Cold Weather Preparedness Workshop

Thursday, October 26, 2023 | 8:30 a.m. to 11:35 a.m. Central

Via WebEx

MIDWEST RELIABILITY ORGANIZATION

380 St. Peter St, Suite 800
Saint Paul, MN 55102
651-855-1760
www.MRO.net

LOGISTICS

WebEx Login
If any help is needed logging into WebEx please reach out to Shawn Keller at shawn.keller@mro.net.

Audio
Participants will be muted upon entry and will not be able to unmute themselves to speak.

Questions
If you have questions for a speaker, please utilize WebEx's chat feature. Please submit all questions to "All Panelists". If we are unable to get all questions asked/answered during the webinar, a response will be provided after the workshop either directly to the requestor or through another form of outreach.

Presentations
The presentations and recordings from today's workshop will be made available in the near future.

Feedback
Your feedback is very important to us. Please utilize the survey link to provide your feedback.

AGENDA

Thursday, October 26, 2023 | 8:30 a.m. to 11:35 a.m. Central

8:30 a.m. – 8:35 a.m.	**Welcome and Introduction** *Bryan Clark, Director of Reliability Analysis, MRO*
8:35 a.m. – 9:15 a.m.	**Risk Modeling and Consideration of Extreme Cold Weather Events** *Armando Figueroa Acevedo, Senior Engineer, MISO*
9:15 a.m. – 09:25 a.m.	**Break**
9:25 a.m. – 10:30 a.m.	**MRO Generator Winterization Program (GWP)** *Jake Bernhagen, Manager of Reliability Performance, MRO*
10:30 a.m. – 10:40 a.m.	**Break**
10:40 a.m. – 11:20 a.m.	**Winter Storm Elliott Findings and Recommendations from the FERC/NERC Joint Inquiry** *David Marcou, Attorney, FERC* *Eric Oben, Electrical Engineering Specialist, FERC*
11:20 a.m. – 11:35 a.m.	**Wrap up/Questions/Feedback/Adjourn** *Bryan Clark, Director of Reliability Analysis, MRO*

SPEAKER BIOGRAPHIES

Armando Figeroa Acevedo

Senior Engineer, Midcontinent Independent System Operator (MISO)

Armando Figueroa Acevedo holds a dual doctoral degree in Electrical Engineering and Wind, Energy, Science, Engineering, and Policy (WESEP) from Iowa State University. He is a Senior Engineer at MISO, where he focuses on strategic assessments related to resource adequacy and transmission planning. He's also a part-time professor at the University of Puerto Rico, Mayagüez campus, and a registered Professional Engineer.

He is a member of the IEEE Resource Adequacy Working Group and has served as the Group's Chair from 2021-2023.

Bryan Clark

Director of Reliability Analysis, Midwest Reliability Organization

Bryan Clark is the Director of Reliability Analysis at Midwest Reliability Organization (MRO). This group is responsible for regional Reliability Assessments, Event Analysis, and Performance Analysis (Data Collection). Prior to joining MRO in 2018, Bryan spent 8 years with Southwest Power Pool, as a transmission planning engineer, a market operations engineer and a Supervisor of the Day Ahead Operations department. Bryan also worked for Entergy as a Nuclear Operator where he was responsible for monitoring and operating various primary and secondary plant systems at Arkansas Nuclear One (Unit 2).

Bryan has a Bachelor of Science in Engineering from Arkansas State University and is a registered Professional Engineer in Arkansas and Minnesota.

David Marcou

Attorney, Federal Energy Regulatory Commission

David Marcou is an Attorney-Advisory with FERC, in the Office of Enforcement, Division of Investigations. David has been with FERC since 2022 and prior to that was in private practice. He obtained his undergraduate degree from the University of Pennsylvania and a Juris Doctor from the University of Texas School of Law.

2023 COLD WEATHER PREPAREDNESS WORKSHOP: SPEAKER BIOGRAPHIES

Eric Oben

Electrical Engineering Specialist, Federal Energy Regulatory Commission

Eric Oben is an Electrical Engineer with FERC, in the Office of Electric Reliability (OER). He has a Master of Science Degree in Engineering Management and a Bachelor of Science Degree in Electrical Engineering from the University of Kansas. He has 20 years of experience in the electrical utility, oil/gas industries.

Jake Bernhagen

Manager of Reliability Performance, Midwest Reliability Organization

Jake Bernhagen is the Manager of Reliability Performance at the Midwest Reliability Organization (MRO). Prior to joining MRO in 2018, Jake spent 10 years with Northern States Power – Xcel Energy in system protection engineering and design.

Jake holds a Bachelor of Science degree in Electrical Engineering from the University of Minnesota and is a registered Professional Engineer in the state of Minnesota.

MRO DISCLAIMER

Midwest Reliability Organization (MRO) is committed to providing outreach, training, and non-binding guidance to industry stakeholders on important industry topics. Subject Matter Experts (SMEs) from MRO's organizational groups and the industry may develop materials, including presentations, provided as a part of the event. The views expressed in the event materials are those of the SMEs and do not necessarily express the opinions and views of MRO.

PRESENTATIONS

All presentations for today's workshop are included in order of presentation.

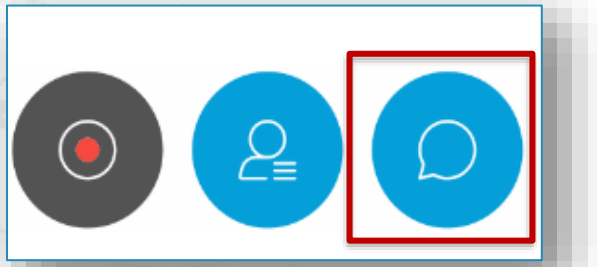
MIDWEST RELIABILITY ORGANIZATION

2023 Cold Weather Preparedness Workshop

Moderator – Bryan Clark,
Director of Reliability Analysis, MRO

WebEx Chat Feature

Open the Chat Feature:



The chat feature will appear to the right of the WebEx window.

Attendees should chat their questions to: “All Panelists”.

Select All Panelists by using the drop-down arrow in the “To” field.

Please take a moment to complete the survey

https://www.surveymonkey.com/r/VSZD5FG

MRO Upcoming Events

- **Webinars**
  - Regional Winter Assessment Webinar: December 12, 2023, 10:00 a.m. – 11:00 a.m.
- **Conferences**
  - July 24, 2024: CMEP Conference, The Westin Kansas City at Crown Center, Kansas City, MO
  - May 15, 2024: Annual Reliability Conference, Saint Paul, MN

Disclaimer for organizational group hosted events or materials

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Risk Modeling and Consideration of Extreme Cold Weather Events

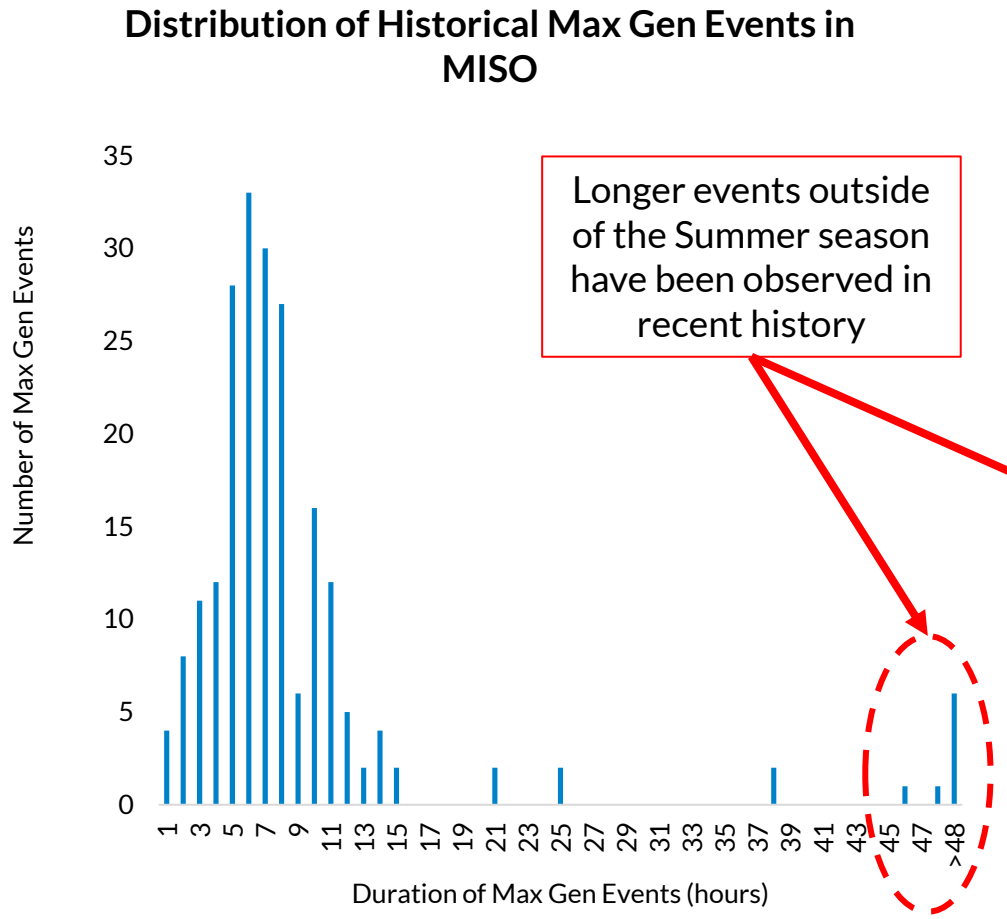
Cold Weather Preparedness Workshop

Midwest Reliability Organization (MRO)

October 26, 2023

Armando Figueroa Acevedo, PhD, PE
Sr. Engineer – Strategic Assessments
afigueroa-acevedo@misoenergy.org

Longer and more severe emergency events have been observed in recent history, driving the need to better acknowledge emerging risks in planning models



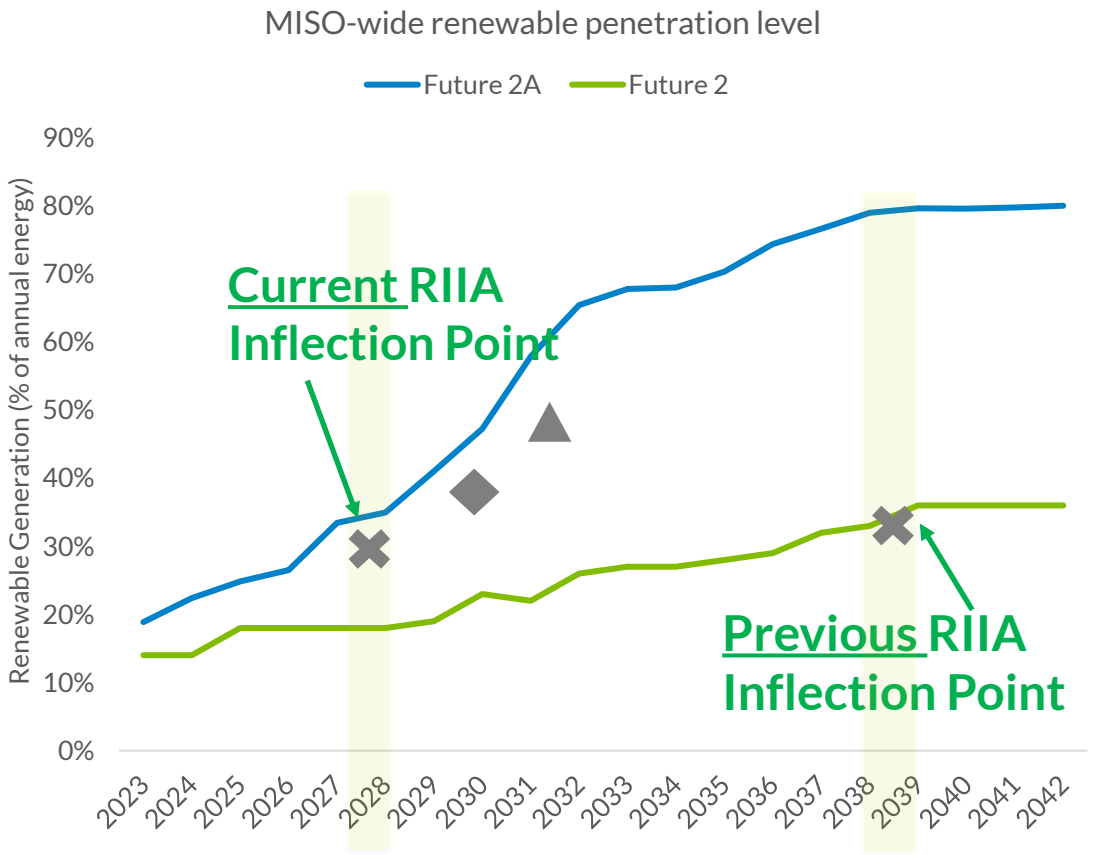
Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
2011	0	0	0	0	0	10	7	0	0	0
2012	0	0	0	0	0	5	9	0	0	0
2013	0	0	0	0	0	0	5	0	0	0
2014	11	0	6	0	0	0	0	0	0	0
2016	0	0	0	0	0	8	8	10	0	8
2017	0	0	0	8	0	0	0	0	8	0
2018	25	0	0	0	60	13	11	0	11	0
2019	46	0	0	0	10	8	0	0	0	0
2020	0	3	0	0	0	0	7	12	0	0
2021	0	82	0	0	0	11	7	14	0	11
2022	8	0	0	0	9	7	0	0	0	0

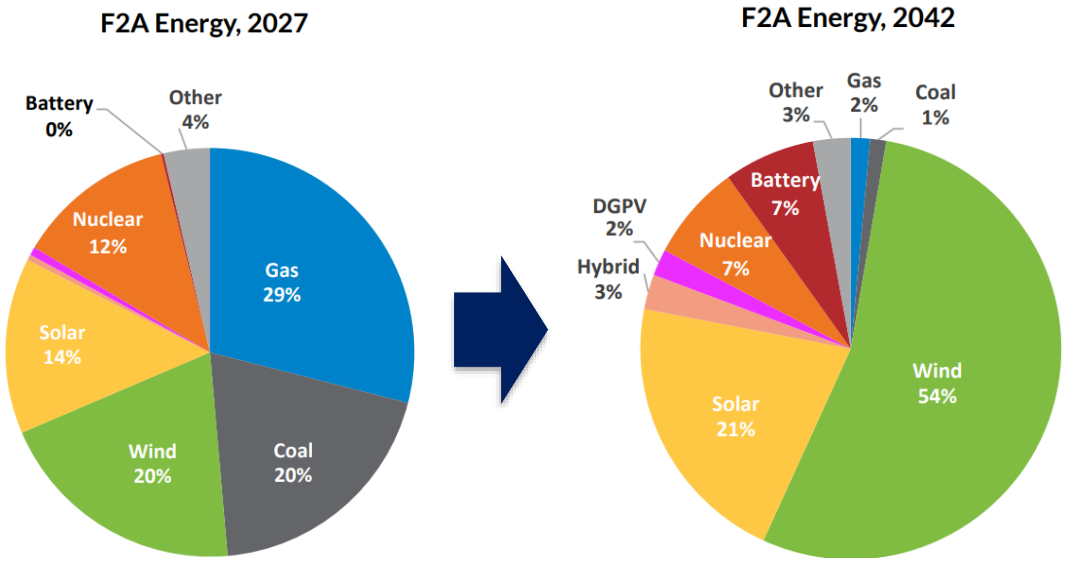
Long duration

Mid duration

Short duration

Also, the MISO region is experiencing continued resource transition acceleration and tight system conditions which are expected to affect reliability and market efficiency





Future 2A's expansion and retirements approaches/surpasses levels seen in Future 3, which will transform our current resource fleet

✖ 30% Penetration ◆ 40% Penetration ▲ 50% Penetration

RIIA: Renewable Integration Impact Assessment

What MISO is doing to address these challenges?

