Resource Planning MARS Models Assumptions

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Agenda

- Background
- Reliability Planning Processes
- GE's Multi Area Reliability Simulation (MARS)
- Resource Planning: various MARS model assumptions

Background

Background

- In 2022 the NYSRC developed a white paper responding to a NYSRC 2022 goal for the NYSRC Reliability Rules Subcommittee (RRS) to: *"identify actions to preserve NYCA reliability for extreme weather events and other extreme system conditions"* and its corresponding action plan to: *"evaluate the potential need for new resource adequacy and transmission planning design rules for planning the system to meet extreme weather and other extreme system conditions."*
  - Accordingly, the paper presents 10 Extreme Weather Resilience Plan recommendations which are designed to ensure that the NYS electric system continues to deliver reliable performance in the face of a changing climate.
- In continuation of the 2022 effort into 2023, the NYSRC created an Extreme Weather Working Group (EWWG)
  - First meeting on December 15, 2022
- To support the EWWG, the NYISO staff proposed to present insights on what the current resource planning MARS models' key assumptions are, in order to anchor the discussion into what else needs to be changed under design criteria and modeling practices, if anything, to prepare for an increase in frequency and magnitude of extreme weather events
  - The reliability planning MARS models (study year 1 through 10) have been developed and used for the NYISO's reliability planning processes to identify resource adequacy reliability criteria violations and needs
  - The 2022 Reliability Needs Assessment (RNA) has been completed in November 2022 and is posted here [report link] [appendix link]

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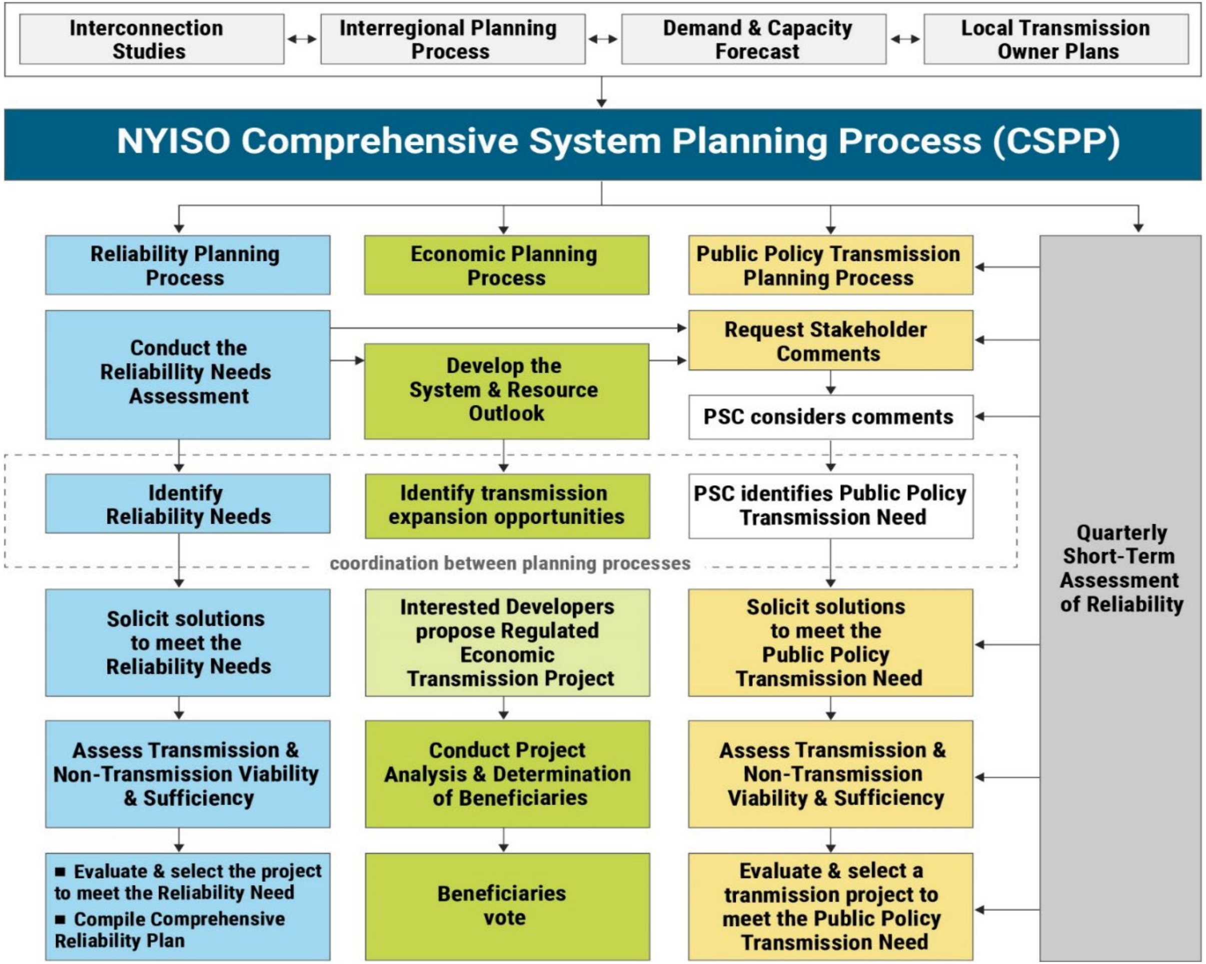
NYISO’s Reliability Planning Processes


