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Independent System Operator

Load Duration Curve Review – 2002 to 2020

Max Schuler

Demand Forecasting & Analysis

Load Forecasting Task Force

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Load Duration Curve (LDC)

- A load duration curve shows per-unit load values by ranked day or hour

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

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Analysis Summary

- **Load Duration Curve (LDC) Analysis for 2002 to 2020 summers**
  - All analysis performed at the system level
  - 2003 excluded due to the blackout
  - Daily LDCs - Comparison of earlier (2002–2011) and more recent (2012-2020) summers
  - Daily LDCs - Comparison of steeper and flatter load duration curves
  - Daily LDCs - Comparison of load duration curves between hotter and cooler summers, determined by peak day Cumulative Temperature & Humidity Index (CTHI)
  - Hourly LDCs - Comparison of earlier and more recent summers
  - Comparison of Daily LDCs against Hourly LDCs
  - LDC Coefficient of Variation (CV) – summary of variability in loads across ranked summer hours

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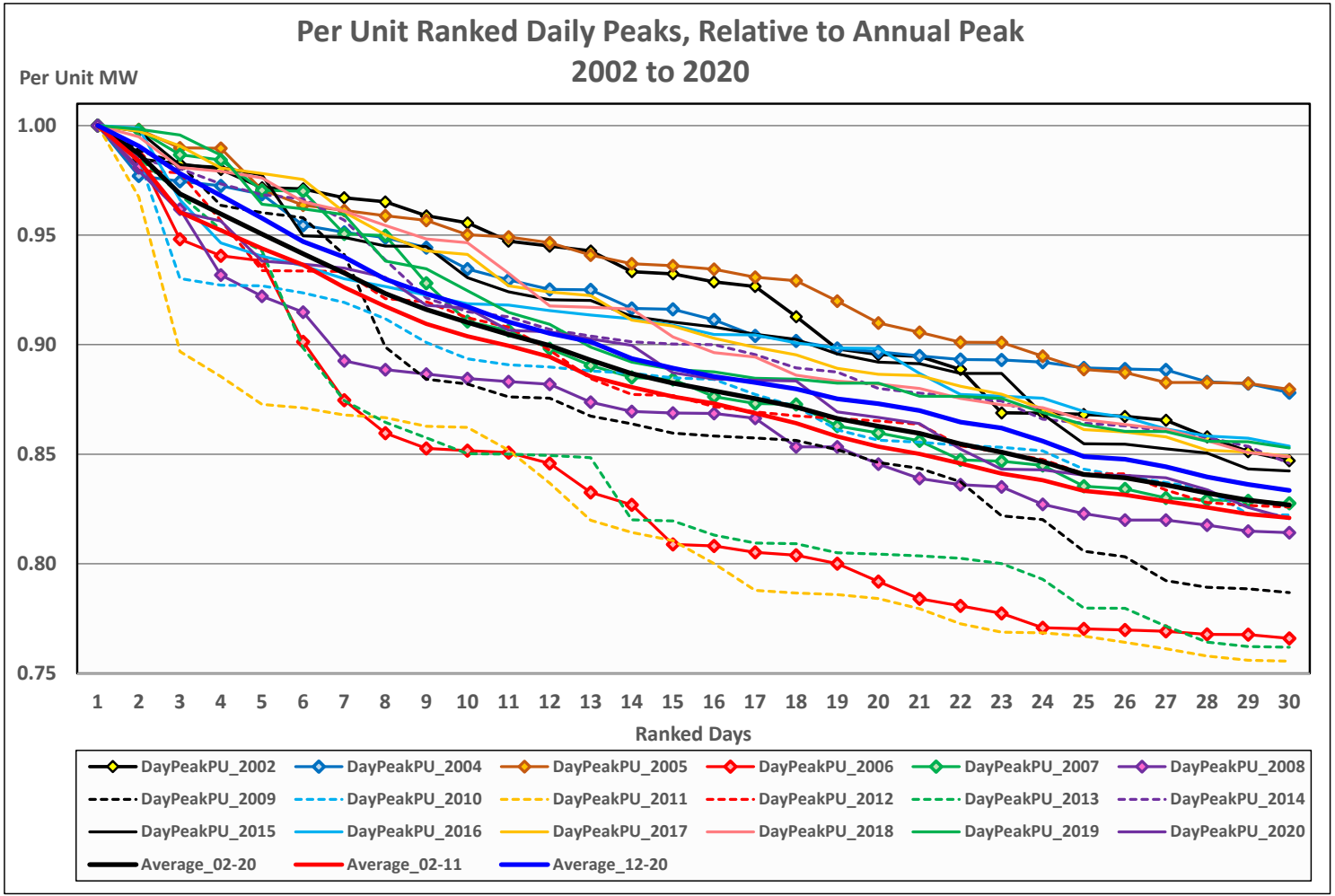

- Per-unit loads (relative to annual peak) of top 30 days
- Three averages were calculated: 2002-2011, 2012-2020, and 2002-2020. All are fairly similar

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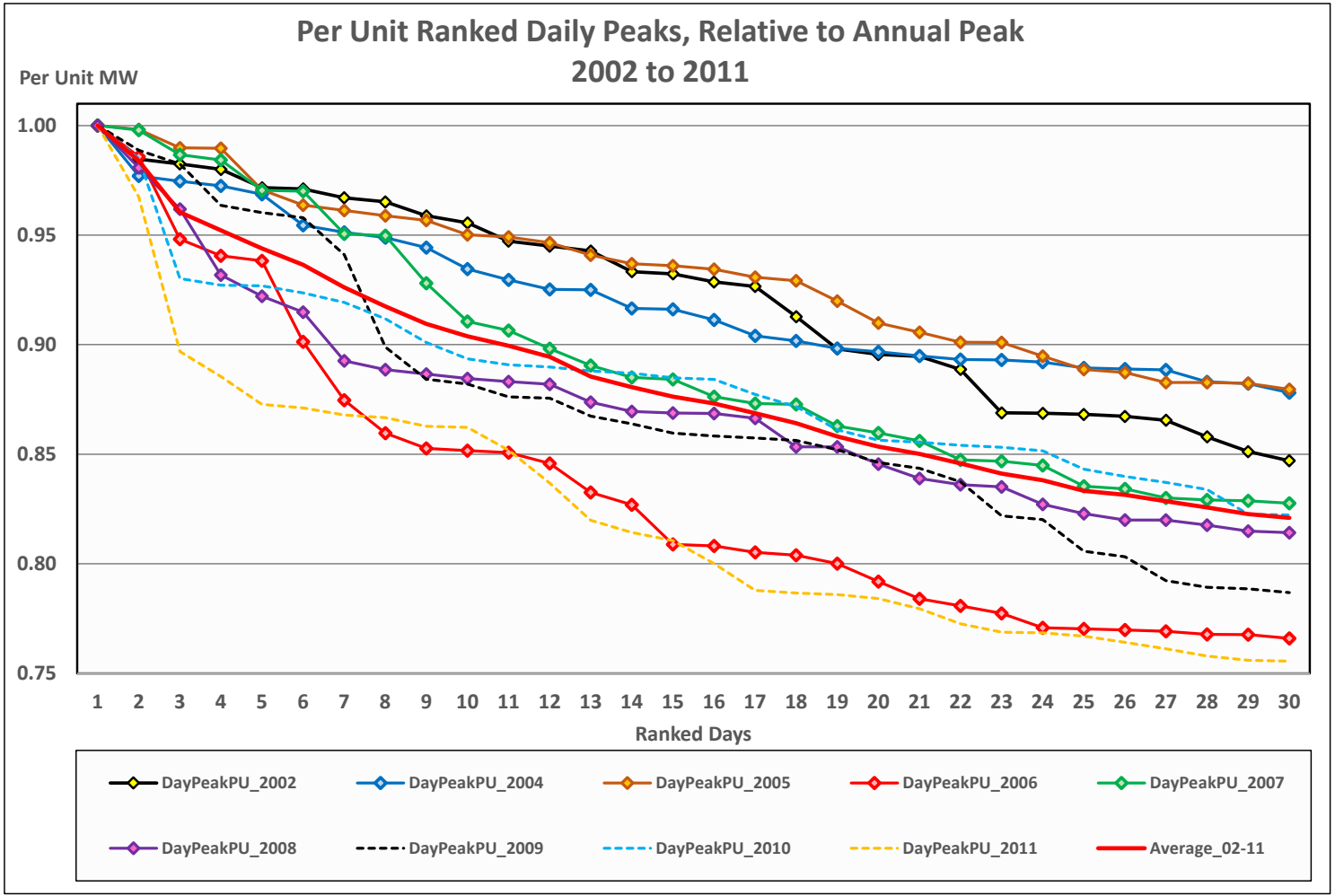

- 2002, 2004 and 2005 have a higher number of near peak load days – fairly flat LDCs
- 2006 and 2011 are steep, with sharp declines in the near peak days
- 2007, 2008, 2009 and 2010 are close to the average

