BTM Solar and Enhanced Load Modeling

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Agenda

- Overview of the Modeling Effort
- Enhanced Load Modeling Effort
- Proposed ELM Methodology
- Impact Assessment
- Next Steps
- Appendix –BTM Solar Modeling Enhancements

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Overview of the Modeling Effort

The 2024 BTM Solar Modeling Effort

- **As part of the 5-year modeling improvement strategic plan for 2024, the New York State Reliability Council (NYSRC) Installed Capacity Subcommittee (ICS) developed a methodology to model Behind-the-Meter (BTM) solar explicitly as a supply resource in the installed reserve margin (IRM) model**
  - Currently, the impact of BTM solar is embedded within the underlying load shapes and the IRM study is conducted on a net-of-BTM-solar basis (i.e., load shapes and peak forecast are net of BTM solar)
  - With the expectation of increasing BTM solar penetration over time, it is critical to monitor and quantify the impact of the BTM solar resource in the IRM model
- **The methodology to explicitly model BTM solar requires adjustments to both load and generation modeling**
  - The impact of BTM solar needs to be "added back" to the load shapes and peak forecast to provide load modeling on a gross basis
  - BTM solar production also needs to be reflected as generation using 5 years of historical production profiles consistent with the modeling of other intermittent resources
- **When adding the impact of BTM solar back to the load shapes, it was discovered that the current load shape adjustment procedure* would, absent refinement, significantly overstate the impact of BTM solar**
  - The current procedure adjusts all hours of the load shape consistently to meet the forecasted summer peak
  - If the impact of BTM solar is added back to the underlying load shapes, the current adjustment procedure would significantly increase the assumed level of BTM solar production during all the non-peak hours, resulting in an overstatement of the energy requirement as part of the load modeling
- **The ICS recommended improvement of the load shape adjustment procedure and implementing such improvements together with the BTM solar modeling changes****

* https://www.nysrc.org/wp-content/uploads/2024/02/IRM-Load-Shape-Adjustment-Procedure-02272024-ICS28518.pdf

** BTM-Solar-Modeling-Whitepaper-11122024.pdf

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Enhanced Load Modeling for 2025

- As part of the updated modeling improvement strategic plan for 2025, the load modeling improvement effort will focus on seasonal specific load modeling to reflect summer and winter peak forecasts in the IRM model
- The load modeling enhancements effort for 2025 will also seek to address the following in response to the findings and recommendations of the 2024 BTM Solar Modeling Whitepaper:
  - Production of load shapes aligned with winter peak forecasts
  - Production of load shapes aligned with annual energy forecasts
- The following sections address the proposed methodology for enhanced load modeling as well as the potential impact on the IRM of the BTM solar and enhanced load modeling (ELM) improvements

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Enhanced Load Modeling Effort

Annual Energy and Winter Peak Demand Modeling Assumptions

- **Annual energy requirement modeled as:**
  - Baseline zonal annual energy forecast (2024 Load & Capacity Data report or "Gold Book," Table I-2)
    + Behind-the-meter Net Generation Resource (BTM:NG) energy

- **Winter peak demands modeled as:**
  - **Non-Coincident Peak (NCP):**
    2025-2026 Winter NCP forecast
    + BTM:NG peak proxy load
  - **Coincident Peak (CP):**
    2025-2026 Winter zonal CP forecast
    + BTM:NG peak proxy load
  - **G-J Locality Peak:**
    2025-2026 Winter G-J Locality peak forecast (2024 Gold Book, Table 1-5)
    + BTM:NG peak proxy load

Modeled Energy (TWh)

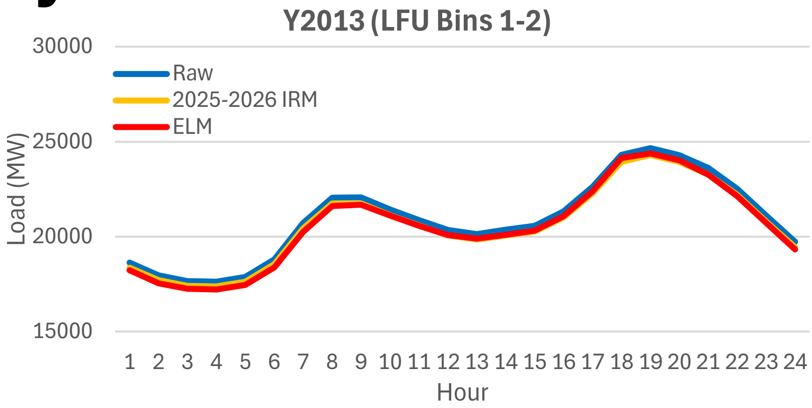
2025-2026 IRM			ELM		
Y2013	Y2017	Y2018	Y2013	Y2017	Y2018
154.1	167.2	157.0	152.5		

