New York ISO
Independent System Operator

LFU Phase 2 Study - Updated Load Shape Recommendation

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Agenda

- Introductory Slides
- NYCA Load Duration Curve Analysis
- Behind-the-Meter Solar Adjustment
- Additional Analysis
- Summary and Load Shape Recommendation

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Existing LFU Phase 2 Study Work

- **LFU Phase 1 Whitepaper**
  - March 2021 (Paper, Presentation)
- **LFU Phase 2 Scope Discussion**
  - May 2021 (link)
- **Load Duration Curve Review - 2002 through 2020**
  - May 2021 (link)
- **Load Duration Curve Review – BTM Solar Impacts**
  - July 2021 (link)
- **Impact of BTM Solar on LFU Multipliers**
  - July 2021 (link)

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Load Duration Curve (LDC)

- A load duration curve shows per-unit load values by ranked day or hour, sorting summer loads from any given historical year from highest to lowest.

- Per-unit load values are daily or hourly MW values expressed as a percentage of the summer peak MW value.

- The purpose of a load duration curve analysis is to assess how near-peak load days and hours compare to the summer peak load hour for any historical year.

- Higher relative near-peak load days and hours generally result in more stressed system load conditions, while lower relative near-peak load days and hours generally result in less stressed system load conditions.

- The load duration curve analysis conducted for discussion today analyzes load duration curves as found, and investigates the impacts of increasing penetration of behind-the-meter (BTM) solar resources between 2012 and 2022 in order to identify potential differences in the load duration curves caused by these changes.

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Load Duration Review Summary

- **Analysis primarily performed at the system level, with some analysis in constrained zones**
- **All load values add back estimated NYISO program demand response impacts**
- **Standard Load Duration Curve (LDC) Review (no BTM Solar adjustment)**
  - 2002, 2006 and 2007 LDCs are reviewed due to their use in prior NYISO reliability studies
  - 2013, 2017 and 2018 LDCs are reviewed as candidates for use in future studies
- **Load Duration Curve (LDC) Analysis for the 2012 through 2020 summers was repeated to capture the impacts of behind-the-meter (BTM) Solar**
  - BTM solar impacts for each historical year were scaled up to reflect the 2022 projected BTM solar capacity – creating adjusted load shapes
  - Review of 2013, 2017 and 2018 LDCs
  - 2002, 2006 and 2007 LDCs are not reviewed, as the NYISO has estimated actual BTM Solar impacts only back to 2012.

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Selection of Candidate Load Shapes

- **2013, 2017, and 2018 have been selected as candidate load shapes for use in NYISO reliability studies, primarily based on the LDC analysis and calendar properties**
- **Load Duration Curve Analysis**
  - Select a subset including historical years representative of the distribution of summer types (e.g., hot, mild peak weather conditions)
  - Includes a hot summer with a relatively steep load duration curve and low load factor representative of upper percentile LFU bins - 2013
  - Includes normal and cool summers with flat load duration curves and high load factors representative of mid-to-lower percentile LFU bins – 2017 and 2018
  - The three selected load shapes do not drop off significantly in the top five days or top 25 hours relative to the long-term average, ensuring appropriately stressed system conditions
- **Calendar Properties**
  - Select a subset of load shapes with optimal calendar properties
  - July or August weekday peak
  - Late afternoon system peak hour after adjusting for 2022 BTM PV level
  - Favor recent load shapes due to the evolving nature of system loads

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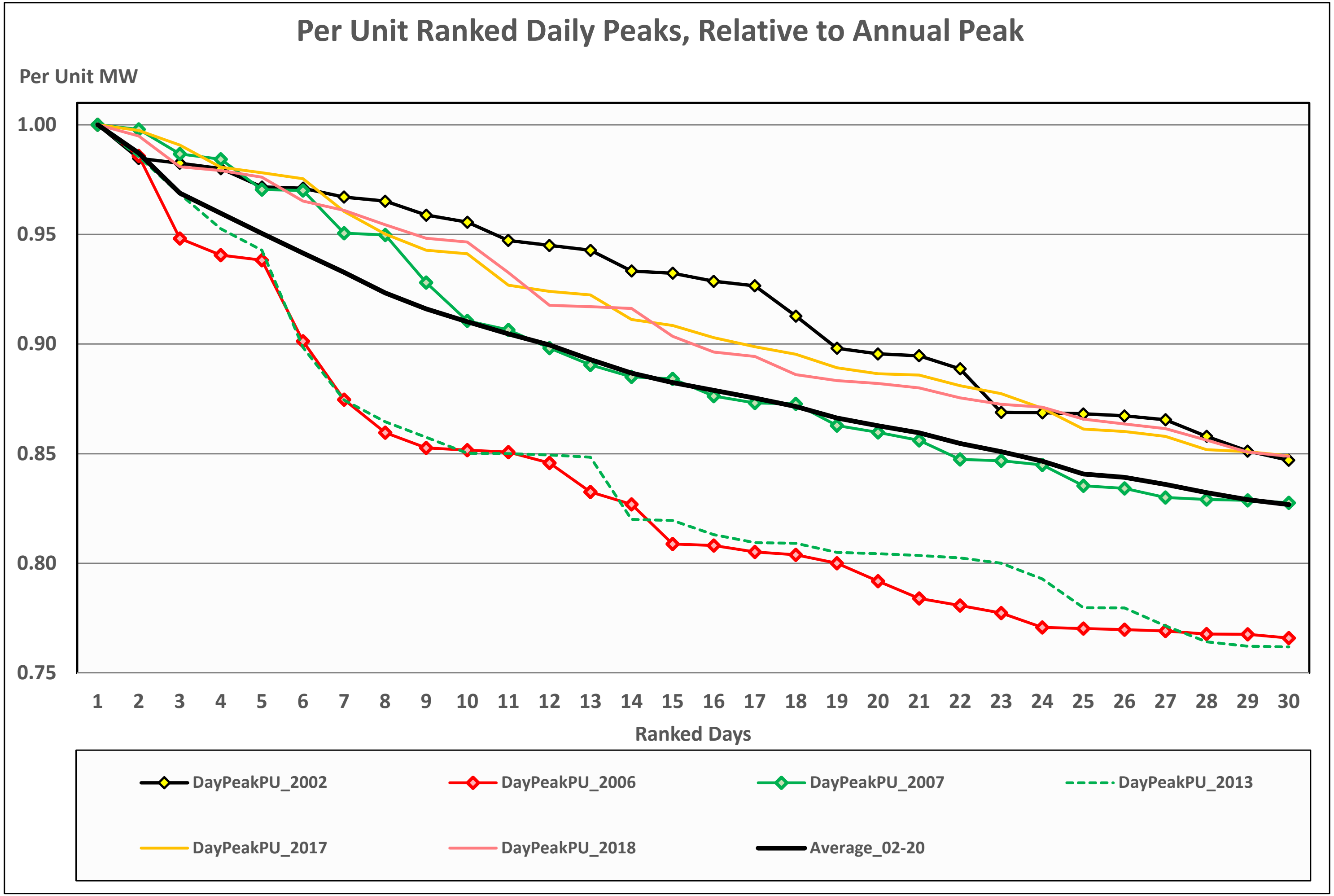
NYCA Load Duration Curve Analysis



