Clean Power Plan Assessment
- Interim Report

New York Independent System Operator

July 2016

Caution and Disclaimer

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Executive Summary

New environmental regulations, technological advances, and market trends are transforming the methods, locations, and characteristics of the resources used to generate and deliver electricity. The promulgation of the United States Environmental Protection Agency (EPA) Clean Power Plan (CPP) sends clear policy signals across the nation that tomorrow's electricity should be generated with fewer carbon dioxide (CO_2) emissions. Those signals are reinforced by the on-going review of the Regional Greenhouse Gas Initiative (RGGI), which is considering additional reductions in CO_2 emissions from the power industry in the Northeast. Beyond efforts to reduce CO_2 emissions, EPA has also proposed further reductions in emissions of ozone precursors emitted from power plants in New York and the surrounding region through its proposed Cross-State Air Pollution Rule (CSAPR) Update Rule and associated ozone season NO_x limits.

Based on the above-referenced environmental initiatives, among others, the composition and operation of the New York Control Area (NYCA) fleet will need to adjust to comply with these new requirements, while continuing to meet reliability criteria at a reasonable cost. This Study is designed to provide the New York State Department of Environmental Conservation (DEC), other policymakers, market participants, and interested stakeholders important information about the ability of the NYCA to achieve compliance with these new regulations, information about changes in emission patterns, and the impacts on costs.

This Study has been designed in two stages—first, to build upon existing work at the NYISO, and then to perform additional work over a longer planning horizon. This Study has looked at various CO_2 caps and changes in the resource mix. Further work will examine system intra-hour operational performance, resource adequacy, transmission security, and system stability under various operating conditions.

This Interim Report, *Clean Power Plan Assessment – Interim Report*, reviews work completed to date and outlines the plans to further study the impact of the CPP, RGGI, and proposed CSAPR Update Rule on the reliability needs of the Bulk Power System (BPS) and wholesale competitive electricity markets of New York State. Preliminary findings suggest that the NYCA will be able to comply with the requirements of the CPP in the scenarios studied for 2024 with consideration of future potential RGGI caps and ozone season NO_x limits. In addition, New York will be able to comply with the RGGI requirements, understanding that in some of the cases studied, out-of-state allowances were required to offset emissions in excess of the RGGI caps. The proposed ozone season NO_x budgets were exceeded in all cases, which suggests that the NYCA may need to procure out-of-state allowances for those emissions above the budget to achieve compliance. If emissions are above the trading limit, a penalty may apply.

Clean Power Plan
Assessment - Interim Report

1. Introduction and Background

The United States Environmental Protection Agency (EPA) Clean Power Plan (CPP) has established a national program to reduce carbon dioxide (CO_2) from existing fossil fuel-fired steam and combined cycle generators by 32% by 2030 as compared to the 2005 emission levels. The plan is novel in its approach to regulating emissions at the state level by providing options for the states to design compliance programs. The CPP schedule calls for states to submit an Initial Plan (IP), in lieu of a final State Plan (SP), by September 6, 2016. In the event that a state fails to submit a final SP by September 6, 2018 (*i.e.*, three years after the promulgation of the regulation), the EPA will notify the state and approve a Federal Plan (FP) created by the EPA.

The CPP has attracted a number of legal challenges and is currently under a stay issued by the Supreme Court of the United States. During the pendency of the stay and resolution of the legal challenges, the Governor of New York has directed the New York State Department of Environmental Conservation (DEC) and other agency staff to continue with planning for implementation of the CPP.

The NYISO's *Clean Power Plan Assessment – Interim Report* has four purposes. Its primary purpose is to provide input to the New York State's planning process on issues relating to bulk electric system reliability, as well as, bulk electric system efficiency, emissions, and essential reliability services.

Second, this Study is intended to examine the impacts of potential CO_2 caps, as well as the retirement of nuclear resources, to provide input to the Regional Greenhouse Gas Initiative (RGGI) 2016 Program Review that is currently underway. The objectives of the RGGI Program Review are: (i) an identification of modifications potentially desirable to satisfy CPP criteria, (ii) establishment of a CO_2 cap post-2020, (iii) review of flexibility mechanisms and regulated sources, (iv) consideration of criteria for additional partners, and (v) consideration of other program design elements.

The third purpose of this Study is to examine the impacts of the EPA proposed Cross-State Air Pollution Rule (CSAPR) Update Rule and associated ozone season NO_x limits.

The fourth purpose of this Study is to examine the operational characteristics of the generating fleet as intermittent resources are added to the system and older, controllable resources leave the system. The North American Electric Reliability Corporation (NERC) has provided guidance to system planners and operators on the need to monitor the availability of "essential reliability services" (ERS). These services include frequency support, ramping, and voltage control. This Study will examine recent operations and compare the need for and availability of ERS in the scenarios examined.

This Interim Report will provide recommendations for the scope of work to be performed in additional analysis under this Study. Further, tasks currently planned to be undertaken include: (i) an examination of the intra-hour operations that may occur as the quantity of intermittent renewable generators increases, with a focus on system stability during periods marked with light load/high renewable generation, and (ii) an examination of the ability of potential future resource mixes to support operations during extreme weather situations.

This analysis has been developed to evaluate scenarios that are estimated to approximate compliance with the CPP and the RGGI when the standards of comparison are based on the mass-based limits prescribed by the CPP and RGGI. Understanding that the CPP provides alternative approaches for states to use in their State Plans, such as rate-based approaches that are defined in terms of #CO_2/net-MWH, this Interim Report also details the mass-based scenario results in terms of rate-based outcomes for purposes of comparison.

1.1. Study Objectives

The primary objective of the this Study is to examine potential changes to the composition of the NYCA generation resources, increasingly stringent limits on emissions (*i.e.*, the CPP, RGGI, and proposed CSAPR Update Rule), and the ability of the NYCA generators to supply essential reliability services that are necessary to support the operation of the New York State Bulk Power System (BPS) under a variety of possible scenarios. The scenarios selected for this Study are intended to approximate compliance with the CPP, RGGI, and the proposed CSAPR Phase 2 ozone season NO_x limits. The scenarios, however, are not forecasts and are not intended to predict the future states of NYCA's transmission system.

1.2. Study Scope

This Study is designed as a two-step analysis. The initial examination is intended to determine how environmental limits may impact operations in the year 2024. To perform this analysis, the Study will use five scenarios. The "Business As Usual" (BAU) case is built on an updated *2015 Congestion Assessment and Resource Integration Study* (CARIS) model. Two additional scenarios are designed to evaluate the potential impacts of two variations of the RGGI program post-2020. Two other scenarios are designed to examine two contrasting approaches to the replacement of various amounts of capacity from nuclear generator—one of which is weighted towards renewable resources and the other is weighted towards the use of natural gas fueled combustion turbines. Additional work under this Study will extend the analysis out to the 2030 horizon year for the CPP and include additional studies of: resource adequacy, transmission security, system stability, extreme weather, and intra-hour simulations and net load volatility.

The results are reported in terms of standard CARIS metrics for New York and emissions across RGGI and CSAPR affected states. This Study will examine the changes in ERS, which will be tracked and reported across the simulated year.

GridView, a production cost simulation model,[1] was used to capture the effects of increased intermittent renewable resources in the NYCA fleet. GridView can simulate intra-hour variations to capture the increased starts and stops of quick response generators and report the increased emissions associated with the increase in the number of starts. As regulatory programs require increasingly stringent emission reductions and increasing amounts of intermittent renewable resources are installed in the NYCA, system operators and planners will need to adapt to the changing resource mix while effectively maintaining system reliability.

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[1] Additional information on GridView is available at http://new.abb.com/enterprise-software/energy-portfolio-management/market-analysis/gridview.

1.2.1. Regulatory Process

This Study examines the emission limitations established by three regulations: the CPP, RGGI, and the CSAPR Update Rule. Each of these regulations is designed to limit emissions from fossil fuel-fired Electric Generating Units (EGUs). When implemented, these regulations can impose limits on the production from affected facilities during the respective compliance periods. Further, scenarios are postulated that pose changes in the resource mix available to meet load. These resource changes along with the new limits on production give rise to the question of whether or not the BPS can be operated in a manner that still satisfies reliability criteria. Additional questions arise about the resultant economic and environmental outcomes of the application of these new regulations.

Clean Power Plan (CPP)

The CPP establishes technology-specific emission rates measured as #CO_2/net-MWH for EGUs in 47 continental states.[2] The affected EGUs include existing fossil fuel-fired Steam Turbine (ST) and natural gas Combined Cycle (CC) generators.[3] The CPP, among other things, requires states to implement plans that meet the interim CO_2 performance rates between 2022 and 2029 and the final emission performance target beginning in 2030. The rule also provides an optional four-step schedule of reductions for states to follow. The CPP allows states to select among various plan design options (most broadly mass- or rate-based plans), each having several subtypes. States can also, depending on plan design, decide to allow regulated interstate trading of compliance attributes. The possible State Plan/Federal Plan pathways are shown in Figure 1-1, as provided by the EPA.[4]

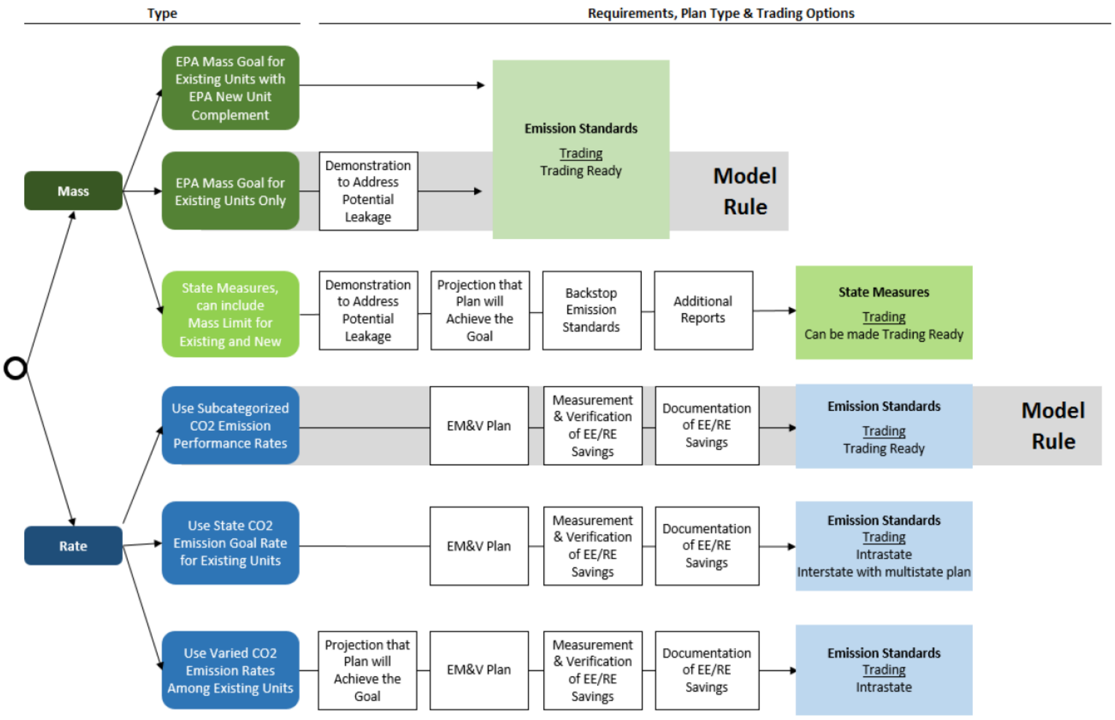

Figure 1-1 EPA State Plan Pathways Decision Tree

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[2] *See* 80 Fed. Reg. 64661, 40 C.F.R. part 60.
[3] *See* 80 Fed. Reg. 64959, 40 C.F.R. § 60.5880.
[4] https://www.epa.gov/sites/production/files/2015-08/documents/flow_chart_v6_aug5.pdf

States that do not submit an approvable SP will be subject to a FP created by the EPA. The EPA plans on releasing the final Model Trading Rule (MTR) in fall 2016, which will inform the FP design.

The identified alternative rate-based approaches, to the technology-specific rate-based approach, include:

- a state rate program in which states can choose to implement a program that blends the technology-specific emission rates, and
- a state program that assigns specific emission rates to specific units.

The CPP converts the specified state emission rate goals into mass-based caps, which states may choose to implement.

The specified mass-based limits can be used for the design of state plans with several allowable options that can include:

- existing affected units only,
- existing units plus an allowance of new sources, and
- plans that are based on unique state measures such as energy efficiency or non-electric sector programs.

All state plans are required to assign the ultimate responsibility for compliance to specific entities and must consider the reliability of the system in developing the plan.[5]

The CPP allows trading of CO_2 allowances and Emission Rate Credits (ERCs) between states that have suitable and approved trading arrangements and includes a "trading ready" option allowing states the potential opportunity to seamlessly join a multi-state program. States trading with each other generally are required to select similar compliance approaches.

Figure 1-2 compares CPP mass-based (red numbers on the left axis) and CPP rate-based (black numbers on the right axis) compliance options, together with the RGGI Program Cap applicable to New York (NY Allocation) and the historic RGGI Affected Emissions.[6] Figure 1-2 shows significant reductions during the period of the RGGI program. Until 2020, the RGGI Program Caps are defined to reduce CO_2 by 2.5% year-on-year, which for New York is the equivalent of a reduction from 34.4 million tons to 30.4 million tons between 2015 and 2020. As shown in Figure 1-2, the annualized CPP mass-based compliance goal for existing units in New York declines from 35.5 million tons (in 2022-24)[7] to 31.3 million tons (beginning in 2030).

Concurrently, states are able to consider rate-based compliance options as a means of achieving emission reductions, based off either a nation-wide, technology-specific (CC and ST) performance assessment or a proportion of the state's EGU fleets' operations in 2012. In Figure 1-2, the upper (brown for ST) and lower (green for CC) circles show the estimated retroactive fleet emission rates in 2005 and 2014 in addition to values provided by EPA in 2012. The corresponding bold lines display the technology-specific rate goals for ST and CC EGUs. New York's "blended" rate (blue line) reflects the

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[5] *See* 80 Fed. Reg. 64946, 40 C.F.R. § 60.5745(a)(7).

[6] The lists of affected unit under the CPP and RGGI contain differences. Both the CPP and RGGI regulate EGUs above 25 MW nameplate capacity; however, the CPP generally does not regulate simple-cycle gas turbine configurations or new units, unless a state decides to address leakage in that fashion in their State Plan.

