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Independent System Operator

# Impact of High Behind the Meter (BTM) Solar on Load Forecast Uncertainty (LFU)


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# Agenda

- Impact of Behind-the-Meter (BTM) Solar on the Peak Load Hour
- Impact of BTM Solar on Load Forecast Uncertainty (LFU)
- Questions & Discussion

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# Background, Motivation and Summary Results



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# Background & Motivation

- Load patterns are continuing to evolve across the New York Control Area (NYCA)
- Increased penetration of BTM Solar is impacting the peak load
  - Shifting the peak load towards later hours
  - Decreasing the peak MW
- Developing Load Forecast Uncertainty (LFU) involves modeling the peak
- The variation of model structure, along with changes in MW load levels may impact the LFU values
- Goal: Examine what higher levels of BTM Solar impact will have on regional peak load hour characteristics and LFU models in the future

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# BTM Solar Scenarios

- Analyses were performed under three BTM solar scenarios
- Under each scenario, net load was calculated by subtracting corresponding solar level at that scenario capacity from the gross load
- The scenario net loads were analyzed for peak hour and load forecast uncertainty (LFU)

*BTM solar scenarios:*

| | |
|---|---|
| Scenario 1 | BTM Nameplate Capacity 7,000 MW at NYCA level |
| | Projected to reach by early 2026 (GB 2022) |
| Scenario 2 | BTM Nameplate Capacity 8,500 MW at NYCA level |
| | Projected to reach by the end of 2027 (GB 2022) |
| Scenario 3 | BTM Nameplate Capacity 10,000 MW at NYCA level |
| | Projected to reach by late 2029 (GB 2022) |

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# Summary Results

## ΔLFU Delta

**AE**

| | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| Bin 1 | 1.85% | 1.96% | 2.04% |
| Bin 2 | 0.84% | 0.88% | 0.91% |
| Bin 3 | 0.27% | 0.27% | 0.27% |

**FG**

| | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| Bin 1 | 2.73% | 2.90% | 2.90% |
| Bin 2 | 1.36% | 1.43% | 1.42% |
| Bin 3 | 0.48% | 0.49% | 0.48% |

**HI**

| | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| Bin 1 | 0.08% | 0.45% | 0.80% |
| Bin 2 | 0.04% | 0.23% | 0.41% |
| Bin 3 | 0.01% | 0.07% | 0.12% |

**J**

| | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| Bin 1 | 0.28% | 0.31% | 0.43% |
| Bin 2 | 0.13% | 0.14% | 0.20% |
| Bin 3 | 0.03% | 0.04% | 0.05% |

**K**

| | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| Bin 1 | 1.52% | 2.44% | 2.07% |
| Bin 2 | 0.82% | 1.30% | 1.13% |
| Bin 3 | 0.33% | 0.51% | 0.45% |

- Overall, the peak hour shifts towards later hours
- Overall, upper bins LFU values increase with the increased level of BTM solar
- In general,

$$\Delta @ \boldsymbol{Bin\ 1} > \Delta @ \boldsymbol{Bin\ 2} > \Delta @ \boldsymbol{Bin\ 3}$$
$$\Delta @ \boldsymbol{Scen\ 3} > \Delta @ \boldsymbol{Scen\ 2} > \Delta @ \boldsymbol{Scen\ 3}$$

- For Bin 1, Scenario 3,
  - largest change is observed in Zones F&G (~3%)
  - ~2% change for Zones A-E and Zone K
  - small change in Zones H&I and Zone J (less than 1%)
- The upward change is primarily driven by reduced reference load
- All changes are relative to current LFU values

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# General Methodology



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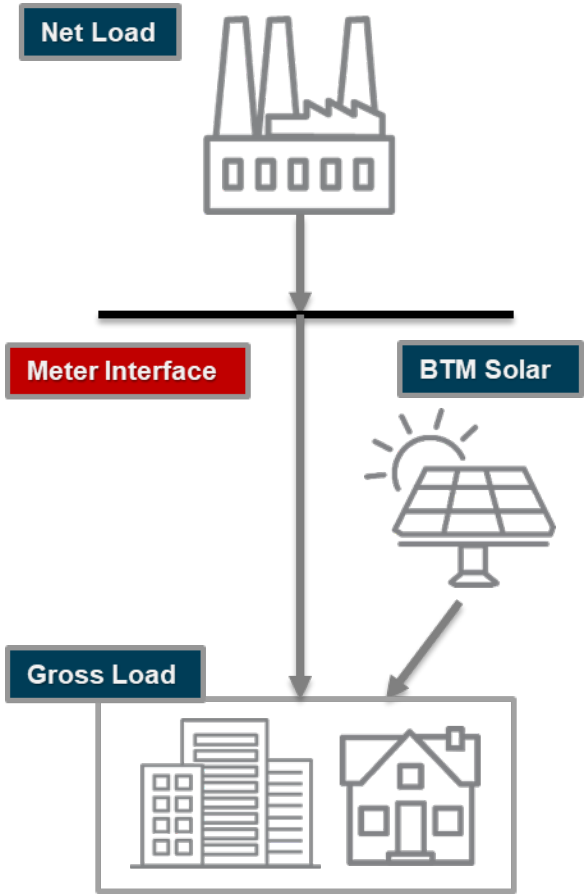
# Methodology