- Per-unit loads (relative to annual peak) of top 30 days
- Average 2002-2020 LDC is included
- 2002 has a very flat slope; and 2017 and 2018 have fairly flat slopes
- 2007 has a fairly flat slope at the upper days, followed by a typical slope
- 2006 and 2013 have relatively steep slopes

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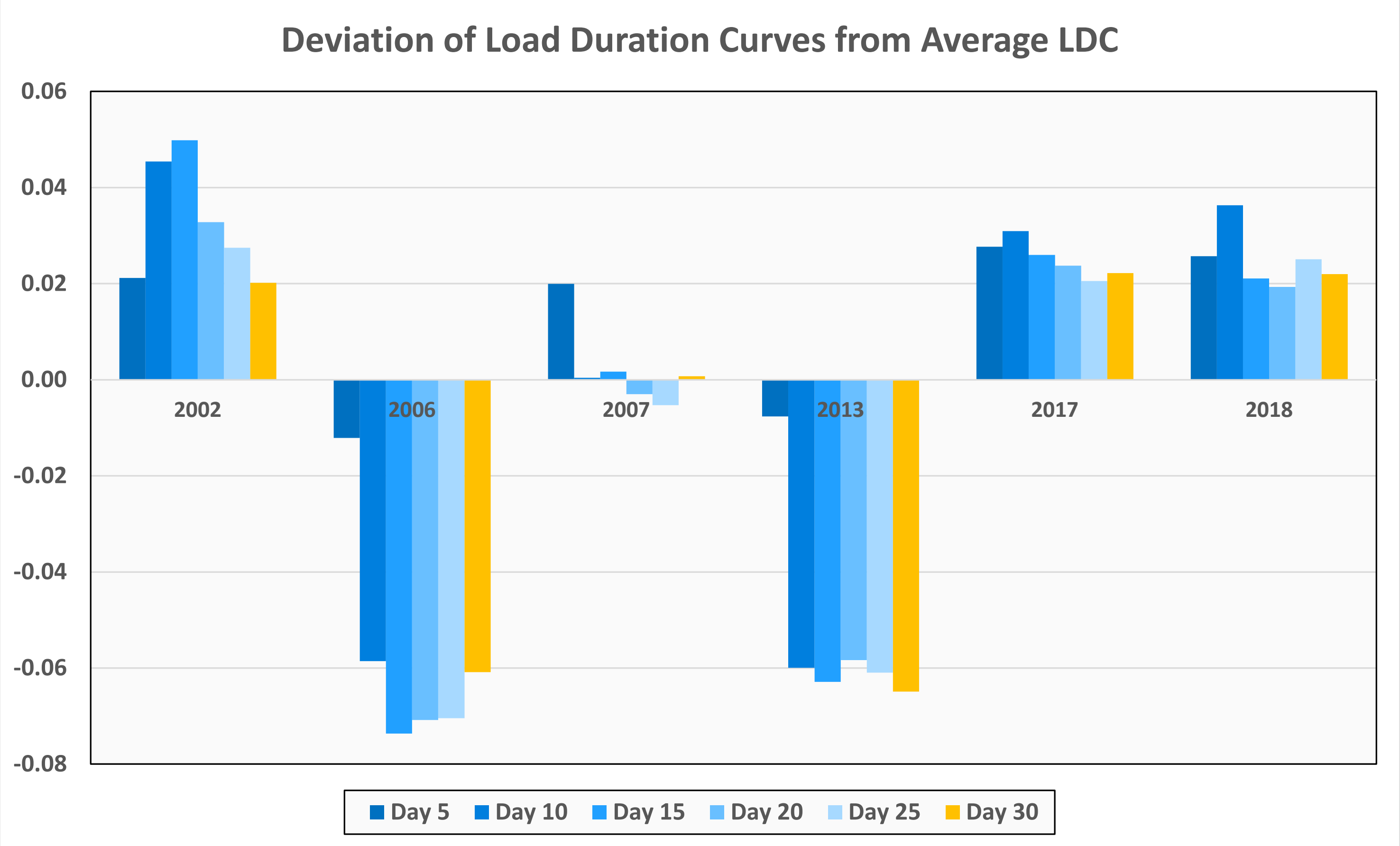

- 2006 and 2013 are significantly below average (steeper LDCs). However, both are near-average for the first 5 days
- 2002, 2017, and 2018 are generally above average (flatter LDCs)
- 2007 is fairly close to average

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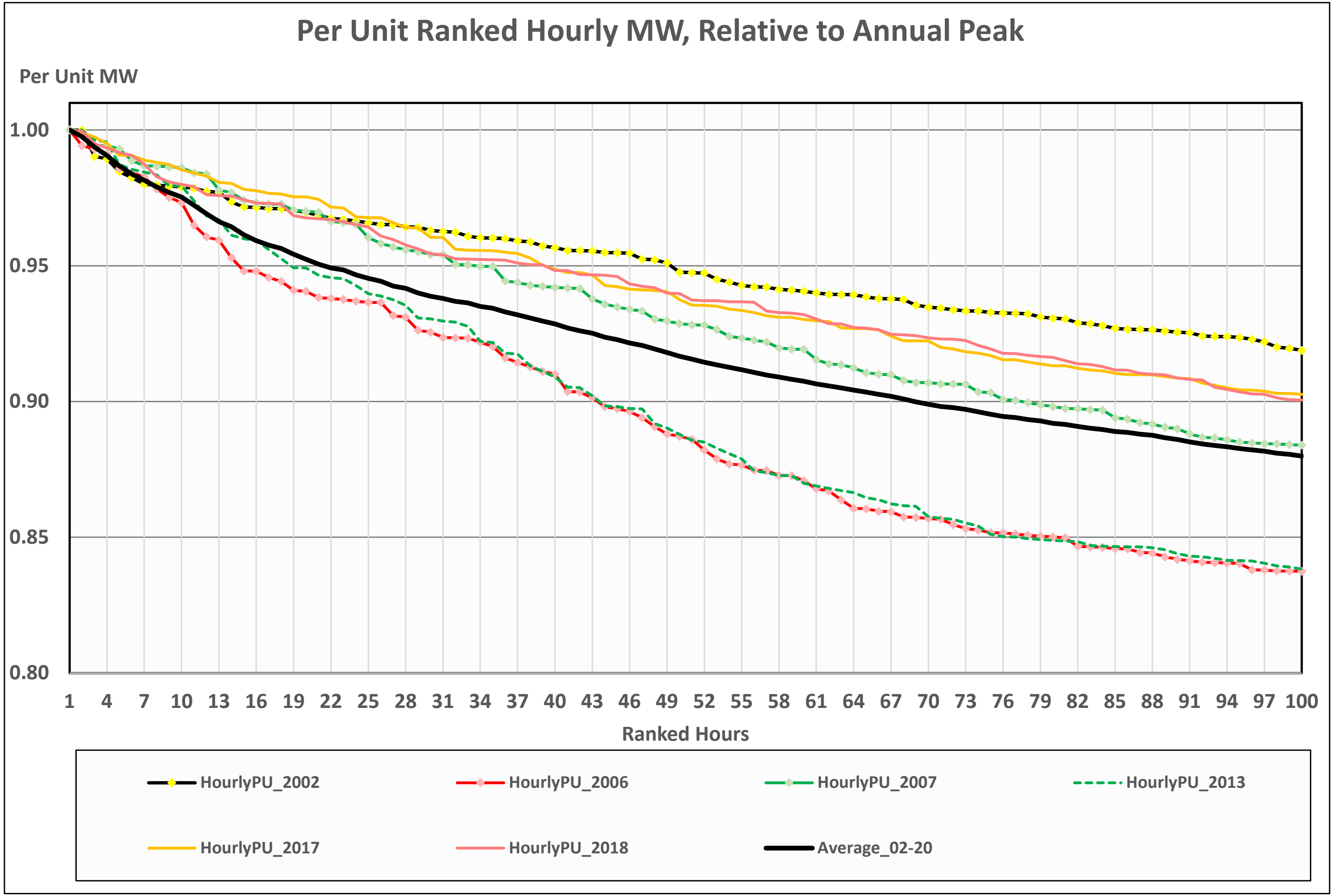

