# CAL MARITIME 2024

## PROJECT DEVELOPMENT FINAL REPORT

# CYCLONE ENERGY

## BUILDING A SUSTAINABLE FUTURE

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Matthew Rizzi | Project Development Team Lead | mwrizzi@outlook.com

Nikhil Hunter | Strategy and Hybrid Specialist | nikhil-hunter@outlook.com

Brennan White | Policy and Environmental Analyst | bwhite8291@csum.edu

Gavin Murray | Siting and Geotechnical Analyst | gmurray@csum.edu

Strategic Advisors: Tom Nordenholz | Ryan Storz | Al Germain

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CROWLEY NREL NATIONAL RENEWABLE ENERGY LABORATORY RWE Hornblower

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## 1.0 Executive Summary & Power Purchase Agreement

Cal Maritime presents this proposal for a 495MW wind farm located in the southern basin of Lake Michigan. Cal Maritime has named its operation, Cyclone, both in its literal sense as a wind system and as a metaphor for the quickly shifting atmosphere of renewable energy. Site development was conducted through programs such as UL's OpenWind, the System Advisory Model (SAM), the Jobs and Economic Development Impact (JEDI) model, and NREL's HOPP program. Cal Maritime plans to sell its electricity to the Midcontinent Independent System Operator (MISO) and privately to companies who pledge to minimize their carbon footprint. The farm will have a 42.4% capacity factor, have an initial PPA price of \$88.7/MWh, and average an annual energy production of 1,837,285.9 MWh. Cal Maritime also explored the economic impacts and scalability of green hydrogen when serving the higher-energy density requirements of heavy industry and battery storage technology.

## 2.0 Site Description

Cal Maritime has selected the southern basin of Lake Michigan as the location for its planned 495MW floating wind farm. The wind farm will be situated approximately 18 kilometers northwest of Burns Harbor, Indiana, where Cyclone's terminal will be placed. The location was selected based on its proximity to existing electrical infrastructure, an advantageous wind resource, and minimized ice buildup. To reduce infrastructure costs, Cyclone will utilize pre-existing high-power cabling and transmission systems along the south shore of the lake. The Burns Harbor area has an active railway connection adjacent to the terminal that will alleviate the substantial transportation requirements of terminal development.[1] The harsh winters of the Great Lakes bring significant icing to the edges of Lake Michigan; Cyclone's turbines are strategically placed outside of the ice's edge, so the turbines should experience minimal impacts from icing.[2] Access to and from Cyclone's site does not coincide with established shipping fairways. Cyclone's Point of Interconnection (POI) was selected based on the farm's proximity to pre-existing 540MW infrastructure from a local coal plant.[3] The interconnection will be in Michigan City, Indiana, approximately 10 miles northeast from Cyclone's port.

***Figure 1***- *Overview of Cyclone's Location:*

## 2.1 Geotechnical Data/ Bathymetry

Cyclone's selected lease area has depths ranging from 75 to 130 meters.[4] Areas of shallow water located around Burns Harbor highlight the potential need for harbor dredging to allow for the free steering of vessels and floaters. The U.S. Geological Survey reported that the repeated formation and breakup of nearshore ice results in 20 to 25 centimeters of sediment relocation per year.[5] Cal Maritime identified a preexisting wave break barrier to protect the onshore terminal from this erosion. Geotechnical data shows that the southern lakebed is mostly composed of sand and clay pockets at Cyclone's turbine locations.[4] This lakebed composite has previously resulted in insufficient anchor embedding during installation.[6,7] To mitigate this, Cal Maritime will use suction anchors as this type of mooring excels in such composite.

## 2.2 Wave Analysis

During the summer season, the area identified typically experiences an average wave height of 0.5 meters, occasionally having outliers up to three meters high. During the winter season, Lake Michigan enters a stormy period where waves have been recorded to reach heights of 7 meters. Additionally, strong wind flares have been measured up to 80mph.[8] Cal Maritime has identified a floating foundation, the NOV Tri-Floater, which has successfully completed model testing for applications in extreme weather conditions with waves up to 13.5 meters. Cal Maritime has similarly identified turbines that are certified to operate in these conditions. The selection of floating foundation and turbine technology results in minimal impact from waves and wind found in the Great Lakes.

## 2.3 Wind Resource

The identified lease location displays an annual wind speed ranging from 8.00 to 8.93m/s at a hub height of 100m. These measurements were obtained from NASA ERA-5 data and processed through UL's Windographer software.[9,10] Illustrated in *Figure* 2, wind data from Windographer was imported as unique Met Mast layers into the Openwind optimizing software.[11] Shown in *Figure 3,* four specific sectors were used to compute a Wind Resource Grid (WRG). It was found that the southwestern section of Lake Michigan exhibited the highest wind yield and thus was selected for further development. This area, centered at the coordinate 42.00N, 87.00W, has a prevailing wind direction originating from the south-southwest and yielded the highest wind speed of 8.93m/s. From this, Cyclone's turbines face in a south-southwest direction.

