wake effects from neighboring turbines. Meteorological masts from the DOE Wind Integration National Dataset were used to construct a wind map based on historical data in Openwind (“Openwind - UL”). The prevailing west winds drove the wake effects and turbine layout. Constraints were applied to turbine locations as detailed in **Table 4**. The final turbine layout has 0.28 acres/MW of permanent direct impact area, a standard impact area tp similar scale wind farms (Denholm).

Table 4. Specification of turbine layout constraints.

Element	Buffer	Constraint
Buildings	500 m	Outside
Roads	120 m	Outside
Elevation Gradient	Less than 10°	Inside
Waterbodies	20 m	Outside
Transmission Lines	250 m	Outside

Table 5. Rosebud Wind Farm Energy Estimation

Total MW	99 MW
Net Energy	486.8 GWh
Capacity Factor	50.48%
Mean Free Wind Speed at Turbines	9.12 m/s

Transmission

All turbines are within 2km of the 115kV transmission line owned by Lacreek Electrical Association. The underground collection system will connect to a newly constructed substation as the two existing substations are too far away to be feasible options. Available capacity on the line is driven by the 320MW Fort Randall Hydroelectric plant (EIA).

Roads

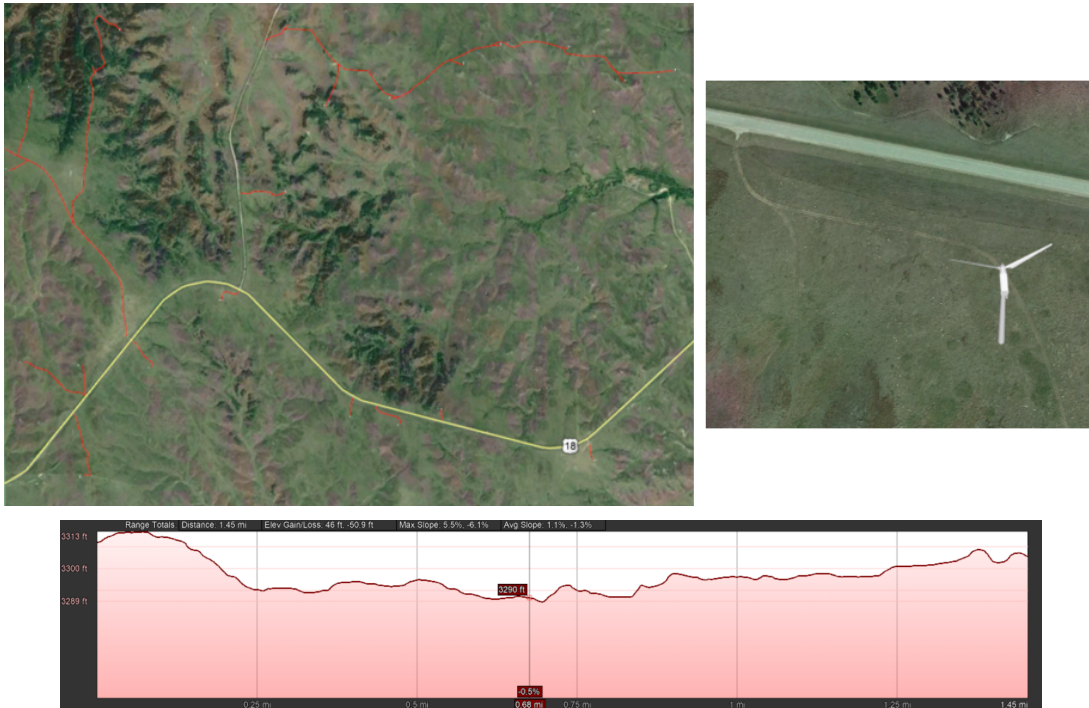


Figure 3. a) Map of site access roads (red) and elevation gradient of the Rosebud Wind Farm site. **b)** An example of existing farming roads that will be converted to site access roads. **c)** Elevation profile of primary access road

Existing roads were used for the transportation of large turbine component shipments and heavy construction equipment. The relatively flat grasslands of the site and existing farm roads will be upgraded for a width requirement for utility-scale wind turbines of 18 feet. Furthermore, the turning radius was kept to a minimum for ease of access for turbine materials and slope below 7%, the maximum allowed by most

turbine manufacturers. **Figure 3.** illustrates the road network to each turbine location and details elevation profiles of critical routes.