- This graph shows the hourly LDCs. The top 100 summer hours are shown
- These LDCs are comparatively similar to the daily LDCs across years
- 2002 has a very flat slope; 2017 and 2018 have fairly flat slopes
- 2007 has a fairly typical slope
- 2006 and 2013 have relatively steep slopes

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Annual Load Duration Curve and Peak Weather Metrics with Rankings						
Year	10-day Load Factor	Peak Day CTHI	Peak MW (incl DR)	Rank Load Factor	Rank CTHI	Rank MW
2002	0.974	83.03	31,142	2	11	11
2004	0.963	81.40	28,433	8	16	18
2005	0.974	82.92	32,071	1	13	10
2006	0.915	87.60	34,686	17	2	3
2007	0.965	82.00	32,169	7	15	9
2008	0.926	84.61	32,432	15	6	6
2009	0.946	82.27	30,844	13	14	14
2010	0.932	86.70	33,839	14	3	4
2011	0.895	87.74	35,262	18	1	1
2012	0.947	83.26	33,186	12	10	5
2013	0.919	86.56	34,729	16	4	2
2014	0.961	80.54	29,782	9	17	16
2015	0.966	82.95	31,138	6	12	12
2016	0.949	83.41	32,282	10	9	7
2017	0.972	80.38	29,699	3	18	17
2018	0.971	84.59	32,280	4	7	8
2019	0.966	84.96	30,480	5	5	15
2020	0.947	83.56	31,037	11	8	13

- Comparison of the load duration curve to the peak weather and load for that year
- Hot summers (CTHI above the 70th percentile) are shaded in red; cool summers (CTHI below the 30th percentile) are shaded in blue
- The three steepest load duration curves are from the four hottest summers and the three highest peak load days
- A steep load duration curve is most characteristic of load behavior during summers with extreme peak day heat

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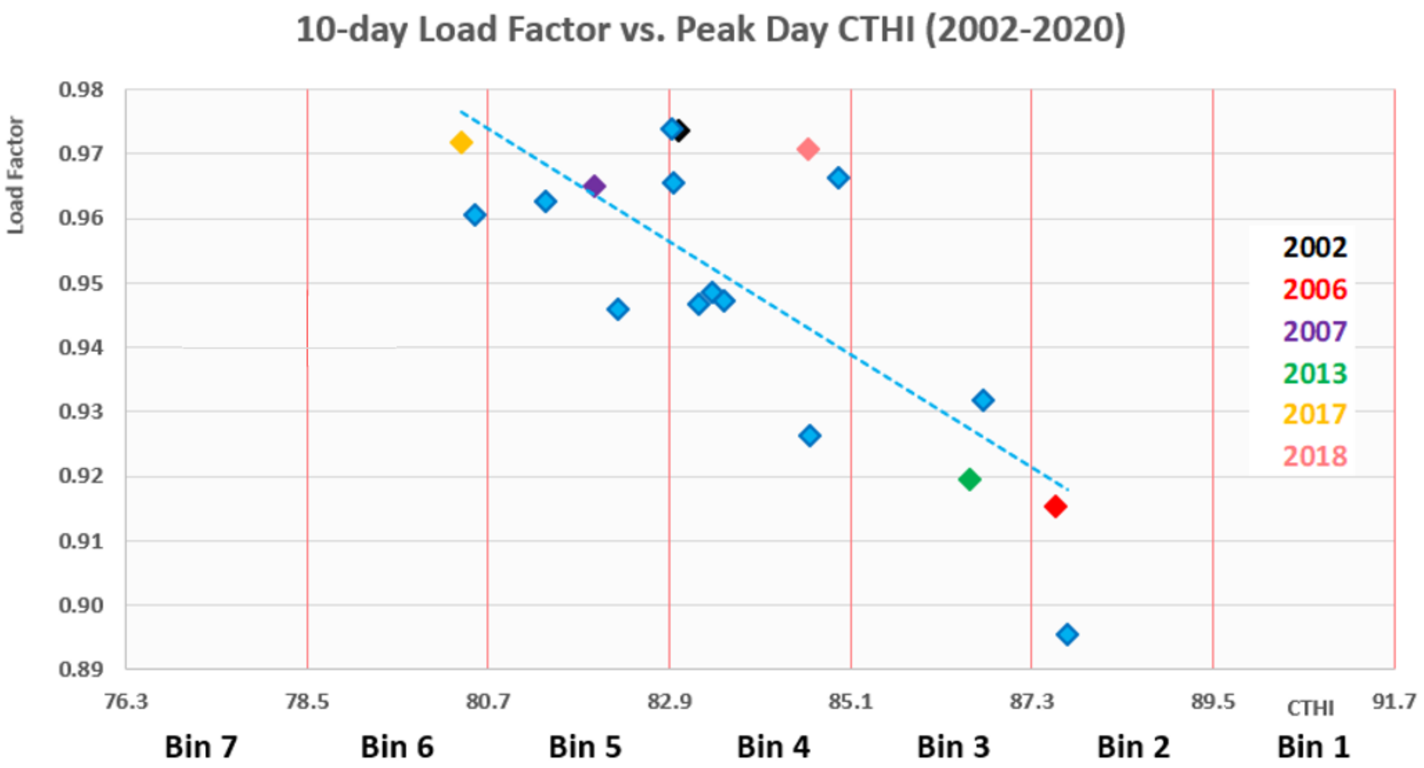
Load Duration Curve Load Factors vs. Peak Day Weather



- X-axis shows peak day weather conditions, cool to hot. Approximate LFU bin bounds are overlayed.
- Y-axis shows average load factor for top 10 load days that summer. Flatter (more conservative) load shapes are higher, steeper duration curves are lower.
- Upper-bin peak day weather corresponds to steep duration curves, and lower near-peak loads as a percentage of the absolute peak.

