1. System & Resource Outlook

1.1. Relevant Planning Study Summary

1.2. Reference Case Development

1.2.1. Baseline Case

1.2.2. Contract Case

1.2.3. Policy Case

1.3. Economic Planning Model Development

1.4. Historic & Future Transmission Congestion

As part of the System & Resource Outlook, the NYISO develops estimates of historic and projected transmission system congestion. Transmission congestion limits the economic transfer of energy between generation resources and demand, creates inefficient generation commitment and dispatch, and increases the cost of electricity when lower cost resources cannot be delivered to consumers. It is important to understand and quantify both the past and projected transmission congestion patterns, including the identification of specific congested paths, impacting the New York Control Area.

The two metrics used to quantify the impact of specific congested transmission elements are demand congestion and constrained hour count. The demand congestion value of a transmission constraint represents the congestion component of the LBMP paid by NYCA load (sum of the total zonal loads) and is defined as the shadow price of each constrained element multiplied by the load affected with consideration for zonal Generator Shift Factors (GSF). The formula used to calculate the demand congestion value of a transmission constraints is as follows:

$$\boldsymbol{Constraint\ Demand\ Congestion} = \sum_{Hour\ h}^{8760} \sum_{Zone\ i}^{Zone\ K} Shadow\ Price_{i,h} \times Zone\ GSF_{i,h} \times Zone\ Load_{i,h}$$

The constrained hour count metric represents the annual number of hours that a specific transmission constraint is active.

Historic actual transmission congestion metrics for constraints that were active in the NYISO's market are currently posted publicly on a quarterly basis to the NYISO website[1]. This data serves as the basis for the historic transmission congestion analysis. For the historic five year period, individual transmission constraints are compiled and reported in descending order according to their demand congestion value. The NYISO will assess and identify transmission constraint groupings based on the individual rankings and proximity of congested elements.

Using the simulation results from each of the Reference Cases (Baseline, Contract, & Policy), the NYISO will compile, rank, and group the 20-year projected transmission constraints. Projected transmission congestion is then joined with congestion data from the historic analysis. The congested elements for the full twenty-five year period (both historic (5 years) and projected (20 years)) are ranked in descending order based on trends in the calculated present value of demand congestion for further assessment. The discount rate to be used for the present value analysis is the current weighted average cost of capital for the New York Transmission Owners. Note that the procedure provides that if future system changes produce a significant declining trend in congestion over an identified congested element in later years of the study period, such element is excluded from the rankings. Elements with significant increasing trend in congestion could also be evaluated.

The NYISO performs these computations for each System & Resource Outlook study and reviews them with the ESPWG.

1.5. Congestion Relief Analysis

The operational and economic impact of transmission congestion on the New York State Transmission System can be quantified through a congestion relief analysis. With the projected potential future constraints and groupings already identified for the Reference Case simulations, additional simulations will be performed to further analyze each transmission path. The NYISO will coordinate through ESPWG to identify the Reference Cases and specific constraints for study.

To perform the constraint relief analysis, selected individual or groups of congested elements is iteratively relieved independently by relaxing its limits. For each binding constraint that has been relaxed, the production cost model is re-run to produce results that reflect the system conditions

[1] See https://www.nyiso.com/ny-power-system-information-outlook/ > Congested Elements Report

that would occur were that transmission element not congested. By comparing this information with the associated Reference Case, the economic and operational impact of the constraint can be determined. The metrics used to evaluate the impact may include production cost, demand congestion, LBMP, and energy deliverability.

Another part of the constraint relief analysis determines if any of the congested elements need to be grouped with other elements, depending on whether new elements appear as limiting with significant congestion when a primary element is relieved.

1.6. Renewable Generation Pocket Formation

When specific areas of the New York State Transmission System contain one or more constrained transmission elements, preventing renewable energy resources from dispatching at full potential, a renewable generation pocket is created. As part of the System & Resource Outlook, the NYISO will use the results from the future transmission congestion projection in the Reference Case(s) to identify, define, and visualize the potential renewable pockets formed. The NYISO will collaborate with stakeholders to identify the Reference Case(s) and simulation year(s) for renewable pocket determination.

To define a renewable generation pocket, the NYISO will first identify the specific renewable generators that experience curtailment throughout the study period being analyzed. Using the GE-MAPS generation shift factor report (YRGSF) the specific transmission constraints directly attributing to the curtailment of the renewable generation can be identified. This can include multiple lines and multiple impacted generators from each congested transmission line. The NYISO will qualitatively or quantitatively collect transmission constraints causing curtailed generation and other electrically similar transmission paths into a grouping to form a renewable generation pocket. The NYISO will report specific transmission paths comprising each renewable generation pocket. Additionally, the NYISO will produce a graphical representation of the identified renewable pockets plotted on a New York State map.

