Load Forecast Uncertainty Models for the 2027-2028 Installed Reserve Margin Study

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Agenda

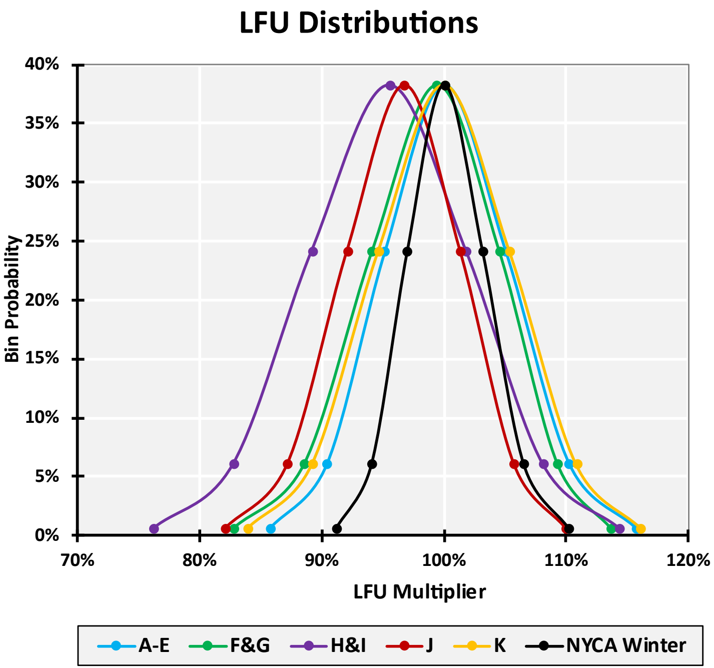
- Background
- Summary of Load Forecast Uncertainty (LFU) Results
- Summer LFU Models
  - Zones A to E, Zones F&G, Zones H&I, Zone J, and Zone K models
- NYCA Winter Base LFU Model
- Appendix

Background

- LFU multipliers are used in NYISO resource adequacy studies to capture the risk of higher Loads due to extreme weather. The distribution of Bin 1 to Bin 7 multipliers represent peak Load uncertainty due to variability in peak day weather. The resulting Load levels are weighted by probability of occurrence.
- Per New York State Reliability Council Policy No. 5-19, summer LFU models are calculated for Zones A to E, Zones F&G, Zones H&I, Zone J, and Zone K; and the winter LFU model is calculated at the NYCA level.
- Peak summer 2025 temperatures were well above normal, providing valuable current information on Load levels during extreme weather. The NYISO in conjunction with the relevant Transmission Owners developed updated summer LFU models. The NYISO recommends that the 2026 Reliability Needs Assessment (RNA) and 2027-2028 Installed Reserve Margin (IRM) study use the resulting summer LFU multipliers.
- Peak winter 2025-2026 temperatures were below (more extreme than) normal. The NYISO developed an updated winter LFU model and recommends that the 2026 RNA and 2027-2028 IRM study use the resulting winter LFU multipliers.

2027 LFU Multipliers

			2027 LFU Multipliers					
			Summer					Winter
Bin	Bin Z	Bin Probability	A-E	F&G	H&I	J	K	NYCA
Bin 1	2.74	0.62%	115.67%	113.59%	114.35%	109.93%	116.11%	110.19%
Bin 2	1.79	6.06%	110.22%	109.24%	108.10%	105.70%	110.83%	106.52%
Bin 3	0.89	24.17%	105.01%	104.48%	101.82%	101.30%	105.37%	103.15%
Bin 4	0.00	38.29%	100.00%	99.41%	95.52%	96.75%	100.00%	100.00%
Bin 5	-0.89	24.17%	95.14%	94.09%	89.17%	92.04%	94.63%	96.99%
Bin 6	-1.79	6.06%	90.38%	88.53%	82.74%	87.16%	89.20%	94.06%
Bin 7	-2.74	0.62%	85.73%	82.77%	76.23%	82.09%	83.93%	91.17%



LFU Multipliers Comparison

			Existing LFU Multipliers					
			Summer					Winter
Bin	Bin z	Bin Probability	A-E	F&G	H&I	J	K	NYCA
Bin 1	2.74	0.62%	113.93%	110.69%	110.18%	108.88%	116.62%	110.48%
Bin 2	1.79	6.06%	109.54%	107.86%	107.34%	105.42%	111.14%	106.68%
Bin 3	0.89	24.17%	104.86%	104.04%	103.09%	101.61%	105.52%	103.22%
Bin 4	0.00	38.29%	100.00%	99.46%	97.81%	97.51%	100.00%	100.00%
Bin 5	-0.89	24.17%	95.00%	94.29%	91.70%	93.12%	94.48%	96.96%
Bin 6	-1.79	6.06%	89.91%	88.61%	84.93%	88.45%	88.89%	94.02%
Bin 7	-2.74	0.62%	84.79%	82.53%	77.65%	83.48%	83.27%	91.16%

			LFU Multipliers Delta (New - Existing)					
			Summer					Winter
Bin	Bin z	Bin Probability	A-E	F&G	H&I	J	K	NYCA
Bin 1	2.74	0.62%	1.74%	2.90%	4.17%	1.05%	-0.51%	-0.29%
Bin 2	1.79	6.06%	0.68%	1.38%	0.76%	0.28%	-0.31%	-0.16%
Bin 3	0.89	24.17%	0.15%	0.44%	-1.27%	-0.31%	-0.15%	-0.07%
Bin 4	0.00	38.29%	0.00%	-0.05%	-2.29%	-0.76%	0.00%	0.00%
Bin 5	-0.89	24.17%	0.14%	-0.20%	-2.53%	-1.08%	0.15%	0.03%
Bin 6	-1.79	6.06%	0.47%	-0.08%	-2.19%	-1.29%	0.31%	0.04%
Bin 7	-2.74	0.62%	0.94%	0.24%	-1.42%	-1.39%	0.66%	0.01%

New York ISO

Summer LFU Models

Summer LFU Model Methodology [1]

- LFU Bin weather distribution determined using 20-year mean and standard deviation (2007-2026) of NYCA peak day CTHI (Cumulative Temperature & Humidity Index)
- Load-weather relationship was established through a regression model
- PI Loads with estimated demand response added back
- Models developed using July through September non-holiday weekdays (with outliers removed)
- 2022 through 2025 summers were considered for each model and used as optimal
- CTHI60 (CTHI relative to 60 degrees), squared, and cubed weather variables
- Additional binary variables included for year, month, and day of week, as appropriate
- Final model for each area was selected based on model accuracy, statistical significance, and overall response and weather sensitivity
- LFU multipliers calculated using the weather distribution and regression results

