

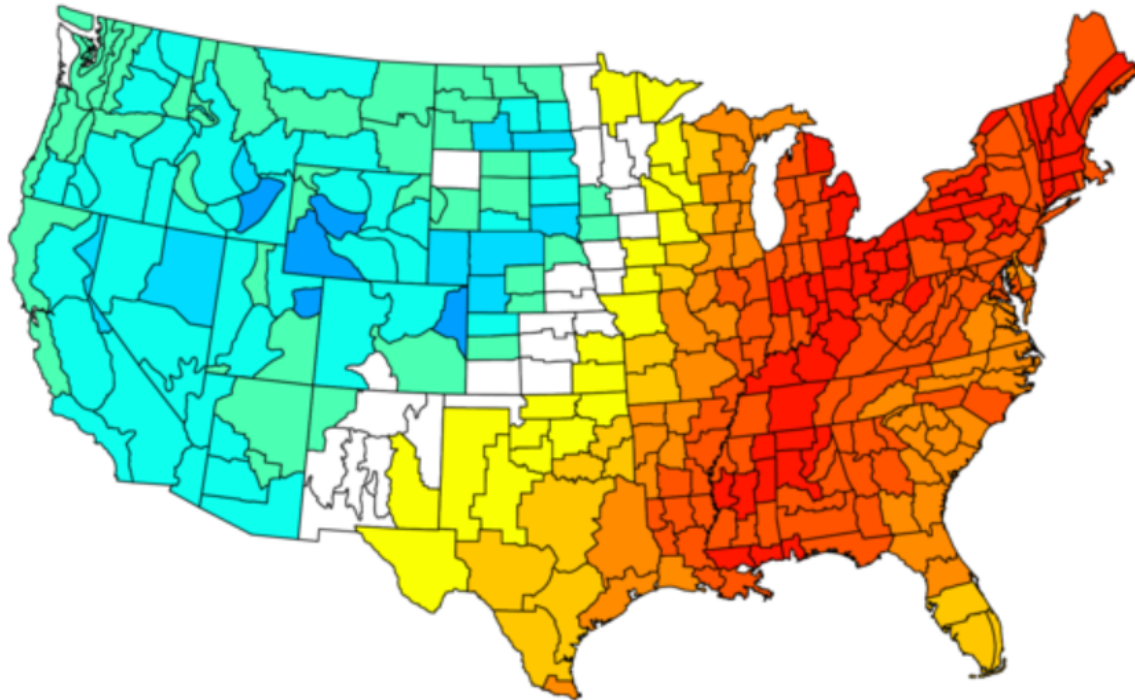


# Winter Operations of the PJM Grid: December 1, 2022 – February 28, 2023

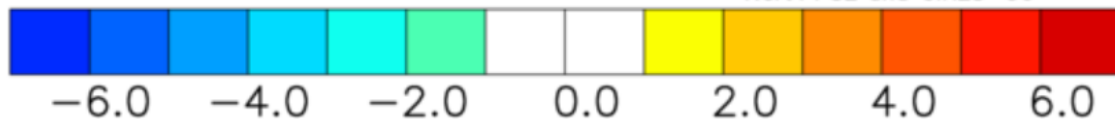
Operating Committee  
April 13, 2023

# Winter 2022/23 Overview

NOAA/NCEI Climate Division Temperature Anomalies (F)  
 Dec to Feb 2022–23  
 Versus 1991–2020 Longterm Average



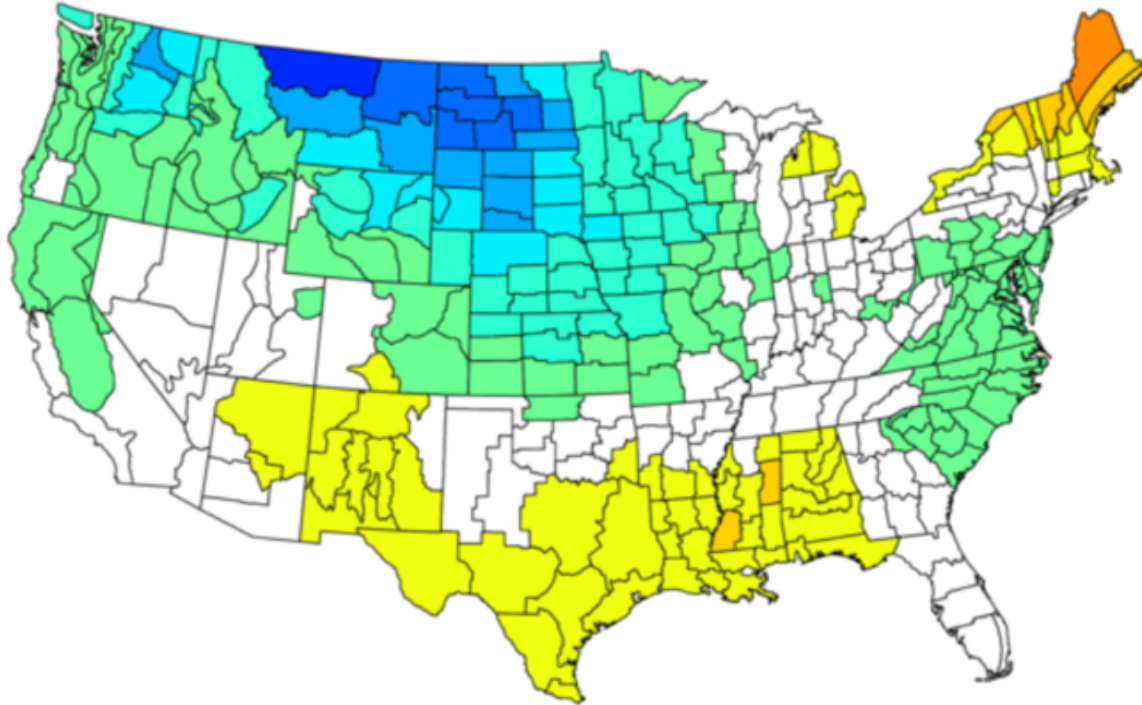
NOAA PSL and CIRES-CU



Source: NOAA/NCEI U.S. Climate Division Data Plots, NOAA Physical Sciences Laboratory

- The winter season as a whole was warmer than normal, due almost entirely to anomalously warm temperatures in the months of January and February.
- Looking at daily temperature averages, several cities in PJM experienced among the warmest recorded Januarys and Februarys.

