COMET WIND

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Project Development Report

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Executive Summary

This report details the plan developed by The University of Texas at Dallas Collegiate Wind Competition (CWC) team (otherwise known as the Comet Wind team) to construct an offshore wind farm in the waters of Port Fourchon, Louisiana located in the US Gulf of Mexico. Comet Wind has determined that the farm is to use thirty-two Vestas V164 turbines arranged in a parallelogram-style formation in order to minimize wake effects. Through careful consideration of various environmental siting factors, and optimization analysis conducted using Solute's Furow and NREL's System Advisory Model, our team has painstakingly considered the benefits and drawbacks of each auction block and decided to place a bid on blocks 216 and 217 in Lot 6A.

Although the Louisiana coast contains many obstacles to offshore wind development in the form of oil lines, fishing areas, and shipping lanes, Comet Wind firmly believes the development of the proposed wind farm (known as Bluestar Farm) is a lucrative opportunity for businesses hoping to enter the world of clean energy. With an LCOE of 103 $/MWh when using a conservative capacity factor, Bluestar Farm provides investors with the opportunity to compete with endemic oil industries, all the while minimizing risk of incurring damages or otherwise disrupting the local environment thanks to a thorough study of the economic and environmental factors for the provided lease area. Financial analysis has shown that with the combination of the Investment Tax Credit, loans received at the industry standard rate, and the use of a partnership flip structure, Bluestar Farm offers a rate of return approaching 10% which is above the current expected rate for offshore wind farm projects.

Throughout the body of this report, Comet Wind will discuss its intended implementation for an optimal offshore wind farm through an analysis of site characteristics, a discussion of the farm's design, plans for energy transmission, evaluation of potential environmental impacts, and finally an outline for the operations and maintenance to be performed.

Site Description & Analysis

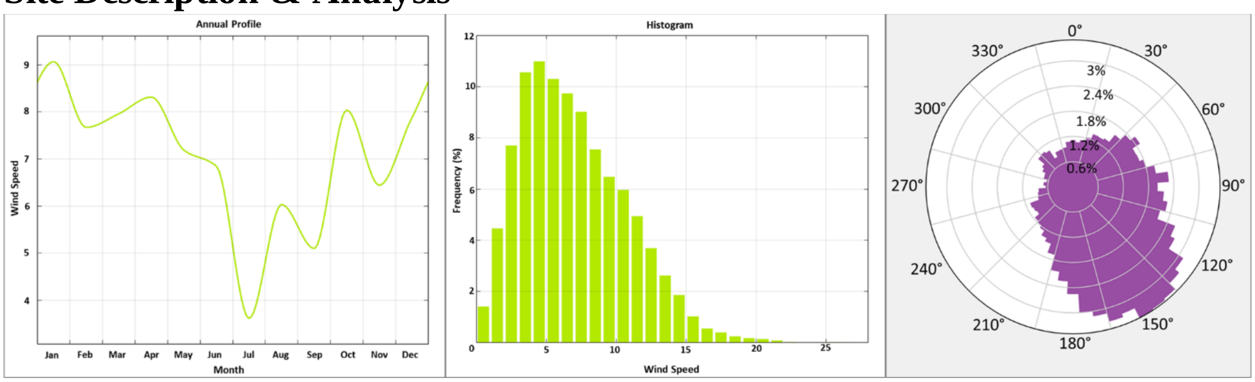


Figure 1. Wind activity at 120m of blocks 216 and 217 in 2017. Left: Annual wind speed profile. Center: Annual wind speed frequency. Right: Wind rose plot for lease blocks.

Based on relevant factors such as wind speeds, bathymetry, the presence of critical assets, and finally various port activities, Comet Wind was able to narrow down the selection of lease blocks. Ideally, we desire to select two neighboring lease blocks within the auction area to provide an optimal design space for Bluestar Farm. With this additional constraint, we were able to narrow down our selection to three optimized pairs that were clustered within the western section of Lots 6 and 6A. Using Furow simulations, as seen in **Figure 1**, we were able to look at WIND toolkit data at 5-minute intervals to visualize wind roses and wind speed information to select Lease Blocks 216 and 217.

Although wind speeds are the primary consideration when planning any wind farm, wind speed data for the Louisiana coast was not a deciding factor in the block selection process because wind speeds tended to be nearly identical across the available lease blocks. Using the NREL WIND Toolkit [1], our team found the yearly mean wind speed at a height of 100 meters for 590 locations within the lease block area as seen in **Figure 2**. The general wind speed of the area was 7 m/s which validates the existing wind resource maps for the coast of Louisiana [2]. Wave height also tended to be similar across the auction area, with values ranging from 2 to 2.5 meters during Winter weather. Additionally, the ocean floor composition throughout the entire auction area is composed mainly of mud and sand [3].

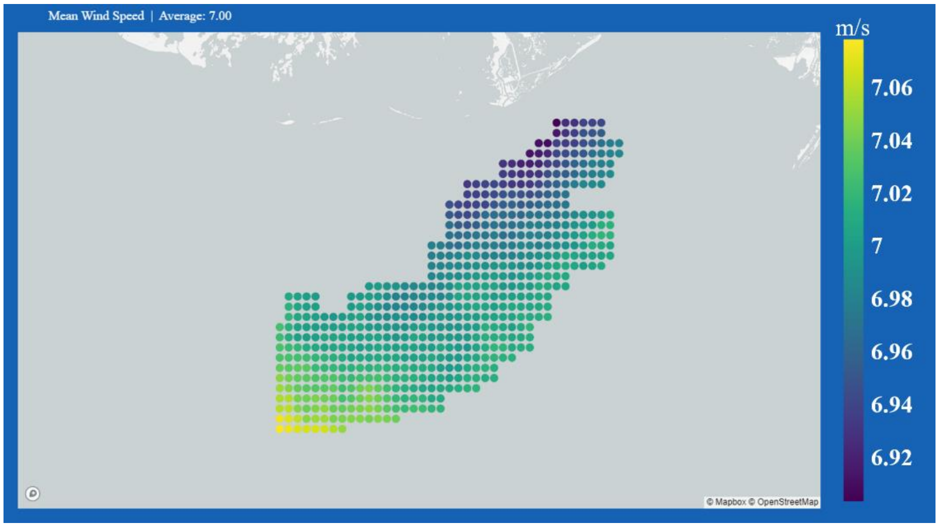


Figure 2. Mean Wind Speeds within Auction Area visualized in NREL's reView software.

