Owl Ridge Wind Farm

U.S. Department of Energy – Collegiate Wind Competition 2021

Project Development Report

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1. EXECUTIVE SUMMARY

The developers at WiscWind are pleased to present the Owl Ridge Wind Farm, a 96.6MW wind energy system located in of central Meade County with an average annual wind speed of 8.5 m/s. This report discusses the siting design process and triple bottom line feasibility of the proposed project along with potential environmental and social impacts of the project and any necessary mitigation efforts. Capital and operating expenses were estimated and a cash flow analysis was conducted along with the calculations of key financial metrics. The proposed layout was optimized to increase energy production and minimize project costs. The collection system and access roads were carefully designed to meet project needs and conform to site constructability constraints. The proposed layout is projected to have a net annual energy production (AEP) of 366.9 GWh/year with a capacity factor of 43.3% at a levelized cost of energy (LCOE) of $0.0254/kWh. Revenue for the project will be generated through a power purchase agreement (PPA) of $20/MWh with a capacity credit from a utility buyer (Basin Electric Co-op) in North Dakota as they have a growing portfolio of wind energy and a necessity to fulfill their resource adequacy needs.

2. SITE & ENERGY ANALYSIS

2.1 SITE SELECTION

In order to select the optimal site within the project boundary of the western half of South Dakota, various selection criteria were studied and considered, such as wind resource availability, accessibility to existing infrastructures like transmission lines and public roads, topography land use, and more. The weighted decision matrix developed to compare these potential sites is shown below in **Table 1**. Each criterion was given a score ranging from 1 to 5, with 5 being the most desirable.

Table 1. The weighted decision matrix for site selection of the proposed 100MW wind farm.

County	Selection Factors						FINAL WEIGHTED SCORE
	Wind Resource (0.5)	Terrain (0.05)	Access to Transmission (0.2)	Community Factors (0.05)	Environmental Considerations (0.1)	Site Access (0.1)	
Perkins	4	3	4	5	3	3	3.80
Meade	5	4	5	5	5	4	**4.85**
Gregory	4	4	5	4	4	3	4.10
Tripp	5	4	3	3	4	4	4.25

The most important factor considered was the wind resource since this factor is directly related to the annual energy production and ultimately the financial viability of the wind project. The second most important parameter was access to electrical transmission. Transmission lines and grid interconnection are very costly, hence sites near an existing grid line large enough to handle the electrical load from the wind farm were prioritized. Site access is important for the purposes of wind farm construction and turbine delivery. Access roads and existing roads are needed for special oversized trailers and cranes to move efficiently in and out of the site during the construction and decommissioning of the wind farm. Similarly, a suitable terrain is needed to build and operate a wind farm. Flat and smooth terrains are preferred since the turbulence is lower and provides great wind availability. Complex terrain landscapes are to be avoided as it can exert heavy wind loads on turbines blades, which can significantly reduce the service life of the wind farm. Environmental factors include the presence of wildlife in the area of the project, construction impacts on surrounding ecosystems and waterways, and more. Wind farms may have an impact on avian species either through direct collision or habitat displacement. Community factors include proximity to households, public acceptance of renewable energy, and others. Many of these factors are considered during the planning stage and ongoing dialogues with the local agencies and residents are necessary.

2.2 SELECTED SITE CHARACTERISTICS

2.2.1 LAND USE & SITE ACCESS

The Meade County site (44°39'56.3"N, 102°39'44.5"W) chosen to develop the wind farm is located between Union Center and Stoneville along Meade County Highway MC-27. Land use in Meade county primarily consists of pasturelands (80%) and croplands (17%), according to the Census of Agriculture._(USDA, 2017). The project area is 14,969 acres, consisting of 32 land parcels with 23 of these parcels having some form of development whereas the rest will be controlled to fulfill setback requirements. **Figure 1** shows the extent of these property lines within the project boundary of the Owl Ridge Wind Farm.

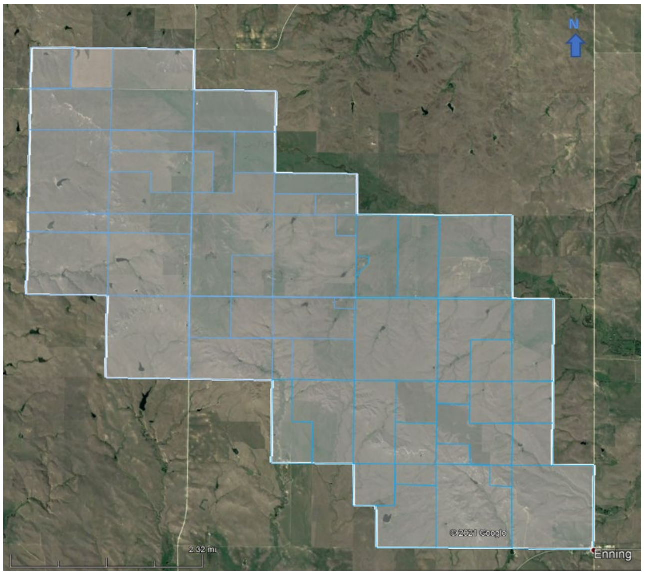

Figure 1. Extent of property lines and project boundary.

2.2.2 WIND RESOURCE

During the site selection, NREL's Wind Prospector was used to identify large regions of high wind speed and their underlying geographic features. **Figure 2** shows a map of an area of 9 to 9.5 m/s wind speeds identified using this tool (Draxl, Hodge, Clifton, & McCaa, 2015) as well as the geographic feature's boundaries. To further estimate the wind speeds at this site, 5 years of 5-minute interval wind data (2007-2012) was downloaded using the NREL Wind Toolkit for various locations within this region. Analyzing this wind data revealed a majority of wind comes from the NNW-WNW directions and the ESE-S directions shown with wind roses in **Figure 3**. All Wind Toolkit locations within this region had a very similar profile in terms of both wind speed and direction with only slight variations.

