Initial Report on the New York Power Grid Study

COMPANION PRESENTATION TO THE JANUARY 19, 2021 INITIAL REPORT ON THE NEW YORK POWER GRID STUDY

FEBRUARY 8TH, 2021

Note

This presentation summarizes the findings explained in the complete version of the Initial Report on the New York Power Grid Study, published in **Case 20-E-0197**, under the Title of Matter: **Proceeding on Motion of the Commission to Implement Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act**, on January 19, 2021 at:

http://documents.dps.ny.gov/public/MatterManagement/MatterFilingItem.aspx?FilingSeq=259215&MatterSeq=62480

The published report was prepared by staff of The New York Department of Public Service (DPS) and New York State Energy Research and Development Authority (NYSERDA) with support and advice from the named authors of The Brattle Group and Pterra Consulting for the New York Public Service Commission under a contract with NYSERDA. It is intended to be read and used as a whole and not in parts.

Contents of this Presentation

I. Overview of the Initial Report on the New York Power Grid Study
II. Utility Transmission and Distribution Investment Working Group Study
III. Advanced Technologies
IV. Offshore Wind Integration Study
V. Zero-Emissions Electric Grid in New York by 2040
VI. Overall Findings and Recommendations

Overview of the Initial Report on the New York Power Grid Study

Background

New York's Climate Leadership and Community Protection Act (CLCPA) requires unprecedented transformation of the State's electricity grid to achieve 70% renewable generation by 2030, zero-emission electricity by 2040, and an 85% economy-wide reduction in greenhouse gas emissions by 2050.

The CLCPA specifies minimum amounts of certain types of resources including:

- 6,000 MW of distributed solar resources by 2025,
- 3,000 MW of storage by 2030, and
- 9,000 MW of offshore wind (OSW) generation by 2035.

Even greater quantities of renewable generation are necessary to achieve the 2040 mandates.

Meeting these milestones will require investment in renewable generation, storage, energy efficiency measures, electrification of the transportation and heating sectors, and electric transmission and distribution (T&D) infrastructure.

The T&D infrastructure will play a critical role in meeting the State's goals.

Overview of the Power Grid Study

The **Accelerated Renewable Energy Growth and Community Benefit Act** directs the Public Service Commission (PSC) to advance the work of identifying T&D upgrades needed to reliably and cost-effectively integrate the required renewable resources, and to establish planning processes to support cost-effective and timely infrastructure development.

To meet these directives, the PSC, through the Department of Public Service and in consultation with NYSERDA, initiated a set of system studies, collectively referred to as the **New York Power Grid Study (PGS).**

- This presentation is a companion document to the published Initial Report on the New York Power Grid Study

The PGS consists of three component studies:

- **Utility Study**: Conducted by the Joint Utilities on local transmission and distribution (LT&D) needs;
- **OSW Study**: Study of offshore and onshore bulk-power transmission scenarios to illustrate possible solutions to integrate the mandated 9,000 MW of offshore wind
  - Study conducted by DNV-GL, PowerGem, and WSP for NYSERDA
- **Zero Emissions Study:** Scenario-based study to analyze transmission, generation, and storage options for achieving 70% renewable generation by 2030 and a zero emissions grid by 2040
  - Study conducted by Siemens for NYSERDA

Utility Transmission and Distribution Investment Working Group Study

SUMMARY, FINDINGS AND RECOMMENDATIONS

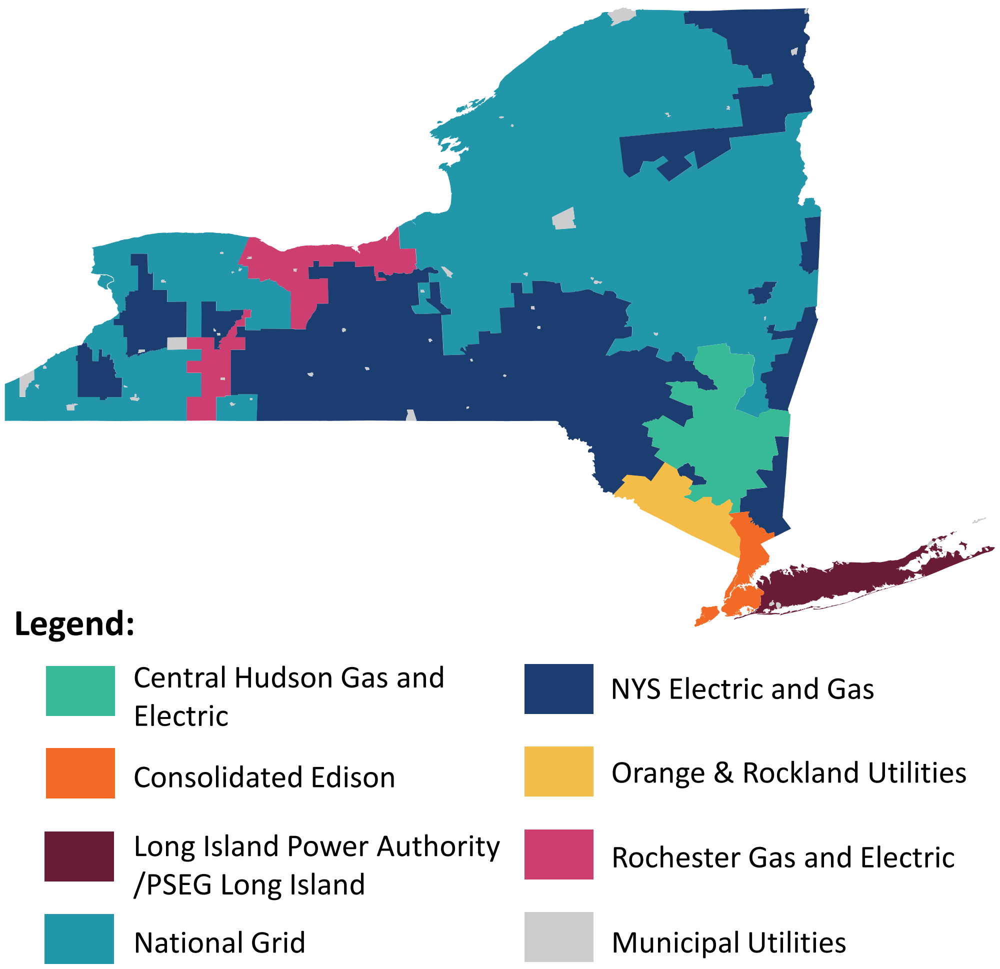
Background

New York's utilities (Utilities) undertook a joint study to identify distribution and local transmission upgrades that are necessary or appropriate to support the achievement of CLCPA goals

- The PSC directed the Utilities to perform the joint study in a May 2020 order.
- The Utility Study was completed and filed on November 2, 2020.

The Utility Study identifies a number of upgrades to the local transmission and distribution systems to accelerate progress towards meeting 70% of the State's electric energy demand with renewable sources by 2030.

New York State Electric Utility Territories



Background (contd.)

The Utility Study responds to guidelines established by the PSC in its May 2020 Order:

- Evaluate the local transmission and distribution system of the individual utility service territories, to understand where capacity "headroom" exists today;
- Identify existing constraints or bottlenecks that limit energy deliverability;
- Consider synergies with traditional capital expenditure projects (i.e., aging infrastructure, reliability, resilience, market efficiency, operational flexibility, etc.);
- Identify least-cost upgrade projects to increase the capacity of the existing system;
- Identify potential new or emerging solutions that can accompany or complement traditional upgrades;
- Identify potential new projects that would increase capacity on the local transmission and distribution system to allow for interconnection of new renewable generation resources; and
- Identify the possibility of fossil generation retirements and the impacts and potential availability of those interconnection points.

Study Assumptions: Renewable Generation

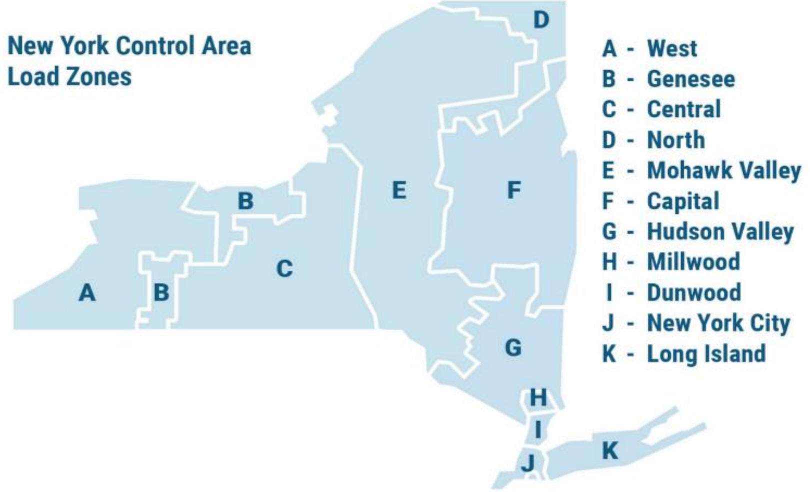
The Utility Study's 2030 renewable generation assumptions are based on NYISO's 2019 CARIS 70x30 scenario

CARIS models approximately 30 GW of utility-scale renewable generation across the 11 NYISO zones by 2030