- Seasonal resource adequacy construct to incentivize availability across the year, including periods of extreme cold weather, and Seasonal accreditation based on Risk Hours to align availability and need in the operational timeframe

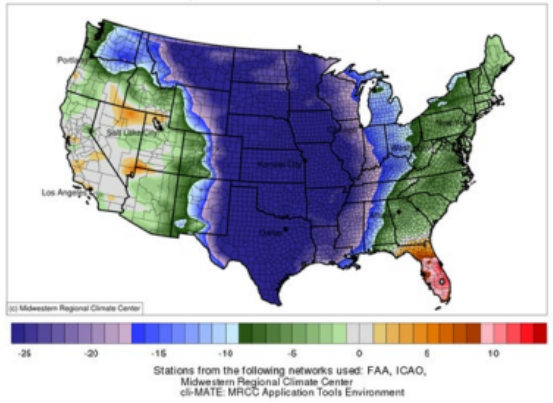
- Acknowledging extreme cold weather risk factors in resource adequacy models **enhance** the overall risk assessment

Seasonal resource adequacy construct and Seasonal accreditation

On December 23, 2023, 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

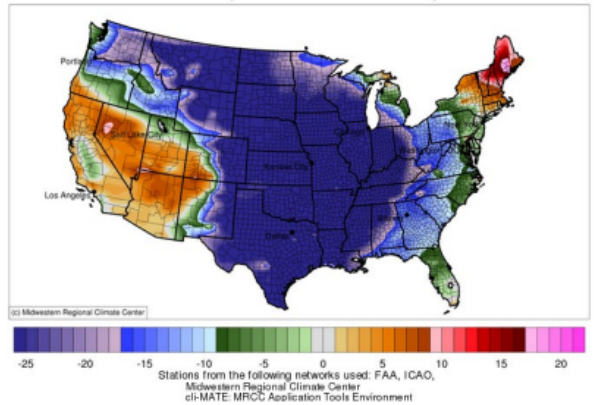
Average Temperature:
Departure from 30-Year Normal



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*	

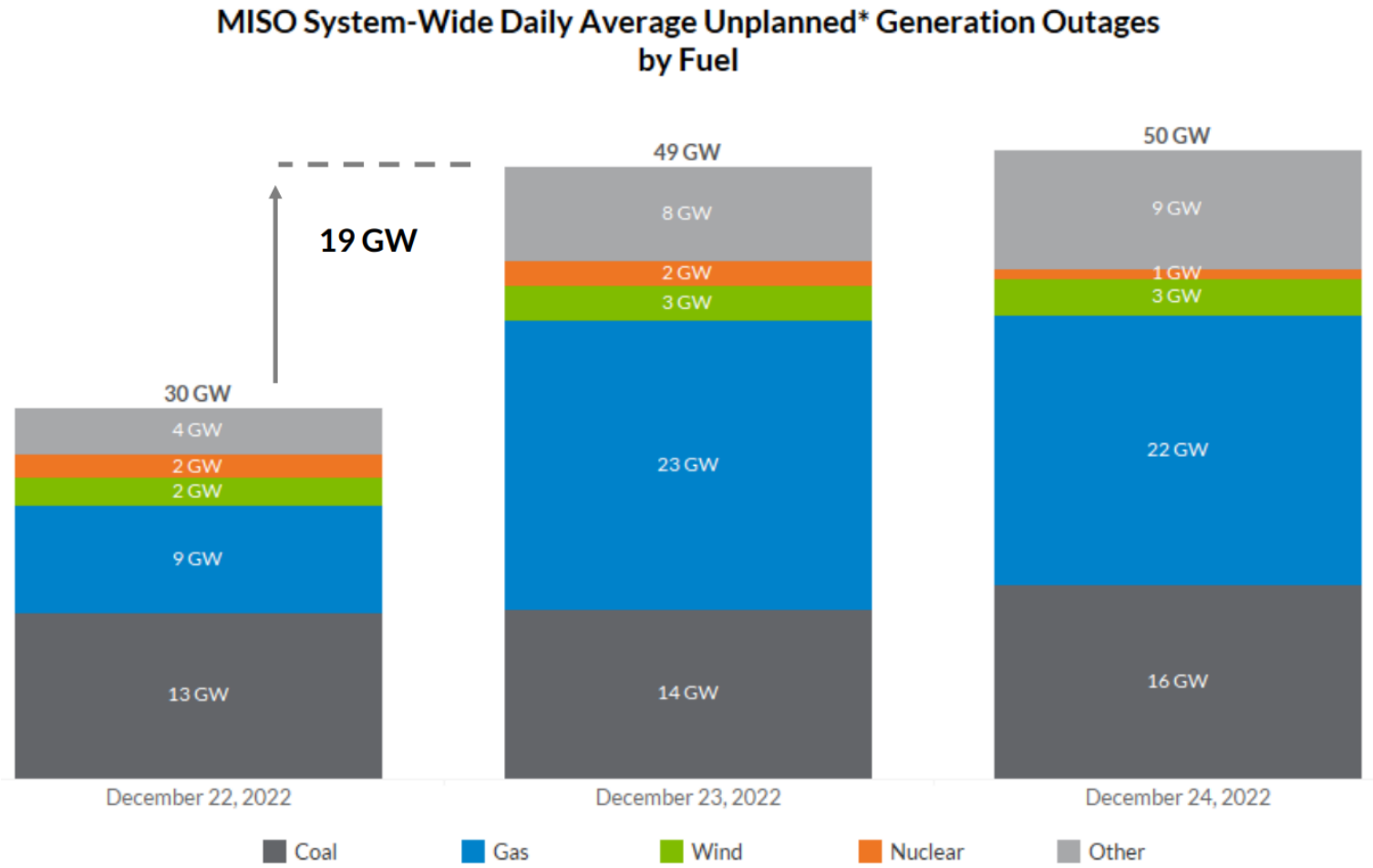
WINTER STORM ELLIOTT
DECEMBER 23, 2022

Average Temperature:
Departure from 30-Year Normal



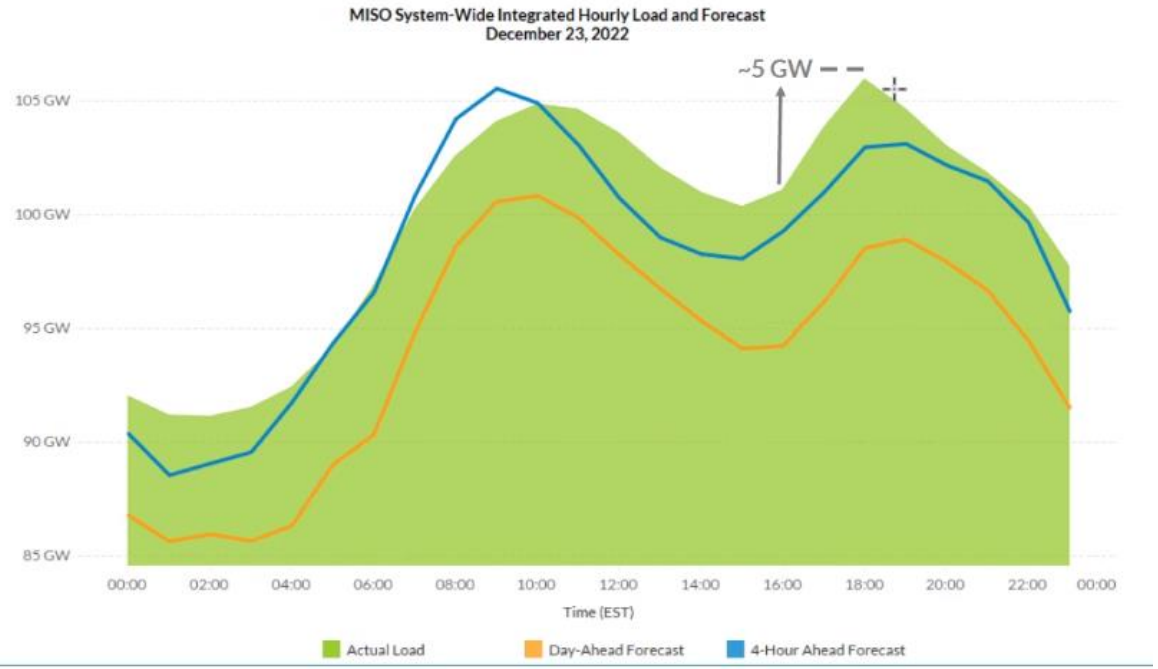
System Peak Load	107 GW
Unplanned Outages *(additional from previous day system-wide)*	19 GW
Scheduled Load Modifying Resources*	1.2 GW
RDT Max Flow & Direction	2.7 GW N-S
Precipitation: *Modest snowfall across MISO's North and Central regions*	

Gas supply availability contributed to increased unplanned outages, particularly in the afternoon, that pushed MISO into emergency procedures

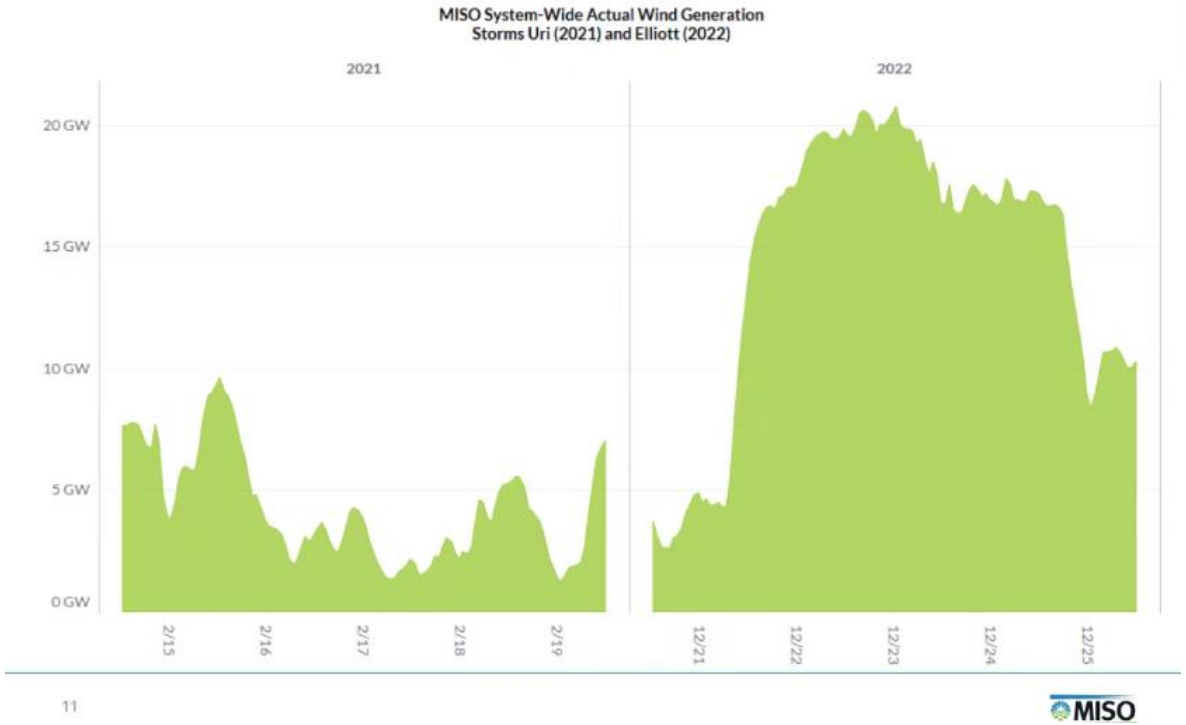


Abnormal extreme conditions led to higher than forecasted load. Load modifying resources and wind helped.

Abnormally high load forecasting errors occurred due to a lack of historical data for similar extreme conditions in December



Wind production remained high during Winter Storm Elliott, providing support to the transmission system



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MISO

MISO

How did the newly adopted seasonal RA construct performed last Winter?

- **Accrediting capacity based on resource performance during times of highest risk helps mitigate operational risk**

- Schedule 53 (accreditation) places much more emphasis on tight hours than a seasonal unforced capacity (UCAP) approach

- Most resource adequacy (RA) Hours last winter occurred during Winter Storm Elliott

12/23/22 Max Gens	Emergency offers from Schedule 53 Resources (MW)	UCAP (MW)	ISAC (MW)	UCAP Deviation	ISAC Deviation
South morning	31,547	33,983	31,363	7.7%	-0.6%
Footprint afternoon to evening	97,894	105,224	99,396	7.5%	1.5%

Key takeaways

- Recent and ongoing reforms will help MISO be better prepared to mitigate risks observed in Winter Storm Elliott.

