New York State Great Lakes Wind Energy Feasibility Study

White Paper

Prepared by

New York State Energy Research and Development Authority

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Abstract

The Great Lakes Wind Energy Feasibility Study investigates the feasibility of adding wind generated renewable energy projects to the New York State waters of Lake Erie and Lake Ontario. The study examines myriad issues, including environmental, maritime, economic, and social implications of wind energy areas in these bodies of freshwater and the potential contributions of these projects to the State's renewable energy portfolio and decarbonization goals under the New York State Climate Act.

The study, which was prepared in response to the New York Public Service Commission Order Case 15-E-0302, presents research conducted over an 18-month period. In describing the key investigations, twelve technical reports were produced. The overall Feasibility Study presents a summary and synthesis of all twelve relevant topics. This technical report offers the data modeling and scientific research collected to support and ascertain Great Lakes Wind feasibility to New York State.

To further inform the study in 2021, NYSERDA conducted four public webinars and a dedicated public feedback session via webinar, to collect verbal and written comments. Continuous communication with stakeholders was available via NYSERDA's dedicated study email address greatlakeswind@nyserda.ny.gov

Additionally, NYSERDA circulated print advertisements in the counties adjacent to both Lake Erie and Lake Ontario as to collect and incorporate stakeholder input to the various topics covered by the Feasibility Study.

Keywords

Great Lakes, Lake Erie, Lake Ontario, wind energy, resource, fixed bottom substructure, floating substructure, siting, cost modeling, economic development, jobs, environmental, regulatory, grid interconnection, risks and benefits infrastructure, ports, vessels, permitting, visual impact, viewshed

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Summary

This white paper has been prepared by the New York Energy Research and Development Authority (NYSERDA) to offer commentary and findings regarding the resource potential and a range of issues to be addressed when considering the development of wind energy projects in the New York State waters of Lake Erie and Lake Ontario (Great Lakes Wind). The paper is based on the analyses from the New York State Great Lakes Wind Energy Feasibility Study[1] (Feasibility Study) and the associated technical reports filed concurrently by NYSERDA.

On June 18, 2020, NYSERDA and the Department of Public Service filed the white paper on Clean Energy Standard Procurements to Implement New York State's Climate Leadership and Community Protection Act. Among other topics, that white paper suggested that a feasibility study for Great Lakes Wind might be warranted to explore the potential long-term benefits of the resource. Accordingly, the Public Service Commission's (PSC) October 15, 2020, Order instructed NYSERDA to conduct a feasibility study of Great Lakes wind energy to commence within 180 days of the Order's effective date.[2] In that Order, NYSERDA was directed to study environmental, maritime, economic, and social issues as well as market barriers and costs of developing wind energy in the Great Lakes as an essential step toward assessing this potential resource's overall value and viability for helping New York State achieve the Climate Leadership and Community Protection Act (Climate Act) goals.

In response to the PSC order, NYSERDA contracted with the National Renewable Energy Laboratory (NREL), the Brattle Group, Pterra Consulting, and Advisian to conduct the Great Lakes Wind Feasibility Study beginning in February 2021. The development of the Feasibility Study included four public webinars to inform the public of the effort and progress, and a dedicated public feedback session to gather insights and concerns of various stakeholders. Additional outreach was completed via a dedicated NYSERDA website,[3] email communication, and local print ads in newspapers and periodicals in the counties comprising New York State lakeshore. The Feasibility Study also included interviews with the State of Pennsylvania, Natural Resources Canada, the provincial governments of Ontario and Quebec, and representatives from Indigenous Nations via the Haudenosaunee Environmental Task Force (HETF). The final Feasibility Study synthesizes twelve technical reports assessing potential project risks, opportunities, and technical feasibility. The technical reports for the Feasibility Study include the following topics:

1. Evaluation of Site Conditions;
2. Physical Siting Analysis;
3. Geophysical and Geohazards Characterization;
4. Ports and Infrastructure;
5. Fixed and Floating Technology Options;
6. Interconnection;
7. Cost Modeling;
8. Economic Development and Workforce Opportunities;
9. Federal and State Permitting Roadmap;
10. Environmental Risk, Benefit, Mitigation Analysis;
11. Visual Assessment;
12. Public Feedback and Stakeholder Session Report.

This white paper summarizes the comprehensive technical studies conducted in the Feasibility Study and provides additional analysis of the role of Great Lakes Wind projects in the context of New York State's renewable energy portfolio and pathways to reach New York State's Climate Act goals.

Based on the totality of this analysis, this concludes that Great Lakes Wind currently does not offer a unique, critical, or cost-effective contribution toward the achievement of New York State's Climate Act goals beyond what existing, more cost-competitive programs are currently expected to deliver. This conclusion is based on a fulsome analysis of the resource development costs, ratepayer impacts, expected State benefits, transmission and interconnection limitations, infrastructure and supply chain constraints, visual impacts, and potential environmental impacts of Great Lakes Wind, as discussed below and throughout the Feasibility Study.

The Feasibility Study analyzed the physical characteristics of Lake Erie and Lake Ontario to determine that they would require a combination of fixed offshore wind foundations in Lake Erie and floating offshore wind foundations in Lake Ontario. The Feasibility Study further notes that the potential theoretical buildout of the New York areas of each lake could result in a generation capacity of up to 1,600 megawatts (MW) in Lake Erie and up to 15,000 MW in Lake Ontario. But this theoretical and technical potential faces numerous practical considerations that would need to be addressed before such projects can be successfully commercialized and benefit the State. These practical considerations include higher relative costs compared to alternative renewable energy generation, risks associated with new technologies (e.g., floating wind platforms and ice loading), lack of an existing supply chain, lack of adequate port facilities and specialized vessels, limited Points of Interconnection (POIs) and associated transmission headroom, and challenges related to visual impacts, wildlife impacts, and uncertainties with regards to environmental risks as well as conflicts with other lake uses including commercial and recreational fishing, shipping, and navigation.

The Feasibility Study estimates costs associated with Great Lakes Wind that at first appear comparable to costs under the Offshore Wind Standard. However, when comparing the costs and benefits of Great Lakes Wind to other renewable energy options in the State's portfolio, the appropriate comparison is to land-based renewables and not offshore wind projects.

Great Lakes Wind does not provide the same electric and reliability benefits that offshore wind offers New York State. The PSC adopted the Offshore Wind Standard "… because of its proximity and direct access to load centers, offshore wind would provide substantial reliability and diversity benefits to the electric system [...] It may also produce significant public health benefits by displacing fossil-fired generation in the downstate area."[4] Great Lakes Wind projects would not have the same proximity and direct access to load centers (Zones J and K) or displace downstate fossil-fired generation. Therefore, at the interconnection points of Great Lakes Wind projects in Central and Western New York, the more appropriate cost comparison is with more cost-effective technologies typically sited in that region such as land-based wind and solar.

This white paper finds that Great Lakes Wind projects would be significantly more costly for ratepayers to support than projects currently advanced under Tier 1 of the Clean Energy Standard (CES), such as land-based wind and solar. For example, the 2021 Tier 1 solicitation resulted in Index REC Strike Prices between $42 and $63/MWh, which is 55 to 230 percent cheaper than the $98 to $138/MWh range estimated for Great Lakes Wind projects. Moreover, that cost differential could increase further as the Feasibility Study cost estimates of Great Lakes Wind do not fully account for additional costs associated with interconnection, infrastructure, and labor, which would require site-specific evaluations and more detailed modeling.

The potential grid Points of Interconnection (POIs) identified for Great Lakes Wind in the Feasibility Study are in areas with limited hosting capacity, with competition from other less expensive land-based renewable generation projects which are also advancing in this region. As a result, Great Lakes Wind projects would incur high interconnection costs to advance and would displace lower-cost alternatives.

From an infrastructure perspective, ports around the Great Lakes would need, in some cases, significant upgrades to support the development of these projects, and in-lakes vessels or purpose-built vessels would need to be used for construction and operation. The required ports, vessel infrastructure, and supply chain investments needed to execute Great Lakes Wind were not quantified in the Feasibility Study and would add to the overall cost of Great Lakes Wind.

Substantial public and regulatory concerns have also challenged wind energy projects in and around the Great Lakes, primarily due to anticipated viewshed impacts and implications of the projects on wildlife. Through the public feedback events and webinars, the public expressed a wide range of interest, both in support of and expressing concerns about Great Lakes Wind. Viewshed, environmental, and public health issues are the primary concerns, and job creation and economic development opportunities are the primary arguments supporting Great Lakes Wind. The Feasibility Study demonstrates that the visual impacts of Great Lakes Wind, at least in Lake Erie, would be considerable given the need for a relatively limited distance from shore necessary to support a project at scale in that lake. For example, in Lake Erie, limiting the viewshed impact by siting turbines beyond 12 miles from shore would reduce the potential hosting capacity from 1,600 MW to less than 200 MW and further diminish the economic viability of these projects.

With regards to the impact of Great Lakes Wind on wildlife species and the environment, this issue is exacerbated by the lack of data relating to the temporal and spatial distributions of wildlife both at specific locations and across the Great Lakes as a whole, including data on aerial fauna, fish habitats, benthic communities, and human uses. Further, sediment contamination is widespread but not well mapped to support least impact site identification. And the extent and duration to which Great Lakes Wind development could resuspend or redistribute these contaminants are uncertain. Each of these issues imparts development risks and uncertainties to potential projects. These issues are not necessarily insurmountable, but additional research, data collection, and analysis are warranted to identify areas of lowest risk and support project development certainty.

While the Feasibility Study identifies job and other economic benefits that could arise from Great Lakes Wind development, without the strategic case for Great Lakes Wind as a critical contributor to the Climate Act goals, these benefits alone do not justify the high level of ratepayer cost given the renewable energy alternatives that have already demonstrated their ability to contribute in more beneficial ways. NYSERDA has not identified unique characteristics of Great Lakes Wind that reflect a component otherwise missing in the State's efforts to achieve the Climate Act goals. The response rate to Tier 1 solicitations indicates an adequate development pipeline in the geographies where Great Lakes Wind could interconnect to and already maximize the contribution from those areas to at least the 70 percent renewables by 2030 target. Without unique characteristics that would set Great Lakes Wind apart from more cost-effective contributors towards the Climate Act goals, the high additional cost is challenging to justify, at least with a view to the 2030 target.

After completing the Feasibility Study and considering these various dimensions collectively, NYSERDA recommends that now is not the right time to prioritize Great Lakes Wind projects in Lake Erie or Lake Ontario.

Taking no action now does not mean there may not be an opportunity to advance Great Lakes Wind at some point in the future. The resource may become a feasible contributor to New York State's goals in the future as the State advances toward its mid-century goals, and the Ohio demonstration project in Lake Erie discussed herein may provide further information to help inform a decision on this matter. Additionally, upgrades in the transmission system or new interconnection opportunities could result in lower costs or create opportunities. Finally, additional studies could be undertaken to reduce environmental risk and gain a better understanding of the estimated cost and benefits of building Great Lakes Wind projects as alternative resources advance toward achieving the mid-century Climate Act goals.

1 Introduction

On July 6, 2015, the New York State Energy Planning Board issued the 2015 State Energy Plan, which stated the goal to achieve 50 percent of the State's electricity generated from renewable resources by 2030 (50x30 goal).[5] In December 2015, Governor Andrew Cuomo directed the Department of Public Service to develop a Clean Energy Standard (CES) to help achieve this goal.[6] On August 1, 2016, the Public Service Commission (PSC) issued its Order, Adopting the Clean Energy Standard, which established the Renewable Energy Standard as the State's principal means of achieving the 50x30 goal.

In July 2019, the State passed the Climate Leadership and Community Protection Act (Climate Act), which represents the most ambitious and comprehensive climate and clean energy legislation in the country. The Climate Act directs the State to reduce its carbon footprint and improve the resiliency of communities across the State, including that 70 percent of electricity comes from renewable energy sources by 2030 (70x30 goal), a commitment for 100 percent zero-emission electricity by 2040, and an 85 percent reduction in greenhouse gas (GHG) emissions by 2050. On October 15, 2020, the PSC issued its Order Adopting Modifications to the Clean Energy Standard in Case 15-E-0302, which adopted several modifications to the CES to align it with the Climate Act mandates, focused on achieving the 70x30 goal.