- Renewable capacities modeled in the Utility Study are generally consistent with CARIS 70x30 assumptions
  - The Utility Study refined the interconnection points for new renewables (both land-based and offshore wind) on the *local transmission system*
- CARIS's 30 GW of renewables included 22 GW of new and 2 GW of existing land-based renewable capacity
  - Approx. 12 GW of the 22 GW of land-based renewables was modeled in CARIS and the Utility Study as interconnecting at the local (69, 115, or 138 kV) transmission level

Total 2030 Renewable Generation Capacity in CARIS 70x30 "Base Load" Case

Base Load				
2030 MW	OSW	LBW	UPV	BTM-PV
A		2,286	4,432	995
B		314	505	298
C		2,411	2,765	836
D		1,762		76
E		2,000	1,747	901
F			3,592	1,131
G			2,032	961
H				89
I				130
J	4,320			950
K	1,778		77	1,176
NYCA	6,098	8,772	15,150	7,542



Utility Study Results: Phase 1 Projects

Phase 1 projects are defined as immediately actionable projects needed to satisfy Reliability, Safety, and Compliance requirements. They additionally (at no incremental cost) expand the "headroom" for renewable energy delivery within a utility's LT&D system

- Utilities estimate that:
  - the proposed Phase 1 **local transmission** projects would unbottle **6.6 GW** of renewable generation
  - proposed Phase 1 **distribution** projects would unbottle **2.0 GW** of renewable generation
- Majority of proposed Phase 1 transmission projects (particularly of *upstate* utilities) address **on-ramp** constraints
  - e.g., National Grid, AVANGRID, Central Hudson
- Most local transmission projects proposed by downstate Utilities (ConEd, LIPA, and Orange and Rockland) address **off-ramp** needs
- For **distribution projects**, most of the incremental headroom capacity addresses projected on-ramp needs
  - assumes renewable energy developed at the distribution level can backfeed to the local transmission system during hours of excess generation
  - a smaller portion of projects address constraints internal to distribution load pockets

Summary of Utilities' Phase 1 Projects and Estimated CLCPA Headroom Benefits

Utility	Projects (No.)	Estimated Project Cost (to Address Traditional Need)	Estimated CLCPA Benefit (MW)
Central Hudson			
Transmission	6	$152.1M	433
Distribution	12	$137.0M	132
CECONY			
Transmission	3	$860M	900
Distribution	8	$1,130M	418
LIPA			
Transmission	8	$402M	615
Distribution	19	$351M	520
National Grid			
Transmission	13	$773M	1,130
Distribution	5	$649M	428
NYSEG/RG&E			
Transmission	16	$1,560M	3,041
Distribution	8	$229M	165.8
O&R			
Transmission	6	$417M	500
Distribution	9	$156M	308
Total	**113**	**$6,816M**	**8,591**
Transmission Total	52	$4,164M	6,619
Distribution Total	61	$2,652M	1,972

Utility Study Results: Phase 2 Projects

Phase 2 projects (generally more preliminary with less detailed specifications) are driven primarily by need to achieve CLCPA targets

- Utilities' estimate that:
  - proposed Phase 2 **local transmission** projects would provide **12.7 GW** of renewable integration headroom benefits
  - proposed Phase 2 **distribution** projects would support **2.8-4.3 GW** of renewable integration headroom benefits
  - headroom estimates for Phase 2 projects were evaluated in a manner similar to the approaches used for Phase 1 projects; However:
    - The Utilities proposed that a benefit-cost (BCA) framework be applied to Phase 2 local transmission projects based on *MWh* of reduced renewable generation curtailment – which will evaluate CLCPA value more robustly than the MW headroom metric.
    - The proposed BCA compares the 40-year present value of renewable unbottling benefits (i.e., the value of avoided MWh of renewable curtailments) with the 40-year present value of unbottling-related (incremental) project costs

Summary of Utilities' Potential Phase 2 Projects and Estimated CLCPA Headroom Benefits

Utility	Projects (No.)	Estimated Project CLCPA Benefit (MW)
Central Hudson		
Transmission	6	766
Distribution	7	222
CECONY		
Transmission	6	7,686
Distribution	2	360
LIPA		
Transmission	6	1,830
Distribution	8	937
National Grid		
Transmission	13	1,500
Distribution	7	1,152 - 2,700
NYSEG/RG&E		
Transmission	11	943
Distribution	5	88.3
Total	**71**	**15,484 - 17,032**
Transmission Total	42	12,725
Distribution Total	29	2759 - 4,307

State-Wide LT&D Takeaways

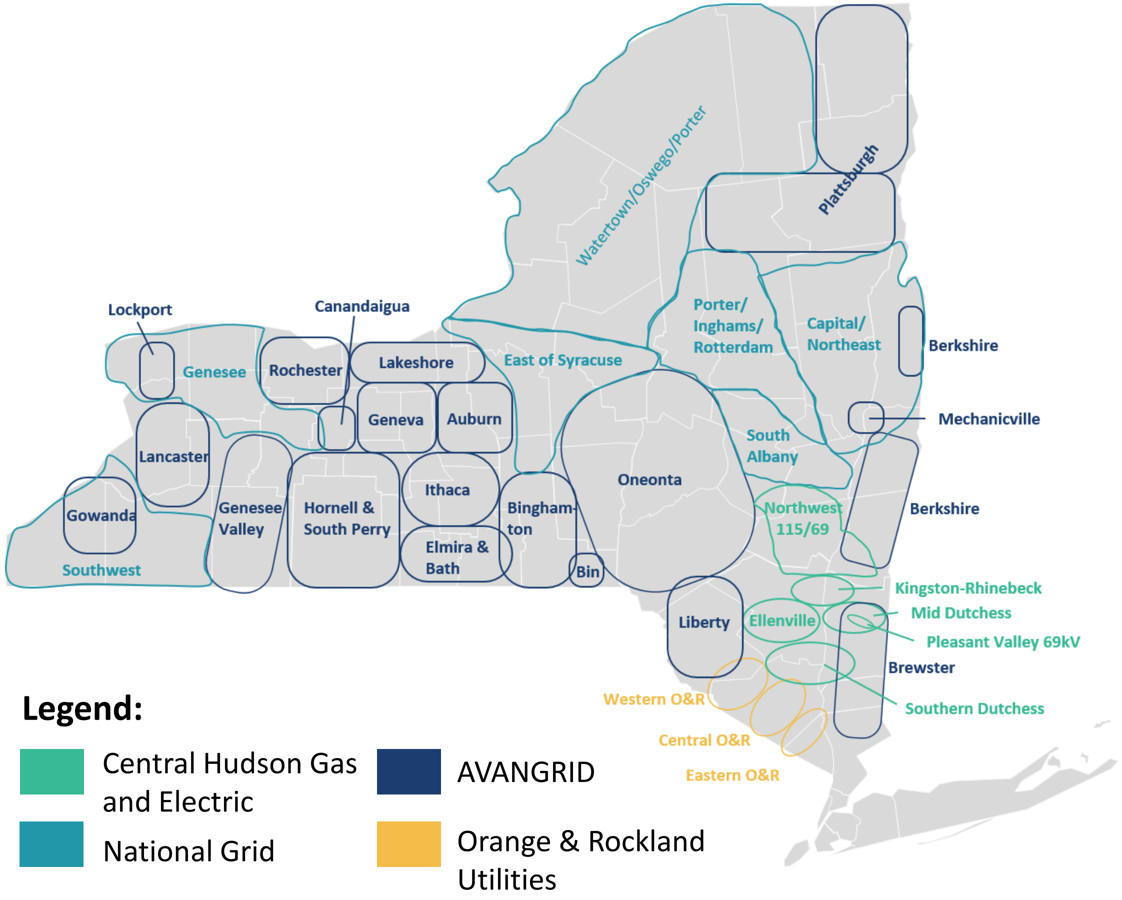
The total LT&D headroom created by the proposed Phase 1 projects appears sufficient to support the integration of land-based renewable resources needed to meet the State's 2030 objective. However:

- The headroom created by Phase 1 projects <u>does not</u> adequately address specific local transmission needs in certain attractive renewable development areas

Some local transmission projects may need to be prioritized for the most attractive renewable development locations

- Accelerate approval and development of some Phase 1 projects (see Appendices A and B of PGS Report)
- Develop/implement Phase 2 projects for attractive renewable generation locations that Phase 1 proposals do not adequately address (see next slide)

Local Transmission Areas in Upstate Utilities' Service Territories



Potential Location-Specific Gaps

Location-specific headroom needs would persist with Utilities' Phase 1 project portfolio. For example, in upstate Utilities' local transmission areas, recent renewable development activities indicate additional headroom requirements beyond those considered in the Utility Study and created by Phase 1 projects

- ***Hornell and South Perry***:
  - Proposed Phase 1 projects provide insufficient headroom to accommodate the projected large interest in renewable development
  - These areas provide flow-through capacity for upstream renewable interconnections
  - Projected renewables and regional transmission conditions likely indicate need for additional on-ramp capacity
- ***Watertown/Oswego/Porter***:
  - Proposed Phase 1 projects appear insufficient to accommodate interconnection of all projected renewables
  - Development of Phase 2 projects are beneficial, may be prioritized to meet immediate headroom needs
- ***Genesee, Lockport and Lancaster***:
  - Recent interconnection queue indicates significant renewable generation development in some areas over others among such electrically proximate areas
  - Lack of coordinated project development between servicing utilities
  - Coordination could identify transmission projects that consider transmission area interactions