- This includes risks related to reliability attributes, such as energy adequacy and flexibility

System reliability attributes

The attributes analysis is divided into three analytical workstreams to model system adequacy, flexibility and system stability in the planning and operational horizons

Planning Adequacy Approach	To build upon current resource adequacy processes and methods to measure resource availability (accreditation) and need (requirements), considering additional system risks factors
Operational Adequacy Approach	To evaluate MISO's current energy & ancillary services market structure, in terms of its ability to procure sufficient reliability attributes
Voltage Stability Approach	To evaluate repeatable and scalable approaches to make visible emerging voltage stability risks that require further analysis and procurement of specific reliability attributes

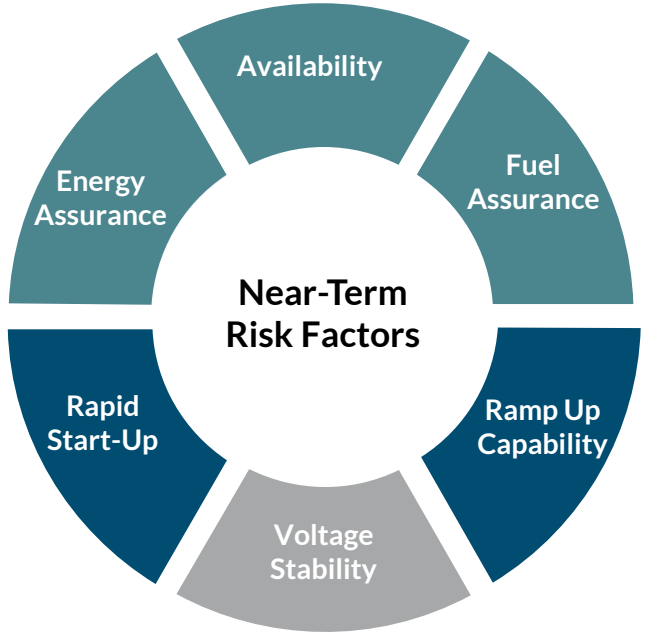
The focus of the planning horizon is to explore the impact of energy adequacy constraints in the existing LOLE model

Workstream	System Attribute	Model	Events	Tools	Data	Metrics
Planning Adequacy	System Adequacy	LOLE – assuming perfect foresight	Normal and extreme events (Probabilistic)	PLEXOS	Existing portfolio (from PY23-24) and Future 2A	LOLE, EUE, LOLH
	Flexibility					
Operational Adequacy	System Adequacy	DA Unit Commitment followed by RT Economic Dispatch	Extreme events	MISO-EGRET*	Historical: max gen/capacity advisory days; Future: F2A stressed scenarios	Unserved energy
	Flexibility					
Voltage	System Stability	Short circuit ratio, Dynamic impedance screening	Fleet Transition	PSSE, Python	MTEP23_AA models	SCR, dynamic stability margin

DA = Day Ahead RT = Real Time LOLE = Loss of load expectation

* MISO-EGRET tool

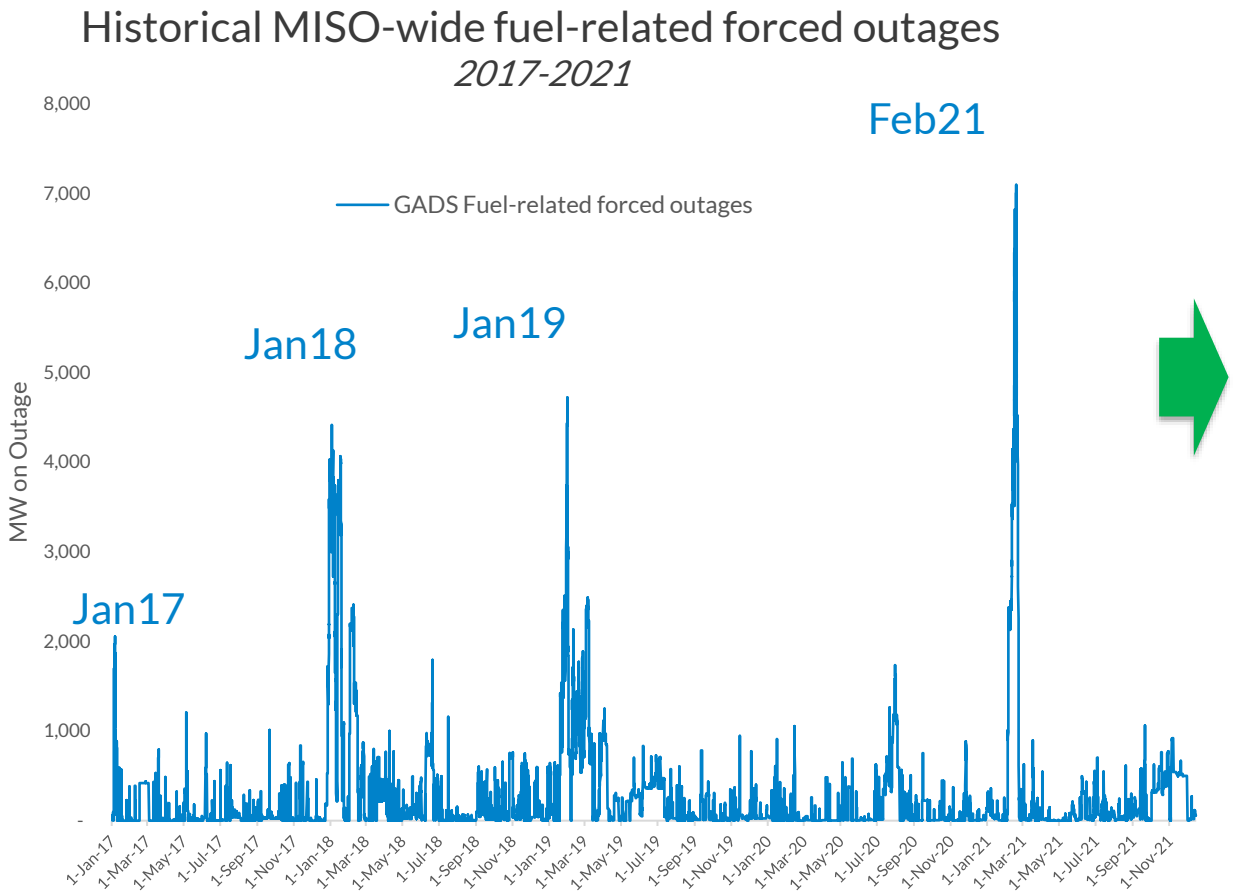
Acknowledging weather and geographical risk factors in RA models enhance the overall risk assessment

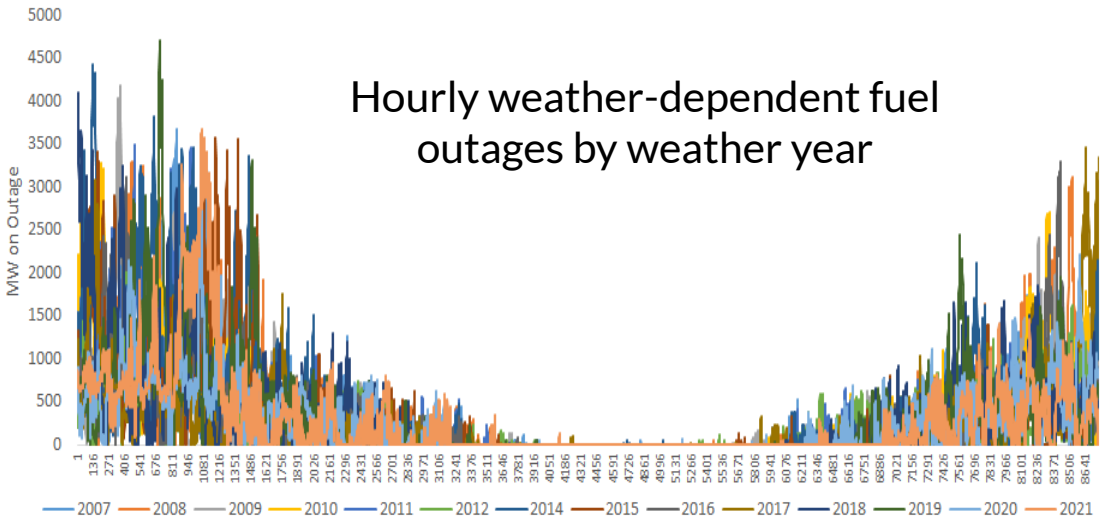


Model Constraint	Description	Availability	Fuel Assurance	Energy Assurance	Rapid Start Up	Ramp-Up Capability
Weather-Dependent Outages: Fuel	Cold weather related forced outages with GADS fuel codes	X	X			
Weather-Dependent Outages: All*	All cold weather related forced outages	X	X	X		
Transmission	RDT constraint between MISO North/Central and South	X		X		
Flexibility	Add generator ramping constraints and minimum stable levels	X			X	X

*Weather-dependent outages are already acknowledged in the latest LOLE model (PY23-24)

GADS fuel-related forced outages from 2017-2021 were gathered and temperature-dependent correlations were developed to capture weather-dependent outage risks

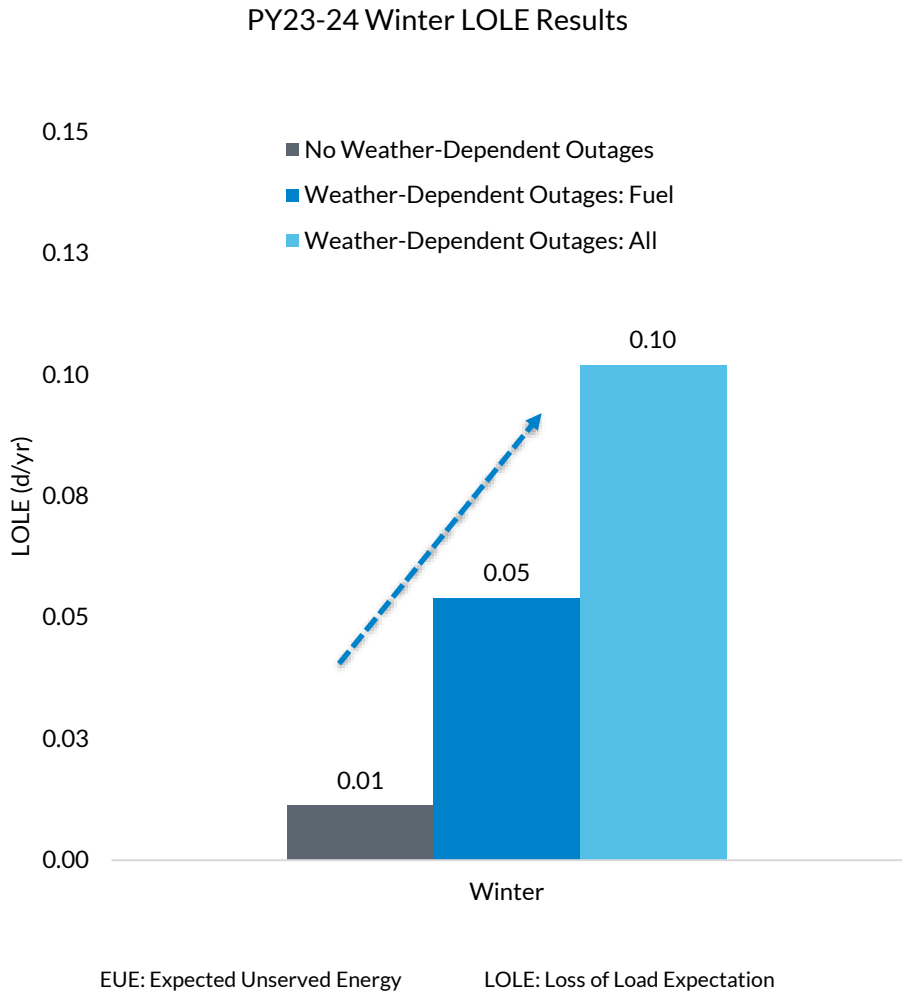




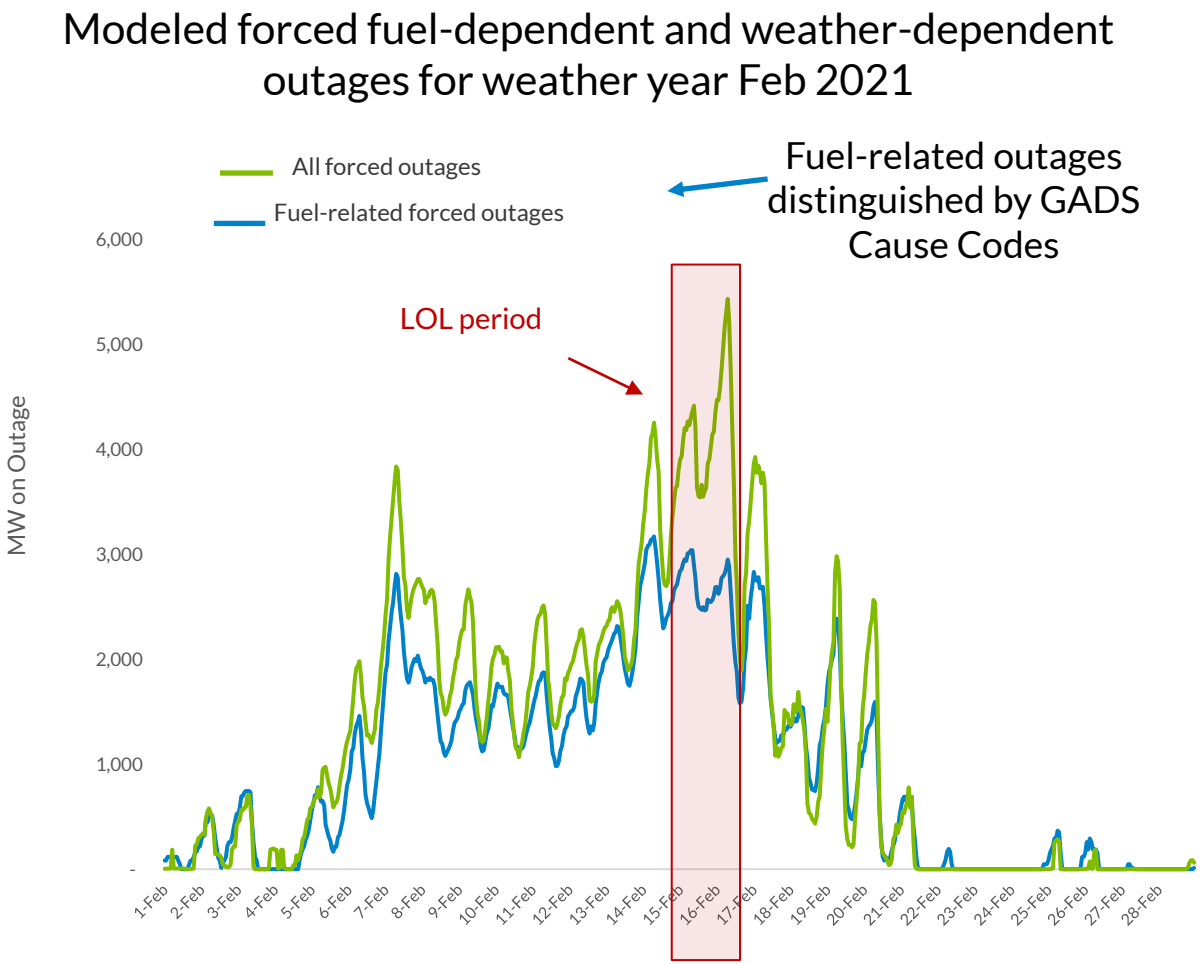
GADS = Generation availability data system
LOL = Loss of load

The weather-dependent outages were based upon the PY23-24 LOLE Study, and the fuel-dependent outages build upon this work by selecting fuel-related outages in GADS Cause Codes.

Accounting for temperature-dependent correlations better capture weather-dependent outage risks in Winter months



EUE: Expected Unserved Energy LOLE: Loss of Load Expectation



GADS = Generation availability data system
LOL = Loss of load

The weather-dependent outages were based upon the PY23-24 LOLE Study, and the fuel-dependent outages build upon this work by selecting fuel-related outages in GADS Cause Codes.

