Fuel and Energy Security Study
Results and Observations

NYISO ICAPWG/MIWG

September 24, 2019

Table of Contents

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

A note on context and terminology

- The study's focus is on event-driven system vulnerabilities under harsh winter conditions
  - Stressed system assessment
  - Intentionally investigating challenging winter conditions; assessing the winter resilience of the system
  - Draws from AG, NYISO, and stakeholder consideration of potential adverse system conditions and events associated with winter operations
- Framework for evaluation
  - Risk: product of ***probability*** (how likely?) and ***consequence*** (magnitude of impact)
  - Difficulty (or relative cost) of ***mitigation*** also matters
- Perspective: focus for identifying the need for any potential enhancements should be on conditions or circumstances that:
  1. Could occur with a probability analogous to or greater than system circumstances or events considered in other operational assessments
  2. Have meaningful consequences (potential for loss of load)
  3. Are not otherwise easily mitigated or eliminated by current operational/market procedures and practices not captured by the modeling

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

A note on context and terminology

- From the start, we have sought terminology avoiding a focus on any single set of conditions (i.e., no "base case")
- Have also tried to use most descriptive terminology
- Starting point is an extended period of stressed winter conditions based on weather data from 1993-2018
- Construct cases that vary along two dimensions related to future expectations and potential contingencies:
  - **Scenarios**: potential variations in future system configurations in winter
    - Additions/retirements of generating capacity
    - Availability of natural gas for power production
    - Power transfers (to and from neighboring regions)
  - **Physical Disruptions**: primarily assessing events that do not necessarily reflect permanent system conditions
    - Temporary loss of or poor performance by operating assets
    - Temporary loss of fuel (oil, natural gas) delivery capability

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

Reminder: Scenarios

- 8 Scenarios were identified to represent different potential future system conditions
- AC and WNY Public Policy Transmission Need (PPTN) transmission upgrades are assumed in-service in all case runs

Scenario Type	Infrastructure	Imports	Oil	Natural Gas
Description	**REN:** delayed construction of new renewables, such that solar capacity is reduced to 38.5% and wind capacity is reduced to 48% of 2017 CARIS Phase 1 "System Resource Shift" case assumed levels	**IM900:** 900 MW capacity imports **IM0:** 0 MW capacity imports	**PK:** potential retirements in response to the requirements for 2023 set forth in the proposed "peaker rule"	**NGR:** Reduced non-firm gas availability to support ~2000 MW of gas-fired generation in zones A-F, ~1000 MW of gas-fired generation in zones G-I, and no non-firm gas to support generation in zones J and K
Scenario 1		**IM900**		
Scenario 2		**IM900**	**PK**	
Scenario 3		**IM0**		
Scenario 4		**IM0**	**PK**	
Scenario 5		**IM900**	**PK**	**NGR**
Scenario 6	**REN**	**IM0**	**PK**	
Scenario 7		**IM0**	**PK**	**NGR**
Scenario 8	**REN**	**IM0**	**PK**	**NGR**

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

Physical Disruptions

- A "*case*" represents a combination of a scenario and a physical disruption
- Each physical disruption represents a single disruptive event (except #1 (no disruptions) and #11 (several disruptions combined))
- All physical disruptions were run for all 8 scenarios

#	Disruption Name	Description
1	**Starting Conditions**	No physical disruptions
2	**SENY Deactivation**	Loss of significant dual fuel capability (1,000 MW) in zones G-I
3	**High Outage**	Double unit forced outage rate compared to historical averages
4	**Nuclear Outage**	Loss of major nuclear facility upstate
5	**No Truck Oil Refill**	Unavailability of truck oil fuel delivery based on historical events such as snow storms
6	**No Barge Oil Refill**	Unavailability of barge oil fuel delivery based on historical events such as rivers freezing
7	**No Oil Refill**	Unavailability of any oil fuel delivery due to severe fuel limitations affecting both barge and truck refueling
8	**Non-Firm Gas Unavailable F-K**	No gas-fired generation capability available in zones F-K
9	**Low Fuel Inventory**	Reduction of initial oil storage by unit and oil fill max tank quantity to half of historical averages
10	**Non-Firm Gas Unavailable NYCA**	No gas-fired generation capability available anywhere in NYCA
11	**Extreme Disruption**	Combination of no gas-fired generation capability available anywhere in NYCA, loss of significant dual fuel capability in zones G-I, and unavailability of any oil refill capability

Table of Contents

Key Output Metrics

- Two types of NYISO actions are modeled if reserves would be violated without action:
  - Reduction of energy-only exports to ISO-NE (up to 1,600 MW reduction)
  - Call of Special Case Resources/Emergency Demand Response Program (up to 4 hours per activation, and 5 days during the modeling period, by zone/region)

- Cases are analyzed based on **number** of:
  - Hours with required emergency actions
  - Hours with reserve violations after emergency actions
  - Hours with potential deficits where load is not met after emergency actions

- And **severity**:
  - Magnitude of any identified reserve and/or supply deficits
  - Duration and frequency of any identified reserve and/or potential supply deficits

Cross-Case Heat Map

- Qualitative "heat map" assessment seek to identify cases:
  - That have the potential for significant reliability risks that may not be addressed, mitigated, or eliminated through existing resources or actions
  - That are probable enough that they warrant further attention and consideration of whether potential remedial action is warranted

		Winter 2023/2024 Scenarios							
		Scenario 1: Initial Conditions + IM900	**Scenario 2:** Initial Conditions + IM900 + PK	**Scenario 3:** Initial Conditions + IM0	**Scenario 4:** Initial Conditions + IM0 + PK	**Scenario 5:** Initial Conditions + IM900 + PK + NGR	**Scenario 6:** Initial Conditions + REN + IM0 + PK	**Scenario 7:** Initial Conditions + IM0 + PK + NGR	**Scenario 8:** Initial Conditions + REN + IM0 + PK + NGR
Physical Disruptions	1. No Disruptions (Starting Conditions)						Day 15	Day 9	Day 9
	2. SENY Deactivation (1000 MW)					Day 3	Day 15	Day 9	Day 6
	3. High Outage			Day 15	Day 15	Day 2	Day 15	Day 3	Day 3
	4. Nuclear Outage		Day 9		Day 15	Day 2	Day 15	Day 8	Day 3
	5. No Truck Refill			Day 7	Day 6	Day 3	Day 15	Day 9	Day 3
	6. No Barge Refill		Day 15	Day 16	Day 15	Day 9	Day 15	Day 7	Day 6
	7. No Refill	Day 15	Day 15	Day 15	Day 15	Day 8	Day 9	Day 6	Day 3
	8. Non-Firm Gas Unavailable (F-K)	Day 8	Day 8	Day 9	Day 15	Day 8	Day 3	Day 15	Day 3
	9. Low Fuel Inventory	Day 16	Day 16	Day 10	Day 10	Day 15	Day 10	Day 10	Day 6
	10. Non-Firm Gas Unavailable (NYCA)	Day 9	Day 2	Day 3	Day 2	Day 2	Day 2	Day 2	Day 2
	11. Non-Firm Gas Unavailable (NYCA) + SENY Deactivation + No Refill	Day 2	Day 2	Day 2	Day 2	Day 2	Day 1	Day 2	Day 1

No identified concerns
Curtailing of energy-only exports to ISO-NE
SCR/EDRP activation
Reserve shortage
Potential for loss of load (first occurring after Day 7)
Potential for loss of load (first occurring on or before Day 7)

Note: White text indicates a concern that is confined to occurring on Long Island only

Scenario Key

REN = Delayed construction of new renewables, such that solar capacity is reduced to 38.5% and wind capacity is reduced to 48% of System Resource Shift assumed levels.

IM900 = 900 MW Capacity Imports.

IM0 = 0 MW Capacity Imports.

PK = NYSDEC "Peaker Rule" Retirements.

NGR = Reduced non-firm gas availability to support ~2000 MW of gas generation in Zones A-F, ~1000 MW of gas generation in Zones G-I, and no non-firm gas generation in Zones J and K.

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

Additional Model Runs Requested by Stakeholders

- Certain additional modeling runs were requested by stakeholders:
  - Unrestricted SCR/EDRP activations (17 days of modeling period, 6-hour runtime per activation)
  - No energy-only exports to ISO-NE in refill disruption cases
- Unrestricted SCRs have minimal impact on timing and duration of potential loss of load compare to restricted SCR cases (further details are provided in Appendix 3)
- Assumption of no energy-only exports to ISO-NE does reduce potential loss of load in no-refill cases (see heat map below for details)

Modeling Results with 0 MW of Capacity Exports During Modeling Period

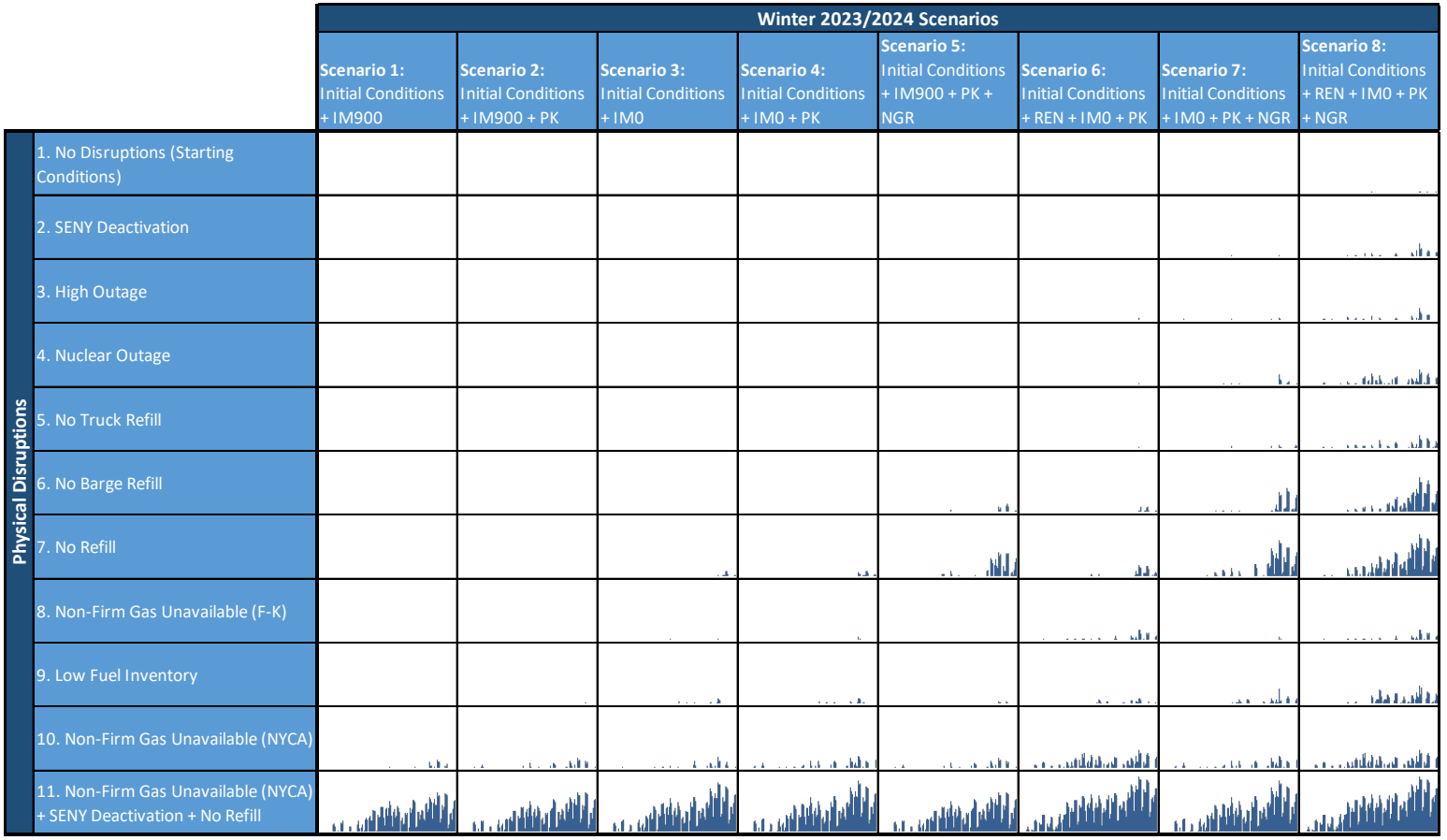
Physical Disruptions	Winter 2023/2024 Scenarios							
	Scenario 1: Initial Conditions + IM900	**Scenario 2:** Initial Conditions + IM900 + PK	**Scenario 3:** Initial Conditions + IM0	**Scenario 4:** Initial Conditions + IM0 + PK	**Scenario 5:** Initial Conditions + IM900 + PK + NGR	**Scenario 6:** Initial Conditions + REN + IM0 + PK	**Scenario 7:** Initial Conditions + IM0 + PK + NGR	**Scenario 8:** Initial Conditions + REN + IM0 + PK + NGR
No Truck Refill			Day 7	Day 6	Day 3	Day 15	Day 9	Day 3
No Barge Refill		Day 15	Day 16	Day 15	Day 9	Day 15	Day 7	Day 6
No Refill	Day 15	Day 15	Day 15	Day 15	Day 8	Day 9	Day 6	Day 3
No Truck Refill - No Exports			Day 10	Day 6	Day 3	Day 6	Day 17	Day 6
No Barge Refill - No Exports				Day 15	Day 15	Day 16	Day 9	Day 7
No Refill - No Exports	Day 15	Day 15	Day 15	Day 15	Day 9	Day 15	Day 7	Day 3

- No identified concerns
- Curtailing of energy-only exports to ISO-NE
- SCR/EDRP activation
- Reserve shortage
- Potential for loss of load (first occurring after Day 7)
- Potential for loss of load (first occurring on or before Day 7)

Note: White text indicates a concern that is confined to occurring on Long Island only

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

Combined Assessment – View of Frequency and Magnitude of Potential Loss of Load Events



Note: The scale of the axes are equal in all cells. The y-axis is set to have a maximum of 16,000 MW.

Scenario Key

REN = Delayed construction of new renewables, such that solar capacity is reduced to 38.5% and wind capacity is reduced to 48% of System Resource Shift assumed levels.
IM900 = 900 MW Capacity Imports.
IM0 = 0 MW Capacity Imports.
PK = NYSDEC "Peaker Rule" Retirements.
NGR = Reduced non-firm gas availability to support ~2000 MW of gas generation in Zones A-F, ~1000 MW of gas generation in Zones G-I, and no non-firm gas generation in Zones J and K.

