LFU Phase 3 Analysis: Variable LFU Scaling

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Agenda

- Background
- Monthly LFU Multipliers
- Hourly LFU Scaling (8760)
- Next Steps

Background

Background and Motivation: LFU Whitepaper Analyses

- Load Forecast Uncertainty (LFU) models quantify the impact of extreme weather variability on seasonal peak loads. The resulting LFU multipliers are a significant input into resource adequacy simulations in both the NYISO planning reliability studies, and in the IRM study approved by the New York State Reliability Council (NYSRC). LFU models and results are discussed with and reviewed by the Load Forecasting Task Force and the NYSRC Installed Capacity Subcommittee (ICS).

- The LFU Phase 1 Study and Whitepaper focused largely on the analysis of weather distributions and their impacts on the year-over-year variability of NYCA and regional peak loads
  - Particular attention paid to the distributions of peak load and temperature analysis
  - Comparison of Temperature-Humidity Indices
  - Long-term Cumulative Temperature & Humidity Index (CTHI) Distribution Analyses (extreme temperatures, goodness of fit of the Normal distribution)
  - Inter-Annual Weather Sensitivity and LFU Trends

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Background and Motivation: LFU Whitepaper Analyses

- **LFU Phase 2 focused primarily on load shape analysis, along with follow-up work stemming from select Phase 1 findings**
  - Recommendation of the 2013, 2017, and 2018 load shapes for use in future reliability studies, following a review of historical load shapes, duration curves, and weather conditions
  - Introduced procedures to account for the increasing impact of BTM solar on load shapes (i.e., calculation of historical gross load shapes, and load shapes adjusted to reflect a projected increase in BTM solar capacity)
  - Assessed the change in load duration curves and peak day shapes resulting from increasing penetration of BTM solar
  - Quantified potential impacts of increasing BTM solar penetration on LFU multipliers

- **LFU Phase 3 aims to address remaining areas of inquiry on LFU and load shape assumptions, with a focus on issues that will become more critical over time**
  - The NYISO is projected to trend toward a winter peaking system due to the increasing penetration of electric vehicles and electric heating
  - Impacts of climate change will enhance focus on extreme weather assumptions and scenarios
  - Increasing levels of BTM solar will continue to add to load variability and contribute to evolving shapes

Existing LFU Study Work

- **LFU Phase 1 Whitepaper**
  - March 2021 (Paper, Presentation)
- **LFU Phase 2: Scope Discussion**
  - May 2021 (link)
- **LFU Phase 2: Load Duration Curve Review - 2002 through 2020**
  - May 2021 (link)
- **LFU Phase 2: Load Duration Curve Review – BTM Solar Impacts**
  - July 2021 (link)
- **LFI Phase 2: Updated Load Shape Recommendation**
  - March 2022 (link)
- **LFU Phase 3: Impact of BTM Solar on LFU Multipliers**
  - February 2023 (link)
- **LFU Phase 3: Upper Bin Weather Duration, and Winter Weather Variable**
  - Presented and posted with today's meeting materials

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Background - Variable LFU Scaling Analysis

- **Historically, LFU multipliers have been defined solely by peak load variability due to weather**
- **However, seasonal LFU multipliers are applied to the entire load shape in MARS, which may not be the optimal approach from a theoretical perspective**
- **Based on analyses to date, there are three options for addressing the potential variable scaling of LFU multipliers**
- **Option 1: Monthly LFU multipliers**
    - Multipliers that differ by month rather than just Summer/Winter
- **Option 2: 8760 Hourly Scaling**
    - Scale all hours of the year by varying amounts to reflect relative variability of seasonal peaks and total energy
- **Option 3: Status quo – no variable scaling**
    - Move to updated load shapes may partially address the scaling concern by using the relatively steep 2013 shape (BTM solar adjusted) in Bins 1 and 2

