# CARIS 70x30 Scenario Sections
# DRAFT for May 4, TPAS/ESPWG
# Comments due May 11 to LBullock@nyiso.com

## 1. Scope

Over the next decades, the Climate Leadership and Community Protection Act (CLCPA) mandates that New York consumers be served by 70% renewable energy by 2030 ("70x30"). The CLCPA includes specific technology based targets for distributed solar (6,000 MW by 2025), storage (3,000 MW by 2030), and offshore wind (9,000 MW by 2035), and ultimately establishes that the electric sector will be emissions free by 2040.[1] Significant shifts are expected in both the demand and supply sides of the electric grid, and these changes will affect how the power system is currently planned and operated. To assist the evaluation of these impacts, the CARIS "70x30" scenario kicks off the assessment using production cost simulation tools to provide a "first look." Focusing on the impact to energy flows, these policy targets were modeled for the year of 2030 in order to examine potential system constraints, generator curtailments, and other operational limitations. Subsequent studies, such as 2020 Reliability Needs Assessment, and Climate Change Study Phase II, will build upon the findings of this CARIS scenario, and provide further assessment of CLCPA implementation focusing on other aspects such as transmission security and resource adequacy analysis.

This scenario examines two potential renewable build-out levels for one assumed distribution pattern across the state, as well as multiple sensitivities to gauge the impact of specific drivers. The transmission constraints identified in this assessment are grouped into geographic pockets to pinpoint the specific areas within New York that could experience generation bottleneck. The generation pockets identified in this study represent the interaction of existing transmission limits and renewable energy (RE) generation with the assumed RE additions across both load levels.

As policy makers advance on the implementation plan of CLCPA, this NYISO assessment is intended to complement their efforts, and is not intended to define the specific steps that must be taken to achieve the policy goals. The boundaries of the generation pockets are for illustration purposes only, and the NYISO will not provide solutions to relieve identified congestion in the pockets in this study.

A number of key modeling assumptions and approaches may have major impact on the results, and are described in detail in subsequent sections of this report. To help readers understand the scope of this assessment, considerations that are outside of the scope of this report are described

1 https://www.nysenate.gov/legislation/bills/2019/s6599

below:

- **Percentage of renewable energy relative to end-use energy –** this study does not define the formula to calculate the percentage of renewable energy relative to end-use energy, (i.e., how to account for 70% renewable energy for the "70 by 30" target. Rather, two potential renewable build-out levels were modeled for corresponding load levels to approximate the potential future resource mix in 2030.
- **Renewable energy modeling –**
    - I. **Siting and sizing**: New RE generators are modeled as interconnecting to 115 kV or greater bus voltage levels, guided by the NYISO Interconnection Queue. There are many alternative possible interconnection points, but this assessment assumes a single approach for sizing and siting of renewable generation. Impacts of siting generators at lower voltage buses are outside the scope of this study. Nevertheless, the NYISO recognizes that constraints at the distribution level will affect the downstream constraints, which may change the energy flows at the higher voltage level. , The principle intent of this study is to analyze transmission bottlenecks and identify constrained pockets rather than define specific location and capacity requirements.
    - II. **Operational constraints:** Renewable resources are modeled as resources that the outputs can change on an hourly basis (hourly resource modifiers, HRM) with defined generation profiles for each unit. These generation profiles are synthetically generated resource shapes constructed using publicly available data and tools. This deterministic modeling approach will not capture the uncertainty involved with particular renewable resources. Since the lowest temporal resolution in MAPS is hourly, sub-hourly variation in RE generation is not captured in this study.
- **Constraint impact on curtailment** - These scenario cases secure additional 115 kV constraints obtained from a 'round trip analysis' performed using TARA software. Securing additional contingencies on lower voltage lines and the addition of RE generation introduced into the existing transmission system topology results in increases and shifts in the congestion patterns and curtailment of RE generation. Identifying the relationship between specific constraints and the resulting curtailment impacts are beyond the scope of this study.

- **Transmission system modeling** – This scenario is not an interconnection level assessment of the RE buildouts, and does not review detailed engineering requirements, such as the impacts from N-1-1 contingencies, voltage or stability impacts, capacity deliverability, or impact to the New York system reserve margin. All transmission facilities are assumed in-service, and unscheduled force outages of transmission facilities are not modeled.
- **Fossil fuel-fired generator modeling** – The modeling of fossil fuel-fired resources in MAPS will commit and dispatch generation in order to: (i) serve load in the absence of sufficient renewable resources, (ii) meet locational reserve requirements, (iii) meet Local Reliability Rules, (iv) serve steam contracts, or (v) reflect operational limitations such as minimum generation levels and minimum generation runtime. The inherent modeling of fossil fuel-fired resources in MAPS does not include: (i) ramp rates and real-time sub-hourly variations, (ii) energy and ancillary service co-optimization; and (iii) fuel availability or gas system constraints. In addition, while regular maintenance outages are included in the model, unscheduled forced outages are not considered.
- **External area representation** – As the neighboring regions develop their plans to achieve higher renewable generation penetration, those regions' demand, generation supply, and transmission system may change. At the time of this report, the plans for NYISO's neighboring regions are taking shape. Due to lack of detailed information, the external area representation remains consistent with the Base Case.
- **COVID-19 impacts** – Due to the rapidly evolving nature of the pandemic, the impacts to the load forecast and other economic indicators are difficult to predict, and are not included in this scenario.

## 2. Methodology

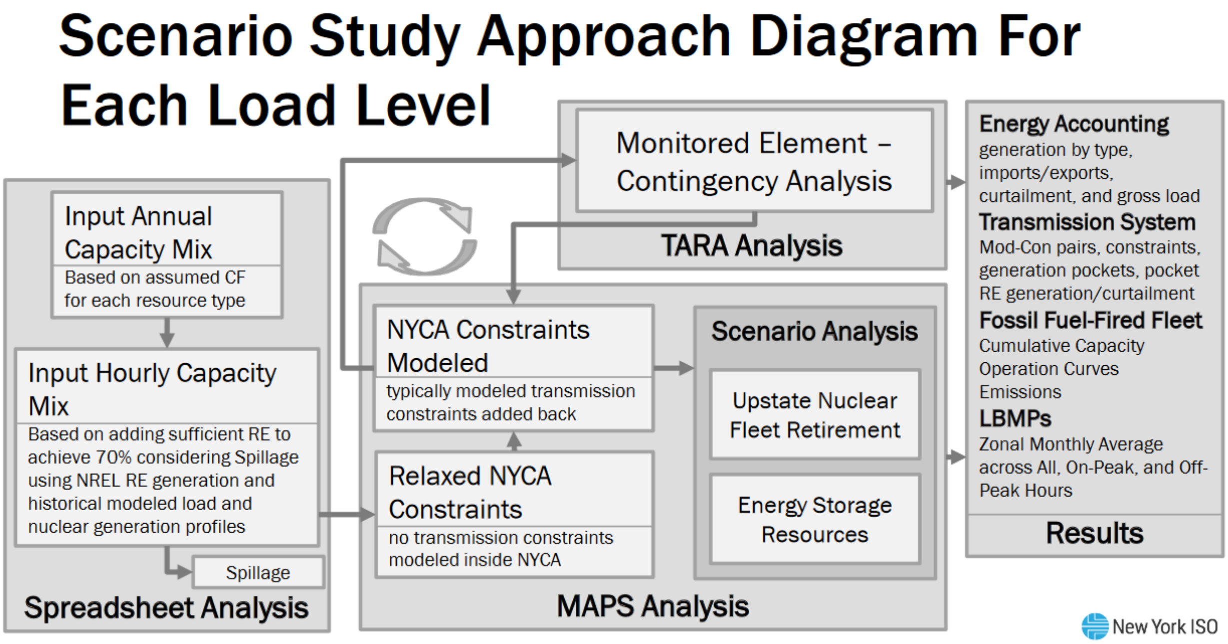
### 1. Overview

The 70x30 Scenario cases were developed using the following overall study approach, which is also shown graphically in

Figure 1:

1. Develop assumptions for the major drivers that could impact transmission congestion patterns:
    a. Develop 70x30 Scenario Load forecast for comparison with the CARIS Base Case forecast
    b. Add renewable generation to approximate achievement of the 70% renewable energy target for each load forecast, considering renewable energy "spillage" (*i.e.*, generation exceeds load)
2. Evaluate system production under "relaxed" conditions:
    a. Model the resulting resource mix in GE-MAPS without internal NYCA transmission system constraints to establish a baseline for the system dispatch when there are no transmission constraints
3. Evaluate the impact of transmission constraints on renewable energy production for the assumed renewable resource mix:
    a. Identify transmission constraints that cause renewable curtailments (*i.e.*, renewable generation pockets)
    b. Quantify the magnitude and frequency of the curtailments for each assumed resource mix
4. Sensitivity analysis to understand impacts to system production and transmission constraints:
    a. Sensitivity analysis of retirement of the entire nuclear fleet
    b. Sensitivity analysis of 3,000 MW of Energy Storage Resources (ESR)
    c. Sensitivity analysis of reduced exports to neighboring regions

**Figure 1: 70x30 Scenario Study Approach Process Flow Diagram**




Utilizing the above approach at each load level, the NYISO developed the cases shown in Figure 2 as part of the 70x30 Scenario. Sensitivities at each load level/generation mix included the assumed retirement of the entire remaining upstate nuclear generation fleet, and the inclusion of 3,000 MW of energy storage resources (ESR). All sensitivity cases, at both the Base Load and Scenario Load levels assume that: (i) all coal generation is retired, and (ii) generic new gas turbine replacements will be added to address the potential resource deficiencies that may result following implementation of the Peaker Rule, as identified in the 2019-2028 Comprehensive Reliability Plan.

**Figure 2: Summary of Sensitivities analyzed in the 70x30 Scenario**

| Case | Load | Relaxed/ Constrained | Nuclear Senstivity | ESR Sensitivity |
|---|---|---|---|---|
| Base Case | Base Case | Constrained | | |
| BaseLoad Relaxed | Base Load | Relaxed | | |
| BaseLoad Constrained | Base Load | Constrained | | |
| BaseLoad Constrained NuclearRetired | Base Load | Constrained | Nuclear Retired | |
| BaseLoad Constrained ESR | Base Load | Constrained | | MAPS ESR |
| BaseLoad Constrained HRM | Base Load | Constrained | | External HRM |
| ScenarioLoad Relaxed | Scenario Load | Relaxed | | |
| ScenarioLoad Constrained | Scenario Load | Constrained | | |
| ScenarioLoad Constrained NuclearRetired | Scenario Load | Constrained | Nuclear Retired | |
| ScenarioLoad Constrained ESR | Scenario Load | Constrained | | MAPS ESR |
| ScenarioLoad Constrained HRM | Scenario Load | Constrained | | External HRM |

An additional sensitivity was performed to assess the impact on the assumed capability of neighboring regions to accept NYISO exports in the absence of explicitly modeled RE buildouts within these regions.

#### 2. MAPS/TARA constraint screening

With the addition of large amounts of renewable capacity added throughout New York, the NYISO developed and performed a detailed hourly contingency screening analysis to capture new constraints/overloads that were not captured in the initial Base Case analysis. The hourly production cost simulation of GE-MAPS uses the transmission network model, and it is necessary to pre-define the monitor/contingency pairs in the simulation runs. This process involves creating multiple power flow cases with MAPS hourly results, and performing contingency screening analysis using TARA iteratively so that constraints caused by temporal factors, such as load shape and renewable generation, can be secured in successive MAPS runs.

**Figure 3: Roundtrip MAPS/TARA Analysis**

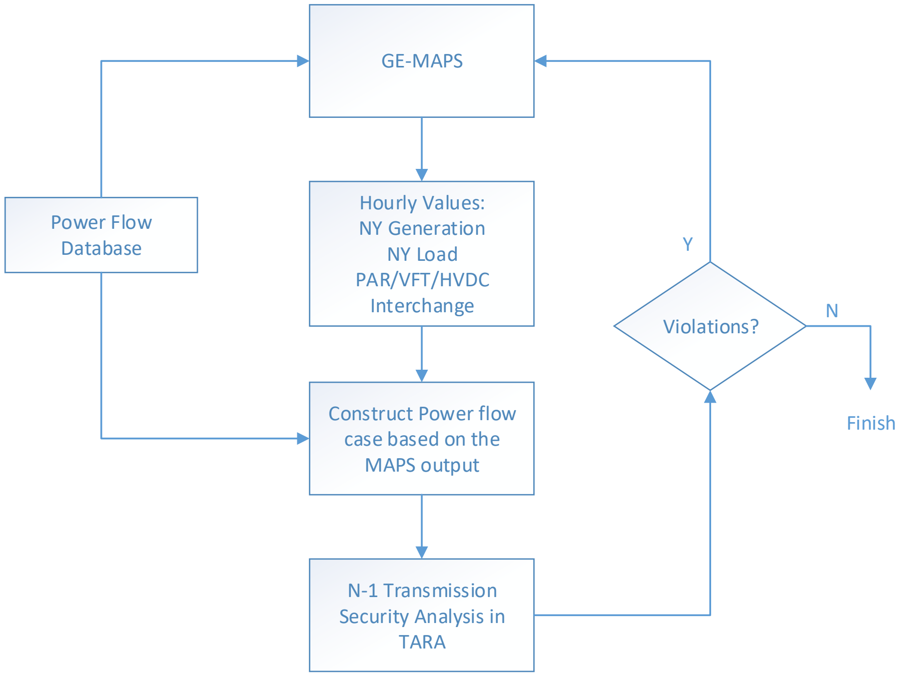



Figure 3 shows the flowchart for Roundtrip MAPS/TARA Analysis. This iterative analysis has three steps:

1. Start with the MAPS production cost run with constraints modeled in the Base Case. The resulting hourly MAPS output is utilized to construct power flow cases and solve in PSS/E using information including hourly NYCA zonal loads, hourly NYCA generation dispatches, and hourly NYCA interchange tie line flows.
2. Perform N-1 transmission security analysis on all created cases in TARA while monitoring NYCA facilities 115kV and above, taking into account all bulk transmission system contingencies as well as local transmission system contingencies. Identify the resulting additional monitored facility/contingency pairs.
3. Add the reported monitored facility and contingency pairs from TARA analysis into the existing production cost database. Secure the expanded monitor facility and contingency pairs in the successive runs.

MAPS output results iteratively interact with TARA analysis until all of the overloaded constraints as reported from TARA are exhaustively modeled within the production cost database.