Land Leasing

A wind farm lease is necessary to get the rights to develop turbines in Todd county. The rental payments will give the property owners incentive to have Chinook develop and their land. Land usage mostly comprises pastoral activities, and Todd county has an average land rent of USD 21.50 per acre (USDA National Agricultural Statistics Service, 2017). Since the site is completely within the Rosebud Indian Reservation, all lease fees and contracts will be paid to and issued through the BIA (Staff, 2013).

Environmental Impacts

The most relevant environmental impacts from the wind farm are the noise and visual impacts of the turbines. There are 10 relevant inhabited buildings near the project site. Figure __. visualizes the noise, shadow flicker, and visual impacts of the turbines at the surrounding buildings. South Dakota Wind Energy Systems (WES) ordinances require a noise level not exciting 45 dB on non-participating residences. The maximum noise level demonstrated in **Figure 4a.** a household is 42 dB. WES ordinances also require a maximum of 30 hours per year (CHAPTER 5.22). **Figure 4b.** Shows that the maximum shadow flicker at a household is 2.5 hours per year. These figures are well within the ordinance limits. Furthermore, mitigation measures for sound and shadow flicker such as noise mitigating landscaping could be implemented if needed.

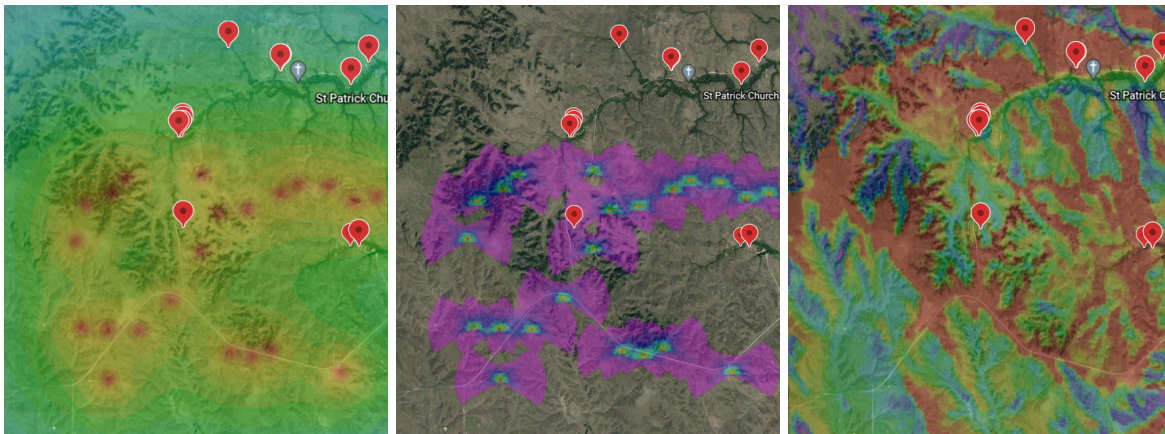


Figure 4. Environmental Impacts of Rosebud Wind Farm a) Noise map of wind farm and surrounding area. Note that yellow is the 45dB limit. b) Shadow Flicker map of wind farm and surrounding area. c) Zone of Visual Impact map of wind farm and surrounding area.

Financial Analysis

After Chinook identified the business opportunity we assembled necessary data and performed the proper economic analysis of the development. The finance assumptions and models were optimized to match the decided wind farm layout and turbine choice made in OpenWind. The financial analysis was primarily completed using the System Advisor Model (SAM) developed by NREL.