- NYISO loads in different LFU modeling areas were collected from DSS
- NYISO DSS database gives the “net” load
- A gross load was derived by adding the estimated actual BTM Solar to the net load
- Load shape and peak producing hours were analyzed using the gross and net loads, under different BTM solar scenarios
- Analysis centered on most recent LFU model years (2018, 2019 and 2021)

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# Peak Hour Shifting, Peak Reduction



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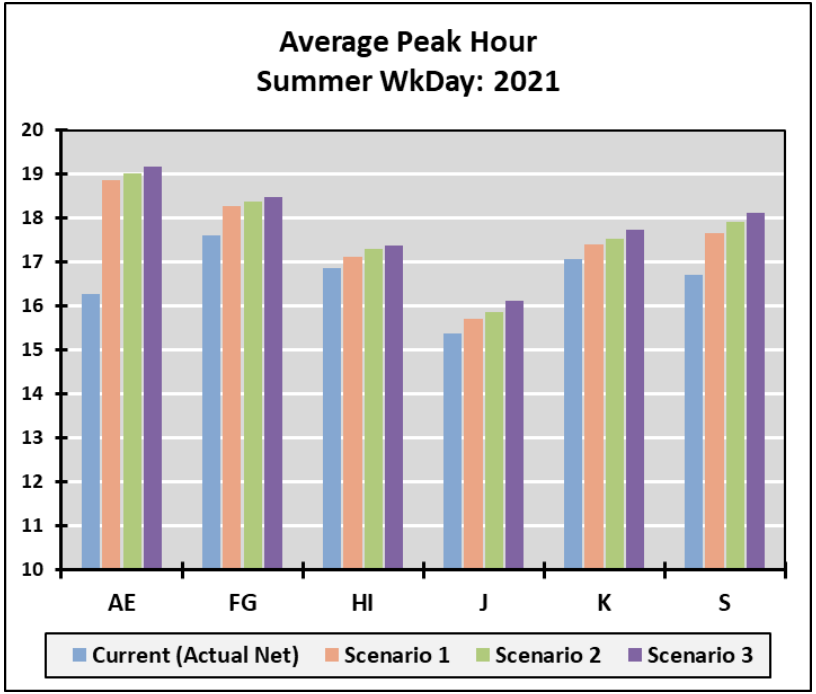
# Peak Hour Shifting

- Peak shifting analysis was performed by examining the average peak hour (calculated as the average of all summer weekday peak hours)
- A general trend of peak hour shifting (towards evening) was observed across all LFU areas with increased BTM solar
- The more the BTM solar, more shifting of peak




| Scenario | AE | FG | HI | J | K | S |
|---|---|---|---|---|---|---|
| Current (Actual Net) | 16.3 | 17.6 | 16.9 | 15.4 | 17.1 | 16.7 |
| Scenario 1 | 18.9 | 18.3 | 17.1 | 15.7 | 17.4 | 17.7 |
| Scenario 2 | 19.0 | 18.4 | 17.3 | 15.9 | 17.5 | 17.9 |
| Scenario 3 | 19.2 | 18.5 | 17.4 | 16.1 | 17.7 | 18.1 |