## 3. Assumptions

### 1. Demand Forecast

In order to assess the impact of potential policies upon future load levels, an alternate additional zonal hourly forecast was developed for comparison to forecasted load levels in with the 2019 Gold Book. The 70x30 Scenario Load forecast includes non-uniform distribution of energy efficiency and electrification (of space heating and vehicles) across the year and Zones in NYCA. Figure 4 outlines the assumptions across four components of policies and technologies included in the Base Load and 70x30 Scenario Load forecasts. The 70x30 Scenario Load forecast was designed to incorporate state policies through 2030, while the Base Load Forecast correspond to load levels in the CARIS Base Case and 2019 Gold Book for the year 2028 with modified BTM-PV forecast.

**Figure 4: Base Load and 70x30 Scenario Load Forecast Assumption Details**

| | Base Case Load Forecast | 70x30 Scenario Load Forecast |
|---|---|---|
| **EV** | 1.3 million Light-duty vehicles by 2030 | 2.2 million Light-duty vehicles by 2030 |
| **Space Heating Electrification** | None | 2015 estimate of 13,600 GWh in 2015 grows by 50% by 2030 for NYCA |
| **PV** | 3,000 MWDC behind-the-meter by 2023 | 6,000 MWDC behind-the-meter by 2025 |
| **EE** | 23,500 GWh of incremental savings by 2030 beyond the 11,000 GWh achieved by 2014 | Additional 30,000 GWh* of savings by 2025 beyond 2014 achievements plus around 2,000 GWh/year** for 2026-30 |
| * This target is based on the retail sales of investor-owned utilities implied by the 2015 Gold Book forecast for the year 2025. | | |
| ** This is based on the targets expressed in the Clean Energy Fund documents. | | |

Salient differences in assumptions of Base Load vs. 70x30 Scenario Load forecasts include:

**Electric Vehicles Impact**: While the Base Load forecast assumes that electrification of transportation will lead to 1.3 million light-duty vehicles and a modest penetration of medium- and heavy-duty vehicles including trucks, transit buses and school buses, the 70x30 Scenario assumes 2.2 million light-duty vehicles plus a relatively higher penetration of medium- and heavy-duty vehicles.

**Space Heating Impact**: The Base Load forecast assumes an electric-heating load consistent with current usage – *i.e.*, that the overwhelming bulk of heating-related energy consumption is due to resistance heating in relatively older housing stock. However, the 70x30 Scenario models that a growing level of electrification of space heating due to the adoption of heat-pumps (both air-source and ground-source) will imply an annual electric heating load that is 50% higher than what it was in 2015 – approximately 19,600 GWh. This approach assumes that current resistance heating will be replaced with the more efficient heat-pumps.

**Energy Efficiency Impact**: Starting with a cumulative impact of 11,000 GWh through 2014, the Base Load forecast assumes that utility and New York State-guided initiatives will add another 23,500 GWh of savings through 2030. The 70x30 Scenario forecast, on the other hand, adopts energy efficiency targets outlined under the CLCPA that amount an additional 45,700 GWh beyond what was achieved through 2014 – *i.e.*, a total of 56,700 GWh through 2030.

**Behind-the-Meter Photovoltaic (BTM-PV) Impact**: Both the Base Load and the 70x30 Scenario adopt the same BTM-PV target, 6,000 MWDC installed by 2030.

**Figure 5: 70x30 Scenario Load and Base Load Forecasts Metrics**

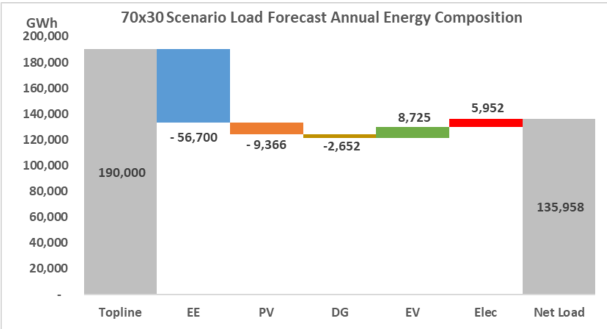
| Base Load Forecast | A | B | C | D | E | F | G | H | I | J | K | NYCA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net Load Peak (MW) | 2,537 | 1,937 | 2,653 | 777 | 1,264 | 2,197 | 2,174 | 637 | 1,405 | 11,589 | 4,730 | 31,303 |
| Net Load Annual Energy (GWh) | 14,590 | 9,695 | 15,394 | 5,337 | 7,095 | 11,312 | 9,544 | 2,807 | 5,881 | 51,749 | 19,608 | 153,012 |

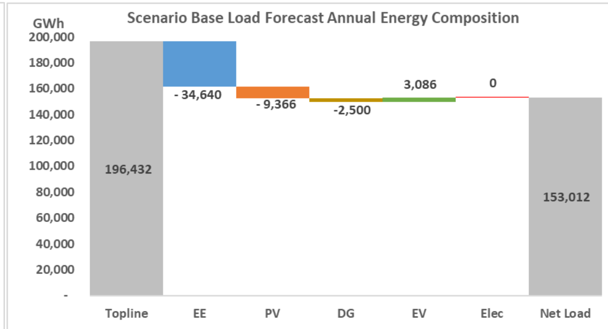
| Scenario Load Forecast | A | B | C | D | E | F | G | H | I | J | K | NYCA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net Load Peak (MW) | 2,234 | 1,417 | 2,264 | 740 | 1,246 | 1,988 | 1,912 | 636 | 1,385 | 9,128 | 3,914 | 25,311 |
| Net Load Annual Energy (GWh) | 13,034 | 7,757 | 12,626 | 5,101 | 5,694 | 9,654 | 7,911 | 2,848 | 5,952 | 46,354 | 19,026 | 135,958 |

Figure 5 shows the zonal (non-coincident) Peak and Annual Energy net load forecasts for the Scenario's Base Load and the 70x30 Scenario Load forecasts. Comparatively, the salient aspects of the 70x30 Scenario Load forecast are: (a) a lower Summer peak largely attributable to efficiency gains in cooling technology, (b) a relatively higher winter peak due to electrification of space heating and transportation, and (c) a noticeably lower annual energy usage due to the considerable impact of energy efficiency that more than offsets the increased load due to electrification. Several upstate Zones become winter peaking by 2030 in the 70x30 Scenario Load forecast even as the state remains summer peaking. Net load includes the impacts of BTM-PV.

Figure 6 exhibits the breakdown of the annual NYCA energy usage in the two forecasts across broad categories impacted by policy and highlights their relative magnitudes. While the impact of BTM-PV is the same in both cases, the lower energy usage in the 70x30 Scenario Load forecast is explained by the reductive effect of aggressive energy efficiency initiatives despite the 14,600 GWh increase in load due to electrification of space heating and transportation.

**Figure 6: 70x30 Scenario and Scenario Base Load Forecasts Energy Component Breakdown**




In summary, the demand in 2030 could be reduced by 11% (135,958 GWh) compared to business as usual (153,012 GWh) due to the impact of energy efficiency. However, the long-term impact of CLCPA in 2040 and 2050 is likely to increase the demand due to electrification. NYISO continues to monitor and provide long-term forecast data, which is contained in the NYISO's annual Gold Book.

### 2. Transmission modeling

The transmission model is based on the Base Case, and includes additional transmission projects listed below:

1. Empire State Line Project/Western PP selected project,
2. Selected Segment A and Segment B AC Transmission Projects, and
3. The proposed rebuild of Moses-Adirondack 230 kV circuits by NYPA.

The 115 kV facilities secured in the production cost database use normal ratings to secure facility for (N-0) and short-term emergency (STE) ratings to secure for (N-1) constraints with 10 MW Capacity Resource Margin assumed. This representation is consistent with the current operational practice on existing 115 kV facilities secured in the NYISO's market model.

### 3. Renewable Energy Generation Resource modeling

A principle component of the 70x30 Scenario is the development of the renewable energy resource capacity mix assumed in the modeled cases. Assumptions regarding the resource technology mix, the siting locations, and the hourly profiles utilized in these scenario cases are discussed in this section.

CLCPA renewable resource targets include 6,000 MW of BTM-PV by 2025, 3,000 MW of ESR by 2030, and 9,000 MW of OSW by 2035. For the 70x30 Scenario the assumed capacity of OSW (6,098 MW) and BTM-PV (7,542 MW) are informed by the CLCPA targets. A separate sensitivity was performed to evaluate the impact of ESR. Land-based wind and utility-scale solar resources were added to reach a nominal 70% RE capacity mix using the approach described in this section.

An additional assumption in the 70x30 Scenario cases relates to the direct importation of hydroelectric generation in NYCA. These cases assume that Hydro-Quebec imports count as renewable energy towards the 70% CLCPA target. In addition, an assumed generic incremental HVDC connection of 1,310 MW between HQ and NYC is included in these cases and also counts as RE towards the 70% target. The dispatch of the generic HVDC facility was modeled by scaling the existing HQ dispatch profile.

The assumed gap in RE generation and the 70% target were met with equal amounts of added utility-scale solar PV (UPV) and land-based wind (LBW). This process was initially performed on an annual energy basis, using nominal fleet capacity factor assumptions to estimate expected energy output of the assumed RE resources. The results of the initial annual calculation are shown in Figure 7, where percentage of renewable energy (%RE) is the ratio of RE to gross load.

**Figure 7: Initial Annual Capacity Mix at Scenario Load**

| | OSW | LBW | UPV | BTM-PV | Hydro | Hydro Imports | RE | Net Load | Gross Load | %RE |
|---|---|---|---|---|---|---|---|---|---|---|
| Base MW | 0 | 2,212 | 77 | 4,011 | | | | | | |
| Additional MW | 6,098 | 1,641 | 6,345 | 3,531 | | | | | | |
| 2030 MW | 6,098 | 3,853 | 6,422 | 7,542 | | | | | | |
| 2030 Capacity Factor | 44% | 30% | 18% | 14% | | | | | | |
| 2030 Calculated GWh | 23,344 | 10,126 | 10,126 | 9,366 | 28,832 | 19,941 | 101,735 | 135,970 | 145,335 | 70% |

However, recognizing the disparity in the hourly production of renewable energy and the NYCA load level, the NYISO developed an additional step to examine the 70% requirement on an hourly basis, prior to modeling in MAPS. The hourly approach considers the impact of assumed nuclear generation and input RE profiles in relation to the hourly load level to define the RE capacity mix to include in these scenario cases.

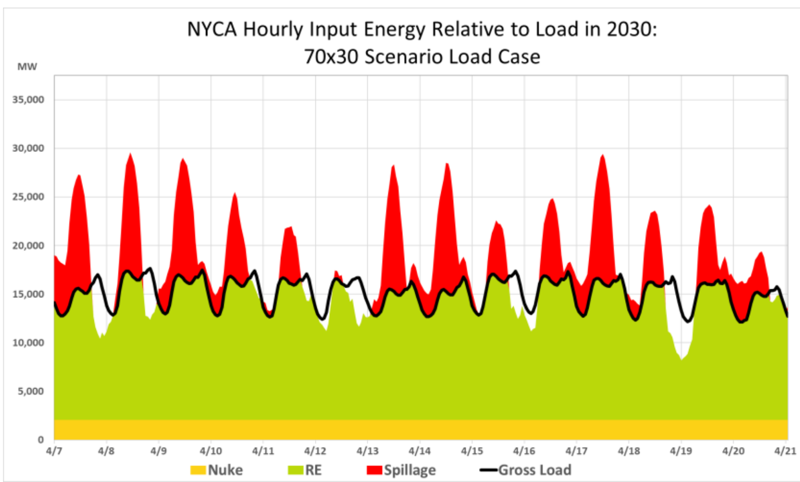
Hourly input renewable energy production profiles were primarily obtained from databases created for the purpose of modeling RE generation in forward-looking grid modeling studies. BTM-PV profiles have been created to model distributed solar resources in the CARIS Base Case. In the 70x30 Scenario cases, the Base Case BTM-PV shapes were scaled to match the assumed annual output. More information on the Base Case modeling assumptions are presented elsewhere in this report. UPV shapes for New York were obtained from NREL's Solar Power Data for Integration

Studies[2] database by aggregating five-minute "actual" data to the hourly level.

LBW and OSW profiles relevant to potential sites within New York and offshore in the New York Bight in the Atlantic Ocean were obtained via NREL's Wind Toolkit.[3] Five-minute production profiles were obtained across hundreds of individual sites in the database and aggregated to the hourly level. Sites were geographically aggregated to the county and/or zonal level for ease of modeling LBW additions. Offshore NREL wind sites were clustered into groups to represent generic OSW project level additions as well as to explicitly represent currently contracted OSW projects (*i.e.*, the South Fork, Sunrise, and Empire OSW projects).

Figure 8 displays an example of a two-week period to illustrate the hourly approach. Comparison of the input nuclear generation and renewable energy profiles to the hourly load on the NYCA level allowed the over-generation of renewables, or "spillage", to be identified. Final capacity mixes were defined when annual aggregate RE production (*i.e.*, the green area in Figure 8) represents 70% of the area under the gross load line.

**Figure 8: Hourly Input Approach Illustration**




The assumption that the UPV and LBW would have nominally equal amounts of input RE persisted in the hourly analysis as well, and resulted in the annual energy balance shown in Figure 9, including the calculated spillage. The values in this table were derived from simulating the zonal RE generation mix using hourly input profiles and comparing the generation profiles to the load profile on an hourly basis within a simple spreadsheet calculation. The percentage of renewable energy is calculated as the ratio of total annual renewable energy input ($RE_{input}$) less spillage

2 https://www.nrel.gov/grid/solar-power-data.html
3 https://www.nrel.gov/grid/wind-toolkit.html

compared to the total annual gross load. Here, gross load includes the load served by BTM-PV.

**Figure 9: Hourly Input Approach Energy Balance Results[4]**

| Input (GWh) | OSW | LBW | UPV | BTM-PV | Hydro | Hydro Imports | $RE_{Input}$ | Spillage | Gross Load | %RE |
|---|---|---|---|---|---|---|---|---|---|---|
| Scenario Load | 23,359 | 16,874 | 16,651 | 9,366 | 28,702 | 19,941 | 114,892 | 12,605 | 145,324 | 70% |
| Base Load | 23,359 | 23,233 | 23,264 | 9,366 | 28,702 | 19,941 | 127,864 | 13,524 | 162,378 | 70% |

The corresponding capacities were developed by incorporating assumptions related to zonal capacity distribution of each RE technology type. Total assumed OSW capacity was split between Zones J and K on a load (energy) ratio share. The BTM-PV was represented as a scaling of the assumed BTM-PV capacity distribution within the Base Case. OSW and BTM-PV are consistently modeled at both load levels as shown in Figure 9 and Figure 11.