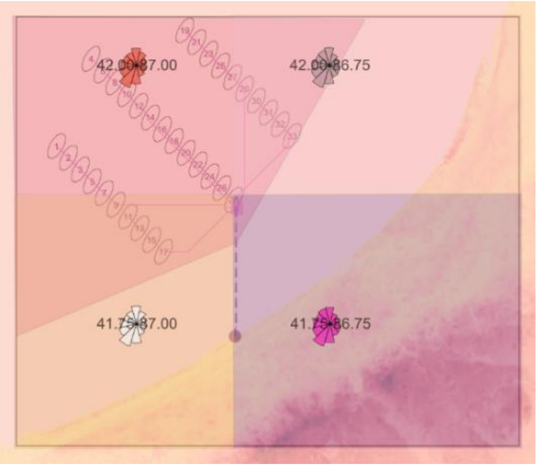


***Figure 2****- Coordinates of Lease Sectors with Directional Wind Vectors*

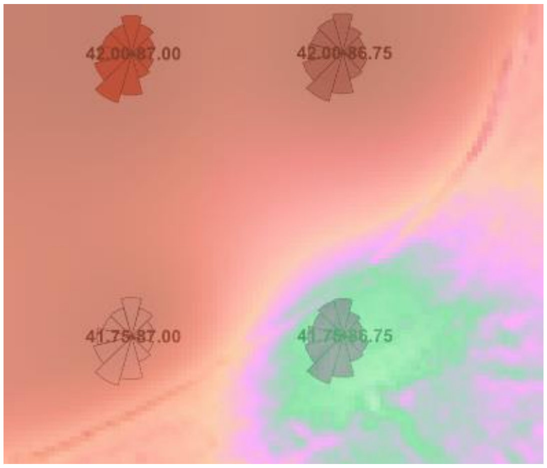


***Figure 3****- Wind Resource Grid (WRG)*

## 2.4 Turbine Technology

Cyclone intends to deploy 33 Vestas V236-15MW turbines, providing a total output of 495MW. The choice of the V236 was driven by its ability to minimize manufacturing, installation, and servicing expenses, while providing a robust and dependable platform.[12] The turbine is an IEC/S class system meaning that it is rated to handle high-wind speeds and prolonged weather deterioration. The V236 can hold up to a 280m hub height and 236m rotor diameter, with cut in speeds at 3m/s and cut out speeds at 31m/s. When compared to other models such as the GE Haliade-X, the Siemens Gamesa SG 14-220 DD, and the MySE 16.0-242, the Vestas platform was selected as the highest yielding option for further development. Due to water depth exceeding the limitations of fixed foundations, Cyclone will be implementing floating foundations.[4] Cal Maritime chose a floating foundation after analyzing recent developments in floating farms such as the west coast's Humboldt Bay Terminal and Ocean Wind's Korean Farm.[13,14] The NOV Tri-Floater, designed by GustoMSC and NOV, offers a scalable semi-submersible platform designed with efficient mass production as a priority. The floater aligns with Cyclones objectives as it was specially designed to maximize construction efficiency while reducing overall material. It achieves this through the integration of hexagonal buoyancy columns, constructed entirely from flat panel steel. This design enables cost-effective mass production of the floater, which can be conveniently assembled locally while ensuring flexibility in the supply chain.[15] The Tri-Floater's inter-array design allows for cables to be individually disconnected without breaking the turbine's circuit and has increased flexibility through multiple mooring styles. This is important as consistent downtime can severely impact the reputation of Cyclone's reliability to effectively supply the grid.[16] This foundation structure will allow Cyclone to retain a constant source of power even in times of maintenance or unplanned turbine disconnects.[15]

## 2.5 Ice Mitigation

In the Great Lakes region, large formations of sheet ice form during the winter months. Wind and wave patterns within the lakes can cause these large sheets of ice to shift, potentially damaging offshore structures.[17] Ice formation can start as early as November and remain as late as April, with peak ice formation occurring between late February and early March.[18] Ice coverage is more prominent in the northern regions of the lakes, particularly in Lake Michigan and Superior.[19] Cyclone Wind is situated in the southeast corner of Lake Michigan where surface is less of a concern. On average, only 2.7% of Lake Michigan is covered with ice every year, most of which accumulates in critical transport locations.[20] Additionally, climate change has caused a significant reduction in total ice coverage of the Great Lakes region. Since 1980, there has been a 30% reduction in the average total annual ice formation.[19] Each of the Great Lakes has been losing around 5% of total surface ice every decade since 1970.[18] The decrease in annual ice coverage along with the location of Cyclone Wind in the southeast corner of Lake Michigan protects the site from the harmful effects of ice movement. However, as shown in *Figure 4,* Cyclone Energy turbine foundations will be equipped with ice cones on the legs of the Tri-Floater where the foundation meets the water line. These ice cones are used to disrupt the structural integrity of large ice sheets as they interact with the turbine foundation. As shown in *Figure 5,* as surface ice shifts into contact with the floating turbine, ice cones cause small sections to break apart from the large ice formations by changing the direction of movement either upward or downward. This technique is similar to how an icebreaker vessel uses the shape of the hull to effectively propel itself forward by disrupting the structural integrity of sheet ice on the surface of the water.[21]

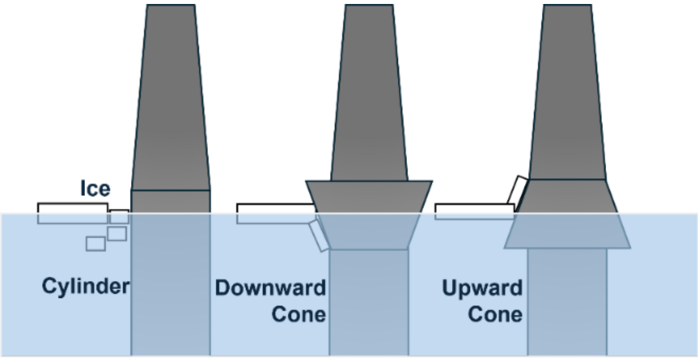


***Figure 4***- *Ice Deflection Collars*

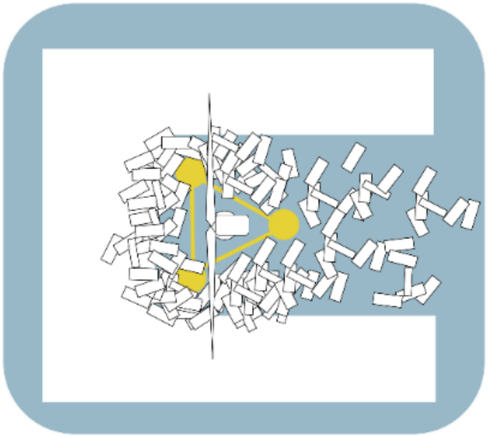


***Figure 5***- *Floater Ice Accumulation*

## 2.6 Detailed Layout

Cyclone has developed a layout located in the northwestern part of the selected lease area. Cabling consists of three parallel south-southwest lines. Each cable can be used for six turbines. Generated energy is fed through 66kV inter array cables connecting to a floating substation located nearest to the shoreside POI. Cyclone has developed a layout for 33 Vestas V236-15MW turbines using UL's Openwind software.