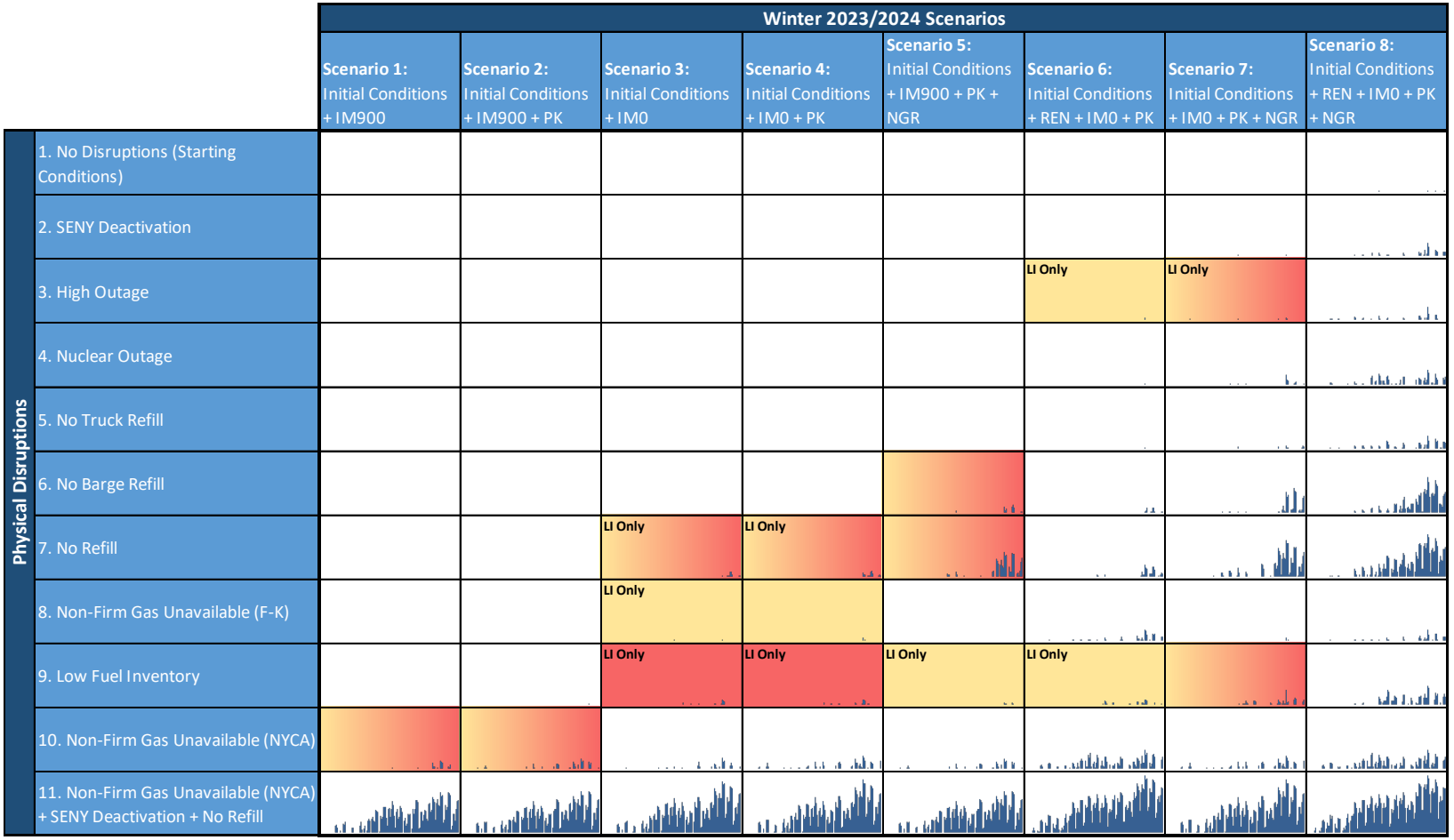
Table of Contents

- **Initial assessment attempts to review cases (combinations of scenarios and physical disruptions), with the goal of reducing them to cases that may warrant further attention**
- **This occurs in three steps:**

1. *Characterize cases by probability of occurrence*
   - Relative to circumstances and contingency combinations seen in other system operational assessments
2. *Characterize cases by severity of potential loss of load*
   - Relative to potential loss of load events that may be avoided by existing system response options (e.g., voltage reductions)
3. *Combine #1 and #2 to reduce to cases for further review that may be characterized as:*
   - Having a probability similar to conditions that may be evaluated in system operational assessments
   - Have potential loss of load outcomes that would be significant enough to warrant consideration of additional mitigating actions (e.g., enhanced procedures or market designs)

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

Key Cases for Consideration



Note: The scale of the axes are equal in all cells. The y-axis is set to have a maximum of 16,000 MW.

Combined Assessment: Based on qualitative assessments of Probability, Consequence, and ease of Mitigation, grouped as follows:

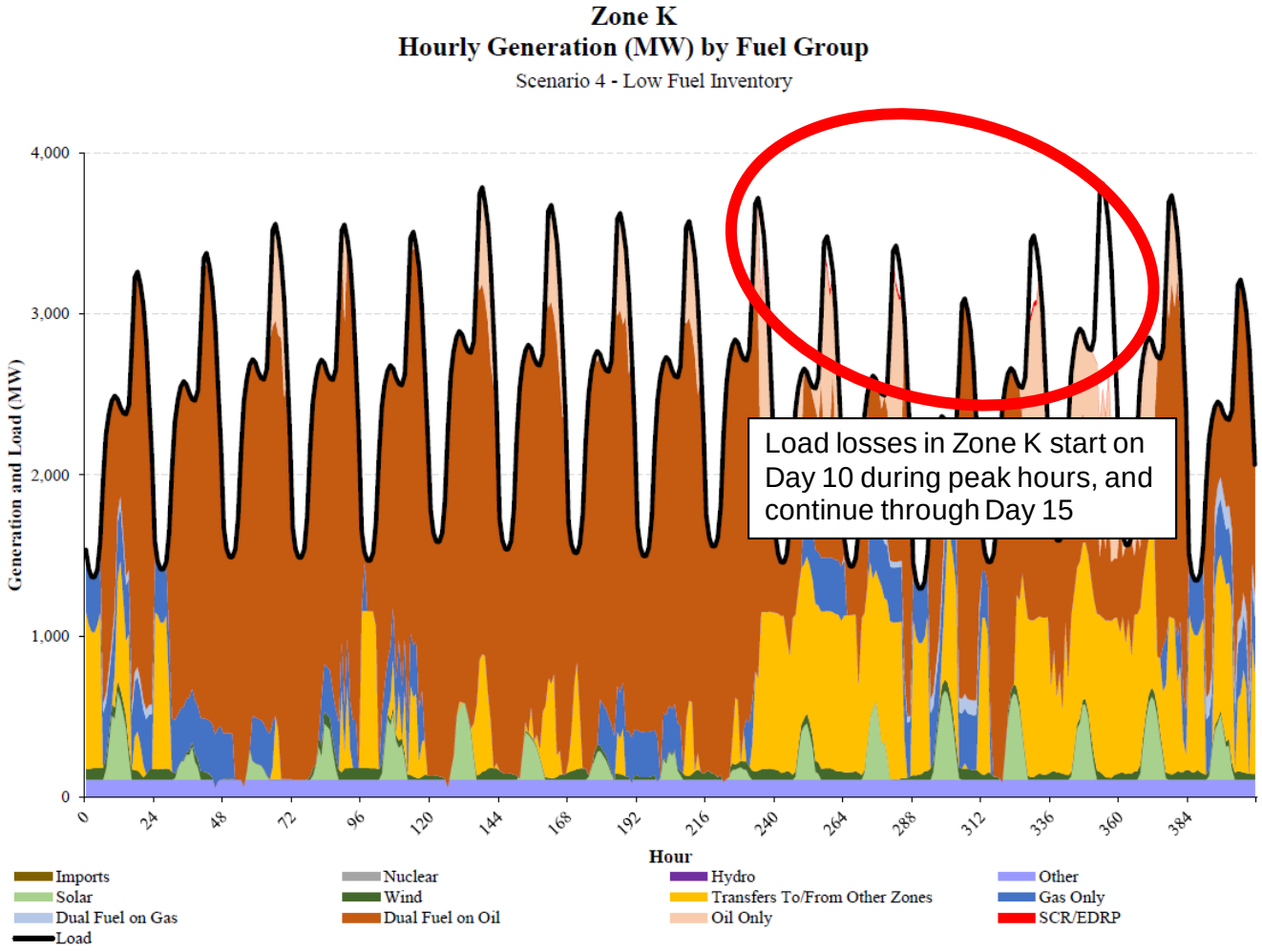
- Consequence 0-100 MW or probability extremely low (far outside normal operational assessments)
- Consequence 100 - 1,500 MW, of moderate duration/frequency, and probability low (meaningfully less likely than normal operational assessments)
- Consequence greater than 1,500 MW, and probability low (meaningfully less likely than normal operational assessments)
- Consequence greater than 1,500 MW, and probability on the order of normal operational assessments

Scenario Key

REN = Delayed construction of new renewables, such that solar capacity is reduced to 38.5% and wind capacity is reduced to 48% of System Resource Shift assumed levels.
IM900 = 900 MW Capacity Imports.
IM0 = 0 MW Capacity Imports.
PK = NYSDEC "Peaker Rule" Retirements.
NGR = Reduced non-firm gas availability to support ~2000 MW of gas generation in Zones A-F, ~1000 MW of gas generation in Zones G-I, and no non-firm gas generation in Zones J and K.

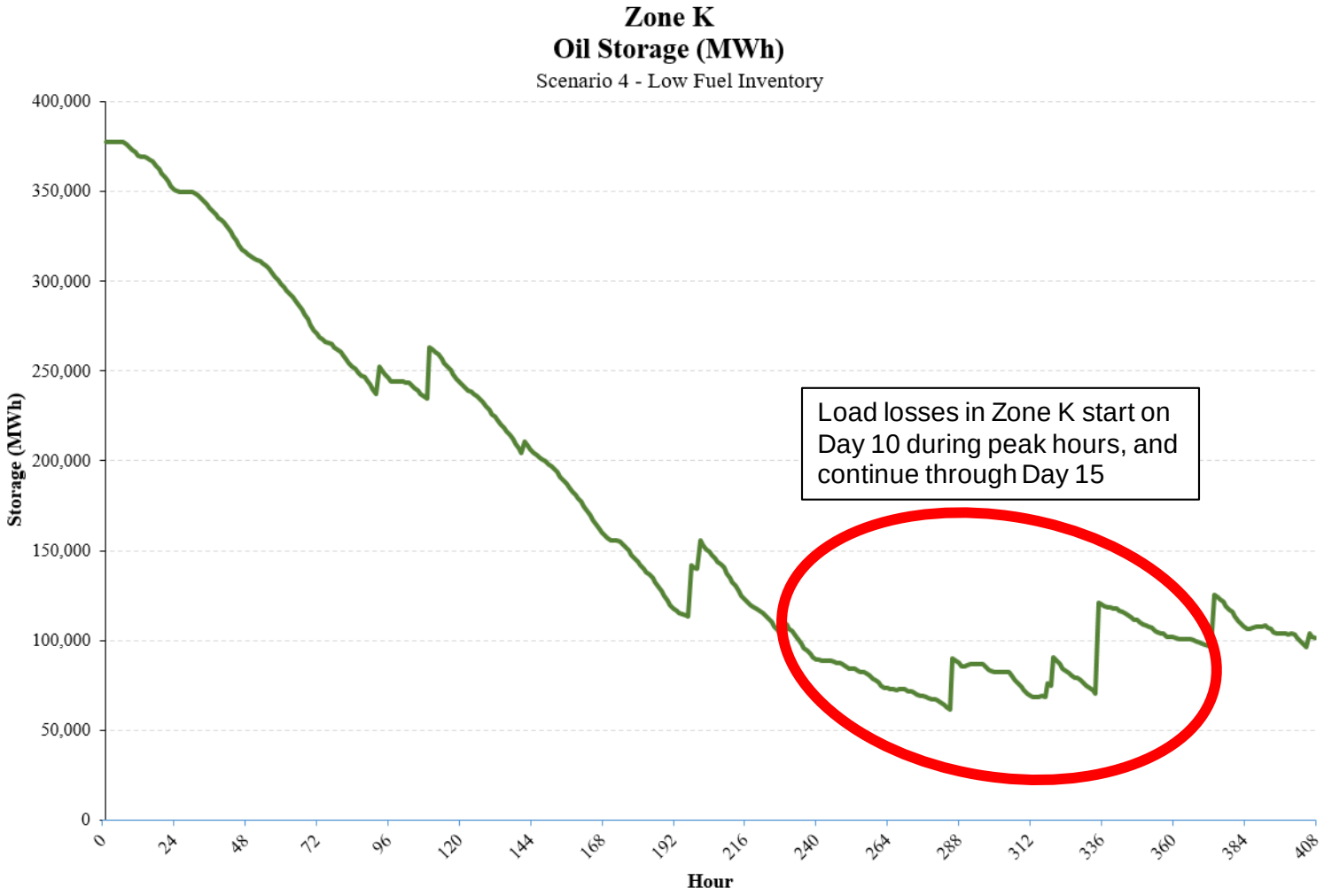
Examples of Cases with Potential Load Loss Events

- Cases with low initial oil inventory are particularly susceptible to fuel security risks on Long Island (zone K), as illustrated by the results from the Low Initial Fuel Inventory case for Scenario 4:



Examples of Cases with Potential Load Loss Events

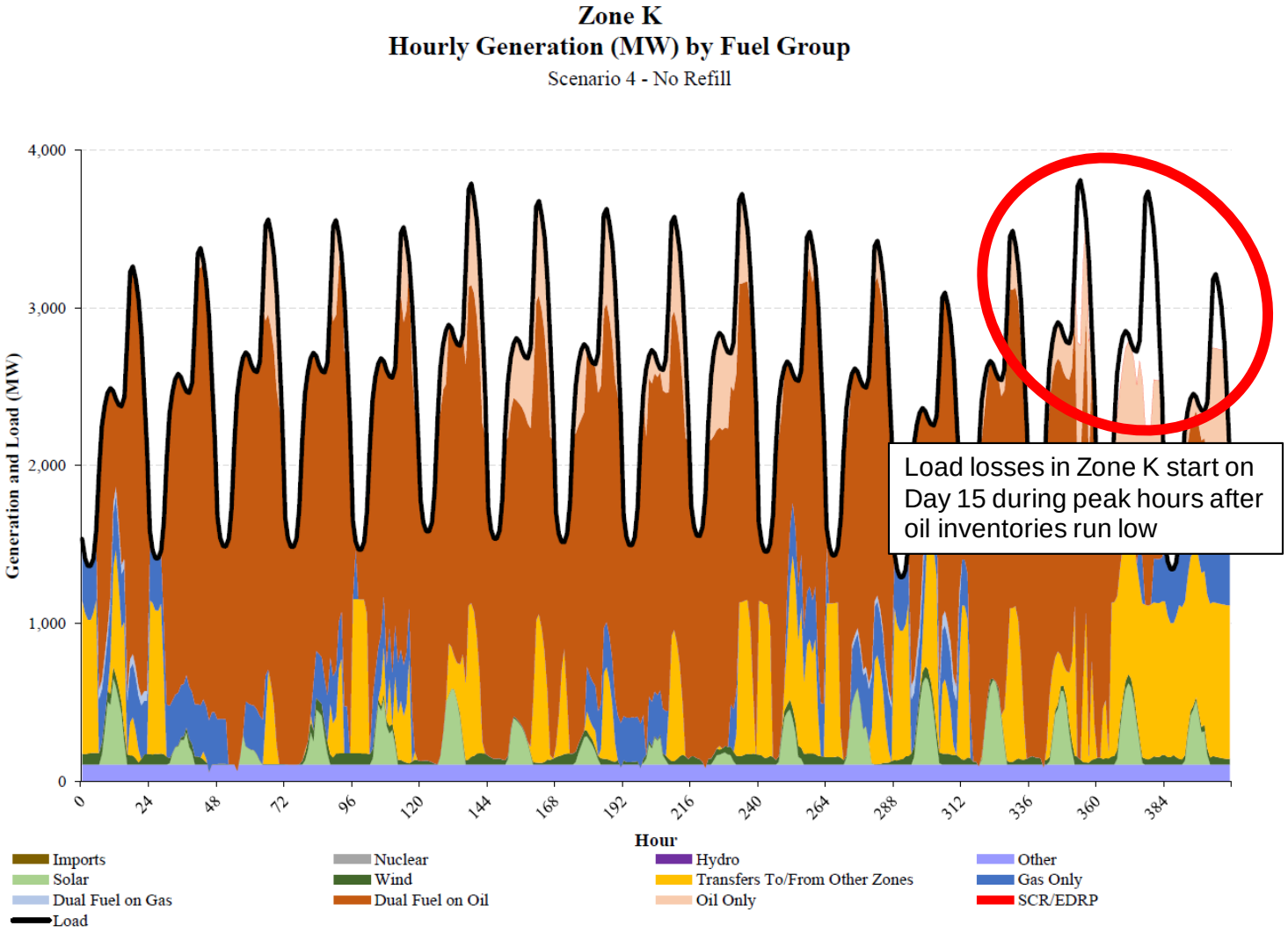
- Potential for load loss events correspond with drawdowns of inventory on Long Island (zone K) that are not able to be refilled rapidly in winter:



Note
[1] Scenario 4 includes initial conditions plus 0 MW of capacity imports, plus NYSDEC "Peaker Rule" Retirements. The offshore wind cases include an additional 816 MW of nameplate offshore wind capacity installed in Zone J, and 880 MW installed in Zone K.

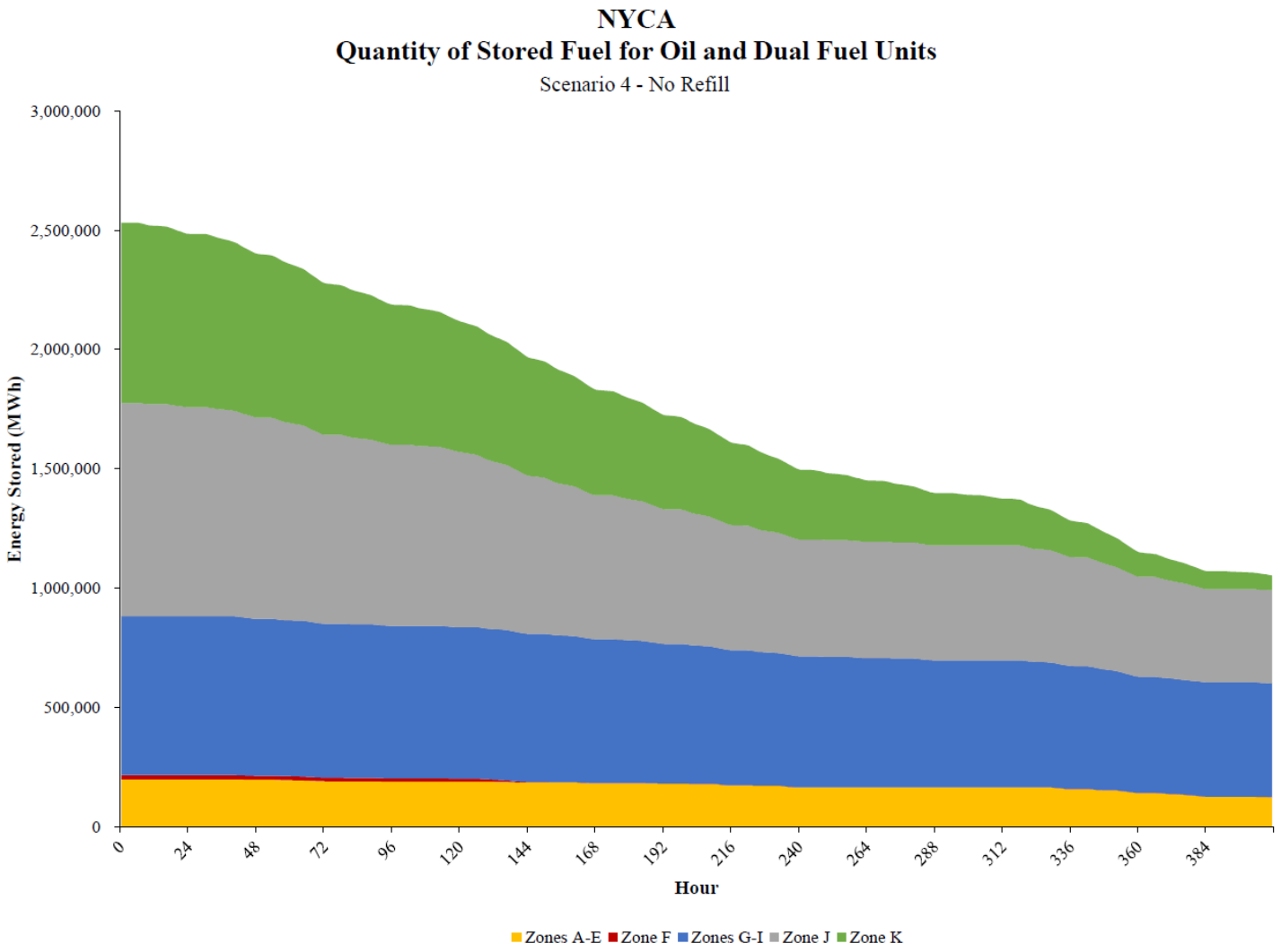
Examples of Cases with Potential Load Loss Events

- Cases with no oil refill capability are also susceptible to fuel security risks on Long Island (Zone K), as illustrated by results from the No Refill case for Scenario 4:



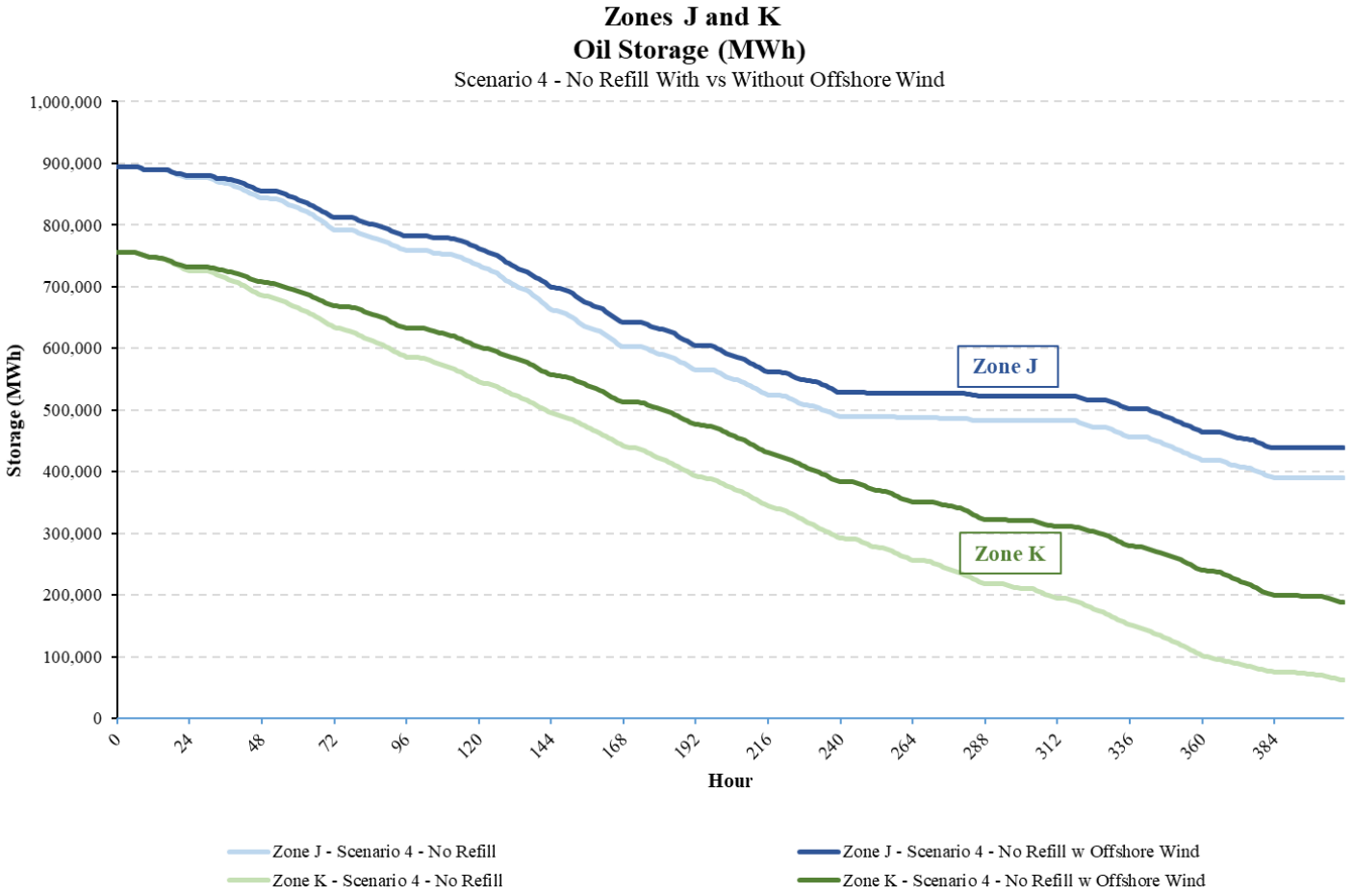
Examples of Cases with Potential Load Loss Events

- Potential for load loss events correspond with drawdowns of inventory throughout NYCA that are not replenished:



Impact of Offshore Wind

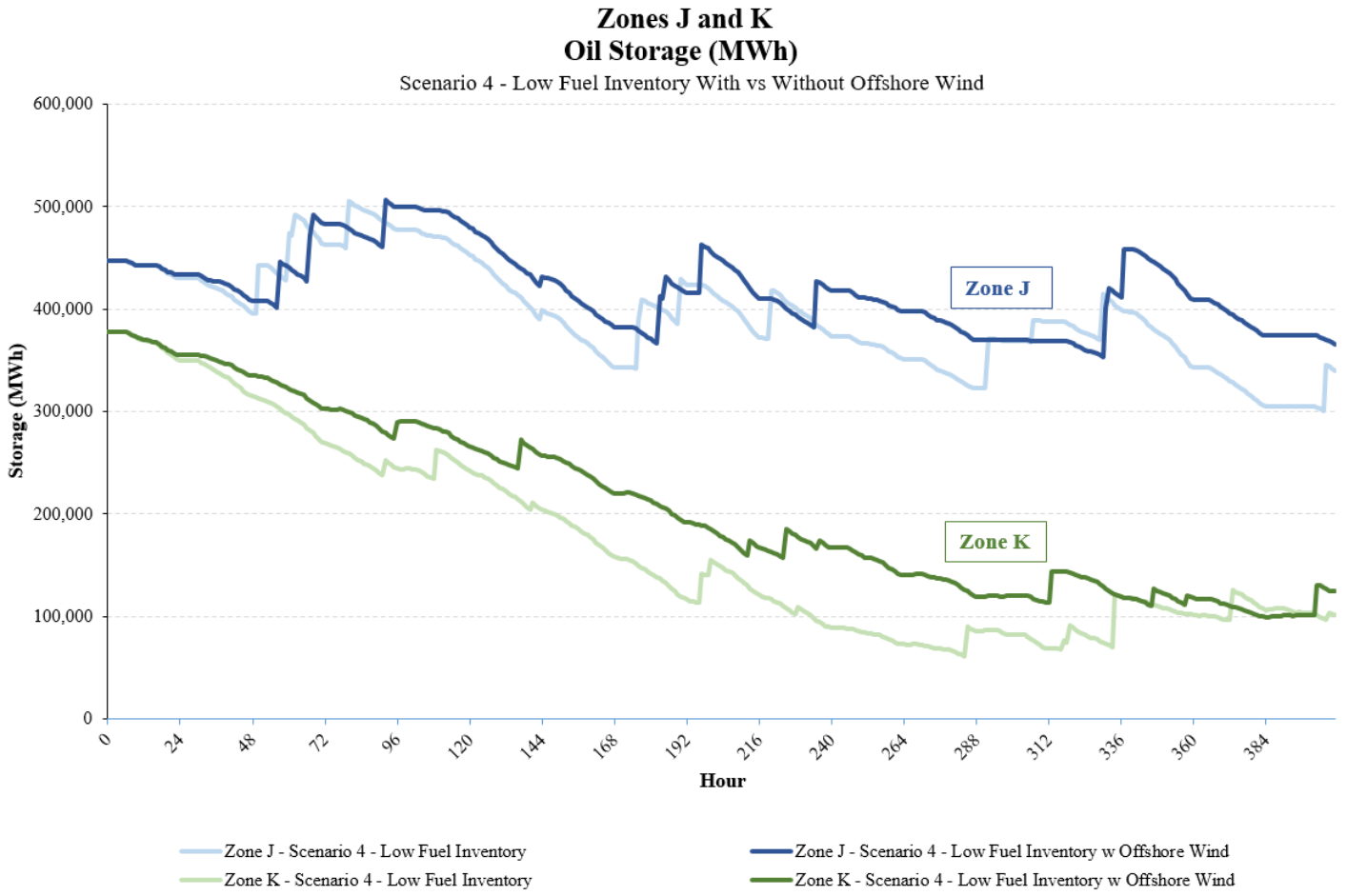
- The addition of offshore wind farms in zones J (816 MW) and K (880 MW) would reduce the amount of oil needed to be burned in these locations, thus preserving oil reserves for later in the modeling period.