Since 2018, NYSERDA has awarded approximately 14,500 megawatts (MW) of new large-scale renewable energy contracts under the CES to a total of over 120 projects under development. Among these projects, the State has contracted with five offshore wind projects in the Atlantic Ocean totaling over 4,300 MW of capacity. Collectively, once these projects are operational, they will provide enough renewable energy to power over five million households and meet nearly 30 percent of the State's electricity needs by 2030. Combined with operating renewables, deployment of 10,000 MW of distributed solar under the NY Sun program, and New York State's procurement of renewables directly into New York City under its Tier 4 program, this represents more than 66 percent of the State's electricity from renewable energy once operational.[7]

In recent years, offshore wind developers and energy regulators in Ohio, Illinois, and Michigan have taken steps to explore the potential of wind energy development in the Great Lakes (Great Lakes Wind), primarily in relatively shallow Lake Erie. Renewable development in the Great Lakes, if feasible and justified, could also play a key role in the State's path to a diversified clean energy economy.

On June 18, 2020, NYSERDA and the Department of Public Service filed the white paper on Clean Energy Standard Procurements to Implement New York State's Climate Leadership and Community Protection Act. Among other topics, that white paper suggested that a feasibility study for Great Lakes Wind might be warranted to explore the potential long-term benefits of the resource. The PSC's October 15, 2020, Order instructed NYSERDA to conduct a feasibility study of Great Lakes wind energy to commence within 180 days of the effective date of the Order. The Order directed NYSERDA to study environmental, maritime, economic, and social issues as well as market barriers and costs of developing wind energy in the Great Lakes as an important step toward assessing the overall value and viability of this potential resource for helping the State achieve the Climate Act goals. The Order added that if, following the completion of the feasibility study, a viable path forward for Great Lakes offshore wind is identified, any proposals to conduct a solicitation shall come before the PSC for consideration and decision.

NYSERDA engaged the National Renewable Energy Laboratory (NREL) to be the primary author of the Feasibility Study, with responsibility for studying the technology, project costs, and benefits assessment. Advisian was selected to conduct supporting studies relating to environmental concerns, regulatory pathways and viewshed. The Brattle Group and Pterra, which supported grid related analysis in the Power Grid Study,[8] were engaged to support transmission and interconnection related work. The study, which is an integrated work product from all consultants, focuses on development of the wind resource in Lakes Erie and Ontario. NYSERDA sought to keep the public informed about the Feasibility Study and its progress through several public webinars, print advertisements in local media, and sought public feedback and perspectives through a dedicated public feedback session. Through this process public input was received and incorporated into this study and white paper.

The white paper discusses data and insights from the Feasibility Study in the context of the State's renewable energy portfolio to develop a better understanding of the potential for Great Lakes Wind to make a meaningful contribution to achievement of the Climate Act goals. Technical potential is summarized in section 2. Barriers and risks to success for Great Lakes Wind projects are considered with respect to ports and vessels (section 3), interconnection and transmission (section 4), costs and benefits (section 5), and environmental and permitting issues relating to wildlife, contaminated sediments, and human uses of the resource (section 6). Finally, in section 7, the white paper summarizes stakeholder views relayed to NYSERDA over the course of the project and describes the key areas of uncertainty or risk informed by NYSERDA's direct experience administering renewable energy programs. Each section of this white paper summarizes information presented in the Feasibility Study on the respective section topics, provides additional context for interpreting the results, and concludes with key findings relevant to New York State policy.

2 Freshwater Wind Energy in the Great Lakes

The development of wind energy projects in marine systems has been ongoing in Europe and Asia for decades and is currently expanding in scope and scale. New York State has been leading the rapid expansion of offshore wind energy development in the U.S., establishing a nation leading offshore wind program, including a mandate of 9,000 megawatts (MW) of offshore wind by 2035, procuring over 4,300 MW of offshore wind projects to date, and investing more than $700 million into port and supply chain development.

Development of wind energy in freshwater lakes has not received the same attention globally as development in the marine environment. This is potentially due to technology concerns with ice loading on the wind turbine platforms, difficulty developing the infrastructure necessary to build to scale in smaller bodies of water, the relative cost in relation to marine development and other renewable energy technologies. There is currently one large-scale freshwater wind energy project found worldwide. Commissioned in 2021, Windpark Fryslân totals 383 MW of energy production. The project is sited approximately 3.7 miles off the coast of the Netherlands in Lake IJssel, a large, shallow (max 7 meters) lake fed by a series of rivers and closed off from the ocean by a manmade dike.[9]

In the United States, there is one Great Lakes offshore wind project currently in active development. Recently, Lake Erie Energy Development Corp.'s (LEEDCo's) Icebreaker Wind, a 20.7 MW demonstration project located 8 miles off Cleveland, Ohio in Lake Erie (six 3.45 MW turbines with mono bucket foundations) cleared permitting and policy legal hurdles to continue development.[10] The Ohio Power Siting Board first issued a certificate to the project in May 2020, requiring the rotors to be turned off from dusk to dawn for the majority of the year to minimize wildlife impacts while studies were ongoing. Icebreaker Wind objected to the condition and requested reconsideration. In October 2020, the shutdown requirement was removed, and the project was instead required to continue monitoring wildlife activity and incorporate harm minimization technologies. The decision was appealed by local residents, and on August 10, 2022, the Ohio Supreme Court found that the Ohio Power Siting Board appropriately granted a certificate of environmental compatibility and public need to the project.[11] One-third of the power from the project is already under contract with the City of Cleveland and Cuyahoga County. Developers are currently working to identify buyers for the remaining two-thirds of the project's production.[12]

2.1 General Characterization of Lake Erie and Lake Ontario

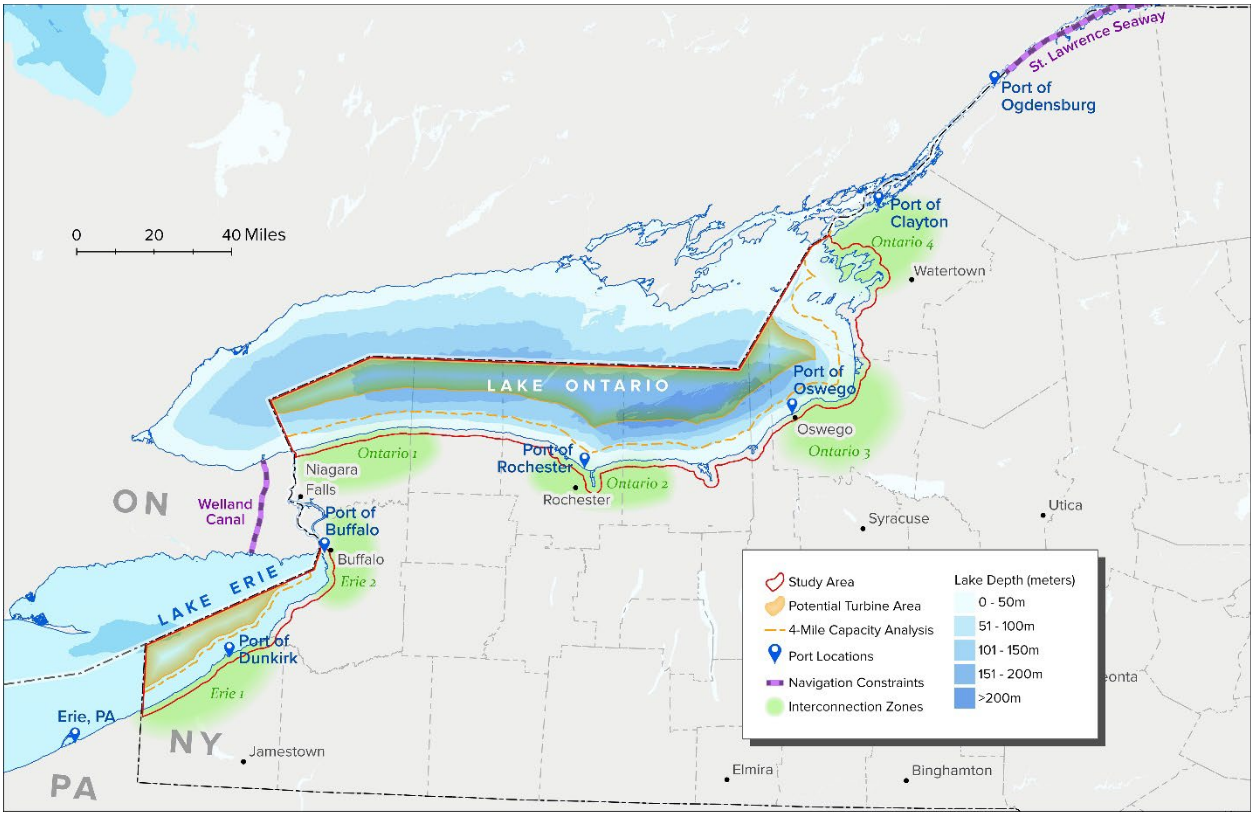
The Great Lakes are the largest group of freshwater lakes on Earth, totaling 94,250 square miles. They are also the second-largest group of freshwater lakes by total volume, containing 21 percent of the world's surface fresh water. New York State's Great Lakes, Erie and Ontario, present a potential opportunity to expand renewable energy resources to support the State's ambitious climate goals.

The Feasibility Study considered the geographic area and physical conditions of the New York State waters of Lakes Erie and Ontario that influence their potential for wind energy development (Figure 1). The potential wind resource area totals approximately 214,000 acres in Lake Erie and 1.6 million acres in Lake Ontario.

Lake Erie is considerably shallower, with an average depth of 19 meters compared to 86 meters in Lake Ontario. The geology of Lakes Erie and Ontario is primarily defined by the history of glaciation in the region. Soil composition in both lakes is relatively soft, but surface sediment thicknesses appear to be deep enough over the bedrock to allow piled substructures.[13] Both lakes exhibit the presence of bedrock within 20 meters or less from the surface in some places.

The mean wind speeds at 100 meters above the lake surface range from 8.3 to 9.0 meters/second (m/s), on par with the mid-Atlantic regions where offshore wind energy is proliferating. The strongest winds are during the winter, while the average August winds are about 3 m/s below the annual average. These wind speeds suggest that capacity factors well over 40 percent could be expected. Based on a conservative nameplate power capacity density of 3 MW/km^2 and a theoretical minimum distance from shore of 4 statute miles, Lake Erie waters could potentially have a theoretical and technical buildout of up to 2,000 MW of wind energy generation, while Lake Ontario waters could technically support up to 18,000 MW.[14] However, several constraining factors that present challenges for wind energy development may reduce the estimated theoretical and technical generation potential of the lakes as discussed in the following section.

Figure 1. New York State Great Lakes Wind Study Area



2.2 Constraints to Wind Development Considered in the Feasibility Study

Early in the development of the Feasibility Study it was found that environmental, technical, and human conflicts with wind development would likely be substantially greater in close proximity to the shore.[15] Near-shore resources, such as avian flyways, fisheries, and public recreation areas may be disproportionally affected by wind turbine stressors (e.g., associated with the installation or operation of wind turbines). Nearshore areas are also associated with greater ice accumulation, more significant visual impacts, and potentially more sediment contamination. All in all, factors, including wildlife or habitat conflicts, shipping constraints, or other factors such as policy on minimum distance from shore, may constrain the potential generation capacity that could be developed in the Great Lakes.

In consideration of these factors, approximately 20 percent of the technical potential area within each lake (2,000 MW in Lake Erie and 18,000 MW in Lake Ontario) was estimated as having potential constraining factors that may present challenges for wind energy development, reducing the estimated technical generation potential to 1,600 MW in Lake Erie, and 15,000 MW in Lake Ontario. Detailed site assessments would need to be carried out in any potential wind energy area to determine its suitability for development and fully assess such constraining factors and their impact on the technical potential of Great Lakes Wind energy generation.

2.3 Findings: Freshwater Wind Energy in the Great Lakes

The physical and climatic conditions of Lake Erie and Lake Ontario play an important role in determining the technical potential of wind energy generation in the Great Lakes. Despite the nascent nature of developing wind energy in freshwater systems of this size and depth, the physical characteristics in Lakes Erie and Ontario would likely require fixed foundations in Lake Erie, and floating foundations in Lake Ontario. After considering viewshed and physical condition constraints, the potential theoretical buildout of the New York areas of each lake could result in a generation capacity of up to 1,600 MW in Lake Erie and up to 15,000 MW in Lake Ontario. But this theoretical and technical potential faces numerous practical considerations that would need to be addressed before such projects can be successfully commercialized and benefit the State, as discussed in the following sections.