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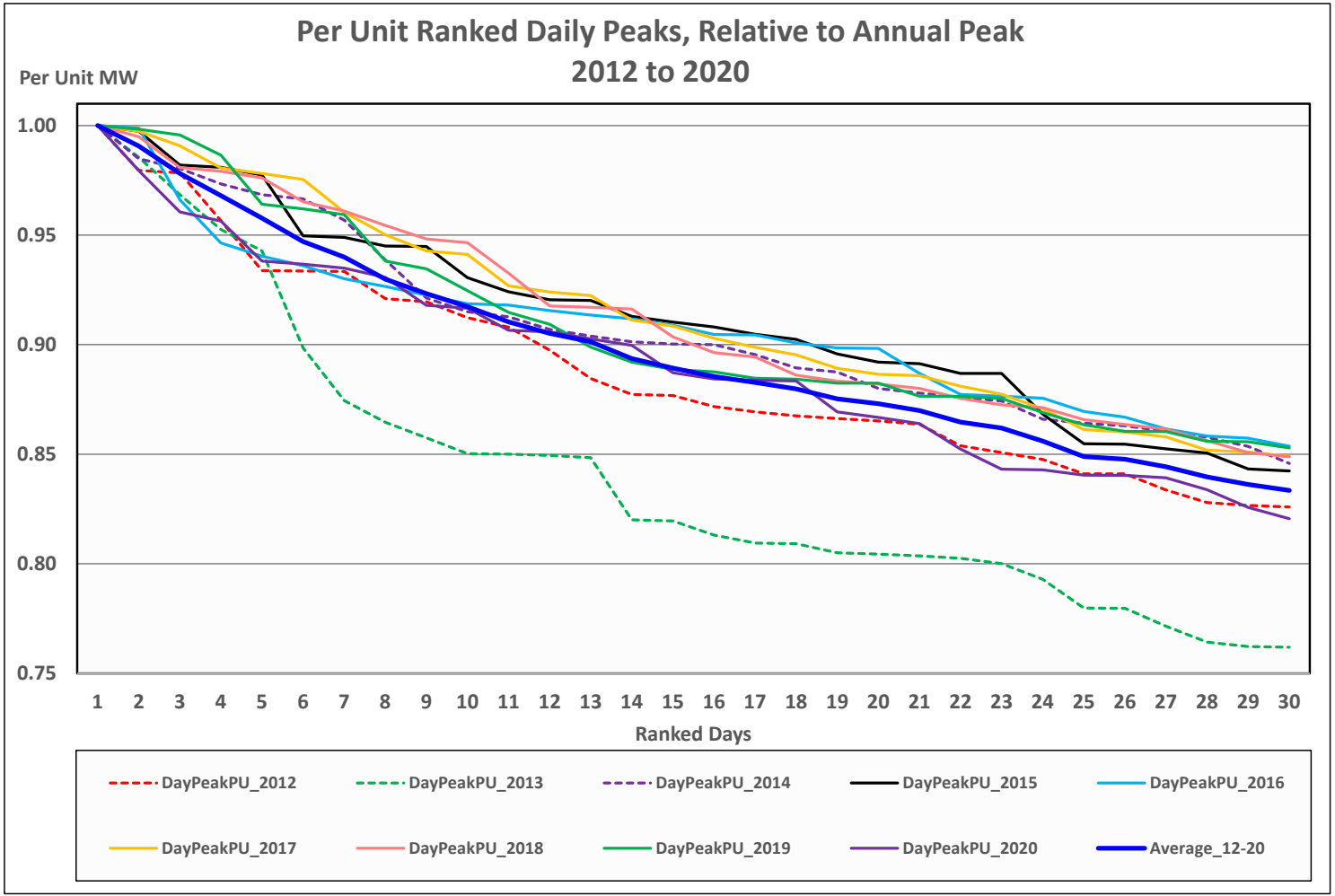

- Most recent years are fairly similar to the long-term average
- 2013 is very steep, with sharp declines in the near peak days
- 2019 is generally near to slightly above average across the top 30 days
- 2020 is generally near to slightly below average across the top 30 days

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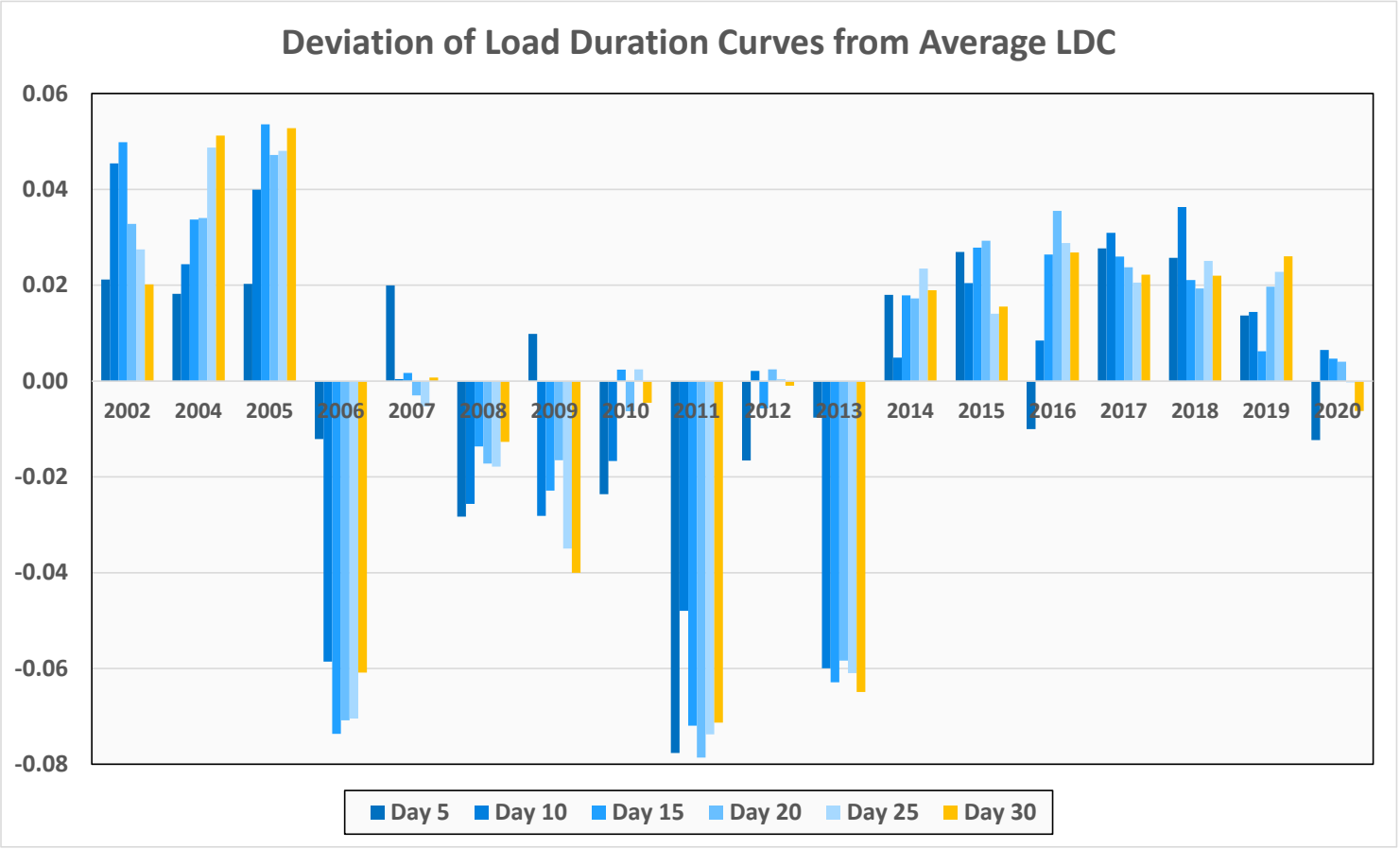

- 2002 through 2005 are generally above average (flatter LDCs)
- 2006, 2011 and 2013 are significantly below average (steeper LDCs)
- 2014 through 2019 are generally above average
- 2020 is fairly close to average

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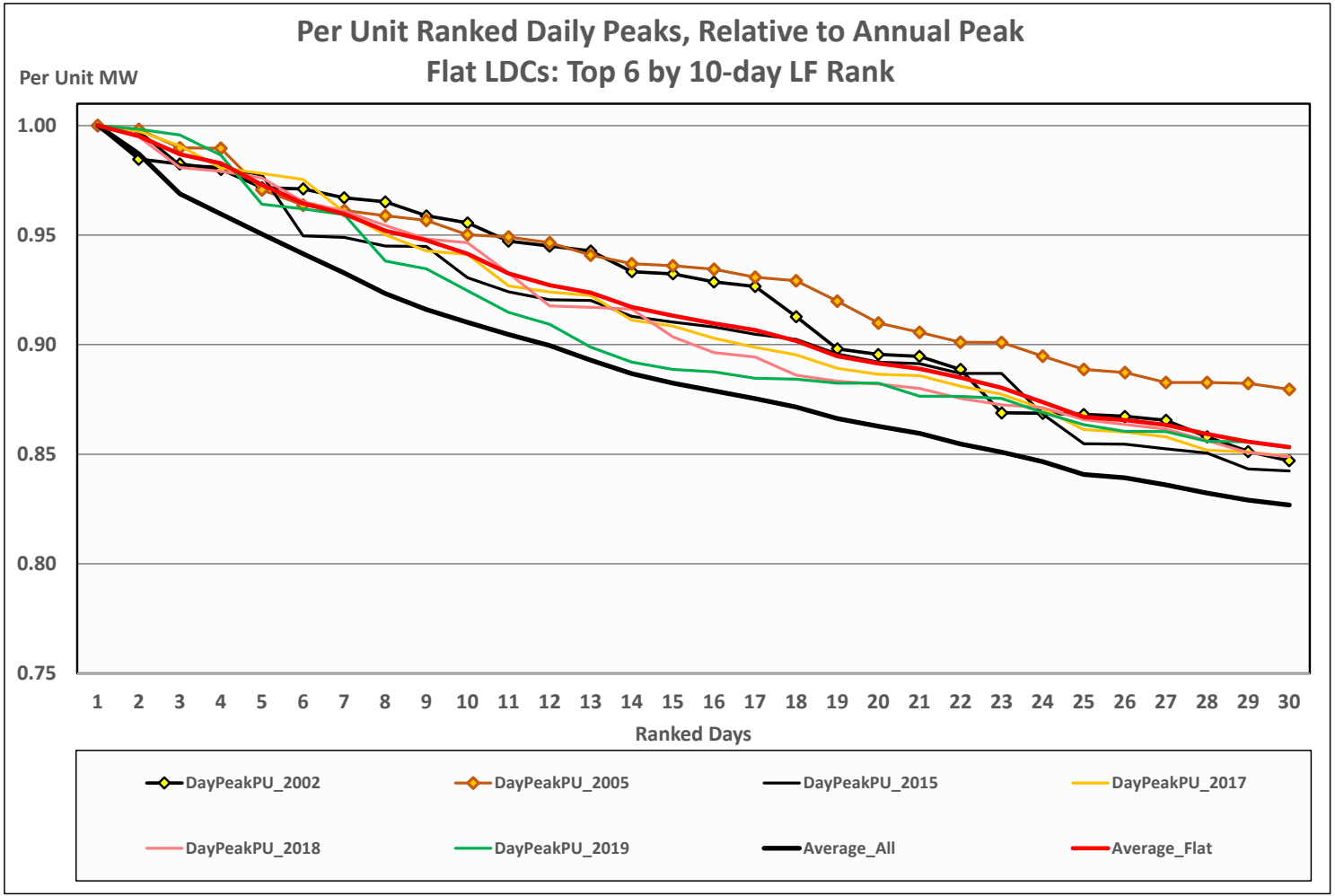