Given this information, Comet Wind prioritized other site factors in its decision to purchase blocks 216 and 217 such as bathymetry, oil line placement, shipping and fishing activity, military operations, and potential ecological disturbances, as described in each of the subsequent paragraphs.

According to the World Bank's Energy Sector Management Assistance Program, fixed offshore wind turbines are suitable for water depths of less than 50 meters [4]. Using this information, we filtered through all lease blocks using bathymetry data from Marine Cadastre, a data visualization software that is capable of referencing information from data platforms such as those from the Bureau of Ocean Energy Management. In this case, we discovered that all auction blocks in Lot 7A were located in the Mississippi Canyon, containing depths ranging from 60 to 110 meters. Additionally, lease blocks located in the southern portion of the auction area were eliminated as ocean depth increased to beyond our search criteria [5].

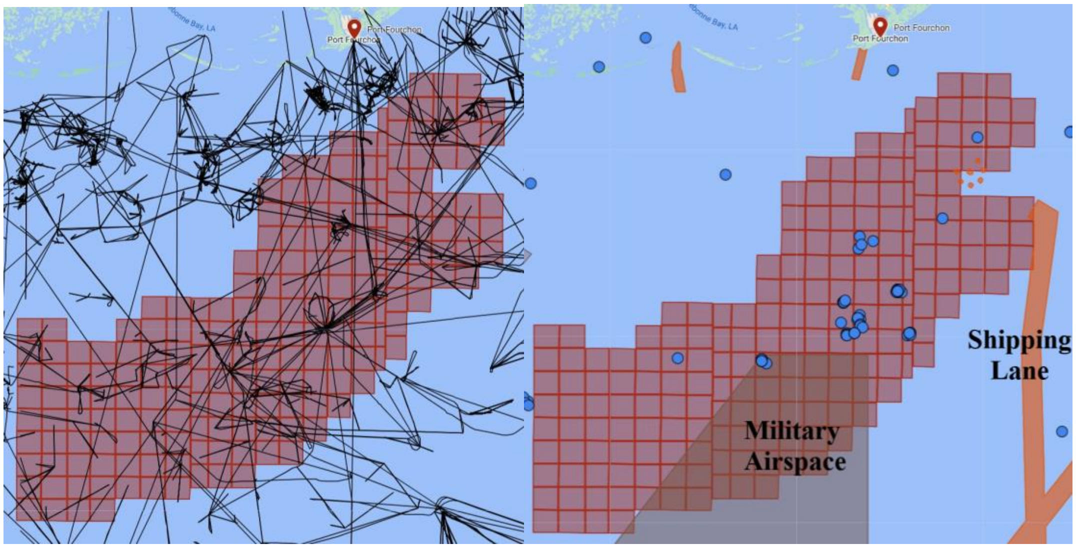


Figure 3A-B: Images made with Google My Maps showing oil lines (black) and shipping lanes (orange), artificial reefs (blue), and military zones (brown) [5][6].

With the remaining lease blocks, we considered present oil lanes and drilling platforms as they are clustered in high densities within the auction area. Being close to these structures would raise risks, such as oil spills and legal repercussions, to the development of the wind farm and environmental considerations. In this specific case, there are no favorable lease block selections that do not contain an oil line, so we reduced our criteria to lease blocks that had favorable conditions for site development. The construction of the wind farm would require large shipping vessels and drilled foundational structures; therefore, lease blocks with multiple clusters of oil lines as seen in **Figure 3A** were removed from consideration.

Another consideration is shipping lanes, as commercial regulations require boats to travel along a designated route and government jurisdictions prohibit construction in these areas. In this case, the nearest major port near the auction area is Port Fourchon, a seaport that accommodates nearly all the oil industry in the US Gulf of Mexico and focuses on expansion to accommodate other sectors such as product refinery and deep-sea exploration. Additionally, Fourchon's facilities contain wide slips up to 1,000 feet wide and 7,000 feet long to accommodate large quantities of vessels [7]. This implies that lease blocks within and slightly around these zones would not be viable as the wind farm would be obstructive and increase the risk of damage as the vessel density would be higher within these areas. Therefore, lease blocks in relatively close proximity to Port Fourchon and those within commercial boating lanes were eliminated from our selection as seen in **Figure 3B.** This decision was supplemented by using an automatic identification system (AIS) map to identify lease blocks with the lease amount of vessel presence and fishing activity [8]. This decision will result in a greater distance from the maintenance port, but is considered an acceptable tradeoff in order to avoid interfering with the aforementioned sectors and potentially damaging the local economy.

Military zones are present within the auction area within Lot 6 and 6A. Within this specialized airspace, any wind disturbance would impact government operations as aircraft performance can be influenced by the presence of wind turbines [9]. With this in mind, the team omitted any lease blocks within the sanctioned area which has also been shown in **Figure 3B.**

The Gulf of Mexico Fishery Management Council has designated and described Essential Fish Habitats (EFHs) located throughout the auction area. This includes sanctioned marine and coral biomes containing species such as shrimp, reef fish, coastal migratory pelagic fish, and red drum [10]. Comparatively, fishing lanes and fisheries can be considered constant throughout the region of the auction area as seasonal marine game [3]; therefore, our research criteria prioritize the placement of artificial reefs, marine sanctuaries, and EFHs [5]. In this case, the eastern portion of Lot 6 contains multiple man-made reefs that can be environmentally disrupted by the construction of an offshore wind farm and lease blocks surrounding the area will be filtered out.