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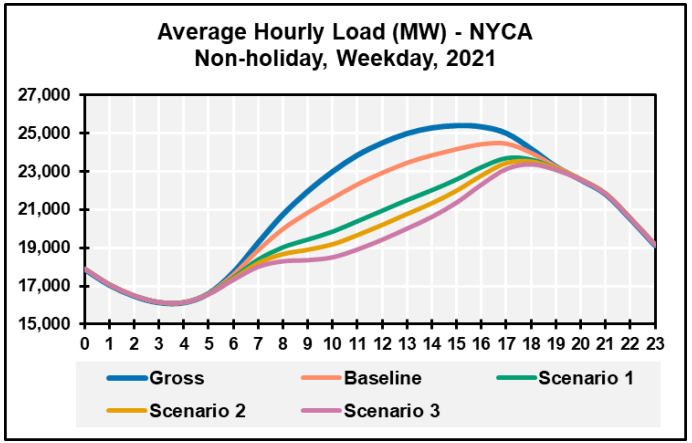
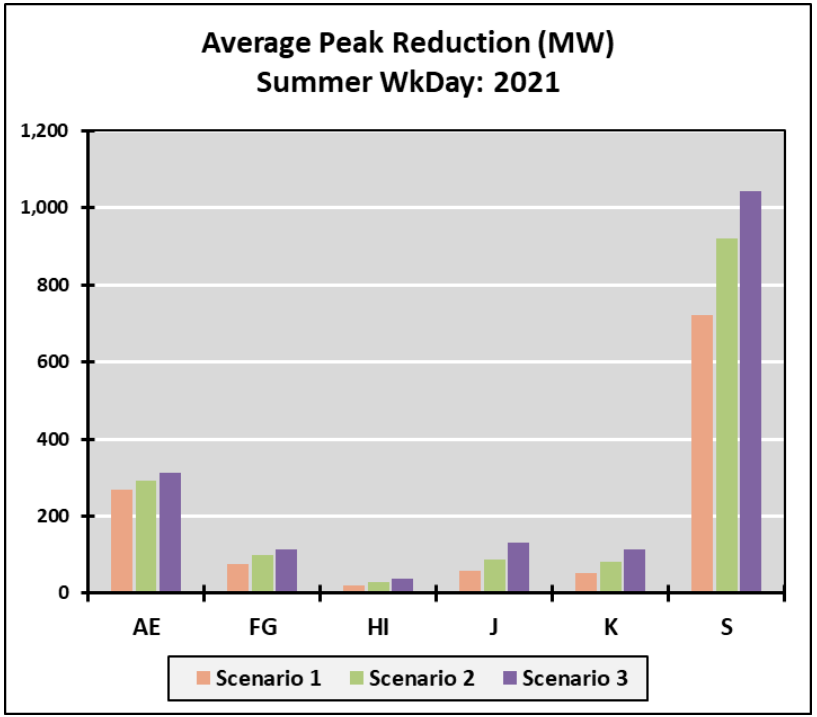
# Peak Reduction

- With the increase of BTM solar, the peak reduces
- LFU area AE has the highest reduction (270~300 MW across three scenarios)
  - Higher BTM capacity, earlier baseline peak
- At the NYCA level, the estimated peak reduction is about 1,000 MW in scenario 3




| MW Peak Change (relative to baseline) | | | | | | |
|---|---|---|---|---|---|---|
| Scenario | AE | FG | HI | J | K | S |
| Scenario 1 | 269 | 75 | 19 | 58 | 53 | 720 |
| Scenario 2 | 291 | 101 | 29 | 87 | 81 | 921 |
| Scenario 3 | 312 | 114 | 38 | 132 | 114 | 1,043 |

# Impact on Summer LFU values



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# Methodology

- LFU multipliers were calculated for each BTM scenario and current net load
- For each scenario, net load was calculated by subtracting scenario BTM solar from the gross load
- LFU models were developed for the scenario net loads
- For each LFU area, a base model structure was developed for the current summer peak loads
- The base model structure and data were kept unchanged across all scenarios for consistency
- All models were found reasonably well in terms of overall fit (R-sq)

***Notes on Base Model***

- Years: 2018, 2019, 2021
- Months: Jun – Aug
- Weekends: Yes
- Outliers removed
- Stepwise regression was performed to determine the "best" model for the base case

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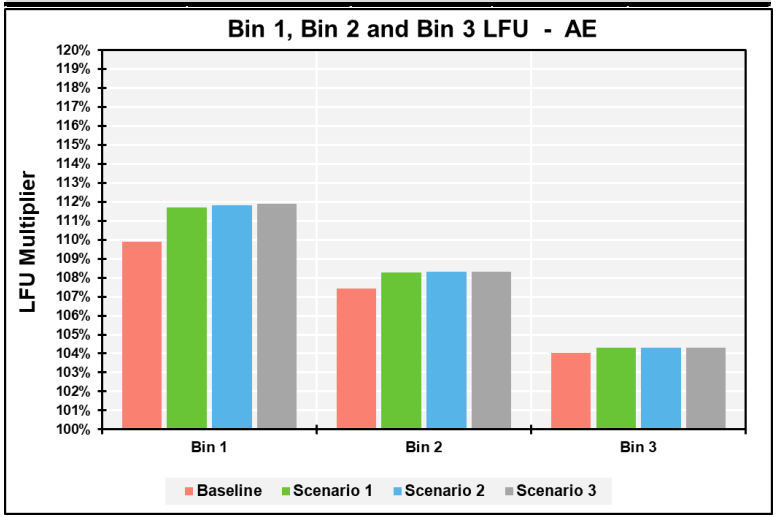
# BTM Solar Impact on LFU: Zones A-E

| | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Bin 1 | 113.18% | 115.03% | 115.14% | 115.22% |
| Bin 2 | 109.25% | 110.09% | 110.13% | 110.16% |
| Bin 3 | 104.80% | 105.07% | 105.07% | 105.07% |




| AE | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| BTM Capacity (MW) | 1,734 | 3,365 | 4,160 | 4,934 |
| Reference Load (MW) | 9,254 | 8,858 | 8,800 | 8,758 |
| Reference Load relative to baseline (MW) | | -396 | -454 | -495 |

- Due to increased BTM solar, both reference load and loads at other bins decrease.
- Reduction in upper bins and reference load have opposite effects.
  - $LFU_{bin_n} = \frac{MW_{bin_n}}{MW_{ref}}$
- Reference load reduces more relative to upper bin load
- LFU increase for reduction in reference load overpowers LFU decrease for decrease of upper bin load
- About +1~2% of LFU change in upper two bins. Negligible change in bin 3.