The Regional Directional Transfer (RDT) constraint between MISO North and South regions was incorporated into the LOLE model to explore deliverability considerations

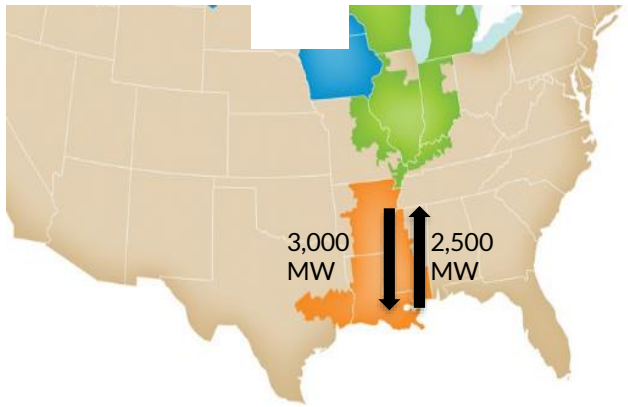
"Copper Sheet" LOLE Model

No transmission included, doesn't explicitly capture attributes related to energy delivery

- Only the RDT constraint was enforced in the model
  - 3,000 MW limit from North/Central to South
  - 2,500 MW limit from South to North/Central

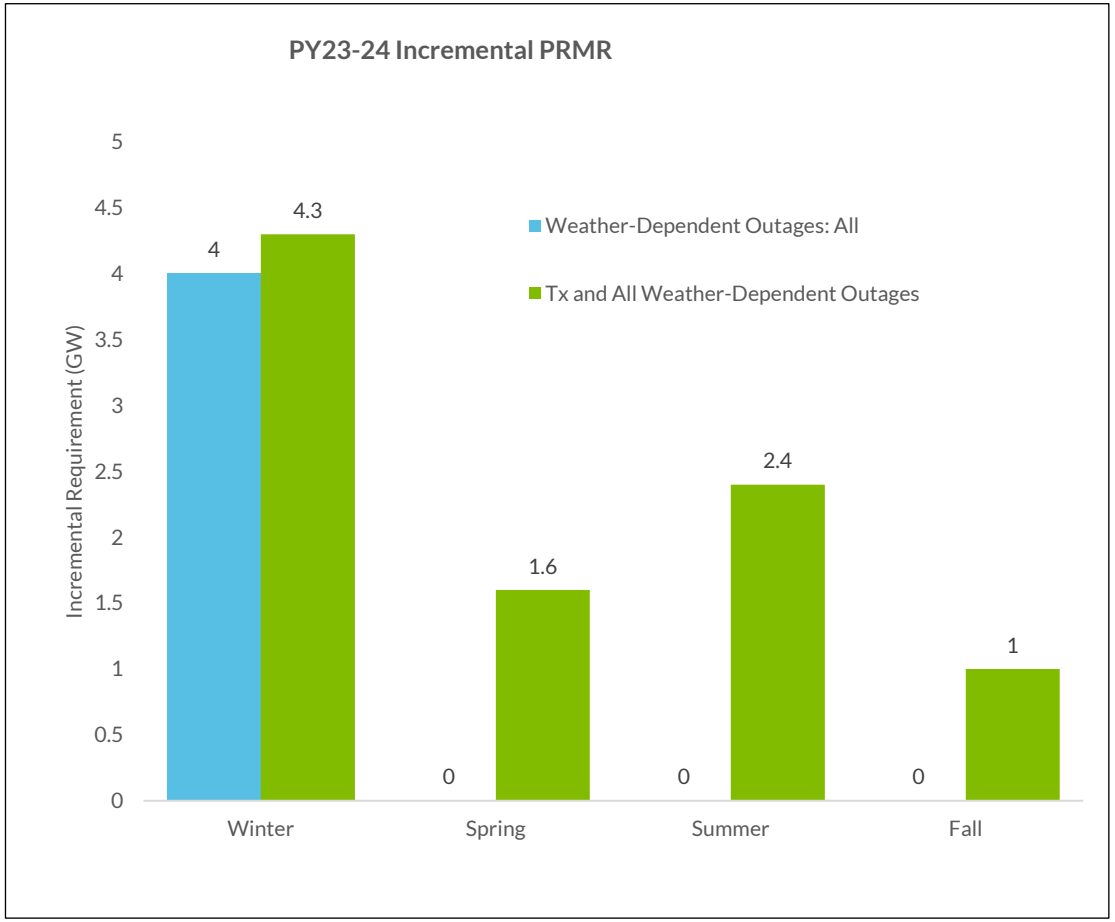
RDT Constrained LOLE Model

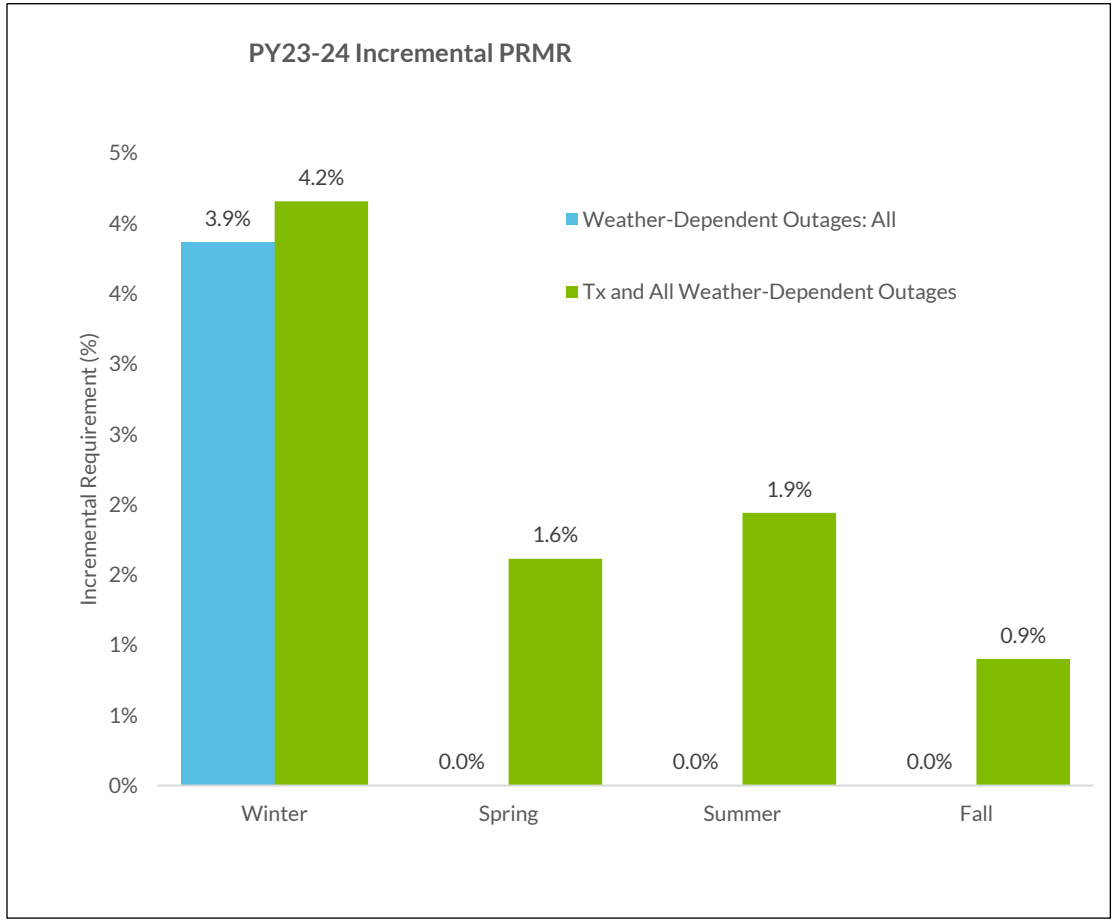
Explicitly captures attributes related to energy delivery between MISO North/Central and MISO South



- Fixed load for the LOLE adjustment was distributed across the two regions based on LRZ contribution to MISO coincident peak

Additional constraints in the LOLE model result in additional fixed load adjustments required to meet the sub-annual LOLE targets

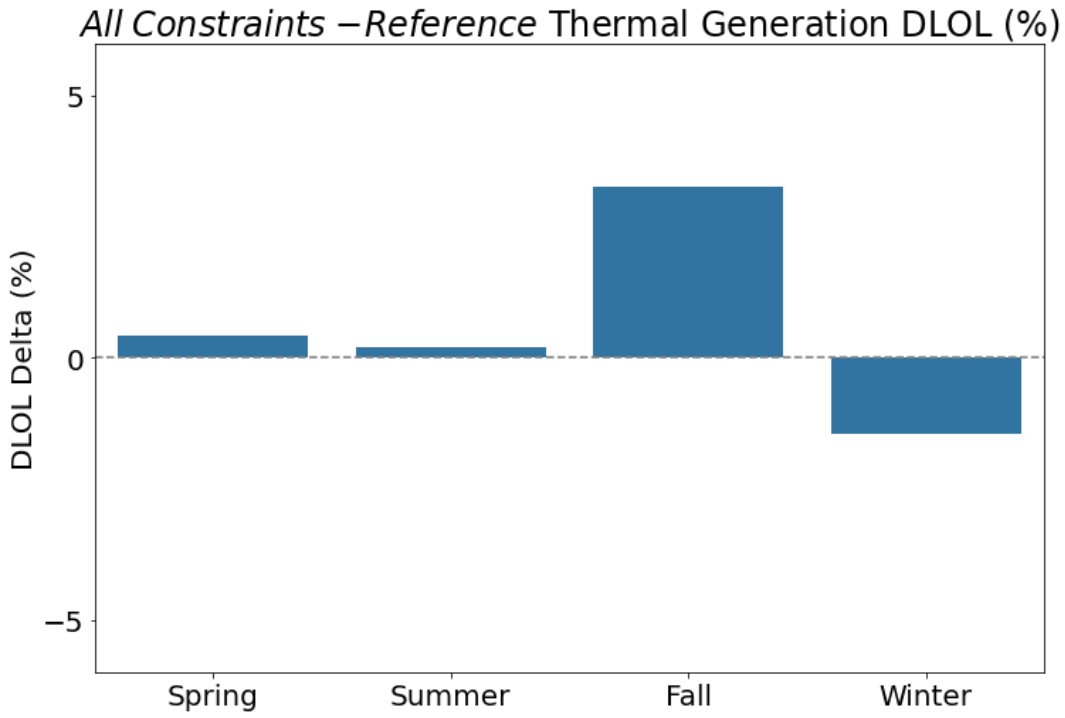




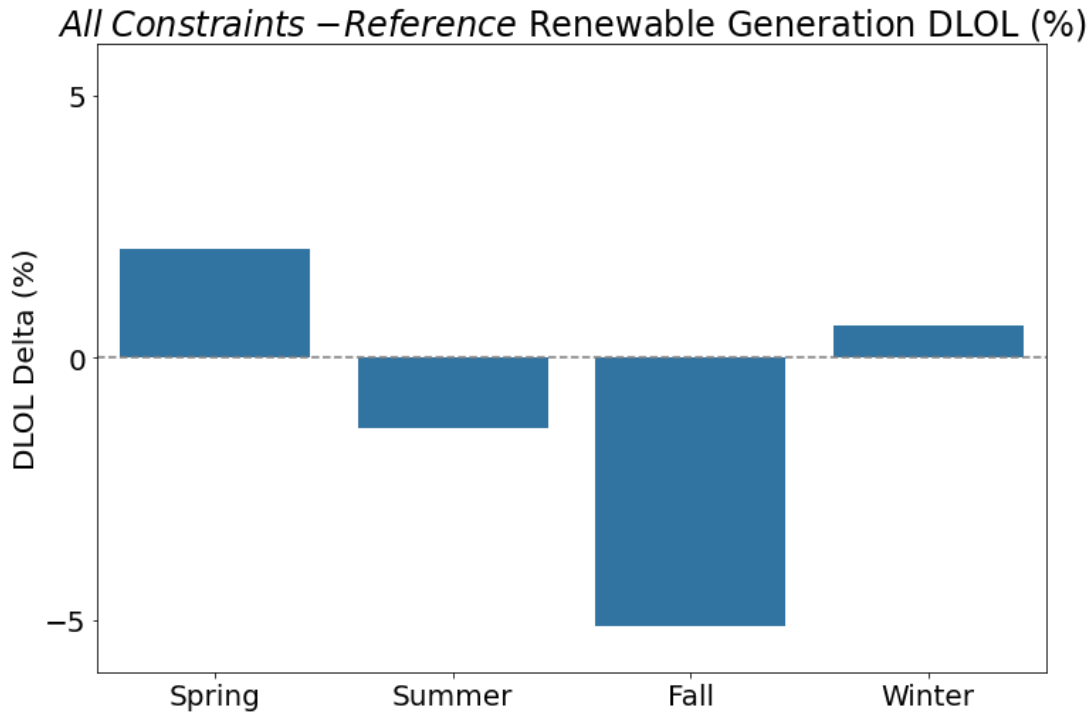
The weather-dependent outages are already reflected in the PY23-24 model.

Both weather-dependent outage and RDT transmission constraints affect the DLOL of thermal and non-thermal resources

Thermal generation DLOL in winter reflects the fuel- and weather-dependent outage scenario assumptions with decreasing contribution



Transmission constrained scenarios shift risk hours in Summer and Fall outside of non-thermal's highest availability, whereas temperature-dependent outages benefit non-thermals in the winter and spring seasons



DLOL: Direct loss of load https://cdn.misoenergy.org/20230117-18%20RASC%20Item%2014b%20Non-Thermal%20Resource%20Accreditation%20(RASC-2020-4,%20RASC-2019-2)%20Presentation627472.pdf

Conclusions

- MISO's seasonal's RA construct incentivizes availability across the year, including periods of extreme cold weather, and have shown more alignment between availability and need
- Accreditation based on Risk Hours to align availability and need in the operational timeframe performed well last Winter
- Acknowledging weather- and deliverability-related risk factors in RA models and **enhance** the overall risk assessment.

Questions?