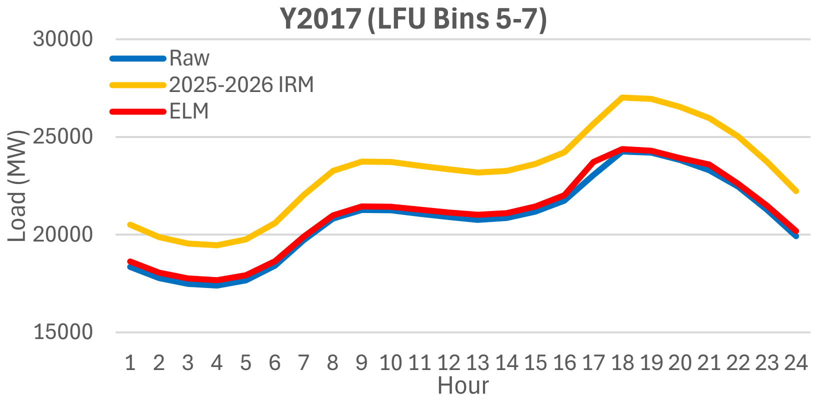
Modeled Winter Peak Demand (MW)

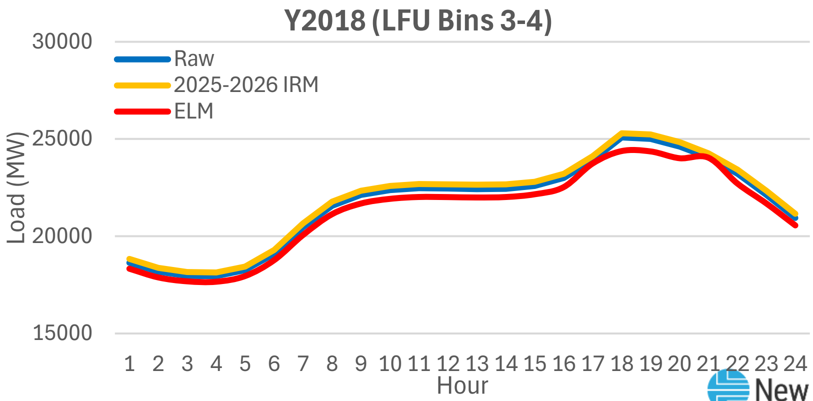
	2025-2026 IRM			ELM		
Max of...	Y2013	Y2017	Y2018	Y2013	Y2017	Y2018
Zone A	2,797.0	3,011.6	2,699.9	2,308.5		
Zone B	1,654.0	1,857.9	1,492.8	1,647.5		
Zone C	2,566.8	2,838.3	2,513.7	2,548.6		
Zone D	856.2	979.9	868.5	1,043		
Zone E	1,274.8	1,450.8	1,426.1	1,316.3		
Zone F	1,981.8	2,214.3	1,934.5	1934		
Zone G	1,680.6	1,889.8	1,757.1	1535		
Zone H	471.2	578.4	545.7	519		
Zone I	887.4	964.8	930.3	895		
Zone J	7,259.0	7,973.4	7,901.5	7,498.3		
Zone K	3,192.4	3,550.0	3,345.9	3,349.4		
NYCA	24,297.3	27,016.7	25,296.0	24,380.6		
G-J Locality	10,187.1	11,261.7	11,082.9	10,384.3		

NYCA Winter Peak Day Load Profiles

- **The graphs presented here are for informational purposes and show the NYCA load profiles of the modeled winter CP day (24-hour period)**
- **In the 2025-2026 IRM Final Base Case (FBC), the winter load levels were overstated, especially in the lower Load Forecast Uncertainty (LFU) Bins**
- **The proposed ELM effectively models the winter peaks to match the target load forecast**
  - The variability of different weather scenarios will be more predictable and be dependent on the existing LFU multipliers in the model