The assumed zonal capacity distribution of recently awarded contracts resulting from NYSERDA administered solicitations for Tier 1 RECs was leveraged to distribute LBW and UPV capacity on a zonal basis. Figure 10 displays the assumed capacity distribution of incremental utility resources as a percentage of the full NYCA MW addition for both UPV and LBW.

**Figure 10: Assumed Zonal Capacity Distribution for Incremental Land Based Bulk Resources**

| Nameplate Capacity Distribution | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | J | K | NYCA |
| UPV | 27% | 3% | 20% | 0% | 10% | 25% | 15% | 0% | 0% | 0% | 0% | 100% |
| LBW | 30% | 5% | 30% | 15% | 20% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |

Combining the assumed total LBW and UPV energy from Figure 9 with the assumed zonal capacity distribution (in Figure 10) and hourly RE profiles allows the final zonal capacity distribution for each RE generation type to be computed. The results of this tabulation are shown in Figure 11 as the total RE capacity at the Scenario Load and Base Load levels modeled in the 70x30 Scenario cases. Each RE capacity mix was modeled consistently across all scenario cases for the load levels identified. A total of nearly 31,000 MW of renewable generation is needed within New York for the Scenario Load level, while a total of nearly 37,600 MW is needed at the Base Load level.

**Figure 11: Total Zonal Capacity of Renewable Generation in 70x30 Scenario Case at Two Load Levels Studied (MW)[5]**

4 Including the additional generic 1,310 MW HVDC from HQ

5 Not including the additional 1,310 MW generic HVDC from HQ.

| 70x30 Scenario Load | | | | |
|---|---|---|---|---|
| 2030 MW | OSW | LBW | UPV | BTM-PV |
| A | | 1,640 | 3,162 | 995 |
| B | | 207 | 361 | 298 |
| C | | 1,765 | 1,972 | 836 |
| D | | 1,383 | | 76 |
| E | | 1,482 | 1,247 | 901 |
| F | | | 2,563 | 1,131 |
| G | | | 1,450 | 961 |
| H | | | | 89 |
| I | | | | 130 |
| J | 4,320 | | | 950 |
| K | 1,778 | | 77 | 1,176 |
| NYCA | 6,098 | 6,476 | 10,831 | 7,542 |

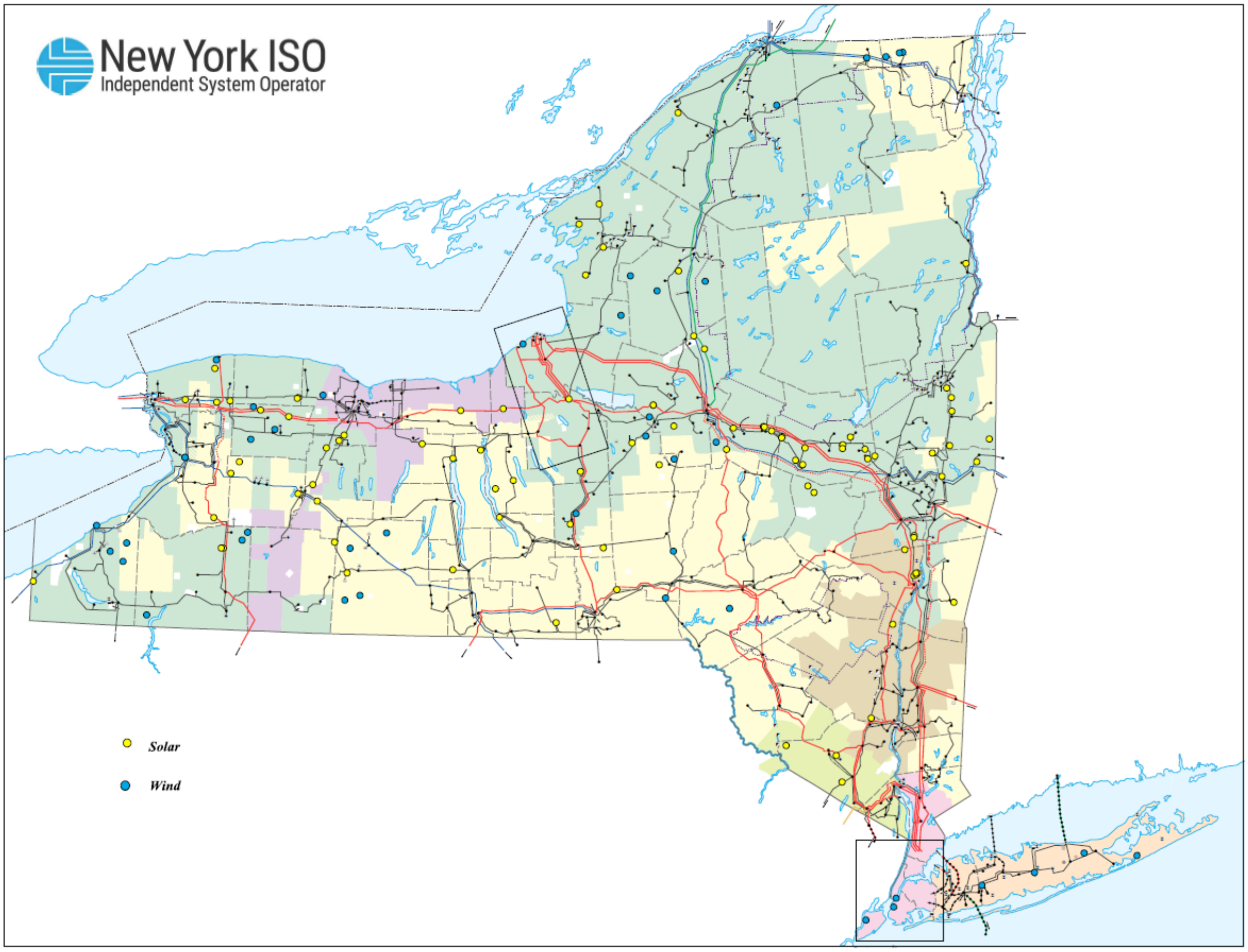
| Base Load | | | | |
|---|---|---|---|---|
| 2030 MW | OSW | LBW | UPV | BTM-PV |
| A | | 2,286 | 4,432 | 995 |
| B | | 314 | 505 | 298 |
| C | | 2,411 | 2,765 | 836 |
| D | | 1,762 | | 76 |
| E | | 2,000 | 1,747 | 901 |
| F | | | 3,592 | 1,131 |
| G | | | 2,032 | 961 |
| H | | | | 89 |
| I | | | |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

Individual projects were located at over 110 sites in the MAPS model by utilizing project level information from the Interconnection Queue.[6] This approach preserved the capacity distribution by RE type within a Zone by distributing the total zonal capacity by type on a pro-rata basis to the Interconnection Queue project locations based on total zonal capacity in the Interconnection Queue. For projects that propose points of interconnection at new substations, the nearest existing substation was assumed as the point of interconnection in the scenario cases. The location and type of generators included in the capacity build out are shown in

**Figure 12**.

[6] https://www.nyiso.com/documents/20142/11738080/11_70x30_RE_Buildout_BaseLoad_ESPWG_2020-04-06.xlsx/a4528988-44a6-573e-7525-36dd1559a2d1

**Figure 12: 70x30 Scenario Renewable Buildout Map**



## 4. Assessment Results

The 2019 CARIS 70x30 Scenario consists of a series of sensitivity cases to study the impact of transmission constraints on a potential hypothetical RE build out which otherwise may achieve a 70% renewable energy mix, as described above in the Renewable Energy Generation Resource modeling section. The NYISO did not compute the resulting %RE based upon the model outputs as the accounting rules for calculating 70x30 attainment are yet to be developed under the framework laid out in the CLCPA. The findings are intended to provide insight of the extent to which transmission constraints may prevent the delivery of renewable energy to New York consumers.

### 1. Transmission Relaxation and NYCA Constraint Modeling Comparison

To understand the impact of existing transmission limits on the delivery of higher levels of renewable energy, cases were first run with the NYCA internal transmission system limits “relaxed”. This modeling approach is the equivalent of having infinite transmission capability within the NYCA, which provides an understanding of “ideal” system behavior. In the “constrained” cases the NYCA transmission limits are all reset to their values in the Base Case.

#### Comparison of Energy

Annual generation by type, net imports by neighboring area, curtailment, and gross load output from each case in GWh are shown in Figure 13 as well as the comparison between the relaxed and constrained cases at the Scenario Load and Base Load levels.

**Figure 13: Base, Relaxed, and Constrained Case Annual Energy Results**

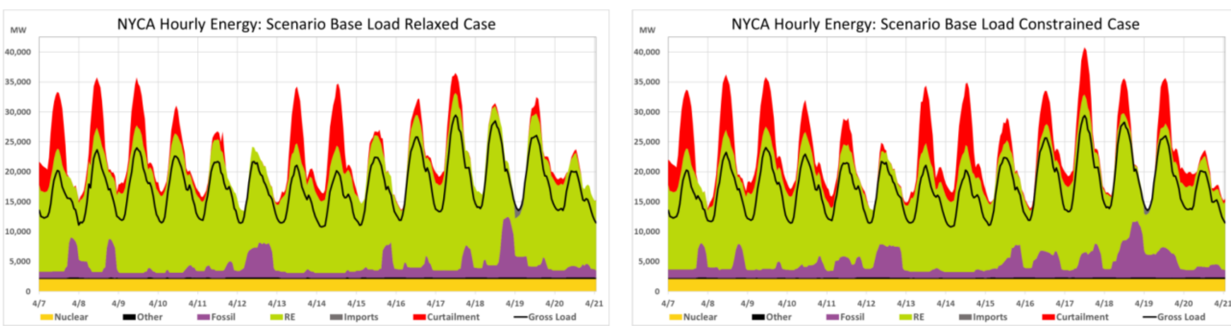
| Energy (GWh) | Base Case | ScenarioLoad Relaxed | ScenarioLoad Constrained | BaseLoad Relaxed | BaseLoad Constrained |
|---|---|---|---|---|---|
| Nuclear | 27,091 | 27,435 | 27,433 | 27,436 | 27,433 |
| Other | 2,368 | 2,164 | 2,110 | 2,158 | 2,102 |
| Fossil | 69,028 | 26,390 | 28,185 | 31,268 | 35,181 |
| Hydro | 28,832 | 28,082 | 28,050 | 27,974 | 28,020 |
| Hydro Imports | 11,564 | 19,803 | 19,775 | 19,780 | 19,769 |
| LBW | 5,038 | 13,960 | 13,290 | 19,243 | 17,117 |
| OSW | - | 22,775 | 21,625 | 22,656 | 21,592 |
| UPV | 115 | 14,764 | 12,666 | 21,782 | 17,982 |
| BTM-PV | 4,988 | 9,269 | 9,266 | 9,302 | 9,327 |
| Pumped Storage | (447) | (878) | (822) | (930) | (868) |
| Storage | - | - | - | - | - |
| IESO Net Imports | (2,862) | (5,550) | (5,817) | (6,030) | (6,250) |
| ISONE Net Imports | (535) | (7,791) | (6,418) | (6,710) | (5,073) |
| PJM Net Imports | 12,239 | (5,479) | (4,446) | (5,996) | (4,528) |
| Renewable Generation | 50,537 | 108,653 | 104,672 | 120,736 | 113,808 |
| Curtailment | 0 | 6,218 | 10,151 | 7,124 | 14,020 |
| Non-Renewable Generation | 98,488 | 55,990 | 57,728 | 60,861 | 64,717 |
| GrossLoad | 157,418 | 144,948 | 144,897 | 161,934 | 161,807 |

Relaxation of the transmission constraints results in reductions in fossil generation and curtailments with an increase in RE generation and net exports (i.e., negative net imports). In order to examine the system condition more closely, four two-week periods across the annual hourly simulations were reviewed that are representative of combinations of RE generation and load levels:

- January: during winter peak load and low renewable generation period
- April: during spring low net load period (high renewable generation during low load)
- July: during summer peak load period
- October: during fall low load and low renewable generation period

A closer examination reveals that the results of relaxing transmission constraints on an hourly basis mirror outcomes in the annual energy comparisons. Generally, the results are consistent across the seasons and are provided in the appendix for both load levels. Figure 14 displays NYCA generation output, curtailment, and gross load over a two-week period in early April in the relaxed and constrained cases at the Base Load level.