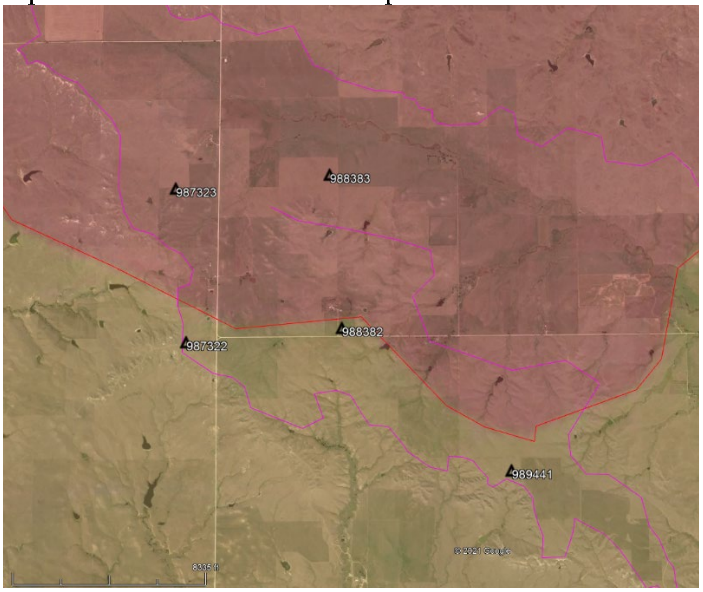

Figure 2. NREL Wind Prospector 100m wind speed map overlayed with NREL Wind Toolkit Locations.

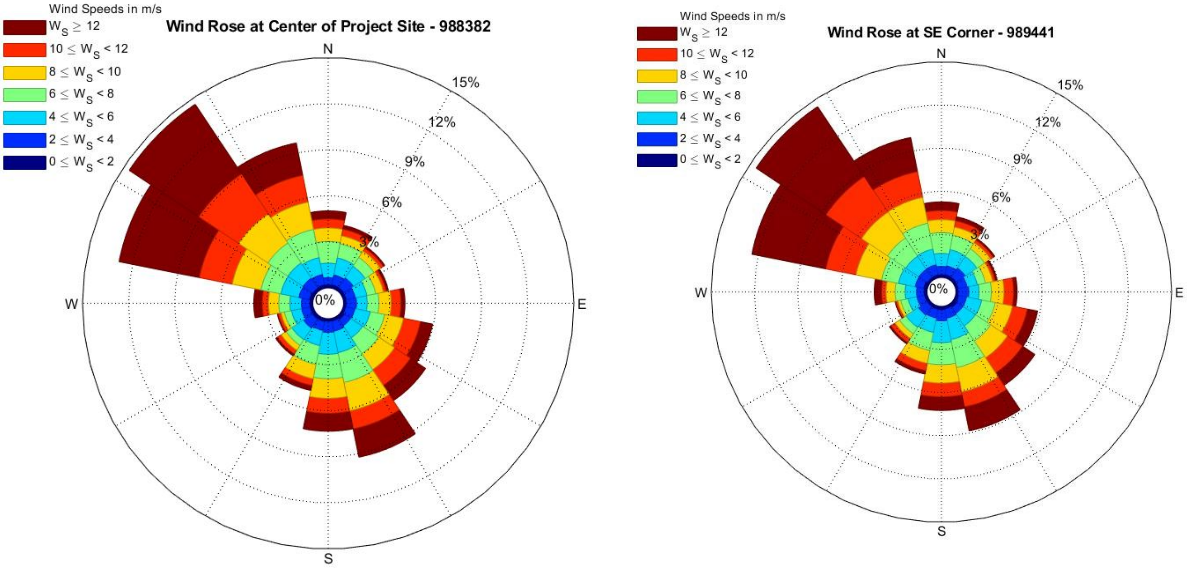

Figure 3. Typical wind roses based on data obtained from NREL Wind Toolkit.

2.2.3 ELECTRICAL TRANSMISSION

A 230kV transmission line, owned by Western Area Power Administration (WAPA), runs through the proposed site parallel to the MC-27 highway. The existing line is connected to the New Underwood and Maurine substations, 40 miles south and 25 miles north respectively (USDHS, 2021). A new substation is to be constructed on-site that will tie-in to the existing transmission line to deliver power generated to the grid.

2.2.4 SITE TERRAIN & SOIL PROPERTIES

The terrain of the site is mostly flat with low slopes of 0%-6% and some rolling hills with slopes up to 25%. Based on the USCS Soil Survey for Meade County, the stratigraphy comprised of stiff sandy and silty clay overlying weathered shale bedrock with localized soil variations. The bedrock and groundwater are sufficiently deep and will not pose as obstacles to the site's constructability.

2.3 SITE LAYOUT

2.3.1 TURBINE SELECTION & LOCATION

The turbine selection was conducted between Vestas, General Electric, and Siemens Gamesa turbine models, which are all established onshore turbine brands in the United States. **Table 2** shows the comparison of the three turbine models and the resulting cost per unit power. Since the Vestas V136-4.2MW turbine had the lowest cost per installed power, this was the model chosen to use at the Owl Ridge Wind Farm site. The power curve of the V136-4.2MW turbine as seen in **Figure 4** was utilized to generate the annual energy production (AEP) for the Owl Ridge Wind Farm.

Table 2. Turbine models comparison and selection.

Turbine Model	**Hub Height**	**Initial Cost / Turbine**	**Number of Turbines**	**Transportation Miles**	**Construction Cost Adder (CCA)**	**Transportation Cost Adder (TCA)**	**Total Turbine Cost ($)**	**$/kW (installed)**
Vestas V136 - 4.2MW	105	3145000	23	992	1.263	0	76,433,431	**758.3**
Siemens Gamesa (SG) 4.5-145	107.5	3442500	22	1498	1.158	1.510	77,755,591	785.4
GE 5.3-158	101	3948500	19	2088	0.000	2.105	76,600,581	760.7

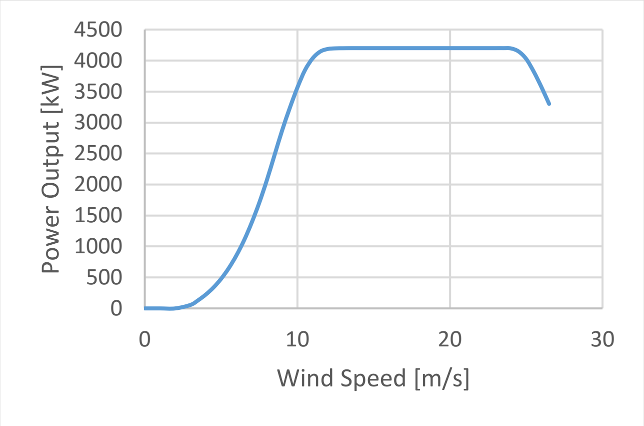

Figure 4. Power curve for the V136-4.2MW turbine.

