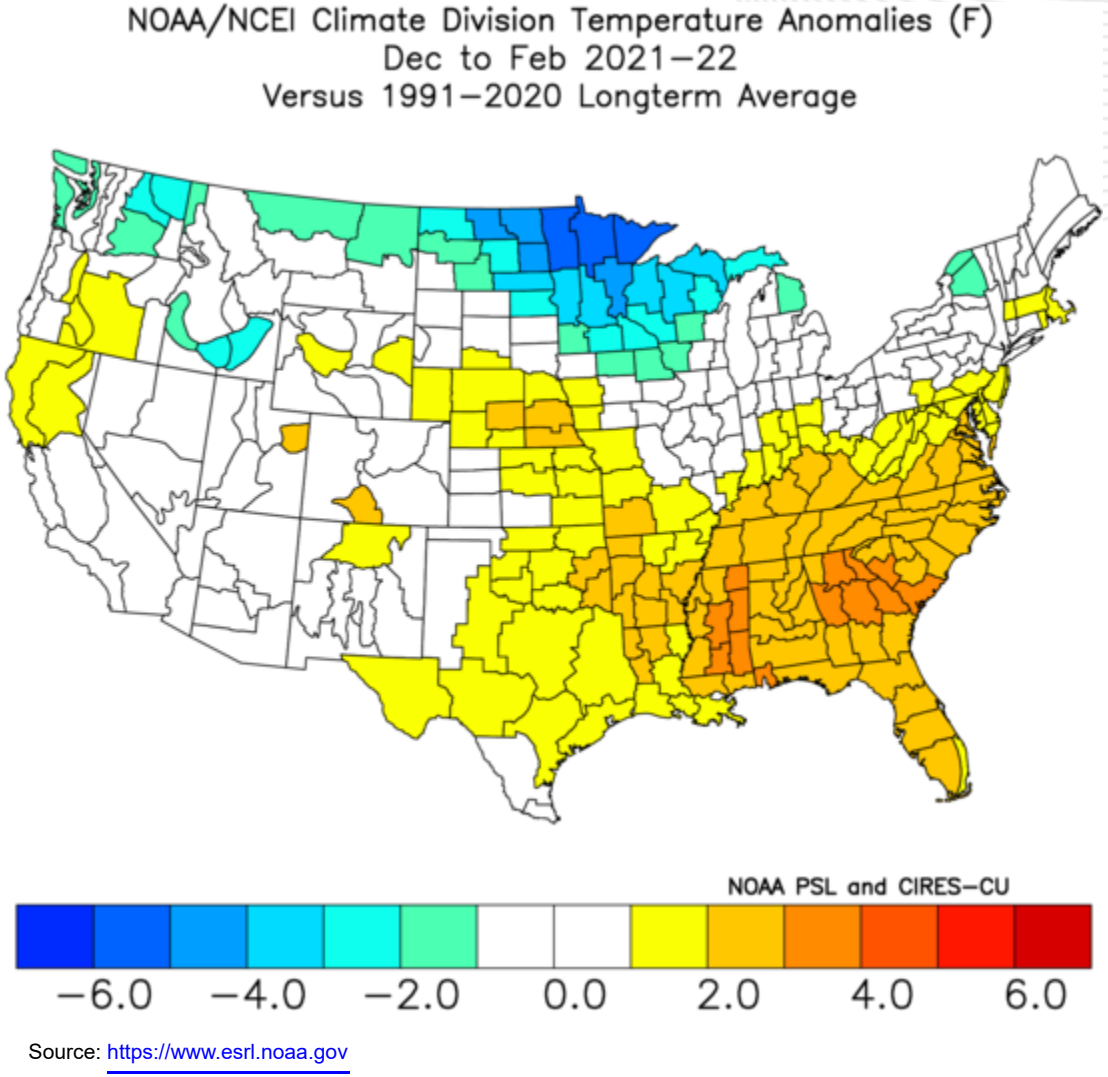
Winter Operations of the PJM Grid: December 1, 2021 – February 28, 2022

Operating Committee

April 14, 2022

Winter 2020/21 Overview

Average Temperature Dec. 1 – Feb. 28



Source: https://www.esrl.noaa.gov

- Overall, temperatures approached average this winter.
- December ranked in the top three warmest Decembers for almost every state in the PJM footprint.
- A below-average January followed, with all 7 of the winter's Cold Weather Alerts occurring in that month.

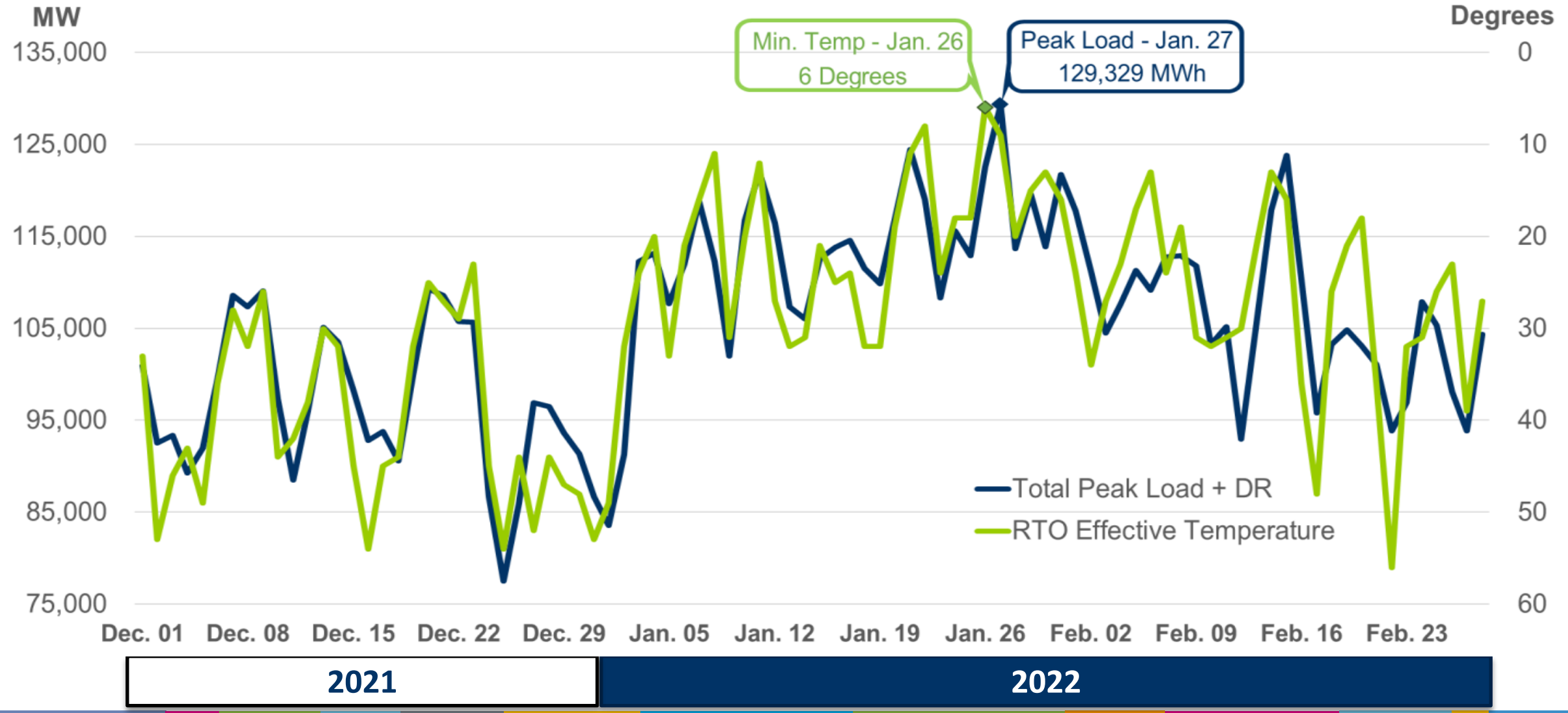
January 15-17, 2022 - MLK Holiday Weekend