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BTM Solar Adjustment

BTM Solar Adjustment

- The NYISO has developed a time series of estimated actual behind-the-meter (BTM) solar generation for the 2012 through 2020 period
- Pre-2017 estimated actuals are modeled values based on historical Global Horizontal Irradiance (GHI) and solar capacity level data
- 2017 through current year estimated actuals are based on sampled inverter data
- Adjusted historical loads were determined by scaling historical estimated actual BTM Solar data to reach the projected 2022 solar capacity level:

$$Load_{Adjusted} = Load_{Net} + BTM\_Solar_{Y,\ D,H} - BTM\_Solar_{Y,\ D,H} * (BTM\_Capacity_{2022} / BTM\_Capacity_{Y})$$

Where: Y=Year, D=Date, H=Hour; and BTM_Solar is a positive value reflecting estimated actual generation

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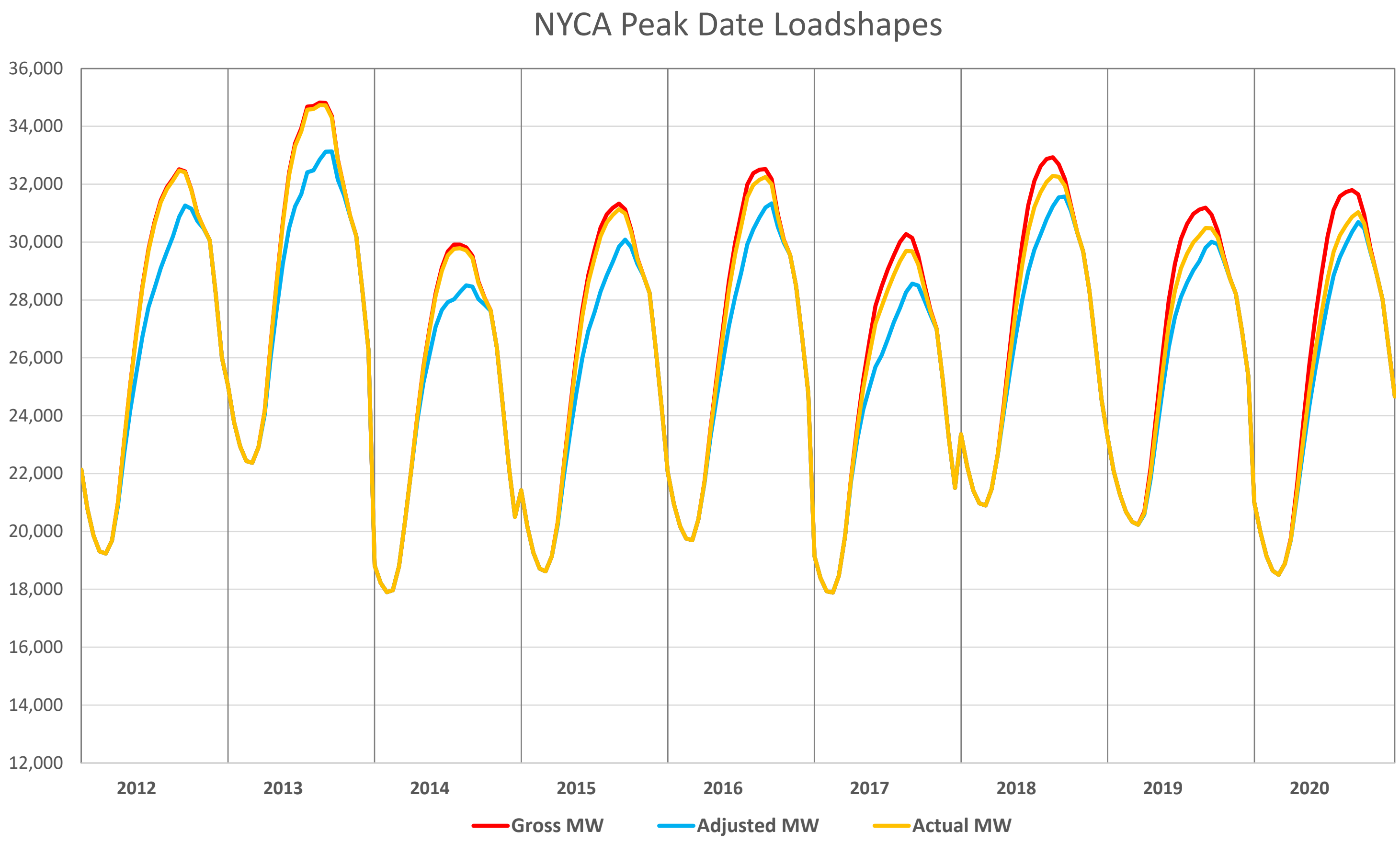
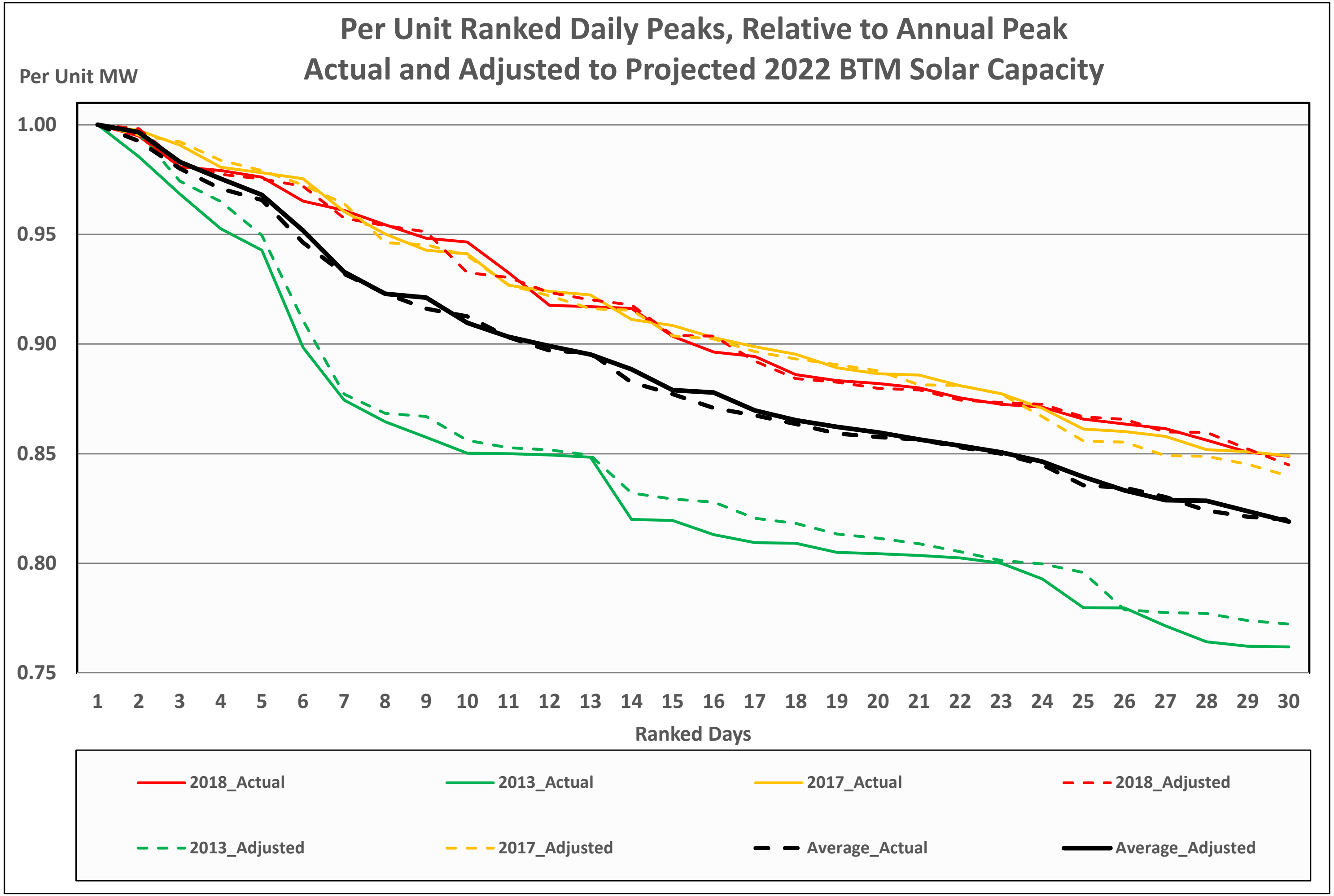
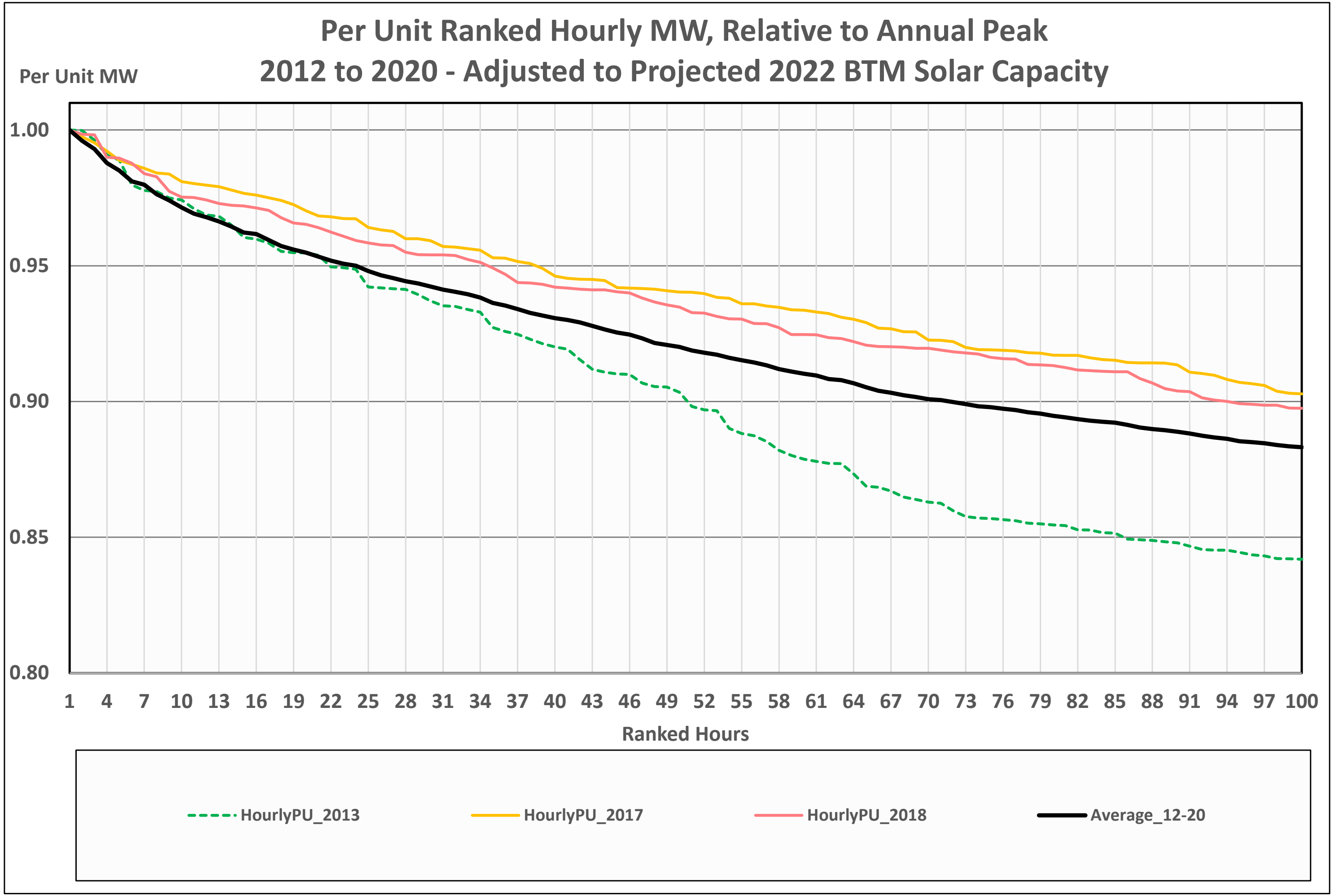


Year	Peak Date
2012	7/17/2012
2013	7/19/2013
2014	9/2/2014
2015	7/29/2015
2016	8/11/2016
2017	7/19/2017
2018	8/29/2018
2019	7/20/2019
2020	7/27/2020

- Actual MW represents metered load.
- Gross MW represents load with all BTM solar impacts added back.
- Adjusted MW represents what the load would have been assuming the projected 2022 BTM solar penetration.
- All load values include estimated NYISO program demand response impacts added back.