- 2002, 2005, and 2015-2018 are the six summers with the flattest load duration curves based on the load factor over the first ten days
- The average of this subset (shown in red) is higher than the overall average (shown in black)

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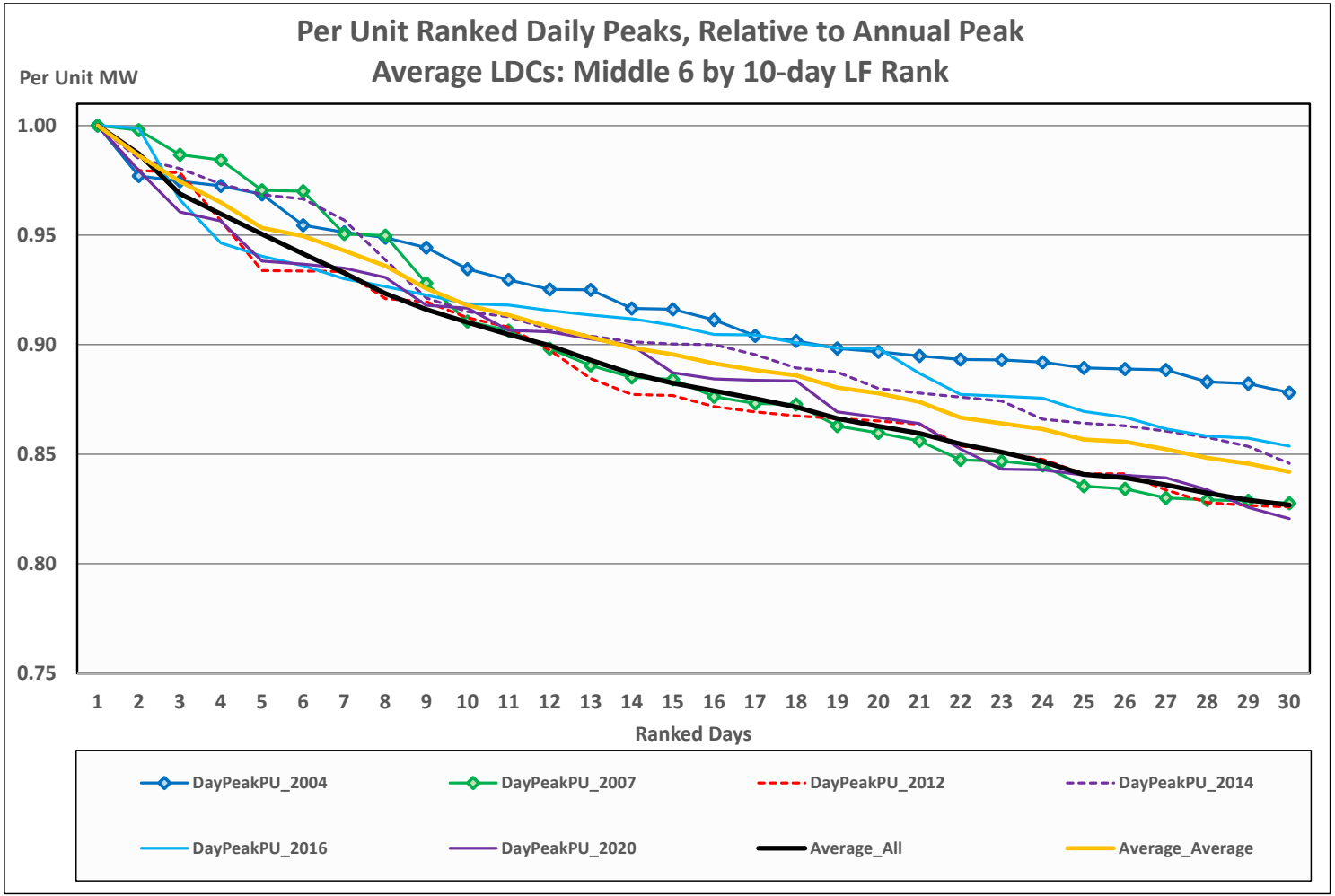

- 2004, 2007, 2012, 2014, 2016 and 2020 are the six middle ranked LDCs based on the load factor over the first ten days
- The average of this subset (shown in yellow) is higher than the overall average (shown in black), suggesting some skewness in the overall distribution

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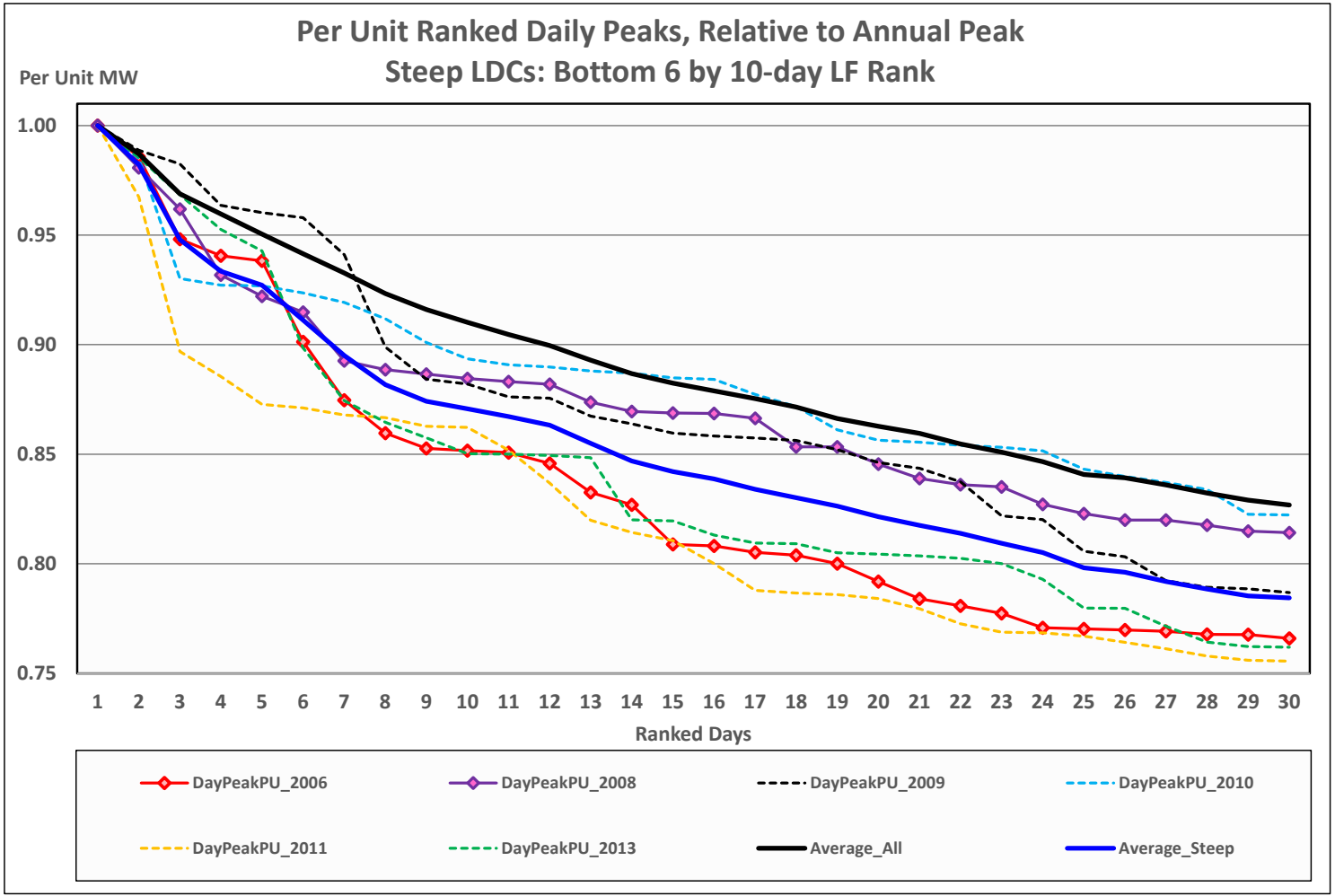

- 2006, 2008-2011 and 2013 are the six bottom ranked LDCs based on the load factor over the first ten days
- The average of this subset (shown in blue) is significantly lower than the overall average (shown in black)
- There is a much greater difference relative to the typical LDC