Interconnection Studies
Interregional Planning Process
Demand & Capacity Forecast
Local Transmission Owner Plans
NYISO Comprehensive System Planning Process (CSPP)
Reliability Planning Process
Economic Planning Process
Public Policy Transmission Planning Process
Conduct the Reliabillity Needs Assessment
Develop the System & Resource Outlook
Request Stakeholder Comments
PSC considers comments
Identify Reliability Needs
Identify transmission expansion opportunities
PSC identifies Public Policy Transmission Need
coordination between planning processes
Quarterly Short-Term Assessment of Reliability
Solicit solutions to meet the Reliability Needs
Interested Developers propose Regulated Economic Transmission Project
Solicit solutions to meet the Public Policy Transmission Need
Assess Transmission & Non-Transmission Viability & Sufficiency
Conduct Project Analysis & Determination of Beneficiaries
Assess Transmission & Non-Transmission Viability & Sufficiency
Evaluate & select the project to meet the Reliability Need
Compile Comprehensive Reliability Plan
Beneficiaries vote
Evaluate & select a tranmission project to meet the Public Policy Transmission Need

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Reliability Planning Studies

- **Short Term Assessments of Reliability (STARs)**
  - Conducted quarterly in direct collaboration with Transmission Owners
  - Five-year study, with a focus on addressing needs arising in the first three years
- **Reliability Needs Assessment (RNA)**
  - Conducted biennially to identify long term reliability needs in years 4-10
  - Considers all Transmission Owner LTPs and updates throughout the process
  - If reliability needs are identified, the NYISO issues a competitive solicitation for solutions, and TOs are required to propose Regulated Backstop Solutions
- **Comprehensive Reliability Plan (CRP)**
  - Biennial report that documents the plans for a reliable grid over the 10-year planning horizon
  - Includes evaluation and selection of transmission solutions to reliability needs in years 4-10

RPP = Reliability Needs Assessment (RNA) + Comprehensive Reliability Plan (CRP)

2-year planning cycle

NERC, NPCC, NYSRC Reliability Criteria on BPTF

Study Year 4 through Year 10

RNA

- Transmission Security/Resource Adequacy Evaluations
- Reliability Needs Identification
- Responsible Transmission Owner Designation
- Scenario Evaluations

CRP

- If Reliability Needs, solicitation of solutions
- Viability & Sufficiency Assessment
- Evaluation & Selection of the more efficient or cost effective transmission solution
- Trigger Date Determination
- Gap Solution, if needed

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Reliability

- **NYSRC Reliability Rules rev 46 [link] Glossary**
  - Reliability – The degree of performance of the bulk electric system that results in electricity being delivered to customers within accepted standards and in the amount desired. Reliability may be measured by the frequency, duration, and magnitude of adverse effects on the electric supply. Electric system reliability can be addressed by considering two basic and functional aspects of the electric system – adequacy and security.
    - Adequacy – The ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.
    - Security – The ability of the electric system to withstand disturbances such as electric short circuits or unanticipated loss of system elements.
- **Resource Adequacy - NYSRC Reliability Rules rev 46 criterion:**