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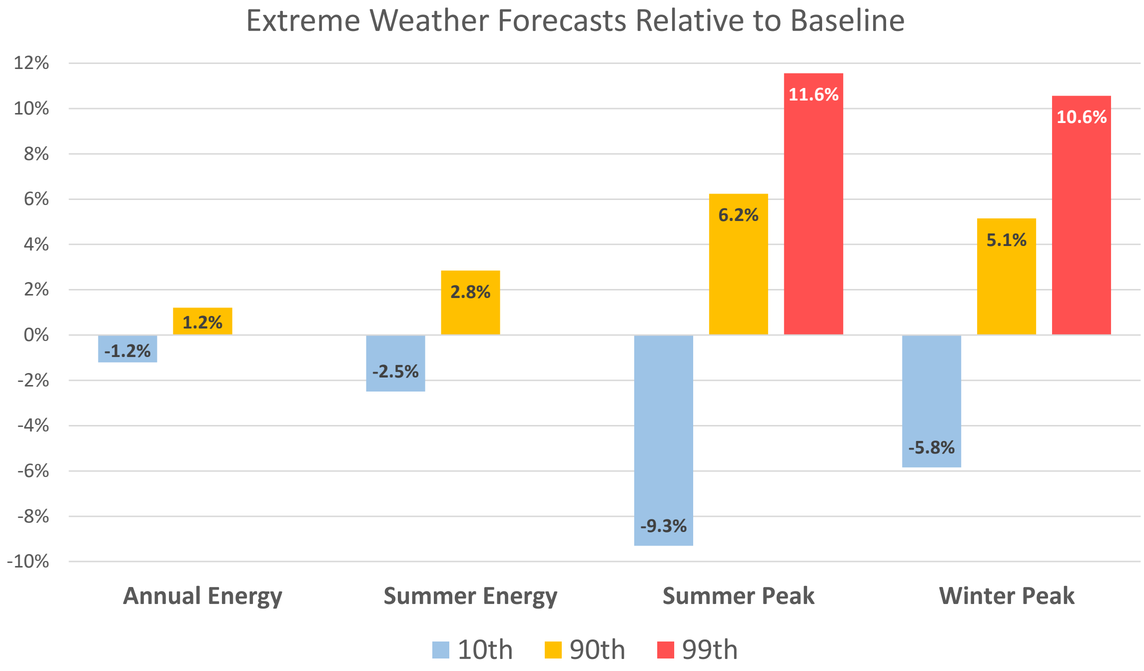
Energy vs. Seasonal Peak Variability



2022 Energy and Peak Forecasts				
Forecast	Baseline	10th	90th	99th
Annual Energy (GWh)	151,260	149,430	153,090	--
Summer Energy (GWh)	56,200	54,800	57,800	--
Summer Peak (MW)	31,765	28,810	33,747	35,436
Winter Peak (MW)	23,893	22,497	25,123	26,417

- This graph compares the uncertainty due to weather across annual energy, summer energy, summer peak, and winter peak forecasts.
- The seasonal peak ratios are defined using the LFU process. Annual energy ratios are based on the historical distribution of weather-related impacts on annual energy usage. These ratios are from the 2022 Gold Book.
- Deviations in summer energy were estimated using the historical distribution of weather-related impacts on energy usage in June through September.
- The load variability due to weather is much greater on seasonal peak demand than on energy usage. This implies that the variability on the peak hour is larger than that on an average hour.

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Monthly LFU Multipliers

Monthly LFU Development

- **Monthly LFU multipliers were developed by assessing the historical variability in monthly loads caused by weather deviations from normal**
  - Analysis of 2008 through 2022 actual monthly energy vs weather normalized monthly energy
- **July and January LFU multipliers remain as current, with off-peak month multipliers scaled down**
  - The 2013 shape used in LFU Bins 1 and 2 peaks in July, with a January winter peak
  - January and July are historically the most common seasonal peak months, and the projected peak months based on a typical year
  - January and July have the largest historical energy deviations due to weather for winter and summer months respectively
- **Analysis was performed at the NYCA level, but could be replicated by LFU area**

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Monthly LFU Scaling Factors - Calculation

Month	Average GWh	Average Absolute GWh Deviation due to Weather	Seasonal LFU Scaling Factor
Jan	13,925	241	100%
Feb	12,463	194	99%
Mar	12,794	182	82%
Apr	11,485	82	43%
May	12,164	233	49%
Jun	13,674	325	63%
Jul	16,252	635	100%
Aug	15,652	527	86%
Sep	13,209	285	57%
Oct	12,179	128	27%
Nov	12,104	136	67%
Dec	13,419	197	85%