NOAA/NCEI Climate Division Temperature Anomalies (F)  
Dec 2022  
Versus 1991–2020 Longterm Average

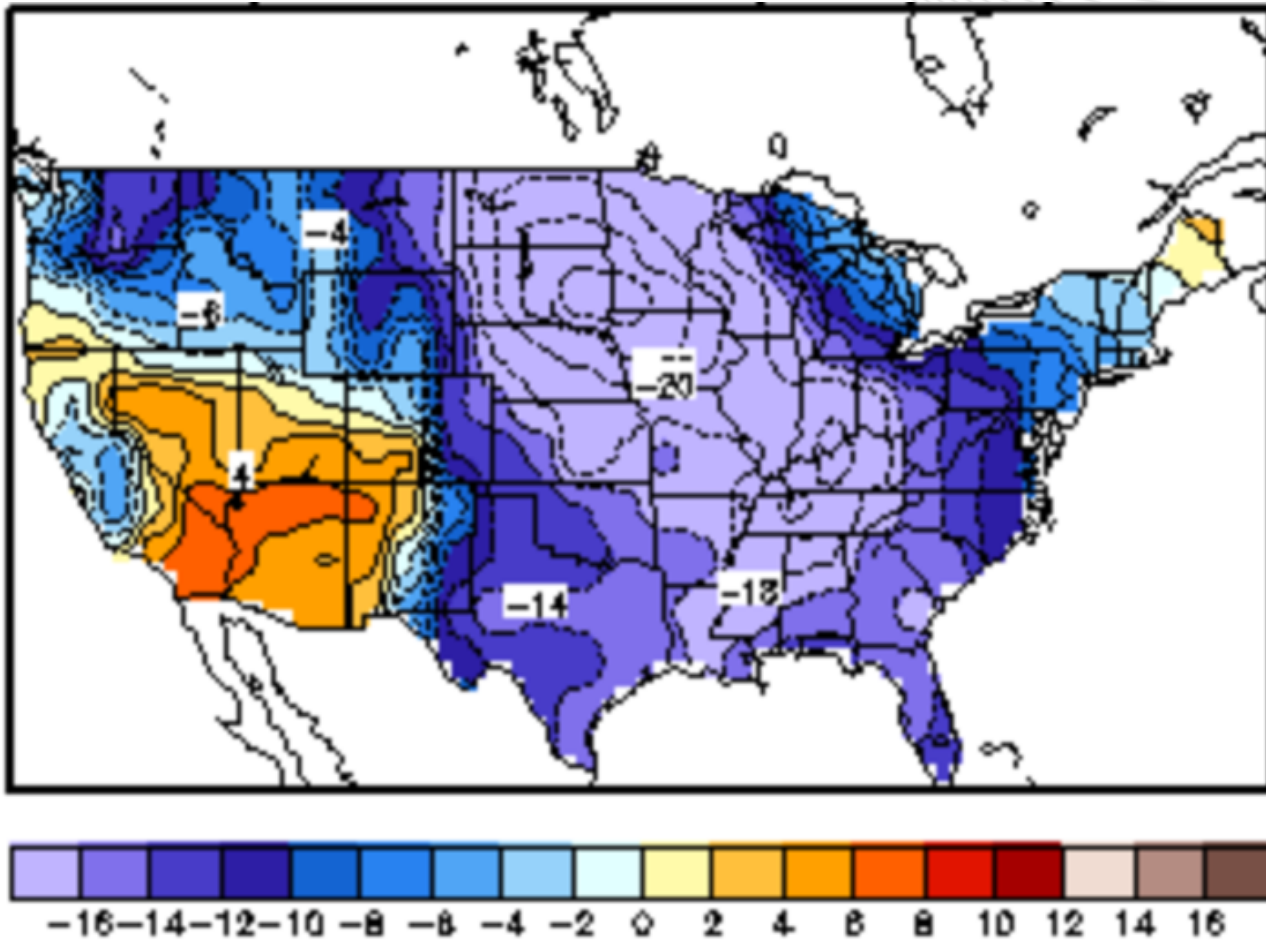


NOAA PSL and CIRES-CU



- Temperatures in December were at or just below normal throughout PJM.
- December's below average temperatures were driven mostly from extreme cold weather experienced during Winter Storm Elliott.

## Minimum Temperature Anomaly (F)



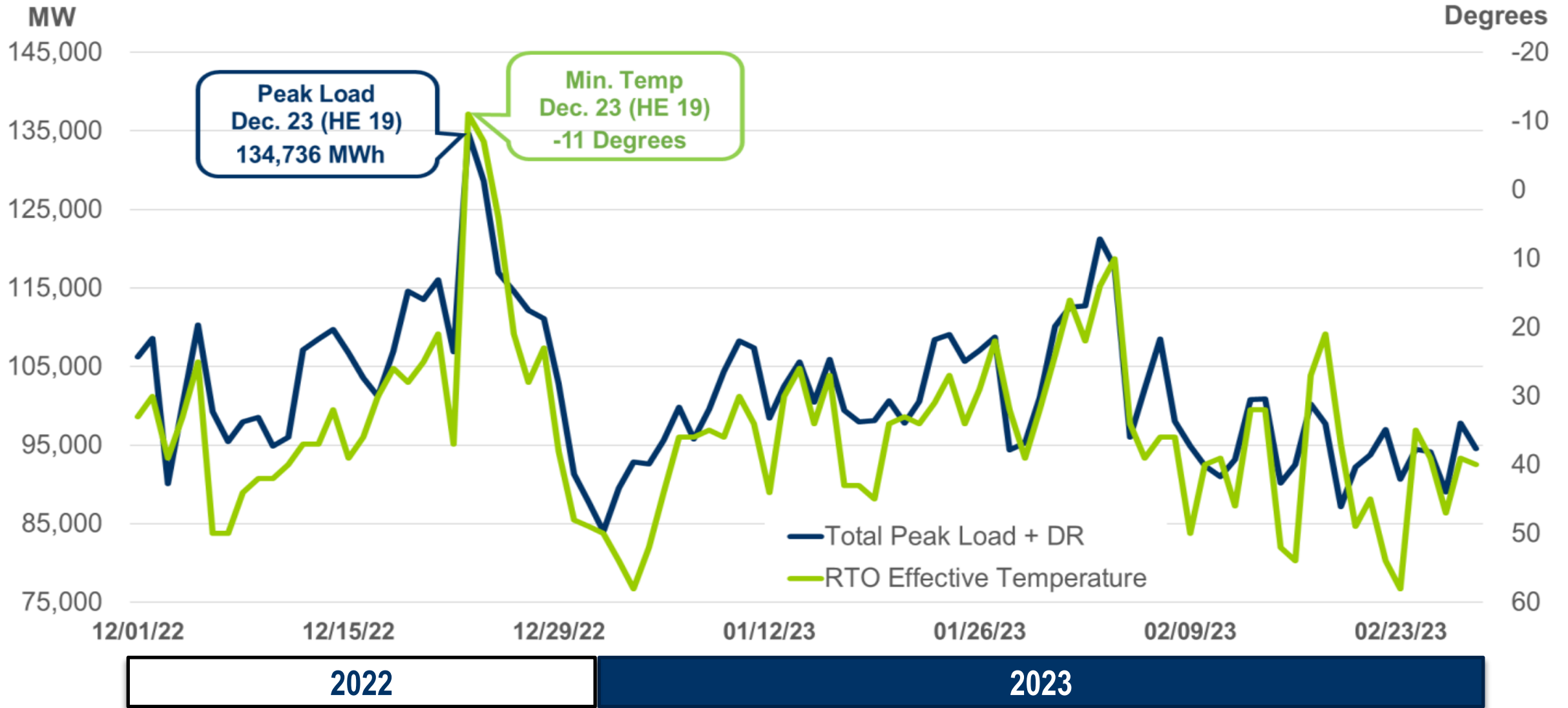
- Winter Storm Elliott brought rapid temperature drops, lows in the single digits and negatives, high wind speeds, and notable snow accumulation throughout PJM.
- Temperatures throughout PJM ranged between 10 and 20 degrees below normal for the duration of the storm.