  "R1.1. NYSRC Resource Adequacy Criterion

  The loss of load expectation (LOLE) of disconnecting firm load due to resource deficiencies shall be, on average, no more than 0.1 loss of load Event-Days per year. LOLE evaluations shall make due allowance for demand uncertainty, scheduled outages and deratings, forced outages and deratings, assistance over interconnections with neighboring control areas, NYS Transmission System emergency transfer capability, and capacity and/or load relief from available operating procedures.
- **Main tool used to perform resource adequacy simulations: GE's MARS**

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NYISO Reliability Planning Processes and Resource Adequacy Simulations

MARS simulations performed for various processes at the NYISO, such as:

- **Reliability Planning Process (RPP) with its RNA and CRP**
  - Study Years 4 through 10 (includes an actionable Base Case, and also scenarios for information): https://www.nyiso.com/library
- **Short Term Reliability Process (STRP) with its quarterly–performed STAR**
  - Study Years 1 through 5: https://www.nyiso.com/short-term-reliability-process
- **Installed Reliability Margin (IRM) Study, followed by the Locational Capacity Requirement (LCR):**
  - performed annually by the NYISO for NYSRC for the following Capability Year (e.g., IRM study performed in 2022 for the 2023-2024 Capability Year): https://www.nysrc.org/NYSRC_NYCA_ICR_Reports.html
- **Capacity Accreditation: https://www.nyiso.com/accreditation**
- **Other simulations to support economic and public policy planning, operations, or markets**

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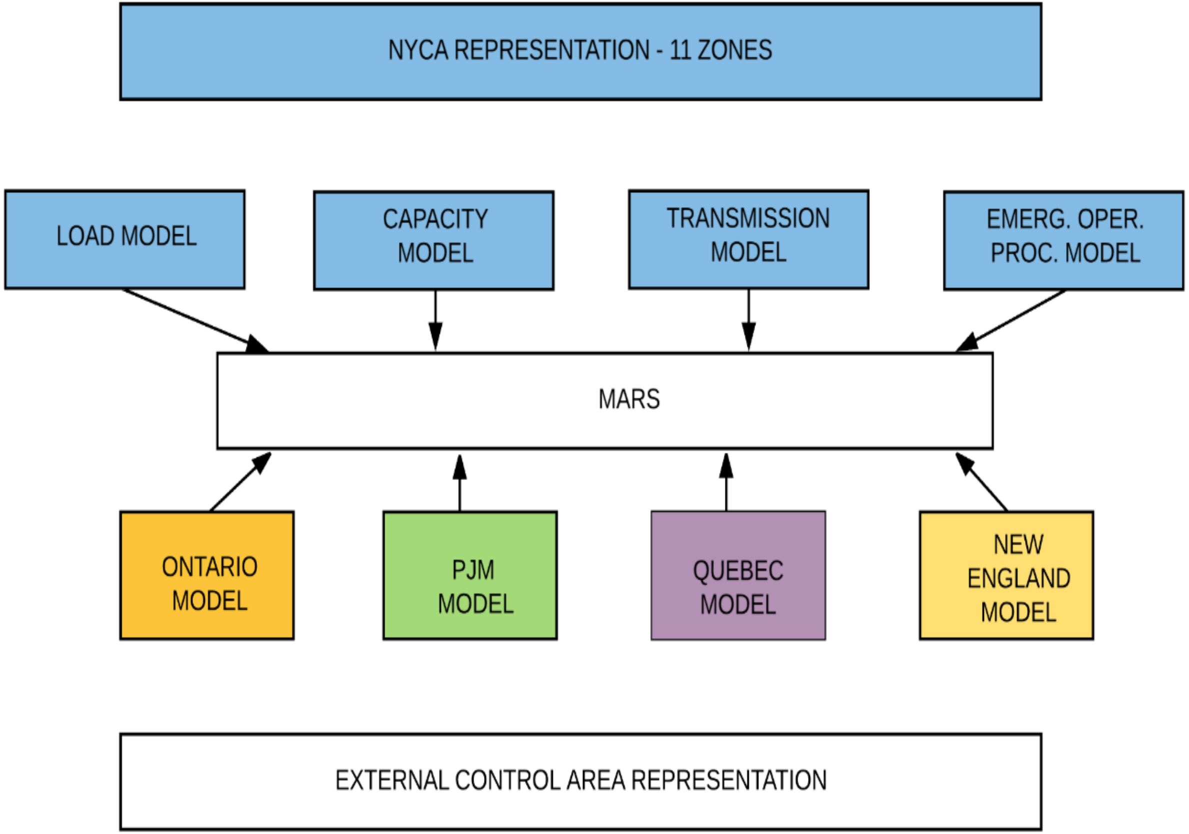
GE-MARS Overview