- Winter Storm “Izzy” moved through PJM during the MLK Holiday weekend and included freezing rain events that impacted VA and MD, as well as states south of PJM.
- Overall, PJM performed well in balancing load and generation while managing constraints on the system.
- With the storm came temperature forecast errors as well as a significant impact on the shape of the load on Sunday the 16th, both causing notable Load Forecast error.
- Load forecast models performed well on the other days.

Daily RTO Peak Load and Effective Temperature

- 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 it's 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.

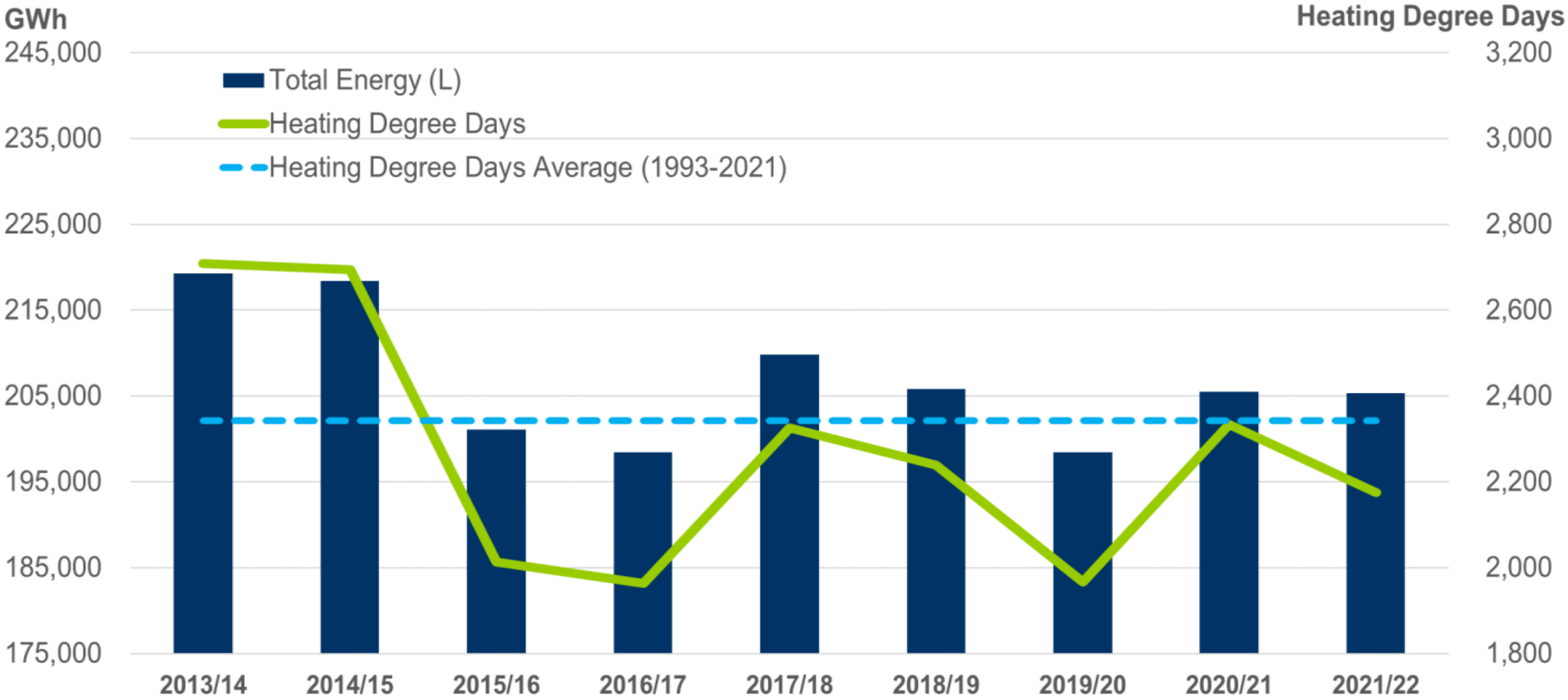
Daily RTO Peak Load and Effective Temperature



Historic Load and Weather

- 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.
- While total energy in 2021/22 overall is very similar to 2020/21, heating degree days are lower indicating a milder winter.
- Despite milder temperatures, Winter 2021/22 utilized as much energy as 2020/21 most likely due to on-going impacts of COVID-19 in 2020/21.