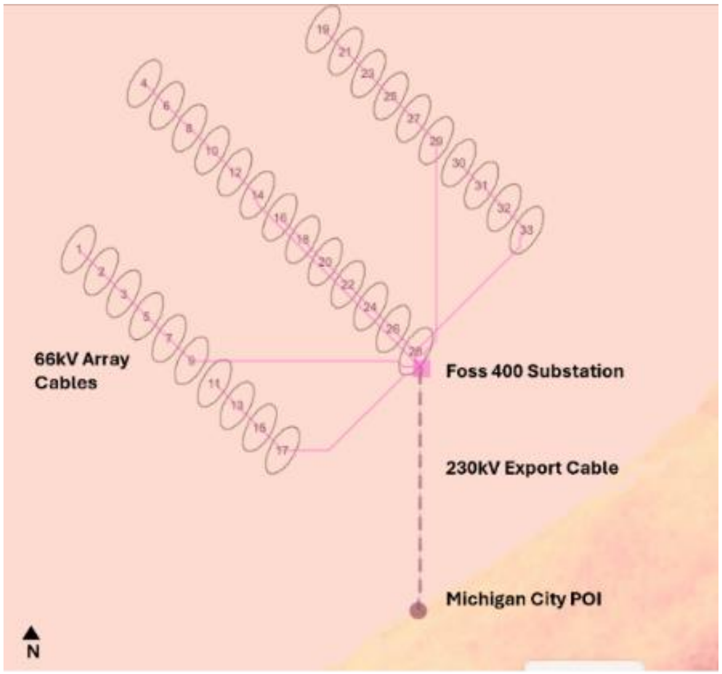


***Figure 6***- *Turbine Layout & Transmission Array*

## 2.7 Transmission Integration

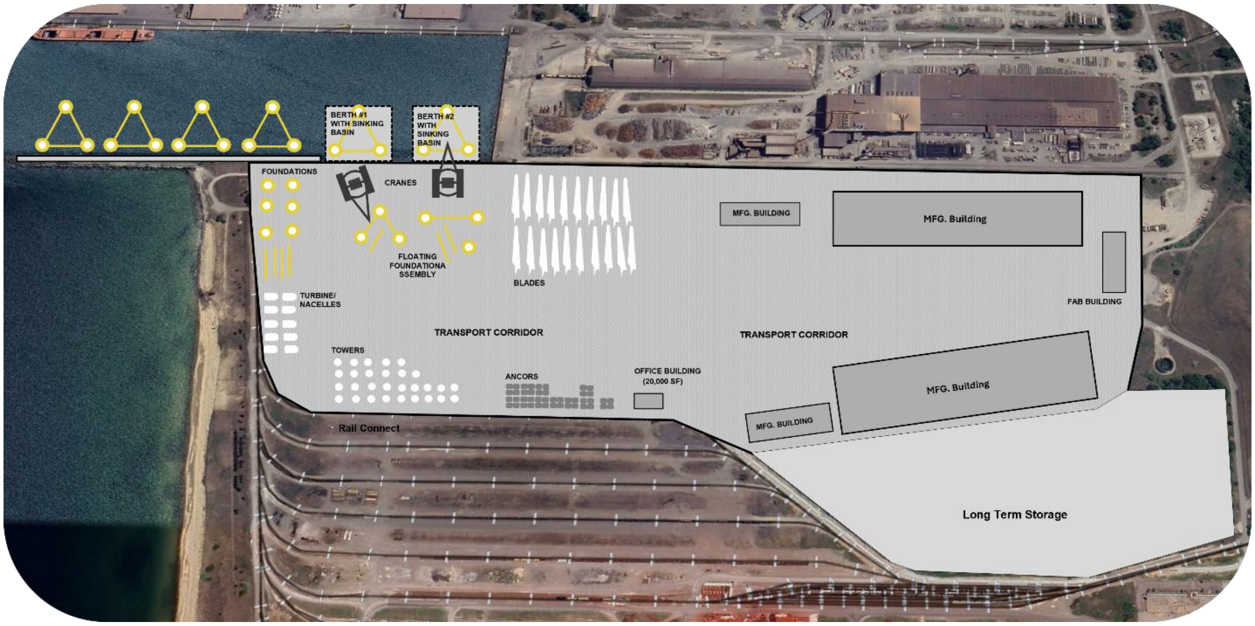
Inter-array cables will interface with one of two Hitachi ABB step-up transformers, anticipated to be housed within a FOSS-400 floating substation.[22] Subsequently, this system will elevate the initial 66kV line to a single XLPE 230kV high-voltage export cable, establishing connection with the strategically located POI.[23]

Upon shoreside arrival, the power will be integrated into existing grid infrastructure through a 345kV substation and additional 345kV transmission lines.[3]

## 3.0 Terminal Infrastructure

Located in Burns Harbor, Indiana, Cyclone will develop a 226-acre terminal to store, stage, and construct turbines. As mentioned previously, the siting of the Cyclone's terminal was based off its pre-existing wave-break infrastructure and its proximity to expansive rail network and industry partners. The main objective in Cyclone's terminal development was to reduce CapEx. Through partnering with companies such as Keystone Tower Systems and Tugdock, Cyclone is set up to receive flat-steel for on-site foundation and variable-width tower construction while hosting a dynamic staging area for turbines to be assembled before being easily shifted to storage call-zones.[24] On-site tower construction decreases the need for expensive turbine shipping, and hosting a floating dock allows Cyclone to operate efficiently within a smaller spatial footprint. Operating on as little as 45 degrees of modular track, Mammoet's SK600 radial crane is specifically engineered for large turbine construction.[25] Cyclone's waterfront will be hyper-efficient through construction with the combination of a radial crane and semi-submersible barge technology. The crane will place assembled foundations onto a semi-submersible dock where turbine towers will be laid and nacelles can be installed. The semi-submersible barge built by TugDock operates on a modular system of airbags, that depending on pressure will allow the barge to control buoyancy. This allows for fully assembled floaters to be easily towed off via tugboat. When researching vessel repair in the Great Lakes, Cal Maritime found that there are no drydocks easily accessible to vessel operators. When vessels need repair operators must navigate back through the Great Lakes St. Lawrence Seaway to drydock in New York or other East Coast shipyards.[26] If Cyclone was to restructure later, Cyclone would assess its financial situation and attempt to partner with other large firms to bring a drydock beside its terminal. With the modular track of Mammoet's SK6000 radial crane, Cyclone can commission one of its cranes to provide heavy-lift assistance in the dock, creating a positive-sum game for partners.