- Values in table reflect 2008 through 2022 averages
- Scaling factors are calculated seasonally (May through October for summer, and November through April for winter)
- Scaling factors reflect monthly variability in energy due to weather, adjusted for load level and number of days

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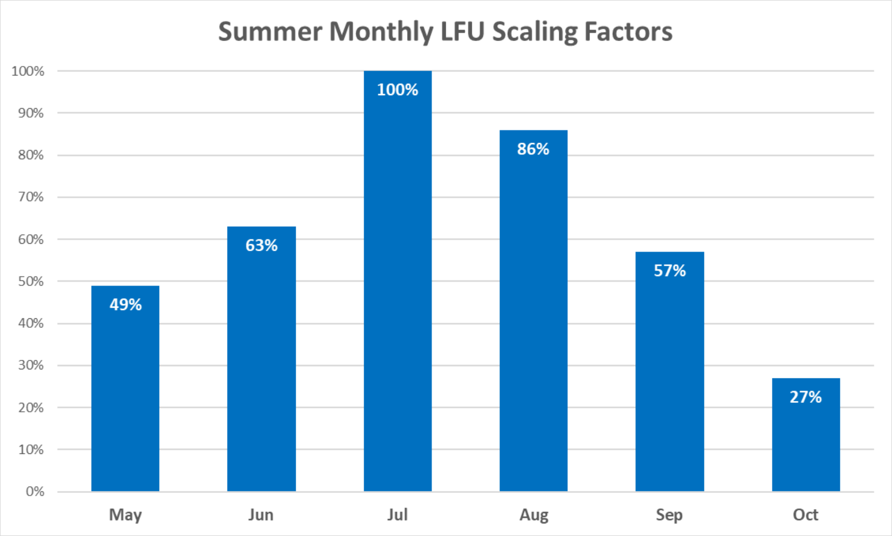
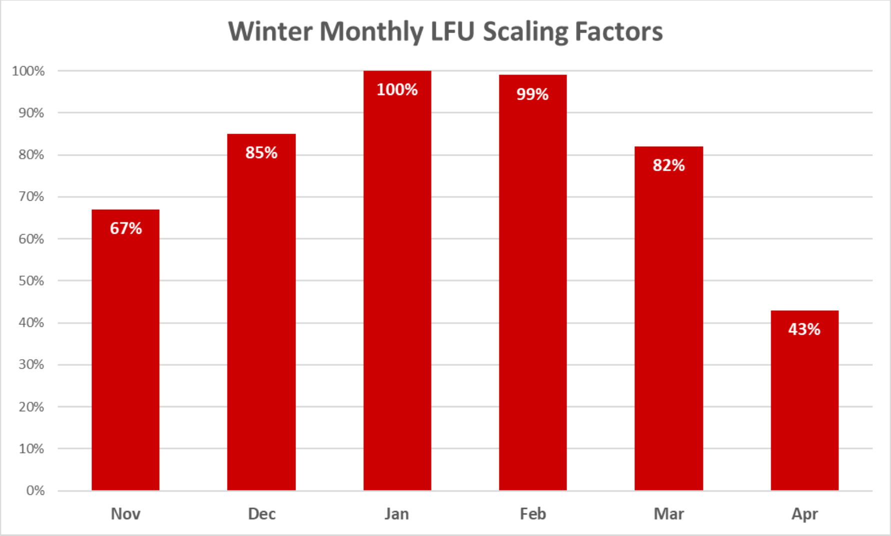
Monthly LFU Scaling Factors

- Monthly scaling factors represent the portion of the LFU multiplier load increase to be applied in a given month.
- For example, if the calculated summer Bin 1 LFU multiplier was 110.0%, the July multiplier would be 110.0%, and the September multiplier would be 105.7%.