Note
[1] Scenario 4 includes initial conditions plus 0 MW of capacity imports, plus NYSDEC "Peaker Rule" Retirements. The offshore wind cases include an additional 816 MW of nameplate offshore wind capacity installed in Zone J, and 880 MW installed in Zone K.

Impact of Offshore Wind

- Under the Low Fuel Inventory physical disruption, oil refueling can be delayed due to the oil preserved by offshore wind generation.

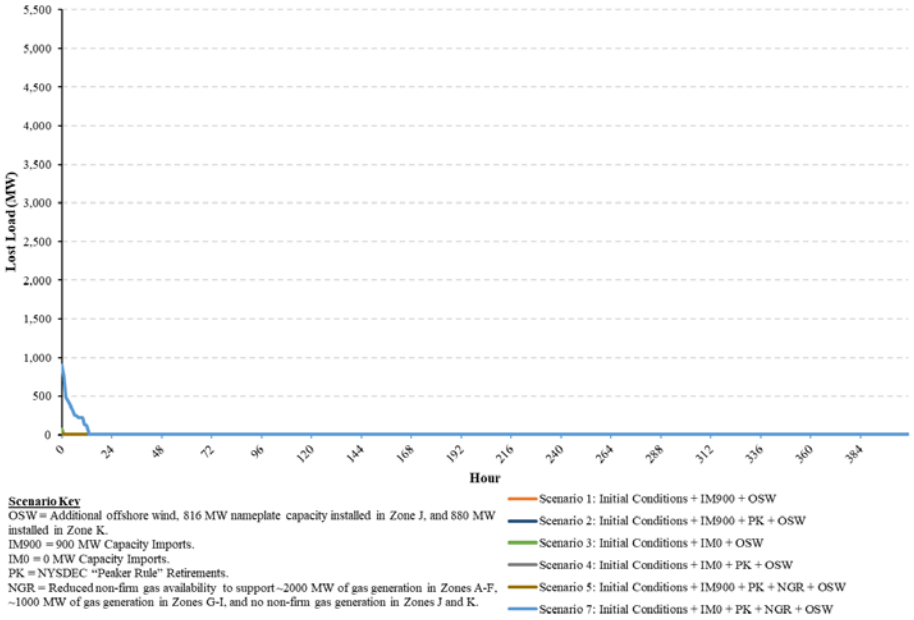


Note
[1] Scenario 4 includes initial conditions plus 0 MW of capacity imports, plus NYSDEC "Peaker Rule" Retirements. The offshore wind cases include an additional 816 MW of nameplate offshore wind capacity installed in Zone J, and 880 MW installed in Zone K.

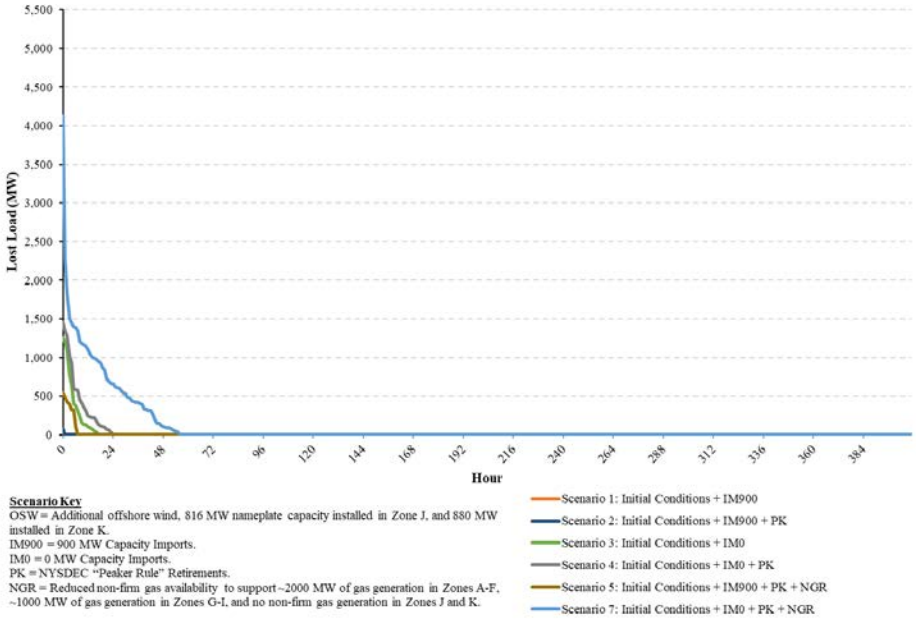
Impact of Offshore Wind

- The addition of offshore wind generation also reduces the number and severity of hours with potential for lost load across all cases where there is currently a reliability risk, especially in the Low Initial Fuel Inventory cases.

NYCA
Lost Load Duration (MWh)
Low Fuel Inventory With OSW



NYCA
Lost Load Duration (MWh)
Low Fuel Inventory Without OSW



- **As currently configured, the New York power grid is well equipped to manage energy/fuel security risks**
- **It is difficult to run into significant reliability challenges without relatively low probability combinations of system conditions and physical disruptions**
  - Generally, it requires adverse combinations of system conditions (limited gas availability, peaker rule retirements and/or limited imports), and physical disruptions (reduced oil inventory/refill, and/or reduced gas supply to support electric generation) that tend to be far less likely than conditions typically considered for system operations assessments

Actions to-date Addressing to Fuel Security Risks

- **Part of the reason New York is well positioned is because many steps have already been taking to monitor, evaluate, and address potential risks associated with the availability of fuel and responsiveness of supply resources. These steps include:**
  - A variety of practices and requirements intended to ensure continuous monitoring of assets and fuel inventories, and visibility into the operations, capacities and constraints of interstate pipelines and local natural gas LDC systems
  - Coordination of the timing of natural gas and electricity markets and the ability of supply resources to account for fuel opportunity costs in offers
  - Institution of requirements on downstate generators related to the capacity to operate on multiple fuels and switching fuels if and as needed based on prevailing temperature conditions
  - Incorporation of dual-fuel requirements for peaking plant technologies in the setting of the ICAP Demand Curves for downstate capacity regions (zones G-K)
  - Adjustment of reserve requirements statewide and downstate to reflect reliability reserve needs in system operations.
- **The set of steps already taken through changes in market rules and/or operating procedures have the effect of both increasing operator awareness of the risks and instituting requirements and financial incentives supporting the availability of fuel and the operation of assets important for reliable winter operations**

- **Some case results**
  - For cases with no physical disruptions, the potential load losses are only seen in the most extreme scenarios
  - Potential loss of load (LOL) exceeds 1,000 MW only in severe cases, with extreme disruptions causing loss of gas generation and/or disruption in fuel oil inventories or supplies
  - Cases with reduced initial storage see load losses on par with loss of gas generation to zones F-K
  - Cases with imports of 900 MW (or more) generally see few emergency actions, even with severe oil refill and non-firm gas availability restrictions
  - Delays in the expected addition of new renewable resources (relative to initial condition assumptions) increases the potential for LOL events
- **Loss of gas-fired generation capability presents significant concerns**
  - Large, long, and frequent potential for LOL events in all scenarios with gas interrupted NYCA-wide
  - Comparatively, gas-fired generation unavailability limited to zones F-K has materially lesser impact
  - Reduced gas *scenarios* run into trouble quickly when combined with other system conditions (reduced imports, potential retirements resulting from the proposed "peaker rule") and fuel interruptions

- **Significant potential LOL events appear in cases involving reduced operation of oil-fired generating assets, particularly in the downstate regions.**
  - Most cases assuming low initial fuel inventories result in potential LOL events (ranging from a few hundred MW for 10 hours or so, up to 5,000 MW with a hundred hours of disruptions)
  - Most scenarios run into *large* impacts without refill capability
    - Barge refill capability is most important (impacts range from 2,000 MW for tens of hours to 10,000 MW for 140 hours)
    - Limitations to truck refill capability becomes a problem in only the most extreme scenarios (scenarios 7 and 8, with potential LOL events at 800 MW/12 hours and 3,500 MW/70 hours, respectively)
- **As a result, dual fuel capability - with oil as a backup fuel to natural gas - is vital for maintaining reliability during the ongoing transition of the resource fleet over the coming years.**
- **A majority of circumstances leading to potential LOL events are constrained to Long Island.**
  - Reduced fuel oil inventories and/or limitations on fuel oil refill are particularly problematic on LI in most scenarios
  - Reduced imports and potential resource retirements resulting from the proposed "peaker rule" increase the potential LOL vulnerability on LI

Observations, cont'd

- **Maintaining power imports during cold weather conditions, and meeting the state's renewable resource goals can provide valuable reliability support, and this may be particularly true with respect to offshore wind**
  - A recent offshore wind solicitation conducted by NYSERDA led to the approval of almost 1,700 MW of new offshore wind to be injected into zones J (NYC) and K (LI)
  - Alternative scenarios modeling low initial oil inventory but additional offshore wind show avoided or significantly reduced potential loss of load events
- **Over the longer term, the potential magnitude and pace of change to the New York power system stemming from requirements under the Climate Leadership and Community Protection Act (CLCPA) may be of far greater importance to evaluate than all other considerations, scenarios and physical disruptions evaluated in this fuel and energy security study with respect to winter operational risks**
  - Hydro and nuclear resources are critical in winter operations, particularly where delivery of oil or gas is compromised
  - Production by renewables is potentially important to preserve capability from other resource types, including fossil fired generation
  - Downstate offshore wind production potentially has a major impact on reducing/mitigating potential LOL events in NYC and LI (however, this observation is based on the use of generic operating profiles for offshore wind in the Northeast)

Options

- **NYISO has taken many steps focused on the natural gas-electricity link; these actions and fuel oil requirements downstate address many potential risks**
- **Continued/future monitoring and analysis is critical**
  - Analysis identifies potential areas of vulnerability; NYISO should continuously monitor vulnerabilities and expand on this analysis as needed
  - Frequent review of key assumptions underlying assessment
    - Changes in demand growth (both electric and retail natural gas)
    - Availability of natural gas for power generation and trends in oil-fired capability
    - Starting fuel oil inventories, refill actions, and potential disruptions in barge/truck refill
    - Import and export capability and outcomes during winter peaks
- **The pace and nature of changes in the power system to meet the requirements of the CLCPA warrant close review and continuous forecasting and assessment**
  - Additional renewables and energy storage can help reduce or mitigate fuel security-related risks
  - This heightens the importance of understanding the operating profile of such resources under cold weather conditions (this is particularly important for offshore wind downstate)
  - On the other hand, the CLCPA may also increase uncertainty and risk if (a) demand significantly increases and/or changes in nature due to electrification of heating/transportation sectors, or (b) it accelerates the retirement of resources vital for winter reliability (i.e., oil and dual fuel capability) that is not well coordinated with the addition of viable replacement supply options

Options, cont'd

- **Focus on the possible impacts of potential retirements in response to the proposed "peaker rule"**
  - Assets impacted by the proposed "peaker rule" play a critical winter reliability role downstate
  - As NYISO evaluates potential reliability impacts from the proposed "peaker rule," it should pay particular attention to winter operations
- **Consider the potential of geographically-targeted development of new renewable and energy storage resources stemming from the CLCPA**
  - Targeted locations of resources developed in response to the CLCPA can help reduce potential winter reliability risks
- **If continued monitoring reveals meaningful winter reliability risks in the future related to the key vulnerabilities of oil/dual-fuel operations, further assess the adequacy of incentives related to ensuring appropriate pre-season fuel oil inventory levels and/or replenishment arrangements**
  - Downstate oil-firing capability is currently key to winter power system reliability
  - Should issues arise, may consider whether additional actions are warranted to address potential adverse changes in oil inventory levels

Initiatives from Other Regions – New England Experience

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

- **New England has considered or implemented numerous initiatives**
  - New England faces unique fuel security risks
  - Many initiatives have already been implemented or considered by NYISO; only some of the remaining balance may be worth considering in the NY context
- **Miscellaneous ISO-NE initiatives**
  - Risk assessment formally evaluating fuel security risks
  - Attempt to impose real-time fuel responsibility for capacity resources (rejected)
  - Energy-gas market timing
  - Reserve levels and prices
  - Generating unit posturing
- **Specific ISO-NE market design initiatives**
  - "Pay for Performance" in capacity market
  - Winter Reliability Program and Interim Compensation (purchasing fuel in advance of winter)
  - Fuel Security Reliability Assessment (applied in retaining Mystic generating units that proposed to retire)
  - Opportunity costs (in energy market offers)
  - Market-based fuel security designs under consideration
    - Multi-day day ahead market construct, new ancillary service markets to purchase energy reserves day ahead
    - Forward energy reserve market

Table of Contents

- Finalize Report
  - Currently anticipated schedule for completing report:
    - Draft report posted for stakeholder review on or before September 30, 2019
      - NYISO will provide notice to stakeholders when the draft report is posted
    - Submission of stakeholder comment on draft report by October 14, 2019
      - Intend to provide a two-week period for review and submission of comments; comment deadline would be adjusted accordingly if the draft report is posted after September 30, 2019
    - Seek to finalize and post final report by the end of October 2019/early-November 2019
- NYISO/stakeholders consider potential actions (if any) to address identified risks