MARS: Multi-Area Reliability Simulation
program developed by General Electric (GE)



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GE-MARS Program Overview

- **Sequential Monte Carlo simulation method to determine the reliability indices of a system**
  - 2,000 replications for each load bin simulated for one study year (total of 14,000 for 7 load bins per study year)
- **Randomly occurring events are taken into consideration, such as:**
  - forced outages of thermal generating units,
  - forced outages of transmission “pipes” (using a simplified “bubble and pipes” or “MARS topology” representation of transmission in MARS)
    - Underground cables only due to longer time to restore in service
  - 8760 hourly MW shapes selection (front-of-meter wind, solar, run-of-river, landfill gas, behind- the- meter solar)
    - Previous 5 years of historical data (where available)
  - deviations from the forecasted loads (Load Forecast Uncertainty multipliers – LFU).
- **Load, generation, and transmission representation for both NYCA and neighboring systems**
  - The transmission system is modeled through transfer emergency criteria limits on the interfaces between pairs of interconnected NYCA areas, aka “the MARS topology”
  - The 4 adjacent neighboring ISOs (Ontario, Quebec, New England, and PJM) are also represented
- **Emergency Operating Procedures (EOPs, MW) are also modeled for the NYCA**

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MARS ‘Replications’ Considerations

- **For the planning studies such as RNA: we run 2000 replications for each of the 7 load levels (bins) concurrently, for a total of 14,000 simulations per Study Year**
- **For each study year:**
  - In a single MARS replication, the zonal MW hourly margins (MW surplus or deficit) are calculated for each of the 7 load bins using LFU-applied-load, forced outage calculations, hourly shape values (i.e., front-of-meter wind, solar, run-of-river, landfill gas, and behind the meter solar), contracts, and interface flows.
  - In instances where there is a deficit in any area, EOP steps are completed (providing for additional MW as needed and available) until either the deficits are gone, or there are no more EOP steps to call.
  - Once all of this is completed MARS calculates the reliability indices (LOLE, LOLH, LOEE) for the replication. This occurs concurrently across all load levels (bins) simultaneously: MARS lumps them all together in a weighted sum to get a single value for each replication.
- **Every replication could be different**
  - For instance, for every replication the program randomly choses one yearly shape for each of the run-of-river, wind, solar, and BtM solar, each ultimately affecting the net load
- **For one replication, MARS will pick the same shapes for each of the 7 load bins, to match the hourly load (*e.g.,* same outages, same shapes, for each of the 7 load levels, for one replication).**

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Load:

1. Historical Load Shapes
2. Peak Load Forecasts: Energy and Demand
3. Load Forecast Uncertainty (LFU)

Load: Historical Load Shapes

- **Historical 8760 hourly MW shapes are used for each of the 7 MARS load bins**
  - March 24 LFTF Load Shapes Analysis presentation link
  - Starting with the 2022 planning models:
    - Load Bins 1 and 2: 2013
      - 2013: hot summer with a relatively steep load duration curve and low load factor representative of upper percentile LFU bins
    - Load Bins 3 and 4: 2018
    - Load Bins 5 to 7: 2017
      - 2017, 2018: normal and cool summers with flat load duration curves and high load factors representative of mid-to-lower percentile LFU
  - The three selected load shapes do not drop off significantly in the top five days or top 25 hours relative to the long-term average, ensuring appropriately stressed system conditions
  - Bin 4 represents the expected shape – close to the Gold Book forecast