[1] NYISO developed models

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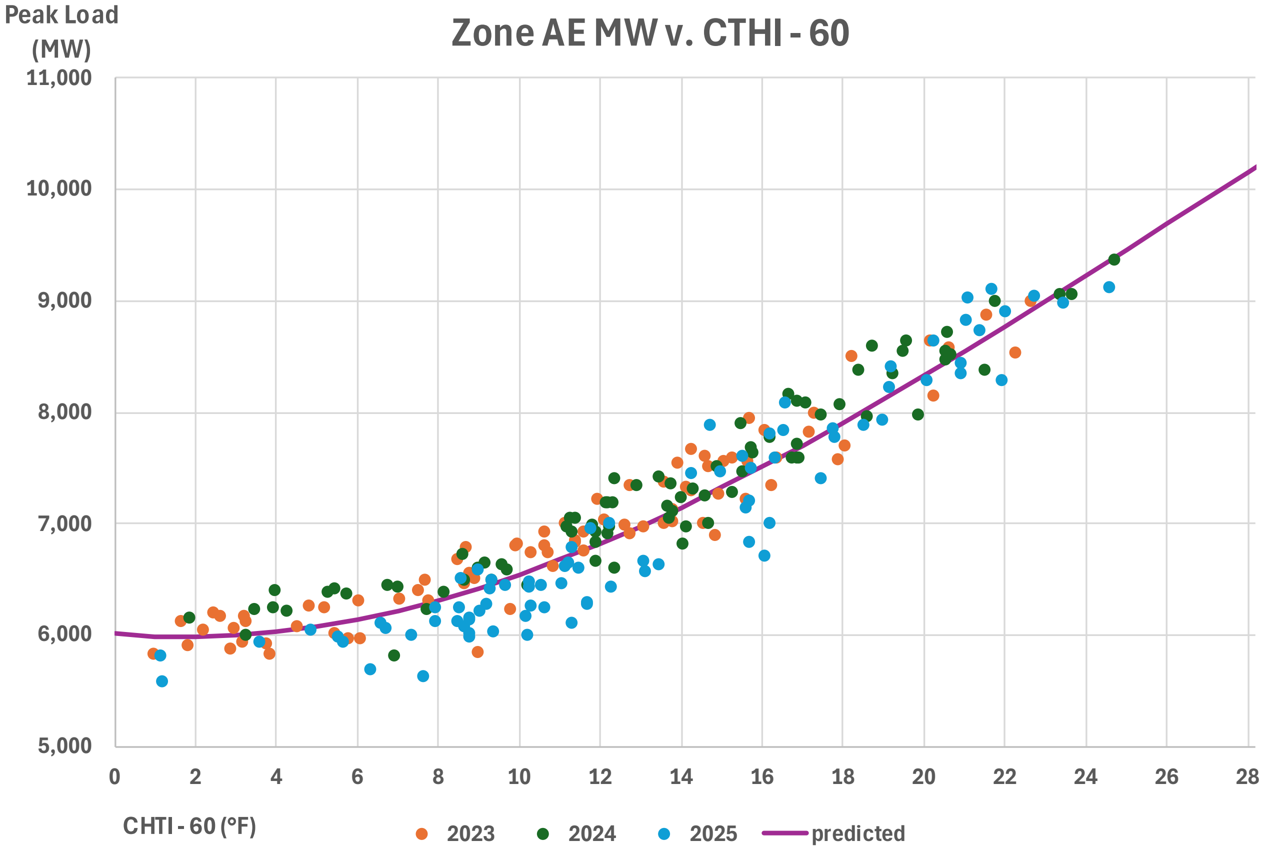
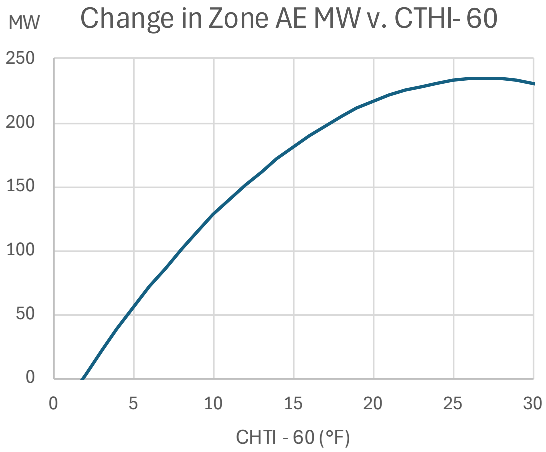
Zones A to E Model



NYISO developed model using CTHI and 2023, 2024, & 2025 non-holiday weekdays.



Zones A to E Model (cont.)

Regression Statistics	
Multiple R	0.973
R Square	0.947
Adjusted R Square	0.946
Standard Error	208.29
Observations	246

ANOVA

	df	SS	MS	F	Significance F
Regression	8	185072837	23134105	533	0
Residual	238	10282290	43203		
Total	246	195355127			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	6016.512	96.381	62.424	0.000	5826.644	6206.381
AE_CTHI	-34.933	27.233	-1.283	0.201	-88.582	18.716
AE_CTHI_SQ	9.995	2.447	4.085	0.000	5.175	14.816
AE_CTHI_CU	-0.124	0.065	-1.905	0.058	-0.251	0.004
FRIDAY	-155.587	33.784	-4.605	0.000	-222.142	-89.033
JUNE	-233.446	34.038	-6.858	0.000	-300.501	-166.391
SEPTEMBER	-154.474	36.322	-4.253	0.000	-226.029	-82.920
2023	211.464	33.154	6.378	0.000	146.151	276.776
2024	260.437	32.695	7.966	0.000	196.030	324.845

Bin	Z	CTHI	MW	Mult
Bin 1	2.74	28.21	10,212	115.67%
Bin 2	1.79	26.16	9,731	110.22%
Bin 3	0.89	24.19	9,271	105.01%
Bin 4	0.00	22.26	8,829	100.00%
Bin 5	-0.89	20.33	8,399	95.14%
Bin 6	-1.79	18.36	7,980	90.38%
Bin 7	-2.74	16.31	7,569	85.73%
Design	0.00	22.26	8,829	100.00%