Priority Phase 2 Project Recommendations

- Prioritizing Phase 2 local transmission projects can help meet additional capacity needs in attractive renewable development areas, where Phase 1 project headroom capabilities are insufficient:
  - ***AVANGRID's Hornell, Elmira, & Bath Phase 2 Reinforcement – Phase 2 component***:
    - Provides 500 MW of incremental headroom benefit in an area with substantial renewable development interest
- Some Phase 2 Projects should be prioritized to replace proposed Phase 1 alternatives, and for their high cost-effectiveness considerations:
  - ***Central Hudson's Q Line***:
    - Recommend approval of Phase 2 version of the Q Line project over the Phase 1 version
    - Proposed Phase 2 version would support substantially more renewable development
    - 115 kV rebuild will address voltage limitations in this area
  - ***Central Hudson's 10 & T-7 Line State Connections***:
    - Highly cost-effective
    - Facilitates reliable transfer of upstate renewable generation to downstate load centers

Summary of LT&D Project Recommendations

- The PSC should consider implementing expedited approval process for proposed **Phase 1 local transmission and distribution projects**.
  - Many of these projects can facilitate timely interconnection of renewable generation in constrained upstate generation pockets.
- Utilities' proposed Phase 2 projects need further evaluation, including:
  - Additional evaluation of the CLCPA benefits of certain *off-ramp* projects
  - Phase 1 projects that can be expanded cost-effectively to provide additional CLCPA benefits
  - Application of the Utilities' proposed project selection and cost-benefit framework criteria
- Some of the proposed **Phase 2 projects should be prioritized**
  - They provide unique opportunities to expand Phase 1 projects to address high-interest, high-potential renewable generation pockets (e.g., Hornell and two other generation pockets).
  - PSC should work with the Utilities and NYSERDA to identify and advance additional high-priority Phase 2 projects to address headroom constraints in high-interest, high-potential renewable generation development areas for which neither the proposed Phase 1 nor potential Phase 2 projects create sufficient headroom

Summary of LT&D Project Recommendations (cont'd.)

- Significant renewable generation potential also appears to exist in areas of the State that currently do not have access to existing transmission infrastructure.
  - These areas are not addressed in the Utility Study (or the NYISO CARIS study).
  - The PSC should explore whether several such areas should be developed as **local renewable energy zones (REZ)** through the construction of new local transmission infrastructure
- Some candidate Phase 1 projects represent good opportunities for the application of **advanced transmission technologies** (e.g., dynamic line ratings). Similarly, Phase 2 projects can be designed with built-in advanced technology features to enhance CLCPA benefits
- The Utilities' individual Phase 1 and Phase 2 project proposal are discussed and evaluated in Appendices A and B of the Initial PGS Report

Recommendation for Future Analyses

As the state moves further toward a 70% clean energy grid by 2030 and Utilities seek PSC approval of specific projects, the PSC should consider requiring the Utilities to provide a more detailed evaluation of how the proposed projects address the renewable unbottling needs

Specifically, PSC should seek:

- Updated data on renewable generation development activities within the analyzed generation pockets to provide additional justification for the need to act on the advancement of the proposed projects
- Headroom assessment in terms of both MW-capacity and MWh-energy benefits to broaden the types of solutions that may be viable and cost-effective to address needs
- A more accurate assessment of both existing headroom and the headroom created by proposed projects through a more coordinated planning and improved power flow analyses
  - This would more accurately capture how renewable generation and local transmission project development affect local and bulk transmission in nearby or upstream areas (including those in neighboring utility service territories)
- Coordinated assessments of distribution project headroom and local transmission project headroom to avoid unforeseen constraints for DER development that backfeeds to the local transmission level
- More detailed technical information for proposed projects

Advanced Technologies

SUMMARY, FINDINGS AND RECOMMENDATIONS

Summary of Advanced Technologies Findings

- In the Utility Study, the Advanced Technologies Working Group (ATWG) made recommendations for research and development plans for new and underutilized technologies that are able to advance CLCPA goals
- The recommendations focus on roles and opportunities for investments in advanced technologies through 2030
- ATWG evaluated seven groups of advanced technologies capable of alleviating and unbottling constrained renewable and hydro resources, increase circuit loading, and optimize the utilization of existing transmission and rights of ways:
  - Dynamic line ratings and improved transmission utilization
  - Power flow control devices (both distributed and centralized)
  - Energy storage for transmission and distribution services
  - Tools for improving operator situational awareness
  - Transformer monitoring
  - Advanced high-temperature, low-sag (HTLS) conductors
  - Compact tower design

Utility Study Proposal on Advanced Technologies

ATWG's recommendations on advanced technologies include the following:

- Opportunities exist to transfer knowledge among the Utilities
  - Several utilities are already implementing some advanced technology solutions
- R&D knowledge should be shared on a regular basis, and include collaboration in testing new technologies
  - Should be facilitated by NYSERDA funding
  - Joint R&D effort should first focus on **dynamic line ratings, power flow control devices, and deploying storage for T&D services**
- Transmission Operators should be encouraged to utilize new technologies, such as low-sag conductors and innovative tower design, when more cost effective than traditional solutions
- Benefit estimates for new technologies may need to be adjusted down to account for the additional risks associated with relying on new technologies
- A Utility R&D consortium should be created in 6 months to evaluate "state-of-the-art and advanced technologies that are already being used elsewhere in the U.S. or the world"
  - Proposes that the Utilities pursue two or three R&D projects over the next 1-2 years
  - Selected projects would be funded by NYSERDA and through Commission-approved rate-case allowances

Power Grid Study Recommendations

The Utility Study recommendations to deploy advanced technologies do not go far enough to take advantage of well-tested technologies that could quickly provide CLCPA benefits and reduce costs

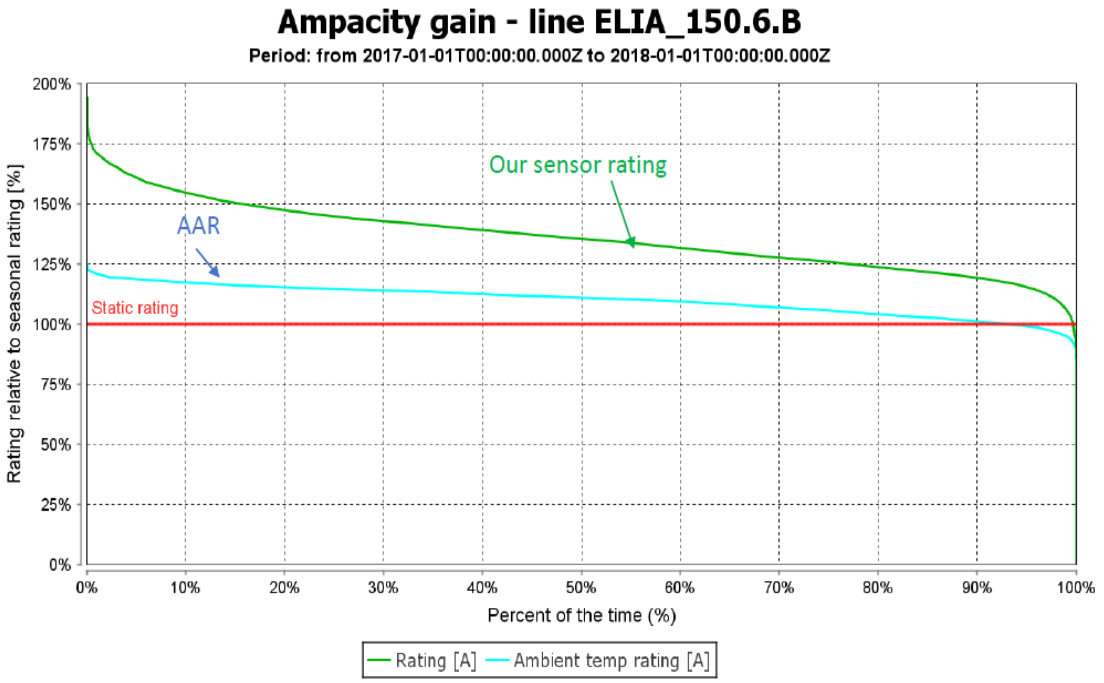
- The State should encourage the Utilities and other transmission owners to more expeditiously evaluate and deploy **advanced transmission technologies**
  - Many technologies can be deployed to both the local and bulk-power grid more quickly and cost-effectively than traditional transmission upgrades to expand the renewable resource integration capability
  - They can enhance the transfer capability of both the existing grid and that of Phase 1 and Phase 2 projects
- Several of the available technologies have advanced well beyond their research and development and pilot program phases and are ready for commercial deployment in the State.
  - For example, commercial-scale applications of Dynamic line ratings (DLR) technology elsewhere have already demonstrated a 20-30% increase of average annual transmission capacity above static ratings, while maintaining or enhancing system reliability
  - Collectively, the Utilities have experience with most of the advanced technologies evaluated in the Utility Study
- Both Utility and NYISO transmission planning processes should be improved to recognize the unique advantages that advanced technologies can provide to address CLCPA-driven needs
- Cost recovery mechanisms will need to be clarified for storage facilities that address T&D needs but also participate in wholesale power market

Example: Dynamic Line Ratings (DLR) Technology

DLR is particularly effective in reducing (on-ramp-related) curtailments of wind energy

- Elia, the grid operator in Belgium, has used DLR since 2008;
  - Currently, has deployed DLR on a system-wide scale, involving 35 transmission lines.
- As shown, DLR is more effective and more reliable than Ambient Adjusted Ratings (AAR)
  - DLR can increase transmission ratings above static ratings by 27-30% on average over a year
  - Increase % varies depending on system conditions: exceeds 10% during 90% of the year, 25% during 75% of the year, and 50% during 15% of the year.
  - only during 2% of the year dynamic line ratings are below static ratings to maintain reliability.