Historic Total Energy and Heating Degree Days



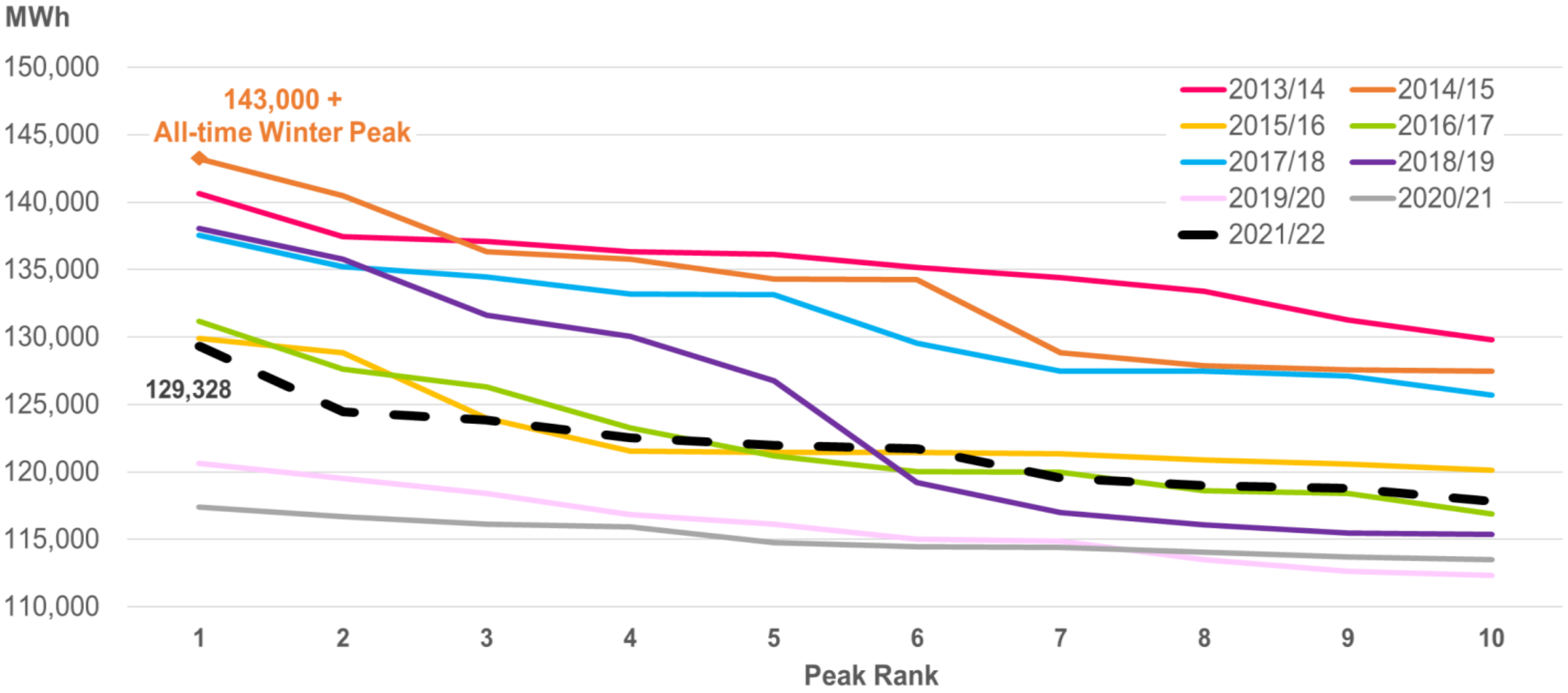
Top 10 Winter Peaks

- The following slides show the top 10 winter peaks for 2021/22 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 this winter, peaks were also lower than in most other recent winters.
- Peaks in the previous two winters are lower than most years due to on-going COVID-19 impacts and mild weather.

Top 10 Winter Peaks – 2021/22

Peak Rank	Date	Hour Ending	Peak
1	Thursday, January 27, 2022	8	129,328
2	Friday, January 21, 2022	9	124,434
3	Tuesday, February 15, 2022	8	123,829
4	Wednesday, January 26, 2022	8	122,547
5	Tuesday, January 11, 2022	9	121,979
6	Monday, January 31, 2022	8	121,700
7	Saturday, January 29, 2022	19	119,570
8	Saturday, January 22, 2022	9	118,998
9	Friday, January 07, 2022	19	118,787
10	Monday, February 14, 2022	8	117,829