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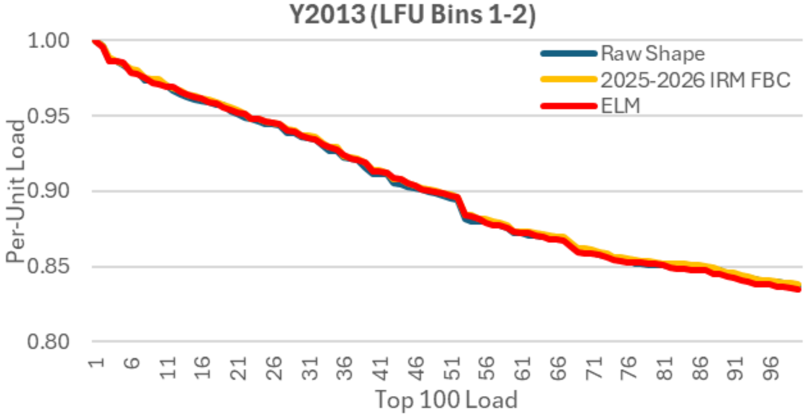
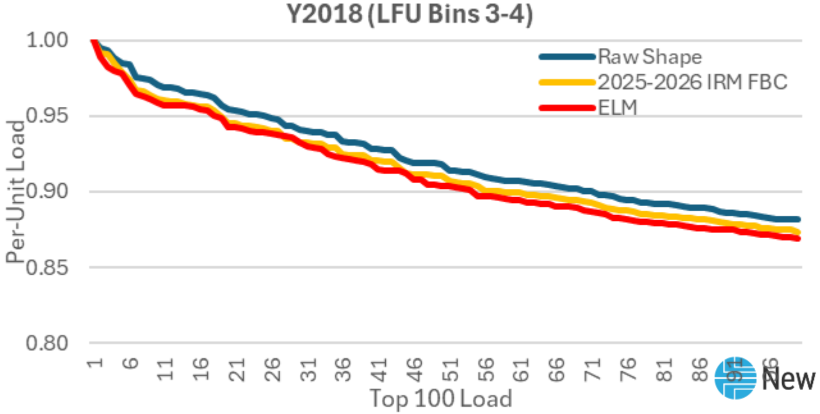
Load Duration Curves – 2013 & 2018

- The NYISO conducted a load duration curve (LDC) comparison analysis based on the per-unit loads (relative to annual peak) of top 100 hours of the historical load shapes used in the 2025-2026 IRM FBC
  - No winter load is represented in the top 100 load hours
- 2013 load shapes show negligible differences in the load profiles between the raw shape, the load shape used in 2025-2026 IRM FBC, and the load shape created using the proposed ELM
  - The proposed ELM retains the "peakier" load profile (with a more prominent peak) of the 2013 load shape
- 2018 load shapes show slight differences in the load profiles between the load shape used in 2025-2026 IRM FBC and load shape created using the proposed ELM
  - The observed difference is due to the reduction in modeled energy





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Proposed ELM Methodology

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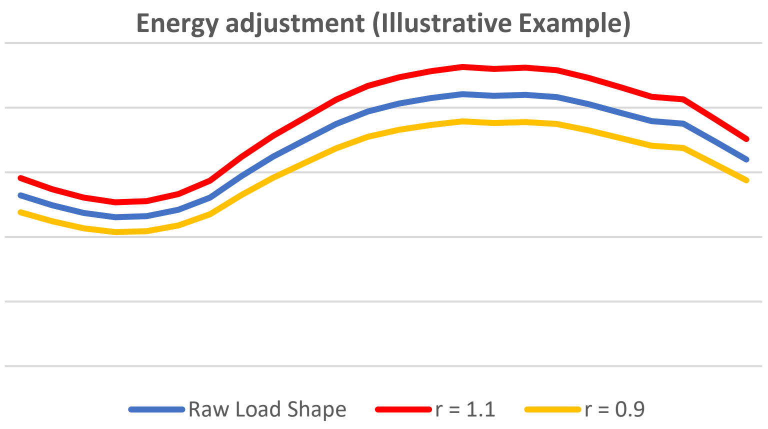
Energy Adjustment

