New York ISO
Independent System Operator

Load Forecast Uncertainty (LFU) Models for the 2024 Install Reserve Margin (IRM) Study

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Demand Forecasting & Analysis

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May 26, 2023

Overview

- Summary of Load Forecast Uncertainty (LFU) Results
- Summer LFU
  - Zones A-E, Zones F&G, Zones H&I, Zone J, Zone K
- Winter LFU – NYCA
- Questions/Discussion

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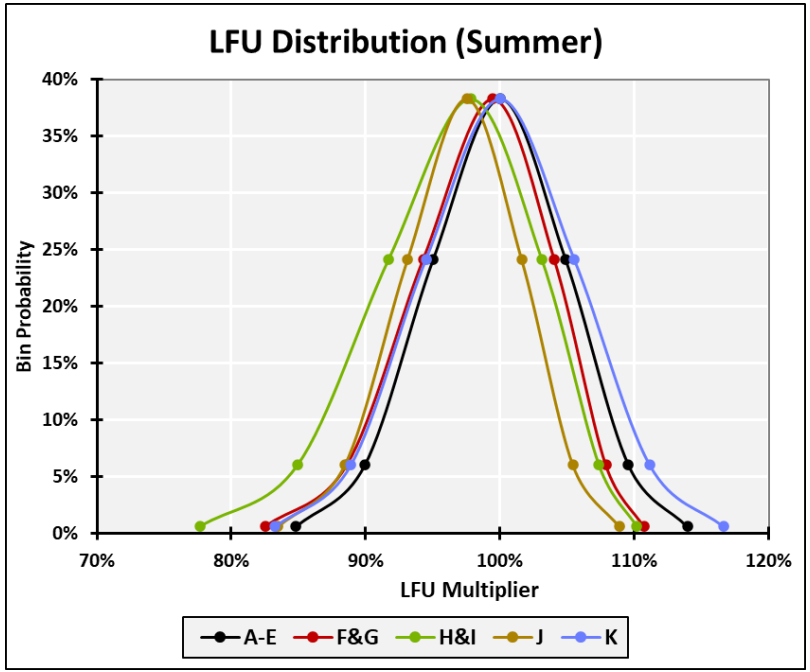
Recommended LFU

			New Recommended 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%	110.37%
Bin 2	1.79	6.06%	109.54%	107.86%	107.34%	105.42%	111.14%	106.37%
Bin 3	0.89	24.17%	104.86%	104.04%	103.09%	101.61%	105.52%	102.75%
Bin 4	0.00	38.29%	100.00%	99.46%	97.81%	97.51%	100.00%	99.42%
Bin 5	-0.89	24.17%	95.00%	94.29%	91.70%	93.12%	94.48%	96.29%
Bin 6	-1.79	6.06%	89.91%	88.61%	84.93%	88.45%	88.89%	93.30%
Bin 7	-2.74	0.62%	84.79%	82.53%	77.65%	83.48%	83.27%	90.41%



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LFU 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%	113.18%	111.42%	110.50%	109.10%	116.30%	110.29%
Bin 2	1.79	6.06%	109.25%	108.20%	107.41%	105.78%	111.32%	106.26%
Bin 3	0.89	24.17%	104.80%	104.14%	103.08%	102.05%	105.60%	102.65%
Bin 4	0.00	38.29%	100.00%	99.46%	97.82%	97.98%	100.00%	99.37%
Bin 5	-0.89	24.17%	94.96%	94.28%	91.83%	93.60%	93.87%	96.32%
Bin 6	-1.79	6.06%	89.75%	88.67%	85.21%	88.90%	86.89%	93.46%
Bin 7	-2.74	0.62%	84.49%	82.72%	78.09%	83.89%	80.04%	90.74%

			LFU Multipliers Delta (Recommended - Existing)					
			Summer					Winter
Bin	Bin z	Bin Probability	A-E	F&G	H&I	J	K	NYCA
Bin 1	2.74	0.62%	0.75%	-0.73%	-0.32%	-0.22%	0.32%	0.08%
Bin 2	1.79	6.06%	0.29%	-0.34%	-0.07%	-0.36%	-0.18%	0.11%
Bin 3	0.89	24.17%	0.07%	-0.11%	0.01%	-0.44%	-0.07%	0.10%
Bin 4	0.00	38.29%	0.00%	0.00%	-0.02%	-0.47%	0.00%	0.05%
Bin 5	-0.89	24.17%	0.04%	0.01%	-0.12%	-0.48%	0.61%	-0.03%
Bin 6	-1.79	6.06%	0.16%	-0.05%	-0.28%	-0.45%	2.00%	-0.16%
Bin 7	-2.74	0.62%	0.30%	-0.19%	-0.45%	-0.41%	3.22%	-0.33%