DLR Example – Elia



Source: Alexander, "Elia Large Scale DLR Deployment," slides 9 and 13.

Phase 1 Project Candidates for DLR Deployment

- **The report identified several candidate Phase 1 projects, representing opportunities to include advanced transmission technologies.**
  - Similarly, Phase 2 projects can be designed with built-in advanced technology features to enhance CLCPA benefits of phase 2 projects
- **The Power Grid Study further recommends that the planning process be modified so more reliable information on transmission constrained locations and head-room needs can be developed**
  - Possibly develop needs with input from renewable generation developers
  - Cost-effective solutions could then be developed by the utilities and solicited from advanced technology vendors to address these constraints

Phase 1 Local Transmission Candidates for DLR Implementation

Utility	Region	Project Name
National Grid	Southwest	Dunkirk – Falconer 115kV Line Upgrades
	Porter/Inghams/Rotterdam	Inghams – Rotterdam 115kV Line Upgrades
	Capital region	Rotterdam – Wolf/State Campus 115kV Line Upgrades
	Albany South	Churchtown– Pleasant Valley 115kV Upgrades
Central Hudson	Northwest 115/69 kV	H & SB Line
	Zone G	SK Line
	Northwest 115/69 kV	H & SB Line
	Westerlo Loop	NC Line
	69 kV E Line	New Smithfield Area Line
	Pleasant Valley	Q Line
LIPA	Zone K	138 kV Riverhead to Canal New Circuit
	Zone K	Wildwood to Riverhead 69 kV to 138 kV Conversion
NYSEG/RG&E	Lockport Area	Lockport Area Phase 1 Upgrades
	South Perry Area	South Perry Area Phase 1 Upgrades
	Binghamton Area	Binghamton Area Phase 1 Reinforcement
	Binghamton Area	Binghamton Area Phase 1 Reinforcement
	Ithaca Area	Ithaca Area Phase 1 Reinforcement

Offshore Wind Study

SUMMARY, FINDINGS AND RECOMMENDATIONS

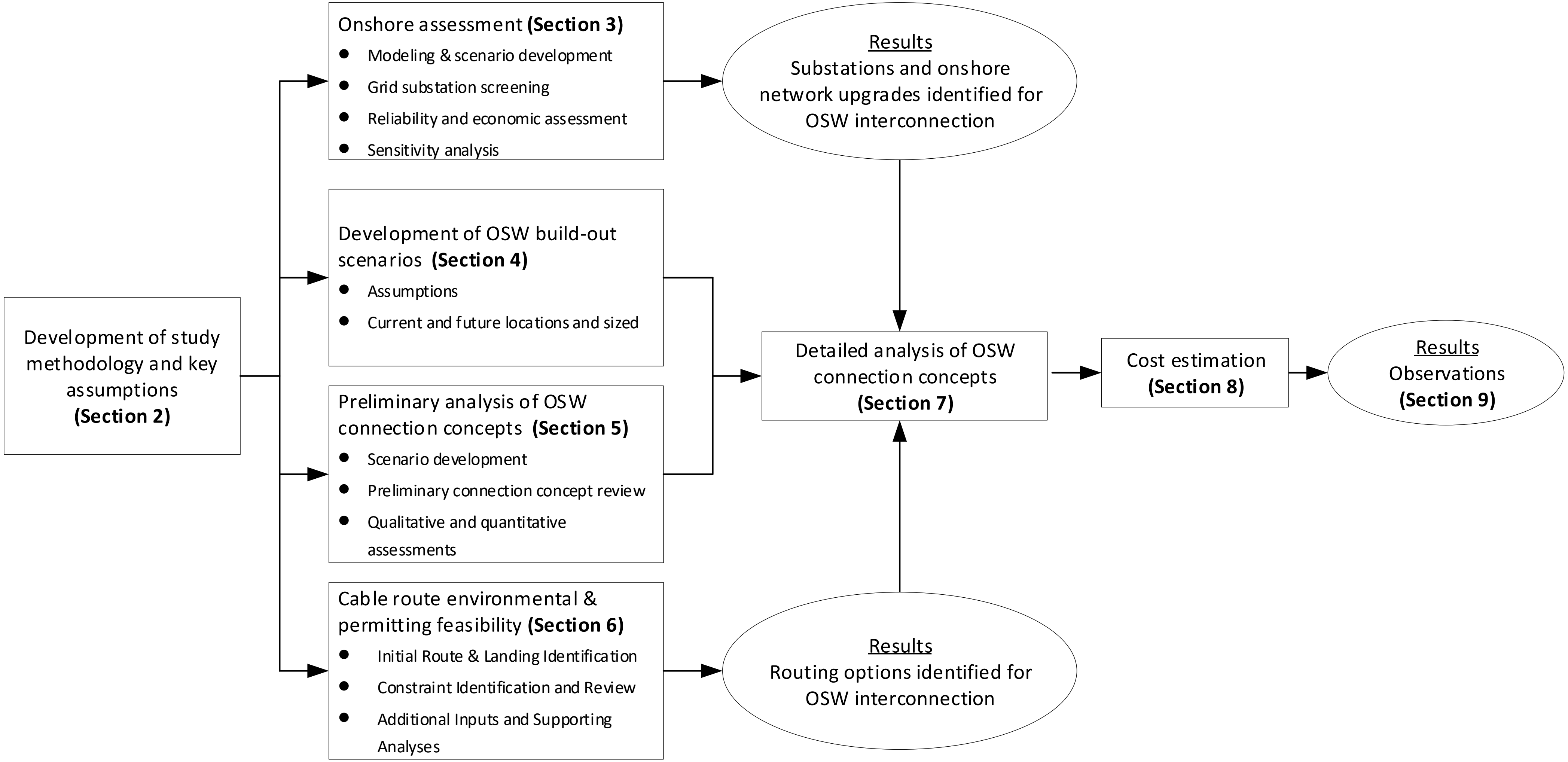
Introduction

The Offshore Wind Integration Study (OSW Study) identifies possible grid interconnection points and offshore transmission configurations. It assesses onshore bulk transmission needs relating to the integration of 9,000 MW of offshore-wind generation.

OSW Study conducts a detailed analysis of OSW connection concepts and costs. This analysis relies on four supporting analyses:

1. “Onshore assessment” to identify points of interconnection (POIs) and on-shore bulk-power transmission upgrades needed to cost-effectively integrate 9,000 MW of OSW generation
2. Development of viable offshore buildout scenarios regarding offshore wind energy areas and submarine transmission technologies to selected POIs
3. Analyzing several offshore grid transmission configuration options that would connect OSW plants through meshed or backbone offshore transmission
4. Preliminary environmental permitting and feasibility study of offshore cable routes and onshore landing points.

OSW Study Modeling Process



Source: Offshore Wind Study

OSW Points of Interconnection (POIs)

The OSW study identified POIs through an iterative screening process.

- Thermal transfer screen analysis to identify 36 substations (>69 kV) in NYC and Long Island that could accept at least 300 MW of OSW
- 20 substations with the least curtailments selected based on additional reliability assessment, market analysis, transfer assessments and engineering judgement

The study then evaluated multiple POI combinations that could deliver 5,000 to 7,000 MW into the NYC area, with the remainder located in Long Island.

- **Scenario 1** (Base case):
  - Zone J (NYC): Farragut (1,400 MW), Rainey (1,250 MW), Mott Haven (1,250 MW), and West 49th St. (1,200 MW)
  - Zone K (Long Island): New Bridge (600 MW), Shore Rd. (500 MW), Northport (400 MW), and Syosset (300 MW), and Brookhaven (270 MW)
- **Scenario 2**: Moved Zone K injections at Brookhaven, New Bridge, and Northport to Ruland Rd (970 MW) and East Garden City (ECG) (300 MW).
- **Scenario 3**: Based on Scenario 2 but moves 915 MW of OSW POIs from Zone J to Zone K

Scenario 1 and Scenario 2 POIs

Developing the POIs will depend on availability of sites with enough space to accommodate inverters and other equipment, and on being able to route cables from the wind energy lease areas to these points and interconnect them to the existing substations

Scenario 1

Scenario 2

Takeaways

- Delivering 6,000 MW into Zone J would require six cables (four beyond the two for already-contracted OSW) to reach ConEd substations in Manhattan and Brooklyn.
  - Routing and permitting through the Narrows and into New York's inner harbor will be challenging.
    - Study indicates feasibility if collaboratively planned and researched with maritime agencies and stakeholders.
    - Alternative routes to New York City through Long Island Sound were not fully explored in the OSW Study but could provide options if cables are constrained via other routes
- Matching cable technology and associated transfer capability to available routing space into New York Harbor and optimal capacity of the POIs is important.
  - Zone J has scarce cable routing and substation space, but the current single largest loss-of-source contingency limited the cable size for this study to 1,310 MW
    - The ideal technology is currently 320 kV symmetric monopole HVDC cables (525 kV for larger POI injections)
    - For smaller injections of up to 450 MW and for distances of less than 70 miles, the Study indicates that 220 kV HVAC cables are likely the most cost-effective.
- Study finds "meshed" configuration of offshore transmission is the most flexible and can adapt to the availability and locations of future wind energy lease areas

Takeaways (cont'd.)