[7] Interim Step 1 Goal is the first time period (*i.e.*, 2022-2024) of compliance during the Interim Period (2022-2029). *See* 80 Fed. Reg. 64960, 40 C.F.R. § 60.5880.

proportion of 2012 generation share among the CC (73%) and ST (27%) fleets applied to the applicable technology-specific goals. The values for 2005 and 2014 reflect the actual operational shares estimated from reported EPA Air Market Program Data (AMPD)[8] and annual energy by generator from the NYISO Load & Capacity Data Reports (Gold Book).[9] Under rate-based approaches Emission Rate Credits (ERCs) are issued to qualifying new renewable resources[10] and affected EGUs that operate below emission rate targets.[11] ERCs may be used to achieve the rate-based standards by including zero emission MWH generation credits in the computation of the applicable affected EGU compliance obligation, as follows:

$$Rate = \frac{Emissions\ (lb)}{Generation\ (MWH) +\ ERCs}$$

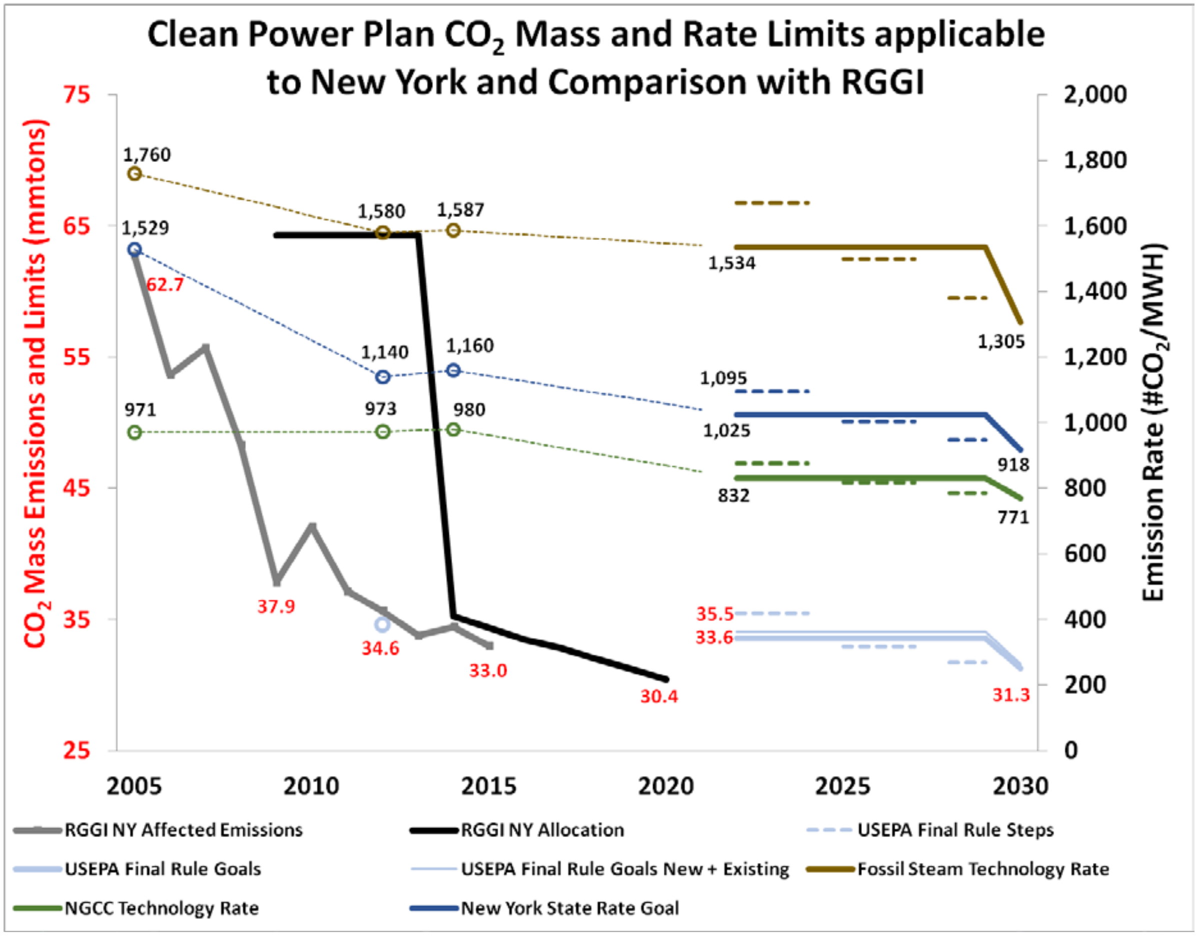

Figure 1-2 Comparison of CPP and RGGI Goals to Historic Emissions and Rates

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[8] Air Market Program Data (AMPD), *available at* https://ampd.epa.gov/ampd/ ("The Air Markets Program Data tool allows users to search EPA data to answer scientific, general, policy, and regulatory questions about industry emissions.").

[9] NYISO Load & Capacity Data Reports are available at: http://www.nyiso.com/public/webdocs/markets_operations/services/planning/Documents_and_Resources/Planning_Data_and_Reference_Docs/Data_and_Reference_Docs/2006_NYCA_Generators.xls and http://www.nyiso.com/public/webdocs/markets_operations/services/planning/Documents_and_Resources/Planning_Data_and_Reference_Docs/Data_and_Reference_Docs/2015_NYCA_Generators_Revised.xls

[10] *See* 80 Fed. Reg. 64950, 40 C.F.R. § 60.5800(a).

[11] *See* 80 Fed. Reg. 64950, 40 C.F.R. § 60.5795.

In February 2016, the Supreme Court of the United States stayed the implementation of the CPP, which effectively put on hold all further compliance obligations for the states. Nevertheless, the Governor of New York State directed state agencies to continue planning for CPP implementation while the rule remains under judicial review. In May 2016, the District of Columbia Circuit Court of Appeals announced hearings will be held in September 2016.

Regional Greenhouse Gas Initiative (RGGI)

The RGGI is a multi-state[12] market-based power sector cap-and-trade approach among Northeastern and Mid-Atlantic states to reduce emissions of CO_2. Figure 1-3, below, shows the RGGI member states in green. RGGI has required the surrender of allowances to cover CO_2 emissions since 2009. The program has a model rule and states share agreements that are generally adopted by the member states. The program affects all fossil fuel-fired units greater than 25 MW, in contrast to the CPP that only applies to existing fossil fuel-fired steam and natural gas fired combined cycles. Allowances are auctioned quarterly and are generally available to generators and the public. In 2012, the RGGI states completed a program review, agreeing to decrease the program caps and to set other program parameters. The current RGGI program caps limit emissions to 91 million tons in 2014 with an annual reduction of 2.5% and a final target of 78,175,215 tons in 2020. The actual quantities of allowances available for auction are reduced to compensate for the banked allowances available through 2014.

Figure 1-3 RGGI States Map

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[12] RGGI is a cooperative effort among the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont to cap and reduce CO_2 emissions from the power sector. Further information is available at https://www.rggi.org/.

Currently, the member states are undergoing a RGGI 2016 Program Review to assess program design decisions post-2020 and to begin planning for compliance with the CPP. Specifically, the review will focus on potential adjustments to the nine-state emissions cap, affected EGU determination, and adjustments that may be necessary to comply with the CPP. The program review is considering various potential designs for reductions between 2021 and 2030.

In light of the RGGI 2016 Program Review, this Study examined two potential scenarios—the 2020 flat cap and post-2020 continued declining cap at 2.5% year-on-year. The details of these scenarios are discussed in Section 2.3 of this Interim Report.

Proposed Cross-State Air Pollution Rule (CSPAR) Update Rule NO_x Reductions

The CSAPR limits SO_2 and NO_x from fossil fuel-fired EGUs greater than 25 MW in 28 eastern states by establishing emission caps and limited allowance trading programs. The proposed CSAPR Update Rule, as published in the Federal Register on December 3, 2015,[13] addresses interstate transport under the 2008 Ozone National Ambient Air Quality Standard (NAAQS) of 75 parts per billion (ppb). Significant ozone season reductions in 23 states were proposed and the affected states are shown as green in Figure 1-4, below. New York's ozone season NO_x cap was reduced by 58%, while neighboring states such as New Jersey and Pennsylvania face reductions in excess of 70%. Historic New York EGU operations are close to the proposed interstate trading limit of 5,277 tons, which is 21% above the ozone season budget of 4,361 tons. Should the sum of emissions from all affected units in New York exceed the trading limit, all emissions above the budget will require three allowances to be surrendered for each ton emitted above the budget by units that exceed their respective budgets. Future operations below the trading limits are highly sensitive to the continued operation of the NYCA nuclear generation fleet. The final CSAPR Update Rule is scheduled for release in the fall of 2016.

In a separate action, the New York DEC petitioned the EPA for the authority to distribute the CSAPR allowances, which was approved by the EPA and codified in Parts 243, 244, and 245 of Title 6 of the New York Code of Rules and Regulations (NYCRR). These rules and the proposed CSAPR Update Rule would become effective concurrent with the CSAPR program Phase 2 ozone season in May 2017, with the ozone season occurring annually from May 1 through September 30.

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[13] 80 Fed. Reg. 75706 (to be codified at 40 C.F.R. parts 52, 78, and 97).

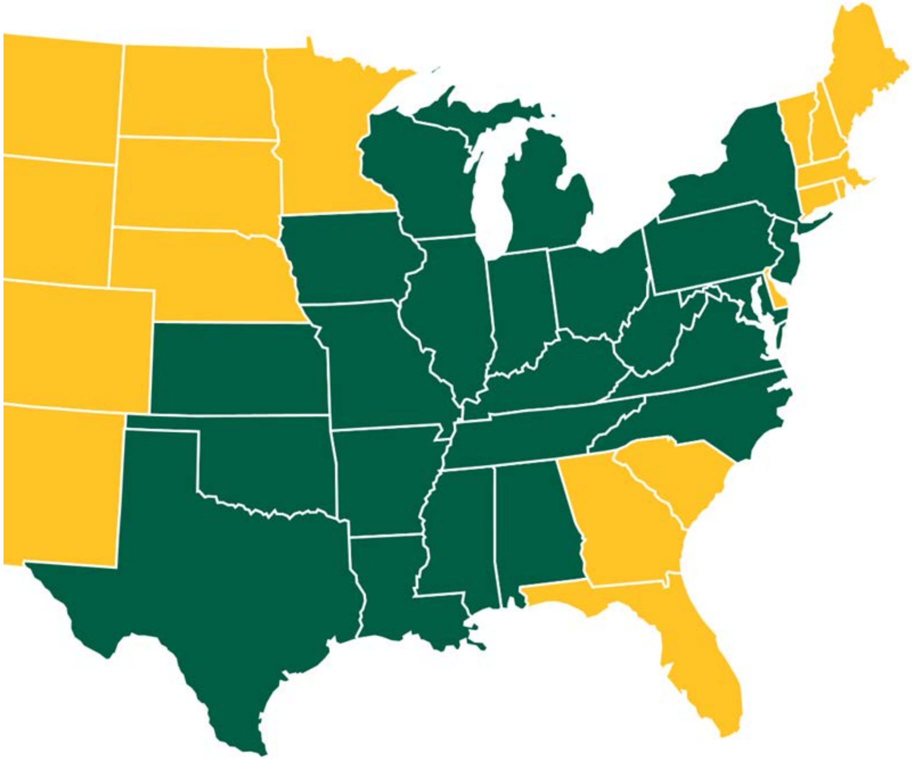

Figure 1-4 State Applicability in the Proposed CSAPR Update Rule

1.2.2. Operational Parameters

Operational parameters for this Study were classified into two categories—applied permit limitations and prime mover characteristics. The former are regulatory conditions applicable by way of their inclusion in air and water permits or other regulatory limitations, while the latter are physical limits imposed by the characteristics of the EGUs themselves.

Permits for fossil fuel-fired generators in New York contain numerous conditions. Some permits limit the quantities of various fuels that can be consumed, while other permits limit the quantity of emissions or the duration of operations in a specific time period. These limits were assembled and the results of the production simulations were constrained by these limits.

In addition to MWHs, NYCA generators supply what NERC terms “essential reliability services” (ERS), which are critical to the operation and stability of the BPS. ERS include voltage control, frequency support, and ramping capability. These services are physically delivered to the system by the inertia supplied by operating alternating current machines, reactive power that machines can inject or withdraw, and the rate of change of output that machines can provide. The quantities of and demand for these ERS will change as the portfolio of generators change over time. A large portion of the new renewable generators do not currently provide ERS. Specific time periods of low load and high renewable participation will be identified for further studies of system stability and sub-hourly simulation.

1.2.3. Economics

The GridView production cost simulation model considers electric system constraints, unit efficiencies, unit costs, and other generating unit characteristics as input and reports production costs, load payments, congestion costs, losses, and emissions. The costs associated with construction of new generators and transmission reinforcements are beyond the scope of this Study and, therefore, not included in the presented economic analysis.

1.3. Other Studies

The NYISO has participated in several other studies of potential impacts of the CPP including:

- The North American Reliability Corporation (NERC) recently released two reports: *Potential Reliability Impacts of EPA's Clean Power Plan Phase II* and *Essential Reliability Services Task Force Measures Framework Report*,
- The Electric Power Research Institute Program 103 Energy and Policy Analysis,
- RGGI 2016 Program Review, and
- New York State Public Service Commission/Transmission Owner State Resource Planning Assessment of the RGGI Program Review, the Clean Power Plan, and the New York State Clean Energy Standard.[14]

In addition, the NYISO conducted studies of the potential impacts of additions of varying amounts of intermittent renewable resources, including *Growing Wind* and more recently releasing a report, *Solar Impact on Grid Operations - An Initial Assessment.*

1.3.1. North American Reliability Corporation (NERC) Studies

The 2016 NERC study, *Potential Reliability Impacts of EPA's Clean Power Plan Phase II*,[15] was designed to provide an assessment of reliability impacts potentially arising from the CPP, resource adequacy evaluations, and a framework for regional and localized studies. The study found that:

- the implementation of the CPP will accelerate the change in generation fuel mix away from coal and increase the use of natural gas and renewable resources,
- under the CPP, load growth is expected to flatten,
- trading of allowances under a national program could result in more coal use and decreased use of natural gas, and
- resource mix changes have regional significance, which will spur the need for additional transmission and pipeline infrastructure.

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[14] By way of background, the New York State Public Service Commission (NYSPSC) has proposed the Clean Energy Standard (CES) to implement the New York State Energy Plan goals for energy efficiency, increased use of renewable energy, and decreased CO_2 emissions. The CES proposal calls for incremental renewable resources to annually produce 33,700 gigawatt-hours (GWH), while energy efficiency programs reduce loads by 35,627 GWH annually by the year 2030.

[15] NERC, *Potential Reliability Impacts of EPA's Clean Power Plan Phase II, available at* http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/CPP%20Phase%20II%20Final.pdf (May 2016).

The NERC study recommended that utility commissions and state environmental officials should:

- ensure that sufficient levels of ERS are planned and included in resource plans in order to manage the large levels of asynchronous generation anticipated to be added to the BPS,
- account for the timing considerations for the development of new resources and the development of the gas and electric infrastructure necessary to support the new resources,
- all State Plans must retain adequate reserve margins,
- account for changes in regional exchange of electricity, and
- assess how required emission reductions can be met through trading of emission allowances or emission rate credits.

In addition to examining air regulatory policy impacts on electric system reliability, NERC has also been extensively involved in understanding and tracking which operational parameters are of interest to grid operators to accommodate an evolving resource mix environment. NERC recently released *Essential Reliability Services Task Force Measures Framework Report* ("NERC ERS Report").[16] The stated purpose of the report is to "develop measures, use data from across North America to assess the validity of these measures, and provide insight into trends and impacts of the changing resource mix."[17] NERC focused their analysis on metrics or "measures" that Balancing Authorities (BAs) can track and assess to identify potential reliability concerns which may arise as the resource mix evolves.

An evolving concern of grid operators is the ability to maintain reliability as increasing amounts of variable and renewable energy resources alter the characteristics of the generating fleet and, therefore, potentially change the operational characteristics of the BPS. In addition, policies favorable to the additional use of distributed energy resources will require new approaches for system planners and operators to maintain reliability. These new approaches will consider:

- **Resource Retirements:** Owing to their large spinning mass and inertia, conventional EGUs provide frequency support services and reactive support for voltage control to maintain balanced system operations within reliability standards.
- **Resources Replacements:** As the resource mix changes towards greater renewable resource penetration, the operational characteristics of the replacement resources should be implemented in a manner that does not harm reliability. In addition, it will become necessary for the capability to control generation and load resources to adjust in response to changing system conditions, particularly during periods of ramping, to become integrated into operations, market, and planning.
- **Resource Capability and Characteristics:** Characteristics of generation and transmission resources necessary for providing ramping capability and other ERS are required to maintain the balance between generation and load. Reliable operation of the grid is dependent upon adequate amounts of ERS at the right place and time.

NERC has identified voltage control, frequency support, and net demand ramping capability as the critical components to assess when considering reliable grid operations and discusses the importance of ensuring all generation resources provide sufficient ERS as conventional EGUs comprise a shrinking portion of resources used to serve the load.

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[16] NERC, *Essential Reliability Services Task Force Measures Framework Report, available at* http://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/ERSTF%20Framework%20Report%20-%20Final.pdf (November 2015).

[17] *Id.* at p. v.

1.3.2. Electric Power Research Institute (EPRI) Study

The EPRI Program 103 Energy and Policy Analysis, of which the NYISO is a member, provides ongoing analyses of the timing, costs, risks, and emissions that result from various approaches for states to choose to comply with the CPP. Key insights gained to date include:

- Trading of emission allowances and/or ERCs reduce the national cost of compliance; however, the results are specific to the compliance approaches selected by a state,
- Development of a simulator for evaluating compliance strategies,
- Identification of potential approaches to trading both allowances and ERCs within a state that provide attractive compliance cost reduction opportunities, and
- Identification of compliance actions that can be influenced by assumptions about post-2030 CO_2 regulations.

1.3.3. RGGI Program Review

As briefly discussed above in Section 1.2.1, the RGGI 2016 Program Review is being conducted by the member states for the purpose of evaluating the effectiveness of the existing program, examining potential modifications for the RGGI program design and identifying changes that may be necessary for the program to meet the design criteria of the CPP.[18] The current program is designed to continue annual reductions of 2.5% until 2020. Proposals to continue cap reductions, as well as maintaining the 2020 cap, are being studied. The RGGI program has several design features that are intended to avoid price spikes and to avoid situations where the CO_2 reduction requirement could interfere with electric system reliability. These include a Cost Containment Reserve and emission offsets. Others under investigation are the continued inclusion of gas turbines that are not subject to the CPP, participation in the CPP Clean Energy Incentive Program, and broader markets.