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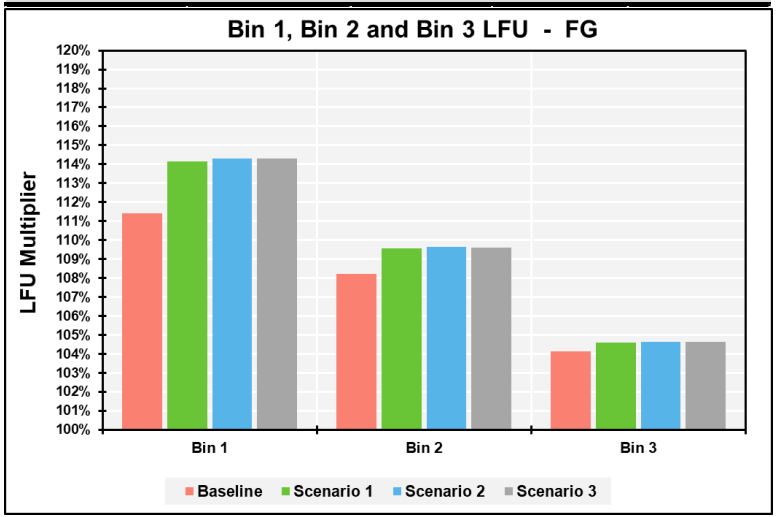
# BTM Solar Impact on LFU: Zones F&G

| | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Bin 1 | 111.42% | 114.15% | 114.32% | 114.32% |
| Bin 2 | 108.20% | 109.56% | 109.63% | 109.62% |
| Bin 3 | 104.14% | 104.62% | 104.63% | 104.62% |




| FG | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| BTM Capacity (MW) | 1,158 | 1,827 | 2,203 | 2,525 |
| Reference Load (MW) | 4,543 | 4,379 | 4,351 | 4,329 |
| Reference Load relative to baseline (MW) | | -164 | -192 | -214 |

- Reference load decrease is about 2~2.5 times the load decrease in upper bins
- Higher relative decrease of reference load caused increase in LFU in the upper bins
  - 2.7~2.9% in bin 1
  - about 1.5% in bin 2
  - about 0.5% in bin 3

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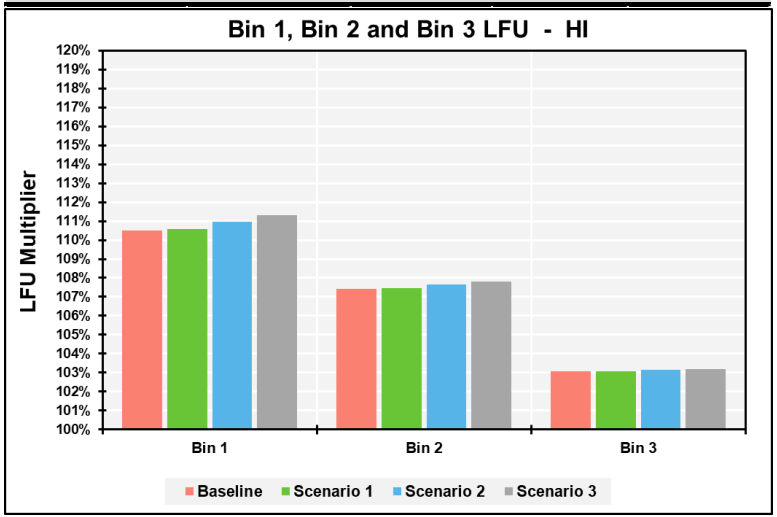
# BTM Solar Impact on LFU: Zones H&I

| | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Bin 1 | 110.50% | 110.58% | 110.95% | 111.30% |
| Bin 2 | 107.41% | 107.45% | 107.64% | 107.82% |
| Bin 3 | 103.08% | 103.09% | 103.15% | 103.20% |




| HI | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| BTM Capacity (MW) | 140 | 210 | 262 | 314 |
| Reference Load (MW) | 1,977 | 1,946 | 1,935 | 1,926 |

| | | | |
|---|---|---|---|
| Reference Load relative to baseline (MW) | -31 | -42 | -51 |