To achieve the 100MW or less target nameplate capacity of the wind farm, a total of 23 V136-4.2MW turbines were placed in areas with high wind speeds and elevation. To minimize wake effects, a turbine spacing of 7-14 and 3-7 rotor diameters were used for the primary (NW/SE) and secondary (SW/NE) wind directions, respectively. Additionally, turbine locations had to abide by the setbacks listed under Meade County Ordinance 32 (County of Meade, 2019). Under this ordinance, a 2 times structure height (346m consisting of the tower height plus blade radius) setback was used for participating property lines, roads, and occupied residence building foundations and a 5 times structure height (865m) was used for non-participating property lines. The resulting turbine layout of the wind farm can be seen in **Figure 5** below.

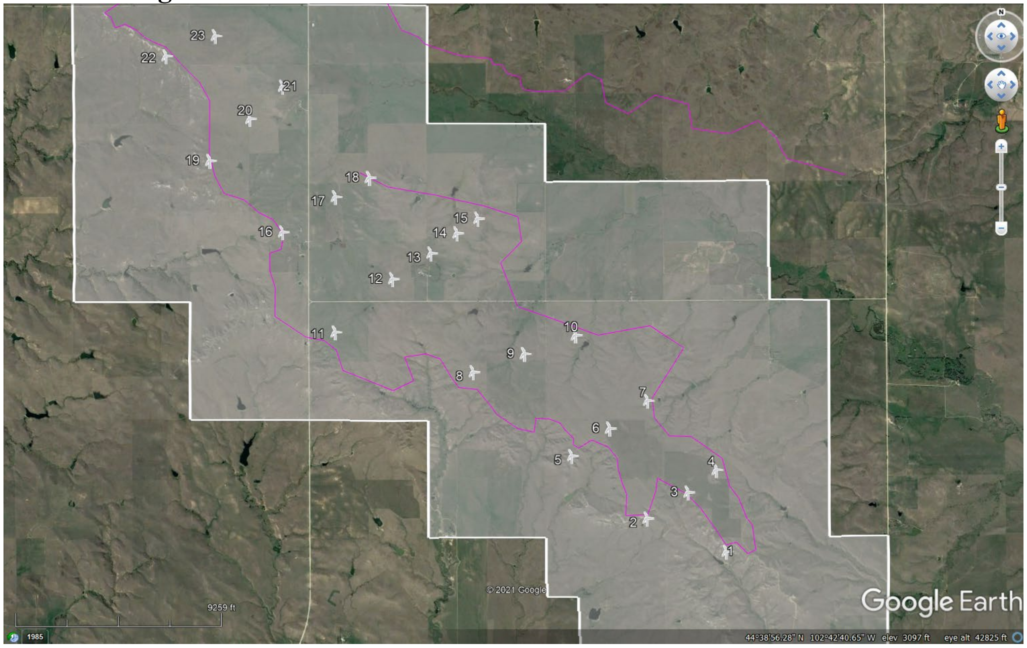

Figure 5. Turbine locations with project boundary & lines indicating elevation drops.

2.3.2 COLLECTION SYSTEM

The collection system for the Owl Ridge Wind Farm was designed to address the need of transmitting the electricity generated at the turbines to the grid. In total, 6 circuits were used to carry this electricity to the substation where the voltage is stepped up from 34.5kV to 230kV before being transferred to the existing transmission line. The power cables are sized to meet the electrical load of the project with 2 turbines being able to fit on a smaller cable size and 4 turbines being able to fit of a larger cable size. **Figures 6 and 7** shows the collector system layout and the accompanying one-line diagrams.

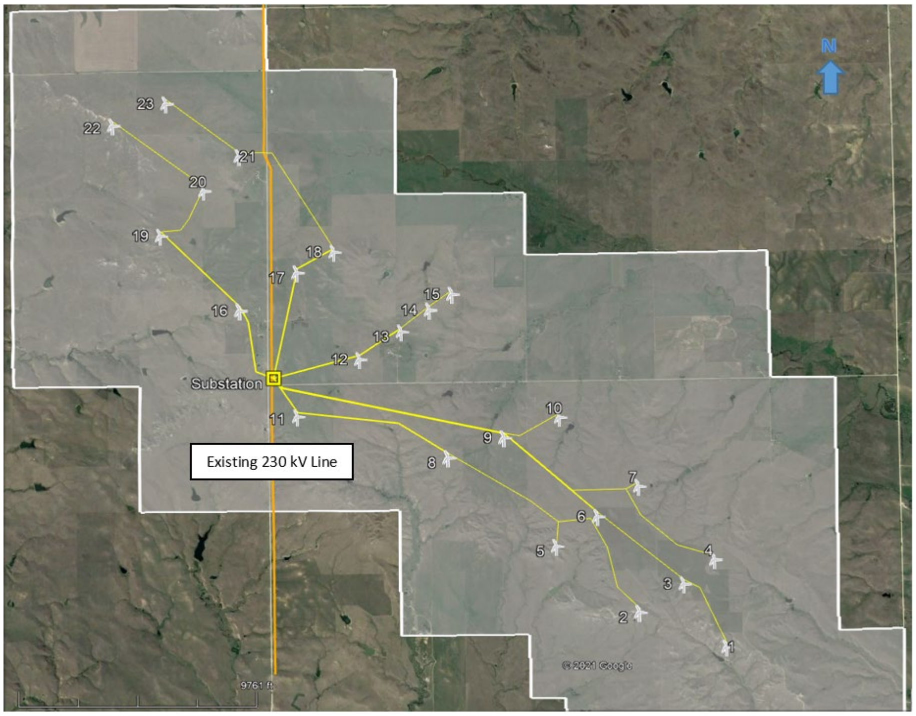

Figure 6. Collection system with location of turbines and existing transmission line.