Financing Needs

Chinook is looking for outside financing to cover the initial capital cost of USD 121,768,880 for the project. The SAM model suggests that a loan for \$92.8 mil will provide the best return for investors. Chinook expects the Rosebud project to qualify for 60% of the full PTC amount which should aid in securing the financing needed. With an interest rate of 4%, the loan can be paid off by year 18. This loan will also cover the majority of installation costs.

Chinook is also looking for an outside equity investment in the company to maintain an industry standard debt-to-equity ratio for the project to reduce risk and bring more experience to the company. Using current industry project valuation multipliers and the average EBIT across the 20 year lifetime of the project, the Rosebud wind farm has a value of \$173 mil (Christensen). Chinook is seeking investors to take a 20% stake in the company and accompany our board of directors. The Rosebud project will be the marquee project for Chinook Wind Energy and will attract investors as it is profitable and will establish Chinook as a player in the field of wind development. Having knowledgeable equity investors funding Chinook will help reduce the risk during economic uncertainty and will ensure future strategic decisions are made.

The Rosebud project predicts an internal rate of return of 13% by year 20 making it an attractive investment. The project takes advantage of some of the best wind resources in the country and provides immense social and community benefits on top of the financial returns.

Key Assumptions

The financial assumptions Chinook made for the Rosebud project reflects a combination of industry standard and site specific data. Much of our data came from academic and government studies as well as open source aggregations of historical values and data published by wind development companies on similar projects. Siting a wind farm is a complex process already and because the site is on an indian reservation there was an added layer of complexity in siting the Rosebud project. Those factors, and reliance on publicly available data, required extra diligence in research efforts to build an accurate model. All major assumptions are backed up by multiple sources and the team consistently did reality checks and comparisons to industry standards for the outputs of our model. **Table 6.** covers the most important assumptions made for the Rosebud project.

Table 6. Financial Assumptions for SAM simulation.

Parameter	Value
Turbine Installation Cost	\$1,094 / kW
O&M costs	\$12 / MWh / year (“Distributed Generation Renewable Energy Estimate of Costs”)
Balance of Plant Cost	\$350 / kW
Federal Income Tax	21% (Bhattacharyya)
Sales Tax	0% (Tax Fact Tribal)
Salvage Value	3% (Daniels, Pardo)

Project Term Debt	60% (Christensen)
State Income Tax	0 %
Initial Production Tax Credit	\$.018 / kWh
Minimum DSCR	1.21
Inflation Rate	2.5%
Interest Rate of Debt Financing	4% (Wiser et al., 2018)

Overview of Financial Results

Chinook conducted substantial financial modeling for the Rosebud site and verifies the financial viability for this project. Values from both OpenWind and SAM models were compared and adjusted to reflect a realistic projection of the Rosebud sites financial positioning. To build the 22 wind turbines needed for the project Chinook projects a total install cost of approximately \$154.7 mil, or about \$1,444 / kW. These numbers are slightly higher than the industry average install costs which is a result of higher than average balance of system costs coming from interconnection to a lower voltage, rural transmission line and models being conducted with the outdated Gamesa G128 turbine (Distributed, Milborrow). The install costs, and the cost of securing financing, results with a projected \$154.7 mil initial capital cost for the project.

The SAM model also provides insight to the projected annual operating expenses (OpEx) of the Rosebud project. OpEx costs have been decreasing each year as wind related technology improves and the Rosebud project shares the same trend. The SAM model predicts an average yearly expenditure of \$4.95 mil on operations and maintenance over the 20 year lifespan. That price puts the Rosebud project right in the middle of the industry average for OpEx even with a model conducted with an outdated turbine (Reuters).