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Monthly LFU Multipliers Input Table - Example

A to E Monthly LFU Multipliers							
Month	**Bin 1**	**Bin 2**	**Bin 3**	**Bin 4**	**Bin 5**	**Bin 6**	**Bin 7**
Jan	1.1029	1.0626	1.0265	0.9937	0.9632	0.9346	0.9074
Feb	1.1018	1.0620	1.0263	0.9937	0.9636	0.9352	0.9084
Mar	1.0843	1.0513	1.0218	0.9948	0.9698	0.9464	0.9241
Apr	1.0442	1.0269	1.0114	0.9973	0.9842	0.9719	0.9602
May	1.0646	1.0453	1.0235	1.0000	0.9753	0.9498	0.9240
Jun	1.0831	1.0583	1.0302	1.0000	0.9683	0.9355	0.9023
Jul	1.1318	1.0925	1.0480	1.0000	0.9496	0.8975	0.8449
Aug	1.1134	1.0795	1.0412	1.0000	0.9567	0.9119	0.8666
Sep	1.0751	1.0527	1.0273	1.0000	0.9713	0.9416	0.9116
Oct	1.0356	1.0250	1.0129	1.0000	0.9864	0.9723	0.9581
Nov	1.0689	1.0419	1.0178	0.9958	0.9754	0.9562	0.9380
Dec	1.0874	1.0532	1.0226	0.9946	0.9687	0.9444	0.9213

January and July LFU values are assigned the full LFU multipliers calculated relative to the peak day.
LFU multipliers in the other months have been adjusted using the scaling factors, tightening the Bin 1 to Bin 7 distribution.

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Hourly LFU Scaling

8760 Hourly Duration Curve Scaling

- Scale all 8760 hours of the year by varying amounts
- Summer peak hour would be scaled by current bin LFU multiplier
- Total energy across a season and across the year varies less due to weather than the peak hour
- Average across all hours scaled by analogous bin multiplier for seasonal energy (lower than peak multiplier)
- Input load shapes for each bin are scaled with a load factor adjustment, such that the desired relationship between energy and peak variation is maintained after application of LFU multipliers
- Relative scaling of each hour based solely on load level

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Discussion on 8760 Hourly Scaling

- **Provides a theoretical improvement on the current LFU single peak multiplier approach**
- **However, NYISO has concerns with implementing variable LFU scaling using the method investigated to this point:**
  - There are numerous methods for scaling to reach the same desired relationship between energy and peak variability
  - The scaling method is agnostic to load shape chronology (hour of day, season, heatwave, peak day or week, etc.)
  - Hourly load shape adjustments may provide false precision, especially in the case of Bins 1 and 2, which are already extrapolations to extreme weather conditions beyond those observed in recent history
  - The Bin 2 load shape was changed from 2002 (very flat shape) to 2013 (steep shape reflective of a hot summer peak). Further shape adjustments could lead to "double counting" of these impacts
  - The top number of load hours are most critical in the MARS resource adequacy analyses. Thus, preserving the seasonal peak uncertainty may be more important than scaling to reflect overall load variability

