Appendix D

(to Initial Report on New York Power Grid Study)

Offshore Wind Integration Study

Offshore Wind Integration Study: Final Report

Prepared for:

New York State Energy Research and Development Authority

Albany, New York

New York State Department of Public Service

Albany, New York

Prepared by:

DNV GL Energy Insights USA, Inc.

Katy, Texas

Mike Tabrizi
Head of North America Power System Advisory

PowerGEM LLC

Clifton Park, New York

Manos Obessis
Executive Vice President

WSP Global Inc.

Lancaster, New York

Steven MacLeod
Lead Environmental Scientist

NYSERDA Contract 147290A

December 2020

Notice

Disclaimer

This document is intended for the use of the State Team, who have entered into a written agreement with DNV GL. To the extent permitted by law, neither DNV GL nor any group company (the Group) assumes any responsibility whether in contract, tort including without limitation negligence, or otherwise howsoever, to third parties, and no company in the Group other than DNV GL shall be liable for any loss or damage whatsoever suffered by virtue of any act, omission or default (whether arising by negligence or otherwise) by DNV GL, the Group or any of its or their servants, subcontractors or agents. This document must be read in its entirety and is subject to any assumptions and qualifications expressed therein as well as in any other relevant communications in connection with it. This document may contain detailed technical data, which is intended for use only by persons possessing requisite expertise in its subject matter.

This document has been produced from information relating to dates and periods referred to in this document. This document does not imply that any information is not subject to change. The Study results and findings presented herein are based on the specific input data, assumptions and methodology used. In the eventuality that actual data and relevant attributes differ from what has been assumed for this assessment, the Study outcome may differ from what has been documented herein.

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

A	Ampere
BMP	Best management practice
BOEM	Bureau of Ocean Energy Management
CAPEX	Capital expenditures
CHPE	Champlain Hudson Power Express
CLCPA	Climate Leadership and Community Protection Act
CMP	Coastal Management Program
ConEd	Consolidated Edison
DoD	Department of Defense
DOT	New York State Department of Transportation
DPS	New York State Department of Public Service
FHWA	Federal Highway Administration
GBS	Gravity based solutions
GIS	Geographic information systems
GW	Gigawatt
HB	Half bridge
HDD	Horizontal directional drilling
HVAC	High-voltage alternating current
HVDC	High-voltage direct current
KWH	Kilo-watt hour
LIPA	Long Island Power Authority
LTCOE	Levelized transmission cost of energy
LTE	Long-term emergency
LTP	Local transmission plan
M$	Millions
M/S	Meters per second
MVA	Megavolt ampere
MW	Megawatts
MWh	Megawatt hour
NEPA	National Environmental Policy Act
NLCD	National Land Cover Database
NMFS	NOAA National Marine Fisheries Service
NPV	Net present value
NREL	National Renewable Energy Lab
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
NYCRR	New York Codes, Rules and Regulations
NYISO	New York Independent System Operator’s
NYSERDA	New York State Energy Research and Development Authority
OPAREA	Operating Area
OPEX	Operational expenditures
OREC	Offshore Wind Renewable Energy Certificate

OSW	Offshore wind
PAR	Phase Angle Regulator
PCB	Polychlorinated biphenyl
PFA	Polyfluoroalkyl substance
POI	Point of interconnection
PPA	Power purchase agreement
REPEX	Replacement expenditure
ROW	Right of way
SHPO	State Historic Preservation Office
STE	Short-term emergency
T&E	Threatened and endangered
TLA	Transmission Load Areas
TO	Transmission Owner
TRL	Technology readiness level
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
V	Volt
VSC	Voltage Source Converters
W	Watt
WACC	Weighted average cost of capital
WEA	Wind energy area
XPLE	Cross linked polyethylene

Executive Summary

In July 2019, Governor Andrew M. Cuomo signed the Climate Leadership and Community Protection Act (CLCPA), which adopted the most ambitious and comprehensive state climate and clean energy legislation in the country. The CLCPA requires New York State to achieve a zero-emission electricity system by 2040 and reduce greenhouse gas emissions 85% below 1990 levels by 2050. As part of this push to decarbonize the grid, the CLCPA codifies groundbreaking goals under the Green New Deal, including a mandate for at least 70% of New York's electricity to come from renewable energy sources, such as wind and solar, by 2030. This ramp-up of renewable energy is expected to include quadrupling New York's offshore wind (OSW) target to 9,000 megawatts (MW) by 2035, up from 2,400 MW by 2030.

The achievement of this goal is likely to require investments in New York's electricity system. In this context, the State Team (NYSERDA and DPS) engaged DNV GL, PowerGEM, and WSP to conduct analysis that supports the development of potential long-term OSW transmission solutions (the Study).

The main objectives of the Study were to identify better-performing onshore substations to interconnect 9 GW of OSW into New York City and Long Island in a reliable and cost-effective manner; evaluate the environmental and permitting challenges associated with bringing the OSW power to selected onshore substations; and evaluate plausible offshore transmission solutions for collecting and delivering the remaining 7,175 MW of OSW that is not procured yet.

Development of feasible OSW transmission strategies to collect and deliver up to 9 GW of wind energy from offshore locations to New York City and Long Island requires detailed consideration of various technical aspects and practical limitations, including but not limited to, technology availability, scalability, cost-effectiveness, grid reliability and compliance, energy market fundamentals, as well as environmental, physical, and geographical limitations associated with the offshore seabed, narrows, shorelines and landing points. To achieve the Study's main objectives while accounting for the previously mentioned technical aspects, a Study methodology was developed that included three main tasks, namely onshore grid assessment; offshore transmission assessments; and environmental constraint analysis. Given the intrinsic dependency and relations that exist among the technical aspects and practical limitations, these three tasks were performed partially in parallel and partially in sequence to more effectively inform and guide one another.

The first step of onshore grid assessment consisted of screening of the existing substations in zones J and K using reliability security analysis and production cost modeling. Subsequently, building on the results of substation screening, onshore grid assessment was performed for two alternative OSW injection splits between New York City and Long Island regions: ~6 GW of OSW allocated to New York City and ~3GW to Long Island and 5 GW of OSW allocated to New York City and ~4GW to Long Island. The reliability security and production cost analyses were conducted using a range of onshore grid operating conditions and demand forecasts. The use of energy storage facilities was also incorporated into various scenarios in the analysis. Overall, the analysis identified scenarios of 6 GW into New York City and 3 GW into Long Island that minimized onshore transmission system upgrades and involved very limited OSW curtailment. However, if more OSW capacity (~4GW) is injected into Long Island, there is expected to be an increased risk of OSW energy curtailment and onshore system upgrades are likely needed and may necessitate the addition of a new tie-line to export energy off of Long Island.

A transmission cable routing feasibility assessment was conducted to evaluate the environmental and permitting challenges of routing transmission cables from potential offshore lease areas to substations identified in the onshore grid assessment. Major potential constraints were identified for many of the illustrative route segments, but these challenges may be overcome with suitable planning and outreach efforts. Thus, the assessment supports a finding that the illustrative routings are feasible. Other key findings of the routing assessment include the following:

- The analyzed onshore routes could feasibly accommodate between two and six separately installed cable circuits.

- Six separate cables (or circuits) could feasibly be installed through New York Harbor to the analyzed substations.

As part of the offshore transmission assessment, uncertainties around the future development of OSW projects, including their locations and area sizes, were considered by developing five illustrative OSW build-out scenarios. These scenarios represent a possible range of geographically diverse future outcomes that could potentially occur. For each OSW build-out scenario, five offshore transmission connection concepts (Radial, split, shared substation, Meshed, and Backbone) were developed. The OSW connection concepts were established using the combination of 220 kV HVAC and ±320/525 High-voltage direct current (HVDC) technologies, subject to technical characteristics and physical limitations as documented in the report. Preliminary analysis of the assumed OSW build-out scenarios along with the OSW connection concepts were indicative of the following key observations:

- The relative benefits and cost comparisons of OSW connection concepts remained consistent in all assumed OSW build-out scenarios, which suggests a single representative OSW build-out scenario can be utilized for detailed analysis to determine the relative performance of the OSW connection concepts with minimal risk of compromising key findings.

- For OSW networked connection concepts (i.e., substation sharing, Mesh, or Backbone) to be economically justifiable, the networked connection concept should encompass at least three OSW projects with minimum aggregate rating of approximately 3 GW.

- Uncertainty related to the availability of wind energy areas (WEAs) makes it challenging to pivot from an OSW's Radial connection concept to other OSW networked connection concepts.

    - However, these challenges could be overcome by proper upfront preparation and investments (e.g., over-sizing cables, converters, and additional breaker positions).

    - In addition, among all OSW connection concepts studied, the Meshed connection concept was observed to be the most flexible considering WEA uncertainty.

    - Furthermore, moving from a Radial connection concept to substation sharing connection concept is expected to be relatively more challenging given WEA and OSW project location uncertainty.

- Close coordination with the Bureau of Ocean Energy Management (BOEM) to make more WEAs available will foster more competitive OSW procurements and facilitate the potential development of networked offshore transmission systems.

- With key findings in mind and considering Radial and split connection concepts were observed to have very similar performance in the preliminary assessment, the Radial, Meshed and Backbone connection concepts were shortlisted for the further detailed offshore analysis that included detailed levelized transmission cost of electricity (LTCOE) and availability assessments.

Detailed calculations were conducted for the shortlisted OSW connection concepts, including both the wet-side and dry-side (between the landing points and onshore grid substations) components. Furthermore, to provide a better comparison between the three shortlisted OSW connection concepts by considering the magnitude of OSW energy that they would deliver to the onshore grid, LTCOE was calculated to reflect the cost of transferring the OSW energy for each delivered MWh of OSW energy to the onshore grid.

Offshore Radial and Meshed connection concepts were observed to result in lower LTCOE compared to the Backbone connection concept. In addition, OSW Meshed connection concept resulted in a higher availability and operational benefits among the three shortlisted OSW connection concepts.

Provided draft Call Areas in the New York Bight become WEAs, 9 GW of OSW connected to New York's electricity system by 2035 is possible. Though more technical assessment should be completed to more robustly evaluate solutions, the Study finds there exists feasible options for offshore cable concepts and routing, cable landfall and onshore cable routing, and existing substations for the interconnection of 9 GW of OSW. For all options, smart systematic planning is key to cost-effective outcomes.

1 Background

In July 2019, Governor Andrew M. Cuomo signed the Climate Leadership and Community Protection Act (CLCPA), which adopted the most ambitious and comprehensive state climate and clean energy legislation in the country. The Act requires New York State to achieve a zero-emission electricity system by 2040 and reduce greenhouse gas emissions 85% below 1990 levels by 2050. As part of this push to decarbonize the grid, the CLCPA codifies groundbreaking goals under the Green New Deal, including a mandate for at least 70% of New York's electricity to come from renewable energy sources, such as wind and solar, by 2030. This ramp-up of renewable energy is expected to include quadrupling New York's offshore wind (OSW) target to 9,000 megawatts (MW) by 2035, up from 2,400 MW by 2030.The achievement of this goal is likely to require investments in New York's electricity system. In this context, the State Team engaged DNV GL, PowerGEM, and WSP to conduct technical analysis (the Study), as described in following sections of this report, to support the development of potential long-term OSW transmission strategies to achieve the OSW milestones The Study assessed various aspects of the electricity system in and around New York City (Zone J) and Long Island (Zone K) to determine reliable and low-cost solution(s) to accommodate the OSW target capacities in 2025, 2030, and 2035.

1.1 Study Goals

The Study aimed to address the following research questions:

1. **Question 1**: Where are good opportunities at onshore substations for adding 9 GW of OSW into New York City and Long Island in a reliable and low-cost manner?

2. **Question 2**: What are the environmental and permitting challenges associated with bringing OSW to existing onshore substations?

3. **Question 3**: Considering the 1,825 MW of OSW that have recently been procured,[1] what are plausible offshore transmission strategies for collecting and delivering the remaining 7,175 MW of OSW? How does an illustrative networked offshore transmission strategy compare to a Radial connection scenario?

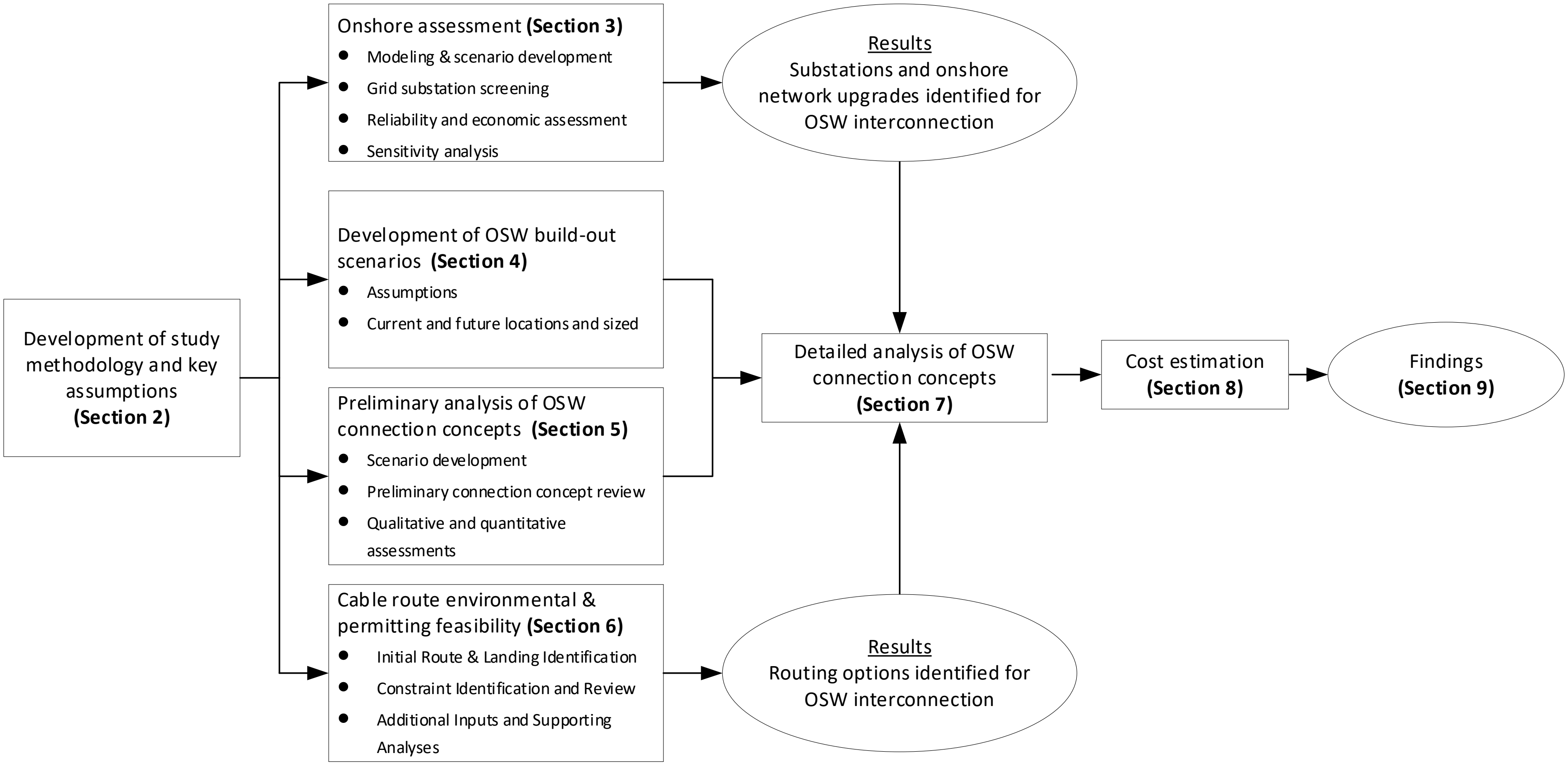
[1] For more detail, refer to https://www.nyserda.ny.gov/All-Programs/Programs/Offshore-Wind/Focus-Areas/NY-Offshore-Wind-Projects

2 Study Methodology

Development of a feasible transmission strategy to collect and deliver up to 9 GW of wind energy from offshore locations to New York City and Long Island requires detailed consideration of various technical aspects and practical limitations including, but not limited to, technology availability, scalability, cost-effectiveness, grid reliability and compliance, energy market fundamentals, as well as environmental, physical and geographical limitations associated with the offshore seabed, narrows, shorelines and landing points. To that effect, a detailed methodology to answer the research questions noted in Section 1.1, and to achieve the State Team's overall goals related to OSW transmission system planning, was developed by DNV GL, PowerGEM, and WSP and approved by the State Team.

The Study methodology included three main tasks, namely: onshore grid assessment; offshore grid assessments; and environmental constraint analysis. Given the intrinsic dependency and relations that exist among the technical aspects and practical limitations of these three tasks, each were performed partially in parallel and partially in sequence to more effectively inform and guide one another. Figure 2-1 illustrates an overview of the Study methodology and notes where each task is described in this report.

Figure 2-1. Overview of the Study Methodology and Tasks Mapped to Sections of the Report



A more detailed summary of each task's methodology and scope is provided in the following Sections (2.1, 2.2, and 2.3). Further details, such as key limitations, opportunities, and applicable assumptions, are discussed in subsequent Sections 3 through 8, each dedicated to a specific Study task, which present analysis results and observations.

In support of the Accelerated Renewable Energy Growth and Community Benefit Act, that drove the need for this analysis, DNV GL and the rest of the consulting team worked with Department of Public Service and NYSERDA staff in consultation with the New York Power Authority, the Long Island Power Authority, the state's grid operator and utilities, to conduct this study.

2.1 Onshore Assessment

The Study onshore assessment consisted of the following tasks:

- Substation screening
- Development and analysis of OSW connection scenarios

2.1.1 Onshore Substation Screening

In this task, all substations within zones J and K were evaluated as feasible OSW connection points. Based on combination of reliability assessment and market analysis, as well as system topology, transfer analysis results and engineering judgment, a set of 20 substations were selected as candidate OSW connection points. These substations should not be construed as optimal OSW connection points; rather, the purpose of substation screening was to establish an initial manageable set of possible connection points, so that analytical scenarios could be developed and studied.

2.1.2 Analysis of OSW Connection Scenarios

Three different OSW allocation scenarios were developed and analyzed in this task. Two of the three scenarios allocated 6 GW of OSW to zone J and 3 GW of OSW to zone K, whereas a third scenario considered an increased amount of 4 GW of OSW connecting to zone K and the remaining 5 GW of OSW connecting to zone J.

Scenario analysis consisted of reliability security assessment and production cost modeling. In addition to the base scenarios, several sensitivities were also considered varying modeling parameters, such as availability of storage facilities, demand profiles, generation must-run status, etc.

Analytical results including steady state thermal overloads as well as annual OSW curtailment were developed for each scenario. Mitigating approaches, as needed, were developed to address system adverse reliability impacts and reduce OSW curtailment.

2.2 Offshore Assessment

As of the date of this Study, three OSW projects had already been procured and hence, were assumed fixed as Radial connected during the Study. The three procured OSW projects are Southfork (130 MW), Sunrise Wind (880 MW), and Empire Wind (816 MW), resulting in a remaining nominal OSW capacity target of 7.2 GW by 2035.

The Study's offshore assessment task consisted of the following three subtasks:

- Development of illustrative OSW future build-out scenarios
- Preliminary analysis of OSW connection concepts
- Detailed analysis of OSW connection concepts

2.2.1 Development of Illustrative OSW Build-Out Scenarios

For the remainder of targeted 7.2 GW of OSW, five plausible OSW build-out scenarios were considered. The OSW build-out scenarios were developed keeping in mind the uncertainties around OSW project geographic location and size, and timelines for development and construction. Scenarios also take into consideration projects currently in development. Based on differing assumptions related to BOEM wind energy area lease availability, turbine sizing and spacing requirements (that impact overall lease area capacity), and competition for OSW capacity located near Massachusetts and New Jersey, five plausible future OSW build-out scenarios were ultimately created (see Section 4.3). These five OSW build-out scenarios do not represent any preference of the State Team toward specific OSW projects or project locations. Rather they represent a possible range of future outcomes that could occur and are deliberately intended to be geographically diverse while still offering plausible OSW project locations and capacities given the current state of the OSW industry in the Northeastern U.S. as of the date of this report. The five developed OSW build-out scenarios can be found in Annex C.

2.2.2 Preliminary Analysis of OSW Connection Concepts

For each of the five future OSW build-out scenarios, five different connection concepts were studied (Dedicated Radial, Split, Mesh, Shared Substation, and Backbone; details regarding the different concept definitions can be found at Section 5 of this document). The result of this subtask was 25 different offshore connection topologies, each including a phased construction timeline for the 2025, 2030, and 2035 Study Years.

Based upon the sensitivities affirmed through the initial onshore analysis (see Section 3) as to the efficient split between New York City (NYISO Zone J) and Long Island (Zone K), the offshore analysis assumed injections of 6 GW of OSW into New York City and 3 GW of OSW into Long Island. During this phase of the Study, the High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC) technologies selection criteria were established considering limitations associated with onshore grid, landing points and routings to reach the onshore points of interconnections (POIs).

Each of the 25 offshore connection topologies consists of a high-level grid design in which quantity and ratings of main electric power equipment (cables, converters, transformers, etc.) are considered. Given that the results associated with onshore assessment were being developed as a parallel workstream (such as selected POIs and environmental routing), the initial 25 offshore connection topologies were analyzed and ranked qualitatively using industry guidelines.

2.2.3 Detailed analysis of OSW connection concepts

The onshore assessment and environmental assessments completed in parallel with the preliminary analysis of OSW connection topologies led to a refinement of the initial 25 offshore connection topologies down to three feasible connection concepts. The feasible connection concepts of Radial s, Meshed, and Backbone were selected for detailed design and more thorough illustrative analysis.

Recognizing commonalities across many of the plausible OSW build-out scenarios, the Radial, Meshed and Backbone connection concepts were studied further using one illustrative OSW build-out scenario. As a result, the 25 connection topologies were reduced to three variants. Complete conceptual designs were created for each variant, including all major electrical components, cable lengths and sizing, and other associated infrastructure. With quantitative inputs from onshore and environmental studies, capital expenditures (CAPEX), operational expenditures (OPEX), replacement expenditures (REPEX), and LTCOE calculations were completed, including both offshore and onshore equipment. In addition, in order to compare benefits of each variant beyond cost, an availability analysis was also completed for each of the three variants.

A detailed discussion of the complete offshore assessment and key results are included in Sections 4, 5, 7, and 8.

2.3 Environmental Constraints Analysis (Routing Assessment)

A transmission cable routing feasibility assessment (hereafter the Routing Assessment) was performed to address the following research question: what are the environmental and permitting challenges associated with bringing offshore wind energy to existing onshore substations?

The general scope and primary objectives for addressing the research question consisted of the following:

- Identify potentially feasible routes and landing areas to connect offshore power inputs with onshore substations to support an illustrative 6 GW (New York City) / 3 GW (Long Island) transmission strategy.
- Evaluate the environmental and permitting challenges for the representative routes and landing sites.
- Determine the major environmental constraints that might adversely impact the illustrative transmission strategy being examined.

Overall, the feasibility of the transmission strategy was assessed in two steps:

- **Initial assessment**: A screening-level analysis was performed to identify major constraints that might substantially hinder or prevent the installation of a transmission cable along several potential routes.
- **Route Refinement**: Based on the initial analysis and further refinement of other non-environmental aspects of the strategy, a limited number of routing alternatives were carried forward for further evaluation to confirm the feasibility of the illustrative transmission strategy with respect to routing.

2.3.1 Initial Route and Landing Site Identification

To identify and evaluate multiple route alternatives between offshore lease areas and onshore substations, also referred to as POIs, the routes were divided into three primary components:

- Offshore route corridors
- Shore approach segments and landing sites
- Onshore route segments

Representative offshore route corridors were delineated between potential offshore wind lease areas and the nearshore coastal region of New York State. The nearshore segments of the representative routes, identified as the shore approach, connect the offshore route corridors to landing sites along the Long

Island shore and the New York City waterfront. Onshore route segments extend from the shore landing sites to representative POIs identified during the onshore grid substation assessment (see Section 3). Potentially suitable landing sites and potentially feasible onshore routes were initially identified based primarily on a visual interpretation of aerial photographs and GIS data layers. Ultimately, representative route alternatives connecting to 11 different POIs were analyzed, including four POIs in New York City (ConEd interconnections) and seven POIs on Long Island (LIPA interconnections).

2.3.2 Constraint Identification and Review

To identify the potential environmental and permitting challenges for the representative routes and landing sites, GIS data layers of environmental resources and specially designated areas were compiled for all areas that may be affected by the different route segments extending from potential offshore lease areas to the identified POIs. These GIS layers were obtained from publicly available websites and included in a project-specific web mapper that allowed them to be overlaid with each other on base maps in order to consider representative route segments in relation to multiple potential constraints. Representative routes and landing sites were analyzed based on the presence and degree of constraints considered potentially critical to the feasibility of each route segment. Scoring matrices were developed to help visualize and compare the relative feasibility of the representative routes with respect to each critical constraint.

2.3.3 Route Refinement and Supporting Analyses

The results of the screening-level critical constraints analysis were considered in conjunction with other inputs and additional analyses to develop a refined list of representative routes for illustrative purposes. The additional inputs and analyses included:

- Further evaluation of the transmission strategy to yield a revised set of POIs for consideration — four in New York City and four on Long Island.
- Consideration for several specific cable installation methods and electrical engineering parameters.
- Further investigation to identify potential sites for HVDC converter stations and HVAC transformer stations.
- Evaluation of the number of cables and/or trenches that could potentially be installed along nearshore and onshore locations where constraints are greatest (i.e., “bottlenecks” or “restriction points”).

A detailed discussion of the Routing Assessment methodology and key results are included in Section 6. Supporting material developed as part of the Routing Assessment is provided in Annex B - Transmission Cable Routing Assessment Supporting Attachments. The refined list of representative routes was used in the costing analysis discussed in Section 8.

3 Onshore Assessment

3.1 Introduction

New York State recently enacted the CLCPA that requires the State to reach a carbon-free power system by the year 2040. As part of the modeling process for this Study, the State has also set intermediate milestones that involve:

- Connecting 9,000 MW (9 GW) of offshore wind (OSW) by 2035, with an intermediate level of 5.6 GW by 2030 on the glide path to the final targets. This is significantly more than the ~1.8 GW that has been procured to date and is expected to connect by 2025.
- Deploy 3,000 MW (3 GW) of energy storage facilities by 2030, with an interim target of 1.5 GW of storage by 2025.

Figure 3-1 illustrates the targets and milestones considered in the CLCPA.

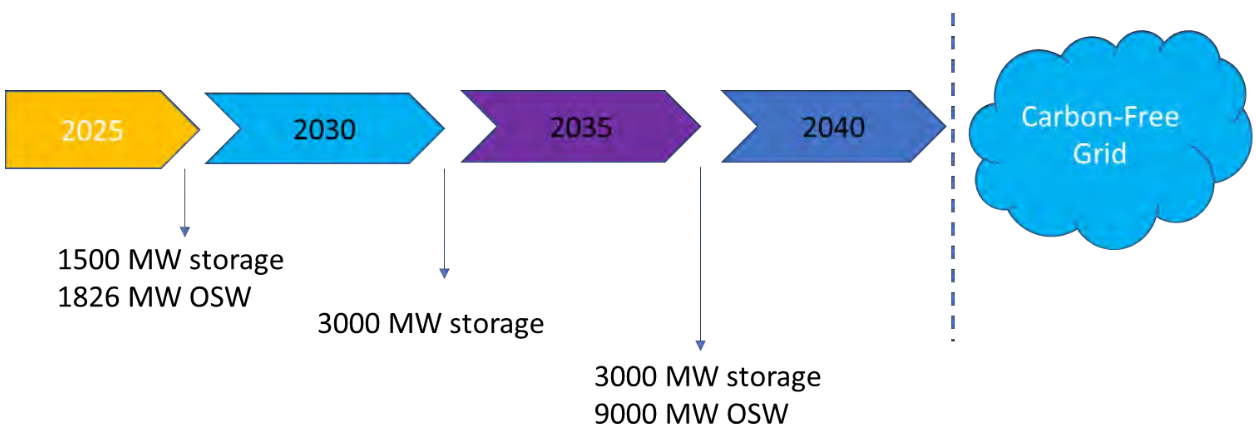


Figure 3-1. Intermediate Milestones Toward a Carbon-Free NYS Grid

One of the key objectives of the Study commissioned by NYSERDA is to identify potential transmission strategies in order to achieve the State goals. As part of the Study, PowerGEM performed onshore analysis to assess strategies and options to connect 9 GW of OSW to zones J and K. The remaining sections in this Chapter 3 of the Study report discuss the development of various scenarios, the analytical approach followed, and the analytical findings.

As part of the onshore analysis, PowerGEM performed reliability security analysis and production cost economic analysis. The analysis performed should not be construed as a replacement of the formal interconnection studies that each OSW project will need to undergo as part of the NYISO interconnection process. The formal interconnection process involves several analytical components that were outside the scope of the Study. Rather, the analysis performed in the Study aimed to provide insights into the capability of the current system to accommodate 9 GW of OSW and present various interconnection options.

Chapter 3 of the Study was prepared by PowerGEM in the course of performing work sponsored by the State Team. Any opinions expressed in this chapter do not necessarily reflect those of the State Team, and any references to specific products, services, process, or methods does not constitute an implied or expressed recommendation or endorsement of it.

This Chapter 3 of the Study report is structured as follows:

- Following this introductory Section 3.1, Section 3.2 discusses the study methodology, technical assumptions, and data used in onshore analysis
- Section 3.3 discusses the initial stage of onshore analysis that involved screening of existing system substations
- Section 3.4 discusses the development of a base OSW allocation (Scenario 1) and presents analytical findings
- Section 3.5 discusses the development of an alternative OSW allocation to zone K (Scenario 2) and presents analytical findings
- Section 3.6 discusses the development of an alternative OSW allocation that connects increased OSW resources to zone K (Scenario 3) and presents analytical findings
- Section 3.7 provides the final conclusions reached in onshore analysis

3.2 Study Methodology & Assumptions

The onshore analysis in the Study proceeded in accordance with the methodology and subject to the assumptions and study parameters outlined in this section.

3.2.1 Study Area

The Study focused primarily on the 115 KV and above portion of the New York State Transmission System (NYSTS), in the Dunwoodie (zone I), New York City (zone J), and LIPA (zone K) areas that are most likely to be affected by the connection of OSW. Specifically, for the LIPA region, the 69 kV and above network was considered in the N-0/N-1 steady-state reliability analysis (in addition to 115 KV and above facilities). These areas are collectively referred to as the Study Area in the remainder of this report.

3.2.2 Study Database

The NYISO provided summer peak 50/50 power flow models and associated contingencies and modeling files for 2024 and 2029 planning years. The models provided were based on the NYISO Class Year 2017 ATBA base case with 2019 FERC-715 2024/2029 system representations.

Starting from the power flow models provided by the NYISO, base cases were developed for each of the 2025, 2030, and 2035 study years. The 2024 summer peak case was used to develop the base case for the 2025 study year. The 2030 and 2035 base cases were developed using the 2029 summer peak case.

The following considerations were taken into account for developing the study base cases:

a) Already procured OSW projects (i.e., Empire, Sunrise, and South Fork projects) were modeled in service at full capacity in all three base models.

b) The Champlain Hudson Power Express (CHPE) project was not considered in any of the study years.[2]

c) Both segments A and B of the AC Transmission PPTN projects were included in all models.

d) The Poseidon OSW model was initially included in the study models. However, in the course of the study, PowerGEM and the State Team were informed that Poseidon has withdrawn and was no longer a valid project. Base models were updated to remove Poseidon from consideration. This will be further discussed in Section 3.5.

e) Two load profiles were used in the study: a) base demand profile, and b) higher demand sensitivity profile. Both profiles followed load forecasts considered in the Pathways to Deep Decarbonization in

[2] Based on Study assumptions regarding availability of non-OSW resources to be dispatched and curtailed, inclusion of the CHPE project would likely have minimal impact on analytical findings of the Study.

New York State study[3] for the 2025, 2030, and 2035 horizon years. Snapshot power flow models, appropriate for reliability analysis, were developed based on the New York Control Area (NYCA) coincidental peak load. Production cost models, appropriate for market analysis, considered the entire annual (i.e., 8760-hour) load profile for each of the study years. NYCA coincidental peak load values considered in the Study are tabulated in Table 3-1. Values in Table 3-1 are after netting out Behind-The-Meter (BTM) PV.

Table 3-1. NYCA Coincidental Peak Load (MW)

Demand Forecast	Study Year		
	2025	2030	2035
Base Demand Profile	29,101	29,711	33,305
Sensitivity Demand Profile	29,159	33,719	36,592

f) Following targets specified in the New York State Energy Storage Roadmap, 1,500 MW of energy storage units were included in the 2025 base case. Energy storage units totaling 3,000 MW were used in the 2030 and 2035 base cases. Initially, energy storage facilities were added to the NYCA backbone system based on load-weighted share of individual substations. In subsequent stages of analysis, storage facilities were moved to different location. Figure 3-2 illustrates the size and location of the storage units added in the base cases.

For purposes of analysis, storage facilities were considered fully dispatchable in their entire range. In production cost analysis, storage units were modeled as four-hour units.

[3] https://climate.ny.gov/-/media/CLCPA/Files/2020-06-24-NYS-Decarbonization-Pathways-Report.pdf. The base demand follows the High Technology Availability case and the higher demand profile leverages information from the Limited Non-energy case.

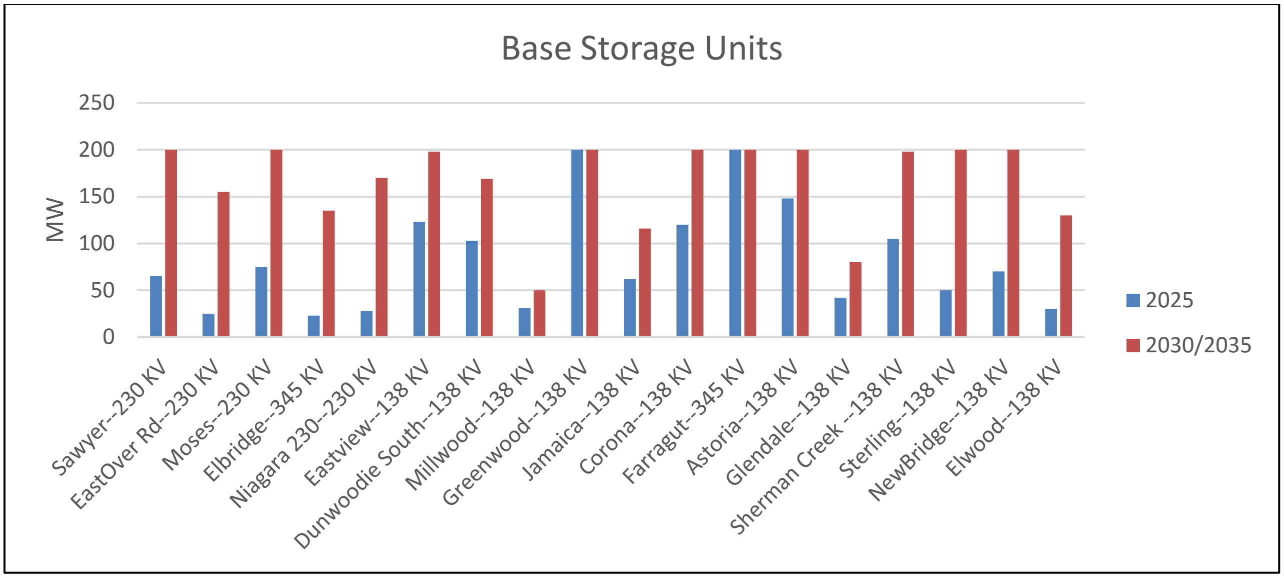


Figure 3-2. Base Case Storage Units

g) NYCA generation retirements posted by NYISO on or before January 2020 were considered in the development of base models. Retirements of peaker units were also considered in accordance with the individual unit compliance plans, as filed. A comprehensive list of generation retirements considered in the Study is included in Attachment 3-I (Annex A).

h) Select upgrades from Local Transmission Plans (LTP) of NYCA Transmission Owners were also considered in the development of the base models. Table 3-2 presents a partial list of system changes considered, based on LTPs filed for zone K (LIPA). A comprehensive list of local upgrades considered in the Study was included in Attachment 3-II (Annex A).

Table 3-2. Partial List of Local Upgrades (LTP) Considered in LIPA

Description	Study Year
King Highway 138 KV Substation	2025, 2030, 2035
East Garden City to Valley Stream new 138 KV ckt	2025, 2030, 2035
Wildwood to Riverhead 69 KV to 138 KV conversion	2030, 2035
Riverhead to Canal new 138 KV ckt	2030, 2035
Syosset to Shore Rd new 138 KV ckt	2030, 2035

i) To avoid generation deficiencies noted in the NYISO 2019 Comprehensive Reliability Plan study, base models for all three study years included a 420 MW non-renewable compensatory unit at

Greenwood 138 KV substation. The unit was considered available for dispatch in its entire range in all analysis.

j) To achieve the policy targets in the CLCPA, a non-OSW build mix was developed during the first quarter of 2020, based on preliminary Clean Energy Standard Cost Study analysis. This information was leveraged to provide the remaining renewable energy build mix, which was added at the NYCA backbone system and modeled as land-based wind and solar units. Total land-based wind and solar MWs considered in the base cases are summarized in Table 3-3.

Table 3-3. Total Solar and Onshore Wind (MW)

Study Year	Solar	Wind	Total
2025	5,027	4,229	9,256
2030	14,242	5,709	19,951
2035	16,842	6,108	22,950

3.2.3 Modeling Assumptions

Phase Angle Regulators (PARs), switched shunts, and load-tap-changing (LTC) transformers were allowed to regulate in pre-contingency conditions; they were locked (non-regulating) in post-contingency conditions. Static var compensator and Flexible AC transmission system devices in NYCA were set to zero reactive power output pre-contingency but were allowed to regulate up to their full output post-contingency.

The ConEd-LIPA wheeling constraint[4] was observed in all study analysis. Flows over the NNC cables were set at zero MW in all analysis. Flows over DC tie lines between LIPA and PJM (Neptune) and ISONE (Cross Sound Cable) were allowed to fluctuate as imported flows; no exports were allowed over the DC lines. The LIPA system was allowed to import (export) from (to) the rest of the NYCA subject only to the applicable pre/post contingency ratings of the Y49 and Y50 tie lines[5] (i.e., no other modeling constraints were applied on LIPA imports or exports over the Y49/Y50 tie lines).

[4] Total of 300 MW over the Jamaica PAR-controlled lines

[5] Unless specifically noted otherwise, post-contingency flows on the Y49 and Y50 tie lines were limited to the LTE ratings of the cables.

3.2.4 Study Methodology

3.2.4.1 Steady-State Reliability Analysis

Steady-state reliability security analysis was performed using the PowerGEM TARA software.

Steady-state thermal N-0, N-1, and N-1-1 analyses were conducted in accordance with NYISO and NERC planning criteria. The planning philosophy whereby normal thermal ratings shall not be violated under pre-contingency conditions (i.e., N-0 or N-1-0) and the applicable emergency rating shall not be violated under post-contingency conditions (i.e., N-1 or N-1-1) was applied. Under post-contingency conditions, the flows on facilities within the Study Area were limited to Short-Term Emergency (STE) ratings for underground cable circuits in the ConEd service area and Long-Term Emergency (LTE) ratings for the remaining underground feeders, overhead circuits and transformers.

N-1-1 analysis was performed allowing for security-constrained reliability re-dispatch between contingencies. After the first contingency and prior to the second contingency, analysis allowed existing online NYCA generation (excluding OSW per study assumptions, as well as nuclear and hydro facilities) and regulating PARs to adjust. PARs, switched shunts, and LTC transformers were modeled as regulating devices in pre-contingency conditions and non-regulating devices in post-contingency conditions following the second contingency.

In accordance with the ConEd transmission planning criteria, N-1-1-0 analysis was also performed. N-1-1-0 analysis limited flows on ConEd facilities within select load areas to pre-contingency ratings. Following the second contingency, the analysis allowed system adjustments, including re-dispatch of generation resources and adjustment of regulating PARs, in preventive or corrective mode, if and as needed. OSW adjustment (i.e., curtailment) was allowed but only as last resort for resolving relevant N-1-1-0 overloads. In other words, an OSW unit was allowed to be curtailed under N-1-1-0 conditions only if the OSW unit was impacting an overload and that specific overload could not be mitigated with adjustment of PARs and/or dispatch of other generation resources. As already stated, OSW curtailment was not allowed under N-0, N-1, and N-1-1 contingency conditions.

Steady-state reliability security analysis was performed for summer peak loading conditions only, consistent with established planning study guidelines. As will be discussed in the next section, production cost analysis is based on an annual period, thus properly accounted for light load conditions.

3.2.4.2 Production Cost Analysis

Production costing analysis was performed using the PowerGEM PROBE LT software.

Production cost analysis is an annual economic-based analysis that simulates detailed hourly operation of a given energy market over an 8760-hour time frame. Production cost modeling (PCM) software performs this simulation by finding the least cost dispatch of a complex system of interconnected generators to reliably meet load in every hour of the day at every location. PCM commits and schedules generation with respect to the expected input costs and operating parameters for each power plant and physical limitations of the transmission system. There are many applications for PCM software; typically, it is used to assist in deciding how much generation to add and where should the generation be placed on the system, study economic benefits of new transmission, and/or to evaluate numerous other future market outcomes such as pricing, transmission congestion, and emissions.

In the context of the Study, the primary objective of the production cost analysis is to determine wind curtailment risks with consideration of renewable variability over time. This enables further evaluation of the suitability of various wind interconnection locations.

Production cost analysis requires additional inputs and assumptions as compared to steady-state reliability analysis. In addition to the transmission model, input data include generator heat rates and operating characteristics, hourly zonal demand for all hours of the study year, renewable energy profiles, emissions rates and costs, and fuel price forecasts. Sources of PCM data for the Study included:

- S&P Global Market Intelligence — primary source for power plant data for NYISO market generators
- NYISO Gold Book — supplemental NYISO power plant data
- eia.gov — specifically forms 860 and 923 as a cross-reference for generator heat rates
- NYISO-provided data — load flow models, including base dispatch profiles
- NYSERDA/State Team — hourly zonal demand profiles, offshore wind profiles, onshore wind and solar profiles, NYISO queue generator information, natural gas prices. Figure 3-3 shows a summary of the natural gas price forecast used in the Study

To meet the primary objectives of the Study, production cost analysis required specific assumptions in addition to those noted in section 3.2.3. A key assumption in the economic analysis is that onshore wind, solar, and hydro will be curtailed before offshore wind. This approach ensures OSW is not reduced due to statewide over-generation scenarios, to properly test zones J/K transmission. Additional base case assumptions in the simulations include:

- All thermal generation, except nuclear, can be re-dispatched and/or decommitted.
- Offshore wind profiles were developed from the NREL Wind Toolkit Database for a 2009 meteorological year.
- Analysis monitored 100 KV and above elements only.
- An offshore wind average capacity factor of 53% was used. This figure was informed by the Clean Energy Standard cost study.

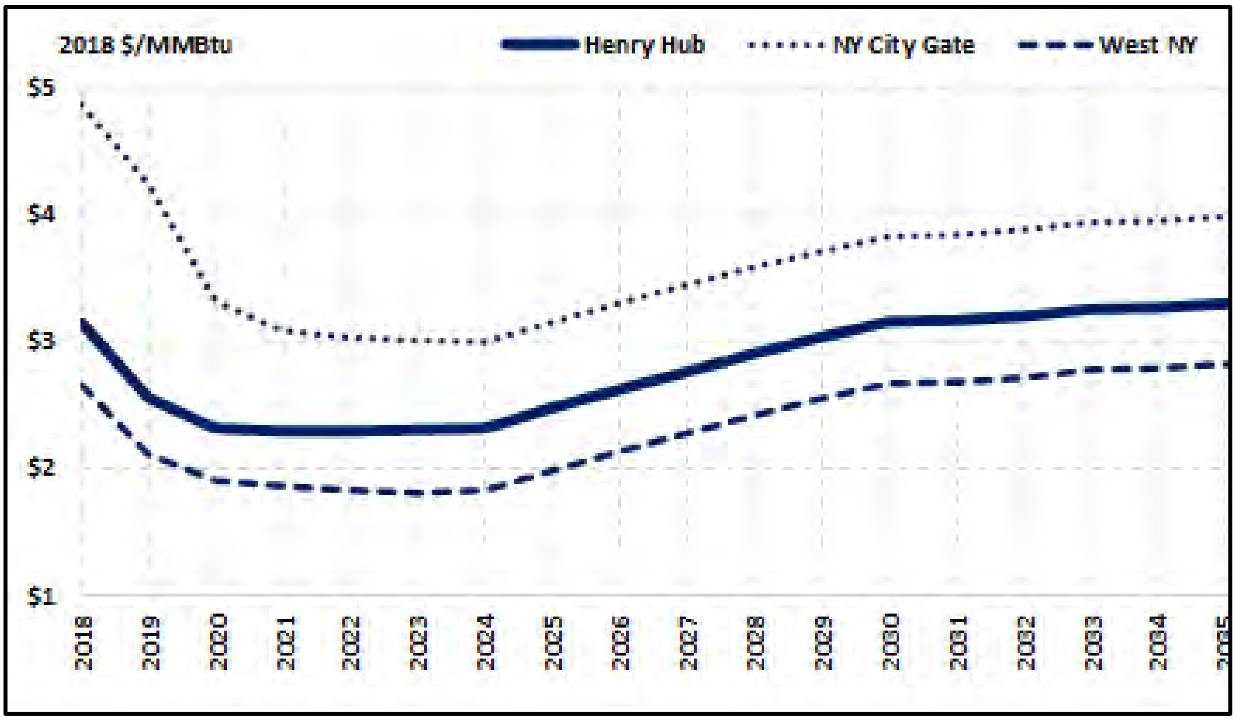


Figure 3-3. Natural Gas Price Forecast (2018$/MMBTU)

3.3 Substation Screening

As the first step in onshore analysis, screening of existing substations was performed to qualitatively evaluate and rank existing substations in zones J and K for the connection of OSW resources. The purpose of screening was to filter the list of substations based on measurable metrics, considered both individually as well as in small clusters, and provide a much reduced, initial list of candidate substations for the connection of OSW.

3.3.1 Screening Methodology

Substation screening was performed based on two steps:

a) Step 1: Linear thermal transfer analysis was performed for every existing substation in zones J and K. Available information on the configuration and connectivity of each substation was also examined. Thermal transfer analysis proceeded by modeling a generation injection on a selected sending node (the source or sending subsystem) and then incrementally scaling generation up, while a subset of existing generation resources (the sink or receiving subsystem) is scaled down accordingly. In the Study, every substation rated at 69 kV and above was considered individually as source, and generation was scaled up against a variety of possible sinks testing system stresses in various directions. The transfer level between the source and the sink continued to increase (while simultaneously simulating contingency events) until the flow on some transmission element exceeds its applicable rating (either pre- or post-contingency), at which point the injection limit at the source was determined. Despite the limitations of thermal transfer analysis, such as dependency on initial dispatch conditions, definition of sources and sinks, etc., it can provide insight into system capabilities and coupled with additional analytical approaches, it can filter existing transfer capabilities as part of a screening approach.

Although the Study did not have a predetermined number of possible OSW connection points, or a minimum or maximum OSW MW injection at any particular station, it became apparent that in order to analyze connection of OSW to a manageable set of substations, a minimum injection threshold needed to be established. For purposes of the Study, a minimum of 300 MW of OSW per injection point was considered throughout the Study, unless otherwise noted. This was partially informed by the sizing of projects in the NYISO interconnection queue at the time of study parameter development; further, at that same time, it was unclear how different amounts of OSW could be split and brought onshore.

As a result of Step 1, 37 substations were selected for further consideration in Step 2.

b) Step 2. Using both power flow and production cost analyses, substations shortlisted in Step 1 were further evaluated. As part of this step, set injections were modeled at each substation, with maximum injections capped at 1,000 MW and 500 MW for 345 kV and 138 kV buses, respectively. Step 2 analysis focused primarily on the loading of the system rated at 100 KV and above, under snapshot (power flow) and annual (production costing) assessments.

The approach to screening substations in production cost modeling was designed with an understanding that it would be infeasible to test every potential combination of 37 substations at different MW levels, as this would result in a really large number (in the order of tens of thousands) of annual production cost simulations. Thus, the production cost modeling approach proceeded as follows:

First, a 2035 base case simulation was completed as a general test, to act as a benchmark case, and to inform next steps. This initial simulation also ensures there are no significant curtailments of the procured 1.8 GW of OSW after adding the Study assumptions but prior to adding additional OSW.

Then, selecting from the initial list of 37 substations, injections totaling an increment of 7.2 GW of OSW at various combinations of substations were added to the model and a complete annual simulation was performed per each configuration. The combination of injection levels and locations was based on voltage, existing OSW injections, and prior PowerGEM experience / system knowledge. The evolution of the process for substation screening via PCM analysis, targeting 7.2 GW for every 2035 scenario, can be loosely summarized as follows:

- Inject ~400 MW OSW at 17 locations (four simulations)
- Several additional simulations that inject ~800 MW OSW at 8 locations, excluding stations that failed screening at 400 MW
- Many additional scenarios, building on prior results, adding 400–1,000 MW per location
    - For example, if a location showed curtailment in multiple 400 MW scenarios, it was likely not tested again and excluded from further consideration
- Upon completion of each simulation scenario, each OSW injection was reviewed for number of hours of curtailment and total MWh curtailed

In total, 26 production cost simulations were completed to test possible combinations of OSW injection points and determine curtailment risks. In all simulations, all existing generation resources, other than nuclear units, were available for re-dispatch and de-commitment. Onshore wind and solar generation were curtailed before OSW, if and as needed. Total curtailment of OSW resources over the annual simulation period was the key metric applied in the ranking of each substation.

Snapshot power flow analysis was also performed. Simulations included full N-0 and N-1 contingency analysis and were performed based on concurrent OSW injections at the shortlisted substations, subject to generation dispatch and PAR optimization. In power flow analysis, dispatch optimization ignored economic cost differences associated with different generation resources.

OSW curtailment from yearly production costing analysis was the primary criterion considered in substation ranking. Results obtained from snapshot power flow analysis were considered as supplemental input.

3.3.2 Screening Results

Using the simulation results from the analytical approach outlined in the previous section, a total of 20 substations were identified that indicated promising performance. The list is provided in Table 3-4. In general, these substations exhibited insignificant or very little OSW curtailment in production costing analysis and little or no concerns in power flow analysis. Some of these substations merited consideration on a case-by-case basis due to special circumstances and general system knowledge.

However, under no circumstances should the list of stations presented in Table 3-4 be considered as a list of stations recommended for OSW interconnection. Rather, the purpose of substation screening in the Study was solely to establish an initial manageable set of possible connection points, so that analytical scenarios could be developed and further studied.

The list of stations that passed Step 1 but were not included in the list from Step 2 is included in Table 3-5. Whereas ultimately not selected as part of the list of candidate OSW connection points, several stations in Table 3-5 might very well merit further consideration under different study and modeling assumptions. Therefore, under no circumstances should the list of substations in Table 3-5 be construed as inadequate or infeasible for connection of OSW resources.

Table 3-4. Substation Screening Results

Name	kV	zone	Name	kV	zone
Farragut	345	J	Brookhaven	138	K
Goethals	345	J	Newbridge Rd.	138	K
Mott Haven	345	J	Northport	138	K
Rainey	345	J	Shore Rd.	345	K
W49th str.	345	J	Syosset	138	K
Academy	345	J	Glenwood	138	K
Astoria	345	J	Pilgrim	138	K
Freshkills	345	J	Port Jefferson	138	K
Gowanus	345	J	Ruland Rd.	138	K
East Garden City	138	K	Shoreham	138	K

Table 3-5. Step 1 Shortlisted Substations, Not Included in Final Screening List

Name	kV	zone	Name	kV	zone
E13th str.	345	J	Corona	138	J
Tremont	345	J	E13th str.	138	J
Astoria	138	J	E179th str.	138	J
Jamaica	138	J	Sherman Creek	138	J
Hudson Ave	138	J	East Garden City	345	K
Greenwood	138	J	Barrett	138	K
Foxhills	138	J	Holbrook	138	K
Parkchester	138	J	Shore Rd.	138	K

3.4 Scenario 1: Base Allocation of 9 GW of OSW Between Zones J and K — Analysis and Results

Onshore analysis considered several different allocations of 9 GW of OSW between zones J and K that will be presented in the remainder of this Chapter 3.

As the first step of the analysis, a base allocation was established to provide a base scenario for the connection of the 9 GW of OSW to zones J and K. As part of the development of the base allocation, all the candidate substations resulting from the substation screening process were assumed to be available for

OSW connection. This section discusses the development of the base allocation, the analysis approach, and presents analytical findings.

3.4.1 Initial Simulations and Development of Scenario 1

In order to develop OSW allocations that exhibited the least number of adverse system impacts, a large number of initial models were developed, where the 9 GW of OSW were allocated to zones J and K in various proportions, ranging from 5 GW to 7 GW of OSW allocated to zone J and the remainder allocated to zone K. Connecting stations and specific MW injections also varied among the models.
Following preliminary screening of the full set of initial models, six models were further developed and were subject to initial test run simulations. All test runs were performed for the 2035 study year. Figure 3-4 shows the zone J/K split considered in the test run simulations. Among the test runs considered, test run #5 indicated the most promising performance, i.e., fewer adverse system impacts based on reliability security analysis. Therefore, the base allocation and scenario was developed based on the OSW allocation and injections considered in test run #5. This allocation will be referred to as Scenario 1 in the remainder of this section. Figure 3-5 shows the approximate locations of the Points of Interconnection (POIs) selected in Scenario 1.

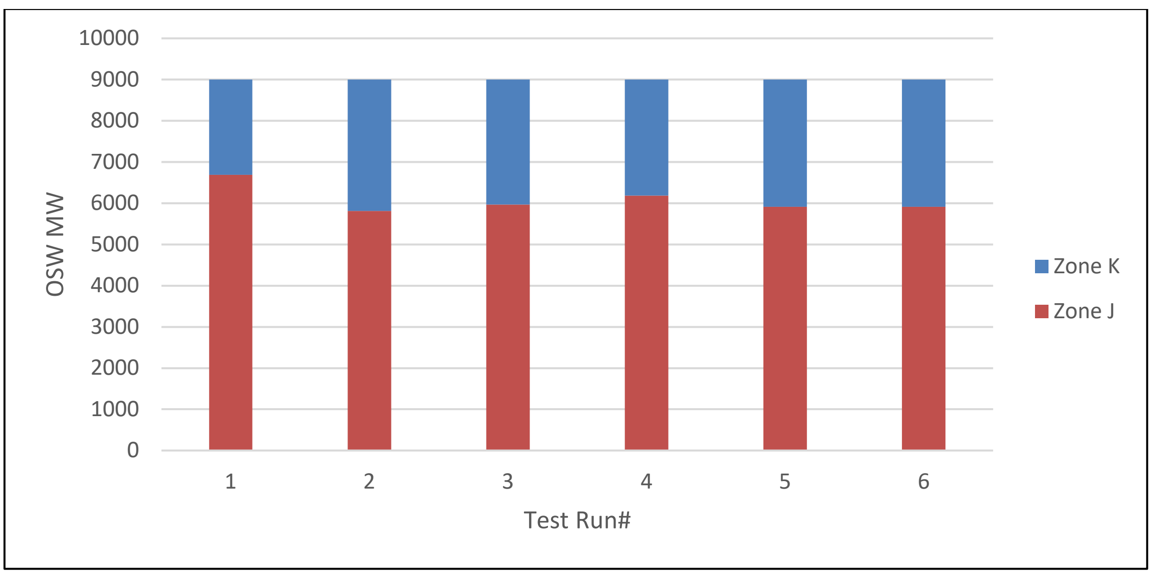


Figure 3-4. Zone J/K OSW Allocations in Test Runs (Including Already Procured OSW)

For the development of Scenario 1 for the 2030 study year, the OSW injections for 2035 were reduced to meet the OSW study targets described in Section 3.1. Regarding study year 2025, the already procured

OSW projects (Empire, Sunrise, and South Fork projects) fully address the study targets for the 2025 study year. Therefore, no additional OSW were considered for the 2025 study year. Table 3-6 summarizes the OSW injections for each study year. Similar information is presented in Figure 3-6.

Figure 3-5. POIs Considered in Scenario 1

Table 3-6. OSW Injections - Scenario 1

Already procured OSW (MW)									
Study Year	Gowanus (Empire) 345 kV		Holbrook (Sunrise) 138 kV			East Hampton (South Fork) 138 kV			
2035	816		880			136			
2030	816		880			136			
2025	816		880			136			
Scenario 1 additional OSW injections (MW)									
	Farragut 345 kV	Mott Haven 345 kV	Rainey 345 kV	W49th str 345 kV	Shore Rd 345 kV	Brookhaven 138 kV	Newbridge 138 kV	Northport 138 kV	Syosset 138 kV
2035	1400	1250	1250	1200	500	270	600	400	300
2030	1400	None	1250	None	500	None	300	400	None
2025	None	None	None	None	None	None	None	None	None

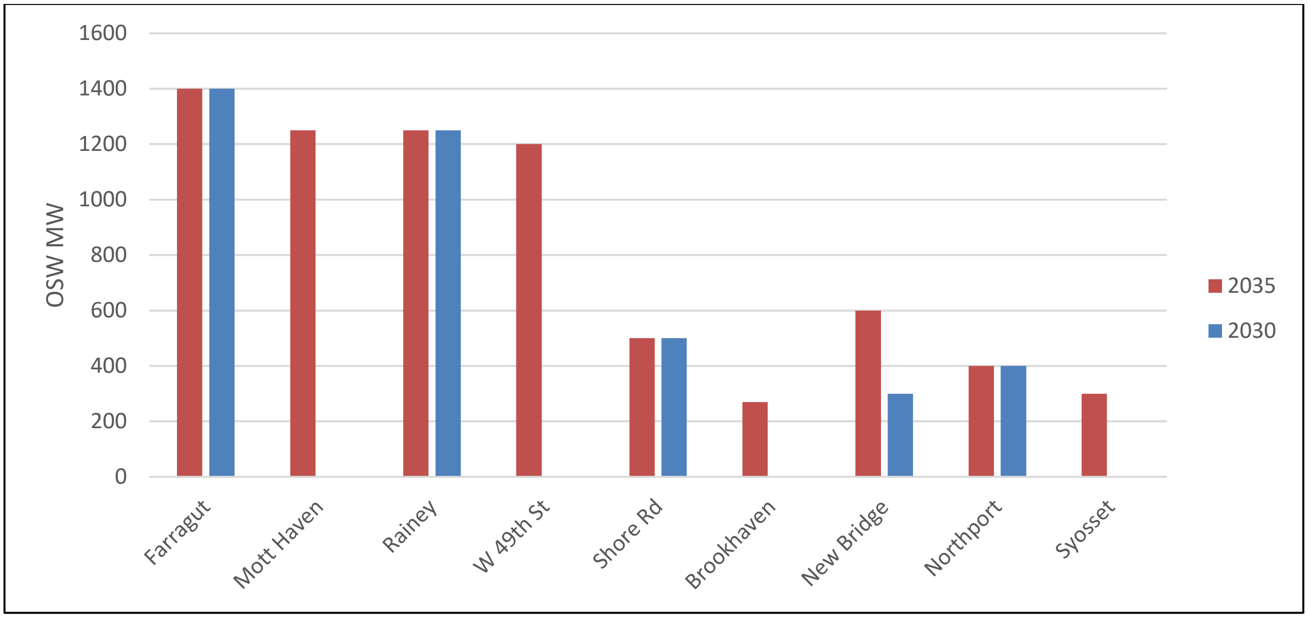


Figure 3-6. Additional OSW Injections - Scenario 1

3.4.2 Base and Sensitivity Conditions

In addition to the base conditions outlined earlier in this and prior sections, various additional sensitivities were considered in both reliability and production cost analysis to further evaluate the performance proposed in Scenario 1. Some of the sensitivities were based on PowerGEM suggestions and some were formed based on feedback from the Study Advisory Group. Table 3-7 outlines some of the different sensitivities considered under Scenario 1. The same sensitivities were also considered in additional scenarios, as will be discussed in subsequent sections.

Table 3-7. Sensitivity Conditions - Scenario 1

Sensitivity	Description	Analysis*	Study Years
Load sensitivity	Sensitivity demand forecast	RS/PCM	All
Ancillary services	Co-optimize Energy & AS (enforce NYISO AS requirements)	PCM	2035
Increased generation	10% non-dispatchable fossil generation	PCM	2030, 2035
No Storage	Remove zone K storage facilities	PCM	2035
Modified zone K	Modified zone K parameters, as described in report	PCM	2035

* RS-Reliability Security, PCM-Production Cost Modeling

3.4.3 Reliability Security Analysis

Following the methodology described in section 3.2, steady state contingency analysis was performed that included N-0, N-1, and N-1-1 analysis, in accordance with established criteria and study practices. N-1-1-0 analysis was also performed for select ConEd Transmission Load Areas (TLA) zones. Steady-state analysis focused primarily on thermal performance of the network. As already stated in section 3.2, OSW resources were considered as non-curtailable/non-dispatchable in reliability analysis; except that OSW curtailment/redispatch was allowed in N-1-1-0 analysis as resource of last resort to mitigate system overloads, if and as needed. All analysis was performed under peak loading conditions.

3.4.3.1 Steady State Thermal Contingency Analysis

Initial simulations were performed with energy storage units located as described in section 3.2. All storage units were considered fully dispatchable within their entire (charge/discharge) range. Contingency analysis results for the 2035 base-load forecast are summarized in Tables 3-8 and 3-9. Very similar results, qualitatively and quantitatively, were observed for the load sensitivity analysis. Tables 3-8 and 3-9 also include recommendations for transmission-based mitigating system upgrades, as needed.

It should be noted that analysis results also showed overloads on Farragut X10 and E13th str. transformers, in zone J. Based on feedback received from ConEd, those overloads were excluded from further consideration, as mitigation plans are already in place.

Table 3-8. Scenario 1: N-1 Contingency Analysis Results

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Contingency	Mitigation System Upgrade
MALVERN---West Hempstead 69 KV	102	47	59	193: EGC6060	Reconductor line
MASPEQUA2---PLNEDGE 69 KV	100	62	74	225: MS 660	Reconductor line

Table 3-9. Scenario 1: N-1-1 Contingency Analysis Results

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Outage	Contingency	Mitigation System Upgrade
Lk Success---SHORE RD2 138 KV #2	134	249	430	138-367	Base Case	Reconductor line
Lk Success---SHORE RD2 138 KV #1	134	249	430	138-368	Base Case	Reconductor line
Riverhead 138/69 KV transformer #1	106	118	145	S_FORK-GEN	138-910	Upgrade transformer

In accordance with the Study scope, an alternative approach to mitigate system adverse impacts was also considered, based on improved positioning and utilization of existing energy storage facilities. As part of the alternative approach, no new storage units were added; instead, some of the already modeled storage units were strategically repositioned. The new locations were selected with the sole purpose to mitigate adverse system impacts to the extent possible and thus reduce the scope of system impacts. Unless otherwise noted, the new locations remained unchanged for any remaining analysis scenarios. Table 3-10 shows the modified sizes/locations considered in the development of the alternative mitigation scenario.

Table 3-10. Revised Sizing/Placement of Storage Facilities

Bus	Initial Placement/Allocation		Revised Placement/Allocation	
	2025	2030/2035	2025	2030/2035
Farragut-345 KV	200	200	None	None
Sherman Creek-138 KV	105	198	None	None
Water St 27 KV-Unit1*	None	None	100	100
Water St 27 KV-Unit2*	None	None	100	100
E13 138 KV- Unit1*	None	None	52.5	99
E13 138 KV- Unit2*	None	None	52.5	99
Sterling-138 KV	50	200	None	None
Elwood-138 KV	30	130	None	None
LK Success-Unit1	None	None	25	100
LK Success-Unit2	None	None	25	100
Riverhead-Unit1	None	None	15	65
Riverhead-Unit2	None	None	15	65

*) Following comments from ConEd, some storage facilities were further revised to their original placement, or considered offline, with no impact to analysis results

Tables 3-11 and 3-12 show thermal overloads in the 2035 study year with the base load forecast and revised placement of energy storage units. Relocation of the storage units addressed 138 kV N-1-1 constraints previously observed. Similar results were observed in the sensitivity scenario based on high-load forecast.