- OSW Study concludes that 9,000 MW of offshore wind generation can be integrated **without requiring major onshore bulk transmission upgrades** to mitigate adverse system impacts or curtailments
  - Simulated curtailments were less than 4 GWh in 2035 in base case; however, "Modified Zone K parameters" (reflecting input from LIPA on Long Island system operations) had 24 GWh curtailment
  - Assumes well-coordinated system development, feasible siting and permitting, low congestion and curtailments, reliability needs defined by summer-peak-load conditions, and local impacts that will be addressed separately
  - New transmission from Long Island to the rest of the state will be needed if more than 3 GW of OSW is interconnected on Long Island
- The OSW Study and other studies do not provide the same conclusions on suitable POIs, nor are the studied POIs identical to the Utility Study assumptions and the NYISO interconnection queue
  - Not all of the POI capacities identified in OSW Study are at most cost-effective scale of different cable types: POIs that cannot accommodate at least 400 MW might not be desirable POI candidates for cost-effective OSW development

Range of POIs Selected in the OSW and Other Studies

Source		Points of Interconnection for Potential Projects	
		Zone J	**Zone K**
OSW Study (Scenario 1)	[1]	Farragut (1400 MW) Rainey (1250 MW) Mott Haven (1250 MW) West 49th St. (1200 MW)	New Bridge (600 MW) Shore Rd. (500 MW) Northport (400 MW) Syosset (300 MW) Brookhaven (270 MW)
Zero Emissions Study	[2]	Farragut Rainey West 49th Street Fresh Kills	Ruland Rd. East Garden City River Head
Anbaric Study	[3]	Gowanus (2000 MW) Fresh Kills (1700 MW) Rainey (1200 MW)	Ruland Rd. (1200 MW) East Garden City (1084 MW)
CARIS 70x30	[4]	Farragut (1440 MW) Fresh Kills (1424 MW) Gowanus (816 MW)	Brookhaven (384 MW) Ruland Rd. (384 MW)
Utility Study: ConEd and LIPA	[5]	Two new OSW interconnection hubs with 3000 MW and 2180 MW.	Ruland Rd. (1400 MW) East Garden City (700 MW)
NYISO Interconnection Requests	[6]	Gowanus (2080 MW) Fresh Kills (880 MW)	Ruland Rd. (1816 MW) Brookhaven (880 MW) Barrett (2500 MW)

Note: The OSW Study also considered additional POIs not listed in the table above, including Ruland Rd. and East Garden City.
The 2490 MW Beacon and Empire 2 projects (provisionally awarded to Equinor in Jan 2021), are expected to interconnect at Astoria 138 kV in Queens and Barrett Substation in Nassau.

Recommendations

- **Additional bulk transmission should be developed between Long Island (NYISO Zone K) and the rest of the State**
  - Additional tie-line capacity would be needed by 2035–2040 as renewable requirements expand and emissions limits tighten
  - Avoiding further bulk transmission upgrades requires careful selection of interconnection locations and planned colocation of 1.7 GW battery storage at NYC and Long Island substations, utilized for integrating OSW generation
- Costs are likely to increase if development realities and onshore grid conditions differ from those assumed and simulated due to siting constraints and transmission constraints
  - Integrating 5-6 GW of offshore wind into Zone J may be more difficult and costly than anticipated
    - Planning this integration should be undertaken in a coordinated manner in order to manage cost
  - More than 3 GW of offshore wind may need to be connected to Zone K by 2035 (if not earlier) to meet the 9 GW goal, which likely would necessitate bulk transmission enhancements between Long Island and the rest of State
    - Advancing a new link to Long Island to 2030 would provide value earlier and would expand the options for meeting the State's OSW goals, thereby mitigating OSW-integration risks
- The decision to implement a meshed system can be delayed, as long as the State keeps the option open to develop a **meshed offshore power grid** in the future
  - OSW plants serving the State should be designed so that they can be connected with each other in the future (and possibly with plants serving needs in New England and New Jersey)
  - A meshed grid could also be designed to create additional transfer capability between Long Island and NYC

Zero Emissions Study

SUMMARY, FINDINGS AND RECOMMENDATIONS

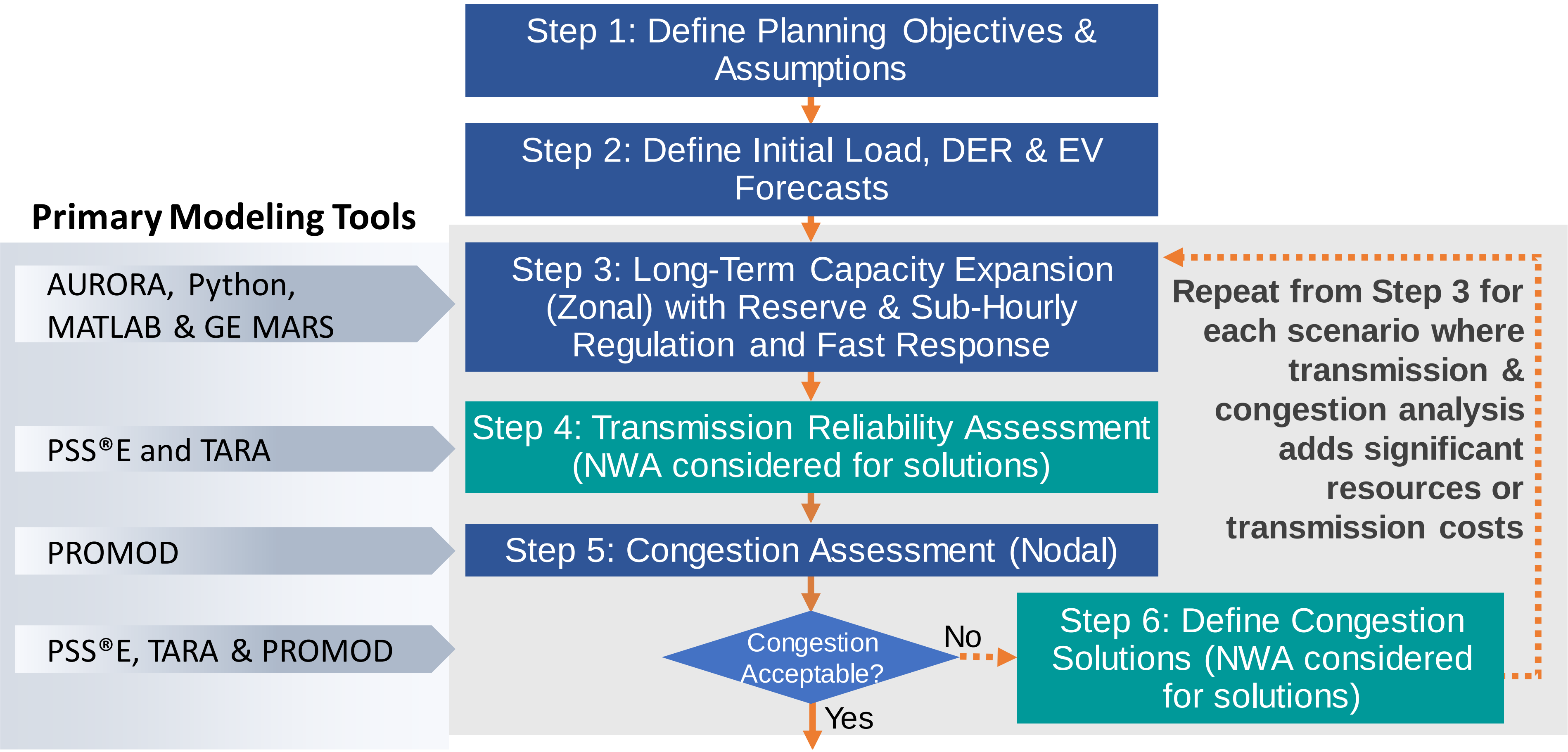
Introduction

The Zero Emissions Electric Grid by 2040 study (Zero Emissions Study) is a **resource planning study** to analyze transmission, generation, and storage scenarios for meeting New York's goals of zero-emission electricity by 2040 and 70% renewable generation by 2030

- Based on the New York Decarbonization Pathways Study and Utilities' forecasts
  - Developed "Initial Scenario" and "High Demand Scenario" based on load and Distributed Energy Resource (DER) forecasts
- The study:

1. Simulated **Optimized Generation and Storage Capacity Expansion for 2030 and 2040**:
   Optimized capacity expansion simulations were performed with zonal resolution
2. Performed a **Transmission Reliability Assessment**:
   Analyzes thermal and voltage violations for pre-contingency and local and design criteria contingency conditions
3. Performed a **Transmission Congestion Assessment**:
   Nodal analysis identified congestion and renewable curtailments
4. Developed **Potential Transmission Expansions** to address the reliability and congestion challenges identified in prior steps
   This further helped refine the optimized capacity expansions for 2030 and 2040