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Methodology (Summer LFU)[1]

- Load: DSS load. Demand response was added back.
- Load-weather relationship was established through regression model.
- For each LFU area, models were developed using summer (Jun-Aug) data from the years 2019, 2021 and 2022:
  - Pooled 1: 2019, 2021, 2022
  - Pooled 2: 2021, 2022
  - Pooled 3: 2019, 2022
  - Standalone: 2022
- Final model was selected based on model accuracy, statistical stability and overall response and weather sensitivity
- Stepwise regression was used for variable selection

[1] NYISO developed models

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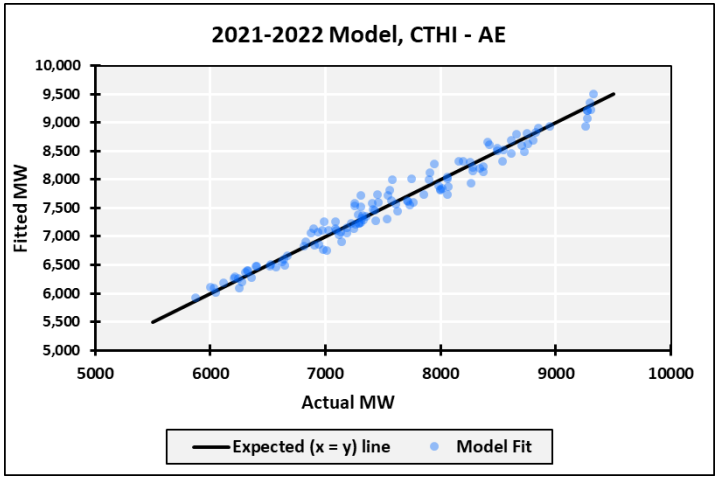
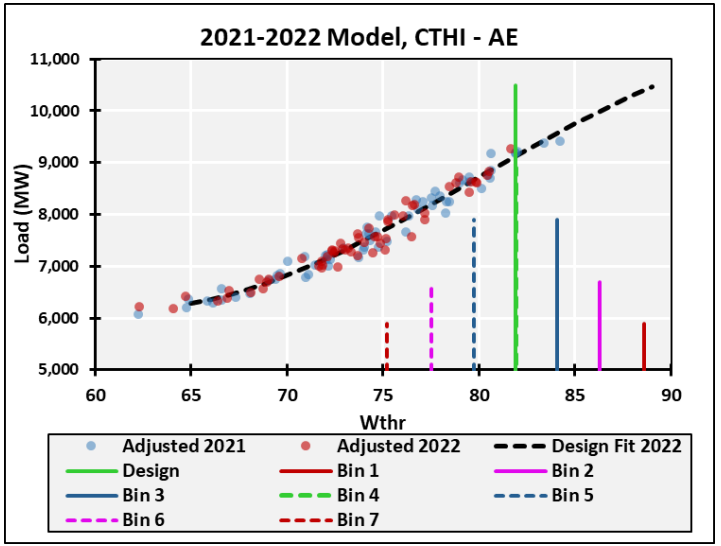
Summer LFU: Zones A-E

- NYISO developed model
- Two-year model (2021, 2022)
- Primary weather variable: CTHI[1]

Mult-R: 98.4%	R-Sq: 96.9%		Adj. R-Sq: 96.7%	
Var	**Coeff.**	**Std Err**	**t-Stat**	**P-value**
Intercept	104371.55	35365.89	2.95	0.4%
wthr	-4013.50	1461.55	-2.75	0.7%
wthr_sq	52.86	20.07	2.63	1.0%
wthr_cb	-0.220	0.092	-2.41	1.8%
Y_2021	87.37	29.46	2.97	0.4%
Jun	-171.01	36.35	-4.70	0.0%
Fri	-134.65	35.86	-3.75	0.0%

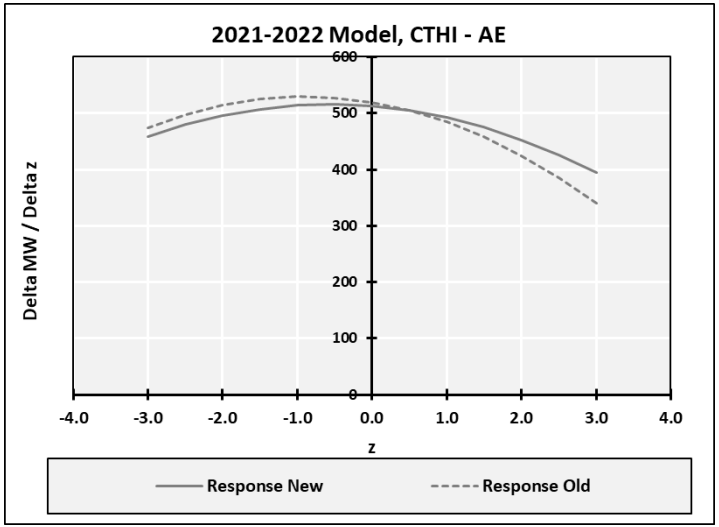




[1] CTHI – Cumulative Temperature and Humidity Index

Note: Adjusted actual values in charts represent loads adjusted for binary effects