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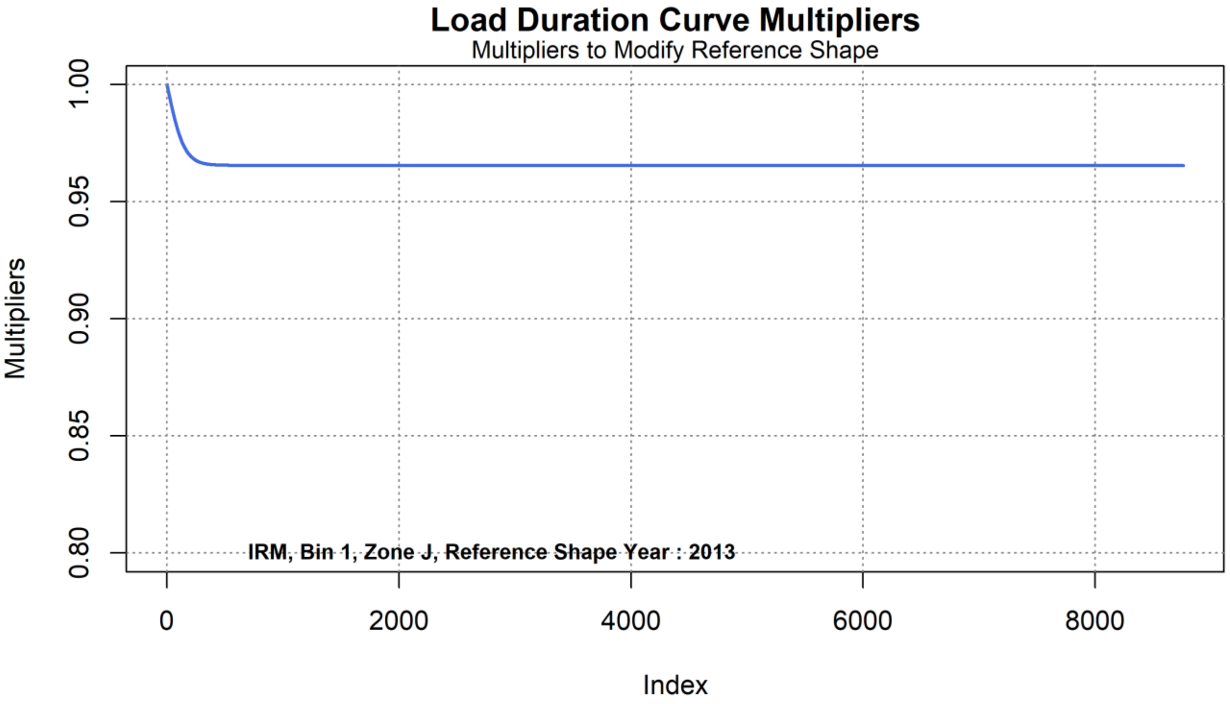
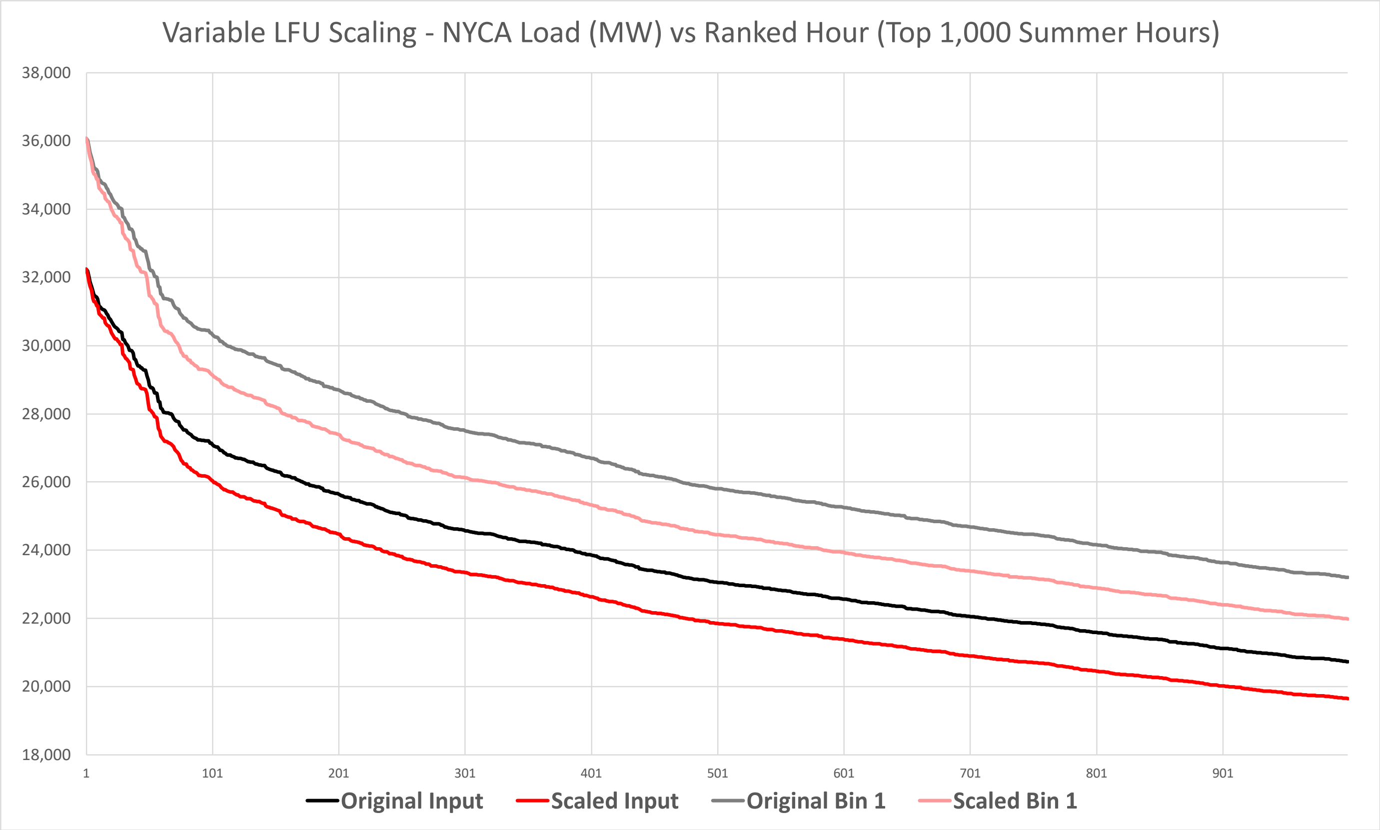
Load Shape Adjustment