- **Overview of the NYCA load shape adjustment workflow:**
  - 2025-2026 IRM FBC: NCP adjustment ⟶ CP adjustment ⟶ G-J Locality peak adjustment
  - Proposed ELM: **Energy Adjustment** ⟶ NCP adjustment ⟶ CP adjustment ⟶ G-J Locality peak adjustment ⟶ **NCP correction** ⟶ **Energy Recalibration**
- **Target annual energy requirement:**
  Baseline zonal annual energy forecast (Gold Book, Table I-2) + BTM:NG energy
  - The impact assessment presented herein uses the energy forecast for 2025 from the 2024 Gold Book
  - BTM:NG energy assumes 2025-2026 BTM:NG zonal peak proxy load * 8,760
- **Calculate the zonal energy adjustment ratio as follows:**

$$r_{Zone} = \frac{Target\ Energy_{Zone}}{Historical\ Energy_{Zone}}$$

  - For example, if the historical energy for Load Zone A was 15,349 GWh, and the target annual energy for Load Zone A was 15,964 GWh including BTM:NG load, then $r_A = \frac{15{,}964}{15{,}349} \approx 1.04$
- **Scale up/down the historical zonal load shapes by multiplying the hourly load of the historical load shapes by the corresponding zonal energy adjustment ratio**
- **The zonal energy adjustment ratio is calculated for each zone and all hours in the zone are multiplied by the same ratio**



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NCP Adjustment

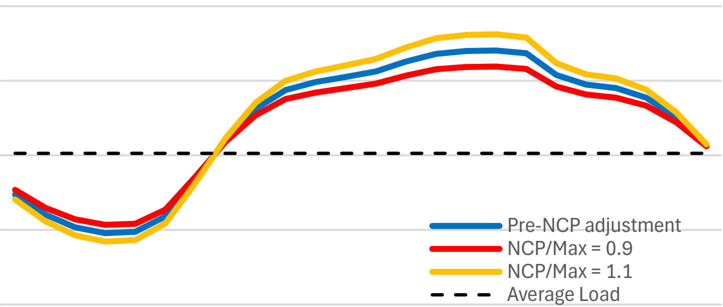
- To accurately reflect seasonal peak forecasts, the energy adjusted historical load shapes are separated into summer (May-October) and winter (January-April, November-December) shapes prior to the NCP adjustment and treated separately
- Target NCP (used in the impact assessment herein):
  - Summer: 2025-2026 IRM Fall Load Forecast* + BTM:NG peak proxy load
  - Winter: 2025-2026 Winter NCP forecast (2024 Gold Book, Table I-4b) + BTM:NG peak proxy load
- Calculate the NCP adjustment factor for each load hour as follows:

$$\lambda_{Load_{i,Z}} = 1 + \underbrace{\frac{Load_{i,Z} - \overline{Load_Z}}{Max(Load_Z) - \overline{Load_Z}}}_{\text{\% deviation of load value from the average load value, compared to the deviation of the max load value from the average load}} \times \underbrace{\frac{NCP_Z - Max(Load_Z)}{Max(Load_Z)}}_{\text{\% deviation of NCP from the max load value of the zone}}$$

where $Load_{i,Z}$ represents the load value at ith (chronological) load hour of Load Zone Z, and $\overline{Load_Z}$ represents the average load value of Load Zone Z

- Each hourly load value $Load_{i,Z}$ is multiplied by the corresponding adjustment factor $\lambda_{Load_{i,Z}}$, i.e., $\lambda_{Load_{i,Z}} \cdot Load_{i,Z}$
- This adjustment method captures the NCP with minimal changes to the previously adjusted energy level, i.e., "shrink and stretch" method

NCP Adjustment - behavior near the average load (Illustrative Example)



*: https://www.nysrc.org/wp-content/uploads/2024/10/01-NYSRC-Fall-Forecast-Update-2025-Final-Installed-Reserve-Margin-Forecast.pdf

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CP Adjustment

- Target CP (used in the impact assessment herein):
  - Summer: 2025-2026 IRM Fall Load Forecast + BTM:NG peak proxy load
  - Winter: 2025-2026 Winter zonal CP forecast (2024 Gold Book, Table I-3b) + BTM:NG peak proxy load
- Identify the dates and hours of the historical NYCA seasonal peaks as the target NYCA summer/winter CP hours and calculate the difference between the scaled historical (after NCP adjustment) summer/winter maximum NYCA load and the forecasted CP of the corresponding season by zone