The ongoing RGGI 2016 Program Review report is scheduled to be released in mid-year 2016. Further work planned for this Study will incorporate program amendments that are adopted by the RGGI program, as appropriate.

1.3.4. NYSPSC-TO State Resource Plan Assessment

The New York State Public Service Commission/Transmission Owner State Resource Plan Assessment Study ("NYSPSC-TO SRP Assessment") was initiated to examine effects of various public policies on New York's electric system.[19] The SRP study examines various portfolios of new resources, electric and gas transmission reinforcements, and retirements to determine potential approaches to achieve developing public policies. The study will undertake power flow transfer analyses, resource adequacy tests, and estimate production costs and associated emissions as directed by the NYSPSC. The NYSPSC-TO SRP Assessment is planned to be completed later in 2016.

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[18] https://www.rggi.org/design/2016-program-review

[19] *See* New York State Resource Planning Analysis, Presentation to NYISO Management Committee, *available at* http://www.nyiso.com/public/webdocs/markets_operations/committees/mc/meeting_materials/2015-12-17/Agenda%2004_NYSDPS%20SRP%20Presentation_revised.pdf (December 17, 2015).

1.3.5. NYISO Wind Study

The NYISO 2010 Wind Study, *Growing Wind*, determined that, with appropriate increases in regulation, up to 8,000 MW of wind could be added to the NYCA system.[20] The results showed, in the higher wind penetration cases, curtailments of wind generation could be reduced with appropriately planned transmission system upgrades. The wind modeling work from the Wind Study has been captured in this CPP Study.

1.3.6. NYISO Solar Study

The NYISO 2016 Solar Study, *Solar Impact on Grid Operations - An Initial Assessment*, determined that with appropriate increases in regulation up to 9,000 MW of photovoltaic (PV) and 4,500 MW of wind capacity can be accommodated without impacting reliability.[21] The solar modeling work from the Solar Study was captured in this Study. In particular, Scenario 2 of the Solar Study (*i.e.*, 3,500 MW wind and 3,000 MW PV) was adopted for behind-the-meter PV modeling in the high penetration scenarios of this Study.

1.3.7. Summary of Studies

Various elements of the above-referenced studies were incorporated in the study scope for this Study as identified below.

The NERC study created a framework with which to capture the current status of the response capabilities of a system and project changes that may arise from the introduction of increasing amounts of intermittent renewable resources. This Study incorporates the use of the NERC recommendations with respect to ERS and for a reliability review as included in the future work scope.

The EPRI program has created a model to simulate the operation of the nation’s grid under various scenarios, estimate costs and emissions, and identify potentially attractive trading groups. The emission results of the EPRI program study are reported both as a mass-based and rate-based framework to aid in the analysis of potential trading arrangements. Following this approach, this Study examined both rate-based and mass-based options for CPP compliance and regional solutions, such as RGGI.

The resource assumptions on location and output variability of renewable resources contained within the NYISO Wind Study and Solar Study were adopted in the high penetrations case of this Study.

Additionally, the findings in this Study are intended to offer input to the RGGI 2016 Program Review, as available, including detailed simulations that go beyond the level of analysis provided in the ICF International Integrated Planning Model (IPM).[22] GridView provides more granular analysis by capturing the constraints of New York’s electric system and simulating every hour of a study year.

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[20] *See* NYISO, *Growing Wind: Final Report of the NYISO 2010 Wind Generation Study, available at* http://www.nyiso.com/public/webdocs/media_room/press_releases/2010/Child_New_York_Grid_Ready_for_More_Wind_093010/GROWING_WIND_-_Final_Report_of_the_NYISO_2010_Wind_Generation_Study.pdf (September 2010).

[21] *See* NYISO, *Solar Impacts on Grid Operations – An Initial Assessment, available at* http://www.nyiso.com/public/webdocs/markets_operations/services/planning/Documents_and_Resources/Special_Studies/Special_Studies_Documents/Solar%20Integration%20Study%20Report%20Final%20063016.pdf (June 30, 2016).

[22] http://www.icfi.com/insights/products-and-tools/ipm

2. Study Tasks and Methods

2.1. Task 1: Develop Operational Limitations

In order to assess key parameters recommended within the NERC ERS Report and required by regulatory programs, various databases were assembled at the unit-level. Five years of data from prior Gold Books were used to build the base unit list. Table 2-1 contains the parameters for each EGU aggregated to the Gold Book PTID and the model unit name from GridView.

Table 2-1 Operational Limitation Database Parameter Information

Variable	Description	Symbol (Units)
Gold Book Data	Generator data reported to the NYISO	Various
Inertia	Generator inertial rating	H (MW-sec/MVA)
MVA Rating	Apparent power rating	Mbase (MVA)
Leading/Lagging MW and MVAR	Reactive capability	Various
Black Start (BS) Validation	Unit BS capability	N/A
Min Run Time	Minimum time of dispatch	(hours)
Min Down Time	Minimum time from shutdown to startup	(hours)
Max Stops/Day	Maximum number of stops per day	(# stops/day)
Min Gen	Minimum generation level	MG (MW)
Emergency Response Rate	Emergency response rate	EmRR(MW/min)
Response Rate Curve	Normal response rate	RR(MW/min)
Reg Mvmt Response Rate	Regulation movement response rate	RMRR(MW/6Sec)
EPA AMPD Annual and OS Data	EGU data reported to the EPA	Various
Permitted Limits	EGU environmental limits	Various

EPA Air Market Program Data (AMPD) was obtained at the EPA ID level[23] aggregated to annual and ozone season values for 2012-2015. AMPD data consists of gross generation (MWH), heat input (mmBtu), CO_2, NO_x, and SO_2 emissions (tons), hours of operation, and regulatory program registrations for the CPP, RGGI, and the proposed CSAPR Update Rule.

A database containing unit specific information and permitted limitations was developed to approximately quantify bounds of thermal unit operations at 136 NYCA "generators"[24] representing 31 GW of summer capability and 108 terawatt-hours (TWH)[25] of generation in 2015 (approximately 80% and 76% of NYCA totals, respectively). Information was compiled from environmental permits[26] and regulations,[27] site visits, generator provided information, and analysis of EPA AMPD hourly datasets.

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[23] Unique combination of Facility ID (ORISPL) and Unit ID as reported by AMPD.

[24] Several generators listed in the Gold Book may be combined and modeled as a single "generator" in the environmental limits database.

[25] A terawatt-hour or TWH is equivalent to one million MWH.

[26] The environmental permits included: Title V and State Facility DEC Air Permits, State Pollutant Discharge Elimination System (SPDES) Permits, and Nuclear Regulatory Commission Operation Licenses.

[27] Consideration of the EPA's Mercury and Air Toxics Standards (MATS) limits to oil- and coal-fired generators (*i.e.*, 10% or 8% capacity factor limits on oil firing) were included, as was 15% capacity factor limits from the Clean Water Act 316(b) Intake Structures Rule found in SPDES permits, effective over the five-year permit term.

Permitted oil use, emissions, load/capacity factor, fuel/heat input, water/thermal, and other limits with the potential to restrict an EGU's operations were assessed. The most restrictive set of limitations was imported into this Study's database and is included in Table 2-1 as "Permitted Limits." Generally, these are annual NO_x and fuel use limitations imposed within the Title V air permits issued by DEC.

In addition, the impact of air regulations (mentioned above) will be assessed. The NYISO operational database includes unit level identification for the CPP, RGGI, and CSAPR ozone season (OS) NO_x programs. EGUs external to the NYISO were assigned to regulatory programs based upon satisfaction of specific criteria—whether they were greater than 25 MW and were of the appropriate type, vintage, and fuel use composition. Modeling of these program assignment criteria were fine tuned by comparing them to the NYCA EGUs' actual unit level program assignments.

2.2. Task 2: Update 2015 CARIS Study

The starting point for this Study was the 2015 CARIS study. The assumptions and data were reviewed and revised to reflect new resource additions, retirements, load forecasts, fuel forecasts, emission price forecasts, and transmission reinforcements.

2.2.1. Fuel Forecast

This Study uses an updated fuel price forecast that includes regional long-term forecasts of natural gas, fuel oil, coal, and nuclear fuel prices for New York and neighboring control areas. The CARIS study developed a fuel price forecast methodology that has been vetted with NYISO stakeholders and market participants. The methodology is based upon the United States Energy Information Administration (EIA) yearly national delivered long-term fuel price forecasts and adjusted to reflect both local constraints as well as historic volatility patterns. In essence, regional basis and seasonal factors based on analysis of historical spot prices from selected hubs are used to forecast prices over the study horizon. Weekly fuel prices were developed using the CARIS methodology, which is assessed annually and updated regularly, reflecting the most recent information available.

The weekly oil and natural gas fuel price forecasts[28] used for this Study are shown in Figure 2-1 and Figure 2-2. The oil prices are relatively flat throughout the year—approximating $20/mmBtu for distillate fuel oil (DFO) and $12/mmBtu for residual fuel oil (RFO) —although there is some variation across the year and the oil hubs. Natural gas prices are expected to remain at or near historic lows on average. However, winter spikes, which are driven by insufficient gas system capabilities, are expected to continue without new gas transmission capacity reinforcements.

An additional natural gas price ("TCM3-Leidy") was applied to specific generators in central Pennsylvania that are located behind constrained pipeline corridors. This price forecast was based upon analysis of the Leidy and Transco price histories.

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[28] Unless otherwise stated, all dollar values presented in this Interim Report are in nominal dollars in 2024.

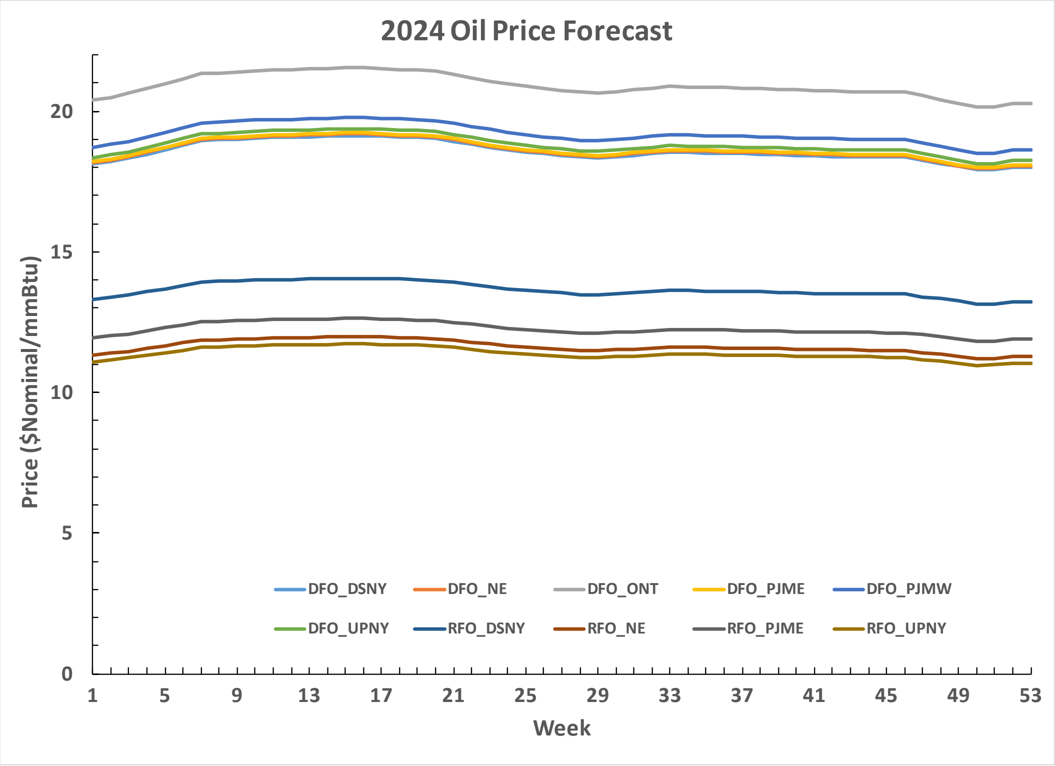

Figure 2-1 CPP Study Oil Price Forecast

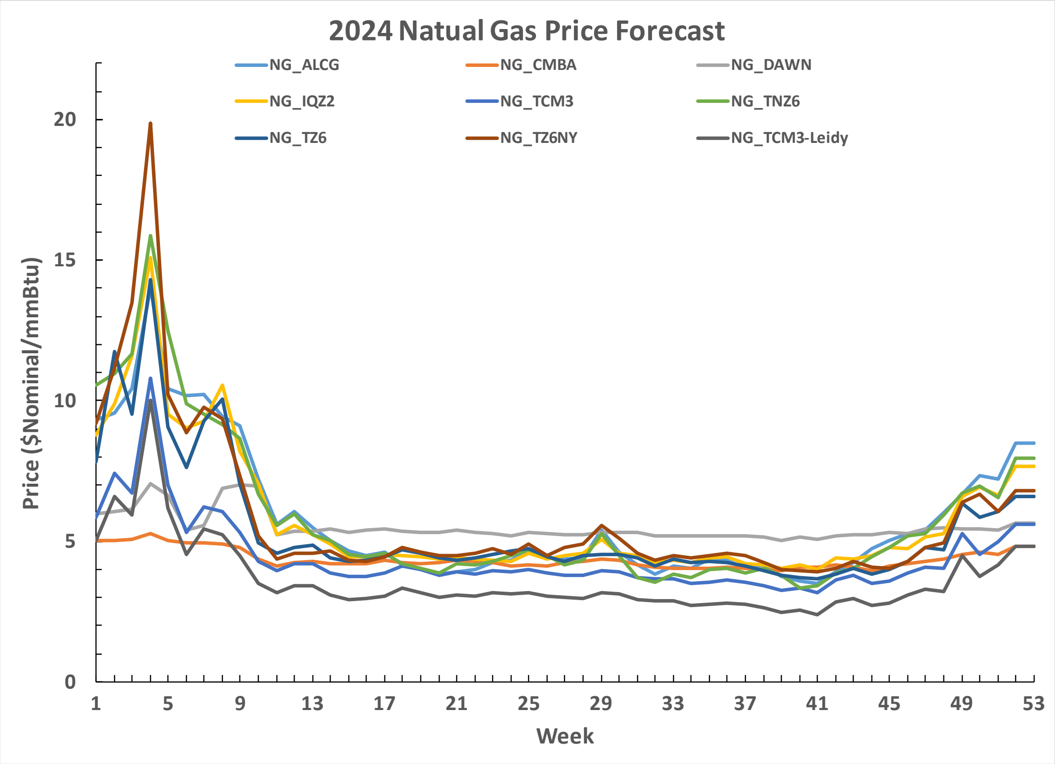

Figure 2-2 CPP Study Natural Gas Price Forecast

2.2.2. Resource Changes

This Study started with the 2015 CARIS 1 base case[29] and integrated resource additions and retirements to reflect those changes in the ongoing 2016 CARIS 2 database development efforts. Supplemental additions were performed to align the CARIS model with incremental modeling assumptions that did not meet the inclusion rules for CARIS.

Resource Additions

The 2015 CARIS 1 base case was updated to reflect all unit additions in the NYCA and in neighboring external control areas. Across NYISO, PJM, ISO-NE, and IESO, a total of 15.5 GW of capacity was added between the 2015 CARIS 1 base case and this Study's BAU case.

The NYISO resource additions were based on the 2016 Gold Book Addition list subject to the Reliability Needs Assessment (RNA) inclusion rules. Generation additions in PJM were based on the latest generation interconnection queue.[30] This Study used the latest ISO-NE 2019-2020 Forward Capacity Market (FCM) cleared unit list to add resources for ISO-NE.[31] IESO's latest 18 month outlook report was the data source used to build additions in IESO.[32]

As of summer 2020 12.7 GW of thermal units were added; a sizable majority being combined cycle units. Control area thermal additions for the CPP Study are summarized in Table 2-2.

Table 2-2 Thermal Additions by Control Area

Unit Type	Summer Capacity as of 2020 (MW)				
	NYISO	PJM	ISO-NE	IESO	Total
CC-Gas	678	9,213	-	-	9,891
CC-O/G	-	-	2,146	-	2,146
CT-Gas	-	-	93	-	93
CT-O/G	-	-	263	-	263
IC	-	96	-	-	96
ST	-	228	-	-	228
Total	678	9,537	2,502	-	12,717

As of summer 2020, 2.8 GW of renewable resources were added, most of which represents wind units. Control area and unit level renewable additions for the CPP Study are summarized in Table 2-3.