- This graph illustrates the adjustment made to the Zone J Bin 1 IRM load shape (adjustments are made similarly across all areas)
- There is no adjustment to the peak hour, with increasing adjustments made to the off-peak hours
- Following the first few hundred hours, each hour is derated by about 3 to 4 %
- Several different scaling methods would achieve the desired energy variability

Preliminary Duration Curve Scaling



- Top 1,000 summer hours duration curve based on 2013 solar adjusted net load shape with 2023 forecast targets
- Peak hour scaling set by Bin 1 LFU multiplier
- Average hour scaling set by historical deviations in summer energy due to weather
- Scaling the input shape results in the scaled Bin 1 shape after application of LFU, preserving the typical variation in seasonal energy relative to peak
- IRM forecasts include no demand response reductions, and include BTM:NG load added back
- Bin 1 peak load reflects a 1 in 160-year summer weather event

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Bin 1 MW Duration Values

Estimated Bin 1 MW Values

Rank Hour	Original	Scaled	Difference	Percent
Peak	36,086	36,086	0	0.0%
Hour 2	36,028	35,907	-121	-0.3%
Hour 3	35,822	35,650	-172	-0.5%
Hour 5	35,522	35,391	-131	-0.4%
Hour 10	35,106	34,881	-225	-0.6%
Hour 20	34,440	34,095	-345	-1.0%
Hour 30	33,785	33,296	-489	-1.4%
Hour 40	33,106	32,487	-619	-1.9%
Hour 50	32,434	31,645	-790	-2.4%
Hour 100	30,367	29,159	-1,208	-4.0%
Hour 200	28,717	27,405	-1,311	-4.6%
Hour 300	27,530	26,137	-1,393	-5.1%
Hour 400	26,713	25,337	-1,377	-5.2%
Hour 500	25,806	24,461	-1,346	-5.2%
Hour 1,000	23,199	21,987	-1,212	-5.2%
Average	20,431	19,388	-1,043	-5.1%
Minimum	13,373	12,666	-707	-5.3%

Estimated Bin 1 Count of Hours

Threshold	Original	Scaled	Difference	Percent
36 GW	2	1	-1	-50%
35 GW	10	8	-2	-20%
34 GW	29	20	-9	-31%
33 GW	40	35	-5	-13%
32 GW	57	48	-9	-16%
31 GW	74	57	-17	-23%
30 GW	112	74	-38	-34%

- May through October hours, using the 2013 solar-adjusted input load shape, calibrated to forecast targets, with Bin 1 LFU multipliers applied
- Load values listed and used in IRM MARS modeling are prior to potential demand response reductions