$$\Delta_Z = Target\ CP_Z - Scaled\ Historical\ CP_Z$$

  - For example, if the peak for Load Zone A after NCP adjustment was 2,000 MW, and the forecasted CP for Load Zone A was 2,050 MW, then $\Delta_A = 2{,}050 - 2{,}000 = 50$
  - Likewise, if the scaled historical peak for zone B is 1,900 MW, and the forecasted CP for zone B is 1,880 MW, then $\Delta_B = 1{,}880 - 1{,}900 = -20$
- Add the calculated difference Δ_Z to the scaled zonal demand of the CP hour for each season, and verify that the new values of the zonal CP matches the target for each zone

$$Scaled\ Historical\ CP_Z + \Delta_Z = TargetCP_Z$$

- To smoothen the load shape around the peak, $0.5 \cdot \Delta_Z$ (50% of Δ_Z) and $0.25 \cdot \Delta_Z$ (25% of Δ_Z) are subsequently added to the $CP \pm 1$ and $CP \pm 2$ hours respectively for each zone

G-J Locality Peak Adjustment

- **Target G-J Locality Peak (used in the impact assessment herein):**
  - Summer: 2025-2026 IRM Fall Load Forecast + BTM:NG peak proxy load
  - Winter: 2025-2026 Winter G-J Locality peak forecast (2024 Gold Book, Table 1-5) + BTM:NG peak proxy load
- **The G-J Locality peak adjustment procedure is similar to the coincident peak adjustment procedure described on the prior slide**
- **Identify the dates and hours of the historical G-J Locality seasonal peaks as the target G-J Locality summer/winter peak hours**
  - If the historical G-J Locality peak occurs at the same time as the NYCA CP, select the hour preceding the CP hour as the determined G-J Locality peak hour
- **For each zone of the G-J Locality, calculate the difference between the zonal load of the determined G-J Locality summer/winter peak hour and the corresponding zonal values associated with the forecasted G-J Locality peak**

$$\delta_Z = Target\ GJ_Z - Determined\ GJ_Z$$

- **Add the calculated difference δ_Z to the scaled zonal demand of the G-J Locality peak hour for each season and verify that the new values of the G-J Locality seasonal peaks match the target for each zone**

$$Determined\ GJ_Z + \delta_Z = Target\ GJ_Z$$

NCP Correction

- As a result of the CP and G-J Locality peak adjustments, some zones, which were previously adjusted to match the corresponding summer/winter NCP targets, may have deviated from the target
    - Does not always happen, but if it occurs, further adjustments are necessary to meet the target
- For each seasonal NCP that has deviated from its target, choose the hours succeeding the seasonal CP as the determined seasonal NCP hour for the applicable zone and replace the load value to match the corresponding target NCP

Energy Recalibration

- **As a result of NCP, CP, and G-J Locality peak adjustments, the zonal annual energy may have deviated from the target annual energy of each zone**
  - Based on the analysis conducted for this proposal, the NYISO observed that the average deviation of the modeled annual energy caused by the subsequent peak adjustments is less than 0.15% of the target annual energy at the NYCA level
- **For each zone, find the delta between the modeled energy and the target annual energy**

$$Energy\ Delta_Z = Target\ Energy_Z - Modeled\ Energy_Z$$

- **Proportionally add back the energy to the shoulder months by multiplying the zonal factor ε_Z calculated using the formula below:**

$$\varepsilon_Z = 1 + \frac{Energy\ Delta_Z}{Shoulder\ Months\ Energy_Z}$$

  - Based on the analysis conducted for this proposal, the NYISO observed that the modeled CP, NCP, and G-J Locality peaks do not occur during the shoulder months (March-May, October-November)
- **Each hourly load value, $Load_{i,Z}$ of the shoulder months is multiplied by the corresponding zonal factor ε_Z, i.e., $\varepsilon_Z \cdot Load_{i,Z}$**

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External Load Modeling

- **For each External Control Area, the same historical load shapes selected for the NYCA (i.e., currently 2013, 2017, and 2018) are used**
- **These external load shapes are adjusted to ensure that the external areas have the same top three summer and top three winter peak load days as the NYCA**
  - Identify the dates of top three summer/winter load days of the adjusted NYCA load shapes and external areas
  - If the dates of the top three load levels for the external areas are different from that of the adjusted NYCA load shapes, swap the daily load shape data (the 24-hour period) of the dates for each external area to match the dates of the top NYCA load days

Impact Assessment

Impact Assessment (Tan45)