3 Ports and Vessel Infrastructure and Supply Chain Development

Due to relatively shallow water depths, projects in Lake Erie would likely use fixed-bottom substructures, whereas projects in the relatively deeper water depths of Lake Ontario would likely use floating substructures. Fixed-bottom projects typically use installation vessels equipped with heavy-lift cranes to assemble and install the substructure and turbine components on site. For floating projects, the general development procedure includes assembly of the substructure and turbine at port, transiting of the assembled substructure and turbine from port to site, and connecting the floating system to a pre-installed mooring system. Most floating systems require sizable quayside space and heavy-lift cranes at the port for assembly.

Wind turbine size is a key parameter that affects installation logistics. Larger turbines allow for significant reductions in per-MW costs of installation, operation, and maintenance because there are fewer units to install and maintain for a given power output. However, making use of these larger machines requires a commensurate increase in vessel sizes and port capacities, and consideration of this balance in costs is necessary to find the most cost-effective approach. The Feasibility Study assumes that the Great Lakes Wind turbines would have a nameplate capacity between 4 and 7 MW.

3.1 Ports

To support wind farm development, sufficient port infrastructure is required to assemble turbines and substructures and transfer them to installation vessels, in particular for floating projects.

The Feasibility Study considers the following ports: Buffalo, Dunkirk, and Erie (PA) on Lake Erie; and Clayton, Ogdensburg, Oswego, and Rochester on Lake Ontario. Each of these ports has unique benefits, but all Great Lakes ports would require significant upgrades to support Great Lakes Wind energy development. Most of the Great Lakes ports would require additional cranes to move the bigger, heavier components of the turbines, and most of the ports would also require expanded quayside space along with dredging of the channels and cargo ports to be able to accommodate the large vessels required to transport, assemble, and install wind turbines in either Lake Erie or Lake Ontario at the scale of a commercial project. More substantial improvements may be required to enable existing ports to support installation of floating projects in Lake Ontario than for fixed projects in Lake Erie due to requirements for sizable quayside space and heavy-lift cranes for assembly.

3.2 Vessels

The most limiting physical constraint on the types of vessels available in the Great Lakes is the St. Lawrence Seaway's dimensions. The seaway allows vessels to reach the Great Lakes from the Atlantic Ocean through seven locks amongst four canals between Montreal and Lake Ontario, and eight locks that connect Lake Ontario to Lake Erie. The Feasibility Study reports that most conventional vessels used for offshore wind development are too large to transit the series of locks and canals. Conventional vessels used for offshore wind development can be up to 70 meters in width, and up to 13.5 meters in draft. The maximum vessel size that can be accommodated through the locks is less than 24 meters wide and around 8 meters in draft. The smaller sizes of some, but not all, conventional offshore wind vessel types would be able to transit the seaway.

However, the Feasibility Study indicates that existing tugboats and barges in the Great Lakes could be used to install wind turbines, as an alternative to conventional offshore wind installation vessels. As a final option, vessels could also be constructed or retrofitted specifically for Great Lakes Wind development. The economic feasibility of constructing such vessels would depend on achieving a large enough pipeline of wind energy development throughout the Great Lakes considering constraints on transiting the vessels between lakes.

The vessel requirements differ for fixed bottom installations in Lake Erie from floating installations in Lake Ontario. At the turbine sizes envisioned in the Feasibility Study (4–7 MW), non-conventional, innovative installation vessel solutions have potential in Lake Erie, such as an altered barge, assembled from smaller barges, with a land-based crane. A custom-built installation vessel that could permanently reside in the Great Lakes is another possible solution if regional development of Great Lakes Wind expands beyond New York State and between-lakes locks allow, but none exist today, and adaptation of existing vessels likely constitutes a lower-cost approach. For floating installations in Lake Ontario, the substructure could be assembled at quayside using only cranes and no other specialized equipment, and then transferred to a barge using a land-based crane. The completely assembled turbine and substructure could then be towed to the project site using tugboats and then connected to the mooring system and subsea cable using smaller installation vessels. The Feasibility Study reports that many tugboats and barges that currently exist in the Great Lakes could be used to transport floating systems of any size from port to the project site.

3.3 Supply Chain

Substructure designs for both fixed and floating installations to support Great Lakes Wind will be different from the design of turbines used in ocean conditions, both as a result of the different environmental conditions for Great Lakes Wind and the need to adapt the design of the installations to reflect the capabilities of the relevant port facilities for substructure fabrication, quayside turbine assembly, loadout to site, and service.

NYSERDA's previous awards to downstate offshore wind projects include a staging facility at the South Brooklyn Marine Terminal, a tower factory at the Port of Albany, and an advanced foundations manufacturing facility at the Port of Coeymans. These projects are supported, in part, by $200 million in State funding advanced through ORECRFP20-1. Additionally, the currently open ORECRFP22-1 includes the first phase of $500 million of New York State funding for supply chain investment in the State. The Feasibility Study indicates, however, that these components would not be compatible with Great Lakes Wind projects because of constraints in the locks system, and the limited capacity of heavy lift cranes, and potential viewshed considerations. The particular site conditions in the Great Lakes dictate other design considerations as follows:

- The fixed bottom foundations expected to be used in Lake Erie would be subjected to freshwater ice loads, requiring substructure modifications. Additionally, soil conditions in the Great Lakes are notably different from other parts of the world where offshore structures are developed. The manufacturability and cost of any substructure deployed on the Great Lakes will be challenged by supply chain development because there are no facilities currently available. However, it is potentially feasibly that the foundation sub-components could be manufactured elsewhere and assembled quayside. The optimal fixed-bottom substructure type for Great Lakes Wind will likely be some adaptation of one of the substructures that meets the ice, geotechnical, and logistical requirements for Lake Erie, introducing advancements necessary to account for the lake's unique physical and logistical conditions.
- In Lake Ontario, water depths indicate that floating technology would be used. Surface ice loading can impart significant loads to floating installations as well, which becomes a primary consideration when assessing the feasibility of floating substructures for Great Lakes Wind. New floating substructure designs, customized for these conditions, are expected to be the most feasible design for a Great Lakes Wind project.

The expected turbine sizes align with land-based turbine models, which would enable Great Lakes Wind to potentially leverage a domestic supply chain that already exists to serve land-based wind installations in the Great Plains, western New York State and Pennsylvania, among other United States regions. Manufacturing facilities for these turbines and complementary components, however, do not currently exist in New York State. Unless and until these are developed on the Great Lakes, turbine and substructure components would have to be transported from outside manufacturing facilities, potentially outside of New York State, to a Great Lakes port by either water, rail, or highway. Economic benefits would only accrue if manufacturing capability for such components were developed in the State.

3.4 Findings: Ports and Vessel Infrastructure and Supply Chain Development

Port infrastructure would need substantial upgrades to support development of wind energy projects in the Great Lakes at a commercial scale. The Feasibility Study does not quantify the cost of such upgrades, but the cost would add to the overall cost of Great Lakes Wind reflected in section 5. Vessel size limitations imposed by the lock system would necessitate the use of existing in-lakes vessels (or locally manufacturing new in-lakes vessels) since available canal infrastructure will not allow sufficiently large vessels to be brought in from elsewhere, particularly along the St. Lawrence Seaway. Use of the existing local vessel fleet could be accomplished with limited modifications. Installation components compatible with Great Lakes Wind, in particular turbines, could be provided by the existing regional manufacturing supply chain for land-based wind facilities and could be transported to the Great Lakes by rail, road, or ship, though questions remain whether this supply chain would need to adapt its offering to provide compatible substructure components. In order for economic development benefits associated with supply chain and manufacturing described in the Feasibility Study to be realized in the State, additional investment would be required to develop the necessary capabilities.

4 Interconnection

4.1 Capacity Headroom Analysis

In the case of both Lakes Erie and Ontario, generation from any Great Lakes Wind project does not coincide with the large electric load centers (demand) such as those associated with New York Independent System Operator (NYISO) Zones J and K. Therefore, the generation associated with a Great Lakes Wind project would need to have sufficient on-ramp headroom to the bulk transmission system to address need at load centers in New York State.

The Feasibility Study includes a high-level capacity headroom analysis of possible POIs along the shorelines of Lake Erie and Lake Ontario. The headroom analysis was conducted using an approach similar to that proposed by DPS staff,[16] and used to determine how much capacity could be accommodated at specific POIs. The study evaluated capacity headroom for both the existing system and with conceptual transmission upgrades in place.[17] This analysis provides useful information from a feasibility of interconnection perspective, but it does not replace the actual multi-stage interconnection study that would need to be done by the NYISO to determine the cost of interconnection, culminating in the NYISO class year process.

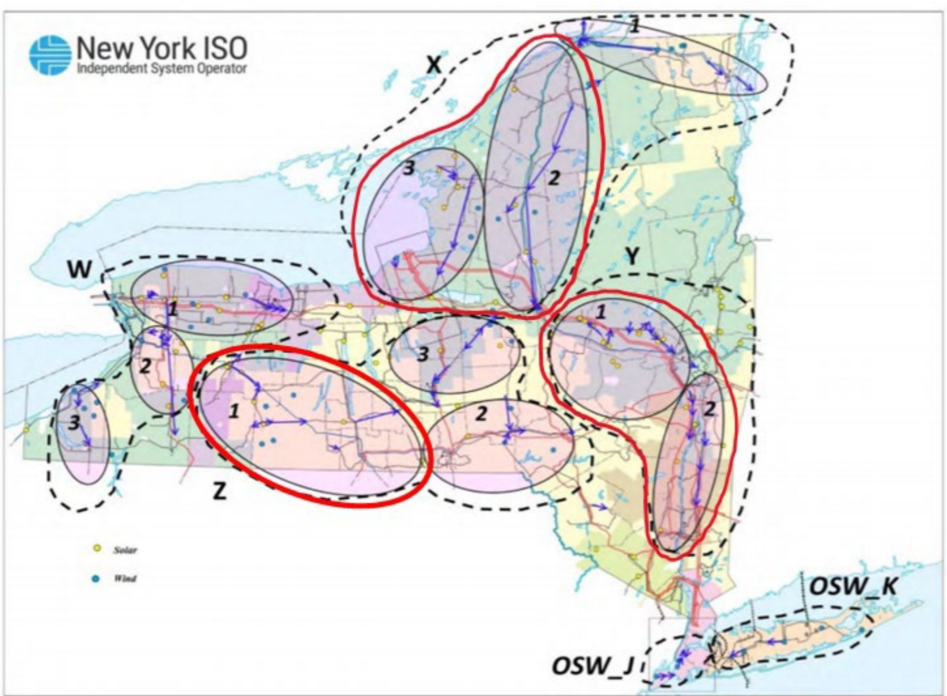
The Feasibility Study's headroom analysis concludes that there is currently limited available capacity at the POIs in the areas where Great Lakes Wind projects would bring power onto shore, identifying up to 270 MW of transmission headroom for Lake Erie projects and up to 1,140 MW for Lake Ontario projects.[18] The Feasibility Study found that the addition of conceptual transmission upgrades could increase available headroom by 60 MW to 330 MW for Lake Erie and by 140 MW to 1,280 MW for Lake Ontario. The details supporting these findings are presented in the Feasibility Study.[19]

4.2 Implications of Headroom Limitations Near Lakes Erie and Ontario

The high-level capacity headroom analysis included in the Feasibility Study represents the potential available capability at POIs relevant to Great Lakes Wind after other projects (solar and wind)—already in the NYISO Interconnection queue as of June 2021— have been considered. However, significant further solar and wind project development in Upstate New York is expected as a result of New York State's continuing CES procurements. In order to achieve the Climate Act goals, NYSERDA expects to award at least 10,080 MW of new renewable capacity across the State under Tier 1 solicitations to be held between 2022–2026.[20] The headroom identified in the Feasibility Study as potentially available to Great Lakes Wind projects would also be available to any other generation resource that may want to interconnect at the same POI(s). The NYISO market for new generation is economically competitive, and any Great Lakes Wind project would need to compete with other resource developments to utilize the available headroom. Generators that have earlier queue positions will generally have lower interconnection costs than later projects intending to connect in the same locations.