***Figure 7**- Preliminary Terminal Layout*



## 3.1 Required Vessels

Vessels used for Cyclone's operations will need to be used for a broad range of specific needs. The initial site design will use survey vessels to determine an accurate mapping of the site's geotechnical specifications. Cal Maritime couldn't procure pricing specifics related to transporting large components such as blades and nacelles, but these can be transported by contracting with local companies such as Spliethoff, utilizing their Seawaymax compliant F-Type bulk carriers. Spliethoff is currently active in the offshore wind sector and has experience in transporting wind turbine blades and other components by sea.[27] Turbine towing will be contracted to companies like Crowley Wind Services utilizing Ocean Class Tugs when towing out assembled turbines to and from the site location.[28] Cable laying will be completed by VTB and Kokosing Industrial, utilizing their modular barge technology. VTB and Kokosing are prominent vessel suppliers in the Great Lakes region, and using these local companies will reduce the supply chain implications of sourcing the required vessels.[29,30] Once operational, Cyclone will use Crew Transport Vessels (CTVs) and Service Operation Vessels (SOVs) during the day-to-day operations. Examples of these vessels include Damen Shipyard's 7017 SOV and the WindCat CTV.[31,32] Cyclone recognizes that hybrid vessels are still in their early stages of development and may not yet be sufficiently mature to be integrated into operations. However, once the proposed Great Lakes Clean Hydrogen Hub starts to deliver low-cost hydrogen, Cyclone intends to explore the potential of hydrogen-powered Crew Transfer Vessels (CTVs) and Service Operation Vessels (SOVs).

## 3.2 Supply Chain

Located in the Great Lakes, Cyclone won't have access to the same supply network that a coastal farm would have. For example, vessels traditionally used for transporting turbine components, tugboat operations, and any transfer processes must be Seaway Max compliant. Seaway Max compliance mandates vessels to have a maximum beam of 23.8 meters, length of 225.55 meters, and a draft of 8.08 meters.[33] Cyclone's terminal was selected for its proximity to the Burns Harbor rail network, where Cyclone will have cost-effective access to ship terminal construction components such as variable-width plate steel for foundations, turbine towers, and anchoring systems. The Vestas V236-15MW turbine will require nacelles to be sourced from Taranto, Italy. As mentioned previously, Cyclone will ship the Vestas nacelles to the terminal via vessels navigating the Great Lakes St. Lawrence Seaway System. Cyclone will partner with Keystone Tower Systems, who pioneered the usage of flat steel and spiral welding to construct on-site turbine towers. This partnership will decrease CapEx by sourcing flat steel rather than traditionally permitting and chartering over-sized load trucks to deliver the larger components.[34] Plate steel can also be used to construct the GustoMSC NOV Tri-Floater foundations. After sourcing flat-steel, the hexagonal tri-floater can be welded and assembled on-site. GustoMSC also offers an automated manufacturing process where buoyancy columns can be produced at a high-volume with a relatively low cost. The tri-floater also has a pending patent that can ensure an ultra-shallow draft of 10m which will be compatible with Cyclone's semi-submersible barges.[26] Partnerships alleviate OpEx as labor is contracted, manufacturing is streamlined, and joint ventures can be pursued.

The Great Lakes region experiences periods of vast icing during the winter months, with the potential for 2-3 months of downtime from ships being unable to break thick ice in the Northern Great Lakes. Cal Maritime believes that responsibly stocking equipment and spare parts will be essential to ensure minimal operational downtime. Cyclone's terminal layout has allotted 50 extra acres for additional security stock. With the potential for turbine maintenance and failure in the winter months, stockpiling additional supplies will ensure minimal downtime. Currently, there are six operational ice breakers on the Great Lakes; however, the fleet has an average age nearing 40 years old. President Biden signed the Defense Authorization Act at the end of 2022, containing the Great Lakes Winter Commerce Act which enhances the US Coast Guard's role in icebreaking activities on the Great Lakes. The bill calls for a new icebreaker that is capable of breaking ice up to 32 inches thick. Congressional budget constraints may delay the delivery time of an icebreaker for up to 10 years.[35] In the meantime, there is ability to commission a retired 65-foot harbor tug that can break ice up to 12 inches deep.

## 4.0 State vs Federal: Policy and Incentives

In the Great Lakes region, there is an overlap between state and federal jurisdiction that creates a great deal of uncertainty for developers in the regulatory process. The Federal Submerged Lands Act allows states in the Great Lakes region to govern the land beneath their navigable waterways up to the state's outer boundary.[36] Michigan's outer boundary extends into Lake Michigan, encompassing the area designated for Cal Maritime's lease block.[37] As a result, the federal regulatory permitting process provided by the Bureau of Ocean Energy Management (BOEM) is not applicable to the region.[38] Cal Maritime must work with each competing federal, state, and local agency separately to acquire the necessary permitting for Cyclone Wind. Some of these agencies include the National Oceanic and Atmospheric Administration, the Michigan Department of Natural Resources, and the U.S. Army Corps of Engineers. Cyclone Wind must meet the needs of each of these authorities to ensure that the project will have a positive effect on the economy and the environment. Michigan state legislature introduced bill HB 6564 in 2010 that outlines regulations for the leasing and permitting of offshore wind projects within the territorial bounds of the state.[39] Within the bill, a process is laid out that joins federal, state, and local agencies in an open forum to address the specific needs of each stakeholder.[38] Although the state of Michigan holds the power to govern its submerged lands, offshore projects are still subject to federal review under the National Environmental Policy Act (NEPA) and the Coastal Zone Management Act of 1972 (CZMA).[40,41] Each state in the Great Lakes region has its own Coastal Zone Management Program outlining requirements for coastal resource maintenance.[42] In Michigan, leases for energy production within state boundaries are granted by the Michigan Department of Natural Resources (DNR).[43] The federal Rivers and Harbors Act, Clean Water Act, and National Historic Preservation Act are all legislations governed by the U.S. Army Corps of Engineers (USACE).[44] The development and installation of offshore turbines must not disrupt any of the components protected by these acts, including the water quality that might be affected by dredging and filling materials used in the installation of Cyclone Wind's transmission lines. USACE will have to issue a clean water permit once the agency determines that the installation of Cal Maritime's transmission lines will not harm the environment.[45]

## 4.1 Federal Incentives

From a federal standpoint, several incentives exist for the development of offshore wind energy sites. In August 2022, the Senate passed the Inflation Reduction Act to incentivize renewable energy production.[46] Within the IRA, a provision is provided regarding interregional and offshore wind electricity production. The provision allocates $100 million for convening stakeholders in the process of interregional and offshore wind transmission development.[47] This provision is provided to aid in the process of transmission planning, modeling, and site analysis. Section 13702 of the Inflation Reduction Act (IRA) provides a clean energy investment tax credit for wind energy related goods and components which may include the construction of specialized offshore wind installation vessels.[48] Additionally, the Investment Tax Credit (ITC) provides 30% tax credit for offshore wind installation projects that begin their development before January 2026.[49] Additionally, a federal tax incentive known as the Modified Accelerated Cost Reduction System (MACRS) exists to recover the cost of property involved with offshore wind development.[50] Substantial capital investments are necessary for the construction and operation of offshore sites. Investments must be made upfront to obtain the necessary components of an offshore site including turbines, foundations, cables, and substations. To alleviate the burden of capital investment, MACRS depreciation offers "recovery periods" for certain assets depending on their expected operating lifespan, determined by the IRS.[51] Offshore wind equipment generally falls around the 5-7 year expected period, qualifying it for accelerated depreciation over that length of time.[52]