Table 3-11. Scenario 1: N-1 Contingency Analysis Results (Adjusted Storage Facilities)

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Contingency	Mitigation System Upgrade
MALVERN---West Hempstead 69 KV	102	47	59	193:EGC6060	Reconductor line
MASPEQUA2---PLNEDGE 69 KV	100	62	74	225:MS 660	Reconductor line

Table 3-12. Scenario 1: N-1-1 Contingency Analysis Results (Adjusted Storage Facilities)

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Outage	Contingency	Mitigation System Upgrade
None						

For simplicity in reporting, in the remainder of this section, Scenario 1 with adjusted storage facilities as shown in Table 3-10 will be referred to as Scenario 1 and all analytical findings are based on adjusted energy facilities as noted earlier.

Scenario 1 was also studied for the 2030 and 2025 study years. Tables 3-13 through 3-16 present reliability analysis findings for study years 2030 and 2025, based on base load forecast. Unless noted otherwise in subsequent results tables, similar analysis results, qualitatively and quantitatively, were observed for the load sensitivity analysis.

As shown in Table 3-16, an overload was observed under N-1-1 conditions, for study year 2025, on the Carle Place--East Garden City 138 kV line. This constraint was fully resolved through LIPA's LTP included in the modeling of the 2030 and 2035 study years.

Table 3-13. Scenario 1: N-1 Contingency Analysis Results, 2030 Study Year*

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Contingency	Mitigation System Upgrade
MALVERN---West Hempstead 69 KV	101	47	59	193: EGC6060	Reconductor line

*) results in this table reflect load sensitivity analysis; no adverse impacts under base load analysis

Table 3-14. Scenario 1: N-1-1 Contingency Analysis Results, 2030 Study Year

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Outage	Contingency	Mitigation System Upgrade
None						

Table 3-15. Scenario 1: N-1 Contingency Analysis Results, 2025 Study Year

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Contingency	Mitigation System Upgrade
None					

Table 3-16. Scenario 1: N-1-1 Contingency Analysis Results, 2025 Study Year

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Outage	Contingency	Mitigation System Upgrade
CARLE PL-- E.G.C. 138 KV line	105	263	303	138-367	138-366	Addressed by LTP

3.4.3.2 N-1-1-0 Analysis

N-1-1-0 analysis was performed for select ConEd TLA zones. As part of this analysis, OSW resources were considered curtailable as resource of last resort to mitigate system overloads, if and as needed.

Simulations were performed for all three study years using both the base and sensitivity load forecasts. No overloads were observed, and in all simulations, OSW curtailment was minimal (less than 5 MW).

3.4.3.3 Short Circuit Ratio Analysis

Short Circuit Ratio (SCR) analysis was performed to evaluate the relative strength of the system at the selected OSW connection points under consideration. For each connection point, SCR was calculated as the ratio between the system’s short circuit capacity and the size of OSW injection. All local generators in the Study Area were assumed offline. SCRs were calculated at the OSW POIs.

Table 3-17 lists short circuit ratios calculated assuming that no transmission outages exist. With all lines in-service, E. Hampton indicated the minimum short circuit ratio among all the connection points tested.

In order to capture impacts of local outages, a similar analysis was performed assuming that a line connected at the connection point under study is out-of-service (line-out conditions). Table 3-18 lists SCR calculated under line-out conditions.

SCR requirements depend on the technology of wind-turbine generators. The traditional requirement for inverter-based projects is to have a SCR higher than five on the high side of the step-up transformers. However, the minimum manufacture required SCR for interconnection of OSW in 2035 is currently unknown.

Table 3-17. SCR at OSW Connection Points — All-Lines-In Conditions

Connection Point	OSW	KV	3PH Fault Current (A)	Fault MVA	OUTAGE Terminal	OSW MW	SCR
Shore Rd	Additional	345	20184	12061	N/A	500	24.12
Syosset		138	21006	5021	N/A	300	16.73
W 49th St		345	28550	17060	N/A	1200	14.21
Mott Haven		345	28971	17312	N/A	1250	13.84
Rainey		345	28647	17118	N/A	1250	13.69
Farragut		345	28705	17153	N/A	1400	12.25
New Bridge		138	26706	6383	N/A	600	10.63
Northport		138	17776	4249	N/A	400	10.62
Gowanus		345	13704	8189	N/A	816	10.03
Brookhaven		138	9292	2221	N/A	270	8.22
Holbrook	Procured	138	12859	3074	N/A	440	6.98
West Bus		138	12760	3050	N/A	440	6.93
East Hampton		69	5249	627	N/A	136	4.61

Table 3-18. SCR at OSW Connection Points — Line-Out Conditions

Connection Point	OSW	KV	3PH Fault Current (A)	Fault MVA	OUTAGE Terminal	OSW MW	SCR
Syosset	Additional	138	16744	4002	SHORE RD1	300	13.34
W 49 St		345	26755	15988	REACM52	1200	13.32
Mott Haven		345	27083	16184	REAC71	1250	12.94
Rainey		345	26841	16039	BUS123	1250	12.83
Farragut		345	27848	16641	BUS138	1400	11.88
New Bridge		138	25705	6144	LCST GRV	600	10.24
Gowanus		345	11035	6594	GOWANUS 42SR	816	8.08
Brookhaven		138	8716	2083	SILLS RD2	270	7.71
Northport		138	12765.60	3051	NRTHPRT2	400	7.62
Shore Rd		345	4183	2499	DUNWOODIE	500	4.99
Holbrook	Procured	138	10999	2629	RULND RD	440	5.97
West Bus		138	9861	2357	HOLBROOK	440	5.35
East Hampton		69	3584	428	BUELL	136	3.14

3.4.4 Production Cost Analysis

Following the methodology described in section 3.2, production cost economic analysis was performed for Scenario 1, as developed, for all three study years.

3.4.4.1 Production Cost Scenario Development and Assumptions

The detailed case set-up with PROBE LT input data for the NYISO market was completed during the initial screening task, supplementing load flow input data used in reliability analysis with data provided by the State Team.

Offshore wind and energy storage injections were consistent with Scenario 1, as developed and discussed in the previous section. Specifically, OSW injections in economic analysis are as listed in Table 3-6 and energy storage size and locations are as listed in Table 3-10.

As already stated in section 3.2, a key assumption in economic analysis is that onshore wind, solar, and hydro would be curtailed before OSW. This approach ensures OSW is not reduced due to statewide over-generation scenarios or other reasons not directly relevant to the Study Area, to properly test zones J/K transmission.

In addition to base and sensitivity simulations, listed in Table 3-7, the following Scenario 1 sensitivities were also performed:

- no energy storage facilities on Long Island (2035 study year).
- modified zone K parameters (2035 study year). In this sensitivity, normal ratings were used for tie lines Y49 and Y50 for both pre- and post-contingency conditions. Further, approximately 400 MW of must-run and minimum reliability non-OSW generation (i.e., non-dispatchable non-OSW generation) was also considered in specific locations. Parameters for this sensitivity were developed reflecting LIPA operational consideration.

3.4.4.2 Production Cost Modeling / Economic Analysis Results

Consistent with Study objectives, the economic analysis focused almost exclusively on successful OSW integration with respect to local transmission; therefore, the key metrics were directly related to OSW curtailment and associated transmission congestion. Table 3-19 identifies curtailment for base and select primary sensitivities studied as part of Scenario 1.

Table 3-19. Curtailment Identified in Economic Analysis

Testing Conditions	Unit-Hours of OSW Curtailment	OSW MWh Curtailed
Base Assumptions (2030)	0	0
Base Assumptions (2035)	15	2,035
No Storage in zone K (2035)	26	3,881
Modified zone K parameters (2035)	176	23,521

The economic analysis identified minimal OSW curtailment in Scenario 1 simulations. As shown in Table 3-19, for the 2035 base case simulation, only 2,035 MWh of curtailment occurred, which is negligible considering the maximum possible OSW production for the year in zones J and K combined is nearly 42,000,000 MWh. All curtailment occurred in zone K regardless of sensitivity.

When applying modified operating parameters, such as the sensitivity with modified zone K parameters, curtailment increases to 23,521 MWh. There are several factors that explain the minimal OSW curtailment. First, during the initial substation screening task, many production cost scenarios and sensitivities were completed (in addition to the accompanying reliability analysis) that provided significant guidance on the potentially stronger locations for OSW connection. Therefore, since the analysis phase of the Study aimed at developing and analyzing an OSW interconnection scenario resulting in minimal adverse system impacts and OSW curtailment, screening results were utilized to place and size OSW such that severe local congestion was avoided.

Second, in nearly all hours, OSW local production did not greatly exceed local demand. It is expected that curtailment occurs due to targeted localized congestion and/or more generalized over-generation situations, where OSW production exceeds demand by such a significant amount that it cannot be exported to other regions. However, an hour-by-hour review of OSW output versus hourly demand indicates that for the majority of hours, OSW production did not exceed local demand Figure 3-7, which also accounts for zone K exports, further illustrates that OSW wind production only exceeds the local demand plus Zone K export capability for a few hours of the year. In the figure, this is represented by the small portion of the duration curve that dips below zero. In hours where OSW exceeds demand plus export capability, over-generation may still be absorbed by energy storage facilities.

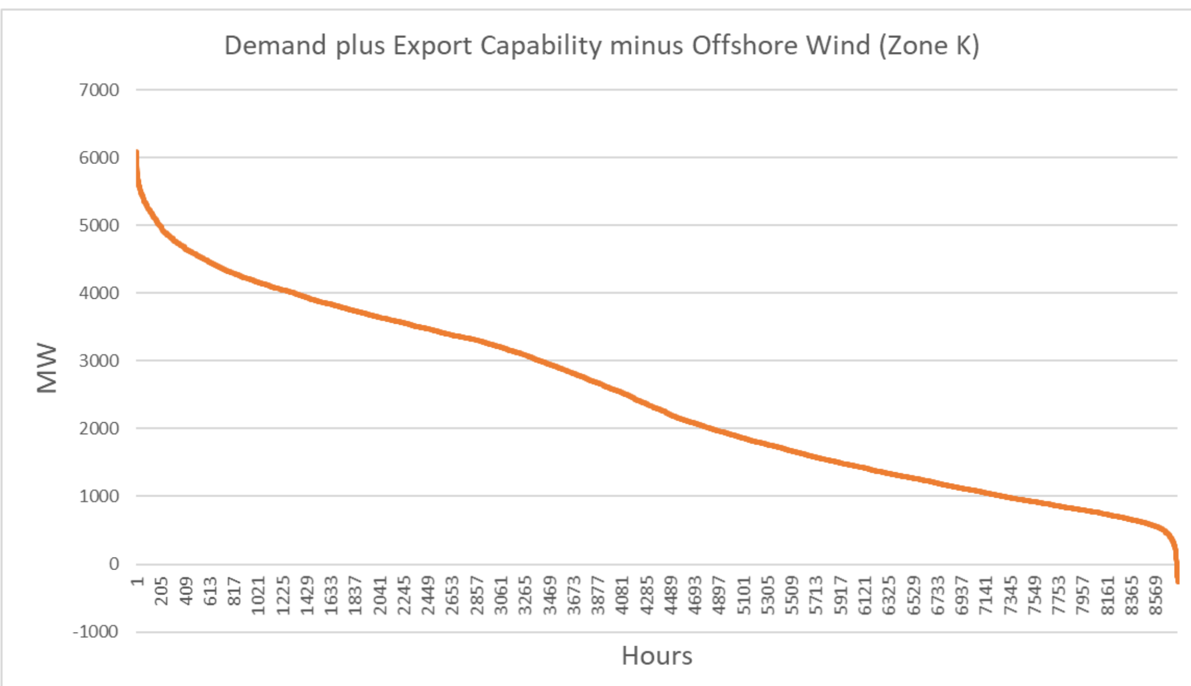


Figure 3-7. Zone K Demand + Exports — OSW (MW)

The two factors explaining the minimal OSW curtailment must be considered in the context of the specific Study assumptions; specifically, the assumption that all onshore renewable generation would be curtailed before OSW and all thermal generation could be decommitted except in the sensitivities as noted.

The additional sensitivities shown in Table 3-7 did not reveal significant OSW curtailment or transmission system weaknesses; in nearly all cases curtailment remained zero or negligible:

- All 2030 scenarios—base case, load sensitivity, and increased thermal generation—showed no OSW curtailment.
- The 2035 high-demand scenario reduced curtailment to only 823 MWh. The reduction in curtailment is expected as more OSW is utilized to serve the increased local demand.
- The 2035 scenario enforcing a minimum level of thermal generation revealed 3,903 MWh of OSW curtailment. Consistent with earlier explanation, even with increased thermal generation, excess production is still able to be exported to other NYISO zones.
- The scenario enforcing NYISO ancillary services requirements showed 2,421 MWh of curtailment. It was considered that enforcing ancillary services might force more thermal generation online and therefore increase offshore wind curtailment. However, since most ancillary service requirements can be met by power plants anywhere in NYISO, offshore wind curtailment was not significantly impacted.
- The 2025 simulation, which includes only procured OSW, also did not show any OSW curtailment.

3.4.5 Scenario 1: Summary of Findings

Scenario 1 provided an initial allocation and connecting stations for the connection of 9 GW of OSW in zones J and K by 2035. Based on the analysis performed, it can be concluded that the system is capable of accommodating a total of 9 GW of OSW, allocated into 6 GW in zone J and 3 GW in zone K, without exhibiting major adverse system impacts or the need for extensive OSW curtailments. Therefore, the full amount of 9 GW of OSW could be connected without the need for major system upgrades, other than substation upgrades for the direct connection of the OSW resources.

3.5 Scenario 2: Alternative Allocation of OSW to Zone K — Analysis and Results

Upon completion of the development and analysis of Scenario 1, an alternative scenario for connecting OSW to zone K was developed. The key underlying and differentiating assumption for the development of this alternative scenario was that only the following substations in zone K were available for connection of OSW (in addition to already procured OSW):

a) Shore Road (138 / 345)
b) East Garden City (138 / 345)
c) Newbridge Road,
d) Ruland Road
e) Syosset
f) Pilgrim

This alternative scenario for connecting OSW to zone K will be referred to as Scenario 2 in the remainder of this section. Clearly Scenario 2 only focuses on the 2030 and 2035 study years; the 2025 study year was studied and reported as part of Scenario 1. This section discusses the development of Scenario 2, the analysis approach, and presents analytical findings.

3.5.1 Development of Scenario 2

Development of Scenario 2 was informed by the fact that the Poseidon project, originally considered connected at Ruland Rd. 138 kV station, was no longer a valid project. In addition, this scenario reduced the number of substations on the north shore of Long Island. Scenario 2 focuses solely on OSW connections to zone K; OSW allocation to zone J remains unchanged from Scenario 1. The overall allocation remains at 6 GW of OSW connecting to zone J and 3 GW of OSW connecting to zone K.

Table 3-20 presents the OSW allocation selected for Scenario 2. Figure 3-8 illustrates the allocation differences between Scenarios 1 and 2 for the 2035 study year. Injections at Brookhaven, Newbridge, and Northport previously considered as part of Scenario 1, were moved to Ruland Rd and East Garden City in Scenario 2. Figure 3-9 shows the approximate locations of the LIPA POIs considered in Scenario 2.

Table 3-20. OSW Injections - Scenario 2

Already procured OSW (MW)								
Study Year	Gowanus (Empire) 345 kV			Holbrook (Sunrise) 138 kV			East Hampton (South Fork) 138 kV	
2035	816			880			136	
2030	816			880			136	
Scenario 2 additional OSW injections (MW)								
	Farragut 345 kV	Mott Haven 345 kV	Rainey 345 kV	W49th str 345 kV	Shore Rd 345 kV	Ruland Rd 138 kV	East Garden City 138 kV	Syosset 138 kV
2035	1400	1250	1250	1200	500	970	300	300
2030	1400	None	1250	None	None	970	300	None

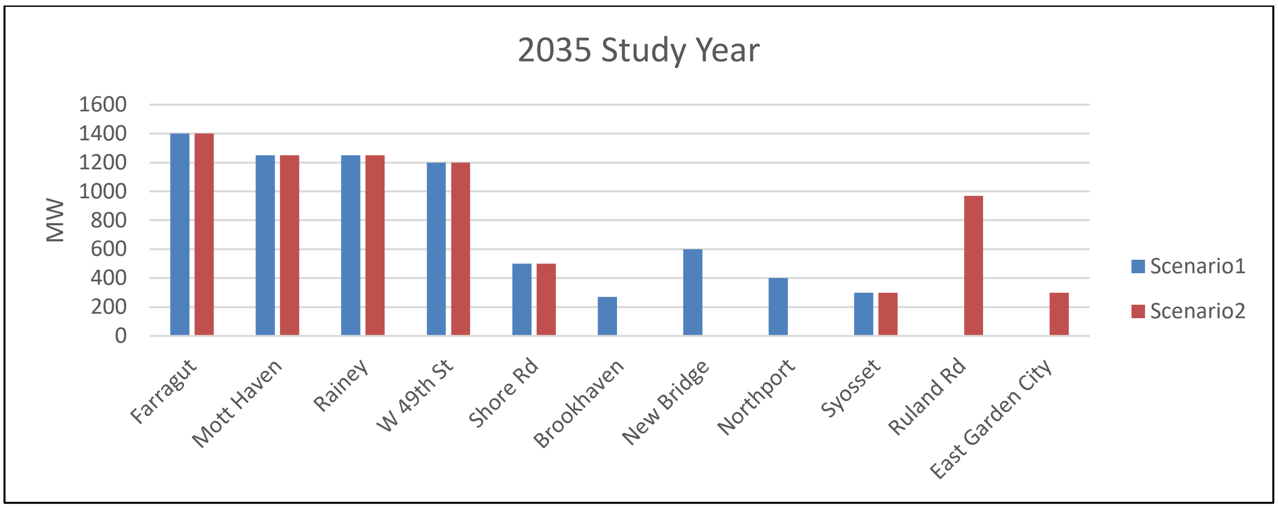


Figure 3-8. Scenario 2 vs. Scenario 1 Allocation (Study Year 2035)

Figure 3-9. LIPA POIs Considered in Scenario 2

Energy storage facilities in Scenario 2 are consistent in size and locations with those in Scenario 1, as listed in Table 3-10. This is because the system overloads that the storage facilities were successful in mitigating appear to be local, likely systemic issues, and thus not immediately impacted by OSW connection points. Therefore, the location and sizing of storage facilities remaining the same continues to help mitigate such system overloads.

3.5.2 Base and Sensitivity Conditions

Same as for Scenario 1, reliability and production cost analyses were performed for base and multiple sensitivity conditions. The various sensitivities considered in the Study were outlined in Table 3-7.

3.5.3 Reliability Security Analysis

Following the methodology described in section 3.2, steady state contingency analysis was performed that included N-0, N-1, and N-1-1 analysis. Steady state analysis focused primarily on thermal performance of the network. All analysis was performed under peak loading conditions.

Tables 3-21 through 3-24 present Scenario 2 reliability analysis findings for study years 2035 and 2030, based on base load forecast. Unless noted otherwise in subsequent results tables, similar analysis results, qualitatively and quantitatively, were observed for the load sensitivity analysis.

System performance under reliability security analysis was almost identical as under Scenario 1. Reallocation of OSW resources as part of Scenario 2 did not introduce any new reliability constraints.

Table 3-21. Scenario 2: N-1 Contingency Analysis Results, 2035 Study Year

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Contingency	Mitigation System Upgrade
MALVERN---West Hempstead 69 KV	102	47	59	193:EGC6060	Reconductor line
MASPEQUA2---PLNEDGE 69 KV	100	62	74	225:MS 660	Reconductor line

Table 3-22. Scenario 2: N-1-1 Contingency Analysis Results, 2035 Study Year

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Outage	Contingency	Mitigation System Upgrade
None						

Table 3-23. Scenario 2: N-1 Contingency Analysis Results, 2030 Study Year*

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Contingency	Mitigation System Upgrade
MALVERN---West Hempstead 69 KV	101	47	59	193:EGC6060	Reconductor line

*) results in this table reflect load sensitivity analysis; no adverse impacts under base load analysis

Table 3-24. Scenario 2: N-1-1 Contingency Analysis Results, 2030 Study Year

Monitored Facility	Loading %	Rate Base (MVA)	Rate Cont. (MVA)	Outage	Contingency	Mitigation System Upgrade
None						

3.5.4 Production Cost Analysis

Production cost analysis completed for Scenario 2 is consistent with the production cost analysis approach, assumptions, and objectives followed for Scenario 1 and described in section 3.4.

3.5.4.1 Production Cost Sensitivities

Offshore wind and energy storage injections are consistent with Scenario 2, as developed and discussed earlier in this section. Specifically, OSW injections in economic analysis are as listed in Table 3-20 and energy storage size and locations are consistent with Scenario 1, as listed in Table 3-10.

In addition to base and sensitivity simulations, listed in Table 3-7, the following Scenario 2 key sensitivity was also performed:

- Modified zone K parameters (2035 study year). In this sensitivity, normal ratings were used for tie lines Y49 and Y50 for both pre- and post-contingency conditions. Further, approximately 400 MW of must-run and minimum reliability non-OSW generation (i.e., non-dispatchable non-OSW generation) was also considered in specific locations.

3.5.4.2 Production Cost Modeling / Economic Analysis Results

Same as for Scenario 1 and consistent with Study objectives, the economic analysis focused almost exclusively on successful OSW integration with respect to local transmission, and therefore the key metrics were directly related to OSW curtailment and associated transmission congestion. Table 3-25 identifies curtailment for select conditions studied as part of Scenario 2.

Table 3-25. Curtailment Identified in Economic Analysis

Testing Conditions	Unit-Hours of OSW Curtailment	OSW MWh Curtailed
Base Assumptions (2030)	0	0
Base Assumptions (2035)	0	0
Modified zone K parameters (2035)	106	22,135

Results of the economic analysis for Scenario 2 continue to show zero or negligible curtailment; there is actually a slight reduction as compared to Scenario 1, which also assumed 3.1 GW OSW connected to zone K, but at different POIs. The reason for the slight reduction is moving OSW from Newbridge (in Scenario 1) to East Garden City (in Scenario 2) eliminating any remaining congestion along the Newbridge-EGC corridor. All curtailment continues to occur in zone K.

Specifically, the sensitivity with modified zone K parameters is the only sensitivity that shows any OSW curtailment with 22,135 MWh curtailed. This represents only 0.053% curtailment of total OSW production.

The same factors discussed in section 4.5.2 explaining the lack of any appreciable OSW curtailment are still applicable under Scenario 2.

The secondary sensitivities, one modeling higher demand and another modeling minimum on-line thermal generation in both Zones J and K, did not reveal significant OSW curtailment or transmission system weaknesses; OSW curtailment remained zero or negligible.

3.5.5 Scenario 2: Summary of Findings

Scenario 2 was developed to provide an alternative OSW allocation for zone K, informed primarily by the withdrawal of the Poseidon project that was modeled connected at Ruland Rd. in prior simulations. Based on the analysis performed, and consistent with Scenario 1 analysis, it can be concluded the system in zone K is capable of accommodating a total of 3 GW of OSW, without exhibiting major adverse system impacts or the need for extensive OSW curtailments. Therefore, 3 GW of OSW could be connected to zone K without the need for major system upgrades, other than substation upgrades for the direct connection of the OSW resources.

3.6 Scenario 3: Alternative Allocation of 4 GW of OSW to Zone K — Analysis and Results

Both Scenarios 1 and 2 were based on an overall OSW allocation of 6 GW to zone J and 3 GW to zone K. Given the uncertainty regarding the availability of cable routings to effect the connection of 6 GW in zone J and the latest OSW project pipeline in the NYISO interconnection queue, an alternative scenario was developed that considered connection of 4 GW of OSW to zone K, with the remaining 5 GW connected to zone J.

The purpose of Scenario 3 was to evaluate any need for and benefits of system expansion, focusing primarily on the potential addition of a new tie-line connecting zone K to zone I and/or zone J, in order to mitigate adverse impacts from connecting an increased allocation of OSW to zone K. This section discusses the development of Scenario 3, the analysis approach, and presents analytical findings.

3.6.1 Development of Scenario 3

Scenario 3 focuses solely on OSW connections to zone K. Compared to previous scenarios, Scenario 3 increases zone K OSW injection by 0.9 GW with a corresponding decrease in zone J OSW injection. Thus, whereas the total OSW injection remains at 9 GW, it is allocated with 5 GW connecting to zone J and 4 GW connecting to zone K.

Scenario 3 was analyzed for the 2035 study year only, under the base loading forecast.

Table 3-26 presents the OSW allocation selected for Scenario 3. Compared to Scenario 2, the incremental injection to zone K was mainly allocated at the East Garden City substation, while the reduction in zone J was taken from the injection at Mott Haven.

Table 3-26. OSW Zone K Injections - Scenario 3

<table>
<tr><th colspan="6">Already procured OSW (MW)</th></tr>
<tr><th>Study Year</th><th colspan="2">Gowanus (Empire)
345 kV</th><th colspan="2">Holbrook (Sunrise)
138 kV</th><th>East Hampton (South Fork)
138 kV</th></tr>
<tr><td>2035</td><td colspan="2">816</td><td colspan="2">880</td><td>136</td></tr>
<tr><th colspan="6">Scenario 3 additional OSW injections in zone K (MW)</th></tr>
<tr><td></td><td>Shore Rd
345 kV</td><td>Ruland Rd
138 kV</td><td>E.G.C.
138 kV</td><td>E.G.C.
345 kV</td><td>Syosset
138 kV</td></tr>
<tr><td>2035</td><td>500</td><td>970</td><td>450</td><td>700</td><td>315</td></tr>
</table>

3.6.2 Reliability Analysis

Following the methodology described in section 3.2, steady-state contingency analysis was performed that included N-0, N-1, and N-1-1 analysis. Steady-state analysis focused primarily on thermal performance of the network. All analysis was performed under peak loading conditions.

Analysis results were similar to those in Scenario 2. No system adverse impacts were observed, other than those in Scenario 2 analysis.

3.6.3 Production Cost Analysis

Production cost analysis completed for Scenario 3 is consistent with the production cost analysis approach, assumptions, and objectives followed for Scenario 2 and described in section 3.5.

3.6.3.1 Production Cost Sensitivities

Offshore wind and energy storage injections are consistent with Scenario 3 as developed and discussed earlier in this section. Specifically, OSW injections in economic analysis are as listed in Table 3-26 and energy storage size and locations are consistent with Scenario 1, as listed in Table 3-10. The wind injections as shown in Table 3-26 for Scenario 3 result in connection of 4 GW of OSW to zone K versus the 3.1 GW assumed in all prior study scenarios.

Five simulations were completed as part of Scenario 3, a core scenario plus four additional sensitivities, listed in Table 3-27. Each simulation is for study year 2035.

3.6.3.2 Production Cost Modeling / Economic Analysis Results

Similar to Scenario 2 and consistent with Study objectives, the economic analysis focused almost exclusively on successful OSW integration with respect to local transmission; therefore, the key metrics were directly related to OSW curtailment and associated transmission congestion. Table 3-27 identifies curtailment for the conditions studied as part of Scenario 3.

Table 3-27. Curtailment Identified in Economic Analysis

Testing Conditions	Zone K Storage	Additional Assumptions	New Tie Line	Zone K OSW Curtailment (MWh)
Core Scenario	Yes	Initial assumptions	No	30,064
Sens. A	No	Initial assumptions	No	151,545
Sens. B	No	Initial assumptions	New 345 kV tie line (from EGC to Dunwoodie)	8,302
Sens. C	Yes	Modified zone K assumptions	No	1,229,206
Sens. D	Yes	Modified zone K assumptions	New 345 kV tie line (from EGC to Dunwoodie)	384,799

In the core scenario, where assumptions remained consistent with base-case simulations in previous scenarios, OSW curtailment increases to 30,064 MWh. This increase is to be expected due to the increase of OSW injections to zone K to 4 GW versus the 3.1 GW in the previous scenarios.

The core Scenario 3 included energy storage. Under Sensitivity A, the assumptions were essentially the same except that storage was removed and curtailment increased to 151,545 MWh. The presence of approximately 530 MW of energy storage reduced curtailment by 121,481 MWh.

Under Sensitivity B, storage was not included, but a new 345 kV tie line from East Garden City to Dunwoodie was added. Under this set of assumptions curtailment was 8,302 MWh. The addition of the tie line reduced curtailment by 143,243 MWh.

Sensitivities C and D return to the base storage assumption, i.e., that storage is expected and modeled, but the case makes adjustments to system modeling parameters. These modified zone K parameters enforce normal ratings on the Y49/Y50 tie lines, even under contingency conditions and require 400 MW of minimum zone K thermal generation on-line during all hours for reliability purposes. Then, simulations are run for two sensitivities—without and then with a new 345 kV tie line (from EGC to Dunwoodie) designed to increase Long Island export capability.

Sensitivity C, without the tie line, results in the highest OSW curtailment measured in any simulation at 1,229,206 MWh. This represents 2.9% curtailment of overall OSW production, and 6.6% curtailment of OSW connected to zone K. Sensitivity D, which adds the tie line, shows 0.92% curtailment of overall OSW production, and 2.1% curtailment of OSW connected to Zone K. Under these operating assumptions, the tie line reduces curtailment by 844,407 MWh per year. Alternative connections points for a new tie, such as from Shore Road 345 kV in parallel with the existing Y50 tie line, could potentially offer similar OSW curtailment mitigation levels.

3.6.4 Scenario 3: Summary of Findings

Scenario 3 was developed to provide an alternative OSW allocation to zone K totaling 4 GW of OSW, in response to increasing uncertainty regarding availability of cable routings to zone J and informed by the OSW project pipeline in the latest NYISO interconnection queue. Based on the analysis performed, with 4 GW of OSW connected to zone K, production cost analysis indicates increased instances of OSW curtailments. Variation of modeling assumptions based on operational considerations, specifically the pre- and post-contingency ratings of the Y49/Y50 tie-lines, could further increase potential curtailments. The addition of a new tie-line between zone K and zone J and/or New York mainland system significantly reduced potential curtailments.

3.7 Summary of Onshore Analysis Findings

Based on the data used, assumptions made, and the analysis performed as part of Onshore Analysis, the following findings were observed:

A) Connecting a total of 9 GW of OSW to zones J and K, allocated 6 GW to zone J and 3 GW to zone K:

- Reliability analysis indicates the system in zones J and K could reliably accommodate the total amount of 9 GW of OSW without major adverse impacts
- Production cost economic analysis indicates that the system in zones J and K can accommodate 9 GW of OSW without significant OSW curtailment
- Therefore, the system could accommodate the 9 GW of OSW without a need for major bulk system upgrades, other than substation upgrades for the direct interconnection of OSW resources

B) Injecting 4 GW of OSW into zone K:

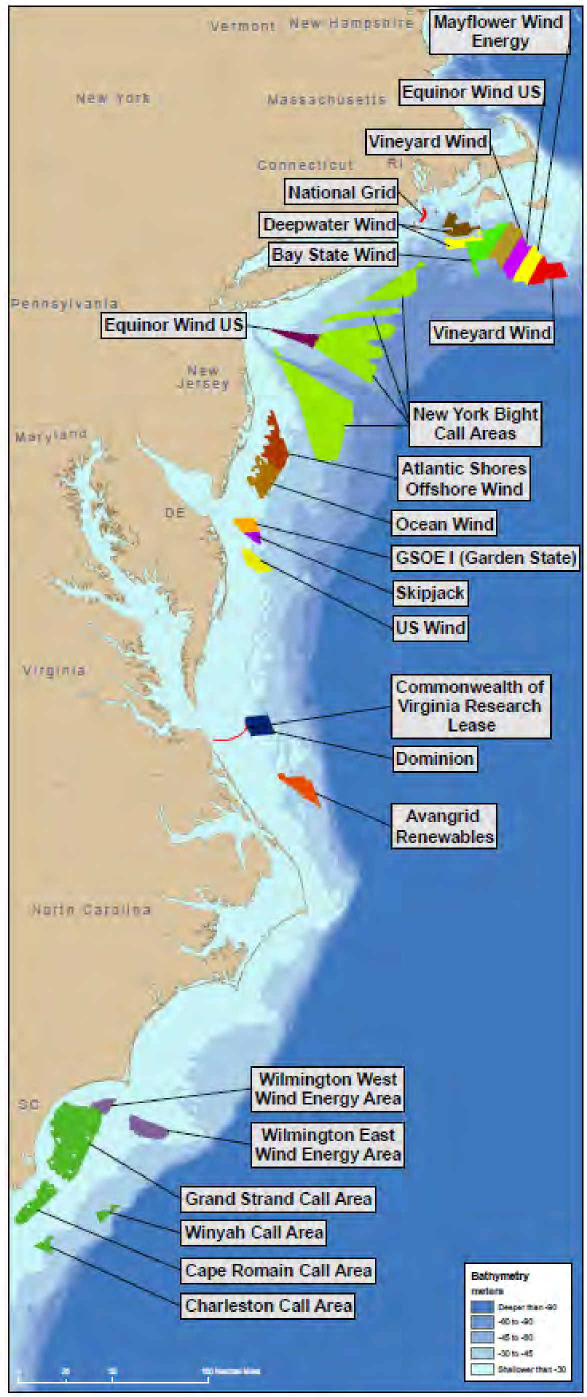
- Reliability analysis indicates that the system in zone K could reliably accommodate the increased amount of 4 GW of OSW without major adverse impacts
- Production cost economic analysis indicates increasing instances of potential OSW curtailment
- A new tie line from zone K appears to significantly mitigate the potential for OSW curtailment

4 Development of OSW Build-Out Scenarios

The offshore wind industry in the United States is primarily driven by two key factors: individual state energy policies, and the availability of Bureau of Ocean Energy Management (BOEM) offshore Wind Energy Areas (WEAs) for development. Figure 4-1. shows the BOEM offshore renewable energy program for the U.S. east coast outer continental shelf, including currently leased BOEM WEAs and draft Call Areas. The draft Call Areas are expected to be finalized into WEAs and auctioned in the coming years.

This section describes the process of developing future OSW build-out scenarios to be used in subsequent Study tasks, including a technology review of HVAC and HVDC design, a summary of general OSW connection concepts, and the preliminary qualitative review process completed.

Figure 4-1. BOEM Offshore Wind Lease Areas and Additional Primary/Secondary Areas of Interest



(source: BOEM)

4.1 Key Assumptions

In order to achieve 9 GW of OSW interconnected to New York by 2035, based on historical progress and the terms of the State's Clean Energy Standard,[6] it is assumed that intermittent amounts of OSW capacity will be added on an approximate year-by-year basis, facilitated by NYSERDA's Offshore Wind Renewable Energy Certificate (OREC) solicitations. For the purposes of this Study, the State Team and DNV GL collaborated to develop the following illustrative schedule for OSW capacity additions:

- Study Year 2025: 1,826 MW of OSW interconnected, comprised the contracted Empire Wind, Sunrise Wind, and Southfork projects

- Study Year 2030: 3,774 MW of additional OSW interconnected, bringing the total to 5,600 GW. This value is one rough potential glidepath on the way to the achievement of 9,000 MW by 2035

- Study Year 2035: 3,400 MW of additional OSW interconnected, bringing the total to 9,000 GW

4.2 Current and Future OSW Project Locations and Capacities

Given the expectations that large OSW projects interconnected to New York State will be constructed in federal waters, it is a given that these projects will be located within BOEM-managed WEAs. Thus, for the purposes of forecasting future OSW build-out scenarios, and recognizing the State's geographic centrality and cost-effective reach to the easternmost lease area in New England, and equivalent distances to the south, as demonstrated in NYSERDA's 2018 procurement, DNV GL evaluated the capacity of all WEAs in the U.S. Northeast previously auctioned and under development, as well as the New York Bight draft Call Areas. This evaluation considered a range of potential turbine spacing and power ratings, and power purchase agreements (PPAs) previously executed and their associated project area requirements. It also considered adding capacity to projects currently in development. It is important to note that given the OSW capacity targets of Massachusetts, Connecticut, and New Jersey, competition for capacity from WEAs exists.

For WEAs, which have already been auctioned, determining their capacity and likely development schedule is reasonably straightforward. For the BOEM draft Call Areas, there is considerable uncertainty regarding what geographic areas will be finalized into WEAs and when they will be auctioned. Thus, in

[6] New York State Public Service Commission. Case 15-E-0302. Order Adopting Modifications to the Clean Energy Standard. October 15, 2020 nyserda.ny.gov/-/media/Files/Programs/Clean-Energy-Standard/2020/October-15-Order-Adopting-Modifications-to-the-Clean-Energy-Standard.pdf

order to produce a reasonable forecast of future OSW build-out, a high-level review of New York Bight Call Area feasibility was completed to rule out any locations which are unlikely for future development, as well as to determine potential build-out schedules. The results of this high-level review, for the purposes of this Study, include the following related to the New York Bight Call Areas:

- OSW capacity from each of the Hudson Fairway Areas was excluded due to their relatively small size, which limits their economic viability, and unknown risk related to navigational issues.

- "Primary" Call Areas in Hudson North, Hudson Central, and Hudson South were considered most likely to be auctioned first, prior to "Secondary" Call Areas in these locations.

    - Three of the five future offshore wind buildout scenarios included OSW capacity from Primary Call Areas in 2030 and from Secondary Call Areas in 2035.
    - The remaining two of the five future offshore wind buildout scenarios did not include any OSW capacity from Primary or Secondary Call Areas in 2030 and included OSW capacity from only Primary Call Areas in 2035. Thus, these two scenarios did not include any OSW capacity from Secondary Call Areas in any Study Year.

4.3 Five Resulting OSW Future Build-out Scenarios

Based on the evaluation described above, DNV GL created five future OSW build-out scenarios. Maps illustrating the location and relative capacity size of OSW projects totaling 9 GW in 2035 are included in Annex C. These illustrations are not a recommendation for the State Team, nor do they represent any preference of the State Team toward specific projects or project locations. Instead, the maps represent a possible range of future outcomes that could occur and are deliberately intended to be geographically diverse while still consisting of plausible project developments that could reach 9 GW given the current WEA and Call Area environment as of the date of this report. DNV GL's further offshore assessment work considered these five scenarios to better understand how results and conclusions were either similar (to offer a representative view) or differed given varying future build-out possibilities.

5 Preliminary Analysis of OSW Connection Concepts

5.1 OSW Connection Technologies Options

HVAC and HVDC technologies were analyzed as the transmission solutions to deliver the offshore power to onshore. Technical feasibility and costs related to both technologies were used as a basis for the development of the offshore connection concepts.

5.1.1 HVAC Technology

HVAC illustrates the Radial connection approach used by the offshore wind industry to date with more operating experience and industrially mature technology. This technology requires reactive compensation schemes at cable terminals and midpoints in case of transmission distances beyond 70 miles. Long HVAC cable systems (> 70 miles) have also been observed to result in challenges related to harmonics, control interactions, operational configuration management and voltage regulation.

The Study considered 220 kV HVAC technology for dedicated Radial solutions and for establishing a Backbone connection configuration associated with offshore coordinated grid solutions. An illustrative example is provided in Figure 5-1. It should be noted that considering the geographical proximity (under 70 miles) of several anticipated OSW projects, the use of 220 kV HVAC technology for Backbone configuration for planned interconnected offshore network in combination with HVDC technology to deliver the OSW energy to shore proved to be a viable option. This solution has the advantage that the need of costly HVDC circuit breakers (required in a full HVDC Backbone) can be partially eliminated. HVAC technology was considered assuming following specifications:

- Three-phase HVAC cable system rated at 220 kV with maximum transfer capacity of 450 MW requiring multi-parallel HVAC circuits for higher power transfers.
- 70 miles was considered as the viable distance threshold for HVAC technology, meaning that for distances more than 70 miles HVDC technology was considered as an alternative.
- Maximum cable conductor cross section: 1,600 mm.^{2}
- Number of offshore trenches for one three-phase cable system: one.

Figure 5-1. A 220 kV HVAC Dedicated Radial Configuration — Illustrative Example

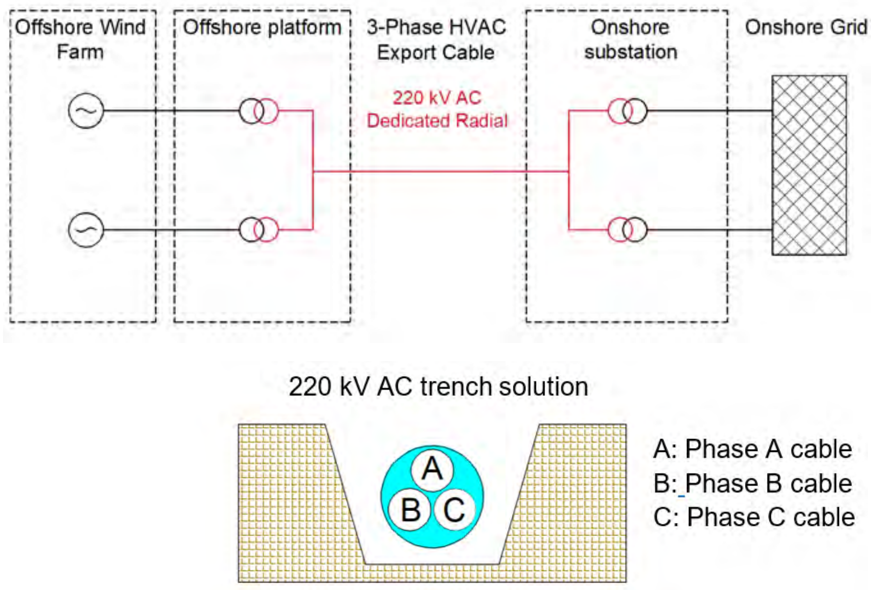


Figure 5-2. shows a more-detailed illustrative schematic of a single line diagram for a 220 kV HVAC OSW project Radially connected to the onshore grid.

Figure 5-2. Single Line Diagram of 220 kV HVAC OSW Project Grid Connection — Illustrative Example

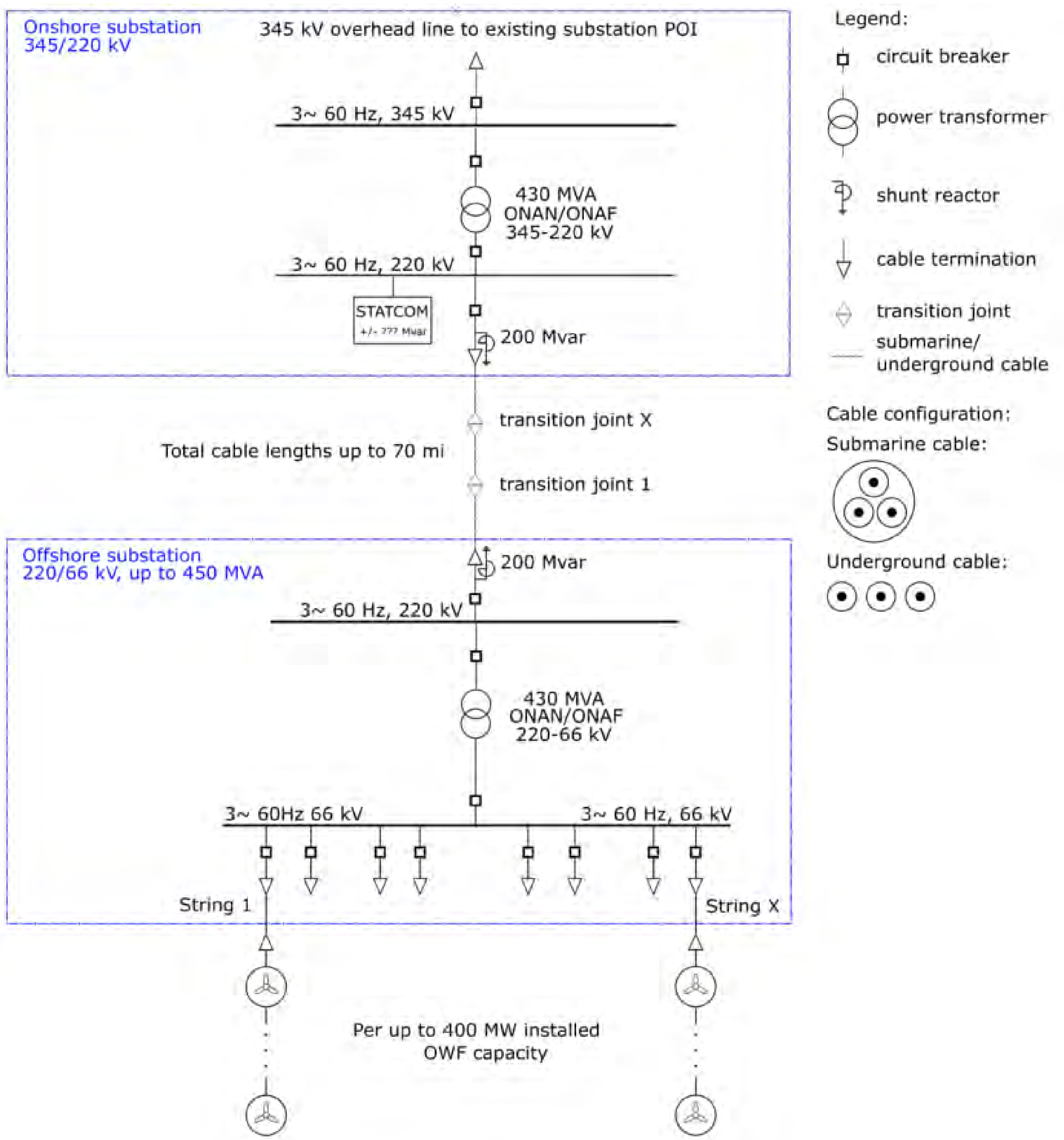
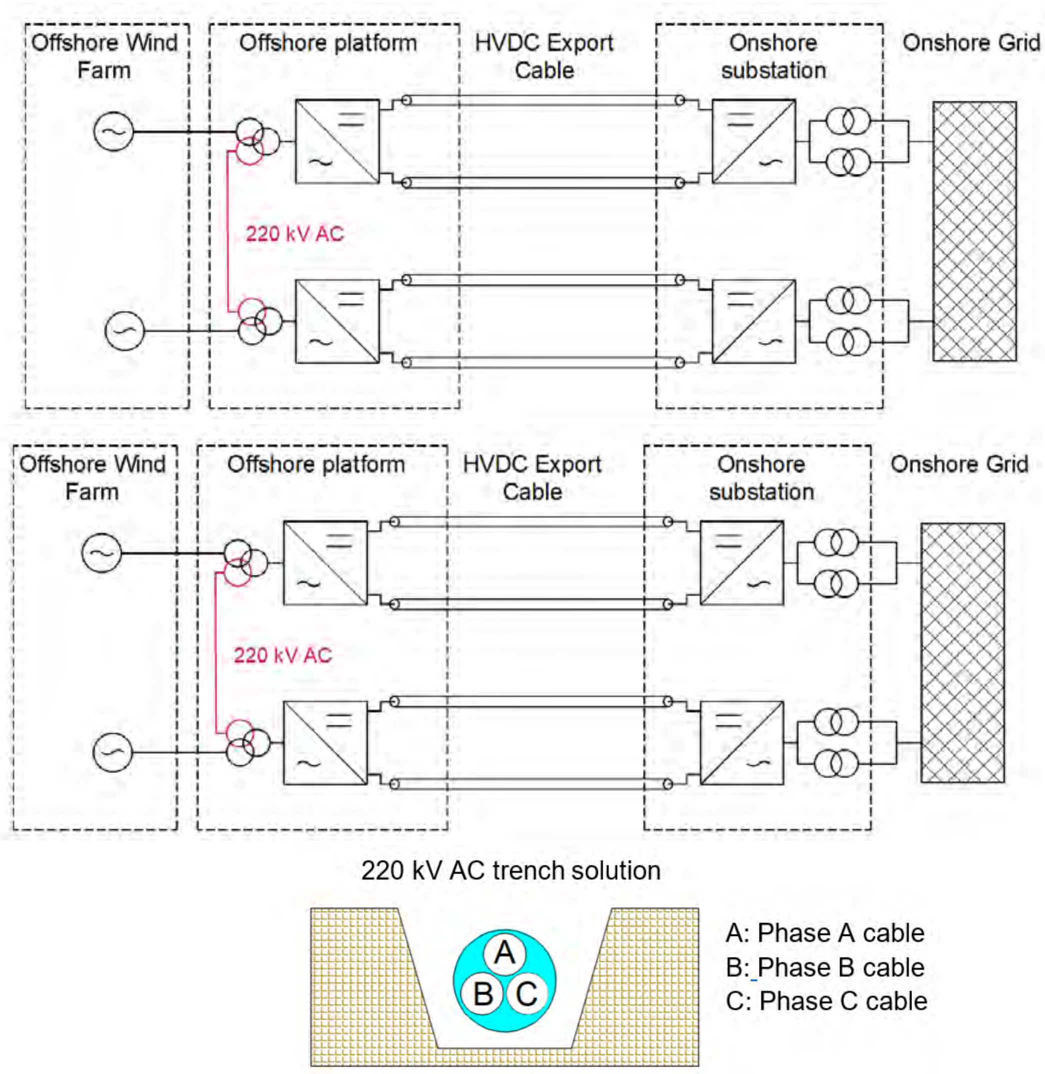


Figure 5-3. shows the application of the 220 kV HVAC line as an interconnection in order to realize Meshed OSW projects where both projects have a stand-alone HVDC connections to the onshore POI.

Figure 5-3. HVDC-Connected OSW Projects with 220 kV HVAC Meshed Option — Illustrative Example



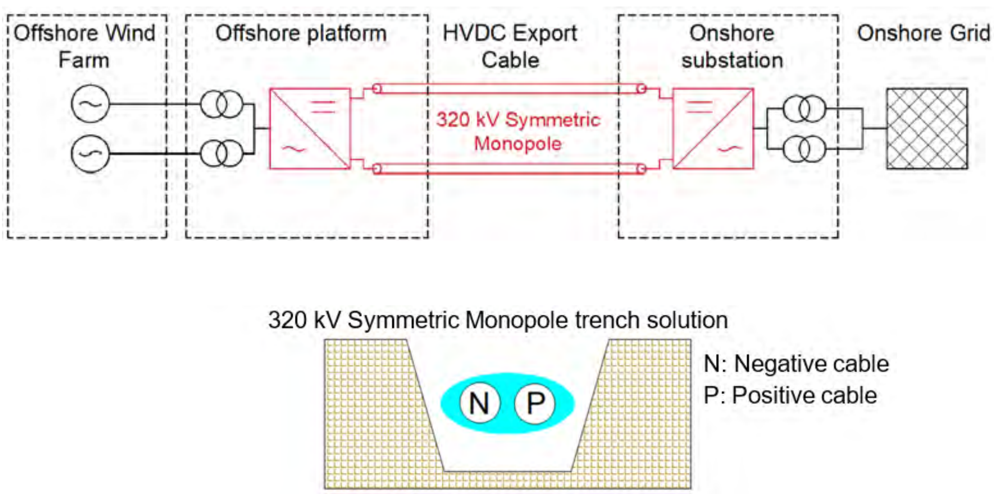
5.1.2 HVDC Technology

HVDC converters can be divided in two main technologies: Line Commutated Converters and insulated bipolar transistor based Voltage Source Converters (VSC). Since line commutated converters need to be connected to a relatively strong AC network, which is rare in coastal urban regions, VSC technologies are the superior and technically feasible HVDC option for OSW connections. VSC technologies can also be controlled to provide voltage and frequency support to the onshore grid and have black-start capabilities. For the purpose of this Study, 320 kV symmetric monopole and 525 kV symmetric bi-pole HVDC technologies were considered.

The 320 kV HVDC symmetric monopole technology consists of a two-cable system with the maximum rating limited to the allowed maximum contingency level of 1,310 MW,[7] though the technology was considered for connections ratings up to 1,400 MW. Both monopole cables can share the same trench as illustrated in Figure 5-4. Specifications associated with the 320kV HVDC technology considered for this Study are as follows:

- Voltage level: ±320 kV
- Maximum transmission power: 1,300 MW
- Maximum cable conductor cross section: 2,500 mm2
- Maximum cable system length in proposed connection designs: 168 miles
- Number of offshore trenches: one

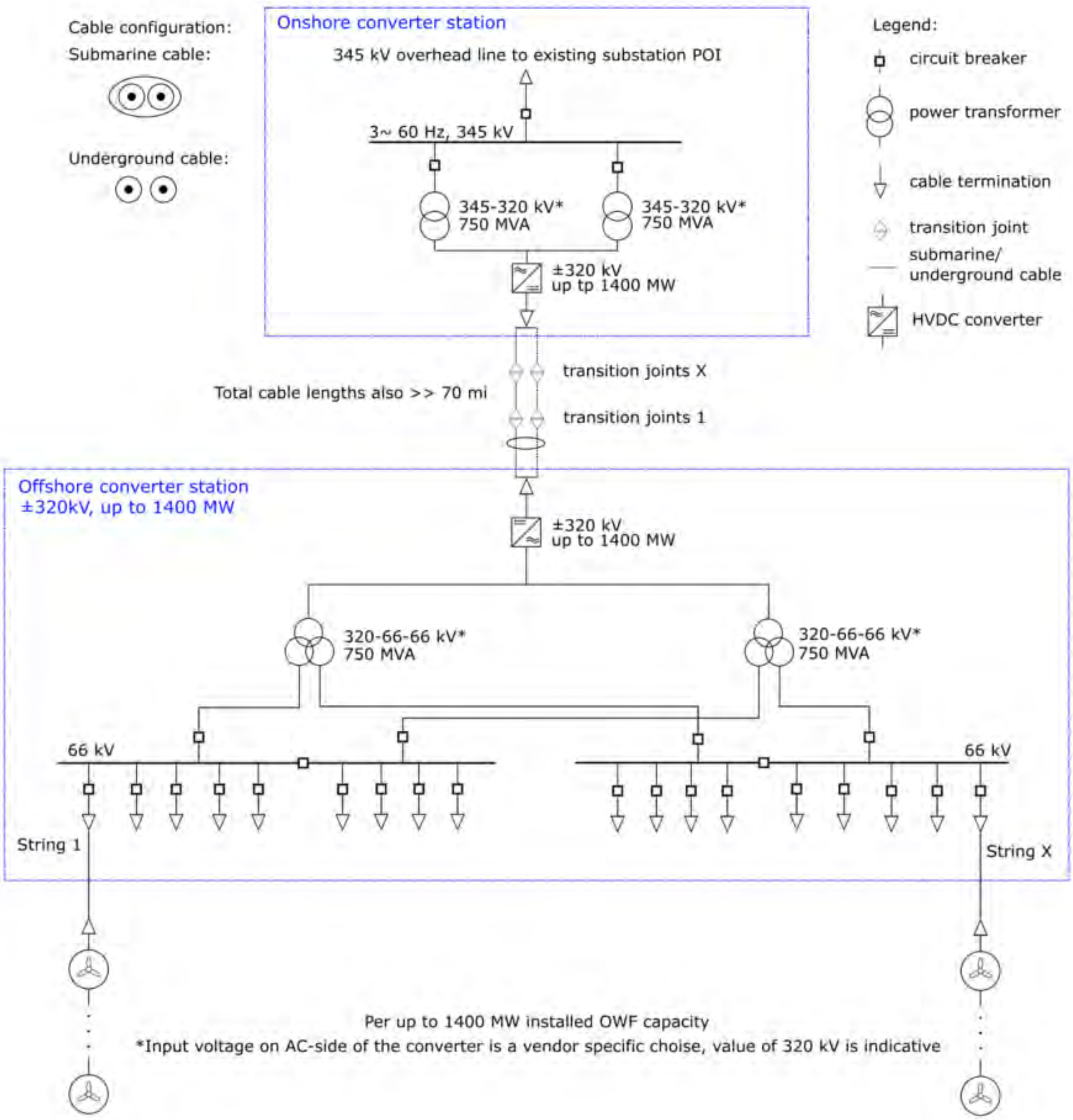
Figure 5-4. 320 kV Symmetric Monopole HVDC Schematic and Trenching - Illustrative Example



[7] Refer to Section 5.2.3 for more details

Figure 5-5. shows a more-detailed illustrative schematic of a single line diagram for a 320 kV symmetric monopole HVDC for a sample OSW project Radially connected to the grid.

Figure 5-5. Single Line Diagram of 320 kV HVDC OSW Project Symmetric Monopole Grid connection — Illustrative Example



The 525 kV symmetric bi-pole HVDC technology is a four-cable system consisting of a two-pole configuration with two dedicated metallic returns. This configuration allows for 50% redundancy as each pole can work independently. Each pole can be connected to a different onshore POI by sharing metallic returns. This topology was considered for OSW ratings higher than 1,400 MW. While there is no precedent for use of 525kV symmetric bi-pole HVDC technology for export of offshore energy to the onshore grid, the Study assumes that such technology will be available for implementation by 2030. As illustrated in Figure 5-6., the bipolar cable system requires two trenches, one cable per trench to allow for the 50% redundancy in case of cable failure on either one of the poles. Specifications associated with the 525 kV symmetric bi-pole HVDC technology considered for this Study are follows:

- Voltage level: ±525 kV
- Maximum transmission power: 1,700 MW
- Maximum cable conductor cross section: 2,500 mm2
- Maximum cable system length in proposed connection concepts: 106 miles
- Number of offshore trenches: two

Figure 5-6. 525 kV Symmetric Bi-pole HVDC Schematic and Trenching — Illustrative Example

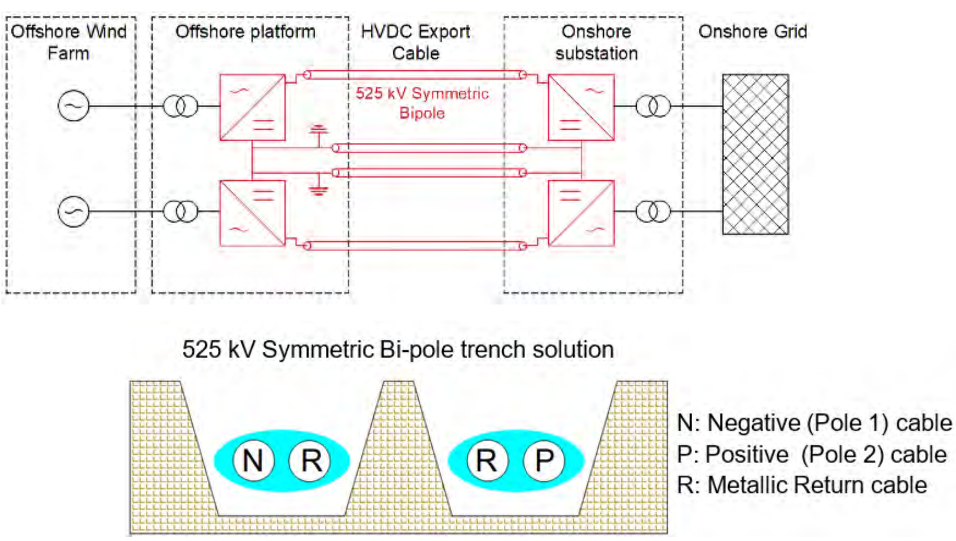
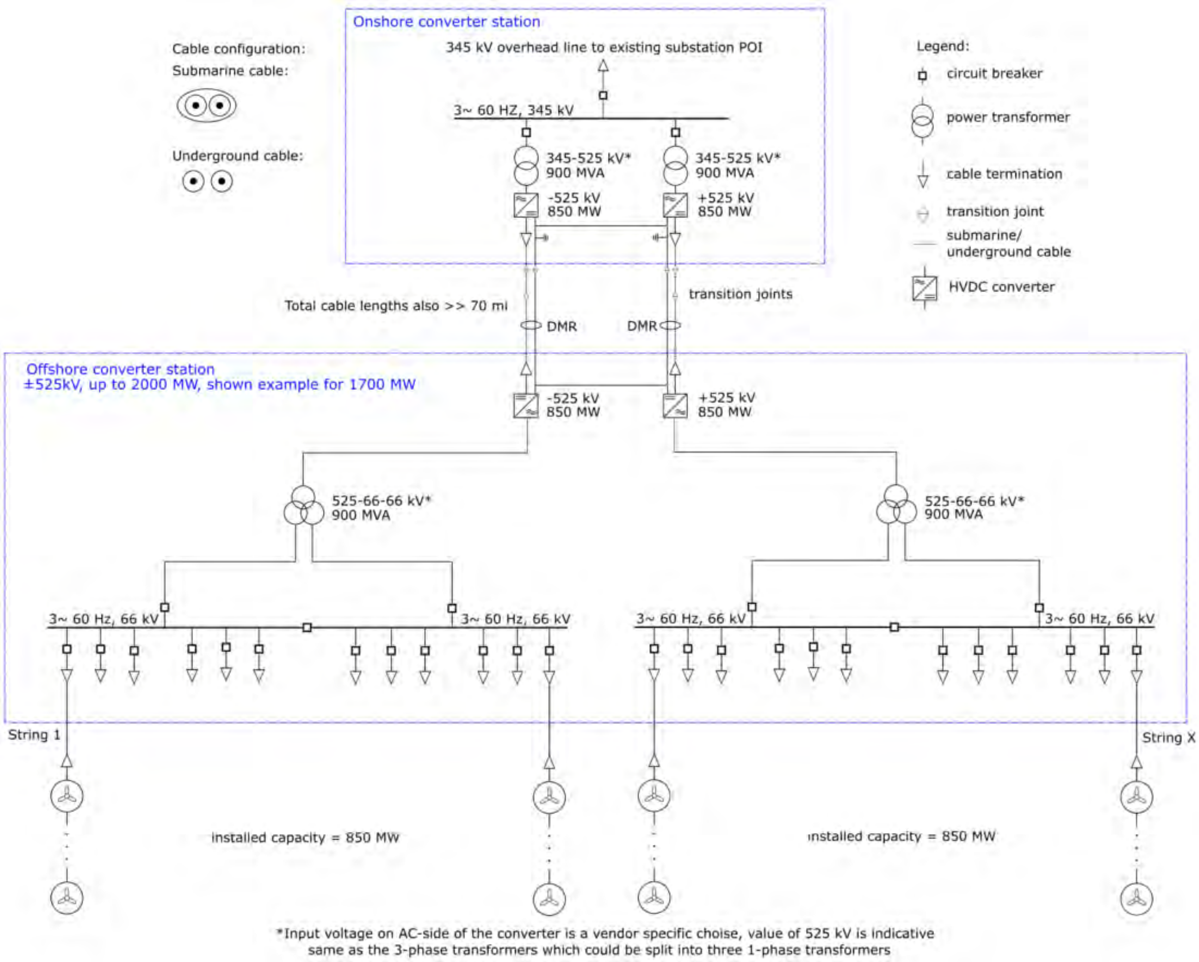


Figure 5-7. shows a more-detailed illustrative schematic of a single line diagram for a 525 kV symmetric bi-pole HVDC technology Radially connected to the grid.

Figure 5-7. Single Line Diagram of 525 kV HVDC OSW Symmetric Bi-pole Grid Connection — Illustrative Example



The maturity of HVDC technology is also comparable to that of HVAC systems. Several HVDC OSW projects are already operational or under commissioning. Hence, HVDC offshore systems possess a sufficiently high-technology readiness level to be considered for development of future offshore transmission. Unlike HVAC technology, HVDC cables do not have any distance restrictions.

5.2 OSW Connection Concept Design and Preliminary Analysis

Theoretically, there are many different design options to connect the planned 9.0 GW offshore wind to the onshore grid of New York State. In this Study, we developed OSW connection designs using the POIs identified as part of the onshore assessment described in Section 3 and the five connection concepts illustrated in Table 5-1.

5.2.1 Design Criteria

For the purpose of this Study, the offshore connection concepts were assumed to be constrained by the following limiting criteria:

Technology limitation:

- The power rating of each 220 kV HVAC cable circuit should not exceed 400 MW. The length of HVAC cables should not be longer than 70 miles.
- The power rating of a ±320 kV monopole HVDC circuit should not exceed 1,400 MW.
- The power rating of each ±525 kV bi-pole HVDC circuit should not exceed 2,650 MW, which corresponds to approximately 2.5 kA current in each individual cable conductor.

Location-specific and environmental limitations:

- Aggregated power injection in each selected onshore substation will be limited to a specific amount as determined by the onshore analysis Scenario 2 presented in Section 3.
- Number of cables extending from offshore to onshore are limited to specific numbers as determined by the environmental and permitting analysis presented in Section 6.