The potential POIs identified in the Feasibility Study overlap with transmission-constrained "renewable generation pockets" identified by the NYISO, including those identified as Areas of Concern by the PSC,[21] reflecting an expectation that—based on the forecasted onshore solar and wind development alone (i.e., even without adding Great Lakes Wind capacity to the system)—constraints in these areas will arise. Both NYISO renewable generation pockets (represented by black outlines) and Areas of Concern (represented by red outlines) are depicted in Figure 2 below.[22]

Figure 2. NYISO Renewable Generation Pockets and Areas of Concern



Even without considering renewables procurements in future years, the current 2021 NYISO Class Year study deemed five projects non-deliverable at POIs identified in the Feasibility Study as being possible POIs for Great Lakes Wind. Preliminary non-binding System Deliverability Upgrades (SDUs) cost estimates for these projects are $200 million, indicating potential additional costs of $40 million per project, on average.[23] Any Great Lakes Wind project connecting to POIs identified as non-deliverable could also be expected to be exposed to costly SDUs.

Separate from potentially high interconnection costs, headroom constraints could also impact Great Lakes Wind projects in the form of curtailment issues. Adding more capacity in these locations would increase curtailment risk for all projects connected or seeking to connect at these POIs. The PSC has acknowledged the importance of considering the potential curtailment effects on existing and contracted facilities associated with adding new resources to the grid. From the perspective of Great Lakes Wind projects themselves, the prospect of potentially high curtailment levels could also impact project returns, potentially making projects more difficult to finance or at least translating into a higher required REC price that would be passed on to ratepayers.

In order to remove such interconnection barriers, headroom would need to be increased through transmission upgrades. Since, as noted above, consideration of the need of transmission upgrades is not limited to any specific project or technology but rather needs to be considered on a system-wide basis to reflect the full portfolio of current and expected resource deployment, this barrier cannot be addressed in isolation for Great Lakes Wind only. Relevant proceedings to consider transmission upgrades are already underway, in particular through the Area of Concern proposals filed by the utilities in response to the PSC's Phase 2 Order.[24]

4.3 Findings: Interconnection

POIs identified for Great Lakes Wind in the Feasibility Study are in areas with limited transmission capacity headroom, leading to high interconnection costs that individual projects need to pay. Great Lakes Wind is also likely to experience competition for limited transmission headroom from other renewable generation projects (i.e., land-based wind and solar).

The challenges related to limited transmission headroom and high interconnection costs are not specific to Great Lakes Wind. POIs identified for Great Lakes Wind in the Feasibility Study are in areas with limited transmission capacity and high interest from other renewable projects (i.e., land-based wind and solar).

The PSC has recognized the need to identify transmission upgrades in areas of existing curtailment and strong developer interest (i.e., the Areas of Concern), and utilities have proposed transmission improvements in the Areas of Concern in response to this stated need. The utilities are also required to file additional proposals for transmission upgrades to facilitate integration of renewable generation by January 1, 2023. While the PSC has approved and/or is currently considering proposed Phase 1/Phase 2A/Phase 2 upgrades, these upgrades were not designed to accommodate projects beyond those already considered in an advanced stage of development and therefore do not contemplate Great Lakes Wind.

The cost to interconnect any Great Lakes Wind project to the New York Control Area (NYCA) will ultimately be determined only by having the project proceed through the NYISO interconnection process.

5 Project Costs and Benefits

Many renewable energy generation projects require financial support beyond standard energy and capacity revenue. New York State has a framework in place for providing such support through the CES. Within the CES, the Tier 1 program is the primary mechanism for providing support to a wide range of eligible technologies, including Great Lakes Wind.[25] The State also operates a more specific Offshore Wind Standard that offers support for offshore wind projects, but eligibility is limited by the PSC to projects located in ocean waters of the United States that have obtained an offshore wind energy area lease from the Bureau of Ocean Energy Management rendering Great Lakes Wind projects ineligible.

To date, NYSERDA has not received bids from Great Lakes Wind projects in response to its series of annual Tier 1 solicitations. The lack of participation is likely in part due to the barriers discussed throughout the white paper and the Feasibility Study. This section assesses the extent to which Great Lakes Wind projects also face higher costs than other Tier 1 projects, potentially further compounding the challenges Great Lakes Wind would currently face in terms of developing feasible project proposals.

5.1 Estimated Costs for Great Lakes Wind Projects

The Feasibility Study did not include an exhaustive assessment of costs, but it does provide high-level cost estimates representative of most aspects of commercial-scale wind energy projects that could be installed in the New York State waters of Lakes Erie and Ontario and thus enables initial consideration of levels of financial support that might be needed. The Feasibility Study cost estimates are provided in terms of a levelized cost of energy (LCOE) (i.e., reflecting the total project cost per unit of electricity generation over the assumed project lifetime[26].) The key cost drivers of Great Lakes Wind relate to the technology (i.e., fixed-bottom in Lake Erie or floating substructure in Lake Ontario), project size, project location, and commercial operation date (COD). Key input assumptions are summarized in Table 1.[27] Further details of this analysis are available in the Feasibility Study.

Table 1. Feasibility Study Cost Input Assumptions for Great Lakes Wind

	Erie	Ontario West	Ontario Center	Ontario East
Nominal fixed charge ratea	7.64%	7.64%	7.64%	7.64%
2030 COD				
CapEx ($/kW)	$3,727	$4,090	$4,104	$4,078
OpEx ($/kW-yr)	$85	$93	$84	$82
Net Capacity Factor	42.5%	43.6%	45.2%	45.0%
2035 COD				
CapEx ($/kW)	$3,576	$3,914	$3,929	$3,903
OpEx ($/kW-yr)	$78	$89	$80	$78
Net Capacity Factor	43.4%	45.0%	46.7%	46.4%

[a] Fixed charge rate is akin to a discount rate, defined as the annual revenue required per dollar of investment to pay taxes and carrying charges on the investment.

Several uncertainties could impact cost estimates but were not quantified in the Feasibility Study as they would require more detailed modeling and/or site-specific evaluations that were beyond the scope of the Feasibility Study. These uncertainties include the following considerations:

- The Feasibility Study does not consider the full cost of interconnection. As discussed in section 4 above, the Feasibility Study does not fully consider all the cost of interconnection to the NYISO system. Section 4 notes the limited level of headroom available in current transmission infrastructure that would be relevant to Great Lakes Wind projects. Depending on the nature of required upgrades, the NYISO might require Great Lakes Wind projects to incur project-specific interconnection costs not included in the LCOE estimates. This includes (1) the cost to interconnect the project to the NYCA under the NYISO Minimum Interconnection Standards[28] and (2) the cost of any upgrades assessed as part of a Class Year process[29]. While the PSC has approved and/or is currently considering proposed Phase 1 / Phase 2A / Phase 2 upgrades, these upgrades were not designed to accommodate projects beyond those already considered in an advanced stage of development.
- Feasibility Study cost estimates do not include port upgrade costs. As discussed in section 3.1 above, port upgrades on Lake Erie or Lake Ontario would be required to enable the construction and maintenance of Great Lakes Wind projects. The Feasibility Study LCOE estimates do not include port upgrade costs, instead assuming that they would be borne by other parties such as port operators, or potentially New York State through a program similar to the $500 million investment in the offshore wind supply chain. If these upgrades are instead funded by the project developer, the associated costs would be rolled into REC prices bid by projects.
- Feasibility Study cost estimates do not include prevailing wage. The Feasibility Study cost estimates do not include labor cost increases associated with prevailing wage, which is a requirement for NYSERDA's Tier 1 and offshore wind solicitations, and required under New York State Labor Law, and would therefore be expected to increase Great Lakes Wind project costs.[30]

- Feasibility Study cost estimates do not account for market conditions post 2021. The Feasibility Study cost estimates conservatively reflect latest available cost data but do not account for current market conditions post 2021. Project construction costs incurred closer to the COD might well be higher than for equivalent construction activities in 2021, particularly given recent market observations on interest rates, inflation, shipping/freight, and supply constraints. Similarly, operating expenses incurred over the project lifetime could be higher than for equivalent activities in 2021. Depending on project developers' market outlook and risk tolerances, these dynamics could translate to significantly higher REC prices bid by projects.

No quantification is currently available for the impact of the first three of the above four considerations. With regard to the fourth issue—impact of recent market developments on cost—analysis sensitivities are provided to test the impact of an assumed 2.4 percent nominal annual inflation.[31]

- 2.4 percent inflation was applied to the project CapEx amounts shown in Table 1, between 2021 (which reflects the cost data used in the Feasibility Study) and two years before COD (reflecting the last year of development shown in the Feasibility Study, used as a proxy for when construction costs are expected to be finalized),
- 2.4 percent inflation was applied to the project OpEx amounts shown in Table 1 annually over the 25-year project life
- LCOE was then recalculated based on these inflated CapEx and OpEx amounts.

Table 2 shows the resulting LCOE estimates for Great Lakes Wind cost estimates compared to the uninflated LCOE estimates presented in the Feasibility Study.

Table 2. Great Lakes Wind Levelized Cost of Energy Estimates ($/MWh nominal)

Project Size and COD	Inflation Assumption	Erie	Ontario West	Ontario Center	Ontario East
2030 COD					
100 MW LCOE	None	$152	N/A	N/A	N/A
	2.4%	$198	N/A	N/A	N/A
400 MW LCOE	None	$99	$106	$100	$100
	2.4%	$129	$138	$130	$129
800 MW LCOE	None	N/A	$104	$98	$98
	2.4%	N/A	$136	$127	$127
2035 COD					
400 MW LCOE	None	$92	$98	$93	$93
	2.4%	$134	$143	$134	$133

As Table 2 shows, the LCOEs for Great Lakes Wind projects at "commercial size" (400–800 MW) are estimated as a minimum of $98–106/MWh for a 2030 COD or $92–98/MWh for a 2035 COD, in each case without accounting for the four uncertainties discussed above. When including the inflation assumption discussed above, these estimates rise to $127–138/MWh for a 2030 COD and $133–143/MWh for a 2035 COD, indicating significant sensitivity of the estimates to uncertainties around cost assumptions. The other uncertainties, and unaccounted costs associated with interconnection, infrastructure and labor could increase these estimates further.

5.2 Cost Comparison to NYSERDA's Tier 1 and Offshore Wind Programs

For purposes of examining the Great Lakes Wind cost estimates discussed in section 5.1 in the context of renewable energy projects' prices awarded by NYSERDA, the Great Lakes Wind estimated LCOE values are assumed to correspond to the Index (O)REC Strike Prices that projects would offer in response to a NYSERDA solicitation, in each case reflecting all-in project costs per MWh of electricity generated.[32] However, caution should be taken in comparing these estimates as the LCOE estimated for Great Lakes Wind, as described in section 5.1, do not account for all of the costs included in the all-in bid reflected in the (O)REC project costs, including additional costs needed to build out the ports, vessels, and supply chain required for Great Lakes Wind.

Table 3 places the Great Lakes Wind values in the context of prices for Tier 1 and offshore wind projects that have been awarded contracts by NYSERDA. The comparison is based on commercially sized projects between 400 and 800 MW. For this purpose, cost estimates for a 100 MW Great Lakes Wind project (as shown in section 5.1) are excluded because inclusion of this project in the comparison would be unhelpful for comparison due to the much higher cost for a project of this size.

Table 3. Strike Price Cost Comparison of Great Lakes Wind to NYSERDA Contracted Projects

Program/ Projects	Strike Price Range (Nominal $/MWh)
Great Lakes Wind 400 MW and 800 MW projects[a], 2030 COD	$98-$138
Great Lakes Wind 400 MW projects, 2035 COD	$92-$143
2018 OSW RFP Awards	$110-$121
2020 OSW RFP Awards[b]	$108-$118
2020 Tier 1 RFP Awards[c]	$42-$63
2021 Tier 1 RFP Awards[d]	$63

a Excludes 100 MW Lake Erie project because of the much higher LCOE and is not inclusive of all development costs as described in section 5.1.

b Strike price range for 2020 OSW RFP Awards includes port investments from the developer.

c Prior to the 2020 solicitation, NYSERDA did not have an Index REC Strike Price mechanism and therefore only comparative Index REC Strike Prices are provided. Land-based wind resources were procured through Tier 1 solicitations in the 2017, 2018 and 2019 solicitations. Notably, Index REC Strike Prices for contracted land-based wind projects are approximately $27.50/MWh lower than the low-range LCOE for Great Lakes Wind.

d The award group for RESRFP21-1 was announced by Gov. Hochul on June 2, 2022, and project-specific index prices have not yet been published in OPEN NY. The 2021 awarded projects were all solar resources, with a weighted average Index REC Strike Price of $63.08/MWh.