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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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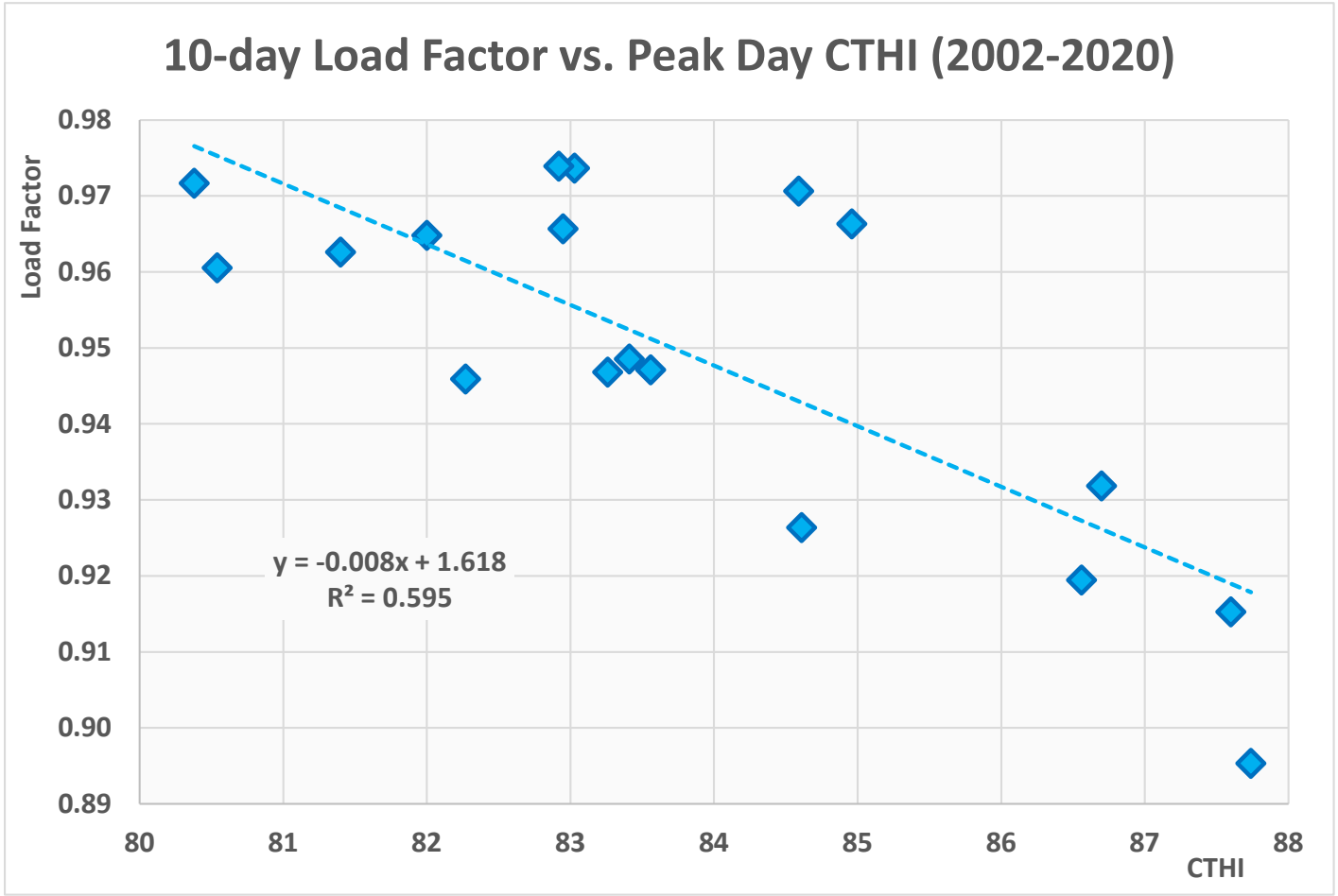

- There is a significant negative correlation between peak day weather and flatness of the load duration curve
- Years with flatter LDCs represent summers with typical or cooler peak weather

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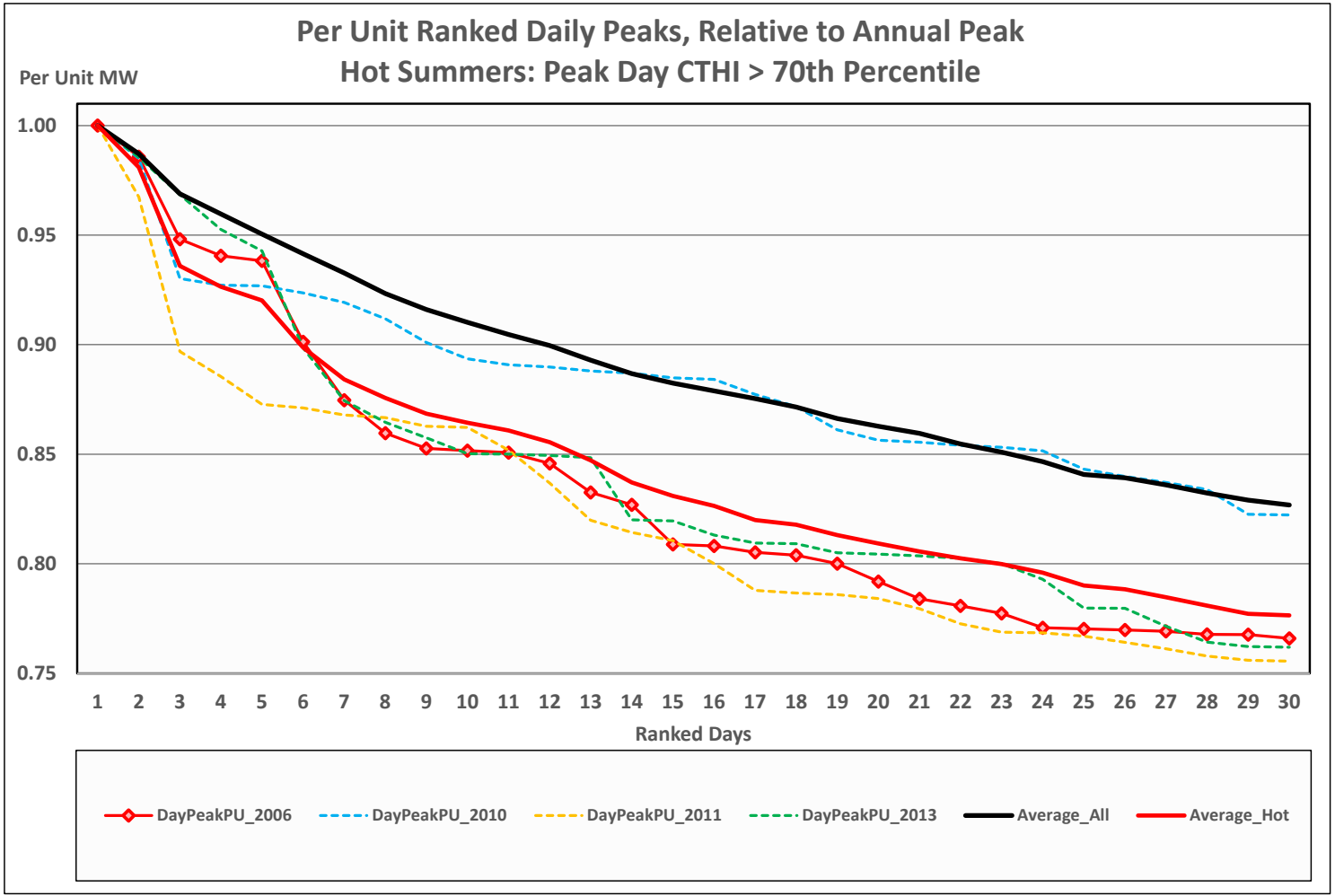

- 2006, 2010, 2011 and 2013 are the four summers with significantly hotter than normal peak-producing weather conditions
- The average of this subset is significantly lower than the overall average across all years
- These curves better represent expected load behavior applicable to the upper bin LFU multipliers (bins 1 to 3)