NYCA Operating Reserve Requirement:

In order to ensure reliability and resiliency, grid operators and planners attempt to plan the network in a manner that limits how much generation power can be lost due to outages and/or contingencies. These limits are typically determined based on the available operational reserves and operational reserve locational requirements defined by applicable reliability guidelines and standards. Currently, NYISO's operating reserve requirement for the NYCA region is 1,310 MW, which is equal to NYCA's existing most severe operating capability loss.[8]

Many factors could lead to a change in the locational operating reserve requirements in future years. Since there is a lot of uncertainty about how these requirements might be set. The Study assumes the 1,310 MW of operating reserve requirement (also referred to as the largest single contingency limit) will remain intact during the Study horizon.

Offshore Connection Concepts

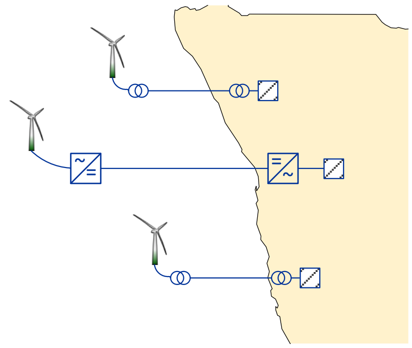
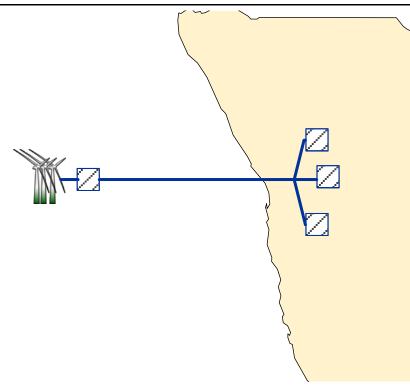
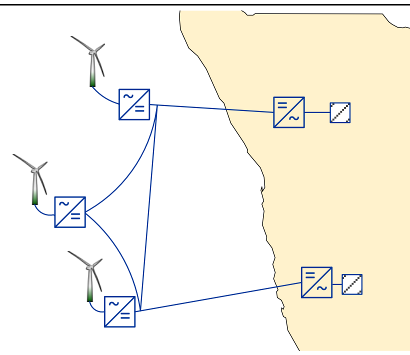
Offshore connection concepts are determined by such factors as:

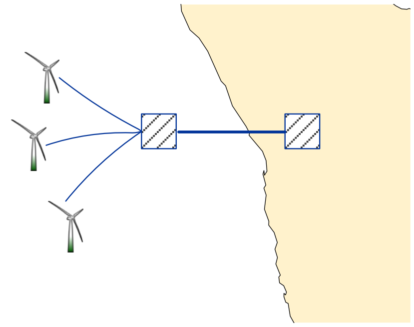
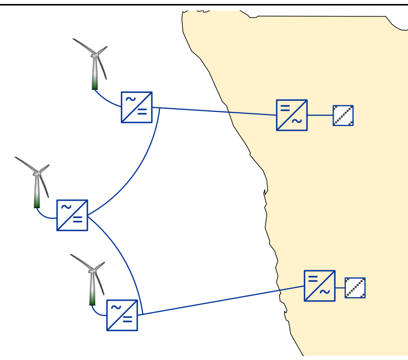
(i) the location of an OSW project
(ii) the relative proximity of adjacent OSW project
(iii) OSW project size (e.g. smaller projects < 400 MW or larger projects > 400 MW)
(iv) the type and capacity of electrical cables used (typically approximately 400 MW for HVAC technologies each or 1,200 MW of HVDC technologies)
(v) distance from the OSW project to the shore (typically within < 70 miles HVAC designs will be cost-effective, whereas > 70 miles HVDC designs may be more cost effective)
(vi) environmental and permitting considerations that may dictate cable routes
(vii) capacity available at an onshore substation (POI)
(viii) adequacy of the transmission system into which a POI is integrated to distribute power

Give the foregoing factors, up to five connection concepts are possible as listed in Table 5-1.

[8] Even though operating reserve locational requirements for Zone J and K are lower than 1,310 MW, for the purpose of the Study, NYCA operating reserve requirement was considered - For further information on the locational reserve requirements, please see the document at the following link:
http://www.nyiso.com/public/webdocs/markets_operations/market_data/reports_info/nyiso_locational_reserve_reqmts.pdf

Table 5-1. Connection Concept Descriptions

OSW Connection Concept	Description	Illustrative Figure
Dedicated Radial Design	Each OSW project is connected to the onshore grid via a dedicated Radial connection, which can be either HVAC (for distances to onshore POI up to ~70 miles) or HVDC for distances over ~70 miles. Note this design relies on (i) the capacity of the export cable from the OSW project to shore (maximum capacity of that export cable limited to e.g., 400 MW HVAC or 1,200 MW HVDC), and (ii) the available capacity of the POI on the onshore grid. This approach offers a simplicity in design and the smallest total amount of cable laid offshore but does not provide any redundancy or associated reliability benefits.	
Split Design	In this design, one OSW project is connected by a single export cable circuit to the shore, which will be further split to two or more onshore substations. Note, this design relies on (i) the capacity of the export cable from the OSW project to shore (maximum capacity of that export cable limited to e.g., 400 MW HVAC or 1,200 MW HVDC), and (ii) the available capacity of the POI on the onshore grid. This design is usually applied when an individual onshore substation is not able to absorb the full amount of power injection, offering additional interconnection optionality.	
Mesh Design	In this design, multiple OSW projects are interconnected in a Meshed offshore grid, which is further connected to the onshore grid by two or more connections. Note, this design relies on close or adjacent project areas that can efficiently gather energy, and onshore substations that are capable of interconnecting significant energy capacity associated with multiple projects, to fewer onshore substations. This design balances the additional costs of interconnecting the offshore array with the potential advantage of increased redundancy and reliability.	

OSW Connection Concept	Description	Illustrative Figure
Shared Substation Design	In this design, multiple OSW projects are connected to one offshore hub (shared substation) before being further connected to the onshore grid. Note, this design relies on (i) smaller OSW projects that can aggregate to a common export cable to shore (maximum capacity of that common cable limited to e.g., 400 MW HVAC or 1,200 MW HVDC) and (ii) relies on a POI on the onshore grid that can handle significant injections of energy. This design minimizes the cable landfall footprint but adds reliability risk given the lack of redundancy.	
Backbone Design	In this design the OSW projects are interconnected in an offshore grid, which is connected to the onshore grid as a multi-terminal system (non-Meshed). Note, this design relies on close or adjacent project areas and onshore substations that have the capacity to host significant injections of energy associated with multiple projects to fewer onshore substations. This design balances the additional costs of interconnecting the OSW projects in an offshore grid with the potential advantage of increased redundancy and reliability.	

5.2.2 Preliminary Review of Connection Concepts

For each of the five future OSW build-out scenarios, five different connection concepts described in Table 5-1. above were developed, resulting in a total of 25 different connection topologies. Informed by early stages of the onshore system analysis, the Study assumed injections of 6 GW of OSW into New York City and 3 GW of OSW into Long Island.

The initial 25 offshore connection topologies were analyzed and ranked qualitatively and quantitively using existing industry guidelines and adopted practices accounting for potential benefits, risks, and LTCOE.

Qualitative analyses involved comparing the 25 connection topologies from the following aspects:

- Resiliency and Redundancy: The ability of the conceptual OSW connection topologies to collect and deliver rated power after a failure event in one component (i.e., N-1 event) assuming no over-sizing of components.

- Expandability**:** The modular flexibility of a connection topology to expand into an interconnected system without the need of upgrading components; together with the flexibility of component replacement or dismantling without having a major impact to the rest of the offshore grid.

- Operational Benefits**:** Standardization and compatibility of the connection topologies and technologies, together with the capability of the offshore connection scheme to provide additional supplementary benefits such as voltage support and control capabilities of power flows toward the onshore grid.

The quantitative analysis involved calculation of the LTCOE considering costs as well as performance components as described:

Costs: The CAPEX, OPEX, and REPEX were estimated using cost data at the component level, including components at onshore landing substation. REPEX was factored in due to the substation's secondary and auxiliary equipment age, or that the equipment will become obsolete over 10 to 15 years, whereas electrical power equipment is typically designed to have a lifetime of 35 years. It should be noted that these cost estimates were subsequently updated for three detailed design variants as part of the detailed assessment of OSW connection concepts task. The methodology, key assumptions, and results of this work is presented in Section 8.

Performance: Performance includes component availability and energy losses within power transformers, converters and cables. Component availability was calculated considering downtime due to planned and unplanned outages on cables, converters, and transformers.

Summary tables showing consolidated results across all five OSW build-out scenarios are presented in the following section. Results of the qualitative review for each of the individual OSW build-out scenarios are included in Annex D.

Table 5-2. Summary of Preliminary Review

Connection Concept	Average LTCOE ($/MWh)	Operational Benefits	Resilience & Redundancy	Implementation given OSW geographic uncertainty
Dedicated Radials	Lowest	Moderate	Weak	Easy
Split				
Shared Substations	Middle	Weak	Moderate	Very Challenging
Mesh	Higher	Strong	Strong	Complex but possible
Backbone				

Table 5-3. Conclusions Based on Preliminary Review

Connection Concept	Preliminary Observations
Dedicated Radials	Lowest LTCOE and simplest rollout given uncertainty with OSW project geography and capacity. Weak resilience and redundancy and moderate operational benefits. Operationally, grid support would be certain with DC connection. Preliminary review does not include onshore costs - depending on number/location of POIs, onshore grid reinforcement costs may be high, making these concepts less attractive.
Split	
Shared Substations	LTCOE in the middle of the range observed across all connection concepts. Phased rollout would be extremely difficult given uncertainty in OSW project geography and capacity. Moderate resilience and redundancy due to the length and number of cables; weakest/riskiest operationally due to large amount of AC cables.
Mesh	Higher LTCOE and potentially complex phased rollout (but possible with appropriate planning) but offers strong resilience and redundancy and strongest operational benefits. Offers grid supports which can improve utilization of offshore POIs and optimize onshore grid reinforcement.
Backbone	Higher LTCOE and complex phased rollout, but strong resiliency and redundancy. The operational benefits are high, but slightly less that Mesh.

5.3 Findings

Key initial observations associated with the preliminary analysis of the OSW connection concepts for New York State can be summarized as follow:

- As shown in Annex D, the qualitative ranking of each connection concepts was generally consistent across all five OSW build-out scenarios. Meaning, the OSW project location uncertainty (represented by the five differing OSW build-out scenarios considered which reflect existing and prospective future lease areas) does not significantly impact the preliminary assessment of the five OSW project connection concepts.

- The overall benefits and relative cost comparisons of each connection concept remained consistent in all build-out scenarios, which suggests that a single representative scenario can be utilized for detailed analysis and costing with minimal sensitivity risk of compromise to findings.

- Radials offer the lowest total footprint in terms of offshore cable lengths (miles) of all design concepts and across all future buildout scenarios examined in this study.

- Radials and split concept designs have lower LTCOE, though offer less operational benefits, resiliency and redundancy, across all future OSW buildout scenarios. Radials and split concepts were observed with very similar performance during the preliminary review, under the Study conditions.

- Moving from Radial connections to a substation sharing concept, where individual OSW projects connect to an offshore substation(s) built outside a specific project development to reduce the number of required export cables to onshore POIs, is problematic given BOEM WEA and selected project location uncertainty. Planning for a Mesh or Backbone connection concept is complex given the uncertainty, but achievable.

- Mesh and Backbone concept designs provide extra operational benefits, resiliency and redundancy, but with an extra LTCOE cost.

- Moving from Radials to a networked strategy (either substation sharing, Mesh, or Backbone), the coordinated offshore network should encompass at least three OSW projects with minimum aggregate rating of approximately 3 GW to be financially feasible.

- Radial connections can be later converted to Mesh or Backbone with upfront preparation and investment such as additional control and protection functionality for future Meshed integration, OSW project substation platform sizing and design with reserve space for circuit breaker bays and future cable connection. Cost associated with such preparations will vary depending on the chosen methods for Meshing but is expected to fall in the range of 5% of overall platform cost for an AC Mesh connection and 10% of overall platform cost for a DC Mesh connection.

- Given the previously mentioned observations, Radials, Meshed and Backbone connection concepts are shortlisted for further detailed analysis as presented in Section 7.

6 Environmental and Permitting Analysis (Routing Assessment)

6.1 Assessment Approach

The transmission cable routing feasibility assessment (Routing Assessment) was based on a review of environmental and permitting constraints for multiple representative routes to determine the feasibility of routing for an illustrative transmission strategy suggested by the analysis in Section 3 of injecting 6 GW into New York City POIs and 3 GW into Long Island POIs. This section describes the methodology and major assumptions used to perform the Routing Assessment. Section 6.1.1 explains how preliminary routes and landing sites were identified for analysis based on POIs associated with an example base allocation of 9 GW (Scenario 1 described in Section 3.4), and lists all route segments and landing sites that were considered as part of this assessment. Section 6.1.2 describes the process used to identify route constraints, assess the feasibility of routes, and develops a refined set of representative routes based on POIs associated with an example alternative allocation of 9 GW (Scenario 2 described in Section 3.5). Section 6.1.3 presents additional inputs and supporting analyses considered in assessing the feasibility of installing multiple cables along multiple routes, which is necessary to support the illustrative transmission strategy. The results of these analyses are presented in Section 6.2.

6.1.1 Initial Route and Landing Site Identification

This section describes the approach to identify preliminary representative routes and associated landing sites. To evaluate multiple route alternatives between offshore lease areas and onshore substations, also referred to as POIs, the routes were divided into three primary components:

- Offshore route corridors (segments between lease areas and nearshore waters).
- Shore approach and landing sites (segments between the offshore corridors and shore crossings).
- Onshore routes (segments between landing sites and POIs).

To assist the analyses, a project-specific web-based mapping application (web mapper) was established using an Esri ArcGIS Portal web platform. Spatial data resources obtained from publicly available websites were downloaded and integrated into the project’s Enterprise Geodatabase (using industry standard Microsoft SQL Server and ArcGIS for Enterprise). In some instances where data files were large or challenging to acquire, authoritative map services were linked with the web mapper (for example, National Oceanographic and Atmospheric Administration raster nautical charts and automatic identification system vessel density grids). This allowed for review of authoritative geographic information system (GIS) data without directly downloading the information.

6.1.1.1 Offshore Route Corridors

During an initial screening-level assessment, four representative offshore route corridors were delineated, extending from the potential offshore wind lease areas to the nearshore coastal region of New York State including:

- ***Atlantic North Corridor:*** Extends from the lease areas identified as Massachusetts Region, South Fork, and Sunrise on Figure 6-1.
- ***Atlantic Central Corridor:*** Extends from the lease areas identified as Empire, Empire Buildout, Expansion, and Hudson Central on Figure 6-1.
- ***Atlantic South Corridor:*** Extends from the lease areas identified as Hudson South and New Jersey Region on Figure 6-1.
- ***Long Island Sound Corridor:*** Extends through Long Island Sound from the *Atlantic North Corridor* on Figure 6-1.

Corridors were identified, as opposed to specific offshore routes, to account for similarity of constraints throughout the given corridor and the relative flexibility to adjust a given route in open ocean to avoid obstructions and other constraints. Multiple potential lease areas were grouped and included in the representative offshore route corridors where the lease areas were located near each other and where cable routes would follow a similar general direction to reach potential POIs on Long Island and in New York City.

In refining the representative routes considered for further analysis in this Routing Assessment, the Study focused on approaches primarily from the south shore of Long Island and New York Harbor; however, New York State recognizes that routing through Long Island Sound likewise offers a similarly feasible potential corridor between offshore wind lease areas and POIs in New York City or on Long Island. The three representative offshore route corridors (Figure 6-1) further analyzed for illustrative purposes are as follows: the Atlantic North Corridor, the Atlantic Central Corridor, and Atlantic South Corridor.

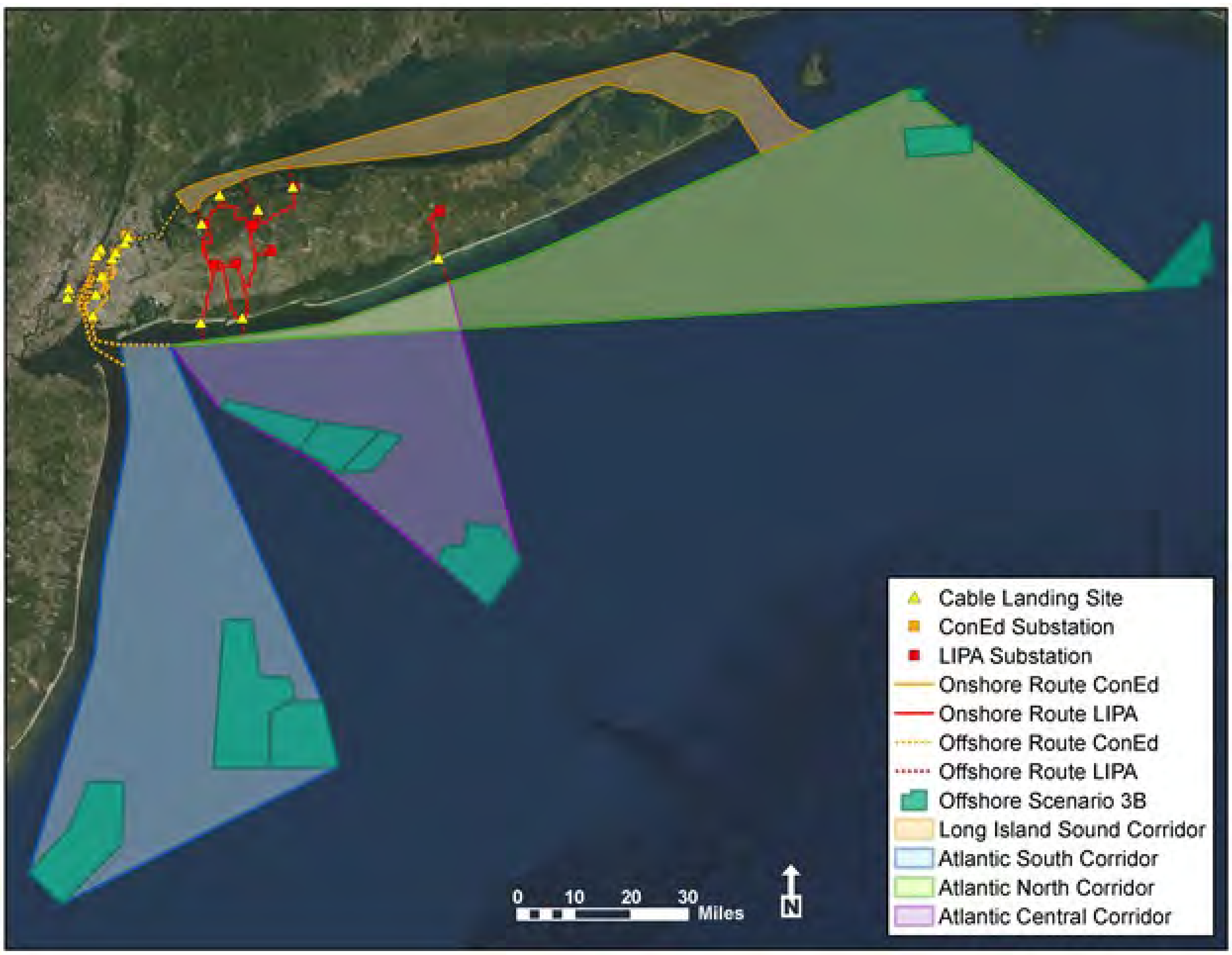
To limit the number of route iterations within each corridor, the potential lease areas associated with the Atlantic South Corridor were assumed to connect only with POIs in New York City (via New York

Harbor). Also, excluding routes through Long Island Sound, potential leases associated with the Atlantic North Corridor were assumed to connect only with Long Island POIs.

Figure 6-1 shows representative offshore route corridors, shore approach and landing sites, and onshore routes for cable interconnection from offshore lease to POIs in New York City and Long Island. These assumptions notwithstanding, the Study authors recognize that a multitude of offshore origins and connections to shore are possible and so again, affirm that the representative study is one of many feasible approaches to integrate OSW projects into New York and this presentation does not confer a recommendation of the State Team to the use of these corridors or any individual routes.

Figure 6-1. Overview of Analyzed Route Segments

Source: WSP 2020; DNVGL 2020; ESRI 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)



6.1.1.2 Shore Approach and Landing Sites

The nearshore segments of the representative routes, identified as the shore approach, connect the representative offshore route corridors to landing sites along the Long Island shore and the New York City waterfront (Figure 6-2). Some shore approach and landing site configurations also include crossings of intracoastal bays and tidally influenced waterbodies (e.g., East River). Potential landing sites were initially identified based primarily on a visual interpretation of aerial photographs considering the following general criteria:

- Access to landing site (for construction equipment)
- Suitable location for horizontal directional drilling (HDD), including size and type of area
- Proximity of landing site to POIs
- Adjacent public right-of-way (ROW) and/or transmission corridor to POI that could potentially accommodate cable colocation
- Avoidance or limited extent of open water and potential wetland crossings (i.e., bays, tidal wetlands/marshes), as feasible
- Separation distance between landing sites to support reasonably distinct onshore route alternatives

Most landing sites were identified as locations closest to a POI where a shore crossing could potentially be feasible. In addition, several other landing site alternatives were included for site-specific reasons. For example, although not considered as a POI in this analysis, the waterfront near the Gowanus substation was identified as a landing site given the potential available workspace and to avoid East River constraints.

6.1.1.3 Onshore Routes

Onshore route segments of the identified representative routes extend along the terrestrial environment, from a shore landing site to a POI (Figure 6-2). Potential onshore routes were initially identified based on GIS data layers and visual interpretation of aerial photographs. Existing infrastructure (e.g., transmission lines, aqueduct, pipeline, and sewer mains) was identified to determine if the corresponding ROWs would potentially be suitable for adjacent placement or colocation of the cable. In addition, the following general criteria was considered in selecting potential onshore routes:

- Presence of adjacent public ROW, transmission corridor, or railroad corridor wide enough to support a tractor trailer delivering equipment.
- Preference for roads and transmission corridors that offered a continuous, more direct route.
- Avoidance of residential neighborhoods, where possible.

Onshore route segments included in the refined list of representative routes are shown in Figure 6-2.

6.1.1.4 Route Refinement

Following screening-level critical constraint analysis and ranking of routes (see Annex B, Part 2: Preliminary Route Feasibility Scoring Matrices for additional details), further evaluation of the transmission strategy yielded a revised set of POIs for consideration. Accounting for the updated set of POIs, potentially feasible routes were evaluated more closely with consideration for several engineering parameters and a more detailed analysis of potential sites for HVDC converter stations and HVAC transformer stations. In some cases, routes and/or landing sites were shifted to improve their feasibility. Based on this additional analysis, a revised set of feasible representative routes was identified for illustrative purposes.

<u>Transmission Strategy Adjustments</u>

The initial list of POIs identified for the preliminary routing analysis included nine substations — four in New York City (ConEd service area/electrical system) and five on Long Island (LIPA service area/electrical system). These initial POIs were associated with the example base allocation of 9 GW (Scenario 1) described in Section 3.3 that could inject 6 GW into New York City and 3 GW into Long Island. The list of POIs was adjusted based on the development of the example alternative allocation of 9 GW (Scenario 2) described in Section 3.4, which could also inject 6 GW into New York City and 3 GW into Long Island through a different configuration of Long Island POIs than the example base allocation. Therefore, the final illustrative list of eight POIs analyzed as part of the Routing Assessment consisted of the following, associated with the Alternative Allocation (Scenario 2) configuration:

- New York City (ConEd) POIs
  - Farragut
  - Mott Haven
  - Rainey
  - West 49th
- Long Island (LIPA) POIs
  - East Garden City
  - Ruland Road
  - Shore Road
  - Syosset

Preliminary results indicated that routing to all identified POIs was potentially feasible (see Annex B, Part 2: Preliminary Route Feasibility Scoring Matrices for details) via a diversity of access routes, including routes extending through the Long Island Sound, though additional research was warranted for suitable converter station sites along some routes. In the representative design, the Planning Study authors have utilized southern routes to simplify costing analysis, but affirm that the routes utilized in the representative study do not reflect either an optimal route selection or the recommendations of the State Team.

All evaluated shore approach segments and associated Long Island and New York City landing sites included as part of the refined list of representative routes are listed in Table 6-1 and Table 6-2.

Figure 6-2 shows shore approach routes, landing sites, and onshore routes for cable interconnection to New York City and Long Island.

Figure 6-2. Shore Approach Routes, Landings, and Onshore Routes to New York City and Long Island

Source: WSP 2020; DNVGL 2020; ESRI 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)

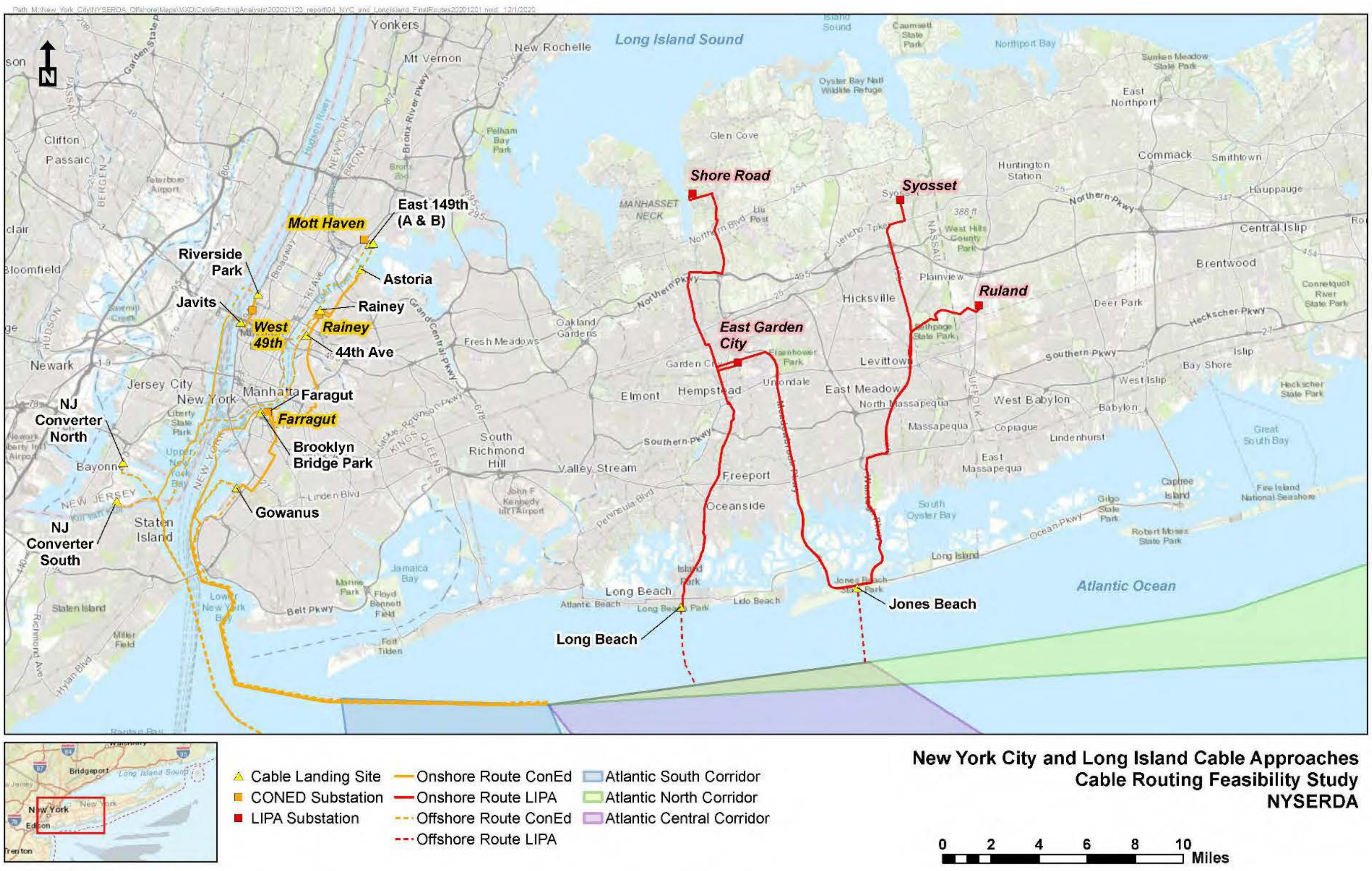


Table 6-1. Analyzed Offshore Route Corridors, Shore Approach and Landing Sites, and Points of Interconnection for NYC Routes

Offshore Route Corridor	Atlantic South Corridor							Atlantic Central Corridor	
Shore Approach and Landing Site	Riverside (Narrows West & NJ Converter-South)	Riverside (Narrows West & NJ Converter-North)	Javits Center Pier	44th Ave	Brooklyn Bridge Park	149th Street (Narrows West)	Rainey Park & 149th Street via Astoria (Narrows East)	Gowanus (Pierline segment)	Gowanus (Bay Ridge Flats segment)
Point of Interconnection	West 49th	West 49th	West 49th	Rainey	Rainey	Mott Haven	Mott Haven	Farragut	Farragut

Table 6-2. Analyzed Offshore Route Corridors, Shore Approach and Landing Sites, and Points of Interconnection for LI Routes

Offshore Route Corridors	Atlantic Central Corridor					Atlantic North Corridor
Shore Approach and Landing Site	Jones Beach	Jones Beach	Jones Beach	Long Beach	Long Beach	Jones Beach
Point of Interconnection	Syosset	Shore Road	East Garden City	Shore Road	East Garden City	Ruland Road

6.1.2 Constraint Identification and Review

This section summarizes the offshore and onshore issues evaluated in this assessment, with a focus on those considered more critical to the feasibility of a given representative route. Offshore constraints pertain to the offshore segments of the routes within the open ocean. Shore approach and landing site constraints pertain to the nearshore areas of the Atlantic Ocean and Long Island Sound, the shore landing itself, as well as any bay/intracoastal and tidally influenced waterbody crossings. Onshore constraints pertain to the terrestrial portion of a route extending from the landing site to the POI, but do not consider the landing site or the substation at the POI. To identify constraints for the different route segments, GIS data and resource layers were compiled for all applicable resources and specially designated areas that may be affected by the potential cable routes within an area extending from potential offshore lease areas to the identified POIs. These GIS layers were included in the project-specific web mapper that allowed them to be overlaid on base maps and charts for the surrounding terrestrial and marine environment. Tables 6-3 and 6-4 present GIS-based data layers evaluated as potential constraints for the Routing Assessment. A summary description and source information for each layer are presented in Annex B, Part 1: GIS Data Source List. Using the web mapper, potential cable routes were assessed to identify existing constraints for specific resources, including designated areas, political boundaries, and other geographical features crossed by the routes.

Table 6-3. GIS Data Layers Evaluated as Potential Constraints to Offshore Corridors, Shore Approach Route Segments, and Landing Sites

Coastal Management Programs	Offshore Dredge Material Disposal / Dumping Grounds
New York State and Federal (National Oceanographic and Atmospheric Administration [NOAA]/U.S. Fish and Wildlife Service) Endangered, Threatened and Special Concern Species	U.S. Department of Defense (DoD) Mission Compatibility
NOAA Essential Fish Habitat (EFH)	Submarine Transit Lanes
Shellfisheries	Naval Undersea Warfare Testing Range
New York State Critical Environmental Areas	Military Installations, Ranges and Training Areas
New York State Department of State Significant Coastal Fish and Wildlife Habitats	DoD Operation Areas
Submerged Aquatic Vegetation	Federal - Coastal Storm Risk Management
Natural Heritage Communities	Coastal Project Offshore Sand Borrow Areas
Critical Habitat	Property Ownership
Habitat Area of Particular Concern	Land Type
Important Bird Areas	Coastal Barrier Resource Areas
North Atlantic Right Whale Areas	Vessel Monitoring System Data
Currents/Bottom Stress	Aquaculture
Sand Waves	Unexploded Ordnance
Hardbottom	Anchorage Areas
Water Depth	Fish Trap Areas/ Lobster Pot Areas
Sediment Grain Size Distribution	Shipping Lanes
Potential Contamination	Aids to Navigation
Cultural Resources	Artificial Reefs
New York State Heritage Areas	Pilot Boarding Areas
Wrecks/Obstructions	Danger Zones and Restricted Areas
National Historic Register/Landmarks	Traffic Separation Schemes/Traffic Lanes and Precautionary Areas
Cable Crossings (Electrical Transmission and/or Telecommunication)	Maintained Navigation Channels
Pipeline Crossings	Vessel Traffic
Sewer Lines	Vessel Activity and Marine Infrastructure
	Bureau of Ocean Energy Management Lease Areas and New York State Call Areas

Table 6-4. GIS Data Layers Evaluated as Potential Constraints to Onshore Route Segments

Important Bird Areas	U.S. Environmental Protection Agency Superfund National Priorities List Sites
Federal Lands	NYSDEC Remediation Sites
Recognized Ecological Complexes	Critical Environmental Areas
Priority Marine Activity Zones	National Oceanographic and Atmospheric Administration (NOAA) and New York State Critical Coastal Habitats
Ecologically Significant Maritime and Industrial Areas	Existing Infrastructure: Telecommunication Cables, Roadways, Railways, Transmission Lines, Sewer Lines
Significant Maritime Industrial Areas	Farmland
Special Natural Waterfront Areas	Tidal Wetlands
Coastal Barrier Resource System Boundaries	Waterbodies
Indian Territories	NYSDEC Freshwater Wetlands/Check Zones
Public Fishing and Recreational Use Areas	Federal Emergency Management Agency Flood Hazard Zones
National Historic Landmarks	New York State Tax Parcel Data
National Register of Historic Places	National Land Cover Database
New York State Parks, Historic Sites, and Heritage Areas	County Parcel Data
New York State Department of Environmental Conservation (NYSDEC) Trails and Lands	
New York State Local Waterfront Revitalization Communities	
Primary Aquifers	

The resources and spatial features that potentially pose a significant challenge to power cable installation were then grouped into critical constraint categories with similar attributes or designations. The constraints deemed most critical to routing a cable from an offshore wind energy lease area to POI are discussed in the following section. The critical constraint categories are listed in 6-5. A description of each critical constraint category is summarized below according to route segment. The results of the constraints analysis for specific routes and landing sites are also presented, as applicable.

Table 6-5. Critical Constraint Categories for Each Route Segment

Critical Constraint Category	Route Segment		
	Offshore	Shore Approach/ Landings	Onshore
Infrastructure Crossings (including need for horizontal directional drilling)	✓	✓	✓
Designated Marine Zones (traffic lanes, danger zones)	✓		
Department of Defense Areas	✓		
Sensitive Habitats	✓	✓	✓
Marine Geology and Oceanography	✓	✓	
Other Regulatory Constraints (e.g., additional State approvals)	✓	✓	
Stakeholder Concerns	✓	✓	✓
Landing Site Complexity		✓	
Navigation Channels, Anchorage Areas, and U.S. Army Corps of Engineers Coastal Storm Risk Management Projects		✓	
Contaminated Sediments		✓	✓
Cultural Resources		✓	✓
Route Distance			✓
Available Land for Converter Station			✓
Parkway/Highway (permitting constraint)			✓

Assumptions and analytical limitations affecting more than one critical constraint category or route segment include the following:

- Substrate at all potential offshore and onshore specialized crossings is assumed to be suitable for specialized routing methods. Site-specific assessments would be needed to confirm this assumption.
- Only publicly available data for infrastructure (e.g., sewer, aqueduct, subway, gas pipeline, telecommunication cable, and electrical transmission line) were considered. Site-specific assessments would be needed to confirm the presence and exact location of existing utilities along the routes.

6.1.2.1 Critical Constraints for Offshore Route Corridors

Infrastructure Crossings

Numerous subsea cables exist along the seafloor in the Atlantic Ocean. Crossing these existing cables add complexity to cable installation and an increased risk of liability. Crossings would require measures to protect both new and existing cables that would need to be agreed on with the cable owners and the regulatory agencies. These agreements include considerations such as construction methodology and depth/type of cover and are typically required before permits/easements are granted.

The burial depth of existing cables in these offshore areas likely varies and no comprehensive database on the depth of existing cables has been identified. In recent decades, federal regulatory guidance for projects in or near New York State has specified that cables located in open marine waters shall be buried a minimum of four feet below the seafloor in areas with soft sediments and a minimum of two feet in areas of rock or other hard substrate (USACE 2009, 2017, 2019; 49 CFR §195.248). This excludes designated navigation channels and anchorage areas, which require greater depth of cover but generally do not overlap with the identified offshore corridors. Recent comments from the New York State Department of Environmental Conservation (DEC) on offshore wind cable burial depth recommend that offshore cables should be buried at least six feet deep to avoid interactions with fishing gear [1]. Some existing cables may have been installed at shallower depths prior to the recent burial depth guidelines and/or may have been affected by natural submarine sediment transport processes (erosion or deposition), which have altered the actual burial depth.

Designated Marine Zones

There are multiple designated marine zones within the Atlantic Ocean on approach to New York State waters. Examples of such zones that may need to be crossed by cables include shipping lanes/fairways associated with major ports, as well as navigation Safety and Security Zones [2]. Installation of a cable across these zones is likely not precluded but would require coordination with regulatory agencies and maritime stakeholders to ensure navigation is not impacted during installation. Additionally, zones identified as Safety and Security Zone: Danger Area may contain old mines and other unexploded ordnance and therefore may require geophysical surveys prior to cable routing.

Department of Defense Areas

Routes within the Atlantic Ocean would route through U.S. Department of Defense's (DoD) Operating Areas (OPAREA) and would require coordination with the DoD. U.S. military vessels (surface and subsurface) use the OPAREAs for training, testing, and qualifying systems (e.g., onboard radar systems) [3]. The DoD also uses areas surrounding the OPAREAs for military activities, including specific submarine transit lanes. These areas and lanes are identified on navigation charts or through publicly available data, but others may not be.

Based on current publicly available GIS data for DoD wind mission compatibility, none of the cable routes cross offshore wind exclusions areas, although there are portions of routes that are in areas with site-specific stipulations. However, graphics presented at a November 2018 DoD Mission Compatibility Assessment, New York Bight Task Force meeting identify an alternate set of proposed boundaries for wind exclusion and site-specific stipulation zones that differ from the publicly available GIS data [4]. As a result, additional areas considered in this Routing Assessment may be within proposed DoD wind exclusion areas, such that cable installation associated with offshore wind activities may be prohibited by the DoD due to interference with current operations. In other instances, installing cables in an OPAREA may need further coordination or site-specific stipulations such as time-of-year construction restrictions to avoid interference with specific missions or training.

Sensitive Offshore Habitats

A cable route in the Atlantic Ocean would cross several sensitive habitats, including New York State and federally listed threatened and endangered (T&E) species habitats. Species-specific seasonal restrictions and best management practices (BMPs) would likely be required to avoid or minimize adverse impacts for work in these areas. Consultation with the following agencies would be required:

- NOAA National Marine Fisheries Service (NMFS) under Section 7 of the Endangered Species Act for marine T&E species.
- U.S. Fish and Wildlife Service (USFWS) under Section 7 of the Endangered Species Act for terrestrial T&E species, including avian species which may be in the marine environment.
- NYSDEC under 6 New York Codes, Rules, and Regulations (NYCRR) Part 182 for New York State T&E species.
- NOAA NMFS under the Marine Mammal Protection Act of 1972 for marine mammals.
- NOAA NMFS under the Magnuson-Stevens Fisheries Conservation and Management Act for Essential Fish Habitat.

Marine Geology and Oceanography

The geological characteristics of the Atlantic Ocean within the analyzed offshore corridors are generally understood to be conducive to cable installation (i.e., predominantly sandy substrate with some areas of sand/silt/clay mixtures and patches of coarse-grained gravel, find-grained silt, rocky outcrops, and mud deposits [5][6]). Seasonal storms and winter conditions in the open ocean waters can delay installation and cause scour around installed cables.

Further Regulatory Constraints

Routing cables in the Atlantic Ocean in or near a state's territorial waters may require Coastal Management Program (CMP) consistency review and concurrence under the federal Coastal Zone Management Act of 1972. Such review and concurrence may be required if a state determines that the installation of a cable along a given route may have a reasonably foreseeable effect on the state's coastal resources, including activities outside state waters that may impact coastal uses. For example, routing a cable into New York Harbor may require consistency review and concurrence under CMP for New York and New Jersey as a result of potential impacts on those state waters and associated users. These two state consistency reviews would likely be required even assuming the cable route only crossed through the waters of New York State because of the proximity of the route to the coastal resources of the other state, which could result in potential effects on those state resources during installation and/or operation of the cable. Similar considerations would be required of a cable route through the Block Island and Long Island Sounds, including a potential consistency review by Massachusetts, Rhode Island and Connecticut. Multiple state consistency reviews increase the risk of concerns to a route, which could significantly delay cable installation and/or require route realignment. Additionally, Local Waterfront Revitalization Program (LWRP) review may apply. LWRPs are a subset of the New York CMP and contain more detailed implementation plans for local communities in the State's coastal policies.

<u>Potential Stakeholder Concerns</u>

Marine waters within the Atlantic Ocean support high levels of commercial and recreational fishing [7]. A cable route that crosses or is adjacent to productive fishing grounds is likely to generate concern. Certain commercial and recreational fishing grounds may not be mapped and, therefore, would require input from fisheries representatives to identify. Also, high concentrations of recreational and commercial marine vessels are present in the offshore waters approaching New York Harbor [8], and in association with other ports, harbors and marinas along New York's coast. Marine vessel operators and representatives may have concerns regarding cable placement in such high traffic areas, especially if navigation may be impacted during installation. Other offshore stakeholders including, but not limited to, environmental non-governmental organizations and communities reliant on coastal/offshore resources may also have concerns if it is perceived that cable installation and operation may negatively impact regionally important resources.

6.1.2.2 Critical Constraints for Shore Approach and Landing Sites

<u>Infrastructure Crossings</u>

As with the offshore corridors, existing submarine cables may also need to be crossed by new transmission cables through nearshore areas to landing sites. Additional linear infrastructure may be crossed during the shore approach and landings, including pipelines, and through New York Harbor in particular, transportation tunnels supporting train, road, and subway systems. Specialized crossing methods, including HDD and/or armoring, may be required to suitably protect both the new cable and existing infrastructure. Therefore, crossing this existing infrastructure may present a logistical challenge for cable installation and an increased risk of liability, but such crossings are expected to be feasible if measures to protect both the existing infrastructure and new cables are agreed upon by the new cable owner, the existing infrastructure owner and the regulatory agencies. These agreements include considerations such as construction methodology, depth/type of cover, and separation distance from the existing infrastructure. Such agreements are typically required before permits and easements would be granted for a new cable.

Sensitive Habitats

Several sensitive habitats in New York State's nearshore coastal waters present constraints for installation of cables in the approach to a landing site. Such sensitive habitats may include State- and federally listed T&E species habitats.

Sensitive habitats that may be affected during intracoastal (back-barrier) bay crossings include tidal wetland marsh and eelgrass meadows, as well as New York State Significant Coastal Fish and Wildlife Habitat and Critical Environmental Areas [9].

As with the offshore environment, the presence of these sensitive habitats in the nearshore and at the landing sites would likely result in species-specific seasonal restrictions and BMPs to avoid or minimize adverse impacts on the sensitive habitats. Specialized crossing methods may be required, including trenchless methods such as HDD or the jack-and-bore technique. Such methods can substantially reduce impacts on certain environmental features but can be more costly and require much more time than typical installation methods (e.g., open trenching). Consultation with the following agencies would be required:

- NOAA NMFS under Section 7 of the Endangered Species Act for marine T&E species
- USFWS under Section 7 of the Endangered Species Act for terrestrial and avian T&E species
- NYSDEC under 6 NYCRR Part 182 for NYS T&E species
- NOAA NMFS under the Marine Mammal Protection Act of 1972 for marine mammals
- NOAA NMFS under the Magnuson-Stevens Fisheries Conservation and Management Act for Essential Fish Habitat

Marine Geology and Oceanography

The Atlantic Ocean nearshore environment south of Long Island is highly dynamic as a result of winds, waves, and currents that are constantly shifting seafloor sediments in this area. Placement of a cable in these environments may present challenges to maintain cable burial depth requirements over time. Additionally, shallow bedrock or exposed hardbottom structure may be present in some areas of New

York Harbor. It may be challenging to meet burial depth requirements during cable installation in these areas, such that armoring the cables may be necessary.

Further Regulatory Constraints

As with the offshore environment, cable routing in the nearshore area on approach to a landing site may trigger the need to obtain CMP consistency review and concurrence under the federal Coastal Zone Management Act of 1972 from multiple states if cable installation adjacent to a state's territorial waters/coastal zone boundary is determined to have a reasonably foreseeable effect on the state's coastal resources. Additionally, specific to cable installation into New York Harbor, some potential routes may cross into New Jersey waters and trigger the need to obtain all applicable state permits in addition to other New York State and federal regulatory approvals necessary for the project. The need for additional regulatory approvals increases the risk of objection to and delay of a project.

Potential Stakeholder Concerns

Several reasonably anticipated stakeholder concerns regarding installation of cables through nearshore areas to a landing site are similar to those in the offshore environment. These include potential concern from commercial or recreational fisheries, the maritime community, and communities reliant on coastal/offshore resources. Marine waters on approach to New York City and Long Island landing areas support high levels of commercial and recreational fishing. A cable route that crosses or is adjacent to productive fishing grounds is likely to generate concerns. Additionally, marine vessel operators and representatives may have concerns regarding cable placement in New York Harbor high traffic areas, especially if a new cable crosses any navigation channels and/or anchorage areas. Concerns could include, but not be limited to, navigation impacts during cable installation and burial depth of the new cable during the operation phase. There are likely to be additional stakeholder concerns over the shore approach and landings, including intracoastal bay crossings. These include potential impacts on shellfishing grounds, marsh habitats, and water quality.

Landing Site Complexity

Cable shore crossings have a varied level of complexity depending on the natural and engineered features present along the waterfront at the landing sites. For example, the barrier islands along the south shore of Long Island require crossing the back-barrier bay (intracoastal) in several locations. At landing sites in New York City, existing coastal structures present greater technical challenges as the depth and extent of waterfront facility foundations may not be known and there is a potential for encountering unanticipated buried structures. Additionally, landing sites within areas of increased development may have substantial technical difficulties associated with limited staging area for installation equipment, regulatory restrictions, and stakeholder concerns.

Navigation Channels/Anchorage Areas/U.S. Army Corps of Engineers Project Areas

Multiple federally designated navigation channels and anchorages may need to be crossed along a shore approach to a landing site. In some cases, these features can be avoided, but for most routes into New York City crossing several channels or anchorages is likely necessary. In recent decades, regulatory guidance for New York State required a minimum burial depth for cables and pipelines of 15 feet below the seafloor or authorized channel depth (whichever is deeper) in navigation channels and anchorage areas (USACE 2009, 2017, 2019; 49 CFR §195.248). In addition, there are numerous U.S. Army Corps of Engineers (USACE) Coastal Storm Risk Management projects along Long Island's Atlantic Ocean shoreline, mainly consisting of beach nourishment. Further, navigation channels are present within several bays around Long Island. Any cable that crosses part of a Coastal Storm Risk Management project, navigation channel, or anchorage area would require a USACE Section 408 authorization under Section 14 of the Rivers and Harbors Act for alteration of a public work. The USACE, in consultation with other maritime stakeholders, may require route adjustments or impose project-specific requirements such as minimum depth of cover that may significantly increase the cost and/or delay a project. Non-designated channels and anchorages are also a potential constraint, but these were not mapped as part of this analysis.

Contaminated Sediments

Sediments in New York Harbor and its adjacent waterways may contain contaminated sediments, in part as a result of historical industrial activities in those areas as well as the presence of a significant number of combined sewer overflows [10]. Contaminant modeling would likely be required for sediments identified by the DEC as having Class C concentrations (i.e., high contamination: acute toxicity to aquatic life). Additionally, strict BMPs may be required to control sediment plumes during cable installation. As many of these contaminated areas are likely not mapped, sediment sampling along potential cable routes would be necessary to determine the potential presence and level of contamination.

Cultural Resources and Wrecks/Obstructions

Cable routes through nearshore waters may be constrained by shipwrecks and other obstructions, some of which may be considered cultural resources. To reach New York City landing sites, a cable route would cross through the viewshed of many waterfront sites of historical significance [9], which would therefore be affected by installation activities. Accordingly, there is the potential for extensive New York State Historic Preservation Office (SHPO) review to ensure avoidance of cultural resources and minimization of visual impact from designated sites. The SHPO is likely to require marine archeological surveys along a proposed route, which may reveal more potential historical features than are currently mapped. Generally, these cultural resources are avoidable, but route adjustments may be necessary following surveys and/or during construction if unanticipated objects are encountered.

6.1.2.3 Critical Constraints for Onshore Routes

Infrastructure Crossings

Specialized crossing methods would likely be required along several onshore routes, including trenchless methods such as HDD and the jack-and-bore technique. Such methods can substantially reduce impacts on certain environmental and infrastructure features but can be more costly and require much more time than typical installation methods (e.g., open trenching). Sufficient equipment staging areas are also necessary for specialized crossings to be feasible. For this Routing Assessment, locations assumed to require trenchless technologies include bridge crossings over water, other roadways, or railroads; existing utility crossings; and intersection with a major arterial roadway. Site surveys to determine soil conditions and precise location of existing utilities would be necessary during a future crossing design phase to confirm the appropriate crossing method.

Sensitive Habitats

Several sensitive habitat constraints for installation of cables through onshore areas are similar to those encountered at potential landing sites (including intracoastal bay crossings). These habitats include tidal and freshwater wetlands and wetland buffers, which fall under the purview of the USACE (Section 404 of the Clean Water Act) and NYSDEC (e.g., Tidal Wetlands Act and Freshwater Wetlands Act). Additional sensitive habitats may be crossed along onshore cable routes. These include Important Bird Areas, Coastal Barrier Resource System, Special Groundwater Protection Areas, and Coastal Critical Habitat. References for GIS layer data sources are presented in Annex B, Part 1: GIS Data Source List. Trenchless construction techniques, as previously described for onshore infrastructure crossings, can avoid or minimize impacts to these sensitive habitats.

Potential Stakeholder Concerns

Potential stakeholder concerns regarding installation of onshore cables and associated equipment include, but are not necessarily limited to, construction noise, traffic restrictions/congestion, natural resource impacts, and effects on visual aesthetics. For the screening analysis, the number of municipal jurisdictions crossed by a route was used as one proxy for estimating the potential that stakeholder concerns could pose a major constraint for cable installation. This corresponds to the number of municipal and county reviews and approvals that would be required, which increases the risk of project delay due to local stakeholder concerns. Further, compared to routes through commercial and industrial areas, a greater number of stakeholders are expected to raise concerns for routes through residential areas, particularly neighborhoods with single-family homes. Therefore, routes were analyzed for the type of 2016 National Land Cover Database classification crossed by the routes on Long Island and for the type of zoning classification crossed by routes in New York City. The length of route that passes through low- and medium-density developed areas was calculated as an indicator of passing through or near highly residential areas.

Contaminated Sites

Historical industrial activities have led to localized, inactive areas of contaminated sediments in New York City and Long Island, such as those containing polyfluoroalkyl substances (PFAs), polychlorinated biphenyls (PCBs), and heavy metals. Construction in or through these areas may require specialized construction methods, additional monitoring, and possibly remediation, which could potentially delay a project prior to and during construction.

Cultural Resources

Section 106 of the National Historic Preservation Act and Section 14.09 of the New York State Historic Preservation Act requires consultation with the SHPO. Additional consultation with the New York State Museum would be required under Section 233 of the New York State Education Law for construction on State lands. A majority of these onshore routes pass within or close to known historic properties listed on the National Register of Historic Places (NRHP). Successful permit acquisition to install cables along these routes may require more extensive cultural resource investigation. Some routes pass through State parks but remain within the footprint of existing infrastructure. Additionally, there is a possibility of encountering previously unidentified archaeological resources throughout most of Long Island as it hosts several sensitive archaeological areas. It is assumed that this potential increases for longer onshore routes.

Onshore Route Distance

The overall distance of the route may be considered a critical issue because of the greater cost that may be incurred and greater risk of encountering unforeseen issues associated with a relatively longer route through a given environment or jurisdiction. Both the extended length and unforeseen issues could delay regulatory approval and/or extend construction timelines.

Converter Station Parcels

Long Island and New York City consist of densely developed urban and suburban areas. Open, undeveloped areas are often encumbered by environmental and permitting constraints such as wetlands, parks, or other protected areas. Initially, parcel centroids from New York State tax data were used in GIS to identify vacant parcels of: at least two acres for HVAC transformer stations, and at least five acres for HVDC converter stations within 0.5 mile of the identified onshore routes. The five-acre parcel size for an HVDC converter station was considered sufficient to handle power input of at least 1.3 GW at +/-320 kV. When this analysis returned no suitable parcels along certain onshore routes in New York City, the criteria were widened to include vacant parcels of 2.5 acres or larger within one mile of the New York City onshore routes. The smaller 2.5-acre space is consistent with the area provided on offshore converter station platforms, though more expensive installation equipment and multi-floor construction may be required. With respect to the HVAC transformer stations, two acres were considered reasonably conservative to accommodate the minimum 1.2 acres expected to be necessary for the equipment.

Parkway/Highway Permitting

While parkway and highway ROWs on Long Island and in New York City often present a relatively wide corridor that could be used for installing onshore cables, a major permitting constraint is introduced through the need for approval from both New York State Department of Transportation (DOT) and the Federal Highway Administration (FHWA), which partially funds these major roads. Additionally, the New York State Parks Department owns Long Island parkways (including causeway segments) as they are Controlled Access Expressways. The Accommodation Plan and New York State law (17 NYCRR 131 in accordance with 23 CFR §645.211) does not generally permit utilities along expressways, parkways, or interstate highways except for those special cases in which installation of power cables within the ROW was permitted [11]. To be granted permission, the applicant must conduct alternative alignment analyses and prove that installation along other public ROWs that permit utility colocation are not feasible. Approval is not guaranteed, can result in uncertain timeline extensions, and in addition to several State department approvals, the FHWA must approve the installation through the National Environmental Policy Act process [11].

6.1.2.4 Critical Constraint Scoring

Scores were assigned to critical constraints along each evaluated route, reflective of the relative degree of potential challenge to the feasibility of a route due to the given constraint. The purpose of the scoring exercise was to provide a tool for identifying which routes (and route segments) had substantial constraints that warranted consideration, and to consider the comparative merits of route alternatives to a given POI when more than one representative route to the POI was identified. Four separate feasibility scoring matrices were developed in two stages:

1. A screening-level matrix for 21 routes to New York City (Con Ed) POIs
2. A screening-level matrix for 26 routes to Long Island (LIPA) POIs
3. A refined route matrix for eight routes to Con Ed POIs
4. A refined route matrix for 12 routes to LIPA POIs

For screening-level matrices, see Annex B, Part 2: Preliminary Route Feasibility Scoring Matrices; for refined route matrices, see Annex B, Part 3: Refined Route Feasibility Scoring Matrices. Within each matrix, critical constraint categories for each route were assigned a number (one through six) to reflect the relative challenge of installing a cable along a route segment with regards to the particular constraint. For visual purposes, the numbers are represented by color. For example, a value of one is represented as dark green and reflects that no significant constraints were identified for that category on the given route segment. A value of six is represented as black, indicating the challenges associated with that constraint are considered potentially insurmountable for the given route segment.

The individual constraint scores were then summed for each route. The overall scores were considered when comparing two or more routes to a given POI. However, the intent was not to identify a single optimal route because several routes to multiple POIs would be required to achieve the identified transmission strategy. Rather, the overall scores were considered to help develop a relative understanding of the challenges associated with each representative route. A summary of results of the constraint scoring for the refined set of representative routes and landing sites are discussed in Section 6.2.

6.1.3 Additional Inputs and Supporting Analyses

This section summarizes additional inputs and analyses used to develop the refined list of representative routes following the screening-level analysis of critical constraints and transmission strategy adjustments.

6.1.3.1 Engineering Considerations

The feasibility of routes was further reviewed based on additional engineering parameters and guidelines pertaining to the logistics of cable installation from the shore approach to the POIs and the characteristics of the cables associated with the OSW connection technologies identified in Section 5.1. Engineering considerations applied to the routing analysis are presented as follows.

Shore Approach and Landing Site Engineering Considerations:

- The HVDC cables extending from the offshore lease areas were assumed to be 320 kV symmetric monopole circuits with either a dual-core or a two-single-core bundled configuration in a single trench. The HVAC cables were assumed to be 220 kV three-phase circuits with a three-core or three-single-core bundled (trefoil) configuration in a single trench.
- To allow for maintenance following installation of cables in open marine waters, a minimum separation distance of at least twice the water depth is generally applied, providing room to lay a spliced loop next to the existing line [12]. In shallow or constrained nearshore waters, suitable cable spacing depends on factors such as the number of cables, induction effects, cable alternating current versus direct current, length, installation method, depth of cover, sequence/timing, and concerns about resiliency/reliability [12]. For purposes of this assessment, a minimum in-water cable spacing of 200 ft was assumed.
- Suitable geologic conditions are necessary to perform HDDs in the marine environment. Certain sediments along a potential HDD route, particularly gravel and cobble, can increase the risk of an inadvertent release of drilling fluid (i.e., a frac-out) or failure of the HDD bore hole ([14][15]). With suitable geologic conditions and straight horizontal alignment, an HDD of one mile in the marine environment (water-to-water or water-to-land) is feasible; this was the limit assumed for the routing assessment. However, if conditions are favorable, a longer drilling distance may be feasible (e.g., [16][17]).
- For HDD at landing sites:
    - A workspace with a length of at least 300 ft was considered preferable for suitable pullback distance behind possible landing/transition sites. A workspace shorter than 200 ft would be difficult and shorter than 150 ft was considered unsuitable. Adequate workspace width is also necessary to support HDD operations and depends on factors such as equipment used and the number and spacing of cables to be brought ashore for a given landing site.
    - Crossing under bulkheads increases the distance of an HDD and the entry/exit points must extend farther from the shoreline to provide a bending radius compatible with the HDD casing material. For shorelines with revetments, the minimum distance is generally shorter than for bulkheads, as bulkheads would typically extend deeper.
    - Minimum cable separation distance at landfall was assumed to be 30 feet. It can be less depending on onshore cable installation guidelines and the comfort level of the offshore installer to drill at distances closer than 30 feet from an installed cable.

Onshore Route Engineering Considerations:

- At the onshore portion of the landing site, it was generally assumed a circuit with three single-core cables would be installed, with each cable in its own conduit in a concrete filled duct bank. A single 35 kilovolt (kV) circuit duct bank would be approximately 7 feet by 2 feet and can be installed vertically or horizontally. Duct bank dimensions for a 345 kV for a double circuit in this analysis would be approximately 7 feet by 5 feet and can be installed vertically or horizontally. A single-circuit duct bank would be approximately 7 feet by 5 feet.
- Duct bank separation of 15 feet was generally assumed to maintain thermal independence for up to three parallel HVAC or HVDC circuits.
- Where necessary to conserve space and/or minimize magnetic fields (e.g., at certain HDD crossings), it was assumed single-core HVAC cables could be bundled in trefoil formation with a minimum spacing of 2.6 ft from similarly configured HVAC circuits. This assumed a minimum burial depth of five feet. More than 2.6-ft inter-circuit spacing would likely be required for more than two parallel HVAC circuits.
- Concrete manholes of approximately 30 feet by 10 feet by 10 feet were assumed necessary for every two to four bends of the cables.
- Onshore route segments where open trenching was potentially not feasible were reviewed by engineers to examine the feasibility of trenchless methods. Based on the engineering analysis, some route segments were shifted to make trenchless methods more feasible.
- Specialized trenchless land-to-land crossings were assumed to require an open area for laydown and pull back operations/equipment that is approximately 50 feet wide by 200 feet long. For shorter crossings, working areas for jacking and receiving pits to support jack and bore (i.e., auger boring) methods were also considered.
- Routes were also modified to avoid extensive colocation with utilities and infrastructure where practicable, particularly utilities and infrastructure with continuous metal components subject to induction of electrical current from HVAC line issues (e.g., pipelines, aqueducts, and subways), as well as avoiding potential conflicts with existing structural foundations and subsurface structures (e.g., bridge piers, buildings, basements, and tunnels [19]).
- During the initial representative route identification, installation of overhead HVAC and HVDC lines was assumed for certain onshore segments that were colocated with existing overhead alternating current lines and/or railroad ROW. Due to ROW spatial constraints and simplify the Study's separate costing exercise, overhead HVAC and HVDC lines were omitted from the final representative route assumptions.
- During the initial representative route identification, installation of overhead HVAC and HVDC lines was assumed for certain onshore segments that were co-located with existing overhead alternating current lines and/or railroad ROW. Due to ROW spatial constraints and to simplify the Planning Study's separate costing analysis, overhead HVAC and HVDC lines were omitted from the final representative route assumptions.

6.1.3.2 Converter Station and Transformer Parcels

Based on the initial screening analysis, land parcels suitable for converter stations were not identified along certain example HVDC routes. At least one suitable parcel was considered necessary for route feasibility, so a more extensive search for suitable land was conducted. This expanded search was conducted by BJH Advisors, a real estate planning firm. BJH considered currently utilized properties within manufacturing zoning districts that are generally in an appropriate location for the utility use, of suitable size, and not subject to conflict with known development plans. However, no representation is made that they can be acquired or that, upon further screening, would be found appropriate for this use. For consistency, the same search criteria were applied for all onshore routes in New York City and one route on Long Island where HVDC lines are identified as part of the Planning Study's representative transmission strategy.

If no parcels were identified during the expanded search, the onshore HVDC route was not considered further if there was at least one other feasible route option to the given POI. If there were no feasible routes identified to a POI due to lack of suitable converter station parcel, further efforts were made to review parcel options until at least one representative route with at least one feasible converter station was identified for each POI. This included consideration of parcels in New Jersey along the New York Harbor waterfront.

6.1.3.3 Routing Restriction Point Analysis

Initial routing analyses focused on identifying the feasibility of transmission cable routes to each POI considering installation of an individual cable circuit. However, the illustrative transmission strategy would require installing multiple cables/circuits along certain routes/corridors. Therefore, further analysis was conducted for the refined list of representative routes to estimate the number of cables and/or trenches that could potentially be installed at locations where physical constraints are greatest (i.e., bottlenecks or restriction points).

It was assumed that the offshore cable corridors in the Atlantic Ocean have enough space to accommodate any number of cables that could feasibly be used to transfer power to shore.

Factors used to determine the number of cables/trenches that appear feasible for the shore approach corridors included the following:

- The width of the waterway, defined by the presence of land features, was a fundamental constraint for shore approach route segments.
- Water depth was considered, where shallow waters may present logistical challenges for cable installation but could be more favorable to avoid user conflict in certain areas.
- Existing infrastructure (e.g., bridge foundations) and physical obstructions (e.g., rock outcrops and wrecks) must also be avoided, though it may be possible to cut through or remove smaller

obstructions of historic significance after appropriate cultural analysis and documentation has been completed.

- Specially designated areas such as navigation channels and anchorage areas were avoided to the the extent possible.
- Minimum cable spacing of 200 feet was assumed for multiple transmission cables to allow for suitable maintenance workspace and system resiliency. See Section 6.1.3.1 for a discussion of engineering considerations regarding cable spacing.

Factors used to determine the number of cables/trenches that appear feasible at the landing sites included the following:

- The amount of open land that would be suitable as a temporary workspace and staging area was reviewed with consideration for current uses.
- Waterfront infrastructure was considered with respect to shore landing methods and necessary workspace (e.g., where longer HDD might be necessary to pass under a bulkhead).
- A 30-foot cable spacing was assumed for multiple cable landings at the same site. See Section 6.1.3.1 for a discussion of engineering considerations regarding cable spacing.

Factors used to determine the number of cables/trenches that appear feasible along the refined list of onshore routes included the following:

- Cables were assumed to remain within public ROW where possible. In New York City, the width of the ROW was identified by measuring the width of the linear corridors between land parcels in tax parcel data layers.
- On Long Island, specific parcel boundary data were not available. Therefore, ROW corridors were identified based on Esri World Imagery (Clarity) data layer, which is a basemap layer with hybrid reference overlay of multiple layers depicting the clearest and/or most accurate imagery from the Esri archive (Annex B, Part 1: GIS Data Source List). Since representative data of ROW width were not available, a conservative approach using only the road width was used.
- Larger duct bank sizes and spacing were considered to accommodate multiple cables. For example, to support two 345 kV circuits, a seven-foot duct bank width was used with a spacing of 15 feet between duct banks. Therefore, a total width of 30 feet was used to represent the placement of four 345 kV circuits. See Engineering Considerations Section for additional discussion of engineering considerations regarding cable circuits and duct banks.