While the wide range of cost estimates for Great Lakes Wind projects is indicative of the preliminary and uncertain nature of the current analysis, in all cases the conclusion appears clear that Great Lakes Wind strike prices would be considerably higher than those seen for Tier 1 projects. As noted in Table 3—when comparing to offshore wind strike prices, notwithstanding the wider range of Great Lakes Wind cost estimates compared to the prices seen for offshore wind projects or the locational value of the renewable energy generated—the mid points of the estimates appear broadly on par, a conclusion that can be interpreted as reflecting the use of some similar offshore technology in both cases.

To compare the level of financial support the State needs to provide Great Lakes Wind projects with the level of support currently provided under the Tier 1 and Offshore Wind programs, a more appropriate measure to examine would be the Levelized Net REC Cost (LNRC) instead of the Index (O)REC Strike Prices.[33] The Index (O)REC Strike Price reflects a project's all-in development cost, which includes the portion of project cost satisfied through sales of the project's energy and capacity commodities. When assessing project bids received in CES solicitations, NYSERDA calculates LNRC by removing an estimate of market energy and capacity revenues from the Index (O)REC Strike

Price. LNRC thus represents the effective level of public support provided to projects awarded in CES solicitations; in other words, the net cost to ratepayers (also referred to as the "Net REC Price"). The Feasibility Study does not estimate or forecast energy and capacity revenues, and thus does not provide an estimate of LNRC. Nonetheless, some high-level observations in respect of energy and capacity revenue are available to Great Lakes Wind projects, and thus the resulting LNRC of such projects, can be made.

- Great Lakes Wind projects would be expected to interconnect in Upstate New York to NYISO Zone A, B, or C. In current Tier 1 agreements, NYSERDA's monthly REC settlement prices are determined by the zone in which the project is located, and the zonal energy and capacity revenues are subtracted from the Index (O)REC Strike Prices. All Tier 1 projects awarded to date are located in Zones A–G (upstate) would receive similar energy and capacity revenues that would be available to a Great Lakes Wind project interconnecting to NYISO Zones A, B, or C.
- Offshore wind projects are interconnected in NYISO Zones J and K and receive much higher market energy and capacity revenues than those available to Great Lakes Wind projects or Tier 1 projects upstate.

Historical locational energy and capacity prices are shown in Figure 3 and Figure 4.

Figure 3. Historical NYISO Energy Prices by Zone

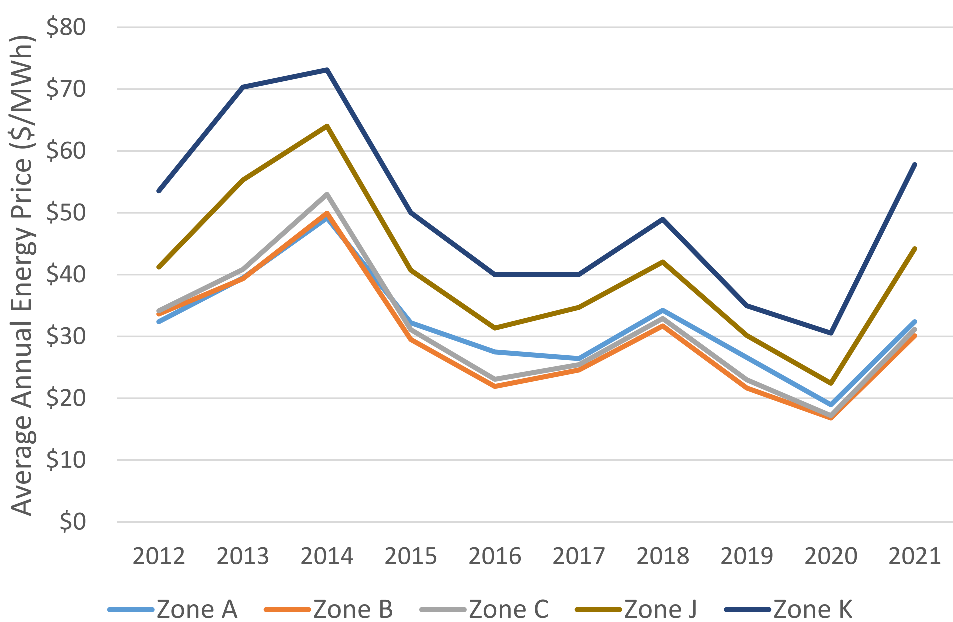
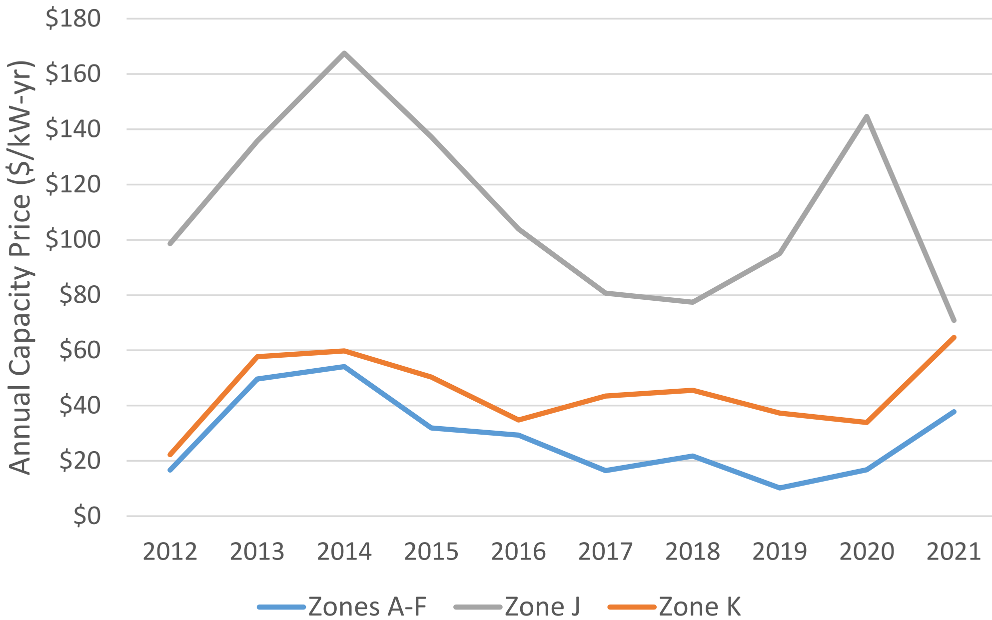


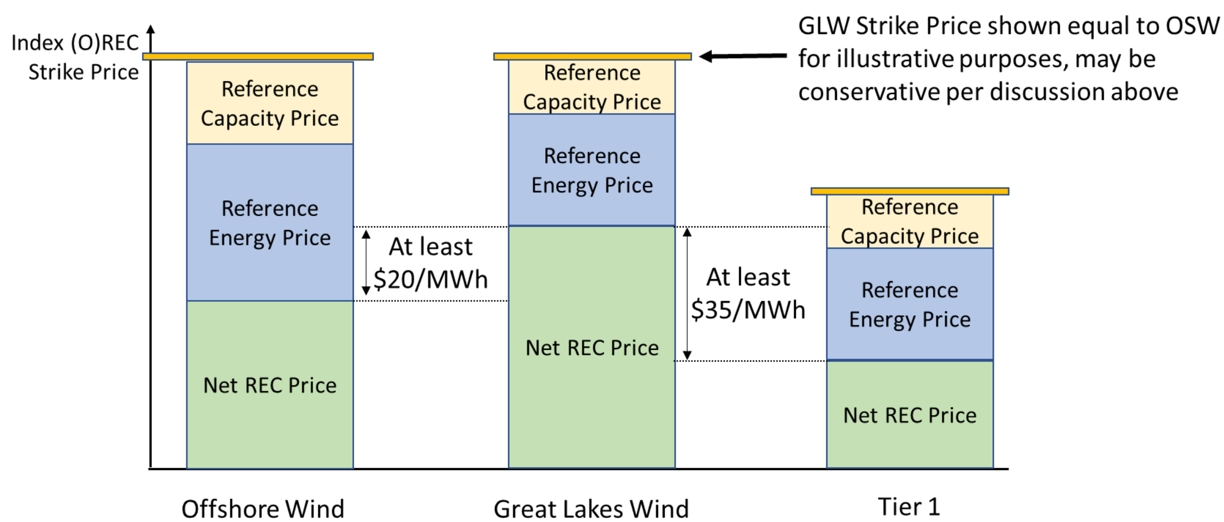
Figure 4. Historical NYISO Capacity Prices by Location



Because the upstate energy and capacity revenues available to Tier 1 and Great Lakes Projects could broadly be expected to be similar, the difference in Index REC Strike Price between the two would likely translate to a similar difference in LNRC. Tier 1 Index REC Strike Prices were quoted above as $42 to $63/MWh, compared to a range of $98 to $138/MWh for Great Lakes Wind 2030 COD projects, not including the costs described in section 5.1 that are not accounted for in the Great Lakes Wind estimates. This would suggest that even in the best-case scenario—comparing the highest Tier 1 price to the lowest Great Lakes Wind estimate—the LNRC of Great Lake Wind projects would exceed that of Tier 1 by at least $35/MWh, with the incremental cost potentially even rising to as much as $100/MWh or even more once the other uncertainties described in section 5.1 are considered. As a result, Great Lakes Wind projects would be roughly 55 to 230 percent more costly for ratepayers to support than projects currently advanced under Tier 1 of the Clean Energy Standard (CES).

Comparing Great Lakes Wind to offshore wind projects is a false comparison if the intention is to understand costs to ratepayers. However, as discussed above, strike prices (neglecting costs not captured in the Feasibility Study as described in section 5.1) can be seen as broadly on par, so any difference in LNRC would likely be primarily as a result of different levels of market energy and capacity revenue due to the different location of Great Lakes Wind upstate and offshore wind projects downstate. In 2021, the average energy prices in Zones A through C (upstate) and Zones J and K (downstate) were $31/MWh and $51/MWh, respectively, yielding an approximately $20/MWh difference between energy revenue that a potential Great Lakes Wind would have been able to access upstate and an offshore wind project downstate.[34] This suggests that, based on energy revenue alone, the LNRC of Great Lakes Wind might exceed that of offshore wind by at least that amount (i.e., $20/MWh), subject to future energy price differentials. Capacity prices are also higher downstate than upstate, which would further increase the differential between the LNRCs for Great Lakes Wind and offshore wind. The scale of this additional differential related to capacity revenue is dependent on project-specific inputs and subject to uncertainty due to changing NYISO market rules. These cost relationships are illustrated in Figure 5.

Figure 5. Index (O)REC Components by Program. (Net REC Price is reflective of the cost to ratepayers)



5.3 Great Lakes Wind in the Context of New York State's Renewable Energy Portfolio

The above observations suggest—when considered over the time horizon of potential Great Lakes Wind projects aiming to be operational by 2030—that such projects would be expected to be substantially more expensive than Tier 1 both in terms of total project cost (Strike Price) and net ratepayer-funded support amount needed from an applicable CES program (LNRC). This reinforces the likelihood that project cost is at least a contributing factor to the lack of Great Lakes Wind proposals to date in NYSERDA's existing Tier 1 solicitations. These findings also indicate that based on the net cost of support (LNRC), Great Lakes Wind projects would even be somewhat more expensive than downstate offshore wind projects. Any assessment of options to potentially address this financial support gap must therefore consider whether a strong rationale exists that would justify ratepayers incurring such additional cost relative to other CES programs.

