Overview of Winter Storm Elliott December 23, Maximum Generation Event

Reliability Subcommittee

January 17, 2023

All data included in this presentation is preliminary as of January 12, 2023, and is subject to change
Executive Summary

- Winter Storm Elliott delivered rapid, extreme cold to the Eastern Interconnect in December as well as gas supply challenges and historic load forecast volatility
- MISO had enough capacity to manage uncertainty while serving exports to our neighbors
- There were no customer interruptions
- Lessons learned from Winter Storm Uri contributed to successful operations during Elliott; subsequent analysis will lead to additional lessons learned
- Load forecast uncertainty and fuel supply availability are examples of the increasing uncertainty being addressed under MISO’s Reliability Imperative
On December 23, Winter Storm Elliott brought significantly below normal temperatures to MISO, driving high demand for heating; drawing similarities to Winter Storm Uri in 2021.

**WINTER STORM URI**
**FEBRUARY 12-18, 2021**

**Average Temperature:**
Departure from 30-Year Normal

- System Peak Load: 103 GW
- Unplanned Outages (South): 18 GW
- Scheduled Load Modifying Resources*: 531 MW
- RDT Max Flow & Direction: 3.2 GW N-S
- Precipitation: Abundant snowfall across MISO’s South and Central regions

**Unplanned Outages**
(South)

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**WINTER STORM ELLIOTT**
**DECEMBER 23, 2022**

**Average Temperature:**
Departure from 30-Year Normal

- System Peak Load: 107 GW
- Unplanned Outages (additional from previous day system-wide): 19 GW
- Scheduled Load Modifying Resources*: 1.2 GW
- RDT Max Flow & Direction: 2.7 GW N-S
- Precipitation: Modest snowfall across MISO’s North and Central regions

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*Load Modifying Resources requested for the peak load hour for the noted storm time period*
Emergency operations were required to access additional capacity to mitigate uncertainty and support our neighbors.

### ALERTS

**Cold Weather Alert (South)**
DEC 22, noon EST – DEC 26, noon EST

Unseasonably cold weather expected across MISO

### WARNINGS

**Maximum Generation Warning (South)**
DEC 23, 9:15 a.m. – 12:45 p.m. EST

**Conservative Operations (South)**
DEC 23, 9:15 a.m. EST – DEC 26, midnight EST

Tightened conditions due to unit trips and failures to start (~2 GW), higher-than-forecast South load (~2.5 GW), and reduced RDT flow limit N-S (to 1.5 GW)

### EVENTS

**Maximum Generation Event, Step 1b (Footprint)**
DEC 23, 5:30 p.m.

Tight conditions worsened with real-time transmission congestion and diminishing generation deliverability

**Maximum Generation Event, Step 2a (Footprint)**
DEC 23, 6 p.m. – 9 p.m. EST

Emergency procedures allowed access to demand response, which reduced the peak demand

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Note: All times indicate the effective time of each declaration
Reserve capacity was closely monitored, and exports would have been curtailed if conditions had worsened.

- **Peak Demand Plus Exports December 23, 2022**
  - 111 GW

- **Actual Peak Demand December 23, 2022**
  - 107 GW

- **Winter Season Probable Peak Demand Scenario December 23, 2022**
  - 102 GW

- **Winter Season High Peak Demand Scenario December 23, 2022**
  - 109 GW
MISO consistently exported power to southern neighbors with a maximum value of nearly 5 GW

Multiple Balancing Authorities employed emergency procedures utilizing demand response and, at times, load shed

Image represents average flows into and out of MISO December 23, 2022

RDT = Regional Directional Transfer, which has a North-South limit of 3.0 GW and South-North limit of 2.5 GW
MISO complied with Joint Parties requests to reduce flows by 1,500 MW during the morning peak, which contributed to an emergency declaration in the South and a recall of non-firm exports.
Two local transmission emergencies were declared to manage severe congestion on transmission lines:

Local Transmission Emergency
SE Wisconsin
6:45 p.m. – 8 p.m. EST
December 23
(No customer interruptions)

Local Transmission Emergency
Central Missouri
6:27 p.m. – 8 p.m. EST
December 23
(No customer interruptions)
Abnormally high load forecasting errors occurred due to a lack of historical data for similar extreme conditions in December.
Gas supply availability contributed to increased unplanned outages, particularly in the afternoon, that pushed MISO into emergency procedures.