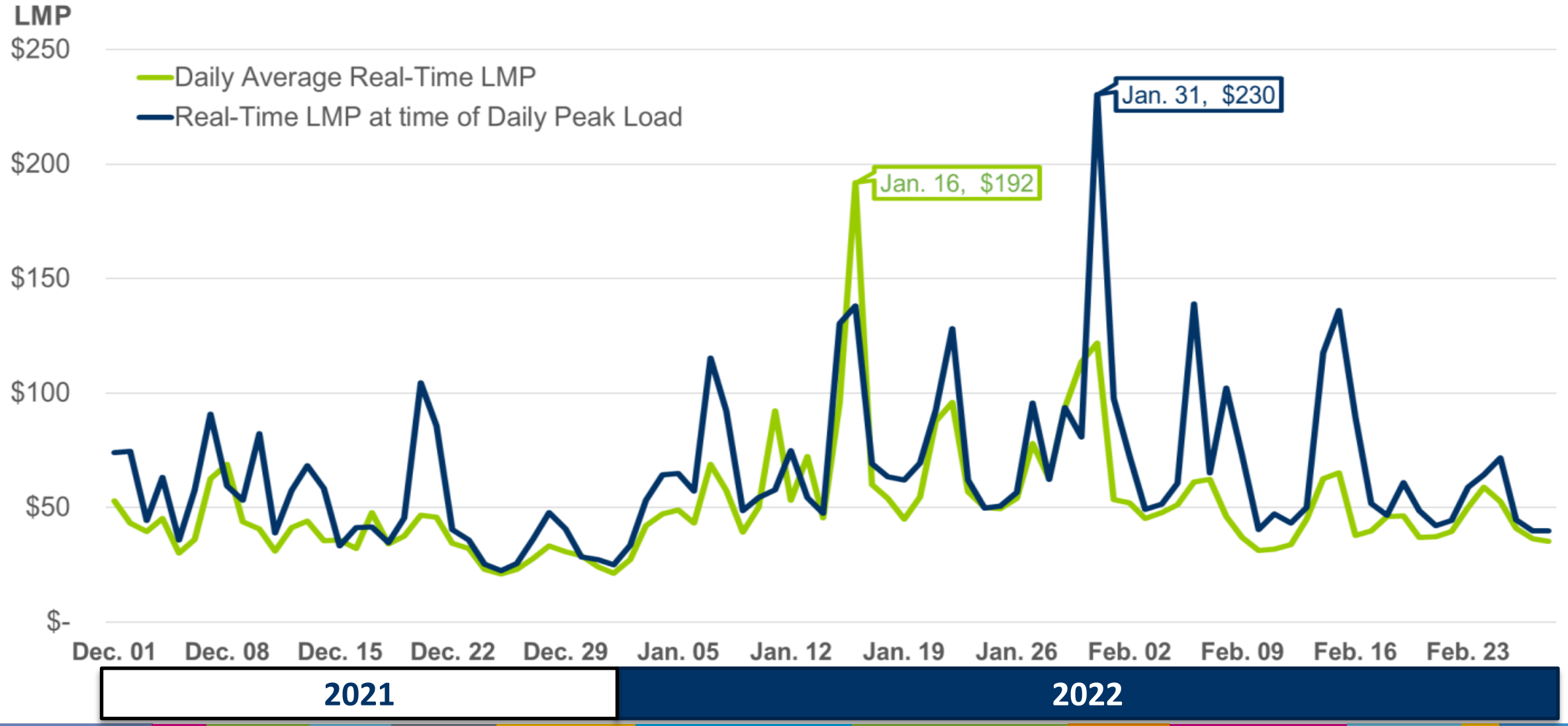
Top 10 Winter Peaks by Year



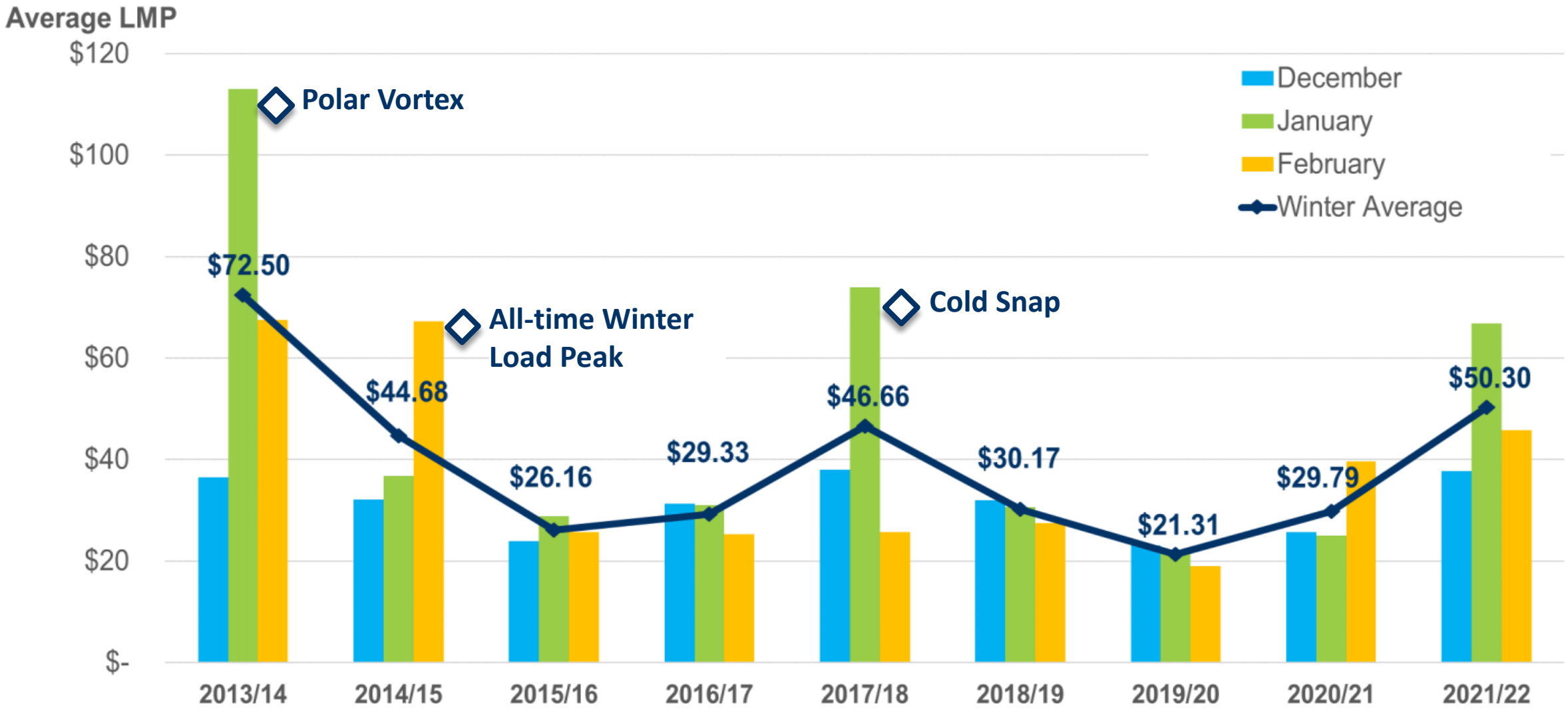
Real Time Locational Marginal Prices

- 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.
- LMPs were driven higher this winter than in recent winters due to higher natural gas prices.
- LMPs were highest in January when temperatures were at their lowest and natural gas prices were at their highest.

