MISO January 30-31 Maximum Generation Event Overview

February 27, 2019

Purpose & Key Takeaways

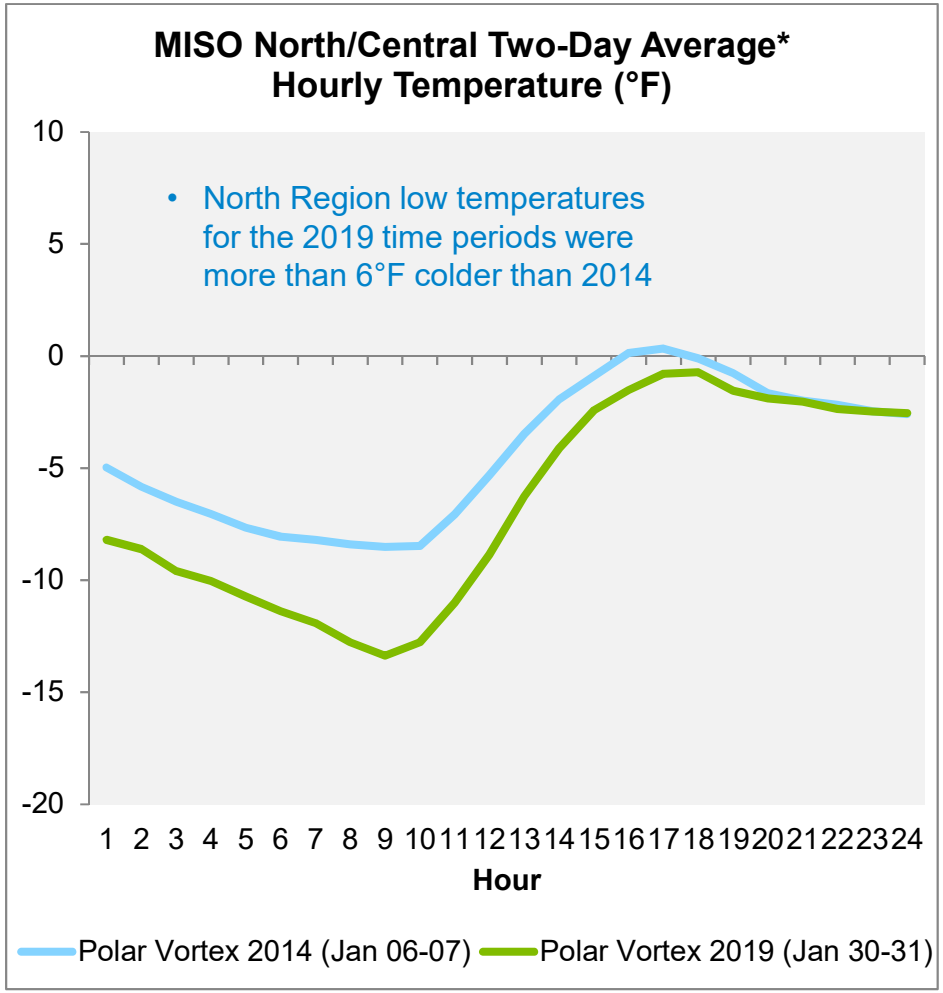
Purpose:

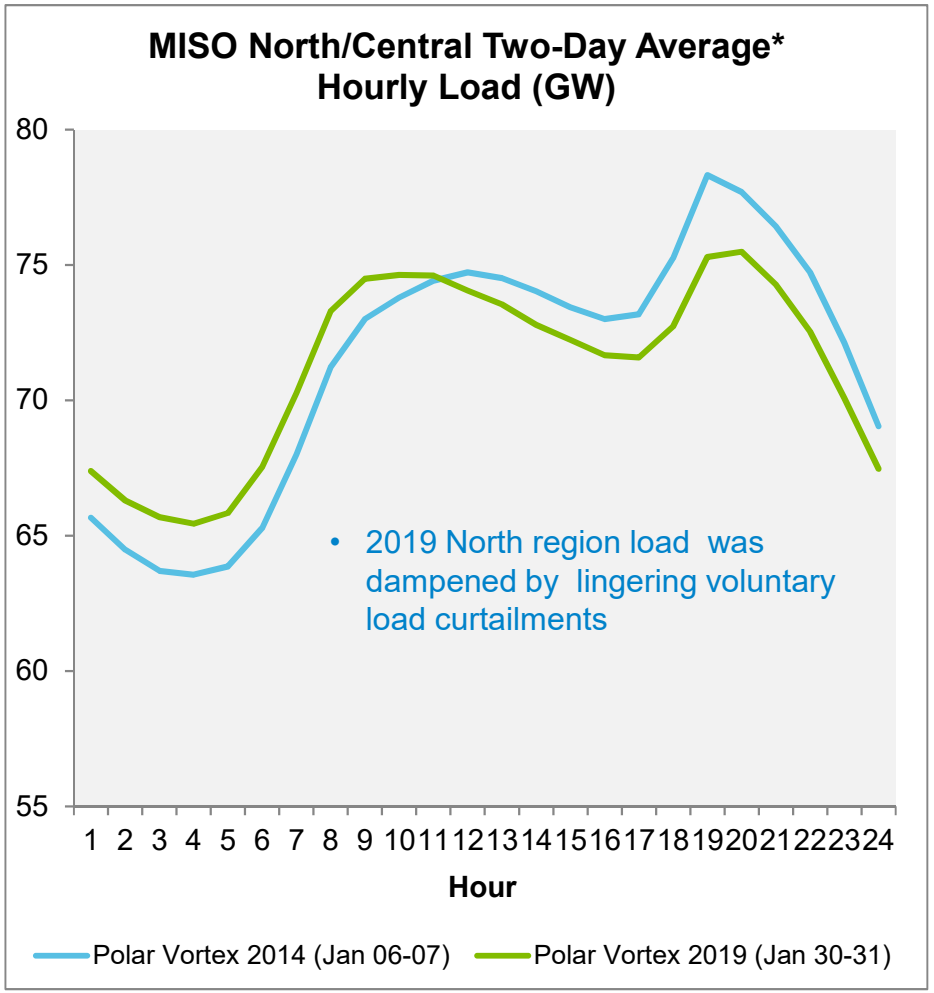
Summary of operations during the January 30 – 31 North and Central Region Maximum Generation Event

Key Takeaways:

- MISO and Members reliably managed operations during extreme cold, where temperatures fell below -30°F in some parts of the North and Central regions
- Resulting high load, unavailable generation, and uncertainty in both load and supply created challenges throughout the event
- Emergency procedures were implemented and maintained from early January 30 through the afternoon of January 31 to reliably manage the grid and maintain public safety
- Winter preparedness by MISO and its members ensured readiness for the extreme conditions, but, we note areas of needed improvement in load and wind forecasting, and voluntary load curtailment impacts

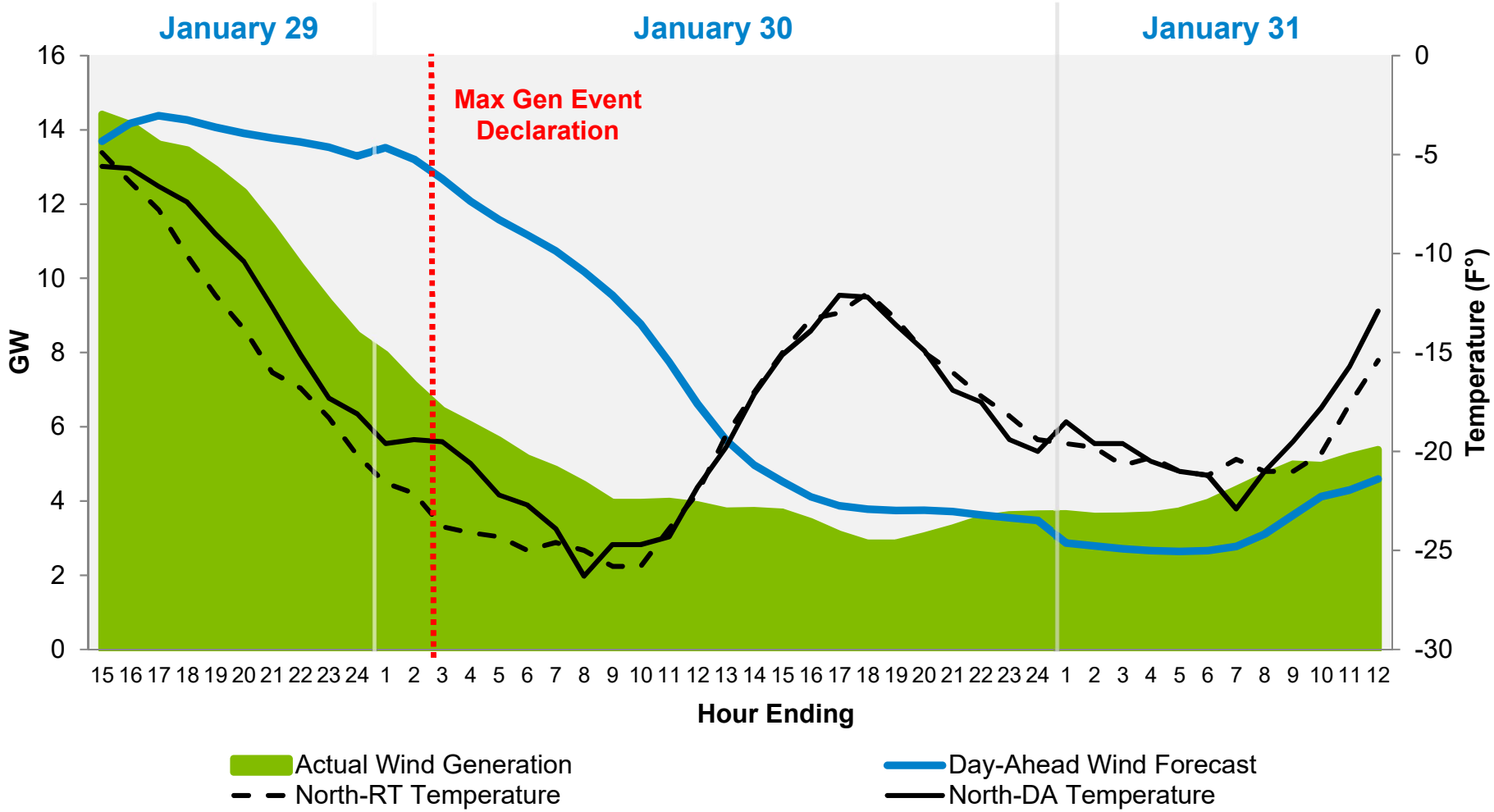
A strong arctic high pressure system brought historic cold to the North and Central Regions on January 30-31, driving temperatures below Polar Vortex 2014 levels