5.3.1 Great Lakes Wind and New York State's Offshore Wind Target

Great Lakes Wind projects have some technology aspects in common with offshore wind projects, but many other factors are in common with terrestrial wind and solar energy. The PSC previously instituted a solicitation program for offshore wind through the Offshore Wind Standard, in pursuit of the State's goal of deploying 9,000 MW of offshore wind by 2035. The eligibility for the Offshore Wind Standard is currently limited to projects located in ocean waters of the U.S. and thus excludes Great Lakes Wind projects. This is due to the fact that the PSC adopted the Offshore Wind Standard "to maximize the value potential of new offshore wind resources by jumpstarting the industry to serve New York State." In establishing the Offshore Wind Standard, the PSC stated further that:

> …offshore wind is projected to provide numerous benefits in addition to playing a significant role in contributing toward achieving the CES targets and reducing greenhouse gas emissions. Because of its proximity and direct access to load centers, offshore wind would provide substantial reliability and diversity benefits to the electric system. Offshore wind also has the potential to create thousands of jobs for New Yorkers, both in construction of the facilities and in the operations and maintenance of the completed projects. It may also produce significant public health benefits by displacing fossil-fired generation in the downstate area.[35]

Great Lakes Wind projects would not have the same proximity and direct access to load centers or displace downstate fossil-fired generation, and this critical part of the PSC's rationale for approving the Offshore Wind Standard should not be applied equally to Great Lakes Wind.

With regards to jumpstarting the offshore wind industry, as noted in section 3, Great Lakes Wind projects would use different technology and components from those used for oceanic offshore wind. section 3 discusses that some of these components will likely be more similar to land-based wind. Others, such as floating turbines and substructures, could be more unique to Great Lakes Wind projects.

A final distinction between Offshore Wind and Great Lakes Wind, has been asserted by NYSERDA and other New York State agencies on multiple occasions, including most clearly in the Power Grid Study.[36] The distinction underlines that the State's upstate region already benefits from significantly higher levels of renewable generation and project development than downstate (referred to as the "Tale of Two Grids"). As long as interconnection capacity relevant to Great Lakes Wind is limited or constrained (see section 3), providing the high levels of support that would make Great Lakes Wind projects feasible might effectively crowd out more cost-effective Tier 1 projects that could otherwise have connected in the area in question. As a result, even if ratepayer cost for the procurement of such a project were similar to other offshore wind projects, the result for New York State could be a reduction in Tier 1 deployment and a resulting overall increase in the cost of achieving target goals.

5.3.2 Great Lakes Wind and New York State's Land-Based Renewables Program

As noted above, an increase in support levels for upstate Great Lakes Wind would require a strong rationale to justify costs to ratepayers. Whether such a rationale exists should primarily be considered by reference to the effort needed to achieve Climate Act targets. Given the binding nature of these targets, New York State seeks to advance clean energy programs that contribute to the most cost-effective path of achieving our targets, by fulfilling one or more critical roles in delivering the overall target. Examples include programs supporting transmission, storage, distributed generation and offshore wind. However, while Great Lakes Wind has the resource potential to contribute meaningfully to the State's renewable goals (see section 2), NYSERDA has not identified unique characteristics of Great Lakes Wind that reflect a component otherwise missing in the State's efforts to achieve the Climate Act goals. The response rate to Tier 1 solicitations indicates that there is an adequate development pipeline in the geographies where Great Lakes Wind could connect and maximize the contribution from those areas to at least the 70x30 target. With regards to the State's post 2030 targets, it is too early to make an assessment while the approach beyond 2030 in Tier 1 and many other programs remains to be determined. Without such unique characteristics that would set Great Lakes Wind apart from more cost-effective contributors towards the Climate Act goals, 2030 the significant additional level of cost is challenging to justify at least with a view to the 2030 target. This aspect should continue to remain under consideration with a view to the longer-term 2040 net-zero emissions target. If New York State's renewable energy portfolio is determined to be constrained in achieving the 2040 goals, or there are material changes in the industry (for example, a substantial reduction in cost associated with the development of Great Lakes Wind), further evaluation of Great Lakes Wind could be reconsidered at that time.

5.3.3 Jobs and Economic Benefits

The Feasibility Study highlights a range of potential economic benefits that could contribute to a justification to support Great Lakes Wind, with New York State as an early adopter. As part of the Feasibility Study, NREL performed an analysis of job and economic impacts resulting from Great Lakes Wind. NREL identified substantial economic benefits, including jobs and economic output in the State, associated with the development, construction, and operation of Great Lakes Wind. These are summarized in Table 4.[37]

Table 4. Feasibility Study Potential Direct Economic Impacts in New York State for Great Lakes Wind

	Lake Erie, 400 MW, 2030 COD	Lake Ontario, 400 MW, 2030 COD
Development and Construction		
Jobs (FTE Years)	3,729 to 7,051	6,478 to 9,782
Jobs (FTEs)[a]	2,500 to 4,700	3,800 to 6,400
Output ($ millions)[b]	$995.4 to $1,982.2	$1,841.0 to $2,819.5
Operation (annually)		
Jobs (FTEs)	47	47
Value Added ($ millions)	$3.5	$3.5

a ”FTE” means full-time employee. Jobs are estimated based on the maximum number of annual jobs illustrated in the Feasibility Study graphs showing the distribution of jobs over the development and construction period.

b Output is the sum of all expenditures.

However, the model used in the Feasibility Study estimated total job creation but did not distinguish where those jobs would be located, in New York State, elsewhere in the United States or overseas. As a result, to better understand the opportunity indicated by these job estimates, a direct or “apples-to-apples” comparison with job creation figures in the offshore wind program can be helpful as the offshore wind program incentivizes and invests in the development and use of a New York supply chain and workforce. The offshore wind program has reported a total of 6,800 expected direct jobs in New York State for 4,300 MW of project capacity based on economic benefits proposals submitted by developers.

As experienced by developing the State offshore wind program, and as analyzed in the Feasibility Study, a large proportion of jobs created to support Great Lakes Wind projects will stem from Manufacturing and Supply Chain activities—according to the Feasibility Study more than half of the FTE-years and output, and substantially more than half of the jobs, for each project are projected to be in the area of Manufacturing and Supply Chain. As discussed in section 3.3, the offshore wind turbines needed for Great Lakes Wind would represent a different technology from the turbines used downstate, meaning that the emerging offshore wind supply chain in New York State cannot be utilized to support Great Lakes Wind. To support Great Lakes Wind, the State would need to create and build a supply chain capable of producing lake-specific wind energy components and facilitating their installation. As with downstate offshore wind, this requires further State investment beyond that taken into account in the Feasibility Study and the cost quantification in this section.

5.4 Findings: Project Costs and Benefits

The analysis in the Feasibility Study leads to the conclusion that providing a level of financial support to render Great Lakes Wind projects commercially feasible would be expected to be substantially more expensive for ratepayers to support than existing options for upstate renewable energy generation, such as Tier 1. In addition, the projected REC price for Great Lakes Wind is more expensive than (downstate) offshore wind, especially when considering the additional ports and supply chain investments needed to build Great Lakes Wind, at least in the near term, and the transmission capacity necessary to bring Great Lakes Wind energy to target load centers, such as New York City and Long Island. Moreover, Great Lakes Wind may potentially crowd out more cost-effective Tier 1 development upstate where there is limited remaining transmission headroom capacity.[38]

These costs, relative to other renewable energy technologies and programs, outweigh the potential benefits associated with Great Lakes Wind, as attractive as they may be. For example, while there are job creation and economic development opportunities, without the strategic case for Great Lakes Wind as a critical cost-effective contributor to the Climate Act goals, jobs and broader economic benefits alone do not justify the higher relative costs. Moreover, for job benefits to accrue—at least the portion of jobs related to manufacturing and infrastructure—additional State investments would be required, further increasing Great Lakes Wind costs.

6 Permitting, Environmental, and Shared Resource Uses

Wind energy projects in and around the Great Lakes, such as LEEDCo's Ice Breaker Wind in Ohio and the now withdrawn "Galloo Island Wind" project in eastern Lake Ontario, have been challenged by substantial public and regulatory concerns due in large part to anticipated implications on wildlife. As part of project development, Great Lakes Wind would need to undergo thorough siting and permitting processes to demonstrate avoidance, minimization, and potential mitigation of these impacts.

There are two primary regulatory pathways for Great Lakes Wind projects, contingent upon projects size and location. The New York State Office of Renewable Energy Siting's (ORES's) 94-c process for projects 25 MW or larger[39] or the NYS SEQRA review for smaller, demonstration sized project that are less than 25 MW.[40] In either case, if the transmission lines are greater than 10 miles, Article VII would also apply. To date, five projects, including one wind energy project, have completed the 94-c process and received permits for Major Renewable Energy Facilities.[41] Notably, these four of the five projects were initiated under Article 10 of the Public Service Law and opted to transition to ORES for 94-c consideration. There are 11 94-c applications currently before ORES, all of which are for solar projects.[42]

Through the 94-c process, Great Lakes Wind projects would need to first determine where to responsibly site the project to avoid insurmountable environmental barriers and they would furthermore need to demonstrate avoidance, minimization, and mitigation of potential adverse impacts of the project. Key topics relating to these issues are summarized below from the Feasibility Study.

6.1 Wildlife and Habitat Impacts

The Feasibility Study considered impacts to wildlife and the environment and identified numerous data gaps and areas where additional data and/or further analysis is required. The Feasibility Study concludes that there was not enough data to map bird and bat distributions over Lake Erie and Lake Ontario and thus estimate the potential impact of Great Lakes Wind on these populations. Similarly, the Feasibility Study also finds that habitat distribution and use patterns of fisheries, including subsistence and cultural fisheries, are not refined for purposes of assessing Great Lakes Wind development.[43] The Feasibility Study did not undertake a detailed analysis of potential wildlife stressors (e.g., sound generation during construction, electromagnetic field [EMF] during operation).[44]

Direct species distribution data are not refined for benthic organisms in Lake Erie and Lake Ontario.[45] At this time, there is not sufficient available information to thoroughly assess the impacts Great Lakes Wind may have on wildlife and each lake presents different risks regarding data gaps. Accordingly, the Feasibility Study recommends considering additional study and data gathering to better understand the relative risk of Great Lakes Wind development on wildlife species and the environment and to put potential development sites in context with other areas. Overall, the study finds that it may be feasible to develop wind in either lake eventually, although different constraints apply to each, and filling data gaps and/or developing predictive models could help to reduce risk.

6.2 Freshwater Contamination

The Feasibility Study also finds that lake bottom disturbance, either during the pre-construction or construction phases of Great Lakes Wind development, could potentially, at least temporarily, release chemical contaminants into the lake environment potentially resulting in new accumulations in wildlife and vegetation. The Great Lakes have historically been subjected to various types of anthropogenically sourced contamination, such as mercury and polychlorinated biphenyls (PCBs) accumulation and phosphorus loading.[46] To prevent further damage to lake ecosystems from contamination, Lakewide Action and Management Plans (LAMPS) have been established for both Lake Erie and Lake Ontario.[47] Both lakes are currently rated “fair” with “improving” trends for chemical concentrations by the United States EPA.[48] Additional studies are necessary to determine whether bottom disturbance occurring during construction could release chemical contaminants in the lake environment.

The Feasibility Study did not analyze the potential for future impacts from existing contamination, as such studies are location dependent and outside the scope of the study. The study notes that further identification of areas with chemical contamination and higher resolution of contamination distribution mapping would be helpful to assess impacts of proposed projects should Great Lakes Wind Energy move forward. These types of studies could be conducted in advance of siting or be undertaken as part of the regulatory process after sites have been proposed. Mitigation methods would also need to be considered and developed, depending on the findings of site-specific assessments.

6.3 Human Resources and Shared Uses

The Feasibility Study identifies a lack of understanding in regard to distribution and variability in patterns of human use concerning the Great Lakes, including recreational activities, tourism, and cultural uses.[49] The Feasibility Study concludes that there are few data available on refined patterns of use by fisheries, recreational users, or communities and Indigenous Nations, and thus was unable to determine the relative risk associated with Great Lakes Wind development.[50] Development of Great Lakes Wind near areas with relatively high use conflict may trigger additional regulatory processes and require more extensive mitigation measures including considerations of cultural and sustaining resource use by Indigenous Nations. Further studies assessing the potential conflicts and impacts of Great Lakes Wind to such sensitive environments could be undertaken to better understand where projects could be sited or deferred to the regulatory process after the sites have been proposed. In either case, additional data gathering, and analyses will be necessary to determine the potential impacts of Great Lakes Wind on anthropogenic uses of Lake Erie and Lake Ontario.