Daily Average and Peak Real Time LMPs



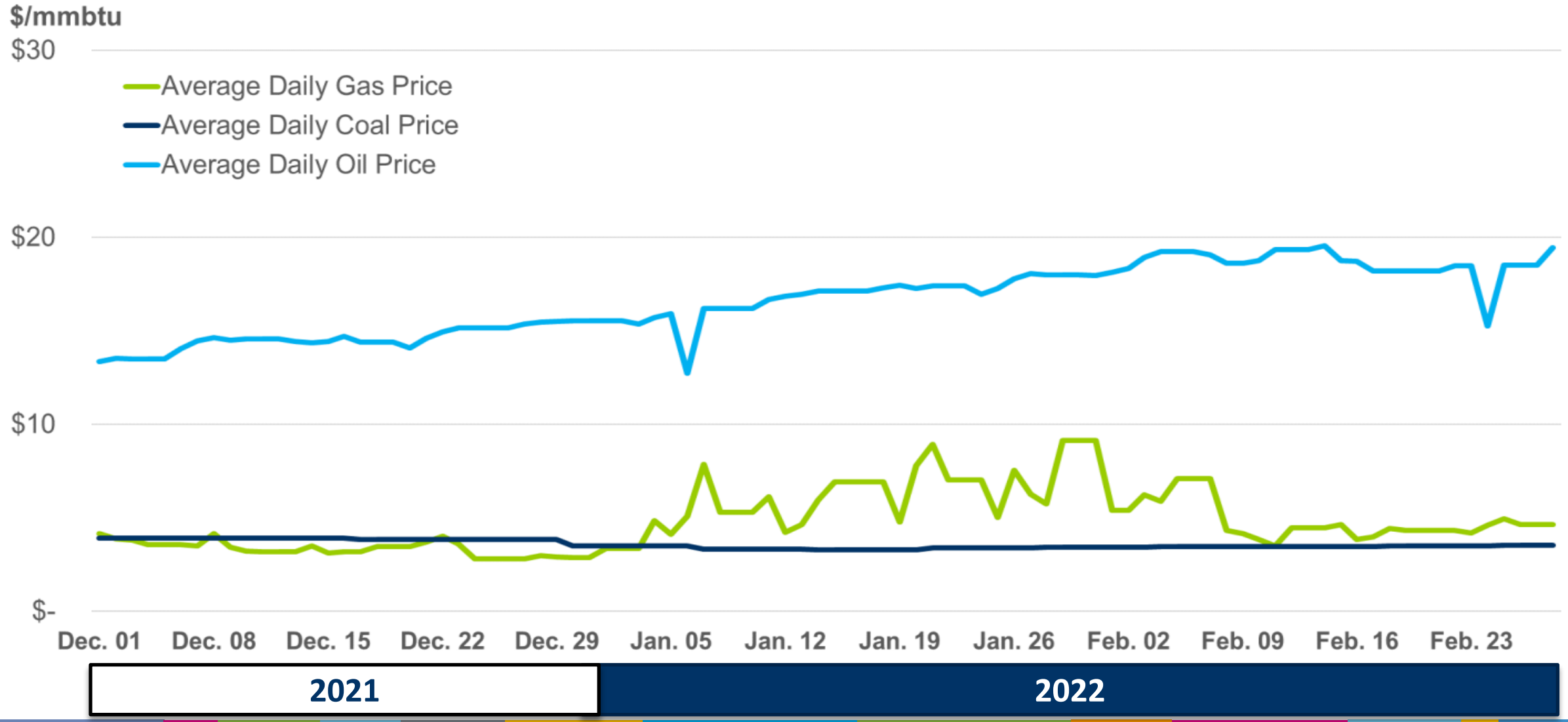
Historic Winter Average Real Time LMPs



Fuel Prices

- 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, nor are they meant to represent the price that any particular market participant may have experienced.
- Natural Gas Spot and Futures prices are generally double what they were compared to 12 months ago, primarily due to higher demand and lower storage levels. However, for context, prices last year and the prior year were also abnormally low compared to historical levels.

Average Fuel Prices

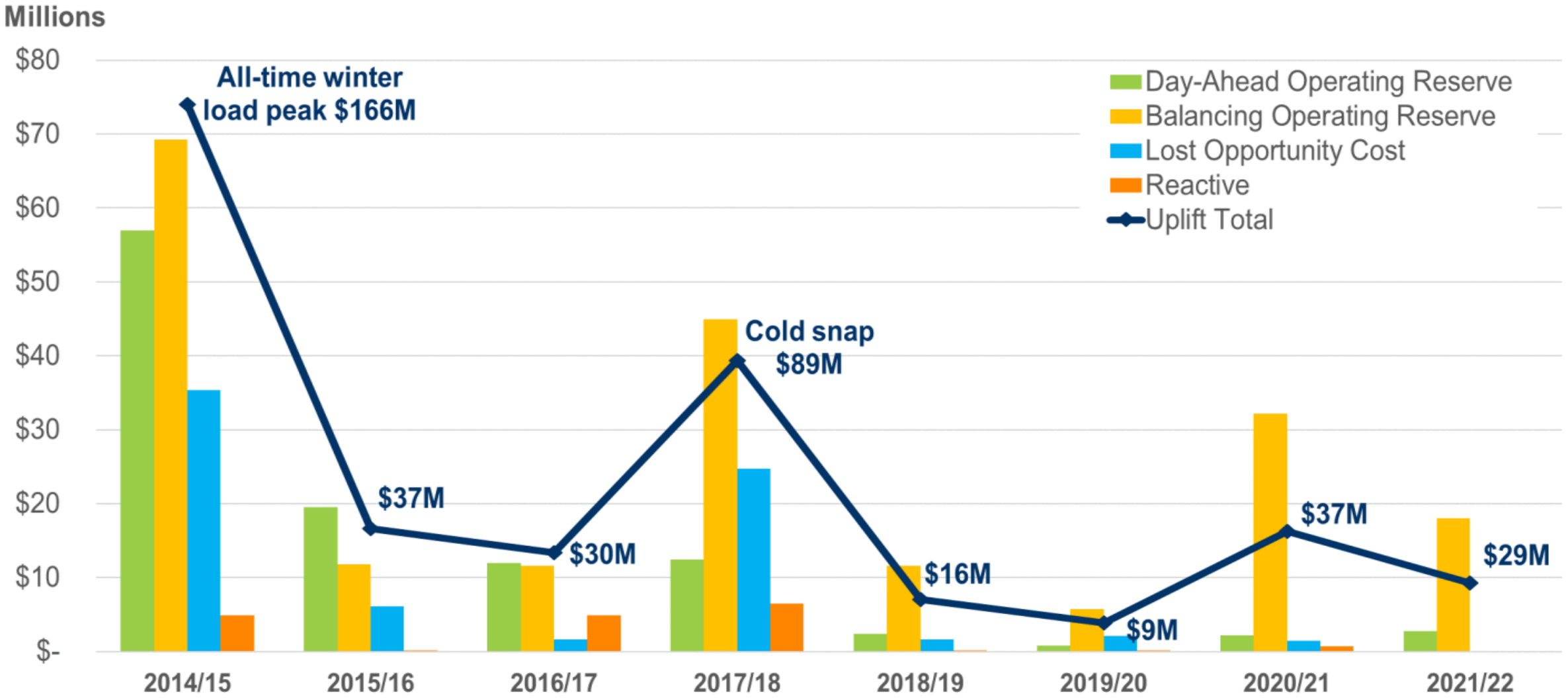


Fuel Price Source: S&P Global Platts

Winter Uplift

- The following slide shows uplift for the past eight winters.
- 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.
- Interface constraints, as well as generally more active constraints due to cold weather, contributed heavily toward the higher uplift as units were put on and kept on for constraint control.

Winter Uplift



Illinois Climate and Equitable Jobs Act

- Public Act 102-0662, which includes the Energy Transition Act and related legislation (the “Act”), was enacted by the Illinois General Assembly with an effective date of September 15, 2021.
- The Act includes a number of provisions that seek to phase out carbon emissions and other pollutants from fossil fuel-based electricity generation.
- The Act also establishes a ceiling for a broad range of pollutants emitted from privately owned, natural gas-fueled electricity generation. Additionally, the Act includes provisions by which individual generators can be granted limited and temporary exceptions to the emissions ceiling if they are deemed necessary to maintain the reliability of the bulk electric system.
- The Act preserves PJM’s ability, as the RTO serving northern Illinois, to call upon emission-limited generators within its footprint to produce electricity necessary to maintain the reliability and stability of the grid.
- The following guidance was developed in coordination with the Illinois EPA to help provide additional clarity on the CEJA legislation. PJM continues to work with the Illinois EPA and Governor’s office to ensure the reliability of the Illinois area and PJM RTO.

https://www.pjm.com/-/media/committees-groups/committees/oc/postings/illinois-ceja-reliability-guidance.ashx

Operations

Emergency Procedures

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

- There were very few Emergency Procedures enacted this winter.
- There were no natural gas pipeline conditions that had significant impacts on Winter operations in the PJM system.