One example of a potential risk or possibly a fatal flaw within the lease block area as a whole can be seen through meteorological data which shows that the auction area has experienced extreme natural disasters such as Hurricane Ida and Katrina and could likely experience category 4 and 5 wind speeds ranging from 130 to just above 157 mph [11] in future hurricane seasons [12]. Similarly, buoy data records significant wave height of 16.9 meters and records from the NOAA NDBC suggest that the maximum wave height could potentially have been 32.1 meters within the auction area during these periods. These calculations were based on collapsed buoy data, meaning the wave heights during the hurricane(s) may have exceeded this value [13]. The Comet Wind team will be emphasizing these factors in the wind farm design section.

Wind Farm Design and Energy Estimation

The turbine model selected for use on Bluestar Farm is the Vestas V164 – 9.5 MW turbine with a rotator diameter of 164 meters. This turbine has a cut-in speed of 3 m/s and a cut-out speed of 25 m/s meaning it will be able to safely handle the range of wind speeds within the selected lease blocks, and should be able to generate power for the vast majority of the year under stable weather conditions [14]. Based on the rotor diameter, a minimum hub height of 82 meters (or half the diameter) is required. During extreme weather conditions such as a hurricane, wave height could potentially reach upwards of around 30 meters as mentioned previously. With this in mind, although the hub height of the Vestas turbine is variable, we plan on building at a height of 120 meters to maximize power generation and minimize installation and manufacturing costs, as well as any ocean interference.

The foundation style that we plan to use for the turbine are twisted jacket foundations, which provided additional protection against hurricane damage and can be provided by Louisiana-based labor in the case of Keystone Engineering [15]. Jacket foundations will also be a better fit for the soft soils of the US Gulf of Mexico area compared to other foundation options like the monopile [16].

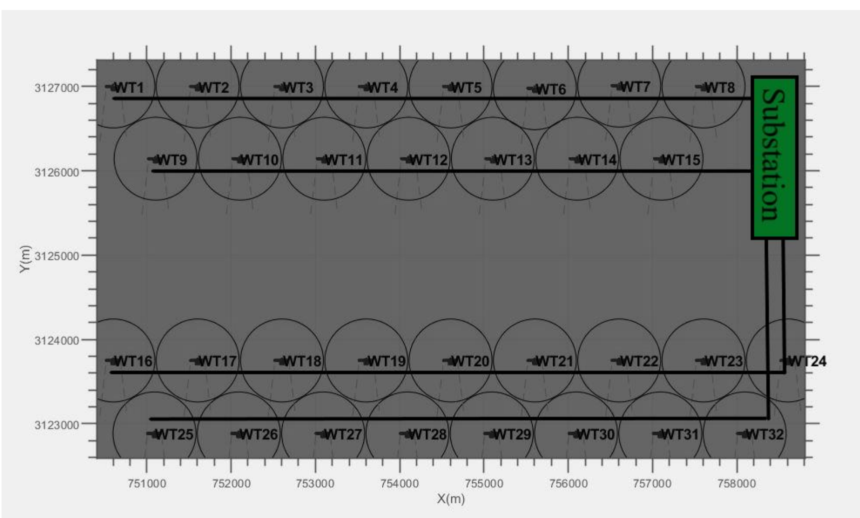


Figure 4. Bluestar Farm Site Layout in Lease Blocks 216/217 in Lot 6A.

Regarding the potential losses in produced energy due to wake effects of multiple turbines in relatively close proximity, we plan to space each turbine at a minimum 3 rotor diameters apart from nacelle to nacelle [17]. Bluestar Farm will consist of four rows of turbines, with each pair of rows being grouped into trapezoidal formation as seen in **Figure 4**. With this pattern in mind, Comet Wind utilized the Furow software to optimize energy yield based on the Bastankhah wake effect model. Although net energy capacity was the main concern with turbines of this scale, other factors such as installation and maintenance costs for each turbine were also considering before settling on having thirty-two turbines on the farm.

The site will also include an offshore substation located in the north eastern corner of the lease blocks, which is illustrated by the top right corner of **Figure 4**. Transmission cables will run from the substation through the middle of each "group" of turbines. For example, a line will run between the first and second rows, and another that goes toward the bottom of the farm and runs between the third and fourth rows.

This spacing pattern ended up yielding a farm of 32 Vestas turbines, which differed from the original 24 turbines as mentioned in the preliminary report. The addition of these new turbines allowed for an increase of 127.9 GWh in terms of the net energy produced, which outweighs the added $288.8 million dollars in initial investment for long term profit margins. As such, Comet Wind opted to make use of the extra space available in the lease blocks by adding as many turbines as possible without compromising on the effectiveness of each individual unit. Overall, the final site layout experienced wake effect losses of around 7.95%. This led to a final net energy capacity of around 28%, which translates to around 682.11 GWh of total production after accounting for unavailability and other issues using standard industry values.