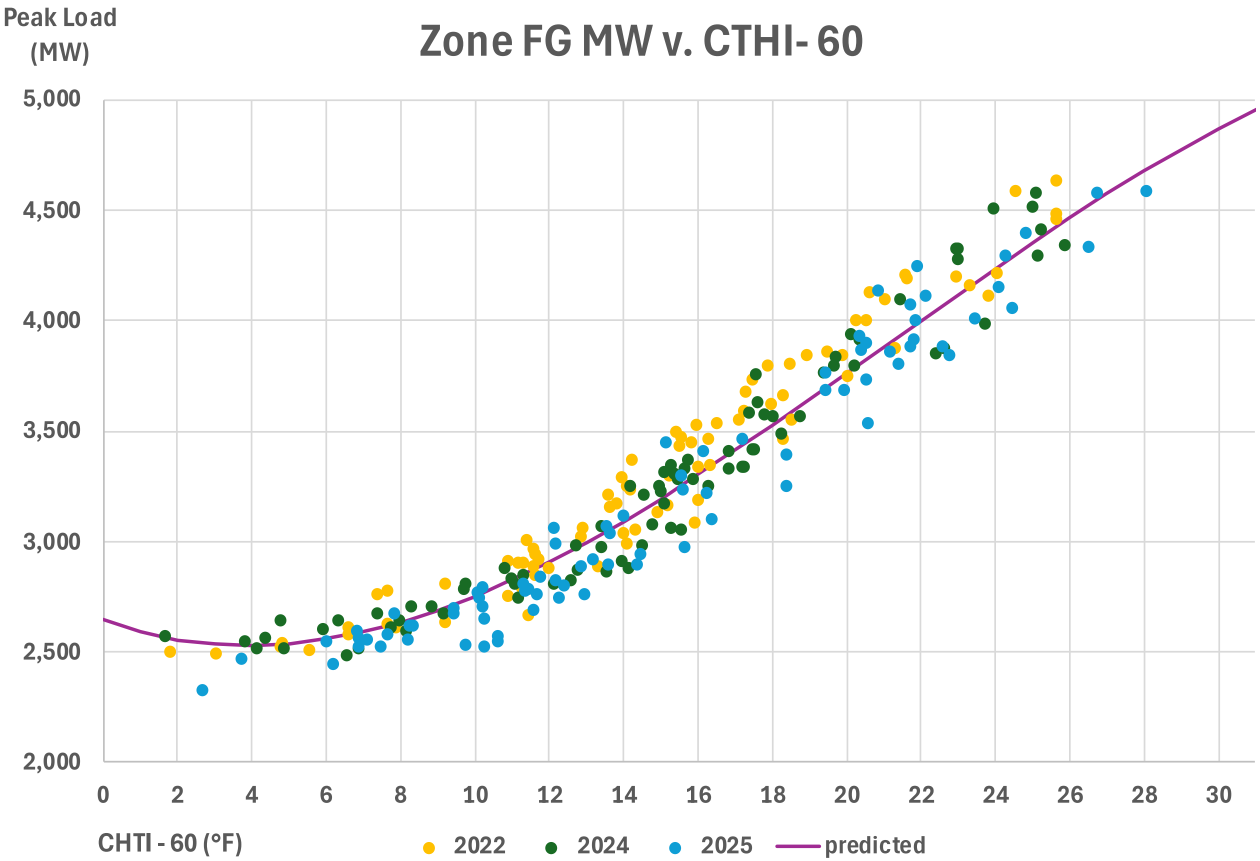
CTHI Distribution

Mean: 82.26

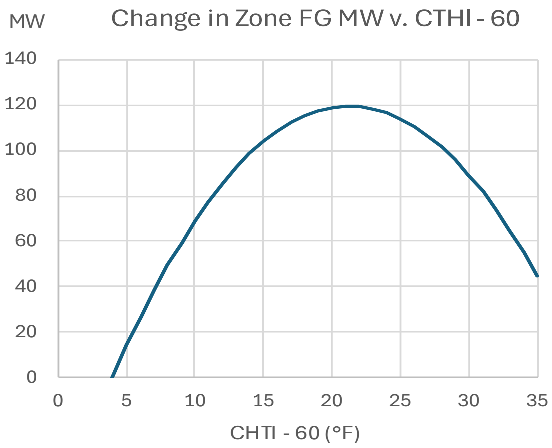
Standard Deviation: 2.18

New York ISO

Zones F&G Model



NYISO developed model using CTHI and 2022, 2024, & 2025 non-holiday weekdays.



New York ISO

Zones F&G Model (cont.)

Regression Statistics	
Multiple R	0.983
R Square	0.967
Adjusted R Square	0.965
Standard Error	108.79
Observations	248

ANOVA

	df	SS	MS	F	Significance F
Regression	9	81843463	9093718	768	0
Residual	239	2816663	11785		
Total	248	84660125			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	2645.341	69.947	37.819	0.000	2507.550	2783.133
FG_CTHI	-60.770	16.887	-3.599	0.000	-94.037	-27.504
FG_CTHI_SQ	8.480	1.264	6.708	0.000	5.990	10.971
FG_CTHI_CU	-0.133	0.028	-4.668	0.000	-0.189	-0.077
FRIDAY	-65.856	17.717	-3.717	0.000	-100.758	-30.954
JUNE	-91.558	18.237	-5.021	0.000	-127.484	-55.633
SEPTEMBER	-97.497	20.866	-4.673	0.000	-138.602	-56.393
2022	133.530	17.071	7.822	0.000	99.902	167.158
2024	69.331	17.069	4.062	0.000	35.707	102.956

Bin	Z	CTHI	MW	Mult
Bin 1	2.74	30.97	4,950	113.59%
Bin 2	1.79	28.86	4,761	109.24%
Bin 3	0.89	26.83	4,553	104.48%
Bin 4	0.00	24.84	4,332	99.41%
Bin 5	-0.89	22.86	4,100	94.09%
Bin 6	-1.79	20.83	3,858	88.53%
Bin 7	-2.74	18.71	3,607	82.77%
Design	0.10	25.07	4,358	100.00%