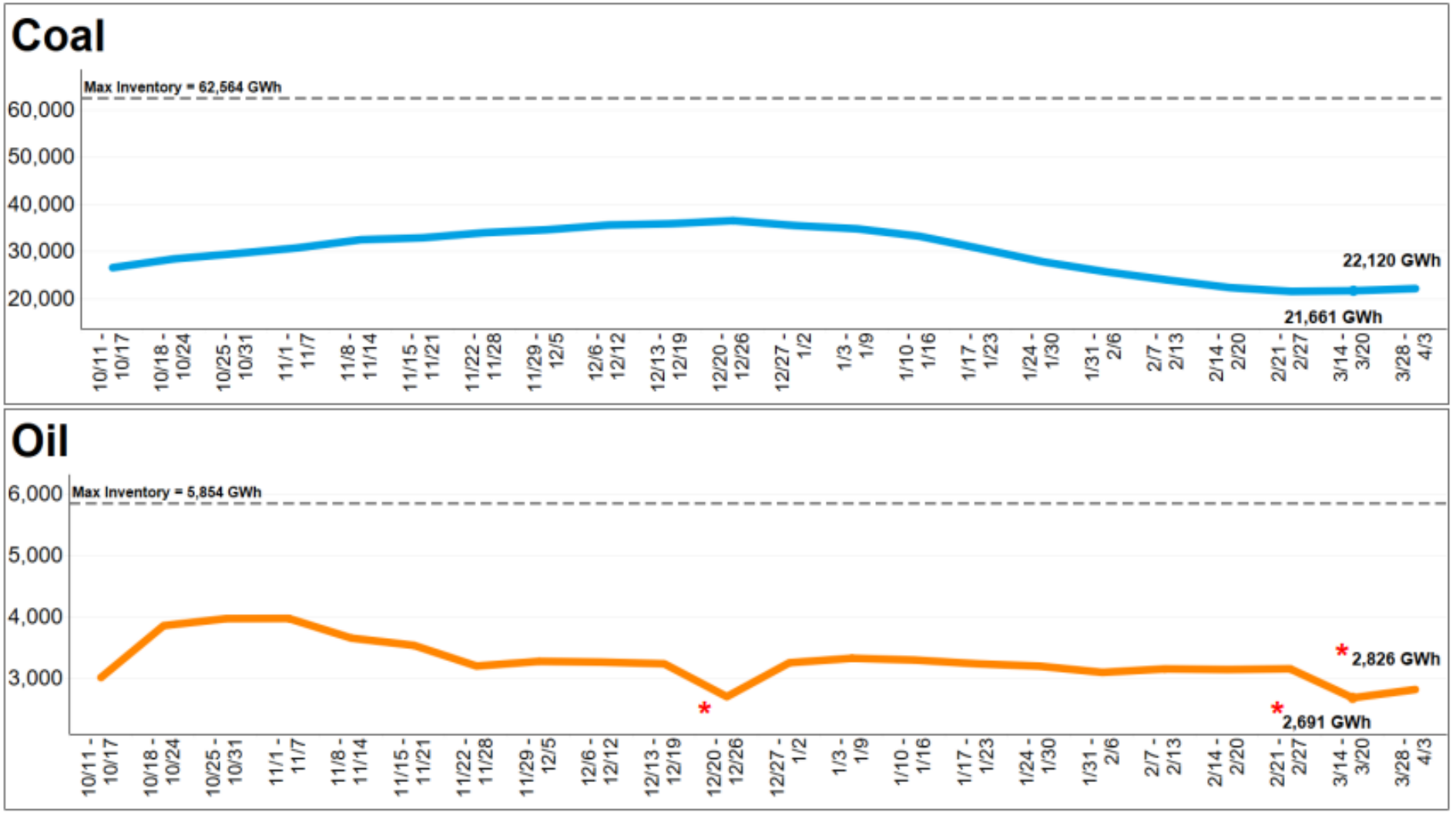
Gas Pipeline Conditions

- Pipeline operations remained relatively strong throughout the winter with no significant disruptions.
- Operational Flow Orders and Ratable Take Requirements continue to be highly utilized by the pipelines to maintain operational integrity and daily balancing.
- Well freeze-offs did occur in the southwestern U.S. during portions of February, but resulted only in a limited reduction in output.
- Production in the PJM footprint (Marcellus and Utica shale regions) remained very strong.

Fuel Inventory Data Request

- Generation resources communicated existing and future supply and delivery concerns with fuel and non-fuel consumables in Fall 2021.
- PJM issued a weekly data request to coal and oil resources (including dual-fuel units) with a focus on fuel and non-fuel consumable inventories as well as remaining run hours for operation planning purposes and situational awareness.
- Overall there were no major concerns with coal and oil inventories in PJM.
  - Coal inventory levels experienced a downward trend through the peak of winter due to increased coal operations driven by commodity prices and challenges with supply and deliveries.
  - Oil inventory levels remained stable throughout the winter.