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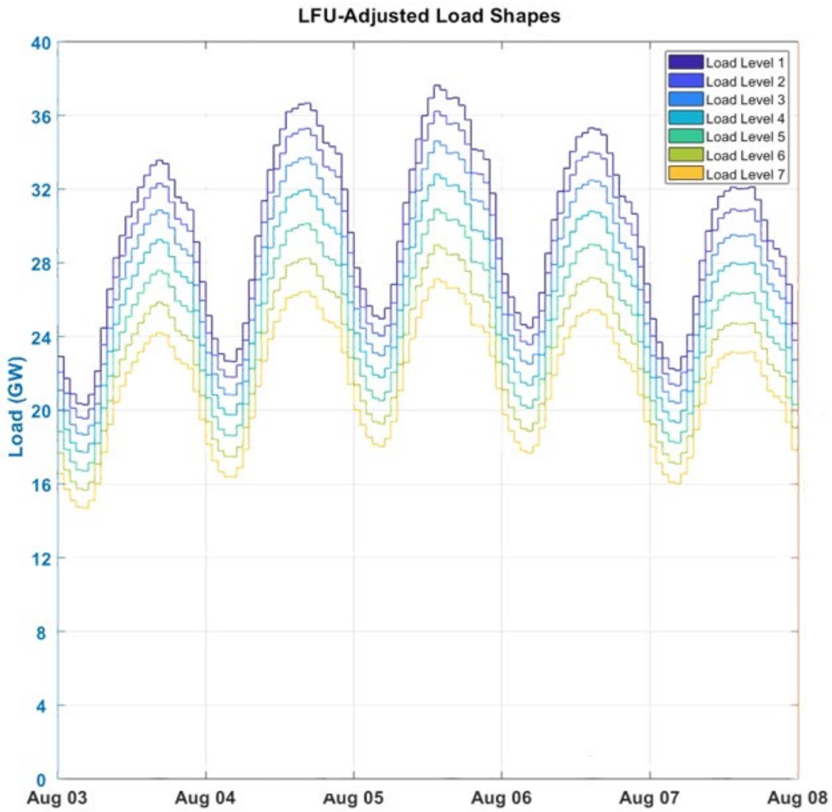
Load: MARS Load Levels / Bins

- **Historical load shapes are adjusted to meet zonal (as well as G-J) coincident and non-coincident peak forecasts (summer and winter), while maintaining the energy targets.**
- **The same historic reference years are used for the external areas**
- **Load Levels / Bins**
  - MARS can use up to 10 different load levels for the simulation – we use 7
  - The load levels, or bins, use LFU (Load Forecast Uncertainty) as scalar multipliers **to every hour of the year**
  - See the figure to the right*, Load Level 4 is approximately the 50th percentile load shape, i.e. expected load (i.e., closer to the Gold Book forecast)



*Note: The figure is an example of LFU application, not what is actually in the model

Peak Load Forecasts: Energy and Demand

- **Energy (MWh) and peak demand (MW) are scaled to match the applicable Gold Book forecasts for each Study Year**
- **The Gold Book baseline forecast includes:**
  - Upward adjustments for increased usage of electric vehicles and other electrification, and
  - Downward adjustments for the impacts of energy efficiency trends, distributed energy resources (including energy storage) and behind-the-meter solar PV.
  - The relative BtM solar impact on peak load declines over time as the NYBA summer peak is expected to shift further into the evening
  - The forecast of BtM solar PV-related reductions to the winter peak is zero because the sun sets before the assumed peak hour of 6 p.m. Eastern Standard Time in January
  - The impacts of net electricity consumption of all energy storage units are added to the baseline energy forecast, while the peak-reducing impacts of BtM energy storage units are deducted from the baseline peak forecasts.
- **The planning MARS models use gross load forecasts (with the BtM solar reductions added back) in order to discretely model the BtM solar as 5 years of 8760h MW shapes, randomly picked each replication.**

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Load: Load Forecast Uncertainty (LFU)

- The load forecast uncertainty (LFU) model captures the impacts of weather conditions on future loads
- LFU is applied hourly, for all hours and load bins
- The LFU gives the MARS program information regarding 7 load levels (3 loads lower and 3 loads higher than the median peak) and their respective probabilities of occurrence
- For each modeled hour, the MARS program determines the resource adequacy and calculates an average loss of load expectation for the capability year for each of the 7 load levels
- MARS uses this information to evaluate a probability weighted-average LOLE for each area
- Recognizing the unique LFU nature of individual NYCA zones, the LFU model is subdivided into five separate areas:
    - New York City (Zone J), Long Island (Zone K), Zones H and I, Zones F and G, and the rest of New York State (Zones A-E).
- Additional LFU info here: April 21, 2022 LFTF: link