- 2017 and 2018 adjusted LDCs are similar to the actual LDCs, with no persistent deviation
- 2013 adjusted LDC is similar to the actual LDC, however the adjusted is slightly above the actual, yielding a flatter shape
- The average adjusted LDC across this timeframe is very similar to the average actual LDC
- In general, the adjusted LDCs are very similar to the actual LDCs



- Hourly LDCs adjusted to hit projected 2022 BTM solar capacity level
- 2017 and 2018 are flatter than the average
- 2013 values begin to fall below the average starting in ranked hour 25

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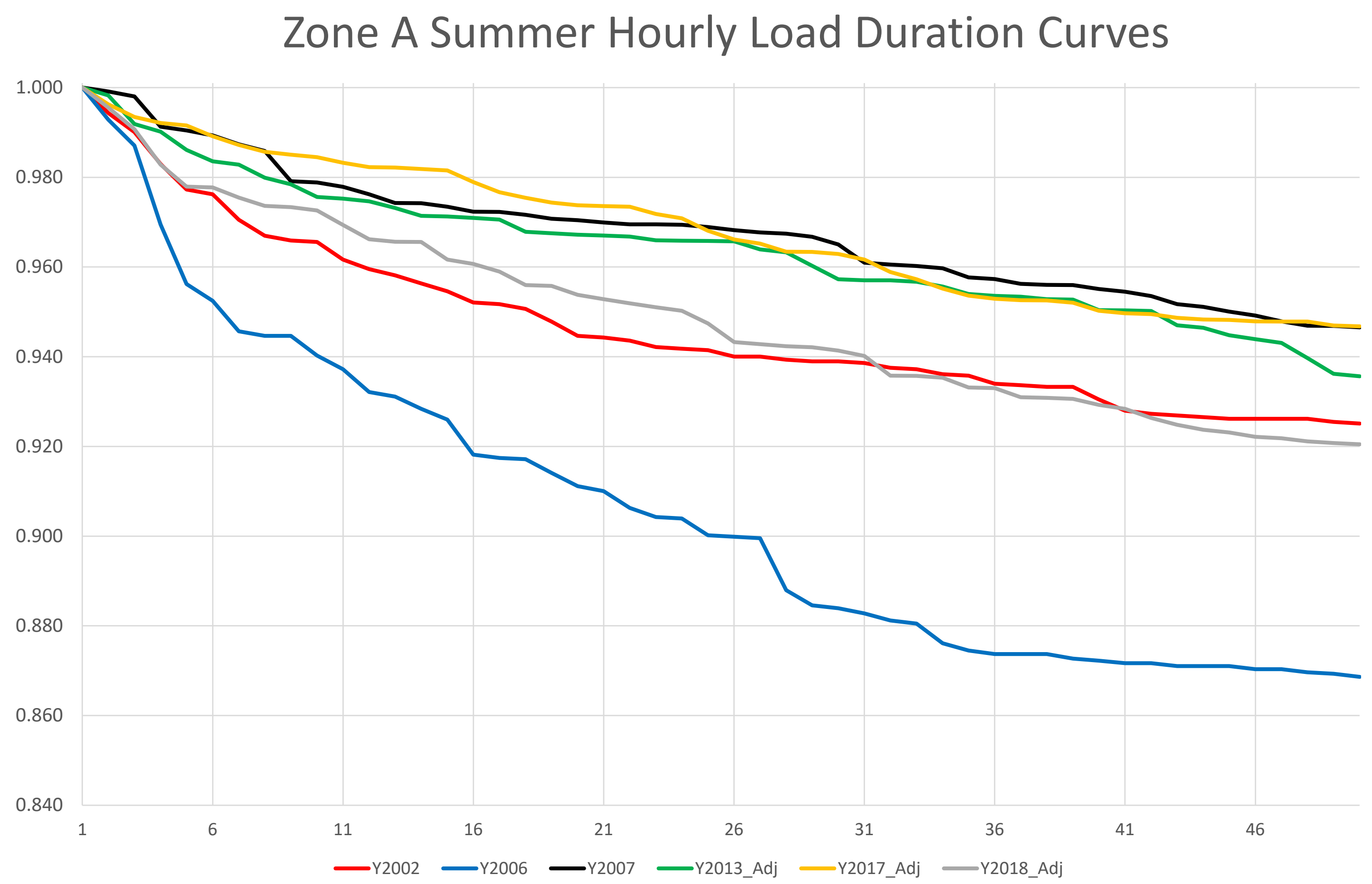
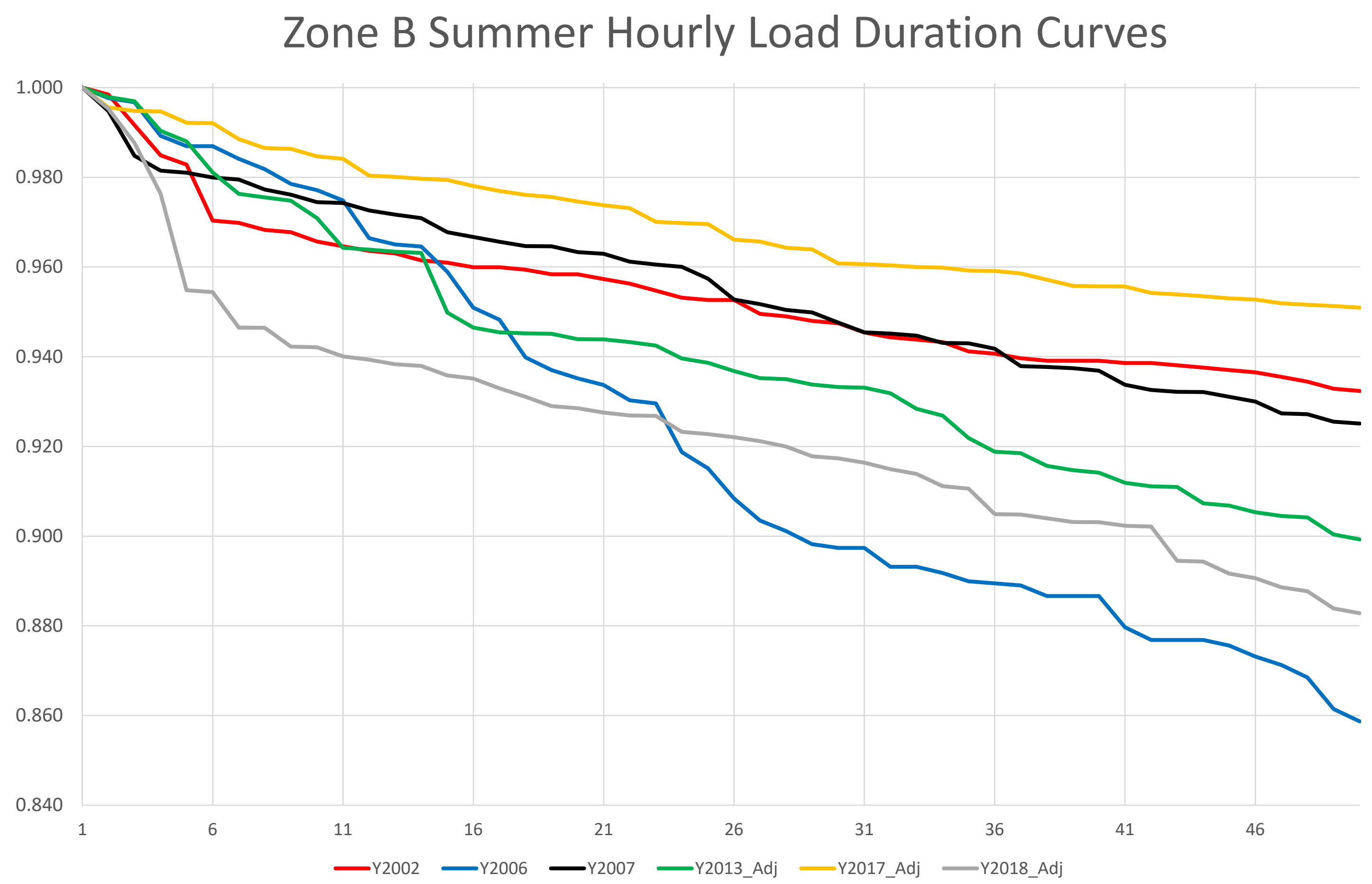
Additional Analysis