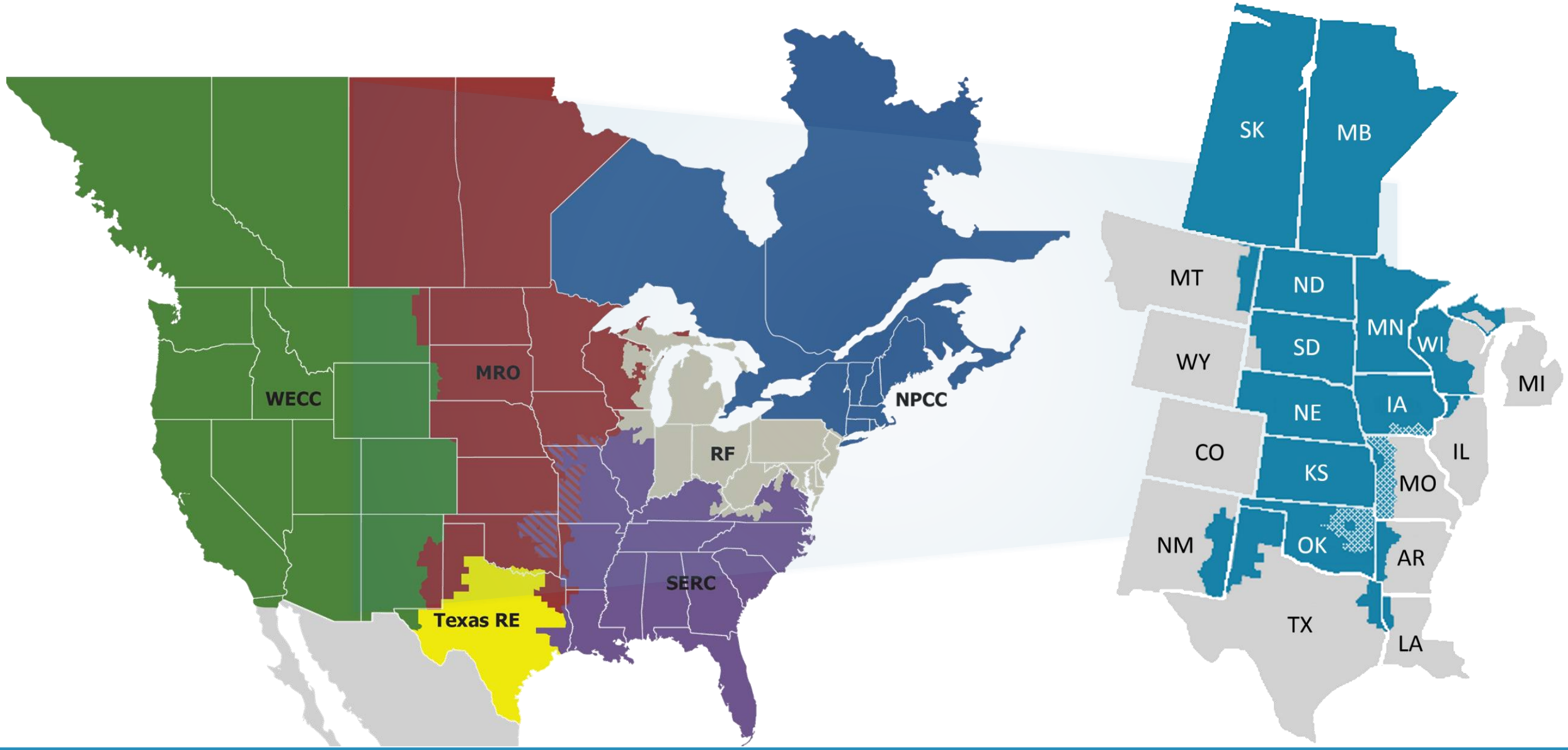
MIDWEST RELIABILITY ORGANIZATION

MRO Generator Weatherization Program (GWP) 2023 Overview

Jake Bernhagen, P.E.

MRO Manager of Reliability Performance

CLARITY | ASSURANCE | RESULTS



The ERO Enterprise and MRO

About MRO's Reliability Analysis Department

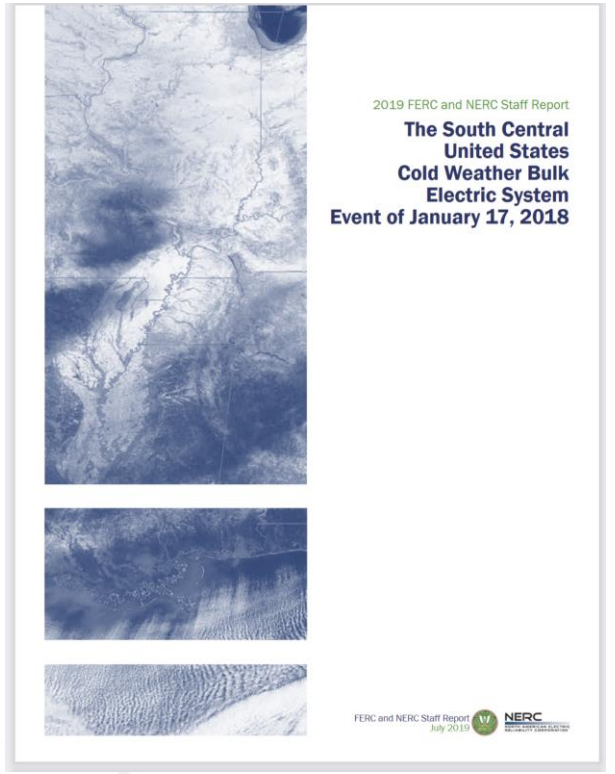
- **What we do:**
  - Reliability Assessments
  - Bulk Power Situational Awareness
  - Event Analysis
  - Performance Analysis
  - Entity Registration and Certification

MRO Generator Winterization Program

- Address risk not covered by Reliability Standards
- Promotes winter weather preparedness for Generator Owners/Operators
- Voluntary program
- Winterization Readiness Evaluation
- Identify best practices and recommendations

Background

- **February 1-5, 2011 (Southwest Cold Weather Event)**
- **January 3-7, 2014 (Polar Vortex)**
- **January 15-19, 2018 (South Central Cold Weather Event)**
  - Report recommendation: enhanced outreach to Generator Owners & Generator Operators
- **February 8-20, 2021 (Winter Storm Uri)**
  - 23,418 MWs of firm load shed
  - 28 recommendations from the February 2021 Cold Weather Report
- **December 21-26, 2022 (Winter Storm Elliot)**
  - Report expected to be published in Q4 2023



MRO Generator Winterization Program Summary

Survey	• High level survey to develop baseline understanding of facility's winterization efforts
Generator Site Visit	• Observation of efforts taken by generation facilities to minimize impact of cold weather to plant operations
Site Report	• Summarize findings from the survey and site visit, identify best practices and make recommendations
Findings Report	• Summary of program data analysis and findings (annual comparisons)

MRO Generator Winterization Program Summary

Survey	• High level survey to develop baseline understanding of facility's winterization efforts

- Current survey consists of 60 questions
- Questions are broken into 8 categories
- Survey sent to all site visit participants
- Additional surveys sent out on as needed basis
- Survey available on MRO's website for self-evaluation

MRO Generator Winterization Program Summary

Generator Site Visit

- Observation of efforts taken by generation facilities to minimize impact of cold weather to plant operations

- **Sites chosen based on GADS data, regional location, and program needs/goals. For 2023:**
  - Nuclear Power Plant practices/procedures
  - Newer Units
  - Hydro Power Plant practices/procedures
  - Wind Farm/Plant practices/procedures
  - Units of different geographical location (northern, middle continent/regional, and southern)
  - Units with special protections

MRO Generator Winterization Program Summary

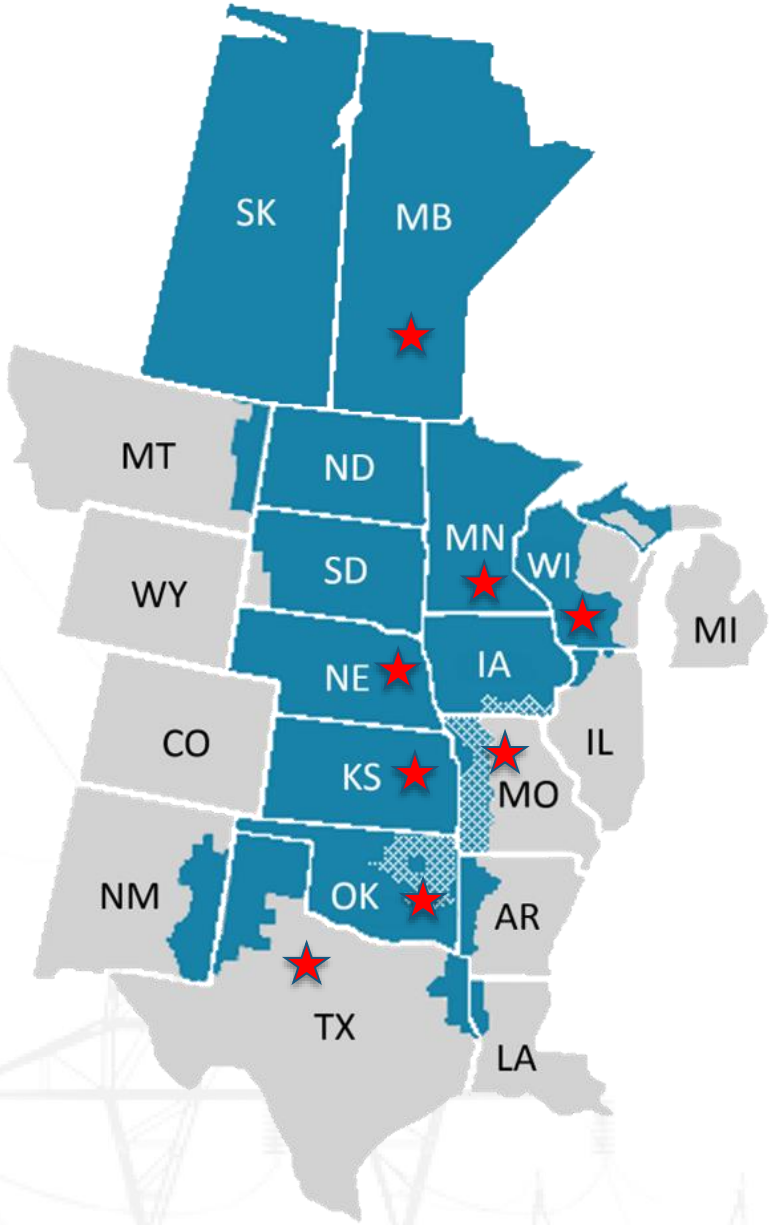
Site Report

- Summarize findings from the survey and site visit, identify best practices and make recommendations

- Non-binding deliverable
- Review of winter preparedness (performance rating)
- Review of winterization plan/program and effectiveness (measured against NERC Guideline's seven key components)
- Identification of positive observations, best practices and recommendations

3 years of visits…

- **2021**
  - Four site visits in MN
  - Natural gas, fuel oil
- **2022**
  - Seven site visits across six states
  - Coal, natural gas
- **2023**
  - Nine site visits across six states
  - Nuclear, hydro, wind, coal, natural gas



MRO Generator Winterization Program

- **Introduced in 2021**
  - Focused on identifying preparations and establishment of winterization program/plan
  - Ten GOs volunteered
  - On-site visits at four of the ten sites, others surveyed
  - All had some level of winter preparation activities taking place, but not all had an established winterization program/plan
  - Heat tracing and insulation were identified as the prominent preventative measures

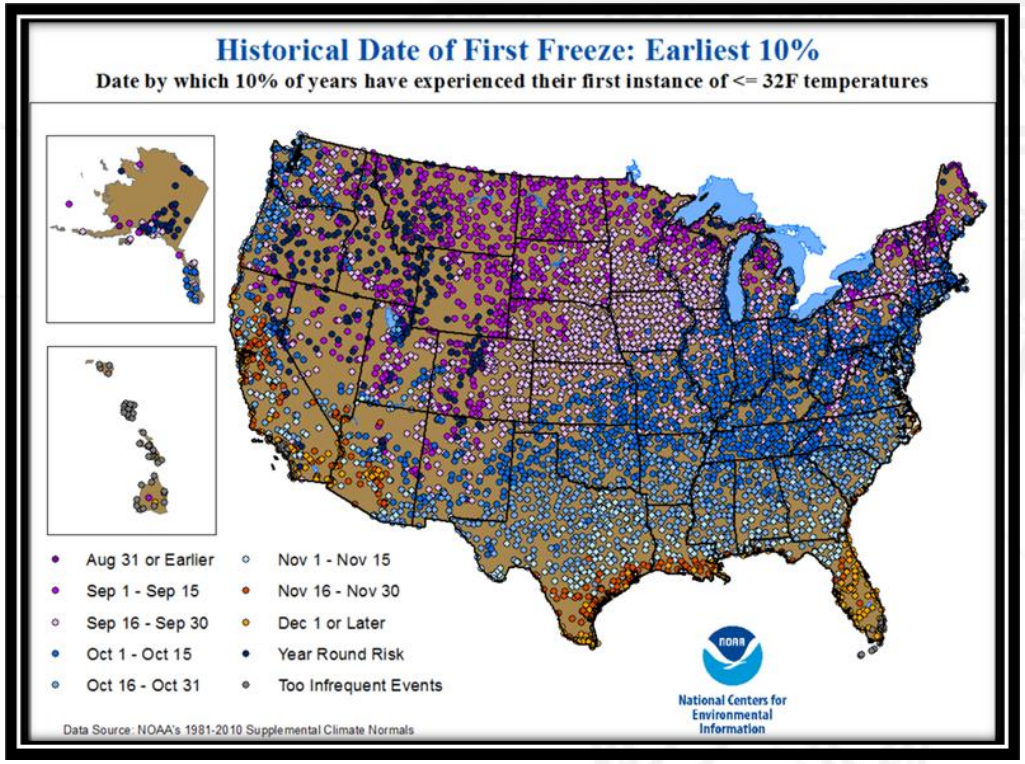
MRO Generator Winterization Program

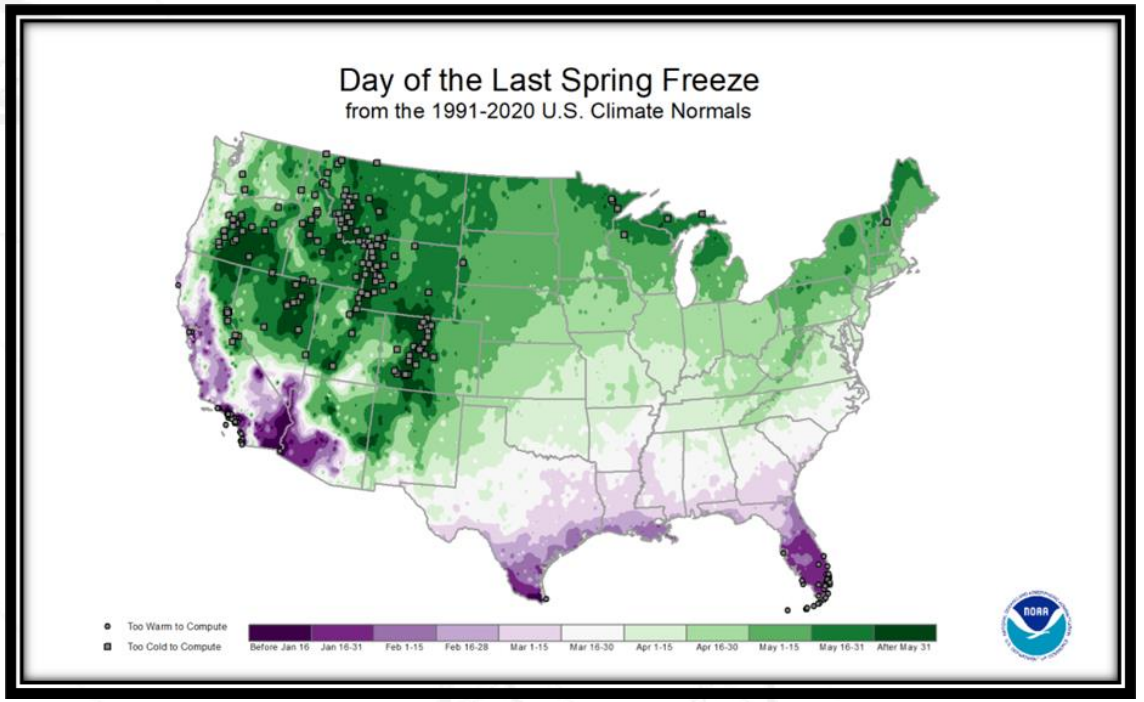
- **2022 GWP Program**
  - Focused on level of readiness and the program/plan's effectiveness
  - Surveyed and conducted six on-site visits
  - All had establishment of winter preparedness activities and documented program/plans
  - Challenges in determining plant OEM minimum designed or operating temperatures
- **GWP 2021-2022 general findings report published in 2023**