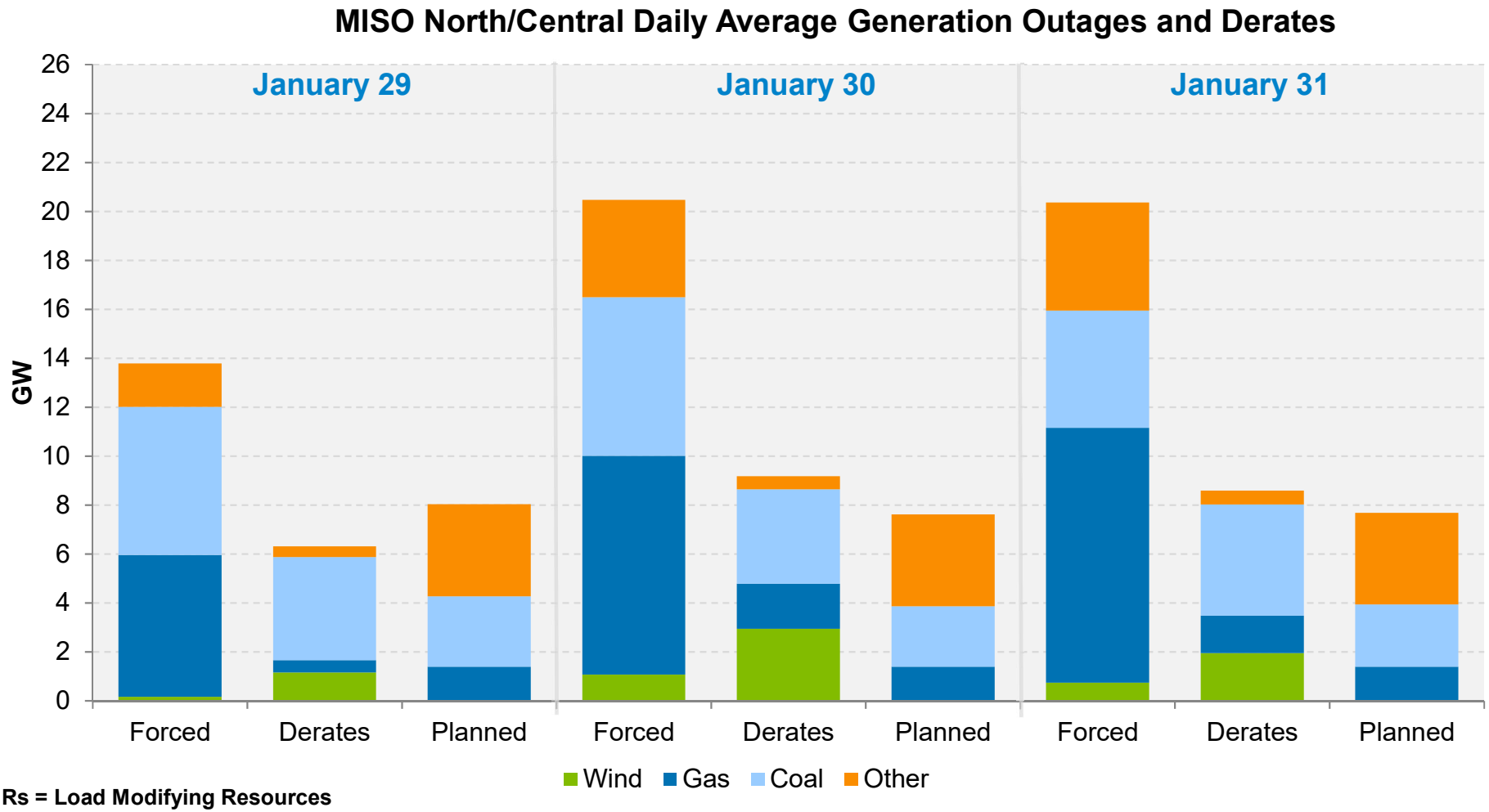


*Average is for the two days listed

An earlier than expected drop in wind, primarily caused by cold weather cutoffs, increased risk of insufficiency for morning peak, triggering Max Gen Event Step 1a, effective for 0500 EST



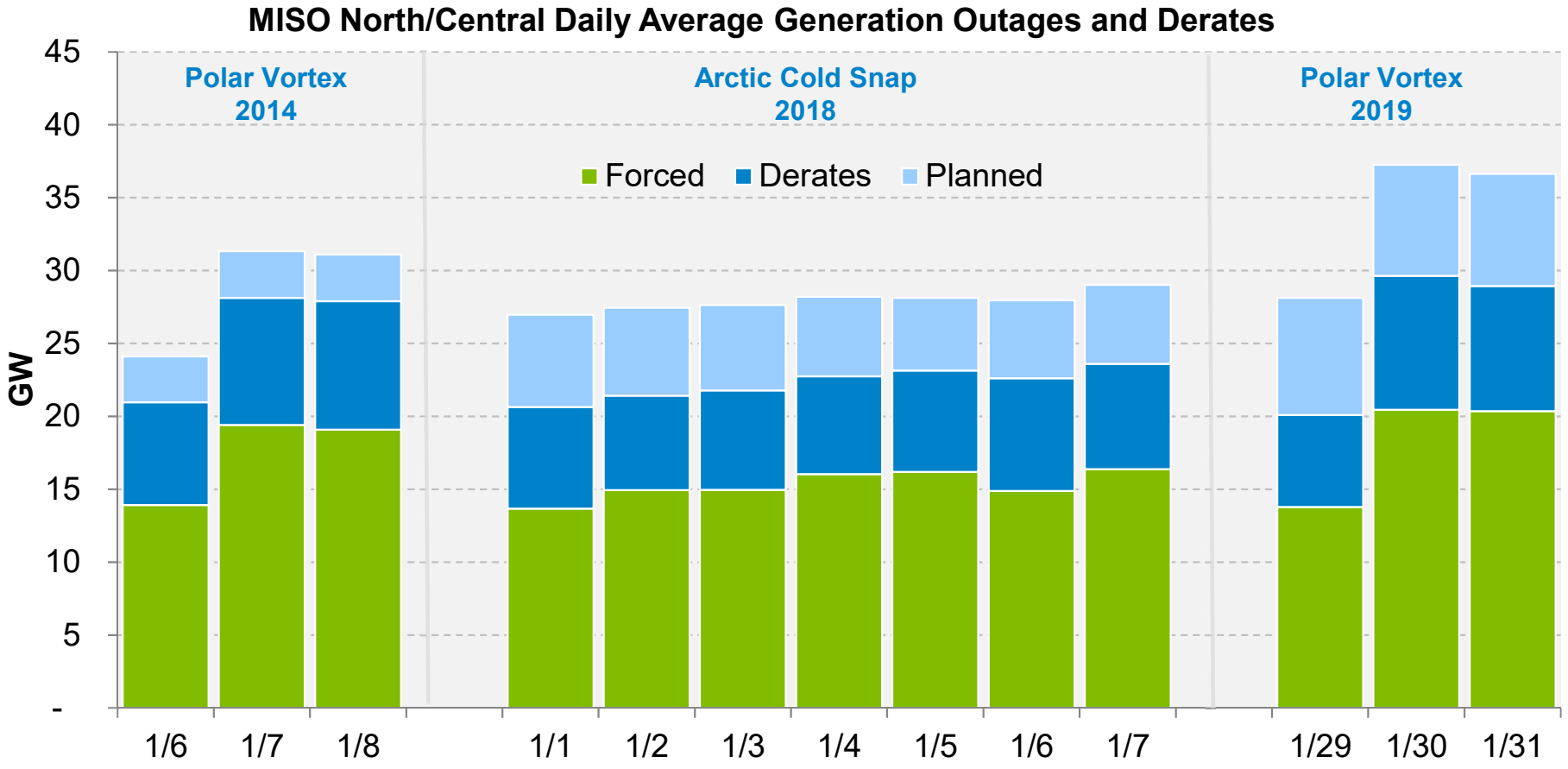
Subsequent forced conventional generation outages, as well as load forecast uncertainty and potential of additional outages, prompted a Max Gen Event Step 2a/b to access LMRs



LMRs = Load Modifying Resources

The outage chart reflects the data as it resided in the CROW Outage system on Feb 11, 2019
Wind often reported as derate over the time period

Total outages were higher than previous cold weather events with approximately 25% unavailable due to unplanned outages*