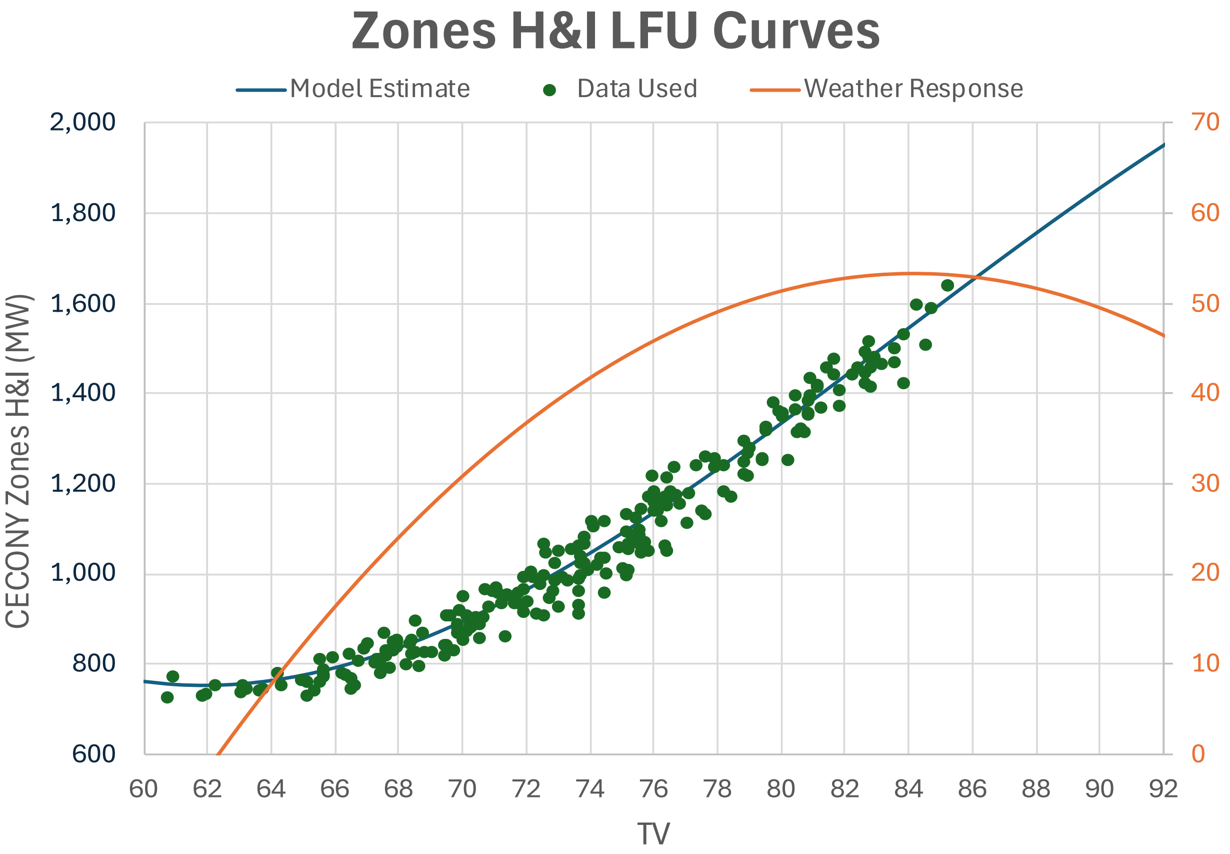
CTHI Distribution

Mean: 84.84

Standard Deviation: 2.24

New York ISO

Zones H&I Model



- Con Ed developed model, validated by NYISO
- 2023 to 2025 non-holiday weekdays with outliers removed
- Uses Con Ed's Temperature Variable (TV)
- NYISO independent model using NYISO H&I Loads and CTHI produced similar results

Zones H&I Model (cont.)

Model:						
Variable	Coefficient	Std_Error	t_stat	p_value	CI_Lower	CI_Upper
Friday	-16.049	6.234	-2.574	0.011	-28.333	-3.766
Intercept	18926.084	4264.081	4.438	0.000	10524.622	27327.546
TV	-730.238	175.789	-4.154	0.000	-1076.592	-383.884
TV2	9.362	2.407	3.890	0.000	4.620	14.105
TV3	-0.037	0.011	-3.407	0.001	-0.059	-0.016
Year_2023	-15.257	5.451	-2.799	0.006	-25.997	-4.516
Adj R^2:						
0.973						

Bin	Z	TV	Load	LFU Mult
1	2.74	90.68	1,888	114.35%
2	1.79	88.58	1,784	108.10%
3	0.89	86.57	1,681	101.82%
4	0.00	84.60	1,577	95.52%
5	-0.89	82.64	1,472	89.17%
6	-1.79	80.63	1,366	82.74%
7	-2.74	78.53	1,258	76.23%
Design		*86.00*	*1,651*	*100.00%*