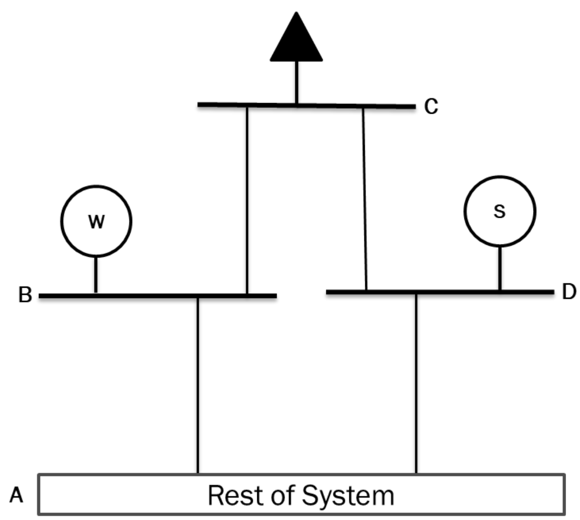
1.7. Energy Deliverability Analysis

The NYISO will evaluate the relationship between transmission congestion and the operation of resources throughout the system utilizing an energy deliverability metric. This metric quantifies the energy projected to be produced by a Resource considering the impact of applicable local, statewide, and interregional transmission constraints as compared to the total amount of energy that such Resource is capable of producing in the absence of transmission constraints, and accounting for fuel availability of each Resource type including wind, solar, and water. The formulation used to determine energy deliverability for each resource on the system is as follows:

$$Energy\ Deliverability\ (\%) = \frac{Energy\ Production}{Energy\ Production\ Capability}\ x\ 100$$

Data from production cost simulations will be used to quantify the collective impact of resources on energy deliverability at locations on the system that are identified as being constrained. Generation shift factors, which quantify the incremental impact of generation on the flow of transmission facilities, will be used to identify groupings of generators with similar energy deliverability impacts. Information on the collective impact of transmission congestion on resource groupings will be provided.

Shown below is a fictitious example system with a load, wind generator, and solar generator interconnected by four transmission lines and 3 buses. The example network is assumed to connect to a larger bulk power system.



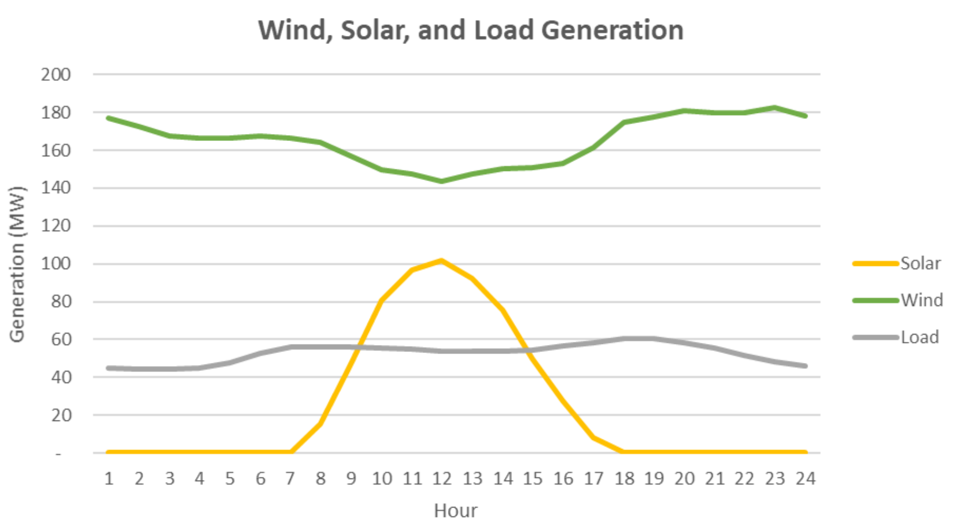
Parameter	Value
Wind "W" Capacity	500 MW
Solar "S" Capacity	250 MW
Load	100 MW
Line Limits	100 MW