Study and Modeling Process



Source: Zero Emissions Study

Summary of Results: Generation Mix and Storage

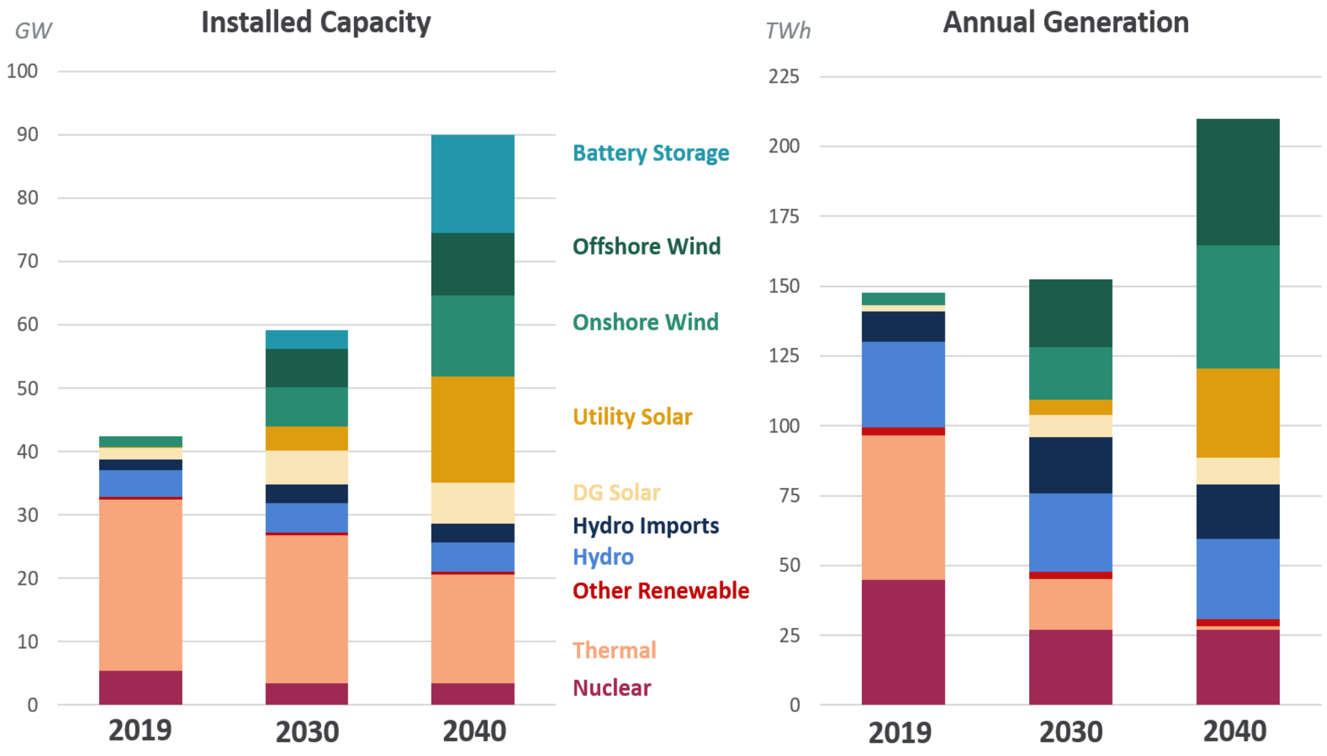
New York's 2030 goals can likely be met at low levels of curtailment and congestion without significant bulk-power transmission upgrades beyond those already planned and under development.

- However, by 2040, high levels of congestion and some curtailments point to **the potential for cost effective bulk transmission upgrades**

Projected capacity and generation (2030 and 2040 vs. 2019 levels):

- Share of 2040 generation from onshore wind, offshore wind, and solar is roughly equal
  - Deploys 15.5 GW of battery storage
- In 2040, 17 GW of "other thermal" generation capacity remains operational for backup power needs but is fueled by renewable natural gas
  - Use of renewable natural gas only occurs in very few hours of the year (3% capacity factor for thermal capacity)

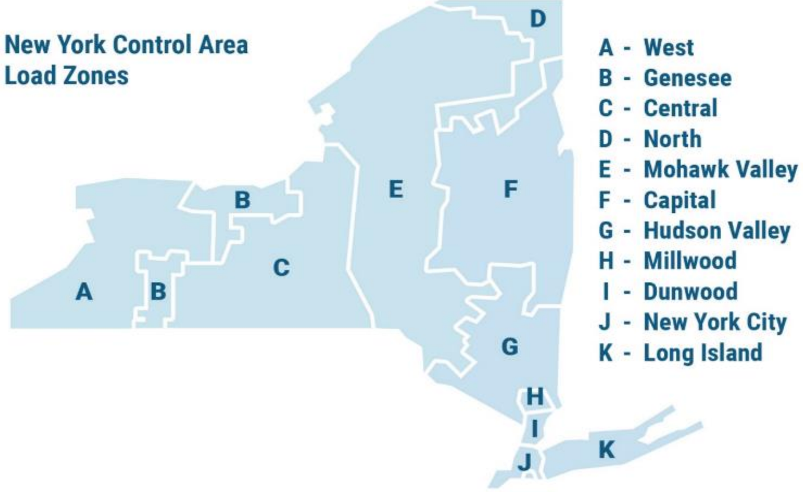
Initial Scenario: Capacity and Generation by Technology



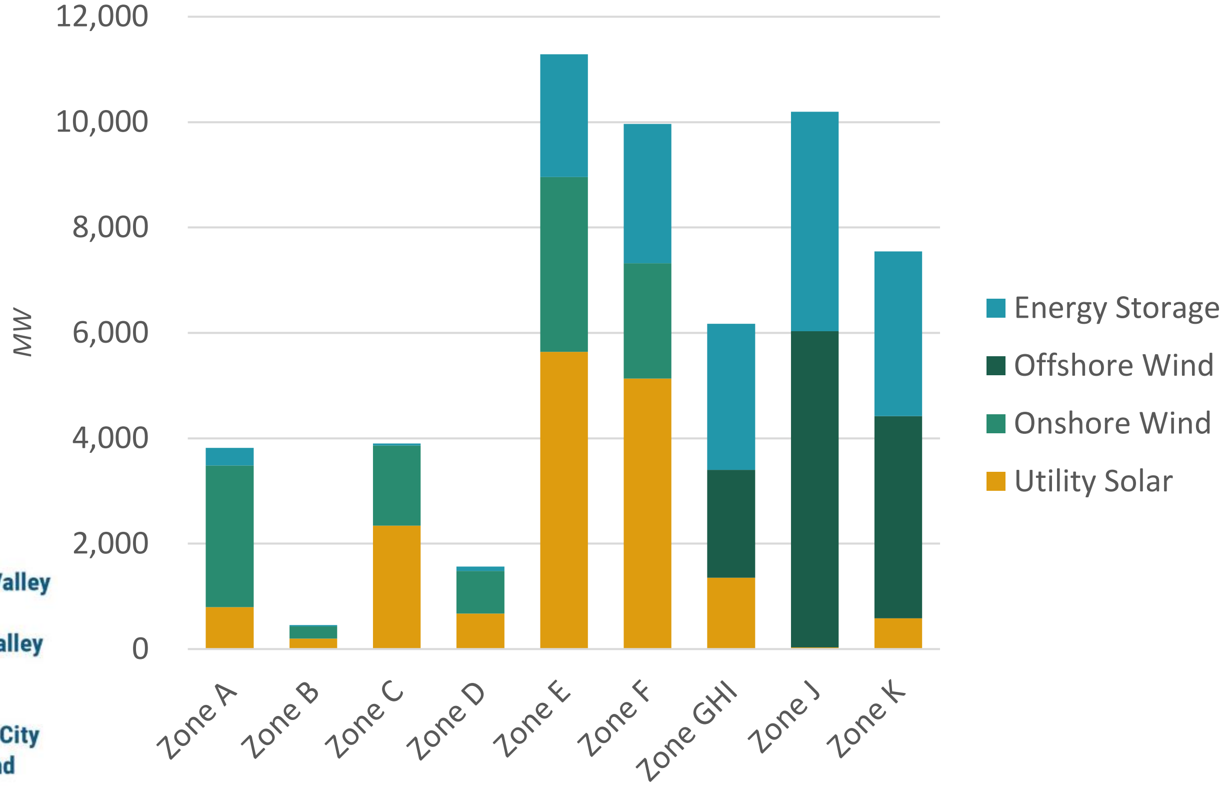
Summary of Results: Zonal Capacity Buildout in 2040

Projected zonal capacity in 2040:

- Study simulations result in new solar and onshore wind primarily in upstate Zones A-F, and offshore wind downstate
  - **Zones A-F** (upstate): 14.8 GW solar, 10.8 GW onshore wind
  - **Zones G-K** (downstate): 2 GW solar, 11.9 GW offshore wind
- Storage buildout projections almost entirely located in Zones E-K to help mitigate transmission congestion