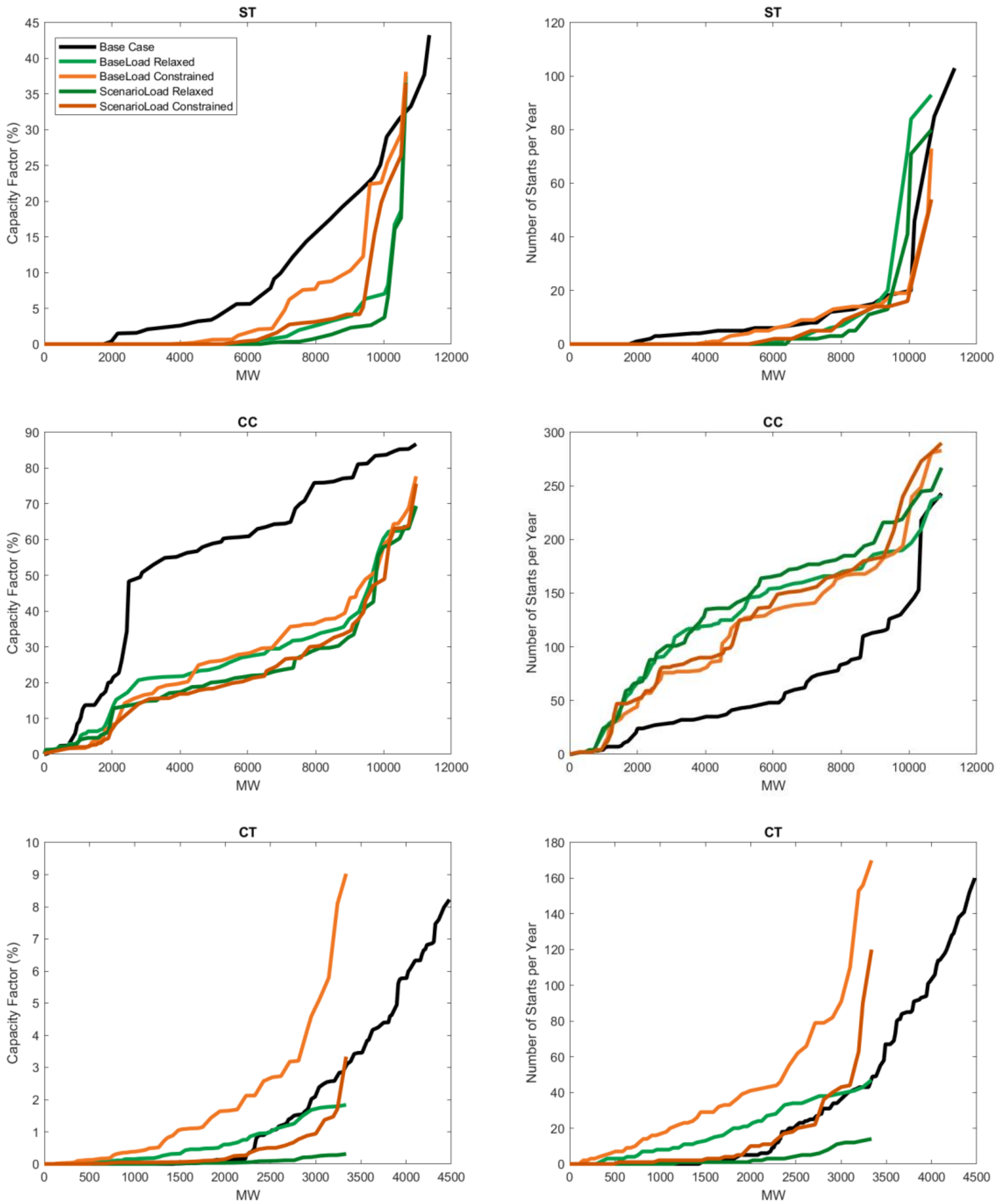
**Figure 14: Base Load Relaxed and Constrained Cases Hourly Results across a Low Net Load Period**




## Comparison of Fossil Fleet Operations

The impact of increased RE, transmission system modeling assumptions, and differing load profiles could impact the operation of the fossil fuel-fired fleet. Cumulative capacity curves display the amount of capacity that operated at or below a given parameter value, as each point on the curve represents one unit's annual operation. To concisely illustrate independent operational aspects of fossil generator operations, the unit level annual capacity factors and number of unit starts are displayed in the figures below.

**Figure 15: Base Load Relaxed and Constrained Cases Fossil Fleet Cumulative Capacity Curves**



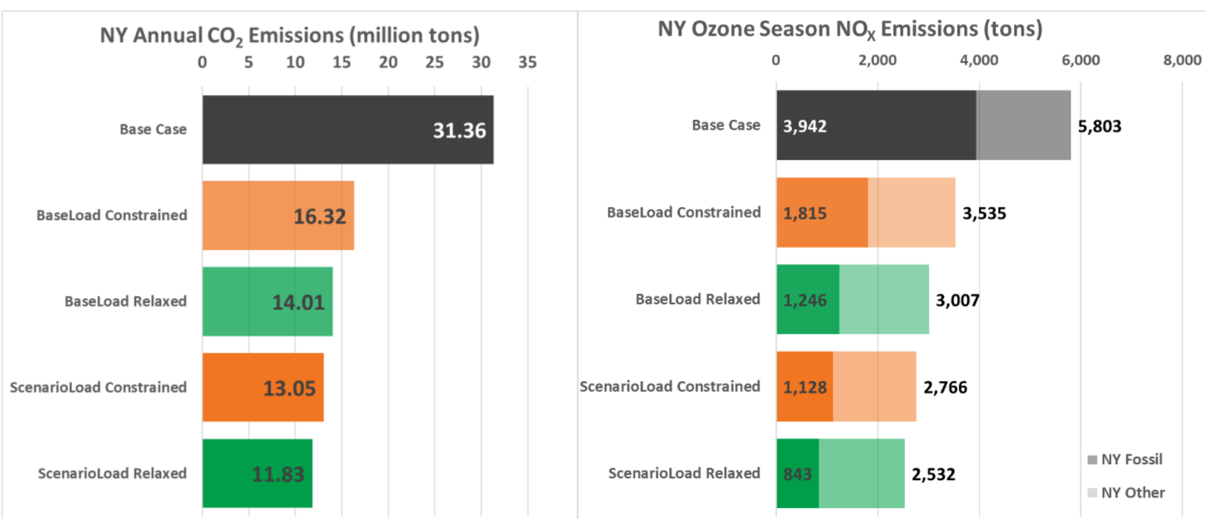

With the substantial addition of intermittent renewable generation modeled in the scenario cases, output from the fossil fleet is lower in comparison to the Base Case, however in many cases the reduced output is accompanied by an increased number of starts indicating the need for a more flexible operating regimen. With lower load, as represented in the Scenario Load case, fossil output is lower compared to the higher Base Load case. The fossil fleet operation can also be highly dependent on transmission constraints. In particular, comparison of simple-cycle combustion turbine (CT) operation between the relaxed and constrained cases makes apparent that CTs may run more and start more often due to transmission constraints.

In short, the large amount of intermittent renewable energy additions will change the operations of the existing fossil fleet. It is likely that the units that are more flexible will be dispatched more often, while the units that are less so may not be dispatched as often or at all.

## Comparison of Emissions

Carbon dioxide ($CO_2$) emissions decrease significantly across the scenario cases due to lower loads, increased RE output, and corresponding decreased fossil fleet operations relative to the Base Case. The higher loads in the Base Load cases relative to the Scenario Load cases also result in comparatively higher emission levels. The modest emission reductions observed between the constrained and relaxed cases can partially be explained by the relative increase in exports in the relaxed cases which are partially met with increased fossil generation in state. The emissions of ozone season $NO_X$ are split between fossil and other generators by type. Here and elsewhere in the report 'Other' refers to methane (biogas), refuse (solid waste), and wood fuel-fired generators. As no change in assumptions were made for this fleet of generators in the scenario cases, their emissions are similar across all cases including the Base Case. These 'Other' associated $NO_X$ emissions become a significant portion of projected ozone season $NO_X$ emissions as the fossil emissions decrease.

**Figure 16: Base Load Relaxed and Constrained Cases $CO_2$ and Ozone Season $NO_X$ Emissions Projections**




The assessment shows that emissions could be significantly reduced due to the RE generation additions. However, the long-term impact and achievement of economy-wide emission reductions of 40% by 2030 and 85% by 2050, and the emission-free power sector requirement in 2040 are topics beyond this scenario. These topics will likely be the subjects of future studies, including the NYISO Climate Change Impact and Resilience Study.

### 2. Summary of Congestion, Curtailment, and Generation Pockets

The primary purpose of the 70x30 scenario is identifying transmission constraints that may prevent the delivery of renewable energy to achieve the policy target. Combining the congestion and constraint results from sensitivity cases, generation pockets are identified in areas within NYCA to illustrate transmission constraints that could prevent fully utilizing renewable generation.

The resulting renewable curtailment in the scenario could result from a combination of drivers, including: (i) resource siting location, (ii) size of renewable buildout, (iii) the congestion pattern of transmission constraints, and (iv) existing thermal unit operations. Renewable generation located upstream of transmission constraints is more likely to be curtailed compared with those located at downstream of the constraints. In general, renewable curtailments due to transmission constraints include constraints inside generation pockets, tie line constraints, and constraints outside of generation pockets.

Overall, the constraints on the bulk system level remain largely consistent pre- and post-RE build-out, but certain existing constraints could be more congested due to resource shifts. The most congested element in the NYCA system remains Central East, though the congestion has been significantly reduced with the addition of AC Transmission Public Policy projects. In general, the bulk power system is more interconnected, and designed to transfer large amounts of power. The underlying lower voltage system, however, was designed to serve load in the local area and in most cases not designed to deliver power to the bulk system. Much of the renewable generation build-out modeled in this scenario is constrained by the underlying system before the power ever reaches the bulk system. Figure 17 summarizes the NYCA demand congestion for bulk level constraints in the Base Case, Scenario Load, and Base Load cases.

**Figure 17: 70x30 Scenario bulk level constraints demand congestion summary (Nominal $M)**

| Constraints | Base Case | Scenario Load | Base Load |
|---|---|---|---|
| CENTRAL EAST | 167 | 464 | 577 |
| NEW SCOTLAND KNCKRBOC | 5 | 113 | 161 |
| PRNCTWN NEW SCOTLAND | - | 57 | 112 |
| DUNWOODIE TO LONG ISLAND | 28 | 66 | 56 |
| ISONE-NYISO | 4 | 47 | 36 |
| SUGARLOAF 138 RAMAPO 138 | - | 26 | 59 |
| GREENWOOD | 10 | 18 | 26 |
| PJM-NYISO | 2 | 19 | 18 |
| N.WAVERLY LOUNS | 11 | 7 | 20 |
| DUNWOODIE MOTTHAVEN | 15 | 1 | 13 |
| EGRDNCTY 138 VALLYSTR 138 1 | 4 | 6 | 7 |
| RAINEY VERNON | 0 | 2 | 5 |
| CRICKET VALLEY PLSNTVLY | 3 | 0 | 0 |
| E179THST HELLGT ASTORIAE | 1 | 0 | 1 |
| FARRAGUT GOWANUS | - | 0 | 2 |
| LOUNS STAGECOA | 0 | 1 | 0 |
| MOTTHAVEN RAINEY | 0 | 0 | 0 |

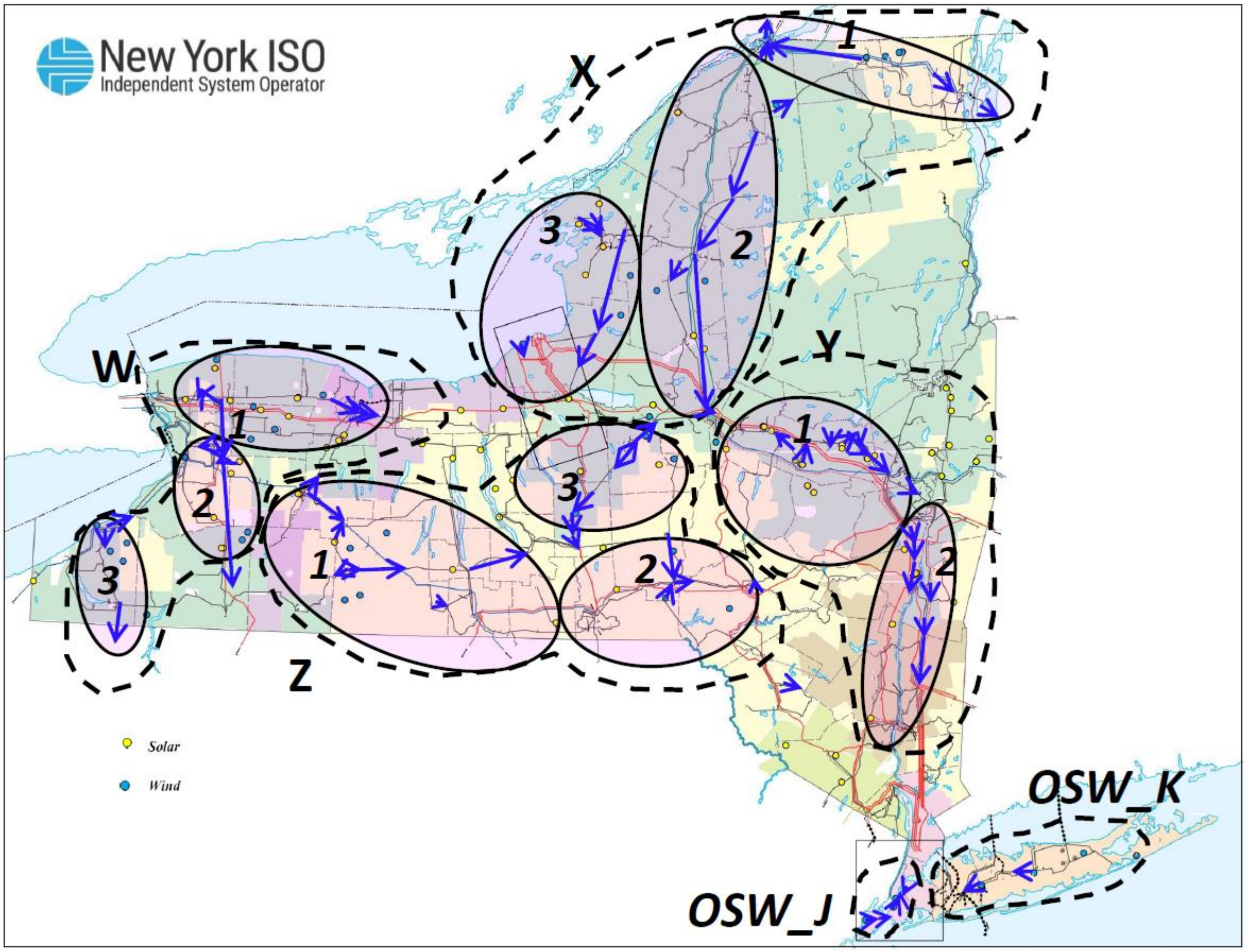
Due to the resource shift, new constraints appear, and mostly at the lower kV level, mainly on the 115 kV network. To better understand the impacts from these new constraints, generation pockets are identified based on their geographical locations, and for each pocket, the following information and data is provided:

- Congested transmission facilities: the terminals of the transmission facilities and the voltage levels are listed to identify the constraint elements that result in the most congestion in this assessment;
- Congested hours: the hours that these transmission facilities in the pocket experience congestion and the hours are listed facility by facility. This is the number of hours out of the annual total of 8,760 hours. The higher the number, the more likely this transmission facility constrains the renewable generation from being fully utilized; and
- Curtailed energy percentage: the total curtailed energy for the generators in the pocket divided by the total energy, and counted by the resource type, such as hydro and land based wind. The higher the number, the less renewable generation in this pocket can be utilized by the load. The Input RE in GWh is also provided to put the curtailed energy (%) into

context.

Figure 18 depicts the renewable generation pockets identified in this study.

**Figure 18: Renewable Generation Pockets**




The generation pocket assignments are based off two main considerations; renewable generation buildout location, and the constraints congestion results from both the Scenario Load and Base Load levels. Each pocket depicts a geographic grouping of renewable generation, and the transmission constraints in a local area are further highlighted in sub-pocket. Generation in a pocket but not near the transmission constraints are not counted in sub-pockets. The arrow direction is the binding direction in MAPS.