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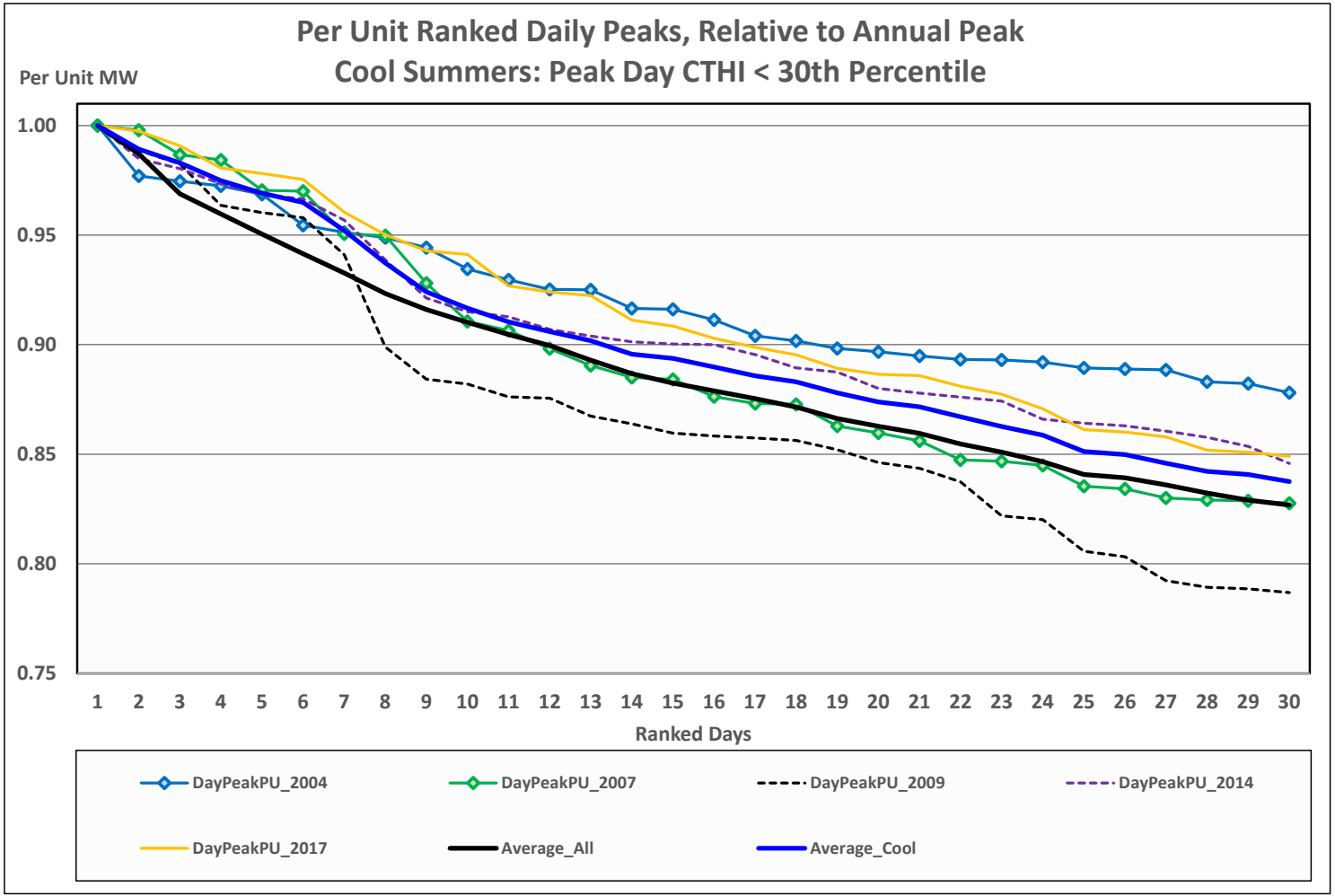

- 2004, 2007, 2009, 2014 and 2017 are the five summers with significantly cooler than normal peak-producing weather conditions
- The average of this subset is slightly higher than the overall average across all years
- These curves better represent expected load behavior applicable to the lower bin LFU multipliers (bins 5 to 7)

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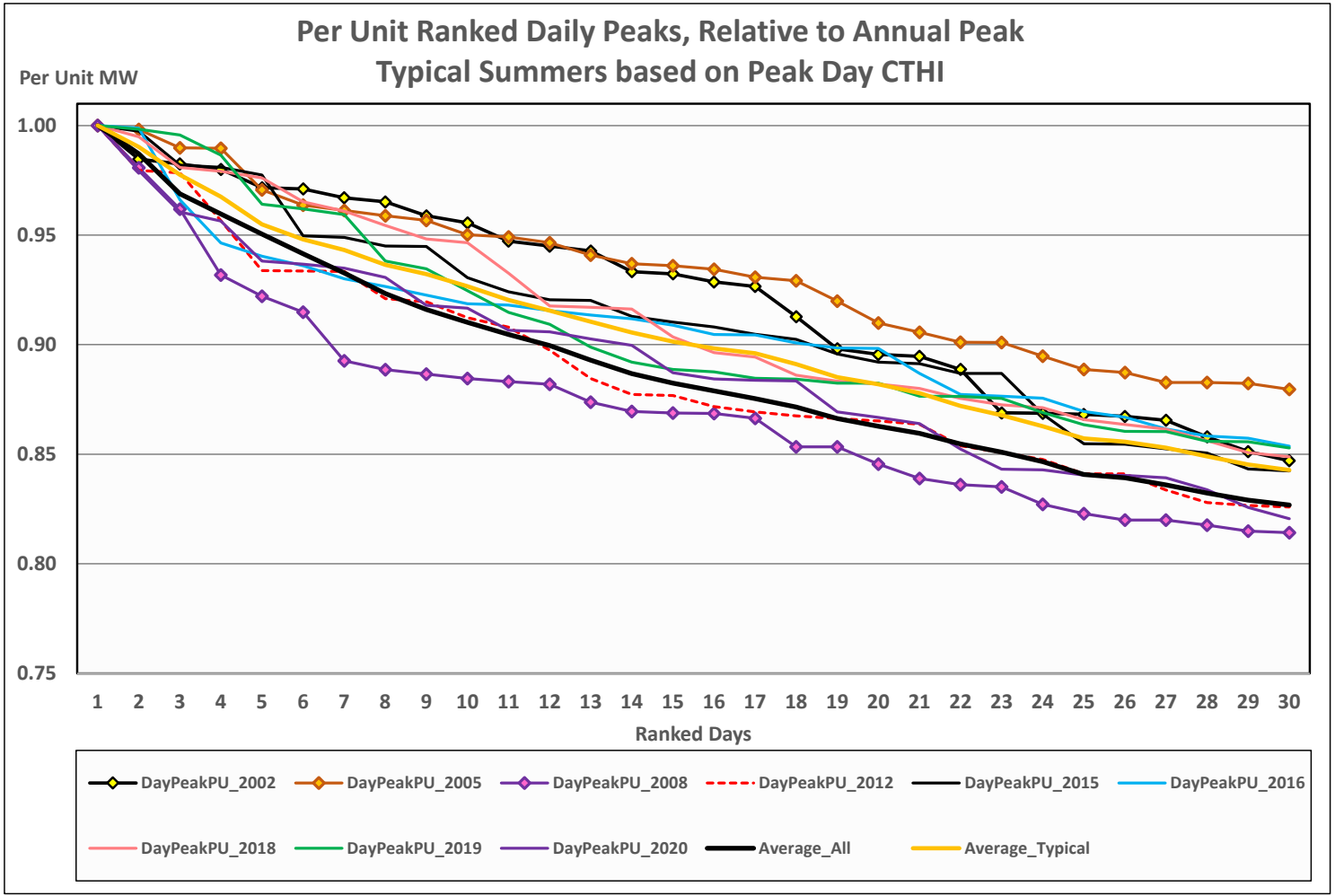

- This graph shows the LDCs for the remaining summer with near-normal peak day weather (peak day CTHI between the 30th and 70th percentiles)
- The average of this subset is slightly higher than the overall average across all years, and fairly similar to the average for cool summers

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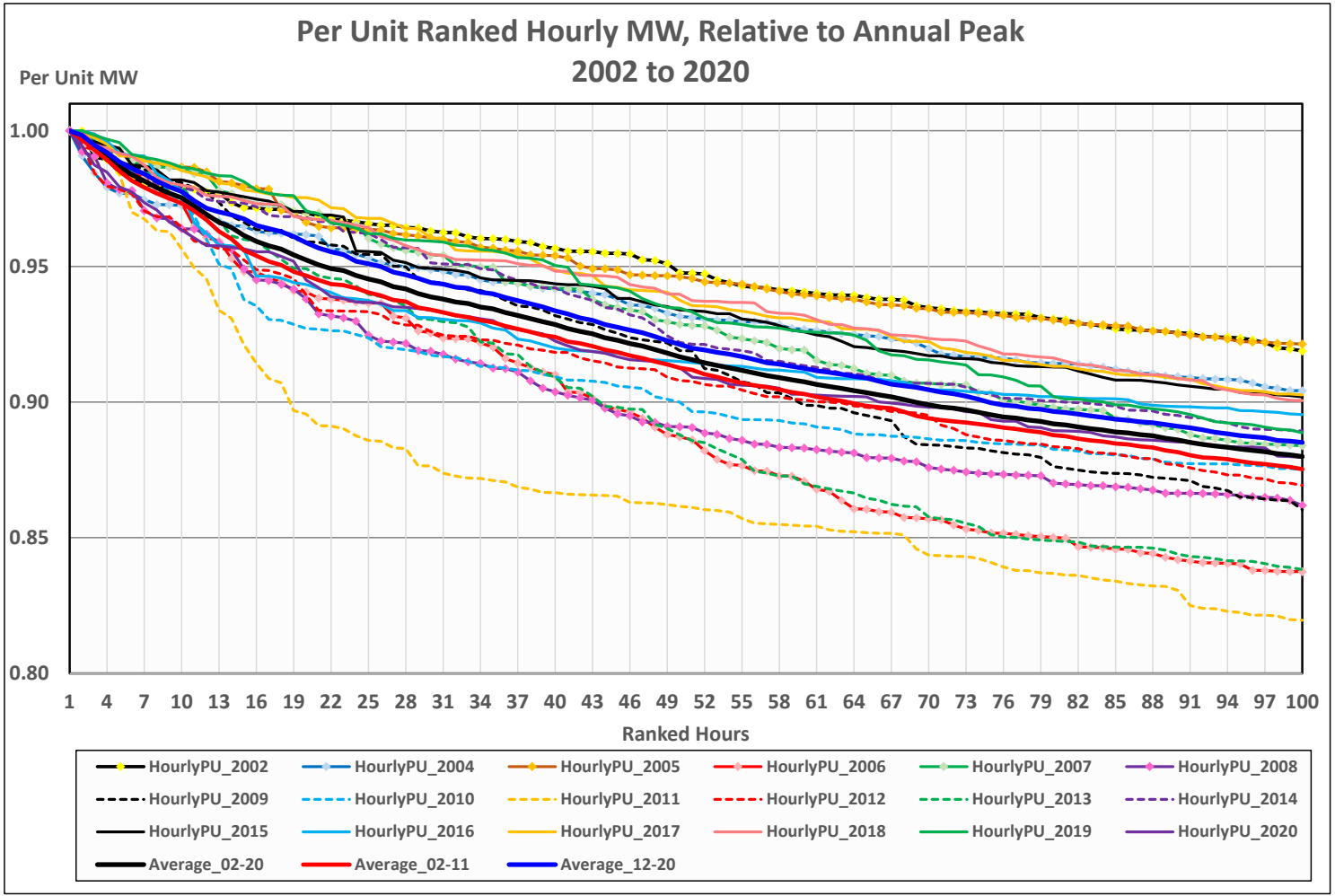