Summer LFU: Zones A-E



Summer - AE

Bin	Bin z	Bin Probability	MW	New LFU	Current LFU
Bin 1	2.74	0.62%	10,393	**113.93%**	113.18%
Bin 2	1.79	6.06%	9,993	**109.54%**	109.25%
Bin 3	0.89	24.17%	9,566	**104.86%**	104.80%
Bin 4	0.00	38.29%	9,122	**100.00%**	100.00%
Bin 5	-0.89	24.17%	8,667	**95.00%**	94.96%
Bin 6	-1.79	6.06%	8,202	**89.91%**	89.75%
Bin 7	-2.74	0.62%	7,735	**84.79%**	84.49%
		Design	***9,122***		

- Suppressed based load (-0.8%)[1]
- Slightly stronger load growth at warmer temperature
- Overall increase in LFU

[1] Relative to prior base load, which was calculated for prior reference year (2021)

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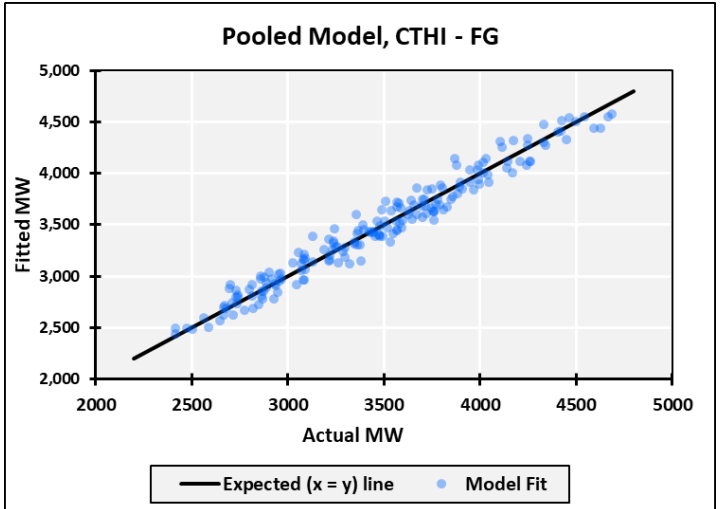
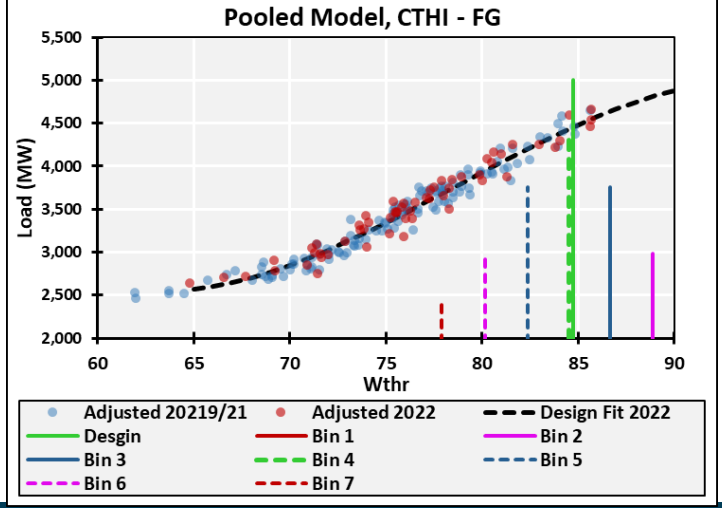
Summer LFU: Zones F&G

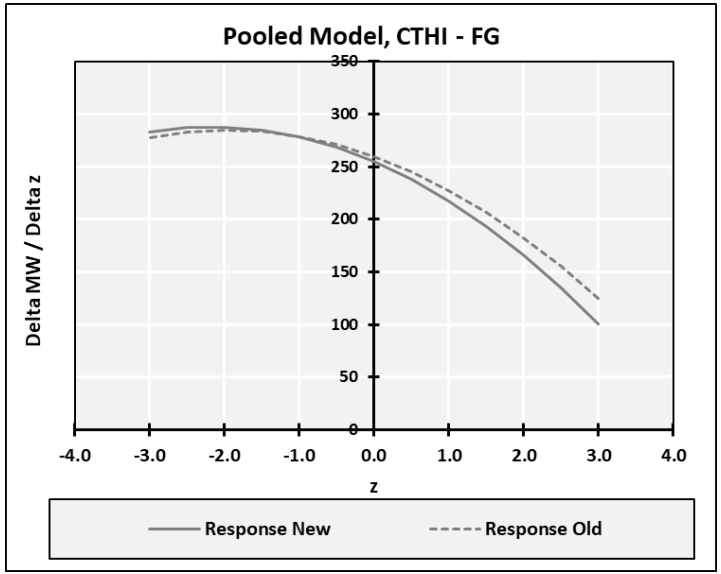
- NYISO developed model
- Pooled model (2019, 2021, 2022)
- Primary weather variable: CTHI