The generation pockets identified in this analysis include:

- **Western NY (Pocket W)**: Western NY constraints, mainly 115 kV in Buffalo and Rochester areas:

  1) **W1**: Niagara-Orleans-Rochester Wind (115 kV)

2) **W2**: Buffalo Erie region Wind & Solar(115 kV)

3) **W3**: Chautauqua Wind & Solar(115kV)

- **North Country (Pocket X)**: Northern NY constraints, including the 230 kV and 115 kV facilities in the North Country:

1) **X1:** North Area Wind (mainly 230 kV in Clinton County)

2) **X2**: Mohawk Area Wind & Solar (mainly 115 kV in Lewis County)

3) **X3**: Mohawk Area Wind & Solar (115 kV in Jefferson & Oswego Counties)

- **Capital Region (Pocket Y)**: Eastern NY constraints, mainly the 115 kV facilities in the Capital Region:

1) **Y1**: Capital Region Solar Generation (115 kV in Montgomery County)

2) **Y2**: Hudson Valley Corridor (115 kV)

- **Southern Tier (Pocket Z)**: Southern Tier constraints, mainly the 115 kV constraints in the Finger Lakes area:

1) **Z1**: Finger Lakes Region Wind & Solar (115 kV)

2) **Z2**: Southern Tier Transmission Corridor (115kV)

3) **Z3**: Central and Mohawk Area Wind and Solar (115kV)

- **Offshore Wind:** offshore wind generation connected to New York City (Zone J) and Long Island (Zone K)

RE generation capacity by generation pockets assignment is shown in

**Figure 19** and Figure 20 by generator type in the Base Load and Scenario Load level cases, respectively. A majority of the RE capacity is located in pockets in upstate New York and represents varying blends of RE capacity types.

**Figure 19: Generation Pocket Renewable Energy Capacity in Scenario Load Cases**

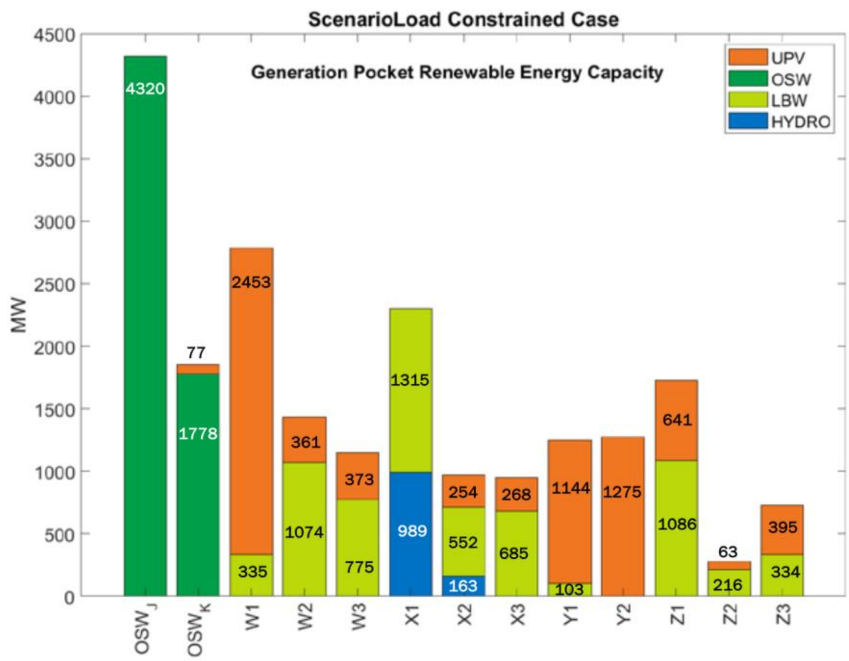
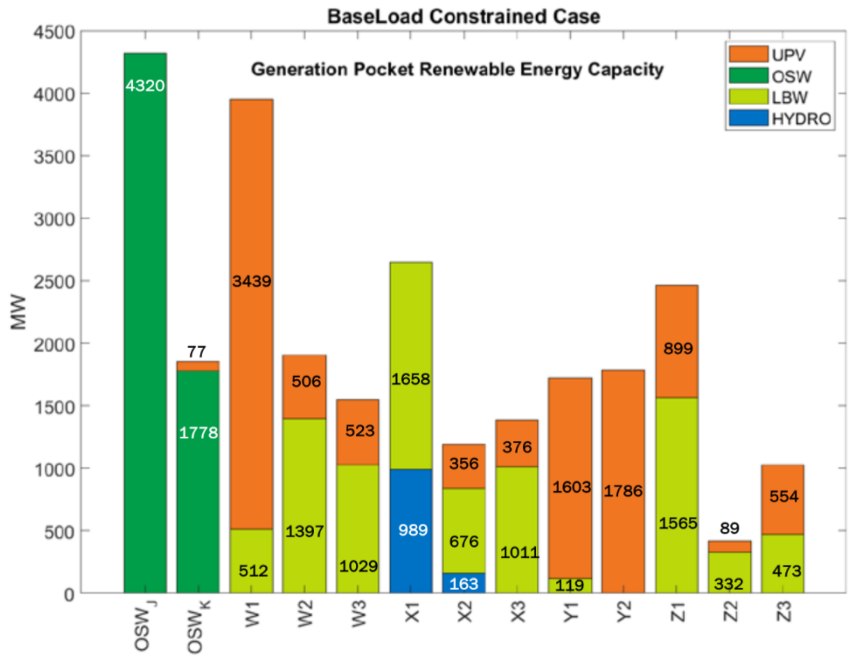



**Figure 20: Generation Pocket Renewable Energy Capacity in Base Load Cases**




Each RE generator is associated with an hourly generation profile for modeling purposes. Owing to the local load, RE generation, local transmission system topology and loading, and system transmission system conditions, a portion of potential RE generator output may be curtailed within the simulations. This is particularly prevalent when RE generators are located upstream of transmission bottlenecks or in local regions with limited export capability. As described above, the NYISO identified 13 renewable generation pockets based upon the combination of RE output and transmission system modeling assumptions. Aggregate RE curtailments within these generation pockets represents approximately 90% of the NYCA RE curtailments observed across the scenario cases.

Figure 21 displays the summary of the generation pocket curtailments as a percentage of input RE energy by type across the generation pockets identified. In depth results for each pocket, including congested hours, input RE, and curtailed energy percentage are reviewed in the following section. Additional detailed generator pocket information is available on the NYISO website.[7]

**Figure 21: Curtailed Energy Percentage by Pocket Summary in Scenario Load Constrained Case**

[7] Annual metrics provided in https://www.nyiso.com/documents/20142/12126107/04%20CARIS2019_70x30Scenario_CaseOutputByTypeByPocket.csv/9a37bf26-d879-504f-271b-5ad7093b86ac and hourly information provided in https://www.nyiso.com/documents/20142/12126107/04%20CARIS2019_70x30Scenario_HourlyPocketInformation.xls/f10ab987-2171-a477-f51a-f59d9720203f

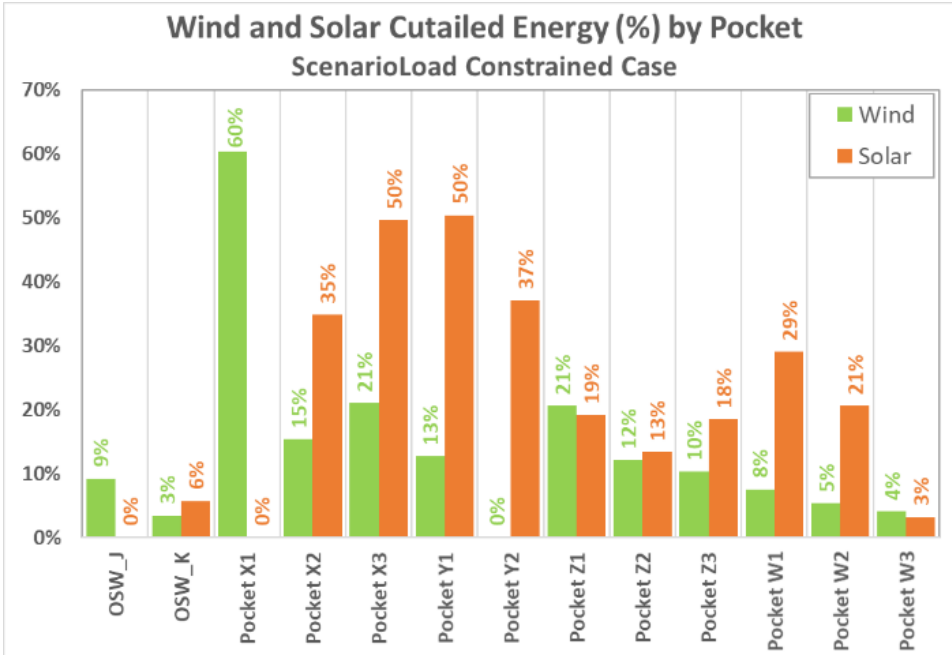
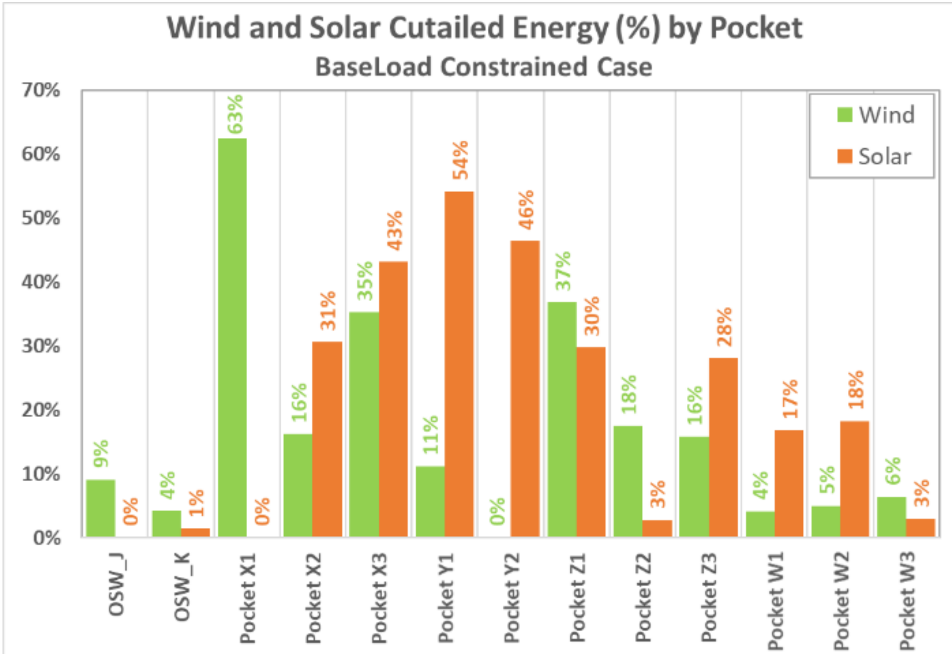



**Figure 22: Curtailed Energy Percentage by Pocket Summary in Base Load Constrained Case**




The simulation shows that generation pockets result from both the existing renewable resources and the large amount of additional resources. Four major pockets are observed in areas of land-based renewable resources: Western New York, North Country, Capital Region, and Southern Tier. In particular, North Country exhibits the highest level of curtailment by percentage, the highest curtailed energy by GWh, and the most frequent congested hours. These curtailments are generally due to lack of a strongly interconnected network to deliver power, at both bulk power and local system levels. Two additional pockets are observed in areas of offshore wind connecting to New York City (Zone J) and Long Island (Zone K) due to transmission constraints on the existing grid after the power is brought to shore.

**Figure 23** summarizes the total renewable capacity (MW), the total input energy by renewable resources (GWh), and total curtailed energy by renewable resources (GWh) in each generation pocket. Further details for each sub-pocket is discussed in the section below.

**Figure 23: Pocket Summary Table**

| Base Load | W | X | Y | Z | OSW_J | OSW_K |
|---|---|---|---|---|---|---|
| total renewable capacity (MW) | 7,405 | 5,229 | 3,508 | 3,911 | 4,320 | 1,855 |
| total input energy (GWh) | 14,572 | 17,761 | 5,836 | 9,137 | 16,100 | 7,373 |
| total curtailed energy (GWh) | 1,421 | 4,411 | 2,807 | 2,703 | 1,462 | 306 |

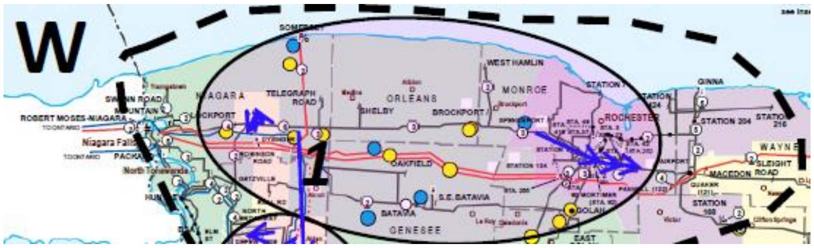
| Scenario Load | W | X | Y | Z | OSW_J | OSW_K |
|---|---|---|---|---|---|---|
| total renewable capacity (MW) | 5,371 | 4,227 | 2,522 | 2,735 | 4,320 | 1,855 |
| total input energy (GWh) | 10,515 | 15,483 | 4,215 | 6,311 | 16,100 | 7,373 |
| total curtailed energy (GWh) | 1,453 | 3,115 | 1,749 | 1,130 | 1,484 | 255 |

### 3. Discussion of each Renewable Generation Pocket

**<u>Western New York (Pocket W):</u>** Significant hydro generation (Niagara) is already located in this pocket prior to the renewable generation additions in this study. Large additions of UPV are assumed in this pocket, particularly in the sub-pocket W1, and result in curtailments. Though the curtailment percentage is not as high as other pockets, the transmission facilities in this pocket could experience frequent congested hours.