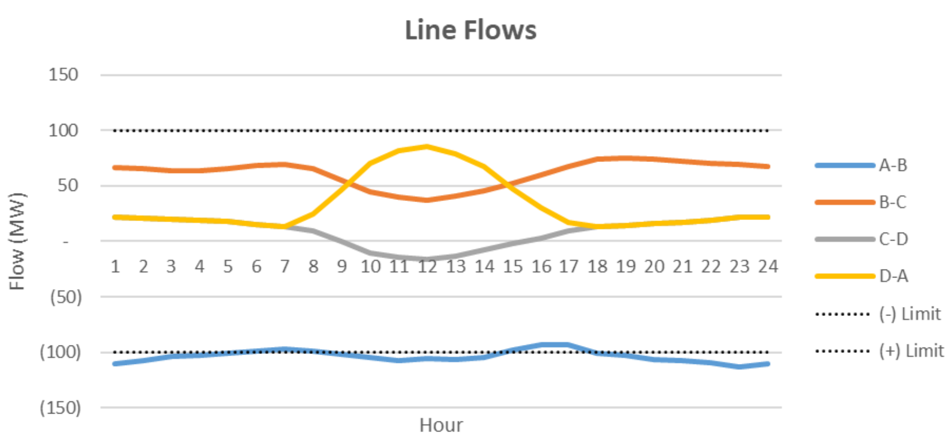
Transmission line flows on the example system are dictated by the electrical impedances of the transmission lines, which are assumed to be equal in this example. In this example, assuming that bus "A" acts as the reference point, if the wind generator at bus "B" produced 1 MW, 0.75 MW would flow on line "B-A" and 0.25 MW would flow on lines "B-C", "C-D", and "D-A". The full set of relationships between generators and the transmission system can be captured through a generation shift factor matrix. The GSF matrix for this example system is show below:

GSF Matrix	A-B	B-C	C-D	D-A
Wind	-0.75	0.25	0.25	0.25
Solar	-0.25	-0.25	-0.25	0.75
Load	0.5	0.5	-0.5	-0.5

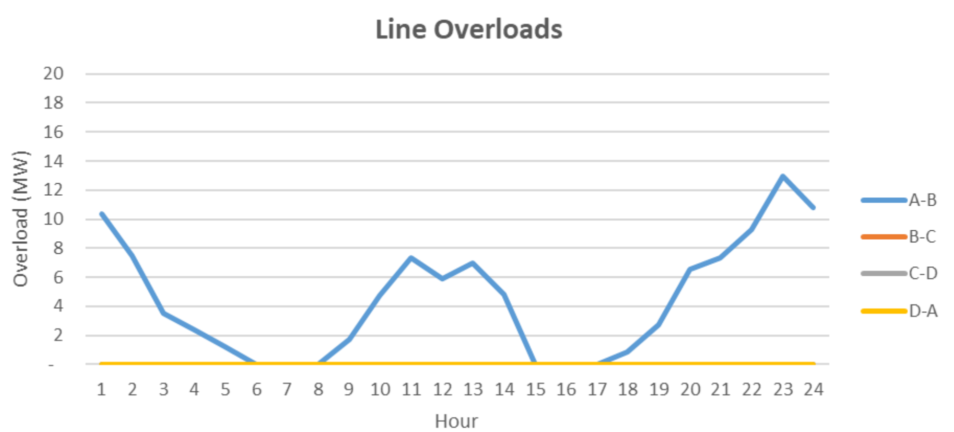
Note that GSF values are always between the values of 0 and 1 and can be either positive or negative, depending on the defined direction of the transmission line.

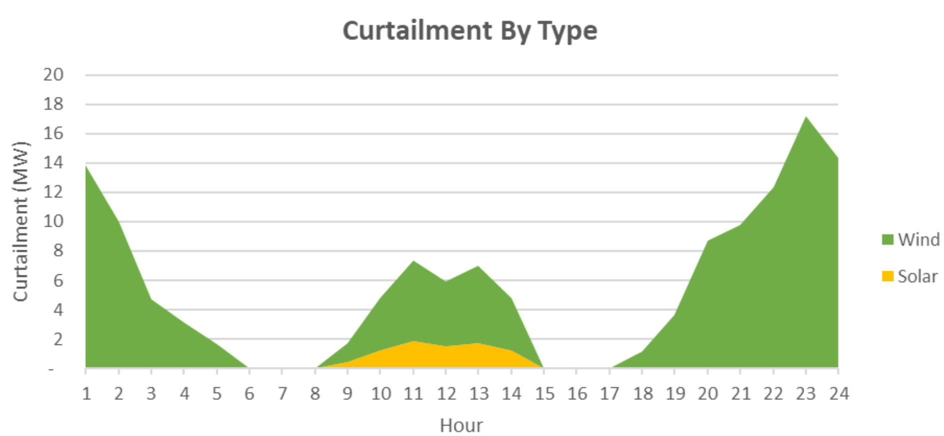
With the example system defined, a representative day of generator and load dispatch values can be applied to evaluate the transmission flows compared to their limits. This allows for the identification of transmission constraints and generator curtailments. The charts below show an example 24 hour period of generator dispatch and transmission line flows.