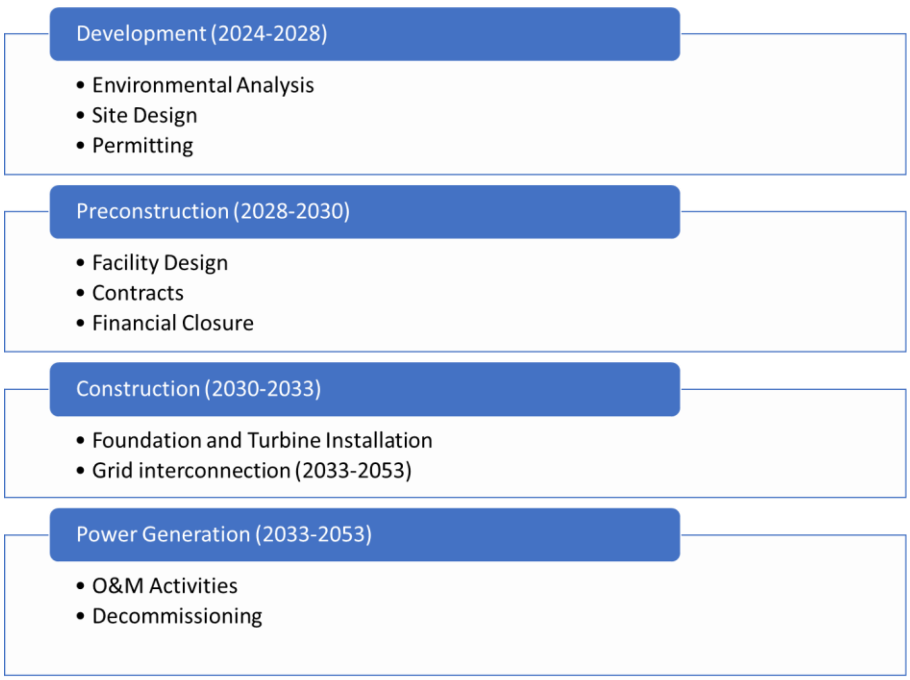


Figure 5. Project Timeline

According to Spanish renewable energy corporation Iberdrola, the timeline for construction of an offshore wind turbine generally follows the design flow outlined above. The development, involving environmental analysis (of factors such as presence of aquatic and avian life), site design (including port activities), and permitting (legal processes) will take approximately 4 years to be completed. Preconstruction will last for about two years, and includes facility design (distance from substation(s)), contracts (supply chain/size of labor decisions), and financial closure (document signage and capital inflow from investors). Then, following preconstruction, construction of the foundations and turbines as well as grid connections will take place for another three years. The wind farm would then be fully functional, and its twenty-year lifetime would begin, in which it undergoes O&M and at the end of the project's lifetime, decommissioning.

Transmission Plan

Louisiana in recent years has worked tirelessly to improve energy opportunities and accessibility for the public. We plan to use the onshore Entergy substation located next to the beach at Grand Isle. This substation was recently upgraded for resilience to storms and winds up to 150 mph [18] following Hurricane Ida. Alongside the upgrades to the substation itself, Entergy along with the Army Corps of Engineers are initializing a $122 million project towards repairing Grand Isle's storm defenses [19].

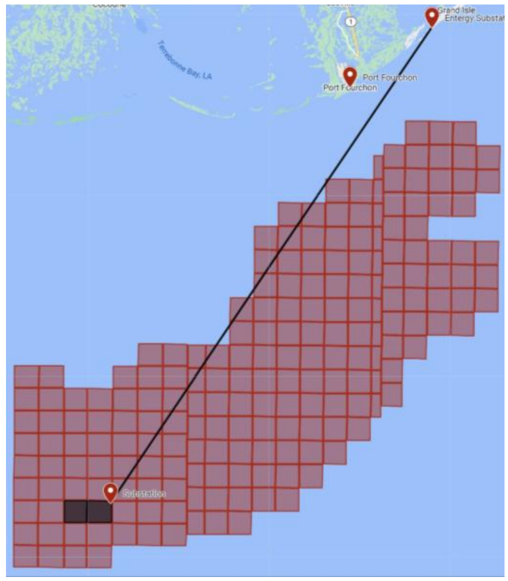


Figure 6. Transmission and Interconnection from Bluestar Farm to Entergy Substation

Bluestar Farm plans to utilize direct current as opposed to alternating current considering the furthest point of the lease block is around 115 kilometers (70 miles) from the shore as seen in **Figure 6**, which exceeds the generally accepted "break-even distance" of 50 kilometers for underwater HVDC cables [20]. This will require the creation of an offshore substation in close proximity to the turbines, ideally positioned near the northeast side of the farm to minimize distance to the Entergy substation. With the turbines having a nominal voltage of 66 kV, the HVDC cables will connect the array to offshore substation and directly to the onshore station, approaching the shore from the North towards Louisiana Highway 1. An onshore substation transformer would be utilized to convert the voltage back to a three-phase 138 kV alternating current, which can then be connected to the main line on Highway 1. This would allow the newly generated power to be sent into Entergy's Louisiana power grid, thereby becoming available for consumption.

Although the usage of HVDC technology and the creation of an additional offshore substation would require greater initial investment, we believe it will lower overhead and open the port Fourchon area to more opportunities with offshore wind in the future. Based on current development patterns, offshore wind will be supported through the expansion of the electricity grid, leading to a sustainable solution to provide clean energy for an expanding population.

We plan to use the onshore Entergy substation located in Grand Isle, as it is both the closest power station and has recently undergone upgrades to increase its resilience to storms, which will increase the reliability of our wind farm. Because the lease blocks we selected fall further than 30 miles from our desired onshore power station, we will have to convert the generated power from AC to DC, which reduces power losses over long distances [21]. This will require an offshore substation to be built to handle this conversion, which will increase initial costs but result in less energy loss over the life of the farm, thereby increasing profits and efficiency in the long run. Further, the existence of an offshore substation will allow the possibility of interconnection with future wind farm projects, increasing the viability of the US Gulf of Mexico as an offshore wind farm location.

Environmental Impacts and Mitigations

Wind project installations have the benefits of creating habitats for marine life, increasing marine ecosystem biodiversity, and improving scavenging opportunities for certain species of fish and other mammals and birds [22]. According to a project done by the NOAA in Atlantic waters, the effects of offshore wind farm development can be monitored by tagging fish such as cod and then monitoring said fish via an autonomous underwater glider over an extended period of time [23]. The telemetry data gathered can help identify spawning and gathering hotspots for key species, and how these patterns change over time in response to development of lease block areas. Similar measures can be taken for Louisiana's offshore wind projects to monitor long-term effects on local fish populations.

Underwater noise caused by foundation installation can potentially injure or disrupt the natural behavior of organisms such as fishes, sea turtles, and some mammals. Side effects include fleeing, hiding, and startling, which can also interrupt certain migratory patterns and other movement behaviors. Vibrations may echo into the seafloor during wind turbine operation, which can impede the activities of benthic species [22]. To minimize these effects, twisted jacket foundations can be used since the acoustic effects caused by installing these foundations have a smaller spatial area [24].