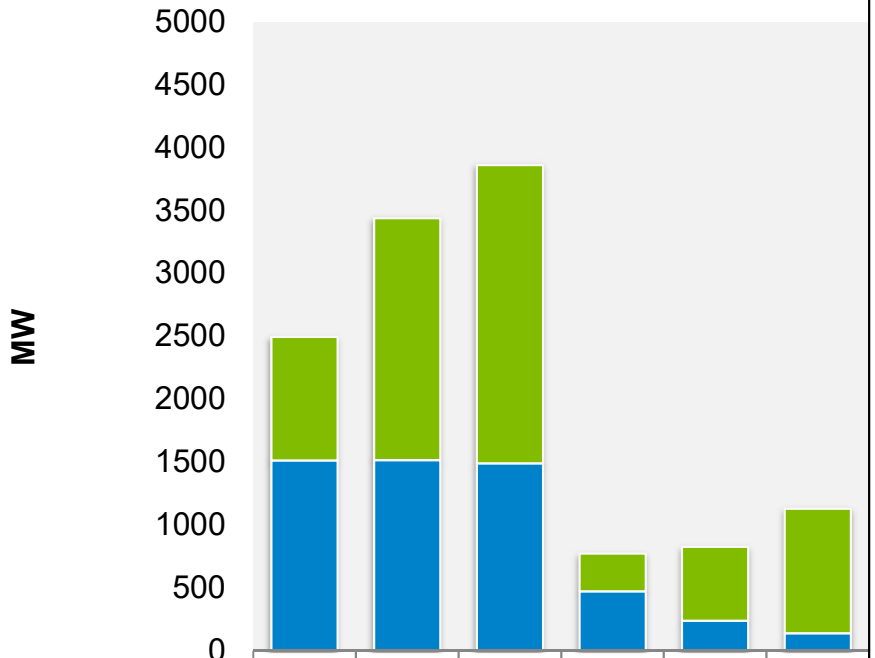
Unplanned Outages (GW)	**20.1**	**29.6**	**28.9**
% Unplanned^	**18%**	**26%**	**26%**

*Unplanned: Forced plus derates

The outage chart reflects the data as it resided in the CROW Outage system on Feb 11, 2019
Wind often reported as derate over the time period
^Percent based on PRA cleared generation plus uncleared internal MISO generation

Deployed and self-scheduled LMRs, school/business closings, and other voluntary load management across the North/Central Region aided in dampening demand below expectations

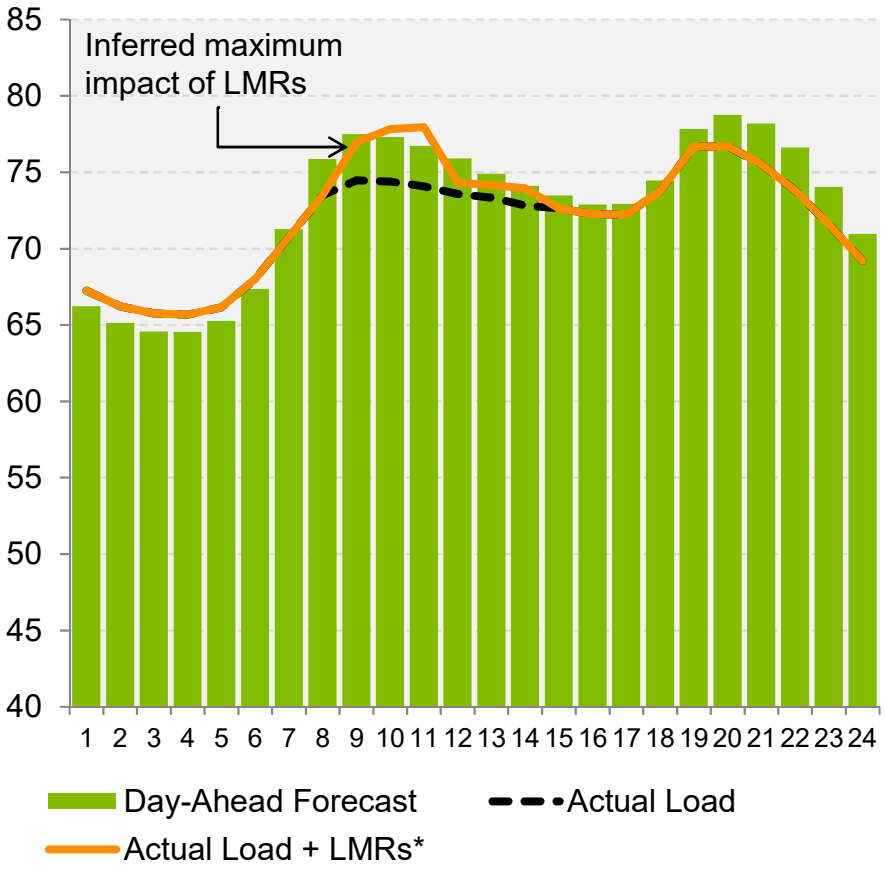
MISO North/Central Load Management Resources (LMRs) for Jan 30



	9	10	11	12	13	14
LMR/LMM	983	1923	2373	300	588	990
Self Sched LMR	1512	1514	1488	470	237	138