Table 7. Financial Results

Parameter	Value
Levelized PPA Price (real)	4.38 ¢/kWh
Levelized COE (real)	3.98 ¢/kWh
Capacity Factor	37.3%
Equity	\$61,936,224
Size of Debt	\$92,842,168
Net Present Value	\$14,344,720
Net Capital Cost	\$154,778,400

IRR	13.16%
Annual Energy Produced	323,094,208 kWh
Average Annual OpEx Costs	\$4.95 mil

Chinook was also able to put together a 20 year cash flow projection for the project. With the projected levelized cost of electricity at \$39.8 / MWh and an assumed levelized vPPA price of \$43.8 / MWh, the project estimates an IRR of just over 13% by year 20. The investment of the equity investors will be paid off by the end of year 10 and the loan by year 18. Throughout the project, Chinook maintains a reasonable debt service coverage ratio and has sufficient positive cash flow and reserve cash to be prepared for uncertainties and unforeseen costs. Below is a graph of the projected after tax cash flow for the life of the project. The graph clearly displays the impact of the PTC through the first ten years of the project and the impact of decommissioning profits in year 20.

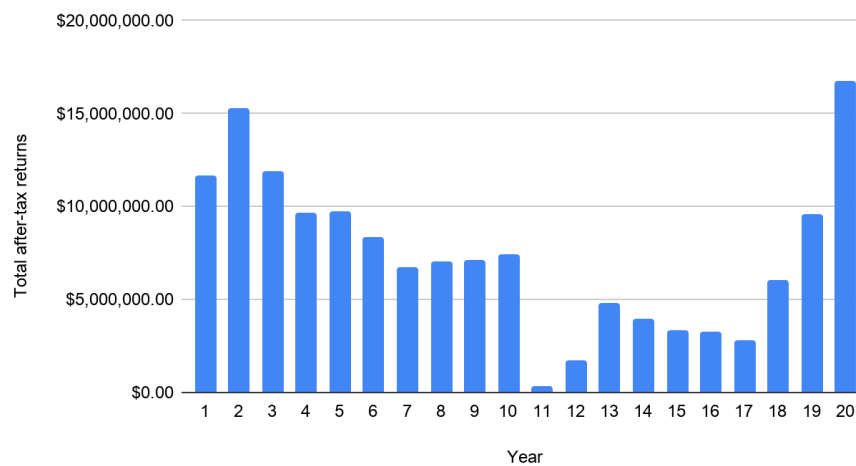


Figure 5. Total after-tax returns vs. Year

Permitting

Developing a wind project requires federal, state, and local permits to reduce environmental and community risks. Federal ordinances and permits are to ensure the project will not cause environmental problems or interfere with existing government entities. The permitting matrix shown in **Table 8.** shows the required permits needed to comply with federal ordinances. Some notable permits include compatibility between renewable energy project and military operations,

Table 8. Federal permits required for wind projects.

Permit/Approval	Regulatory Entity	Permit Description	Notes
DoD Siting Clearinghouse	United States Department of Defense	Promote compatibility between renewable energy & military mission operations	Impacts of to military operations must be coordinated with DoD
Endangered Species Act (ESA)	US Fish and Wildlife Service	Incidental Take Permits may be issued if applicant minimizes	Permit must be acquired by US Fish and Wildlife Service emphasizing

		risk of take and avoidance measures	plan to minimize eagle take
Determination of No Hazard to Air Navigation	Federal Aviation Administration (FAA)	Applications to be filed for turbines and met towers, if met and turbine towers exceed 200 ft. height requirements or are within airport overlay.	
Federal Water Pollution Control Act (CWA)404 Authorization	United States Army Corps of Engineers	If dredge and fill activities involve jurisdictional “waters of the United States” under the CWA, permit would be required.	
Environmental Impact Statement (EIS)	National Environmental Policy Act (NEPA)	Environmental Assessment (EA) shows potential of environmental impacts while explaining purpose and need of proposed action	EIS is not needed if EA proves no significant effects. FONSI is prepared rather than EIS and made available to public before review (Office of Facilities, Environmental and Cultural Resources, 2012)
NPDES Permit	EPA	Storm water discharge from construction activity to promote Clean Water Act	

At the state level, South Dakota’s Public Utility Commission (PUC) must be aware of the wind project. The South Dakota Codified Laws states that any wind facility above 5 MW must give notice of the site’s size, location, and interconnection method (Kahn & Shields, 2020). Since Chinook’s wind project fits in this category, a construction permit must be obtained prior to building. Since Chinook will be on an indian reservation, cultural impacts must also be considered. The local level permits are critical to ensuring no unintended consequence occurs when bringing clean energy to the area. The Bureau of Indian Affairs (BIA) plays an influential role in local permitting. An Avian Assessment is needed to acquire proper permitting through the BIA. It is also important to have a cultural assessment to satisfy the Tribal Historical Preservation Office and minimize cultural impacts (*Rosebud Sioux Tribe - 2003 Project*, n.d.).