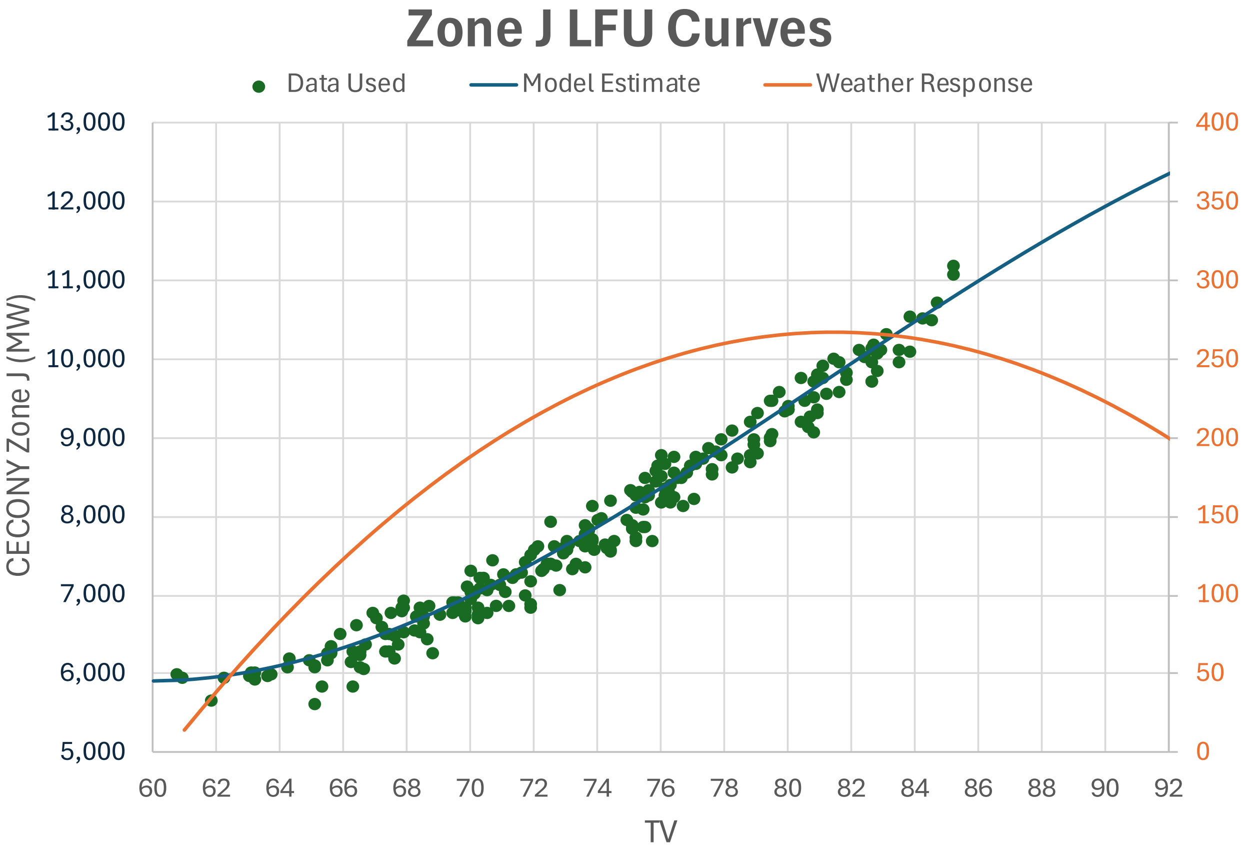
TV Distribution

Mean: 84.60

Standard Deviation: 2.22

New York ISO

Zone J Model



- Con Ed developed model, validated by NYISO
- 2023 to 2025 non-holiday weekdays with outliers removed
- Uses Con Ed's Temperature Variable (TV)
- NYISO independent model using NYISO Zone J Loads and CTHI produced similar results

Zone J Model (cont.)

Model:						
Variable	Coefficient	Std_Error	t_stat	p_value	CI_Lower	CI_Upper
Friday	-171.094	30.407	-5.627	0.000	-230.995	-111.193
Intercept	94876.940	21479.221	4.417	0.000	52563.272	137190.608
TV	-3691.846	884.284	-4.175	0.000	-5433.869	-1949.823
TV2	48.899	12.093	4.044	0.000	25.077	72.721
TV3	-0.201	0.055	-3.665	0.000	-0.310	-0.093
Year_2023	-140.040	26.535	-5.278	0.000	-192.313	-87.767
Adj R^2:						
0.978						

Bin	Z	TV	Load	LFU Mult
1	2.74	90.68	12,074	109.93%
2	1.79	88.58	11,610	105.70%
3	0.89	86.57	11,126	101.30%
4	0.00	84.60	10,626	96.75%
5	-0.89	82.64	10,109	92.04%
6	-1.79	80.63	9,573	87.16%
7	-2.74	78.53	9,017	82.09%
Design		*86.00*	*10,983*	*100.00%*

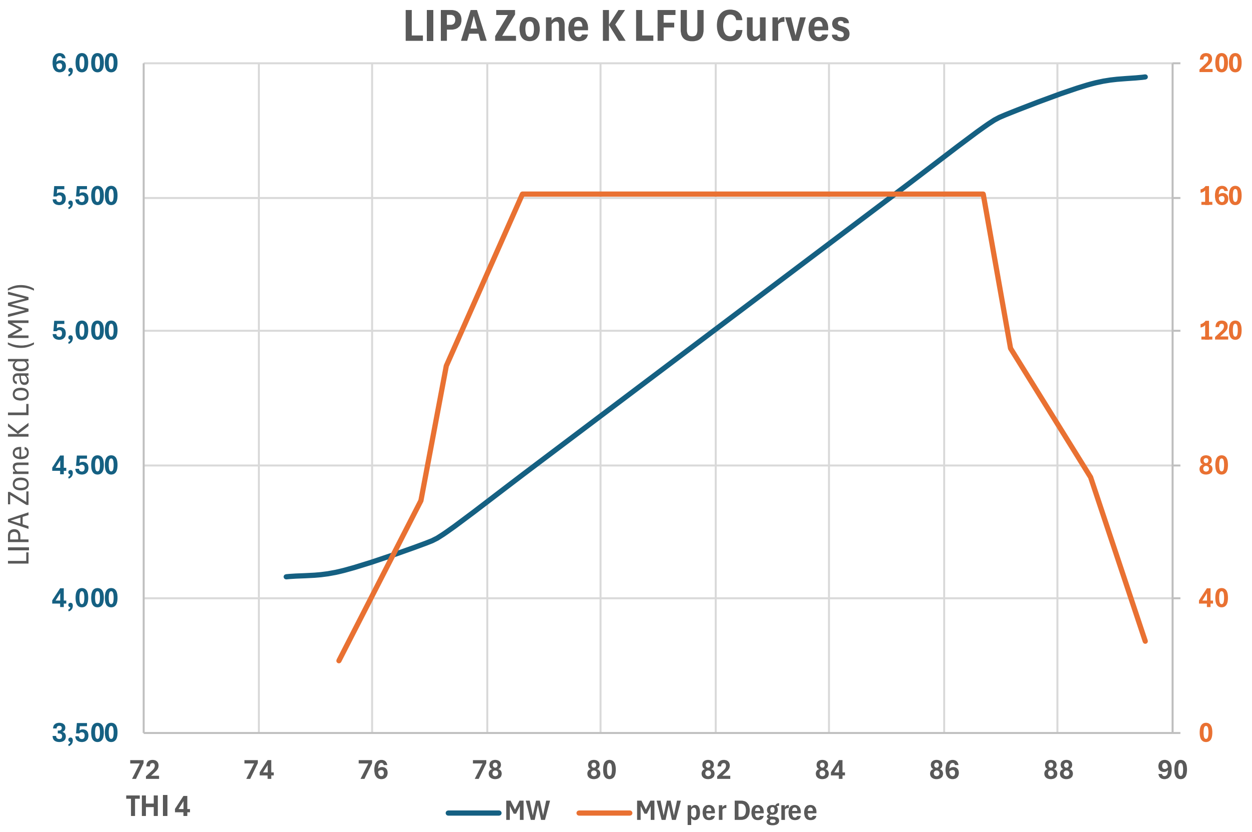
TV Distribution

Mean: 84.60

Standard Deviation: 2.22

New York ISO

LIPA Zone K Model



- LIPA developed model
- Uses LIPA's THI 4 variable (THI of 4 hours preceding LIPA peak hour)
- NYISO independent model using NYISO Zone K loads and CTHI produced similar results (shown in the Appendix)

New York ISO

LIPA Zone K Model (cont.)