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NYISO Forecasts and Extreme Weather

Included/Accounted For

- LFU multipliers account for year-to-year variability and potential extremes in peak load levels based on historical weather variation (>99th percentile summer and winter peak day weather)
- Annual energy and seasonal peak forecasts incorporate increasing temperature trends
- Increasing winter peak load levels and weather sensitivity due to heating electrification

Not accounted for

- Potential changes in weather variability over time
- Greater or lesser than baseline temperature trends

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Generation

Types

Forced Outage Modeling

Maintenance Outage Modeling

Generation: Hourly MW Generation Shapes

- Wind, landfill gas, run-of-river hydro, utility solar, and behind the meter (BtM) solar are modeled using 5 years of historical hourly MW shapes
- MARS randomly selects a shape for each replication year

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Generation: Thermal

- Input energy for units are assumed to be always available
- Unit type may be internal combustion (IC), combined cycle (CC), combustion turbine (GT), steam turbine (ST) or jet engine (JE)
- Power output of the thermal units depend on available capacity states, transition rates, and forced outages rates or scheduled maintenance
  - Forced outage rates are determined by 5 years of historical GADS data, which includes outages due to weather related events and fuel shortages
- MARS can derate the unit output based on factors such as percent of peak load in the area the unit is located in

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Generation: Energy Limited Resources (ELR) and Energy Storage (ES)

- **ELR**
  - Units may be pumped storage or large hydro
  - Modeled as thermal units whose operation may be restricted due to unavailability of fuel or limited water availability
  - The maximum capacity available at any time may be less than that determined by unit's current capacity state
- **ES**
  - Similar restrictions to ELR units, but with a need to charge as well

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Generation: Co-generation

- Net-generating thermal units have an associated hourly load profile

Transmission

Transmission: MARS Topology Cont.

- A MARS model does not use a discrete transmission network model of the bulk power system (BPS) facilities
- The transmission system is generally modeled through emergency transfer limits on the interfaces between pairs of interconnected areas (“bubbles and pipes” transportation model, aka “the MARS topology”
  - Forced outages of transmission “pipes”: underground cables only due to longer time to restore in service
- A graphical representation of the MARS topology is developed and provided as a communication tool
- MARS simulations model every hour of the year, representing thousands of combinations of system conditions, different load, renewable generation output, generator availability, etc.
  - Each different system condition could result in different interface transfer limits.
  - Since a single limit is typically modeled for interfaces and applies to the entire year, the transmission model in MARS is a major simplification and it should not be described in terms of how “accurate” it is: the objective of a good MARS topology model is to reasonably reflect system constraints for the calculation of system LOLE.