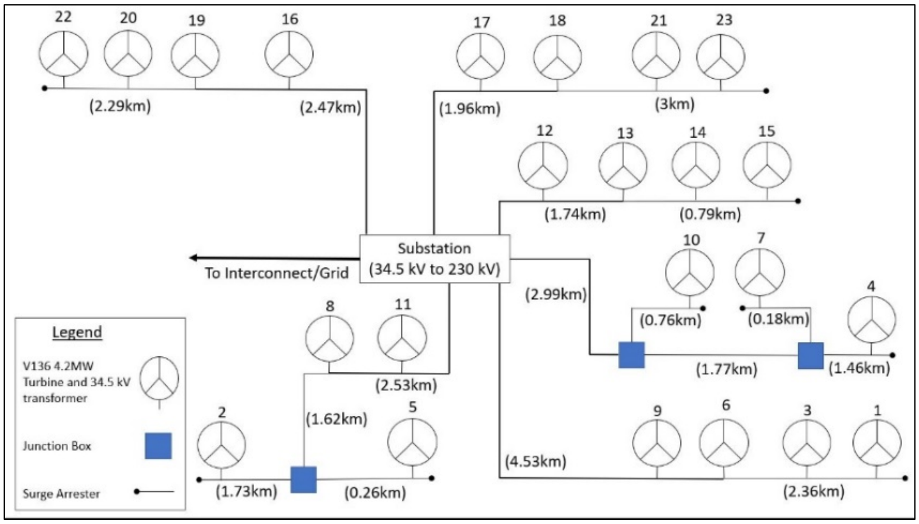

Figure 7. One-line diagram for proposed collector system at the Owl Ridge Wind Farm.

2.3.3 ACCESS ROADS

The access roads for the Owl Ridge Wind Farm were designed to optimize the delivery of turbines to each turbine location and also for operational and maintenance of the wind farm. A total of 54,966 feet (10.4 miles) of access roads will be needed to achieve this. The access roads are connected to the main existing roads of County Highway MC-27 from north to south and Upper White Owl Road that runs from west to east of the site. The access road layout is shown in **Figure 8** with the existing roads highlighted in green, yellow and red. A road design of 2% cross slope for drainage, 9 ft lane width, thickness of roadway of 20'' total with 12'' larger gravel stabilizing subgrade and an 8'' well-graded crushed gravel wearing course on top. The cross section of the access road is shown in **Figure 9** on level terrain.

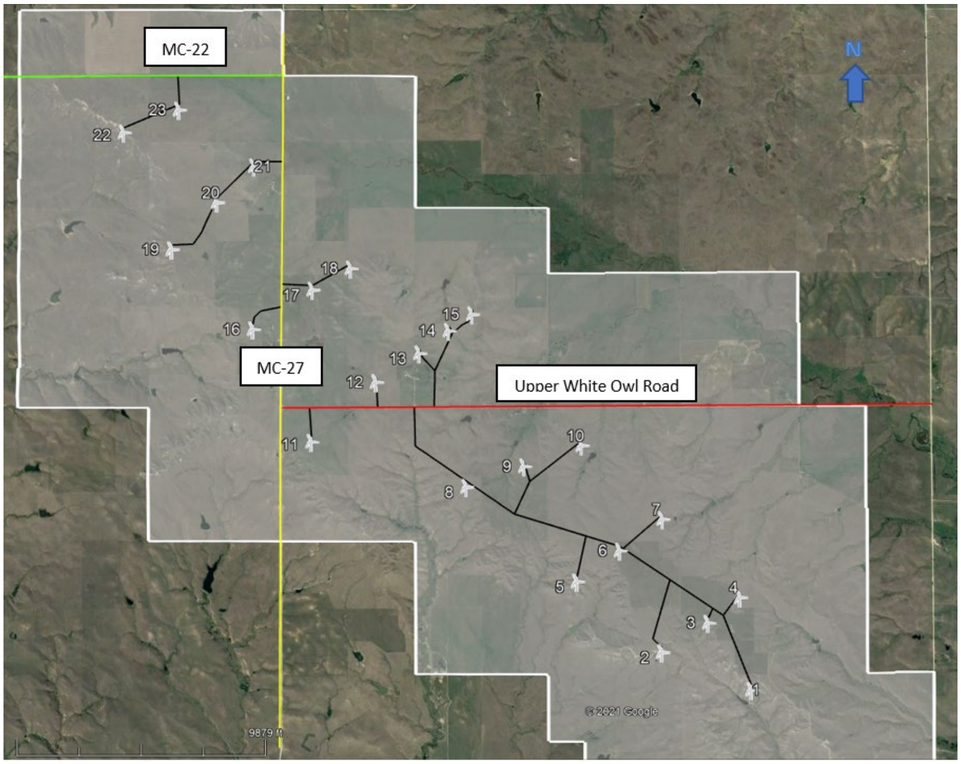

Figure 8. Access road layout and locations of existing roads.

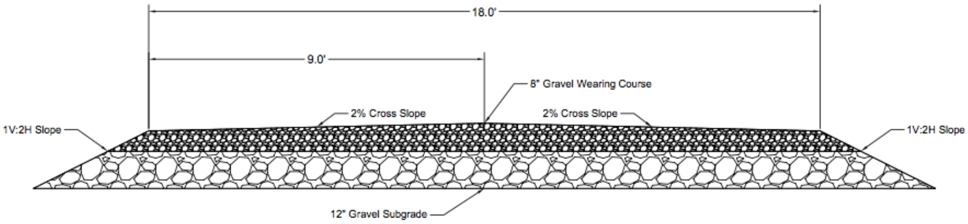

Figure 9. Access road cross-section design on level terrain.

2.3.4 LAYDOWN YARD & MONITORING FACILITY

The laydown yard is about 10.5 acres and can be accessed via the site along the Upper White Owl Road. It acts as a central hub for construction activities and provides ample space for contractor trailers, temporary equipment storage, dumpsters for disposal of wastes. The monitoring facility will be permanently built adjacent to the laydown yard. This 40’x60’ building will provide on-site engineers the ability to monitor the power production of the wind farm. The SCADA system will have a centralized computer system housed in the monitoring facility. The facility can also be expanded to act as an educational space where the public can engage with wind industry experts to learn more about renewable energy in general. Both the monitoring facility and laydown yard are shown in **Figure 10**.