The charts show the interaction between the varying dispatch patterns of the generators on the system with the transmission system. For the "A-B" transmission line, it can be noted that the flow exceeds the line limit of 100 MW. In this scenario the generators contributing to the line limit violation would be curtailed to reduce the flows to within operating limits. The chart below shows curtailment of the wind and solar generators necessary to keep the transmission system within its limits.





Note that, for this example system, if only one of the technology types is producing energy at the time of line overloads, the amount of curtailment necessary to remedy line overloads will exceed the overload amount. This is due to a particular generators shift factor relationship to the overloaded line.

Using the 24-hour period from this example, the energy deliverability metric can be calculated for each of the technology types. The table below shows the potential energy, curtailed energy, actual energy, and energy deliverability metrics relevant to this example.

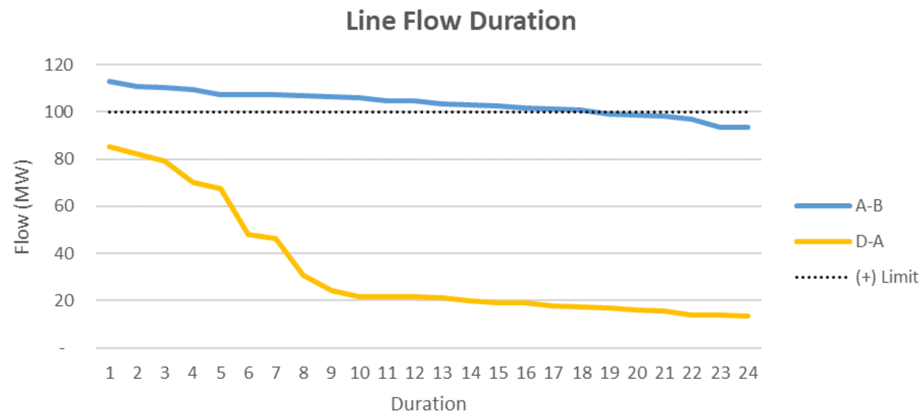
Energy (MWh)	Potential	Curtailment	Actual	Energy Deliverability (%)
Solar	595	8	587	99%
Wind	3,963	124	3,839	97%

The potential energy metric shows the total amount of energy that each resource is capable of producing in the absence of transmission constraints, and accounting for fuel availability of each Resource type including wind, solar, and water. The actual energy metric quantifies the energy projected to be produced by each resource considering the curtailed energy metric, which is impacted by applicable local, control area-wide, and interregional transmission constraints.

Where applicable, the energy deliverability metric may also include quantification of the collective impact of Resources at locations on the system that are identified as being constrained in whole or in part. For example, if the sample system presented were identified as a renewable pocket, the individual metrics can be calculated and presented for the combined resource. The table below shows the calculation for a renewable generation pocket encapsulating the example system.

Energy (MWh)	Potential	Curtailment	Actual	Energy Deliverability (%)
Pocket	4,558	132	4,426	97%

Where available, resource areas that have been identified will also include such additional information resulting from the study analysis concerning capability remaining on the transmission system to support energy deliverability. The metric may be expressed as a percentage of such total amount of energy or as the amount of curtailed energy. As an example, the hourly flows for line "A-B" and "D-A" can be quantified and compared to the line limit to determine the capability of the line to support additional flows. A duration curve for both of these lines during the sample time period is shown below.



In the chart, the area below each curve represents the energy transferred throughout the day over the line. The area above the curve but below the line limit represents the unused capability of the line to transact energy, sometimes knows as energy headroom. Any area below a curve but above the line limit represents the transmission line overload, which results in curtailed energy. Calculation of this quantity requires simulations from the congestion relief analysis. These values are quantified in the table below.

Energy (MWh)	Max Flow	Actual Flow	Overload	Headroom	Headroom (%)
Line A-B	2,400	2,487	107	20	1%
Line D-A	2,400	803	0	1,597	67%

As part of the analysis, results from simulations may be analyzed to identify electrical, geographic, and/or temporal patterns in energy deliverability.

1.8. Projected Operations & Market Impact Analysis

1.9. Sensitivity Simulations

1.10. Study Report

1.11. Generic Dataset & Model Posting