*Unplanned = forced outages and derates

Charts reflect data in the CROW outage system on January 5, 2023

Wind often reported as derated over the time period.
Wind production remained high during Winter Storm Elliott, providing support to the transmission system.
Requested 3 GW of Load Modifying Resources at 17:37 to meet increasing load and continue exports to neighbors.
While each storm is unique, lessons learned from Winter Storm Uri in 2021 contributed to successful operations during Elliott

<table>
<thead>
<tr>
<th>Refined Winter Readiness Activities</th>
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<tbody>
<tr>
<td>• Increased focus on extreme scenarios</td>
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<tr>
<td>• Improved understanding of generator winter preparedness through coordinated seasonal assessment and fuel and consumables data requests</td>
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<tr>
<td>• Implemented cold weather-specific operator drills in addition to emergency procedure drills and winter readiness workshops</td>
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<th>Process Improvements</th>
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<td>• Process Improvements to Unit Commitment Processes and Operator Situational Awareness improved our ability to respond to changing risk profile during the operating day</td>
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<th>Improved Coordination</th>
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<td>• Improved coordination activities with our neighbors that resulted in quicker decision making during the storm</td>
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View the complete February Arctic Event report on the MISO website
Appendix
MISO’s operating procedures ensure reliability and gain access to additional resources during extreme situations.

### MARKET CAPACITY EMERGENCY PROCEDURE STEPS

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Pricing</th>
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</thead>
<tbody>
<tr>
<td><strong>Normal Operations</strong></td>
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<td>Normal Pricing</td>
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<tr>
<td><strong>Capacity Advisory</strong></td>
<td>Advance notice of forecasted capacity shortage, requests Stakeholders update offer data</td>
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<tr>
<td><strong>Alert</strong></td>
<td>Define boundaries/suspend maintenance</td>
<td>Emergency Pricing Tier 0</td>
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<tr>
<td><strong>Warning</strong></td>
<td>Schedule in external resources, curtail export transactions, activate reconfiguration</td>
<td>Emergency Pricing Tier I Offer Floor</td>
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<tr>
<td><strong>Event Step 1</strong></td>
<td>Commit emergency resources, declare NERC (Energy Emergency Alert) EEA 1, activate emergency limits</td>
<td>Emergency Tier II Offer Floor</td>
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<td><strong>Event Step 2</strong></td>
<td>Declare NERC EEA 2, implement Load Modifying Resources (LMRs), Load Management Measures (LMMs) Stage 1, commit Emergency Demand Response (EDR) resources, emergency energy purchases, public appeals</td>
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<td><strong>Event Step 3</strong></td>
<td>Utilize operating reserves and LMMs Stage 2</td>
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<td><strong>Event Step 4</strong></td>
<td>Reserve call and emergency reserve purchases</td>
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<td><strong>Event Step 5</strong></td>
<td>Declare NERC EEA 3, firm load shed, and set Locational Marginal Prices (LMPs) and Market Clearing Prices (MCPs) to the VOLL</td>
<td>Value of Lost Load (VOLL) Pricing</td>
</tr>
<tr>
<td><strong>Termination</strong></td>
<td>Terminate Max Gen and possibly Capacity Advisory</td>
<td>Normal Pricing</td>
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### MAXIMUM GENERATION

- **Tier 0** (Emergency Pricing): Emergency Tier I Offer Floor
- **Tier II** (Emergency Pricing): Emergency Tier II Offer Floor
- **Normal Pricing**: Value of Lost Load (VOLL) Pricing

**Data Source:** [SO-P-EOP-00-002 Rev 14 MISO Market Capacity Emergency](#)
Winter Storm Elliott continued to impact the Eastern Interconnect through December 25

WINTER STORM ELLIOTT
DECEMBER 24, 2022

Average Temperature:
Departure from 30-Year Normal

WINTER STORM ELLIOTT
DECEMBER 25, 2022

Average Temperature:
Departure from 30-Year Normal
MISO maintained its support for neighbors December 23-24
MISO maintained its support for neighbors December 23-24