Source: [https://www.cpc.ncep.noaa.gov/products/tanal/temp\\_analyses.php](https://www.cpc.ncep.noaa.gov/products/tanal/temp_analyses.php)

- There is a strong relationship, a correlation of approximately 75%, between load and effective temperature. Effective temperature is a measure similar to wind chill that takes into account wind speed and its chilling effect.
- In the winter, as temperatures go down, the load goes up (and vice versa), exhibiting a strong, inverse relationship.
- The following slide plots effective temperatures from high to low, rather than the traditional low to high, to show the close tracking between load and effective temperature.



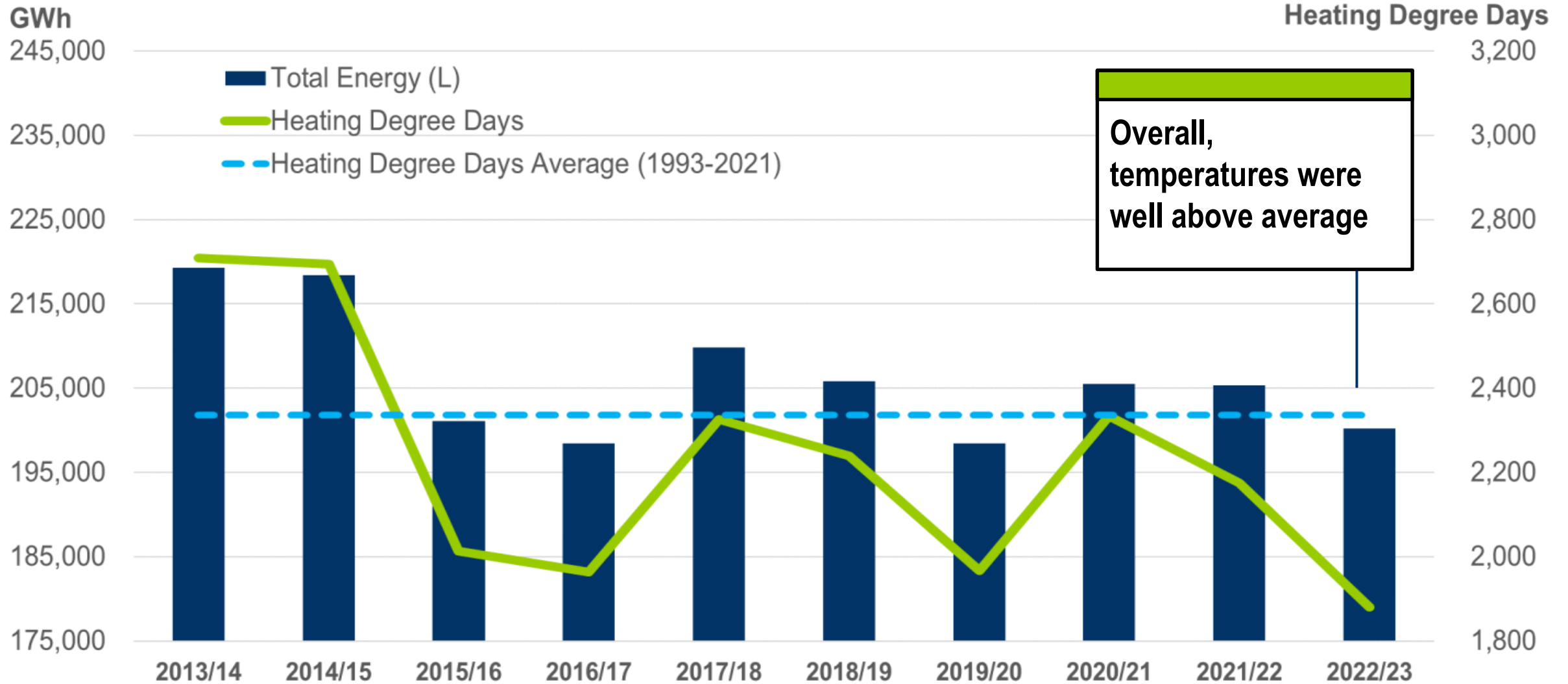
# Daily RTO Peak Load and Effective Temperature



- The following slide shows the historic relationship between heating degree days and total energy.
- Heating degree days measure the temperature's cumulative deviation from a base point, in this case 60 degrees, over a specified time period.
- With the exception of cold temperatures and corresponding high loads during Winter Storm Elliot, mild weather throughout the winter led to relatively low total energy for the winter of 2022/23.