## 4.2 Environmental Concerns & Mitigation

In the Great Lakes region, there are dozens of endangered bird and bat species protected by the Migratory Birds Act.[53,54] Environmental agencies warn against the possibility of bird and bat strikes against turbine blades in offshore wind farming.[55] However, large migratory birds tend to stay away from the central part of the lake, migrating in areas closer to shore.[56] Cyclone Wind is situated far enough away from the shoreline that the construction and operation of the turbines will have little to no effect on the migration and nesting patterns of the protected species in the area. To mitigate the possibility of bird strikes against turbine blades, Cyclone Wind will employ artificial intelligence systems to monitor and deter endangered species within the region of the lease block. Technologies like Identiflight will be utilized to properly monitor populations of protected species.[57]Additionally, acoustic systems provided by Wildlife Acoustics will be used to disrupt the echolocation patterns of keystone bat species in the area, ensuring their survival through deterrence.[59]

## 5.0 Hybrid Implementation

Cal Maritime agrees that the synergy between wind energy and other forms of renewable power generation will ultimately accelerate the progress towards net-zero. In 2020, it was estimated that the Great Lakes St. Lawrence region contributed almost 1.5 Gigatons of carbon emissions, largely due to the manufacturing sector operating round-the-clock shifts.[60] This year, Cal Maritime thoroughly investigated the potential of hydrogen to serve the high energy density requirements of heavy industry in the Great Lakes.

## 5.1 The Current Hydrogen Market

The current hydrogen market is dominated by Blue Hydrogen, currently priced at $2.27 per kg, representing 71% of the global hydrogen supply.[61] Blue hydrogen is derived from reforming natural gas, but without sufficient carbon capture technologies, the yield fails to be zero-carbon. Green Hydrogen is currently priced at $4-6 per kg and is produced via electrolysis from water.[62] Green hydrogen can be created in two purity levels. Alkaline hydrogen can be used in heavy-industrial applications such as steel-blast furnaces and chemical production. Proton Exchange Membrane (PEM), hydrogen yields higher purity hydrogen needed for vessels, locomotives, and fuel cells.[63] Specifically in the Great Lakes region, hydrogen can be used in the industrial sector in steel production, mineral refining, and chemical processing.[64] If hydrogen infrastructure were to be developed in the Great Lakes, Cal Maritime recommends producing Alkaline hydrogen to protect Cyclone from going too far into niche markets by starting in industrial use cases. Producing low-purity, low-cost, and high-volume hydrogen wouldn’t preclude Cyclone from pursuing high-purity energy requirements. Even though a lower quality of hydrogen may be produced at the terminal, the hydrogen can always be further refined downstream in the supply chain. Hydrogen development in the Great Lakes has started off in industrial applications with the largest steel producer in the US, Cleveland Cliffs Steel, conducting many trials using Alkaline produced hydrogen gas instead of coal and other fossil fuels in their blast furnaces.[65] Using an oxygen blast furnace under hydrogen enriched conditions decreased carbon emissions by 9-14%, and further decreased by 38-44% when carbon capture technology was used in parallel.[47] Being in the heart of American industrial manufacturing, the Great Lakes area has significant potential to show downstream industries such as transportation the successes of carbon reduction.

## 5.2 Hydrogen Incentives

There are currently no publicly available metrics on the price of commercial scale hydrogen electrolyzers. The Cal Maritime team reached out to Siemens, McPhy, Cummins, and PlugPower for price estimates. All companies but PlugPower refused to provide further information, citing heavy workloads and a strict focus on local markets. PlugPower is headquartered out of Latham, New York and a principal engineer provided a $6,000,000 quote for the EX-2125D electrolyzer.[66] According to Cal Maritime's Hydrogen Model, the EX-2125D produces up to 2,125 kg per day with 5MW of capacity, making the price of hydrogen $7.74 per kg. For Green Hydrogen to be competitive in the developing market, it needs to be profitable for investors, meaning it should be priced at $2 per kg.[67] The Investment Tax Credit (ITC) offers a 30% credit for electrolyzer technology, and the Production Tax Credit (PTC) offers up to a $3 per kg subsidy for green hydrogen production.[68] These incentives can be crucial as they bridge the gap between high infrastructure costs and delivering scalable, low-cost hydrogen to consumers. However, even after the 30% electrolyzer ITC and the $3 PTC subsidy, the cost of hydrogen from Plug Power's electrolyzer was $2.41 per kg. The cost of hydrogen storage must also be considered as it directly correlates to the price of hydrogen offered. Currently, the Levelized Cost of Hydrogen Storage (LCHS) of above-ground compressed gaseous storage is $0.33 per kg. Recent research suggests that salt caverns may be the cheapest storage option with a LCHS of approximately $0.14 per kg.[69] The salt in the caverns is a natural nonpermeable barrier that doesn't expose the hydrogen to atmospheric oxygen. Pressurized hydrogen is pumped through a single well head with adequate casings to later transmit gas.[70] Rock salt and Brines have been mined for ≈150 years under the city of Detroit and throughout the lower peninsula of Michigan.[71] There hasn't been enough research to fully prove the feasibility of salt cavern storage yet, however this may change as we start to see economies of scale grow in the region. Incentives laid forth in Biden's infrastructure bills have shifted the market to make green hydrogen competitive, but the final green hydrogen price may not be low enough to compete with the cheap cost of blue hydrogen.