6.1.3.4 The Narrows Cable Limitations

To support a transmission strategy that assumes multiple cable routes through New York Harbor, a preliminary evaluation was conducted to determine the number of transmission cables that could feasibly be installed through The Narrows, the natural waterway in New York City connecting Lower New York Bay to Upper New York Bay. As part of this investigation existing data were evaluated to determine critical constraints for the installation of electrical power cables through The Narrows, including the following:

- Spatial constraints such as existing infrastructure
- Seabed conditions
- Operational requirements for installation and cable repair
- Regulatory requirements

Our evaluation considered the following sources of information:

- Publicly available GIS data layers
- Publicly available reports describing the geology and providing sediment data for the study area
- Literature regarding industry standards for cable installation
- Intertek's (2020) presentation *Anbaric Export Cables into New York Harbor, Cable routing through The Narrows and Export Cable Installation* [12]
- Applicable laws and regulations

Based on the identified constraints, anticipated minimum cable spacings were applied to the potentially available width of submerged lands through the narrowest portion of The Narrows to estimate a total number of cables that may feasibly be installed. Different factors that may increase or decrease the feasible number of cables are also discussed.

6.2 Assessment Results

This section discusses the findings of the feasibility assessment following application of the methodology as previously described. Section 6.2.1 summarizes the major environmental and permitting constraints that apply to routes crossing through the Study's representative offshore route corridors. Section 6.2.2 summarizes the major environmental and permitting constraints identified for the example shore approach segments and landing sites. Section 6.2.3 summarizes the major environmental and permitting constraints identified for example onshore routes and the potential converter station sites. The discussion in sections 6.2.1 through 6.2.3 is organized based on the general location of the POIs (i.e., in New York City or on Long Island). Finally, section 6.2.4 provides a synthesis of the various analyses and a summary of how the Routing Assessment has addressed the State Team's questions regarding the feasibility of the routes considering environmental and permitting constraints and opportunities.

6.2.1 Constraints Analysis for Representative Offshore Corridors

This section summarizes critical constraints applicable to route segments crossing the four previously identified offshore corridors. Figure 6-3 shows several of the GIS layers of features present in the offshore New York Bight and New Jersey area that could constrain the routes through the offshore corridors. Based on distance between lease areas and potential POIs, lease areas associated with the following offshore corridors were assumed to potentially connect to Long Island POIs as follows:

- **Atlantic North Corridor** — connecting to a southern Long Island shore approach
- **Atlantic Central Corridor** — connecting to a southern Long Island shore approach only

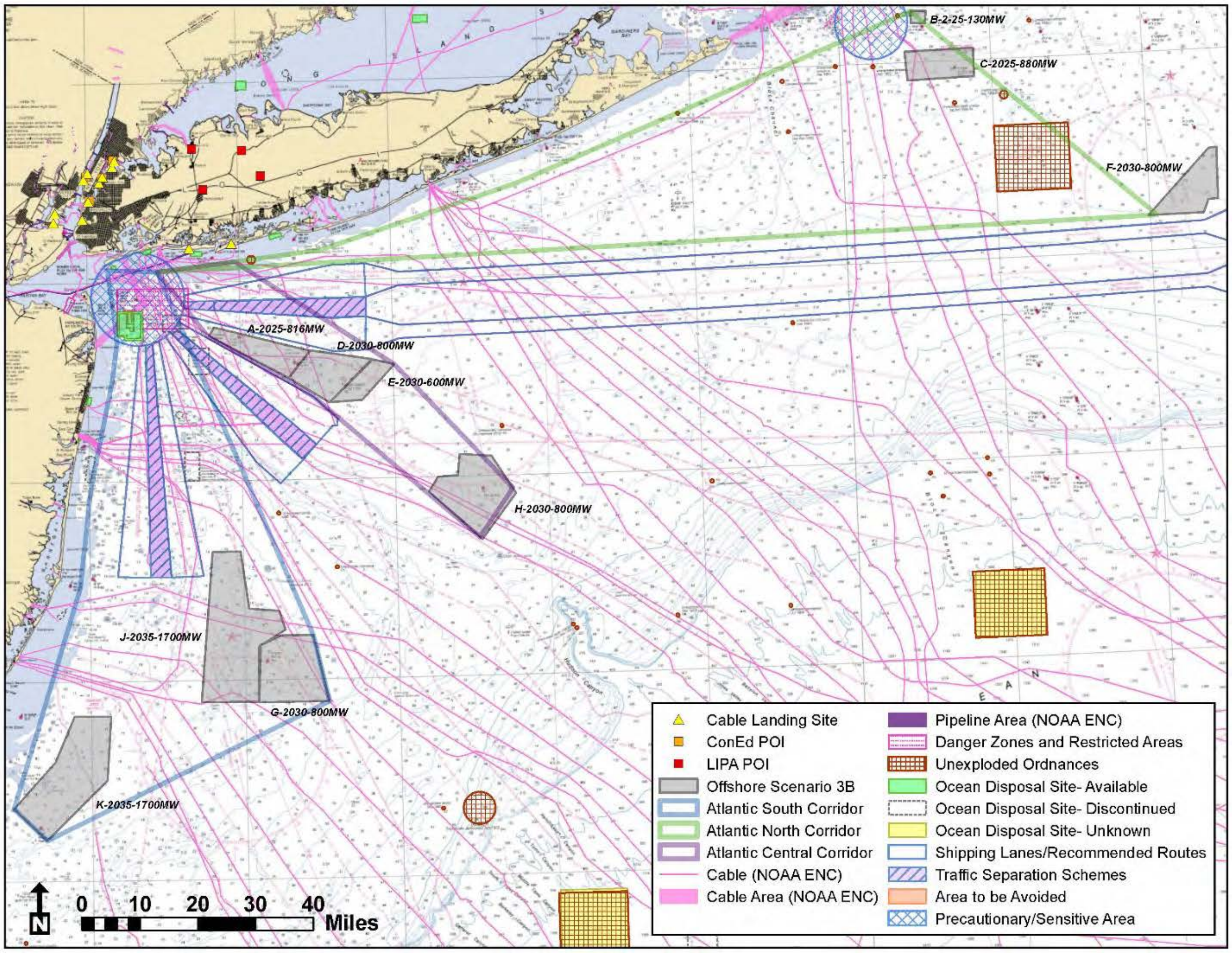
Similarly, the lease areas associated with the following offshore corridors were assumed to potentially connect to New York POIs:

- **Atlantic Central Corridor** — connecting through New York Harbor
- **Atlantic South Corridor** — connecting through New York Harbor

The corridors leading to the same collection of POIs (i.e., on Long Island or in New York City) were evaluated in comparison to each other with respect to the level of constraints. Please see Annex B, Part 2: Preliminary Route Feasibility Scoring Matrices for tables that present a visual representation of the relative constraint scoring and ranking for all evaluated routes through the offshore corridors to POIs on Long Island and in New York City.

Figure 6-3. Constraints in the Offshore Segment adjacent to New Jersey and Long Island

Source: WSP 2020; DNVGL 2020; NOAA ENC 2018, 2020; NOAA RNC 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)



6.2.1.1 Infrastructure Crossings

<u>Long Island</u>

Due to the number of existing cables that land along the south shore of Long Island or route into Rhode Island, a cable route through the Atlantic North Corridor has the most infrastructure crossings for interconnection to Long Island. A cable route through the Atlantic Central Corridor has the least number of crossings for interconnection to Long Island, mainly because it has the shortest distance and the most direct route to the Long Island mainland.

New York City

A cable route through the Atlantic South Corridor has the highest number of infrastructure crossings on an approach to New York City POIs. This is due to the large number of existing cables that land along the New Jersey shoreline, most notably on Long Beach Island and within Manasquan, which must be crossed on approach to New York City. A cable route through the Atlantic Central Corridor contains the least number of infrastructure crossings in the offshore area since a cable from the offshore lease area may be run parallel to many of the existing cables located within this region as they are also routing to New York City.

6.2.1.2 Designated Marine Zones

Long Island

For interconnection to Long Island, a cable within the Atlantic Central Corridor crosses the most designated marine zones. Routing through the Atlantic Central Corridor to the Long Island coast would require crossing the Nantucket to Ambrose Shipping Lanes (Fairways North and South). A cable within the Atlantic North Corridor on approach to Long Island could generally be routed to avoid designated marine zones.

New York City

A cable through the Atlantic South Corridor would likely cross the most designated marine zones for interconnection to New York City; though, a cable through the Atlantic Central Corridor would also cross a high number of designated marine zones. The number of zones crossed may vary for specific routes as some designated marine zones could be avoided. For example, features such as the Ambrose to Barnegat Shipping Lanes can potentially be avoided when routing a cable from the Hudson South lease areas, but this would likely result in increased cable length. There is a risk of encountering unexploded ordnance (mines) in the charted Danger Area east of Sandy Hook, New Jersey, and south of Rockaway Beach, New York; a cable route could avoid the area, but may require a longer route into New York City. Generally, all Atlantic Ocean routes into New York City must cross the charted Precautionary Area where traffic from all shipping lanes converge on approach into New York Harbor.

6.2.1.3 Department of Defense Areas

Long Island

A cable through any of the Atlantic Ocean corridors for interconnection on Long Island would cross several DoD areas. It is likely that all routes for interconnection to Long Island must cross the

Narragansett OPAREA and a Naval Undersea Warfare Testing Range. Additionally, a cable through the Atlantic North Corridors may also need to cross a submarine transit lane that extends south from Block Island, Rhode Island. Routing around the submarine transit lane is potentially feasible but this would lead to an increase in the route distance.

New York City

Routing a cable through the Atlantic Central Corridor crosses the most DoD constraints for interconnection to New York City, including the Atlantic OPAREA, a submarine transit lane, and a Naval Undersea Warfare Testing Range. Based on currently available GIS data, the Atlantic South Corridor has the least number of DoD constraints as a cable within this corridor would only cross the Atlantic City OPAREA. This assumes the DoD does not redesignate some or all of this OPAREA as an offshore wind exclusion area. This redesignation consideration has been under review since 2018.

6.2.2 Constraints Analysis for Shore Approach and Landing Sites

This section summarizes critical constraints applicable to the shore approach and landings for the evaluated routes. The following figures depict several of the GIS layers for the critical constraints considered in the feasibility assessment with respect to the shore approach route segments and landing sites (Figure 6-4, Figure 6-5, Figure 6-6). The first figure, Figure 6-4, shows several constraints along the shore approach routes and at landing sites along the Atlantic Ocean and intracoastal waterway for cable interconnection to western Long Island.

Figure 6-4. Constraints on the Atlantic Ocean for Shore Approach and Landings at Long Beach and Jones Beach

Source: WSP 2020; DNVGL 2020; NOAA ENC 2018, 2020; PLATTS 2009; MARCO 2019; SCFWH 2013; NY NHC 2018; ESRI 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)

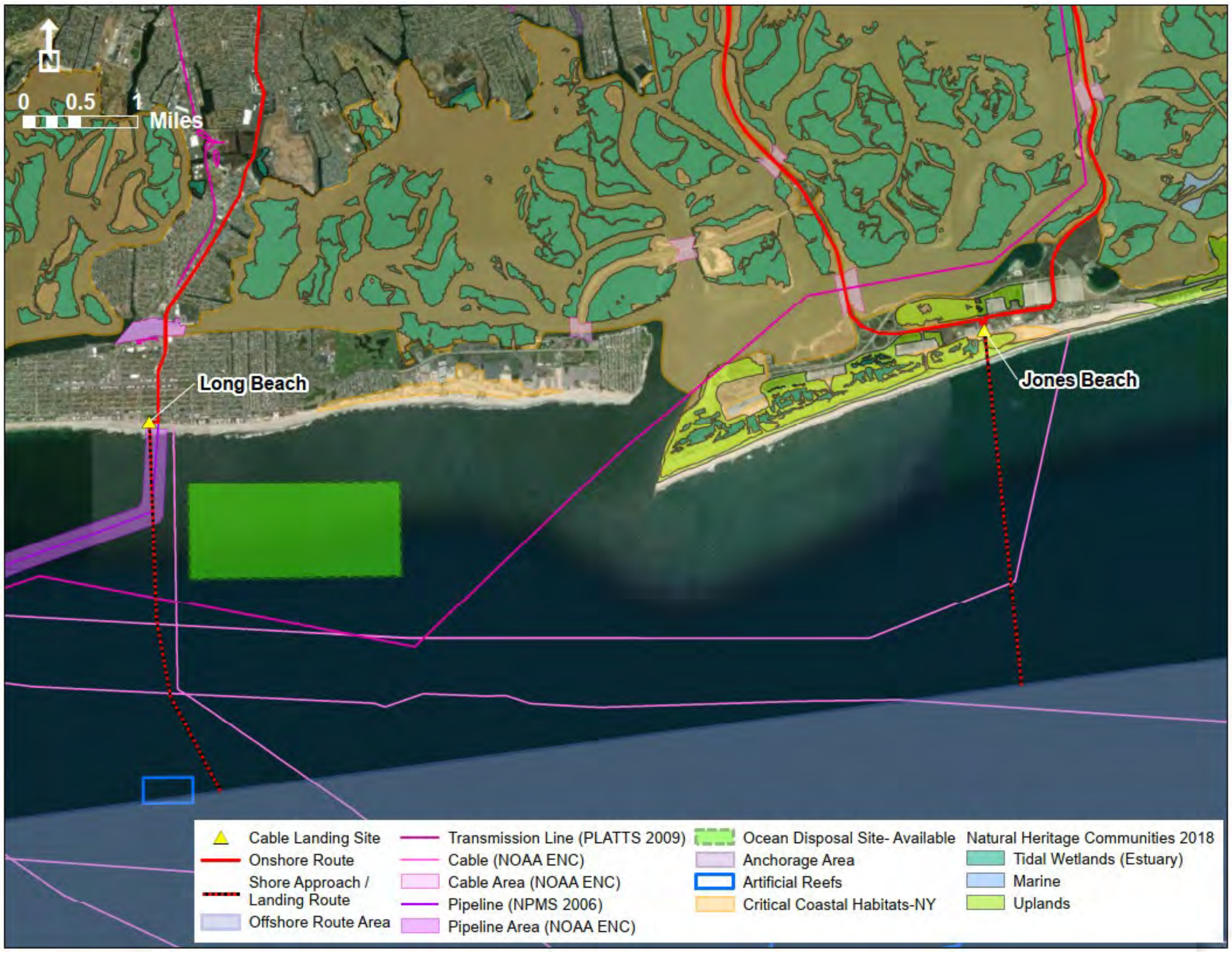


Figure 6-5 shows several constraints along the shore approach routes and at landing sites within Lower New York Bay for cable interconnection to New York City.

Figure 6-5. Constraints within Lower New York Bay for Shore Approach and Landings

Source: WSP 2020; DNVGL 2020; NOAA ENC 2018, 2020; NOAA CCH 2018; PLATTS 2009; NPMS 2006; NYC Aqueducts 2020; NYC Subways 2017; ESRI 2016, 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)

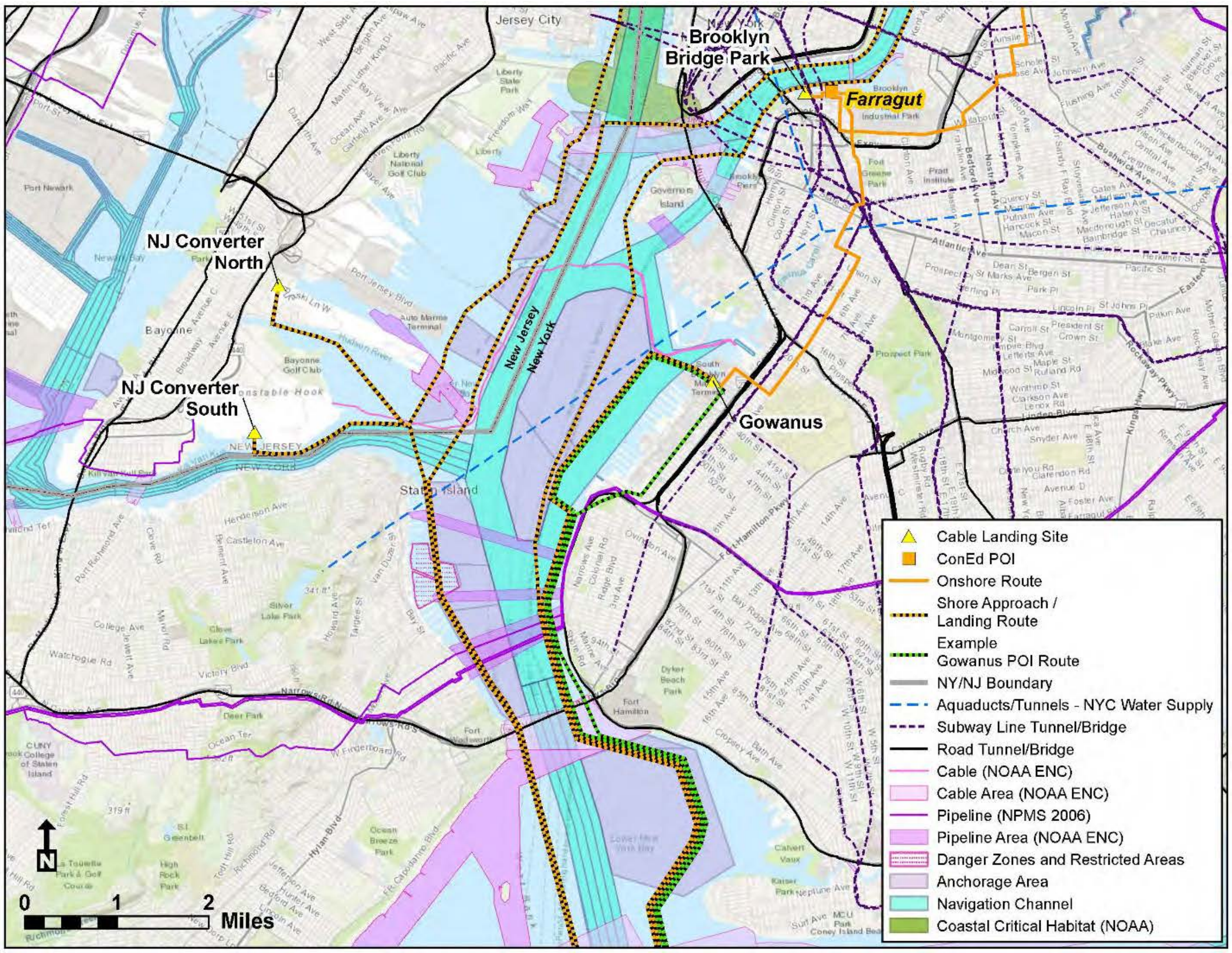
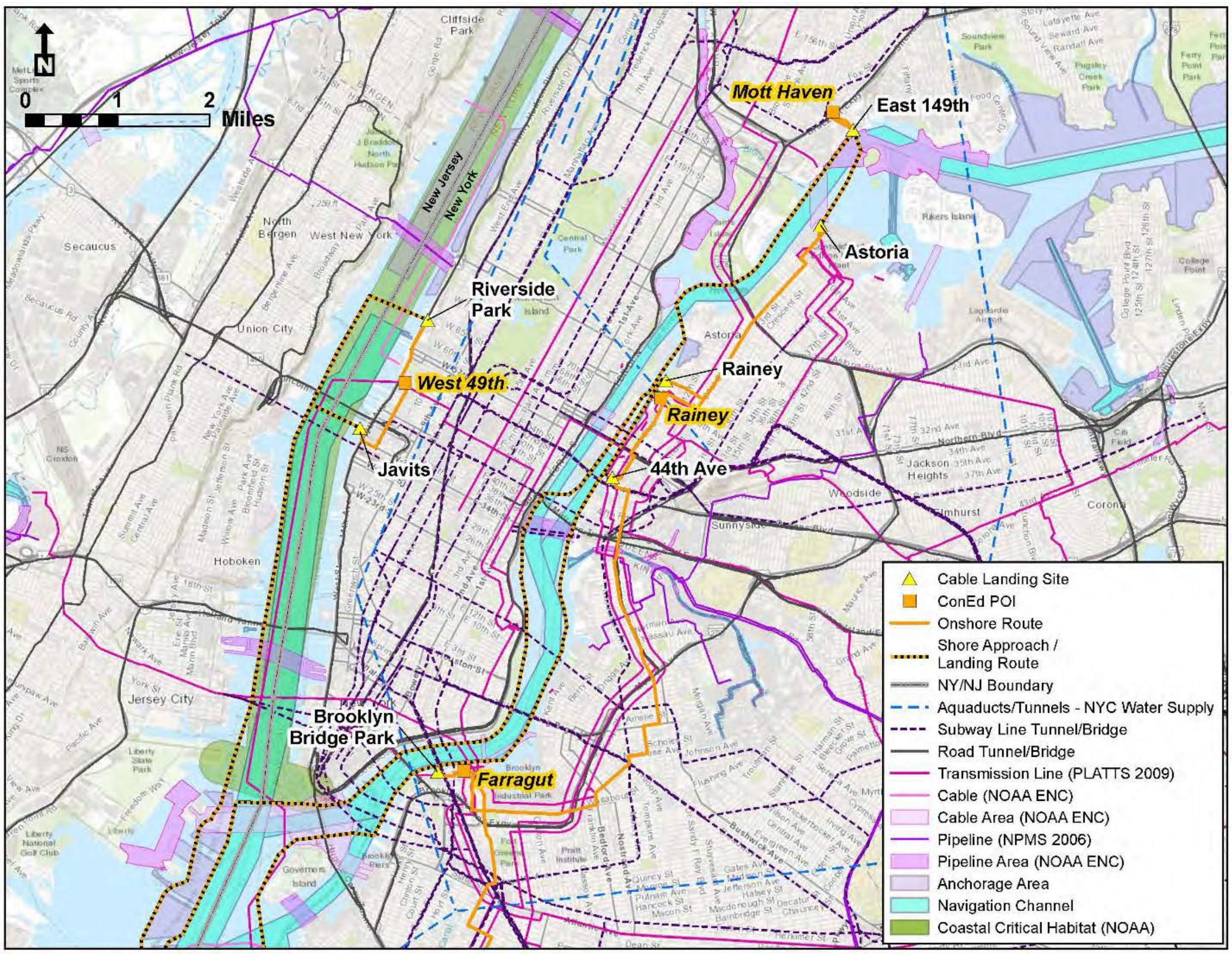


Figure 6-6 shows several constraints along the shore approach routes and at landing sites within the Hudson River and East River for cable interconnection to New York City.

Figure 6-6. Constraints within the Hudson River and East River for Shore Approach and Landings

Source: WSP 2020; DNVGL 2020; NOAA ENC 2018, 2020; NOAA CCH 2018; PLATTS 2009; NPMS 2006; NYC Aqueducts 2020; NYC Subways 2017; ESRI 2016, 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)



6.2.2.1 Infrastructure Crossings

Long Island

A Long Beach shore approach and landing would have the most infrastructure crossings for all the Long Island sites. Just south of the Long Beach shoreline in the Atlantic Ocean are several existing cables that must be crossed and one pipeline that exists but potentially could be avoided. Landing at Jones Beach requires about 25% less infrastructure crossings than Long Beach. Multiple cable bundles south of the eastern part of Long Island must be crossed in addition to two sewer outfalls at Jones Beach and channels under Wantagh and Meadowbrook parkways as part of back bay crossings.

New York City

There is a large amount of existing infrastructure present on approach to landing sites in New York City. As a result, shore approach routes with increased distance would cross more existing infrastructure. This would add to the complexity of a given route, which may present significant logistical challenges.

Shore approaches to landing sites in the East River would encounter the most infrastructure constraints particularly for an offshore route from the Atlantic Ocean. To get to the East River an in-water route must cross the existing infrastructure in Lower and Upper New York Bay including multiple pipelines and cables within The Narrows. While this would present logistical challenges, the largest infrastructure constraint for the East River is a result of the numerous transportation tunnels that exist between Manhattan and the Brooklyn shoreline. In the area spanning from Governors Island to the Farragut landing site, five subway tunnels and one road tunnel exist that must be crossed. Additional transportation tunnels are present south of Roosevelt Island within the East River and would constrain an approach to the 44th Avenue/Rainey Park landing sites.

Initial investigation into the depth of these tunnels and the amount of cover, identified that while some do likely have sufficient cover, or are within bedrock, others have limited cover and/or no information was obtained. As result a more detailed investigation would be necessary to ensure the depth of the existing tunnels and the amount of cover to ensure that cable installation to required depths in these areas could be completed while still maintaining necessary setbacks from the existing infrastructure. Furthermore, consultations with the various infrastructure owners would be required to identify if approval to cross these features could be obtained. A shore approach and landing at Gowanus has the least amount of infrastructure crossings for the New York City landings at about 26 crossings, four less than the other shore approach and landings.

6.2.2.2 Sensitive Habitats

Long Island

For shore approach and landing sites on Long Island, areas such as Jones Beach contain an increased number of sensitive habitats. Along the south shore barrier island at Jones Beach, endangered nesting shorebird habitat exists. Additionally, the back-barrier bay areas are classified as New York State Significant Coastal Fish and Wildlife Habitat and contain unique emergent tidal marsh and eelgrass meadow habitats. The landing site at Long Beach along the south shore of Long Island, likely has the least habitat constraints for Long Island, as the area has increased development and fewer sensitive habitats.

New York City

Sensitive habitats were examined and analyzed for shore approach and landing sites in New York City; however, no major constraints were identified for these areas. For further detail, see Annex B, Part 3: Refined Route Feasibility Scoring Matrices.

6.2.2.3 Marine Geology and Oceanography

Long Island

Marine geology and oceanography were examined and analyzed for shore approach and landing sites on Long Island; however, no major constraints were identified for these areas. For further detail, see Annex B, Part 3: Refined Route Feasibility Scoring Matrices.

New York City

For a New York City shore approach and landing, routes that extend north through the East River have the largest potential geologic and oceanographic (i.e., hydrologic) constraints. Shallow bedrock is likely present within areas of the East River. With shallow bedrock, cable burial depth requirements may be difficult to achieve and maintain over time. As a result, armoring of a cable may be necessary. Exact locations and depth of bedrock throughout East River was not identified through a search of publicly available GIS data layers and documents, so further investigations are likely necessary to obtain this information. Additionally, the East River is a tidal channel with strong currents that have a high potential for causing seafloor scour around an installed cable as well as logistical challenges during cable installation. Shore approaches and landings in other areas of New York City such as Lower/Upper New York Bay and the Hudson River present fewer geological constraints as initial investigations indicate that these areas are generally dominated by unconsolidated sediments.

6.2.2.4 Further Regulatory Constraints

Long Island

Further regulatory constraints were examined and analyzed for shore approach and landing sites on Long Island; however, no major constraints were identified for these areas. For further detail, see Annex B, Part 3: Refined Route Feasibility Scoring Matrices.

New York City

Shore approaches along the east side of Ambrose Channel, while within New York State waters are in proximity to New Jersey's coastal zone boundary, such that New Jersey CMP consistency review and concurrence would likely be required. Additionally, shore approaches along the west side of Ambrose Channel and within New Jersey State waters would require all applicable New Jersey state permits in addition to all other necessary federal and New York State regulatory approvals for the project.

6.2.2.5 Potential Stakeholder Concerns

Long Island

For shore approach routes and landing sites on the south shore of Long Island that are located adjacent to or through commercial or recreational fishing grounds, stakeholder concerns are likely. This would include commercial shellfishing areas such as the back-barrier bay regions adjacent to the Jones Beach approach and landing site that potentially support shellfishing activities. Additionally, stakeholder concerns are likely from communities reliant on coastal/offshore resources such as Long Beach, where activities such as surfing and beachgoing are part of the cultural identity of the area.

New York City

The largest stakeholder group that may be significantly affected by any shore approach and landing within New York City is likely the maritime community given the high number of vessels in the area and the diverse maritime user groups. Marine vessel operators and maritime industry representatives are expected to have concerns regarding cable placement in New York Harbor's high-traffic areas, particularly where a potential cable route crosses any navigation channels and/or anchorage areas. Concerns would include, but not be limited to, navigation impacts during cable installation and burial depth of the potential cable. While all shore approach and landings in New York City waterways may raise concerns with specific marine groups, it is likely that routes along or through especially busy anchorages, channels, and pier terminals would be scrutinized the most due to increased risk of anchor strike/snag on a cable in these areas and associated mariner liability.

6.2.2.6 Landing Site Complexity

Long Island

Shore approach and landing sites along the south shore of Long Island present increased landing site complexity as a result of the need to cross the barrier island and the back-barrier bay at multiple locations along a given route. A landing at Jones Beach would require the most crossings of the back-barrier bay, with three crossings being necessary for a route along either the Meadowbrook Parkway or the Wantagh Parkway. Designated cable areas exist within several of these back-barrier bay crossings, which indicates that cables likely have been installed, and caution would be needed for any cable installation in the same area to avoid impacting existing cables. Potential methods for crossing the back-barrier bay areas were evaluated at a high level:

- Attaching a cable to the bridges along the parkways or other roadways: Preliminary investigation of DOT regulations suggests that attaching a cable to the parkway bridges is likely not feasible. The DOT further indicated attaching cables to the Wantagh and Meadowbrook Parkway bridges have not been permitted in the past. Additionally, one of the bridges on each parkway as well as the bridge connecting Long Beach and Smith Point to the Long Island mainland is a drawbridge, which precludes attaching a cable.
- HDD under back-barrier bay areas: HDD is likely feasible to cross some of the back-barrier bay areas. However, adequate space for staging an HDD at some crossings (i.e., some crossings on the Wantagh and Meadowbrook Parkways) is likely limited and would not be feasible.
- Trenching across back-barrier bay areas: Open trenching at these water crossings is potentially feasible if HDD cannot be completed. But this method is likely to receive increased regulatory scrutiny as a result of seafloor disturbance and impacts on water quality.

Landings along the Atlantic Ocean would also be complex as a result of the need to install the cable at sufficient depths under the dynamic beach and nearshore areas. However, cable landings have been successfully installed along New York's Atlantic Ocean shoreline in the past (e.g., USACE 2019a).

New York City

Landing site complexity in New York City is mainly driven by the presence of existing waterfront structures and limited available space to support the installation of cables at many of the potential landing site. At every landing site considered as part of this analysis there was a coastal protection structure (i.e., bulkhead or revetment). In most cases bulkheads were present, which increased the landing site complexity as installation methods such as HDD are likely required to penetrate beneath the lowest point of the structure in order to avoid impact on the structure. Accordingly, installing a cable using HDD requires a large staging area for equipment and installation activities. Given the density of development in New York City, finding available space for these staging areas is more challenging compared to Long Island landing sites. As a result, all the landing sites in New York City have increased landing site constraints. Landing sites with major constraints due to complexity include Riverside Park and 149th Street landings. The landing sites of Gowanus and Rainey Park are less complex relative to other New York City landings but still likely present logistical challenges.

6.2.2.7 Navigation Channels/Anchorage Areas/U.S. Army Corps of Engineers Project Areas

Long Island

Shore approach and landings along the south shore of Long Island would likely cross USACE Coastal Storm Risk Management beach nourishment projects that are authorized at each of the landing locations: Jones Beach and Long Beach. As a result, a cable landing at these locations would likely require an additional USACE Section 408 authorization for alteration of a public work in addition to other State and federal regulatory approvals, but this extra approval does not necessarily present a major regulatory constraint. A Jones Beach shore approach and landing would be further constrained by the need to cross three marked navigation channels in the back-barrier bay area. While navigation charts do not appear to indicate that these are federally designated/maintained channels, one or more of them are main or secondary routes marked by beacons or buoys that are maintained seasonally by State or private interests (NOAA 2020b), such that crossings may still be subject to greater avoidance and burial requirements.

New York City

New York City’s waterways contain several anchorage areas and navigation channels that support various maritime activities. Any shore approach in New York City would likely have to cross or route adjacent to multiple anchorage areas or navigation channels on route to a landing. As a result of the presence of these navigation channels and anchorages in virtually all of New York City’s waterways, longer shore approaches are likely to have increased navigation constraints. Accordingly, shore approaches that route through Lower New York Bay and Upper New York Bay and into the East River have increased navigation constraints due to the need to cross or route adjacent to more of these designated areas. Additionally, routing outside of anchorage areas or navigation channels within New York Harbor still poses a significant risk of encountering other types of constraints such as conflicts with private berth owners if a cable would cross between their property and a channel or the potential presence of debris and unmarked obstructions that may exist in the unmaintained areas.

An analysis was conducted to determine the number of cables that could potentially be routed through The Narrows using 300-foot (Figure 6-7) and 200-foot (Figure 6-8) cable spacings. The submerged areas both east and west of the Ambrose navigation channel were considered viable for placement, assuming placement at least 100 feet from the shoreline and excluding the 25-yard Safety and Security Zones (SSZs) around the Verrazano Bridge towers. Two different cable spacings were assessed: a 300-foot distance between cables (Figure 6-7) and a 200-foot distance between cables (Figure 6-8). These spacing distances were identified based on industry guidance for cable spacing. In particular, water depths within The Narrows approach 100 feet, so a minimum spacing of 200 feet reflects guidance to provide space that is at least twice the water depth [13]. The spacing is also generally consistent with considerations made in a related study conducted by Intertek (2020). [12]

Three separate routing scenarios were considered. The scenarios considered were as follows:

- **East1 Scenario:** The east side of The Narrows from the Ambrose Channel to the Brooklyn shoreline with the shoreline buffer and SSZ restriction previously described.
- **East2 Scenario:** Similar to East1 Scenario, but also excluding Safety Zone 165.172 that extends 110 yards around a point approximately 70 yards southeast of the eastern Verrazano Bridge tower.
- **West Scenario:** The west side of The Narrows from the Ambrose Channel to the Staten Island shoreline with the shoreline buffer and SSZ restriction previously described.

To clarify the difference between the East1 and East 2 Scenario, the East 1 Scenario assumes it is feasible to route through Safety Zone 165.172 if suitable safety precautions are observed to avoid the related obstruction(s), and pending consultation with the U.S. Coast Guard and/or Captain of the Port of New York/New Jersey. Based on the assumptions for the analysis of these three scenarios, it is feasible to potentially install between eight and 11 separate cables or cable bundles (i.e., circuits) through The Narrows (Table 6-6) assuming suitable planning and coordination between regulatory agencies, developers, and other affected parties. Other constraints in New York Harbor are likely to further limit the number of transmission cables/circuits that could feasibly be installed through the harbor. At a minimum, The Narrows has the capacity to support a solution of six separate cables/circuits identified as part of the illustrative transmission strategy.

Table 6-6. Cable Routes through the Narrows

Cable Spacing[1]	Number of Cables per Routing Scenario			Total Number of Cables for The Narrows	
	East1 Scenario: East Side of The Narrows	East2 Scenario: East side of The Narrows excluding Safety Zone 165.172[2]	West Scenario: West Side of The Narrows	East1 & West Scenario	East2 & West Scenario
200-foot	5	5	6	11	11
300-foot	4	4	4	8	8

[1]In addition to cable spacing, a 25-yard area surrounding the Verrazano Bridge supports was excluded pursuant to Safety and Security Zone 165.169 and a 100-foot setback from coastal protection structures was identified to provide a buffer from shore.

[2]Scenario East2 excludes Safety Zone 165.172 to the southeast of the eastern Verrazano Bridge Foundation.

Figure 6-7. Cable Spacing of 300 ft through The Narrows

Source: WSP 2020; NOAA ENC 2018, 2020; NOAA RNC 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)

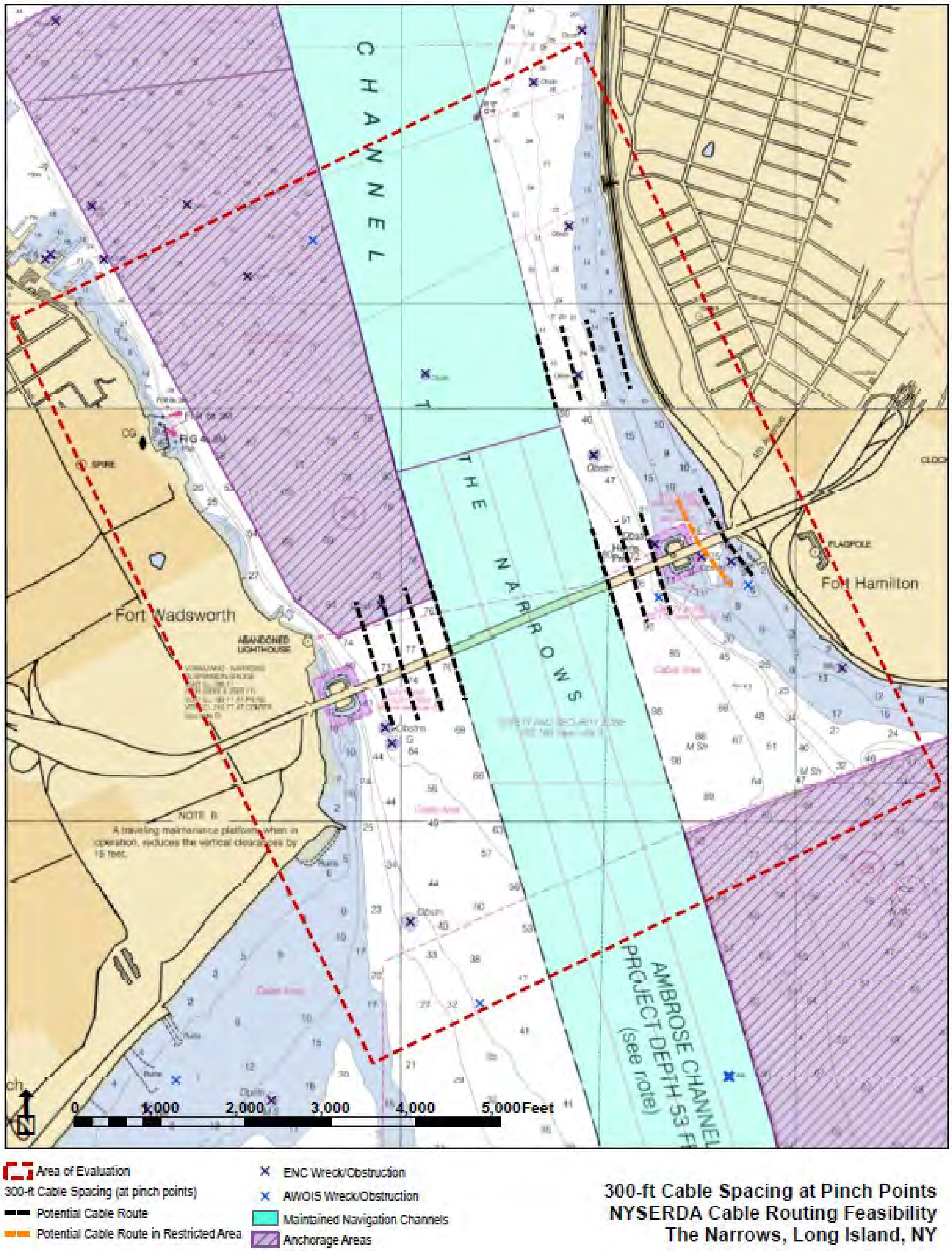
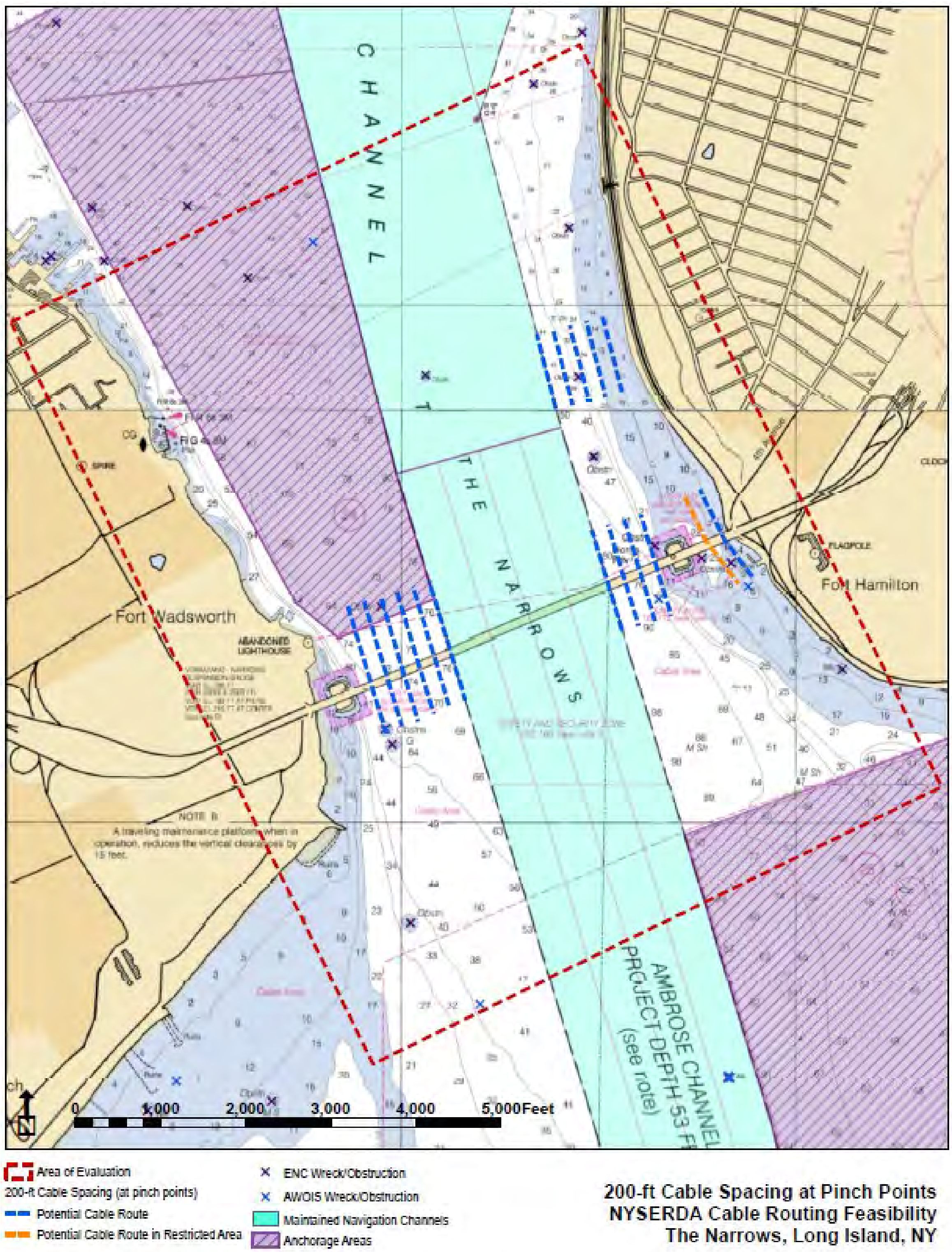


Figure 6-8. Cable Spacing of 200 ft through The Narrows

Source: WSP 2020; NOAA ENC 2018, 2020; NOAA RNC 2020. (See Annex B, Part 1: GIS Data Layer List for full list of figure references.)



6.2.2.8 Contaminated Sediments

Long Island

Contaminated sediments were examined and analyzed for shore approach and landing sites on Long Island; however, no major constraints were identified for these areas. For further detail, see Annex B, Part 3: Refined Route Feasibility Scoring Matrices.

New York City

New York City's waterways have elevated sediment contamination as a result of discharges for historic industrial activities as well as combined sewer overflows. In general, the longer the shore approach route though New York waterways the increased potential for contamination. The Hudson River itself is a DEC remediation area. Additionally, the Superfund sites of Gowanus Canal and Newtown Creek connect directly to Upper New York Bay and the Lower East River. A site that likely contains a reduced level of contaminates is Lower New York Bay, since it is outside of Upper New York Bay and further from historic industrial activities; however, potential for contamination still exists. Site-specific sediment sampling is likely necessary to confirm whether sediment contamination exists.

6.2.2.9 Cultural Resources and Wrecks/Obstructions

Long Island

Cultural resources and wrecks/obstructions were examined and analyzed for shore approach and landing sites on Long Island; however, no major constraints were identified for these areas. For further detail, see Annex B, Part 3: Refined Route Feasibility Scoring Matrices.

New York City

There are many shipwrecks in westernmost Long Island Sound and the northern East River. As a result, there is the potential for extensive SHPO review to ensure avoidance of cultural resources. The SHPO is likely to require that marine archeological surveys to be completed, which may reveal additional targets that are not currently mapped. Additionally, shore approach routes in New York City would also pass many sites of historical significance along the shoreline that would be within the viewshed of any installation activities. Accordingly, there is the potential for extensive SHPO review to ensure avoidance of visual impact from designated sites.

6.2.3 Constraints Analysis for Onshore Routes and Converter Station Sites

This section summarizes critical constraints applicable to the evaluated onshore routes, including potential converter station sites for HVDC circuits. The following Figures depict several of the GIS layers for the critical constraints considered in the feasibility assessment with respect to the onshore cable route segments and converter station sites (Figure 6-9 through Figure 6-11). Figure 6-9 shows several constraints for the onshore routes for cable interconnection to Long Island.

Figure 6-9. Constraints for Onshore Routes on Long Island

Source: WSP 2020; DNVGL 2020; PLATTS 2009; NHD 2018; NWI 1979; NYSDEC 1999; NRHP2017; NYSOGIS 2017; DEC CEA 2020; DEC Rem 2010; ESRI 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)

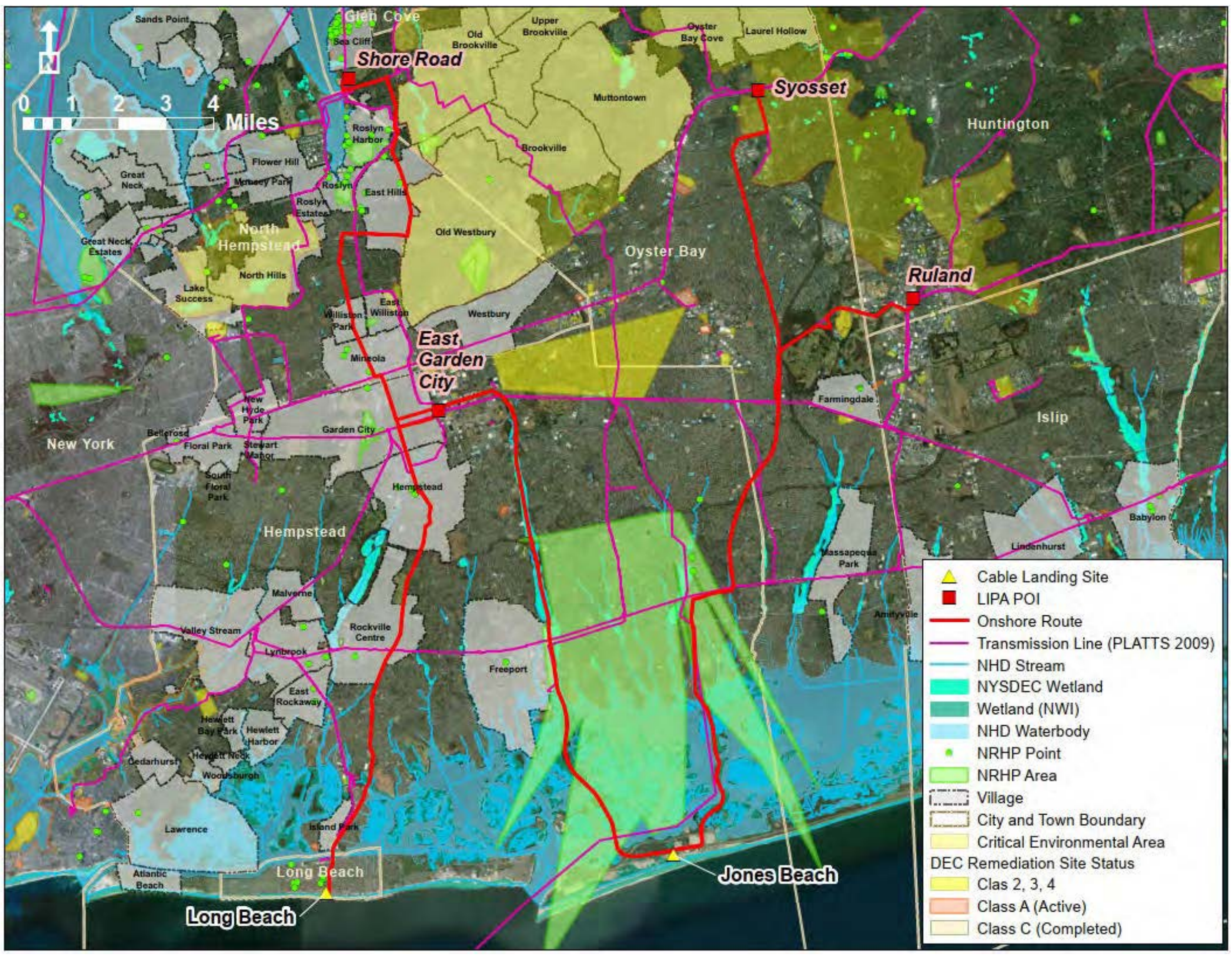


Figure 6-10 illustrates several constraints for the onshore routes in Brooklyn, Queens, and Manhattan for cable interconnection to New York City.

Figure 6-10. Constraints for Onshore Routes in Brooklyn, Queens, and Manhattan

Source: WSP 2020; DNVGL 2020; PLATTS 2009; NPMS 2006; NRHP2017; NYC Aqueducts 2020; NYC Subways 2017; NYC Sewer 2019; DEC Rem 2010; ESRI 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)

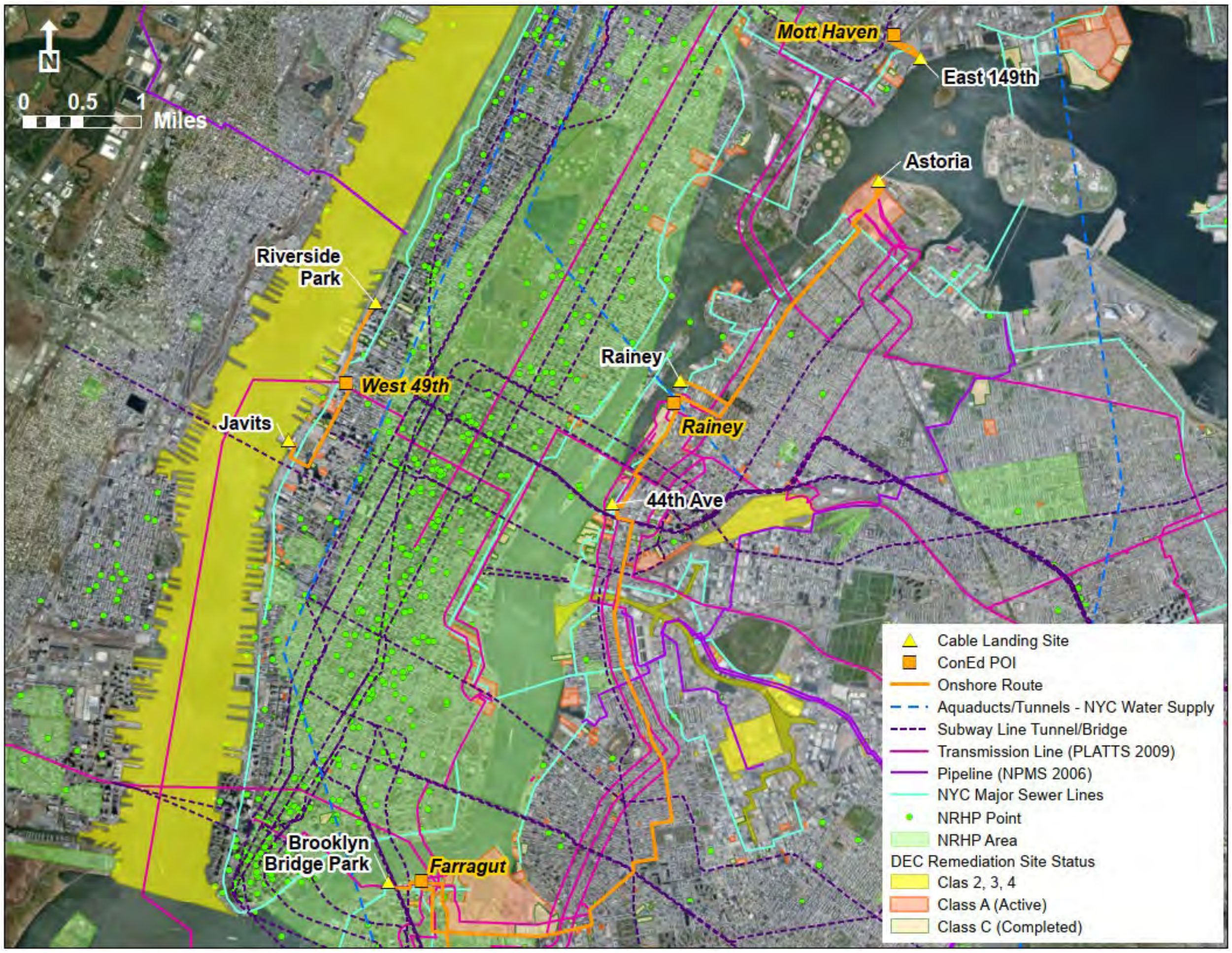


Figure 6-11 shows several constraints for the onshore routes in Brooklyn for cable interconnection to New York City.

Figure 6-11. Constraints for Onshore Routes in Brooklyn

Source: WSP 2020; DNVGL 2020; PLATTS 2009; NPMS 2006; NRHP2017; NYC Aqueducts 2020; NYC Subways 2017; NYC Sewer 2019; DEC Rem 2010; ESRI 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)

6.2.3.1 Infrastructure Crossings

<u>Long Island</u>

A majority of the existing transmission lines on Long Island are alternating current overhead cables that do not require infrastructure crossings to intersect. However, the highways and major arterial roads on Long Island represent a significant portion of the infrastructure crossings. The longer onshore routes have an increased number of infrastructure crossings. Jones Beach to Syosset has an extensive number of infrastructure crossings at 10 (Figure 6-12a). Nine out of 10 of those crossings are required because the Seaford-Oyster Bay Expressway has numerous small bridges that transect major and minor arterial roadways. Due to thermal constraints, the cables cannot be attached to the underside of the bridge and an HDD or other specialized drilling technique must be used to cross the roadway. The shortest Long Island onshore route, Long Beach to East Garden City, has the fewest infrastructure crossings, with only one.

The most constrained restriction point for onshore routes on Long Island is along North and South Long Beach Road for Long Beach Landing to East Garden City POI and Long Beach Landing to Shore Road POI (location C on Figure 6-13). The routes extend along this road for 3.65 miles and the road width ranges from 40-feet to 28-feet wide. The measurement is conservative and does not include sidewalks or grassy areas that may be contained within the ROW. From the public data available, there does not appear to be any colocation of other utilities along this ROW, still making it feasible for installation of two circuits. Additionally, both Shore Road routes (from Long Beach and Jones Beach) are constrained to two circuits at Glen Cove Avenue (location D on Figure 6-13). The remaining three Long Island routes are wide enough to support four to six circuits (Table 6-7).

New York City

Unlike Long Island, most of the infrastructure crossings in New York City were necessary to transverse existing utilities. Routes requiring the fewest infrastructure crossings are those for which the landing is close to the POI. These POIs include West 49th Street (one infrastructure crossing) and Rainey (one infrastructure crossing). Gowanus to Farragut and Brooklyn Bridge Park to Rainey onshore routes require the most infrastructure crossings, with eight and 13, respectively. Brooklyn Bridge Park to Rainey must cross Newtown Creek in addition to crossing the Buckeye Pipeline and an aqueduct as well as numerous other underground transmission lines and sewer utility lines (Figure 6-12b). Gowanus to Farragut also crosses an aqueduct and various underground transmission and sewer lines. It was expected that the longer route, Brooklyn Bridge Park to Rainey (7.91 miles) would have more infrastructure crossings than Gowanus to Farragut (4.94 miles). In addition to length, the crossings for Gowanus to Farragut are more condensed (crossing multiple existing utility lines per HDD) rather than spread out (crossing a single utility line per HDD) in the Brooklyn Bridge Park to Rainey route.

For the restriction point analysis on New York City onshore routes, the most constrained route portions are those originating and terminating at or near Farragut: Gowanus to Farragut and Brooklyn Bridge Park to Rainey (location G on Figure 6-14 and Table 6-7). The ROW bordering Farragut POI, John Street is about 42-feet wide for 0.19 miles. This width is enough to accommodate two circuits based on a review of

GIS data layers that indicate no other utility lines are present. The restriction points in the remainder of the New York City onshore routes are wide enough to support four circuits in horizontal alignment (Table 6-7).

Figure 6-12 (a and b). Onshore Routes for Long Island and New York City with the Highest Number of Specialized Crossings (Jones Beach to Syosset; Brooklyn Bridge Park to Rainey)

Source: WSP 2020; PLATTS 2009; NPMS 2006; NYC Aqueducts 2020; NYC Sewer 2019; ESRI 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)

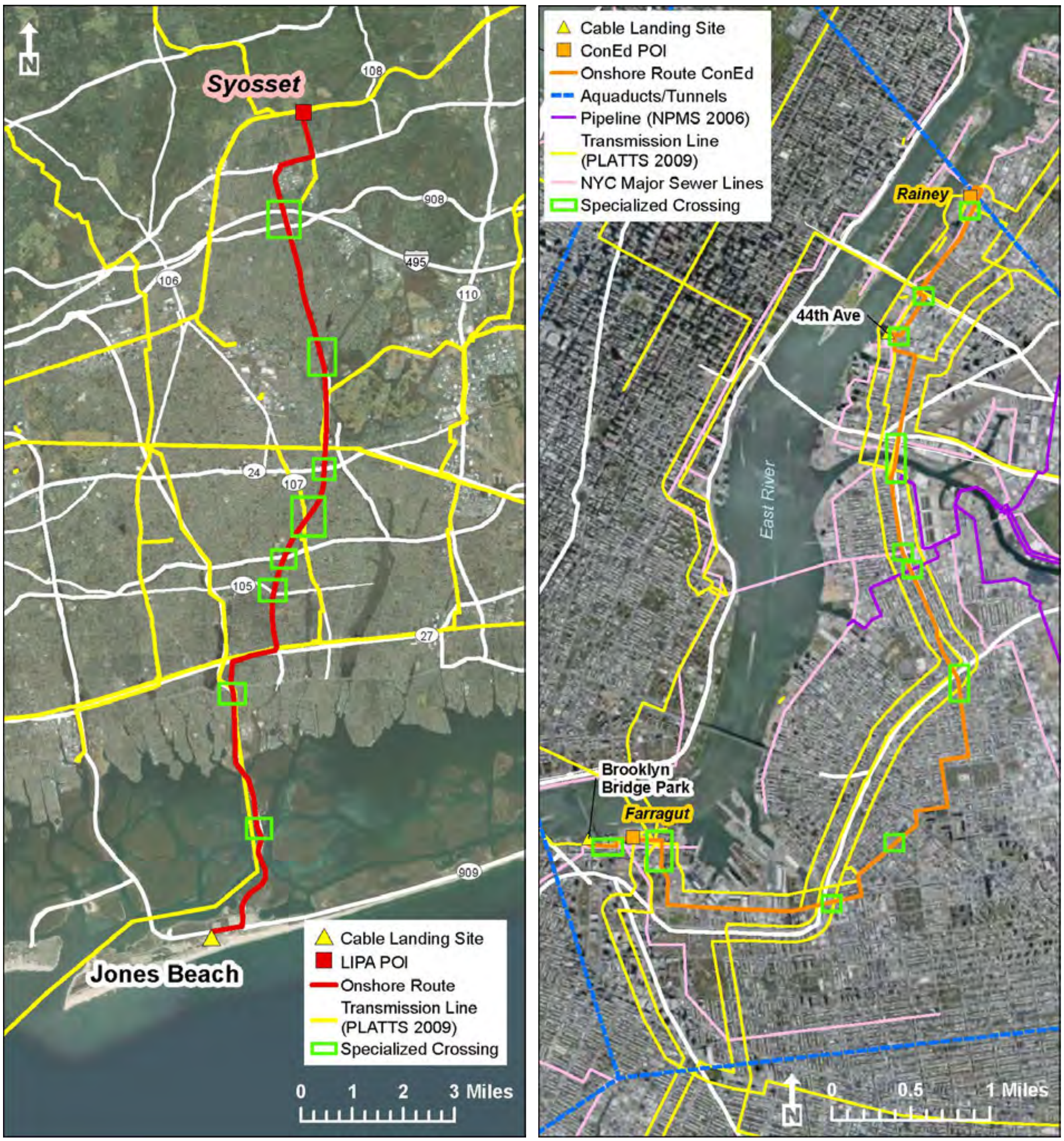


Table 6-7. Right-of-Way Restriction Point Results

Route	Restriction Point	Width[a] (feet)	Number of Circuits[b]	Letter in Figure 23 and 24
Jones Beach to Ruland Road	Wantagh Avenue	65	6	A
Jones Beach to Syosset	South Woods Road at Substation	42	4	B
Long Beach to East Garden City, Shore Road	N. Long Beach Road at McDermott Road	28	2	C
Jones Beach to Shore Road	Glen Cove Avenue	28	2	D
Jones Beach to East Garden City	Stewart Avenue	75	6	E
44th Avenue to Rainey	Vernon Boulevard	45	4	F
Gowanus to Farragut/Brooklyn Bridge Park to Rainey	John Street	20	2	G
Rainey Park to Mott Haven	35th Avenue between 12th and Vernon Boulevard	44	4	H
Javits Center Pier and Riverside Park to West 49th	West 49th	33	4	I

[a] Roadway only; does not include sidewalk or grassy right-of-way.
[b] Number based on horizontal alignment; potential for more with vertical alignment.

Figure 6-13. Location of Right-of-Way Restriction Point Results on Long Island

Note: Blue letters match road widths presented in the table above.