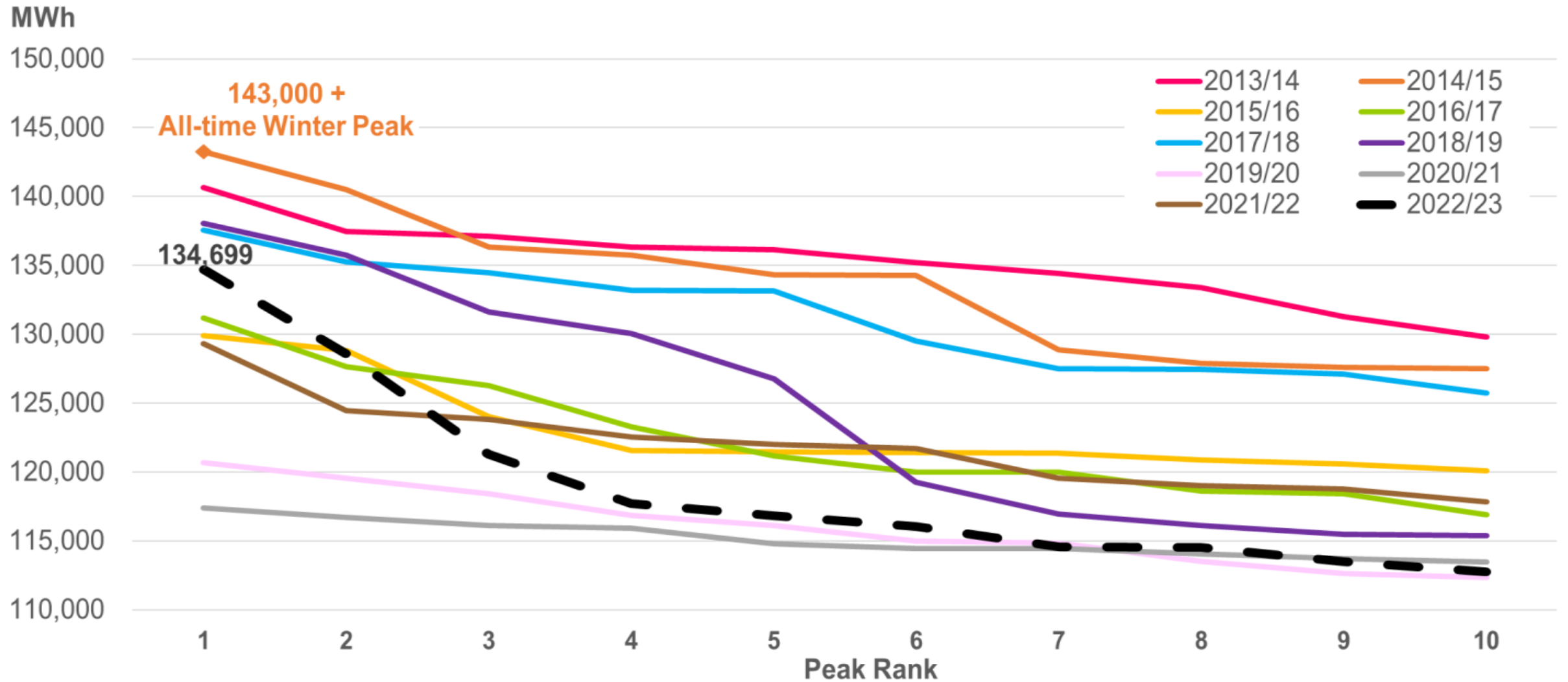


# Historic Total Energy and Heating Degree Days



- The following slides show the top 10 winter peaks for 2022/23 and all recent winters including 2013/14 (Polar Vortex, dark pink line) and 2014/15 (all time winter peak, orange line), respectively.
- Because temperatures were relatively mild during most of this winter, aside from peaks set during Winter Storm Elliot, peaks were lower than in most other recent winters.
- Three of the top five peaks this winter occurred on weekend days.

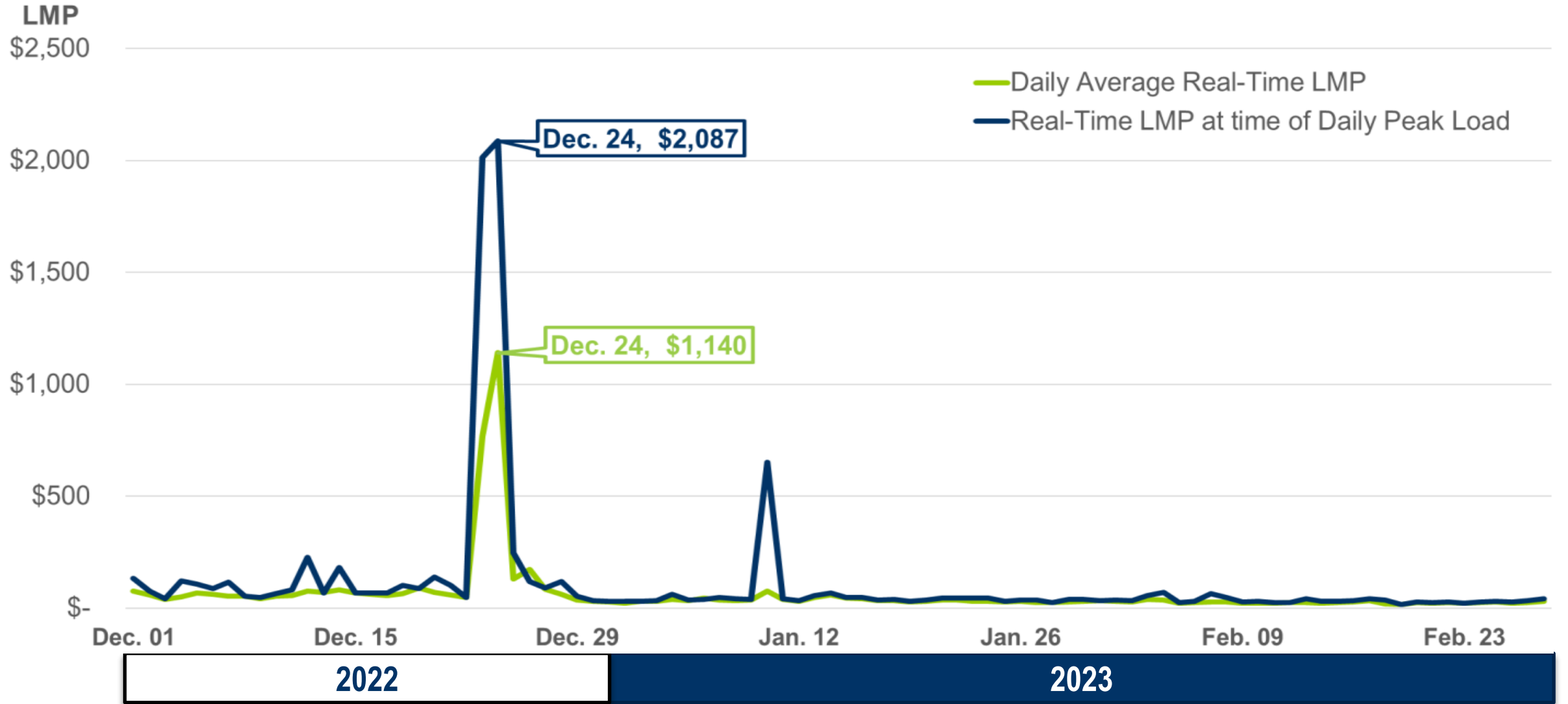
Peak Rank	Date	Hour Ending	Peak
1	Friday, December 23, 2022	19	134,699
2	Saturday, December 24, 2022	9	128,541
3	Friday, February 03, 2023	20	121,278
4	Saturday, February 04, 2023	8	117,702
5	Sunday, December 25, 2022	8	116,828
6	Wednesday, December 21, 2022	8	116,032
7	Monday, December 19, 2022	19	114,590
8	Monday, December 26, 2022	19	114,507
9	Tuesday, December 20, 2022	8	113,502
10	Thursday, February 02, 2023	8	112,739



- The following two slides show the daily average LMP and the LMP at the time of the daily load peak, and the historic monthly average LMPs, respectively. Following this is a slide showing hourly LMPs through Winter Storm Elliott.
- LMPs were driven higher in December due to Winter Storm Elliott and corresponding higher natural gas prices.
- LMPs fell in January and February due in large part to lower natural gas prices.