- This graph shows the hourly LDCs for all summers in the analysis. The top 100 summer hours are shown
- These LDCs are comparatively similar to the daily LDCs across years

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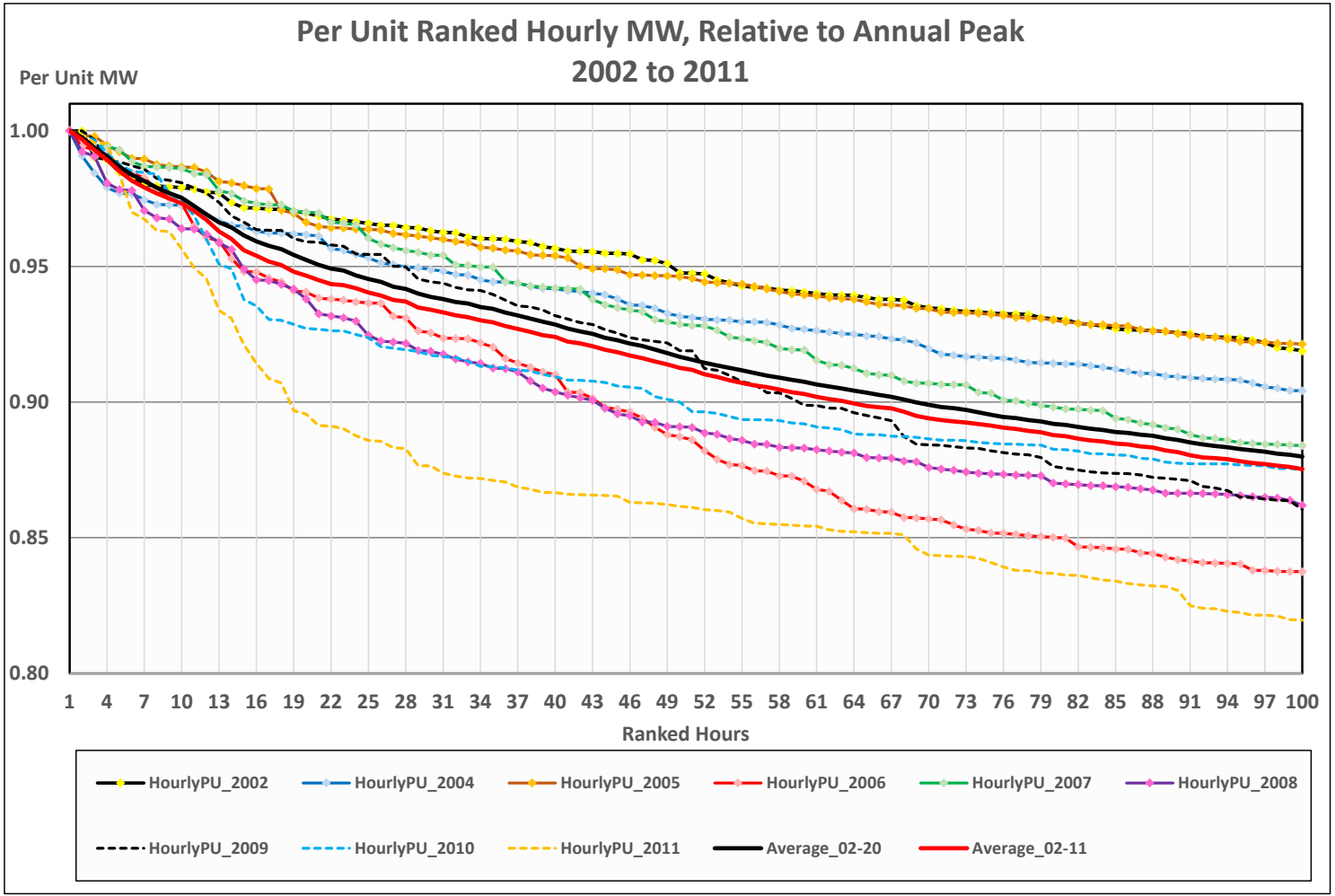

- This graph shows the hourly LDCs for 2002-2011. The top 100 summer hours are shown
- The average of this subset is similar to the overall average

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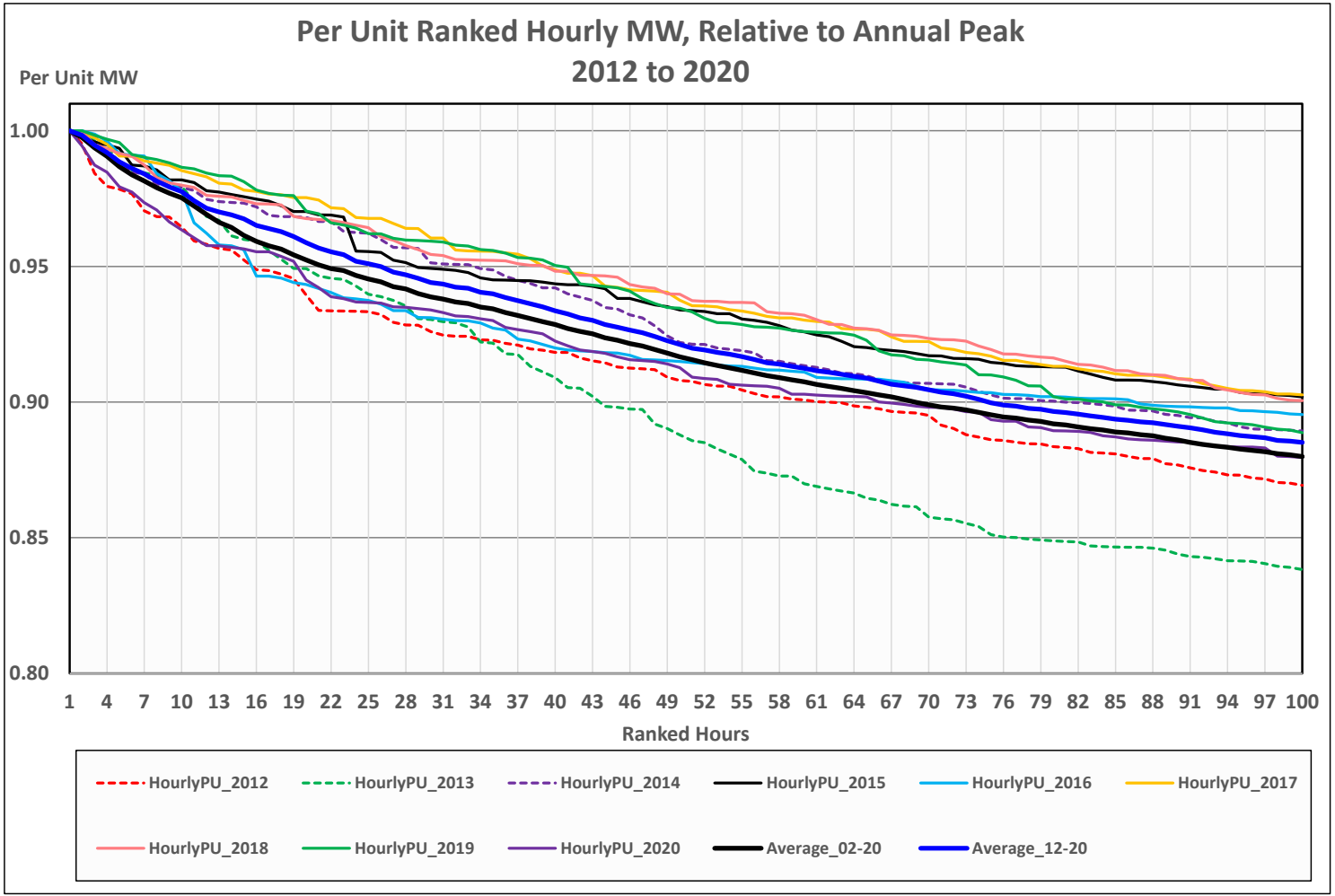

- This graph shows the hourly LDCs for 2012-2020. The top 100 summer hours are shown
- The average of this subset is similar to the overall average

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Annual Load Duration Curve Metrics with Rankings						
Year	Peak Day CTHI	10-day Load Factor	50-hour Load Factor	Rank CTHI	Rank Day Load Factor	Rank Hour Load Factor
2002	83.03	0.974	0.968	11	2	1
2004	81.40	0.963	0.956	16	8	9
2005	82.92	0.974	0.968	13	1	2
2006	87.60	0.915	0.937	2	17	15
2007	82.00	0.965	0.962	15	7	6
2008	84.61	0.926	0.932	6	15	17
2009	82.27	0.946	0.955	14	13	10
2010	86.70	0.932	0.934	3	14	16
2011	87.74	0.895	0.904	1	18	18
2012	83.26	0.947	0.939	10	12	14
2013	86.56	0.919	0.941	4	16	13
2014	80.54	0.961	0.960	17	9	8
2015	82.95	0.966	0.962	12	6	7
2016	83.41	0.949	0.945	9	10	11
2017	80.38	0.972	0.967	18	3	3
2018	84.59	0.971	0.964	7	4	5
2019	84.96	0.966	0.966	5	5	4
2020	83.56	0.947	0.943	8	11	12

- Rankings for the hourly load duration curves are generally similar to the rankings for the daily LDCs
- Hot summers (CTHI above the 70th percentile) are shaded in red; cool summers (CTHI below the 30th percentile) are shaded in blue