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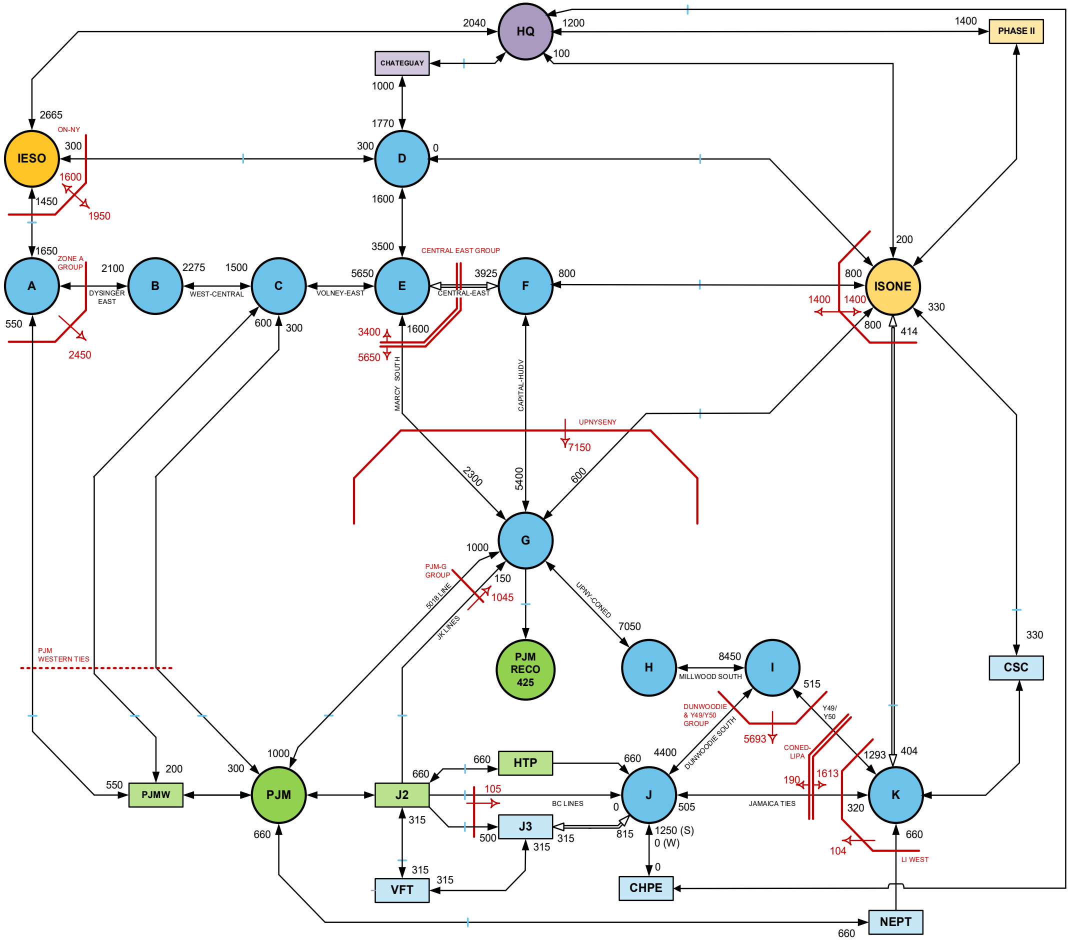
MARS Topology Visual

- The transmission system is a simplified transportation model: transfer emergency criteria limits (“pipes”) are modeled on the interfaces between pairs of interconnected NYCA areas (“bubbles”), aka “the MARS topology”
- The 4 adjacent neighboring ISOs (Ontario, Quebec, New England, and PJM) are also represented, each in one “bubble”



Notes

1. PJM to NY emergency assistance (EA) assumption for calculating the PJM-NY Western ties, PJM-G Group, and ABC Line Group flow distribution limit: 1500MW

2. NYCA EA simultaneous import limit: 3,500 MW

3. External areas representation based upon information received from the NPCC CP-8 WG

Legend

- Interface
- Unidirectional Interface
- Interface w/ Dynamic Ratings
- Interface Group
- Interface Group w/ Dynamic Ratings
- Monitoring Interface Group
- NYCA EA Interface Group Marker
- XX “Dummy Bubble” i.e. no load

NOTE: An interface is considered to not have a MW limitation if no number is specified

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Contracts

Transactions – MARS Contract Models

- UDRs, grandfathered rights, wheel-throughs, sales/purchases
- To model scheduled interchanges of capacity between areas
- Transactions may be modeled using the "firm contract MARS model" or the "curtailable contract MARS model":
  - Firm - the Contract will be scheduled regardless whether sending area has sufficient resources. For example, sales to ISO-NE and PJM from NY.
  - Curtailable - Contract will be scheduled only if sending area has sufficient resources or it can receive sufficient resources as emergency assistance from other areas. For instance, capacity associated with UDRs.
- Interfaces along the contract path can be defined so that MARS can reduce MW flow

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Neighboring Systems

Neighboring Systems: Four Bubbles

- One MARS bubble for each: ISO-NE (US) ,PJM (US), IESO (Canada),HQ (Canada)
- Models received via the NPCC CP-8 WG
- External assistance is one of the EOP steps
  - Emergency assistance limits modeled on the “pipes”
- Several modeling assumptions are employed in the planning models to limit reliance on external areas, such as:
  - The top three summer peak load days of an external Control Area is modeled as coincident with the NYCA top three peak load days.
  - Load and capacity fixed through the study years.
  - EOPs are not represented for the external Control Area capacity models.
  - External Areas adjusted to be between 0.1 and 0.15 days/year LOLE
  - Implemented a statewide emergency assistance (from the neighboring systems) limit of 3500 MW

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Emergency Operating Procedures (EOPs)