MRO Generator Winterization Program

- **2023 GWP Program**
  - Focus continues on level of readiness and the program/plan's effectiveness
  - Survey and conduct nine on-site visits
  - Focus on a greater variety of generation types
- **GWP 2022-2023 general findings report to be published in 2024**

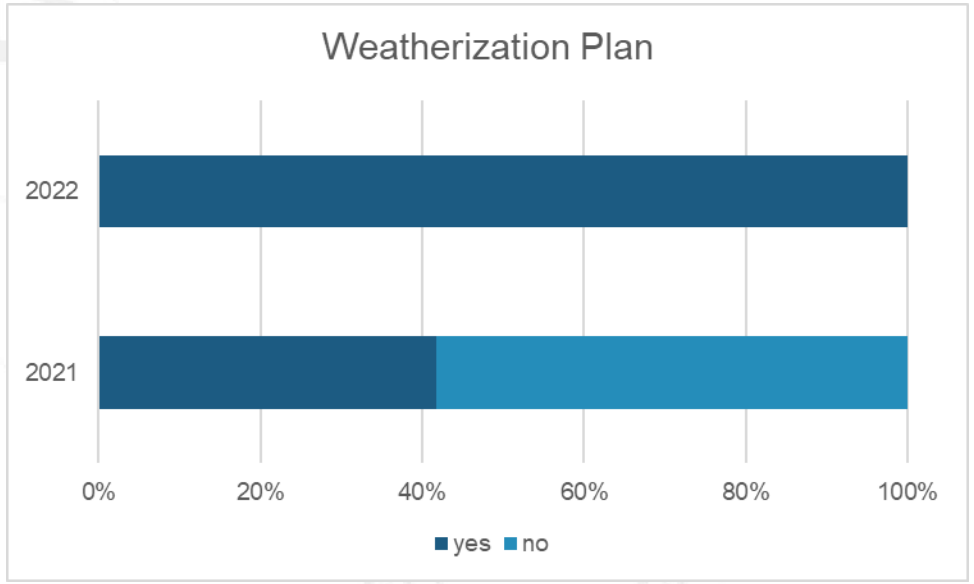
What Have We Found So Far?



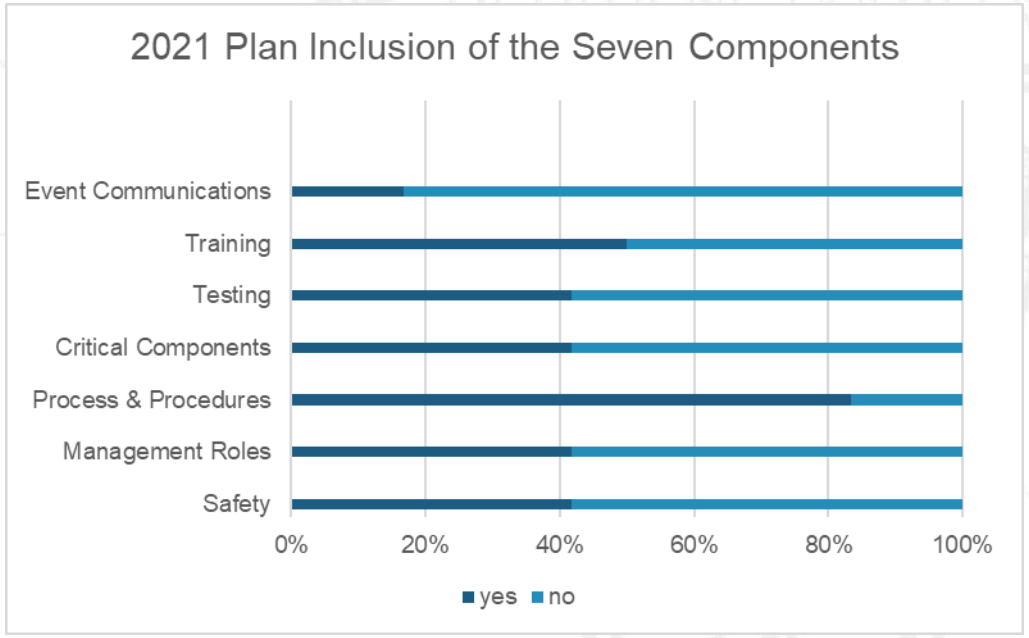


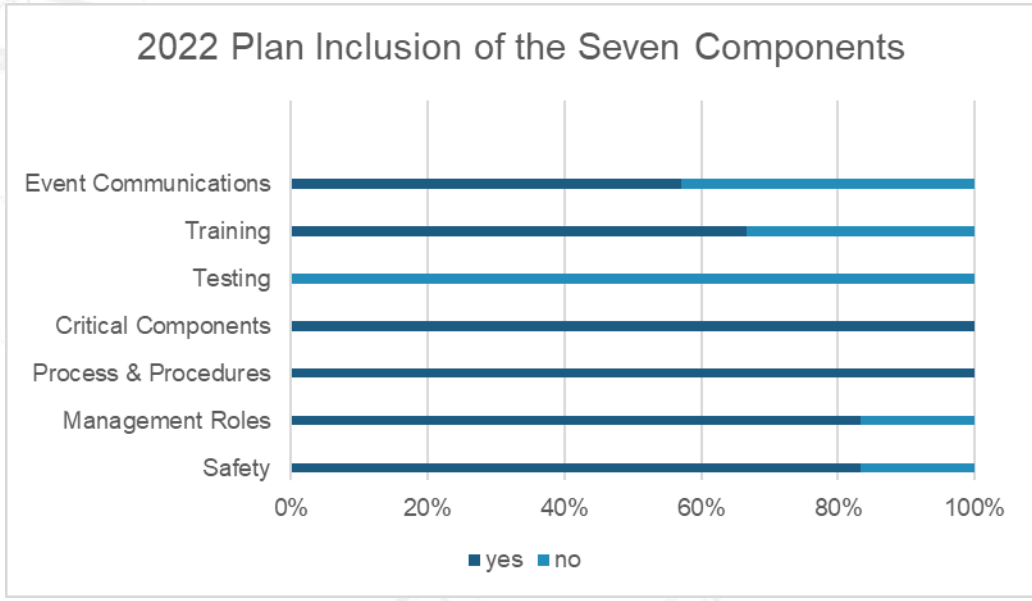
What Have We Found So Far?

- **NERC's Generating Unit Winter Weather Readiness Guideline**
  - Safety
  - Management Roles and Expectations
  - Processes and Procedures
  - Evaluation of Potential Problem Areas with Critical Components
  - Testing
  - Training
  - Communications



What Have We Found So Far?





A Few Best Practices:

- Enclose, insulate, and heat critical equipment
- Maintain and test equipment regularly
- Prepare cold weather tools before the cold hits
- Construct windbreaks when possible
- Incorporate lessons learned into winter preparedness program

Unique and Interesting Observations

- Creative solutions for removing frost/ice buildup on air-intake screens
- Cooling tower safety decking, structural upgrades, wind screens
- Variety of heat trace monitoring solutions
- If it’s critical, enclose and heat!

Upcoming MRO Outreach

- 2023 Regional Winter Assessment Webinar – **December 12, 2023, 10:00 – 11:00 AM Central**

MRO's Generator Winterization Program

For more information, please contact:

Jake Bernhagen, Manager of Reliability Performance
Jake.Bernhagen@mro.net

Questions?

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

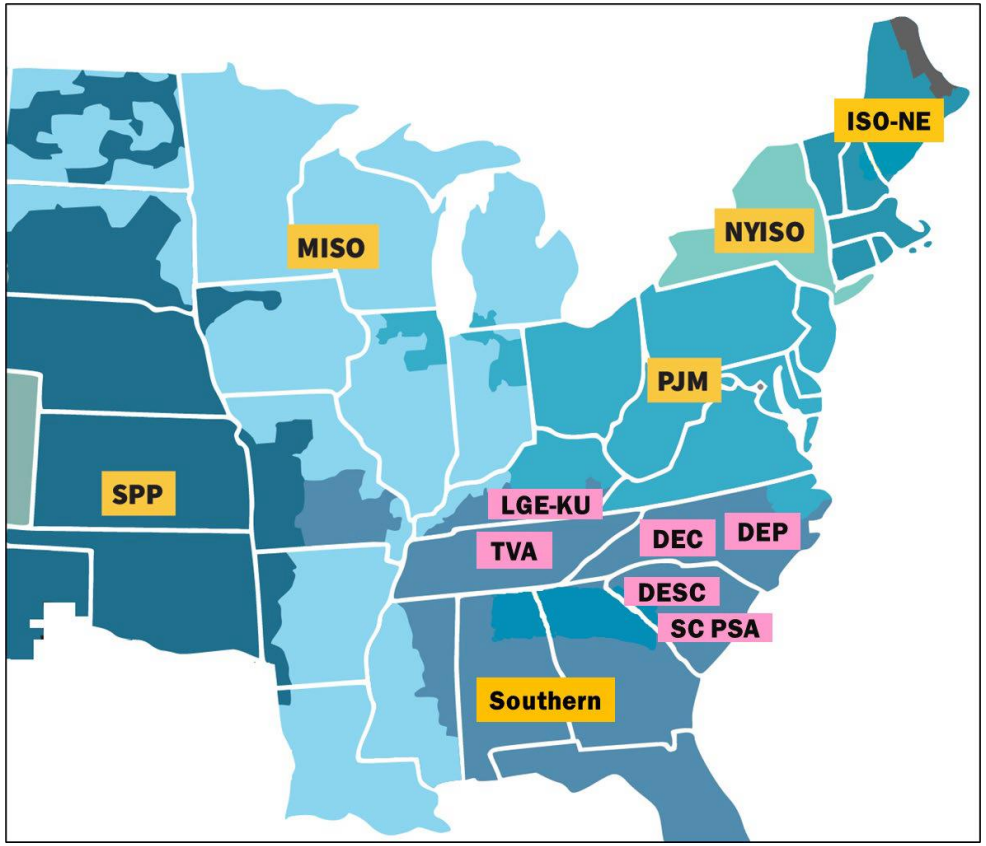
December 2022 Winter Storm Elliott Grid Operations: Key Findings and Recommendations

FERC, NERC, and Regional Entity Joint Staff Inquiry

September 21, 2023

Winter Storm Elliott's Effects on the Bulk-Power System During Worst Conditions, December 23-24, 2022

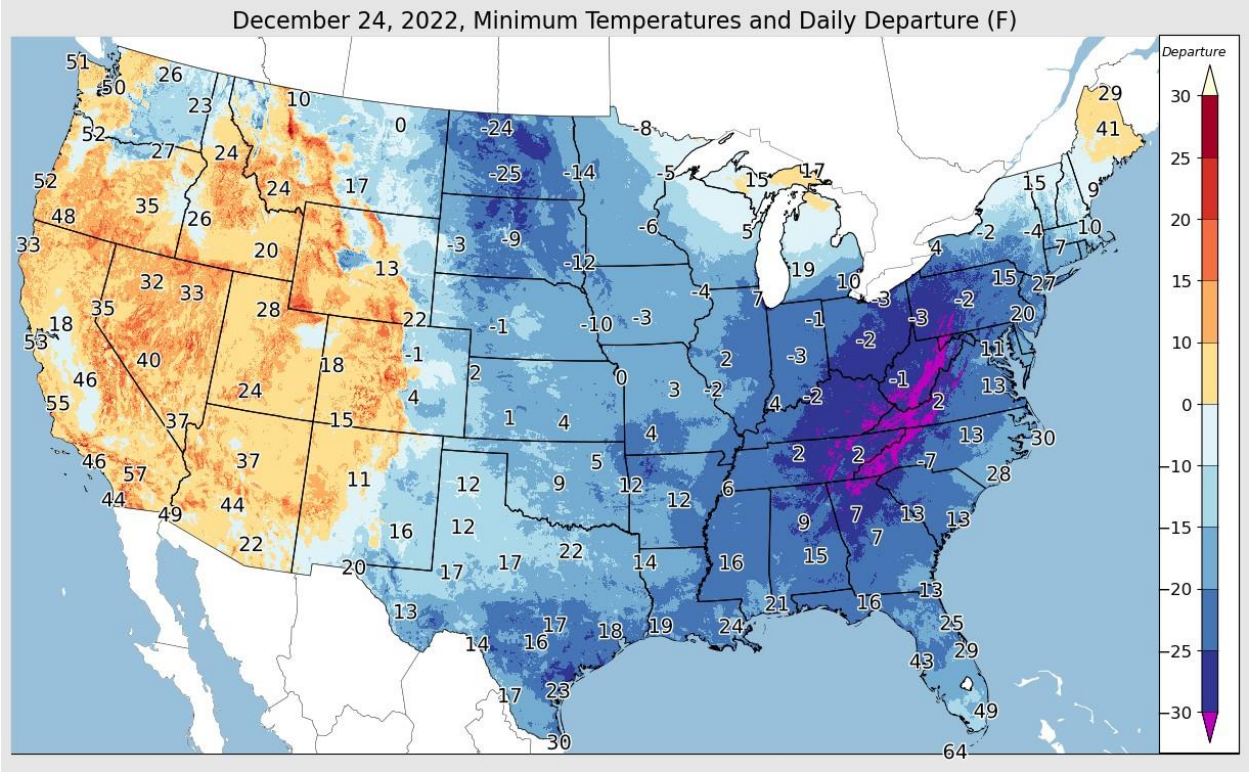
- Unprecedented electric generation outages coincided with winter peak electricity demands (i.e., winter peak loads)
- Several Balancing Authorities (BAs) in the Eastern U.S. declared Energy Emergencies, and to maintain electric grid reliability, some in the southeastern U.S. ordered firm load shed at different times, in total exceeding 5,000 MW during the extreme cold weather:
  - Tennessee Valley Authority (TVA) BA: nearly eight hours total and at its worst point, 3,000 MW
  - Duke Energy Carolinas (DEC) and Duke Energy Progress (DEP) BAs: approximately three hours total and at worst points totaled over 1,900 MW
  - Louisville Gas and Electric – Kentucky Utilities (LGE-KU) BA: approximately four hours total and at its worst point, over 300 MW
  - Dominion Energy South Carolina (DESC) and South Carolina Public Service Administration/Santee Cooper (SC PSA) BAs: at worst point totaling 94 MW (DESC) and 86 MW (Santee Cooper), for 9 and 17 minutes, respectively



PJM, Southern, MISO, SPP, and ISO-NE BAs also declared Energy Emergencies, but conditions improved, sparing them from the need to order firm load shed.