Sources: WSP 2020; PLATTS 2009; ESRI 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)

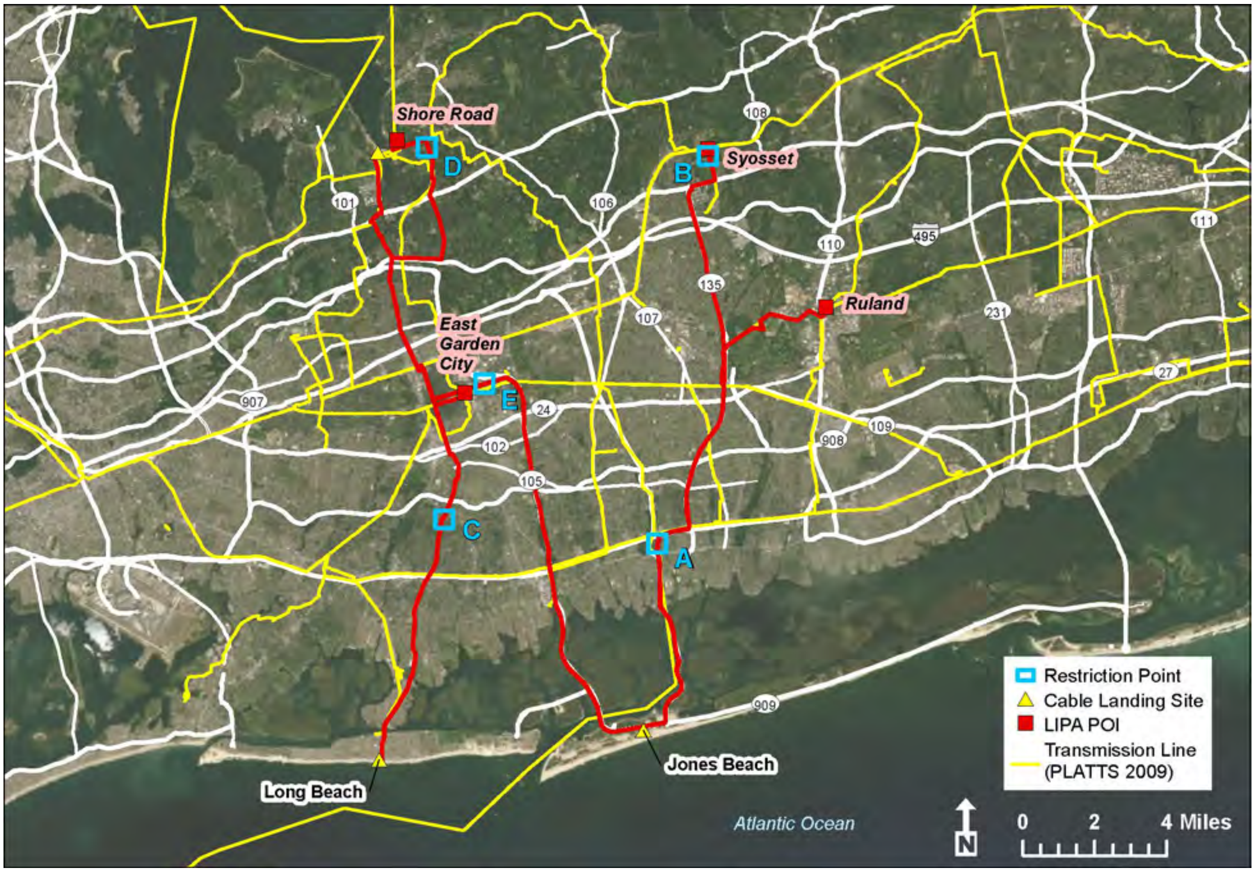
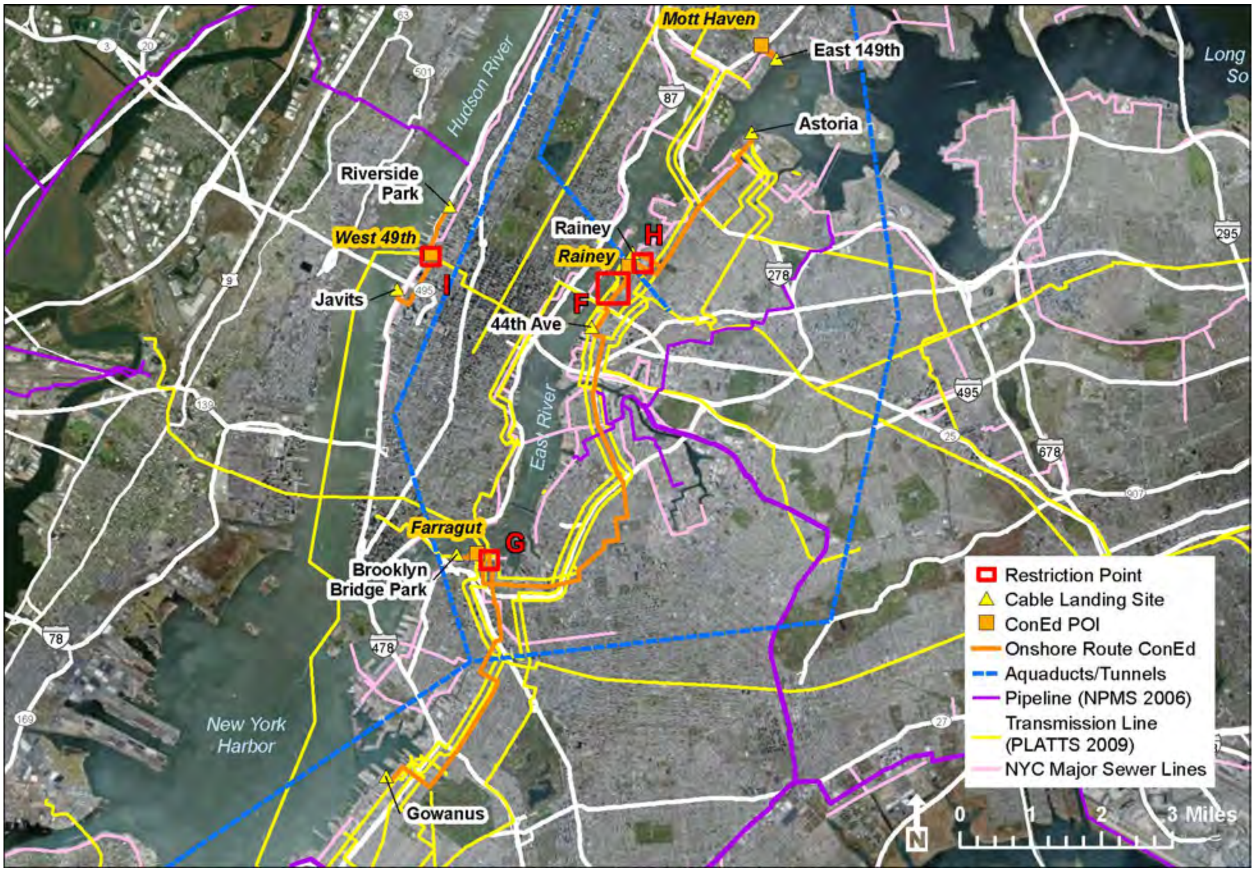


Figure 6-14. Location of Right-of-Way Restriction Point Results in New York City

Note: Red letters match road widths presented in the table above.

Sources: WSP 2020; PLATTS 2009; NPMS 2006; NYC Aqueducts 2020; NYC Sewer 2019; ESRI 2020. (See Annex B, Part 1: GIS Data Source List for full list of figure references.)



6.2.3.2 Wetlands and Sensitive Habitats

<u>Long Island</u>

Overall, the more developed an area, the less existing wetlands and sensitive habitats. Therefore, the Long Island routes that cross the least wetlands and sensitive habitats are those landing in Long Beach and terminating at East Garden City and Shore Road POIs. While the back-bay crossings of Long Beach to East Garden City and Long Beach to Shore Road pass through Important Bird Areas and mapped National Wetlands Inventory areas, these crossings are few in number and relatively short. Long Beach to Shore Road also passes through some of the Tidal Wetlands Boundary. Onshore Long Island routes that cross the most wetlands and sensitive habitat are those that extend from Jones Beach along the Meadowbrook Parkway: Jones Beach to East Garden City and Jones Beach to Shore Road. The three back bay crossings are similar to those on the Jones Beach Causeway routes; however, once on land the

Meadowbrook Parkway is surrounded by the wetlands of Meadowbrook Creek for just over five miles. All the locations where routes pass through wetlands or sensitive habitat do so within the boundaries of existing infrastructure and impact to these areas should be minimal.

New York City

Wetlands and sensitive habitats were examined and analyzed for onshore routes in New York City; however, no major constraints were identified for these areas. For further detail, see Annex B, Part 3: Refined Route Feasibility Scoring Matrices.

6.2.3.3 Potential Stakeholder Concerns

Long Island

In part due to the increased length of onshore routes on Long Island, the potential for stakeholder concerns are greater than in New York City. The longest onshore route, Jones Beach to Shore Road has highest potential for stakeholder concerns. The Jones Beach to Shore Road route crosses through nine local municipalities. Nearly three quarters (13.07 of 17.89 miles) of the Jones Beach to Shore Road route also crosses low- and medium-intensity developed land, which was assumed to be indicative of residential areas, including single-family homes. Though the Jones Beach to Syosset route is not one of the longest routes analyzed, more than 70% (13.33 of 18.48 miles) of the route crosses low- and medium-intensity developed land. Increased distances through the low- and medium-intensity developed land is expected to potentially affect more residential areas, thereby increasing the potential for stakeholder concerns from homeowners and tenants along the route.

New York City

Potential stakeholder concerns were examined and analyzed for onshore routes in New York City; however, no major constraints were identified for these areas. For further detail, see Annex B, Part 3: Refined Route Feasibility Scoring Matrices.

6.2.3.4 Contaminated Sites

Long Island

The presence of contaminated sites was examined and analyzed for onshore routes on Long Island; however, no major constraints were identified for these areas. For further detail, see Annex B, Part 3: Refined Route Feasibility Scoring Matrices.

<u>New York City</u>

New York City has a much higher concentration of contaminated sites than Long Island. The routes of East 149th to Mott Haven and Riverside Park to West 49th do not skirt or intersect any contaminated sites. Rainey Park to Mott Haven lands and transverses through the DEC Remediation Site CE Astoria manufactured gas plant. The contaminants of concern on the site are coal tar, its components (benzene, toluene, ethylbenzene, xylene, and polycyclic aromatic hydrocarbon), and PCBs. This route would require consultation and permitting with the State Superfund Program. Another route, Brooklyn Bridge Park to Rainey, borders much of the DEC Remediation Site the Brooklyn Navy Yard Industrial Park. Contaminants of concern found on this site are arsenic, benzo(a)pyrene, mixed xylene, PCBs, lead, and naphthalene, but because the analyzed route not crossing into the site, consultation and permitting by the Volunteer Cleanup Program may not be required. Another area of concern along the Brooklyn Bridge Park to Rainey route is the DEC Remediation Site Newtown Creek. Contaminants of concern for this site include PCBs and heavy metals from oil storage facilities, inactive hazardous waste disposal sites, active manufacturing facilities, spills, and other uncontrolled sources from the industry in the upland areas surrounding its banks. Specialized crossing through Newtown Creek would require consultation and permitting with the State Superfund Program.

6.2.3.5 Cultural Resources

<u>Long Island</u>

For all routes, the onshore cables would be installed in the public ROW alongside an NRHP site or National Historic Landmark but would not directly impact the sites. All routes originating at the Jones Beach landing site cross significant portions of Jones Beach State Park and the Causeways and Parkways System. Additionally, Jones Beach to Ruland Road traverses some of Beth Page State. Since the representative routes are colocated with existing public ROW to the extent practicable, impact on cultural resources should be minimal.

<u>New York City</u>

Brooklyn and Manhattan counties have more dense areas of NRHP and NYS National Register sites than Queens and the Bronx. Onshore New York City routes that avoid most cultural resources are Riverside Park to West 49th and East 149th to Mott Haven. Gowanus to Farragut is one of the routes that physically intersects the most NYS National Register sites including Greenwood Cemetery, Fort Green Historic District, and DUMBO Industrial District. Brooklyn Bridge Park to Rainey also passes through the Fulton Ferry District, DUMBO Industrial District, along Brooklyn Navy Yard, and under the Queensboro

Bridge. Similar to Long Island, the rest of the routes may skirt or pass NRHP sites or parks, but impact to the actual sites should be minimal.

6.2.3.6 Converter Station Parcels

<u>Long Island</u>

Overall, there were more available parcels on Long Island. Parcel size requirements were mostly smaller on Long Island due to the ability to use HVAC (except for Jones Beach to Ruland Road) instead of the HVDC needed for the New York City routes. However, only one suitable option was identified for the Jones Beach to Syosset route. The POIs with the most viable transformer station options were Shore Road and East Garden City POIs from both Long Beach and Jones Beach landings.

<u>New York City</u>

The extremely dense development in New York City presented significant obstacles for successfully converting direct current to alternating current. The lack of available converter station parcels in New York City prevented some routes from being advanced for further analysis and consideration from the screening-level stage. A real estate planning firm, BJH advisors, was engaged to conduct a more thorough search for suitable parcels in New York City. Onshore routes that crossed through Queens presented the most number of feasible parcel options, including 44th to Rainey (five locations), Brooklyn Bridge Park (five locations) to Rainey, and Rainey Park to Mott Haven (nine locations).

6.2.3.7 Parkway/Highway Permitting

<u>Long Island</u>

Parkways, highways, and expressways were used heavily when routing on Long Island to avoid wetlands, sensitive habitats, and residential areas. Although Long Beach to Shore Road and Long Beach to East Garden City are not short routes, they each only intersect two highways, Sunrise Highway, and Southern State Parkway. The longest colocation of a cable route with a highway are Jones Beach to Syosset at 14.66 miles (4.92 miles on the Wantagh Parkway and 9.74 miles on the Seaford-Oyster Bay Expressway). These routes would likely require extensive consultation and permitting with the New York State Parks, DOT, and FHWA.

<u>New York City</u>

Parkway/highway intersection in New York City onshore routes is less when compared to Long Island. Gowanus to Farragut and Brooklyn Bridge Park to Rainey routes were the most constrained for highway permitting. When routing cables from Gowanus to Farragut, the Brooklyn Queens Expressway would be crossed under twice and the Prospect Expressway once. Similarly, the Brooklyn Bridge Park to Rainey route would cross under the Brooklyn Queens Expressway twice, the Long Island Expressway once, and the Queensboro Bridge once. Since these routes are crossing under the expressways and not directly impacting the roadway, permitting should be less involved than what is necessary on Long Island.

6.2.4 Synthesis and Summary of Findings

This Routing Assessment identified and evaluated the environmental and permitting challenges associated with bringing offshore wind energy to existing onshore substations (i.e., POIs). This was accomplished by identifying potentially feasible routes and landing areas to connect offshore power inputs with onshore POIs; evaluating the environmental and permitting challenges for the representative routes and landing sites; and determining the major environmental constraints that might adversely impact the illustrative transmission strategy.

The iterative feasibility assessment process included an initial screening level analysis performed to identify critical environmental and permitting constraints associated with potential routes from offshore wind lease areas to POIs, followed by a more detailed analysis for a refined set of representative routes to confirm the feasibility of an illustrative OSW transmission strategy for injecting 6 GW into New York City POIs and 3 GW into Long Island POIs. Supporting analyses were conducted to identify the approximate number of cables that could be installed through restricted points along the potential cable routes/corridors.

The overall environmental and permitting feasibility of the refined set of representative routes is summarized for interconnections with Long Island POIs and New York City POIs, including comparative ranking to identify more favorable route alternatives at a screening level and highlight the permitting challenges in terms of the major route constraints. This is followed by a set of declarative statements that summarize several findings of this Routing Assessment.

It is noted that not all route alternatives were included in the refined analysis, and the representative routes do not necessarily reflect a preferred or optimal solution for the transmission strategy. Other potentially feasible routes were identified in the preliminary route feasibility analysis, such as alternative routes to Long Island and New York City POIs through Long Island Sound, particularly recognizing the strong POIs in the City’s northern boroughs and cumulative constraints associated with longer cables in constrained waterways through New York Harbor. However, the refined set of representative feasible routes was developed for illustrative purposes.

6.2.4.1 Refined Routes Constraint Summary

The scoring matrices for the refined set of representative routes (see Annex B, Part 3: Refined Route Feasibility Scoring Matrices) reflect adjustments that improved the feasibility of certain routes, such as shifts to avoid colocating with long sections of railway. Potentially major constraints were still identified for most identified routes. However, these challenges may be overcome with suitable planning and outreach efforts. Thus, the results of the analysis for these routes supports a finding that the representative transmission strategy is feasible.

For routes to Long Island POIs from an Atlantic North Corridor or Atlantic Central Corridor, potentially major constraints along the offshore and shore approach segments include DoD operation area crossings, numerous infrastructure (utility) crossings, multiple or extensive sensitive habitats, navigation channel and/or USACE Coastal Storm Risk Management project crossings, and potential concerns from fisheries and/or coastal communities. Potentially major constraints along the onshore segments for several routes include infrastructure crossings (e.g., roadways requiring HDD), numerous stakeholders (i.e., routes through or near multiple municipalities and/or residential areas), and an extensive permitting process associated with colocating along parkways and highways. For some route segments, the presence of wetlands or other sensitive onshore habitat, the proximity of multiple designated cultural resources, or the limited availability of suitable converter/transformer station land were also major routing constraints. Further, onshore route distances of 15 miles or longer were considered a major constraint for some routes as distance increases the risk of encountering multiple and/or unanticipated challenges.

For routes to New York City POIs from the Atlantic South Corridor or Atlantic Central Corridor, potentially major offshore constraints include numerous crossings of linear infrastructure (utilities) and designated marine zones (e.g., traffic lanes and danger zones). Potentially major constraints exist in every critical constraint category for the nearshore approach segment of the routes through New York Harbor to New York City POIs, including marine geology, landing site complexity, presence of sensitive habitat, multiple infrastructure crossings (e.g., linear utilities and tunnels), numerous navigation channels/anchorages, potentially high levels of sediment contaminants, high likelihood of requiring additional regulatory approval from New Jersey, numerous submerged wrecks/obstructions, and high likelihood of concerns from some stakeholders (e.g., marine vessel operators). The major constraints for onshore portions of the routes vary greatly depending primarily on the length of the onshore segment. The number of major infrastructure crossings (e.g., roadways requiring HDD), the presence of multiple designated cultural resources, permitting requirements for colocating with parkways/highways, and the limited availability of suitable converter station land are examples of major constraints that affect some of the routes to New York City.

Because several of these routes are necessary to support the illustrative transmission strategy examined in this Routing Assessment, overall ranking of the refined set of representative routes was not warranted. However, while all the refined routes are potentially feasible, a comparison of scores for two route options leading to the same POI can be informative for considering which option would be more challenging. These differing scores mainly reflect different landing site alternatives. For example, routing to the East Garden City POI via Jones Beach is considered more constrained overall than routing via Long Beach partly because of greater number of wetlands/sensitive habitats, more navigation channel crossings, higher likelihood of stakeholder concerns, and permitting requirements for extensive colocation with parkways/highways. Still, the Long Beach landing poses more challenges than the Jones Beach landing, such as more infrastructure crossings and higher likelihood of stakeholder concerns for the shore crossings.

For multiple routes to a single New York City POI, the route option that scores better overall (i.e., has fewer constraints) is generally the route that has a shorter onshore segment—although they typically have a longer shore approach segment. The routes with the longer onshore segments provide feasible alternatives, should further investigation and stakeholder outreach indicate that routes with a longer shore approach segments are more challenging than anticipated.

6.2.4.2 Findings

The Routing Assessment supports the following declarative statements regarding routing transmission cables from offshore wind energy areas to New York State POIs:

- The Planning Study's illustrative transmission strategy (6 GW to New York City and 3 GW to Long Island), which assumes four POIs in New York City and four POIs on Long Island, is feasible in terms of cable routing.

- There is enough space along the representative onshore routes to accommodate the cables needed to support the illustrative transmission strategy. A maximum of two to six, two-cable HVDC or three-cable HVAC circuits can likely be accommodated at the narrowest (i.e., most restricted) points of the analyzed onshore routes.

- Siting six cables through New York Harbor to the representative POIs identified as part of the transmission strategy is feasible given suitable planning and coordination with the maritime community, but each individual cable (or circuit) installation becomes cumulatively more challenging.

- Major environmental and permitting constraints identified for cable routing through the representative offshore route corridors are as follows:
  - Infrastructure Crossings (linear utilities)
  - Designated Marine Zones
  - DoD Areas
- Major environmental and permitting constraints identified for cable installation along the shore approach and landing segments of the representative cable routes are as follows:
  - Long Island
    - Infrastructure Crossings (i.e., linear utilities)
    - Presence of Sensitive Species or Habitat
    - Potential Stakeholder Concerns (e.g., fisheries/coastal communities)
    - Landing Site Complexity (e.g., back-bay crossings)
    - USACE Coastal Storm Risk Management Projects
  - New York City
    - Infrastructure Crossings (i.e., linear utilities)
    - Marine Geology and Oceanography (e.g., seabed, erosion, bedforms)
    - Further Regulation (i.e., additional state approval requirements)
    - Potential Stakeholder Concerns (e.g., maritime community)
    - Landing Site Complexity (e.g., shore structure crossings, dense development)
    - Navigation Channels and Anchorage Areas
    - Contaminated Sediments
    - Cultural Resources and Wrecks/Obstructions
- Major environmental and permitting constraints identified for cable installation along the onshore segments of the representative cable routes are as follows:
  - Long Island
    - Infrastructure/Specialized Crossings
    - Wetlands; Sensitive Habitats
    - Jurisdictions/Stakeholders
    - Cultural Resources
    - Available Land (Converter/Transformer Station)
    - Parkway/Highway Permitting
  - New York City
    - Infrastructure/Specialized Crossings
    - Contaminated Sites
    - Cultural Resources
    - Available Land for Converter Station
    - Parkway/Highway Permitting

7 Detailed Analysis of OSW Connection Concepts

In parallel with the onshore assessment task, the initial offshore assessment was completed as described in Section 4. Subsequent to the onshore assessment and initial offshore assessment, the environmental constraints analysis was completed as described in Section 6. Each of these Study tasks provided results and initial observations, which facilitated a more detailed evaluation of OSW connection concepts and their associated costs and benefits.

7.1 Basis for Detailed Analysis

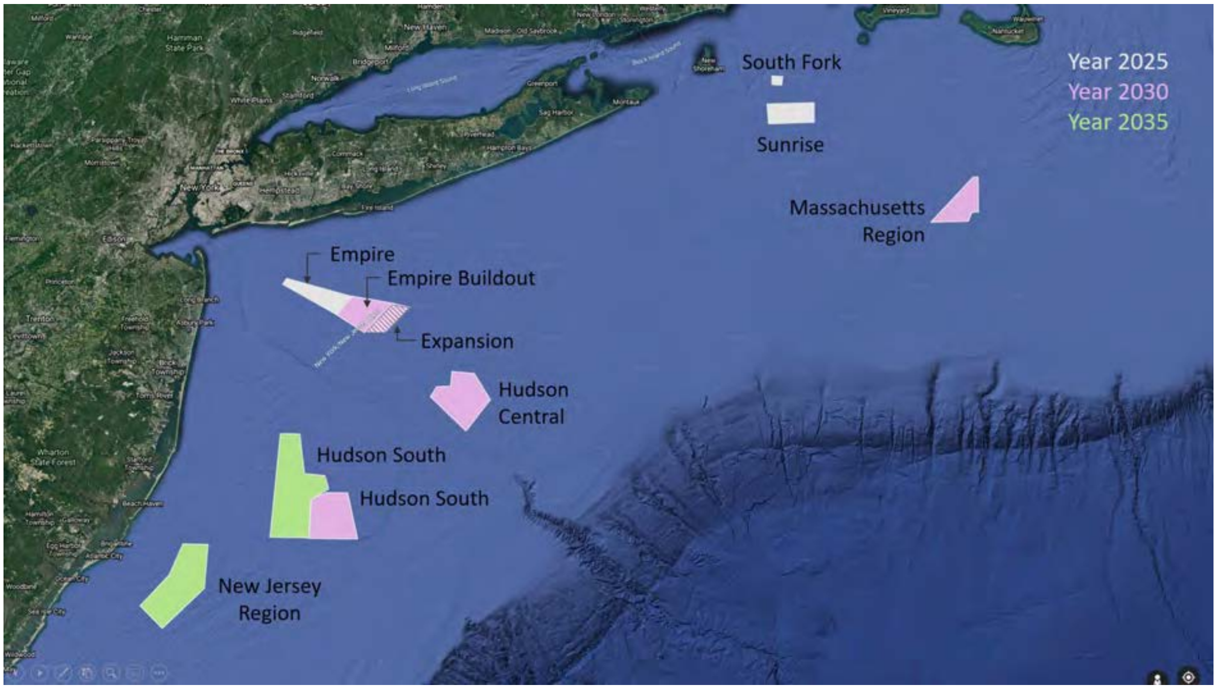
In order to complete a more detailed assessment of OSW connection concepts, it was necessary to re-evaluate initial OSW connection concepts considering findings associated with cable routing limitations, identified feasible landing areas, and onshore POIs as presented in sections 3 and 6. As part of this detailed assessment, the Study elected to focus attention on just one OSW build-out scenario (out of the five OSW build-out scenarios previously defined and presented in Annex C), as shown in Figure 7-1, with the following labeling of lease areas.

2025 Study Year	2030 Study Year	2035 Study Year
South Fork (So) Sunrise (Su) Empire (E)	Massachusetts Region (L) Empire (E) Buildout Empire (E) Expansion Hudson Central (HC) Hudson South (HS) I	Hudson South (HS) II New Jersey Region (A)

The decision to focus on one illustrative OSW build-out scenario was made to reduce complexity since the preliminary OSW connection assessment concluded that OSW project location uncertainty, as represented in the Study by the five differing OSW build-out scenarios considered, does not materially impact the relative performance of the five OSW transmission connection concepts. Thus, it is expected that the overall Study conclusions would not vary if a different future OSW build-out scenario were selected for this detailed OSW connection concept analysis.

The selection of one illustrative future OSW build-out scenario is not indicative of a State Team preference or recommendation by the Study authors.

Figure 7-1. OSW Project Locations for Detailed Analysis of OSW Connection Concepts



The onshore assessment and environmental and permitting analysis identified limitations and opportunities that frame the offshore concepts interfaces. Starting from the OSW project arrangement illustrated in Figure 7-1, topology concepts for the OSW connections were fine-tuned iteratively, considering the following:

- Onshore POIs with sufficient available additional injection capacity as determined by the analysis presented in Section 3 to avoid and/or minimize the onshore grid upgrades.
- Restrictions of the available cable trenches, especially to New York City, according to Section 6.
- Limitations of the lease area size and the corresponding maximum offshore capacity that can be assumed from these areas.

Figure 7-2 exhibits the injection levels to be used for each POI in New York City and Long Island as identified in Section 3, Scenario 2.

Figure 7-2. OSW MW Injection Levels for Select Onshore POIs for Study Year 2035 (Does not Reflect Offshore Power Already Procured for 2025)

As concluded from the preliminary analysis presented in Section 5, the detailed analysis of OSW connection concepts focuses on Radial, Meshed, and Backbone configurations. Design characteristics of each of the shortlisted connection variants are summarized in Table 7-1 for ease of comparison. Each of the three variants is discussed in more details in the following subsections.

Table 7-1. Details of Three Illustrative Connection Concept Variants

Variant	V1	V2	V3
Connection concept	**Radial**	**Meshed**	**Backbone**
Total cable system length (HVAC / HVDC)	732.8 mi (176 mi / 556 mi)	891.7 mi (335 mi / 556 mi)	913.5 mi (345 mi / 576 mi)
Maximum rated capacity	7,200 MW added to already procured 1,826 MW = 9,026 MW	7,200 MW added to already procured 1,826 MW = 9,026 MW	7,200 MW added to already procured 1,826 MW = 9,026 MW
Connection technology	220kV AC 320kV DC	220kV AC 320kV DC	220kV AC 320kV DC
Need for onshore transmission reinforcement	No	No	No
Required number of trenches NYC/LIPA	6/7	6/7	6/7
Max. MW injection to the POIs	1,310 MW	1,310 MW	1,310 MW
Degree of redundancy	Intra OSW partial redundancy for 2 AC connected OSW projects[9]	Intra OSW partial redundancy for 2 AC connected OSW projects Inter OSW partial redundancy for 4 OSW projects[10]	Intra OSW partial redundancy for 3 AC connected OSW projects Inter OSW partial redundancy for 4 OSW projects

7.2 Variant 1 (Radial)

Under the Radial Connection Concept (Variant 1) shown in Figure 7-3, all OSW projects will be connected to the grid separately using dedicated lines. Grid connection technology was selected depending on the distance between lease areas and the offshore grid. For lease areas located within 70 miles radius of the relevant onshore POIs, 220kV HVAC technology was considered while ±320kV HVDC technology (symmetric monopole) was assumed for those located outside the 70 miles radius.

Due to the power rating limitation of the HVAC cables, two HVAC connection cables are required for each of the two OSW projects of lease area E, resulting in partial redundancy for these two OSW projects.

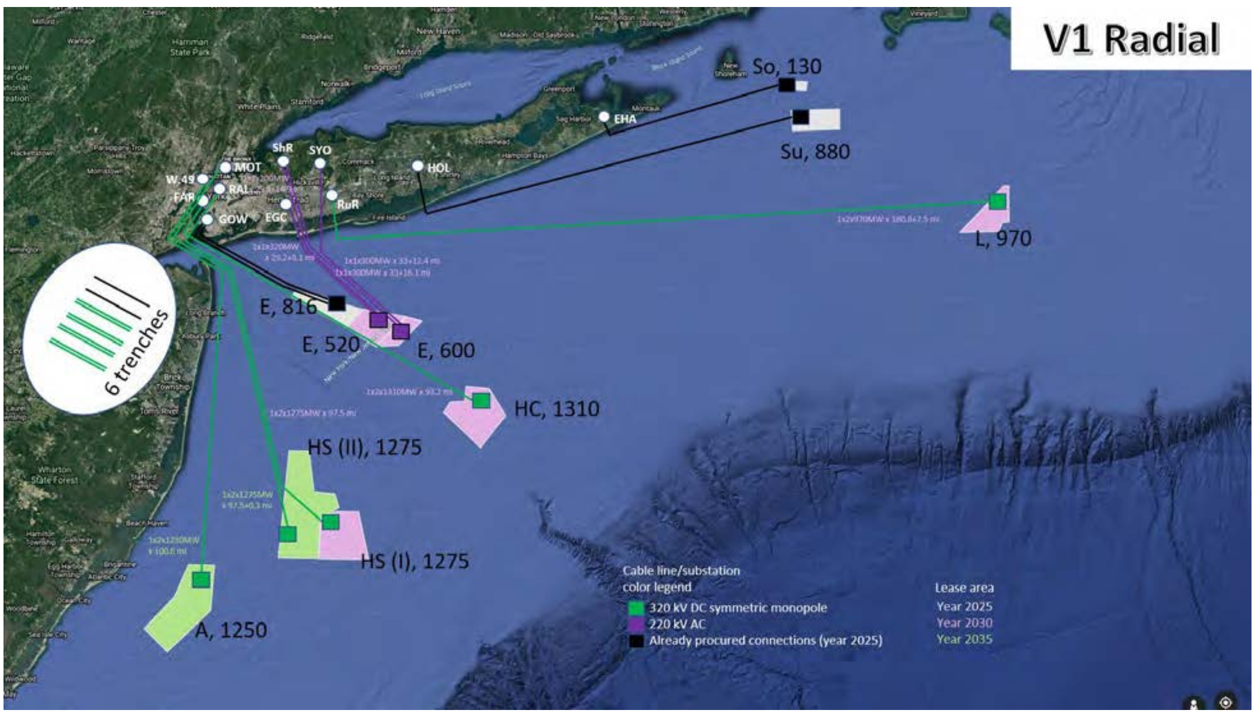
[9] For all Variants, partial redundancy is inherent with the two 2030 OSW projects of Lease Area E (connected to LI). In case of an outage of one cable, up to a certain wind speed level the remaining cable can carry a part of the energy of the damaged cable. While this does not fulfill the N-1 principle it does provide a partial redundancy.

[10] For Variant 2 and 3, partial redundancy is inherent for the four OSW projects connected to NYC given that between these projects is 220 kV HVAC connections. In case of an outage of a grid connection, up to a certain wind speed level the generated wind energy can be redistributed to the remaining grid connections. However, since no over ratings are considered, the redistribution is not possible at higher wind speeds. Thus, while this does not fulfill the N-1 principle it does provide a partial redundancy.

In addition, by converting the two HVDC pole cables, used for OSW projects in lease area A, HS and HC, into a bundled cable, each HVDC circuit from these lease areas occupy only one cable trench reducing the total number of trenches for AC and DC cables to 6. This connection topology meets the six-trench constraint to NYC identified in Section 6. In total, the cable length of Variant 1 amounts to 733 miles, consisting of 176 miles of HVAC cable and 557 miles of HVDC cable.

It should be noted that, in order to comply with the restrictions on the number of available cable trenches and the identified onshore POI MW injection levels, as obtained from the parallel analyses presented in Section 3 and 6, and still be able to use a Radial solution, the OSW total power assigned to individual lease areas for Study years 2030 and 2035 was adjusted compared to what was initially assumed in the initial OSW build-out scenarios.

Figure 7-3. Variant 1 (Radial) Connection Concept, Study Year 2035

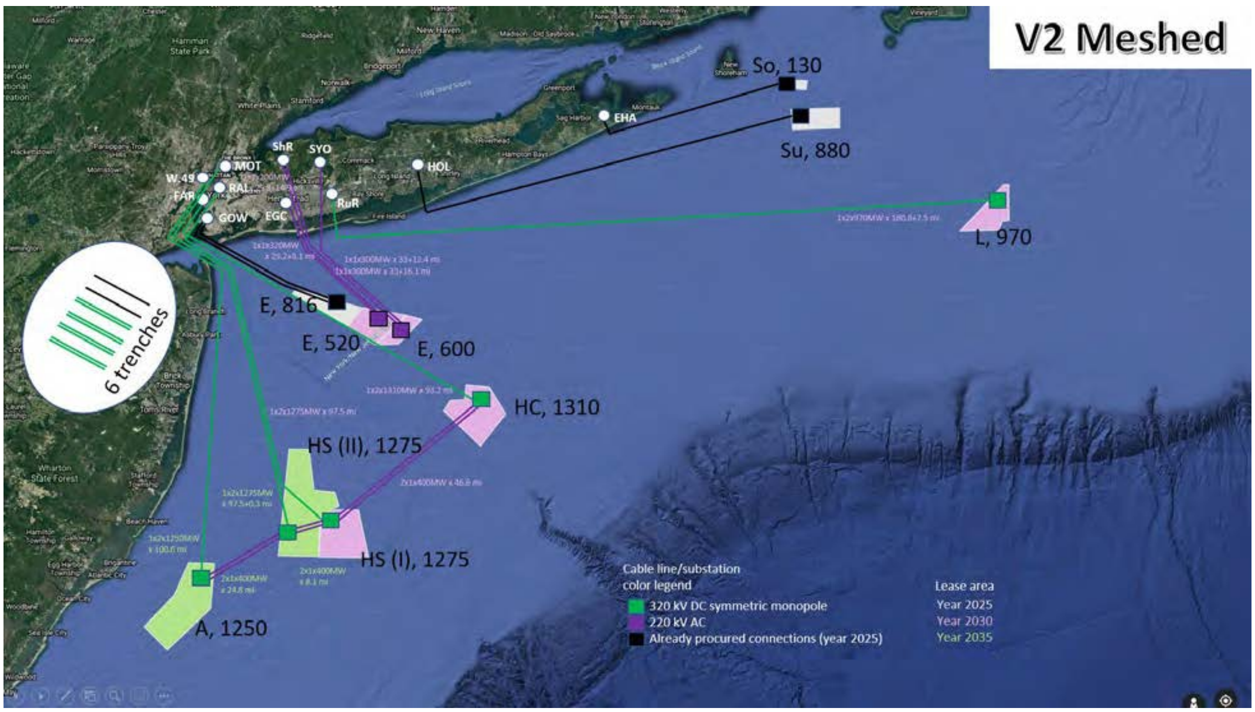


7.3 Variant 2 (Meshed)

The Meshed Connection Concept (Variant 2) shown in Figure 7-4 is similar to the Radial Connection Concept (Variant 1), with additional 220 kV AC double circuits between Lease Sites A, HS (II), HS (I), and HC. Similar to Variant 1, HVAC technology was assumed for lease areas within 70-mile radius of relevant onshore POIs. The additional 220 kV AC circuits are intended to increase the degree of redundancy of the grid connections and thus the availability of the OSW projects. For this Variant 2 concept, apart from the additional 220kV AC circuits connecting the lease areas, the offshore platform designs for the corresponding OSW projects would also have to be larger and equipped with an additional 220 kV busbar and transformer bays, as compared to Variant 1.

This design meets the six-trench constraint to NYC via the Narrows identified in Section 6. The total cable length of Variant 2 amounts to 893 miles, consisting of 336 miles of HVAC cable and 557 miles of HVDC cable.

Figure 7-4. Variant 2 (Meshed) Connection Concept, Study Year 2035

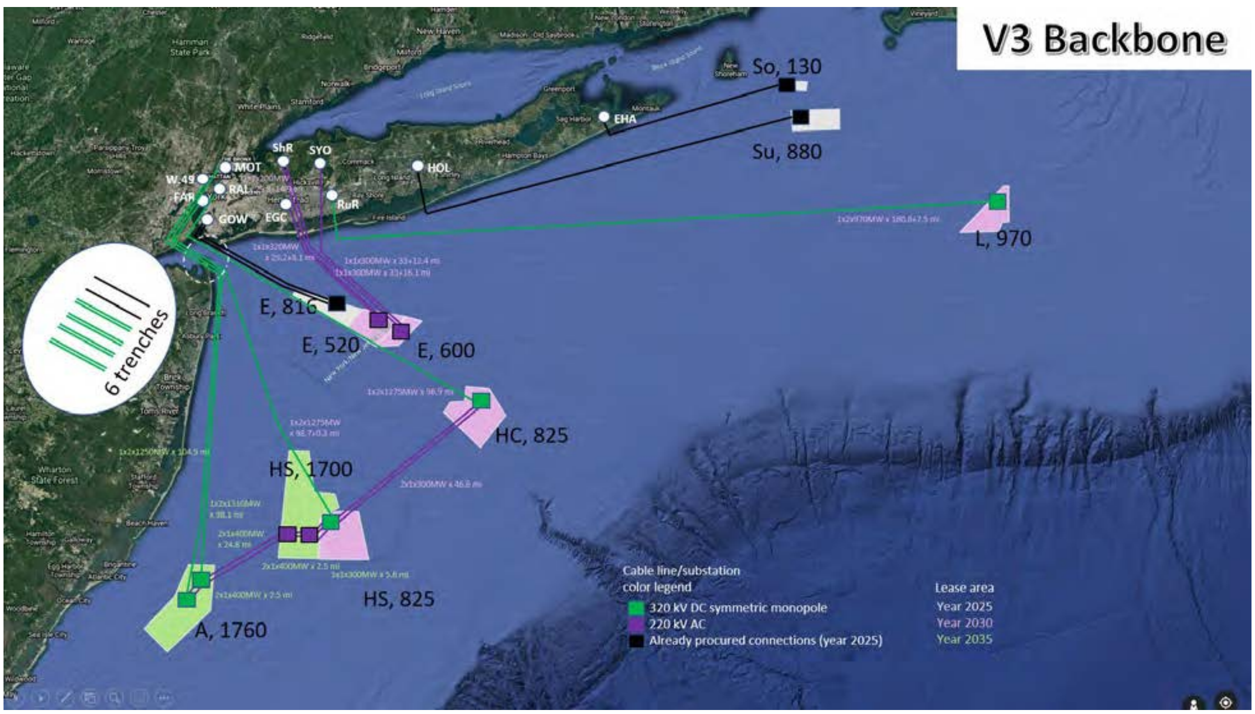


7.4 Variant 3 (Backbone)

The Backbone Connection Concept (Variant 3) shown in Figure 7-5 is the third of the shortlisted offshore topology concepts being evaluated for collecting and delivering OSW power. The offshore lease areas E and L are connected identically as compared to Variants 1 and 2. For the other lease areas, not all hypothetical OSW projects receive a stand-alone grid connection. Rather, the ±320 kV HVDC grid connections for OSW projects labeled as A 1,760, HS 825, and HC 825 are assumed to be oversized to be able to transfer the rated power of the OSW project HS 1,700 to New York City. Compared to Variants 1 and 2, this connection concept includes the installation of additional two offshore platforms, one HVDC converter platform for A 1,760 and one HVAC platform for HS 1,700 (showing in total two HVAC platforms for the Backbone concept) in order to be able to divide the power between the New York City POIs, to comply with the POIs' MW injection limits while retaining the ±320 kV HVDC maximum power transfer limit of 1,400 MW. To distribute the output power of HS 1,700 to the other outlets, double 220 kV HVAC submarine cables are assumed, similar to Variant 2, resulting in a partial redundancy and slightly increased availability.

Similar to other variants, Variant 3 converts the two HVDC pole cables to a bundled cable in a single trench allows the design to meet the six-trench constraint to New York City identified in Section 6. In total, the cable length of Variant 3 amounts to 914 miles, consisting of 346 miles of AC cable and 568 miles of DC cable.

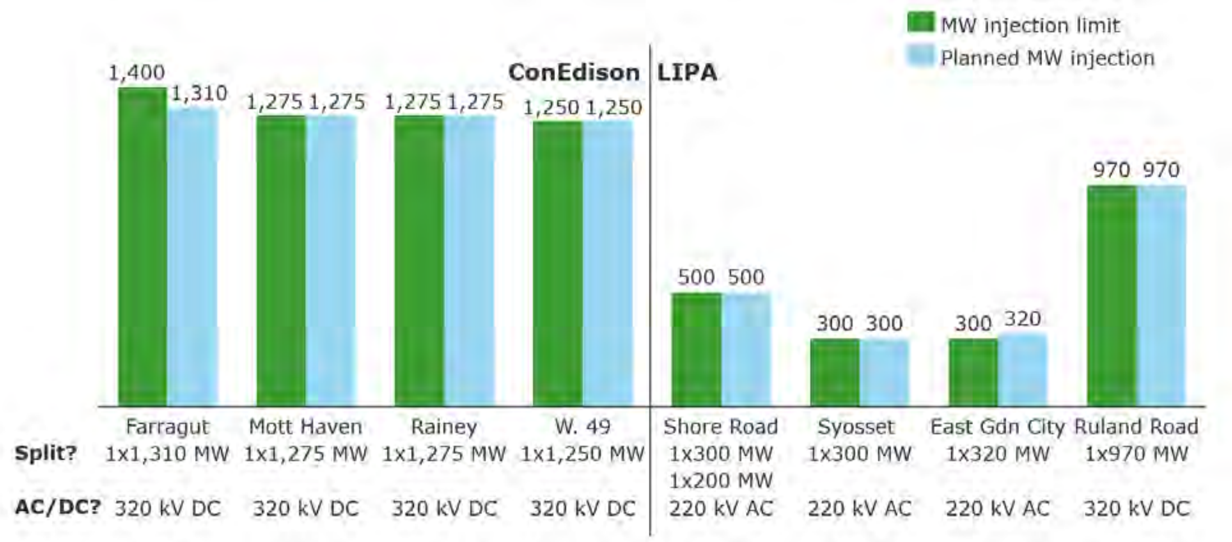
Figure 7-5. Variant 3 (Backbone) Connection Concept, Study Year 2035



7.5 Planned MW injections into the POIs

Figure 7-6 illustrates the magnitude of offshore power that is connected to each individual onshore POI for Study Year 2035 as the result of OSW connection concepts Variant 1 (Radial), Variant 2 (Meshed) and Variant 3 (Backbone). None of the POIs' MW injection limits are exceeded except for a marginal excess at East Garden City (20 MW). The OSW power split between New York City and Long Island is 5,926 MW and 3,100 MW, respectively for the full 9.026 GW build-out of OSW considered.

Figure 7-6. OSW Power Connected to Each Shortlisted POI Under Variant 1 (Radial), Variant 2 (Meshed) and Variant 3 (Backbone) Connection Concept, Study Year 2035



As shown in Figure 7-3 throughFigure 7-5, all 3 Variants use the same connection configuration for POIs on Long Island.

Specific to NYC, Variant 1 and Variant 2 use the following connection configuration:

- OSW project HC 1310 MW to Farragut substation
- OSW project HS (I) 1275 MW to Rainey substation
- OSW project HS (II) 1275 MW to Mott Haven substation
- OSW project A 1250 MW to West 49 substation

Specific to NYC, Variant 3 uses the following connection configuration:

- OSW project HC 825 MW via 1275 MW cable connection (which carries energy from other OSW projects) to Rainey substation
- OSW project HS (I) 825 MW via 1275 MW cable connection (which carries energy from other OSW projects) to Mott Haven substation
- OSW project HS (II) 1700 MW without stand-alone connection
- OSW project A 1760 MW
    - via 1250 MW cable connection to West 49 substation
    - via 1310 MW cable connection to Farragut substation

7.6 Routes for Landing Points to the Grid POIs

Based on the three OSW connection concepts described, eight viable cable routes were identified (See Section 6). The identified onshore routes are identical among the three offshore connection concept variants (Radial, Meshed, and Backbone). Each route consists of AC or DC cables from landing points to the onshore POI along with transformer or converter stations, as applicable.

Table 7-2. Routes for Landing points to grid POIs — Variant 1, 2, 3

ConED		LIPA	
Route	**Technology**	**Route**	**Technology**
Gowanus to Farragut	HVDC	Long Beach to Shore Road	HVAC
E 149th to Motthaven	HVDC	Jones Beach to Syosset	HVAC
44th Ave to Rainey	HVDC	Jones Beach to Ruland Road	HVDC
Riverside to W. 49th	HVDC	Long Beach to E. Garden City	HVAC

8 Cost and Availability Analysis

A detailed cost estimate and availability analysis was completed for each of the three OSW connection concepts or variants described in Section 7. The cost assessment includes all cost of the transmission systems from the OSW projects via the landing points to the onshore POI stations. This section is structured as follows:

- The cost assessment related to onshore routes of the OSW connections, i.e. from the landing points to the POI stations, is presented in Section 8.1. This cost is referred to as onshore cost in the rest of the Study and is the same for all three variants. The onshore cost studied here does not include any upgrade or reinforcement of the existing onshore grid, given such system upgrades were not determined to be a necessity in the onshore assessment (Section 3).

- The unit cost of major offshore components for each variant is presented in Section 8.2.

- The results of onshore and offshore cost assessments are combined and presented in Section 8.2.3.

- The assumption and methodology used for the availability assessment, as well as the availability results are presented in Section 8.3.

Unless stated otherwise explicitly, M is used to represent million in quantities to make the tables and figures more succinct throughout this section. For example, a million U.S. dollars will be shorten as M$.

8.1 Onshore Costs

The accuracy of the cost estimates is dependent upon the various underlying assumptions, inclusions, and exclusions. Actual costs may differ and can be significantly affected by factors such as changes in the external environment, the manner in which the relevant constructions and/or upgrades are executed and managed, and other factors that may directly or indirectly impact the estimate basis. Cost estimation provided is based on the specific input data, assumptions, and methodology used. In the eventuality that actual data and relevant attributes differ from what has been assumed for this assessment, the cost estimates may differ from what has been documented.

8.1.1 Methodology, Assumption, Exclusions, and Risks

The onshore cost assessment has been conducted based on the following assumptions and methodology:

- Methodology:
    - If available, material prices were obtained using historical data and escalated for 2020 prices accordingly. No escalation was considered beyond 2020.
    - There is 8% sales tax included in both material and service-related costs.
    - Historical data were used to estimate the weight of engineered steel pole. Cost of steel was assumed to be $2.2 per pound.
    - DNV GL's in-house cost database was used to provide the CAPEX data of onshore HVDC converter stations, and the cost data were further adjusted for the Study area based on an early study for Empire State Connector [18].
    - A parcel of five acres was considered for each onshore HVDC converter station and a parcel of two acres was assumed for each onshore HVAC transformer station.

- Key assumptions:
    - Construction cost including mobilization/de-mobilization, construction of duct bank (all-inclusive conduit, steel, etc.), manhole, testing of cable, and lying the cable in conduits,
    - HVAC material estimates account for three phases (e.g., three surge-arrester, 3x2 terminations, 3x2 riser poles), whereas HVDC estimates account for two poles.
    - Duct for single circuit cable (with dimension of 7'x 2') and for double circuit (with dimension of 7'x 5') as a guideline, however these were adjusted for the size of HVDC/HVAC cables for different transmission line routes.
    - One termination pole per phase is assumed on either side of duct,
    - Surge arrestor is included on termination poles.
    - Excavation for trenches was assumed to be done by excavating machine, additional cost factor was included for HDD wherever identified in the route.
    - Three manholes per mile along the cable route
    - One mobilization and de-mobilization for construction crew
    - Financial security for performance and warranty was assumed to be ~5% of total cost.

- Exclusions:
    - Cost for any upgrade of substation A-frame/termination/equipment
    - Cost associated with land, environmental, regulatory, and facility application delays due to stakeholder issues, regulatory or permitting approvals and mitigations
    - Costs associated with right of way (ROW), development of new roads, maintenance of existing roads, and tree clearing
    - Environmental mitigation cost, e.g., hazardous materials and contaminated waste removal
    - Extra duct provision in duct bank
    - Cost related to relocate the existing utilities and constructions in ROW
    - Cost for underground/overhead facilities and mitigation plan
    - Underground survey cost

- Work associated with unforeseen environmental and geotechnical issues
- Survey related free and cost
- Cost related to spare equipment
- Cost for energized cable work and helicopter-assisted tower erection
- cost of temporary feeders and temporary power supply
- Hotline work
- Temporary line
- Helicopter work
- Other contingency costs

- In addition to what has been excluded in the onshore cost estimate, following might have material impact on the provided cost estimate:

    - Construction period was assumed to be summer and fall months; winter construction factor was not included. Seasonal or weather-related impacts were not considered.
    - Due to limited access to detailed specifications and engineering data, cost estimates associated with some material items and construction activities such as HVAC and HVDC power cable, engineering steel pole, foundation, and duct bank cost prices may be less accurate compared to others. It is understood that the cost of such items and activities may vary and could affect the accuracy of the estimate.
    - Assumed transmission line foundation and duct bank design may change after geo-tech results, which could affect the provided cost estimation.
    - Additional permits due to transmission lines crossing roads and/or railway.
    - Community opposition due to transmission lines and cables crossing residential and commercial communities.
    - More changes in pole location due to residential/commercial area and underground facilities.

8.1.2 Onshore Cost Estimate Results

Based on the three OSW connection concepts described in Section 7, eight cable routes were identified and evaluated from a cost standpoint. The identified onshore routes are identical among the three offshore connection concept variants (Radial, Meshed, and Backbone) described in Section 7. Each route consists of AC or DC cables from landing points to the onshore POI along with transformer or converter stations, as applicable.

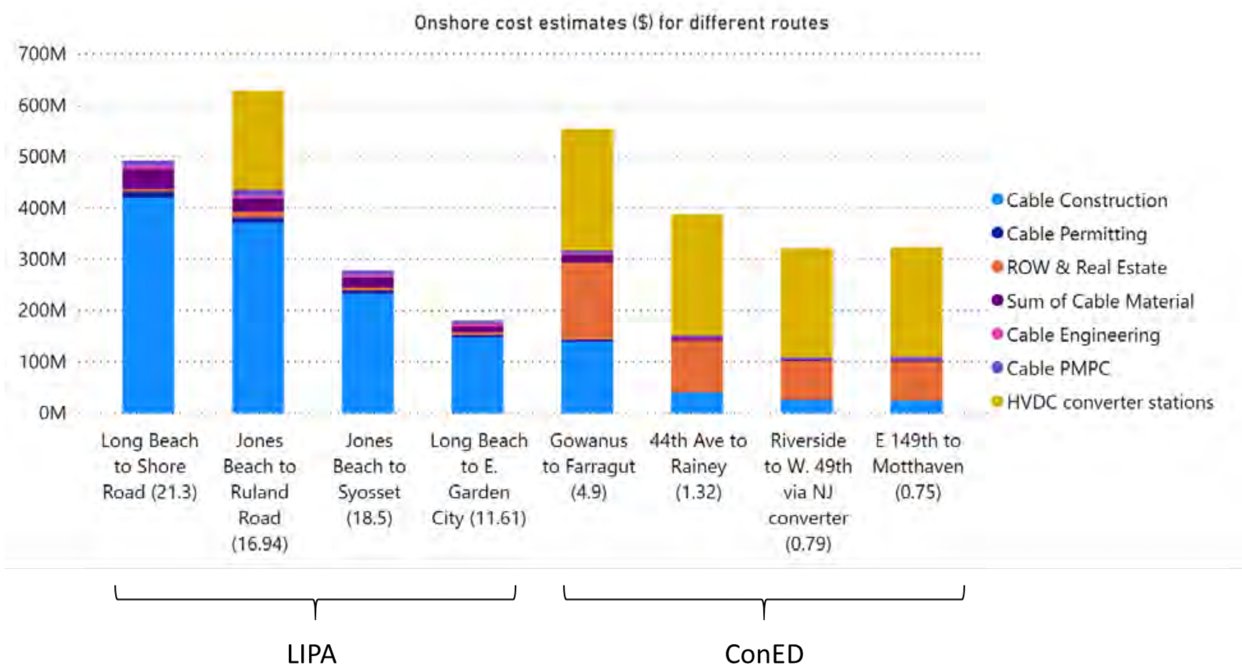
The costs are illustrated in Figure 8-1 with the following key observations:

- For the five routes involving HVDC converter stations, the costs of HVDC converter stations are the largest or second largest cost item.

- For the routes in LIPA area, the major cost component is related to construction of underground AC and DC cables due to relatively long onshore cable lengths.

- The ROW and real estate costs contribute substantially to the four HVDC routes in the ConED area, driven by the larger parcel areas and high land cost in the area.

Figure 8-1. Cost Estimate of the Eight Onshore Cable Routes



M=U.S. $millions

Numbers in (parenthesis) after the route names indicate the cable lengths in miles

Table 8-1 presents the detailed cost estimate buildup for each of the eight onshore cable routes. The column Cable Size specifies the configuration of underground AC and DC cables, including voltage level, conductor material, number of cables, and conductor size. For example, cell text 2x2250mm2 Cu 320kV HVDC specifies that the cable route consists of HVDC cable section with two single-core 320 kV HVDC cables, copper conductor with cross-section of 2250 mm^2 each.

Table 8-1. Onshore Cable Routes and Cost Estimate Overview

Route #/Name	Underground cable							Converter/ Transformer Stations	ROW & Real Estate	Total Cost Ex Land
	Cable Size	DC / AC Cable Length (Mile)	Material	Construction	Engineering	*PMPC	Permitting			
Gowanus to Farragut	2x3x1400mm2 Cu 345 kV HVAC	0/4.94	$14.79 M	$138.61 M	$2.56 M	$6.78 M	$4.16 M	$236.70 M	$150.00 M	$403.59 M
E 149th to Motthaven	2x2250mm2 Cu 320kV HVDC and 2x3x1400mm2 Cu 345kV HVAC	0.45/0.3	$3.71 M	$23.46 M	$0.69 M	$6.02 M	$0.70 M	$213.25 M	$75.00 M	$247.83 M
44th Ave to Rainey	2x3x1400mm2 Cu 345 kV HVAC	0/1.32	$5.60 M	$39.43 M	$1.40 M	$33.18 M	$1.18 M	$236.70 M	$100.00 M	$287.48 M
Riverside to W. 49th via NJ converter	2x3x1400mm2 Cu 345 kV HVAC	0/0.79	$3.41 M	$24.85 M	$0.37 M	$3.44 M	$0.75 M	$213.25 M	$75.00 M	$246.07 M
Long Beach to Shore Road	3x800 mm2 Cu & 3x500 mm2 Cu 220 kV HVAC	0/21.3	$38.63 M	$418.95 M	$6.27 M	$10.70 M	$12.57 M		$4.80 M	$487.12 M
Jones Beach to Syosset	3x800mm2 Cu 220kV HVAC	0/18.5	$19.85 M	$232.64 M	$4.53 M	$8.44 M	$6.98 M		$4.80 M	$272.44 M
Jones Beach to Ruland Road	2x1800mm2 Cu 320 kV HVDC and 3x3x2500mm2 Cu 138 kV HVAC	16.62/0.32	$26.15 M	$370.00 M	$4.87 M	$12.03 M	$11.10 M	$193.14 M	$11.00 M	$617.29 M
Long Beach to E. Garden City	1x3x800mm2 Cu 220 kV HVAC	0/11.61	$13.19 M	$147.23 M	$3.80 M	$6.76 M	$4.42 M		$4.80 M	$175.40 M
Total			$125.34 M	$1,395.17 M	$24.50 M	$57.35 M	$41.85 M	$1,093.02 M	$425.40 M	$2,737.22 M

The cost data as listed in Table 8-1 will be used in the combined onshore/offshore cost assessment as follows:

- The aggregated ROW and real estate cost is ~ $425 million, as most of the intended area are at least partially owned by public entities in the New York State, it is not likely that land will/can be procured using commercial real estate price. During the later parts of this report, land costs are excluded from the cost assessment.
- The aggregated onshore cost excluding the land cost is ~ $2,737 million, and this cost item will be used among the three offshore variants.

8.2 Offshore Costs

8.2.1 General Assumptions

Offshore cost estimation includes procurement cost, installation cost, and project overhead cost. Procurement cost includes direct material cost, labor cost, R&D cost, and profit margins. The project overhead cost covers the cost related to project management, surveys, and studies.

Market fluctuations and location-specific cost drivers are excluded from the offshore cost estimation. The cost estimation for 2020 is based on historical cost data from year 2017. The cost of each OSW project could be impacted by certain specific cost drivers such as required ancillary services, redundancy level, the scope of service contract, ambient temperatures, water depth, and cable routing. Except for offshore platforms, those specific drivers will not be considered at each OSW project level, instead they were considered on an average basis.

In the majority of cases, the primary focus will be the technical performance parameters of the offshore electrical components specifically power and voltage ratings for HVDC converters and cables. The cost estimation will generally not differentiate among alternative implementations that offer the same functionalities and performances, for instance:

- When applied in VSC HVDC applications, both XLPE (cross-linked polyethylene) cable and mass impregnated cable can be used and have similar performances.

- Various solutions of offshore HVDC platforms can be used such as jacket, jack-up, and gravity-based structures (GBS).

8.2.2 Unit Cost Data of Key Offshore Components

In this subsection, the unit cost data for major offshore components are presented. The offshore component cost is then broken down to different cost elements with their corresponding percentage contribution to total. The cost elements include the cost of equipment, installation and transportation, civil works, project management, right of ways, risk contingency, and profit margin. For the important component categories, high-level cost breakdowns are also provided in stacked totem charts.

HVDC and HVAC Cables

- For HVDC cables, two separate cables (positive and negative pole) which will be laid in parallel to connect the HVDC converter station with symmetric monopole topology. Two metallic return cables were considered if the topology of bi-pole with metallic return was selected for the HVDC converters.

- For HVAC cables, the underground section was assumed to use three single core cables whereas the submarine section was assumed as one three core cable.

- The total cost of cables includes procurement cost, installation and transportation cost, project overhead cost and ROW cost.

The unit cost data of HVDC and HVAC cables at various voltage and power ratings are listed in Table 8-2 and Table 8-3, where for each configuration the cost data of submarine cables are provided.

Table 8-2. Unit Cost Data of HVDC Submarine Cables

Voltage (kV)V	Rating of the Pair (MW)	CAPEX for Two Poles (M$/Mile)
±320	1,000	2.9
	1,300	3.1

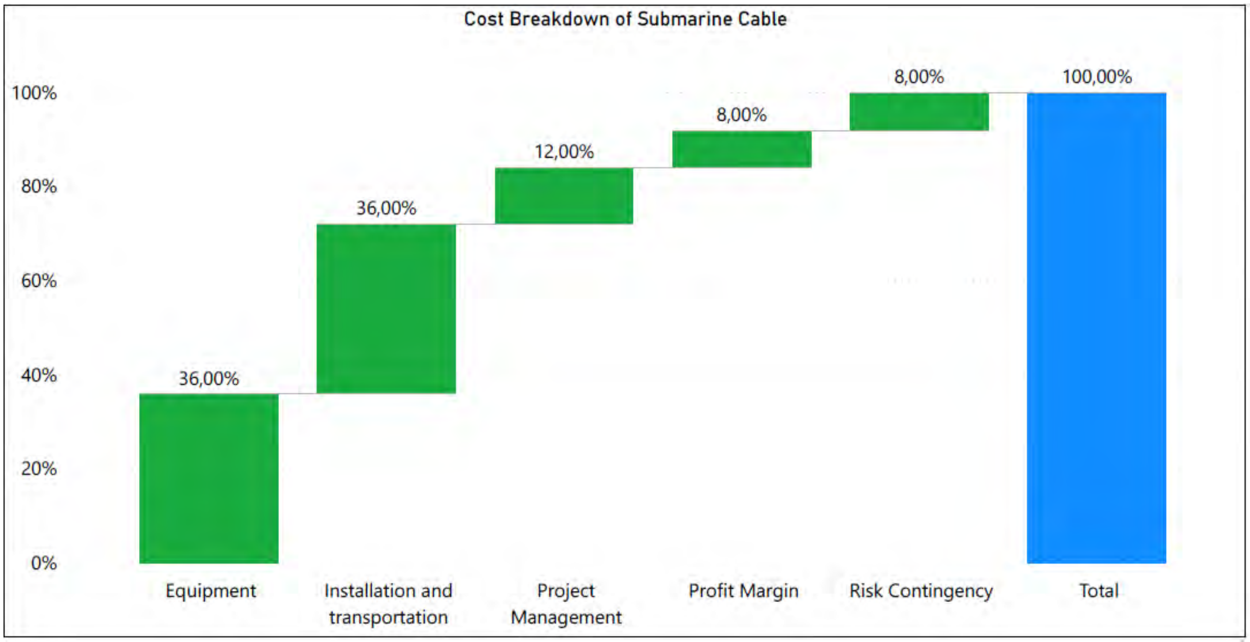
Table 8-3. Unit Cost Data of HVAC Submarine Cables

Voltage (kV)	Rating of the Pair (MW)	CAPEX for three-core submarine cables (M$/Mile)
220	300	2.5
	400	2.7
	500	2.9

OPEX is assumed to be approximately 2.5% of the CAPEX for submarine cables, and 0.05% for underground cables.

Typical cost breakdown for the submarine cables is shown in Figure 8-2. It is worth noting that within the cost breakdown for submarine cables, the cost of the equipment (cables) is equal to those of installation and transportation.

Figure 8-2. CAPEX Breakdown for Submarine Cables



HVDC converter stations

The unit cost data of Half-Bridge (HB) VSC converter stations are listed in Table 8-4. It is worth highlighting the following:

- **Impact of converter configuration:** The majority of the awarded HB VSC based OSW projects have chosen the symmetric monopole configuration; therefore, it was assumed the cost data from various sources are mainly based on the symmetric monopole configuration. With the increase of power rating, voltage levels, and requirement for higher redundancy in the HVDC projects, it is foreseeable that some OSW projects might adapt configurations such as rigid bipole or bipole with metallic return. The change from symmetric monopole to bipole will incur higher cost for the converter stations due to more expensive converter transformers, additional switchgears, electrodes, and increased complexity of control and protections.

- **Impact of physical location:** The cost of offshore converters is expected to be substantially higher than onshore converters with the identical technical parameters, mainly caused by the offshore related requirement.

Table 8-4. Unit Cost Data of Half-Bridge (HB) VSC HVDC Converter Station

Voltage (kV)	Rating (MW)	CAPEX (M$)	
		Onshore HB VSC	Offshore HB VSC
±320	1,000	212.2	265.3
	1,300	260.0	325.0

In addition, the cost data provided herein is intended to cover the entire converter station, including the converter transformers, DC reactors, AC/DC yards, gas insulated switchgear (GIS), control and protection system.

OPEX for converter stations was assumed to be 0.07% of the CAPEX for the onshore stations, and 2% for the offshore stations. Typical cost breakdown for offshore and onshore converter stations are shown in Figure 8-3 and Figure 8-4, respectively.