Table 2-3 Renewable Resource Additions by Control Area

Unit Type	Summer Capacity as of 2020 (MW)				
	NYISO	PJM	ISO-NE[33]	IESO	Total
Wind	93	1,480	-	833	2,406
Solar	-	280	-	140	420
Total	93	1,760	-	973	2,826

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[29] 2015 Congestion Assessment and Resource Integration Study(CARIS) Phase 1 Final Report, *available at* http://www.nyiso.com/public/webdocs/markets_operations/services/planning/Planning_Studies/Economic_Planning_Studies_(CARIS)/CARIS_Final_Reports/2015_CARIS_Report_FINAL.pdf (November 17, 2015).

[30] http://www.pjm.com/planning/generation-interconnection/generation-queue-active.aspx

[31] http://www.iso-ne.com/markets-operations/markets/forward-capacity-market

[32] http://www.ieso.ca/Pages/Participate/Reliability-Requirements/Forecasts-&-18-Month-Outlooks.aspx

[33] No new incremental ISO-NE renewable resources are assumed beyond the amount assumed within the ISO-NE load forecast.

Transmission

Generally, this Study used the NYCA transmission system model.[34] Figure 2-3, below, displays a simplified representation of the NYCA BPS. This transmission model generally consists of facilities 230 kV and above. However, the transmission model also includes certain 138 kV and 115 kV facilities as set forth in the NYISO's tariffs and manuals. In addition, Figure 2-3 shows key transmission interfaces.

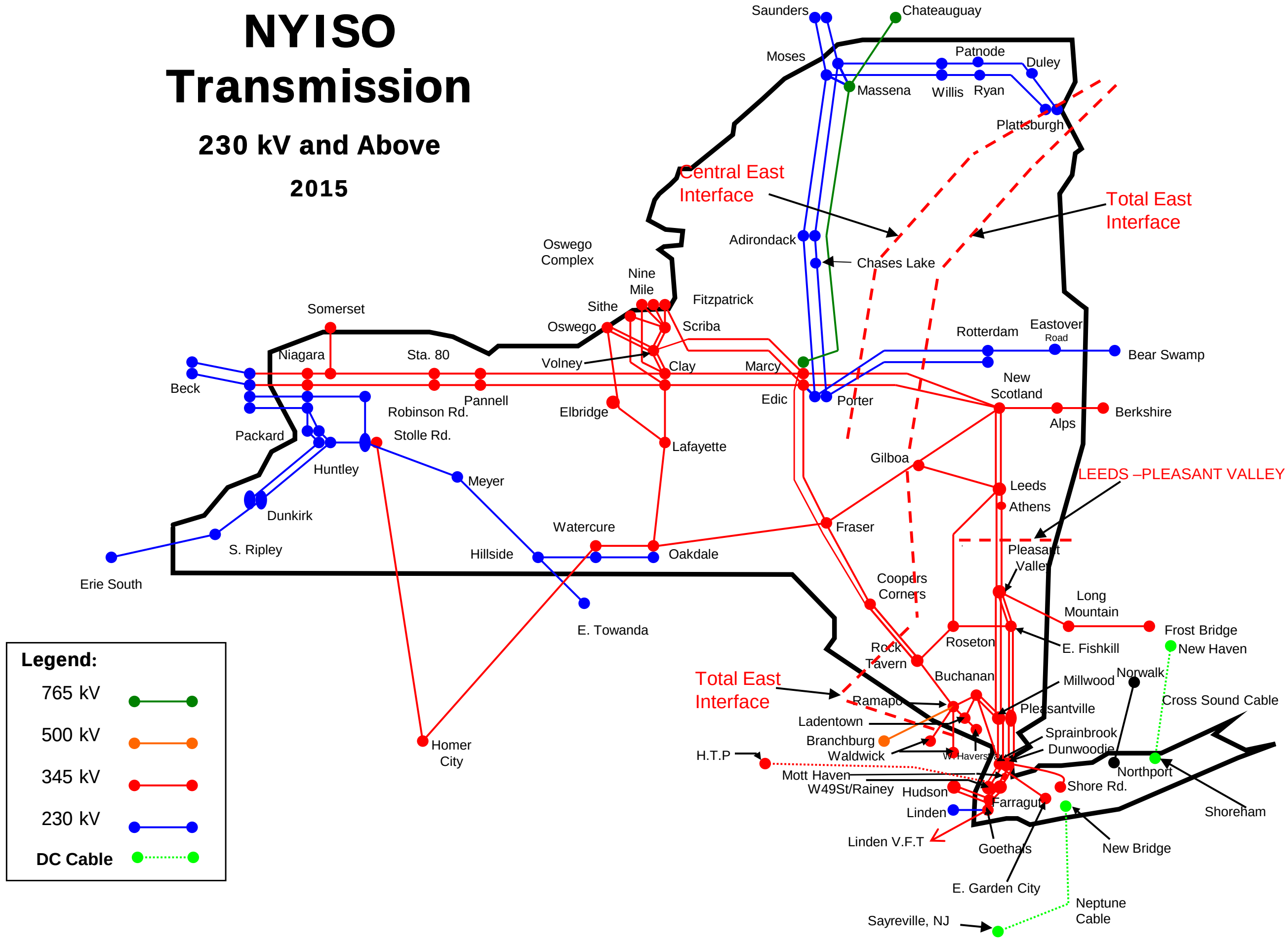

Figure 2-3 NYISO 230 kV and above Transmission Map

This Study also included incremental transmission changes to the 2015 CARIS 1 base case prior to the 2024 run year as follows:

- Staten Island Un-bottling Project Phase 2 was removed pursuant to a NYSPSC order modifying the Transmission Owner Transmission Solution (TOTS) projects following the announcement that the PSEG ConEd Wheeling Agreement will be cancelled,
- Packard Sawyer 77 & 78 1.5% series reactor was added,

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[34] 2015 CARIS – Phase 1 Appendices B-J

- Station 122 and Station 80 upgrade - Ginna Retirement Transmission Alternative (GRTA) was added, and
- Leeds Hurley 21% series compensation was added.

External Area Model

The external areas immediately adjacent to the NYCA, namely ISO-NE, IESO and PJM, were represented in the Study's model. Since Hydro Quebec (HQ) is asynchronously tied to the NYCA's bulk electric system, proxy buses representing the direct ties from HQ to NYISO, HQ to IESO and HQ to ISO-NE were modeled. The Study modeled the import capacity from HQ to NYISO as 1,310 MW.

Retirements

The Study also updated the model to reflect known announced unit retirements in the NYCA and in neighboring external control areas. The NYCA announced retirements were based on the 2016 Gold Book,[35] subject to the latest 2016 RNA modeling assumptions. Generation retirements in PJM were based on the latest Future PJM Deactivation list.[36] The NYISO modeled ISO-NE retirements using the Status of Non-Price Retirement Requests unit lists.[37] IESO's latest 18-month outlook was used to obtain retirements in IESO.[38]

Across NYISO, PJM, ISO-NE, and IESO, a total of 3.6 GW of capacity retired between the 2015 CARIS 1 and this Study's BAU Case of which included 2.5 GW of coal and nuclear unit retirements. Control area and unit level thermal retirements for this Study are summarized in Table 2-4, below.

Table 2-4 Retirements by Control Area

Unit Type	NYISO	PJM	ISO-NE	IESO	Total
CT-O/G	26	-	-	-	26
CT-OIL	118	-	-	-	118
ST-GAS	435	-	-	-	435
ST-O/G	-	443	-	-	443
ST-BIO	43	-	-	-	43
NUC	-	614	702	-	1,316
COAL	1,062	135	-	-	1,197
Total	1,684	1,192	702	-	3,578

2.2.3. Load Forecast

This Study uses a load shape model that is based on historical load data. Load peak and energy is summarized as follows:

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[35] *See* Section IV of the 2016 Gold Book, *available at* http://www.nyiso.com/public/webdocs/markets_operations/services/planning/Documents_and_Resources/Planning_Data_and_Reference_Docs/Data_and_Reference_Docs/2016_Load__Capacity_Data_Report.pdf (April 2016).

[36] http://www.pjm.com/planning/generation-deactivation.aspx

[37] http://www.iso-ne.com/system-planning/resource-planning/nonprice-retirement

[38] http://www.ieso.ca/Pages/Participate/Reliability-Requirements/Forecasts-&-18-Month-Outlooks.aspx

- The NYISO load forecast is based on the 2016 Gold Book Baseline Forecast of Annual Energy and Non-Coincident Peak Demand, including the impacts of Energy Saving Programs & Non-Solar Behind-the-Meter Generation.[39]
- The PJM load forecast is based on posted 2016 Load Forecast of Annual Energy and Non-Coincident Peak Demand.[40]
- The ISO-NE load forecast is based on 2016 Capacity, Energy, Load, and Transmission (CELT) Report Sub-area Load Forecast of Annual Energy and Non-Coincident Peak Demand prior to the impact of BTM solar PV and passive demand resources.[41]
- The IESO load forecast is from IESO Planning Group's 2015 Q2 Long Term Zonal Outlook Annual Energy and Non-Coincident Peak Demand prior to the impact of Net Conservation and Embedded Generation.

2.2.4. Behind-the-Meter Photovoltaic (BTM PV) Forecast

The NYISO's BTM PV forecast incorporated into the CARIS process was developed using an adoption-model approach. The forecast assumes that, over the forecast period, the cumulative NYCA capacity approaches the NY-Sun Initiative ("NY-Sun") goal of around 3,200 MW DC, or approximately 2,500 MW AC, of BTM PV, as shown in Table 2-6, below.[42]

Typically, BTM PV hourly generation is apportioned from zonal totals to load buses by the annual load shares of each load bus to the total zonal load. In this Study, in order to develop an equitable and reasonable modeling of BTM PV across Zone J (New York City) territory, the NYISO developed an updated methodology to apportion the forecasted PV by load bus. This methodology provides that the geographic distribution of PV in the model reflects the share of forecasted installed capacity.

The NYISO's methodology involves the following:

- Determine the NYISO county-level forecasts of PV capacity (measured in MW DC),
- Map Zone J load buses to the territory's counties, and
- Assign the shares of Zone J's coincident Summer Peak load by load bus from the Power Flow model used in the NYISO's planning analyses.

Using Queens for example, the forecasted PV capacity for a given year was allocated across that county's load buses based on the shares implied by the Power Flow. While the load bus shares are not constant over time, the differences across years were negligible at these adoption rates.

The PV shapes and forecasts were obtained from the CARIS study and augmented with additional BTM PV generation taken from the NYISO Solar Study. The 5-minute zonal shapes from the NYISO Solar Study were used for the HiRE and HiGT cases as a proxy for BTM PV generation by scaling the shape from Scenario 2 of the NYISO Solar Study to the appropriate installed incremental capacity levels in each case. Figure 2-4, below, displays the cross-correlation between the zonal BTM PV shapes from

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[39] *See* 2016 Gold Book.
[40] http://www.pjm.com/planning/resource-adequacy-planning/load-forecast-dev-process.aspx
[41] http://www.iso-ne.com/system-planning/system-plans-studies/celt
[42] Additional information on the NY-Sun is available at http://www.nyserda.ny.gov/All-Programs/Programs/NY-Sun.

Scenario 2 of the Solar Study. The more yellow the box the higher the correlation throughout the year. It is observed that the resource is moderately correlated across the NYISO's zones (83% correlated at a minimum); however, there are geographic regions within which the variations across zones diminish significantly.

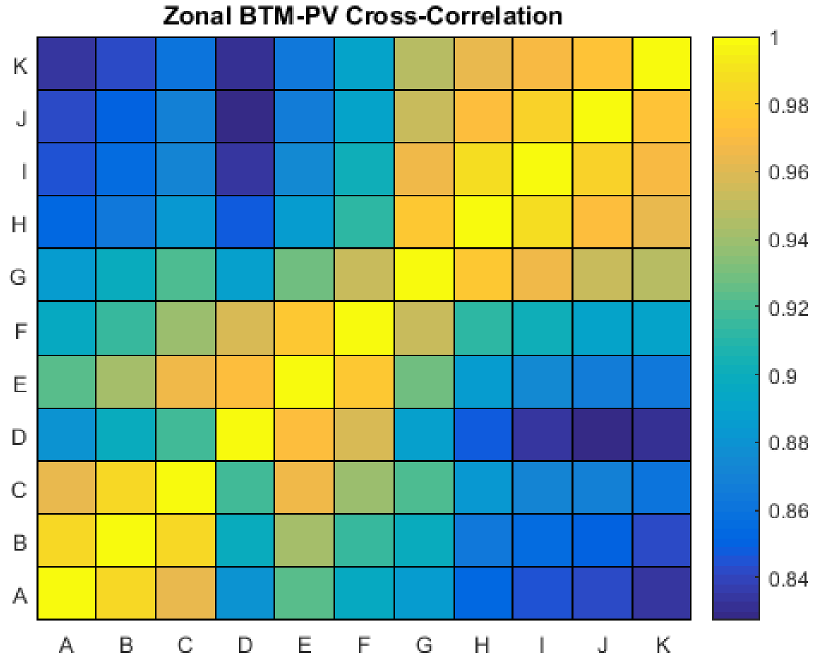

Figure 2-4 Zonal Correlation of PV Production Profiles from *Solar Impact on Grid Operations - An Initial Assessment* Scenario 2 - 3,000 MW BTM PV

2.2.5. Emission Price Forecast

The CARIS 2015 emission price forecast was updated in this Study. The prices for 2024 in Table 2-5, below, were used initially. In cases where NYISO noted emissions exceeded the RGGI-wide program cap, the RGGI CO_2 emission prices were increased until approximate compliance levels were achieved in the simulations. Prices were developed by examination of various historic emission allowance indexes and allowance auction clearing prices and forecasts as available. During the ozone season, the price of the sum of the OS and Annual NO_x allowances were applied as the emission price.

Table 2-5 CPP Study Emission Price Forecast

Emission Price Forecast ($/ton)				
Year	**Annual CO_2**	**OS NO_X**	**Annual NO_X**	**Annual SO_2**
2024	$18.41	$232.50	$45.00	$5.00
2030	$24.68	$202.50	$15.00	$5.00

2.3. Task 3: Develop Study Cases

The years 2024 and 2030 were selected for examination in this Study. The mid-term 2024 date was selected to examine compliance with the CPP during the Interim Step 1 compliance period (*i.e.*, 2022-2024), while the 2030 horizon year aligns with the first year of the final CPP compliance obligation. This Interim Report focuses on 2024, with sub-hourly and horizon year simulations reserved for further study.

The five cases studied were:

Business As Usual ("BAU"): Ginna and FitzPatrick nuclear units remain in-service; the CO_2 allowance price is zero for non-RGGI states; and RGGI CO_2 Cap is kept flat post-2020 at 78.175 million ton for 2024 and 2030.

Flat Cap ("FlatCap"): Ginna and FitzPatrick nuclear units retired before 2024; CPP is modeled as an imposed RGGI BAU price in non-RGGI states; and RGGI CO_2 Cap is kept flat post-2020 at 78.175 million ton for 2024 and 2030.

Declining Cap ("DecCap"): Ginna and FitzPatrick nuclear units retired before 2024; CPP is modeled as an imposed RGGI BAU price in non-RGGI states; and RGGI CO_2 emissions are capped by a 2.5% annual reduction post-2020 at 70.646 million tons for 2024 and 60.690 million tons for 2030.

High Renewable Energy ("HiRE"): Ginna, FitzPatrick, and Indian Point nuclear units retired before 2024; CPP is modeled as an imposed RGGI BAU price in non-RGGI states; RGGI CO_2 emissions are kept flat post-2020 at 78.175 million ton for 2024 and 2030; and Indian Point capacity and energy are replaced by 1,400 MW Gas Turbine (GT) units at the Indian Point plant location, 6,791 MW of wind generators in upstate New York, 1,400 MW offshore wind off Long Island, and 3,538 MW BTM PV distributed across New York.

High Gas Turbine ("HiGT"): Ginna, FitzPatrick, and Indian Point nuclear units retired before 2024; CPP is modeled as an imposed RGGI BAU price in non-RGGI states; RGGI CO_2 emissions are kept flat post-2020 at 78.175 million ton for 2024 and 2030; and Indian Point capacity and energy are replaced by 2,500 MW GT units at the Indian Point plant location, 4,619 MW of wind generators in upstate New York, and 3,288 MW PV distributed across New York.