- Similar decrease in reference and upper bin loads
- Almost no change in upper LFUs in scenario 1
- Modest change in upper two bins
  - Maximum change 0.8% (scenario 3, bin 1)

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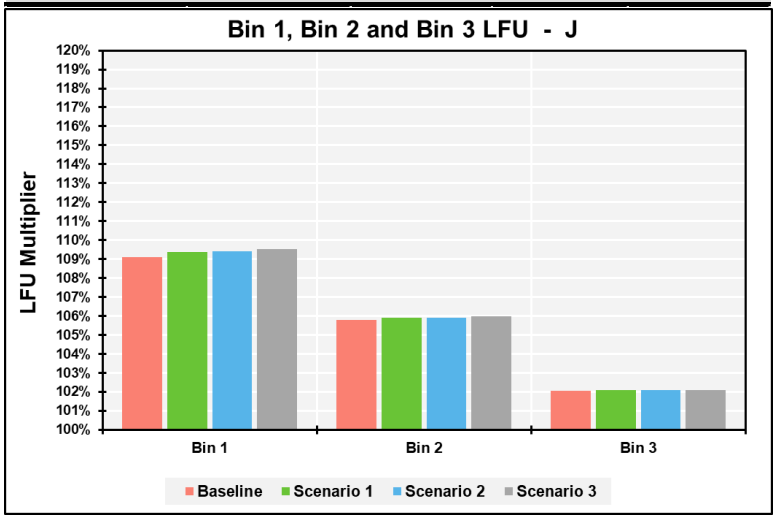
# BTM Solar Impact on LFU: Zone J

| | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Bin 1 | 109.10% | 109.38% | 109.41% | 109.53% |
| Bin 2 | 105.78% | 105.91% | 105.92% | 105.98% |
| Bin 3 | 102.05% | 102.08% | 102.09% | 102.10% |




| J | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| BTM Capacity (MW) | 367 | 499 | 603 | 758 |
| Reference Load (MW) | 10,658 | 10,591 | 10,556 | 10,508 |
| Reference Load relative to baseline (MW) | | -67 | -102 | -150 |

- Modest change in the LFUs
  - Maximum change 0.4% (scenario 3, bin 1)
- Reference load decrease is larger than upper bins load decrease (~120% to 150%)
- However, since relative changes are small (for higher Zone J load level), the resulting change in LFU is modest

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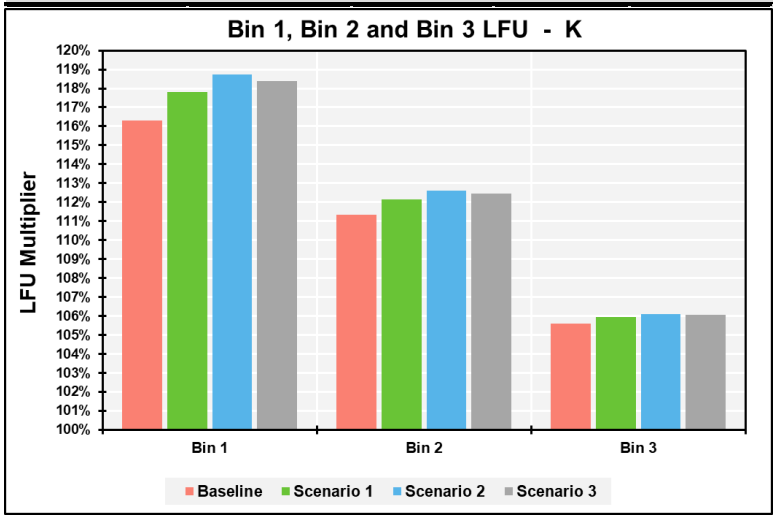
# BTM Solar Impact on LFU: Zone K

| | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Bin 1 | 116.30% | 117.82% | 118.74% | 118.37% |
| Bin 2 | 111.32% | 112.14% | 112.62% | 112.45% |
| Bin 3 | 105.60% | 105.93% | 106.11% | 106.05% |




| K | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| BTM Capacity (MW) | 870 | 1,099 | 1,272 | 1,469 |
| Reference Load (MW) | 5,144 | 5,082 | 5,046 | 5,007 |
| Reference Load relative to baseline (MW) | | -62 | -98 | -138 |

- **Relatively higher MW change of reference load with respect to upper bin loads**
  - Bin 1 LFU increases by about 1.5~2.5%
  - Bin 2 LFU increases by about 0.8~1.3%
  - Bin 3 LFU increases by about 0.5%

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# Questions



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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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# Reference Slides