**<u>Pocket W1 Summary:</u>**

**Figure 24: Pocket W1 Congestion and Curtailment Summary**



**Pocket W1**

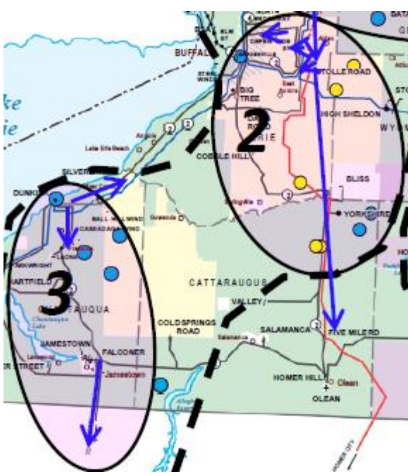
| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| Q545A_DY 345.00-Q545A_DY 345.00 | 4,525 | 3,191 |
| Q545A_ES 345.00-5MILE345 345.00 | 541 | 776 |
| HINMN115 115.00-LOCKPORT 115.00 | 199 | 1 |
| HINMN115 115.00-HARIS115 115.00 | 86 | 1 |
| MORTIMER 115.00-SWDN-113 115.00 | 19 | 512 |
| S135 115.00-S230 115 115.00 | 3,222 | 2,575 |
| STA 89 115.00-PTSFD-25 115.00 | 301 | 431 |
| PANNELLI 115.00-PTSFD-24 115.00 | 184 | 344 |
| ROBIN115 115.00-A.LUD TP 115.00 | - | 1,065 |
| ARS TAP 115.00-S82-1115 115.00 | 250 | 344 |
| NIAGAR2W 230.00-NIAG115E 115.00 | 71 | 57 |

| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| LBW | 975 | 1,497 | 8% | 4% |
| UPV | 3,452 | 4,838 | 29% | 17% |

Pocket W1 is located in Niagara-Orleans-Rochester area. UPV is curtailed at 29% and 17% for the Scenario Load and Base Load cases respectively in this pocket due to the significant solar buildout around Dysinger/Somerset area, which is located upstream of the 345 kV transmission corridor, as shown in Figure 24.

**Pocket W2 Summary:**

**Figure 25: Pocket W2 Congestion and Curtailment Summary**




**Pocket W2**

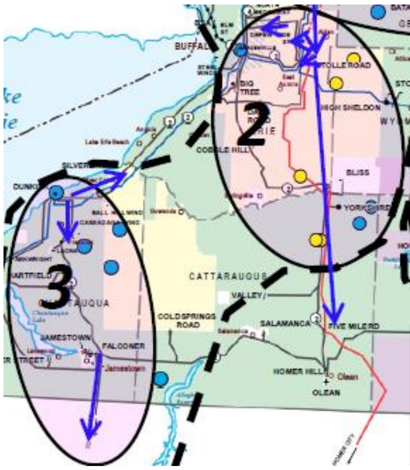
| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| STOLE115 115.00-GIRD115 115.00 | 594 | 495 |
| DEPEW115 115.00-ERIE 115 115.00 | 227 | 519 |
| STOLE115 115.00-STOLE345 345.00 | 124 | 218 |
| CLSP-181 115.00-YNG-181 115.00 | 50 | 25 |
| SPVL-151 115.00-ARCADE 115.00 | - | 54 |
| ERIE 115 115.00-PAVMT115 115.00 | 15 | 50 |

| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| LBW | 2,882 | 3,837 | 5% | 5% |
| UPV | 583 | 817 | 21% | 18% |

Pocket W2 is located in the Buffalo area. UPV is curtailed at 21% and 18% for the Scenario Load and Base Load cases respectively in this pocket due to transmission limitations that constrain the ability of renewable generation to serve load in Buffalo area, as shown in Figure 25.

**Pocket W3 Summary:**

**Figure 26: Pocket W3 Congestion and Curtailment Summary**




**Pocket W3**

| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| FALCONER 115.00-MOON-161 115.00 | 718 | 1,272 |
| EDNK-161 115.00-ARKWRIGH 115.00 | 270 | 645 |
| EDNK-162 115.00-ARKWRIGH 115.00 | 15 | 71 |
| SLVRC141 115.00-DUNKIRK1 115.00 | 29 | 226 |

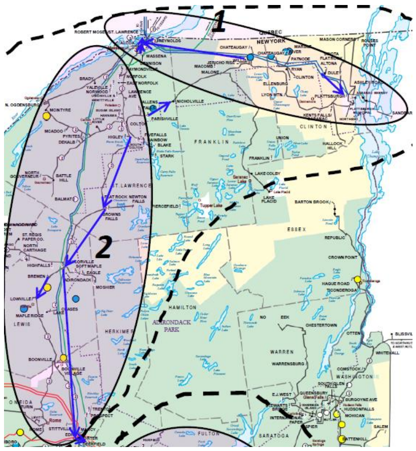
| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| LBW | 2,099 | 2,847 | 4% | 6% |
| UPV | 525 | 737 | 3% | 3% |

Pocket W3 is located in Chautauqua county. LBW is curtailed at 4% and 6% for the Scenario Load and Base Load cases respectively in this pocket due to wind resources being mostly located upstream of the 115kV transmission corridor, as shown in Figure 26.

**North Country (Pocket X):** This pocket already had significant hydro and wind plants prior to the additions assumed in these scenarios. In general, the wind and solar generation in this pocket experience very high curtailment percentage, and the transmission facilities in this pocket see the most congested hours among all pockets. This is mainly due to lack of strongly interconnected bulk power transmission facilities, and the geographical proximity to exporting constraints to Ontario and New England.

## Pocket X1 Summary:

**Figure 27: Pocket X1 Congestion and Curtailment Summary**




**Pocket X1**

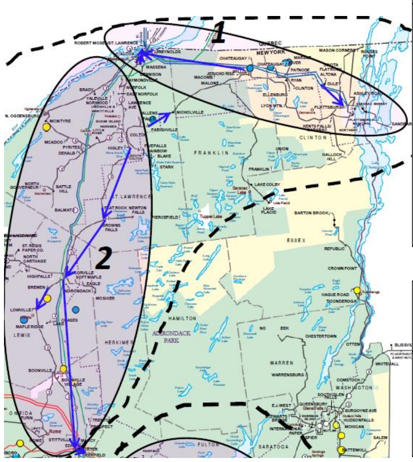
| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| TIE-LINES: NORTH -VT | 8,113 | 8,014 |
| NorthTie: OH-NY | 8,751 | 8,755 |
| ALCOA-NM 115.00-ALCOA N 115.00 | 839 | 766 |
| DULEY 230.00-PLAT T#1 230.00 | 217 | 490 |
| ALCOA-NM 115.00-DENNISON 115.00 | 387 | 355 |
| MOSES W 230.00-WILLIS E 230.00 | 19 | 90 |

| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| Hydro | 7,638 | 7,638 | 3% | 3% |
| LBW | 3,104 | 3,966 | 60% | 63% |

Pocket X1 is generally located in Clinton County in the North Country. Land Based Wind generators are curtailed 60% and 63% for Scenario Load and Base Load cases respectively in this pocket due to the wind being located much closer to the transmission constraints shown in Figure 27 compared with existing hydro generation. In this pocket, the two tie-line constraints connecting with ISO-NE toward the east side and connecting with Ontario toward the west side show significant congested hours in both the Scenario Load and Base Load cases. The 230 kV line between Duley and Plattsburg is also highly congested from wind generation existing to other areas in NYCA. The two constraints in the Alcoa/Dennison area are mainly due to constrained renewable generation to serve load in the Alcoa area.

## Pocket X2 Summary:

**Figure 28: Pocket X2 Congestion and Curtailment Summary**




**Pocket X2**

| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| BREMEN 115.00-BU+LY+MO 115.00 | 1,025 | 2,233 |
| LOWVILLE 115.00-BOONVL 115.00 | 633 | 1,712 |
| BRNS FLS 115.00-TAYLORVL 115.00 | 170 | 238 |
| BRNS FLS 115.00-HIGLEY 115.00 | 63 | 107 |
| EDIC 345.00-PORTER 2 230.00 | 11 | 17 |
| PORTER 2 230.00-ADRON B2 230.00 | 5 | 9 |
| NICHOLVL 115.00-PARISHVL 115.00 | 33 | 7 |

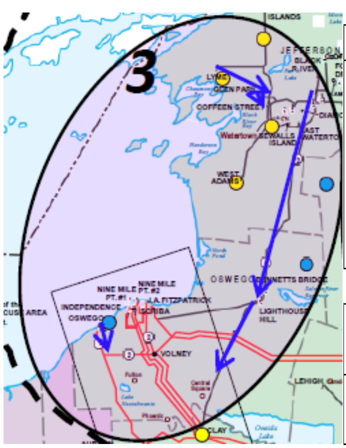
| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| Hydro | 960 | 960 | 18% | 16% |
| LBW | 1,354 | 1,661 | 15% | 16% |
| UPV | 336 | 471 | 35% | 31% |

Pocket X2 is located in Lewis County of the Mohawk Area. UPV is curtailed at 35% and 31% for the Scenario Load and Base Load cases respectively in this pocket due to the UPV buildout being mostly located at upstream of the 115 kV transmission constraints(Brown Falls – Taylorville – Boonville), as shown in Figure 28.

The 115 kV constraints in Pocket X2 are in parallel with the 230 kV corridor constraints from Adirondack to Porter. The renewable generation modeled in this pocket is mainly interconnected to the 115 kV system, therefore the congestion occurs more on the 115 kV versus 230 kV facilities in this pocket. Note that the congestion currently observed in the 230 kV path is mainly caused by transmission outages on the parallel Moses – Adirondack path. Due to software limitations, these outages and associated congestion are not captured in this study; therefore congestion and curtailment amounts from this analysis are underestimated.

**Pocket X3 Summary:**

**Figure 29: Pocket X3 Congestion and Curtailment Summary**




**Pocket X3**

| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| HTHSE HL 115.00-MALLORY 115.00 | 2,530 | 3,718 |
| HMMRMILL 115.00-WINE CRK 115.00 | 457 | 1,448 |
| COFFEEN 115.00-E WTRTWN 115.00 | 535 | 883 |
| COFFEEN 115.00-LYMETP 115.00 | 3 | 87 |
| HTHSE HL 115.00-COPEN_PO 115.00 | 18 | 4 |
| COFFEEN 115.00-GLEN PRK 115.00 | 706 | 1,156 |

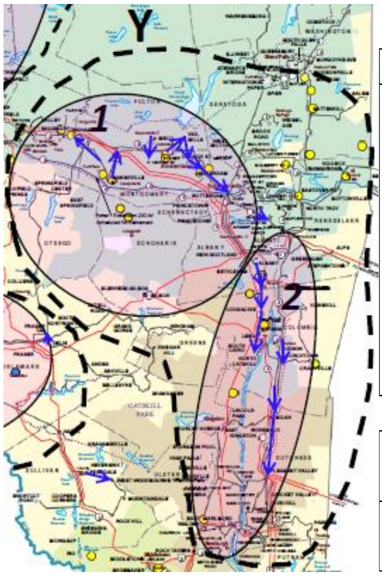
| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| LBW | 1,735 | 2,567 | 21% | 35% |
| UPV | 356 | 498 | 50% | 43% |

Pocket X3 is located in Jefferson & Oswego Counties. UPV is curtailed at 50% and 43% for the SScenario Load and BBase Load cases respectively in this pocket due to the UPV buildout being mostly located upstream of the 115kV transmission constraints, as shown in Figure 29. These limitations directly increase the utilization of the neighboring transmission facilities.

**Capital Region (Pocket Y):** This pocket encompasses the Mohawk Valley and upper Hudson Valley regions, centered on the Albany metro area. A large amount of solar generation, mainly UPV, is modeled in this pocket, particularly on the 115 kV network. These new resources experience high levels of curtailment on the 115 kV network, which is generally not designed for high levels of generation injection.

## Pocket Y1 Summary:

**Figure 30: Pocket Y1 Congestion and Curtailment Summary**




**Pocket Y1**

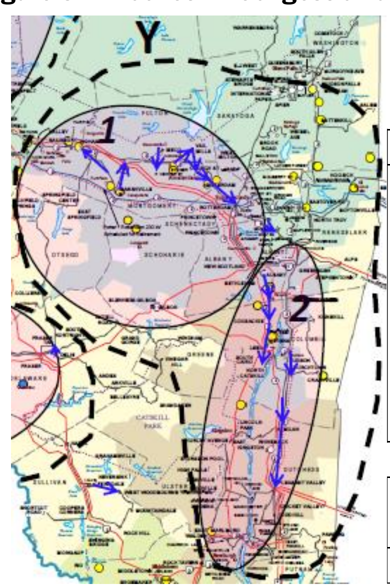
| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| RTRDM1 115.00-AMST 115 115.00 | 2,392 | 2,814 |
| STONER 115.00-VAIL TAP 115.00 | 2,037 | 2,259 |
| INGHAM-E 115.00-ST JOHNS 115.00 | 508 | 1,454 |
| CHURCH-W 115.00-VAIL TAP 115.00 | 1,034 | 1,509 |
| CLINTON 115.00-TAP T79 115.00 | 293 | 725 |
| CHURCH-E 115.00-MAPLEAV1 115.00 | 293 | 543 |
| AMST 115 115.00-CHURCH-E 115.00 | 149 | 302 |
| CENTER-N 115.00-MECO 115 115.00 | 20 | 170 |
| EVERETT 115.00-WOLF RD 115.00 | 149 | 7 |

| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| LBW | 247 | 286 | 13% | 11% |
| UPV | 1,826 | 2,557 | 50% | 54% |

Pocket Y1 is located in the vicinity of the Mohawk Valley of the Capital Region. UPV is curtailed at 50% and 54% for the Scenario Load and Base Load cases respectively in this pocket due to the UPV buildout being mostly located upstream of the 115 kV transmission constraints, as shown in Figure 30. The 115 kV transmission corridor runs in parallel with the 345 kV corridor utilized by Segment A of the AC Transmission Public Policy projects.

## Pocket Y2 Summary:

**Figure 31: Pocket Y2 Congestion and Curtailment Summary**




**Pocket Y2**

| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| N.CAT. 1 115.00-CHURCHTO 115.00 | 2,079 | 2,371 |
| MILAN 115.00-PL.VAL 1 115.00 | 1,913 | 2,256 |
| OW CRN E 115.00-BOC 7T 115.00 | 151 | 93 |
| MILAN 115.00-BL STR E 115.00 | 145 | 282 |
| JMC1+7TP 115.00-BLUECIRC 115.00 | - | 213 |
| JMC2+9TP 115.00-OC W +MG 115.00 | 17 | 54 |
| ADM 115.00-HUDSON 115.00 | 12 | 74 |
| N.CAT. 1 115.00-BOC 2T 115.00 | - | 22 |

| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| UPV | 2,142 | 2,993 | 37% | 46% |

Pocket Y2 is located in the upper Hudson Valley corridor. UPV is curtailed at 37% and 46% for the

Scenario Load and Base Load cases respectively in this pocket due to the UPV buildout being mostly located at upstream of the 115 kV transmission constraints corridor as shown in Figure 31. The 115 kV transmission corridor runs in parallel with the 345 kV corridors utilized by Segment B of the AC Transmission Public Policy projects.