Figure 8-3. CAPEX Breakdown for Offshore VSC Converter Stations

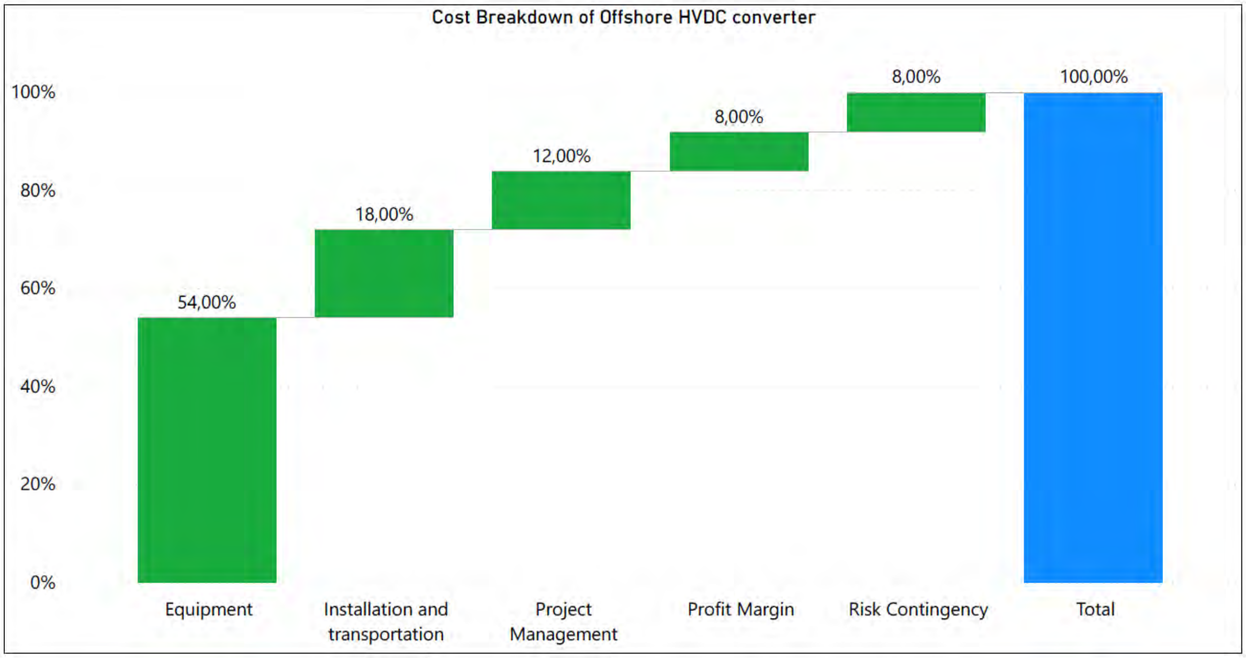
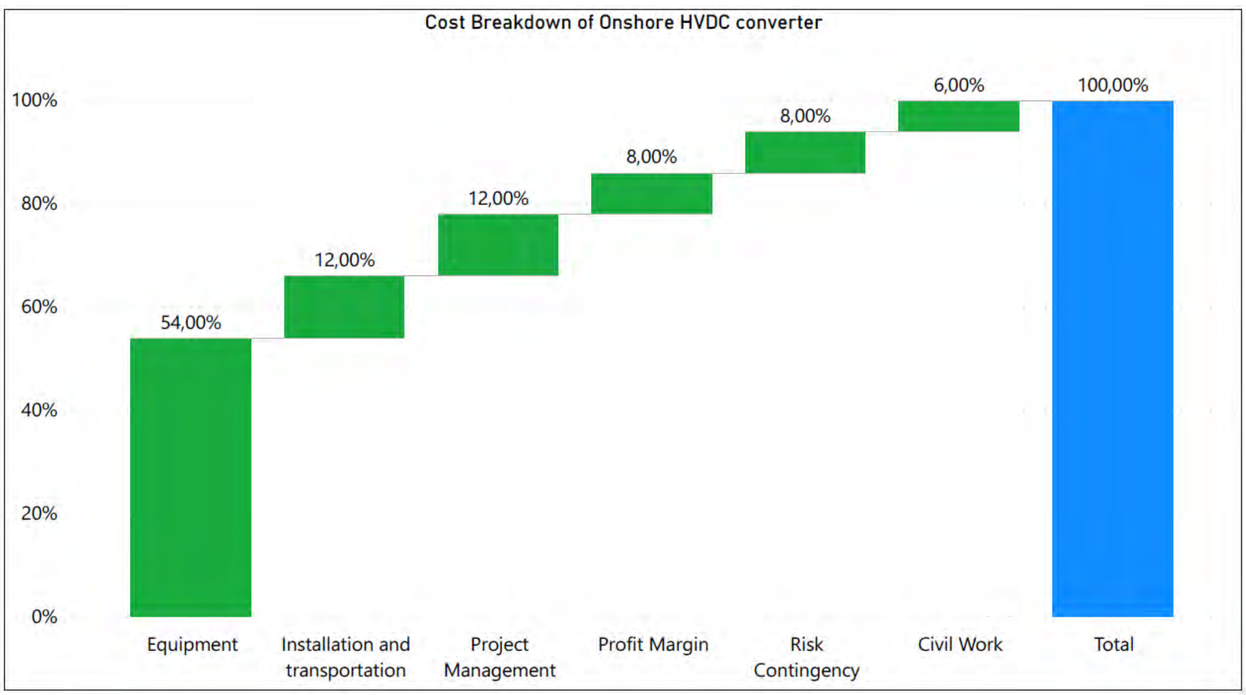


Figure 8-4. CAPEX Breakdown of Onshore VSC Converter Stations



Offshore HVAC and HVDC Platforms

The unit cost data for offshore HVAC and HVDC platforms are provided in Table 8-5 and Table 8-. Due to the high-level characteristics of the Study, no detailed studies were carried out to determine specific sites or foundation structures for proposed offshore platforms. Therefore, the cost specified here and used in later sections is generic data which represents the mean values of a relatively wide cost range for each of the power and voltage ratings. Note, the following factors should be considered when applying this cost data:

- **Platform design**. The type of platform design will impact the platform cost. There are three main types of platform structural design: jacket, jack-up, and GBS. Jacket is expected to be in the lower range of the cost interval, while jack-up and GBS designs are traditionally more expensive.
- **Water depth**. The platform cost will increase with the water depth; a taller substructure is needed for deeper water.
- **Geological condition on the seabed**. More complex seabed increases the installation cost.
- **Weather conditions**. Higher wind and/or wave load will increase the need for a stronger and heavier substructure.
- **Installation concept**. The transportation and installation cost will differ depending on the installation concept.

  - Heavy lift. The lifting capacity of the crane vessel is the main constraint associated with heavy lift installations. Large topsides must be installed as prefabricated topside modules and assembled in the field.
  - Float-over installation concept exceeds the maximum capacity of heavy lift vessels and allows platform topsides to be installed as one integrated package without a crane vessel. Hence, an integrated topside can be completed onshore, which reduces the substantial costs of doing commissioning offshore.
  - GBS concept has the lowest transportation and installation cost, however the structure (semi-submersible) is more complicated and hence with higher construction cost.

Table 8-5. Unit Cost Data of Offshore HVAC Platforms

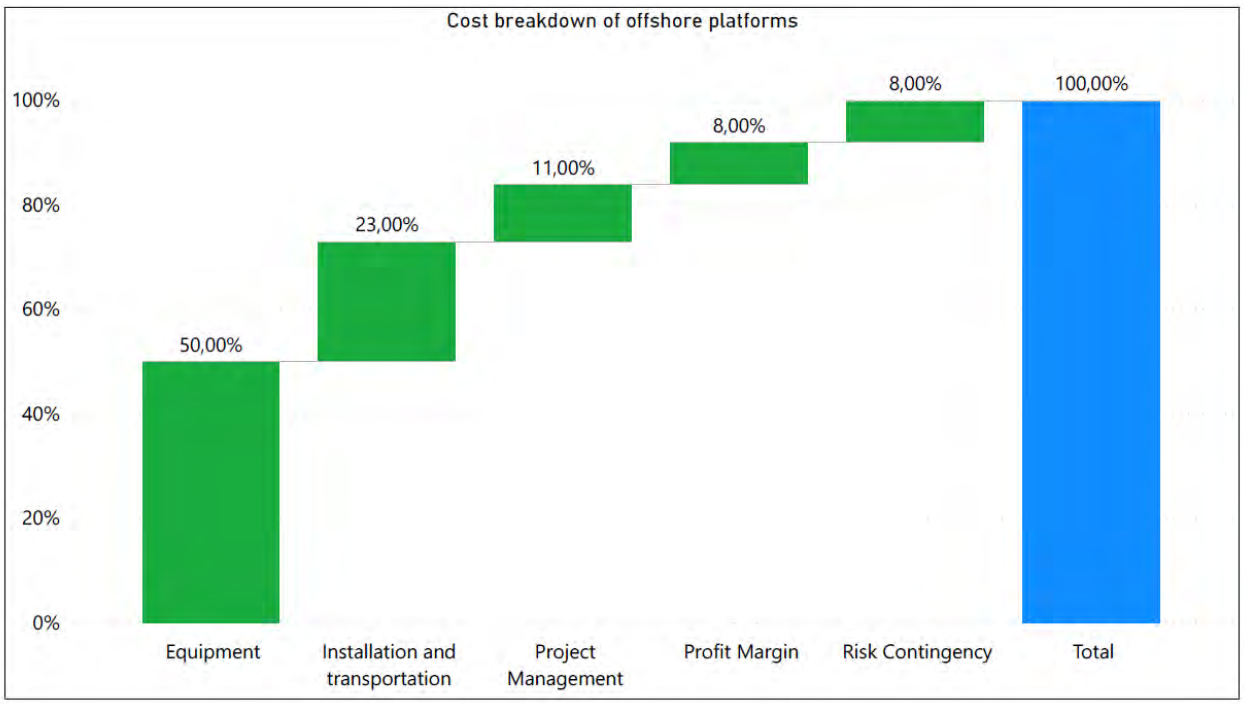
Voltage (kV)	Rating (MVA)	CAPEX (M$)
220	300-500	62.7

Table 8-6. Unit Cost Data of Offshore HVDC Platforms

Voltage (kV)	Rating (MW)	CAPEX (M$)
±320	1,000	337.7
	1,300	407.3

OPEX for offshore platforms is about 2% of the CAPEX including installation. A typical cost breakdown for offshore platforms is shown in Figure 8-5.

Figure 8-5. CAPEX Breakdown for Offshore Platforms



8.2.3 Combined Onshore and Offshore Cost Assessment

Using the unit cost data as defined in Section 8.2.2 and the connection designs in Sections 7.1 through 7.4, the overall CAPEX/OPEX/REPEX of the offshore grids to connect 7.2 GW OSW projects were calculated for the three variants (V1: Radial, V2: Meshed, and V3: Backbone). Those, together with the onshore cost estimate results, are listed in Table 8-6 in 2020 nominal dollars. The cost breakdown of the three variants are further illustrated as waterfall bar charts in Figure 8-6, Figure 8-7, and Figure 8-8, respectively.

Table 8-6. The Comparison of Combined CAPEX of the Three Variants

	V1 Radial		V2 Meshed		V3 Backbone	
	CAPEX (M$)	Item Count or Cable Length (Mile)	CAPEX (M$)	Item Count or Cable Length (Mile)	CAPEX (M$)	Item Count or Cable Length (Mile)
HVAC submarine cable	376	225	767	457	773	474
HVDC Submarine Cable	1,627	885	1,627	885	1,657	901
HVDC Offshore Converter	1,373	5	1,373	5	1,373	5
AC Transformers	28	8	28	8	46	12
Reactive Compensation	47	8	115	20	175	30
HVAC Offshore Platform	228	4	228	4	433	8
HVDC Offshore Platform	1,710	5	1,710	5	1,710	5
Onshore Cost	2,737		2,737		2,737	
Total CAPEX	**8,127**		**8,586**		**8,905**	

Figure 8-6. CAPEX Breakdown of V1 Radial

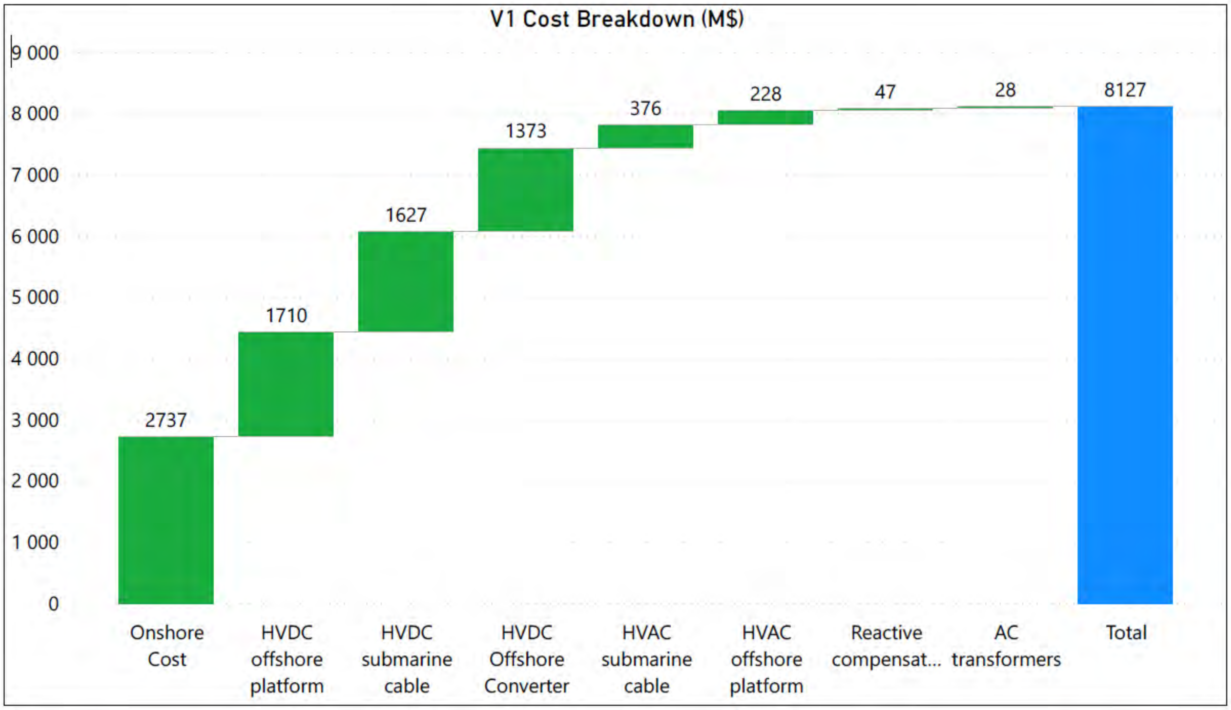


Figure 8-7. CAPEX Breakdown of V2 Meshed

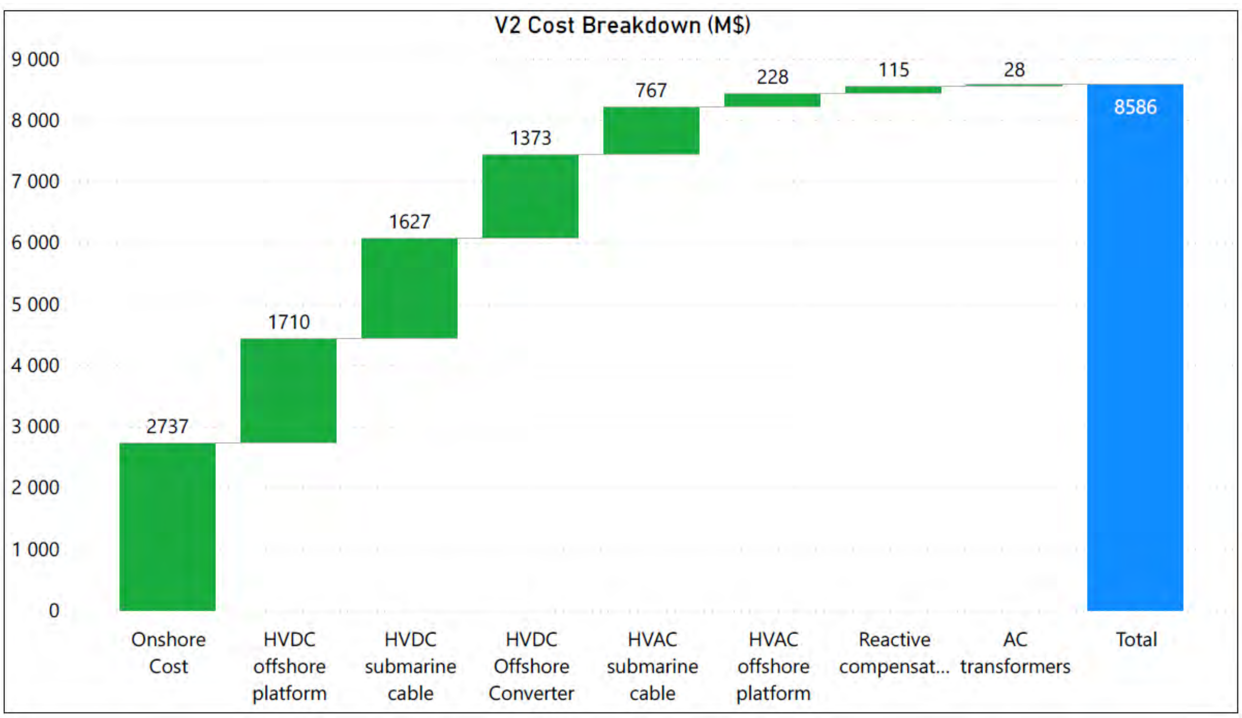
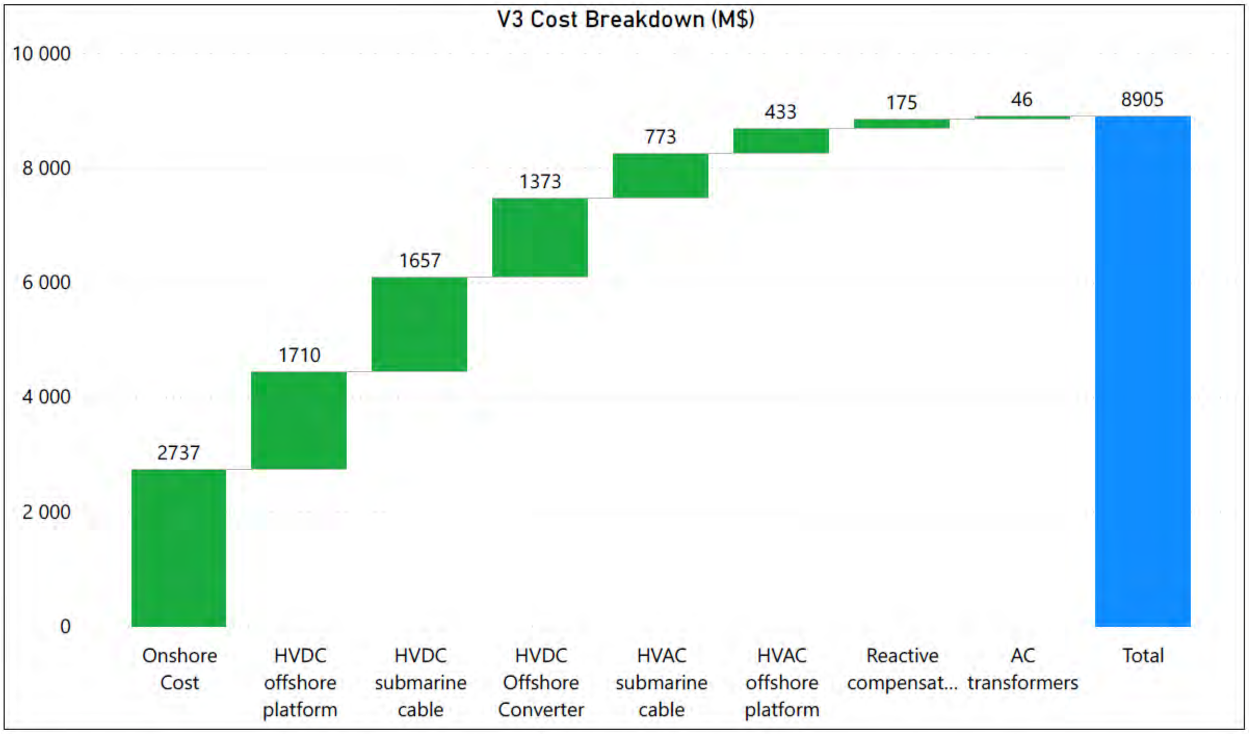


Figure 8-8. CAPEX Breakdown of V3 Backbone



The OPEX and REPEX of the three variants are listed in Table 8-7. The REPEX is estimated to be $15.5 million per platform in nominal 2020 values, occurring two times over the project lifetime.

Table 8-7. OPEX and REPEX of the Three Variants

	OPEX (M$/year)	REPEX (M$)
V1 Radial	127	278
V2 Meshed	138	278
V3 Backbone	144	402

It should be noted that the onshore and offshore cost estimates provided in previous sections will be impacted by factors such as local seabed soil, wind and wave conditions, and market and supply chain fluctuations. Those factors could result in a ±30% error band on the cost estimate; furthermore, the uncertainty on future cost reduction of power transmission system componentry could result in an additional ±9.5% uncertainty. These factors together suggest a total uncertainty associated with the cost estimates of ±39.5%.

8.2.4 Levelized Transmission Cost of Energy (LTCOE)

An industry standard approach to calculate the costs of generating electricity and compare energy production technologies at conceptual stage is using a levelized cost of generating electricity. This is an overarching comparison parameter where the summation of discounted CAPEX, REPEX, and OPEX are divided by the discounted electricity generation. It is important to note that in the context of this study, only transmission costs have been evaluated, not other large cost drivers like the turbine and turbine foundation costs. In order to compare the different transmission costs with their estimated electricity generation, the LTCOE has been introduced. It follows the same principles as the LCOE, but only considers the costs evaluated in this study. The LTCOE is the ratio of lifetime costs to lifetime electricity generation, both discounted. The LTCOE reflects a price of electricity required for the total 7.2GW buildout, where revenues would equal transmission costs, including a return on capital invested equal to the discount rate. The formula applied is:

$$LTCOE = \frac{\sum_{t=1}^{n} \frac{C_t + M_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

Where:

LTCOE	= Levelized Transmission Cost of Energy
C_t	= Capital expenditures in the year t
M_t	= Operations and Maintenance expenditures in year t
E_t	= electricity generation in year t
r	= discount rate, equal to the weighted average cost of capital (WACC)
n	= economic life of the system

Capital expenditures in nominal 2020 values are provided in Table 8-6. The capital expenditures have been split by investments related to the wind generation capacity operational by 2030 and by 2035. The costs have been made real by applying an inflation rate per year of 1.45%, which equals the average

OECD producer price indices over the period 2015 to 2020. It is assumed that investments are made two years before start of operations.

Operations and maintenance expenditures in nominal 2020 values are provided in Table 8-7. The split is made between the 2030 and 2035 operational wind generation capacity and costs have been inflated accordingly. REPEX has been included twice over the project lifetime.

The net present value of the total costs has been calculated by discounting the costs with a discount rate equal to the WACC of 7.5%, reflecting 55% debt, 45% equity, a cost of equity of 12%, a cost of debt of 5% and a corporate tax rate of 21%. An economic life of the overall system has been set to 25 years.

The electricity generation in each year has been estimated by multiplying the total installed production capacity in that year with a net capacity factor, the hours in a year and accounting for losses from blade degradation.

Main assumptions:

Total installed production capacity	=	7.2 GW
Net capacity factor (Radial design)	=	53%
Hours in year (including leap years)	=	8,766 hours
Losses from blade degradation	=	0.06% per year

The net capacity factor is defined as the capacity factor measured at POI, therefore it accounts for transmission losses and availability (availability values presented in Section 8.3).

This gives an estimated yearly electricity generation from the Radial design in a year with the full 7.2 GW operational of 33.2 TWh per year, reducing to 32.7 GWh per year after 25 years of operations due to assumed losses from blade degradation over the project lifetime.

The electricity generation in each year is discounted with the same discount factor of 7.5%. This might be observed counter intuitive as electricity generation is not a monetary value but is explained by electricity generation reflects future revenues, meaning the time value of money needs to be considered.

Table 8-8 provides the LTCOE of the three variants. The LTCOE of Radial is 31.5 $/MWh and the LTCOE of the Meshed is 33.3 $/MWh. This means the Meshed design would require an estimated 1.8 $/MWh higher electricity price over the 25 years of operating 7.2 GW in capacity than the Radial design to cover transmission costs, including a return on capital invested equal to the discount rate.

Table 8-8. LTCOE of the Three Variants

7.2 GW of OSW Projects		
	LTCOE Estimate ($/MWh)	**Uncertainty Range ($/MWh)**
V1 Radial	31.5	22.6 - 44.0
V2 Meshed	33.3	23.9 - 46.5
V3 Backbone	35.1	25.2 - 49.0

The baseline uncertainty in the onshore and offshore cost estimates of ±30% combined with the ±9.5% uncertainty due to the technology learning curve applied to model reduction in costs over time, directly translates into the LTCOE uncertainty, presented in the second column of Table 8-8. The Meshed design has all the components from the Radial design plus added cables and reactive compensation. This means there is no situation where the Meshed design would have a lower LTCOE than the Radial design due to uncertainty span in the estimates.

8.2.5 Sensitivity of LTCOE results to the WACC

Offshore wind is very capital-intensive and has zero fuel costs. The weighted average cost of capital (WACC) applied as discount rate has therefore a critical role in the LTCOE calculations. The main purpose of the LTCOE in this study is to provide a comparative ratio of lifetime costs to lifetime electricity generation to compare the different designs. Every design is evaluated using the same discount rate of 7.5%.

There is, however, large uncertainty in what the WACC will be in 10 to 15 years from now. In today's low-interest environment, a discount rate of 7.5% is considered relatively high, as it reflects 55% debt, 45% equity, a cost of equity of 12%, a cost of debt of 5% and a corporate tax rate of 21%. Currently observed in the market is a reducing risk perception for offshore wind, resulting in higher leverage and lower cost of debt. In order to quantify the impact of the WACC, a sensitivity has been analyzed where the WACC is set to 5%, which implies 70% leverage, 10% cost of equity and 3.7% cost of debt. The LTCOE for the Radial, Meshed, and Backbone variants are reduced by 18%, all else equal.

8.3 Offshore Topology Availability Analysis

8.3.1 Availability Calculation Methodology

An important aspect in comparing grid concepts is the expected availability of the link. The average annual transmission availability is expressed in terms of available transmission capacity, outage times and, ultimately, the respective energy not transmitted. The transmission availability is generally defined as the ratio of the time integral of available power capacity over the time integral of an uninterrupted year's power capacity [20].

$$Transmission\ Availability = \frac{Transmitted\ Energy}{Total\ Available\ Energy}$$

where Total Available Energy is defined as: $E_{normal} + \sum E_{i,planned} + \sum E_{i,unplanned}$

where E_{normal} is the energy actually transmitted in *no-outage* condition, $E_{i,planned}$ is the energy that would have been transmitted during *planned-outages* condition periods(e.g. planned maintenance), and $E_{i,unplanned}$ is the energy that would have been transmitted during *unplanned-outage* periods (e.g. forced outage due to export cable failure).

The latter definition of availability is used to determine the performance of each of the 3 OSW connection concepts developed (Radial, Meshed, and Backbone). Usually an availability target is set as an incentive scheme for grid developers and owners: typical values of availability target are set around 97% to 98% [21].

To estimate the annual transmission availability, it is crucial to know the reliability (i.e., the failure probability) of the transmission assets (i.e., cables, joints, terminations, etc.). The failure of an asset has a fundamental impact on the forced outage of the respective transmission that can last for an extended period of time, until repair. The transmission availability is calculated by considering annual forced and planned outage times of the main components: the converter stations/transformers and the cables. A typical availability study considers:

- Probability of a failure
- Outage duration in case of a failure
- Remaining or redundant capacity during outage time

Cable outage statistics are typically expressed as a failure rate or mean time between failures (MTBF). The only publicly available repository of cable failure rates is the Conseil International des Grands Réseaux Electriques brochure [22]. Please note it is not recommended to use these values to compute the MTBFs of a system in realistic absolute terms to predict failures; however, it is considered reasonable to adopt these values for a comparative analysis between different grid concepts.

For the reliability calculation, a distinction is made between the type of component (e.g., joint, cable, or termination) and the type of failures due to internal causes (e.g., degradation of insulation material, poor installation practice, bad cable manufacturing, etc.) or external causes (e.g., damage by an anchor or a digging machine, etc.). Furthermore, a distinction is made between different voltage ratings, insulation material, AC and DC cables, underground or submarine, and various cable protection (installation or burial) methods.

To account for the mean time to recovery, the outage time between the occurrence of a failure and the repaired circuit being taken back into service again have been considered. Generally, these are divided in three parts [23]:

- Fault identification and restoration time
- Preparation and waiting time
- Repair and commissioning

After an outage has occurred on a specific link (planned or unplanned) the remaining unaffected part of the system can continue its transmission operation. The remaining power export capacity of the system during an outage is thus determined by the specific system topology. The presence of redundant links can generally increase the remaining capacity during outages. For the specific three OSW connection concepts evaluated, it is assumed the export capabilities during an outage follow a best-path approach, i.e., the power transmitted to shore is maximized compatibly with the redundant and existing link capacity, regardless of possible different control and operation strategies. The available wind power fluctuation is always considered for both normal and outage conditions.

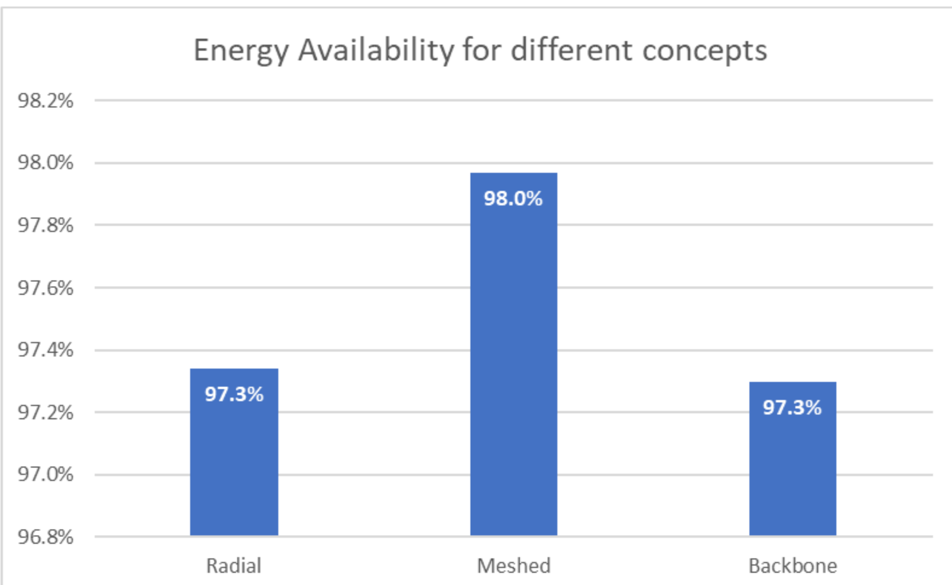
The information about the outage times (planned and unplanned) together with the remaining power export capacity during the respective outage, allows for the calculation of the $E_{i,unplanned}$, $E_{i,planned}$, and E_{normal} previously mentioned and the total transmission availability.

The model developed by DNV GL for availability calculation is periodically benchmarked with real cases and publicly available data (e.g., National Grid ESO report for the Nordic Sea OWF [24]).

8.3.2 Availability Results

The expected availabilities for different concepts are shown in Figure 8-9.

Figure 8-9. Energy Availability for Three Variants

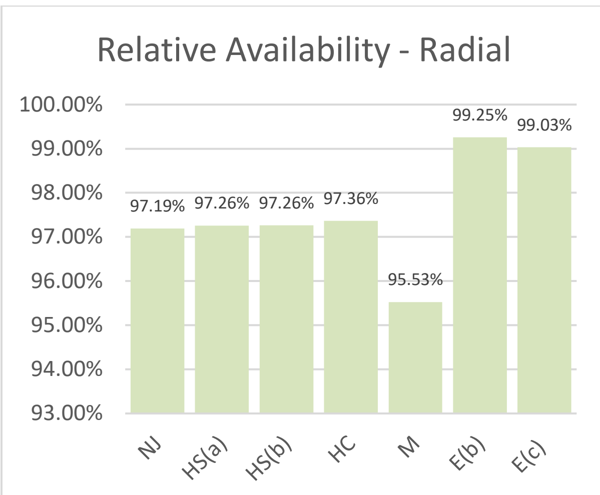


The scenarios have been compared on an annual outage time and energy availability basis. For the actual transmission availability calculations, wind energy profiles and associated net capacity factors for hypothetical OSW projects were provided by NREL. In all cases, the submarine cable configuration impacts the availability calculation, together with the number of necessary joints and technology (AC/DC) used.

A summary of the calculated results is given in the following points:

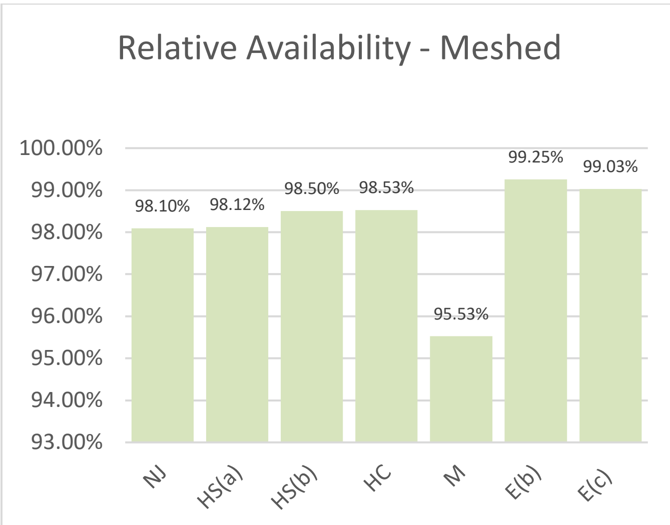
- **Radial concept**: The concept shows a total calculated availability of 97.3% for the entire 7.2 GW studied. All the links to shore are, in fact, point-to-point links. The failure of a link generates the total loss of the energy produced by the respective OSW project connected. A breakdown of the individual connector availabilities is shown in Figure 8-10.

Figure 8-10. Transmission Availability Calculated for the Individual Connections of the Radial Concept



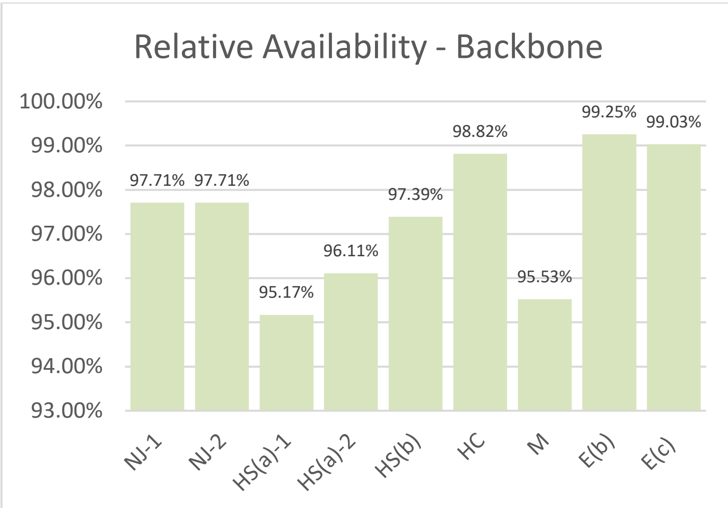
- **Mesh concept**: This concept resulted in the highest calculated availability of 98.0%. This result is mainly attributed to the added redundancy for the energy transmission given by the interconnected OSW projects. The calculated availability reflects on the total 7.2 GW, while Meshing is only part of the design for four OSW projects feeding into New York City. This explains why the Mesh concept shows only a marginal increase in availability when compared to the Radial concept. Moreover, the Mesh links are energized and floating during no contingency and only transmit power during contingency when lower than maximum wind allows for available capacity on adjacent interconnectors. These factors have been considered. A breakdown of the individual connector availabilities is shown in Figure 8-11.

Figure 8-11. Transmission Availability Calculated for the Individual Connections of the Meshed Concept



- **Backbone concept**: The Backbone concept resulted in total availability comparable to the Radial concept. Despite providing interconnection between OSW projects and added redundancy, the reconfiguration of offshore connections (to match onshore POI threshold and maximum single contingency) require that the Backbone length of submarine cables continuously transmit power. This has an impact on availability calculations as the MTBF and mean time to recovery of the Backbone are considered. The main difference with the Mesh is that the Backbone interconnectors are continuously transmitting while in the Mesh concept the interconnectors are transmitting only in case of contingency. In addition, some platforms (HS(a)-1 and HS(a)-2) only reach the shore via platform-interlink routing, even in normal operation condition. This results in a longer route and the transmission is more susceptible to contingencies. A detailed breakdown of the individual transmission availabilities for every platform is given in Figure 8-12. Please note, for the Backbone concept, additional platforms are present when compared to the Radial and Meshed cases.

Figure 8-12. Transmission Availabilities Calculated for the Individual OSW in the Backbone Concept



The result of the transmission availability analysis show that the Mesh concept leads to the highest reliability among the three investigated concepts. The Backbone concept, despite adding redundancy due to the presence of inter-links between platforms, showed comparable reliability to the Radial concept.

9 Findings

Overall, the onshore analysis identified scenarios for injecting of 6 GW of OSW into New York City and 3 GW into Long Island that minimized onshore transmission system upgrades and that involved very limited OSW curtailment. However, if more OSW capacity (~ 4GW) is injected into Long Island, there is expected to be an increased risk of OSW energy curtailment and that onshore system upgrades are likely needed and may necessitate the addition of a new tie-line in order to export offshore wind energy from Long Island.

A transmission cable routing feasibility assessment was conducted to evaluate the environmental and permitting challenges of routing transmission cables from potential offshore lease areas to substations identified in the onshore grid assessment previously mentioned. Major potential constraints were identified for many of the illustrative route segments, but these challenges may be overcome with suitable planning and outreach efforts. Thus, the assessment supports a finding that the illustrative routings examined in the Study are feasible. Other key findings of the routing assessment include the following:

- The analyzed onshore routes could feasibly accommodate between two and six separately installed cable circuits.

- Six separate cables (or circuits) could feasibly be installed through New York Harbor to the analyzed substations.

- Given the complexity of bringing cables into New York City, either via New York Harbor or Long Island Sound, coordination of transmission will be needed regardless of the offshore transmission configuration concept and alternative approaches for bringing offshore wind energy into New York City should also be explored to manage the potential risk.

As part of the offshore transmission assessment, uncertainties around the future development of OSW projects, including their locations and area sizes, were considered by developing five illustrative OSW build-out scenarios. These scenarios represent a possible range of geographically diverse future outcomes that could potentially occur. For each OSW build-out scenario, five offshore transmission connection concepts (Radial, Split, Shared Substation, Meshed, and Backbone) were developed. Preliminary analysis of the assumed OSW build-out scenarios along with the OSW connection concepts was indicative of the following key observations:

- The relative benefits and cost comparisons of OSW connection concepts remained consistent in all assumed OSW build-out scenarios, which suggests that a single representative OSW build-out scenario can be utilized for detailed analysis and costing to determine the relative performance of the OSW connection concepts with minimal risk of compromising key findings.

- For OSW networked connection concepts (i.e. substation sharing, Mesh, or Backbone) to be economically justifiable, the networked connection concept should encompass at least three OSW projects with minimum aggregate rating of approximately 3 GW.

- Uncertainty related to the availability of wind energy areas (WEAs) makes it challenging to pivot from an OSW's Radial connection concept to other OSW networked connection concepts.

    - However, these challenges could be overcome by proper upfront preparation and investments (e.g., over-sizing cables, converters and additional breaker positions).

    - In addition, among all OSW connection concepts studied, the Meshed connection concept was observed to be the most flexible considering WEA uncertainty.

    - Furthermore, moving from a Radial connection concept to substation sharing connection concept is expected to be relatively more challenging given WEA and OSW project location uncertainty.

- Close coordination with BOEM to make more WEAs available will foster more competitive OSW procurements and facilitate the potential development of networked offshore transmission systems.

- With the key findings in mind, and considering that Radial and split connection concepts were observed to have very similar performance in the preliminary assessment, the Radial, Meshed, and Backbone connection concepts were shortlisted for the further detailed offshore analysis that included detailed LTCOE and availability assessments.

Detailed calculations were conducted for the shortlisted OSW connection concepts including both the wet-side and dry-side (between the landing points and onshore grid substations) components. Furthermore, to provide a better comparison between the three shortlisted OSW connection concepts by considering the magnitude of OSW energy that they would deliver to the onshore grid, LTCOE was calculated to reflect the cost of transferring the OSW energy for each delivered MWh of OSW energy to the onshore grid.

Offshore Radial and Meshed connection concepts were observed to result in lower LTCOE compared to the Backbone connection concept. In addition, OSW Meshed connection concept resulted in a higher availability and operational benefits among the three shortlisted OSW connection concepts.

Provided draft Call Areas in the New York Bight become WEAs, 9 GW of OSW connected to New York's electricity system by 2035 is possible. Though more technical assessment should be completed to more robustly evaluate solutions, the Study finds there exists feasible options for offshore cable concepts and routing, cable landfall and onshore cable routing, and existing substations for the interconnection of 9 GW of OSW. For all options, smart systematic planning is key to cost-effective outcomes.

10 References

[1] NYSDEC (New York State Department of Environmental Conservation). 2019. Application of Deepwater Wind South Fork, LLC for a Certificate of Environmental Compatibility and Public Need for the Construction of Approximately 3.5 Miles of Submarine Export Cable from the New York State Territorial Waters Boundary to the South Shore of the Town of East Hampton in Suffolk County and Approximately 4.1 Miles of Terrestrial Export Cable from the South Shore of the Town of East Hampton to an Interconnection Facility with an Interconnection Cable Connecting to the Existing East Hampton Substation in the Town of East Hampton, Suffolk County. Case 18-T-0604.

[2] NOAA (National Oceanographic and Atmospheric Administration). 2020a. Navigation Chart 12300. Approaches to New York. Last correction October 14, 2020. Accessed online at: https://charts.noaa.gov/PDFs/12300.pdf.

[3] NYSERDA (New York State Energy Research and Development Authority). 2017a. New York State Offshore Wind Master Plan Aviation and Radar Assets Study. Accessed online at: nyserda.ny.gov/All%20Programs/Programs/Offshore%20Wind/About%20Offshore%20Wind/Master%20Plan.

[4] BOEM (Bureau of Ocean Energy Management). 2018. DoD Mission Compatibility Assessment: New York Offshore Wind Energy, Briefing to New York Bight Task Force. Accessed online at: https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/NY/DoD_Task-Force-Briefing_28NOV2018v2-%281%29.pdf.

[5] NYSERDA. 2017b. New York State Offshore Wind Master Plan Sand and Gravel Resources Study. Accessed online at: nyserda.ny.gov/All%20Programs/Programs/Offshore%20Wind/About%20Offshore%20Wind/Master%20Plan.

[6] Poppe, L.J., W.W. Danforth, K.Y. McMullen, M.A. Blankenship, K.A. Glomb, D.B. Wright, and S.M. Smith. 2012. Sea-Floor character and sedimentary processes of Block Island Sound, Offshore Rhode Island. Prepared in cooperation with the National Oceanographic and Atmospheric Administration. U.S. Geological Survey Open-File Report 2012–1005.

[7] NYSERDA. 2017c. New York State Offshore Wind Master Plan Fish and Fisheries Study. Accessed online at: .nyserda.ny.gov/All%20Programs/Programs/Offshore%20Wind/About%20Offshore%20Wind/Master%20Plan.

[8] NYSERDA. 2017d. New York State Offshore Wind Master Plan Shipping and Navigation Study. Accessed online at: nyserda.ny.gov/All%20Programs/Programs/Offshore%20Wind/About%20Offshore%20Wind/Master%20Plan.

[9] NYSERDA. 2017e. New York State Offshore Wind Master Plan Cable Landfall Permitting Study. Accessed online at: nyserda.ny.gov/All%20Programs/Programs/Offshore%20Wind/About%20Offshore%20Wind/Master%20Plan.

[10] Varekamp, J.C., A.E. McElroy, J.R. Mullaney, and V.T. Breslin. 2014. Metals, organic compounds, and nutrients in Long Island Sound: Sources, magnitudes, trends and impacts. In: J.S. Latimer et al. (eds.), Long Island Sound. Prospects for the Urban Sea. Springer Series on Environmental Management (doi: 10.1007/978-1-4614-6126-5_6), p. 203–284.

[11] Smith, Eugene. 2020. Personal Communication. E-mail to Kathleen Marean, Ecology and Environment, Inc., dated April 14, 2020. Re: Questions on Co-locating Electric Utility Lines.

[12] Intertek. 2020. Anbaric Export Cables into New York Harbor, Cable Routing through The Narrows and Export Cable Installation. Presentation. Accessed online at: http://ny.anbaric.com/wp-content/uploads/2020/08/Intertek_Anbaric_AEJUN23_P2334_NY_Rev21.pdf

[13] DNV GL AS. 2016. Subsea power cables in shallow water. Recommended Practice DNVGL-RP-0360. (March 2016) Accessed online at: http://rules.dnvgl.com/docs/pdf/dnvgl/RP/2016-03/DNVGL-RP-0360.pdf.

[14] Burden, L.I. and E.J. Hoppe. 2015. Synthesis of Trenchless Technologies. Final Report VCTIR 15-R16 (June 2015). Virginia Center for Transportation Innovation and Research, Charlottesville, Virginia. Accessed online at: http://www.virginiadot.org/vtrc/main/online_reports/pdf/15-r16.pdf.

[15] CAPP (Canadian Association of Petroleum Producers). 2004. Guideline Planning Horizontal Directional Drilling for Pipeline Construction September 2004. CAPP Publication 2004-0022. Accessed online at: https://www.capp.ca/wp-content/uploads/2019/11/Planning_Horizontal_Directional_Drilling_for_Pipeline_Construction-83652.pdf.

[16] Bueno, S.M. 2016. Project of The Year 2016 New Installation Winner: Indian River HDD Crossing. Trenchless Technology. October 17, 2016. Accessed online at: https://trenchlesstechnology.com/project-year-2016-new-installation-winner-indian-river-hdd-crossing/ (power cable 7,020 ft).

[17] Yan, X., S.T. Ariaratnam, B. Ma. 2019. World Record 5.2 km HDD Twin Crossings of the Hong Kong Harbor, Conference Information Pipelines. July 21-24, 2019. Nashville, Tennessee. July 18, 2019. Accessed online at: https://ascelibrary.org/doi/abs/10.1061/9780784482490.075.

[18] PR Newswire, April 2016, Empire State Connector "HVDC" Transmission Project to Deliver Zero Carbon Energy from Upstate New York Directly to NYC. Accessed online at: https://www.prnewswire.com/news-releases/empire-state-connector-hvdc-transmission-project-to-deliver-zero-carbon-energy-from-upstate-new-york-directly-to-nyc-300257538.html.

[19] DNV GL AS (DNV GL Energy Insights USA, Inc.). 2015. Criteria for Pipelines Co-Existing with Electric Power Lines. Prepared for: The INGAA Foundation. Final Report No. 2015-04 (October 2015). Accessed online at: https://www.ingaa.org/File.aspx?id=24732

[20] Protocol for Reporting the Operational Performance of HVDC Transmission System, CIGRÉ Technical Brochure 590, July 2014

[21] OFGEM, UK, Offshore Transmission Owner Revenue Report, 2016, https://www.ofgem.gov.uk/system/files/docs/2016/12/offshore_transmission_ofto_revenue_report.pdf

[22] Update of service experience of HV underground and submarine cable systems, CIGRE Technical Brochure 379, April 2009

[23] Levelized Energy Cost Improvement through Concept Selection and Availability Optimization for the Norfolk Windfarms Export Links, C.A. Plet, M. Hoffmann, W. El-Khatib, A. Alefragkis, M. Kurrat, CIGRE Paris 2020

[24] ESO, National Grid, https://www.nationalgrideso.com/research-publications/transmission-performance-reports

[25] LLC, AWS Truepower; INC, GEO MARINE, NYSERDA, https://www.nyserda.ny.gov/-/media/Files/EIBD/Research/LI-NYC-offshore-wind-climatology.pdf, 2010

Annex A: Onshore Assessment Supporting Attachments

Attachment 3.I

Retirements and Deactivations

LINE REF. NO.	Owner, Operator, and / or Billing Organization	Station Unit	Zone	PTID	Location Town	Location Cnty	Location St	In-Service Date YYYY-MM-DD	Name Plate Rating [(V)] MW	2019 CRIS [(A)] MW SUM	2019 CRIS [(A)] MW WIN	2019 Capability [(B)] MW SUM	2019 Capability [(B)] MW WIN	DUAL	Unit Type	Fuel [(U)] Type 1	Fuel [(U)] Type 2	2018 Net [(C)] Energy GWh	Retirrement/Deactivation were shown by "x" sign: Retire or Deactivate?	Stusy Year 2025	Stusy Year 2030	Stusy Year 2035	Comment
R1701	Somerset Operating Company, LLC	Somerset	A	23543	Somerset	063	36	1984-08-01	655.1	686.5	686.5	685.9	692.5		ST	BIT		593.0	Y	x	x	x	RETIRE
R1067	Binghamton BOP, LLC	Binghamton (RET - 1/9/18)	C	23790	inghamton	007	36	2001-03-01	47.7	43.8	57.2	0.0	0.0	YES	CC	NG	KER	3.5	Y	x	x	x	RETIRE
R1082	Cayuga Operating Company, LLC	Cayuga 1	C	23584	Lansing	109	36	1955-09-01	155.3	154.1	154.1	151.0	151.0		ST	BIT		81.6	Y	x	x	x	Coal retirement/Mothball Outage
R1083	Cayuga Operating Company, LLC	Cayuga 2 (IIFO - 7/1/18)	C	23585	Lansing	109	36	1958-10-01	167.2	154.7	154.7	0.0	0.0		ST	BIT		17.4	Y	x	x	x	Coal retirement/IIFO
R1445	Lyonsdale Biomass, LLC	Lyonsdale (IIFO - 4/1/18)	E	23803	Lyonsdale	049	36	1992-08-01	21.1	20.2	20.2	0.0	0.0		ST	WD		0.0	Y	x	x	x	RETIRE
R1150	Entergy Nuclear Power Marketing	Indian Point 2	H	23530	Buchanan	119	36	1973-08-01	1,299.0	1,026.5	1,026.5	1,016.1	1,025.9		NP	UR		8,000.5	Y	x	x	x	Deactivated
R1151	Entergy Nuclear Power Marketing	Indian Point 3	H	23531	Buchanan	119	36	1976-04-01	1,012.0	1,040.4	1,040.4	1,037.9	1,039.9		NP	UR		8,333.5	Y	x	x	x	Deactivated
R1008	Astoria Generating Company L.P.	Astoria GT 01	J	23523	Queens	081	36	1967-07-01	16.0	15.7	20.5	14.2	18.9		GT	NG		1.0	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1009	Astoria Generating Company L.P.	Gowanus 1-1	J	24077	Brooklyn	047	36	1971-06-01	20.0	19.1	24.9	18.8	24.4		GT	FO2		0.3	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1010	Astoria Generating Company L.P.	Gowanus 1-2	J	24078	Brooklyn	047	36	1971-06-01	20.0	17.1	22.3	19.4	24.9		GT	FO2		0.2	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1011	Astoria Generating Company L.P.	Gowanus 1-3	J	24079	Brooklyn	047	36	1971-06-01	20.0	17.2	22.5	17.7	22.9		GT	FO2		0.2	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1012	Astoria Generating Company L.P.	Gowanus 1-4	J	24080	Brooklyn	047	36	1971-06-01	20.0	17.1	22.3	16.7	21.3		GT	FO2		0.1	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1013	Astoria Generating Company L.P.	Gowanus 1-5	J	24084	Brooklyn	047	36	1971-06-01	20.0	16.5	21.6	17.2	22.3		GT	FO2		0.1	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1014	Astoria Generating Company L.P.	Gowanus 1-6	J	24111	Brooklyn	047	36	1971-06-01	20.0	18.0	23.5	16.6	21.4		GT	FO2		0.1	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1015	Astoria Generating Company L.P.	Gowanus 1-7	J	24112	Brooklyn	047	36	1971-06-01	20.0	17.6	23.0	17.6	22.4		GT	FO2		0.1	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1016	Astoria Generating Company L.P.	Gowanus 1-8	J	24113	Brooklyn	047	36	1971-06-01	20.0	16.1	21.0	15.9	20.9		GT	FO2		0.0	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1017	Astoria Generating Company L.P.	Gowanus 2-1	J	24114	Brooklyn	047	36	1971-06-01	20.0	17.9	23.4	17.0	22.5	YES	GT	FO2	NG	1.9	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1018	Astoria Generating Company L.P.	Gowanus 2-2	J	24115	Brooklyn	047	36	1971-06-01	20.0	18.8	24.6	18.3	24.1	YES	GT	FO2	NG	1.8	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1019	Astoria Generating Company L.P.	Gowanus 2-3	J	24116	Brooklyn	047	36	1971-06-01	20.0	20.6	26.9	19.1	24.9	YES	GT	FO2	NG	1.9	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1020	Astoria Generating Company L.P.	Gowanus 2-4	J	24117	Brooklyn	047	36	1971-06-01	20.0	19.3	25.2	17.3	23.1	YES	GT	FO2	NG	0.8	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1021	Astoria Generating Company L.P.	Gowanus 2-5	J	24118	Brooklyn	047	36	1971-06-01	20.0	18.6	24.3	18.0	23.4	YES	GT	FO2	NG	0.6	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1022	Astoria Generating Company L.P.	Gowanus 2-6	J	24119	Brooklyn	047	36	1971-06-01	20.0	20.3	26.5	19.5	24.9	YES	GT	FO2	NG	1.0	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1023	Astoria Generating Company L.P.	Gowanus 2-7	J	24120	Brooklyn	047	36	1971-06-01	20.0	19.6	25.6	19.1	24.7	YES	GT	FO2	NG	1.0	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1024	Astoria Generating Company L.P.	Gowanus 2-8	J	24121	Brooklyn	047	36	1971-06-01	20.0	17.7	23.1	17.7	22.9	YES	GT	FO2	NG	0.4	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1025	Astoria Generating Company L.P.	Gowanus 3-1	J	24122	Brooklyn	047	36	1971-07-01	20.0	17.7	23.1	16.9	21.9	YES	GT	FO2	NG	0.9	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1026	Astoria Generating Company L.P.	Gowanus 3-2	J	24123	Brooklyn	047	36	1971-07-01	20.0	17.7	23.1	17.1	22.6	YES	GT	FO2	NG	0.7	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1027	Astoria Generating Company L.P.	Gowanus 3-3	J	24124	Brooklyn	047	36	1971-07-01	20.0	19.8	25.9	18.0	23.8	YES	GT	FO2	NG	1.0	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1028	Astoria Generating Company L.P.	Gowanus 3-4	J	24125	Brooklyn	047	36	1971-07-01	20.0	17.9	23.4	16.2	21.4	YES	GT	FO2	NG	1.0	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1029	Astoria Generating Company L.P.	Gowanus 3-5	J	24126	Brooklyn	047	36	1971-07-01	20.0	19.0	24.8	17.3	22.8	YES	GT	FO2	NG	1.4	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1030	Astoria Generating Company L.P.	Gowanus 3-6	J	24127	Brooklyn	047	36	1971-07-01	20.0	17.6	23.0	15.5	21.0	YES	GT	FO2	NG	0.7	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1031	Astoria Generating Company L.P.	Gowanus 3-7	J	24128	Brooklyn	047	36	1971-07-01	20.0	18.1	23.6	18.1	23.9	YES	GT	FO2	NG	0.5	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1032	Astoria Generating Company L.P.	Gowanus 3-8	J	24129	Brooklyn	047	36	1971-07-01	20.0	19.0	24.8	16.9	23.9	YES	GT	FO2	NG	0.5	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1033	Astoria Generating Company L.P.	Gowanus 4-1	J	24130	Brooklyn	047	36	1971-07-01	20.0	16.8	21.9	18.9	24.4		GT	FO2		0.2	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1034	Astoria Generating Company L.P.	Gowanus 4-2	J	24131	Brooklyn	047	36	1971-07-01	20.0	17.3	22.6	17.6	22.5		GT	FO2		0.2	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1035	Astoria Generating Company L.P.	Gowanus 4-3	J	24132	Brooklyn	047	36	1971-07-01	20.0	17.6	23.0	16.6	20.4		GT	FO2		0.1	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1036	Astoria Generating Company L.P.	Gowanus 4-4	J	24133	Brooklyn	047	36	1971-07-01	20.0	17.1	22.3	16.5	22.3		GT	FO2		0.1	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1037	Astoria Generating Company L.P.	Gowanus 4-5	J	24134	Brooklyn	047	36	1971-07-01	20.0	17.1	22.3	16.4	22.1		GT	FO2		0.1	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1038	Astoria Generating Company L.P.	Gowanus 4-6	J	24135	Brooklyn	047	36	1971-07-01	20.0	18.6	24.3	18.1	23.0		GT	FO2		0.1	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1039	Astoria Generating Company L.P.	Gowanus 4-7	J	24136	Brooklyn	047	36	1971-07-01	20.0	16.6	21.7	17.2	21.7		GT	FO2		0.0	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1040	Astoria Generating Company L.P.	Gowanus 4-8	J	24137	Brooklyn	047	36	1971-07-01	20.0	19.0	24.8	17.4	21.9		GT	FO2		0.2	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1041	Astoria Generating Company L.P.	Narrows 1-1	J	24228	Brooklyn	047	36	1972-05-01	22.0	21.0	27.4	19.3	24.9	YES	GT	FO2	NG	6.4	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1042	Astoria Generating Company L.P.	Narrows 1-2	J	24229	Brooklyn	047	36	1972-05-01	22.0	19.5	25.5	17.1	23.8	YES	GT	FO2	NG	3.6	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1043	Astoria Generating Company L.P.	Narrows 1-3	J	24230	Brooklyn	047	36	1972-05-01	22.0	20.4	26.6	18.3	24.9	YES	GT	FO2	NG	4.0	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1044	Astoria Generating Company L.P.	Narrows 1-4	J	24231	Brooklyn	047	36	1972-05-01	22.0	20.1	26.3	18.8	24.9	YES	GT	FO2	NG	2.7	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1045	Astoria Generating Company L.P.	Narrows 1-5	J	24232	Brooklyn	047	36	1972-05-01	22.0	19.8	25.9	19.9	24.9	YES	GT	FO2	NG	3.0	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1046	Astoria Generating Company L.P.	Narrows 1-6	J	24233	Brooklyn	047	36	1972-05-01	22.0	18.9	24.7	16.5	22.2	YES	GT	FO2	NG	3.0	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1047	Astoria Generating Company L.P.	Narrows 1-7	J	24234	Brooklyn	047	36	1972-05-01	22.0	18.4	24.0	19.4	24.9	YES	GT	FO2	NG	6.1	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1048	Astoria Generating Company L.P.	Narrows 1-8	J	24235	Brooklyn	047	36	1972-05-01	22.0	19.9	26.0	17.5	23.2	YES	GT	FO2	NG	4.6	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1049	Astoria Generating Company L.P.	Narrows 2-1	J	24236	Brooklyn	047	36	1972-06-01	22.0	19.4	25.3	19.2	24.8	YES	GT	FO2	NG	3.4	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1050	Astoria Generating Company L.P.	Narrows 2-2	J	24237	Brooklyn	047	36	1972-06-01	22.0	18.7	24.4	16.4	22.9	YES	GT	FO2	NG	3.4	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1051	Astoria Generating Company L.P.	Narrows 2-3	J	24238	Brooklyn	047	36	1972-06-01	22.0	18.4	24.0	17.5	23.8	YES	GT	FO2	NG	3.4	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1052	Astoria Generating Company L.P.	Narrows 2-4	J	24239	Brooklyn	047	36	1972-06-01	22.0	18.4	24.0	17.9	24.2	YES	GT	FO2	NG	7.0	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1053	Astoria Generating Company L.P.	Narrows 2-5	J	24240	Brooklyn	047	36	1972-06-01	22.0	19.9	26.0	18.1	24.4	YES	GT	FO2	NG	4.8	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1054	Astoria Generating Company L.P.	Narrows 2-6	J	24241	Brooklyn	047	36	1972-06-01	22.0	18.1	23.6	16.3	21.9	YES	GT	FO2	NG	2.8	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1055	Astoria Generating Company L.P.	Narrows 2-7	J	24242	Brooklyn	047	36	1972-06-01	22.0	20.7	27.0	18.5	24.9	YES	GT	FO2	NG	6.6	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1056	Astoria Generating Company L.P.	Narrows 2-8	J	24243	Brooklyn	047	36	1972-06-01	22.0	17.5	22.9	16.3	21.9	YES	GT	FO2	NG	6.4	Y	x	x	x	Unavailable in Ozone Season (May1st~Sept30st)
R1101	Consolidated Edison Co. of NY, Inc	59 St. GT 1	J	24138	Manhattan	061	36	1969-06-01	17.1	15.4	20.1	15.5	21.6	YES	GT	KER	NG	0.2	Y	x	x	x	Unavailable-black start only
R1102	Consolidated Edison Co. of NY, Inc	74 St. GT 1	J	24260	Manhattan	061	36	1968-10-01	18.5	19.0	23.5	19.0	19.9		GT	KER		0.2	Y	x	x	x	Unavailable-black start only
R1103	Consolidated Edison Co. of NY, Inc	74 St. GT 2	J	24261	Manhattan	061	36	1968-10-01	18.5	20.1	25.7	18.9	21.2		GT	KER		0.2	Y	x	x	x	Unavailable-black start only
R1109	Consolidated Edison Co. of NY, Inc	Hudson Ave 3	J	23810	Brooklyn	047	36	1970-07-01	16.3	16.0	20.9	16.7	19.5		GT	KER		0.2	Y	x	x	x	Retire by 2023/IIFO
R1110	Consolidated Edison Co. of NY, Inc	Hudson Ave 4	J	23540	Brooklyn	047	36	1970-07-01	16.3	13.9	18.2	0.0	0.0		GT	KER		0.1	Y	x	x	x	RETIRE
R1111	Consolidated Edison Co. of NY, Inc	Hudson Ave 5	J	23657	Brooklyn	047	36	1970-07-01	16.3	15.1	19.7	14.7	19.0		GT	KER		0.2	Y	x	x	x	Retire by 2023
R1342	Helix Ravenswood, LLC	Ravenswood 01	J	23729	Queens	081	36	1967-07-01	18.6	8.8	11.5	7.8	6.4		GT	NG		0.2	Y	x	x	x	Retire by 2023
R1343	Helix Ravenswood, LLC	Ravenswood 10	J	24258	Queens	081	36	1970-08-01	25.0	21.2	27.0	16.7	23.7	YES	JE	KER	NG	2.1	Y	x	x	x	Retire by 2023
R1344	Helix Ravenswood, LLC	Ravenswood 11	J	24259	Queens	081	36	1970-08-01	25.0	20.2	25.7	16.7	24.4	YES	JE	KER	NG	2.6	Y	x	x	x	Retire by 2023
R1345	Helix Ravenswood, LLC	Ravenswood 2-1 (IIFO - 4/1/18)	J	24244	Queens	081	36	1970-12-01	42.9	40.4	51.4	0.0	0.0	YES	JE	NG	KER	0.2	Y	x	x	x	IIFO, 2018 RNA/CRP
R1346	Helix Ravenswood, LLC	Ravenswood 2-2 (IIFO - 4/1/18)	J	24245	Queens	081	36	1970-12-01	42.9	37.6	47.8	0.0	0.0	YES	JE	NG	KER	0.0	Y	x	x	x	IIFO, 2018 RNA/CRP
R1347	Helix Ravenswood, LLC	Ravenswood 2-3 (IIFO - 4/1/18)	J	24246	Queens	081	36	1970-12-01	42.9	39.2	49.9	0.0	0.0	YES	JE	NG	KER	0.0	Y	x	x	x	IIFO, 2018 RNA/CRP
R1348	Helix Ravenswood, LLC	Ravenswood 2-4 (IIFO - 4/1/18)	J	24247	Queens	081	36	1970-12-01	42.9	39.8	50.6	0.0	0.0	YES	JE	NG	KER	0.0	Y	x	x	x	IIFO, 2018 RNA/CRP
R1349	Helix Ravenswood, LLC	Ravenswood 3-1 (IIFO - 4/1/18)	J	24248	Queens	081	36	1970-08-01	42.9	40.5	51.5	0.0	0.0	YES	JE	NG	KER	0.0	Y	x	x	x	IIFO, 2018 RNA/CRP
R1350	Helix Ravenswood, LLC	Ravenswood 3-2 (IIFO - 4/1/18)	J	24249	Queens	081	36	1970-08-01	42.9	38.1	48.5	0.0	0.0	YES	JE	NG	KER	0.0	Y	x	x	x	IIFO, 2018 RNA/CRP
R1351	Helix Ravenswood, LLC	Ravenswood 3-4 (IIFO - 4/1/18)	J	24251	Queens	081	36	1970-08-01	42.9	35.8	45.5	0.0	0.0	YES	JE	NG	KER	0.0	Y	x	x	x	IIFO, 2018 RNA/CRP
R1397	Long Island Power Authority	Glenwood GT 01	K	23712	Glenwood	059	36	1967-04-01	16.0	14.6	19.1	11.6	13.5		GT	FO2		0.0	Y	x	x	x	Retire by 2023
R1421	Long Island Power Authority	Northport GT	K	23718	Northport	103	36	1967-03-01	16.0	13.8	18.0	12.1	11.8		GT	FO2		0.1	Y	x	x	x	Unavailable-black start only
R1429	Long Island Power Authority	Port Jefferson GT 01	K	23713	t Jefferson	103	36	1966-12-01	16.0	14.1	18.4	12.2	15.7		GT	FO2		-0.1	Y	x	x	x	Unavailable-black start only
R1443	Long Island Power Authority	West Babylon 4	K	23714	st Babylon	103	36	1971-08-01	52.4	49.0	64.0	48.9	64.8		GT	FO2		1.9	Y	x	x	x	Retire by 2020

Attachment 3.II

Transmission Upgrades

Description	Zone	KV	Action	Assumption
Install a new 138 kV Circuit from the East Garden City substation to the Valley stream substation	K	138	A generic representation of this project will be considered in all cases.	Specification of the new line was considered similar to the existing line-214 MVA (S/N) and 298 MVA (S/E) ratings
Install 2-Ohm Series Reactor on the 69 kV Whiteside to Stewart Manor circuit to mitigate thermal constraints on the circuit	K	69	A generic representation of this project will be considered in all cases.	
Construct a new 69 kV substation. 69 kV supply will come from tapping the existing East Garden City to Meadowbrook Hospital circuit.	K	69	Modeled based on the CY19 ATBA cases in all study years	
Install a new 138 kV circuit from the Syosset substation to the Shore Rd substation.	K	138	A generic representation of this project will be included in 2030 and 2035 cases.	New line was considered from Syosset to Shore Rd with 0.0019+j0.02586 impedance with 396 MVA (SN) and 482 MVA (SE) ratings.
Install a 27 MVAR capacitor bank at the 69 kV Deer Park substation.	K	69	Modeled based on the CY19 ATBA cases	
Install a 27 MVAR capacitor bank at the MacArthur substation.	K	69	Modeled based on the CY19 ATBA cases	
Construct a new 138 kV substation. 138 kV supply will come from tapping the existing Pilgrim to West Bus circuit.	K	138	Already modeled	
Convert the existing Wildwood to Riverhead circuit from 69 kV to 138 kV.	K	138	A generic representation of this project will be included in 2030 and 2035 cases.	Specification of the new line was considered similar to the existing line-297 MVA (S/N) and 327 MVA (S/E) ratings
Install a new 138 kV circuit from the Riverhead substation to the Canal substation	K	138	A generic representation of this project will be included in 2030 and 2035 cases.	Specification of the new line was considered similar to the existing line-239 MVA (S/N) and 272 MVA (S/E) ratings
Tie feeders B-3402 and C-3403 continue to be on a long term outage	J	345	None	B-3402 and C-3403 feeders are considered out of service in all study case.
Addition of a 345/138 kV PAR controlled Rainey –Corona feeder	J	345/138	None	It was assumed that the PAR corresponds to the existing PAR in power flow cases from Bus#126819 to Bus#126820
Install a third 345/115kV transformer and second 115/34.5kV transformer	E	345/115	Modeled in all study years	
Ratings of the followings elements were changed based on CY19 ATBA case: Pilgrim-Ruland Rd 138 KV ckt Ruland Rd-South Farmingdale 69 KV ckt Canal- South Hampton 69 KV ckt Canal-Canal SR 69 KV South Hampton-Canal SR 69 KV West Bus- Kings 138 KV	K	138 &69 KV	Modeled in all study years	Corrections were applied based on CY19 ATBA case provided by NYISO.