Mult-R: 98.1%	R-Sq: 96.2%		Adj. R-Sq: 96.1%	
Var	**Coeff.**	**Std Err**	**t-Stat**	**P-value**
Intercept	74787.74	14707.01	5.09	0.0%
wthr	-2946.29	597.95	-4.93	0.0%
wthr_sq	38.97	8.07	4.83	0.0%
wthr_cb	-0.165	0.036	-4.56	0.0%
Y_2021	93.70	16.79	5.58	0.0%
Jun	-56.26	20.47	-2.75	0.7%
Fri	-45.02	19.47	-2.31	2.2%





Summer LFU: Zones F&G



Summer - FG

Bin	Bin z	Bin Probability	MW	New LFU	Current LFU
Bin 1	2.74	0.62%	4,934	**110.69%**	111.42%
Bin 2	1.79	6.06%	4,808	**107.86%**	108.20%
Bin 3	0.89	24.17%	4,638	**104.04%**	104.14%
Bin 4	0.00	38.29%	4,434	**99.46%**	99.46%
Bin 5	-0.89	24.17%	4,203	**94.29%**	94.28%
Bin 6	-1.79	6.06%	3,950	**88.61%**	88.67%
Bin 7	-2.74	0.62%	3,679	**82.53%**	82.72%
		Design	***4,458***		

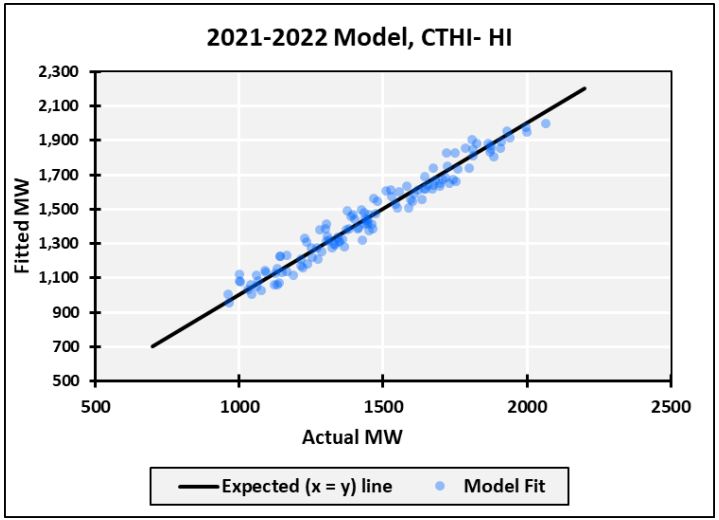
- Decreased base load (-1.2%)
- Slightly stronger saturation at higher temperatures
- Overall decrease in LFU