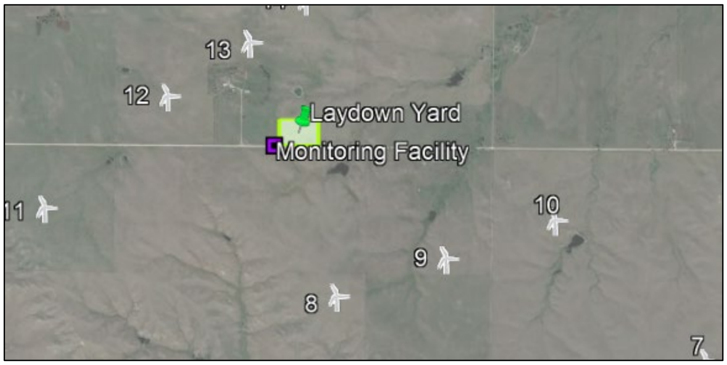

Figure 10. Locations of laydown yard and monitoring facility.

2.4 NET ANNUAL ENERGY PRODUCTION (AEP)

To estimate the energy generation from the Owl Ridge Wind Farm, turbine locations were assigned to the closest Wind Toolkit location. The wind data from these locations was vertically extrapolated to hub height (105m) and fit with a Weibull distribution shown in **Figure 11**. This was then combined with the V136 4.2MW's power curve, to get a gross Annual Energy Production (AEP) estimate of 431,615 MWh/year for the wind farm. Assuming an energy loss of 15% due to factors such as wake loss, electrical transmission, environmental conditions, turbine performance, and curtailment, the proposed project has an estimated AEP of 366,873 MWh/year and a resulting capacity factor of 43.3%.

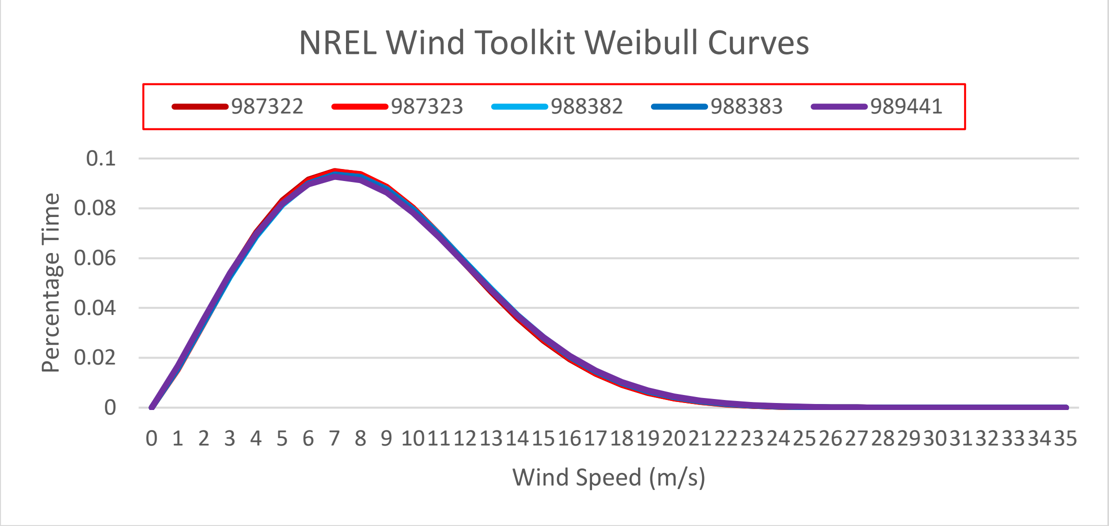

Figure 11. Weibull curves from the NREL Toolkit data.

2.5 ENVIRONMENTAL & COMMUNITY IMPACTS AND MITIGATION

As part of its development, it is essential to take into consideration any potential community and environmental impacts of the Owl Ridge Wind Farm. Addressing these impacts are very important as they will help improve the efficiency and sustainability of the wind farm by providing proper mitigation strategies while preserving and protecting the surrounding ecosystems and its inhabitants.

The Owl Ridge Wind Farm could affect species that occupy the area through direct mortality or habitat displacement. Birds and bats are at high risk of being killed by wind turbines due to the spinning blades and obstruction of airspace (Smallwood, 2013). Direct collision with the blades and towers is the primary source of mortality for bird and bat species at wind farms (Manville, 2009). Habitat displacement occurs through construction of the turbines and site infrastructure can fragment or destroy existing species' habitats causing a decline in population size and health. Additionally, roosting and hunting locations can be disturbed by the construction and operation of wind farms, causing additional stress on a species' population degrading its health. Based on the US Fish and Wildlife Service's *Information for Planning and Consultation (IPaC),* common endangered avian species in Meade County are identified as shown in **Table 3** below.

Table 3. Commonly threatened and endangered avian species in Meade County, SD (USFWS, 2021).

Mammals	
Northern Long-eared Bat (Myotis septentrionalis)	Threatened
Birds	
Least Tern (Sterna antillarum)	Endangered
Red Knot (Caldris canutus rufa)	Threatened
Whooping Crane (Grus americana)	Endangered

In order to understand what, if any, population impacts would have been caused by the development of the wind farm, it was recommended by industry professionals that a Before-After-Control-Impact (BACI) evaluation be conducted with respect to birds and bats and other species that could be affected by the wind turbines (Smallwood, 2013). This evaluation compares the abundance of species found before and after the site is developed. To make this study more accurate, searcher efficiency is calculated to account for missed observations. Additionally, scavenger removal must be estimated to determine if individuals are being removed before the searchers can find them (Manville, 2009). Upon conclusive evidence from the BACI study, if any significant impact to the populations of species' is deemed to have occurred at any of the wind turbines, the following measures should be used in any combination to try and reduce those impacts: increase the wind turbine's cut-in speed, slow or stop the turbine's blade movement, reduce operational hours of the wind turbines, curtailment during times of migration or breeding, and habitat reparations at nearby location(s). Ideally to further reduce species impacts, when choosing the turbine layout, areas of orographic lift and flight corridors would be avoided by implementing setbacks from these regions. To properly account for these factors, an analysis of the site's species' movements would be needed (NREL National Wind Technology Center, 2013).

The two main concerns when it comes to the community impacts are noise and shadow flickers that impact surrounding residents. Noise mitigation was incorporated in the 346m setback from occupied residents which will reduce the noise from the turbines to less than 50db at these residencies. Shadow flicker can be mitigated by constructing vegetative barriers near the residencies however most existing homes already have sufficient vegetative barriers to mitigate any shadow flicker effects from the shadows of the turbine blades. Another potential community problem is that turbines may interfere with microwave tower signals. However, no turbines are believed to conflict with microwave tower Fresnel zones and if they were, slight tower relocation for offending turbines would be able to solve this problem.