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# LFU at Different Scenarios

| AE | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Bin 1 | 113.18% | 115.03% | 115.14% | 115.22% |
| Bin 2 | 109.25% | 110.09% | 110.13% | 110.16% |
| Bin 3 | 104.80% | 105.07% | 105.07% | 105.07% |

| FG | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Bin 1 | 111.42% | 114.15% | 114.32% | 114.32% |
| Bin 2 | 108.20% | 109.56% | 109.63% | 109.62% |
| Bin 3 | 104.14% | 104.62% | 104.63% | 104.62% |

| HI | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Bin 1 | 110.50% | 110.58% | 110.95% | 111.30% |
| Bin 2 | 107.41% | 107.45% | 107.64% | 107.82% |
| Bin 3 | 103.08% | 103.09% | 103.15% | 103.20% |

| J | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Bin 1 | 109.10% | 109.38% | 109.41% | 109.53% |
| Bin 2 | 105.78% | 105.91% | 105.92% | 105.98% |
| Bin 3 | 102.05% | 102.08% | 102.09% | 102.10% |

| K | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Bin 1 | 116.30% | 117.82% | 118.74% | 118.37% |
| Bin 2 | 111.32% | 112.14% | 112.62% | 112.45% |
| Bin 3 | 105.60% | 105.93% | 106.11% | 106.05% |

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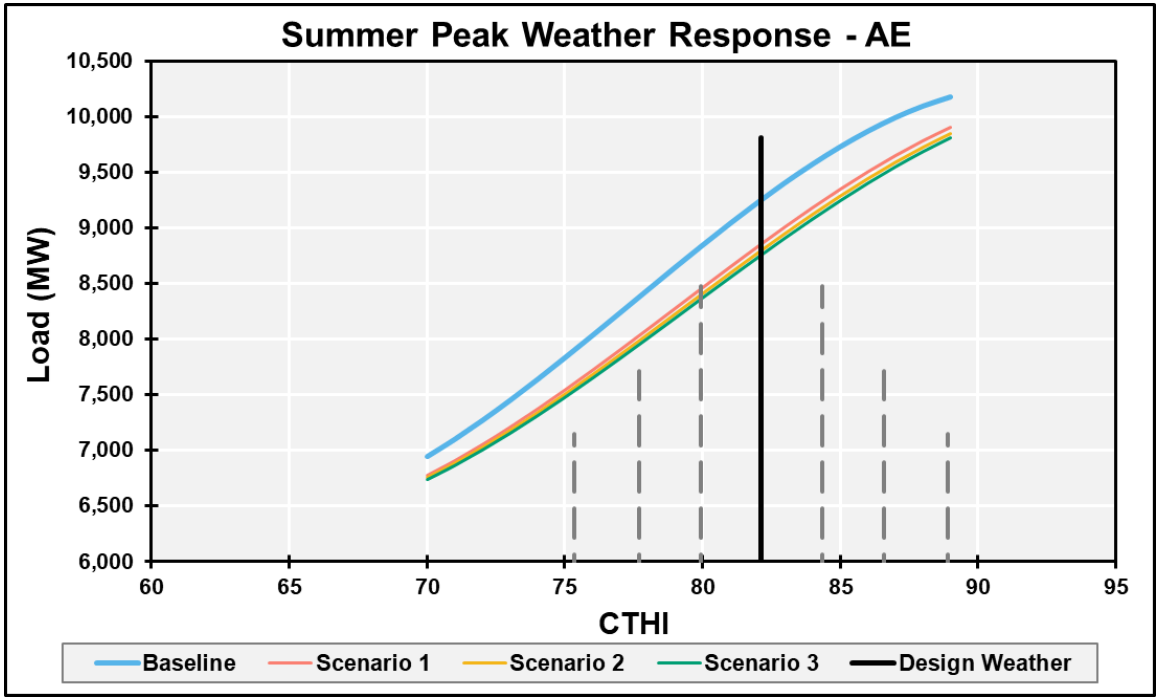
# Weather Response: Zones A-E