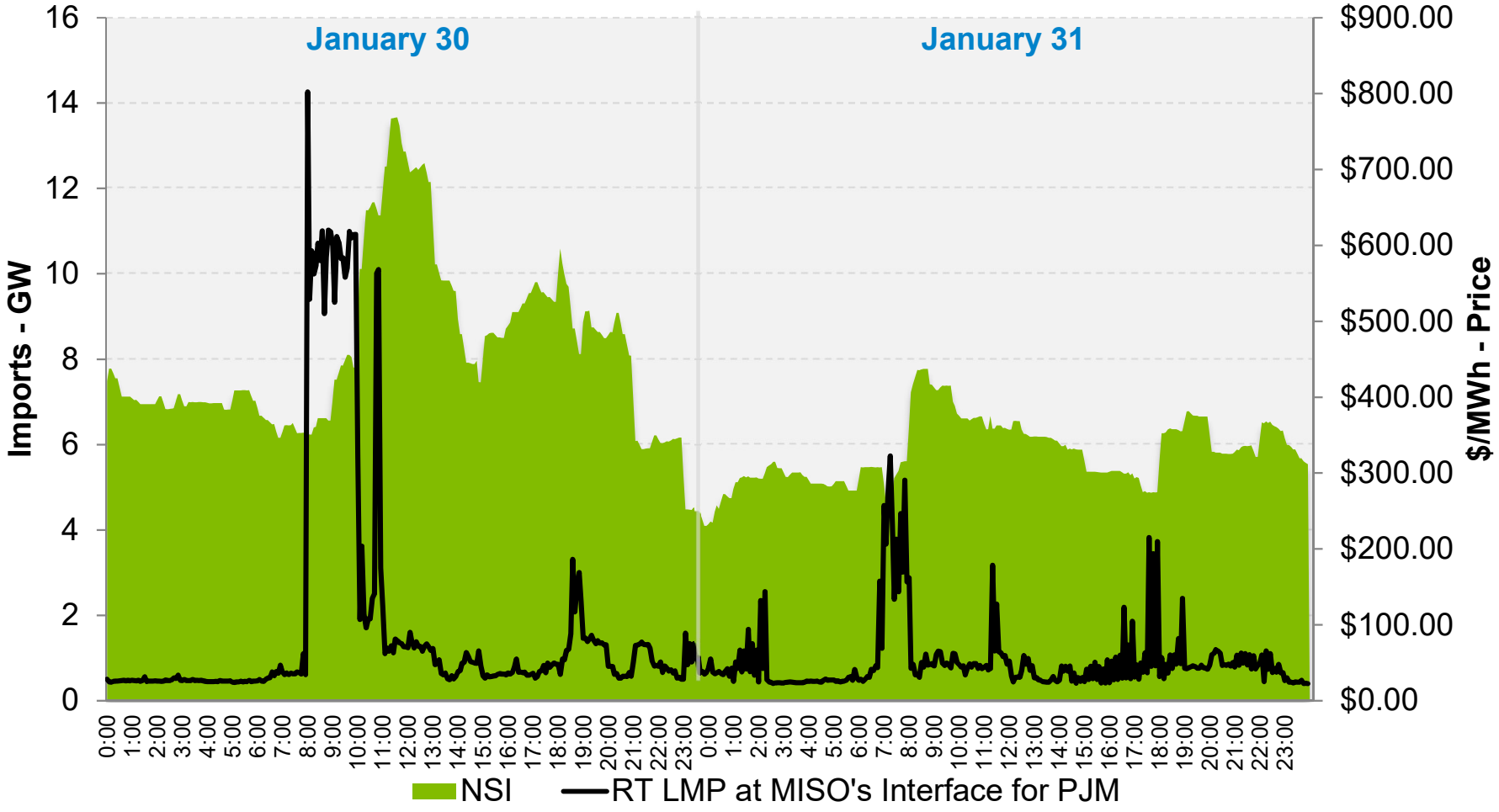
- LMR performance to be evaluated after receipt of meter data towards the end of March