During project development, residents of Meade County are invited to townhall meetings to address social impacts from the project in order to build the community's acceptance. Also, research was done to ensure that the project layout does not interfere with culturally significant land especially with the large presence of Native American tribal community in the state. Strict adherence to local county ordinances and relevant regulatory requirements also helps guide the design process for reducing negative social impacts on the local community. Maintaining open discussions with the Meade County public intends to provide assurance by answering questions and addressing concerns throughout the duration of the construction and service life of the wind farm. Based on the conversations the team had with Meade County representatives from the Department of Equalization and Planning and the research done on the recent success of the Willow Creek Wind Farm in neighboring Butte County, it is clear that there is a growing interest and support in developing utility-scale wind projects in the region. Along with the local support and approval of Meade County residences, the Owl Ridge Wind Farm will leave a positive impact on the community and the state of South Dakota as it transitions towards more renewable energy generation.

3. OPTIMIZATION PROCESS

The optimization of the site layout for the Owl Ridge Wind Farm occurred through three different aspects: Turbine Locations, Collection System, and Access Roads. Turbine locations were optimized first with access roads and the collection system optimized afterward. The design of each of these three components of the wind farm sought to improve energy production and/or reduce balance of plant costs.

The first step in the optimization of the turbine locations was to situate them in the regions with the fastest wind speeds; the flat planes at the top of the hill. Starting out, the turbines were grouped quite closely together with minimal rotor diameter spacing. After looking at the elevation profiles across the site area, it became clear that there was plenty of room to expand the turbines and severely reduce wake loss effects thus boosting the energy output of the wind farm. As the turbines became more spread out, it was important to maintain the highest areas of elevation as those spots usually have the best wind resource. A secondary goal of turbine location optimization was to minimize the agricultural/grazing space taken up by the turbines so that the landowners of the fields are kept happy and their land usage is not impaired.

After the locations of the turbines were finalized, the optimization of the collection system began. The first step in this process was to determine the locations of the substation which was located as close as possible to the existing 230kV transmission. Next, the location and size of each cable connecting the turbines to the substation was planned given that each cable size could hold the current of two additional turbines. To minimize the length and sizing of cable needed, junction boxes were used to connect individual turbines to the rest of the circuit as the cable size increase. The final step in optimizing the collection system was to check the slope of each of the cable paths. This was done because the trenching machines have a threshold slope after which they cannot be operated safely. This threshold slope was estimated to be around 15%.

During the collector system optimization, the access roads were also optimized. In order to reduce costs, the least amount of road was desired and thus a branching network of roads was used to accomplish this. Much like the collection system, the roads were each checked for their slopes. A threshold of 10% was used to ensure safe turbine delivery to each of their locations.

4. FINANCIAL ANALYSIS

4.1 MARKET OPPORTUNITIES

The energy landscape in South Dakota is shifting towards renewable energy generation especially since the state has one of the highest capacity factors for wind energy (Office of EERE, 2018). As coal powered generation is becoming more uneconomical compared to solar and wind energy sources, there is an increasing demand of wind projects to go online as more coal plants are being retired (Gimon, Myers, & O'Boyle, 2021). This is favorable for wind project development and the Owl Ridge Wind Farm is expected to attract various equity investors. With the growing adoption of wind energy generation in the region, utilities within the Southwest Power Pool (SPP) are a likely source for buying electricity for meeting their energy and capacity needs as well as their state's Renewable Portfolio Standard. Basin Electric Power Cooperative, based in Bismarck, North Dakota, is one of these utilities having purchased more than 360 MW of capacity in order to meet their load and resource adequacy requirements in 2020 alone.

4.2 REVENUE

The revenue stream from the project will come from three sources: a power purchase agreement (PPA) consisting of an energy generation component and a capacity component, the Modified Accelerated Cost Recovery System (MACRS) federal incentive program, and the Production Tax Credit

(PTC) federal incentive program. A 20-year power purchase agreement (PPA) will be established between WiscWind, WAPA, and Basin Electric Power Cooperative, both within the SPP region to purchase energy generation and also capacity credit. Under this PPA, it is assumed that this project will have a rate of $20/MWh which is consistent with the average wind PPA prices in the SPP region (Berkeley Lab, 2020) (Level10 cite). An effective load carrying capability (ELCC) study found that the capacity credit percentage for SPP is at 16% of nameplate capacity for wind projects (Haley, 2019). This is to ensure that SPP will have sufficient capacity to serve peak demand obligations. For the price of the capacity credit, it was assumed to be $250/MW-day since that was the cleared price for the Cost of New Entry (CONE) in MISO market Zone 7 and no numbers were found for the SPP market (Resource Adequacy Sub-Committee, 2020). An annual reduction of 2% was added to the AEP to account for turbine component degradation which will result in an annual 2% loss in revenue generated from selling energy under the PPA.

At the end of 2020, Congress extended the Production Tax Credit (PTC) at 60% of the full credit amount assuming the anticipated start of construction is before 31 December 2021 (US EIA, 2021), the Owl Ridge Wind Farm will be eligible for the $0.018/kWh tax credit. Assuming this PTC rate and a 10% fee for the bank to convert the tax credit to cash equity, each year taxes will be netted out and the remaining balance will be cashed in at the bank to reduce debt.

The MACRS is a system that is used to recover investments by accelerating its depreciation. The Owl Ridge Wind Farm will operate under the 5-year schedule with depreciations at 20%, 32%, 19.2%, 11.52%, 11.52%, and 5.76% from year 1 to year 6 respectively.

4.3 COSTS

4.3.1 CAPITAL COSTS

The total capital cost was estimated at $121,390,231 for the Owl Ridge Wind Farm and can be viewed as three main items: turbine costs, balance-of-plant costs, financing costs. The breakdown of the capital expenditures is represented in **Figure 8**.