Risk Management

A wind project on tribal land requires communication and approval from the BIA. However, BIA’s staff limitations and lack of document processes has pushed away renewable energy projects. The BIA could take up to 18 months to review a wind lease, and this delay can cause Chinook higher costs, lost revenues, and missed development opportunities (U.S. Government Accountability Office, 2015). In order to maintain the viability of this project, Chinook aims to maintain a good relationship with OSPA to reduce the risk of slow reviewing processes by the Oceti project partners. Oceti Sakowin Power Project is an alliance of tribes managing Native American land (Jossi). Having OSPA as the bridge between Chinook developers and tribes cuts out the dependence on BIA to acquire data and review documents.

OSPA allows tribes to have the legal and technical capacity for renewable energy projects that will keep Chinook from depending on the BIA for communication with tribe members.

Another risk for the project is securing partnerships with the energy buyers. The Rosebud siting project is located within the Southwest Power Pool territory and is selling to the Midwest Independent System Operator territory with projected vPPA and COE prices higher than the market averages for both territories (Apex). This will certainly present challenges and risks moving forward as we try to secure partnerships with utilities and GM. The project can take advantage of some financial benefits being on an Indian reservation, no sales or property tax for example, but these benefits are not enough to make our PPA prices competitive. We feel that both GM and the utility companies can be convinced that this project is a good investment because of the added social and environmental benefits that come along with the project.

Decommissioning

At the end of the 20 year lifetime, Chinook aims to be as sustainable as possible when it comes to decommissioning the project. About 90 percent of a wind turbine can be recycled or sold to smaller scale wind farms (Institute for Energy Research, 2019). Reusing, recycling, and repurposing as many components as possible will reduce excessive landfill that would cause the project to do more environmental harm than good. However, the blades pose a challenge in recycling and repurposing when decommissioning. The US is expected to have more than 720,000 tons of blade material to dispose of in the next 20 years (Institute for Energy Research, 2019). A good practice of blade disposal is energy recovery through incineration (Adedipe & Shafiee, 2021). On the other hand, more companies have found ways to repurpose these materials by grinding the blades into pellets that can be used for decking material and piping. There have also been instances where blades can be repurposed into public benches, playgrounds, and other public utilities.

Decommissioning a project can be very costly and cause permanent damage to the area if not done correctly. New projects usually commit 2-3 percent of capital costs each year for decommissioning (Institute for Energy Research, 2019). For site restoration, the Best Practicable Environmental Option (BPEO) must be considered to set objectives that provide the most benefits with the least damage to the environment at an acceptable cost (Scottish Natural Heritage, 2013). This includes the removal of all foundations, pads, electrical wires, potentially hazardous materials, and structures. The site's vegetation also must be restored to gain the Landowner's approval.

Optimization Process

The development of Chinook's wind farm is centered on an optimal site by balancing the triple bottom line of people, profit, and the planet. Using NREL's Wind Prospector and the Department of Energy's Energy Map, a list of potential sites were gathered based on adequate wind resources and access to transmission lines. Additional research on each site's community and environmental factors allowed the developers to eliminate certain sites that are costly for wind farm development. Openwind and SAM were used to model the remaining sites for more detailed wind resource and financial information. Once the final site was picked, Chinook completed another iteration of modeling and research to improve analysis within the chosen area. The current proposal provides financial benefits and clean energy with the additional benefits of bringing climate justice that is considerate to the nearby community.



The University of Colorado Boulder Wind Team thanks the Collegiate Wind Competition for the opportunity to gain insight in wind farm development and acquire better practices for future teams. We thank you for your time, guidance, and resources.

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