MISO North/Central Hourly Load for Jan 30

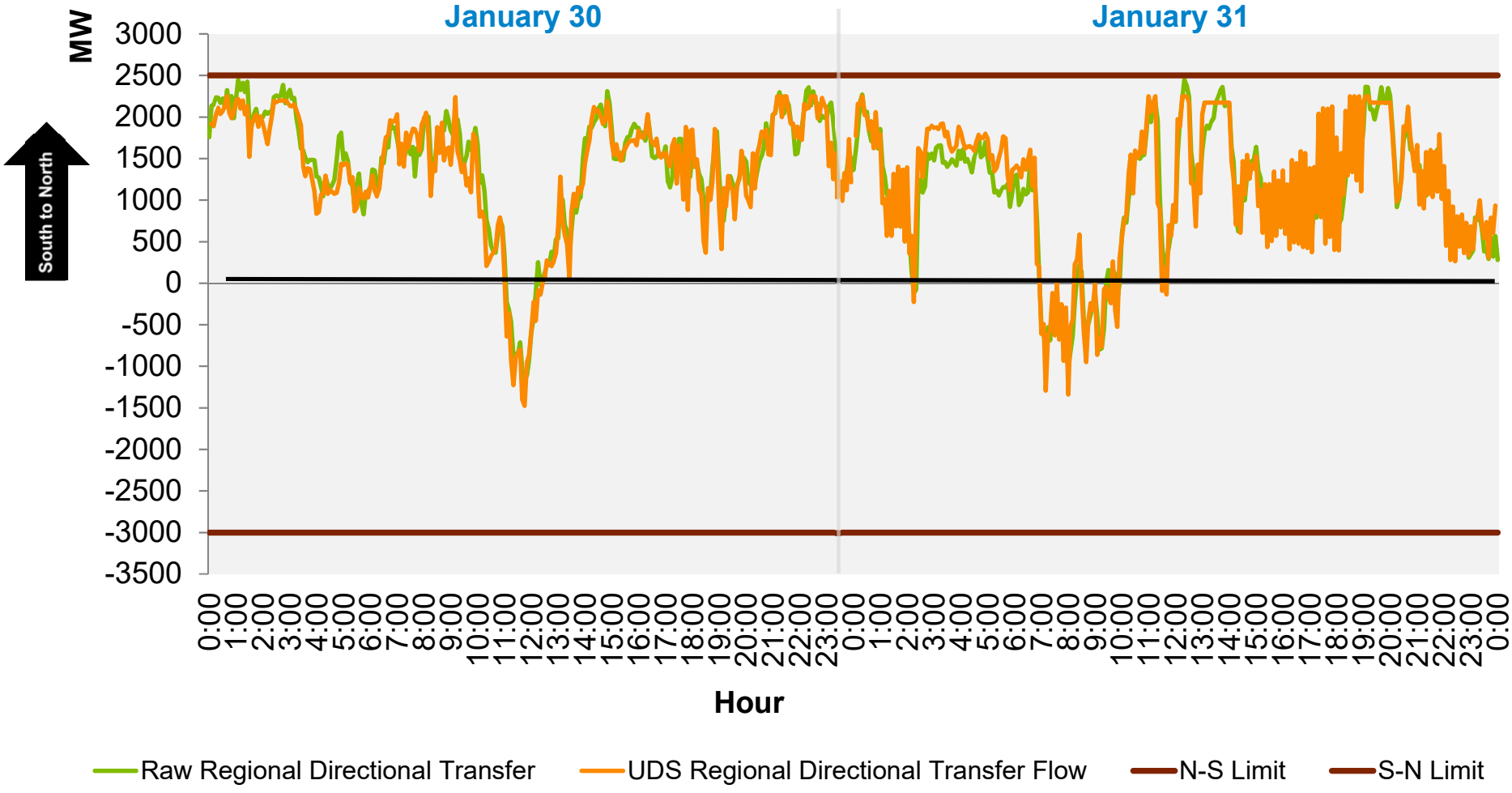


* Does not include impact of closings not accounted for in forecast

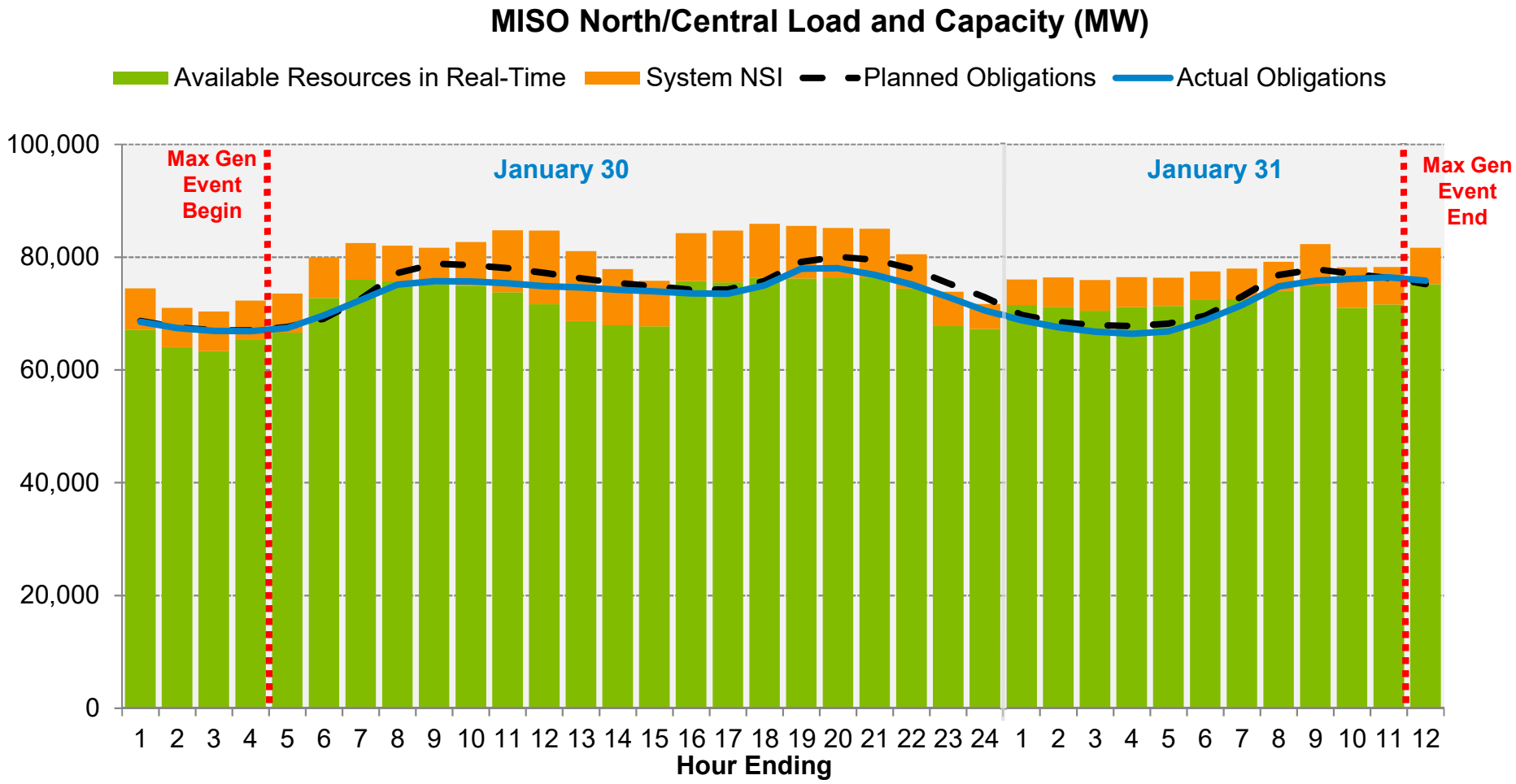
Imports responded to emergency price signals, registering well above 5 GW through the evening peak and Jan 31 morning peak



MISO effectively managed the Regional Directional Transfer flow below limits, while leveraging South Region available capacity