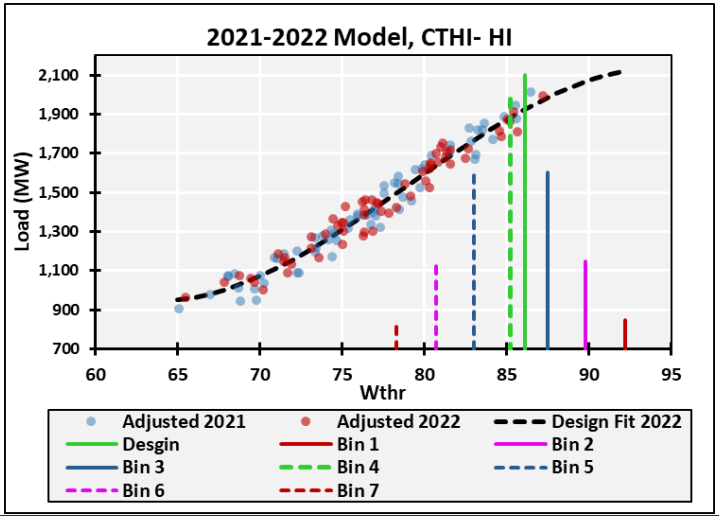
New York ISO

Summer LFU: Zones H&I

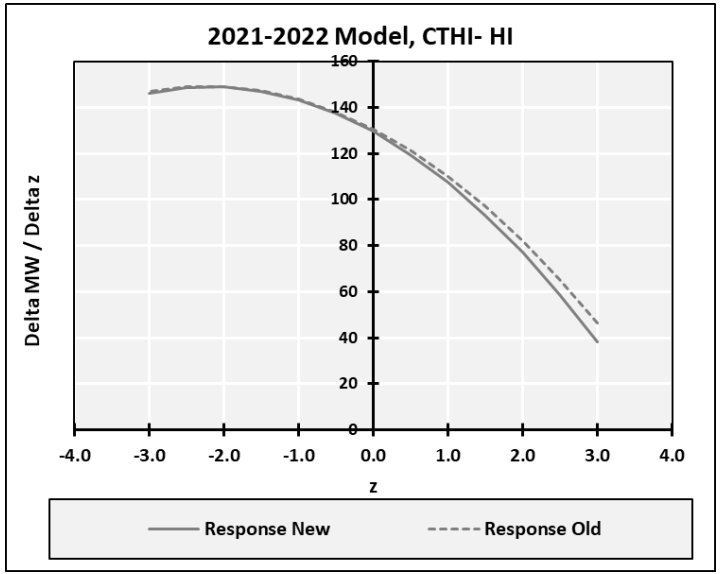
- Developed by NYISO
  - Reviewed by Con Ed
- Two-year model (2021, 2022)
- Primary weather variable: CTHI

Mult-R: 97.9%	R-Sq: 95.9%		Adj. R-Sq: 95.8%	
Var	**Coeff.**	**Std Err**	**t-Stat**	**P-value**
Intercept	38669.03	13288.38	2.91	0.4%
wthr	-1525.18	524.53	-2.91	0.4%
wthr_sq	20.02	6.88	2.91	0.4%
wthr_cb	-0.08	0.03	-2.81	0.6%
Y_2021	53.40	10.21	5.23	0.0%





Summer LFU: Zones H&I



Summer - HI

Bin	Bin z	Bin Probability	MW	New LFU	Current LFU
Bin 1	2.74	0.62%	2,122	**110.18%**	110.50%
Bin 2	1.79	6.06%	2,067	**107.34%**	107.41%
Bin 3	0.89	24.17%	1,986	**103.09%**	103.08%
Bin 4	0.00	38.29%	1,884	**97.81%**	97.82%
Bin 5	-0.89	24.17%	1,766	**91.70%**	91.83%
Bin 6	-1.79	6.06%	1,636	**84.93%**	85.21%
Bin 7	-2.74	0.62%	1,496	**77.65%**	78.09%
		Design	***1,926***		

- Decreased base load (-2.4%)
- Slightly stronger saturation at higher temperatures
- Slight decrease in LFU

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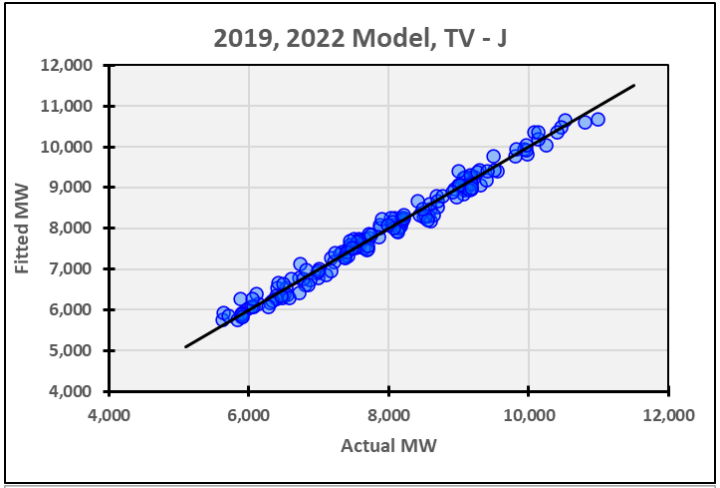
Summer LFU: Zone J

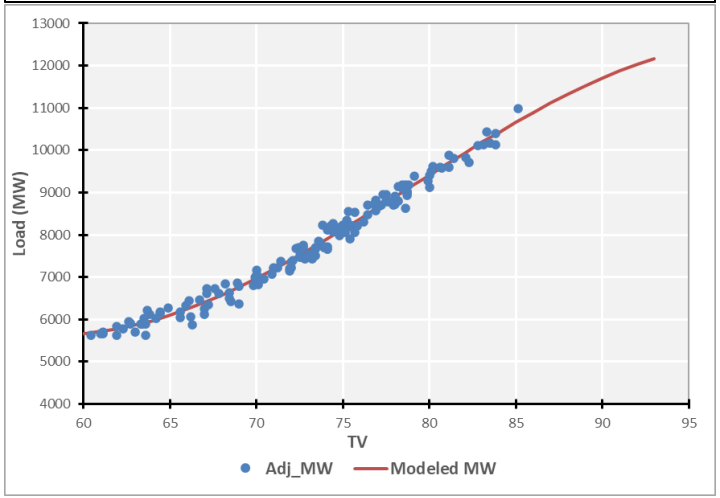
- Developed by Con Ed
  - Reviewed by NYISO
- Two-year model (2019, 2022)
- Primary weather variable: TV