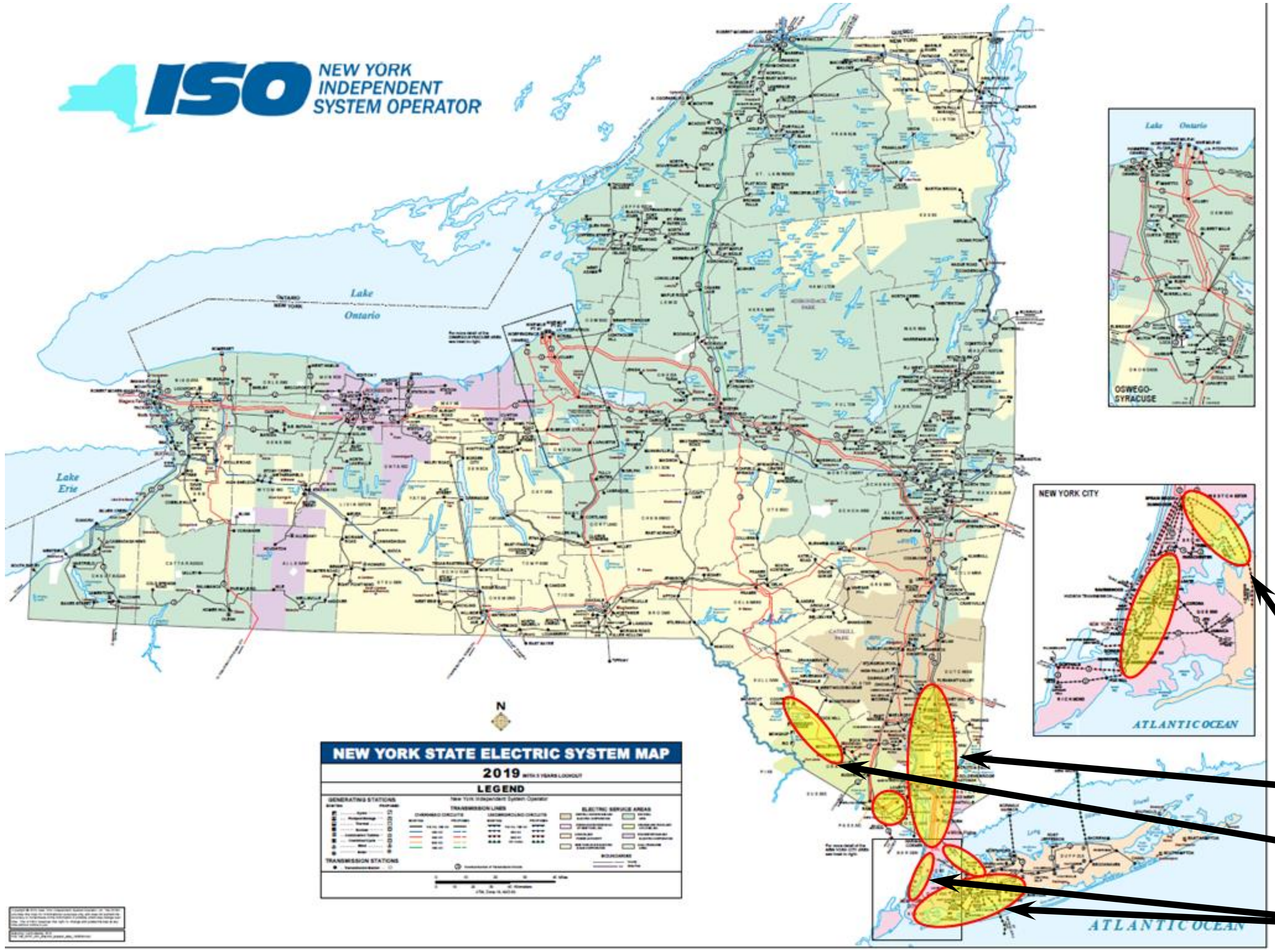
Initial Scenario: Renewable Generation and Storage Capacity Buildout by 2040



Source: Data from Table A-4 in Zero Emissions Study (Appendix E of Initital Power Grid Study Report.

Summary of Results: Bulk Transmission Needs

2040 Projected Congestion Areas



- The Study finds low levels of statewide curtailment and congestion by 2030
  - By 2040, statewide curtailment increases only modestly to 1.5% (Initial) and 3.4% (High Demand), **without bulk transmission upgrades**
  - But high congestion costs are identified in some locations by 2040
- The Study suggests that the identified 2040 curtailments and high congestion costs can be mitigated cost-effectively with transmission projects in four specific grid locations:
  - at the Dunwoodie to Shore Rd cables
  - at the Millwood South Interface
  - downstream of Coopers Corner into Zone GHI
  - at NYC and west Long Island area

Summary Study Results: Bulk Transmission Needs (cont'd)

- To address bulk issues for locations with high simulated congestion costs, the study developed indicative bulk transmission upgrades that likely would be cost-effective
  - Upgrades also reduce 2040 renewable curtailment
    - In **Initial Scenario**: the simulated 2040 curtailment is down to 0.1% from 1.5% in Base Case
    - In **High Demand Scenario**, larger upgrades in the same locations reduce simulated 2040 curtailment to 0.8% from 3.4%

Initial Scenario: Indicative Cost-Effective Bulk Transmission Upgrades

Zone	Indicative Transmission Upgrades in 2040 Upgrade Case
H/I/J	Increase Millwood South Interface transfer capability to 13000 MVA, and increase Dunwoodie South Interface transfer capability to 6000 MVA
I/K	Increase Dunwoodie—Shore Rd cable LTE rating to ~3000 MVA. (likely require two new 345 kV cables in parallel and two new 345/138kV transformers at Shore Rd)
E/G	Increase Coopers Corner—Middletown—Rock Tavern—Dolson Ave 345 kV line sections LTE rating to ~3000 MVA
G	Increase Ladentown—Ramapo 345 kV line LTE rating to ~2500 MVA

Takeaways and Discussion

Future transmission needs will depend on which new resources are developed where—a major uncertainty underlying a transmission study projecting 20 years into the future

The Zero Emissions Study's projected renewable generation and storage investments were optimized to locations consistent with the grid's capabilities. The Study's renewable generation and storage deployments were compared with three similar studies:

- A study conducted by E3 for NYSERDA (Pathways to Decarbonization in New York State)
- A study conducted by Brattle for the NYISO (New York's Evolution to a Zero Emissions Power System)
- NYISO's 2019 Congestion Assessment and Resource Integration Study (CARIS).

Projections from the four studies shows that there is uncertainty as to what the resource generation mix and capacities will likely be in 2030 and 2040 and where these resources will be located (see next slide)

This uncertainty will have implications for the grid's ultimate investment needs.

Takeaways and Discussion (cont'd)

Renewable capacity projections range 29 - 42 GW in 2030, and 53 - 66 GW in 2040 across studies.

- The Zero Emissions Study's Initial Scenario marks the low end of the range, with the Study's High Demand Case representing approximately the average

Projected Renewable Capacity by Zone Groups (GW)

	Zero Emissions Study: Initial Scenario		Zero Emissions Study: High Demand		E3: High Technology Availability		Brattle: Reference Load Case		CARIS: 70x30 Base Load
	2030	2040	2030	2040	2030	2040	2030	2040	2030
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Zones A-F									
Utility Solar	3.4	14.8	4.8	20.6	7.2	NR	14.3	25.6	13.0
Onshore Wind	6.2	10.8	6.8	10.6	4.7	NR	7.1	9.8	8.8
Subtotal	9.6	25.5	11.6	31.3	11.9	NR	21.4	35.4	21.8
Zones G-K									
Utility Solar	0.4	2.0	0.9	2.0	3.4	NR	0.8	4.5	2.1
Onshore Wind	0.0	2.0	0.6	2.0	0.0	NR	0.0	0.0	0.0
Offshore Wind	6.0	9.8	6.0	13.6	6.2	NR	7.1	13.8	6.1
Subtotal	6.4	13.9	7.5	17.6	9.6	NR	7.9	18.3	8.2
Total Hydro (Incl. Imports)	7.6	7.6	7.6	7.6	7.0	8.0	6.1	6.1	1.2*
Total Distributed Solar	5.3	6.4	5.3	6.4	6.0	6.0	6.1	6.2	7.5
Total Storage	3.0	15.5	3.0	14.9	4.4	10.0	5.2	11.9	3.0
Total (Excl. Storage)	**29.0**	**53.4**	**32.0**	**62.9**	**34.5**	**61.0**	**41.5**	**66.0**	**38.7**

Notes:
* CARIS Study models but does not report hydro import capacity.

by Source, Load, and Curtailments (TWh)

	Zero Emissions Study: Initial Scenario		Zero Emissions Study: High Demand		E3: High Technology Availability		Brattle: Reference Load Case		CARIS: 70x30 Base Load
	2030	2040	2030	2040	2030	2040	2030	2040	2030
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Utility Solar	6	32	10	41	19*	50*	17	34	18
Distributed Solar	8	10	8	10			7	7	9
Onshore Wind	19	44	23	42	13	35	16	22	17
Offshore Wind	24	45	24	64	25	40	26	51	22
Hydro	28	29	29	28	30	30	32	32	28
Hydro Imports	20	19	20	19	18	25	13	13	20
Nuclear	27	27	27	27	27	25	17	17	27
Renewable Natural Gas	0	1	0	2	0	0	0	13	0
Natural Gas	18	0	23	0	35	0	26	0	35
Net Non-Hydro Imports	(0)	(0)	(3)	1	NR	NR	5	6	(16)
Other	3	3	3	2	3	5	0	0	3
Total In-State Generation	**132**	**191**	**146**	**217**	**152**	**185**	**142**	**176**	**160**
Gross Load	**152**	**208**	**162**	**233**	**152**	**NR**	**159**	**196****	**162**
Renewable Curtailment	**0**	**0**	**0**	**2**	**NR**	**NR**	**NR**	**NR**	**14**

Notes:
* Total solar generation, E3 does not distinguish between utility and distributed solar.
** Brattle's 2040 Gross Load contains 27 GWh of load from RNG Production.