The combinations of resources to replace retiring nuclear facilities in the HiRE and HiGT cases were selected to provide an approximation of the equivalent replacement capacity and energy. In all cases studied in this Interim Report, CPV Valley is assumed in service by 2024 and the NY-Sun goal of over 3,000 MW DC BTM PV is assumed to have been reached by 2024, as reflected in Table 2-6, below. Wind and solar resources in the BAU, FlatCap, and DecCap cases were derived from the most recent CARIS Phase 1 Study, while in the HiRE and HiGT cases the assumed wind and solar is taken from the NYISO Wind and Solar Studies.

RGGI CO_2 prices, as shown in Table 2-6, were determined by maintaining approximate RGGI-wide compliance with the nine-state program cap for each case in this Study as outlined at the bottom of Table 2-6. To meet the RGGI targeted cap, CO_2 allowance prices were increased for all RGGI states until the cap limits were achieved. As shown in Table 2-6, upward adjustment was required in all cases except the BAU case. Emissions associated with new combined cycle (CC) generators will be counted towards CPP totals within the RGGI states. Conversely, for non-RGGI states, new CC plants will not be included in the CPP emission totals.

The Province of Ontario has announced plans to establish an economy-wide CO_2 emissions cap program that will be linked with Quebec and California. Estimates for allowance prices in California have been used as a proxy for Ontario. It was assumed within non-RGGI states in all cases except the BAU that emitting generators are exposed to the BAU RGGI allowance price.

Table 2-6 Scenario Details for 2024 Study Cases

Assumption	BAU	Flat Cap	Dec Cap	HiRE	HiGT
Ginna and FitzPatrick	In	Out	Out	Out	Out
Indian Point	In	In	In	Out	Out
CPV	In	In	In	In	In
RGGI CO_2 Price ($/ton)	18.48	27.74	36.96	27.74	27.74
Ontario CO_2 Price ($/ton)	36.96	36.96	36.96	36.96	36.96
Non-RGGI CO_2 Price ($/ton)	-	18.48	18.48	18.48	18.48
Wind (MW)	1,820	1,820	1,820	8,191	4,619
PV (MW)	2,538	2,538	2,538	3,538	3,288
Replacement GT (MW)	-	-	-	1,400	2,500
RGGI Wide CO_2 Target (mmtons)	78.18	78.18	70.65	78.18	78.18

2.4. Task 4: Report and Analyze CARIS Metrics and Essential Reliability Services

CARIS Metrics

This Study employed GridView to simulate hourly production in the NYCA and the surrounding control areas—ISO-NE, PJM, and IESO.[43] The model respects the system constraints and is driven by unit-specific inputs, such as: fuel costs, heat rates, start costs, ramp rates, emission rates, and emission allowance costs. For this Study, the results are reported using the format developed for the CARIS study and are augmented to provide reports on the emissions and ERS. Specifically, GridView reports typical CARIS metrics, production cost, load payment, congestion, and emissions.

Each case was examined with GridView. The reported operations were compared to limits for each unit and to the operational limit database. Emissions results were further compared to statewide-emission limits for the CPP, RGGI, and proposed CSAPR Update Rule. The model output reporting was augmented with a review of the ERS characteristics of the NYCA fleet for each hour studied.

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[43] HQ is asynchronously tied to the NYISO's bulk electric system and, therefore, represented by proxy buses directly tied between HQ and other regions.

NERC Essential Reliability Services Task Force Measures Framework

The ERS Task Force found in the NERC ERS Report that the most important ERS are: managing frequency, net demand ramping, and voltage support. The ERS Task Force recommended the following:

- **Frequency support –** track and project the levels of conventional synchronous inertia and the initial frequency deviations in the half second following the largest contingency for each BA area and the interconnection as a whole.
- **Ramping –** track and project the maximum one-hour and three-hour ramps for each BA.
- **Voltage support –** track and project static and dynamic reactive power reserve capabilities to regulate voltage at various points in the system and monitor events related to voltage performance. Periodically review the short circuit current at each transmission bus in the network, as well as perform further analysis of short circuit ratios when penetration of nonsynchronous generation is high or anticipated to increase.

Frequency Support

Synchronous Inertial Response (SIR) is a measure of kinetic energy in the system. NERC recommends coordination among BAs to begin performing interconnection wide analysis.[44] The ERS analysis methodology provides both historical and future views and will assist the NYISO in identifying potential SIR-related issues as the fleet evolves. At the NYCA level, for every hour in a year, the total available inertial response from all on-line synchronous generation was determined. Circumstances resulting in minimum inertial response were identified and examined.

Net Demand Ramping

Changes in net demand[45] require BAs to utilize the load-following capabilities of generators (and loads) to balance the system. As the penetration of nondispatchable and/or variable energy resources increase, a need for enhanced system ramping capabilities to follow larger, and less predictable net demand ramps may arise. Measure D examines net demand ramping variability at the BA level. NERC recommends quantification of historic and projected maximum one-hour and three-hour up and down net variability. The net load is typically calculated by netting the total load of variable energy resource production, although other types of resources may be included. Calculating the net demand ramping variability measure generally requires the most temporally resolved data available.

Voltage Support

Reliable and efficient operation of the BPS depends upon the ability to control the production and absorption of reactive power. Unlike frequency response, which can draw on a large geographic region for support, voltage concerns tend to be more local in nature and typically require a coordinated resource response at the right place or other actions (including, among other things, installation of reactive resources, addition of series compensation, and the use of out-of-merit resources).

Future work in this Study will examine additional ERS metrics/measures, including the reactive capability and voltage performance of the system.

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[44] Measure C (SIR at the BA Level) from the NERC ERS Report is identical to Measure A (at the interconnection level and, therefore, outside the scope of this CPP Study).

[45] “Net Demand” is defined as the load required to be served by the conventional, dispatchable generation fleet and is typically calculated as the net load of all variable energy resource generation, which may potentially include resources in addition to wind and solar generators.

3. Results

Updates to the 2015 CARIS base case were included in this Study's cases as described in the Section 2 of this Study. These changes were incorporated to better represent system conditions as currently forecasted and to provide meaningful comparisons between the cases.

3.1. Task 1: Environmental Limitations

Local, state, and federal regulatory air programs constrain the operation of conventional EGUs. The focus of this Study is on the federal and (multi-)state air regulations impacting the power sector. Particular attention is paid to carbon dioxide (CO_2) and ozone season nitrogen oxides (NO_x) as they represent the largest long-term power sector pollutant and the most-pressing, near-term health concern presented by pending regulations, respectively.

Compliance with the CPP, RGGI, and proposed CSAPR ozone season NO_x limits were assessed at the state level for those states regulated by each program, as well as comparing the program cap to the aggregate emissions among affected states.

3.1.1. EPA CPP

CPP affected EGU emissions and generation were aggregated in each state and compared to the state mass- and rate-based goals provided in the CPP. The comparison of the CPP mass-based goals in this Study uses the New + Existing[46] goal in the eight RGGI member states and the Existing Only goals in the remaining modeled states.

Figure 3-1, below, shows the CPP compliance comparisons in each state and in each case for both state mass- and rate-based approaches. The top panel displays the CO_2 emissions relative to the Interim Step 1 (*i.e.*, 2022-2024) annualized mass-based goals.[47] The corresponding state emission rates and goals are shown in the bottom panel. The states' average emission rate may be reduced by lower emissions at existing sources and by new qualifying renewable energy (RE). The quantities of qualifying RE are indicated by darkened portions of the rate bar segments in the bottom panel of Figure 3-1. In New York and across all scenarios, the forecasted operations are within the Interim Step 1 limits set in the CPP for both mass- and rate-based compliance approaches.

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[46] The CPP does not provide EPA with the authority to regulate emissions from "New Sources" under the same rule as existing sources, unless a state chooses to treat new and existing sources under the same rule in its implementation plan. In contrast, the RGGI program regulates both new and existing sources under the same rule.

[47] In this Study, RGGI state CPP mass-based goals are presented as New+Existing while non-RGGI states mass-based goals are for existing units only. New EGU emissions and generation are not included in the calculated state rates.

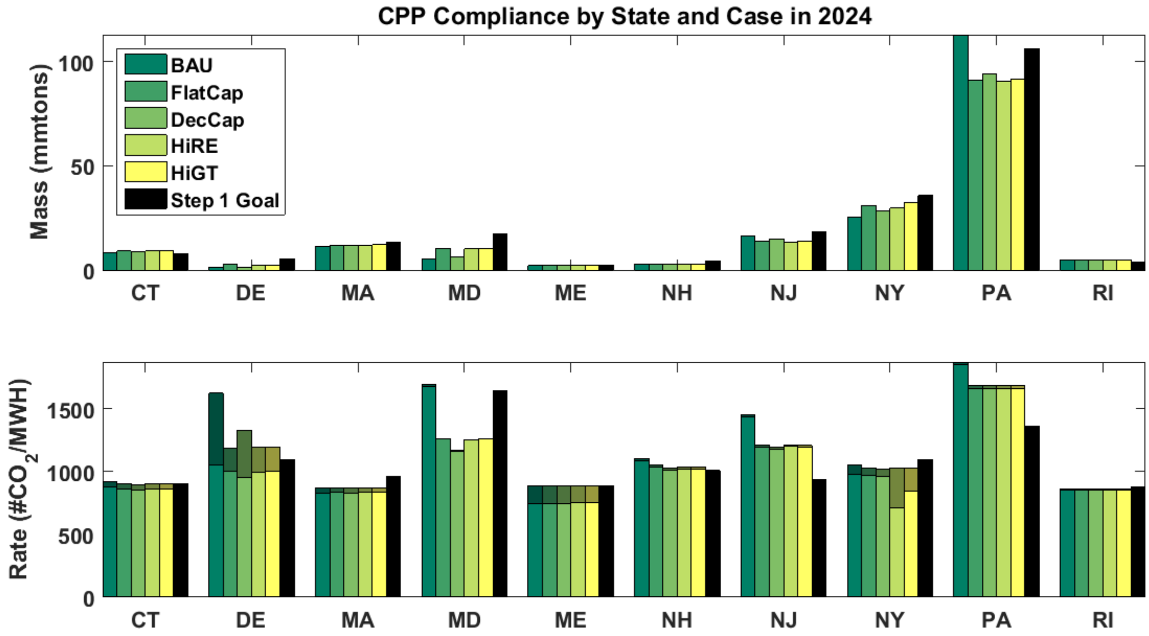

Figure 3-1 Clean Power Plan Mass and Rate Compliance Comparison

ERC-eligible renewable generation is only a portion of the total renewable generation. For the states plotted in Figure 3-1, the total and ERC-eligible (potential) generation is shown in Figure 3-2. The darkened portions of the bar indicate the amount of renewable generation assumed to be eligible for ERC generation.

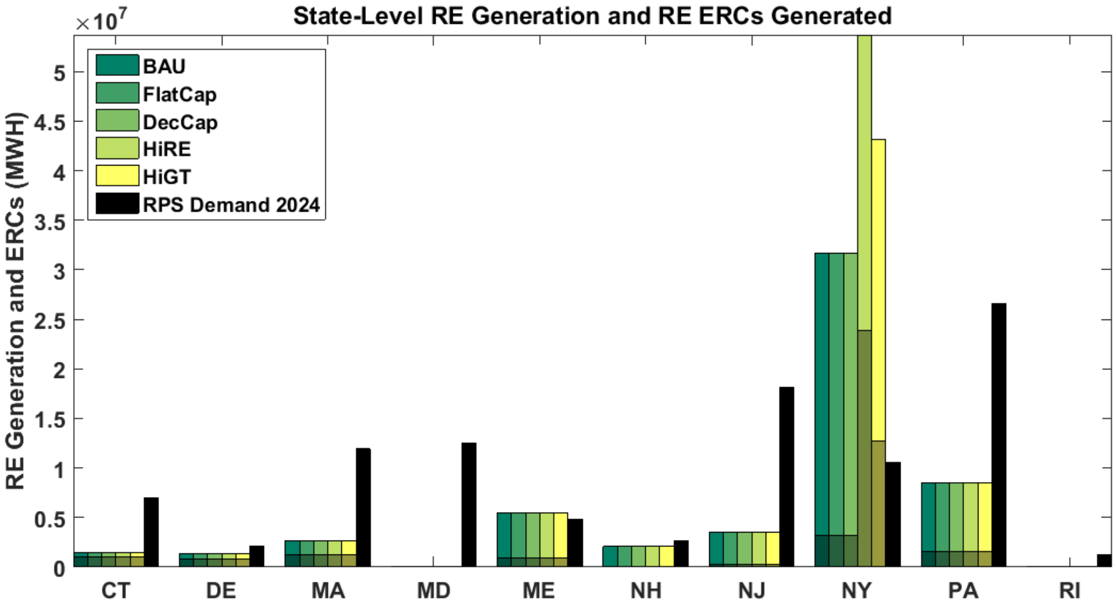

Figure 3-2 Total Renewable and ERC Generation Potential

The projected demand in 2024 for existing renewable portfolio standard (RPS) programs in these states is shown for comparison in Figure 3-2, above.[48] The New York RPS demand of 10.4 million MWH represents the original RPS Main- and Customer-Sited Tier targets for 2015. Based upon the most recent progress report, 2015 attainment towards this goal was approximately 60%.[49] In addition, a reported 24% of New York generation was from renewable energy sources.[50] For comparison, the largest shaded bar in New York, in the HiRE case represents 23.8 million MWH or eligible ERCs generated. New renewable generation imbedded within the CELT forecast for ISO-NE was assumed to generate ERCs and has been included in the darkened bar segments in Figure 3-1 and Figure 3-2.

3.1.2. RGGI 2016 Program Review

The CO_2 emissions for RGGI states (excluding Vermont) are shown in Figure 3-3 across the study cases for the CPP (*i.e.*, the left half of the bars compared to the black limit) and RGGI (*i.e.*, on the right half of the bars compared to the red limit) affected fleets. The CPP (black) and RGGI[51] (red) limits are also shown for comparison. The difference between the RGGI and CPP emissions in a given case reflects the difference in the cohort of regulated or affected units in each program. Generally, due to the state caps and the list of affected units, RGGI is more stringent and imposes larger compliance burdens than the CPP for the RGGI member states. This result seems to be consistent with the most recent analysis by the EIA in their examination of the impacts of the CPP on the RGGI states.[52]

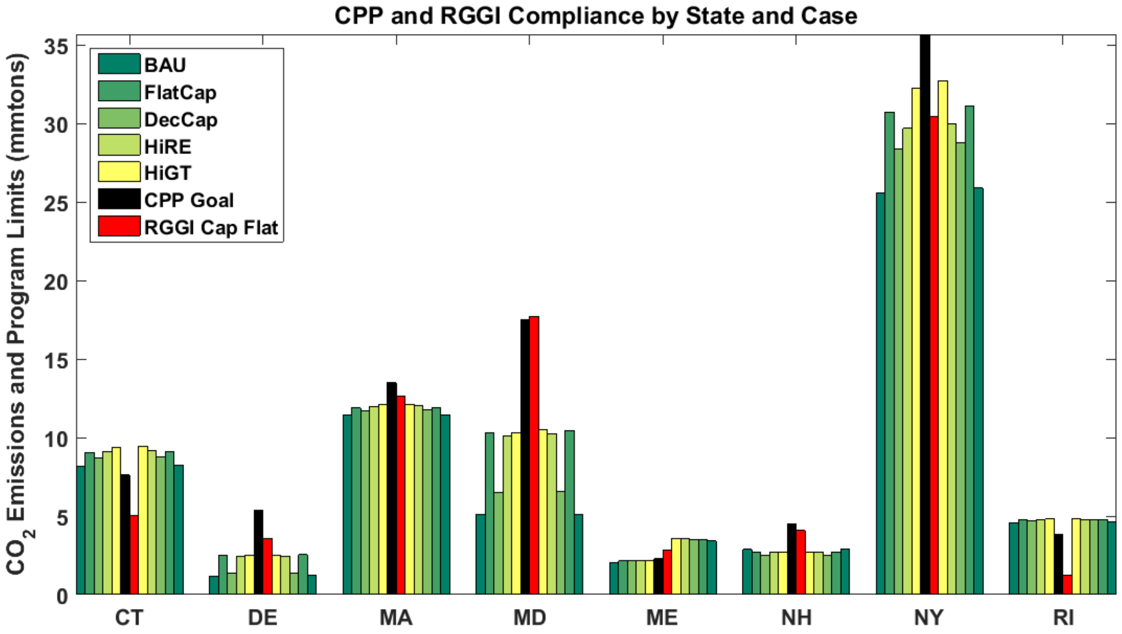

Figure 3-3 Regional Greenhouse Gas Initiative and CPP Mass Compliance Comparison

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[48] Found at https://emp.lbl.gov/projects/renewables-portfolio using values from the most recent RPS demand file available at the time of report drafting https://emp.lbl.gov/sites/all/files/RPS%20Demand%20Projections_March%202016.xlsx
[49] http://www.nyserda.ny.gov/-/media/Files/Publications/Energy-Analysis/RPS/2016-RPS-Annual-Report.pdf
[50] *Id.*
[51] Only the RGGI flat caps are shown. The declining caps are not shown for comparison with the DecCap case here, see Table 3-1.
[52] https://www.eia.gov/forecasts/aeo/cpp.cfm

Figure 3-4, below, shows the compliance margin (*i.e.*, computed as the applicable limit minus the program emissions) or excess allowances that a state would have based upon projected operations. For the FlatCap, DecCap, and HiGT cases, RGGI compliance for New York will depend upon a supply of surplus allowances available from other RGGI states.