EOPs

- Additional MWs are modeled for each of the EOPs below, and are used as needed (i.e., zonal MW deficiency at each hour of each replication) and in a sequential order:
- Special Case Resources (SCRs) (Load and Generator)
- 5% Manual Voltage Reduction
- 30-Minute Operating Reserve (655 MW) to Zero 5%
- Remote Controlled Voltage Reduction
- Voluntary Load Curtailment
- Public Appeals
- Emergency Assistance from External Areas
  - Modeling assumptions are employed to limit reliance on external areas MW (see slide above)
- Part of the 10-Minute Operating Reserve (960 MW of 1310 MW) to Zero

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NYCA LOLE Results Visuals

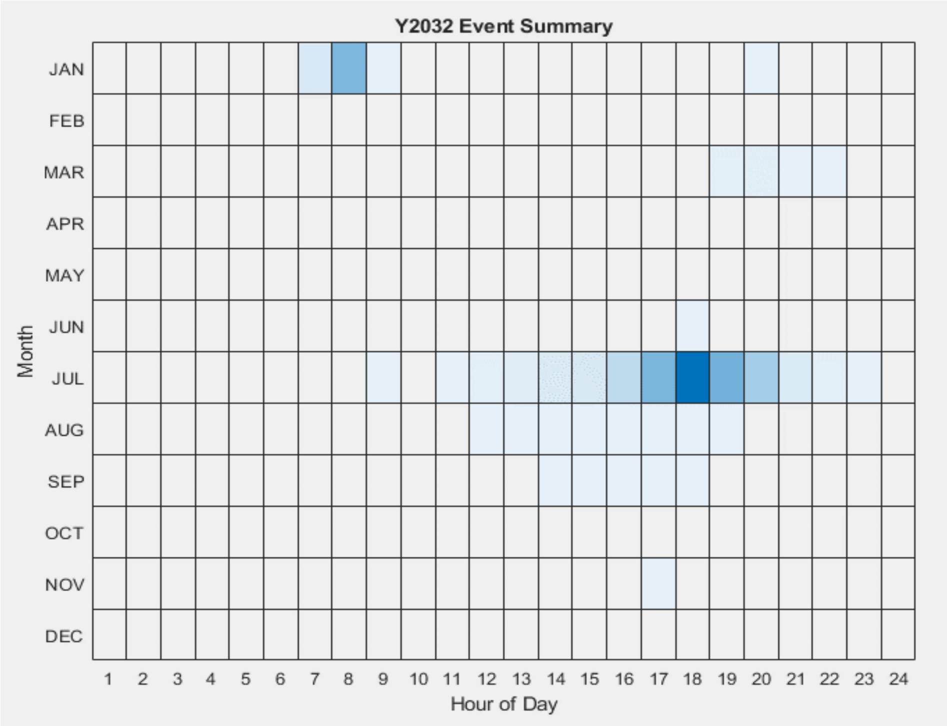
NYCA LOLE Results

Source: 2022 RNA Appendix D [link]

LOLE (dy/yr)

Month	1	2	3	4	5	6	7	Total
Jan	0.0039	0.0005						0.0043
Feb								
Mar	0.0001	0.0002			0.0002	0.0001		0.0006
Apr								
May								
Jun			0.0001					0.0001
Jul	0.0087	0.0057	0.0001					0.0146
Aug			0.0016	0.0006				0.0021
Sep			0.0001	0.0002				0.0003
Oct								
Nov			0.0001					0.0001
Dec								
Annual	0.0126	0.0064	0.0021	0.0008	0.0002	0.0001		0.0222

Load Level



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Questions?

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Roles of the NYISO

- **Reliable operation of the bulk electricity grid**
  - Managing the flow of power on 11,000 circuit-miles of transmission lines from hundreds of generating units
- **Administration of open and competitive wholesale electricity markets**
  - Bringing together buyers and sellers of energy and related products and services
- **Planning for New York's energy future**
  - Assessing needs over a 10-year horizon and evaluating projects proposed to meet those needs
- **Advancing the technological infrastructure of the electric system**
  - Developing and deploying information technology and tools to make the grid smarter

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Our Mission & Vision

Mission

Ensure power system reliability and competitive markets for New York in a clean energy future

Vision

Working together with stakeholders to build the cleanest, most reliable electric system in the nation

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