Contact

Paul Hibbard, Principal
617 425 8171
paul.hibbard@analyisgroup.com

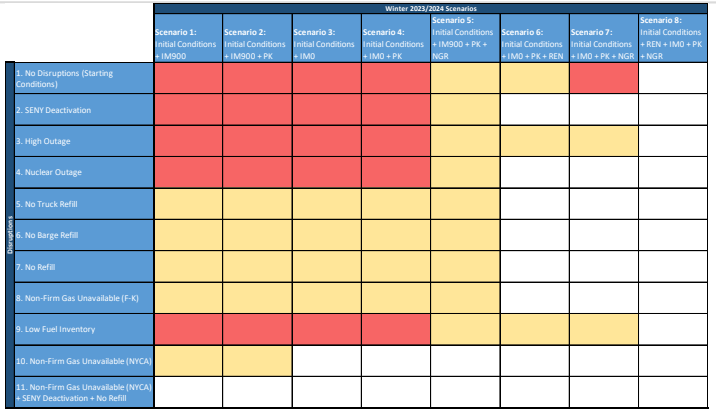
Appendix 1: Case Assessment Charts

Appendix A: Qualitative Assessment and Categorization of Results - Summary

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

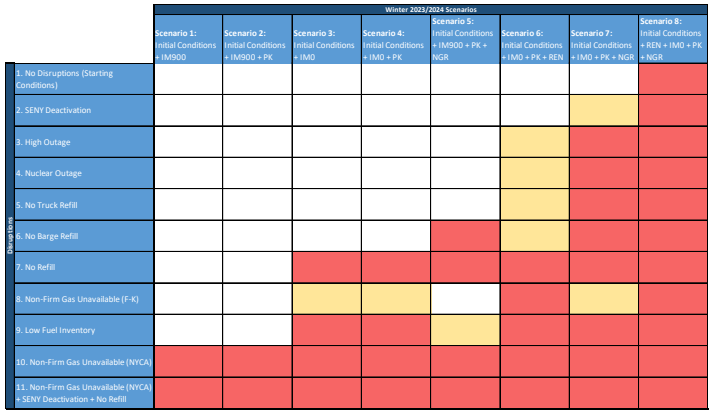
Probability: Assessed qualitatively relative to typical construction of system operational assessment scenarios, grouped as follows:

- Highly unlikely to occur - probablility far outside typical conditions used in system operational assessments
- Probability meaningfully less likely than typical conditions used in system operational assessments
- Probability on the order of typical conditions used in system operational assessments



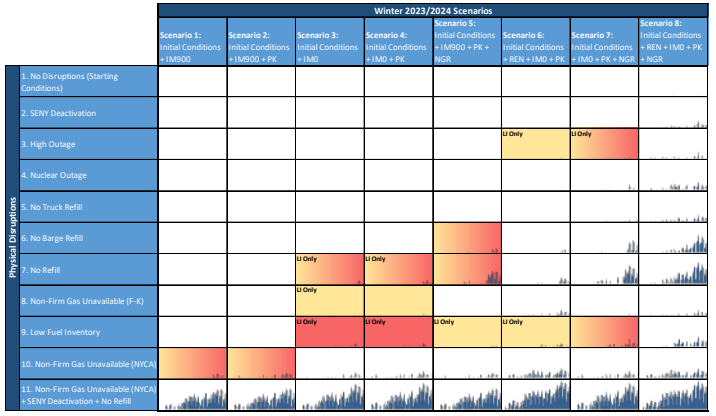
Consequence/Ease of Mitigation: Assessed based on magnitude, duration, and frequency of loss of load, grouped as follows:

- Loss of load zero or less than 100 MW, short duration (less than 4 hours), infrequent (not more than two events over cold snap)
- Loss of load between 100 and 1,500 MW, moderate duration (up to 12 hours), not infrequent (two or three events over cold snap)
- Loss of load greater than 1,500 MW OR between 100 and 1,500 MW with longer duration (more than 12 hours) OR between 100 and 1,500 MW that is frequent (more than three events over cold snap)



Combined Assessment: Based on qualitative assessments of Probability, Consequence, and ease of Mitigation, grouped as follows:

- Consequence 0-100 MW or probability extremely low (far outside normal system operational assessments)
- Consequence 100 - 1,500 MW, of moderate duration/frequency, and probability low (meaningfully less likely than normal system operational assessments)
- Consequence greater than 1,500 MW, and probability low (meaningfully less likely than normal system operational assessments)
- Consequence greater than 1,500 MW, and probability on the order of normal system operational assessments



Appendix B: Qualitative Assessment and Categorization of Results – Probability of Occurrence

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

Disruptions	Winter 2023/2024 Scenarios							
	Scenario 1: Initial Conditions + IM900	**Scenario 2:** Initial Conditions + IM900 + PK	**Scenario 3:** Initial Conditions + IM0	**Scenario 4:** Initial Conditions + IM0 + PK	**Scenario 5:** Initial Conditions + IM900 + PK + NGR	**Scenario 6:** Initial Conditions + IM0 + PK + REN	**Scenario 7:** Initial Conditions + IM0 + PK + NGR	**Scenario 8:** Initial Conditions + REN + IM0 + PK + NGR
1. No Disruptions (Starting Conditions)								
2. SENY Deactivation								
3. High Outage								
4. Nuclear Outage								
5. No Truck Refill								
6. No Barge Refill								
7. No Refill								
8. Non-Firm Gas Unavailable (F-K)								
9. Low Fuel Inventory								
10. Non-Firm Gas Unavailable (NYCA)								
11. Non-Firm Gas Unavailable (NYCA) + SENY Deactivation + No Refill								

Probability: Assessed qualitatively relative to typical construction of operational assessment scenarios, grouped as follows:

- Highly unlikely to occur - probability far outside typical conditions used in system operational assessments
- Probability *meaningfully less likely than* typical conditions used in system operational assessments
- Probability on the order of typical conditions used in system operational assessments

Scenario Key

REN = Delayed construction of new renewables, such that solar capacity is reduced to 38.5% and wind capacity is reduced to 48% of System Resource Shift assumed levels.

IM900 = 900 MW Capacity Imports.

IM0 = 0 MW Capacity Imports.

PK = NYSDEC "Peaker Rule" Retirements.

NGR = Reduced non-firm gas availability to support ~2000 MW of gas generation in Zones A-F, ~1000 MW of gas generation in Zones G-I, and no non-firm gas generation in Zones J and K.

Appendix C: Qualitative Assessment and Categorization of Results – Consequence/Ease of Mitigation

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

Disruptions	Winter 2023/2024 Scenarios							
	Scenario 1: Initial Conditions + IM900	**Scenario 2:** Initial Conditions + IM900 + PK	**Scenario 3:** Initial Conditions + IM0	**Scenario 4:** Initial Conditions + IM0 + PK	**Scenario 5:** Initial Conditions + IM900 + PK + NGR	**Scenario 6:** Initial Conditions + IM0 + PK + REN	**Scenario 7:** Initial Conditions + IM0 + PK + NGR	**Scenario 8:** Initial Conditions + REN + IM0 + PK + NGR
1. No Disruptions (Starting Conditions)								
2. SENY Deactivation								
3. High Outage								
4. Nuclear Outage								
5. No Truck Refill								
6. No Barge Refill								
7. No Refill								
8. Non-Firm Gas Unavailable (F-K)								
9. Low Fuel Inventory								
10. Non-Firm Gas Unavailable (NYCA)								
11. Non-Firm Gas Unavailable (NYCA) + SENY Deactivation + No Refill								

Consequence: Assessed based on magnitude, duration, and frequency of loss of load, grouped as follows:

- Loss of load zero or less than 100 MW, with short duration (less than 4 hours), that is infrequent (not more than two events over cold snap)
- Loss of load between 100 and 1,500 MW, with moderate duration (up to 12 hours), that is not infrequent (two or three events over cold snap)
- Loss of load greater than 1,500 MW OR between 100 and 1,500 MW with longer duration (more than 12 hours) OR between 100 and 1,500 MW that is frequent (more than three events over cold snap)

Scenario Key

REN = Delayed construction of new renewables, such that solar capacity is reduced to 38.5% and wind capacity is reduced to 48% of System Resource Shift assumed levels.

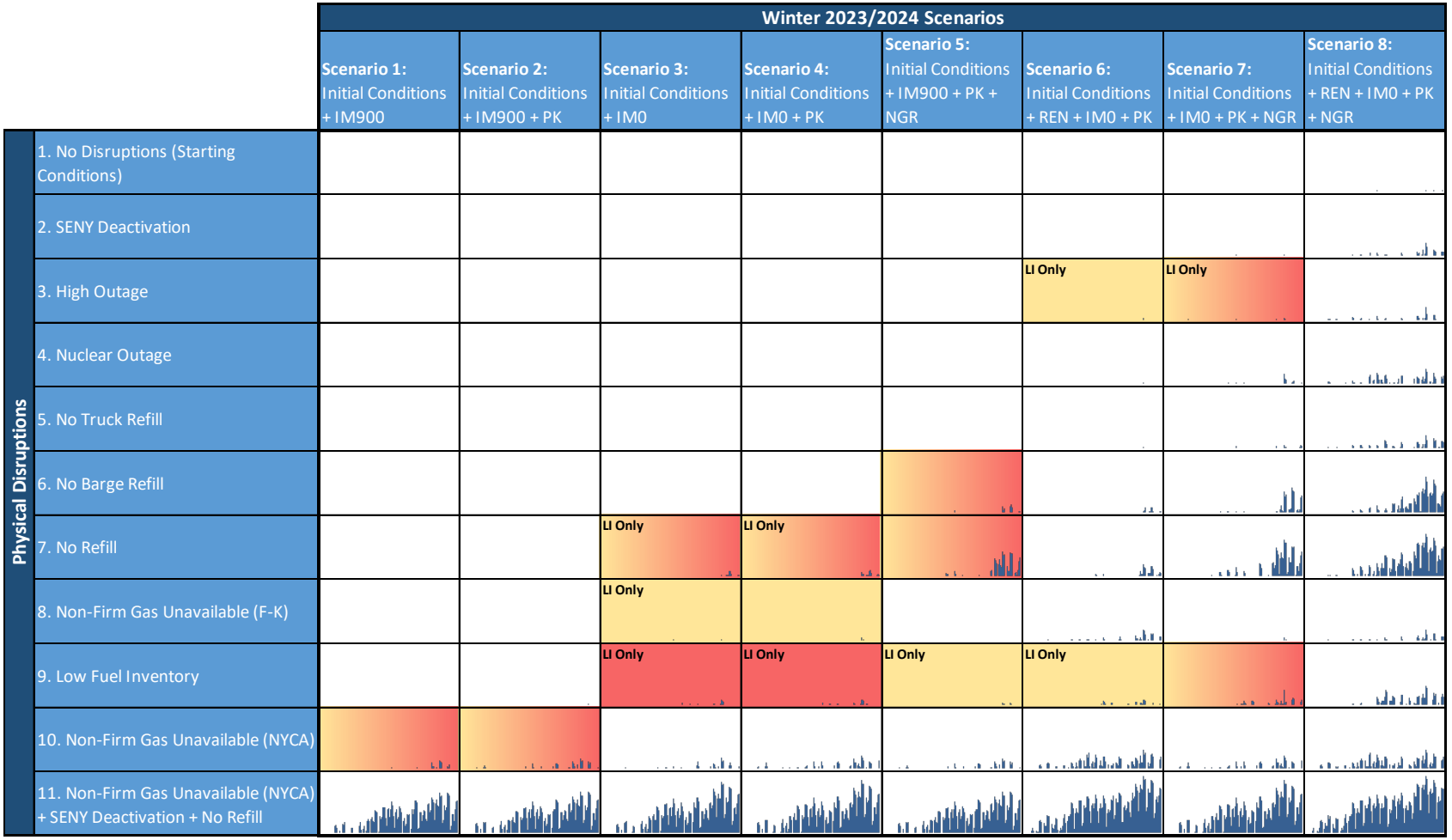
IM900 = 900 MW Capacity Imports.

IM0 = 0 MW Capacity Imports.

PK = NYSDEC "Peaker Rule" Retirements.

NGR = Reduced non-firm gas availability to support ~2000 MW of gas generation in Zones A-F, ~1000 MW of gas generation in Zones G-I, and no non-firm gas generation in Zones J and K.

Appendix D: Qualitative Assessment and Categorization of Results – Combined Assessment



Note: The scale of the axes are equal in all cells. The y-axis is set to have a maximum of 10,000 MW.