Fuel Inventory Survey

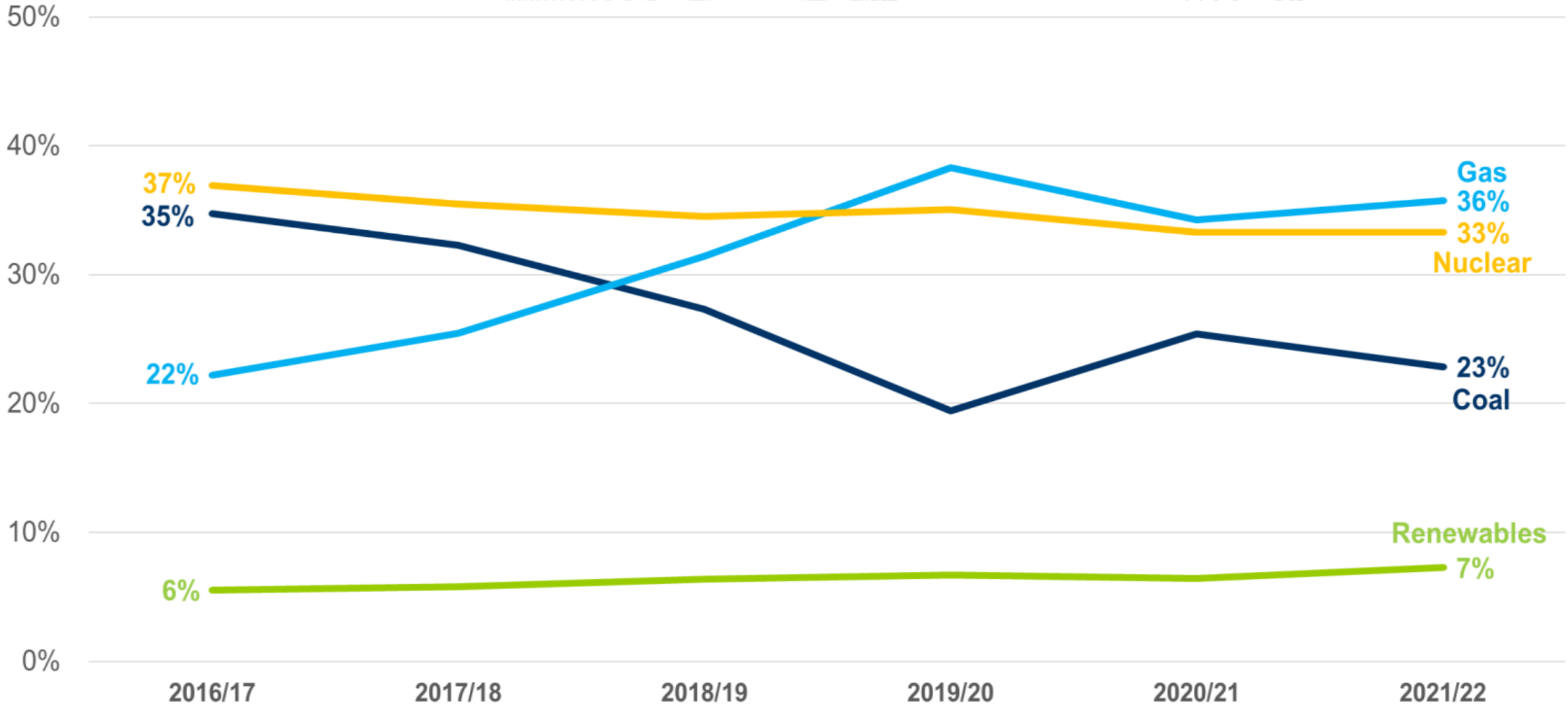


*** A lower oil unit response rate in these weeks impacted the reported inventory level. Values reported reflect data only from units that responded to the survey request.**

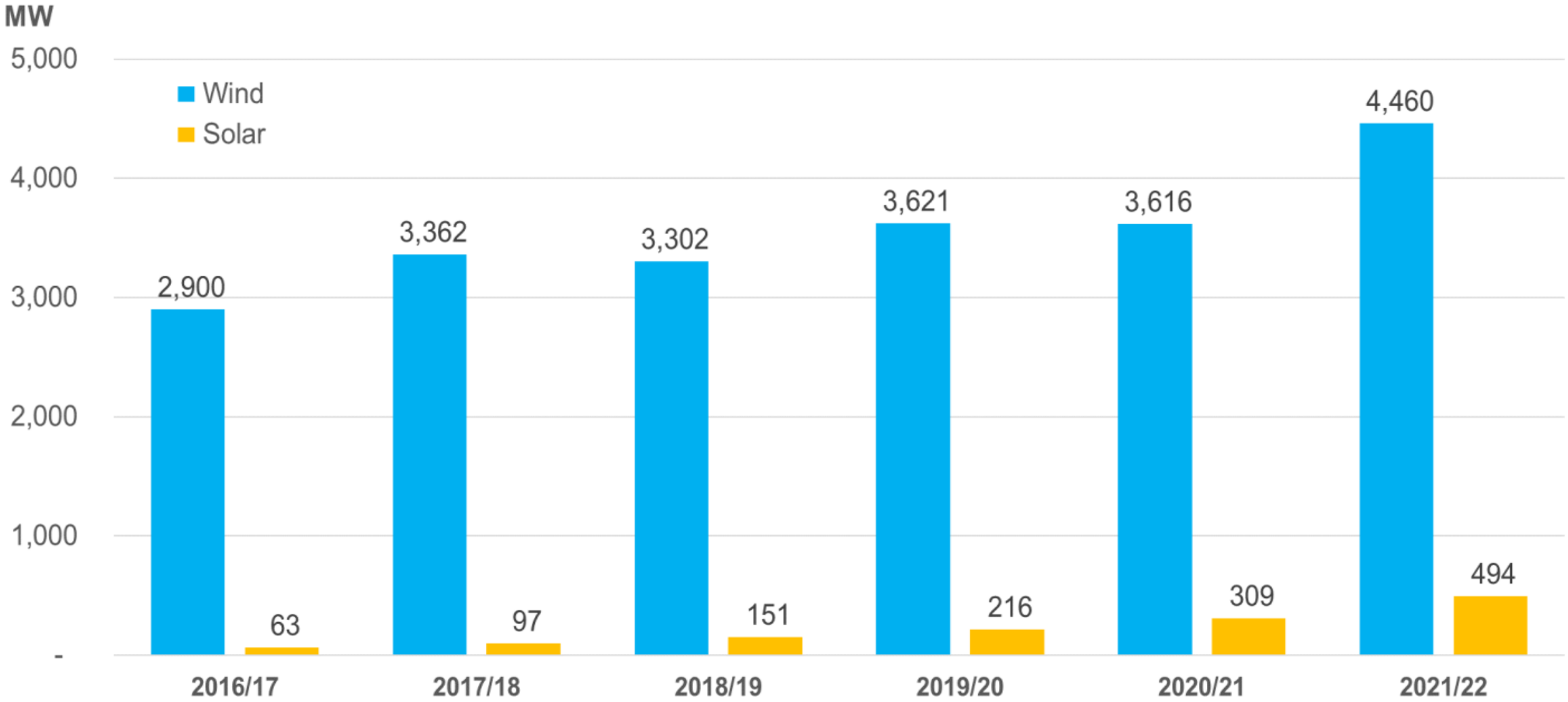
On-line Generation

- The following slides show the fuel mix of on-line generation for the past five winters for all hours. Following that is a slide showing average wind and solar generation for all winter hours.
- Coal's share of the on-line fuel mix decreased from last winter, while natural gas and renewables increased their shares.
- The share of nuclear generation remained consistent from last winter.