Annex B: Transmission Cable Routing Assessment Supporting Attachments

Annex B - Part 1
GIS Data Source List

Included herein is a multiple-page table that provides a description of and source information for publicly accessible GIS-based data layers that were considered as part of the transmission cable routing feasibility assessment (Routing Assessment).

LANDING FEASIBILITY FOR POTENTIAL POINTS OF INTERCONNECTION IN NEW YORK CITY AND LONG ISLAND, NEW YORK - GIS DATA SOURCE LIST

Resource/Area	Year	Description	Web link/ Source
Environmental Areas			
DEC Remediation Sites	2010	This dataset includes a boundary for a subset of sites which are currently included in one of the Remedial Programs being overseen by the Division of Environmental Remediation.	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1097
EPA Superfund Sites/Brownfields	2018	Locations of the EPA's list of National Priority List superfund sites and brownfields within New York.	https://www.epa.gov/superfund/national-priorities-list-npl-sites-state
North Atlantic Right Whale Critical Habitat/Seasonal Management Areas.	2019	This dataset depicts the boundaries of the North Atlantic Right Whale Critical Habitat in ESRI shapefile format for the NOAA Fisheries Service's Greater Atlantic Regional Fisheries Office (GARFO). Additionally, data representing Seasonal Management Area locations where regulations implement speed restrictions in shipping areas at certain times of the year along the coast of the U.S. Atlantic seaboard.	https://www.greateratlantic.fisheries.noaa.gov/educational_resources/gis/index.html
DEC NY Shellfish Closures	2020	Shows certified, seasonally certified and uncertified shellfish growing areas on Long Island. Shellfish closures on Long Island as described in Part 41 of 6NYRR.	https://www.arcgis.com/apps/webappviewer/index.html?id=d98abc91849f4ccf8c38dbb70f8a0042
Shellfish Aquaculture Lease Sites	2014	Identifies operating marine aquaculture facilities based on the best available information from state aquaculture coordinators and programs. Additionally, for this analysis specific information was obtained on the Suffolk County Aquaculture Lease Program.	https://www.northeastoceandata.org/ https://gis3.suffolkcountyny.gov/shellfish/
Significant Coastal Fish and Wildlife Habitats (SCFWH)	2013	Statutory boundaries of Significant Coastal Fish and Wildlife Habitats (SCFWH) as identified and recommended by Environmental Conservation and designated by Department of State.	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=318
Natural Heritage Communities (NY NHC)	2019	Features represent element occurrences of significant natural communities (ecological communities), as recorded in the New York Natural Heritage Program's Biodiversity Database (Biotics).	http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1241
DEC Critical Environmental Areas	2020	This data set contains areas that have been designated as Critical Environmental Areas (CEAs) under 6 NYCRR Part 617 - State Environmental Quality Review (SEQR).	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1330
Important Bird Areas	2017	The Important Bird Area (IBA) Program in the US is administered by the Audubon Society in partnership with Birdlife International. This data set contains available boundaries and associated attributes for Important Bird Areas (IBAs) in the United States, identified as of September 2017.	https://www.northeastoceandata.org/
Threatened and Endangered Species	2019	NYS or Federally listed Threatened and Endangered species and associated Critical Habitat.	https://noaa.maps.arcgis.com/apps/webappviewer/index.html?id=1bc332edc5204e03b250ac11f9914a27 https://ecos.fws.gov/ipac/ https://gisservices.dec.ny.gov/gis/erm/ https://www.northeastoceandata.org/
NOAA Critical Coastal Habitat (CCH)	2018	This dataset is a compilation of the NOAA National Marine Fisheries Service and the U.S. Fish & Wildlife Service designated critical habitat in coastal areas of the United States. Critical habitat is defined as: (1) Specific areas within the geographical area occupied by the species at the time of listing that contain physical or biological features essential to conservation, which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation.	https://marinecadastre.gov/data/
Essential Fish Habitat	2020	The spatial representations of fish species, their life stages and important habitats including Habitat Areas of Particular Concern.	https://www.fisheries.noaa.gov/resource/map/essential-fish-habitat-mapper
Cultural Resources			
National Historic Landmarks/National Register of Historic Places Points/Polygons (NRHP)	2017	Point Locations and Polygon features. A current, accurate spatial representation of all historic properties listed on the National Register of Historic Places is of interest to Federal agencies, the National Park Service, State Historic and Tribal Historic Preservation Offices, local government and certified local governments, consultants, academia, and the interested public.	https://mapservices.nps.gov/arcgis/rest/services/cultural_resources/nrhp_locations/MapServer
New York State Heritage Areas	2012	New York State Heritage Areas Data include boundaries of twenty Heritage Areas designated in Parks, Recreation and Historic Preservation law.	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1188
NYS National Register Site	2018	Data include buildings, structures, objects, historic districts listed in the National Register. Archeological sites and properties determined eligible for listing are not included.	http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=429
NYS State Park or Historic Site	2018	State Park and Historic Site Boundaries - Data include boundaries of state park and historic site facilities.Facility types include state parks, marine parks, boat launch sites, historic sites, historic parks, and park preserves.	http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=430
Wrecks and Obstructions (NOAA AWOIS and ENC)	2020	The Automated Wreck and Obstruction Information System (AWOIS) is an automated file that contains information on wrecks and obstructions, and other significant charted features in coastal waters of the United States subject to NOS Hydrographic Surveys.	https://nauticalcharts.noaa.gov/data/wrecks-and-obstructions.html

LANDING FEASIBILITY FOR POTENTIAL POINTS OF INTERCONNECTION IN NEW YORK CITY AND LONG ISLAND, NEW YORK - GIS DATA SOURCE LIST

Resource/Area	Year	Description	Web link/ Source
Infrastructure			
NYC Aqueducts/Water Tunnels	2020	NYC water Tunnels/ Aqueduct lines from the NYC H2O Hub website.	Extracted from: https://storymaps.arcgis.com/collections/8a62c7993b4f4f40b49b3ac09671ce3c?item=1 https://services9.arcgis.com/jzHsRPm3d1aMJuBp/ArcGIS/rest/services/NYC_H2O_WaterSystemMap3/FeatureServer/2
Interstates/Major Highways	2016	U.S. Major Highways represents the major highways of the United States. These include interstates, U.S. highways, state highways, and major roads. This dataset is from the Census 2000 TIGER/Line files.	From ESRI ArcGIS base data. Can also find at: https://catalog.data.gov/dataset/tiger-line-shapefile-2016-nation-u-s-primary-roads-national-shapefile
Submarine Cables	2015/ 2018	These data depict the occurrence of submarine cables in and around U.S. navigable waters. The purpose of this data product is to support coastal planning at the regional and national scale. NASCA published in 2015 and NOAA published in 2018.	https://marinecadastre.gov/data/
Pipelines	2006	National Pipeline Mapping System GIS data representing the linear locations of gas/utility pipelines. Data acquired in 2006 (newer data is available). Also added a pipeline route for Lower NY Bay Lateral pipeline in Raritan Bay.	https://www.npms.phmsa.dot.gov/
Railways	2017	U.S. National Transportation Atlas Railroads represents a comprehensive database of the nation's railway system at 1:100,000 scale.	https://railroads.dot.gov/maps-and-data/maps-geographic-information-system/maps-geographic-information-system
NYC Subways	2017	New York City subway lines. Data layer name DOITT_SUBWAY_LINE_04JAN2017.	https://data.cityofnewyork.us/Transportation/Subway-Lines/3qz8-muuu
Transmission Lines (PLATTS)	2009	Platts Transmission lines representing the linear locations of transmission/utility lines carrying electricity.	https://www.spglobal.com/platts/en/products-services/electric-power/gis-data
New York City Sewer Atlas	2019	New York City Sewer Atlas Data contains date for the NYC sewer system.	http://openseweratlas.tumblr.com/data
Physical Features			
Conmap sediment grainsize	2005	The purpose of the CONMAPSG sediment layer is to show the sediment grain size distributions. The maps depicted in this series are old and do not accurately depict small-scale sediment distributions or sea-floor variability. This data layer is supplied primarily as a gross overview and to show general textural trends.	https://cmgds.marine.usgs.gov/publications/of2005-1001/htmldocs/datacatalog.htm https://cmgds.marine.usgs.gov/publications/of2005-1001/data/conmapsg/conmapsg.htm
Long Island Soils	2017	The SSURGO database contains information about soil as collected by the National Cooperative Soil Survey over the course of a century.	https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627
Bathymetric Contour	2020	Bathymetry contours covering the project area, from NOAA Navigation Charts at varying scales	NOAA ENC Direct to GIS. https://encdirect.noaa.gov/
Tidal Wetlands	1974	New York State tidal wetlands south of the Tappan Zee Bridge, as of 1974, for tidal wetlands trend analysis.	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1139
Statewide Seagrass	2018	Polygons representing coverage of New York State Seagrass areas (data exported in October 2018 from an ArcGIS REST Service)	https://services6.arcgis.com/DZHaqZm9cxOD4CWM/ArcGIS/rest/services/NYStatewideSeagrass/FeatureServer
National Hydrography Dataset (NHD) Flowlines and Waterbodies	2018	USGS National Hydrography Dataset (NHD) Flowline, linear features and waterbodies, polygon area feature. The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system.	https://www.usgs.gov/core-science-systems/ngp/national-hydrography
National Wetland Inventory Wetlands	1979	This data set represents the extent, approximate location and type of wetlands and Deepwater habitats in the United States and its Territories. These data delineate the areal extent of wetlands and surface waters as defined by Cowardian et al. (1979).	https://www.fws.gov/wetlands/
NYSDEC Freshwater Wetlands and Check zones	1999	Regulatory Freshwater Wetland areas. These data are a set of ARC/INFO coverages composed of polygonal and linear features. Coverages are based on official New York State Freshwater Wetlands Maps as described in Article 24-0301 of the Environmental Conservation Law.	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1274
Primary aquifers	2011	This layer is intended to identify Primary Aquifers at a scale of 1:24,000 or smaller.	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1232
FEMA Flood Zones	2018	The National Flood Hazard Layer (NFHL) data incorporates all Flood Insurance Rate Map (FIRM) databases published by the Federal Emergency Management Agency (FEMA), and any Letters of Map Revision (LOMRs) that have been issued against those databases since their publication date. It is updated on a monthly basis. The FIRM Database is the digital, geospatial version of the flood hazard information shown on the published paper FIRMs.	https://msc.fema.gov/portal/home
Long Island Sound Hard Bottom Model	2014	The hard bottom model is defined as an area with depth less than 9.624 meters, structural complexity greater than 0.257, LPI greater than 40.769, and sediment grain size less than 0.1157 mm. This model captures 94% known hard bottom versus 6% random locations.	The Nature Conservancy (TNC) http://maps.tnc.org/gis_data.html
Bottom Current Stress	2016	Waves and currents create bottom shear stress, a force at the seabed that influences sediment texture distribution, micro-topography, and habitat. Seabed disturbance occurs as a result of bottom shear stress, the combined force waves and currents exert on the sea floor.	USEPA, Supplemental Environmental Impact Statement for the Designation of Dredged Material Disposal Site(S) in Eastern Long Island Sound, Connecticut and New York. https://www.epa.gov/sites/production/files/2016-11/documents/elis_fseis_-_full_report_with_appendices_submitted_04nov16.pdf
Land Cover NLCD	2016	The National Land Cover Database (NLCD) provides nationwide data on land cover and land cover change at a 30m resolution with a 16-class legend based on a modified Anderson Level II classification system.	https://www.mrlc.gov/data/type/land-cover

LANDING FEASIBILITY FOR POTENTIAL POINTS OF INTERCONNECTION IN NEW YORK CITY AND LONG ISLAND, NEW YORK - GIS DATA SOURCE LIST

Resource/Area	Year	Description	Web link/ Source
Offshore Features			
Aids to Navigation	2017	Structures intended to assist a navigator to determine position or safe course, or to warn of dangers or obstructions to navigation. This dataset includes lights, signals, buoys, day beacons, and other aids to navigation.	https://marinecadastre.gov/data/
Anchorage Areas	2017	An anchorage area is a place where boats and ships can safely drop anchor. These areas are created in navigable waterways when ships and vessels require them for safe and responsible navigation.	https://marinecadastre.gov/data/ https://inport.nmfs.noaa.gov/inport/item/48849
Coastal Maintained Channel	2015	This layer shows coastal channels and waterways that are maintained and surveyed by the U.S. Army Corps of Engineers (USACE). These channels are necessary transportation systems that serve economic and national security interests.	https://marinecadastre.gov/data/
Danger Zones and Restricted Areas	2017	These data represent the location of Danger Zones and Restricted Areas within coastal and marine waters, as outlined by the Code of Federal Regulations (CFR) and the Raster Navigational Charts (RNC).	https://marinecadastre.gov/data/ https://inport.nmfs.noaa.gov/inport/item/48876
Ocean Disposal Sites	2018	In 1972, Congress enacted the Marine Protection, Research, and Sanctuaries Act (MPRSA, also known as the Ocean Dumping Act) to prohibit the dumping of material into the ocean that would unreasonably degrade or endanger human health or the marine environment. Virtually all material ocean dumped today is dredged material (sediments) removed from the bottom of waterbodies in order to maintain navigation channels and berthing areas.	https://marinecadastre.gov/data/
Artificial Reefs	2019	These are polygon locations of Mid-Atlantic artificial reefs. They were compiled from various sources, primarily lat/long coordinates of reef corners found on public web sites.	http://portal.midatlanticocean.org/data-catalog/fishing/
Pilot Boarding Area	2018	Pilot boarding areas are locations at sea where pilots familiar with local waters board incoming vessels to navigate their passage to a destination port.	https://marinecadastre.gov/data/
Unexploded Ordnances	2018	Unexploded ordnances are explosive weapons (bombs, bullets, shells, grenades, mines, etc.) that did not explode when they were employed and still pose a risk of detonation, potentially many decades after they were used or discarded.	https://marinecadastre.gov/data/
Shipping Lanes	2020	Shipping fairways and separation zones on approach to major ports.	https://www.nauticalcharts.noaa.gov/data/gis-data-and-services.html#enc-direct-to-gis
USACE Borrow Areas	2018	US Army Corps Borrow Area locations for beach nourishment projects.	https://geospatial-usace.opendata.arcgis.com/datasets/aed16678ea814ddc8fdb5d96f723d90b
USACE Coastal Storm Risk Management Project	2018	USACE Coastal Systems Portfolio Initiative (CSPI) Project Reliability and Phase data. Coastal Risk reduction projects.	https://geospatial-usace.opendata.arcgis.com/datasets/fec7341a4b2b4e43bc1f6258057fd115
Vessel Traffic	2017	Vessel transit counts for all vessels that carry Automatic Identification System (AIS) transponders. AIS are a navigation safety device that transmits and monitors the location and characteristics of many vessels in U.S. and international waters in real-time.	https://www.northeastoceandata.org/data-explorer/
NOAA Navigation Charts	2020	NOAA Navigation Chart tiles, downloaded from NOAA RNC Tile service	https://tileservice.charts.noaa.gov/tileset.html#50000_1-locator
Department of Defense			
DOD Offshore Wind Mission Compatibility Assessments	2014	This data set represents the results of analyses conducted by the Department of Defense to assess the compatibility of offshore wind development with military assets and activities.	https://marinecadastre.gov/data/ https://coast.noaa.gov/arcgis/rest/services/MarineCadastre/OceanEnergy/MapServer/4
Submarine Transit Lanes	2015	Submarine transit lanes are areas where submarines may navigate underwater, including transit corridors designated for submarine travel.	https://www.northeastoceandata.org/data-explorer/
Naval Undersea Warfare Testing Range	2009	The Naval Undersea Warfare Testing Range consists of waters nearshore waters of Rhode Island Sound, Block Island Sound, and coastal waters of New York, Connecticut, and Massachusetts. The Testing Range located is an area is used for research, development, test, and evaluation of Undersea Warfare systems, and, as necessary, to support other Navy and DoD operations.	https://www.northeastoceandata.org/data-explorer/
DoD Operations Area	2015	An OPAREA is an ocean area defined by geographic coordinates with defined sea surface and subsurface training areas and associated special use airspace, and includes danger zones and restricted areas.	https://www.northeastoceandata.org/data-explorer/
Fisheries			
Commercial Fishing Vessel Trip Report Data: Fixed Gear/Mobile Gear	2017	These data are collected by observers through NOAA's Northeast Fisheries Observer Program. Raw data are not shared due to the confidentiality of the program. Fixed gear types include gillnets, hand lines, longlines, pots and traps. Mobile gear types include trawls, dredges, and purse seines.	https://www.northeastoceandata.org/data-explorer/
Commercial Fisheries Vessel Monitoring System Data	2015	This dataset broadly characterizes the density of commercial fishing vessel activity for fisheries in the northeastern U.S. based on Vessel Monitoring Systems (VMS) from fishing vessels. The National Marine Fisheries Service (NMFS) describes VMS is a satellite surveillance system primarily used to monitor the location and movement of commercial fishing vessels in the U.S.	https://www.northeastoceandata.org/data-explorer/
DEC public fishing lakes ponds	2012	This is a shapefile that displays the locations of top lakes and ponds for fishing in New York State, as determined by fisheries biologists working for the New York State Department of Environmental Conservation.	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1252
DEC public fishing rivers streams	2012	This is a shapefile that displays the locations of top rivers and streams for fishing in New York State, as determined by fisheries biologists working for the New York State Department of Environmental Conservation.	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1252
New York Recreational Uses - Recreational Fishing	2014	DOS staff worked with NOAA's Coastal Services Center (CSC) to design and develop a participatory mapping process. Leaders from 30 partner organizations and other knowledgeable individuals were invited to participate in one of five offshore use workshops conducted during the summer of 2011. At the workshops, DOS and CSC trained organizational contacts and knowledgeable individuals to work with their colleagues, constituents, and memberships to collect ocean use information.	http://portal.midatlanticocean.org/

LANDING FEASIBILITY FOR POTENTIAL POINTS OF INTERCONNECTION IN NEW YORK CITY AND LONG ISLAND, NEW YORK - GIS DATA SOURCE LIST

Resource/Area	Year	Description	Web link/ Source
Reference Boundaries			
NY State Parks	2018	State Park and Historic Site Boundaries - Data include boundaries of state park and historic site facilities. Facility types include state parks, marine parks, boat launch sites, historic sites, historic parks, and park preserves.	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=430
DEC Lands	2019	Lands under the care, custody and control of DEC, including Wildlife Management areas, Unique Areas, State Forests, and Forest Preserve.	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1114
New York Protected Areas Database	2017	The New York Protected Areas Database (NYPAD) is intended to be the most comprehensive geospatial dataset of protected lands in New York State. Protected lands are defined as those lands which are protected, designated, or functioning as conservation lands, open space, natural areas, or recreational areas through fee ownership, easement, management agreement, current land use, or other mechanism.	http://www.nypad.org/
State/County/City/Town/Village Boundaries	2017	A vector polygon GIS file of boundaries in New York State. NYS_Civil_Boundaries.gdb	http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=927
Federal Lands	2014	U.S. National Atlas Federal Land Areas represents the federally owned or administered land areas (for example, National Wildlife Refuges, National Monuments, and National Conservation Areas) of the United States.	http://nationalmap.gov/small_scale/atlasftp.html
Indian Territories	2020	A vector polygon GIS file of all Indian Territory boundaries in New York State.	http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=927
Federal Consistency Geographic Location Descriptions	2018	These data represent state geographic location descriptions (GLDs) for state coastal management programs.	https://inport.nmfs.noaa.gov/inport/item/51544
NY Local Waterfront Revitalization Communities	2018/ 2016	This dataset delineates the boundaries of communities with an approved Local Waterfront Revitalization Program (LWRP) under the NYS Coastal Management Program. Including the specific boundaries for the NYC LWRP	https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1284 https://www1.nyc.gov/site/planning/data-maps/open-data.page#zoning_related\
Coastal Barrier Resource Systems Boundaries	2019	This map layer shows areas designated as undeveloped coastal barriers in accordance with the Coastal Barrier Resources Act, which encourages conservation of hurricane-prone, biologically rich coastal barriers by restricting federal expenditures that encourage development.	https://www.northeastoceandata.org/data-explorer/
New York State Tax Parcel Centroid Data	2020	Tax parcel centroids with a concise set of attributes for all counties in New York State.	http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1300 Statewide Parcel Map Program, NYS ITS GIS Program Office
Submerged Lands Act Boundary	2010	The Submerged Lands Act boundary defines the seaward limit of a state's submerged lands and the landward boundary of federally managed OCS lands. In the BOEM Atlantic Region it is projected 3 nautical miles offshore from the baseline.	https://metadata.boem.gov/geospatial/OCS_SubmergedLandsActBoundary_Atlantic_NAD83.xml
U.S. Maritime Boundary	2013	Territorial sea boundary at 12 nautical miles.	https://www.nauticalcharts.noaa.gov/data/gis-data-and-services.html#enc-direct-to-gis National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Office of Coast Survey (OCS)
County Parcels	2018	Kings/Nassau/Suffolk County tax map parcels and ownership data.	http://gis.ny.gov/parcels/ https://lrv.nassaucountyny.gov/map/?s=62&b=13&l=46 https://gis3.suffolkcountyny.gov/gisviewer/
BOEM Lease Areas and NY Call Areas	2019	Active renewable energy leasing areas on the Atlantic OCS as well as the BOEM Call Areas of New York State.	https://www.boem.gov/Renewable-Energy-GIS-Data/

Annex B - Part 2

Preliminary Route Feasibility Scoring Matrices

Below is a map (Figure A) showing preliminary representative routes that were subject to a screening-level analysis during the transmission cable routing feasibility assessment (Routing Assessment). Following the map, two matrices – one for New York City points of interconnection (POIs) and one for Long Island POIs – present the results of the preliminary route feasibility scoring for potential critical constraint categories. Each matrix is split across two pages (11” by 17” format). Blue-shaded headers are carried over onto each page for ease of review.

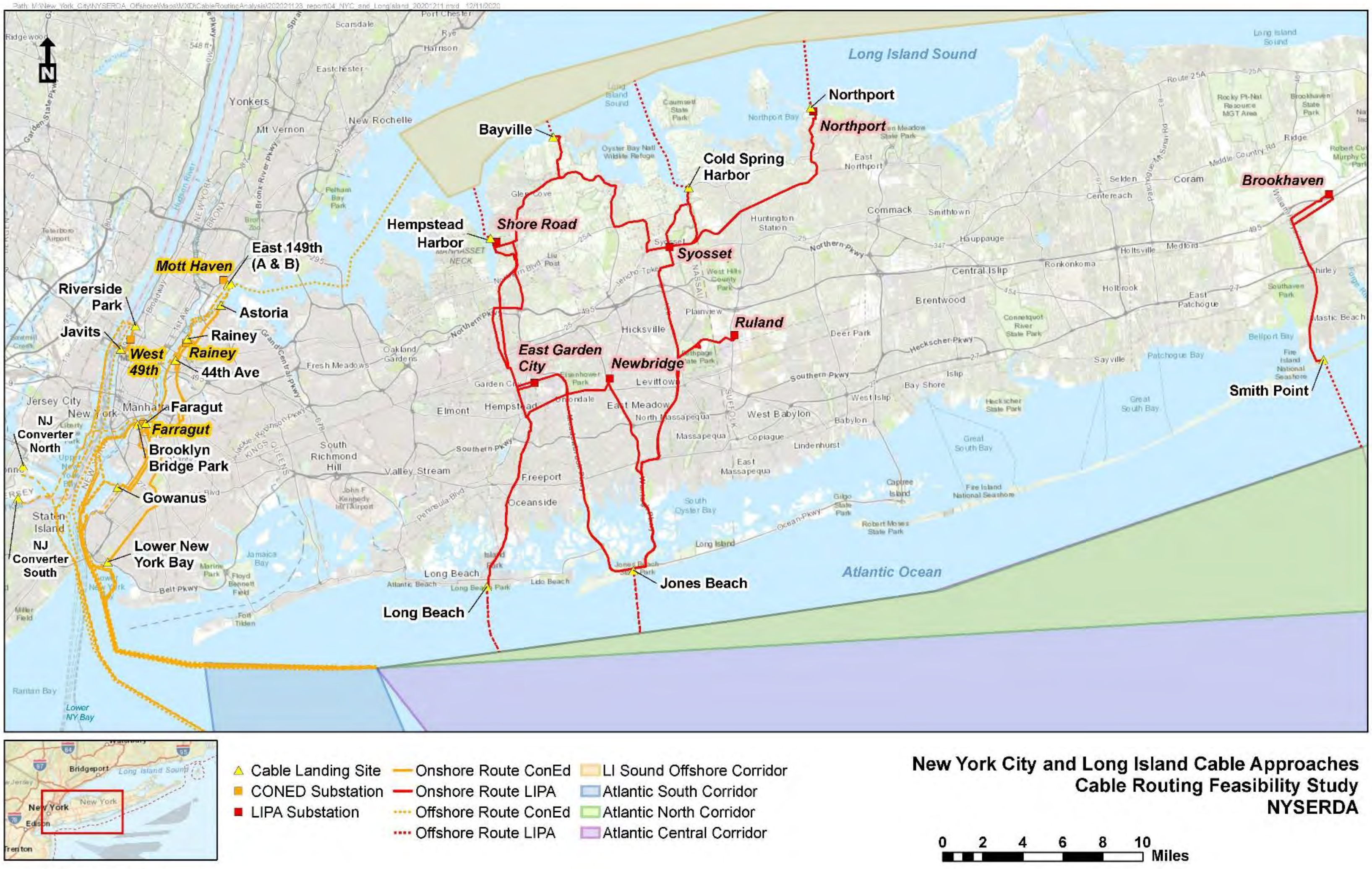
The matrix identifies the preliminary routes split into three segments – (1) offshore, (2) shore approach and landing site, and (3) onshore. The blue-shaded column headers identify the name of each route segment. The scoring for each route segment is presented for each critical constraint category; color coding was applied as a visual aid. The color key at the top-center of each matrix denotes the score value and description of each corresponding color. The total score and relative rank for each representative route can be found at the bottom of the second page of each matrix.

To the right of the color-coded scoring section, in the middle of the page, a column titled “Scoring Explanations” describes the criteria used to assign scores for each constraint category. Farthest to the right, a column titled “Specific Route Scoring Comments” provides a summary of details considered when assigning constraint scores for specific route segments.

Figure A. Preliminary Shore Approach Routes, Landing Sites, and Onshore Routes

Representative shore approach routes, landing sites, and onshore routes for cable interconnection to New York City and Long Island.

Sources: WSP 2020; DNVGL 2020; ESRI 2020. (See Attachment 1 GIS Data Layer List for full list of figure references.)



PRELIMINARY ROUTE FEASIBILITY SCORING IN NEW YORK CITY - CRITICAL CONSTRAINTS MATRIX

wsp

Color Key (with scoring)

Score	Description
1x (Green)	No constraints present
2x (Light Green)	Low constraints present
3x (Yellow)	Moderate constraints present
4x (Orange)	Major constraints present
5x (Red)	Substantial constraints present
100x (Black)	Challenges considered potentially insurmountable

	Lease Area/Region	Hudson North									Hudson South			New Jersey						Massachusetts		
	Offshore Route	Atlantic Central Corridor									Atlantic South Corridor									Long Island Sound Corridor		
	Shore Approach and Landing Site	Lower New York Bay	Gowanus	Farragut (Narrows East)		Farragut (Narrows West)	Rainey	149th Street	Riverside (Narrows West)	Riverside (Narrows East)	Lower New York Bay	Gowanus	Farragut (Narrows East)		Farragut (Narrows West)	Rainey	149th Street	Riverside (Narrows West)	Riverside (Narrows East)	Rainey	Astoria	149th Street
	Point of Interconnection	Farragut	Farragut	Farragut	Rainey	Farragut	Rainey	Mott Haven	West 49th		Farragut	Farragut	Farragut	Rainey	Farragut	Rainey	Mott Haven	West 49th		Rainey	Rainey	Mott Haven
Considerations																						
LEASE TO POI	Approximate route distance in miles (AC Feasibility: +/- 70 miles)	99	100	99	106	94	104	108	99	103	127	128	127	134	107	132	136	126	131	200	200	197
OFFSHORE ROUTE SEGMENT	Infrastructure Crossings (linear utilities)	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Yellow	Yellow	Yellow
OFFSHORE ROUTE SEGMENT	Designated Marine Zones (traffic lanes, danger zones)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Light Green	Light Green	Light Green
OFFSHORE ROUTE SEGMENT	Department of Defense Areas	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange
OFFSHORE ROUTE SEGMENT	Sensitive Habitats (presence of sensitive species or habitat exists)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange
OFFSHORE ROUTE SEGMENT	Marine Geology and Oceanography (seabed, erosion, bedforms, etc.)	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Red	Red	Red
OFFSHORE ROUTE SEGMENT	Further Regulatory Constraints (triggering additional state approvals)	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Light Green	Light Green	Light Green
OFFSHORE ROUTE SEGMENT	Stakeholder Concerns (Fisheries /Marine Vessel Operators)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange
SHORE APPROACH AND LANDING ROUTE SEGMENT	Infrastructure Crossings (linear utilities and tunnels)	Yellow	Orange	Orange	Orange	Orange	Red	Red	Red	Red	Yellow	Orange	Orange	Orange	Orange	Red	Red	Red	Red	Yellow	Light Green	Light Green
SHORE APPROACH AND LANDING ROUTE SEGMENT	Sensitive Habitats (presence of sensitive species or habitat exists)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Yellow	Yellow	Yellow
SHORE APPROACH AND LANDING ROUTE SEGMENT	Marine Geology and Oceanography (seabed, erosion, bedforms, etc.)	Light Green	Light Green	Orange	Orange	Orange	Orange	Orange	Light Green	Light Green	Light Green	Light Green	Orange	Orange	Orange	Orange	Orange	Light Green	Light Green	Orange	Orange	Orange
SHORE APPROACH AND LANDING ROUTE SEGMENT	Further Regulatory Constraints (triggering additional state approvals)	Yellow	Yellow	Yellow	Yellow	Red	Yellow	Yellow	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Yellow	Yellow	Red	Yellow	Yellow	Yellow	Yellow
SHORE APPROACH AND LANDING ROUTE SEGMENT	Potential Stakeholder Concerns (Fisheries /Marine Vessel Operators)	Yellow	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Yellow	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange
SHORE APPROACH AND LANDING ROUTE SEGMENT	Landing Site Complexity (e.g., back-bay crossings, shore structure crossings, dense development)	Yellow	Yellow	Red	Red	Red	Yellow	Red	Red	Red	Yellow	Yellow	Red	Red	Red	Yellow	Red	Red	Red	Yellow	Yellow	Red
SHORE APPROACH AND LANDING ROUTE SEGMENT	Navigation Channels, Anchorage Areas, and USACE Coastal Storm Risk Management Projects	Light Green	Orange	Orange	Orange	Red	Red	Red	Red	Orange	Light Green	Orange	Orange	Orange	Red	Red	Red	Red	Orange	Yellow	Yellow	Yellow
SHORE APPROACH AND LANDING ROUTE SEGMENT	Contaminated Sediments	Yellow	Orange	Orange	Orange	Orange	Red	Red	Red	Red	Yellow	Orange	Orange	Orange	Orange	Red	Red	Red	Red	Orange	Orange	Orange
SHORE APPROACH AND LANDING ROUTE SEGMENT	Cultural Resources and Wrecks/Obstructions	Light Green	Yellow	Orange	Orange	Orange	Orange	Orange	Yellow	Yellow	Light Green	Yellow	Orange	Orange	Orange	Orange	Orange	Yellow	Yellow	Red	Red	Red

Consideration	Scoring explanations (Note that the group of NYC routes are ranked against each other for each consideration. The criteria that defines each rank may not be directly comparable to Long Island routes presented in separate matrix.)	Specific Route Scoring Comments
Approximate route distance in miles	Grey: less than 70 miles No color: more than 70 miles	
Offshore: Infrastructure Crossings (linear utilities)	Green: no crossings Light Green: lower number of crossings > 15 Yellow: moderate number of crossings 15 to 25 Orange: high number of crossings 25 to 35 Red: very high number of crossings 35+	Light Green: Atlantic Central Corridor > 15 crossing varies by route Yellow: Long Island Sound Corridor ~ 17 crossings Orange: Atlantic South Corridor ~27 crossings
Offshore: Designated Marine Zones (traffic lanes, danger zones)	Green: no navigation features present in area Light Green: Route generally avoids navigation features but some in area Yellow: Likely must cross a navigation feature Orange: Must cross multiple navigation features Red: Significant impact to navigation anticipated	Light Green: Long Island Sound some ferry traffic, Newport, RI Precautionary Area Yellow: NY Bight traffic lanes or precautionary area on Atlantic Approach to NY Harbor Orange: NJ Shore traffic lanes or precautionary area on approach to NY Harbor and Danger Zone (mines) on NY Harbor approach
Offshore: Department of Defense Areas	Green: none present Light Green: present in area but can be avoided or no restrictions apply Yellow: must cross a Department of Defense (DoD) area where site specific stipulations apply Orange: must cross a DoD area where site specific stipulations apply and/or multiple other features apply Red: DoD exclusion area present that must be crossed	Yellow: along Jersey Shore OPAREA exists Orange: in Atlantic and on approach to Long Island (LI) Sound OPAREA, Sub lane, testing range exist
Offshore: Sensitive Habitats (presence of sensitive species or habitat exists)	Green: no sensitive habitat present Light Green: some sensitive habitat exists but can be avoided Yellow: sensitive habitat exists in the entire area Orange: increased sensitive habitat designations in area or adjacent Red: high number of sensitive habitats must be crossed	Yellow: Atlantic in this area is biologically important area (BIA) for North Atlantic Right Whale (NARW) Orange: entire Atlantic in this area is BIA for NARW and in LI Sound DEC Critical Environmental Area and NYSDOS Significant Coastal Fish and Wildlife Habitat area must be crossed/routed adjacent to
Offshore: Marine Geology and Oceanography (seabed, erosion, bedforms, etc.)	Green: highly suitable conditions for cable installation cable burial very easily achieved/maintained Light Green: generally suitable conditions for cable installation cable burial easily achieved/maintained Yellow: moderately suitable conditions for cable installation potential difficulty to achieve/maintain cable burial Orange: difficult conditions may exist for cable installation do to structure difficult to achieve/ maintain cable burial Red: cable may not be installed/maintained to required depths due to potential bedrock or moraine armoring may be required	Light Green: Atlantic is generally soft sediments go for cable installation Red: Long Island Sound Corridor presence of rock reefs at moraines may make cable burial difficult to achieve, armoring may be required. Strong current also exits in entrance to Long Island Sound.
Offshore: Further Regulatory Constraints (triggering additional state approvals)	Green: no trigger possible Light Green: trigger of additional state review is not likely Yellow: trigger of additional state coastal management programs is possible Orange: trigger of state coastal management program(s) will occur Red: trigger of state permitting (i.e. Section 401) review will occur	Light Green: unlikely to trigger additional state approvals when coming from Atlantic Central Corridor Yellow: Atlantic South Corridor can reroute to avoid NJ state waters but crossing offshore of NJ waters may trigger coastal management program if determined to impact state users (i.e. fishermen)
Offshore: Stakeholder Concerns (Fisheries /Marine Vessel Operators)	Green: no concerns anticipated Light Green: some concerns anticipated Yellow: moderate concern anticipated Orange: potential opposition anticipated Red: high level of opposition anticipated	Yellow: Atlantic from commercial fishermen and marine vessel operators possible Orange: Long Island Sound from commercial fishermen, marine vessel operators and CT on impacts on their coastal waters
Shore: Infrastructure Crossings (linear utilities and tunnels)	Green: no crossings Light Green: lower number of crossings > 10 Yellow: moderate number of crossings 10 to 20 Orange: high number of crossings 20 to 30 Red: very high number of crossings 30+	Light Green: Long Island Sound 149th ~9 crossings, Astoria ~10 crossings Yellow: Lower NY Bay ~21 crossings, Long Island Sound Rainey ~14 crossings Orange: Gowanus ~26 crossings, Farragut ~29 crossings, Red: Rainey ~37 crossings, 149th Street ~41 crossings, Riverside East Narrows ~33 crossings, Riverside West Narrows ~34 crossings
Shore: Sensitive Habitats (presence of sensitive species or habitat exists)	Green: no sensitive habitat present Light Green: some sensitive habitat exists but can be avoided Yellow: sensitive habitat exists in the entire area Orange: increased sensitive habitat designations in area or adjacent Red: high number of sensitive habitats must be crossed	Yellow: Several sensitive habitats (e.g., EFH) must be crossed, including winter flounder spawning and anadromous fish migratory areas. Endangered sturgeon species in area (Atlantic/Shortnose) Orange: Hudson River is critical habit for Atlantic Sturgeon
Shore: Marine Geology and Oceanography (seabed, erosion, bedforms, etc.)	Green: highly suitable conditions for cable installation cable burial very easily achieved/maintained Light Green: generally suitable conditions for cable installation cable burial easily achieved/maintained Yellow: moderately suitable conditions for cable installation potential difficulty to achieve/maintain cable burial Orange: difficult conditions possible for cable installation due to potential structure/bedrock, difficult to achieve/maintain cable burial (further investigation required) Red: cable may not be installed/maintained to required depths due to potential bedrock or moraine, armoring may be required.	Light Green: Atlantic is generally soft sediments suitable for cable installation Orange: Western Long Island Sound and East River contain structure, potential presence of shallow bedrock in East River may create difficulties to meet cable burial depth requirements, armoring may be required.
Shore: Further Regulatory Constraints (triggering additional state approvals)	Green: no trigger anticipated Light Green: trigger of additional (non-NY) state/federal coastal review unlikely or not burdensome Yellow: trigger of additional state/federal coastal management programs is possible and/or supplemental NY coastal review expected. Orange: trigger of additional state/federal coastal management program(s) expected Red: trigger of multiple additional state/federal permitting (e.g., Section 401 Water Quality Certifications) review will occur	Yellow: Route from Atlantic corridors adjacent to NJ State waters may trigger NJ coastal management program. Routes into New York City (NYC) will also require NYC Local Waterfront Revitilization Program (LWRP) approval Red: Riverside West Narrows and Farragut West Narrows crosses into NJ state waters and all state permit approvals will be necessary. Will also require NYC LWRP approval. May also require NPS submerged land easement approval for routing along west side of Narrows.
Shore: Potential Stakeholder Concerns (Fisheries /Marine Vessel Operators)	Green: no concerns anticipated Light Green: some concerns anticipated Yellow: moderate concern anticipated Orange: opposition anticipated Red: high level of opposition anticipated	Yellow: Lower NY Bay, high marine traffic levels on approach to NY Harbor Orange: NY Harbor and LI Sound - high marine traffic levels
Shore: Landing Site Complexity (e.g., back-bay crossings, shore structure crossings, dense development)	Green: very low complexity Light Green: low complexity Yellow: moderate complexity- given the presence of coastal structures that must be crossed under and urban location, including existing utility lines Orange: high complexity Red: very high complexity: HDD may not be possible other installation method may be required and or additional concerns given size of area and higher usage	Yellow: Lower New York Bay landing requires HDD under Belt Parkway and working in anchorage area, Gowanus requires HDD under revetment and close to channel, Astoria and Rainey required HDD under coastal structures Red: Riverside is in a highly trafficked public park on the waterfront, 149th limited area for HDD, CSO present at end of road, and close proximity to existing infrastructure. Alternate location on site would be on adjacent privately owned lot, Farragut limited area for HDD makes trenchless technology likely not possible, only feasible for open trench
Shore: Navigation Channels, Anchorage Areas, and USACE Coastal Storm Risk Management Projects	Green: no crossings Light Green: lower number of crossings 1 Yellow: moderate number of crossings 2 to 5 Orange: high number of crossings 6 to 9 Red: very high number of crossings +9 or long runs	Light Green: Lower New York Bay ~1, Yellow: Long Island Sound 149th Street ~2, Astoria ~2, LI Sound Rainey ~3 and all run for along distance adjacent to channels and anchorages Orange: Farragut East Narrows ~7, Riverside East Narrows ~7, Gowanus ~6 Red: Riverside West Narrows ~12, Farragut West Narrows ~10, Rainey and 149th Street, given the long length that potentially must run in/adjacent to the channel
Shore: Contaminated Sediments	Green: no contamination Light Green: lower levels of contamination likely Yellow: moderate levels of contamination likely Orange: high levels of contamination likely Red: high levels of contamination very likely	Yellow: Lower New York Bay has pockets of elevated (e.g., NYSDEC Class C) contamination and multiple combined sewer overflows passed Orange: longer route through Lower NY Bay and into Upper NY Bay increases likelihood of contamination, multiple shoreline DEC Remediation areas and combined sewer overflows passed Red: longer route through Upper NY Bay and the East River increases likelihood of contamination passes two marine superfund sites, multiple shoreline DEC Remediation areas and combined sewer overflows, Hudson River is a DEC Remediation Area
Shore: Cultural Resources and Wrecks/Obstructions	Green: none present Light Green: lower number present Yellow: moderate number present Orange: high number present Red: very high number present	Light Green: Lower New York Bay has some wrecks present, and historical sites on shore where consultations would be required Yellow: Gowanus and Riverside longer route through Lower NY Bay and into Upper NY Bay/East River/Hudson increases likelihood of consultations more wrecks/ historical sites Orange: 149th Street, Farragut and Rainey longer route through Upper NY Bay and the Northern East River significantly increases quantity of consultations as more wrecks and cultural sites passed, also Brooklyn Bridge a Natural Historic Landmark is routed adjacent to Red: Western Long Island Sound and northeast East River have high number of wrecks

PRELIMINARY ROUTE FEASIBILITY SCORING IN NEW YORK CITY - CRITICAL CONSTRAINTS MATRIX

Offshore Route	Atlantic Central Corridor									Atlantic South Corridor									Long Island Sound Corridor		
Shore Approach and Landing Site	Lower New York Bay	Gowanus	Farragut (Narrows East)		Farragut (Narrows West)	Rainey	149th Street	Riverside (Narrows West)	Riverside (Narrows East)	Lower New York Bay	Gowanus	Farragut (Narrows East)		Farragut (Narrows West)	Rainey	149th Street	Riverside (Narrows West)	Riverside (Narrows East)	Rainey	Astoria	149th Street
Point of Interconnection	Farragut	Farragut	Farragut	Rainey	Farragut	Rainey	Mott Haven	West 49th		Farragut	Farragut	Farragut	Rainey	Farragut	Rainey	Mott Haven	West 49th		Rainey	Rainey	Mott Haven

ONSHORE ROUTE SEGMENT

Criterion	Scoring explanations (Note that the group of NYC routes are ranked against each other for each consideration. The criteria that defines each rank may not be directly comparable to Long Island routes presented in separate matrix.)	Specific Route Scoring Comments
Infrastructure HDDs and/or Bridge Crossings (roadway and waterway)	Green: No major arterial or waterway crossings Light Green: 1-2 crossings Yellow: 3-4 of crossings Orange: 5-6 crossings Red: 7+ crossings	Green: Farragut to Farragut- 0, Rainey to Rainey- 0 Light Green: 149th to Mott Haven- 2, Riverside to W49th- 1, Rainey Park to Rainey- 1 Yellow: Rainey to Astoria- 4 Red: Lower NY Bay to Farragut- 7, Gowanus to Farragut- 8, Farragut to Rainey- 13
Wetlands, Sensitive Habitats	Green: No sensitive habitats along route Light Green: Small sensitive habitats, which can be avoided Yellow: Sensitive habitat exists in the entire area Orange: Majority of the route passes through sensitive habitat designations or adjacent where additional consultations may be required Red: Route entirety is through or adjacent to sensitive habitats	Green: No wetlands or sensitive habitats were identified along these routes from publicly available data Light Green: Lower NY Bay to Farragut passes along the edge of Prospect Park (Important Bird Area) and within about 200 feet of a DEC Wetland Check Zone for Dyker Beach Park
Potential Stakeholder Concerns/Jurisdictions Crossed	Green: 0 - 0.5 mi of route passes within 0.5 mi of NYC Zoning residential classification and 1 local jurisdiction Light Green: 0.5 - 2 mi of route passes within 0.5 mi of NYC Zoning residential classification and/or 2 local jurisdictions Yellow: 2 - 4 mi of route passes within 0.5 mi of NYC Zoning residential classification and/or 2 - 3 local jurisdictions Orange: 4 - 5 mi of route passes within 0.5 mi of NYC Zoning residential classification and/or 4 local jurisdictions Red: More than 5 mi of route passes within 0.5 mi of NYC Zoning residential classification and/or more than 4 local jurisdictions	Green: Farragut to Farragut 0 mi and 1 jurisdiction, Rainey Park to Rainey 0.13 mi and 1 jurisdiction, 149th to Mott Haven 0.7 mi and 1 jurisdiction, and Riverside to W49th- 0 mi and 1 jurisdiction Yellow: Gowanus to Farragut- 0.42 mi and 1 jurisdiction but passes near Boreum Hill which is known to have concerns about construction , Farragut to Rainey- 1.26 mi and 3 jurisdictions, and Rainey to Astoria 0.77 mi and 1 jurisdiction Red: Lower NY Bay to Farragut 2.06 mi and 1 jurisdiction
Contaminated Sites (total area encountered)	Green: No contaminated sites along route Light Green: Small contaminated sites along route, which may be avoidable Yellow: Crossing small contaminated sites is unavoidable along route Orange: Route passes large contaminated sites, crossing of which can be avoided Red: Large contaminated sites are along route and unavoidable	Green: Farragut to Farragut, 149th to Mott Haven, and Riverside to W 49th have no contaminated sites along the route Light Green: Gowanus to Farragut- passes 4 sites all avoidable, Rainey Park to Rainey- passes 2 sites both avoidable Yellow: Lower NY Bay to Farragut- Passes near Fort Hamilton and Brooklyn Navy Yard two Superfund Sites Orange: Farragut to Rainey- passes Brooklyn Navy Yard and under Newtown Creek, Rainey Park to Mott Haven via Astoria- Astoria is a DEC Remediation site but portions with the most contamination should be avoidable
Cultural Resources	Green: No known cultural resources along route Light Green: Low number and/or avoidable known cultural resources Yellow: Moderate number and/or avoidable known cultural resources Orange: Moderately high number of cultural resources, some of which can not be avoided Red: High number or large area of cultural resources	Green: 149th to Mott Haven, Rainey Park to Rainey, and Rainey to Astoria no known cultural resources along route Light Green: Farragut to Farragut heavily landmarked areas around Farragut (DUMBO Industrial, Brooklyn Navy Yard etc), Riverside to W49th is near but does not pass the Intrepid Orange: Lower NY Bay to Farragut passes through highly religious areas and dense historical areas/districts, Gowanus to Farragut and Brooklyn Bridge Park to Rainey pass through heavily landmarked areas around Farragut (DUMBO Industrial, Brooklyn Navy Yard etc)
Route Distance (miles)	Green: Route is <0.5 mi Light Green: Route is >0.5 mi but <1 mi Yellow: Route is 1-5 mi Orange: Route is 5-10 mi Red: Route is >10 mi	Green: Farragut to Farragut- 0 mi, Rainey Park to Rainey- 0.31 mi, 149th to Mott Haven- 0.75 mi, Riverside to W49th- 0.79 mi Yellow: Gowanus to Farragut- 4.94 mi, Rainey to Astoria- 2.71 mi Orange: Lower NY Bay to Farragut- 8.80 mi, Farragut to Rainey- 7.64 mi
Available Land for Converter Stations (> 2.5 acre parcel)	Green:6+ undeveloped and/or unconstrained 2.5 acre parcels within 1 mi of route or POI (Visual aerial interpretation) Light Green: 4-5 undeveloped and/or unconstrained 2.5 acre parcels within 1 mi of route or POI Yellow: 3 undeveloped and/or unconstrained 2.5 acre parcels within 1 mi of route or POI Orange: Only 2 undeveloped and/or unconstrained 2.5 acre parcels within 1 mi of route or POI Red: Only 1 undeveloped and/or unconstrained 2.5 acre parcel within 1 mi of route or POI Black: No suitable 2.5 acre parcels or only constrained parcels within 1 mi of route - further analysis by real estate planners warranted	Yellow: Gowanus - So. Brooklyn Terminal considered as more than one "parcel" pending Empire Wind, also 640 Columbia St 0.2 mi from route 4 acres but near Red Hook Park and public housing might also now be parking for IKEA; Rainey to Astoria - area at ConEd plant pending CHPE construction & 3-15 26 Avenue 0.5 mi from route 3.1 acres Orange: L NY Bay to Farragut - 595 Dean St. 2.75 vacant acres 0.08 mi from route; Rainey & Rainey to Farragut - 0.7 mi south along east river 42-02 & 44-02 Vernon Blvd totaling 5.2 acres; Mott Haven- old juvenile detention center at 707 Barretto St 0.7 mi from more eastern & favorable landing point Red: Rainey to Farragut - all 4 parcels identified as vacant and over 2 acres did not meet the minimum 80 m wide criteria for converter station
Parkway/Highway (Permitting constraint)	Green: Route does not touch parkway or highway interstate Light Green: Route may touch or cross parkway or highway interstate enough to trigger additional USDOT/FHWA approval Yellow: Moderate amount of route runs along or multiple crossings of parkway or highway interstate Orange: A significant portion of route is along parkway or highway interstate Red: Majority of route is along a parkway or highway interstate	Green: Farragut to Farragut and Rainey Park to Rainey do not touch parkways or highways Light Green: 149th to Mott Haven crosses under Bruckner Expy, Riverside to W49th runs down Hudson Pkwy Yellow: Farragut to Lower NY Bay parallels Principal Arterial Other Fulton Ave, Vanderbilt Ave, Prospect Park W, Prospect Park SW, Coney Island Ave for 3.07 mi and crosses BQE 1x Orange: Rainey to Farragut- parallels McGuinnis Blvd for 1.3 mi (classified as Principal Arterial Other by NYDOT) and crosses BQE 2x, Farragut to Gowanus- parallels Principal Arterial Other Atlantic Ave & 4th Ave 2.78 mi and crosses BQE 2x and Prospect Expressway 1x

Lease Area/Region	Hudson North									Hudson South			New Jersey						Massachusetts		
Offshore Route	Atlantic Central Corridor									Atlantic South Corridor									Long Island Sound Corridor		
Shore Approach and Landing Site	Lower New York Bay	Gowanus	Farragut (Narrows East)		Farragut (Narrows West)	Rainey Park	149th Street	Riverside (Narrows West)	Riverside (Narrows East)	Lower New York Bay	Gowanus	Farragut (Narrows East)		Farragut (Narrows West)	Rainey Park	149th Street	Riverside (Narrows West)	Riverside (Narrows East)	Rainey Park	Astoria	149th Street
Point of Interconnection	Farragut	Farragut	Farragut	Rainey	Farragut	Rainey	Mott Haven	West 49th		Farragut	Farragut	Farragut	Rainey	Farragut	Rainey	Mott Haven	West 49th		Rainey	Rainey	Mott Haven
Count: 1x	0	1	6	1	6	5	5	4	4	0	1	6	1	6	5	5	4	4	6	2	5
2x	7	5	4	3	4	5	5	7	7	5	3	2	1	2	3	3	5	5	3	4	5
3x	11	9	5	6	4	6	5	4	5	12	10	6	7	5	7	6	5	6	6	9	4
4x	3	8	7	11	6	4	4	3	4	4	9	8	12	7	5	5	4	5	6	7	6
5x	2	1	1	3	3	4	5	5	3	2	1	1	3	3	4	5	5	3	3	2	4
100x	1	0	1	0	1	0	0	1	1	1	0	1	0	1	0	0	1	1	0	0	0
Total Points*	169	75	162	84	165	69	71	167	164	172	78	165	87	168	72	74	170	167	69	75	71
Site Ranking**	**19**	**7**	**12**	**10**	**14**	**1**	**3**	**16**	**13**	**21**	**9**	**14**	**11**	**18**	**5**	**6**	**20**	**16**	**1**	**7**	**3**

1x	No constraints present
2x	Low constraints present
3x	Moderate constraints present
4x	Major constraints present
5x	Substantial constraints present
100x	Challenges considered potentially insurmountable

* Note: Lowest points => best option. Weighting factors applied: Light Green x1; Green x2; Yellow x3 Orange x4; Red x5; Black x100.

** Note: Lowest value => best option

PRELIMINARY ROUTE FEASIBILITY SCORING
ON LONG ISLAND, NEW YORK - CRITICAL CONSTRAINTS MATRIX

wsp

Color Key (with scoring)

Score	Description
1x	No constraints present
2x	Low constraints present
3x	Moderate constraints present
4x	Major constraints present
5x	Substantial constraints present
100x	Challenges considered potentially insurmountable

Lease Area/Region	Offshore Route	Shore Approach and Landing Site	Point of Interconnection	Approximate route distance in miles (AC Feasibility: +/- 70 miles)
Hudson North / Empire Wind	Atlantic Central Corridor	Smith Point	Brookhaven	Empire Wind: 51; Hudson North: 58
Hudson North / Empire Wind	Atlantic Central Corridor	Jones Beach	Northport (via Syosset)	Empire Wind: 67; Hudson North: 85
Hudson North / Empire Wind	Atlantic Central Corridor	Jones Beach	Newbridge	Empire Wind: 47; Hudson North: 65
Hudson North / Empire Wind	Atlantic Central Corridor	Jones Beach	Syosset	Empire Wind: 54; Hudson North: 73
Hudson North / Empire Wind	Atlantic Central Corridor	Jones Beach	Shore Road	Empire Wind: 59; Hudson North: 77
Hudson North / Empire Wind	Atlantic Central Corridor	Jones Beach	East Garden City	Empire Wind: 49; Hudson North: 67
Hudson North / Empire Wind	Atlantic Central Corridor	Jones Beach	Ruland Road	Empire Wind: 52; Hudson North: 70
Hudson North / Empire Wind	Atlantic Central Corridor	Long Beach	Newbridge	Empire Wind: 55; Hudson North: 74
Hudson North / Empire Wind	Atlantic Central Corridor	Long Beach	East Garden City	Empire Wind: 53; Hudson North: 71
Hudson North / Empire Wind	Atlantic Central Corridor	Long Beach	Shore Road	Empire Wind: 61; Hudson North: 80
Massachusetts	Atlantic North Corridor	Smith Point	Brookhaven	138
Massachusetts	Atlantic North Corridor	Jones Beach	Northport (via Syosset)	193
Massachusetts	Atlantic North Corridor	Jones Beach	Newbridge	173
Massachusetts	Atlantic North Corridor	Jones Beach	Syosset	181
Massachusetts	Atlantic North Corridor	Jones Beach	Shore Road	185
Massachusetts	Atlantic North Corridor	Jones Beach	East Garden City	175
Massachusetts	Atlantic North Corridor	Jones Beach	Ruland Road	178
Massachusetts	Atlantic North Corridor	Long Beach	Newbridge	183
Massachusetts	Atlantic North Corridor	Long Beach	East Garden City	181
Massachusetts	Atlantic North Corridor	Long Beach	Shore Road	189
Massachusetts	Long Island Sound Corridor	Northport	Northport	166
Massachusetts	Long Island Sound Corridor	Cold Spring Harbor	Syosset East	182
Massachusetts	Long Island Sound Corridor	Cold Spring Harbor	Syosset West	181
Massachusetts	Long Island Sound Corridor	Bayville	Shore Road	188
Massachusetts	Long Island Sound Corridor	Bayville	Syosset	189
Massachusetts	Long Island Sound Corridor	Hempstead Harbor	Shore Road	187

Scoring explanations
(Note that the group of Long Island routes are ranked against each other for each consideration. The criteria that defines each rank may not be directly comparable to NYC routes presented in separate matrix.)

Considerations		Scoring explanations	Specific Route Scoring Comments
LEASE TO POI	Approximate route distance in miles (AC Feasibility: +/- 70 miles)	Dark Grey: less than 70 miles Light Grey: >70 mi but <75 mi No color: more than 75 miles	
OFFSHORE ROUTE SEGMENT	Infrastructure Crossings (linear utilities)	Green: no crossings Light Green: lower number of crossings > 15 Yellow: moderate number of crossings 15 to 25 Orange: high number of crossings 25 to 35 Red: very high number of crossings 35+	Light Green: Atlantic Central Corridor > 15 crossings varies by route Yellow: Long Island Sound Corridor ~ 17 crossings, Atlantic South Shore ~18 crossings
OFFSHORE ROUTE SEGMENT	Designated Marine Zones (traffic lanes, danger zones)	Green: no navigation features present in area Light Green: route generally avoids navigation features but some in area Yellow: likely must cross a navigation feature Orange: must cross multiple navigation features Red: significant impact to navigation anticipated	Light Green: routing could generally avoid desginated marine zones Yellow: traffic lanes or precautionary area on Atlantic Central Corridor
OFFSHORE ROUTE SEGMENT	Department of Defense Areas	Green: none present Light Green: present in area but can be avoided or no restrictions apply Yellow: must cross a Department of Defense (DoD) area where site specific stipulations apply Orange: must cross a DoD area where site specific stipulations apply and/or multiple other features apply Red: DoD exclusion area present that must be crossed	Orange: in Atlantic and on approach to Long Island (LI) Sound DoD OPAREA, Sub lane, testing range exist
OFFSHORE ROUTE SEGMENT	Sensitive Habitats (presence of sensitive species or habitat exists)	Green: no sensitive habitat present Light Green: some sensitive habitat exists but can be avoided Yellow: sensitive habitat exists in the entire area Orange: increased sensitive habitat designations in area or adjacent Red: high number of sensitive habitats must be crossed	Yellow: entire Atlantic in this area is BIA for NARW Orange: entire Atlantic in this area is BIA for NARW and in LI Sound DEC CIA and NYSDOS SCFWH area must be crossed/routed adjacent to
OFFSHORE ROUTE SEGMENT	Marine Geology and Oceanography (seabed, erosion, bedforms, etc.)	Green: highly suitable conditions for cable installation cable burial very easily achieved/maintained Light Green: generally suitable conditions for cable installation cable burial easily achieved/maintained Yellow: moderately suitable conditions for cable installation potential difficulty to achieve/maintain cable burial Orange: difficult conditions may exist for cable installation do to structure difficult to achieve/ maintain cable burial Red: cable may not be installed/maintained to required depths due to potential bedrock or moraine armoring may be required	Light Green: Atlantic is generally soft sediments go for cable installation Red: Long Island Sound Corridor presence of rock reefs at moraines may make cable burial difficult to achieve, armoring may be required. Strong current also exits in entrance to Long Island Sound.
OFFSHORE ROUTE SEGMENT	Further Regulatory Constraints (triggering additional state approvals)	Green: no trigger possible Light Green: trigger of additional state review is not likely Yellow: trigger of state coastal management programs is possible Orange: trigger of multiple state coastal management program(s) expected Red: trigger of multiple state permitting (i.e. Section 401) review will occur	Orange: RI and CT Coastal Management Programs by entering Long Island Sound, as well as multiple Local Waterfront Revitilization Program reviews.
OFFSHORE ROUTE SEGMENT	Stakeholder Concerns (Fisheries /Marine Vessel Operators)	Green: no concerns anticipated Light Green: some concerns anticipated Yellow: moderate concern anticipated Orange: potential opposition anticipated Red: high level of opposition anticipated	Yellow: Atlantic from commercial fisherman and marine vessel operators possible Orange: Long Island Sound from commercial fisherman, marine vessel operators and CT on impacts on their coastal waters
SHORE APPROACH AND LANDING ROUTE SEGMENT	Infrastructure Crossings (linear utilities)	Green: no crossings Light Green: lower number of crossings > 2 Yellow: moderate number of crossings 2 to 10 Orange: high number of crossings 10 to 15 Red: very high number of crossings 15+ -	Light Green: Northport, Cold Spring Harbor, and Bayville 1 crossing Yellow: Hempstead Harbor ~4 crossings, Smith Point ~8 crossings, Jones Beach ~9 crossings Orange: Long Beach ~ 12 crossings
SHORE APPROACH AND LANDING ROUTE SEGMENT	Sensitive Habitats (presence of sensitive species or habitat exists)	Green: no sensitive habitat present Light Green: some sensitive habitat exists but can be avoided Yellow: sensitive habitat exists in the entire area Orange: increased sensitive habitat designations in area or adjacent Red: high number of sensitive habitats must be crossed	Light Green: Long Beach - no Significant Coastal Fish and Wildlife Habitat (SCFWH) or Critical Environmental Area (CEA) uncertified shellfish waters and low presence of shorebirds Yellow: Northport/Bayville routes pass near sensitive habitats and areas with increased likelihood of nesting shorebird presence Orange: Smith Point, Jones Beach CSH, Hempstead Harbor routes all cross sensitive habitat (i.e. SCFWH, natural heritage areas)
SHORE APPROACH AND LANDING ROUTE SEGMENT	Marine Geology and Oceanography (seabed, erosion, bedforms, etc.)	Green: highly suitable conditions for cable installation cable burial very easily achieved/maintained Light Green: generally suitable conditions for cable installation cable burial easily achieved/maintained Yellow: moderately suitable conditions for cable installation potential difficulty to achieve/maintain cable burial Orange: difficult conditions may exist for cable installation do to structure difficult to achieve/ maintain cable burial- Structure present on approach Red: cable may not be installed/maintained to required depths due to potential bedrock or moraine armoring may be required	Yellow: Atlantic Ocean shoreline is highly dynamic
SHORE APPROACH AND LANDING ROUTE SEGMENT	Further Regulatory Constraints (triggering additional state approvals)	Green: no trigger anticipated Light Green: trigger of additional (non-NY) state/federal coastal review unlikely or not burdensome Yellow: trigger of additional state/federal coastal management programs is possible and/or supplemental NY coastal review expected. Orange: trigger of additional state/federal coastal management program(s) expected Red: trigger of multiple additional state/federal permitting (e.g., Section 401 Water Quality Certifications) review will occur	Light Green: No triggering of other states' permitting requirements for shore approach segments. Trigger of Local Waterfront Revitilization Programs not anticipated based on plans approved as of December 2020. NYSDEC Coastal Erosion Management Permit may be required for Jones Beach/Long Beach, but addressed as part of standard New York State Joint Permit Application. Orange: Approach to Bayville and Cold Spring Harbor would trigger Local Waterfront Revitilization Program review.
SHORE APPROACH AND LANDING ROUTE SEGMENT	Potential Stakeholder Concerns (Fisheries /Marine Vessel Operators)	Green: no concerns anticipated Light Green: some concerns anticipated Yellow: moderate concern anticipated Orange: potential opposition anticipated Red: high level of opposition anticipated	Yellow: Atlantic from commercial fishermen and marine vessel operators possible, Orange: Long Island Sound from commercial fishermen, marine vessel operators and CT on impacts on their coastal waters, Cold Spring Harbor likely to have increased concerns as a result of commercial shell fisherman and proximity to village center, Bayville likely to have increased concerns from local community and adjacent homeowners, Long Beach has vocal local population
SHORE APPROACH AND LANDING ROUTE SEGMENT	Landing Site Complexity (e.g., back-bay crossings, shore structure crossings, dense development)	Green: very low complexity Light Green: low complexity Yellow: moderate complexity Orange: high complexity Red: very high complexity	Light Green: Northport and Hempstead Bay landings do not require backbay crossing and HDD can likely be accomplished Yellow: Smith Point has one backbay crossing, Cold Spring Harbor and Bayville HDD feasibility is lower but open trench can likely be completed Orange: Jones Beach has 3 backbay crossings, Long Beach has 1 backbay crossing and is in developed area
SHORE APPROACH AND LANDING ROUTE SEGMENT	Navigation Channels, Anchorage Areas, and USACE Coastal Storm Risk Management Projects	Green: no crossings Light Green: lower number of crossings 1 Yellow: moderate number of crossings 2 to 3 Orange: high number of crossings 3 to 5 Red: very high number of crossings +5 or long runs	Green: Long Island Sound routes would require no crossing of navigation channels, anchorage areas, or USACE Coastal Storm Risk Management Projects Yellow: Smith Point and Long Beach 2, Orange: Jones Beach 4
SHORE APPROACH AND LANDING ROUTE SEGMENT	Contaminated Sediments	Green: no contamination anticipated Light Green: lower levels of contamination likely Yellow: moderate levels of contamination likely Orange: high levels of contamination likely Red: high levels of contamination very likely	Green: Atlantic Ocean contamination is not expected Light Green: Long Beach backbay area has potential for contamination as adjacent shoreline site is DEC remediation area, LI Sound tributaries and harbors have increased likelihood of contamination Yellow: Hempstead Harbor shore has several DEC remediation sites.
SHORE APPROACH AND LANDING ROUTE SEGMENT	Cultural Resources and Wrecks/Obstructions	Green: none present Light Green: lower number present Yellow: moderate number present Orange: high number present Red: very high number present	Light Green: Atlantic wrecks obstructions but can generally be routed around Yellow: Central Long Island Sound has increased concentration of wrecks/obstructions

PRELIMINARY ROUTE FEASIBILITY SCORING
ON LONG ISLAND, NEW YORK - CRITICAL CONSTRAINTS MATRIX

Offshore Route	Atlantic Central Corridor										Atlantic North Corridor										Long Island Sound Corridor					
Shore Approach and Landing Site	Smith Point	Jones Beach						Long Beach			Smith Point	Jones Beach						Long Beach			Northport	Cold Spring Harbor		Bayville		Hempstead Harbor
Point of Interconnection	Brookhaven	Northport (via Syosset)	Newbridge	Syosset	Shore Road	East Garden City	Ruland Road	Newbridge	East Garden City	Shore Road	Brookhaven	Northport (via Syosset)	Newbridge	Syosset	Shore Road	East Garden City	Ruland Road	Newbridge	East Garden City	Shore Road	Northport	Syosset East	Syosset West	Shore Road	Syosset	Shore Road
ONSHORE ROUTE SEGMENT: Infrastructure HDDs and/or Bridge Crossings (roadway and waterway)																										
Wetlands, Sensitive Habitats																										
Potential Stakeholder Concerns/ Jurisdictions Crossed																										
Contaminated Sites (total area encountered)																										
Cultural Resources																										
Route Distance (miles)																										
Available Land for Converter / Transformer Stations (> 2.5 acre parcel)																										
Parkway/Highway (Permitting constraint)																										

Scoring explanations
(Note that the group of Long Island routes are ranked against each other for each consideration. The criteria that defines each rank may not be directly comparable to NYC routes presented in separate matrix.)