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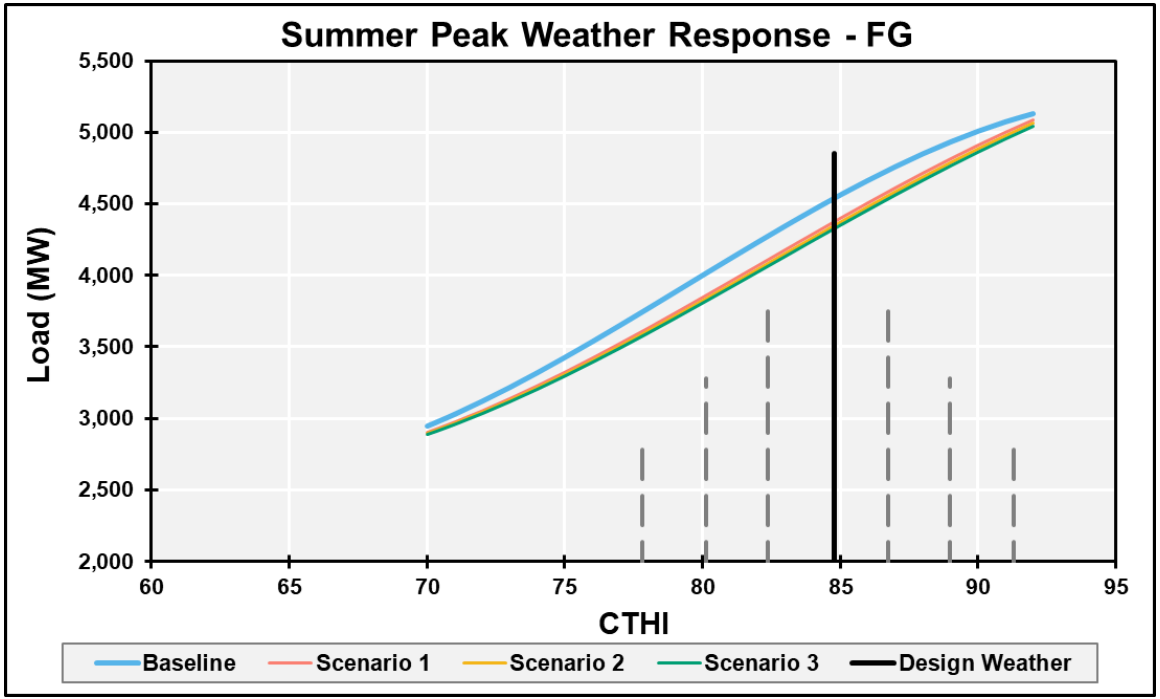
# Weather Response: Zones F&G

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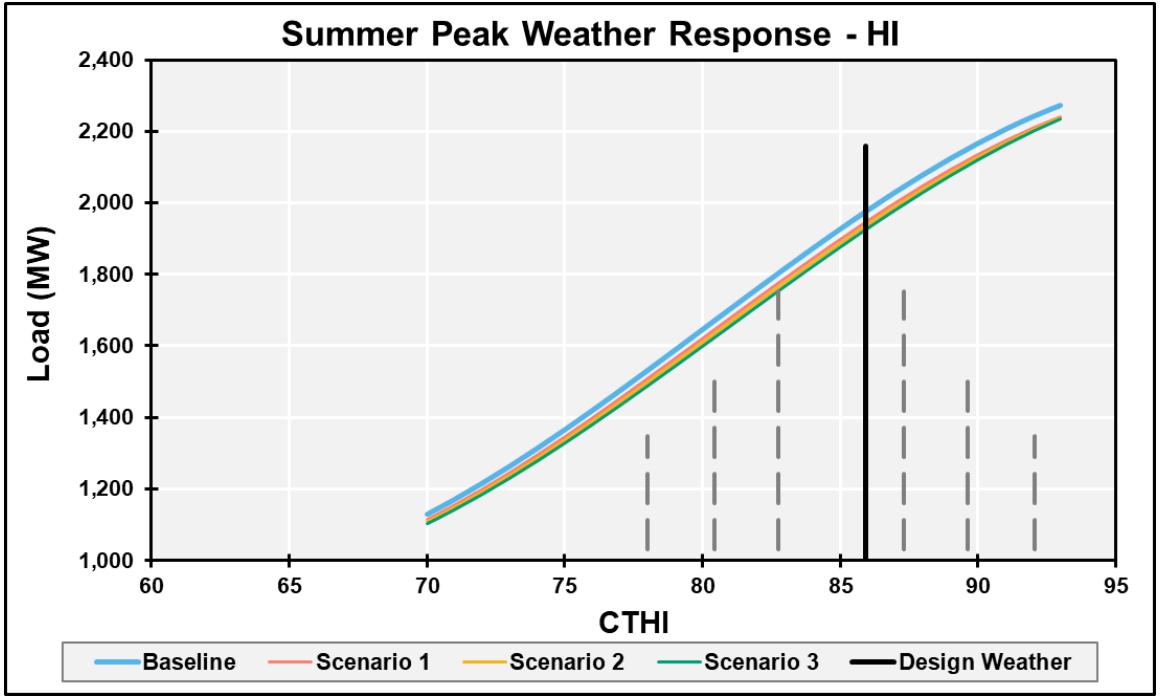
# Weather Response: Zones H&I