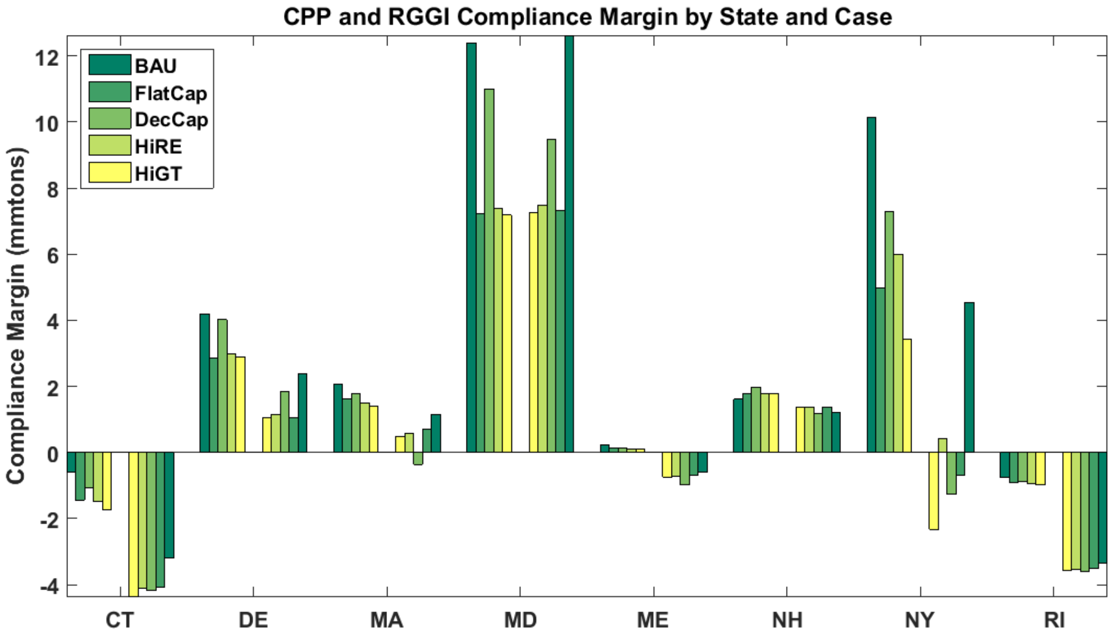

Figure 3-4 Regional Greenhouse Gas Initiative and CPP Mass Compliance Margin Comparison

3.1.3. EPA Proposed CSAPR Ozone Season Phase 2

NO_x emissions in New York and neighboring affected states were examined during the ozone season for comparison with the limits proposed in the proposed CSAPR Update Rule. A detailed review of the results for New York is shown in Figure 3-5, below. The bars show either ozone season emissions or limits in tons of NO_x. Historic emissions in the 2014 and 2015 ozone seasons were well below the current CSAPR Phase 2 NO_x budget of 10,369 tons, but above the proposed budget of 4,361 tons. The budget level in the proposed CSAPR Update Rule represents a 58% reduction from the 2017 budget in the current rule. However, those historic emissions exceeded the proposed trading limit of 5,277 tons (21% above the budget). In addition, examination across the Study cases shows that in no case was the ozone season NO_x emissions under budget and were only within the trading limit in the BAU and DecCap cases, as illustrated in Figure 3-5.

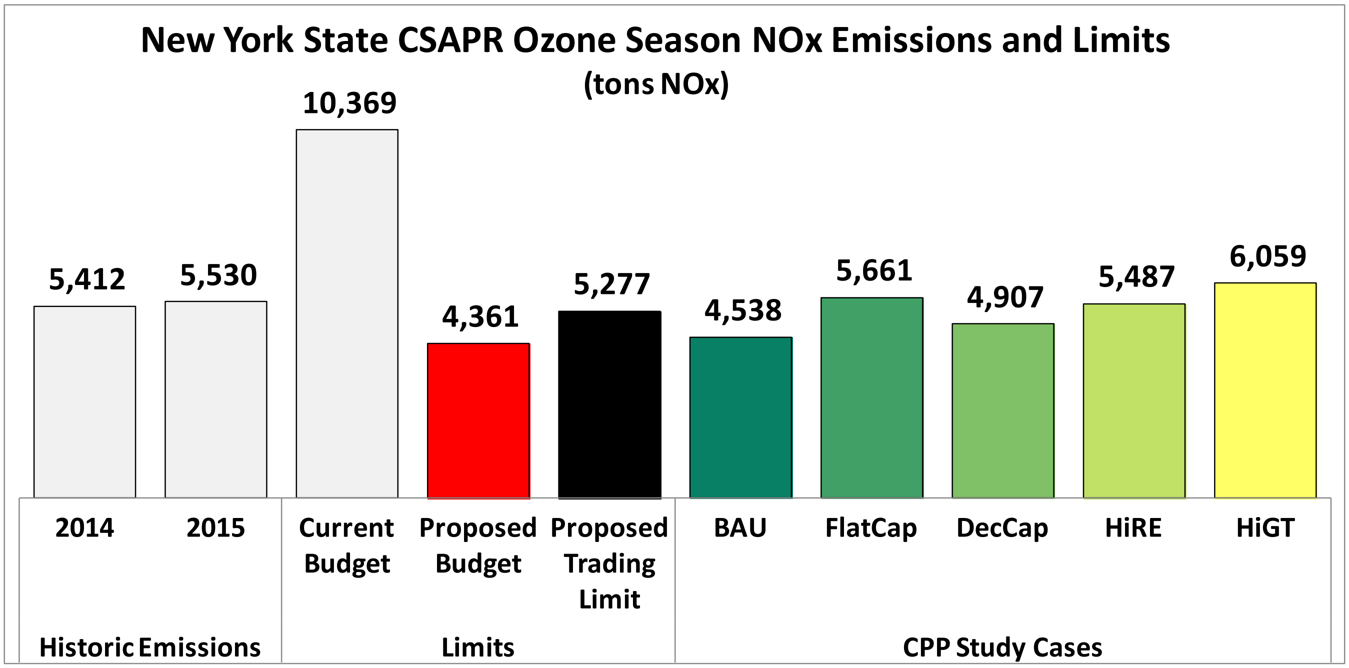

Figure 3-5 New York CSAPR Ozone Season NO_x Emissions and Limits

Ozone season NO_x emissions within Maryland, New Jersey, New York, and Pennsylvania are shown in Figure 3-6, below, relative to their respective statewide budgets and trading limits. The proposed CSAPR Update Rule does not affect the New England states or Delaware. However, significant proposed reductions create an additional compliance burden beginning in May 2017 that would affect New York, as well as Pennsylvania and New Jersey—both of which are facing proposed emission reductions in excess of 70% from their current Phase 2 limits. The constrained limits would likely increase the need for interstate trading and flexibility in the supply of allowances among New York and its neighbors.

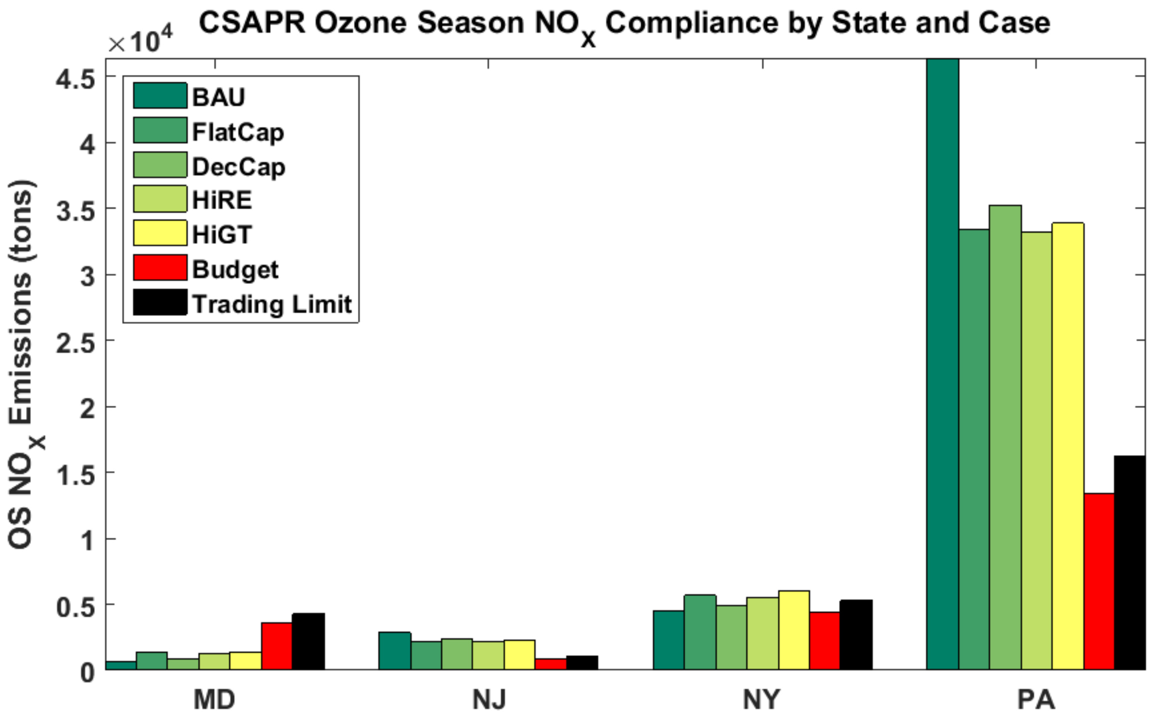

Figure 3-6 CSAPR Ozone Season NO_x Comparison

3.2. Task 4: Production Cost Simulations with Essential Reliability Services Reporting

In addition to the standard metrics typically generated by the CARIS study and other power sector models, a more detailed analysis was employed in Task 4 to examine the load served by NYCA generation. Within each hour, the portion of load served by different fuels was calculated for the BAU case, as presented in Figure 3-7, below. This Study used CO_2 emission rates based upon heat input to perform hourly fuel assignments to determine both the generation and fuel use progressions. Weekly and daily variations were observed, along with the more gradual seasonal changes in load (red line in the top panel of Figure 3-7) between the summer and winter peaks. Based upon the results, the model only used oil for start-up or during the second week in January when the gas price spiked, as shown in Figure 2-2, and attained levels above the less dynamic oil price represented in Figure 2-1.

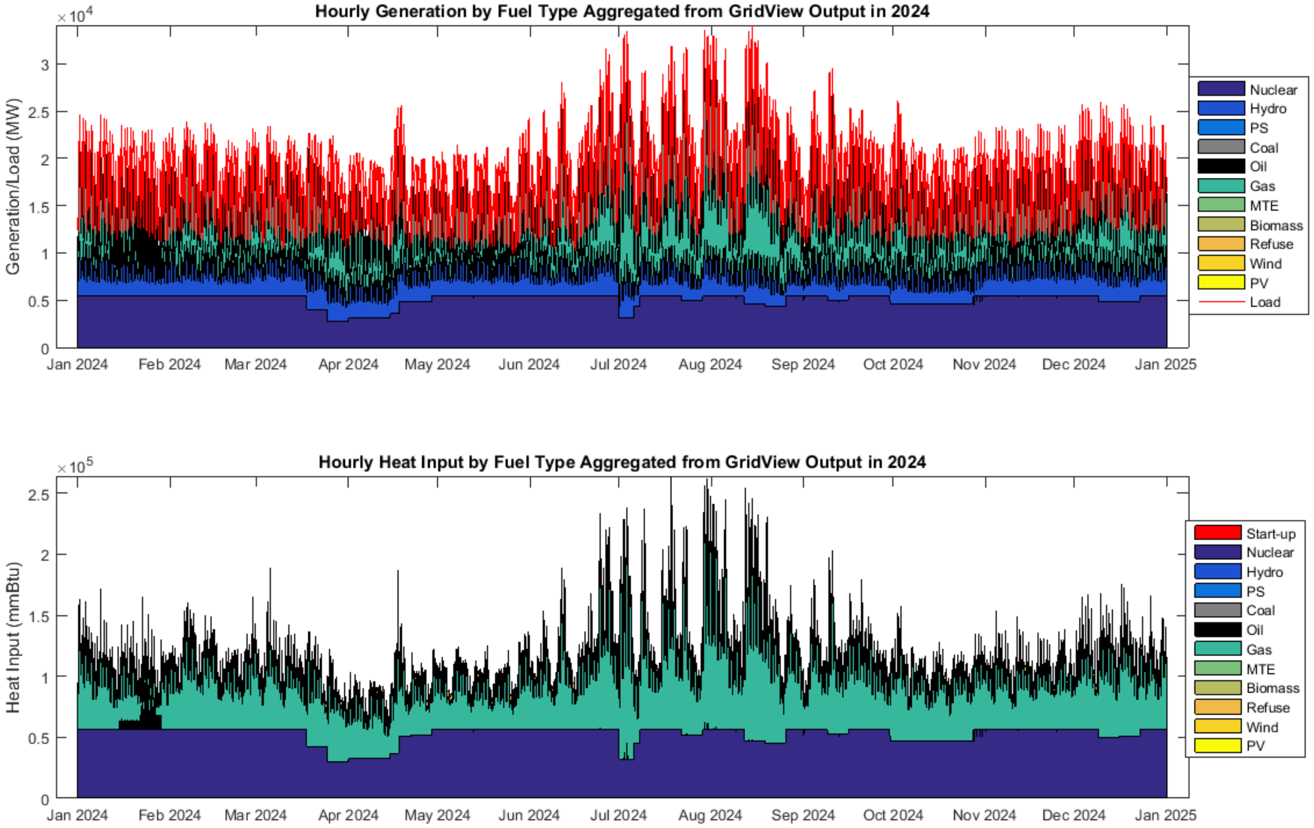

Figure 3-7 Hourly Generation and Heat Input by Fuel Type from BAU Case

In addition, the GridView model output was further analyzed using the methodological recommendations presented in the NERC ERS Report. As outlined above in Section 2.4, this Study primarily focused on the assessment of voltage control, frequency support, and ramping capability.

The recommendations of the NERC ERS Report served as the basis for computing metrics of interest based upon the model output and the assembled database of operational parameters and limitations.

Frequency Response

As discussed in Section 2.4, inertia is an important attribute that the electric system depends on to respond to the loss of resources or interruptions in the network. Frequency is restored by the big rotating mass typical of large synchronous conventional generators. Examination of the inertia, H in MW-sec/MVA, and the kinetic energy, KE = H*MVA[53] in MW-sec, of the operating fleet and the change in these values with evolving generation mix has been identified as an important metric to be tracked by the ERS Task Force.

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[53] MVA refers to the generators MVA rating, or apparent power rating, in megavolt amperes.

Figure 3-8, below, displays the inertia and kinetic energy calculated for the BAU case. The hourly inertia profile, annual average inertia, and duration curves (sorted highest to lowest, not chronologically per the x-axis) are shown, along with similar display for kinetic energy in the lower panel of Figure 3-8. The corresponding histogram for each hourly profile is displayed to the right. In addition, the occurrence of the kinetic energy minimum is indicated by a red point in the lower left panel.