# Daily Average and Peak Real Time LMPs



Average LMP

\$140

\$120

\$100

\$80

\$60

\$40

\$20

\$-



2013/14 2014/15 2015/16 2016/17 2017/18 2018/19 2019/20 2020/21 2021/22 2022/23

\$73

\$44.68

\$26.16

\$29.33

\$46.66

\$30.17

\$21.31

\$29.79

\$50.30

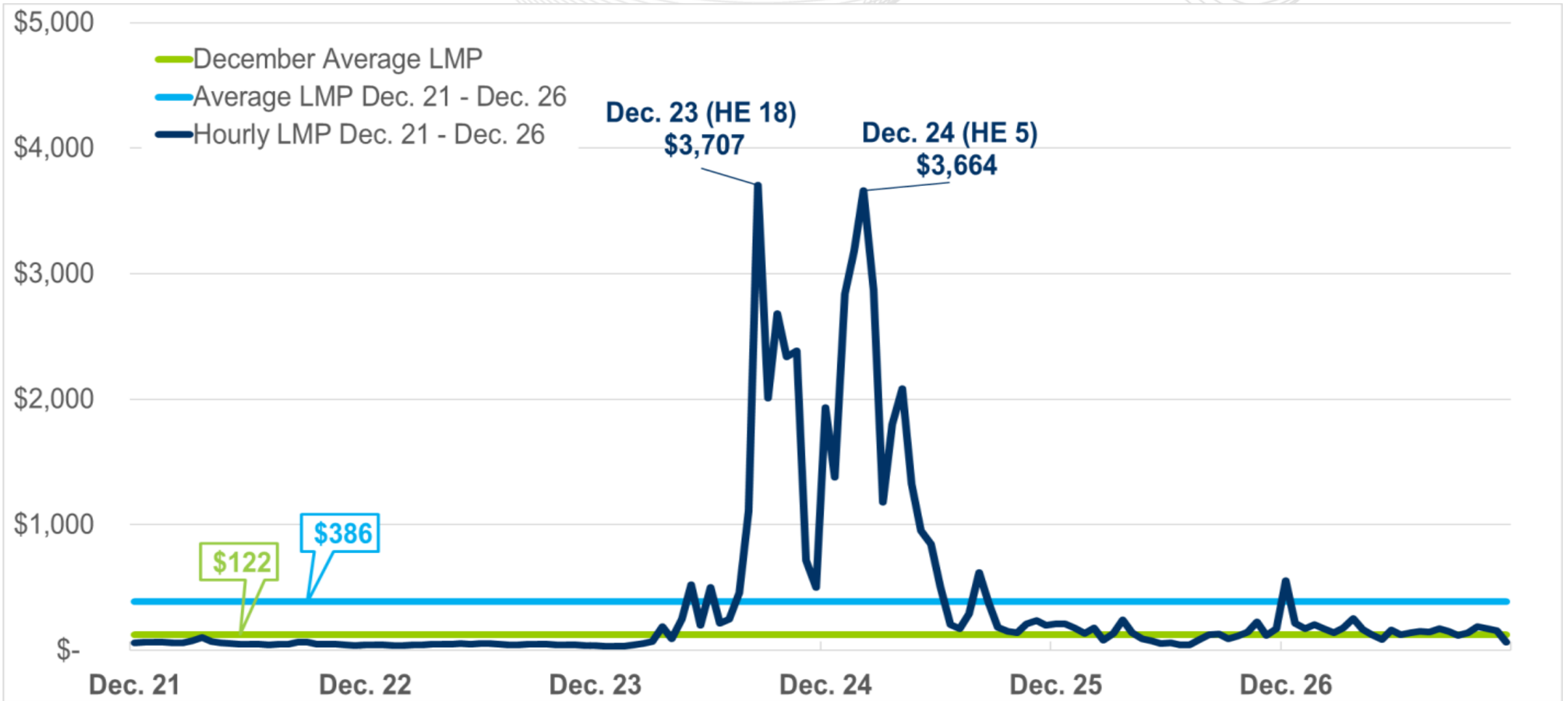
\$62.12

◇ Polar Vortex

◇ All-time Winter Load Peak

◇ Cold Snap

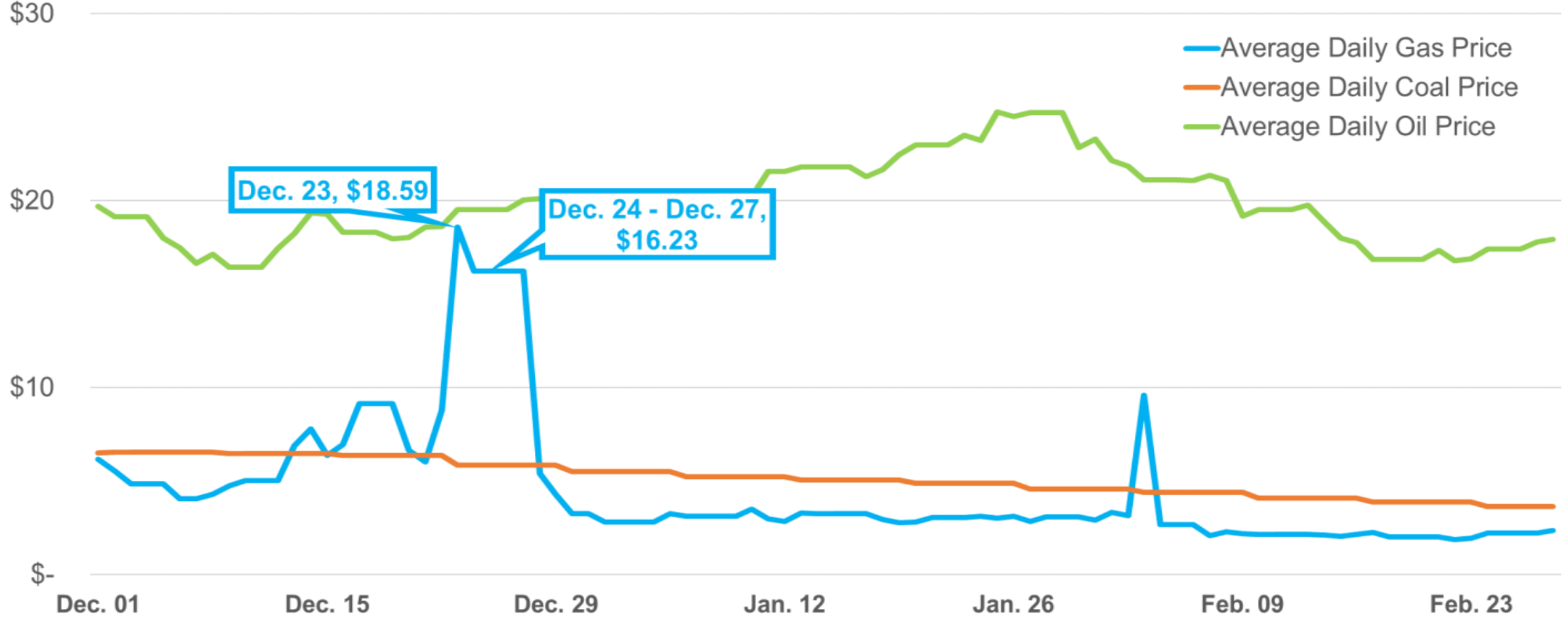
◇ Elliott





- The following slide shows the daily average fuel prices.
- These fuel prices are straight averages of a selection of representative fuel pricing hubs in PJM's footprint. Averages are not load-weighted.
- Winter Storm Elliott contributed to high natural gas prices in December level and if those days are removed from consideration, the average price was under \$6.
- Natural Gas prices in January and February averaged closer to \$3, less than half of the prices seen in December. Natural gas prices were lower due to mild weather and higher inventory levels.