- Zone A hourly LDCs for 2002, 2006, and 2007 (as found); and 2013, 2017, and 2018 (adjusted to hit projected 2022 BTM solar capacity level)
- Unlike the NYCA LDC, the Zone A 2013 curve is fairly shallow (more conservative)
- 2017 is also shallow, while 2018 is fairly typical



- Zone B hourly LDCs for 2002, 2006, and 2007 (as found); and 2013, 2017, and 2018 (adjusted to hit projected 2022 BTM solar capacity level)
- The 2013 Zone B LDC is slightly shallower (more conservative) than the NYCA LDC on a relative basis
- In Zone B, the 2017 LDC is fairly shallow, while 2018 is steep

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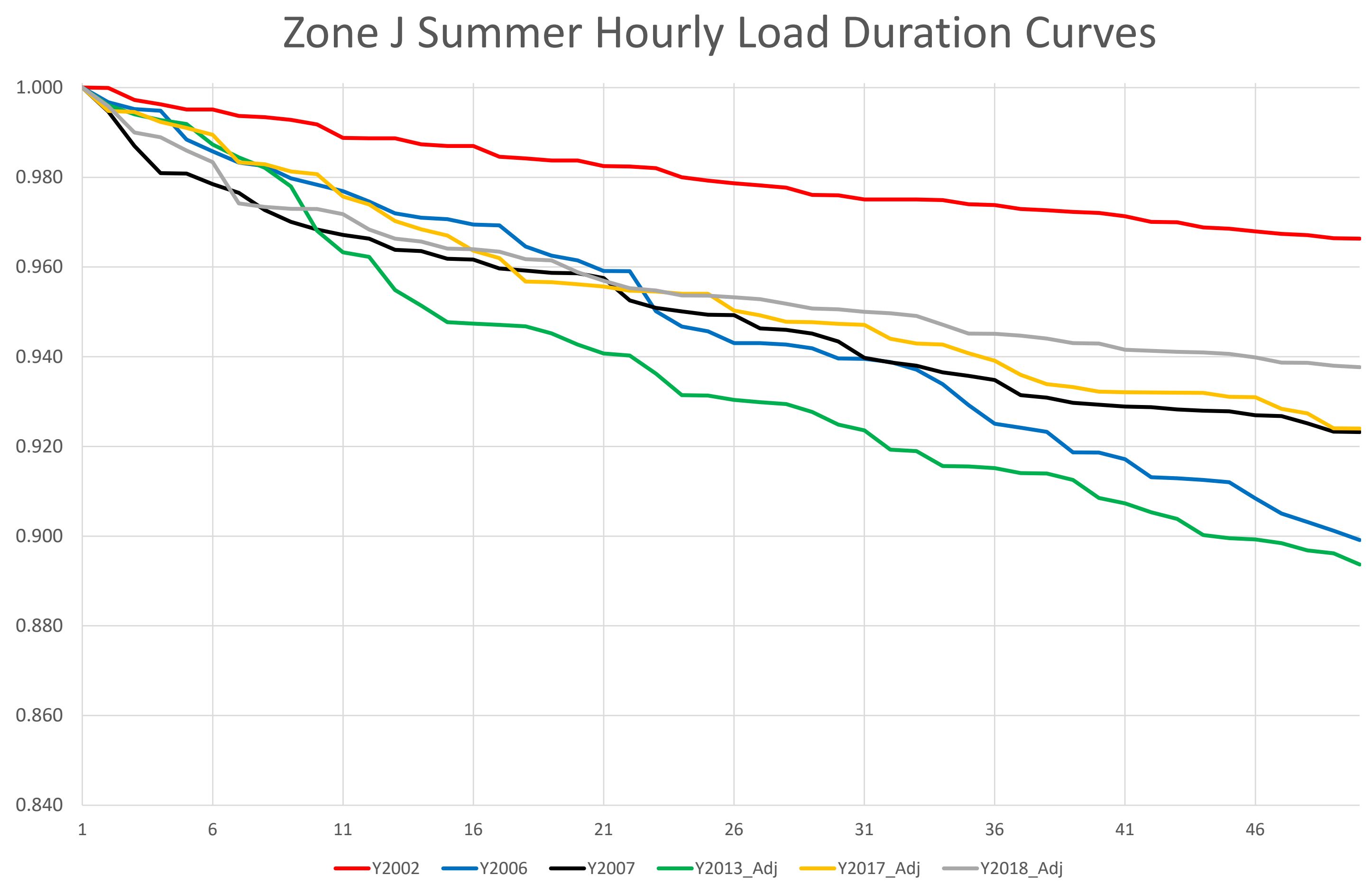

- Zone J hourly LDCs for 2002, 2006, and 2007 (as found); and 2013, 2017, and 2018 (adjusted to hit projected 2022 BTM solar capacity level)
- Similar to the NYCA, the Zone J 2002 LDC is very conservative, while the 2013 curve is steep
- The Zone J 2017 and 2018 LDCs are fairly average