Case (Tan45)	Description	IRM	J LCR	K LCR	G-J Locality
C00	2025-2026 IRM FBC	24.40%	75.58%	107.30%	86.91%
C01	+ BTM Solar	25.42%	76.49%	108.86%	87.57%
	Delta	*1.02%*	*0.91%*	*1.57%*	*0.66%*
C02*	+ ELM	24.16%	75.34%	107.46%	86.73%
	Delta	*-0.24%*	*-0.25%*	*0.16%*	*-0.18%*
C03*	+ BTM Solar and ELM	25.20%	76.04%	108.77%	87.25%
	Delta	*0.80%*	*0.46%*	*1.47%*	*0.34%*

*: The result includes additional Policy 5 adjustments to external areas

- **[C01] The implementation of explicit modeling of BTM solar alone would increase the IRM by 1.02%**
  - The increase is due to the probabilistic nature of the BTM solar modeling construct which increases randomness and uncertainty in the model
  - The Load Zone K minimum locational capacity requirement (LCR) increases by a greater margin because the quantity of BTM solar in Load Zone K is almost double that of Load Zone J
- **[C02] The implementation of the ELM alone would decrease the IRM by 0.24%**
  - The primary driver of the impact is attributed to the decrease in the total energy requirement modeled in the study
  - The target energy modeled for Load Zone K using the ELM is greater than the Load Zone K energy modeled with the load adjustment methodology used in the 2025-2026 IRM FBC, leading to a smaller increase to the Load Zone K LCR
- **[C03] The combined modeling of BTM solar and ELM would increase the IRM by 0.8%**

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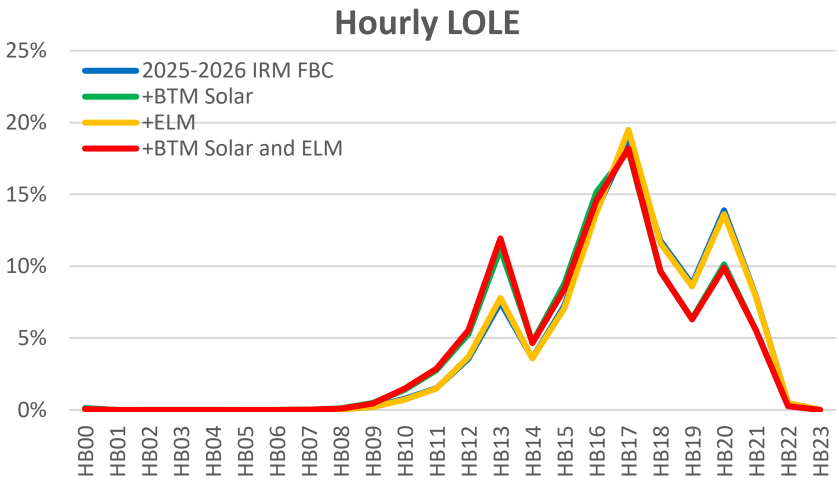
Hourly Risk Analysis

- The NYISO conducted an hourly risk analysis for the 2025-2026 IRM FBC to better understand the impact of the combined modeling of BTM solar and the proposed ELM
- The proposed ELM has minimal impact on the hourly loss of load expectation (LOLE) profile
- The implementation of the combined modeling of BTM solar and ELM improvements would shift the LOLE risks to earlier in the day when large amounts of BTM solar is available
  - The shift is primarily driven by the BTM solar modeling



	HB00	HB01	HB02	HB03	HB04	HB05	HB06	HB07	HB08	HB09	HB10	HB11	HB12	HB13	HB14	HB15	HB16	HB17	HB18	HB19	HB20	HB21	HB22	HB23
2025-2026 IRM FBC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	4%	7%	4%	7%	14%	19%	12%	9%	14%	8%	0%	0%
+ BTM Solar	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	3%	5%	11%	5%	9%	15%	18%	10%	6%	10%	6%	0%	0%
+ ELM	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	4%	8%	4%	7%	14%	19%	12%	9%	14%	8%	0%	0%
+ BTM Solar and ELM	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	3%	6%	12%	5%	8%	15%	18%	10%	6%	10%	6%	0%	0%

Next Steps

Next Steps

- **The NYISO recommends adoption of the explicit modeling of BTM solar and the proposed ELM in the 2026-2027 IRM Preliminary Base Case**
  - The NYISO will provide the Tan45 impact of the implementation but proposes to adopt parametrically in the base case
- **The NYISO will provide ongoing updates to the ICS to share progress and solicit feedback**