Multiple R: 99.2% R-Sq: 98.4% Adj. R-Sq: 98.4%

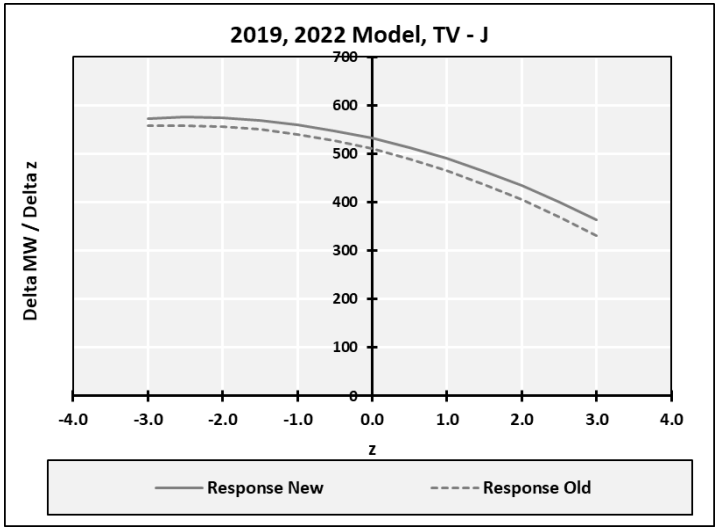
	coef	std err	t	P>|t|
Intercept	94320.00	20900.00	4.505	0.00
TV	-3762.36	872.32	-4.313	0.00
TV_2	51.04	12.06	4.231	0.00
TV_3	-0.22	0.06	-3.9	0.00
Yr_2019	359.88	26.59	13.532	0.00

Data: 2019 and 2022, May – Sep, Mon – Thu, No Holidays





Summer LFU: Zone J



Summer - J

Bin	Bin z	Bin Probability	MW	New LFU	Current LFU
Bin 1	2.74	0.62%	11,856	**108.88%**	109.10%
Bin 2	1.79	6.06%	11,480	**105.42%**	105.78%
Bin 3	0.89	24.17%	11,065	**101.61%**	102.05%
Bin 4	0.00	38.29%	10,618	**97.51%**	97.98%
Bin 5	-0.89	24.17%	10,141	**93.12%**	93.60%
Bin 6	-1.79	6.06%	9,632	**88.45%**	88.90%
Bin 7	-2.74	0.62%	9,091	**83.48%**	83.89%
		Design	***10,889***		

- Increased base load (+4.1%)
- Greater load growth at higher temperature
- Slight decrease in LFU

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Summer LFU: Zone K

- **LIPA developed model**
  - Reviewed by NYISO
- **Ten-year model (2013 – 2022)**
- **Weather variables in model:**
  - Dry Bulb Temperature (Spline)
  - THI4
  - THI24 (Spline)
- **Primary weather variable for uncertainty: THI4**

SUMMARY OUTPUT	
Regression Statistics	
Multiple R	96.2%
R Square	92.5%
Adjusted R Square	92.4%
Standard Error	156
Observations	965

Method = stepwise	*Variable*	*Coeff.*	*Std. Err*	*t Stat*	*P-value*
Intercept	Intercept	1,810.20	27.4	66.0	0.0%
X Variable 1	DB > 66	36.20	2.7	13.6	0.0%
X Variable 2	DB > 80	-25.83	4.0	-6.5	0.0%
X Variable 3	THI_4 > 64	86.40	3.5	24.9	0.0%
X Variable 4	THI_24 > 72	84.84	5.8	14.7	0.0%
X Variable 5	THI_24 > 78	-68.81	38.3	-1.8	7.3%
X Variable 6	SUNDAY	-217.70	15.0	-14.6	0.0%
X Variable 7	SATURDAY	-195.74	14.6	-13.4	0.0%
X Variable 15	2013	331.54	23.3	14.2	0.0%
X Variable 16	2014	277.05	22.5	12.3	0.0%
X Variable 17	2015	203.88	22.2	9.2	0.0%
X Variable 18	2016	216.55	22.1	9.8	0.0%
X Variable 19	2017	143.86	22.8	6.3	0.0%
X Variable 20	2018	180.10	22.4	8.0	0.0%
X Variable 21	2019	148.83	22.4	6.6	0.0%
X Variable 22	2020	62.07	22.5	2.8	0.6%
X Variable 23	2021	60.59	22.6	2.7	0.8%