Bird migrations are located along the coast of Louisiana called the Mississippi Flyway, a flight route that many aviation animals take by cutting through or going around the US Gulf of Mexico to travel up north along the Mississippi River. Species such as geese, ducks, shorebirds, sparrows, blackbirds, thrushes and warblers, are considered priority towards wildlife safety as the presence of an offshore wind farm can impact the population [25]. Bird conservation regions on the coast of Louisiana such as the Gulf Coastal Prairie state that in the winter, waterfowl populations and densities are some of the highest on the continent [26]. Studies showed that avian fatalities can be reduced by nearly 75% by increasing the visibility of the turbine’s rotor blades, in this case, using black paint on one of the blades can allow migrating flocks to avoid Bluestar Farm during the spring and winter [27].

Bats are attracted to wind turbines due to the potential roosting conditions, referring to the warmth of the nacelle and the bug density around the turbine [28]. This behavior suggests that the white structure of the turbine as well as potential lights can attract insects. Birds are also attracted to the turbines for similar reasons, including the ability to feed off of insects. Suggested mitigations include the usage of UV lights on the turbine to avoid attracting insects, and some form of auditory deterrent to prevent collisions with the blades.

According to a report published by the Pacific Northwest National Laboratory, species such as elasmobranchs, crustacea, cetaceans, bony fish, and marine turtles are particularly sensitive to electromagnetic forces. Interaction with magnetic fields can cause altered development and various behavioral effects such as impaired navigation and orientation, and attraction or avoidance of one another. Although these conclusions have been drawn, researchers admitted that data was limited and often varied on an individual or species basis [29]. Impact from electromagnetic fields can be minimized using inter-array cables rather than export cables in the water wherever possible since less power is transmitted. Alternating current cables are also preferred since they generate weak magnetic fields, although high power floating cables may be necessary depending on the distance between points and the scale of the wind farm itself.

A vessel strike or collision is defined as any collision between a boat or another structure and a marine animal [30]. They can lead to injury or even the death of said marine animal. Vessel strikes can be reduced in number or prevented altogether using a variety of strategies. For avoiding collisions with whales, a number of rules have been enacted, such as: enacting speed restrictions for moving vessels, establishing temporary precaution zones and avoiding development in those zones, alerting ship and vessel operators of the locations of whale pods and the turbines themselves, and finally tracking collision occurrence to prevent future collisions in those areas. These precautions are especially important considering the consistent fishing and shipping activity throughout Port Fourchon’s waters.

With the discussed environmental considerations in mind, Comet Wind plans to take various precautions to minimize negative impacts on the local wildlife. For example, Comet Wind intends to utilize black paint on rotor blades to reduce bird strikes, ultraviolet light near the nacelle to deter roosting, and inter-array cables to minimize electromagnetic field interference. As previously mentioned, a twisted jacket foundation will be used to withstand hurricane damages as well as ensure minimal disturbance during turbine deployment. Given the diverse nature of the US Gulf of Mexico waters, Comet Wind seeks to mitigate any possible disturbances to the natural environment and to develop a sustainable yet practical source of renewable energy for Louisiana.

Site Development and O&M

We plan to use Port Fourchon in Louisiana, one of the largest ports in the United States, as an onshore staging point for the turbine materials prior to installation. Port Fourchon, the closest port to the lease block area, currently has open berths as well as existing heavy equipment. There are existing slips available for rent that specialize in cargo and logistics including many with overhead cranes, which will be able to assist in the loading of the wind turbine installation vessel (WTIV) [31]. As such, Port Fourchon will be the logical choice for transporting materials until they are used during construction and will also serve as the primary port used for launching any repair operations should the wind farm sustain damages.

Port Fourchon currently contains a variety of leases belonging to a number of companies, many of which specialize in transportation of some sort. Bluestar farm intends to arrange for turbine materials to be sent across land to one or more of these locations, where they can be loaded onto a vessel and brought to sea for construction. Should borrowing a dock from one of these companies become unattainable, multiple available leases are also available for purchase from the local government itself [32]. The docks around the port also include crane, forklift, and labor services for loading the materials onto vessels prior to construction [33]. As stated in the management agreement, Port Fourchon will provide for utilities such as water, electricity, and handling of sewerage [34] as designated by the contract. Security services will also be in place to ensure project materials are safe during storage.

One potential option for material storage is the shipyard storage yard on the Grand Isle [35]. From the shipyard, materials can be loaded onto trucks and driven directly to the port, or loaded onto vessels onsite and sent over water since the yard is also adjacent to a waterway. Another option would be to use the protected fishing docks near Estay Road since they also provide storage space while also being connected to the rest of the port and its waters.

By collaborating with the Louisiana Universities Marine Consortium, the R/V Pelican can be used to confirm the geotechnical, geophysical, and environmental data within the site lease blocks [36]. This on-site information will provide an in-depth assessment for Bluestar Farm towards turbine and substation placement, cable-array design, and environmental hazards.

The Jones Act, which restricts the transports of goods on foreign vessels, limits our options in terms of transportation and installation of wind turbines. In this case, the only installation vessel that abides this policy is the Charybdis by Dominion Energy. This ship will be unavailable until 2027 as the company has already reserved the vessel after its completion in the final quarter of 2023 [37], but this does not conflict with our timeline as mentioned in **Figure 5**. According to estimates the suggested daily rate would be upwards of $500,000 [38]. An alternative option would be to use barges to transport the turbines to the stagnant foreign installation vessel, this loophole would allow us to comply with the Jones Act as the ship is not transporting any goods.

In terms of establishing the foundation, the installation phases consist of pile driving (hydraulic hammer), jacket lift, transition lift (only for concrete), and grouting. With that in consideration, the selected twisted jacket foundation can be transported on barges pre-assembled with no extra welding or underwater work on-site required due to the composition of the foundations. Additionally, the assembly and removal of the turbine foundations use the same equipment compared to a monopile foundation [39]. There are also notable businesses located in Port Fourchon that provide metalworking services such as Express Supply and Steel that are capable of on-site plasma cutting. They have also provided similar supplies for other sectors such as fabrication, shipbuilding, oil, and gas industries within the gulf coast by delivering to vessels [40]. Based on the high availability of resources used to manufacture and repair existing infrastructure in the US Gulf of Mexico as well as the prevalence of maritime shipping routes into Port Fourchon, we anticipate a streamlined process for the transportation of parts into the onshore staging ground [41][42].