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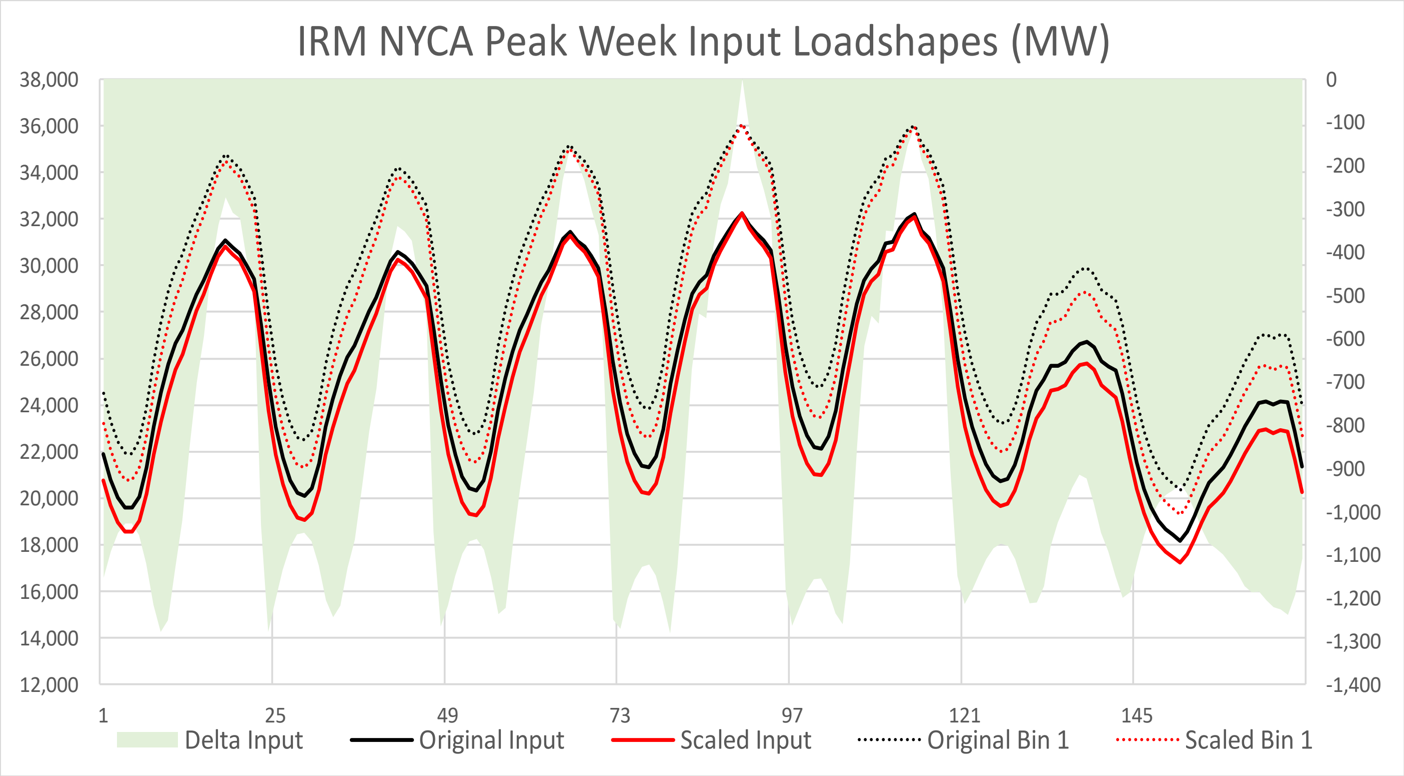
Load Shape Scaling Comparison



IRM Loadshape Deltas (MW)				
NYCA Peak Day				
Hour	Original	Scaled	Delta	Percent
0	24,112	22,842	-1,271	-5.3%
1	22,751	21,550	-1,201	-5.3%
2	21,909	20,753	-1,156	-5.3%
3	21,403	20,275	-1,128	-5.3%
4	21,309	20,187	-1,123	-5.3%
5	21,776	20,628	-1,148	-5.3%
6	22,962	21,752	-1,210	-5.3%
7	24,921	23,639	-1,282	-5.1%
8	26,393	25,263	-1,130	-4.3%
9	27,668	26,750	-917	-3.3%
10	28,773	28,103	-670	-2.3%
11	29,277	28,736	-542	-1.8%
12	29,583	29,030	-553	-1.9%
13	30,414	30,027	-387	-1.3%
14	30,911	30,621	-289	-0.9%
15	31,418	31,176	-242	-0.8%
16	31,869	31,740	-129	-0.4%
17	32,246	32,246	0	0.0%
18	31,742	31,625	-117	-0.4%
19	31,370	31,169	-201	-0.6%
20	31,062	30,804	-258	-0.8%
21	30,640	30,316	-324	-1.1%
22	28,768	28,020	-749	-2.6%
23	26,587	25,405	-1,182	-4.4%
MWh	659,865	642,655	-17,209	-2.6%