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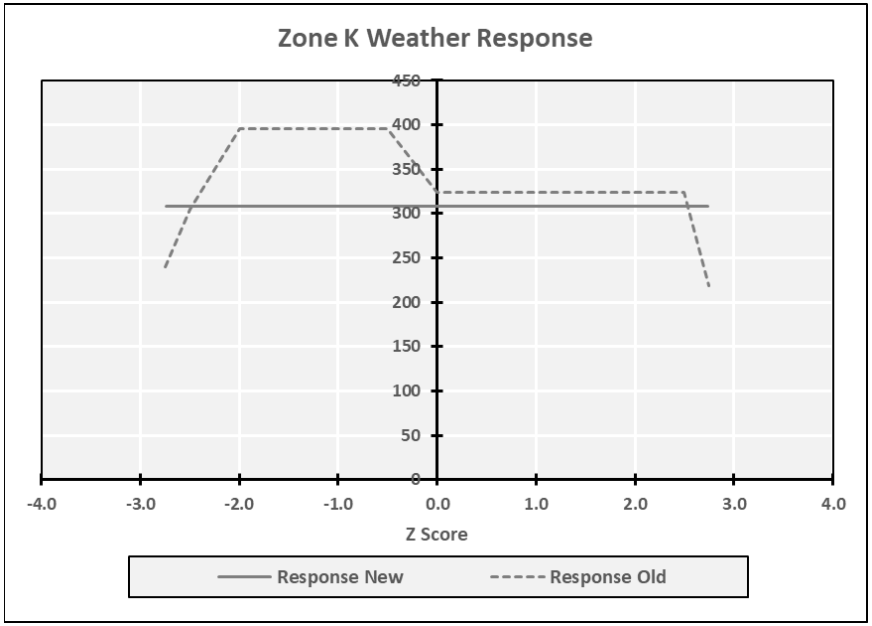
Summer LFU: Zone K



PSEG Last 10 Years Model

Bin	Bin z	Bin Probability	MW	New LFU	Current LFU
Bin 1	2.74	0.62%	5,830	**116.62%**	116.30%
Bin 2	1.79	6.06%	5,555	**111.14%**	111.32%
Bin 3	0.89	24.17%	5,275	**105.52%**	105.60%
Bin 4	0.00	38.29%	4,999	**100.00%**	100.00%
Bin 5	-0.89	24.17%	4,723	**94.48%**	93.87%
Bin 6	-1.79	6.06%	4,444	**88.89%**	86.89%
Bin 7	-2.74	0.62%	4,162	**83.27%**	80.04%
		Design	***4,999***		

- Decreased base load (-2.7%)
- Overall increase in LFU

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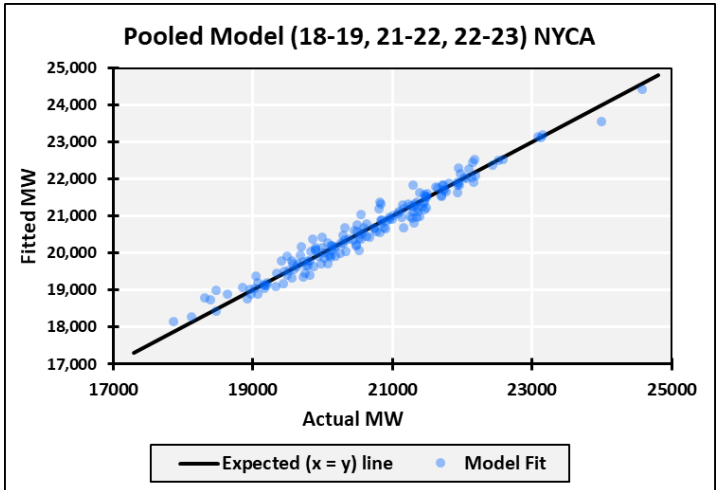
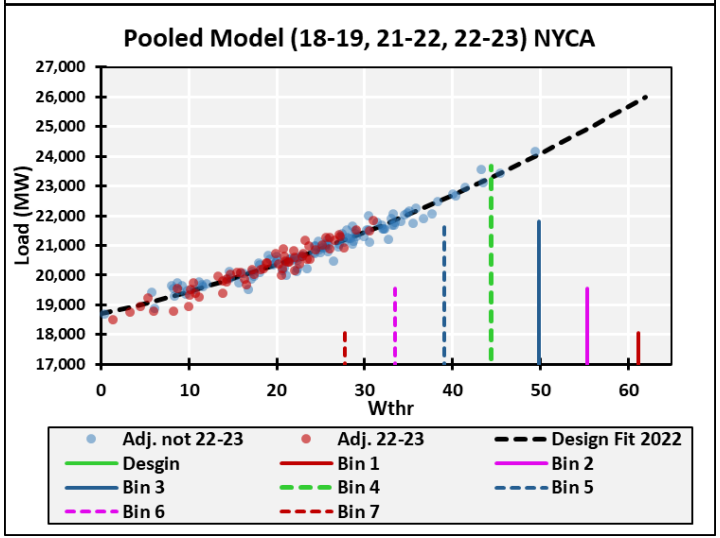
Winter LFU: NYCA