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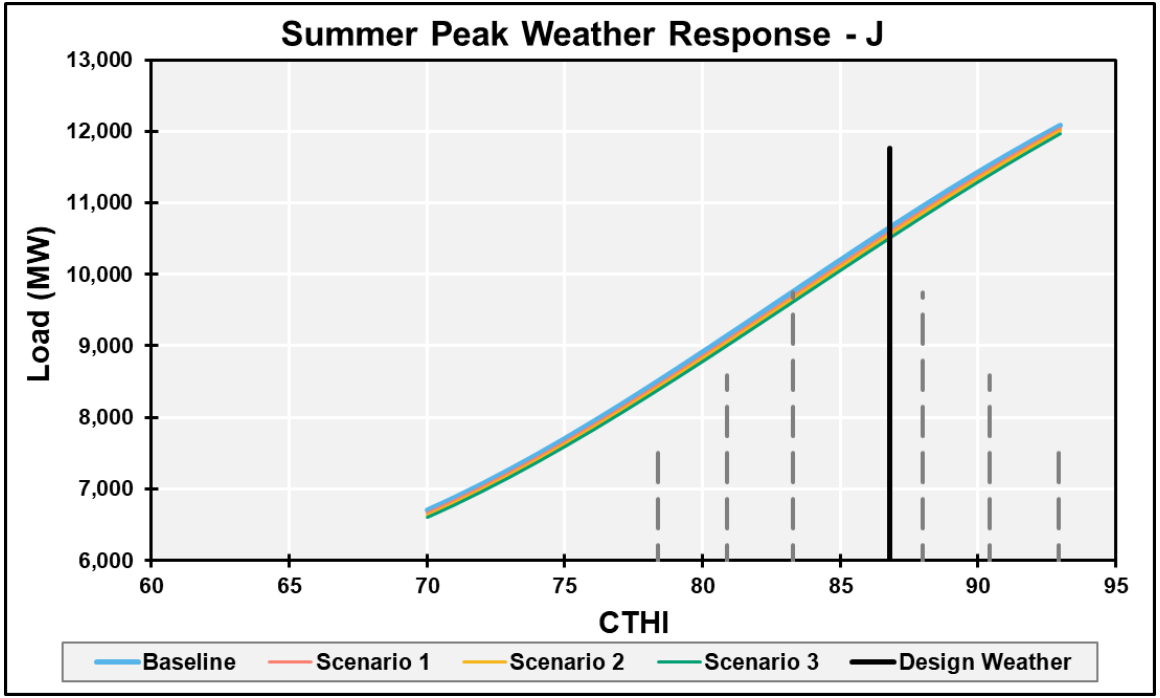
# Weather Response: Zone J

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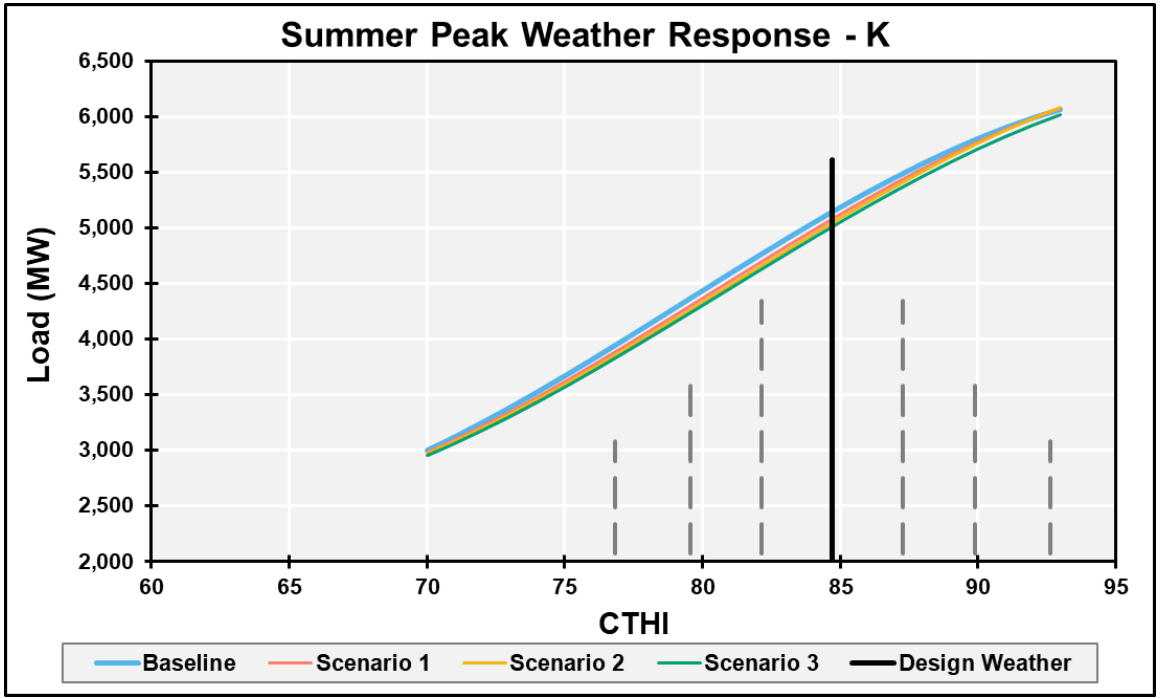
# Weather Response: Zone K

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