Z	Cum Prob	THI 4	MW	ΔMW	ΔTHI 4	ΔMW / ΔTHI 4	MW / $MW_{CP=50\%}$
-4.00	0.003%	74.5	4,085				
-3.50	0.023%	75.4	4,105	20	0.94	21	81.95%
-2.74	0.307%	76.8	4,204	99	1.43	69	83.93%
-2.50	0.621%	77.3	4,254	50	0.45	110	84.92%
-1.79	3.673%	78.6	4,469	215	1.34	161	89.20%
-1.50	6.681%	79.2	4,556	88	0.55	161	90.95%
-0.89	18.673%	80.3	4,740	184	1.15	161	94.63%
-0.50	30.854%	81.1	4,858	118	0.73	161	96.98%
0.00	**50.000%**	**82.0**	**5,009**	**151**	**0.94**	**161**	**100.00%**
0.50	69.146%	82.9	5,160	151	0.94	161	103.02%
0.89	81.327%	83.7	5,278	118	0.73	161	105.37%
1.50	93.319%	84.8	5,463	184	1.15	161	109.05%
1.80	96.367%	85.4	5,552	89	0.55	161	110.83%
2.50	99.379%	86.7	5,765	213	1.33	161	115.08%
2.74	99.693%	87.2	5,817	52	0.45	115	116.11%
3.50	99.977%	88.6	5,925	109	1.43	76	118.29%
4.00	99.997%	89.5	5,951				

THI 4 Distribution
Mean: 82.0
Standard Deviation: 1.88

New York ISO

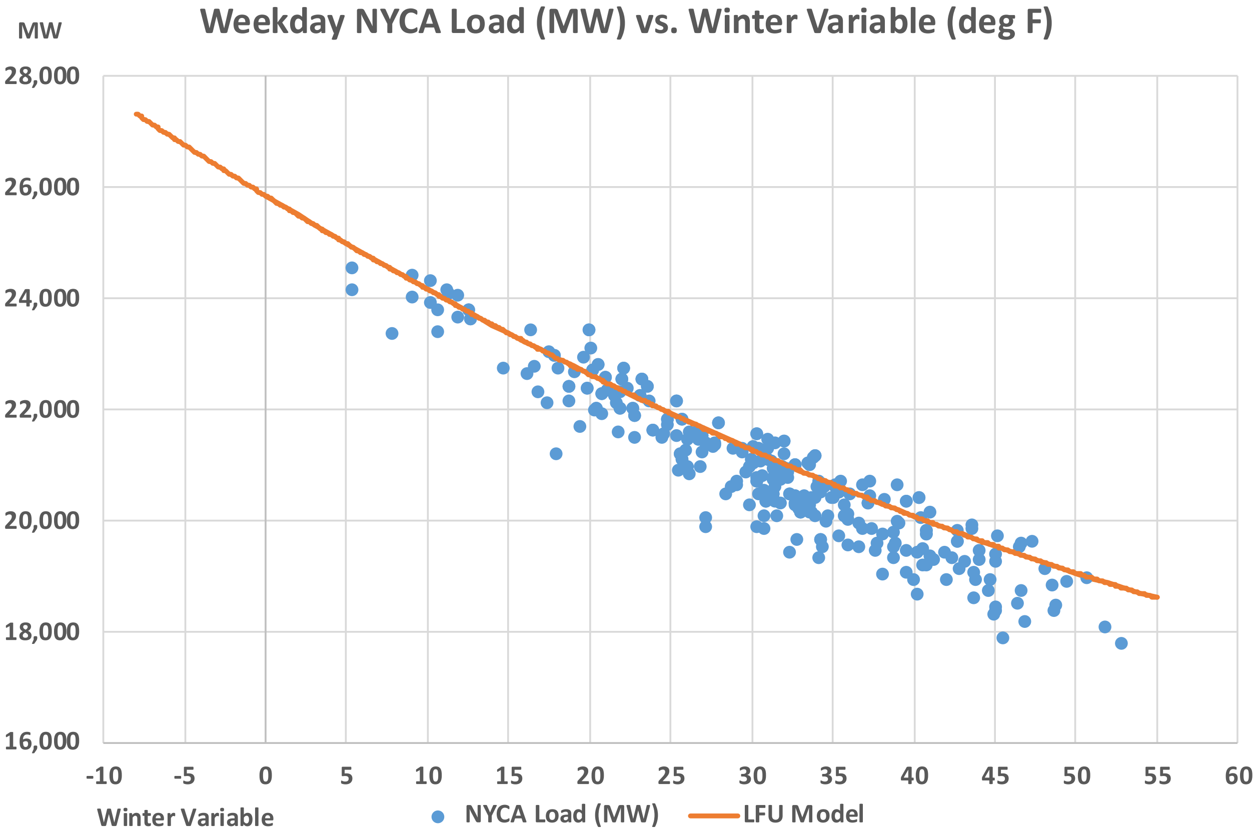
NYCA Winter Base LFU Model

Winter LFU Model Methodology

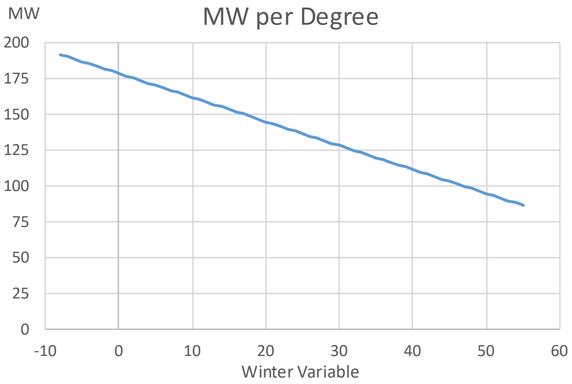
- LFU Bin weather distribution determined using 20-year mean and standard deviation of NYCA seasonal minimum Winter Variable
- Load-weather relationship was established through a regression model
- PI loads with estimated demand response added back
- Model developed using December, January, and February non-holiday weekdays from winters 2022-23 through 2025-26 (with outliers removed)
- Winter Variable and squared variable
- Additional binary variables included for year, month, and day of week, as appropriate
- Final model was selected based on model accuracy, statistical significance, and overall response and weather sensitivity
- LFU multipliers calculated using the weather distribution and regression results

New York ISO

NYCA Winter Model



- NYISO developed model using winter variable and 2022-23 through 2025-26 non-holiday weekdays
- Additional model including weekend days was tested, producing similar LFU multiplier results



New York ISO

NYCA Winter Model (cont.)