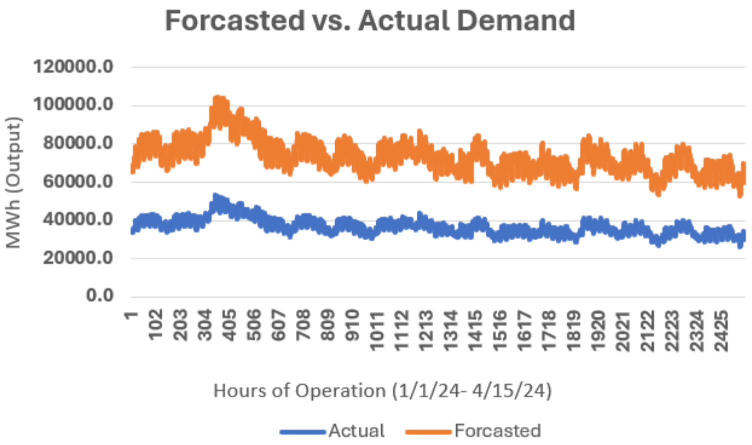
## 5.3 Hydrogen Hub

The Great Lakes Clean Hydrogen Hub is a proposed coalition of many large industrial companies such as Linde, Cleveland-Cliffs Steel, and GE Aerospace.[72] The hub will use nuclear power to produce carbon-free pink hydrogen for the surrounding end-use sectors.[73] With subsidies from the Biden administration, nuclear hydrogen could deliver a LCOH closer to $0.50/kg, whereas, in the best case, green hydrogen can be scaled to $1/kg in the Great Lakes.[74,75] Nuclear hydrogen displays a quicker trajectory to reach economies of scale that can bring lower costs to producers and rapid infrastructure development, decarbonizing the US quicker. However, nuclear energy has a negative reputation among consumers and may not be the way of the future. If nuclear energy is phased out of the US energy grid, Cyclone will be able to produce net-zero hydrogen that can compete with the lower LCOE of pink hydrogen.[76] With extensive research showing the potential for hydrogen to subsidize the heavy-carbon impact from industrial manufacturing, Cyclone may tentatively host hydrogen production.

## 5.4 Battery Storage Potential

Cyclone can also incorporate Lithium-Ion Battery Storage to stabilize energy from the farm and support baseload plants. The graph at the end of this section, *Figure 7*, depicts a 4-month time series of forecasted vs. actual demand data from The Midcontinent Independent System Operater.[77] In Q1 of 2024, there was a slight variance in the forecasted energy created compared to the actual demand. Baseload plants can take days to shut down and power on again in an extremely inefficient process.[78] Large coal and nuclear baseload plants located in the Great Lakes region need to maintain a stable energy output to prevent plant curtailment, driving this disconnect. Hosting on-site battery storage can allow Cyclone to capture the renewable wind resource in the mornings and afternoons when the wind is substantial, and output electricity in the evenings when there is heavier grid demand. Having a hybrid plant provides the framework for other firms to replace carbon intensive coal plants, whose excess electricity is often exported to other grids.[79] Operating a net-zero baseload plant, Cyclone can set precedent for other renewable energy projects aiming to completely replace fossil-fuel power plants. There has been recent skepticism surrounding the cost-modeling of battery storage with overestimates of revenue stemming from not acknowledging the natural aging of batteries. Currently, other battery technologies such as leadacid, sodium-sulfur, and zinc-bromine are the more expensive. Lithium-ion batteries can charge and drain quickly, even out electrical input imbalances, and scale with relatively cheap prices.[80] A report from MIT researchers describes how onshore battery storage operating within its full-state-of-charge yields the highest revenue potential and can compensate for degradation-related costs.[81]

***Figure 7***- *MISO Power Allocation:*



## 6.0 Financial Analysis

### 6.1 CapEx

Cyclone's initial project Capex was calculated at $1,866,714,632 (3,771kW). Derived from NREL's JEDI software, this number compiled costs from turbine components, balance of system, and soft costs.[82] These categories are further subdivided into specific costs per component and required labor. Turbine component costs, comprised of nacelles, drivetrains, blades, and towers, amounted to a total of $643,995,000 (1,301kW). The balance of system and soft costs were broken down into substructure and foundation, electrical infrastructure components, assembly and installation, ports and staging, development and engineering, and management costs, reaching a total of $1,029,219,632 (2,079kW). Soft costs, which included commissioning, construction finance, construction insurance, contingency, and decommissioning costs, totaled $58,843,647 (391kW). A detailed outline is depicted below in *Chart and Table 1*.

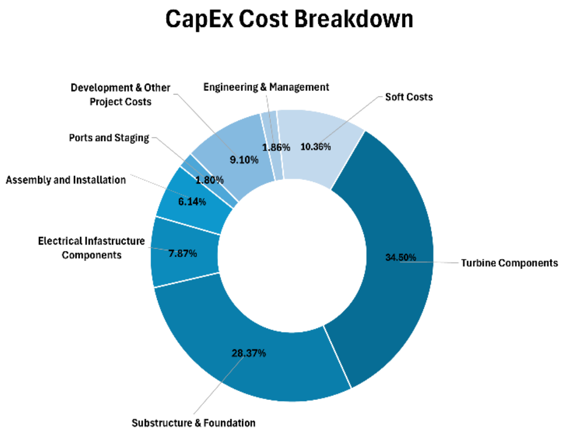
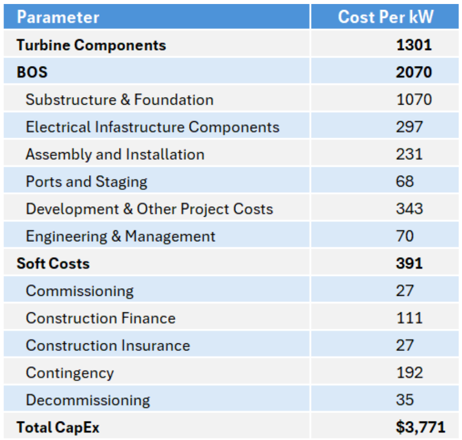


***Chart 2***- *CapEx Expenditure Breakdown Per Percentage*

***Table 3***- *CapEx Expenditure Breakdown By $/kW*



| Parameter | Cost Per kW |
|---|---|
| **Turbine Components** | **1301** |
| **BOS** | **2070** |
| Substructure & Foundation | 1070 |
| Electrical Infastructure Components | 297 |
| Assembly and Installation | 231 |
| Ports and Staging | 68 |
| Development & Other Project Costs | 343 |
| Engineering & Management | 70 |
| **Soft Costs** | **391** |
| Commissioning | 27 |
| Construction Finance | 111 |
| Construction Insurance | 27 |
| Contingency | 192 |
| Decommissioning | 35 |
| **Total CapEx** | **$3,771** |

## 6.2 OpEx

The annual operating expenditures (OpEx) for Cyclone’s farm were computed with the NREL JEDI Model and industry cost averages as references. The total yearly cost was estimated at $58,843,647, equating to $118.88 per kilowatt (kW). Maintenance was broken down into labor costs, spare parts, vessel expenditures and electrical maintenance. These categories came to a total yearly cost of $40,571,462 ($81.96 per kW). Operation costs were compiled from management and administration, operating facilities, environmental health, safety monitoring, insurance, and annual lease fees, equating to a total of $18,272,184 (36.91 kW).[83] A detailed outline is depicted below in *Chart and Table 2*.