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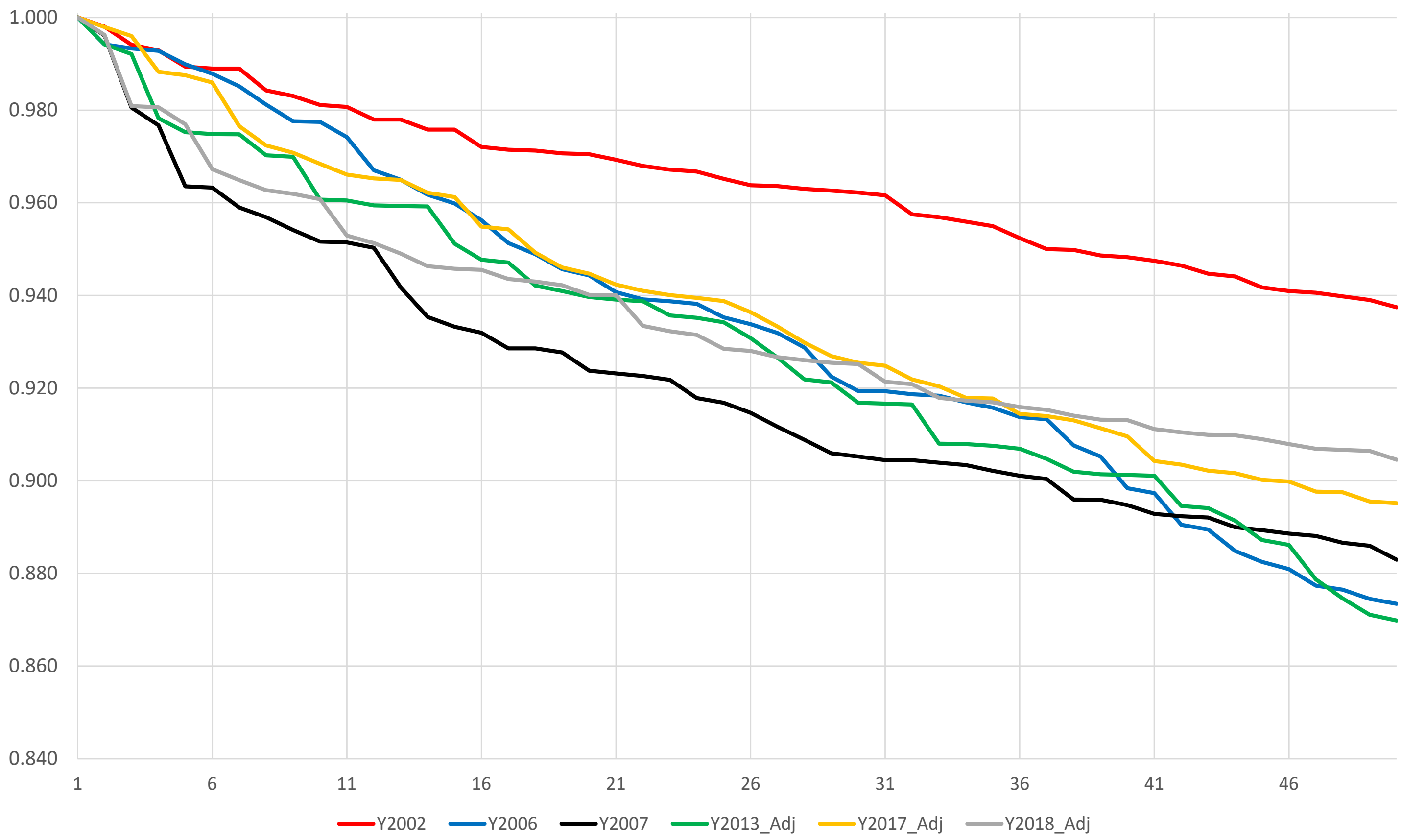
Zone K Summer Hourly Load Duration Curves



- Zone K hourly LDCs for 2002, 2006, and 2007 (as found); and 2013, 2017, and 2018 (adjusted to hit projected 2022 BTM solar capacity level)
- Similar to the NYCA, the Zone J 2002 LDC is very conservative
- The Zone K 2013, 2017, and 2018 LDCs are all fairly average

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2013 Load Shape Adjustment

- The 2013 load shape peaked in July. The secondary monthly peak was in September, due to a fairly low August peak.
- In order to preserve expected load patterns and design conditions, with load levels typically highest in August and September, the 2013 historical load shape was adjusted.
- The August peak day and preceding day were switched with the September peak day and preceding day, and vice-versa. Both sets of days are Tuesdays and Wednesdays, preserving the expected chronology of the weekly load pattern.
- This adjustment preserves relative peak load levels, while changing the chronology to better reflect what we expect to see during a typical summer.

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Load Shape Monthly Peaks

Monthly Peak Loads				
Year	June	July	Aug	Sep
2002	28,920	30,664	31,142	26,954
2006	27,930	32,624	34,686	24,039
2007	31,217	31,741	32,169	28,893
2013*	28,156	33,128	26,654	30,224
2017*	28,163	28,566	28,147	26,470
2018*	27,554	30,876	31,573	31,011

Monthly Relative Peak Loads				
Year	June	July	Aug	Sep
2002	93%	98%	100%	87%
2006	81%	94%	100%	69%
2007	97%	99%	100%	90%
2013*	85%	100%	80%	91%
2017*	99%	100%	99%	93%
2018*	87%	98%	100%	98%

Monthly Peak Loads - 2013 Adjusted				
Year	June	July	Aug	Sep
2002	28,920	30,664	31,142	26,954
2006	27,930	32,624	34,686	24,039
2007	31,217	31,741	32,169	28,893
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Monthly Relative Peak Loads - 2013 Adjusted				
Year	June	July	Aug	Sep
2002	93%	98%	100%	87%
2006	81%	94%	100%	69%
2007	97%	99%	100%	90%
2013*^	85%	100%	91%	80%
2017*	99%	100%	99%	93%
2018*	87%	98%	100%	98%

* 2013, 2017, and 2018 shapes adjusted to reflect expected 2022 BTM solar capacity level
^ 2013 shape adjusted – August and September peaks switched

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Summary and Recommendation

Load Shape Recommendation

- Recommended LFU Bin Structure
  - LFU Bins 1 and 2: 2013
  - LFU Bins 3 and 4: 2018
  - LFU Bins 5 to 7: 2017

- Where possible in conjunction with current or proposed modeling methods, NYISO recommends using load shapes adjusted for changing BTM solar penetrations, i.e. either gross load shapes with BTM solar modeled as a resource or adjusted load shapes with BTM solar penetration scaled to match a target year.

Basis for Assigning Load Shape Years to LFU Bins

- Years with significantly hot peak-producing weather (analogous to Bin 1 and Bin 2 LFU temperatures) have fairly steep load duration curves. 2013 had a hot summer peak day and a steep load shape, and is selected to represent LFU Bins 1 and 2.

- Cool and typical weather summers tend to produce average to flat load duration curves.

- 2018 had fairly average peak-producing weather and a relatively flat load shape. 2018 is selected to represent Bins 3 and 4. Bin 4 represents the expected (average) weather and load level.

- 2017 had a cool summer peak day and a relatively flat load shape. 2017 is selected to represent Bins 5 through 7, which represent summers with milder than expected peak weather conditions.

LFU Phase 2 Summary

- LFU Phase 2 performed an up-to-date analysis of historical load duration curves and assessed the impact of behind-the-meter solar on both LFU modeling and on load shape evolution over time.

- A key deliverable of LFU Phase 2 was an updated load shape recommendation for use in NYISO reliability studies.

- Resource Planning has performed impact analysis of replacing the current load shapes with the recommended load shapes (see accompanying presentation).

- The NYISO will present and solicit potential LFU Phase 3 study topics at LFTF and NYSRC ICS in Q2 of this year.

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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