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Appendix

BTM Solar Modeling Enhancements

BTM Solar Modeling Effort

- **In the current IRM study, the impact of BTM solar production on load is embedded on the load side**
  - The IRM load shapes are adjusted annually to reflect the impact of the increased penetration of BTM solar
    - For example, the 2013 actual load shapes have embedded the BTM solar impact at the 2013 penetration level. To use the 2013 load shapes for study year 2025, the 2013 load shapes are adjusted to account for the expected penetration of BTM solar in year 2025
  - The peak load forecast used in the IRM study is developed from the actual summer peak that reflects the impact of BTM solar
  - LFU multipliers are developed based on the net load shapes that reflect the impact of BTM solar
  - Since the IRM is calculated with the capacity supply resources only, the current process supports the proper calculation for the IRM to be used in the capacity market
- **With the expectation of increasing BTM solar penetration over time, it is important to monitor its impact on the system**
  - While the current process reflects the penetration of BTM solar, the impact cannot be quantified due to the embedded nature of including BTM solar in the load shapes
- **Therefore, the ICS expressed interest in exploring ways to model BTM solar explicitly in the IRM study**

Overview of BTM Solar Modeling Enhancements

- **To model BTM solar explicitly, both the resource side and the load side modeling need adjustments**
- **The NYISO's BTM solar data would be utilized to develop the hourly profiles for BTM solar load for each zone. Inputs include:**
  - NYISO's forecasted annual energy reduction by BTM solar PV (Gold Book Baseline Forecast Table I-9b)

BTM Solar Annual Energy Reductions by Zone (2024 Gold Book Table I-9b) – GWh

Year	A	B	C	D	E	F	G	H	I	J	K	NYCA
2025	457	748	1,078	92	795	882	944	133	186	705	1,382	7,402

  - Energy normalized representative hourly values of BTM solar
    - To be multiplied by the Gold Book Table I-9b data to produce hourly MW values for the applicable year
- **Despite the modeling changes, the calculation method for the IRM should remain unchanged**
  - Net demand forecast should continue to be used as the denominator of the IRM calculation
  - The MW of BTM solar would not be counted in the total ICAP in the numerator of the IRM calculation
  - The derating factor of BTM solar would not be included in the IRM zonal derating factors as a part of the shifting methodology

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BTM Solar Modeling Enhancements: Methodology

Load side modeling

- Modeled as negative Demand Side Management (DSM) units
- The 2013, 2017, and 2018 BTM solar zonal hourly load profiles
- The BTM solar shapes are aligned with the underlying load shapes

  LFU bins 1 – 2: 2013
  LFU bins 3 – 4: 2018
  LFU bins 5 – 7: 2017
- Not subject to the LFU multipliers

Supply side modeling

- Modeled as positive DSM units
- Modeled using the recent 5 years of hourly profiles
  - 2019 – 2023 shapes are used for the impact assessment presented herein
- One of the historical shapes is chosen randomly for each replication during the Multi-Area Reliability Simulation (MARS) analysis
  - The selection will be consistent with the selection of the other DSM resources

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Sensitivity Analysis Results (Tan45)

	IRM	J LCR	K LCR	G-J Locality
2025-2026 IRM PBC	23.60%	75.98%	102.52%	87.54%
Sensitivity #7 - BTM Solar Modeling	24.65%	76.88%	104.14%	88.20%
Delta	*1.05%*	*0.90%*	*1.62%*	*0.66%*

	LOLE (days/yr.)	LOLH (hours/yr.)	EUE (MWh/yr.)	Normalized EUE "Simple Method" (ppm)	Normalized EUE "Bin Method" (ppm)
2025-2026 IRM PBC	0.100	0.388	234.724	1.554	1.386
BTM Solar Modeling	0.100	0.410	260.175	1.723	1.537

- **The explicit modeling of BTM solar would increase the IRM by 1.05%**
  - The increase is due to the probabilistic nature of the BTM solar modeling construct which increases randomness and uncertainty in the model
- **The LCRs would also experience sizeable increase**
  - The Load Zone K LCR increases by a greater margin because the quantity of BTM solar in Load Zone K is almost double that of Load Zone J
- **Modeling BTM solar explicitly in the 2025-2026 IRM PBC database would increase both the Loss of Load Hours (LOLH) and Expected Unserved Energy (EUE)**
  - The BTM solar modeling construct increases randomness and uncertainty in the model

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Our Mission and 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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Questions?

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