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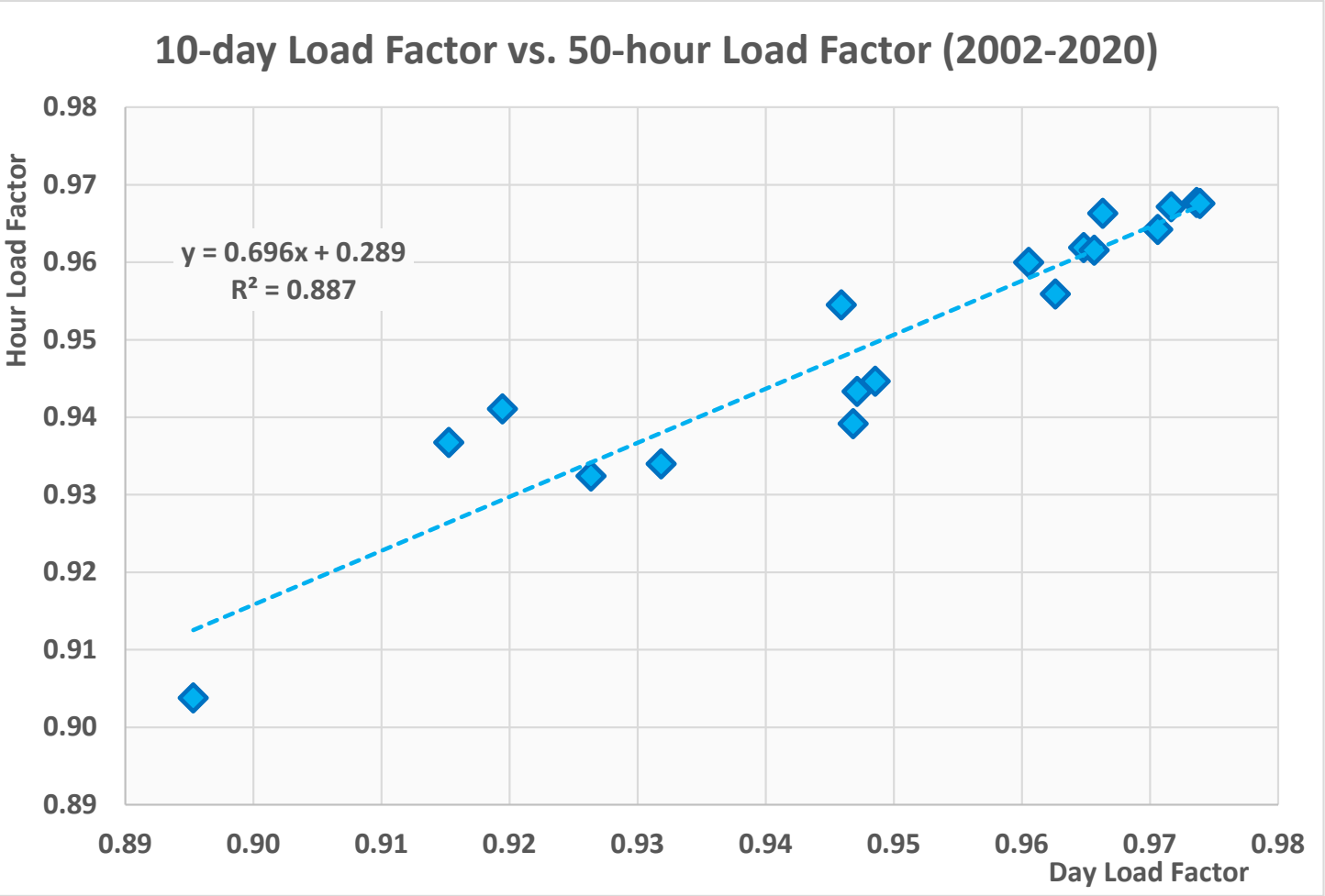

- There is a very strong positive correlation between daily and hourly load duration curve load factors

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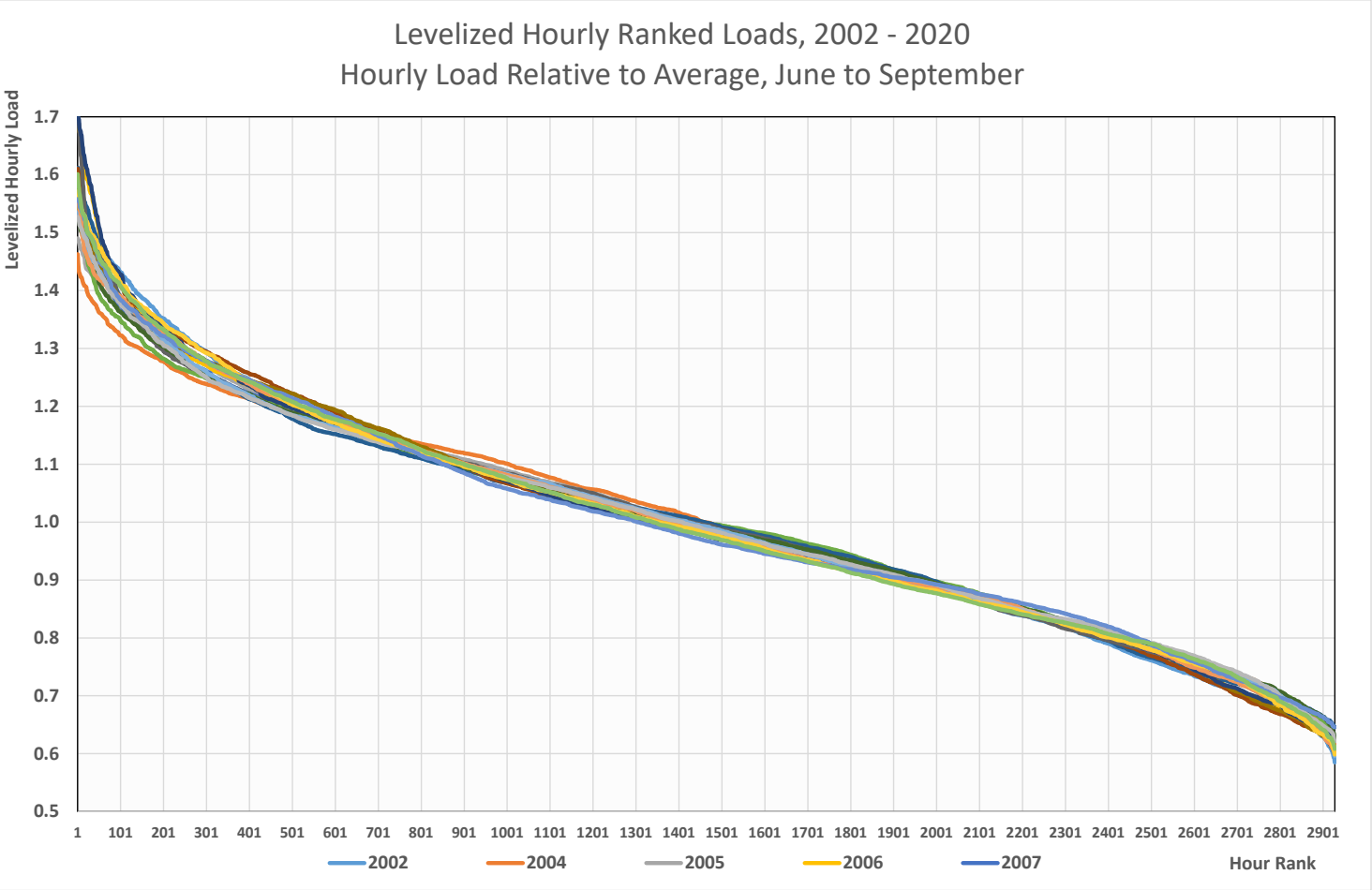

- This graph shows all June to September hourly summer loads by year, relative to average
- There is significantly more variation in the upper load tail relative to the rest of the summer hours