Combined Assessment: Based on qualitative assessments of Probability, Consequence, and ease of Mitigation, grouped as follows:

- Consequence 0-100 MW or probability extremely low (far outside normal operational assessments)
- Consequence 100 - 1,500 MW, of moderate duration/frequency, and probability low (meaningfully less likely than normal operational assessments)
- Consequence greater than 1,500 MW, and probability low (meaningfully less likely than normal operational assessments)
- Consequence greater than 1,500 MW, and probability on the order of normal operational assessments

Scenario Key

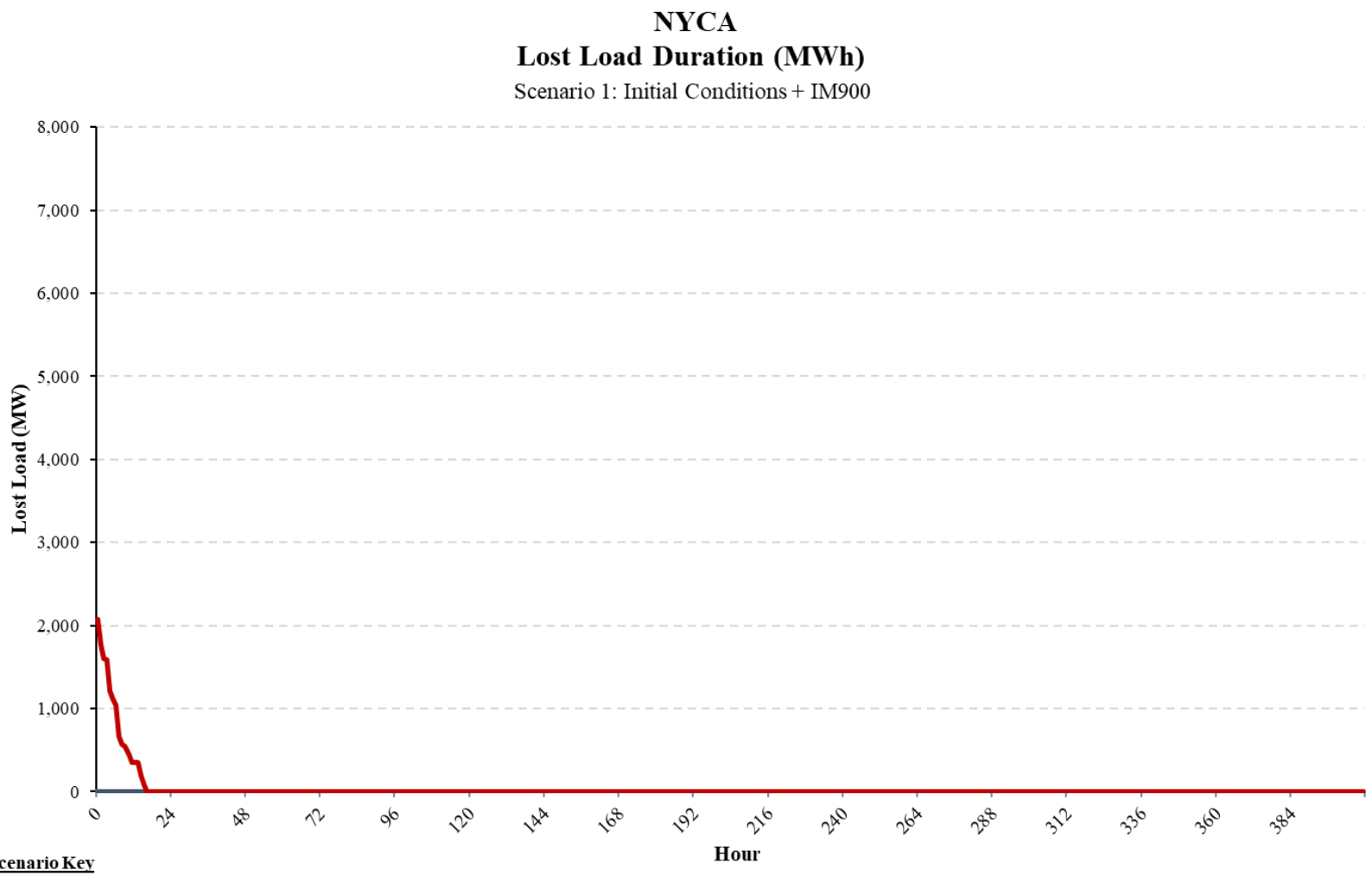
REN = Delayed construction of new renewables, such that solar capacity is reduced to 38.5% and wind capacity is reduced to 48% of System Resource Shift assumed levels.
IM900 = 900 MW Capacity Imports.
IM0 = 0 MW Capacity Imports.
PK = NYSDEC "Peaker Rule" Retirements.
NGR = Reduced non-firm gas availability to support ~2000 MW of gas generation in Zones A-F, ~1000 MW of gas generation in Zones G-I, and no non-firm gas generation in Zones J and K.

Appendix 2: Loss of Load Duration Curves

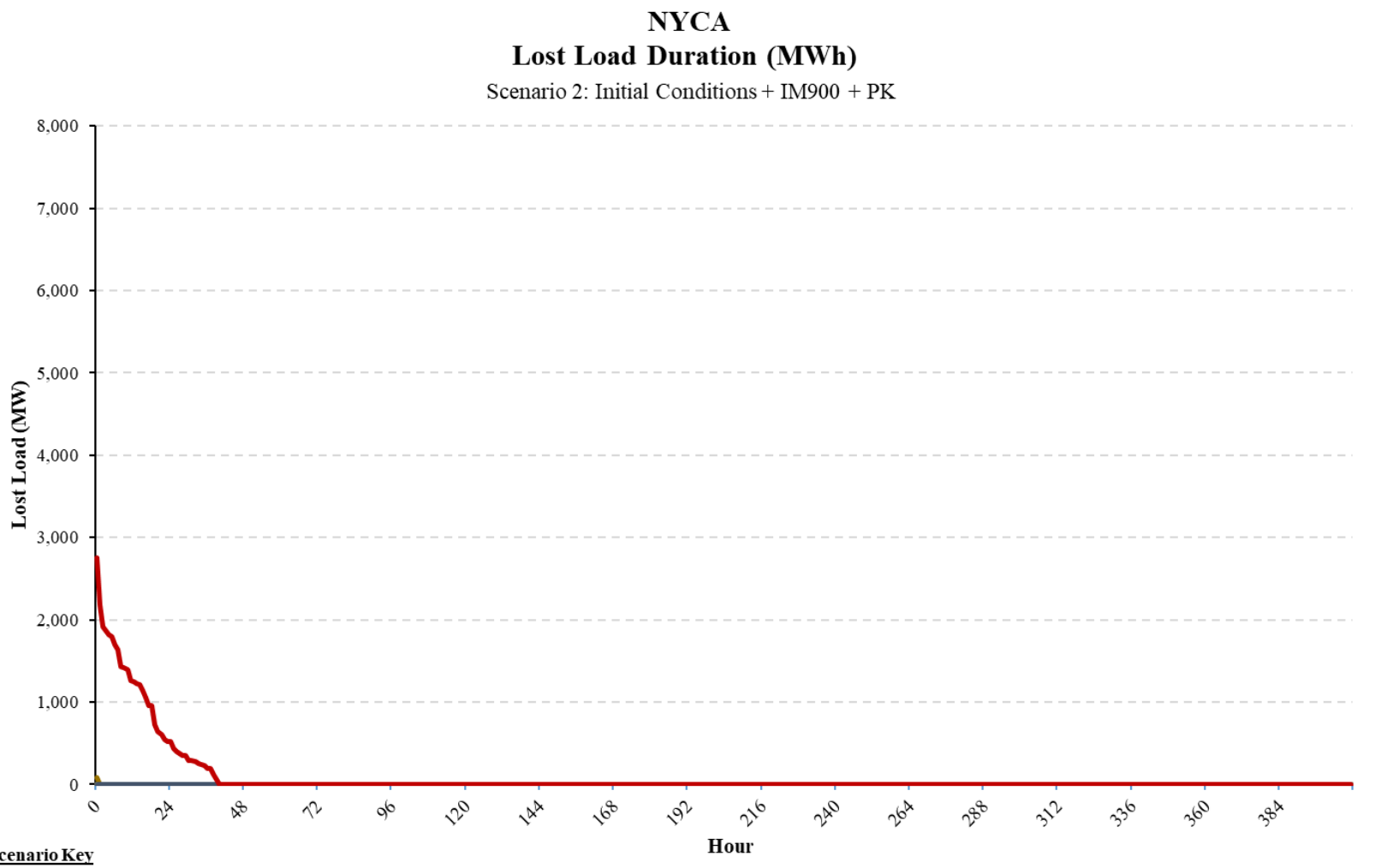
Potential LOL Event Duration Curves

- Loss of load duration curves (LOLDCs) for potential loss of load events
  - Show magnitude and duration of potential lost load events
  - Display relative to figures of merit (e.g., available relief from existing actions/programs, duration of hours, days or longer)
  - Show results by scenario, for all physical disruptions

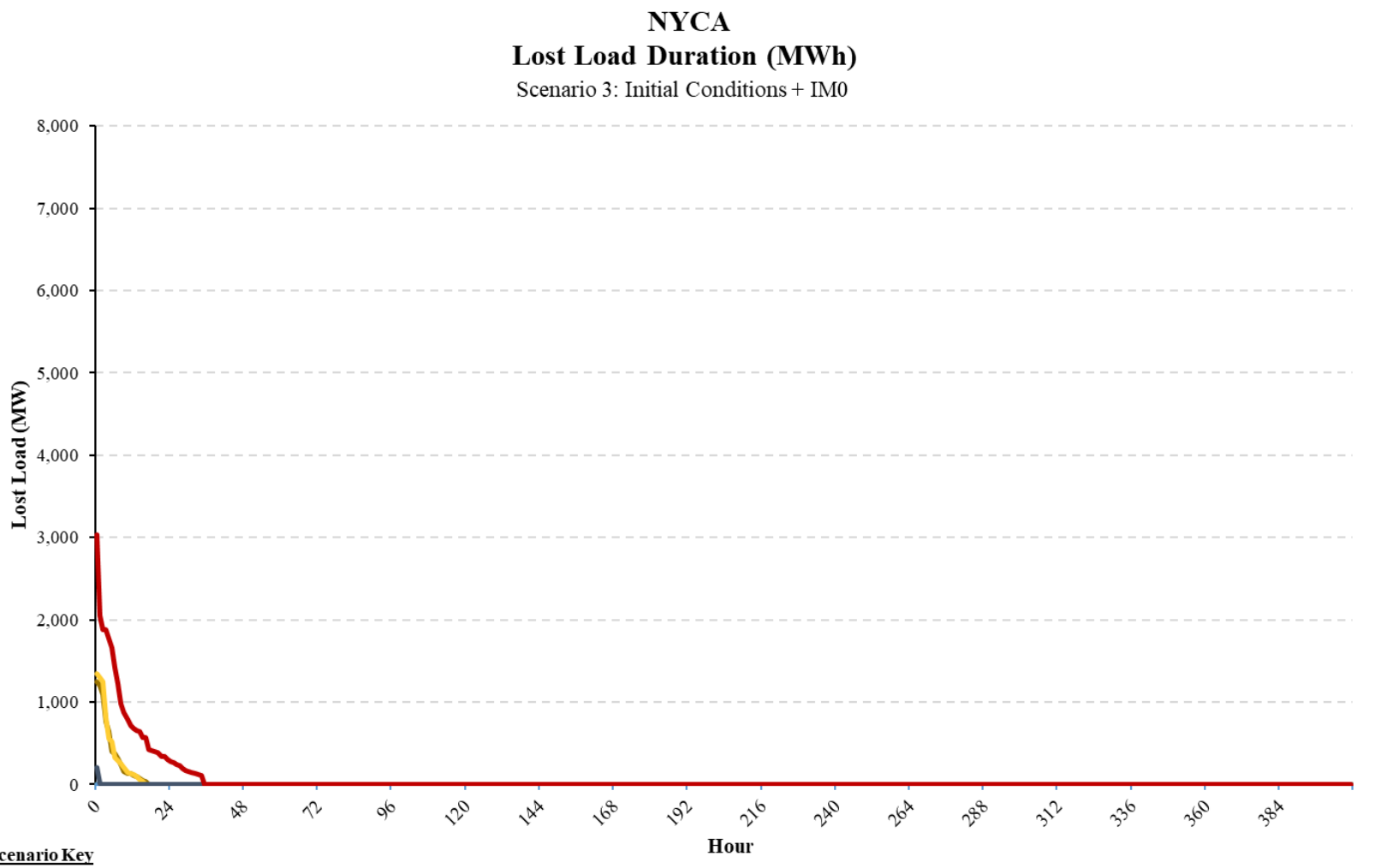
Loss of Load Duration Curves by Scenario



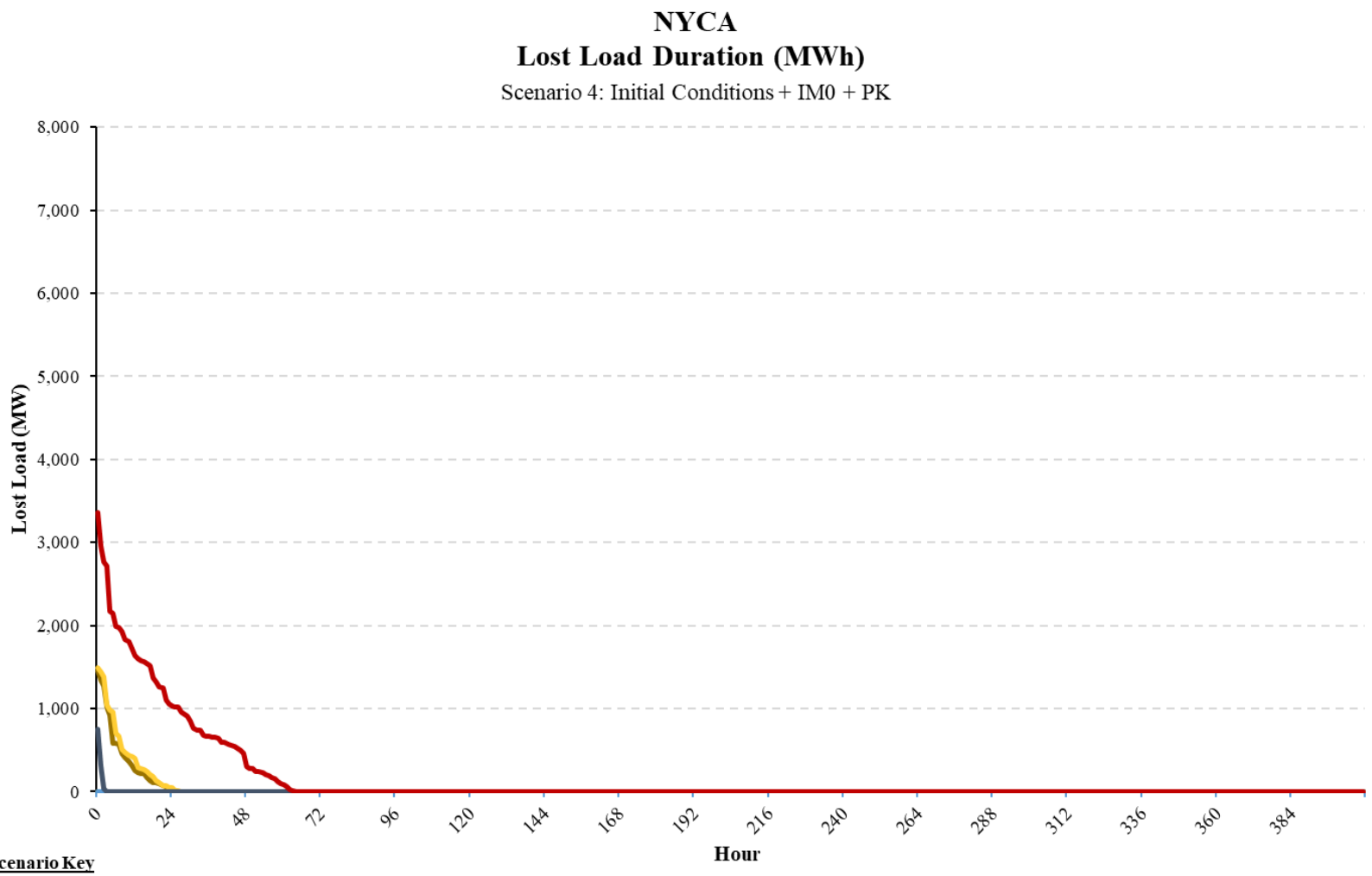
Loss of Load Duration Curves by Scenario