Unplanned Generation Outages Increased to Historic Levels

Departure from Average Daily Minimum
December 24, 2022



(Source: NOAA)

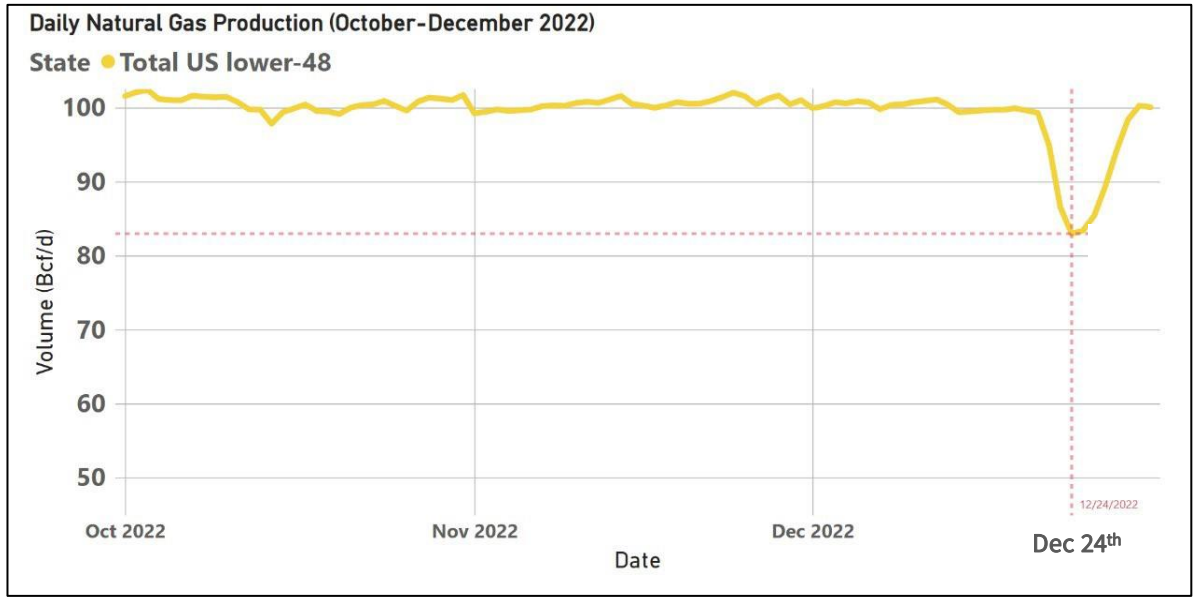
- The Event is the FIFTH in the past 11 years in which unplanned cold weather-related generation outages jeopardized bulk-power system reliability:
  - 2011 – 29,700 MW
  - 2014 – 19,500 MW
  - 2018 – 15,800 MW
  - 2021 – 61,300 MW
  - 2022 – 90,500 MW

    The 90,500 MW of incremental coincident unplanned outages during Winter Storm Elliott represented 13% of the U.S. portion of the anticipated resources* in the Eastern Interconnection.

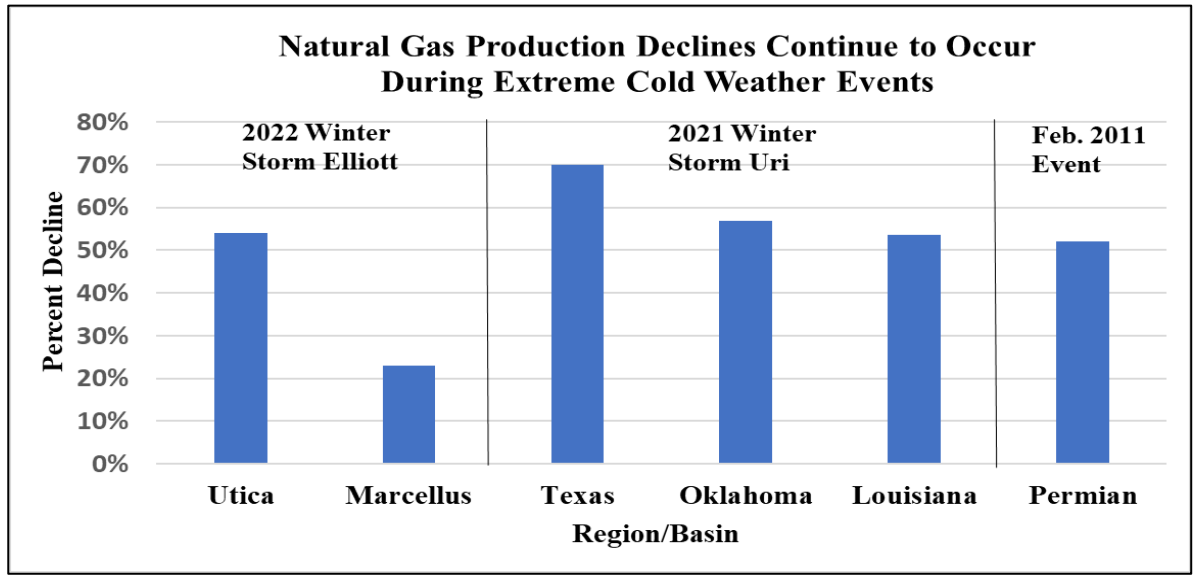
(*Based on data from NERC 2022-2023 Winter Reliability Assessment)

Gas Production Declined

- "Dry natural gas production in the Lower 48 states dropped to a low of 82.5 Bcf on December 24, a 16 percent decrease (16.1 Bcf/d) from December 21…" (EIA)
- Gas production experienced the greatest declines in the Marcellus and Utica Shale formations, where it dropped by 23-54% during The Event. (S&P)
  - "In 2022, the Appalachia region in the Northeast produced more natural gas than any other U.S. region, accounting for 29% of U.S. gross natural gas withdrawals (or 34.6 Bcf/d)." (EIA)

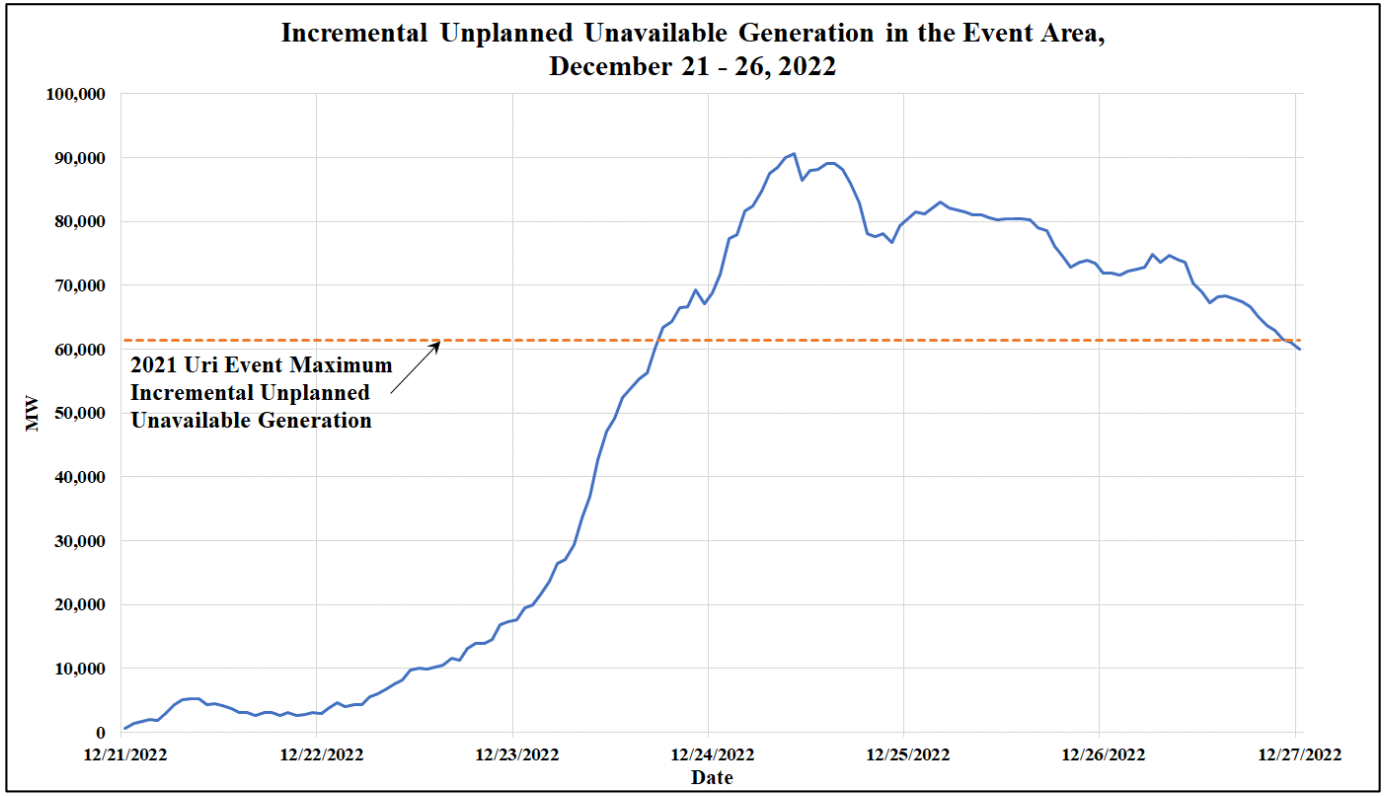


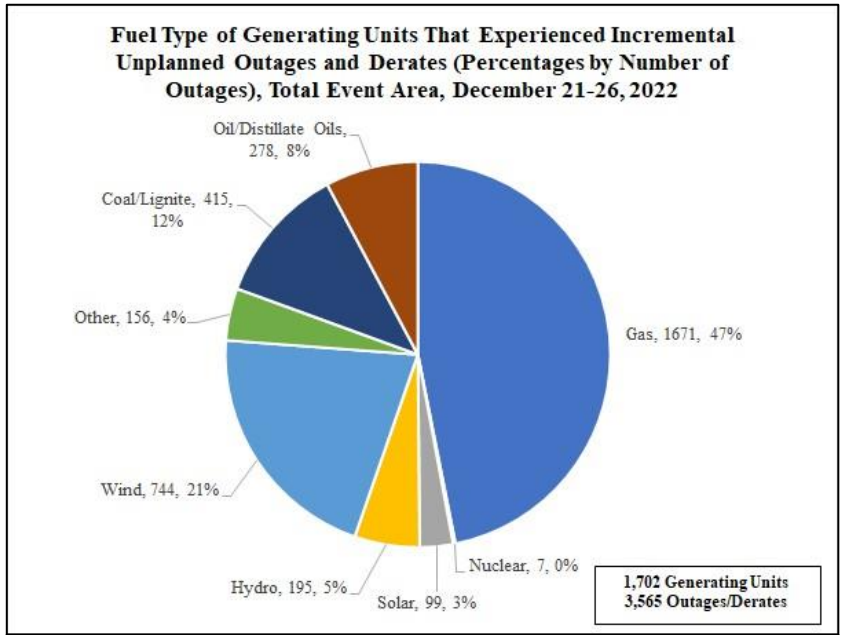
(Source: S&P Global Commodity Insights)

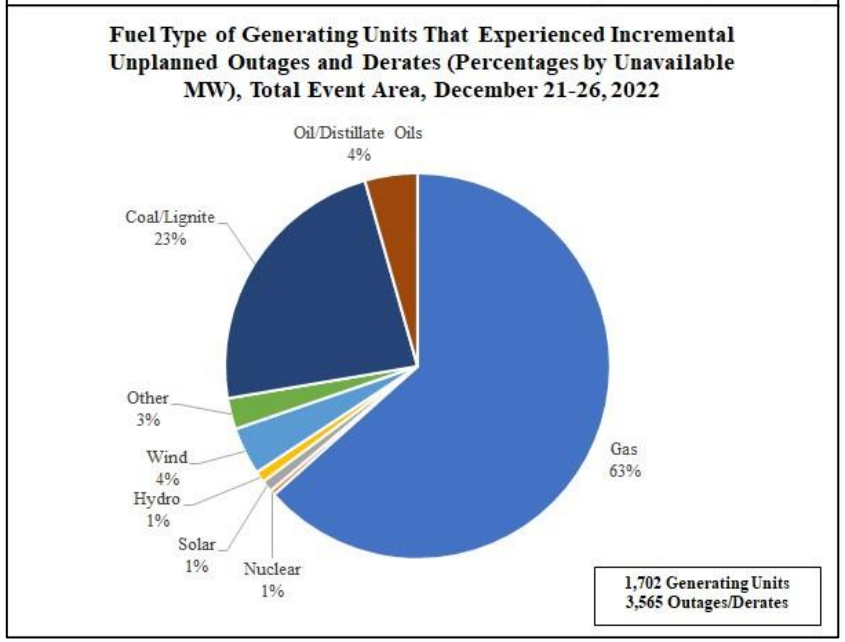


Unprecedented Electric Generation Outages Due to Cold Weather

- 1,702 individual generating units experienced 3,565 outages, derates, or failures to start, of which 825 units were natural gas-fired generators.