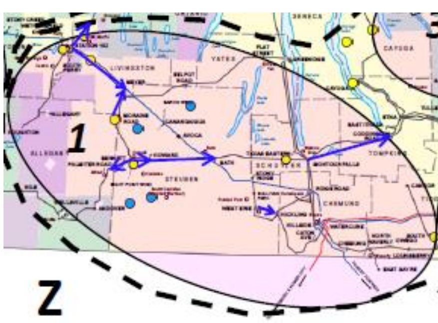
**Southern Tier (Pocket Z):** Large amounts of UPV and LBW are assumed to be added in this pocket, particularly in the sub-pocket of Z1. In general, the wind and solar generation in this pocket experience high levels of curtailments, and the transmission facilities in this pocket show high levels of congested hours. This congestion results mainly from the lack of strongly interconnected bulk power transmission facilities near injection points, and the 115 kV network was not designed for large power transfers.

**Pocket Z1 Summary:**

**Figure 32: Pocket Z1 Congestion and Curtailment Summary**

**Pocket Z1**

| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| HICK 115 115.00-WERIE115 115.00 | 1,966 | 3,115 |
| BATH 115 115.00-HOWARD11 115.00 | 1,438 | 2,694 |
| BENET115 115.00-PALMT115 115.00 | 1,456 | 1,738 |
| MEYER115 115.00-S.PER115 115.00 | 1,371 | 2,307 |
| S.PER115 115.00-S PERRY 230.00 | - | 20 |
| S.PER115 115.00-STA 162 115.00 | - | 1 |
| STA 162 115.00-STA 158S 115.00 | 304 | 466 |
| MEYER115 115.00-MORAI115 115.00 | 611 | 847 |
| BENET115 115.00-HOWARD11 115.00 | 346 | 893 |
| CODNT115 115.00-MONTR115 115.00 | 2 | 12 |



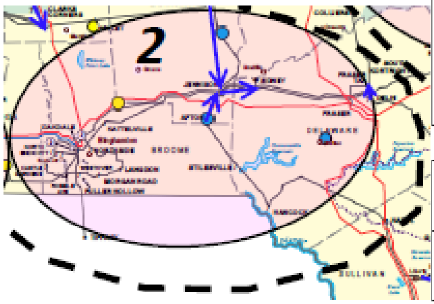

| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| LBW | 3,064 | 4,479 | 21% | 37% |
| UPV | 1,073 | 1,503 | 19% | 30% |

Pocket Z1 is generally located in Finger Lakes Region. LBW is curtailed at 21% and 37% for the Scenario Load and Base Load cases respectively in this pocket due to the wind buildout being mostly located upstream of the 115 kV transmission corridor near the Benet area, as shown in Figure 32.

**Pocket Z2 Summary:**

**Figure 33: Pocket Z2 Congestion and Curtailment Summary**

**Pocket Z2**



| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| DELHI115 115.00-DEL T115 115.00 | 994 | 301 |
| JENN 115 115.00-SIDNT115 115.00 | 575 | 2,018 |
| JENN 115 115.00-AFTON115 115.00 | - | 48 |
| E.NOR115 115.00-JENN 115 115.00 | 6 | 190 |
| STILV115 115.00-AFTON115 115.00 | - | 40 |
| W.WDB115 115.00-FERND115 115.00 | 17 | 60 |

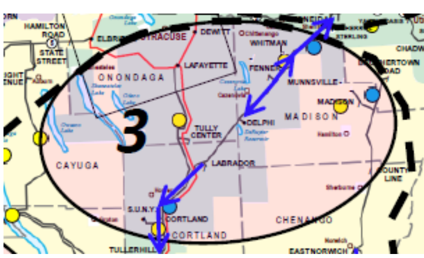
| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| LBW | 531 | 817 | 12% | 18% |
| UPV | 107 | 149 | 13% | 3% |

Pocket Z2 is located in the Southern Tier Region. LBW is curtailed at 12% and 18% for the Scenario Load and Base Load cases respectively in this pocket due to the wind buildout being mostly located upstream of the 115 kV transmission corridor, as shown in Figure 33.

### Pocket Z3 Summary:

**Figure 34: Pocket Z3 Congestion and Curtailment Summary**

**Pocket Z3**



| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| CORTLAND 115.00-TULLER H 115.00 | 14 | 476 |
| CLARKCRN 115.00-TULLER H 115.00 | - | 895 |
| DELPHI 115.00-OM-FENNR 115.00 | - | 123 |
| CORTLAND 115.00-LABRADOR 115.00 | 75 | 431 |
| WHITMAN 115.00-ONEIDA 115.00 | 1,816 | 2,905 |
| WHITMAN 115.00-FEN-WIND 115.00 | 290 | 506 |

| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| LBW | 883 | 1,276 | 10% | 16% |
| UPV | 653 | 913 | 18% | 28% |

Pocket Z3 is located in Central New York Region. UPV is curtailed at 18% and 28% for the Scenario Load and Base Load cases respectively in this pocket due to the solar buildout being mostly located upstream of the 115 kV transmission corridor, as shown in Figure 34.

**Off-Shore Wind in Zone J:** Offshore Wind is curtailed at 9% for both the Scenario Load and Base Load cases in this pocket due to the wind resources being mostly located upstream of the 138 kV and 345 kV transmission corridors, as shown in Figure 35. There are three injection points in New York City, at the Freshkills 345 kV substation, Gowanus 345 kV substation, and Farragut 345 kV substation. The majority of the OSW curtailment results from the injection at the Freshkills substation in the Staten Island load pocket, which is constrained by the 138 kV facility from Freshkills to Willow Brook.

The study also shows that the OSW resources are much higher than the load in the Staten Island load pocket, as well as being constrained by the identified transmission facilities. Accordingly, the OSW resources cannot be transmitted out of the load pocket.

**Figure 35: New York City Offshore Wind Congestion and Curtailment Summary**


**OSW_J**

| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| WILOWBK2 138.00-FRESH KI 138.00 | 3,774 | 4,662 |
| FARRAGUT 345.00-GOWANUS 345.00 | 2,273 | 2,250 |
| E13ST 45 345.00-FARRAGUT 345.00 | 211 | 198 |
| WILOWBK1 138.00-FRESH KI 138.00 | 116 | 97 |
| RAINEY W 345.00-FARRAGUT 345.00 | 23 | 54 |

| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| OSW | 16,100 | 16,100 | 9% | 9% |

**<u>Off-Shore Wind in Zone K:</u>** Offshore Wind is curtailed at 3% and 4% for both the Scenario Load and Base Load cases in this pocket due to the new wind resources being mostly located upstream of the 138 kV transmission corridor, as shown in Figure 36. There are four injection points in Long Island; the Holbrook 138 kV substation, Brookhaven 138 kV substation, Ruland Road 138 kV substation, and East Hampton 69 kV substation. The majority of the OSW curtailment on Long Island results from the injection at Holbrook substation that is constrained by the 138 kV facility from Holbrook to Ronkonk.

**Figure 36: Long Island Offshore Wind Congestion and Curtailment Summary**


**OSW_K**

| Congested Hours | Scenario Load | Base Load |
|---|---|---|
| HOLBROOK 138.00-RONKONK 138.00 | 2,032 | 2,102 |
| NEWBRGE 138.00-RULND RD 138.00 | 236 | 314 |

| Type | Input RE (GWh) | | Curtailed Energy (%) | |
|---|---|---|---|---|
| | Scenario Load | Base Load | Scenario Load | Base Load |
| OSW | 7,259 | 7,259 | 3% | 4% |
| UPV | 115 | 115 | 6% | 1% |

#### 4. Nuclear Generation Retirement Sensitivity

The nuclear generation fleet, which is comprised of the Nine Mile I, Nine Mile II, Ginna and FitzPatrick facilities, are expected to continue in operation until at least March 2029 under the state support provided by Zero Emission Credit Requirements contained in the Clean Energy Standard. These units may continue in operation beyond 2029 and this sensitivity analysis should not be interpreted as forecasting their deactivation. This sensitivity examines what may be the impacts on the system generation output if those units discontinued operations under the Scenario Load and Base Load conditions in 2030. The existing nuclear generation fleet provides emission-free base-load generation with limited dispatch flexibility. Removal of large, consistent supply resources would result in higher utilization of a combination of intermittent and conventional generation. Figure 37 shows the annual energy by unit type and net imports across cases with and without the nuclear units in operation.

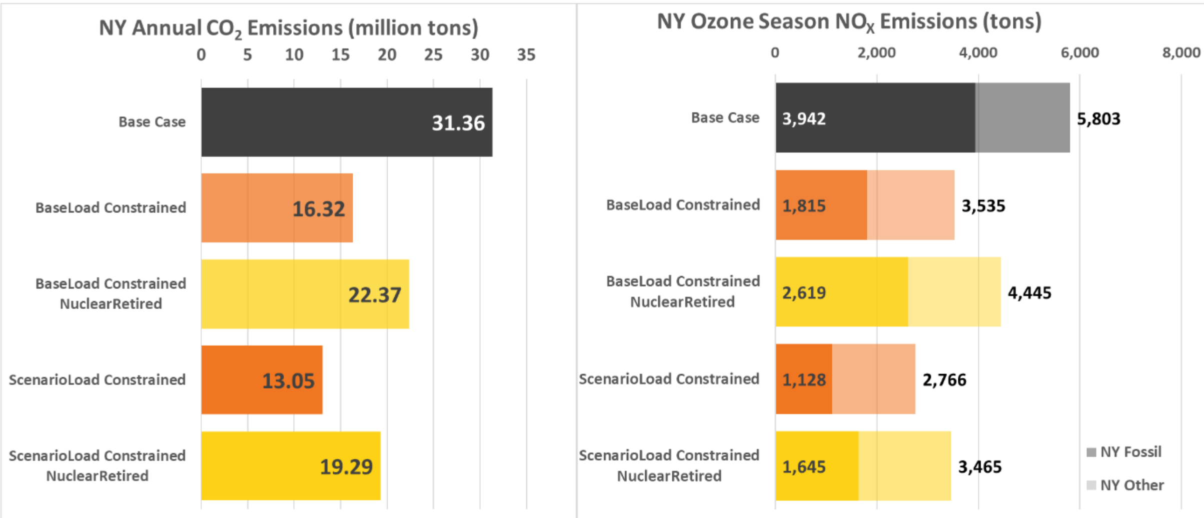
**Figure 37: Base, Constrained, and Nuclear Retirement Sensitivity Case Annual Energy Results**

| Energy (GWh) | Base Case | ScenarioLoad Constrained | ScenarioLoad Constrained NuclearRetired | BaseLoad Constrained | BaseLoad Constrained NuclearRetired |
|---|---|---|---|---|---|
| Nuclear | 27,091 | 27,433 | - | 27,433 | - |
| Other | 2,368 | 2,110 | 2,270 | 2,102 | 2,263 |
| Fossil | 69,028 | 28,185 | 42,924 | 35,181 | 49,448 |
| Hydro | 28,832 | 28,050 | 28,448 | 28,020 | 28,413 |
| Hydro Imports | 11,564 | 19,775 | 19,897 | 19,769 | 19,910 |
| LBW | 5,038 | 13,290 | 14,879 | 17,117 | 18,751 |
| OSW | - | 21,625 | 21,714 | 21,592 | 21,750 |
| UPV | 115 | 12,666 | 14,527 | 17,982 | 19,342 |
| BTM-PV | 4,988 | 9,266 | 9,356 | 9,327 | 9,359 |
| Pumped Storage | (447) | (822) | (988) | (868) | (959) |
| Storage | - | - | - | - | - |
| IESO Net Imports | (2,862) | (5,817) | (4,090) | (6,250) | (4,264) |
| ISONE Net Imports | (535) | (6,418) | (4,385) | (5,073) | (2,867) |
| PJM Net Imports | 12,239 | (4,446) | 287 | (4,528) | 591 |
| Renewable Generation | 50,537 | 104,672 | 108,821 | 113,808 | 117,525 |
| Curtailment | 0 | 10,151 | 6,069 | 14,020 | 10,338 |
| Non-Renewable Generation | 98,488 | 57,728 | 45,194 | 64,717 | 51,712 |
| GrossLoad | 157,418 | 144,897 | 144,838 | 161,807 | 161,733 |

With deactivation of the nuclear generation fleet, the model exhibits a significant increase in fossil fuel generation in the Scenario Load and Base Load cases, mostly in the downstate region. The model also reveals an increase in wind and solar output from upstate renewables that are able to utilize transmission capability previously consumed by the nuclear generation, while offshore wind output remains mostly consistent due to local congestion. The cases with the nuclear fleet retired also have notable reductions in exports to external regions across both the Scenario and Base Load levels.

Increased operation of fossil units in cases with the nuclear generation fleet retired results in increased in $CO_2$ and $NO_X$ emissions, as shown in Figure 38. Emission levels are lower in the Scenario Load case compared the Base Load case owing to lower load and corresponding lower operation of fossil fuel generation.

**Figure 38: Nuclear Retirement Sensitivity Case $CO_2$ and Ozone Season $NO_X$ Emissions Projections**




### 5. Energy Storage Resources (ESR) Sensitivity

State policies, including the CLCPA, support the installation of 3,000 MW of Energy Storage Resources (ESR) in New York by 2030. ESR modeling in production cost simulation is in the development stage at the time of this assessment, and the NYISO investigated different dispatch models, namely ESR method and hourly resource modifier (HRM) method. The detailed modeling approach and comparison of results are included in an appendix. For illustrative purposes, this section of the report focuses on HRM method, and the targeted impact examination of a small amount of ESR capacity to minimize curtailment from individual collocated RE generators in a generation pocket.

In the HRM approach all ESR are assumed to be four-hour duration with 85% round trip efficiency, meaning that ESR can discharge 85% of the energy consumed from charging. Results of the study conducted for the NYSERDA Energy Storage Roadmap[8] were used to inform the zonal MW capacity levels. ESRs were added to the model as a distributed resource at the load buses, on a zonal basis as shown in Figure 39.