- Developed by NYISO
- Winter weather variable was developed by NYISO as part of LFU Phase 3[1]
- Data used:
- 2018-19, 2021-22, 2022-23, Dec – Feb, non-holiday weekdays

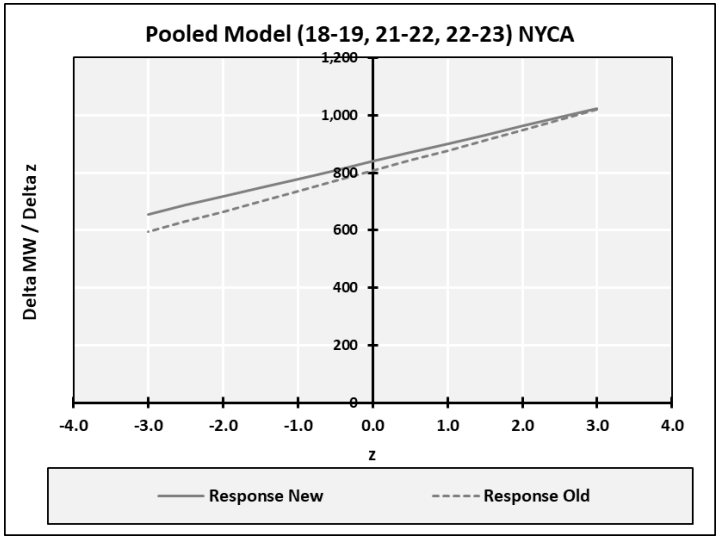
Mult-R: 98.1%	R-Sq: 96.2%		Adj. R-Sq: 96%	
Var	**Coeff.**	**Std Err**	**t-Stat**	**P-value**
Intercept	18695.80	83.77	223.17	0.0%
Wthr	67.07	6.95	9.64	0.0%
Wthr_sq	0.82	0.15	5.54	0.0%
CY_18_19	724.051	44.637	16.22	0.0%
CY_21_22	336.59	43.38	7.76	0.0%
Jan	-309.31	44.20	-7.00	0.0%
Feb	-645.50	43.55	-14.82	0.0%
Fri	-383.41	42.83	-8.95	0.0%





[1] LFTF presentation link
ICS presentation link

Winter LFU: NYCA



Winter - NYCA

Bin	Bin z	Bin Probability	MW	New LFU	Current LFU
Bin 1	2.74	0.62%	25,867	**110.37%**	110.29%
Bin 2	1.79	6.06%	24,930	**106.37%**	106.26%
Bin 3	0.89	24.17%	24,081	**102.75%**	102.65%
Bin 4	0.00	38.29%	23,299	**99.42%**	99.37%
Bin 5	-0.89	24.17%	22,565	**96.29%**	96.32%
Bin 6	-1.79	6.06%	21,865	**93.30%**	93.46%
Bin 7	-2.74	0.62%	21,189	**90.41%**	90.74%
		Design	***23,436***		

- Increased based load (+1.5%)
- Slight increase in load growth at colder temperatures
- Slight increase in LFU at upper bins

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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

New York ISO

LFU Definition – NYSRC Policy 5-14

Section 3.5.1 NYCA Load Model: Load Forecast Uncertainty Model

Load Forecast Uncertainty Model 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 e ach modeled hour, the MARS program determines the resource adequacy and calculates an average loss of load expectation for the capability year for each of the seven load levels. MARS uses this information to evaluate a probability weighted-average LOLE for each area. Recognizing the unique LFU nature of individual NYCA zones, the LFU model is subdivided into five separate areas: New York City (Zone J), Long Island (Zone K), Zones H and I, Zones F and G, and the rest of New York State (Zones A-E).

Preparation of the 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 forecasted 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. 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. The LFU model is built in three steps: The first step creates a relationship between a weather metric and the summer peak load for each zone using as many years of historical data as is available. The second step relates the same weather metric with the daily peak load historical data of selected years that are not older than 10 years. The third step combines the correlations found in the first and second steps to produce a relationship of expected yearly peak load in a per unit base and its probability of occurrence.

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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,

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

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:

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

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):

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

New York ISO

Winter Variable Computation

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

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

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

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

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

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

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

New York ISO