6.4 Findings: Permitting, Environmental, and Shared Resource Uses

Public and regulatory concerns are exacerbated by the lack of data relating to the temporal and spatial distributions of wildlife both at specific locations and across the Great Lakes as a whole.

As noted above and in the Feasibility Study, there is a dearth of information relating to wildlife, including aerial fauna, fish habitats and benthic communities, and environmental conditions in Lake Erie and Lake Ontario relevant to wind energy development. Furthermore, sediment contamination is widespread, but not well mapped to support least impact site identification and the extend and duration to which Great Lakes Wind development could resuspend or redistribute these contaminates is uncertain at this time. If there is an interest in advancing the responsible development of Great Lakes Wind and reducing risks to timelines and natural resources, regional wildlife and/or environmental surveys would need to be initiated years in advance to understand the relative risk of development across the lakes.

Each of these issues imparts development risks and uncertainties on potential projects. These issues are not necessarily insurmountable, but additional research and analysis is warranted. These studies could be undertaken by New York State, Great Lakes Wind developers, or other entities to characterize these resources and uses to better understand where Great Lakes Wind projects could potentially be sited that present the least impacts and greatest opportunities for development of the resource.

7 Stakeholder Perspectives

Public engagement and support are vital to the success of any renewable energy project but is particularly important for Great Lakes Wind along with transparency. A formal public engagement plan, such as the one required in the New York State Offshore Wind Solicitation (ORECRFP22-1),[51] in addition to the required public comment opportunities as part of the regulatory process, should be followed to help ensure all perspectives are considered.

While the Feasibility Study did not seek to be comprehensive in collecting public opinion, or to inform public perceptions about Great Lakes Wind, to the extent practical, it did seek to consider public interests in its design and execution. As such, throughout the course of the Great Lakes Wind Feasibility Study development, NYSERDA hosted a series of public webinars to share updates on the design and initial findings, and to gather feedback from interested stakeholders. NYSERDA also hosted a Virtual Public Feedback session devoted to gathering public input to the study and the development of Great Lakes Wind generally. The public feedback session was intended to ensure that Great Lakes residents' views were considered within the context of the Feasibility Study. The public expressed a wide range of interest both in support of and in expressing concerns about the Great Lakes Wind project. Topics of interest included economic development opportunities, socioeconomic impacts, viewshed concerns, drinking water impacts, the role of Great Lakes Wind in the clean energy transition, State decision-making process, siting considerations, and a wide range of environmental impact considerations, such as disturbance of contaminated sediments and potential impacts to birds and bats. These topics are included, and considered to the extent appropriate, in the Feasibility Study and those relating to social concerns are summarized below.

7.1 Visibility, Property Valuations, and Social Considerations

A wide range of considerations concerning social impacts accompany the development of Great Lakes Wind energy projects. The visibility of a wind energy project from the shore and different points inland is of great importance when taking into account public receptivity. NYSERDA's consultants prepared a Visual Impact Study, which included basic project simulations and a high-level viewshed analyses for select hypothetical turbine locations to provide a general sense of theoretical visibility in the region.[52] The Visual Impact Study found that the land-based "Zone of Theoretical Visibility" covered 206 to 804 square miles from the two hypothetical sites in Lake Erie.[53] In Lake Ontario, the four hypothetical turbine sites resulted in a land-based visibilities of between 164 and 396 square miles.[54]

The extent of visibility from land is an important factor to consider when developing Great Lakes Wind. Simulations of what a generic, theoretical wind farm might look like at different distances from shore were also developed and are included in as an attachment to this white paper. for reference, but viewshed impacts are unique to the viewer. If and when specific sites are selected, a traditional, more detailed viewshed analysis should be conducted using anticipated turbine specifications. (See Appendix A for preliminary hypothetical visual simulations)

Siting, distance from shore and technology selection are all important considerations when seeking to limit potential impacts. Great Lakes Wind has the potential to impact property values along the shorelines of Lake Erie and Lake Ontario. Impacts could result from changes to the viewshed as well as interconnection and cabling concerns. Moreover, whether or not property values are impacted, public perception of property value impacts from Great Lakes Wind is an important factor to consider. Because there are no existing freshwater wind farms in the U.S., no data exists regarding the influence on lakeshore property values from wind development. A 2018 study considered whether the view of an ocean-based offshore wind farm affected the price of residential housing.[55] However, the study analyzed data from wind farms off the coast of the Danish island of Lolland, where public receptivity to wind farms may be different than in the U.S., and specifically the Great Lakes region.[56] A 2012 study analyzed the impact of terrestrial wind farms on property values in New York State and found, generally but not exclusively, that proximity to turbines reduced property values.[57]

7.2 Findings: Stakeholder Perspectives

The New York State Great Lakes Wind Energy Feasibility Study was designed as a desktop study and not a comprehensive siting study or plan. Nevertheless, NYSERDA is committed to stakeholder engagement and as stewards to the residents of New York State provide responsible renewable energy research and policy. Throughout the process of developing and creating the Feasibility Study, the public was kept informed via a variety of media channels and feedback was actively placed into the resulting conclusions of this effort. Considerations for the smallest possible environmental and visual impact, maximum economic value, as well as public health and benefits are forefront for stakeholders. The deployment of large-scale renewable projects to meet the Climate Act targets can only be accomplished in partnership with the public. If Great Lakes Wind projects were to be considered part of the State's future renewable energy portfolio, a comprehensive stakeholder plan should be a component of that work.

Appendix A. Preliminary Great Lakes Wind Visibility Simulations

A.1 Purpose

This Visual Simulation augments the New York State Energy Research and Development Authority's (NYSERDA's) Great Lakes Wind Feasibility Study white paper by providing simulated views of hypothetical wind turbine fields to consider the potential visual impact to individual observers. The simulations focus on hypothetical views across New York waters of Lake Ontario and Lake Erie.

Visual impacts were often identified by stakeholders through the development of the Feasibly Study as important considerations if Great Lakes Wind projects should be advanced in New York State waters. These preliminary and hypothetical visual simulations are meant to provide imagery for consideration, while acknowledging that perceptions of visual impacts are personal to the viewer and vary based on the beliefs and values of individuals. As the Feasibly Study and the white paper note, viewshed is a topic for robust analysis, but the full complement of viewshed perceptions by the public was outside the scope of the Feasibly Study. This Appendix includes simulations for two distances from shore for each lake under one time-of-day, season, and weather conditions for a single project layout. A complete assessment would need to include additional variables that can affect views and how often such conditions exist in each lake.

A.2 Visual Hypothetical Simulations

Because no Great Lakes Wind (GLW) project has been designed or developed to date, the simulated visualization described within this document is entirely theoretical, using a baseline 3D wind turbine design, hypothetical sites, and generic field layout.

The purpose of this document is to provide New York State agencies and the public with simulations of possible expected views of New York Great Lakes Wind projects, should New York decide to pursue such developments. Parameters and site location photographs used for the visual simulation were provided by NYSERDA and the National Renewable Energy Laboratory (NREL). Visual simulations were created by Advisian.

This Appendix does not address specific siting considerations or turbine parameters that may influence the actual selection of equipment design or location of offshore turbines in the Great Lakes. The simulations herein present a hypothetical, generic wind farm at a few different distances from shore to help envision what the visibility of such development might look like. Weather conditions and other elements that may affect visibility are not explicitly addressed in this simulation. It is recommended that a site-specific Visual Impact Assessment with a visual simulation component be conducted for proposed developments if and when a specific development plan is pursued.

Based on consultation with NREL, the lead consultant developing the Feasibility Study, this visualization assumes the baseline turbine model to be similar to a General Electric Renewable Energy (GE) Cypress wind turbine, model 6.0-164. GE's specifications for the Cypress 6.0-164 turbine model, according to their product website (Figure 1). While the Cypress model is not specifically designed for offshore applications at this time, the size is considered to be a reasonable approximation of turbines that may be considered for GLW development.

Energy output for the selected turbine model also plays an important role in the visual simulation as it contributes to the number of turbines that would be considered for the overall field development in order to produce the desired energy output. Considering the GE Cypress 6.0-164 turbine as the base case turbine, a 400-megawatt (MW) field would be 66 turbines. Given the controlling parameters of number of turbines and turbine spacing, the simulations assume a generic grid layout with approximately 0.8 statute-mile spacing.

In addition to the base image for each lake, a 5-mile distance from shore simulation is presented for both Lakes Erie and Ontario. A second simulation is also provided for each lake, 15 miles for Lake Ontario and 12 miles for Lake Erie. The difference in these two distances is due to Lake Ontario's relatively large hosting potential compared to Lake Erie. These simulations should be construed as a suggested minimum distance from shore for either lake. The following sections of this Appendix present the details associated the selected wind turbine structures and the conditions and locations upon which the simulations are developed. Locations identified for these simulations are generic views and should not be construed as suggesting they represent locations where GLW projects may be developed.

Figure A-1. Photo of a Prototype GE Cypress Wind Turbine and Specifications for the Model 6.0-164

Source: GE Renewable Energy https://www.ge.com/renewableenergy/wind-energy/onshore-wind/cypress-platform

GE Cypress 6.0-164 Wind Turbine

- Output: 6.0 MW
- Rotor Diameter: 164 m (~538 ft)
- Hub Height: 112 m (~367.5 ft)
- Frequency: 50 / 60 Hz
- Cut-in: 3 m/s
- IEC Wind Class: S

Lake Ontario

The photographs were collected at locations intended to give a generic view across the lakes and included onshore reference elements for scaling the simulated wind turbines. The photograph acquired for the Lake Ontario visual simulation was collected near Webster, New York, by professional photographers with Darling, based in New York City (Figure 2). The geodetic coordinates (latitude/longitude, WGS84) for the camera placement were 43.260167° North, 77.451805° West. The altitude of the site was approximately 80 ft above sea level. The photo was taken on December 4, 2021, at 12:59 pm local time.

Local weather conditions at the time the photograph was taken were as follows:

- Temperature: 44° F
- Cloud coverage: Mostly cloudy
- Wind: West, 20 miles per hour
- Humidity: 57 percent
- Dew point: 30° F
- Barometric pressure: 30.00 in
- UV index: 1

Figure A-2. Lake Ontario Photograph

LAKE ONTARIO - ORIGINAL VIEW

Advisian
Worley Group

December 7, 2022
LAKE ONTARIO-PHOTO

Figure A-3. Lake Ontario Visual Simulation – Wind Farm Sited 5 miles from Shoreline

LAKE ONTARIO - 5 MILE VIEW

Advisian
Worley Group

December 7, 2022
LAKE ONTARIO-5MILES

Figure A-4. Lake Ontario Visual Simulation – Wind Farm Sited 15 miles from Shoreline

LAKE ONTARIO - 15 MILE VIEW

Advisian

December 7, 2022
LAKE ONTARIO-15MILES

Lake Erie

The photographs were collected at locations intended to give a generic view across the lakes and included onshore reference elements for scaling the simulated wind turbines onto the images. The photograph acquired for the Lake Erie visual simulation was collected near Buffalo, New York, by professional photographers with Darling, based in New York City (Figure 5). The geodetic coordinates (latitude/longitude, WGS84) for the camera placement are 42.788467° North, 78.853155° West. The altitude of the site is noted as approximately 195 ft above sea level. The photo was taken on December 9, 2021, at 12:25 pm local time.

Snow was present on the ground and is apparent in the foreground of the photograph.