Infrastructure HDDs and/or Bridge Crossings:
Green: no major arterial or waterway crossings
Light Green: 1-2 crossings
Yellow: 3-4 of crossings
Orange: 5-6 crossings
Red: 7+ crossings

Wetlands, Sensitive Habitats:
Green: no sensitive habitats along route
Light Green: small sensitive habitats, which can be avoided
Yellow: sensitive habitat exists in the entire area
Orange: majority of the route passes through sensitive habitat designations or adjacent where additional consultations may be required
Red: route entirety is through or adjacent to sensitive habitats

Potential Stakeholder Concerns/Jurisdictions Crossed:
Green: 0 - 1 mi of route passes along low and medium density developed lands, mostly including single family residences and 1 local jurisdiction
Light Green: 1 - 4 mi of route passes along low and medium density developed lands, mostly including single family residences and 1 - 3 local jurisdictions
Yellow: 4 - 6 mi of route passes along low and medium density developed lands, mostly including single family residences and 3 - 5 local jurisdictions.
Orange: 6 - 10 mi of route passes along low and medium density developed lands, mostly including single family residences and 5 - 9 local jurisdictions.
Red: More than 10 mi of route passes along low and medium density developed lands, mostly including single family residences and more than 9 local jurisdictions.

Contaminated Sites:
Green: no contaminated sites along route
Light Green: small contaminated sites along route, which may be avoidable
Yellow: crossing small contaminated sites is unavoidable along route
Orange: route passes large contaminated sites, crossing of which can be avoided
Red: large contaminated sites are along route and unavoidable

Cultural Resources:
Green: no known cultural resources along route
Light Green: Low number and/or avoidable known cultural resources
Yellow: moderate number and/or avoidable known cultural resources
Orange: moderately high number of cultural resources, some of which can not be avoided
Red: high number or large area of cultural resources

Route Distance (miles):
Green: Route is <5 mi
Light Green: Route is 5-10 mi
Yellow: Route is 10-15 mi
Orange: Route is 15-20 mi
Red: Route is >20 mi

Available Land for Converter / Transformer Stations:
Green: 6+ undeveloped and/or unconstrained 2.5 acre parcels within 1 mi of route or POI (Visual aerial interpretation)
Light Green: 4-5 undeveloped and/or unconstrained 2.5 acre parcels within 1 mi of route or POI
Yellow: 3 undeveloped and/or unconstrained 2.5 acre parcels within 1 mi of route or POI
Orange: Only 2 undeveloped and/or unconstrained 2.5 acre parcels within 1 mi of route or POI
Red: Only 1 undeveloped and/or unconstrained 2.5 acre parcel within 1 mi of route or POI
Black: No suitable 2.5 acre parcels or only constrained parcels within 1 mi of route - further analysis by real estate planners warranted

Parkway/Highway:
Green: route does not touch parkway or highway interstate
Light Green: route may touch or cross parkway or highway interstate enough to trigger additional USDOT/FHWA approval
Yellow: moderate amount of route runs along or multiple crossings of parkway or highway interstate
Orange: a significant portion of route is along parkway or highway interstate
Red: majority of route is along a parkway or highway interstate

Specific Route Scoring Comments

Infrastructure HDDs and/or Bridge Crossings:
Green: Northport to Northport- 0, Cold Spring Harbor to Syosset East & West- 0, Bayville to Shore Rd and Syosset assumes OH AC along the railroad therefore no HDD needed, Shore Rd to Hempstead Harbor- 0
Light Green: Jones Beach to Newbridge- 1, Long Beach to East Garden City- 1
Yellow: Brookhaven to Smith Point- 3, Jones Beach to East Garden City- 3
Orange: Jones Beach to Shore Rd- 6, Jones Beach to Ruland Rd- 6
Red: Jones Beach to Northport- 10, Jones Beach to Syosset- 10, Long Beach to Shore Rd- 7

Wetlands, Sensitive Habitats:
Light Green: Routes originating at Long Beach have less overall sensitive habitats due to development. Onshore routes pass near sensitive habitats but not through. Jones Beach to Syosset & Ruland Rd avoids wetlands.
Yellow: Jones Beach to Newbridge passes through wetland check zones on Wantagh Pkwy, Cold Spring Harbor to Syosset East passes through wetland check zones along Harbor Rd
Orange: Jones Beach to Shore Rd & East Garden City must route up extensive portion of Meadowbrook Pkwy which is surrounded by wetlands for much of the route.

Potential Stakeholder Concerns/Jurisdictions Crossed:
Yellow: Bayville to Shore Rd elevated due to crossing 6 local municipalities, but only passes 3.92 mi of low and medium density lands
Orange: Brookhaven to Smith Point only passes through 2-3 local jurisdictions
Red: Long Beach routes elevated even though routes are under 10 mi through single family residence zones due to previous opposition to cable construction in area and passing through 10 local jurisdictions

Contaminated Sites:
Green: Northport to Northport and Hempstead Harbor to Shore Rd pass no contaminated sites
Light Green: Routes pass small sites but are avoidable
Yellow: Jones Beach and Long Beach to Shore Rd passes through 1 small site, East Garden City itself is a completed State Superfund Site that has an environmental easement, bumping up the ranking of both routes, Jones Beach and Long Beach, to yellow.

Cultural Resources:
Light Green: Long Beach to East Garden City and Shore Rd pass and avoid a few small cultural resources
Yellow: Jones Beach to Syosset, East Garden City, and Shore Rd pass near but avoid small cultural resources
Orange: Jones Beach to Ruland Rd must pass through the large Bethpage State Park and golf course

Route Distance (miles):
Green: Northport to Northport- 0 mi, Cold Spring Harbor to Syosset East- 3.34 mi, Cold Spring Harbor to Syosset West- 3.58 mi, Hempstead Harbor to Shore Rd- 0.49 mi
Yellow: Smith Point to Brookhaven- 10.20 mi, Jones Beach to Newbridge- 11.10 mi, Jones Beach to East Garden City- 12.92 mi, Long Beach to Newbridge- 14.17 mi, Long Beach to East Garden City-11.61 mi, Bayville to Shore Rd- 10.88 mi, Bayville to Syosset- 12.30 mi
Orange: Jones Beach to Syosset-18.48 mi, Jones Beach to Ruland Rd-16.92 mi
Red: Jones Beach to Northport- 30.80 mi, Jones Beach to Shore Rd-24.30 mi, Long Beach to Shore Rd-21.34 mi

Available Land for Converter / Transformer Stations:
Yellow: Jones Beach to East Garden City, Jones Beach to Ruland Rd (parcel needed to be 5 acres for DC conversion), Jones Beach to Shore Rd, Long Beach to East Garden City, and Long Beach to Shore Rd all had 3 potential parcels
Red: Jones Beach to Syosset only 1 potential parcel on Boundary Ave, Hempstead Harbor to Shore Rd 1 parcel
Black: Jones Beach to Newbridge & Syosset no unconstrained 2.5 acre parcels within 1 mi of route, further search warranted

Parkway/Highway:
Light Green: Long Beach to Shore Rd and East Garden City only cross Sunrise Hwy, Southern State Pkwy, Northern Pkwy, and LIE
Orange: Jones Beach to Shore Rd and East Garden City parallels Meadowbrook Pkwy for 11.6 mi, Jones Beach to Ruland Rd parallels Seaford-Oyster Bay Expy for 4.3 mi and Sunrise Hwy for 0.76 mi
Red: Jones Beach to Syosset- parallels Watagh Pkwy/Jones Beach Causeway and Seaford-Oyster Bay Expy for 14.3 mi

Lease Area/Region	Hudson North			Empire Wind							Massachusetts										Massachusetts					
Offshore Route	Atlantic Central Corridor										Atlantic North Corridor										Long Island Sound Corridor					
Shore Approach and Landing Site	Smith Point	Jones Beach						Long Beach			Smith Point	Jones Beach						Long Beach			Northport	Cold Spring Harbor		Bayville		Hempstead Harbor
Point of Interconnection	Brookhaven	Northport (via Syosset)	Newbridge	Syosset	Shore Road	East Garden City	Ruland Road	Newbridge	East Garden City	Shore Road	Brookhaven	Northport (via Syosset)	Newbridge	Syosset	Shore Road	East Garden City	Ruland Road	Newbridge	East Garden City	Shore Road	Northport	Syosset East	Syosset West	Shore Road	Syosset	Shore Road
Count: 1x	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	0	0	0	7	5	4	2	3	7
2x	8	7	7	7	5	5	7	10	11	10	8	7	7	7	5	5	7	10	11	10	6	4	7	7	6	4
3x	11	7	8	7	9	10	6	7	8	6	11	7	8	7	9	10	6	7	8	6	4	5	4	8	8	5
4x	4	6	6	5	7	8	10	5	5	5	4	6	6	5	7	8	10	5	5	5	6	9	8	6	6	6
5x	0	3	1	3	2	0	0	2	0	3	0	3	1	3	2	0	0	2	0	3	1	1	1	1	1	2
100x	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Total Points*	66	75	168	171	76	73	73	71	64	73	66	75	168	171	76	73	73	71	66	73	60	69	67	69	68	64
Site Ranking**	4	19	23	25	21	13	13	11	2	13	4	19	23	25	21	13	13	11	4	13	1	9	7	9	8	2

No constraints present
Low constraints present
Moderate constraints present
Major constraints present
Substantial constraints present
Challenges considered potentially insurmountable

* Note: Lowest points => best option. Weighting factors applied: Light Green x1; Green x2; Yellow x3 Orange x4; Red x5; Black x100.
** Note: Lowest value => best option

Annex B - Part 3
Refined Route Feasibility Scoring Matrices

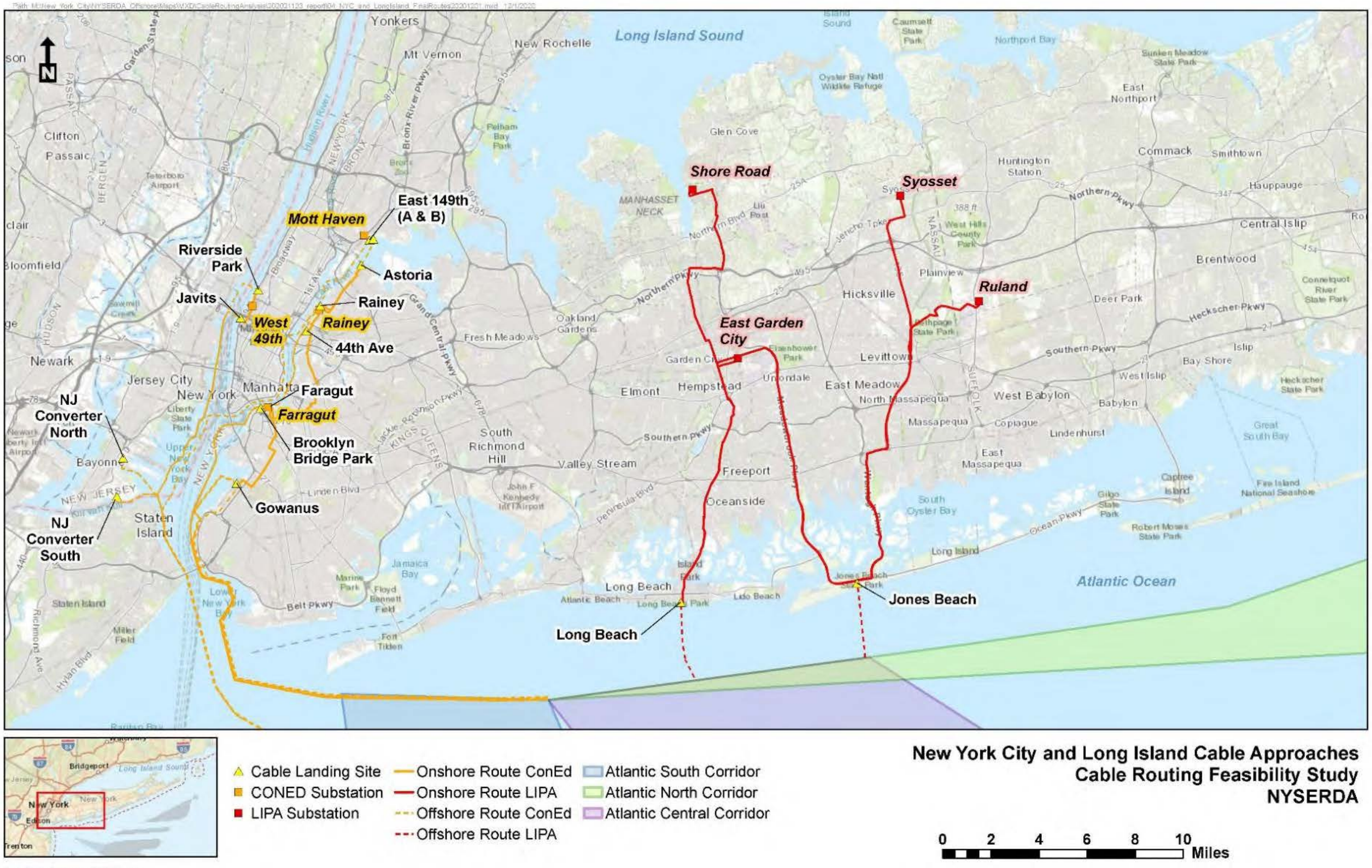
Below is a map (Figure B) showing final representative routes that were subject to a more detailed analysis during the transmission cable routing feasibility assessment (Routing Assessment). Following the map, two matrices – one for New York City points of interconnection (POIs) and one for Long Island POIs – present the results of the preliminary route feasibility scoring for potential critical constraint categories. Each matrix is split across two pages (11" by 17" format). Blue-shaded headers are carried over onto each page for ease of review.

The matrix identifies the preliminary routes split into three segments – (1) offshore, (2) shore approach and landing site, and (3) onshore. The blue-shaded column headers identify the name of each route segment. The scoring for each route segment is presented for each critical constraint category; color coding was applied as a visual aid. The color key at the top-center of each matrix denotes the score value and description of each corresponding color. The total score and relative rank for each representative route can be found at the bottom of the second page of each matrix.

To the right of the color-coded scoring section, in the middle of the page, a column titled "Scoring Explanations" describes the criteria used to assign scores for each constraint category. Farthest to the right, a column titled "Specific Route Scoring Comments" provides a summary of details considered when assigning constraint scores for specific route segments.

Figure B. Refined Shore Approach Routes, Landings, and Onshore Routes to New York City and Long Island

Source: WSP 2020; DNVGL 2020; ESRI 2020. (See Annex B, Part 1 - GIS Data Source List for full list of figure references.)



REFINED ROUTE FEASIBILITY SCORING
IN NEW YORK CITY - CRITICAL CONSTRAINTS MATRIX

Color Key (with scoring)

Score	Description
1x	No constraints present
2x	Low constraints present
3x	Moderate constraints present
4x	Major constraints present
5x	Substantial constraints present
100x	Challenges considered potentially insurmountable

	Lease Area/Region	Hudson North	Hudson South				New Jersey			Scoring Explanations (Note that the group of Long Island routes are ranked against each other for each consideration. The criteria that defines each rank may not be directly comparable to NYC routes presented in separate matrix.)	Specific Route Scoring Comments
	Offshore Route	Atlantic Central Corridor	Atlantic South Corridor								
	Shore Approach and Landing Site	Gowanus (via either pierline segment or Bay Ridge Flats segment)	Brooklyn Bridge Park	44th Ave	149th Street (Narrows West)	Rainey Park & 149th Street via Astoria (Narrows East)	Riverside (Narrows West & NJ Converter-South)	Riverside (Narrows West & NJ Converter-North)	Javits Center Pier Converter		
	Point of Interconnection	Farragut	Rainey	Rainey	Mott Haven	Mott Haven	West 49th	West 49th	West 49th		
Considerations											
LEASE TO POI	Approximate route distance in miles (AC Feasibility: +/- 70 miles)	101	113	111	113	119	126	127	121	Grey: less than 70 miles No color: more than 70 miles	
OFFSHORE ROUTE SEGMENT	Infrastructure Crossings (linear utilities)									Green: no crossings Light Green: lower number of crossings less than 15 Yellow: moderate number of crossings 15 to 25 Orange: high number of crossings 25 to 35 Red: very high number of crossings 35+	Light Green: Atlantic Central Corridor > 15 crossing varies by route Orange: Atlantic South Corridor ~27 crossings (Long Beach Island on Manasquan has multiple infrastructure landings that must be crossed)
OFFSHORE ROUTE SEGMENT	Designated Marine Zones (traffic lanes, danger zones)									Green: no navigation features present in area Light Green: Route generally avoids navigation features but some in area Yellow: Likely must cross a navigation feature Orange: Must cross multiple navigation features Red: Significant impact to navigation anticipated	Yellow: Atlantic Central Corridor traffic lanes or precautionary area on Atlantic Approach to New York (NY) Harbor Orange: Atlantic South Corridor traffic lanes or precautionary area on approach to NY Harbor and Danger Zone (unexploded ordinance) east of Sandy Hook, New Jersey (NJ) and south of Rockaway Beach, NY on NY Harbor approach
OFFSHORE ROUTE SEGMENT	Department of Defense Areas									Green: none present Light Green: present in area but can be avoided or no restrictions apply Yellow: must cross a Department of Defense (DoD) area where site specific stipulations apply Orange: must cross a DoD area where site specific stipulations apply and/or multiple other features apply Red: DoD exclusion area present that must be crossed	Yellow: Atlantic South Corridor - Atlantic City DoD OPAREA exists Orange: Atlantic Central Corridor - Atlantic DoD OPAREA, Submarine transit lane, testing range exist
OFFSHORE ROUTE SEGMENT	Sensitive Habitats (presence of sensitive species or habitat exists)									Green: no sensitive habitat present Light Green: some sensitive habitat exists but can be avoided Yellow: sensitive habitat exists in the entire area Orange: increased sensitive habitat designations in area or adjacent Red: high number of sensitive habitats must be crossed	Yellow: Atlantic in this area is biologically important area for North Atlantic Right Whale
OFFSHORE ROUTE SEGMENT	Marine Geology and Oceanography (seabed, erosion, bedforms, etc.)									Green: highly suitable conditions for cable installation cable burial very easily achieved/maintained Light Green: generally suitable conditions for cable installation cable burial easily achieved/maintained Yellow: moderately suitable conditions for cable installation potential difficulty to achieve/maintain cable burial Orange: difficult conditions may exist for cable installation do to structure difficult to achieve/ maintain cable burial Red: cable may not be installed/maintained to required depths due to potential bedrock or moraine armoring may be required	Light Green: Atlantic is generally soft sediments good for cable installation
OFFSHORE ROUTE SEGMENT	Further Regulatory Constraints (triggering additional state approvals)									Green: no trigger possible Light Green: trigger of additional state review is not likely Yellow: trigger of additional state coastal management programs is possible Orange: trigger of state coastal management program(s) will occur Red: trigger of state permitting (i.e. Section 401) review will occur	Light Green: NYSDOS Coastal Management Program Yellow: NYSDOS Coastal Management Program and NJ Shore can reroute to avoid NJ state waters but crossing offshore of NJ waters may trigger coastal management program if determined to impact state users (i.e. fishermen)
OFFSHORE ROUTE SEGMENT	Potential Stakeholder Concerns (Fisheries /Marine Vessel Operators)									Green: no concerns anticipated Light Green: some concerns anticipated Yellow: moderate concern anticipated Orange: potential opposition anticipated Red: high level of opposition anticipated	Yellow: Atlantic from commercial fisherman and marine vessel operators possible
SHORE APPROACH AND LANDING ROUTE SEGMENT	Infrastructure Crossings (linear utilities and tunnels)									Green: no crossings Light Green: lower number of crossings > 10 Yellow: moderate number of crossings 10 to 20 Orange: high number of crossings 20 to 30 Red: very high number of crossings 30+	Orange: Gowanus ~26 crossings Red: Brooklyn Bridge Park ~30 crossings ,Rainey Park ~37 crossings, 149th Street ~41 crossings, Riverside West Narrows ~34 crossings, additionally all must cross subway/train/road tunnels
SHORE APPROACH AND LANDING ROUTE SEGMENT	Sensitive Habitats (presence of sensitive species or habitat exists)									Green: no sensitive habitat present Light Green: some sensitive habitat exists but can be avoided Yellow: sensitive habitat exists in the entire area Orange: increased sensitive habitat designations in area or adjacent Red: high number of sensitive habitats must be crossed	Yellow: Several sensitive habitats (e.g., EFH) must be crossed, including winter flounder spawning and anadromous fish migratory areas. Endangered sturgeon species in area (Atlantic and Shortnose) Orange: Hudson River is critical habit for Atlantic Sturgeon
SHORE APPROACH AND LANDING ROUTE SEGMENT	Marine Geology and Oceanography (seabed, erosion, bedforms, etc.)									Green: highly suitable conditions for cable installation cable burial very easily achieved/maintained Light Green: generally suitable conditions for cable installation cable burial easily achieved/maintained Yellow: moderately suitable conditions for cable installation potential difficulty to achieve/maintain cable burial Orange: difficult conditions possible for cable installation due to structure/bedrock that may be present difficult to achieve/ maintain cable burial (further investigation required) Red: cable may not be installed/maintained to required depths due to potential bedrock or moraine, armoring may be required.	Light Green: Atlantic is generally soft sediments suitable for cable installation Red: East River contains structure, potential presence of shallow bedrock in East River may create difficulties to meet cable burial depth requirements, armoring may be required. Additionally, East River is a tidal channel with strong currents that have high potential for seafloor scouring and could present logistical challenges during cable installation.
SHORE APPROACH AND LANDING ROUTE SEGMENT	Further Regulatory Constraints (triggering additional state approvals)									Green: no trigger anticipated Light Green: trigger of additional (non-NY) state/federal coastal review unlikely or not burdensome Yellow: trigger of additional state/federal coastal management programs is possible and/or supplemental NY coastal review expected. Orange: trigger of additional state/federal coastal management program(s) expected Red: trigger of multiple additional state/federal permitting (e.g., Section 401 Water Quality Certifications) review will occur	Yellow: Route adjacent to NJ State waters may trigger NJ coastal management program. Will also require New York City (NYC) Local Waterfront Revitilization Program (LWRP) approval Red: Routes along the west side of the Narrows cross into NJ state waters and all relevant NJ state permit approvals will be necessary. Will also require NYC LWRP approval. May also require NPS submerged land easement approval for routing along west side of Narrows.
SHORE APPROACH AND LANDING ROUTE SEGMENT	Potential Stakeholder Concerns (Fisheries /Marine Vessel Operators)									Green: no concerns anticipated Light Green: some concerns anticipated Yellow: moderate concern anticipated Orange: opposition anticipated Red: high level of opposition anticipated	Orange: NY Harbor high marine traffic levels
SHORE APPROACH AND LANDING ROUTE SEGMENT	Landing Site Complexity (e.g., back-bay crossings, shore structure crossings, dense development)									Green: very low complexity Light Green: low complexity Yellow: moderate complexity- given the presence of coastal structures that must be crossed under and presence of site in urban area, including existing utility lines Orange: high complexity: HDD potentially feasible but significant constraints exist Red: very high complexity: HDD may not be possible other installation method may be required and or additional concerns given size of area and higher usage	Yellow: Gowanus requires HDD under bulkhead and close to channel but suitable space, Brooklyn Bridge required HDD under coastal structures and is in public park, Javits can likely land in converter without need for HDD Orange: Riverside is in a highly trafficked public park on the waterfront and need to cross under bulkhead, Rainey/44th must cross under coastal structure, bedrock may be present in nearshore, and strong currents in East River may make it difficult for landing. Red: 149th limited area for HDD, CSO present at end of road and close proximity to existing infrastructure. Alternate landing location on adjacent private lot
SHORE APPROACH AND LANDING ROUTE SEGMENT	Navigation Channels, Anchorage Areas, and USACE Coastal Storm Risk Management Projects									Green: no crossings Light Green: lower number of crossings 1 Yellow: moderate number of crossings 2 to 5 Orange: high number of crossings 6 to 9 Red: very high number of crossings +9 or long runs	Orange: Gowanus 7 Red: Riverside Park 11, Javits 12, Rainey Park 12, 149th Street 13 44th Ave 8 and also long runs adjacent to channel in East River, Brooklyn Bridge Park 8 but must route for long distance adjacent to nav channel
SHORE APPROACH AND LANDING ROUTE SEGMENT	Contaminated Sediments									Green: no contamination Light Green: lower levels of contamination likely Yellow: moderate levels of contamination likely Orange: high levels of contamination likely Red: high levels of contamination very likely	Orange: longer route through Lower NY Bay and into Upper NY Bay increases likelihood of contamination, multiple shoreline DEC Remediation areas and combined sewer overflows passed
SHORE APPROACH AND LANDING ROUTE SEGMENT	Cultural Resources and Wrecks/Obstructions									Green: none present Light Green: lower number present Yellow: moderate number present Orange: high number present Red: very high number present	Yellow: For Gowanus Javits and Riverside longer route through Lower NY Bay and into Upper NY Bay/East River/Hudson increases likelihood of consultations more wrecks/ historical sites passed Orange: 149th Street, Brooklyn Bridge, 44th and Rainey longer route through Upper NY Bay and the Northern East River significantly increases quantity of consultations as more wrecks and cultural sites passed, also Brooklyn Bridge a Natural Historic Landmark is routed adjacent to that shore approach

REFINED ROUTE FEASIBILITY SCORING
IN NEW YORK CITY - CRITICAL CONSTRAINTS MATRIX

										Scoring Explanations (Note that the group of Long Island routes are ranked against each other for each consideration. The criteria that defines each rank may not be directly comparable to NYC routes presented in separate matrix.)	Specific Route Scoring Comments
	Offshore Route	**Atlantic Central Corridor**	**Atlantic South Corridor**								
	Shore Approach and Landing Site	**Gowanus (via either pierline segment or Bay Ridge Flats segment)**	**Brooklyn Bridge Park**	**44th Ave**	**149th Street (Narrows West)**	**Rainey Park & 149th Street via Astoria (Narrows East)**	**Riverside (Narrows West & NJ Converter-South)**	**Riverside (Narrows West & NJ Converter-North)**	**Javits Center Pier Converter**		
	Point of Interconnection	**Farragut**	**Rainey**	**Rainey**	**Mott Haven**	**Mott Haven**	**West 49th**	**West 49th**	**West 49th**		
ONSHORE ROUTE SEGMENT	Infrastructure HDDs and/or Bridge Crossings (roadway and waterway)									Green: No major arterial or waterway crossings Light Green: 1-2 crossings Yellow: 3-4 of crossings Orange: 5-6 crossings Red: 7+ crossings	Light Green: 149th to Mott Haven- 2, Riverside to W49th- 1, Javits to W49th- 1 Yellow: 44th Ave to Rainey- 4 Orange: Rainey Park to Mott Haven via Astoria- 6 Red: Gowanus to Farragut- 8, Brooklyn Bridge Park to Rainey- 13
	Wetlands, Sensitive Habitats									Green: No sensitive habitats along route Light Green: Small sensitive habitats, which can be avoided Yellow: Sensitive habitat exists in the entire area Orange: Majority of the route passes through sensitive habitat designations or adjacent where additional consultations may be required Red: Route entirety is through or adjacent to sensitive habitats	Green: No wetlands or sensitive habitats were identified along these routes from publicly available data
	Potential Stakeholder Concerns/ Jurisdictions Crossed									Green: 0 - 0.5 mi of route passes within 0.5 mi of NYC Zoning residential classification and 1 local jurisdiction Light Green: 0.5 - 2 mi of route passes within 0.5 mi of NYC Zoning residential classification and/or 2 local jurisdictions Yellow: 2 - 4 mi of route passes within 0.5 mi of NYC Zoning residential classification and/or 2 - 3 local jurisdictions Orange: 4 - 5 mi of route passes within 0.5 mi of NYC Zoning residential classification and/or 4 local jurisdictions Red: More than 5 mi of route passes within 0.5 mi of NYC Zoning residential classification and/or more than 4 local jurisdictions	Green: 44th Ave to Rainey 0.33 mi and 1 local jurisdiction, 149th to Mott Haven 0.07 mi and 1 jurisdiction, and Riverside to W49th- 0.03 mi and 1 local jurisdiction Light Green: Rainey Park to Mott Haven via Astoria- 0.92 mi and 2 jurisdictions Yellow: Gowanus to Farragut- 0.75 mi and 1 jurisdiction but passes near Boreum Hill which is known to have concerns about construction , Brooklyn Bridge Park to Rainey- 1.05 mi and 3 jurisdictions, and Javits to W49th- 0.02 mi and 1 jurisdiction but near Lincoln Tunnel.
	Contaminated Sites (total area encountered)									Green: No contaminated sites along route Light Green: Contaminated sites along route, which may be avoidable Yellow: Crossing small contaminated sites is unavoidable along route Orange: Route passes large contaminated sites, crossing of which can be avoided Red: Large contaminated sites are along route and unavoidable	Green: 149th to Mott Haven and Riverside to W 49th have no contaminated sites along the route Light Green: Gowanus to Farragut- passes 4 sites all avoidable, 44th to Rainey- passes 2 sites both avoidable, and Javits to W49th- passes but avoids 5 sites Orange: Brooklyn Bridge Park to Rainey- passes Brooklyn Navy Yard and under Newtown Creek, Rainey Park to Mott Haven via Astoria- Astoria is a DEC Remediation site but portions with the most contamination should be avoidable
	Cultural Resources									Green: No known cultural resources along route Light Green: Low number and/or avoidable known cultural resources Yellow: Moderate number and/or avoidable known cultural resources Orange: Moderately high number of cultural resources, some of which can not be avoided Red: High number or large area of cultural resources	Green: 149th to Mott Haven and Rainey Park to Mott Haven via Astoria no known cultural resources along route Light Green: Riverside to W49th is near but does not pass the Intrepid, 44th to Rainey passes under Queensboro Bridge national register site Yellow: Javits to W49th passes nearer to Intrepid and popular sightseeing areas Orange: Gowanus to Farragut and Brooklyn Bridge Park to Rainey pass through heavily landmarked areas around Farragut (DUMBO Industrial, Brooklyn Navy Yard etc)
	Route Distance (miles)									Green: Route is <0.5 mi Light Green: Route is >0.5 mi but <1 mi Yellow: Route is 1-5 mi Orange: Route is 5-10 mi Red: Route is >10 mi	Light Green: 149th to Mott Haven- 0.75 mi, Riverside to W49th- 0.79 mi Yellow: Gowanus to Farragut- 4.94 mi, 44th to Rainey- 1.32 mi, Rainey Park to Mott Haven via Astoria- 3.65 mi, Javits to W49th- 1.19 mi Orange: Brooklyn Bridge Park to Rainey- 7.91 mi
	Available Land for Converter Stations (> 5 acre parcel) (real estate planning firm analysis)									Green: Multiple potential parcels within 1 mi of route or POI Light Green: Several potential parcels within 1 mi of route or POI Yellow: 3 potential parcels within 1 mi of route or POI Orange: Only 2 potential parcels within 1 mi of route or POI Red: Only 1 potential parcel within 1 mi of route or POI	Green: 44th Ave to Rainey & Brooklyn Bridge Park to Rainey- 5 sites identified Light Green: Farragut to Gowanus- 658 Columbia St, Brooklyn Marine Terminal, 109 25th St;149th to Mott Haven- recycling center & 2 surrounding industrial warehouses Yellow: Riverside to W 49th- likely one parcel available (though 2 ID'd) in NJ and 1 in Manhattan (2 ID'd shown below) Orange: Javits to W 49th- Pier 76 & Pier 90/92 (requires construction to fit converter station dimensions, remain orange)
	Parkway/Highway (Permitting constraint)									Green: Route does not touch parkway or highway interstate Light Green: Route may touch or cross parkway or highway interstate enough to trigger additional USDOT/FHWA approval Yellow: Moderate amount of route runs along or multiple crossings of parkway or highway interstate Orange: A significant portion of route is along parkway or highway interstate Red: Majority of route is along a parkway or highway interstate	Orange: Brooklyn Bridge Park to Rainey- parallels McGuinnis Blvd for 1 mi (classified as Principal Arterial Other by NYDOT) and crosses BQE 2x and exit for Midtown Tunnel, Gowanus to Farragut- parallels Minor Arterial 5th Ave 1.78 mi, crosses Major Arterial Atlantic Ave, and crosses BQE 2x and Prospect Expressway 1x

	Lease Area/Region	**Hudson North**	**Hudson South**				**New Jersey**			
	Offshore Route	**Atlantic Central Corridor**	**Atlantic South Corridor**							
	Shore Approach and Landing Site	**Gowanus (via either pierline segment or Bay Ridge Flats segment)**	**Brooklyn Bridge Park**	**44th Ave**	**149th Street (Narrows West)**	**Rainey Park & 149th Street via Astoria (Narrows East)**	**Riverside (Narrows West & NJ Converter-South)**	**Riverside (Narrows West & NJ Converter-North)**	**Javits Center Pier Converter**	
	Point of Interconnection	**Farragut**	**Rainey**	**Rainey**	**Mott Haven**	**Mott Haven**	**West 49th**	**West 49th**	**West 49th**	
Count:	**1x**	1	2	4	4	3	3	3	1	No constraints present
	2x	6	1	3	5	3	6	6	5	Low constraints present
	3x	9	8	8	5	7	6	6	9	Moderate constraints present
	4x	7	9	6	5	8	6	6	6	Major constraints present
	5x	1	4	3	5	3	3	3	3	Substantial constraints present
	100x	0	0	0	0	0	0	0	0	Challenges considered potentially insurmountable
	Total Points*	58	67	64	68	65	65	65	66	* Note: Lowest points => best option. Weighting factors applied: Light Green x1; Green x2; Yellow x3 Orange x4; Red x5; Black x100.

REFINED ROUTE FEASIBILITY SCORING ON LONG ISLAND - CRITICAL CONSTRAINTS MATRIX

Color Key (with scoring)

Score	Description
1x	No constraints present
2x	Low constraints present
3x	Moderate constraints present
4x	Major constraints present
5x	Substantial constraints present
100x	Challenges considered potentially insurmountable

Lease Area/Region	Hudson North			Empire Wind			Massachusetts					
Offshore Route	Atlantic Central Corridor						Atlantic North Corridor					
Shore Approach and Landing Site	Jones Beach				Long Beach		Jones Beach				Long Beach	
Point of Interconnection	Syosset	Shore Road	East Garden City	Ruland Road	East Garden City	Shore Road	Syosset	Shore Road	East Garden City	Ruland Road	East Garden City	Shore Road
Considerations												
LEASE TO POI: Approximate route distance in miles (AC Feasibility: +/- 70 miles) — Empire Wind	54	60	49	53	53	62	181	185	175	179	181	189
Hudson North	73	79	67	71	71	81						

Segment	Consideration	Scoring Explanations (Note that the group of Long Island routes are ranked against each other for each consideration. The criteria that defines each rank may not be directly comparable to NYC routes presented in separate matrix.)	Specific Route Scoring Comments
LEASE TO POI	Approximate route distance in miles (AC Feasibility: +/- 70 miles)	Dark Grey: less than 70 miles Light Grey: >70 mi but <75 mi No color: more than 75 miles	
OFFSHORE ROUTE SEGMENT	Infrastructure Crossings (linear utilities)	Green: no crossings Light Green: lower number of crossings less than 15 Yellow: moderate number of crossings 15 to 25 Orange: high number of crossings 25 to 35 Red: very high number of crossings 35+	Light Green: Atlantic Central Corridor > 15 crossings varies by route Yellow: Atlantic North Corridor ~18 crossings (multiple cable landings along south shore of Long Island must be crossed)
OFFSHORE ROUTE SEGMENT	Offshore Feature Crossings (traffic lanes, danger zones)	Green: no navigation features present in area Light Green: route generally avoids navigation features but some in area Yellow: likely must cross a navigation feature Orange: must cross multiple navigation features Red: significant impact to navigation anticipated	Yellow: traffic lanes or precautionary area in Atlantic Central Corridor approach (Nantucket to Ambrose Shipping Lanes)
OFFSHORE ROUTE SEGMENT	Department of Defense Areas	Green: none present Light Green: present in area but can be avoided or no restrictions apply Yellow: must cross a DoD area where site specific stipulations apply Orange: must cross a DoD area where site specific stipulations apply and/or multiple other features apply Red: DoD exclusion area present that must be crossed	Orange: in Atlantic, Narraganset OPAREA, Submarine transit lane, Naval Undersea Warfare Testing Range exist
OFFSHORE ROUTE SEGMENT	Sensitive Habitats (presence of sensitive species or habitat exists)	Green: no sensitive habitat present Light Green: some sensitive habitat exists but can be avoided Yellow: sensitive habitat exists in the entire area Orange: increased sensitive habitat designations in area or adjacent Red: high number of sensitive habitats must be crossed	Yellow: entire Atlantic in this area is Biologically Important Area for North Atlantic Right Whale
OFFSHORE ROUTE SEGMENT	Marine Geology and Oceanography (seabed, erosion, bedforms, etc.)	Green: highly suitable conditions for cable installation cable burial very easily achieved/maintained Light Green: generally suitable conditions for cable installation cable burial easily achieved/maintained Yellow: moderately suitable conditions for cable installation potential difficulty to achieve/maintain cable burial Orange: difficult conditions may exist for cable installation do to structure difficult to achieve/ maintain cable burial Red: cable may not be installed/maintained to required depths due to potential bedrock or moraine armoring may be required	Light Green: Atlantic is generally soft sediments go for cable installation
OFFSHORE ROUTE SEGMENT	Further Regulatory Constraints (triggering additional state approvals)	Green: no trigger possible Light Green: trigger of additional state review is not likely Yellow: trigger of state coastal management programs is possible Orange: trigger of multiple state coastal management program(s) expected Red: trigger of multiple state permitting (i.e. Section 401) review will occur	Light Green: NYSDOS Coastal Management Program
OFFSHORE ROUTE SEGMENT	Potential Stakeholder Concerns (Fisheries /Marine Vessel Operators)	Green: no concerns anticipated Light Green: some concerns anticipated Yellow: moderate concern anticipated Orange: potential opposition anticipated Red: high level of opposition anticipated	Yellow: Atlantic from commercial fisherman and marine vessel operators possible
SHORE APPROACH AND LANDING ROUTE SEGMENT	Infrastructure Crossings (linear utilities)	Green: no crossings Light Green: lower number of crossings > 2 Yellow: moderate number of crossings 2 to 10 Orange: high number of crossings 10 to 15 Red: very high number of crossings 15+	Yellow: Jones Beach ~9 crossings Orange: Long Beach ~ 12 crossings
SHORE APPROACH AND LANDING ROUTE SEGMENT	Sensitive Habitats (presence of sensitive species or habitat exists)	Green: no sensitive habitat present Light Green: some sensitive habitat exists but can be avoided Yellow: sensitive habitat exists in the entire area Orange: increased sensitive habitat designations in area or adjacent Red: high number of sensitive habitats must be crossed	Light Green: Long Beach - Endangered Atlantic sturgeon seasonally present nearshore. However, no Significant Coastal Fish and Wildlife Habitat (SCFWH) or Critical Environmental Area (CEA) uncertified shellfish waters and low presence of shorebirds Orange: Jones Beach - Endangered Atlantic sturgeon seasonally present nearshore. Also routes cross sensitive habitat (i.e. SCFWH, natural heritage areas, endangered nesting shorebird habitat)
SHORE APPROACH AND LANDING ROUTE SEGMENT	Marine Geology and Oceanography (seabed, erosion, bedforms, etc.)	Green: highly suitable conditions for cable installation cable burial very easily achieved/maintained Light Green: generally suitable conditions for cable installation cable burial easily achieved/maintained Yellow: moderately suitable conditions for cable installation potential difficulty to achieve/maintain cable burial Orange: difficult conditions may exist for cable installation do to structure difficult to achieve/ maintain cable burial- Structure present on approach Red: cable may not be installed/maintained to required depths due to potential bedrock or moraine armoring may be required	Yellow: Atlantic Ocean shoreline is highly dynamic with winds, waves, and currents.
SHORE APPROACH AND LANDING ROUTE SEGMENT	Further Regulatory Constraints (triggering additional state approvals)	Green: no trigger anticipated Light Green: trigger of additional (non-NY) state/federal coastal review unlikely or not burdensome Yellow: trigger of additional state/federal coastal management programs is possible and/or supplemental NY coastal review expected. Orange: trigger of additional state/federal coastal management program(s) expected Red: trigger of multiple additional state/federal permitting (e.g., Section 401 Water Quality Certifications) review will occur	Light Green: No triggering of other states' permitting requirements. Trigger of Local Waterfront Revitilization Programs not anticipated based on plans approved as of December 2020. NYSDEC Coastal Erosion Management Permit may be required, but addressed as part of standard New York State Joint Permit Application.
SHORE APPROACH AND LANDING ROUTE SEGMENT	Potential Stakeholder Concerns (Fisheries /Marine Vessel Operators/Coastal Communities)	Green: no concerns anticipated Light Green: some concerns anticipated Yellow: moderate concern anticipated Orange: potential opposition anticipated Red: high level of opposition anticipated	Yellow: Atlantic from commercial fishermen, including back bay commercial shellfishermen, and marine vessel operators possible Orange: Long Beach has history of vocal local population when considering cable routing
SHORE APPROACH AND LANDING ROUTE SEGMENT	Landing Site Complexity (e.g., back-bay crossings, shore structure crossings, dense development)	Green: very low complexity Light Green: low complexity Yellow: moderate complexity Orange: high complexity Red: very high complexity	Orange: Jones Beach has 3 backbay crossings, Long Beach has 2 backbay crossing and is in developed area
SHORE APPROACH AND LANDING ROUTE SEGMENT	Navigation Channels, Anchorage Areas, and USACE Coastal Storm Risk Management Projects	Green: no crossings Light Green: lower number of crossings 1 Yellow: moderate number of crossings 2 to 3 Orange: high number of crossings 3 to 5 Red: very high number of crossings +5 or long runs	Yellow: Long Beach 3 Orange: Jones Beach 4
SHORE APPROACH AND LANDING ROUTE SEGMENT	Contaminated Sediments	Green: no contamination anticipated Light Green: lower levels of contamination likely Yellow: moderate levels of contamination likely Orange: high levels of contamination likely Red: high levels of contamination very likely	Green: Atlantic Ocean contamination is not expected Light Green: Long Beach backbay area has potential for contamination as adjacent shoreline site is DEC remediation area
SHORE APPROACH AND LANDING ROUTE SEGMENT	Cultural Resources and Wrecks/Obstructions	Green: none present Light Green: lower number present Yellow: moderate number present Orange: high number present Red: very high number present	Light Green: Atlantic wrecks/obstructions exist but can generally be routed to avoid

REFINED ROUTE FEASIBILITY SCORING ON LONG ISLAND - CRITICAL CONSTRAINTS MATRIX

Offshore Route	Atlantic Central Corridor						Atlantic North Corridor							
Shore Approach and Landing Site	Jones Beach				Long Beach		Jones Beach				Long Beach			
Point of Interconnection	Syosset	Shore Road	East Garden City	Ruland Road	East Garden City	Shore Road	Syosset	Shore Road	East Garden City	Ruland Road	East Garden City	Shore Road	Scoring Explanations (Note that the group of Long Island routes are ranked against each other for each consideration. The criteria that defines each rank may not be directly comparable to NYC routes presented in separate matrix.)	Specific Route Scoring Comments
ONSHORE ROUTE SEGMENT														
Infrastructure HDDs and/or Bridge Crossings (roadway)													Green: no major arterial or waterway crossings Light Green: 1-2 crossings Yellow: 3-4 of crossings Orange: 5-6 crossings Red: 7+ crossings	Light Green: Long Beach to East Garden City- 1 Yellow: Jones Beach to East Garden City- 3 Orange: Jones Beach to Shore Rd- 6, Jones Beach to Ruland Rd- 6 Red: Jones Beach to Syosset- 10, Long Beach to Shore Rd- 7
Wetlands, Sensitive Habitats													Green: no sensitive habitats along route Light Green: small sensitive habitats, which can be avoided Yellow: sensitive habitat exists in the entire area Orange: majority of the route passes through sensitive habitat designations or adjacent where additional consultations may be required Red: route entirety is through or adjacent to sensitive habitats	Light Green: Routes originating at Long Beach have less overall sensitive habitats due to development. Onshore routes pass near sensitive habitats but not through. Jones Beach to Syosset & Ruland Rd avoids wetlands. Orange: Jones Beach to Shore Rd & East Garden City must route up extensive portion of Meadowbrook Pkwy which is surrounded by wetlands for much of the route.
Potential Stakeholder Concerns/ Jurisdictions Crossed													Green: 0 - 1 mi of route passes along low and medium density developed lands, mostly including single family residences and 1 local jurisdiction Light Green: 1 - 4 mi of route passes along low and medium density developed lands, mostly including single family residences and 1 - 3 local jurisdictions Yellow: 4 - 6 mi of route passes along low and medium density developed lands, mostly including single family residences and 3 - 5 local jurisdictions. Orange: 6 - 10 mi of route passes along low and medium density developed lands, mostly including single family residences and 5 - 9 local jurisdictions. Red: More than 10 mi of route passes along low and medium density developed lands, mostly including single family residences and more than 9 local jurisdictions.	Orange: Jones Beach to East Garden City 10.44 mi and 5 jurisdictions, Jones Beach to Ruland Rd 9.84 mi and 6 jurisdictions, Long Beach to East Garden City 4.69 mi and 7 jurisdictions Red: Jones Beach to Syosset 13.33 mi and 8 jurisdictions, Jones Beach to Shore Rd 16.26 mi and 9 jurisdictions, Long Beach to Shore Rd 9.48 mi and 10 local jurisdictions
Contaminated Sites (total area encountered)													Green: no contaminated sites along route Light Green: small contaminated sites along route, which may be avoidable Yellow: crossing small contaminated sites is unavoidable along route Orange: route passes large contaminated sites, crossing of which can be avoided Red: large contaminated sites are along route and unavoidable	Light Green: Routes pass small sites but are avoidable Yellow: Jones Beach and Long Beach to Shore Rd passes through 1 small site, East Garden City itself is a completed State Superfund Site that has an environmental easement, bumping up the ranking of both routes, Jones Beach and Long Beach, to yellow.
Cultural Resources													Green: no known cultural resources along route Light Green: Low number and/or avoidable known cultural resources Yellow: moderate number and/or avoidable known cultural resources Orange: moderately high number of cultural resources, some of which can not be avoided Red: high number or large area of cultural resources	Light Green: Long Beach to East Garden City and Shore Rd pass and avoid a few small cultural resources Yellow: Jones Beach to Syosset, East Garden City, and Shore Rd pass near but avoid small cultural resources Orange: Jones Beach to Ruland Rd must pass through the large Bethpage State Park and golf course
Route Distance (miles)													Green: Route is <5 mi Light Green: Route is 5-10 mi Yellow: Route is 10-15 mi Orange: Route is 15-20 mi Red: Route is >20 mi	Yellow: Jones Beach to East Garden City- 12.92 mi, Long Beach to East Garden City-11.61 mi Orange: Jones Beach to Syosset-18.48 mi, Jones Beach to Ruland Rd-16.92 mi Red: Jones Beach to Shore Rd-24.30 mi, Long Beach to Shore Rd-21.34 mi
Available Land for Converter Stations (> 1.5 acre parcel)													Green: Multiple potential parcels within 0.5 mi of route or POI (Visual aerial interpretation) Light Green: Several potential parcels within 0.5 mi of route or POI Yellow: 3 potential parcels within 0.5 mi of route or POI Orange: Only 2 potential parcels within 0.5 mi of route or POI Red: Only 1 potential parcel within 0.5 mi of route or POI	Light Green: Jones Beach to Shore Rd had several potential parcels within 0.5 mi of the route Yellow: Jones Beach to East Garden City, Jones Beach to Ruland Rd (parcel needed to be 5 acres for DC conversion), Long Beach to East Garden City, and Long Beach to Shore Rd all had 3 potential parcels Red: Jones Beach to Syosset only 1 potential parcel on Boundary Ave
Parkway/Highway (Permitting constraint)													Green: route does not touch parkway or highway interstate Light Green: route may touch or cross parkway or highway interstate enough to trigger additional USDOT/FHWA approval Yellow: moderate amount of route runs along or multiple crossings of parkway or highway interstate Orange: a significant portion of route is along parkway or highway interstate Red: majority of route is along a parkway or highway interstate	Light Green: Long Beach to Shore Rd and East Garden City only cross Sunrise Hwy, Southern State Pkwy, Northern Pkwy, and LIE Orange: Jones Beach to Shore Rd and East Garden City parallels Meadowbrook Pkwy for 11.6 mi, Jones Beach to Ruland Rd parallels Seaford-Oyster Bay Expy for 4.3 mi and Sunrise Hwy for 0.76 mi Red: Jones Beach to Syosset- parallels Watagh Pkwy/Jones Beach Causeway and Seaford-Oyster Bay Expy for 14.3 mi

Lease Area/Region	Hudson North			Empire Wind			Massachusetts					
Offshore Route	Atlantic Central Corridor						Atlantic North Corridor					
Shore Approach and Landing Site	Jones Beach				Long Beach		Jones Beach				Long Beach	
Point of Interconnection	Syosset	Shore Road	East Garden City	Ruland Road	East Garden City	Shore Road	Syosset	Shore Road	East Garden City	Ruland Road	East Garden City	Shore Road
Count: 1x	1	1	1	1	0	0	1	1	1	1	0	0
2x	7	6	5	7	11	10	7	6	5	7	11	10
3x	7	8	11	7	8	7	7	8	11	7	8	7
4x	5	7	7	9	5	4	5	7	7	9	5	4
5x	4	2	0	0	0	3	4	2	0	0	0	3
100x	0	0	0	0	0	0	0	0	0	0	0	0
Total Points*	76	75	72	72	66	72	76	75	72	72	66	72

No constraints present
Low constraints present
Moderate constraints present
Major constraints present
Substantial constraints present
Challenges considered potentially insurmountable

* Note: Lowest points => best option. Weighting factors applied: Light Green x1; Green x2; Yellow x3 Orange x4; Red x5; Black x100.

Annex C: OSW Build-Out Scenario Maps

<u>Scenario 1A and 1B Rationale</u>:

A. Light BOEM lease auction activity and thus:

- 2030 capacity from existing leases only (no call areas available)
- 2035 capacity from existing leases and primary call areas (no secondary call areas available)

B. 1-nm spacing for MA enforced, but relaxed elsewhere

C. 2035 scenario includes expansions of North projects, instead of South, given expected higher competition for New Jersey capacity)

D. Hudson fairways (smaller areas to the north) are excluded entirely for feasibility reasons

Scenario 1A

Scenario 1B

<u>Scenario 2 Rationale</u>:

A. Aggressive BOEM lease auction activity and thus:

- 2030 capacity from existing leases AND primary call areas
- 2035 capacity from existing leases, primary and secondary call areas

B. 1-nm spacing enforced for all locations (i.e. beyond MA)

C. Hudson fairways (smaller areas to the north) are excluded entirely for feasibility reasons

Scenario 2

<u>Scenario 3A and 3B Rationale</u>:

A. Aggressive BOEM lease auction activity and thus:

- 2030 capacity from existing leases AND primary call areas
- 2035 capacity from existing leases, primary and secondary call areas

B. NY Bight projects will be at disadvantage to win PPAs with other states and thus, NY Bight projects will be highly focused on winning PPAs with NY

C. 1-nm spacing enforced for MA, but relaxed elsewhere

D. Hudson fairways (smaller areas to the north) are excluded entirely for feasibility reasons

Scenario 3A

Scenario 3B

Annex D. Summary Tables for Preliminary OSW Connection Analysis

Scenario 1A

	Dedicated Radials	Split	Mesh	Shared Substations	Backbone
Total Offshore CAPEX vs. Radial Baseline	Baseline	+0.2 B	+1.8 B	+0.6 B	+1.3 B
Performance: lost energy due to elec. losses	2224 GWh/yr	2217 GWh/yr	1970 GWh/yr	1928 GWh/yr	2096 GWh/yr
LTCOE Rank (includes CAPEX, OPEX, and losses)	Lowest	Low	Highest	Moderate	Moderate to High
	LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)		LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)		LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)

	Dedicated Radials / Split		Mesh	Shared Substations	Backbone
Resilience & Redundancy Summary	Weak		Strong	Moderate	Moderate
Definition: transmission integrity, auxiliary system redundancy, and component overload dimensioning	Lower level of redundancy, high loss of generated energy in case of single component outages		Higher level of redundancy (bipolar, alternative transmission path, etc)	Lowest loss of generated energy in case of single component outages, but large cable length increase down time	Higher loss of generated energy in case of single component outages than Shared, but smaller cable length decrease down time
Operational Benefits Summary	Moderate		Strong	Weak	Strong
Definition: standardized spare keeping, interconnector topologies, and technologies	Strong onshore voltage control for DC connections		Strong onshore voltage support and strongest power dispatch control	Weakest onshore voltage control and power dispatch, control instabilities require onshore reinforcement.	Strong onshore voltage support and strong power dispatch control

	Dedicated Radials / Split		Mesh	Shared Substations	Backbone
Phased installation considering uncertainty in OSW project locations	Straightforward given inherently a phased approach		Complex but possible – upfront planning required to ensure individual project substation platforms have capability to accept future mesh connection	Very challenging to plan effectively/economically if OSW project locations and sizes remain highly uncertain	Complex but possible – upfront planning required to ensure individual project substation platforms have capability to accept future backbone connection

Scenario 1B

	Dedicated Radials	Split	Mesh	Shared Substations	Backbone
Total Offshore CAPEX vs. Radial Baseline	Baseline	+0.0 B	+1.7 B	+0.7 B	+1.2 B
Performance: lost energy due to elec. Losses	2211 GWh/yr	2211 GWh/yr	1945 GWh/yr	1928 GWh/yr	2077 GWh/yr
LTCOE Rank (includes CAPEX, OPEX, and losses)	Lowest	Lowest	Highest	Moderate	Moderate to High
	LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)		LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)		LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)

	Dedicated Radials / Split	Mesh	Shared Substations	Backbone
Resilience & Redundancy Summary	Weak	Strong	Moderate	Moderate
Definition: transmission integrity, auxiliary system redundancy, and component overload dimensioning	Lower level of redundancy, high loss of generated energy in case of single component outages	Higher level of redundancy (bipolar, alternative transmission path, etc)	Lowest loss of generated energy in case of single component outages, but large cable length increase down time	Higher loss of generated energy in case of single component outages than Shared, but smaller cable length decrease down time
Operational Benefits Summary	Moderate	Strongest	Weak	Strong
Definition: standardized spare keeping, interconnector topologies, and technologies	Strong onshore voltage control for DC connections	Strong onshore voltage support and strongest power dispatch control	Weakest onshore voltage control and power dispatch, control instabilities require onshore reinforcement.	Strong onshore voltage support and strong power dispatch control
Phased installation considering uncertainty in OSW project locations	Straightforward given inherently a phased approach	Complex but possible – upfront planning required to ensure individual project substation platforms have capability to accept future mesh connection	Very challenging to plan effectively/economically if OSW project locations and sizes remain highly uncertain	Complex but possible – upfront planning required to ensure individual project substation platforms have capability to accept future backbone connection

Scenario 2

	Dedicated Radials	Split	Mesh	Shared Substations	Backbone
Total Offshore CAPEX vs. Radial Baseline	Baseline	+0.3 B	+1.8 B	+0.1 B	+1.9 B
Performance: lost energy due to elec. losses	2179 GWh/yr	2179 GWh/yr	2071 FWh/yr	1890 GWh/yr	2317 GWh/yr
LTCOE Rank (includes CAPEX, OPEX, and losses)	Lowest	Low	High	Low	Highest
	LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)		LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)		LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)

	Dedicated Radials / Split	Mesh	Shared Substations	Backbone
Resilience & Redundancy Summary	Weak	Strong	Moderate	Moderate
Definition: transmission integrity, auxiliary system redundancy, and component overload dimensioning	Lower level of redundancy, high loss of generated energy in case of single component outages	Higher level of redundancy (bipolar, alternative transmission path, etc)	Lowest loss of generated energy in case of single component outages, but large cable length increase down time	Higher loss of generated energy in case of single component outages than Shared, but smaller cable length decrease down time
Operational Benefits Summary	Moderate	Strongest	Weak	Strong
Definition: standardized spare keeping, interconnector topologies, and technologies	Strong onshore voltage control for DC connections	Strong onshore voltage support and strongest power dispatch control	Weakest onshore voltage control and power dispatch ,control instabilities require onshore reinforcement.	Strong onshore voltage support and strong power dispatch control

	Dedicated Radials / Split	Mesh	Shared Substations	Backbone
Phased installation considering uncertainty in OSW project locations	Straightforward given inherently a phased approach	Complex but possible – upfront planning required to ensure individual project substation platforms have capability to accept future mesh connection	Very challenging to plan effectively/economically if OSW project locations and sizes remain highly uncertain	Complex but possible – upfront planning required to ensure individual project substation platforms have capability to accept future backbone connection

Scenario 3A

	Dedicated Radials	Split	Mesh	Shared Substations	Backbone
Total Offshore CAPEX vs. Radial Baseline	Baseline	+0.0 B	+1.4 B	+0.4 B	+1.5 B
Performance: lost energy due to elec. losses	2179 GWh/yr	2255 GWh/yr	1989 GWh/yr	1909 GWh/yr	2109 GWh/yr
LTCOE Rank (includes CAPEX, OPEX, and losses)	Lowest	Lowest	High	Moderate	Highest
	LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)		LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)		LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)

	Dedicated Radials / Split	Mesh	Shared Substations	Backbone
Resilience & Redundancy Summary	Weak	Strong	Moderate	Moderate
Definition: transmission integrity, auxiliary system redundancy, and component overload dimensioning	Lower level of redundancy, high loss of generated energy in case of single component outages	Higher level of redundancy (bipolar, alternative transmission path, etc)	Lowest loss of generated energy in case of single component outages, but large cable length increase down time	Higher loss of generated energy in case of single component outages than Shared, but smaller cable length decrease down time
Operational Benefits Summary	Moderate	Strongest	Weak	Strong
Definition: standardized spare keeping, interconnector topologies, and technologies	Strong onshore voltage control for DC connections	Strong onshore voltage support and strongest power dispatch control	Weakest onshore voltage control and power dispatch, control instabilities require onshore reinforcement.	Strong onshore voltage support and strong power dispatch control
Phased installation considering uncertainty in OSW project locations	Straightforward given inherently a phased approach	Complex but possible – upfront planning required to ensure individual project substation platforms have capability to accept future mesh connection	Very challenging to plan effectively/economically if OSW project locations and sizes remain highly uncertain	Complex but possible – upfront planning required to ensure individual project substation platforms have capability to accept future backbone connection

Scenario 3B

	Dedicated Radials	Split	Mesh	Shared Substations	Backbone
Total Offshore CAPEX vs. Radial Baseline	Baseline	+0.0 B	+1.6 B	+0.2 B	+1.2 B
Performance: lost energy due to elec. losses	2022 MWh/yr	2173 GWh/yr	1945 GWh/yr	1865 GWh/yr	2077 GWh/yr
LTCOE Rank (includes CAPEX, OPEX, and losses)	Lowest	Lowest	Highest	Low	Moderate
	LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)		LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)		LTCOE estimates subsequently updated with higher detail conceptual design (See Section 8)

	Dedicated Radials / Split	Mesh	Shared Substations	Backbone
Resilience & Redundancy Summary	Weak	Strong	Moderate	Moderate
Definition: transmission integrity, auxiliary system redundancy, and component overload dimensioning	Lower level of redundancy, high loss of generated energy in case of single component outages	Higher level of redundancy (bipolar, alternative transmission path, etc)	Lowest loss of generated energy in case of single component outages, but large cable length increase down time	Higher loss of generated energy in case of single component outages than Shared, but smaller cable length decrease down time
Operational Benefits Summary	Moderate	Strongest	Weak	Strong
Definition: standardized spare keeping, interconnector topologies, and technologies	Strong onshore voltage control for DC connections	Strong onshore voltage support and strongest power dispatch control	Weakest onshore voltage control and power dispatch, control instabilities require onshore reinforcement.	Strong onshore voltage support and strong power dispatch control

	Dedicated Radials / Split	Mesh	Shared Substations	Backbone
Phased installation considering uncertainty in OSW project locations	Straightforward given inherently a phased approach	Complex but possible – upfront planning required to ensure individual project substation platforms have capability to accept future mesh connection	Very challenging to plan effectively/economically if OSW project locations and sizes remain highly uncertain	Complex but possible – upfront planning required to ensure individual project substation platforms have capability to accept future backbone connection