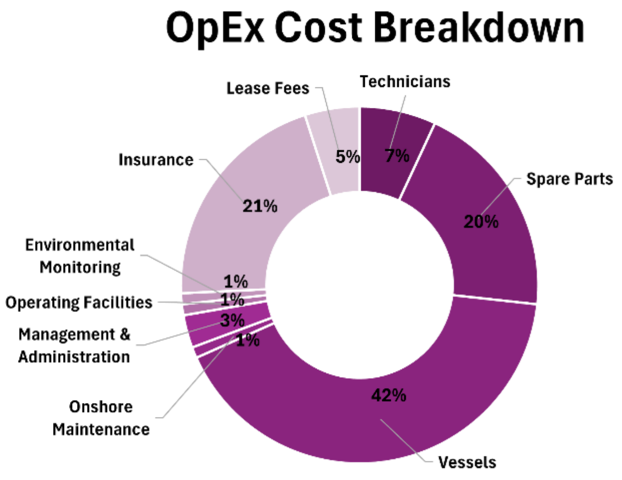
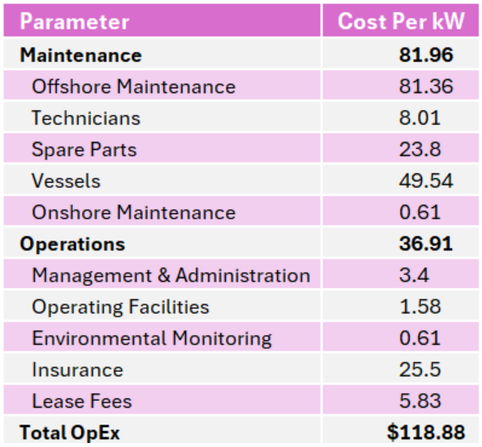


***Chart 2***- *OpEx Expenditure Breakdown Per Percentage*

***Table 2***- *OpEx Expenditure Breakdown By $/kW*



| Parameter | Cost Per kW |
|---|---|
| **Maintenance** | **81.96** |
| Offshore Maintenance | 81.36 |
| Technicians | 8.01 |
| Spare Parts | 23.8 |
| Vessels | 49.54 |
| Onshore Maintenance | 0.61 |
| **Operations** | **36.91** |
| Management & Administration | 3.4 |
| Operating Facilities | 1.58 |
| Environmental Monitoring | 0.61 |
| Insurance | 25.5 |
| Lease Fees | 5.83 |
| **Total OpEx** | **$118.88** |

## 6.3 Financing Plan

Cyclone's financing structure was formed from evaluating capital and operational expenses using industry benchmarks such as the NREL System Advisor Model (SAM).[84] Funding will be provided through a Power Purchase Partnership (PPP) with debt structure. Cyclone will provide an upfront development investment of 20%, financed through debt, and the remaining amount will be provided by private equity firms. Cyclone will partner with companies such as Morgan Stanley, their commercial development partner Crowley Wind Services, and Blackstone’s joint-venture partner Invenergy.[85,86] Currently all these firms have recently expressed their commitment to offshore wind with Crowley’s $426 million dollar investment into the California Humbolt Bay Terminal, along with east coast projects such as the Massachusetts Salem Offshore Wind Terminal. Blackstone has currently invested nearly $4 billion dollars into its partner Invenergy, who currently has plans to facilitate the development of over 250 square miles of offshore farms, supplying over four gigawatts throughout the continental United States.

This partnership will function under a 95/5 tax flip and cash flip structure, through which the investors will assume 95% of both tax credits and operating income until the predetermined flip year where Cyclone will assume 95% of both tax and cash benefits. The Power Purchase Partnership (PPP) will be structured as a debt model, consisting of a debt-to-equity ratio of 46.84%, comprised of $953,426,432 (46.84%) in debt and $1,082,006,272 (53.16%) in equity. With Cyclone's annual AC energy output projected at 1,837,284.992 MWh and a capacity factor of 42.4%, investors can anticipate a return on investment in the seventh year of operation. After the flip, investors will initially receive an Internal Rate of Return (IRR) of

12.11%, which will culminate to an end of project IRR of 12.42%. Ultimately, the farm will have a Levelized Cost of Energy of 7.15¢/kWh. Cyclone will have an initial Power Purchase Agreement (PPA) of 8.87 ¢/kWh, escalating at an annual inflation rate of 2.00%, along with a Debt Service Coverage Ratio (DSCR) of 1.3. Cyclone predicts investor Net Present Value (NPV) of $72,840,816 and a developer NPV of $226,614,960.

## 6.4 Financial Risk Analysis

Recently, many large investment partners such as JPMorgan and State Street have left renewable energy investments. These firms cited that investing in renewable energy conflicted with US laws requiring money managers to act in clients' long-term economic interest.[87] Currently, there is not enough infrastructure to support domestic renewable economies of scale like those seen off the coast of Northern Europe. With Cyclone's infrastructure holding an 8.87¢/kWh production price, and the EIA citing a 12.15¢/kWh 'All Sector' average electricity cost in Indiana, Michigan, Illinois, and Ohio, Cal Maritime believes that its energy will be competitive in the market.[88] Once renewable energy prices drop, Cyclone will have lower capital expenses that will contribute to a highly competitive LCOE relative to coal.[76] With decreased CapEx seen from economies of scale, Cyclone will be able to offer a greater IRR incentive to investors.

## 6.5 Market Conditions

Cal Maritime intends for its electricity to support the decarbonization of MISO's carbon-intensive central region. Currently, 70% of MISO's energy mix is derived from fossil fuels. In 2020, coal was responsible for 33% of energy production and natural gas was responsible for 34%.[89] Cal Maritime's mission was to provide a farm that will set precedent in the Great Lakes region by delivering a low-cost and scalable solution to fossil-fuel alternatives. Cal Maritime also intends to sign PPAs with private companies that are interested in decarbonizing their footprints. For example, companies pledging to net-zero emissions like Amazon have signed PPAs with 44 separate renewable energy projects, totaling a capacity of 6.2GW in 2021.[90] According to ABI Research, with short-term contracts, PPAs may grow at an annual rate of 24%.[91] As the US pushes for net-zero by 2050, Cyclone will continue to market its PPAs to the manufacturing sector of the Great Lakes to decarbonize faster.