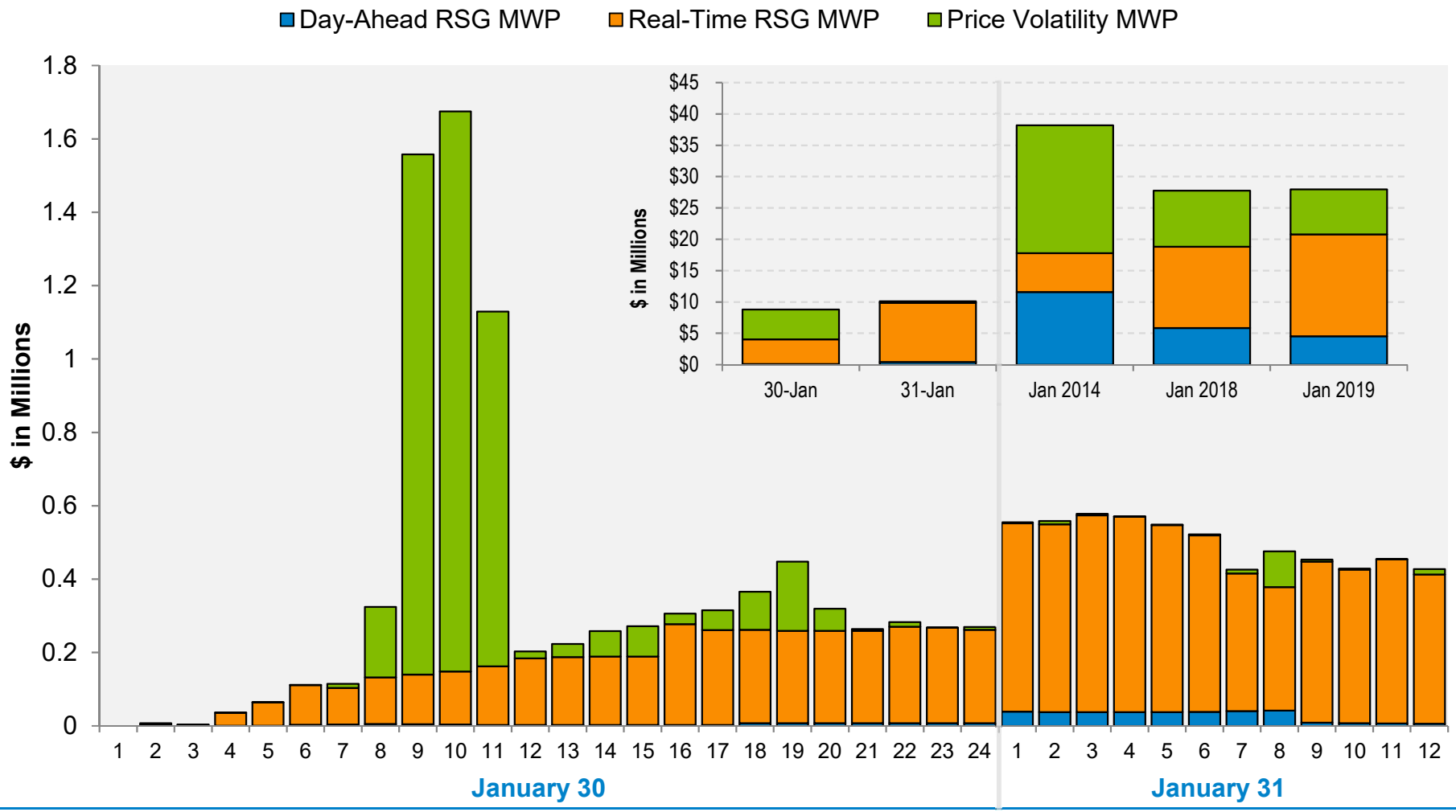


MISO reliably met planned and actual obligations, given extreme temperatures, public safety concerns, forced outage risk, and import volume uncertainty



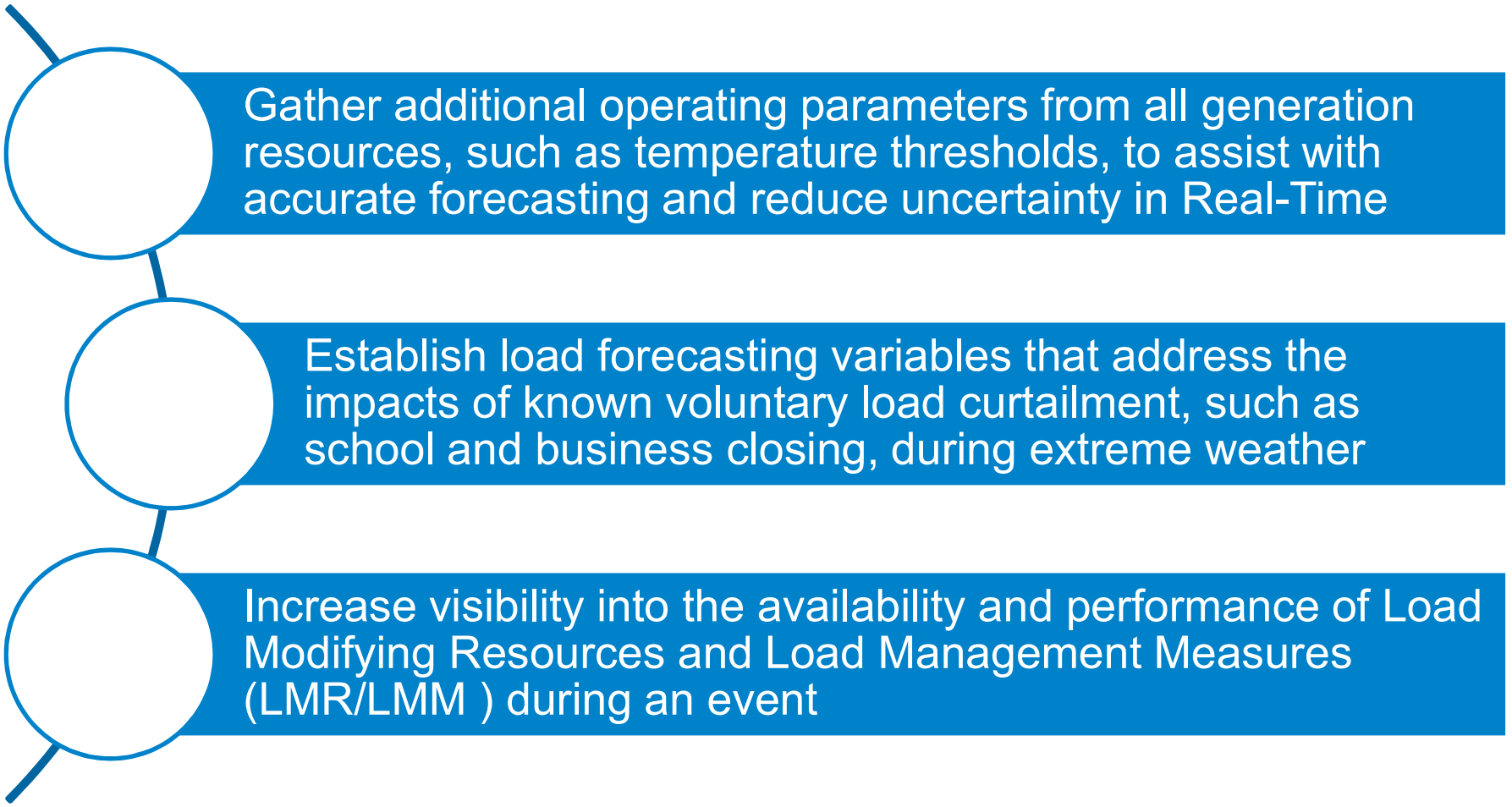
- *Available Resources in Real-Time is the sum of Day-Ahead committed capacity, Forward RAC committed capacity , Intraday RAC committed capacity , and Regional Directional Transfer less "No-Shows" and capacity stranded behind constraints. Obligations include regulation and spinning reserve requirements*

Given extreme conditions, subsequent prudent operating steps resulted in Uplift Charges exceeding $18 million over two days, comparable to previous months with severe cold outbreaks



Note: RSG is amortized over the commitment period, Price Volatility MWP is as occurred

MISO evaluates extreme weather events to capture and incorporate lessons learned as part of its commitment to maintain the reliability of the Bulk Electric System



Appendix

MISO continued to monitor conditions and update communications accordingly during the event

Jan 25

- 1258 EST: Cold Weather Alert for 01/29 – 02/01

Jan 30

- 0238 EST: Max Gen Event 1a for 0500 – 1200 EST
- 0256 EST: Conservative Operations for 0500 – 1200 EST
- 0619 EST: Max Gen Event 2 a/b for 0800 – 1200 EST
- 0840 EST: Extended Conservative Operations through 01/31 1800 EST
- 1050 EST: Extended Max Gen Event 2 a/b through 2200 EST

Jan 30 cont.