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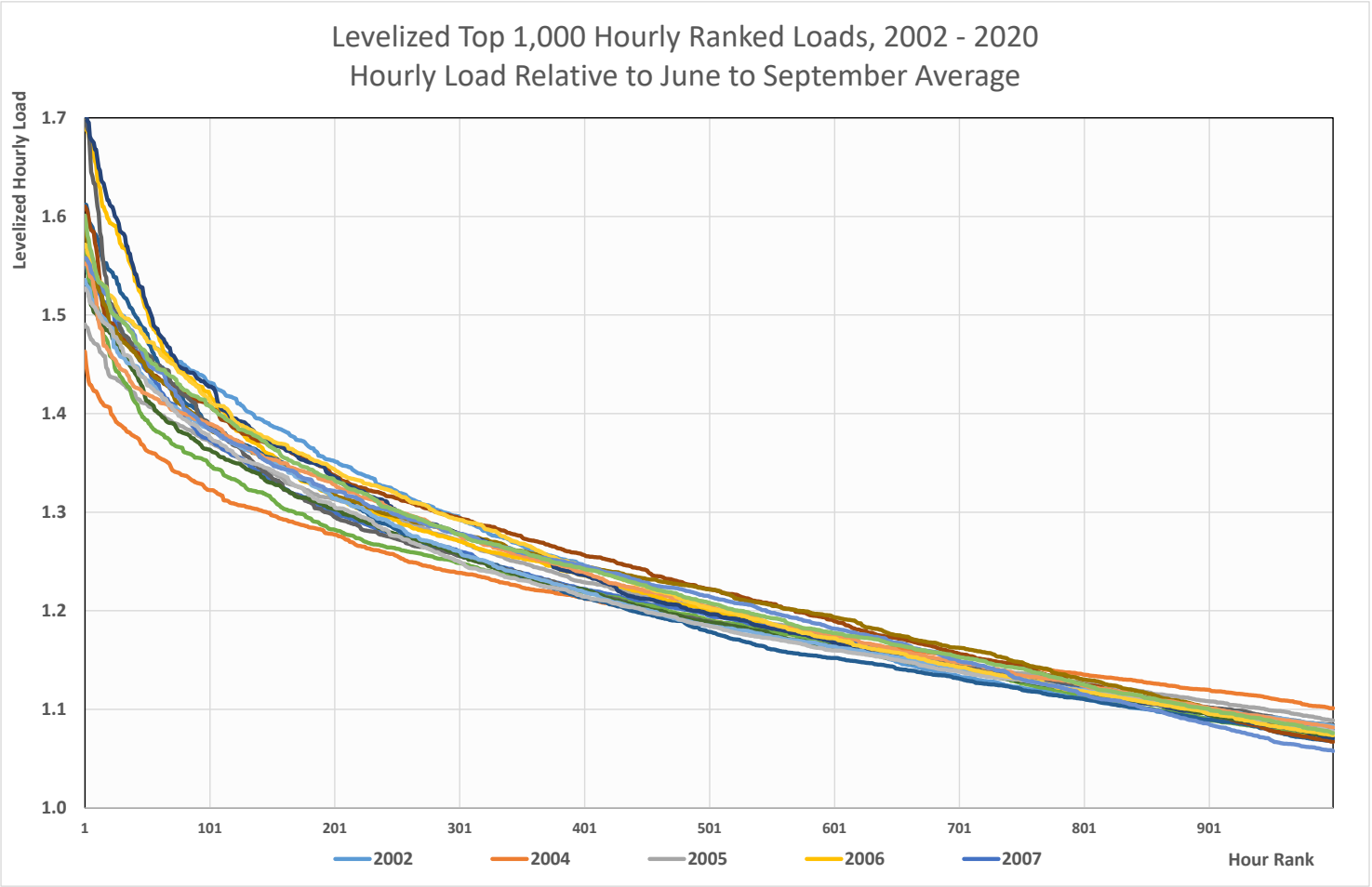

- This graph zooms in to show the top 1,000 hourly summer loads by year, relative to the June to September hourly average
- The variation in hourly loads decreases significantly across the top 1,000 hours

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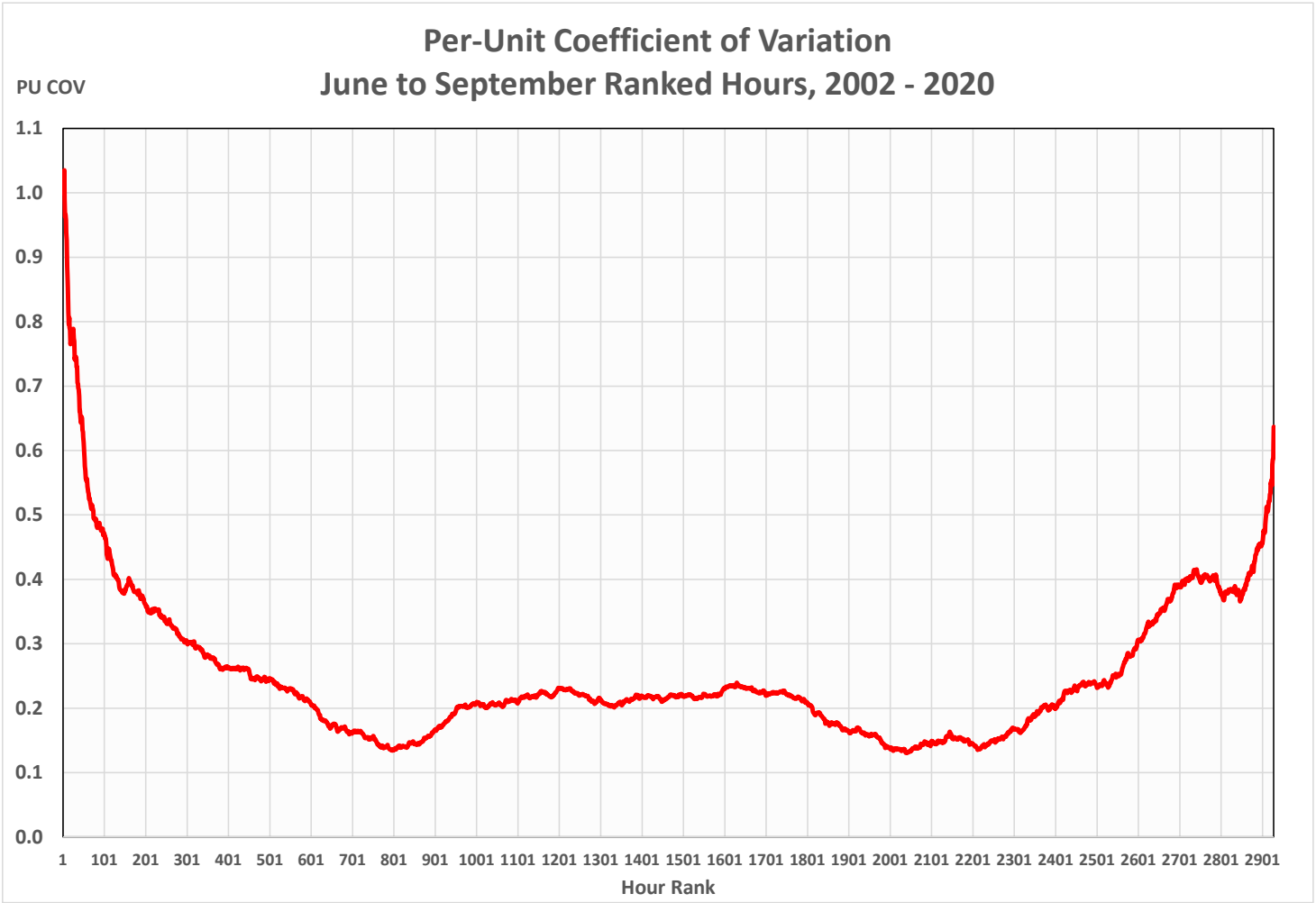

- This graph shows the hourly per-unit coefficient of variation of load sorted by hourly load rank
- The Coefficient of Variation (CV) is the standard deviation divided by the average
- There is a significant drop off in variability over the top 100 ranked summer hours

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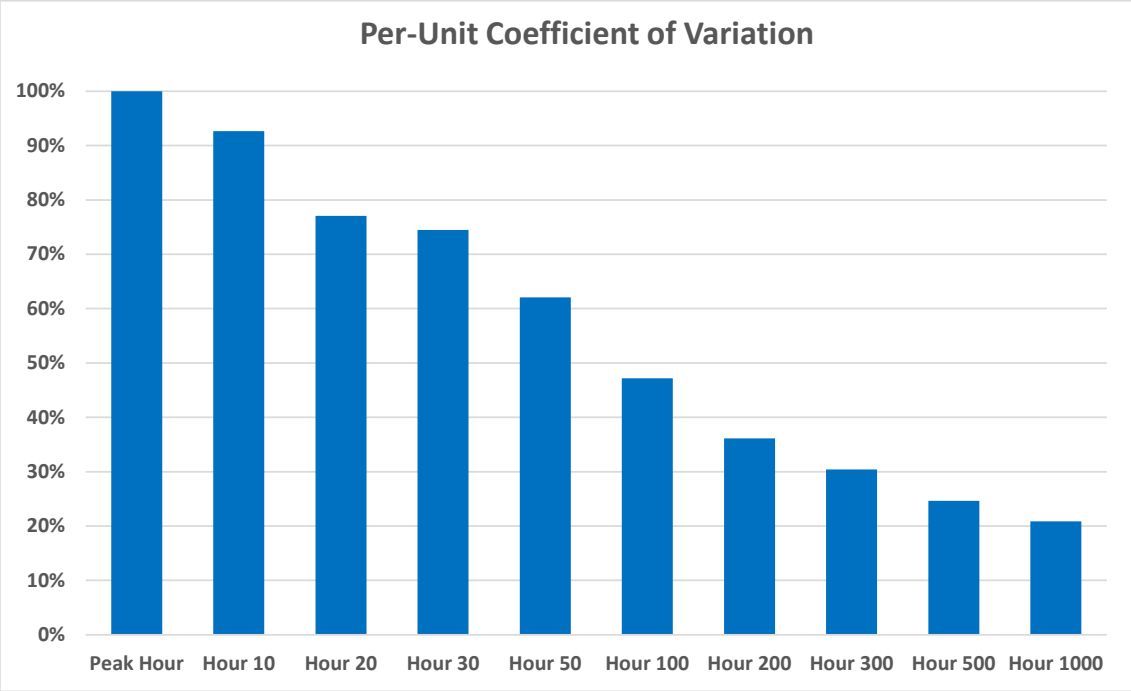
Hour Rank	Per-Unit CV
Peak Hour	100%
Hour 10	93%
Hour 20	77%
Hour 30	74%
Hour 50	62%
Hour 100	47%
Hour 200	36%
Hour 300	30%
Hour 500	25%
Hour 1000	21%



- These figures show the variation in ranked hour load as a percentage of the variation in the single peak load hour, on average across the 2002 through 2020 summers

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Key Takeaways

- 2019 and 2020 are both fairly typical from a load duration curve perspective
- Years with significantly hot peak-producing weather (analogous to Bin 1 to Bin 3 LFU temperatures) have very steep load duration curves
- There is a very strong correlation between daily and hourly load duration curve results
- The variability in hourly load declines quickly and significantly as you move down the ranked hours of the load duration curve

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Questions?

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- Maintaining and enhancing regional reliability
- Operating open, fair and competitive wholesale electricity markets
- Planning the power system for the future
- Providing factual information to policymakers, stakeholders and investors in the power system

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