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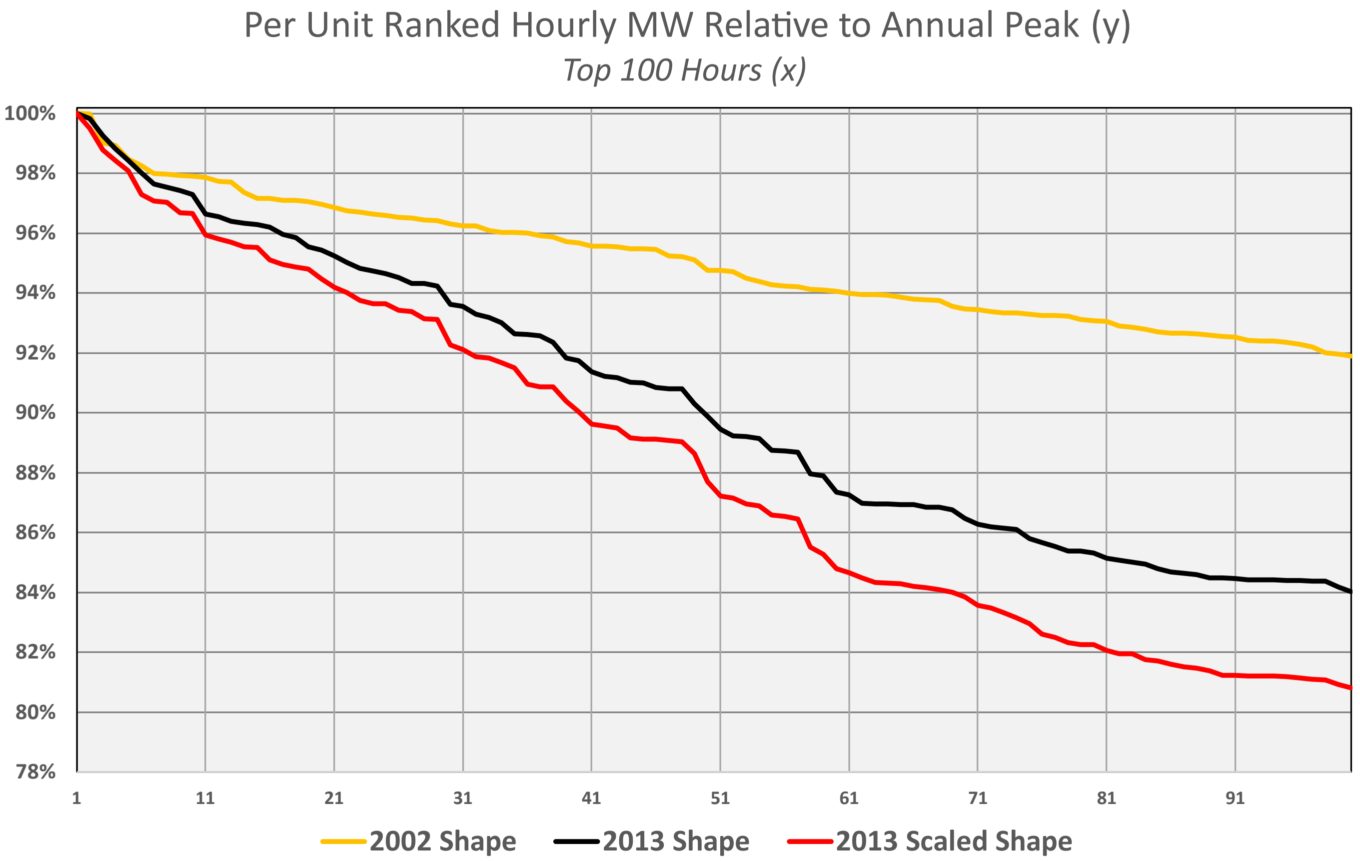
Load Duration Curve Comparison



- The 2002 as found shape was historically used in Bin 2
- Following LFU Phase 2, 2013 was implemented as the Bin 1 shape, reflecting the steeper shape typically observed with a hot summer peak day.
- The 2013 input shape is adjusted to reflect the projected IRM study year solar capacity and resulting shape impacts
- The preliminary 2013 variable LFU scaled shape is shown in red. The switch from using the 2002 shape (yellow) to the 2013 shape (black) is more significant than the prospective change from variable scaling
- Making additional adjustments to the 2013 shape may result in overstating the appropriate load duration curve reductions

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Next Steps

- Additional analyses on potential variable LFU scaling methodologies to be performed as needed

- Continued review and discussion with LFTF and ICS, prior to implementation of any alternative LFU scaling measure

Questions?

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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