Prysmian Group's Global Sentinel is a cable laying and trenching vessel, capable of installing cable lengths up to 99 miles with a depth of 3.3 meters [43]. According to NREL's environmental policy guidelines, this meets the industry standard as it ranges from 3 to 13 feet [44]. As such, Global Sentinel can be utilized by Bluestar Farm to lay transmission cables during the process of foundation installation. Additionally, having a hybrid vessel will accelerate the project timeline and lessen O&M expenses.

Crowley Wind Services, a company that has developed and leased offshore wind facilities and terminals in Massachusetts and California, has recently reached a first refusal agreement in Port Fourchon [45]. With this in mind, this public-private partnership could provide a terminal with the proper logistics and operations to provide equipment and storage for nacelle, tower and blade storage.

Recycling plants hosted by companies such as Veolia North America and GE Renewable Energy take turbine blades and re-purposes them to create materials such as composite cement, fiberglass, thermoplastic pellets, or fabrics [46][47]. According to NREL wind energy analyst Aubryn Cooperman, the amount of wind turbine blades will reach 1.5 million metric tons by 2040. This is due to the increased blade length and lifespan of the turbine blade as new designs are released [48]. In this case, finding a partnership with a recycling plant or waste management service like Veolia would minimize our contribution towards landfills.

Financial Analysis

Capital Expenditures

There are many apparent costs associated with the construction of a wind farm, such as the costs of the wind turbines themselves, installation costs, electrical transmission system costs, and the price of maintenance. However, each of these costs can also vary with factors such the location of the project, the climate near the location, and the availability of nearby ports to name a few factors, which make finding accurate estimates for costs extremely difficult. Moreover, few companies release extensive data regarding exactly what they paid for a project, and the data that is available often contains a large range of values and geographical locations. As such, we will use a combination of data reported by NREL's cost of wind energy review [49], the Offshore Wind Market Report: 2022 Edition [50], and finally values as reported by Catapult Offshore Renewable Energy [51]. Using these resources, we were able to construct estimates of our capital expenditures as seen in **Table 1**, which we verified with our industry contact at Leeward Renewable Resources**.**

Component	**Fraction of Total (%)**	**Cost ($/kW)**	**Cost (Million $)**	**LCOE ($/MWh)**
Turbine	32.89	1250	380	34.15
Foundation	11.84	450	136.8	12.30
Power Cables	11.84	450	136.8	12.30
Installation	13.16	500	152	13.66
Insurance/Contingency	10.53	400	121.6	10.93
Substation	4.61	175	53.2	4.78
O&M	1.32	50	12.2	1.37
Project Development	0.65	25	7.6	0.68

Other costs	13.16	500	152	13.66
Total	100	3800	1,155.2	103.83

Table 1. Cost of various components, reported in % of total, $, $/kW installed capacity, and $/kWh

Due to the distance from shore being greater than 50 km [52] we will need to factor in the offshore substation costs for converting power from AC to DC for transport to shore. This is the reason for the inclusion of a substation component above, which may not be included in all offshore wind farms.

The installation section refers to the various costs associated with installation, including the rental fees required for the Charybdis, as well as other costs associated with preparing the components for installation including leasing of port berths, overland transport of turbine components, and initial siting costs such as permitting for construction and impact analyses on local habitats or wildlife. While these costs would be charged on a daily basis for items such as boat rental fees or per component for transport fees, they have been normalized to reflect the units commonly used for describing wind farm capital expenditures.

Incentives and Depreciation

While the industry LCOE of offshore, and other, types of wind energy power are trending downwards, government tax credits remain a vital component of reducing the cost of utility scale wind farms to viability both in order to breakeven with regards to initial costs and to make wind technology competitive with established forms of power generation such as natural gas, which is prevalent in the US Gulf of Mexico region in which we plan to build. As such, Bluestar Farm plans to take advantage of is the ITC, or Investment Tax Credit. This tax credit allows wind technologies to receive 30% of the investment costs as a tax credit when the project is placed into operation, provided construction begins before 2025 and prevailing wages are met. After 2025, the ITC will be replaced with the Clean Energy Tax Credit, which will serve as an identical opportunity under a different name.

In addition to this 30% base rate, a 10% tax credit referred to as the Domestic Content Bonus can be claimed provided 40% of the manufactured components of the project and all steel or iron used in the project was made in the United States. Because we plan to use a Vestas turbine, we will be able to take advantage of this opportunity as there is a facility in Brighton, Colorado that will produce the nacelle, which alone serves as approximately 35% of a wind turbines mass. Combining this piece alone with the addition of building an offshore substation, we will be able to meet the requirements regarding 40% of the manufactured components being from the United States [53]. In regards to the requirement for the steel and iron we use being produced in America, we will use American steel for the construction of our offshore foundation, and the CS Winds facility in Pueblo, New Mexico produces Vestas' wind turbine towers, allowing us to source exclusively American made products using American Steel [54].

Finally, there is another 10% tax credit called the Energy Community Bonus, which either requires that the local unemployment rate has been higher than the national average within the year prior to construction, or that 25% of the local tax revenue comes from the storage or transportation of oil or natural gases [55]**.** Historical trends show Louisiana's unemployment is typically higher than national unemployment [56]. In particular this is true over the most recent year for which statistics have been recorded. Given that within the US Gulf of Mexico the oil industry is a primary financial driver, we feel confident that we will also meet the tax revenue requirement of the Energy Community Bonus We are unable to completely verify these assumptions, as they may change depending on future trends, but historic data will allow us to assume we will qualify in the near future, barring significant changes [57].