[8] documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={2A1BFBC9-85B4-4DAE-BCAE-164B21B0DC3D}

**Figure 39: Assumed ESR Zonal Power Capacity**

| Nameplate Capacity Distribution (MW) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | J | K | NYCA |
| LBW | 150 | 90 | 120 | 180 | 120 | 240 | 100 | 100 | 100 | 1,320 | 480 | 3,000 |

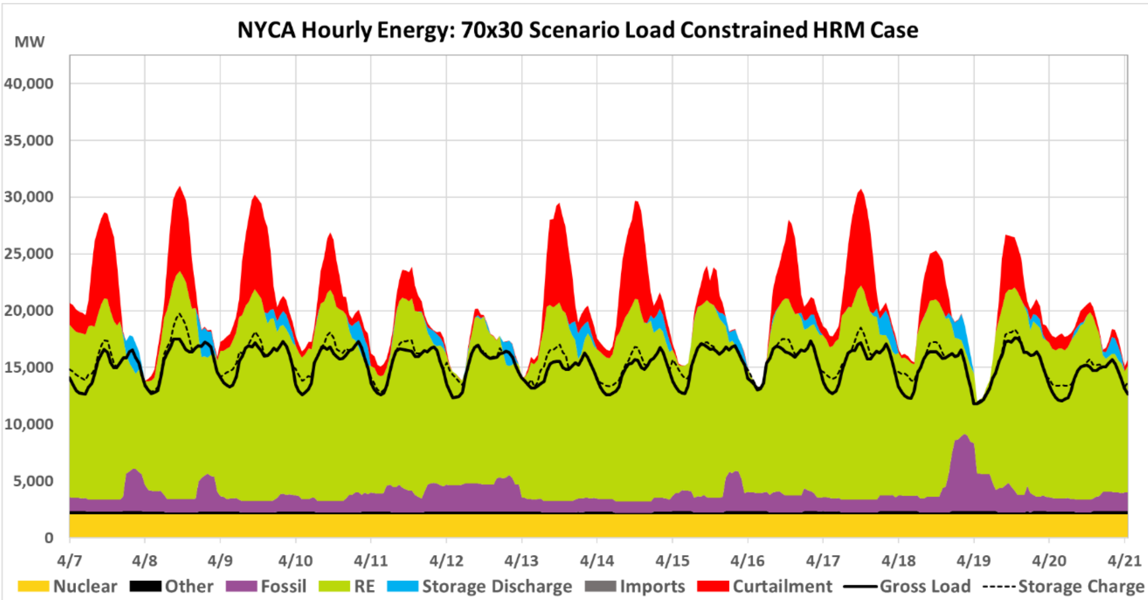
The primary impact of including ESR as a distributed resource in MAPS is a reduction in fossil generation, exports, and curtailments, with an observed increase in RE generation of approximately 1,000 GWh, or 0.9%. Figure 40 displays the annual energy composition of generation, net imports, curtailments, and gross load. Storage resources in the table are shown as net generation values (*i.e.*, net generation = discharge – charge), similar to the calculation of net generation for pumped storage resources.

**Figure 40: Energy Storage Resource Sensitivity Case Results Energy Results (GWh)**

| Energy (GWh) | ScenarioLoad Constrained | ScenarioLoad Constrained HRM | BaseLoad Constrained | BaseLoad Constrained HRM |
|---|---|---|---|---|
| Nuclear | 27,433 | 27,434 | 27,433 | 27,435 |
| Other | 2,110 | 2,126 | 2,102 | 2,117 |
| Fossil | 28,185 | 26,294 | 35,181 | 33,603 |
| Hydro | 28,050 | 28,114 | 28,020 | 28,091 |
| Hydro Imports | 19,775 | 19,808 | 19,769 | 19,808 |
| LBW | 13,290 | 13,532 | 17,117 | 17,376 |
| OSW | 21,625 | 21,743 | 21,592 | 21,821 |
| UPV | 12,666 | 13,124 | 17,982 | 18,350 |
| BTM-PV | 9,266 | 9,288 | 9,327 | 9,329 |
| Pumped Storage | (822) | (630) | (868) | (671) |
| Storage | - | (693) | - | (756) |
| IESO Net Imports | (5,817) | (5,755) | (6,250) | (6,145) |
| ISONE Net Imports | (6,418) | (5,847) | (5,073) | (4,723) |
| PJM Net Imports | (4,446) | (3,648) | (4,528) | (3,838) |
| Renewable Generation | 104,672 | 105,609 | 113,808 | 114,775 |
| Curtailment | 10,151 | 9,266 | 14,020 | 13,097 |
| Non-Renewable Generation | 57,728 | 55,853 | 64,717 | 63,155 |
| GrossLoad | 144,897 | 144,888 | 161,807 | 161,797 |

Graphs over two week sample periods, as shown in Figure 41, display the impacts of ESR on fossil, renewable, imports, and curtailments on an hourly granularity. Modeling distributed ESR resulted in less fossil generation during low net load periods compared, as ESR typically reduces peak fossil demand levels. It was also observed that some (mostly winter) hours during which ESR was charging were also hours when NYCA was a net importer. This implies that the increase charging demand could increase imports and fossil generation in some hours relative to a case without ESR. Renewable curtailments also decreased compared to cases without ESR.

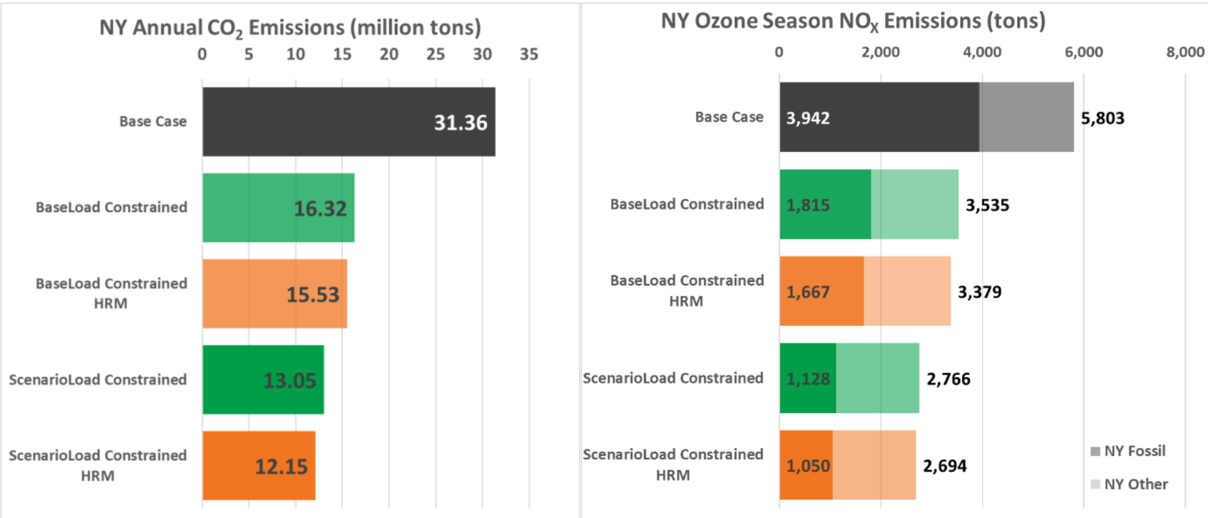
**Figure 41: HRM Energy Storage Resource Hourly Results across a Spring Low Net Load Period**




The introduction of ESR does not inherently result in a reduction in emissions or output of fossil generators because ESR overall increase energy demand due to losses associated in the cycle from charging to discharging.

Figure 42 shows the $CO_2$ and $NO_X$ emissions of generators located in New York across the scenario cases and the Base Case. Emissions across all scenario cases decrease substantially from the Base Case results. The additional reduction of the distributed storage model are relatively small in comparison.

**Figure 42: Energy Storage Resource Sensitivity Case $CO_2$ and Ozone Season $NO_X$ Emissions Projections**




An additional sensitivity examined the impact of ESR on RE curtailments in generation pockets. In the Capital Region Pocket Y1, five UPV generators with the highest level of curtailed energy from the Scenario Load constrained case were chosen for this sensitivity. The five UPV units and their curtailed energy data is shown in Figure 43. An hourly dispatch profile was created for each ESR unit to charge with the curtailed energy from the associated RE unit. In the absence of any curtailment of its associated RE unit, ESR would inject its stored energy into the transmission network. The ESR dispatch profiles were also limited by the power, energy, and efficiency constraints on the ESR itself. All ESR in these cases assumed an 85% charge-to-discharge efficiency.

**Figure 43: Information on Pocket RE Generator and Collocated ESR Capacity**

| RE unit | Capacity (MW) | Higher ESR Capacity (75th percentile) (MW) | Lower ESR Capacity (50th percentile) (MW) |
|---|---|---|---|
| UPV1 | 213 | 150 | 85 |
| UPV2 | 196 | 130 | 100 |
| UPV3 | 109 | 80 | 35 |
| UPV4 | 87 | 70 | 40 |
| UPV5 | 174 | 125 | 90 |

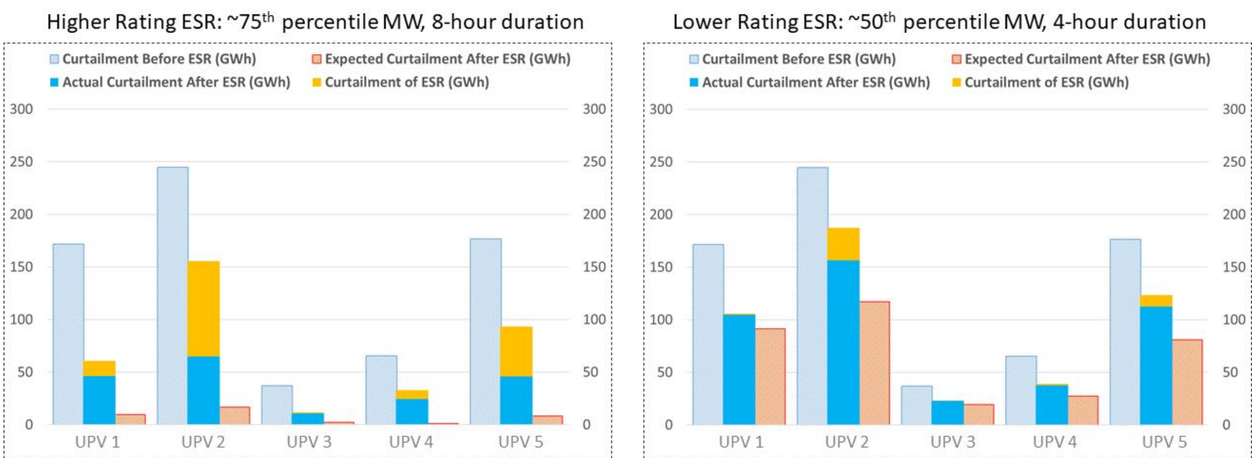
The power rating of the ESR was selected to capture approximately 75th and 50th percentiles of the hourly curtailments of each RE unit. The two power ratings of each ESR used in this sensitivity are shown in Figure 43.

ESR dispatch profiles were included in a MAPS simulation as hourly resource modifiers (HRM) collocated with the associated RE unit.

Figure **44** shows the curtailment results for two MAPS simulations with two ESR rating levels (*i.e.*, higher and lower rated ESR units). It can be seen in

Figure **44** that the MAPS simulation resulted in curtailment of ESR injections because the network constraints still existed in the absence of energy from the RE units. Lower ratings of ESR also resulted in higher curtailments from the associated renewable units with lower associated ESR curtailments.

**Figure 44: Curtailment Results for Pocket RE Generator Collocated ESR Sensitivity Cases**




These results show that while ESR can help in reducing curtailments in constrained pockets to some extent, the transmission limitations in the pockets cannot directly be solved with ESR. Ultimately, MAPS will curtail either the ESR injection or some other renewable unit.

#### 6. Reduced export sensitivity

Based on stakeholder feedback, the NYISO performed an additional sensitivity to examine the impact of reduced exports to external regions (PJM, IESO and ISO-NE) on scenario study results. External areas will likely experience demand and resource shifts while different regions are moving towards their individual renewable and emission reduction targets. The detailed plans of the neighboring areas are not available at the time of this report. Lacking such information, the 70x30 scenario does not assume any renewable generation growth in the neighboring systems beyond limited additions prescribed by inclusion rules assumed in the Base Case analysis. The additional sensitivity effectuates reduced exports from the NYISO to external areas by substantially increasing the export hurdle rate on all ties in the export direction.

Hurdle rates are studied during benchmarking analysis to set inter-regional flows economically to historical averages and remain fixed throughout the Base Case study period. This sensitivity models export hurdle rates at 100 times the Base Case amount to reduce exports to neighboring regions. The results presented in Figure 45 for this sensitivity are intended only to show the directional impacts of increasing export hurdle rates. The NYISO has not optimized or studied hurdle rate values in depth; a large value was arbitrarily chosen to study the directionality of flows and generation.

Increasing export hurdle rates results in decreased exports (increase in net imports) on all inter-regional interfaces, decreased New York renewable and fossil generation output, and increased curtailments.

**Figure 45: Export Sensitivity Case Annual Energy Results**

| Energy (GWh) | Base Case | ScenarioLoad Constrained | ScenarioLoad Constrained 100xHurdleRate |
|---|---|---|---|
| Nuclear | 27,091 | 27,433 | 27,419 |
| Other | 2,368 | 2,110 | 1,621 |
| Fossil | 69,028 | 28,185 | 21,434 |
| Hydro | 28,832 | 28,050 | 25,117 |
| Hydro Imports | 11,564 | 19,775 | 19,830 |
| LBW | 5,038 | 13,290 | 10,453 |
| OSW | - | 21,625 | 19,125 |
| UPV | 115 | 12,666 | 9,074 |
| BTM-PV | 4,988 | 9,266 | 9,072 |
| Pumped Storage | (447) | (822) | (885) |
| Storage | - | - | - |
| IESO Net Imports | (2,862) | (5,817) | 71 |
| ISONE Net Imports | (535) | (6,418) | 972 |
| PJM Net Imports | 12,239 | (4,446) | 1,616 |
| Renewable Generation | 50,537 | 104,672 | 92,671 |
| Curtailment | 0 | 10,151 | 18,985 |
| Non-Renewable Generation | 98,488 | 57,728 | 50,474 |
| GrossLoad | 157,418 | 144,897 | 144,921 |

## 5. Summary of Findings

*(To be written following stakeholder comments)*