\$/mmbtu



2022

2023

- The following slides show uplift for this winter and for the past nine winters, respectively.
- 2013/14, the winter of the Polar Vortex, is not shown on this graph because the magnitude of uplift that year was significantly higher than any subsequent year. Uplift totaled over \$750 million that winter.
- During this winter, 77% of all uplift dollars accrued in December, 65% during Winter Storm Elliot (12/21 to 12/26) and 57% on December 24<sup>th</sup> and 25<sup>th</sup>.

Millions

\$30

\$20

\$10

\$-

Dec. 01

Dec. 15

Dec. 29

Jan. 12

Jan. 26

Feb. 09

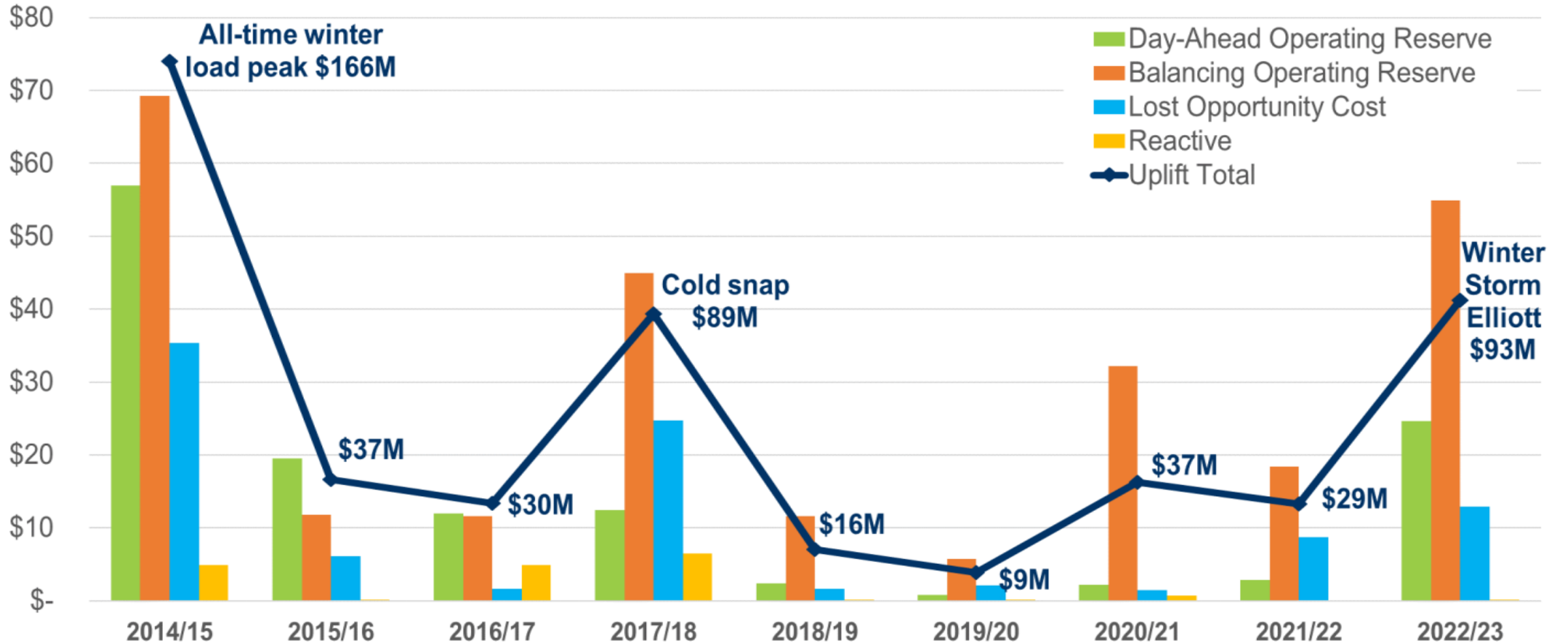
Feb. 23

2022

2023

- Day-Ahead Operating Reserve
- Balancing Operating Reserve
- Lost Opportunity Cost
- Reactive

Millions



# Operations

Emergency Procedure	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
100% Spinning Reserve - RTO and/or MAD	5	5	10	3	4	8	2	2	9
High System Voltages	7	18	6	0	0	3	0	2	0
Minimum Generation Alert	4	13	3	0	1	0	0	0	0
Manual Load Dump Warning or Action	1	0	0	0	0	0	0	0	0
Cold Weather Alert - Any Region	26	2	2	14	8	1	4	7	5
<b>Total</b>	<b>43</b>	<b>38</b>	<b>21</b>	<b>17</b>	<b>13</b>	<b>12</b>	<b>6</b>	<b>11</b>	<b>14</b>

- Over half of all of this winter’s Emergency Procedures occurred in December.
- Overall, pipelines performed very well during the winter season with no major issues to report, except during Winter Storm Elliott.