Upon researching additional incentives for our project, we discovered Louisiana's Revised Statue 47:6037, which allows a tax credit of up to 1 million dollars provided that the capital infrastructure project meets the define guidelines for green energy, which Bluestar Farm does [58]. This benefit is extremely small compared to the hundreds of million-dollar credits associated with the ITC, but it still provides a bonus which Bluestar Farm will use.

Financing Plan

The financing structure that Bluestar Farm has decided on is a partnership flip, as this allows us to effectively leverage the large amount of tax credit we will receive from the ITC in order to reduce our initial costs. The initial cash will be provided in a 60-40 split by the investor and debt taken on by Bluestar farm respectively [59]. Following a mostly standard flip structure, the investor will receive a 99% of the projects tax credits and cash gains or losses until year 5, at which point the flip takes place and the investor receives only 2.5% of the tax credits and cash. While traditionally the investor will receive 5% of the returns after the flip, due to the higher-than-average amount claimed for the ITC, a lower amount is chosen for the after-flip incentive and cashflow, as the investor will have already made a profit. The investor that we plan to partner with for this split structure is JP Morgan, as they are responsible for a significant portion of tax equity transactions and will be able to take full advantage of the associated tax benefits due to the large amount of capital moving through the bank [60].

To cover the remaining portion of capital costs, Bluestar farm will need to take on debt initially in the form of construction loans, which are relatively short term and cover the initial costs associated with the construction of the wind farm. Due to the nature of construction loans covering a project that has not yet been built, they often have high interest rates at up to 10% APY and are be set to have minimal tenor at 1 to 2 years [61]. To avoid running into high repayment amounts in the initial years of our project, these loans will be refinanced in the form of back-leveraged term debt which provides the advantage of a longer-term loan, meaning that Bluestar Farm will be able to focus initially on repaying the flip partner as opposed to the loaning entity. We plan to negotiate a rate of 4% APY for this back leveraged debt, which will be structured in the form of mini-perm debts, allowing banks to see repayment in both the short and long term. In order to secure this financing, we will approach ESFC, a large investment group with experience in providing financing through long term loans to a multitude of industries, including renewable projects such as solar plants and wind farms. The 4% interest rate on this long-term loan falls in line with industry averages [62].

Market Conditions and Power Purchase Agreement

Although the US Gulf of Mexico is heavily focused on oil drilling, emerging social and governmental pressures point towards an increase in industry interest in renewable energy in the coming years. The United States has set the goal of producing 100% clean energy by the year 2035, of which wind-based energy will undoubtedly be a significant contributor [63]. Louisiana has also pledged to achieve reduced greenhouse gas emissions, and although this is at a slower rate than the national government, it will still provide an incentive for increasing the presence of renewable resources [64]. In addition to the renewable power goals set both locally and nationally, we have seen the dramatic effect on supply chains that recent events such as the pandemic have had, which make a locally produced renewable resource a far more attractive choice than an unstable fossil fuel resource. Finally, the growth of wind energy in the United States and around the world in recent years has resulted in LCOE trending downwards, as economies of scale become viable and turbines increase in size and power generation capabilities. These various trends all point towards wind energy being a strong contender in future markets, as it provides stability, domestic production, governmental support, and increasingly competitive costs.

The net zero emission goals have led to Louisiana becoming a leader in the field of hydrogen energy, with 4.5 billion in funding being invested in the state for the purpose of building a clean energy facility that will generate hydrogen gas [65]. This facility is being built in Ascension Parish, which is within power transmission distance of our wind farm. Due to the process of extracting hydrogen being extremely power intensive, this facility represents an opportunity for a large increase in the demand for power, which Bluestar Farm will be equipped to meet.

Due to this investment, as well as Louisiana's long-term goals, Bluestar Farm is in a prime position to seize the initiative and anticipate future needs before they arise. This will allow Bluestar farm to set a competitive price for the power that we are producing, which based on the average costs for electricity in the nearby area as well as average sales prices for offshore wind turbines, will be set at 10 ¢/kWh with a

4%/year escalation rate. As was mentioned above in the transmission section, we plan to approach Entergy to serve as the buyer for this PPA, which will allow us to use the relatively close onshore Entergy substation to feed into the grid. Entergy will take this deal as it provides them with a source of renewable energy to meet the previously mentioned social and governmental trends, as well as providing a large amount of power which will be needed for facilities such as the one located in Ascension Parish.

While a PPA allows us to lock in our price for a number of years, due to fears of economic instability persisting, it will be difficult to determine an accurate long term price model. If high levels of inflation are maintained a PPA price can quickly become obsolete, meanwhile, if a recession strikes it may be difficult for the buyer to continue purchasing power at a relatively high fixed price. To combat these uncertainties, we will use a short term PPA for the period of 5 years which will allow us to guarantee power at the chosen cost during the project's initial years. This will allow us to renegotiate based on market trends after a relatively short amount of time, avoiding one of the major drawbacks of PPA's—that prices cannot respond to market volatility. In addition to allowing us to change our PPA, five years also corresponds to the partnership flip occurring, which can allow us to determine how our prices may need to change based on our increased revenue as Bluestar Farm gains majority equity.

O&M Costs

Operations and management for an offshore wind project can be broken down into scheduled maintenance (which on average occurs around 3 times a year), minor unscheduled maintenance (which on average occurs around 8 times a year, since the annual minor failure rate is 8.3), major unscheduled maintenance (which on average occurs around twice a year, since the annual major failure rate is 2.13), and major unscheduled replacement (which on average occurs about once every 4 years, since the annual replacement rate is 0.28).

Scheduled maintenance can be valued as a fixed annual cost amounting to $9,887,703.36, which was obtained by scaling the cost of a 100MW capacity farm in 2020 and adjusting for an inflation rate of 5.26% over the last 3 years [66]. Using averages provided by a study reviewing the lease block features, size, and output of 1,768 European wind farms, 68% of which had a project lifetime of 3-5 years with the remaining 32% having a project lifetime of 5+ years, total annual minor unscheduled maintenance cost for our Bluestar farm is around $294,303.36 [67]. Using the same dataset, total annual major unscheduled maintenance cost such as a small component failure is about $377,752.96. Finally, each major unscheduled replacement such as a large component/network failure can be approximated as $1,840,000 (considering the fact that 95% of all extreme equipment failure in offshore wind is either failure of the gearbox or the failure of the generator, and averaging over 4 years since this is the approximate period for large equipment failure).