Takeaways and Discussion (cont'd)

Other key observations about this comparison to other similar projections include:

- Utility-scale solar additions vary across studies in both 2030 and 2040
- Offshore wind additions vary in 2040 (10-14 GW), and Zero Emissions Study results fall within this range
- Differences in load assumptions and basic uncertainties about future renewable developments drive differences across the various projections
- Load assumptions differ substantially across studies
  - Initial Scenario has lower load projections, High Demand Scenario has higher load projections
  - Degree of uncertainty that future electrification efforts and energy efficiency programs
- Import and export assumptions differ across studies (partially drives capacity differences)

Zero Emissions Study has addressed 2030 and 2040 renewable curtailments at the bulk level

- Zero Emissions Study evaluated only bulk transmission needs
- Lower-voltage system needs are assessed in CARIS and the Utility Study

Zero Emissions Study projects that zero emissions could be achieved with 17-23 GW of thermal backstop generation fueled with landfill gas, biogas, or other renewable natural gas.

- This solution should be seen as a placeholder until more clarity exists about future technologies, such as green hydrogen and long-duration storage.

Findings

- **The Study's conclusions of limited near-term bulk transmission needs (beyond projects already planned*) are robust given the study assumptions**
  - If more renewable generation is necessary to achieve CLCPA goals or renewable and storage development differs in mix and locations, more bulk transmission than identified in the Study may be required
  - Bulk transmission needs may arise sooner if land-based and offshore wind generation do not interconnect at the jointly planned locations identified in the OSW and Zero Emissions Studies
- Achieving the Study's high level of **coordinated development of location-specific renewable generation, storage, and transmission** may be challenging. It requires:
  - Careful planning and contracting for time and location-specific optimization of storage deployment
  - Updating wholesale market rules to support this market evolution and allow storage facilities to capture the full value they are assumed to provide in the study
  - Development of retail regulations that support distribution-level storage installation and allow for their contribution to wholesale market needs
  - More coordinated and integrated planning processes for generation, storage, bulk transmission, local transmission, and distribution infrastructure

* The already-planned projects assumed to be developed include the Western NY Empire State line 345 kV project in Zone A, the AC Transmission Segment A & Segment B 345 kV projects in Zone E and F, and the Northern New York 345 kV projects in Zone D and E (including upgrades from Porter to Edic). Additionally, the Zero Emissions Study assumes a new 1,250 MW high-voltage direct current transmission line delivering dispatchable renewable energy into New York City

Findings and Recommendations

- The study's simulation results will **tend to understate the congestion, curtailment, and real-time operational challenges**
  - Only performed a high-level screening analysis of the potential operational challenges
  - Modeling tools, as used in this study, will not fully capture real-world congestion and curtailment
- Significant congestion and curtailments can result from **constraints on the lower-voltage transmission** facilities (rated at 115/138 kV), particularly under contingencies on the bulk transmission system
- The State should **revisit recent NYISO, NYSERDA, and Utility study efforts at regular intervals** to ensure that transmission needs are identified pro-actively.
  - More detailed operational assessments should be undertaken in the next years
  - Congestion and curtailment challenges on local and bulk transmission should be studied in a more integrated fashion
  - NYISO's economic and public policy planning processes provide effective mechanisms for identifying bulk needs and developing integrated solutions

Overall Power Grid Study Findings and Recommendations

Findings: Utility Study

- Utilities' ongoing asset maintenance and reliability programs present an opportunity to capture significant CLCPA benefits
- On a state-wide basis, Utilities' Phase 1 projects, or a similar portfolio, appear sufficient to expand existing headroom to support the integration of the land-based renewable resources to meet the State's 2030 objective
  - However, Phase 1 projects do not adequately address **specific local transmission needs in attractive renewable development areas**
- Some Phase 1 projects may need to be accelerated, along with certain high-priority Phase 2 projects for locations with attractive renewable development opportunities (such as the Hornell area)
- The Utility Study discusses the potential for advanced transmission technologies and proposes further research. It does not propose sufficiently specific implementation plans

Recommendations: Utility Study

The Power Grid Study recommends that the PSC:

- Consider implementing an expedited approval process for the proposed **Phase 1 local transmission and distribution projects** (or for a similar portfolio)
- Seek further evaluation of the Utilities' proposed Phase 2 projects
- Prioritize some of the proposed **Phase 2 projects** as they provide unique opportunities to expand Phase 1 projects to address high-interest, high-potential renewable generation pockets
  - Work with the Utilities and NYSERDA to identify and advance additional high-priority Phase 2 projects to address headroom constraints in high-interest, high-potential renewable generation development areas
- Explore providing transmission access to **local renewable energy zones (REZ)** in areas of the State with significant renewable generation potential but no access to existing transmission infrastructure.

Findings: OSW Study

- Study assumptions indicate need for additional bulk transmission between Long Island (NYISO Zone K) and the rest of the State
- No other OSW-related bulk transmission needs identified in OSW and Zero Emissions studies beyond the projects already under development

  This important conclusion depends on several conditions:
  - a high level of coordination in the development of individual OSW plants and their POIs
  - feasible siting and permitting conditions
  - low congestion and curtailment conditions
  - no reliability impacts that are more challenging than during the evaluated summer-peak conditions
  - storage developed at sufficient scale in specific locations
  - no insurmountable local transmission impacts that would change the evaluated bulk transmission solutions
- If development realities and onshore grid conditions differ from those assumed and simulated, congestion and curtailments are likely to increase due to siting constraints and transmission constraints
- A **meshed offshore transmission** network that interconnects the offshore substations of the individual OSW plants could ultimately be more valuable, more reliable, and more resilient
  - The decision to construct a meshed system can be delayed, but the State should ensure that OSW projects with radial connections are constructed such that they include the option to integrate them into a meshed system later

Recommendations: OSW Study

The Power Grid Study recommends that the State:

- Commence development of a tie-line between Long Island and the rest of the Stage by 2030
- Initiate multi-disciplinary planning and coordination efforts to develop cost-effective options for routing up to 6,000 MW of OSW generation into New York City and connecting it with the city's substations
  - Confirm POI availabilities and resolve remaining discrepancies between the OSW Study and the Utility Study's respective findings
  - Ensure that OSW developers understand available, cost-effective interconnection solutions for the State
- Promote options for adding transmission links between offshore substations to create a meshed offshore system if and when desirable in the future
- Continue collaborative studies to assess likely needs for onshore bulk and local transmission upgrades to support OSW targets
- Review policies for planning and developing storage and other advanced technology options to support OSW integration and increase system flexibility

Findings and Recommendations: Zero Emissions Study

- The Zero Emissions Study finds that the State's 2030 goals can be met with low levels of curtailment and congestion, without significant upgrades to the bulk-power transmission grid
  - Assumes all transmission projects already planned and under development will be in service and a new HVDC line delivering dispatchable renewable energy into New York City will materialize as a result of the State's new Tier 4 procurement
- By 2040, projections of high congestion costs and some renewable generation curtailments point to a potential need for additional bulk transmission upgrades:
  - Additional bulk transmission from upstate into the New York City area (from Zone H to Zones I, J, and K) will likely become cost-effective by 2040 as congestion costs increase
  - These congestion-reducing transmission would also reduce upstate renewable curtailments and allow downstate areas to reduce reliance on backstop renewable-fuel thermal generation
- The needs for additional bulk-power and local transmission upgrades may arise sooner than projected in the Utility, OSW, and Zero Emission Studies, if:
  - Renewable generation develops more quickly in certain areas than anticipated
  - Land-based and offshore wind does not interconnect where assumed

Recommendation:

Revisit recent NYISO, NYSERDA, and other studies periodically to proactively identify transmission needs

NYISO's economic and public policy planning processes provide effective mechanisms to identify needs and solutions

Recommendations: Improved Planning and Future Analyses

The Power Grid Study recommends that the State:

- **Improve planning processes** to better coordinate across LT&D upgrades performed by the individual utilities, the bulk-power system planning and generation interconnection processes led by the NYISO, and the renewable generation and storage procurement planned and managed by NYSERDA
- Address **OSW-related transmission on and from Long Island**
  - Due to real-world challenges that will likely exceed those captured in the component studies, it is important to support OSW connection to Long Island well before 2035, taking into account the long-lead time for planning, permitting, and construction
- Initiate multi-disciplinary planning and coordination to support development of cost-effective **options for routing up to 6,000 MW of OSW generation into New York City** and its interconnection with the city's substations.
  - It may be possible to utilize the NYISO's Public Policy Transmission Planning Process, including for local bulk-power-voltage-level upgrades associated with interconnecting OSW to City substations
- Build on existing NYISO studies to further explore the **operational challenges** not fully analyzed in the Power Grid Study, to better understand transmission needs given the likely higher (real-world) flexibility challenges, congestion costs, and renewable curtailments

Recommendations: Improved Planning and Future Analyses

- More detailed and more consistent studies should be developed to **<u>quantify existing headroom</u>** in various transmission-constrained areas on both the local and bulk transmission systems
  - Will help identify high-priority, high-value locations for renewable development and transmission upgrades
  - Improved study methodologies also needed to more consistently and reliably quantify the additional headroom and renewable integration benefits created by proposed transmission upgrades
- Further studies will be needed to better understand **<u>future generation and long-duration storage technology</u>** options that may be available after 2035 to cost-effectively eliminate the residual emissions to achieve a zero emissions grid by 2040
  - These technologies may impact grid investment and operational needs