## 6.6 Triple Bottom Line

Offshore wind development in the Great Lakes region presents a unique opportunity to harness clean and renewable energy while promoting economic and environmental sustainability. Cal Maritime explored the vast potential for renewable energy within Lake Michigan, and Cyclone Wind was designed to be mindful of the environmental and social implications, while creating a self-sustaining energy pillar in the region. From an economic point of view, offshore wind in Lake Michigan presents the opportunity to stimulate the local economy by creating jobs and investing in infrastructure development. Cyclone Wind will employ dozens of engineers, surveyors, environmental consultants, and project developers to create unique and long-term opportunities for individuals in the renewable energy field. From a social standpoint, developers have the opportunity to engage with local stakeholders and the community to promote the benefits of clean and renewable energy.

## 7.0 Blockchain Risk Mitigation

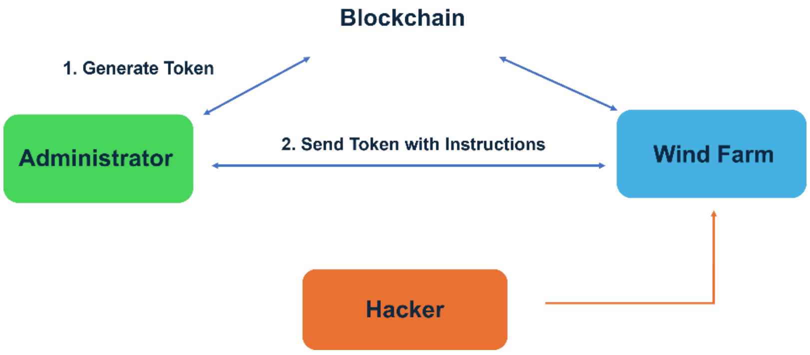


***Figure 8:*** *Sample Blockchain Process Flow*

In Cal Maritime's research and design process, it has been discovered that the security of the American energy infrastructure needs to be considered when looking at any new initiatives. In 2015, Russian hackers attacked the energy grid in Ukraine leaving 225,000 people in the dark.[92] In 2012, Saudi Aramco was forced to shut down 35,000 computers and default to operating with typewriters and fax machines.[93] On May 6, 2021, the Colonial Pipelines were attacked, hindering the flow of jet fuel and gasoline to end-market consumers.[94] From 2020 to 2022, state-sponsored cyberattacks rose 300%.[95] These examples clearly demonstrate the importance of safeguarding the operational integrity of Cyclone's energy installment. Current wind farms use traditional web-based Application Programming Interfaces (APIs) to communicate commands to turbines, retrieve statuses, and update systems remotely. But, as hacks become more targeted and more sophisticated, this web-based approach is increasingly susceptible to malice both foreign and domestic. When making the transition to a net-zero future, Cal Maritime believes that it is important to show citizens that renewable energy is a secure and viable alternative to fossil fuels. Without the proper infrastructure protecting these technologies, both investor and civilian confidence in future renewable projects could plummet. Cal Maritime recommends further exploring the potential of blockchain integration to reach unprecedented levels of security and risk mitigation. The Web3/Blockchain database operates on a decentralized network where data is represented through unique identifiers.[96] When a transaction is published on the blockchain, the identification structure ensures legitimacy through a private key.[97] Using Blockchain security could render the strategy used in traditional cyberattacks obsolete. Cal Maritime 's wind farm will be able to effectively mitigate the risk of cyberthreats to Cyclone's infrastructure.

Shown above in *Figure 8* is an example of a Blockchain security working flow. The process starts off with the Blockchain network generating a decentralized token and sending it to Cyclone's cyber-administrator. The administrative team creates instructions for turbines and other infrastructure to follow. The token is a unique identifier that cannot be copied, substituted, or divided. If any instructions have been manipulated in a way other than the original permissions of the admin, farm infrastructure will immediately invalidate the request. The malicious attempt is also logged, which can provide authorities with information as to where the attack originated and how it was attempted. This is important as the financing of renewable technologies and wind farms are inherently expensive, and losing the ability to interact with Cyclone could result in a significant rise in the farm's LCOE, reducing investor confidence. Cal Maritime believes that incorporating Blockchain security is a vital ancillary component to renewable energy's success as it phases out fossil fuels.

## 8. Optimization Process

Cal Maritime's optimization process was segmented into five phases. Phase one began with an initial scan of all possible locations in Lake Michigan and Lake Erie. After establishing a set of constraints including key areas such as the abundance of wind resource, proximity to established grids and supply chains, ice mitigation, and hybrid opportunities, Cyclone found that the southernmost part of Lake Michigan would be an optimal location for further development. Phase two included the development of a wind resource assessment for the selected area. Procured with NASA's ERA-5 Data, wind averages were processed with the use of UL's Windographer software. This formatted the data into Met Mast layers which were set at a multitude of locations and hub heights. Phase three consisted of designing the farm's turbine layout. Utilizing UL's Openwind farm to model and design potential farm layouts, Cal Maritime built a comprehensive map of the lease location. This included locations set at unique latitude and longitudes, lake bathymetry, proximity to FAA radar towers, shipping fairways, icing zones, elevation data, and lake activities. From these constraints, a validity map was created to demonstrate optimal locations in the selection area.

Phase four incorporated the use of Openwind's optimization feature to design the layout of the farm. Initial testing of the turbine layout was set solely to optimize energy capture, establishing a model of the most efficient layout. In the final phase, financial metrics including array cables, turbines, and export cable costs were minimized. The end model was optimized through over 60,000 iterations for a low cost of energy while producing a market-comparable capacity factor. Specifications were then imported in the NREL JEDI and SAM models to be further analyzed from a cost standpoint.

## 9.0 Auction Bid

Cyclone will propose a bid price of $30,885,000. This amount was obtained through analyzing industry trends and associated risks, while considering the imperative need for community support. The lease area of Cyclone encompasses approximately 6,177 acres. Cyclone will invest at a rate of approximately $5,000 per acre.[98] This metric reflects a financial cushion for the uncertainties found in offshore wind investment. In turn, Cyclone has formulated an operation that strikes a balance between a precedent-setting energy plant with a strong market viability. Drawing insights from bid prices observed in auctions such as the Gulf of Mexico, where bids reached as low as $5,600,000, Cyclone understands the importance of aligning bid prices with risk profiles.[99,100] Moreover, the proposed bid price seeks to foster a regional collaborative environment, incentivizing workforce development through community engagement, and contributing to the sustainable development of the Greater Lake's region.

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