In general, major unscheduled maintenance jobs and replacements are rarely needed, but when they are done, the most expensive components to maintain or replace are the gearbox, hub, blades, transformer, and generator respectively, so the amount provided (which is the average cost of a new gearbox in dollars) is a conservative estimate of possible unscheduled replacement costs. Total O&M costs including the fixed annual cost and the three kinds of unscheduled costs yields $12.39 million, which supports our capital expenditure of $12.2 million. Finally, it is important to note that an overall O&M cost reduction of 10% is possible provided that when maintenance vessels are deployed at sea, their waiting time to do repairs is minimized [68].

Optimization

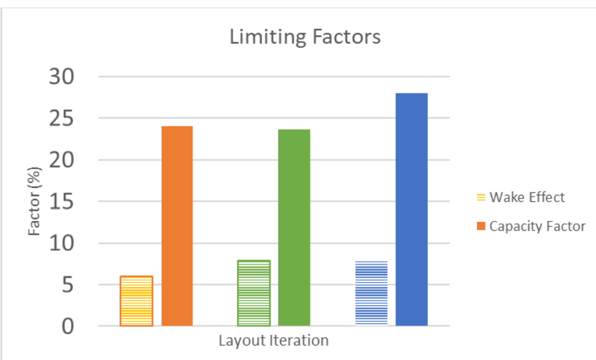
Given the provided lease block area, Comet Wind established that the parameters for a successful offshore wind farm included consistent and high wind speeds, a maximum depth of 50 meters, clearance from oil lines, oil platforms, shipping lanes, and military zones, while also minimizing environmental impact. With this in consideration, it was found that there were no lease blocks had complete clearance of oil lines, the exception to this were lease blocks that contained artificial reefs. To combat this issue, Comet Wind lowered the tolerance of our search criteria to least obstructive oil lines. The resulted potential zones were located as single blocks or paired with neighboring lease blocks. Due to the large rotor diameter of a majority of offshore wind turbines, we concluded that the purchase of two lease blocks compared to a singular lease block would be an additional parameter as the average lease block size within the auction area was roughly 5000 acres would result in too few turbines to be economically viable or a wind farm configuration with high wake loss to be operationally efficient. As a result, lease blocks 216/217 in Lot 6A became the site for Bluestar Farm.

Prior to any financial analysis, the initial preliminary design consisted of 24 Vestas V164 – 9.5 MW with 8% wake loss. Since then, Comet Wind has gone through multiple iterations to further optimize the wind farm layout including modeling different turbines and placements using Furow.

Turbine	Rated Power (MW)	Rotor Diameter (m)	Output Power at 7 m/s (kW)
Vestas V164-9.5 MW	9.5	164	2,030
SG 8.0-167 DD	8	166	2,186
SG 10.0-193 DD	10	193	2,920

Table 2. Turbine Considerations [69]

Referencing **Table 2**, we evaluated a variety of offshore wind turbines in the current market that were capable of performing effectively in low-wind speed conditions and analyzed each power curve at the average wind speed of the lease block, which was 7 m/s. Based on the rotor diameter-power ratios, the turbines are somewhat the same. The determining factor for Comet Wind's decision was availability and transportation logistics, because despite both Vestas and Siemens Gamesa have manufacturing facilities in the United States, the price of domestic production versus importing the parts for on-site assembly versus is significantly more cost-effective due to the Domestic Content Bonus [70][71]. With the turbines being imported from their respective manufacturers to Port Fourchon, this ultimately made the Vestas V164-9.5 MW to be the most viable option due to distance.



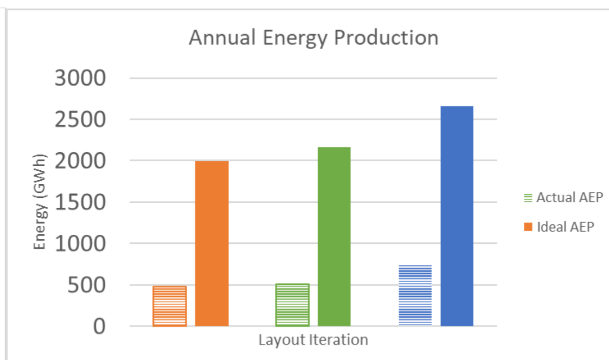


Figure 7A-B: Turbine Placement Optimization

Using Furow and the System Advisor Model, we were able to perform iterations of the wind farm design. Comet Wind referenced NREL's Wind Energy Production Prediction Bias and IEEE's Transmission Design Analysis to calculate conservative values for net capacity factor as seen in **Figure 7** [72][73]. Based on this analysis, we determined that the configuration with the highest net capacity factor would result in the highest energy output by calculating the AEP, or annual energy produced, and comparing this value across the optimized designs as seen in **Figure 7**.

Bid Amount

Our bid amount is approximately $28.92 million, or $3,000/acre times the 9,640 acres that we plan to bid on. Given that the average price per kilometer in an auction in May 2022 was $707,894/km² (approximately $2,865/acre) for a location in the Carolinas, we believe that our bid price is best compared to this value as opposed to sales further north in New York that were more expensive by a factor of 2 or 3

[50]. The significant decrease in the price for this area compared to the further North locations can be attributed to the lack of existing and proven concepts within the Southern United States, as well as the increased risk of storm damage due to the likelihood of hurricanes within the US Gulf of Mexico. From a financial perspective, our project according to SAM will be able to assume the extra cost associated with out bid price without causing issues, as our net cash value at the end of the project (combining the return for both our tax investor and Bluestar Farm) is slightly less than $200 million before the inclusion of lease block bidding. Thus, while $28.92 million is significant, it is well within the financial capacity of the project to cover.

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