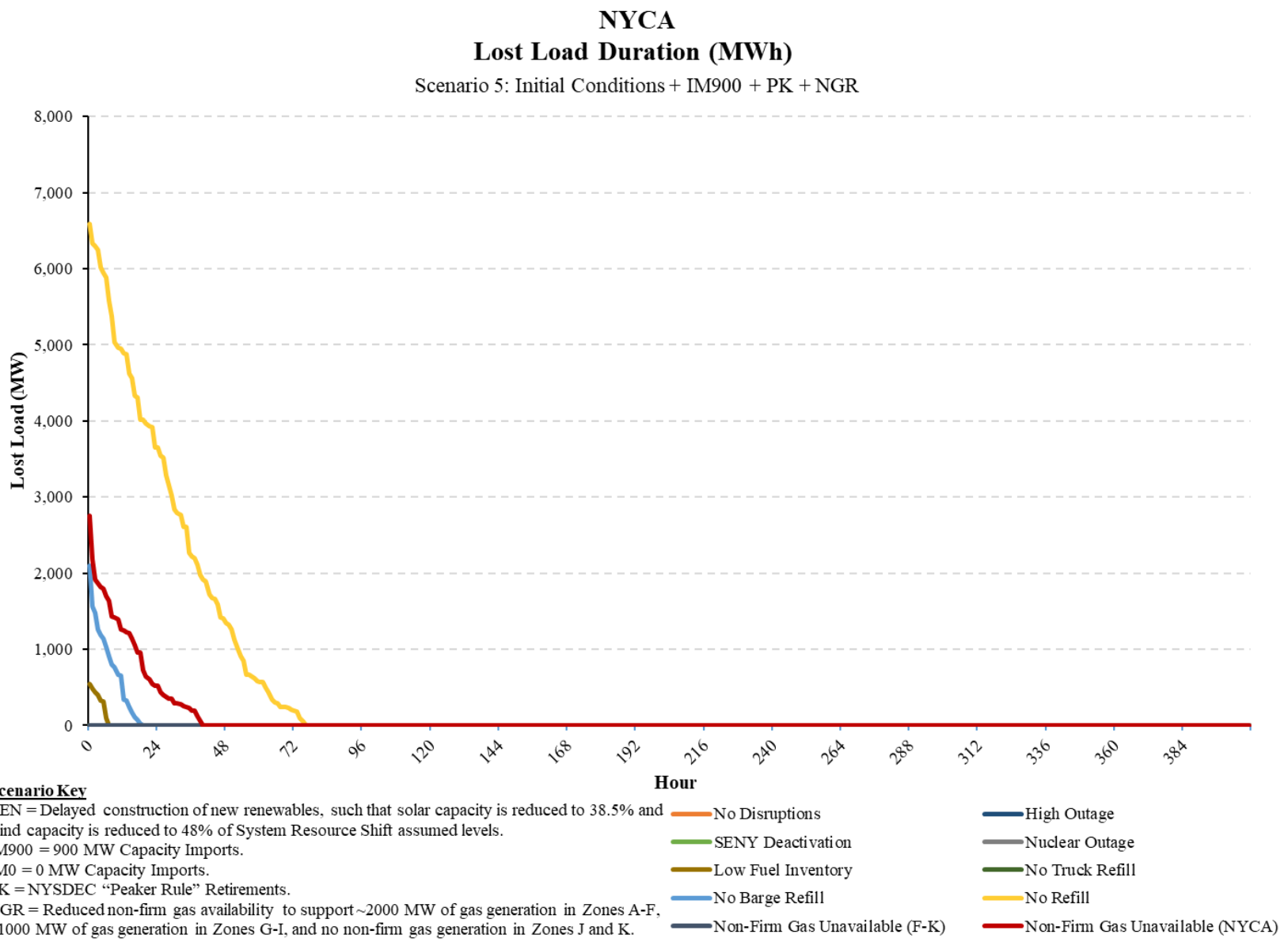
Loss of Load Duration Curves by Scenario



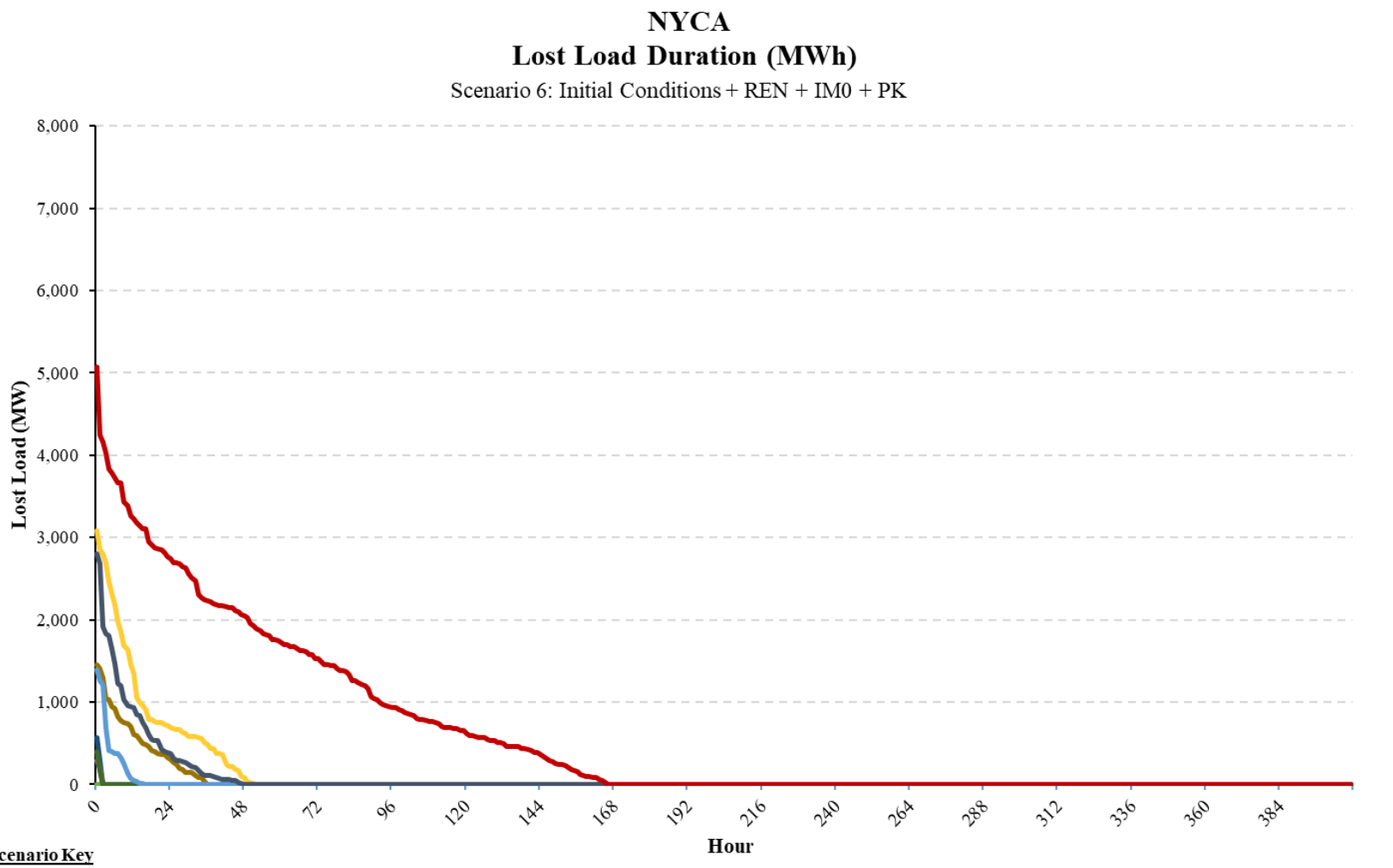
Loss of Load Duration Curves by Scenario



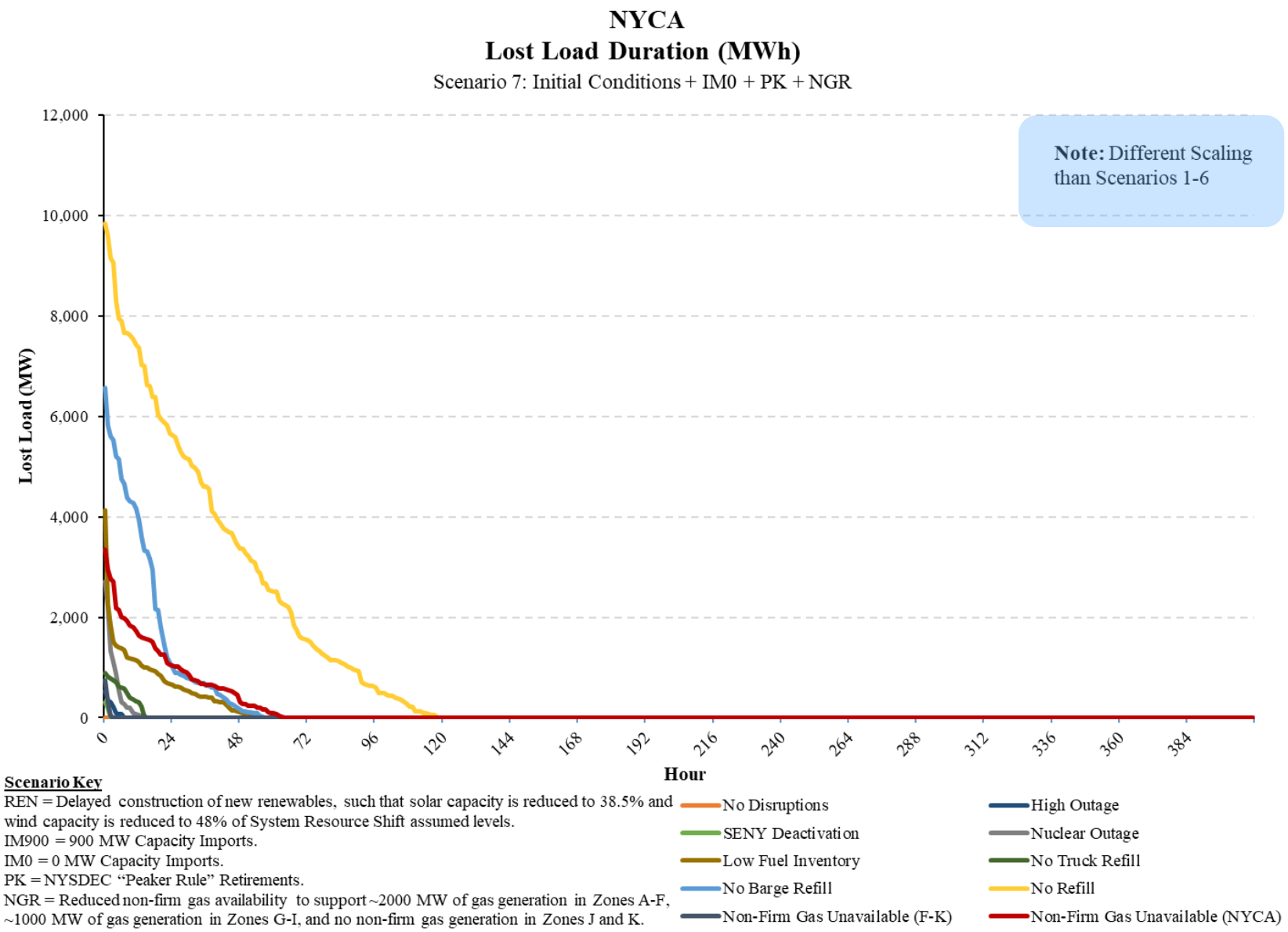
Loss of Load Duration Curves by Scenario



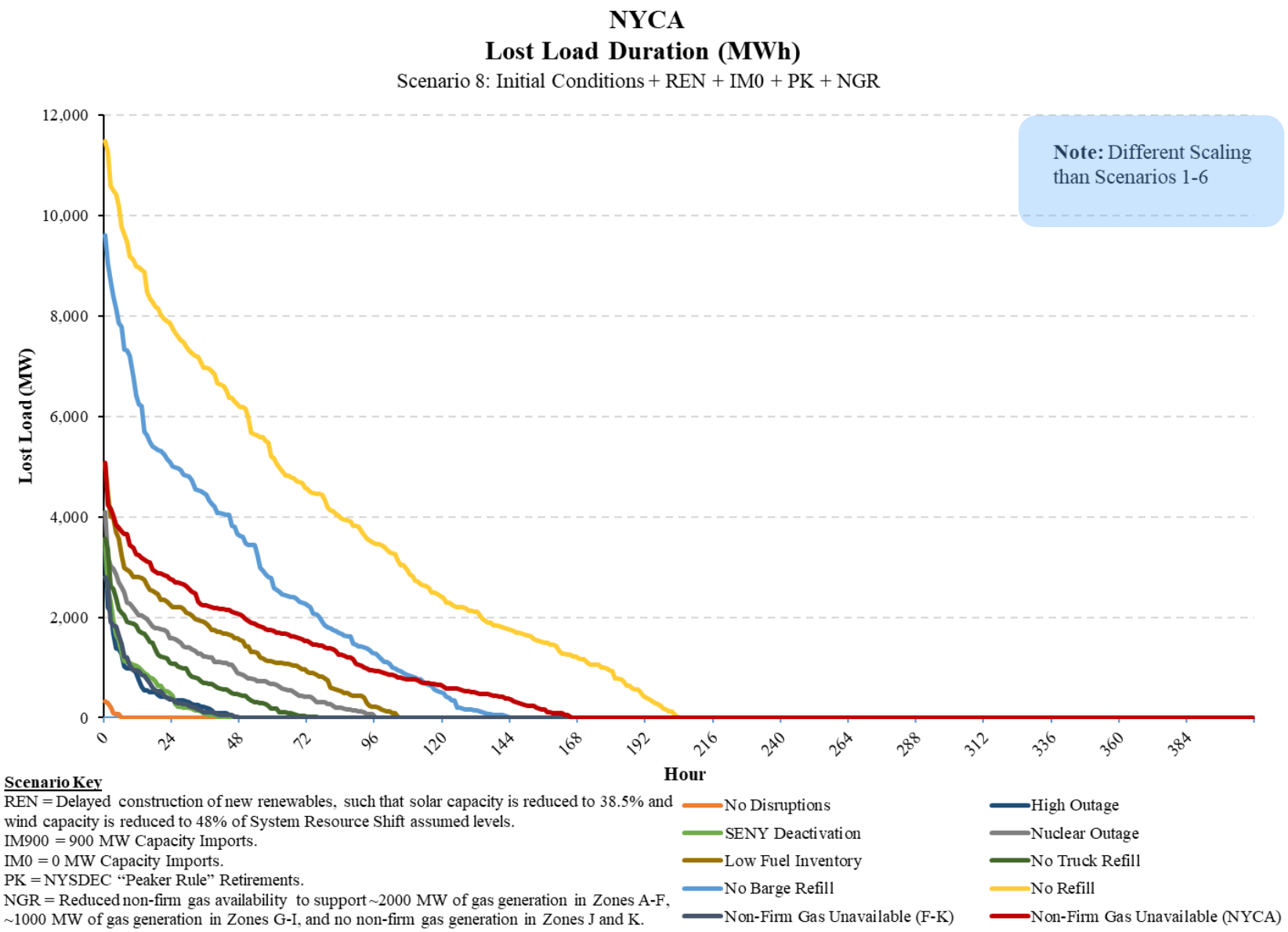
Loss of Load Duration Curves by Scenario