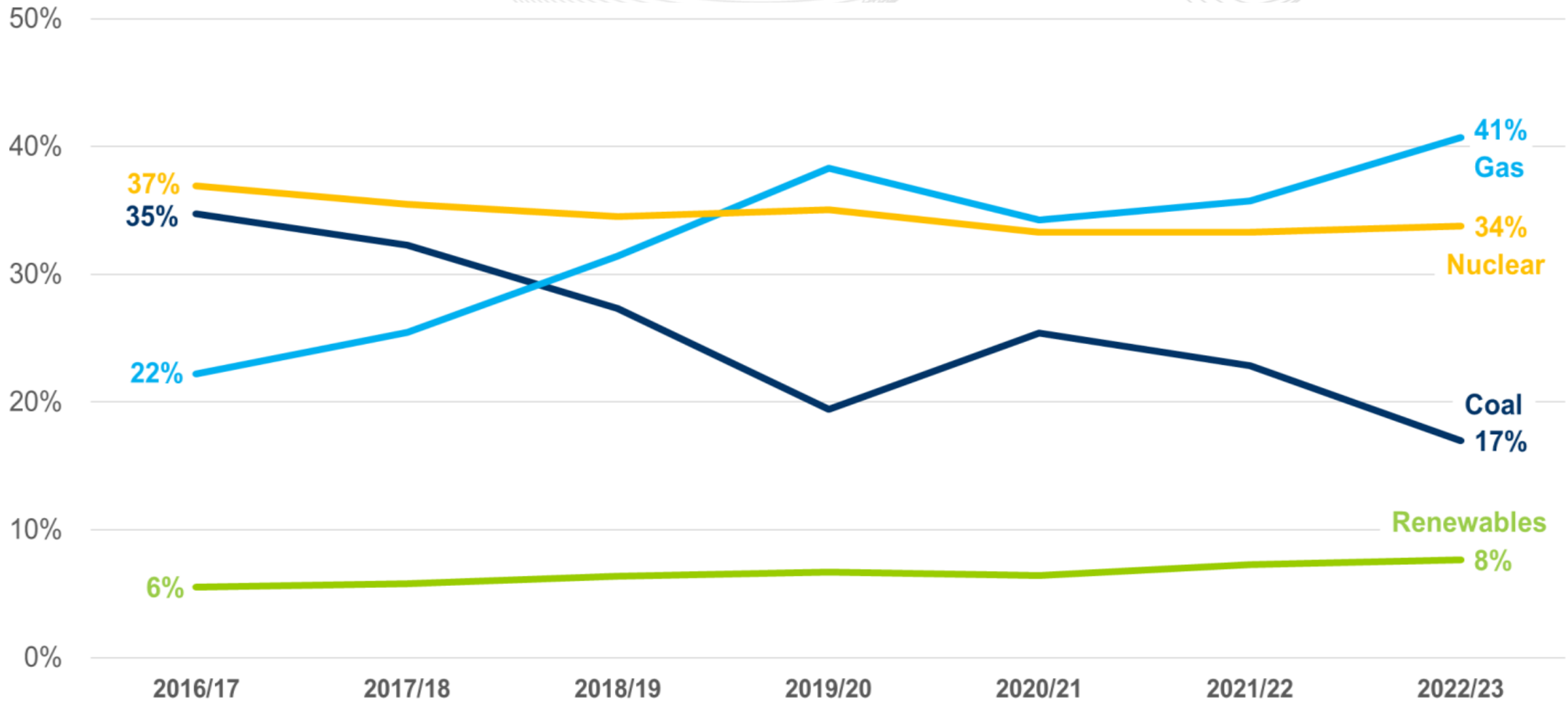
- Winter Storm Elliott resulted in an unprecedented loss of natural gas production in the northeast Appalachian basins. Daily production dropped by nearly 30% or approximately 10 to 11 bcf (billion cubic feet) per day.
- Historically, since the advent of Marcellus and Utica shale gas production in 2007, typical production losses during similar cold weather events have led to production losses of around 2 to 3 bcf/day.
- The loss of gas production beginning on December 23<sup>rd</sup> caused downstream impacts on the interstate pipelines resulting in gas nomination reductions and lower pipeline pressures in portions of the pipeline network. Additionally, the Texas Eastern pipeline experienced the failure of three compressor stations during this period, two in Ohio and one in Pennsylvania. This loss of compression tended to exacerbate the supply and pressure reductions.
- Since December, with the exception of the brief outlier spikes at the beginning of February, spot natural gas prices have trended downwards as the winter progressed on strong gas production and storage fundamentals along with much above average temperatures across the PJM footprint.



- The following slides show the fuel mix of on-line generation for the past seven winters for all hours. Following that is a slide showing average wind and solar output for all winter hours. The fuel mix during daily peak hours was not materially different than the mix during all winter hours.
- Coal's share of the on-line fuel mix decreased from last winter, while natural gas had a corresponding increase.
- The share of nuclear generation and renewables remained consistent from last winter.