Regression Statistics	
Multiple R	0.979
R Square	0.959
Adjusted R Square	0.958
Standard Error	279.336
Observations	310

ANOVA

	df	SS	MS	F	Significance F
Regression	8	549195241	68649405	880	0
Residual	301	23486562	78028		
Total	309	572681803			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	25857.142	123.491	209.384	0.000	25614.126	26100.158
Monday	-74.293	40.982	-1.813	0.071	-154.940	6.355
Friday	-361.573	40.419	-8.946	0.000	-441.113	-282.034
Dec	228.060	40.019	5.699	0.000	149.308	306.812
Feb	-384.018	39.221	-9.791	0.000	-461.200	-306.836
Y2022	-555.849	44.136	-12.594	0.000	-642.704	-468.995
Y2023	-360.039	43.767	-8.226	0.000	-446.168	-273.911
WinVar	-178.021	8.495	-20.956	0.000	-194.738	-161.305
WinVar_sq	0.838	0.140	6.005	0.000	0.563	1.113

Bin	Z	Win Var	MW	Mult
Bin 1	2.74	-6.70	27,087	110.19%
Bin 2	1.79	-1.83	26,186	106.52%
Bin 3	0.89	2.84	25,358	103.15%
Bin 4	0.00	7.41	24,584	100.00%
Bin 5	-0.89	11.98	23,844	96.99%
Bin 6	-1.79	16.66	23,124	94.06%
Bin 7	-2.74	21.52	22,414	91.17%
Design	0.00	7.41	24,584	100.00%

Winter Variable Distribution

Mean: 7.41

Standard Deviation: 5.16

New York ISO

Questions?

Appendix

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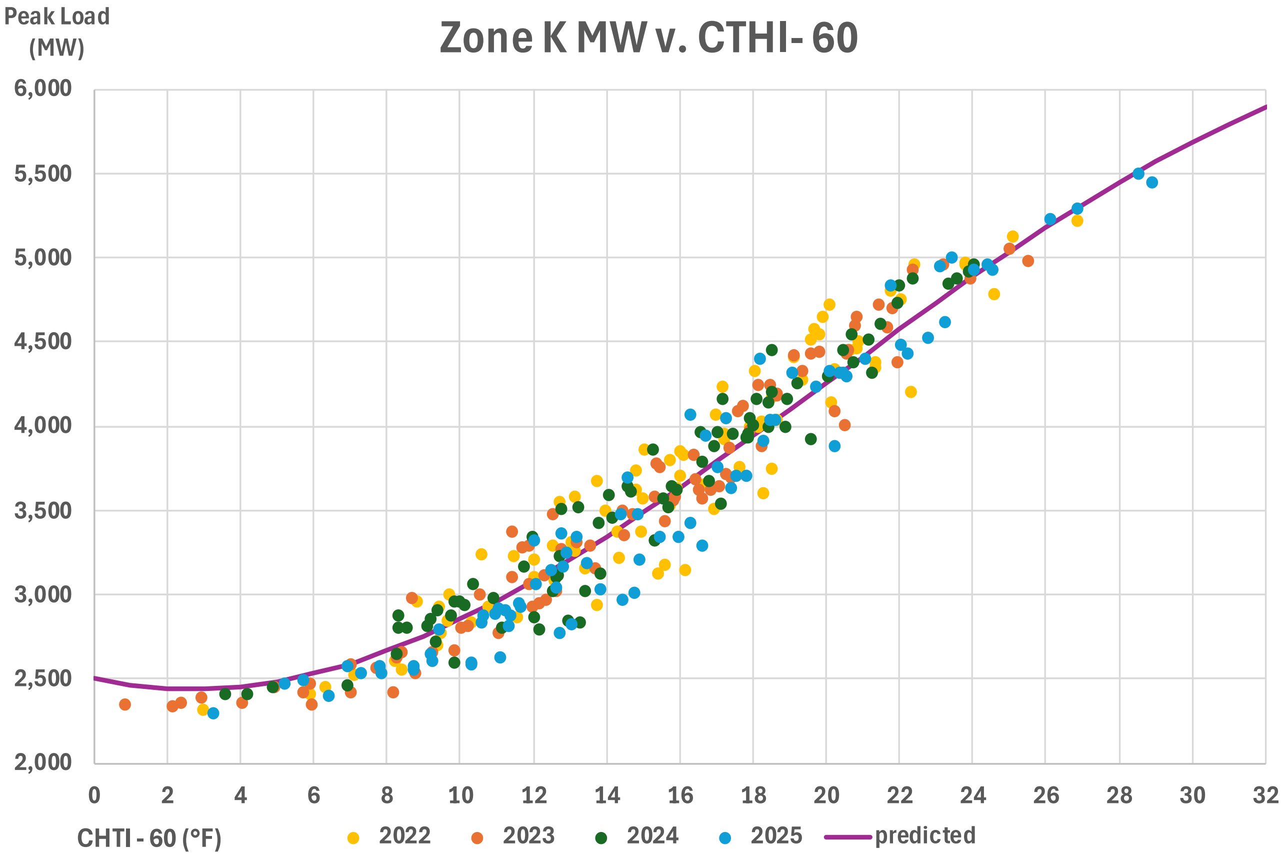
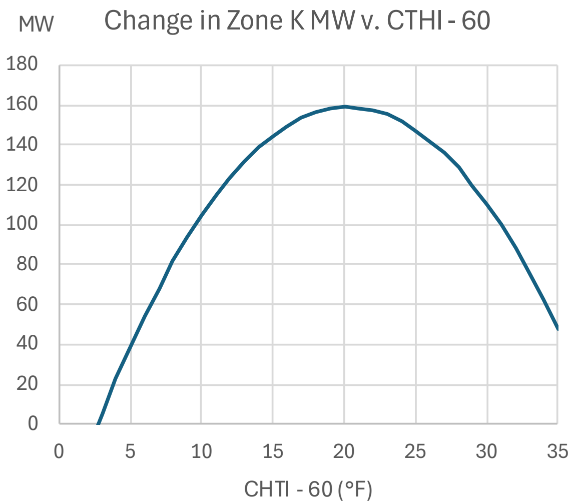
NYISO Zone K Model *(For Reference)*



NYISO developed model using CTHI and 2022 through 2025 non-holiday weekdays.



New York ISO

NYISO Zone K Model *(For Reference)* (cont.)