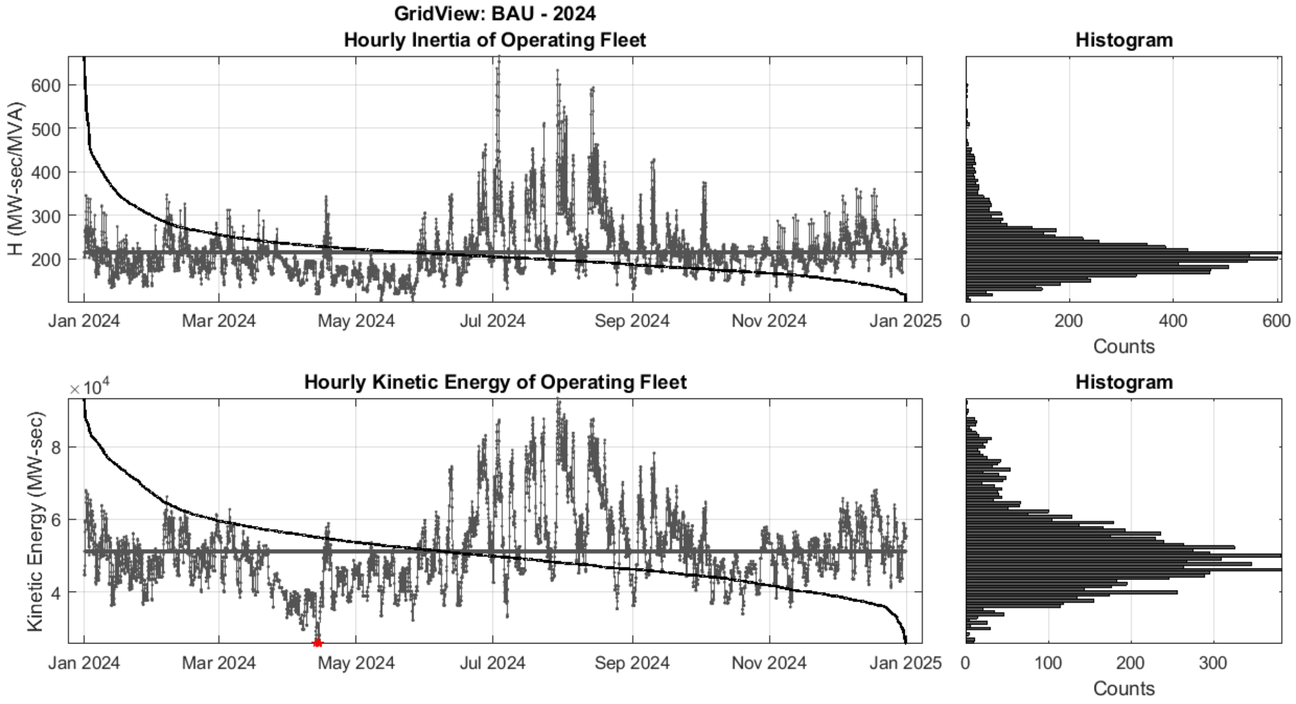

Figure 3-8 Inertia and Kinetic Energy of the Operating Fleet: BAU Case - 2024

A similar assessment for each case was performed with the resultant kinetic energy profiles shown in Figure 3-9, below. The kinetic energy appears to track the chronological load shape throughout the year, by comparing it with the load (red line) in the top panel of Figure 3-7. The results show that kinetic energy is observed to be higher in the summer and winter months than the spring and fall with daily and weekly variations.

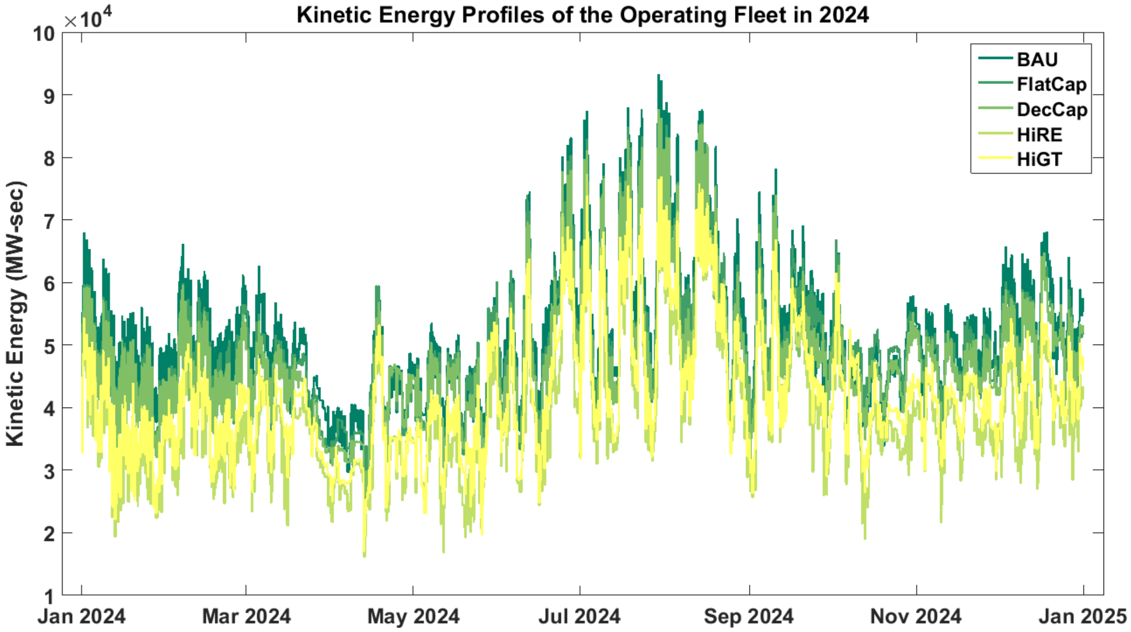

Figure 3-9 Kinetic Energy Profiles of the Operating Fleet: All Cases Studied - 2024

Following the methodology recommendations in the NERC ERS Report, the kinetic energy was plotted as a function of net load in each hour. The linear and quadratic trendlines are displayed for comparison. Figure 3-10, below, clearly demonstrates that the lower the net load, the lower the corresponding kinetic energy and inertia on the system. This means that under the same demand/load assumptions, the more RE resources that are on the system, the lower the net load and the lower the corresponding kinetic energy/inertia. However, the gross load may need inertial response to maintain transient stability, which is currently provided by conventional resources. Therefore, this Study will perform a further detailed stability analysis based on these initial findings.

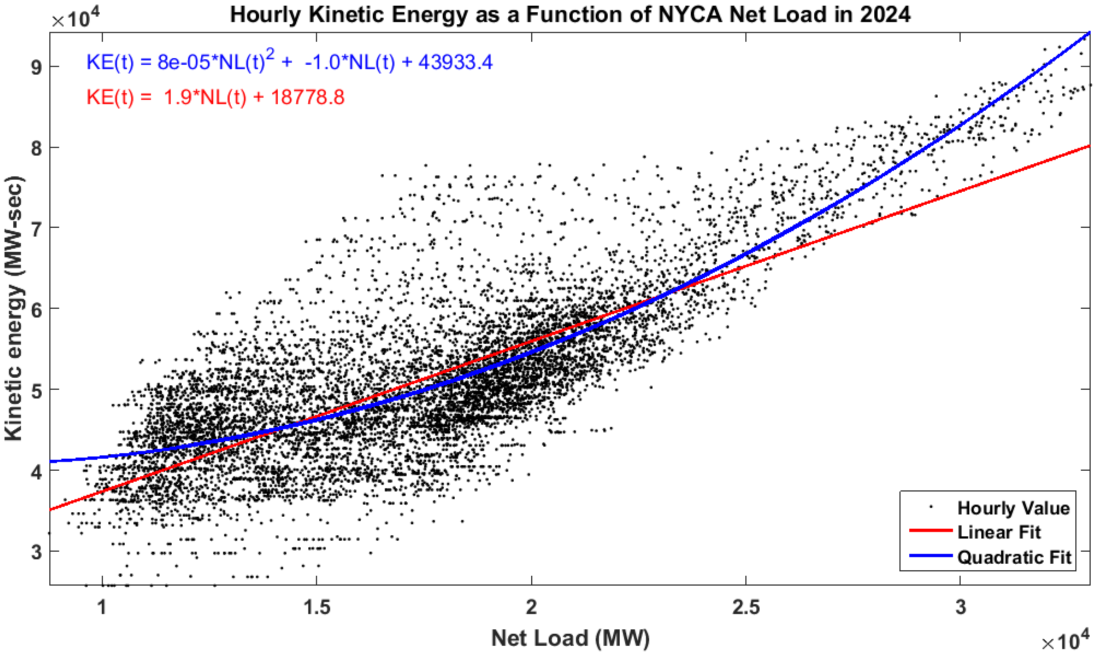

Figure 3-10 Kinetic Energy Plotted against Net Load: BAU - 2024

This Study observed the same phenomenon when examining the kinetic energy distributions for each study case as shown in Figure 3-11, below. The box and whisker plot in Figure 3-11displays the hourly values sorting from largest to smallest and presents information pertaining to the distribution of points in relation to the rest of the values from that case. The median value for each Study case's hourly inertia values are shown by a red line in the center of each blue box. The lower and upper edges of the box represents the 25th and 75th percentile values, while the "whiskers" cover ±2.7σ (99.3% assuming normally distributed data). Outliers outboard of the ±2.7σ cutoff are shown as blue dots for each case. Most outliers are above the normal distribution consistent with the histograms in Figure 3-8, above.

The observed similarity in the hourly profiles in Figure 3-9, above, is also reflected in Figure 3-11, where similar distributional parameters are seen across the Study cases. Importantly, this Study observes that the largest contingency for which the system is planned and operated requires a small portion of the available inertia from within New York even in the high RE cases.[54] No inertia is assumed to be available from wind and solar resources. In study cases with larger shares of generation served by renewable energy resources, namely the HiRE and HiGT cases, lower median kinetic energy values are observed. While only a handful of hourly points fall below the "whiskers," in the HiRE case no such hours are observed. This is due to the fact that in the HiRE case, the system had less inertia in every hour, skewing the distribution parameters downward and squeezing out any bottom end outliers within an assumed normal distribution.

It should be noted here that inertia is not necessarily an indication of system stability. In fact, the physical distribution and interconnection location of generators can have a noticeable effect on the inertial system response in an area. For example, such factors as synchronous torque between regions in

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[54] For a frame of references in reviewing Figure 3-11, the largest NYCA contingency has a kinetic energy value of less than 1 x 10^4 MW-sec.

the BPS matter more than the total inertia for system stability. Based on these preliminary findings, this Study will expand upon a review of stability in a separate detailed stability analysis.

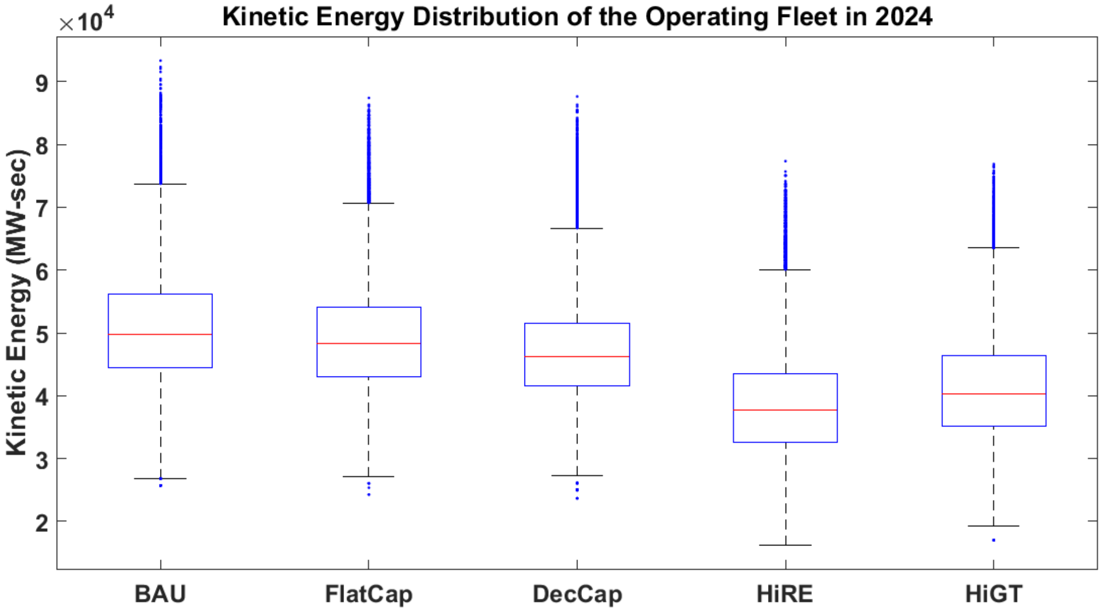

Figure 3-11 Kinetic Energy Distribution of the Operating Fleet: All Cases Studied - 2024

VAR Support

By comparing the hourly output of the GridView model to the operational database, this Study was able to assess the leading and lagging VAR capabilities of operating generation in each NYCA zone for each hour of the simulated year. Figure 3-12, below, displays the zonal composition of the hourly VAR support capability of the operating fleet. Leading VAR capability is plotted as positive and lagging VAR capability is plotted as negative in Figure 3-12 with colors representing the NYCA zones. The presented aggregation simply represents a tally of rated capabilities and not a full assessment of the local upward/downward VAR support that the fleet is capable of providing in a given hour based on current operating conditions, unit specific range limitations, and other factors not considered in this assessment.

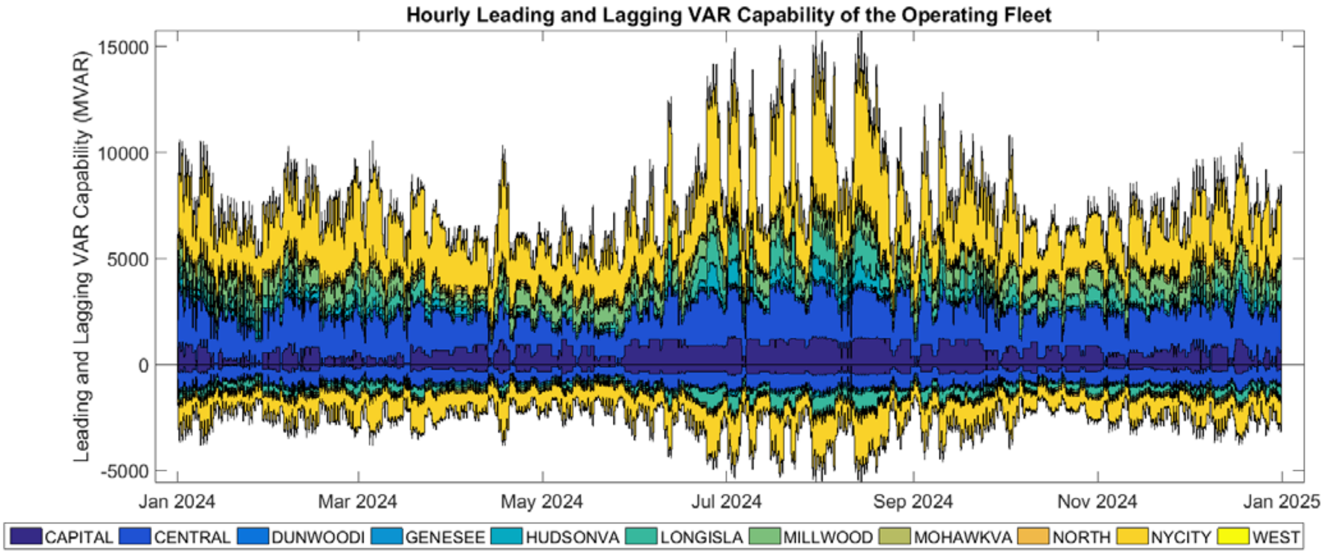

Figure 3-12 Hourly Leading and Lagging VAR Capabilities of the Operating Fleet: BAU – 2024

3.3. Results Analysis

Based on the modeling assumptions and results in this Study, it appears that compliance with the CPP Step 1 Interim Period (*i.e.*, 2022-2024) goals can be achieved for the scenarios studied through the use of either a mass- or rate-based State Plan in New York.

For the FlatCap, DecCap, and HiGT cases, RGGI compliance for New York will depend upon a supply of surplus allowances available from other RGGI states. On the other hand, the BAU and HiRE cases project compliance based upon the quantity of allowances available within New York.

Compliance with the proposed CSAPR Update Rule ozone season NO_x limits will depend upon a supply of surplus allowances from outside New York. The trading limit may be exceeded in which case emissions in excess of the budget will need to be offset at a ratio of 3:1. The relatively short duration of the ozone season coupled with the delays prescribed in rules could create uncertainty in the market as to the correct production costs for affected fossil fuel-fired units.