Historic Online Fuel Mix for All Winter Hours



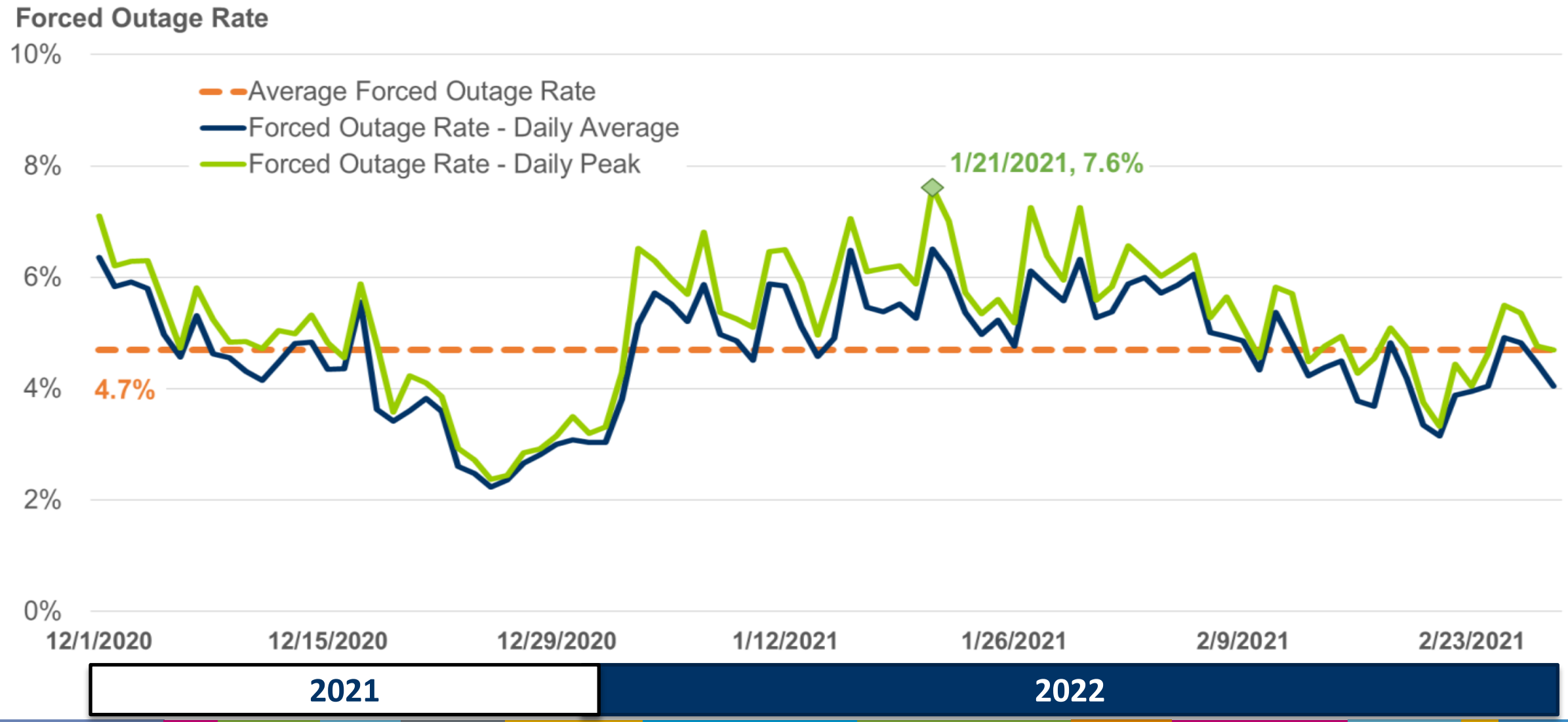
Average Renewable Generation for all Winter Hours



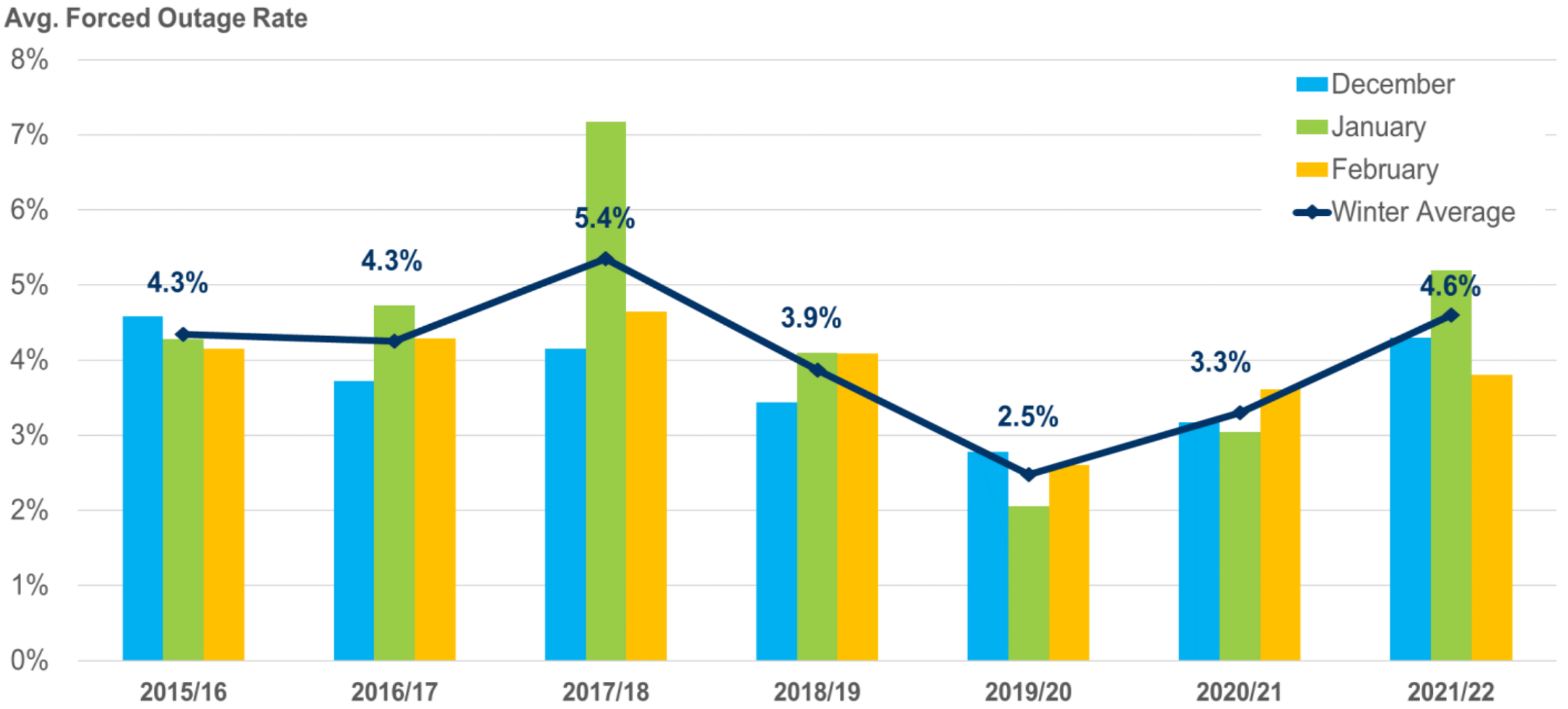
Forced Outage Rates

- 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.
- Both eDART and GADS report an overall winter forced outage rate of approximately 4.6% to 4.7%.

Daily Forced Outage Rates - eDART



Historical Forced Outage Rates – GADS



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