Regression Statistics	
Multiple R	0.975
R Square	0.951
Adjusted R Square	0.950
Standard Error	171.33
Observations	330

ANOVA

	df	SS	MS	F	Significance F
Regression	8	184561442	23070180	786	0
Residual	322	9422303	29262		
Total	330	193983746			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	2505.199	100.693	24.880	0.000	2307.099	2703.298
K_CTHI	-52.298	22.270	-2.348	0.019	-96.111	-8.485
K_CTHI_SQ	10.412	1.623	6.415	0.000	7.219	13.605
K_CTHI_CU	-0.171	0.036	-4.719	0.000	-0.242	-0.100
JUNE	-79.683	26.360	-3.023	0.003	-131.543	-27.824
SEPTEMBER	-172.291	28.121	-6.127	0.000	-227.615	-116.967
2022	112.107	27.197	4.122	0.000	58.602	165.613
2023	76.845	27.219	2.823	0.005	23.296	130.395
2024	103.391	27.267	3.792	0.000	49.747	157.034

Bin	Z	CTHI	MW	Mult
Bin 1	2.74	31.35	5,827	115.22%
Bin 2	1.79	29.22	5,598	110.69%
Bin 3	0.89	27.17	5,339	105.57%
Bin 4	0.00	25.17	5,057	100.00%
Bin 5	-0.89	23.17	4,755	94.03%
Bin 6	-1.79	21.13	4,435	87.69%
Bin 7	-2.74	19.00	4,097	81.01%
Design	0.00	25.17	5,057	100.00%
10th	-1.28	22.28	4,617	91.28%
90th	1.28	28.06	5,456	107.89%
99th	2.33	30.42	5,733	113.36%

CTHI Distribution

Mean: 85.17

Standard Deviation: 2.26

New York ISO

CTHI Computation

Step 1: Calculate hourly THI as a weighted average of the dry bulb temperature (DB) and the wet bulb temperature (WB). There are 24 values per day:

For any day d,

$$(\boldsymbol{THI})_{di} = \mathbf{0.6} \times (\boldsymbol{DB})_{di} + \mathbf{0.4} \times (\boldsymbol{WB})_{di}$$

Where $i = 0, 1, 2, \ldots, 23$ indicate the hours of a day

Step 2: Calculate the THI_max for a day. This is the maximum hourly THI value for that day:

$$(\boldsymbol{THI\_max})_d = \max\left((\boldsymbol{THI})_{di}\right)$$

Step 3: Calculate the daily CTHI using a weighted average of three days (the day for which the CTHI is being calculated and the two preceding days):

$$(\boldsymbol{CTHI})_d = \mathbf{0.7} \times (\boldsymbol{THI\_max})_d + \mathbf{0.2} \times (\boldsymbol{THI\_max})_{d-1} + \mathbf{0.1} \times (\boldsymbol{THI\_max})_{d-2}$$

New York ISO

Winter Variable Computation

$$Wind\ Chill, WC = f(\boldsymbol{DB}, \boldsymbol{WS})$$

- DB = Dry Bulb Temperature (°F)
- WS = Wind Speed (mph)

$$\boldsymbol{WC = 35.74 + 0.6215(DB) - 35.75(WS^{0.16}) + 0.4275(DB)(WS^{0.16})}$$

https://www.weather.gov/ama/windchill

$$X_{Mor} = Avg(X_{HB06}\ to\ X_{HB11})$$
$$X_{Aft} = Avg(X_{HB12}\ to\ X_{HB17})$$

$$\boldsymbol{X = Dry\ Bulb\ or\ Wind\ Speed}$$

In-Day Var for day i, $\boldsymbol{v_i = 0.15DB_{mor_i} + 0.35DB_{aft_i} + 0.35WC_{aft_i} + 0.15WC_{eve_i}}$

Winter Variable for day $i = \boldsymbol{0.8v_i + 0.1v_{i-1} + 0.1v_{i-2}}$

New York ISO

LFU Definition – NYSRC Policy 5-19

Section 3.5.1 NYCA Load Model

Load Forecast Uncertainty Model

Load The load forecast uncertainty (LFU) model captures the impacts of weather conditions on future loads. The LFU gives the MARS program information regarding seven load levels (three loads lower and three loads higher than the median peak) and their respective probabilities of occurrence. For each modeled hour of a given load level, the MARS program determines the resource adequacy and calculates an average loss of load expectation for the capability year. MARS then uses the LOLE results of each load level to calculate a probability weighted-average LOLE for each area.

Recognizing the unique LFU nature of individual NYCA zones, summer LFU models are 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).

Policy 5-19

New York ISO

LFU Definition – NYSRC Policy 5-19 (cont.)

Uncertainty in winter peak load conditions is expected to become more impactful in future years, as winter peak load levels increase due primarily to heating electrification. For this reason, a winter peak LFU model is now also developed using a combination of dry-bulb and wind-chill factors, as appropriate. Currently, the winter LFU is applied to the entire NYCA with no geographic differentiation. Future consideration may be given to constructing winter LFU distributions by area as is being done with the summer models.

Preparation of the summer LFU model is coordinated by the NYISO in collaboration with the TOs. The process used to develop the LFU model generally follows the procedure used to calculate the forecast NYCA ICAP peak as described in the NYISO Load Forecasting Manual. This process follows the development of the NYCA peak, insofar as the LFU is a distribution, not a point estimate. The LFU model is built in three steps: The first step calculates the seven-bin distribution of peak-producing temperature or other weather metric based on historical NYCA peak load days (usually 20 or 30 years). In the second step, regression models are created for each LFU area that estimate the relationship between the weather metric and summer daily peak loads for each LFU area, using one or more recent years of data (not older than 10 years). The third step combines the results from the first and second steps to calculate seven peak load multipliers on a per-unit basis, corresponding to the associated probabilities of occurrence defined by the LFU distribution. Following acceptance from the NYISO Load Forecasting Task Force, the NYISO submits the final LFU model to be used in MARS to ICS for review and approval.

New York ISO

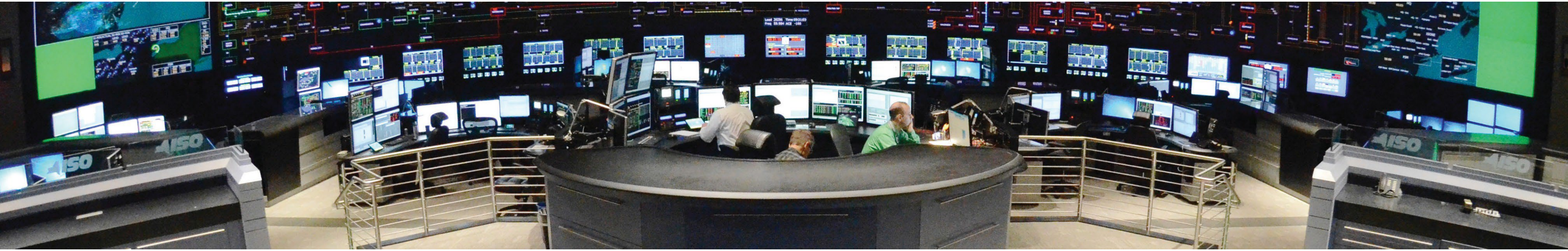
Our Mission and Vision

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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