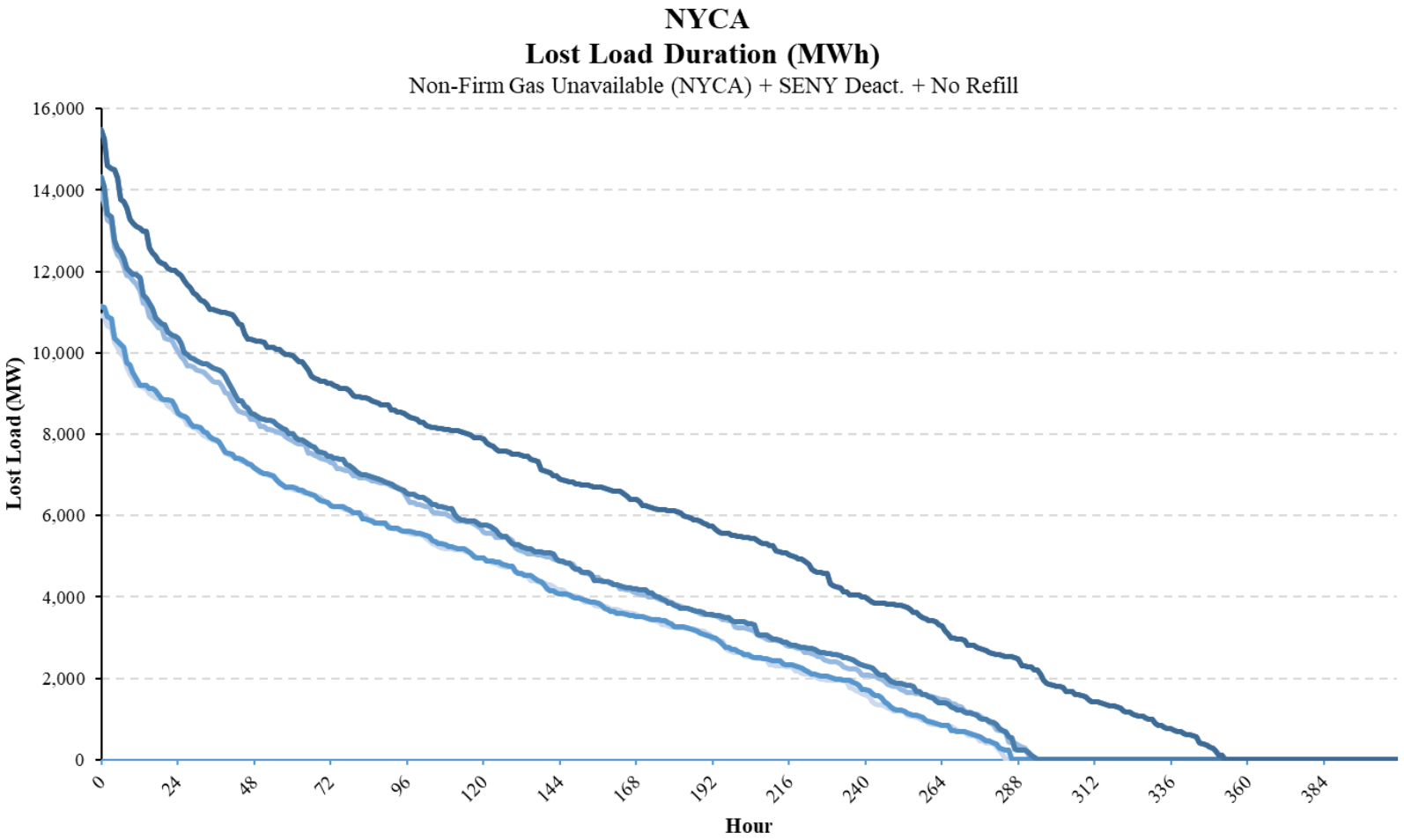
Loss of Load Duration Curves by Scenario



Loss of Load Duration Curves by Scenario



Loss of Load Duration Curves, Extreme Disruption

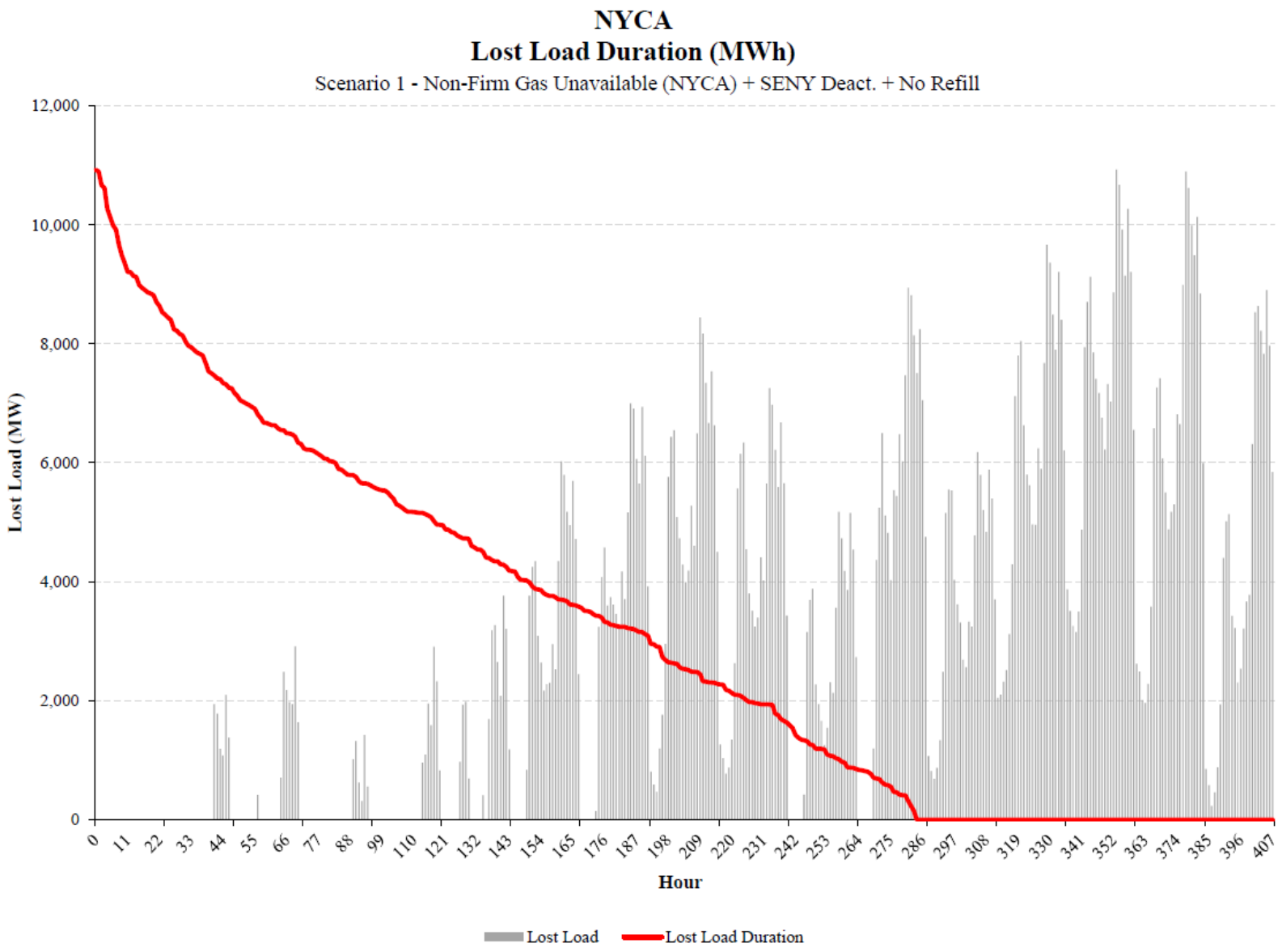


Scenario Key

REN = Delayed construction of new renewables, such that solar capacity is reduced to 38.5% and wind capacity is reduced to 48% of System Resource Shift assumed levels.
IM900 = 900 MW Capacity Imports.
IM0 = 0 MW Capacity Imports.
PK = NYSDEC "Peaker Rule" Retirements.
NGR = Reduced non-firm gas availability to support ~2000 MW of gas generation in Zones A-F, ~1000 MW of gas generation in Zones G-I, and no non-firm gas generation in Zones J and K.

- Scenario 1: Initial Conditions + IM900
- Scenario 2: Initial Conditions + IM900 + PK
- Scenario 3: Initial Conditions + IM0
- Scenario 4: Initial Conditions + IM0 + PK
- Scenario 5: Initial Conditions + IM900 + PK + NGR
- Scenario 6: Initial Conditions + REN + IM0 + PK
- Scenario 7: Initial Conditions + IM0 + PK + NGR
- Scenario 8: Initial Conditions + REN + IM0 + PK + NGR

Loss of Load Duration Curves



Appendix 3: Case Results Comparing Modeling of SCR/EDRP Availability

Follow-up Results (Unrestricted SCR/EDRPs)

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

Modeling Results with Unrestricted SCR (17 Max Days, 6 Hrs per Day) During Modeling Period

		Winter 2023/2024 Scenarios							
		Scenario 1: Initial Conditions + IM900	Scenario 2: Initial Conditions + IM900 + PK	Scenario 3: Initial Conditions + IM0	Scenario 4: Initial Conditions + IM0 + PK	Scenario 5: Initial Conditions + IM900 + PK + NGR	Scenario 6: Initial Conditions + REN + IM0 + PK	Scenario 7: Initial Conditions + IM0 + PK + NGR	Scenario 8: Initial Conditions + REN + IM0 + PK + NGR
Physical Disruptions	No Disruptions (Starting Conditions)						Day 15	Day 9	Day 9
	SENY Deactivation					Day 3	Day 15	Day 9	Day 6
	High Outage			Day 15	Day 15	Day 2	Day 15	Day 3	Day 3
	Nuclear Outage		Day 9		Day 15	Day 2	Day 15	Day 8	Day 3
	No Truck Refill			Day 7	Day 6	Day 3	Day 15	Day 9	Day 3
	No Barge Refill		Day 15	Day 16	Day 15	Day 9	Day 15	Day 7	Day 6
	No Refill	Day 15	Day 15	Day 15	Day 15	Day 8	Day 9	Day 6	Day 3
	Non-Firm Gas Unavailable (F-K)	Day 8	Day 8	Day 9	Day 15	Day 8	Day 3	Day 15	Day 3
	Low Fuel Inventory	Day 16	Day 16	Day 10	Day 10	Day 15	Day 10	Day 10	Day 6
	Non-Firm Gas Unavailable (NYCA)	Day 9	Day 2	Day 3	Day 2	Day 2	Day 2	Day 2	Day 2
	Non-Firm Gas Unavailable (NYCA) + SENY Deactivation + No Refill	Day 2	Day 2	Day 2	Day 2	Day 2	Day 1	Day 2	Day 1
Physical Disruptions, 17 Day SCR	No Disruptions (Starting Conditions), 17-Day SCR						Day 15	Day 15	Day 15
	SENY Deactivation, 17-Day SCR					Day 15	Day 15	Day 3	Day 6
	High Outage, 17-Day SCR			Day 15	Day 15	Day 3	Day 15	Day 2	Day 3
	Nuclear Outage, 17-Day SCR		Day 9		Day 15	Day 2	Day 6	Day 9	Day 3
	No Truck Refill, 17-Day SCR			Day 7	Day 6	Day 9	Day 6	Day 9	Day 3
	No Barge Refill, 17-Day SCR		Day 15	Day 17	Day 15	Day 9	Day 15	Day 9	Day 6
	No Refill, 17-Day SCR	Day 15	Day 15	Day 15	Day 15	Day 8	Day 9	Day 7	Day 3
	Non-Firm Gas Unavailable (F-K), 17-Day SCR	Day 8	Day 8	Day 9	Day 15	Day 8	Day 3	Day 15	Day 3
	Low Fuel Inventory, 17-Day SCR	Day 16	Day 16	Day 10	Day 10	Day 15	Day 10	Day 10	Day 6
	Non-Firm Gas Unavailable (NYCA), 17-Day SCR	Day 15	Day 3	Day 3	Day 2	Day 3	Day 2	Day 2	Day 2
	Non-Firm Gas Unavailable (NYCA) + SENY Deactivation + No Refill, 17-Day SCR	Day 2	Day 2	Day 2	Day 2	Day 2	Day 1	Day 2	Day 1

- No identified concerns
- Curtailing of energy-only exports to ISO-NE
- SCR/EDRP activation
- Reserve shortage
- Potential for loss of load (first occurring after Day 7)
- Potential for loss of load (first occurring on or before Day 7)

Note: White text indicates a concern that is confined to occurring on Long Island only

Scenario Key

REN = Delayed construction of new renewables, such that solar capacity is reduced to 38.5% and wind capacity is reduced to 48% of System Resource Shift assumed levels.

IM900 = 900 MW Capacity Imports.

IM0 = 0 MW Capacity Imports.

PK = NYSDEC "Peaker Rule" Retirements.

NGR = Reduced non-firm gas availability to support ~2000 MW of gas generation in Zones A-F, ~1000 MW of gas generation in Zones G-I, and no non-firm gas generation in Zones J and K.