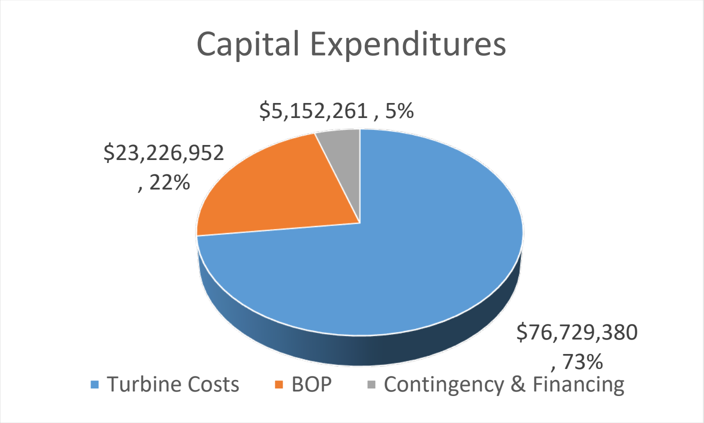

Figure 8. Breakdown of the capital expenditures for the Owl Ridge Wind Farm.

The turbine costs consist of the turbine production and transportation costs. The turbine production cost was estimated to be $ 73,251,780 based on the rate of $758.3/kW per turbine, which was obtained from industry professionals. The transportation cost was determined to be $ 3,477,600 based on the $36/kW rate from the Rush Creek Wind Project in Colorado using propriety data from NREL's WISDEM model (Stefek, Kaelin, Tegen, Roberts, & Keyser, 2019). It's a costly feat to transport the blades, towers, and other parts to the site location since larger and more sophisticated equipment such as Schnabel trailers are needed to mobilize these large structures. The balance-of-plant costs (BOP) include the construction costs for turbines, access roads, electrical infrastructure, laydown yard, and monitoring facility, and also the engineering/technical fees. Along with the Civil & Environmental Engineering capstone group at UW-Madison, the construction costs were estimated using RS Means and opinions of faculty advisors and industry professionals. A 3% fee for necessary engineering and technical services was assumed. The cost of new substation of $ 2.5 million was estimated based on a case study on a similar project by Carroll Electric Cooperative Corporation in Arkansas (Rivera-Linares, 2018). For the costs of setting up access roads and collection cables, $25/LF and $40/LF unit rates are applied based on the experience and recommendations of industry professionals. The contingency was assumed to be 5% of the turbine costs since that's the most expensive component of the entire project. The construction financing cost was assumed to be 2.5% of the BOP cost. Both numbers are taken from the NREL Cost of Wind Energy Report 2019 (Stehly, Beiter, & Duffy, 2020).

4.3.2 OPERATIONAL COSTS

The operational and maintenance cost of the Owl Ridge Wind Farm are annual (recurring) costs that are necessary for the smooth operation of the project. The total annual cost for the operational expenditures of the wind farm was estimated to be $2,629,710. Three main components of the operational cost were estimated and represented in **Figure 9**, which are the turbine O&M costs, land leases, and insurance.

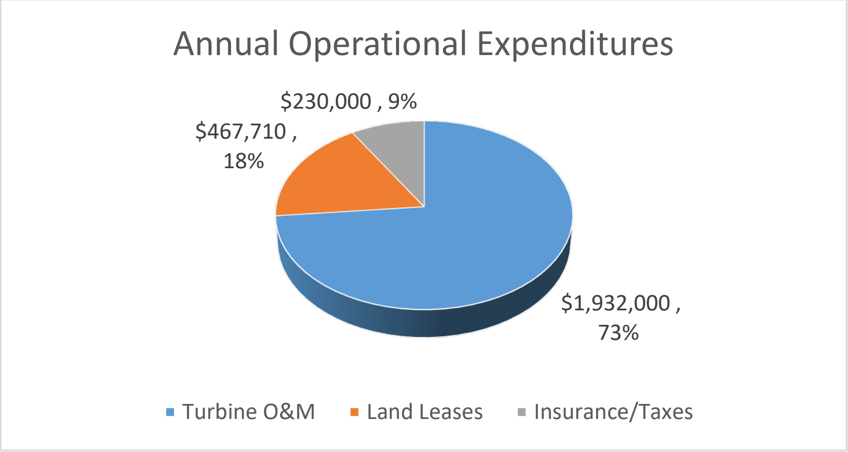

Figure 9. Breakdown of the operational expenditures for the Owl Ridge Wind Farm.

An average of $20/kW-yr on a levelized basis was assumed for the land-based turbine O&M costs based on data from a recent survey of wind industry experts (Wiser, Bolinger, & Lantz, 2019). Given the size of the project, this total cost was determined to be $1,932,000 considering the project has 23 Vestas 4.2MW turbines. Since the project will be operating on leased lands that have existing owners, it is imperative to consider the costs of land leases as an annual operating expense of the project. Based on information from a lease agreement of a similar wind project called the Deuel Harvest Wind Farm, unit leasing rates were assumed for the turbines, access roads, and trenched cables as $ 4000/MW/year, $ 1/LF/year, and $ 0.25/LF/year respectively (SDPUC, 2018). The final land leasing cost is calculated to be $467,710 per year. Another ongoing cost is insurance. Insurance is needed to cover turbine warranty, general liability, equipment protection, business income, and more. The cost of insurance is estimated based on data from Windustry, which cited a range of $8000 to $15,000 per year for each turbine (Windustry, 2007). A value of $10,000 per turbine per year was estimated as the cost for insurance and add a cost of $230,000 per year. An annual escalation of 2% was added to the O&M costs to account for the increase on the cost of living for wages and supplies.

4.3.3 DECOMMISSIONING

After is usable lifetime Owl Ridge Wind Farm will need to be decommissioned. It is anticipated that the total net decommissioning cost for the Owl Ridge Wind Farm will be offset by the salvage value of the recovered materials. The salvage value depends on the volatility of the market price of recycled materials like steel and copper. The salvage value can be estimated based on the weight of the turbine. About 85% of turbine component materials such as steel, copper wires, electronics can be recycled or reused (Gignac, 2020). A typical turbine consists of metallic materials such as the tower and nacelle that can be salvaged while fiberglass composite materials like blades and rotors may have to be hauled to landfills. The current (national average) market price for steel is $158 per ton as of 2021 (iScrap, 2021). The weight of the steel components in a typical turbine is 230 tons (Consumer Energy Alliance, 2009). Assuming a decommissioning cost of $445,000 per turbine as estimated based on 3 different wind projects in the Midwest, the net decommissioning cost is calculated to be $408,660, which totals up to $9,399,180 in 2021 dollars (Zelenak, 2017).