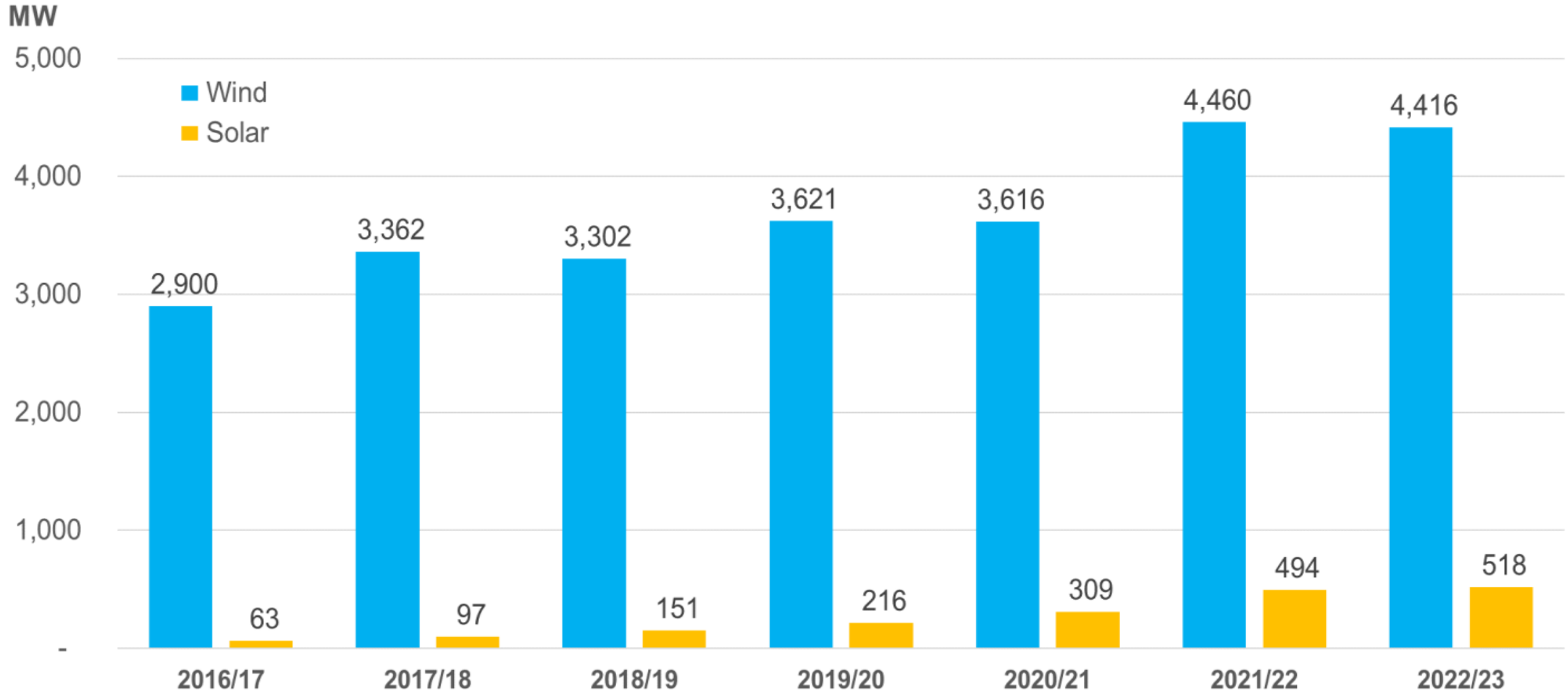


# Historic Online Fuel Mix for All Winter Hours



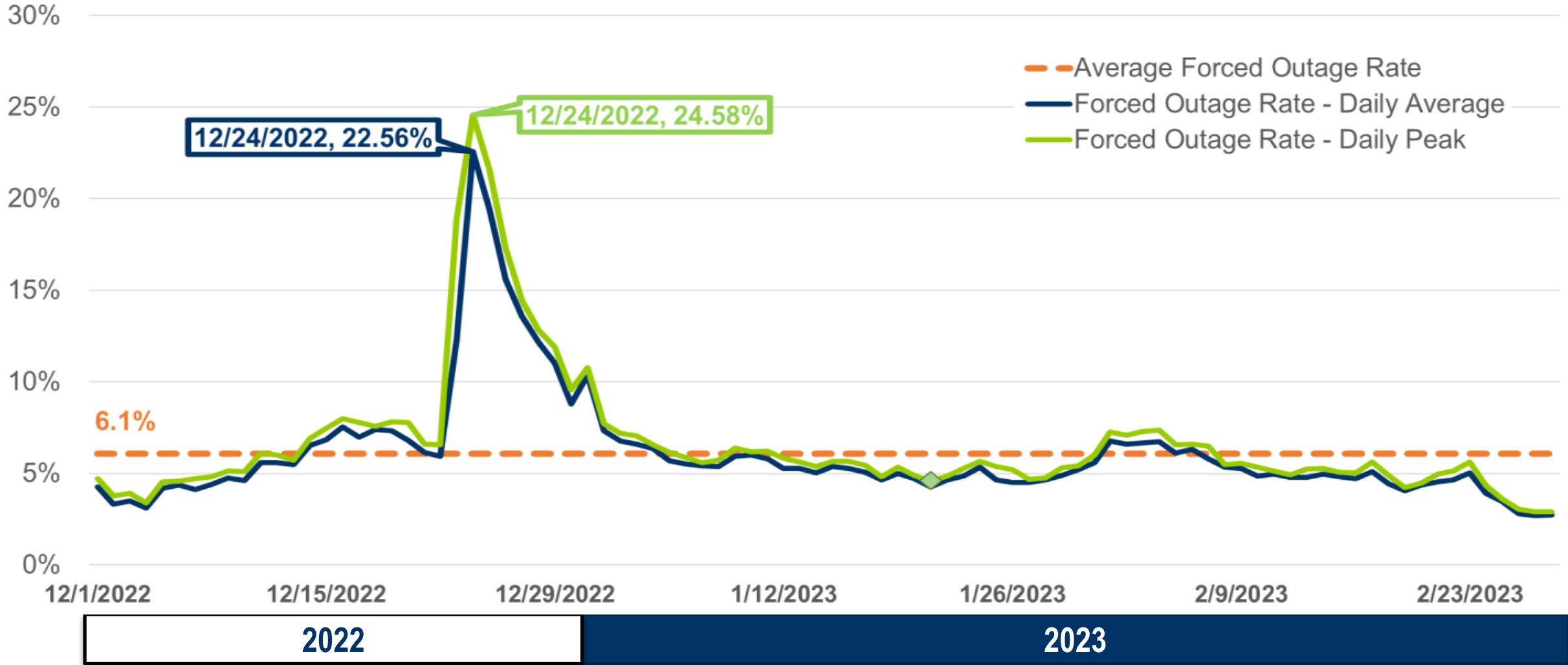


# Renewable Average Output for all Winter Hours

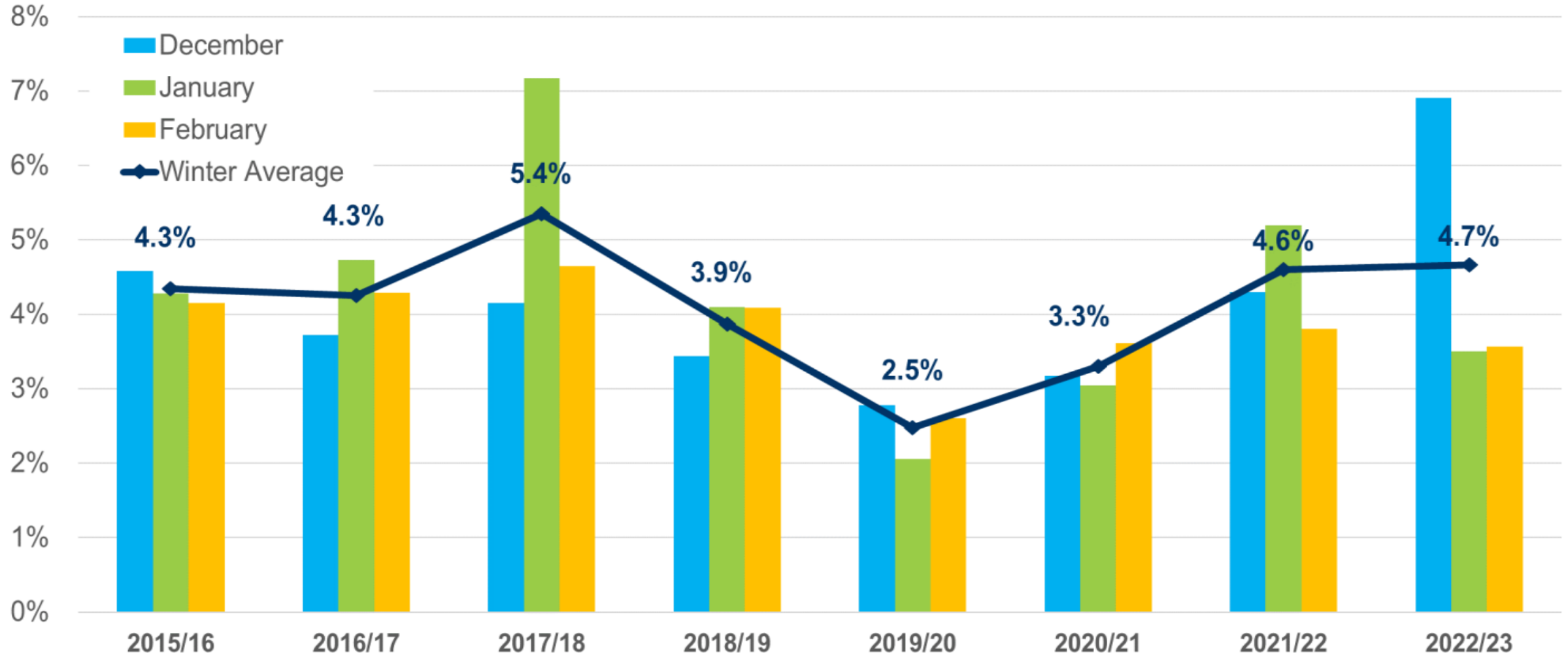


- The following slides show the daily average and daily maximum forced outage rates, as well as the historic average forced outage rates, respectively.
- The daily data is sourced from eDART, however, historical data is from GADS.
- Daily peak forced outage rates may be different than values previously posted due to subsequent changes to eDART tickets.
- The GADS winter forced outage rate is in line with last winter due to lower than average forced outage rates in January and February.

## Forced Outage Rate



Avg. Forced Outage Rate



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## Winter Operations Report



### Member Hotline

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POWER GRID  
THINK BEFORE  
YOU CLICK!**



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malicious  
phishing emails.

**Report suspicious email activity to PJM.**  
(610) 666-2244 / [it\\_ops\\_ctr\\_shift@pjm.com](mailto:it_ops_ctr_shift@pjm.com)