Local weather conditions at the time the photograph was taken were as follows:

- Temperature: 31° F
- Cloud coverage: Cloudy
- Wind: East-Southeast, 7 miles per hour
- Humidity: 70 percent
- Dew point: 23° F
- Barometric pressure: 30.18 in
- UV index: 1

Figure A-5. Lake Erie Photograph

LAKE ERIE - ORIGINAL VIEW

Advisian
Worley Group

December 7, 2022
LAKE ERIE-PHOTO

Figure A-6. Lake Erie Visual Simulation – Wind Farm Sited 5 miles from Shoreline

LAKE ERIE - 5 MILE VIEW

Advisian

December 7, 2022
LAKE ERIE-5MILES

Figure A-7. Lake Erie Visual Simulation – Wind Farm Sited 12 miles from Shoreline

LAKE ERIE - 12 MILE VIEW

Advisian

December 7, 2022
LAKE ERIE-12MILES

Endnotes

1 New York State Energy Research and Development Authority (NYSERDA). 2022. “New York Great Lakes Wind Energy Feasibility Study,” NYSERDA Report Number 22-12. Prepared by the National Renewable Energy Laboratory, Advisian Worley Group, and Brattle Group/Pterra Consulting. nyserda.ny.gov/publications (hereinafter Feasibility Study).

2 Case 15-E-0302, Order Adopting Modifications to the Clean Energy Standard, October 15, 2020

3 NYSERDA dedicated website page to the Great Lakes Wind Feasibility Study: https://www.nyserda.ny.gov/great-lakes-wind-feasibility-study

4 https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={37EE76DF-81B1-47D4-B10A-73E21ABA1549}

5 2015 New York State Energy Plan is available from http://energyplan.ny.gov

6 Letter from Governor Andrew M. Cuomo to Audrey Zibelman, Chair, New York State Department of Public Service, December 2, 2015, available at https://www.governor.ny.gov/sites/governor.ny.gov/files/atoms/files/Renewable_Energy_Letter.pdf

7 Clean Energy Standard Annual Progress Report, 2020 Compliance Year; NYSERDA final Report. January 2022 https://www.nyserda.ny.gov/All-Programs/Clean-Energy-Standard; 2021 NYSERDA Large Scale Renewables Procurements https://www.nyserda.ny.gov/All-Programs/Clean-Energy-Standard/Renewable-Generators-and-Developers/RES-Tier-One-Eligibility/Solicitations-for-Long-term-Contracts/2021-Solicitation-Resources

8 https://www.nyserda.ny.gov/About/Publications/Research-and-Development-Technical-Reports/Electric-Power-Transmission-and-Distribution-Reports/Electric-Power-Transmission-and-Distribution-Reports---Archive/New-York-Power-Grid-Study

9 https://www.windparkfryslan.nl/

10 http://www.leedco.org/index.php/about-icebreaker

11 https://www.supremecourt.ohio.gov/rod/docs/pdf/0/2022/2022-ohio-2742.pdf

12 https://www.portofcleveland.com/ohio-supreme-court-affirms-siting-board-ruling-that-allows-lake-erie-wind-turbine-project-to-proceed/

13 New York State Energy Research and Development Authority (NYSERDA). 2022. “New York State Great Lakes Wind Energy Feasibility Study: Physical Siting Analysis,” NYSERDA Report Number 22-12b. Prepared by the National Renewable Energy Laboratory, Golden, CO, nyserda.ny.gov/publications

14 Feasibility Study, p. 44-45. This reflects wind resource area beginning four (4) miles from the shore, but based on a viewshed analysis, wind turbines would most likely be installed at least five (5) miles from shore in Lake Erie and at least ten (10) miles from shore in Lake Ontario. In addition, a minimum half-mile distance from other state and international waters would likely be maintained. These factors would likely reduce the potential wind resource area.

15 New York State Energy Research and Development Authority (NYSERDA). 2022. “New York State Great Lakes Wind Energy Feasibility Study: Relative Risks, Minimization/Mitigation, and Benefits,” NYSERDA Report Number 22-12i. Prepared by, Worley Group, Inc. (dba Advisian), Reading, PA. nyserda.ny.gov/publications

16 New York State Public Service Commission, Case 20-E-0197, Proceeding on Motion of the Commission to Implement Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act (Transmission Planning Proceeding), Staff Straw Proposal for Conducting Headroom Assessments (issued March 16, 2021), Addendum to Staff Straw Proposal for Conducting Energy Headroom Assessments (filed June 8, 2021), and Order on Local Transmission and Distribution Planning Process and Phase 2 Project Proposals (issued September 9, 2021). DPS Staff’s proposals include assessment of multiple load levels. The Great Lakes Wind Feasibility Study evaluated a single 2030 case representing summer peak conditions.

17 The conceptual transmission upgrades studied assumed that building a new transmission line or transformer parallel to and of the same voltage level and rating as a constrained facility would be sufficient to relieve the constraint. Actual transmission upgrades would likely vary in scope and be more costly than the conceptual upgrades studied.

18 Note that these estimates differ from the Utilities’ August 2022 Revised Headroom Calculations filed in DPS Case 20-E-0197.

19 New York State Energy Research and Development Authority (NYSERDA). 2022. “New York State Great Lakes Wind Energy Feasibility Study: Interconnection,” NYSERDA Report 22-12f. Prepared by Pterra Consulting Albany, NY, and The Brattle Group, Boston, MA, nyserda.ny.gov/publications

[20] Department of Public Service and NYSERDA Staff white paper on Clean Energy Standard Procurements to Implement New York's Climate Leadership and Community Protection Act, Case 15-E-0302, Appendix A: Cost Analysis, Table 24. Base Case, Installed Capacity of Clearing Resources, filed June 18, 2020.

[21] New York State Public Service Commission, Proceeding on Motion of the Commission to Implement Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act, Order on Local Transmission and Distribution Planning Process and Phase 2 Project Proposals, Issued and Effective September 9, 2021.

[22] Case 20-E-0197 - Proceeding on Motion of the Commission to Implement Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act, Phase 2 Order.

[23] New York Independent System Operator, Class Year 2021 Studies, Preliminary Deliverability Analysis, Operating Committee Meeting materials, presented August 18, 2022.

[24] Case 20-E-0197, Petition of Central Hudson Gas & Electric Corporation, et al., Identifying Area of Concern Needs and Recommended Solutions, filed on March 8, 2022.

[25] New York Public Service Commission, Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard, Order Adopting a Clean Energy Standard (issued August 1, 2016), and Order Adopting Modifications to the Clean Energy Standard (issued October 15, 2020).

[26] LCOE measures the lifetime costs of a renewable project divided by the expected energy production of that project and uses a present value of the total cost of building and operating a renewable energy project over an assumed useful life. The LCOE is used as it allows comparison of different renewable technologies (hydro, onshore wind, offshore wind, solar) of unequal useful life spans, project sizes, and capital costs.

[27] Values are presented in nominal 2021$, which excludes the effects of inflation both between 2021 and the COD and throughout the operational lifetime of the project.

[28] NYISO Tariffs - Open Access Transmission Tariff (OATT), 25 OATT Attachment S, Rules to Allocate Responsibility for the Cost of New Interconnection Facilities, section 25.2 Minimum Interconnection Standard.

[29] NYISO Tariffs - Open Access Transmission Tariff (OATT), 25 OATT Attachment S, Rules to Allocate Responsibility for the Cost of New Interconnection Facilities and 30 OATT Attachment X, Standard Large Facility Interconnection Procedures (Applicable to Generating Facilities that exceed 20 MWs and to Class Year Transmission Facilities)

[30] New York State Labor Law § 224-d (2) requires that "Covered Renewable Energy Systems" are "subject to prevailing wage requirements in accordance with Labor Law §§ 220 and 220-b. Labor Law § 224-d (1) defines "Covered Renewable Energy Systems" as "renewable energy system, as such term is defined in Public Service Law 66-p, with a capacity of greater than five megawatts alternating current (MWAC) and which involve the procurement of renewable energy credits by a public entity, or a third party acting on behalf and for the benefit of a public entity."

[31] The inflation rate assumption of 2.4% was established by the New York State Department of Public Service Office of Accounting, Audits and Finance, revised February 8, 2022.

[32] In the Index (O)REC contract structure, payments to the generator rise and fall inversely to a composite average of New York's energy and capacity market prices, which do not reflect actual project revenues but do provide protection for ratepayers and projects against volatility in utility bills and project revenue, respectively over the contracts' lifetime. The Index (O)REC Strike Price also refers to the all-in cost of a project, similar to LCOE, but may include adjustments to account for expected differentials between revenue offsets and actual revenues.

[33] For purposes of this discussion, LNRC is also used to represent Levelized Net OREC Cost (LNOC).

[34] This value differential has ranged from $8.80/MWh to $22.92/MWh over the last ten years. Year-to-date (through July 2022), the monthly differential has ranged from $24.18/MWh to $56.13/MWh, averaging $36.70/MWh.

[35] https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={37EE76DF-81B1-47D4-B10A-73E21ABA1549}

[36] https://www.nyserda.ny.gov/About/Publications/Research-and-Development-Technical-Reports/Electric-Power-Transmission-and-Distribution-Reports/Electric-Power-Transmission-and-Distribution-Reports---Archive/New-York-Power-Grid-Study.

[37] The ranges for the Development and Construction entries represent different levels of New York State content for a project. The low end of each range is for the Base Case, which includes some of the project content coming from outside the State. The high end of each range is for the 100% State Content Case, which estimates the maximum possible economic impact for the projects.

[38] The Index REC Strike Prices for the contracted Tier 4 projects are $129.75/MWh (constant) and $97.50/MWh (escalating at 2.5% per year). These prices include both generation and transmission. The transmission component of the Clean Path New York project is estimated to cost $3.5 billion.

[39] section 94-c of the New York State Executive Law, created in the Accelerated Renewable Energy Growth and Community Benefits Act, covers major renewable energy project siting and permitting with oversight provided by the newly created ORES. The Accelerated Renewable Energy Growth and Community Benefit Act was passed as part of the Fiscal Year 2020-2021 Enacted State Budget. The regulations became effective in March 2021. *See also* 19 NYCRR Part 900.

[40] The ORES 94-c regulations consolidate several New York State permitting processes into a single process led by ORES and are designed to substitute for the Article 10 process in the Public Service Law. The consolidation is intended to eliminate duplication and complexity of the permitting process.

[41] The four projects include: Watkins Glen Solar (DMM 21-01069), Heritage Wind (DMM 21-00026), Morris Ridge Solar (DMM 21-00025), Riverhead Solar 2 (DMM 21-00024), and Cider Solar (DMM 21-01108).

[42] *See* Office of Renewable Energy Siting, Permit Applications, *available at*: https://ores.ny.gov/permit-applications.

[43] New York State Energy Research and Development Authority (NYSERDA). 2022. "New York State Great Lakes Wind Energy Feasibility Study: Relative Risks, Minimization/Mitigation, and Benefits," NYSERDA Report Number 22-12i. Prepared by, Worley Group, Inc. (dba Advisian), Reading, PA. nyserda.ny.gov/publications

[44] *Id.*

[45] *Id.*

[46] New York State Energy Research and Development Authority (NYSERDA). 2022. "New York State Great Lakes Wind Energy Feasibility Study: Geophysical and Geohazards Characterization," NYSERDA Report Number 22-12c. Prepared by the Worley Group, Inc., (dba Advisian), Reading, PA, nyserda.ny.gov/publications

[47] *Id.*

[48] *Id.*

[49] New York State Energy Research and Development Authority (NYSERDA). 2022. "New York State Great Lakes Wind Energy Feasibility Study: Evaluation of Site Conditions," NYSERDA Report Number 22-12a. Prepared by the National Renewable Energy Laboratory, Boulder, CO, nyserda.ny.gov/publications

[50] New York State Energy Research and Development Authority (NYSERDA). 2022. "New York State Great Lakes Wind Energy Feasibility Study," NYSERDA Report Number 22-12. Prepared by the National Renewable Energy Laboratory Golden, CO, Advisian Worley Group, Chicago, IL, Brattle Group, Boston, MA, and Pterra Consulting, Albany, NY. nyserda.ny.gov/publications

[51] https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/Offshore-Wind-Solicitations/2022-Solicitation

[52] New York State Energy Research and Development Authority (NYSERDA). 20212. "New York State Great Lakes Wind Energy Feasibility Study: Visual Impacts," NYSERDA Report Number 22-12j. Prepared by, Worley Group, Inc. (dba Advisian), Reading, PA. nyserda.ny.gov/publications

[53] *Id.*

[54] *Id.*

[55] Jensen et al., 2018, The impact of on-shore and off-shore wind turbine farms on property prices.

[56] *Id.*

[57] Heintelman, Martin D., Tuttle, Carrie M., 2021. Values in the wind: a hedonic analysis of wind power facilities. Land Econ. 88, 547-588.