Preliminary reporting of simulated changes in ERS was presented and will provide input to the extended analysis to be performed. Additional sub-hourly analyses examined in further detail will provide insight into the net-demand ramping and regulation ERS tracking and potential needs.

The generation and summer capacity of the operating fleet in 2014 was compared to results for each case by aggregating based upon the generators' unit fuel type. Figure 3-13 displays the capacity on the left with the corresponding generation on the right. As nuclear units and other conventional generation, retire, renewable resources (*i.e.*, wind and solar) and new gas CC and GT generators were assumed as the primary replacement for the retiring fleet. As observed, the installed capacity increases with increasing renewable energy resource penetration due to the annual energy constraint imposed by renewable resources which have a lower, and less controllable, capacity factor.

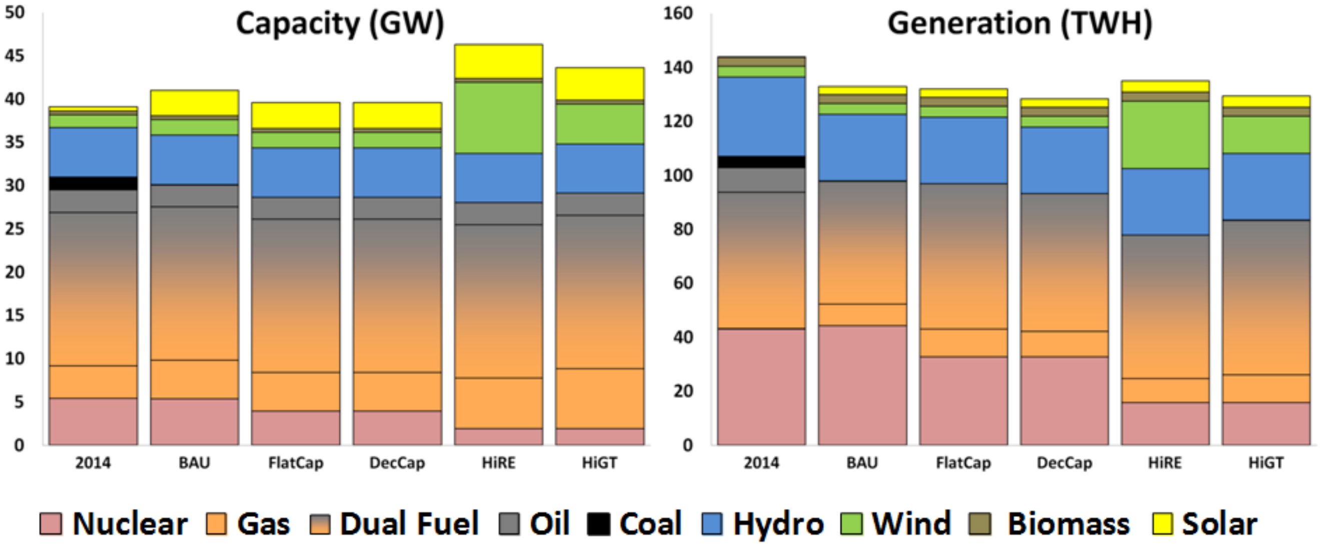

Figure 3-13 Historic Generation and Capacity by Unit Fuel Type of Operating Fleet compared to Modeled Fleet in each of the CPP Study cases

3.3.1. CARIS Metrics

As previously stated, the standard CARIS metrics reported in this Study include: production cost, load payment, generator payment, imports, generation, and emissions. In addition, Table 3-1 reports regulatory program CO_2 emissions (and rates) for the CPP, RGGI, and ozone season NO_x emissions for the CSAPR Update.

The program limits presented at the right of Table 3-1, below, correspond to the 2024 limits applicable to New York for each program—some of which may have two targets. For the CPP mass-based compliance goals, the limits represent the Interim Step 1 Existing only and New+Existing targets. The CPP rate-based compliance targets are the Interim Step 1 state rate-based goal applicable to New York. The New York RGGI limits represent the flat and declining cap, while the CSAPR NO_x limits represent the budget and the trading limit.

Table 3-1 Case Results

Metrics	BAU	Flat Cap	Dec Cap	HiRE	HiGT	Program Limit 1	Program Limit 2
NY CPP CO_2 (mmtons)	25.56	30.74	28.41	29.70	32.26	35.49	35.71
NY CPP EGU Rate (#CO_2/MWH)	1,049	1,026	1,021	1,028	1,025	1,095	
NY CPP EGU Rate w/ RE ERCs (#CO_2/MWH)	980	971	962	712	842	1,095	
NY RGGI CO_2 (mmtons)	25.89	31.11	28.77	30.01	32.62	30.44	27.50
NY CSAPR OS NO_x (tons)	4,538	5,661	4,907	5,487	6,059	4,361	5,277
Generation (GWH)	131,791	130,803	127,170	133,747	128,246		
Total Net Imports (GWH)	27,225	25,729	30,003	21,955	26,911		
ProductionCost (mm$)	3,845	4,646	4,681	4,397	4,752		
Generation Payment (mm$)	6,613	7,640	7,801	7,344	7,451		
Load Payment (mm$)	8,513	9,762	10,244	9,471	9,845		
Load Weighted LMP ($/MWH)	51.02	58.73	61.61	57.21	59.58		

Results and costs could vary greatly based upon the modeling assumptions employed across and between cases. The NYISO anticipates that further analysis will be performed to examine these results and the underlaying assumptions. While higher load and generator payments are the result of the modeling assumptions, much of this added cost can be attributed to the assumed high prices associated with the emissions of CO_2. Assumptions are subject to change in further work based upon the New York State CPP Initial Submittal to the EPA.

3.3.2. Carbon Dioxide Emissions

Figure 3-14, below, builds upon the concepts introduced in Figure 1-2. Here, the mass- and rate-based compliance results for New York from Figure 3-1 and Table 3-1 have been plotted as symbols in 2024. The mass emissions (+) should be compared to the Interim Step 1 (light blue dashed line) mass-based goal of 35.5 million tons. Two versions of the CPP rates are shown for comparison to the state rate-based goal of 1,095 #CO_2/MWH. The generator rate (○) reflects solely the emissions and generation of affected EGUs, where the adjusted rate with new RE ERCs (□) has been reduced by the amount of eligible generation from new RE. In all cases, compliance with the CPP in New York is achieved for both mass- and rate-based approaches. Costs vary greatly among these cases and depend strongly on the SP design selected by the states.

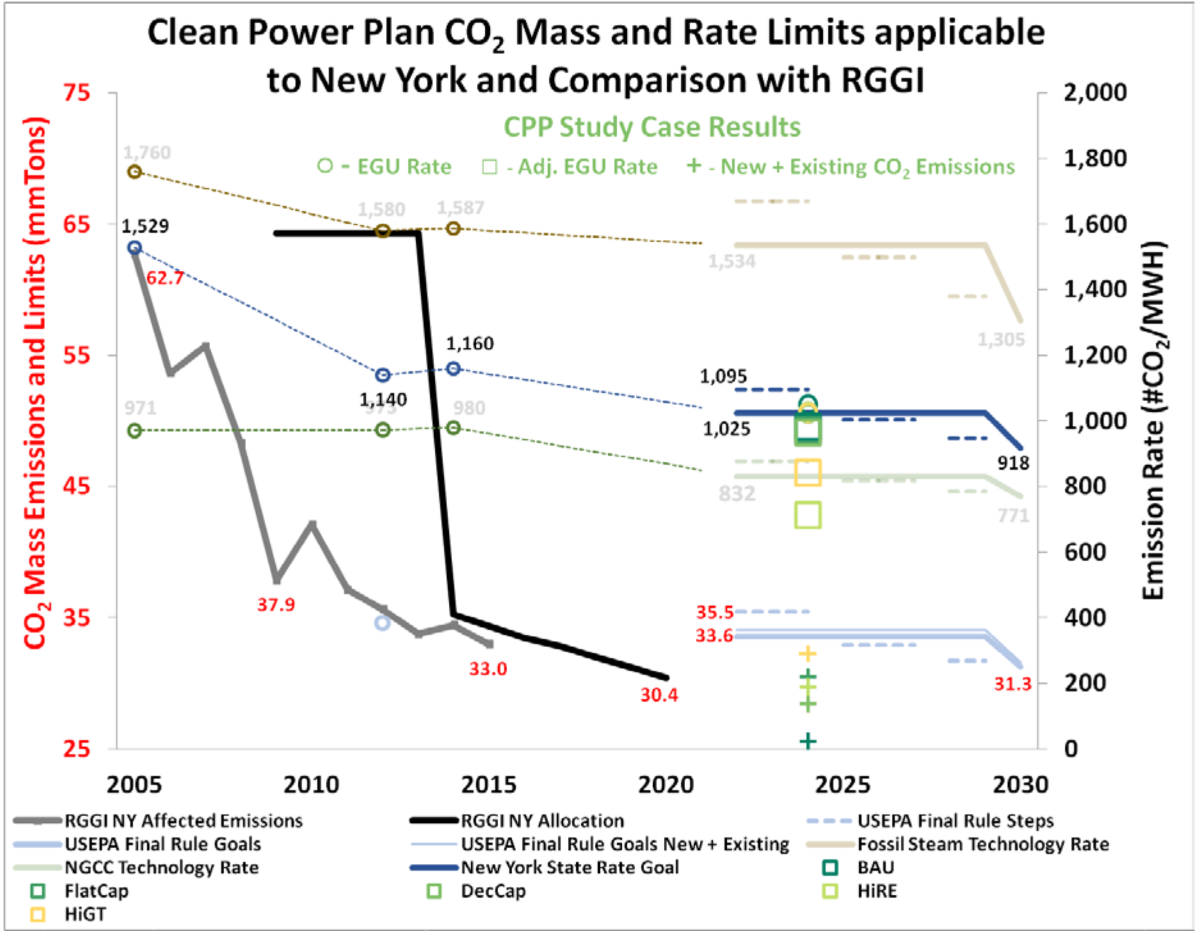

Figure 3-14 Comparison of CPP and RGGI Goals to 2024 Case Results

4. Discussion

Based upon the modeling results and analysis presented, this Interim Report offers the following points for discussion prior to undertaking further examination.

- Compliance with the CPP in 2024 can be achieved with both mass- and rate-based approaches.
- Compliance with the RGGI FlatCap, DecCap and the HiGT cases will depend on whether there is a sufficient quantity of surplus allowances from other RGGI states that can be made available to New York. Under the conditions studied here, such a surplus is projected.
- Compliance with proposed CSAPR Phase 2 ozone season NO_x budget will depend upon whether there is a sufficient quantity of surplus allowances that will be available to New York from other CSAPR OS NO_x states.
- Simulated changes in ERS are presented to initiate discussion on the metrics outlined by the NERC ERS Task Force.
- At this initial stage of examination, achieving compliance with the CPP, RGGI, and proposed CSAPR Update Rule in 2024 does not appear to present a reliability threat to the BPS.

The above discussion points are preliminary and still require significant work to fully examine the impacts of the assumed changes in resources, networks, and regulations. This Study will perform further detailed analysis to study the effects of complying with the CPP, RGGI, and the proposed CSAPR Update Rule out to 2030 and to review the preliminary results of this Interim Report. The next section discusses areas of further study in more detail.

5. Further Study

Significant work remains to fully evaluate potential changes in resources and networks included for examination in the CPP Study. The planned analysis is based upon an assessment of the resource adequacy and transmission security of the NYCA extended to 2030. Detailed examination of sub-hourly intervals using GridView simulations and a separate system stability analysis will assess key emerging reliability issues that arise. In order to examine the potential impact of an expected increase in penetration of intermittent resources in the NYCA's overall mix of generation resources, further analysis will include examination of increased starts and stops of GTs, ramping and regulation requirements, and system stability under light load, high renewable resource penetration conditions. Additional scenarios to assess the impact of extreme winter weather will also be performed. This work will then lead to an assessment of whether there could be a need for the design of new market products to accommodate the changes on the system. Some preliminary details on the reliability portion of this Study are presented for reference.

The NYISO Reliability Needs Assessment (RNA) is a biennial study that examines the resource adequacy and transmission system adequacy and security of the New York State Bulk Power Transmission Facilities (BPTF) over a ten-year study period. The RNA for the study year 2016 to 2025 is currently underway. This Study will perform an extended RNA case to examine 2030—the final target of the CPP.

Resource Adequacy Assessment

This Study will use an extended RNA approach to examine potential resource adequacy violations for the year 2030 for selected scenarios. This approach will involve assessing whether the identified changes in the composition of the future NYCA fleet for various scenarios results in the NYCA meeting its LOLE criteria.[55] The system conditions from the year 2026—taken from the 2016 RNA MARS analysis for resource adequacy—will be extended under various scenarios by projecting the system load and other parameters to the year 2030. If NYCA does not meet the LOLE criteria, resources will be added or transfer limits increased on an iterative basis so that the NYCA will meet the LOLE of 0.1 days per year for the year 2030.

CPP Resource Adequacy Analysis

Base Case

- Year 2030 - Developed from preliminary 2016 RNA base case.
- Extend load forecast to 2030 level.
- Generator Status in 2030 – Same as final year of 2026 in RNA.

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[55] Resource adequacy is the ability of the electric systems to supply the aggregate electricity demand and energy requirements of the customers at all times, taking into account scheduled and unscheduled outages of system elements. Resource adequacy considers the transmission systems, generation resources, and other capacity resources, such as demand response. Resource adequacy assessments are performed on a probabilistic basis to capture the random natures of system element outages. If a system has sufficient transmission and generation, the probability of an unplanned disconnection of firm load is equal to or less than the system's standard, which is expressed as a Loss of Load Expectation (LOLE). The New York State bulk power system is planned to meet a LOLE that, at any given point in time, is less than or equal to an involuntary load disconnection that is not more frequent than once in every 10 years, or 0.1 events per year. This requirement forms the basis of New York's Installed Reserve Margin (IRM) requirement and is on a statewide basis.

- GE MARS Interface Limits – Same as 2026.
- Extend other parameters/assumptions in accordance with CARIS procedure.

Step 1

- Insert renewable resource penetrations by zone.
- Remove retirements by zone, as identified in screening analysis.
- Test to determine if system meets LOLE criteria.

Step 2

- If LOLE criteria is not met in Step 1, run analysis to determine if resource or transmission inadequacy.
- If resource inadequacy, add resources to deficient zones to meet LOLE criteria.
- If transmission is inadequate, determine level of interface rating increase required to meet LOLE criteria.
- If both, determine mix of resources and transmission to meet LOLE criteria.

Step 3

- Develop Load and Capacity tables from Step 1, above, to estimate the impact on the Installed Reserve Margins (IRM) for the NYCA by determining installed capacity levels when the system is at a 0.1 LOLE.
    - This analysis will not perform Tan45 analysis.

Step 4

- Review the cases proposed in overall work scope to identify scenarios for resource adequacy assessment.

Stability Assessment for High Renewable Penetration and Low Synchronous Generation Levels

A stability analysis will be conducted on a scenario with light load and high renewable resource penetration. Stressed system conditions (high transfers) will be examined for the system response (frequency, voltage, and ability to maintain synchronism) to various system disturbances (contingencies).

Set Up Initial Base Case

- Base case – develop the base case from the set of stability cases used for model verification.
- Network updates – TOTS and AC Transmission Proceeding.
- Generation – updated to reflect retirements and new solar and wind resources.
- Review outside world area models and set at a low conventional synchronous generation dispatch at the NYCA borders.

Step 1

- Finalize Case Conditions – high penetration and dispatch levels of wind and both BTM and utility level PV and low commitment of synchronous generators (*i.e.*, weak system conditions). System conditions would be those forecasted for the year 2030.
- Finalize load level to match a relatively low load level and high PV and wind output (*i.e.*, Spring morning). Location of new resources will respect existing transfer limits as much as possible and as identified in the screening for resource adequacy assessment.
- Review previous NYISO studies to select a potential stressed condition and severe contingencies. Identify critical contingencies and potential transfer limit impacts.
- Review literature and studies performed in the industry.

Step 2a

- Report on the impact on composite short circuit ratios and initial inertial response.
- Perform contingency analysis for critical contingencies in the database for the stressed conditions modeled.
- Provide documentation of system performance and ability to maintain synchronism and transient stability, frequency, and voltage response in the 0 to 1 minute timeframe.

Step 2b

- Perform up to three scenario cases representing system conditions resulting from different expansion plans and/or load levels.

Step 3

- Explore longer, slow frequency response performance of the system as time permits. This may include AGC response.

Step 4

- Develop recommendations for future work.