- 1336 EST: Max Gen Event 1a for 13:30 – 22:00 EST
- 1505 EST: Extended Max Gen Event 1a through 01/31 12:00 EST
- 1712 EST: Max Gen 1 b/c for 01/31 0700 – 1200 EST

Jan 31

- 0512 EST: Max Gen Event 1b/c for 0700 – 1200 EST
- 0927 EST: Max Gen Warning for 0930 – 1100 EST
- 1100 EST: Max Gen Event Terminated
- 1800 EST: Conservative Operations and Cold Weather Alert Terminated

Extreme N/C cold drove high load, a sudden and unexpected drop in wind generation, forced outages, and uncertainty, which required the declaration of the Maximum Gen Event

MISO Classic (North/Central Regions)	2014		2018	2019			
	01/06 -21°/-11°F	01/07 -13°/-10°F	01/17 -2°/-3°F	01/28 2°/10°F	01/29 -20°/4°F	01/30 -26°/-10°F	01/31 -21°/-8°F
Integrated Peak Load (GW)	79.9	76.7	73.7	70.4	74.3	76.7	75.1
Average Daily MISO Wind	7.2 GW	2.0 GW	12.0 GW	12.9 GW	12.9 GW	4.3 GW	4.7 GW
Gas Price* ($/MMBtu)	$13.17	$7.39	$3.91	$3.13	$4.23	$7.42	$5.09
Average Daily RT LMP ($/MWh)	$97.74	$225.83	$40.90	$25.53	$26.92	$107.90	$49.29
Max Daily NSI (Import)	4.3 GW	-2.1 GW	3.4 GW	7.1 GW	9.0 GW	13.7 GW	7.8 GW
Cold Weather Alert					Called on Jan25 for Operating Days Jan 29 – Feb 01		
Max Gen Event Step 1a			Step 1				
Conservative Operations							
Max Gen Event Step 2a/b			Step 2				
Max Gen Event Step 1b/c							
Max Gen Alert							
Max Gen Warning							

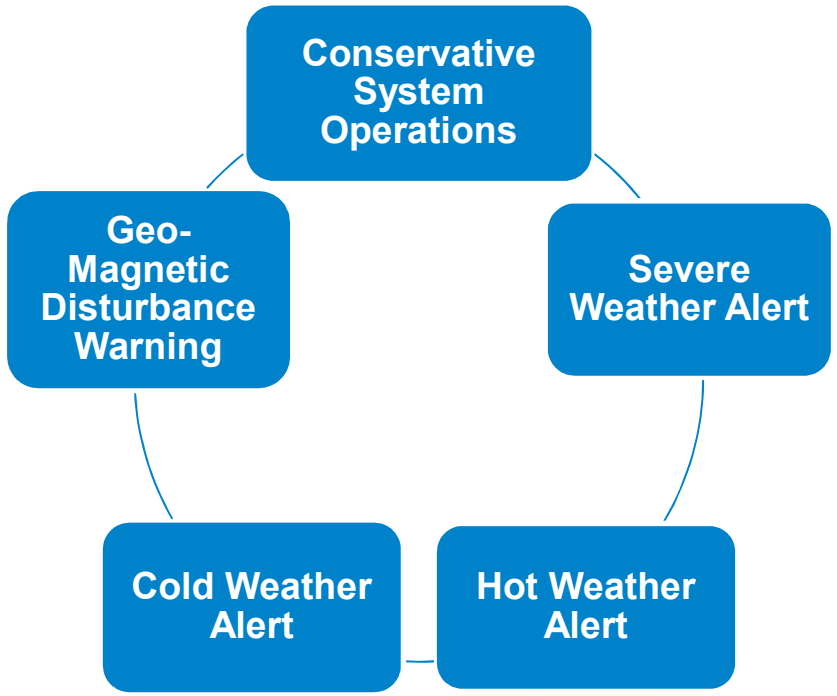
Shading indicates declaration was active during that day

- *Temperatures are daily low values for North and Central Regions*
- *LMP is calculated as an average of Hubs in the North and Central regions*
- ** Chicago City Gate Gas Price*

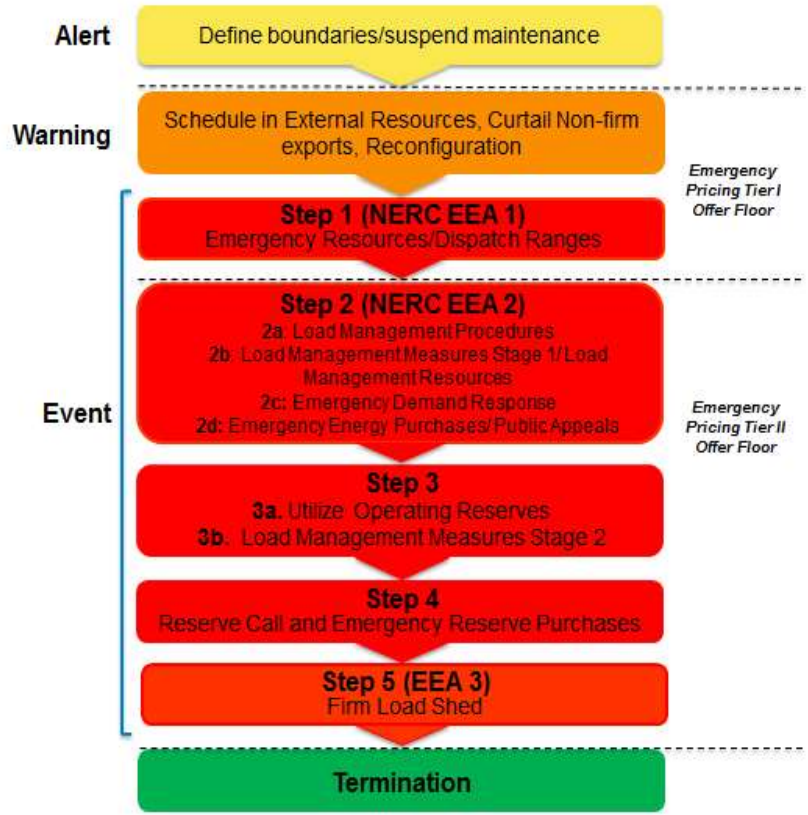
Data Source: Real-Time Operations, Market Analysis, and MISO Website

MISO's operating procedures ensure reliability and gain access to additional resources during extreme situations.

Emergency Operating Procedures guide operator actions when an event has the potential to, or actually does, negatively impact system reliability



Maximum Generation Emergency Procedures



Data Source: SO-P-NOP-00-449 Rev 0 Conservative System Operations and SO-P-EOP-00-002 Rev 3 MISO Market Capacity Emergency procedures

MISO is prepared for emergency situations