4.3.4 TAXES

There were three main tax categories identified that would affect the cash flow of the wind farm: income, sales and use, and property tax. South Dakota does not levy a state income tax however the 21% federal corporate income tax still applies (Tax Policy Center, 2021). Sales and Use Tax can be ignored through South Dakota's "Renewable Energy Facility Sales and Use Tax Reimbursement" incentive program covers the full amount of money that would be paid to this tax (DSIRE, 2021). Talking with Meade and Butte County representatives from Department of Equalization and Planning, property taxes will not be affected by developing the wind energy system because the vast majority of land is zoned as agriculture and the turbines and infrastructure do not alter the soil or land use.

4.4 FINANCING

The project will be financed through a combination of sponsor equity & bank loans through the financing mechanism of partnership-flip with debt. A debt-to-equity ratio of 80:20 will be assumed in order to attract potential investors while still able to acquire the necessary bank loans. By forming a limited liability company (LLC) with outside investors, this entity includes both the developer and investors and serves as the special purpose vehicle (SPV) in this partnership. A typical interest rate of 6% was assumed in our financial analysis to account for the time value of money and inflation.

A unique opportunity worth pursuing is the EPA's Green Power Partnership (GPP) Program, which has become more popular in recent years. By seeking buyers of clean power among GPP members, the project can obtain a positive cash flow while the buyer organization will be able to fulfill their renewable energy goals. The mechanism works by an entity purchasing renewable energy credits (RECs) to offset their carbon emissions. The clean power generated is then sold to the regional grid operator, which is the Southwest Power Pool (SPP) in this project. A similar case study was reflected upon in which Boston University purchased 205,000 MWh of electricity from a wind farm in South Dakota as they seek to cut campus and global operations emissions to zero by 2040 (Barlow, 2020). There are many opportunities to establish a strong partnership with over 700 GPP members that have collectively been using 70 billion kWh of green power annually (USEPA, 2021).

4.5 CASH FLOW DIAGRAM

Figure 10 represents the projected cash flow diagram broken down into individual components of annual profits and losses of the Owl Ridge Wind Farm over a 20-year timespan.

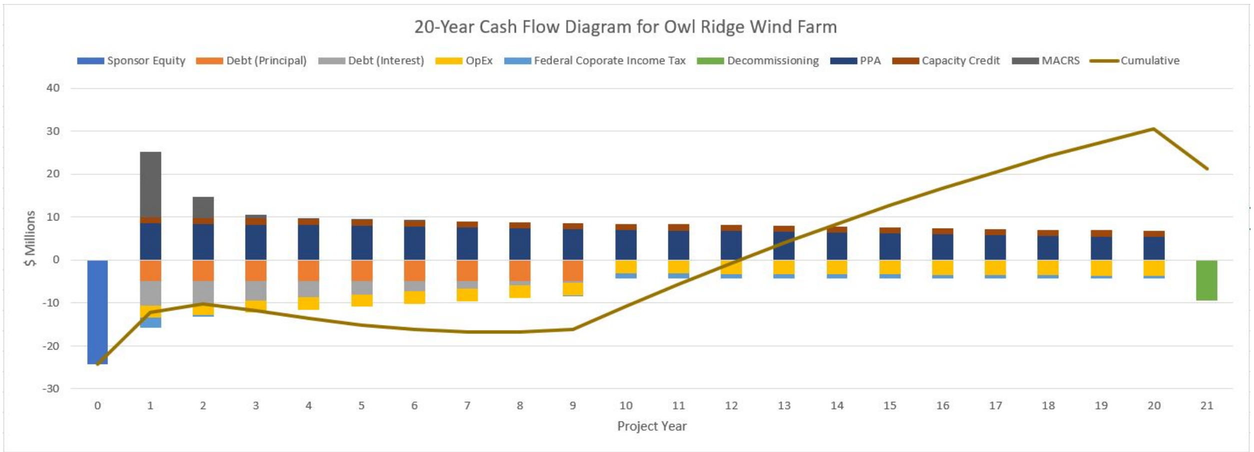

Figure 10. The 20-year projected cash flow for the Owl Ridge Wind Farm.

Under this financial analysis the Net Present Value (NPV) is $79,610, the LCOE is $0.0254/kWh, the Return On Investment (ROI) is 2.26, and the Internal Rate of Return (IRR) is 7%.

5. RISKS & FATAL FLAWS

Wind energy projects are typically capital intensive with large upfront costs and dependent on various market conditions and financial incentives. Hence, it is crucial to identify project risks and determine ways to mitigate them early on in order to keep the project financially viable and the investors comfortable in accepting the risks. The risks associated with onshore wind projects are categorized into 6 groups: preconstruction energy estimation, construction, project development, regulatory, market/selling price, technology/energy production (Schwabe, Feldman, Fields, & Settle, 2017).

Fatal flaws are necessary to be identified as soon as possible to determine if a site is worth investing significant development time and capital. Two main fatal flaws for the Owl Ridge Wind Farm are the availability of electrical interconnection (capacity) and the accessibility of the site. For grid interconnection purposes, a Generator Interconnection Request (GIR) has to be formally submitted to the SPP, which includes a Three-Stage Interconnection System Impact Study and fees associated with it. The interconnection study can provide clarity on the current capacity of the existing grid infrastructure and determine if adjustments are needed for the project to move forward. The site is determined to be accessible by high-level desktop survey of the area via Google Earth and other GIS mapping tools. The project layout is designed to allow direct access from the main county highway MC-27 and a few other existing roads. Road improvements are needed specially to accommodate the large turning radii for turbine delivery and to repair the roads where necessary to maintain its original condition. However, site visits are necessary to identify potential areas of limited setbacks, potential flooding, and other constraints that were not easily identifiable from researching online.

6. CONCLUSION

After conducting a high-level site selection, WiscWind carried out a thorough site design and financial analysis for the 96.6MW Owl Ridge Wind Farm in Meade County of western South Dakota. Once the turbine model is selected and the annual energy production is estimated, the site layout is created via multiple optimizations. By obtaining cost estimates from various credible sources and industry professionals, a cash flow diagram is constructed and key financial metrics like IRR, NPV, and LCOE were calculated. The results of the financial analysis were also based on assumptions and best practices that were determined in case studies and industry reports. It was determined that the project will be financially feasible in the current market.

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