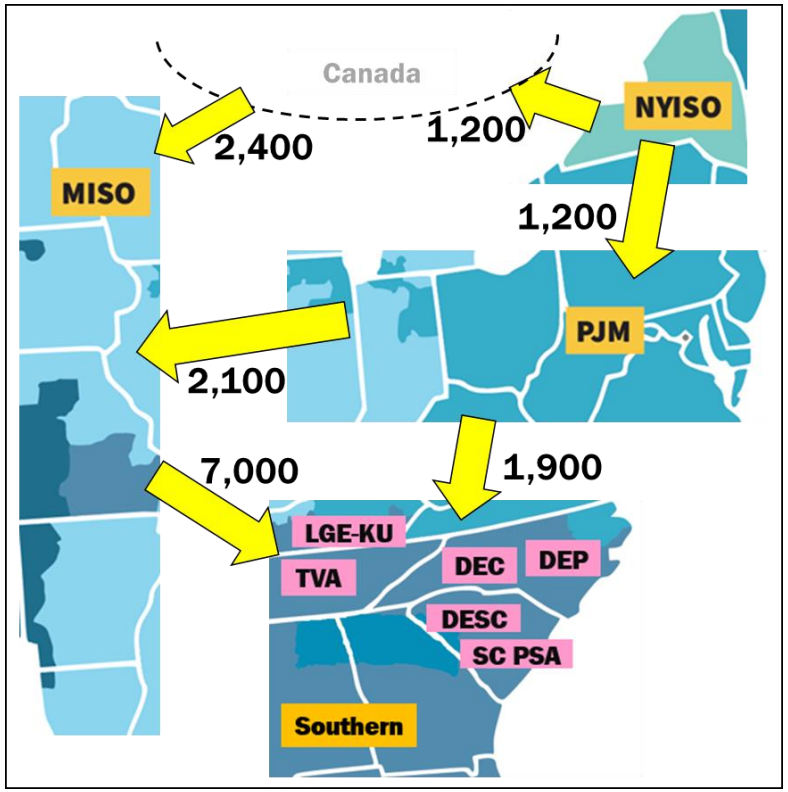




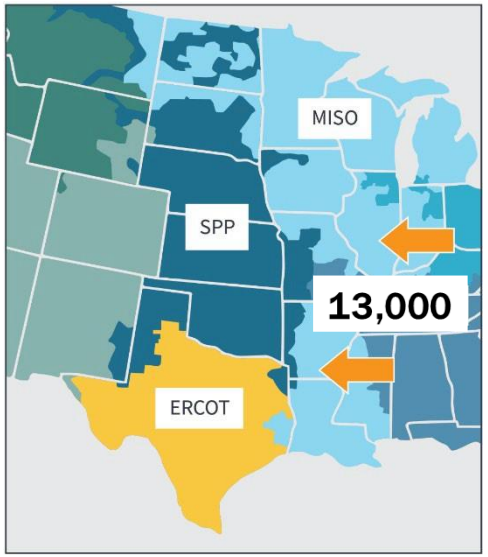
Higher Transmission Flows Resulted in Constraints - Mitigated by Electric Grid Operators' Actions

- PJM, MISO, TVA, Southern, and SPP used generation redispatch and post-contingency mitigation procedures to alleviate most transmission constraints.
- PJM curtailed a power transfer to TVA to resolve a real-time constraint on Dec. 23.
- MISO declared two Local Transmission Emergencies (LTEs) (one was declared to access additional hydro capacity); neither LTE resulted in customer interruptions, Interconnection Reliability Operating Limits (IROLs), or load shed.

Approximate Power Flows (MW), December 24, 2022 Hour Ending 5 A.M. EST



Comparison:
2021 Winter Storm Uri East-to-West Power Flow (MW) February 15, 2021

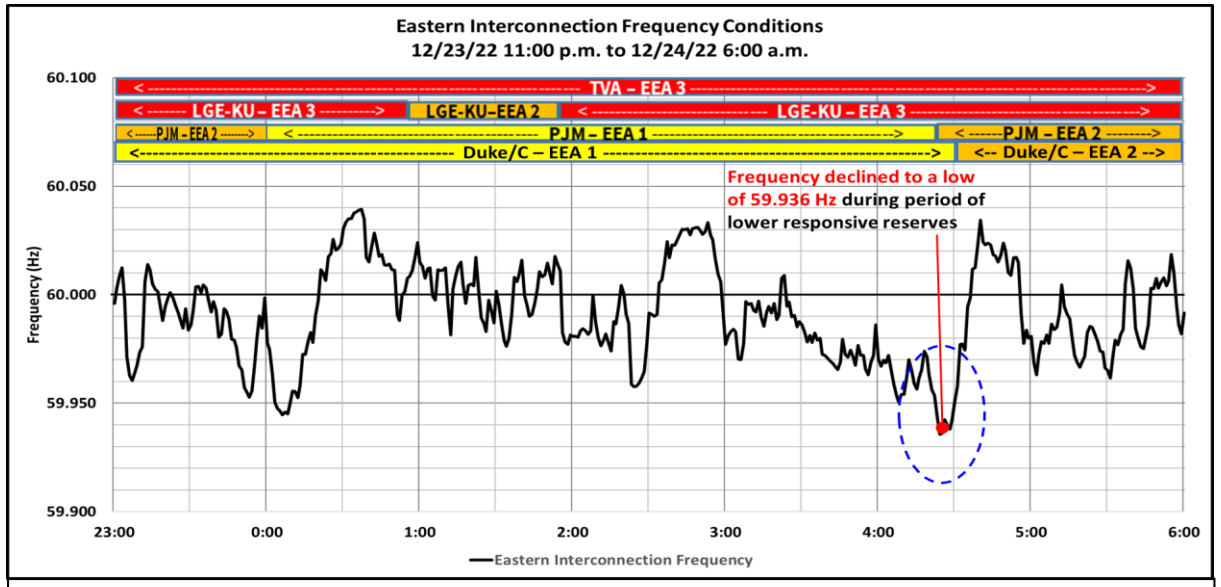


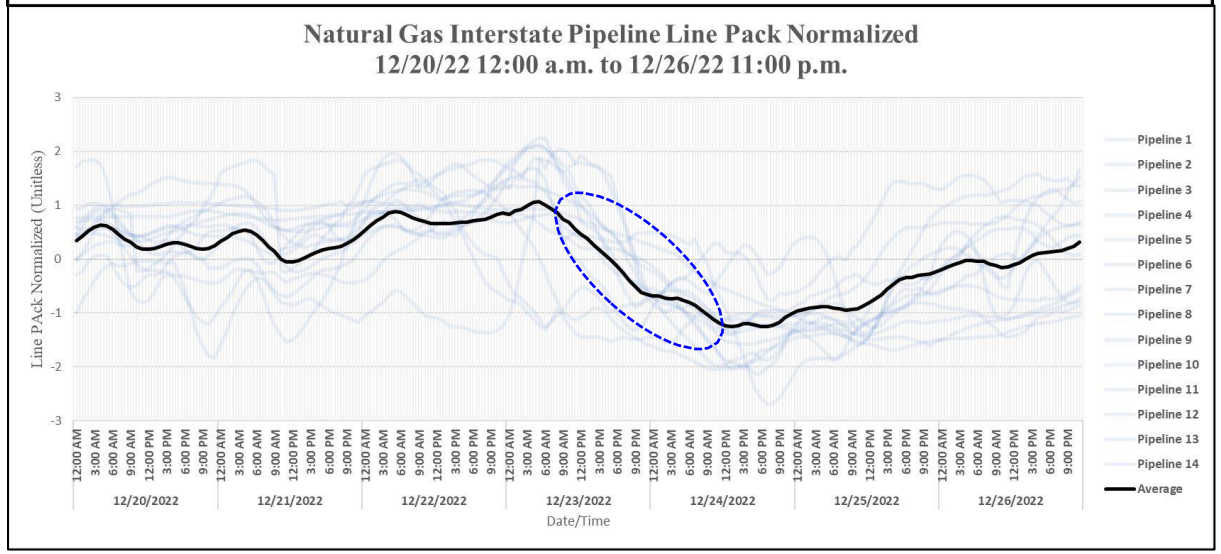
Most power transfers/imports that were curtailed were not due to transmission constraints during the Elliott Event.

Real-Time Operators' Actions

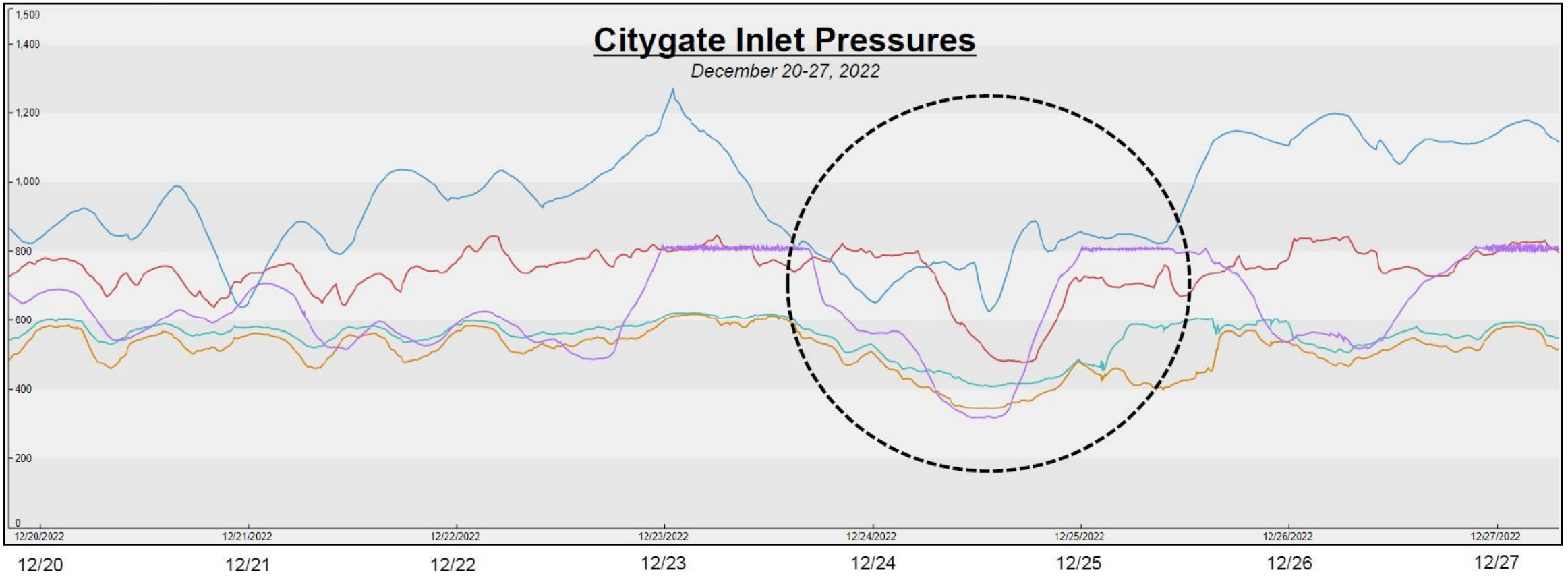
- Electric grid operators: mitigated Eastern Interconnection Frequency (indicator of grid "health") excursions during periods of lower responsive reserves by implementing emergency actions (reduced demand).

- Natural gas pipeline operators: managed system line pack and storage to maintain system integrity despite decreasing receipts on multiple pipelines and increased demand.





Con Edison (ConEd) Gas Operations - 12/24/22 Reliability-Threatening Delivery Pressure Decreases Across all Pipelines



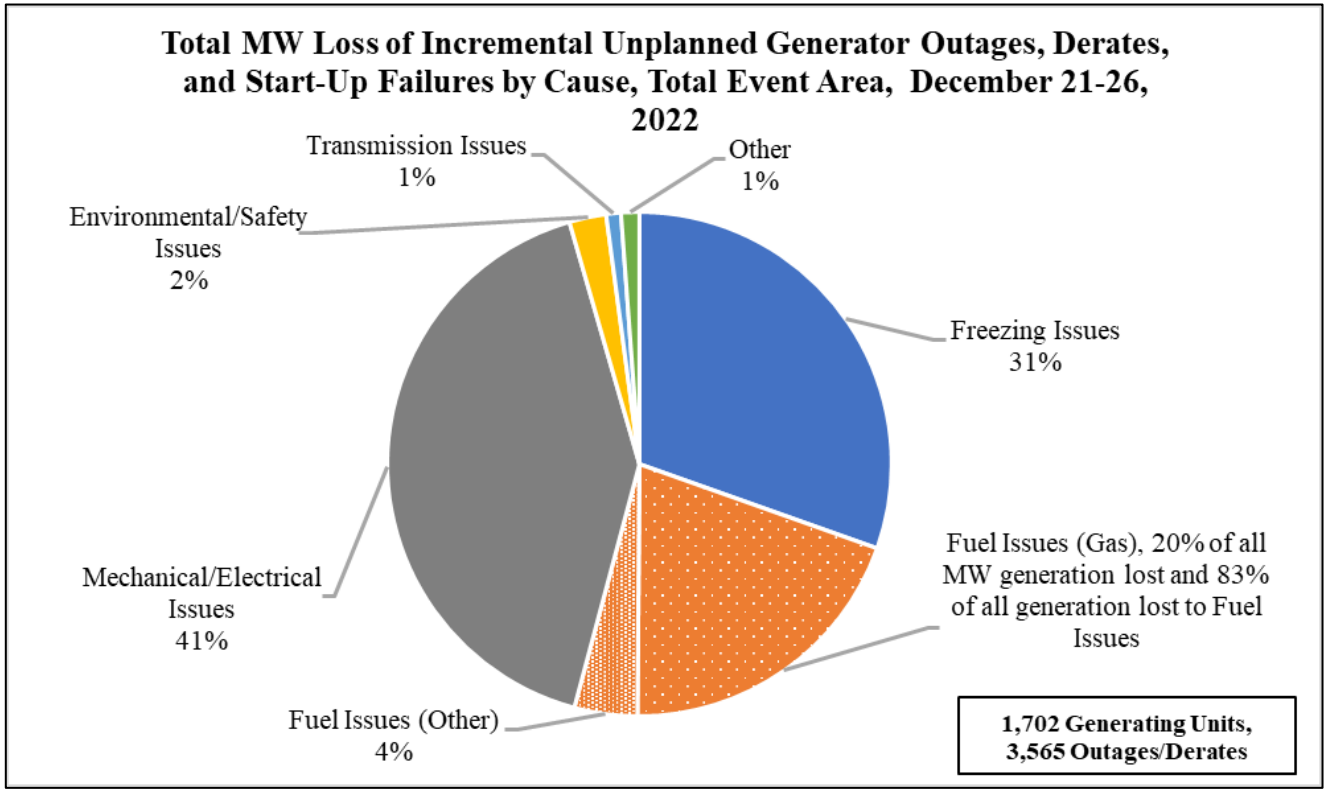
(Source: Con Edison)

ConEd Natural Gas Operations - 12/24/22 Reliability Threatening Delivery Pressure Decreases Across all Pipelines (cont'd.)

- Pipeline pressures at the city gate for ConEd of NY, the natural gas Local Distribution Company for Manhattan, declined precipitously during the morning of December 24. At noon on 12/24/22, ConEd learned on a call with the four interstate gas pipeline companies serving its city gate that their "storage withdrawals were at maximum, line-pack had been expended across the entire transportation system, and low inlet pressures at area meter stations would not recover until demand decreased."
- ConEd declared a Gas System Emergency. It was able to maintain necessary pressure on its system by, among other things, activating its LNG facility.
- Had ConEd's city gate pressures continued to decline, it was in danger of losing pressure below the level needed to operate the system resulting in loss of service to all or portions of its system.
- Loss of natural gas service to its system would not only have left many customers in the life-threatening position of being without heat during extreme cold; but would likely have caused extensive property damage due to damaged water pipes. Restoring service to impacted customers would have required entering each customer site and manually re-lighting gas appliance pilots. Even with assistance of mutual assistance resources, this process could have taken several months.

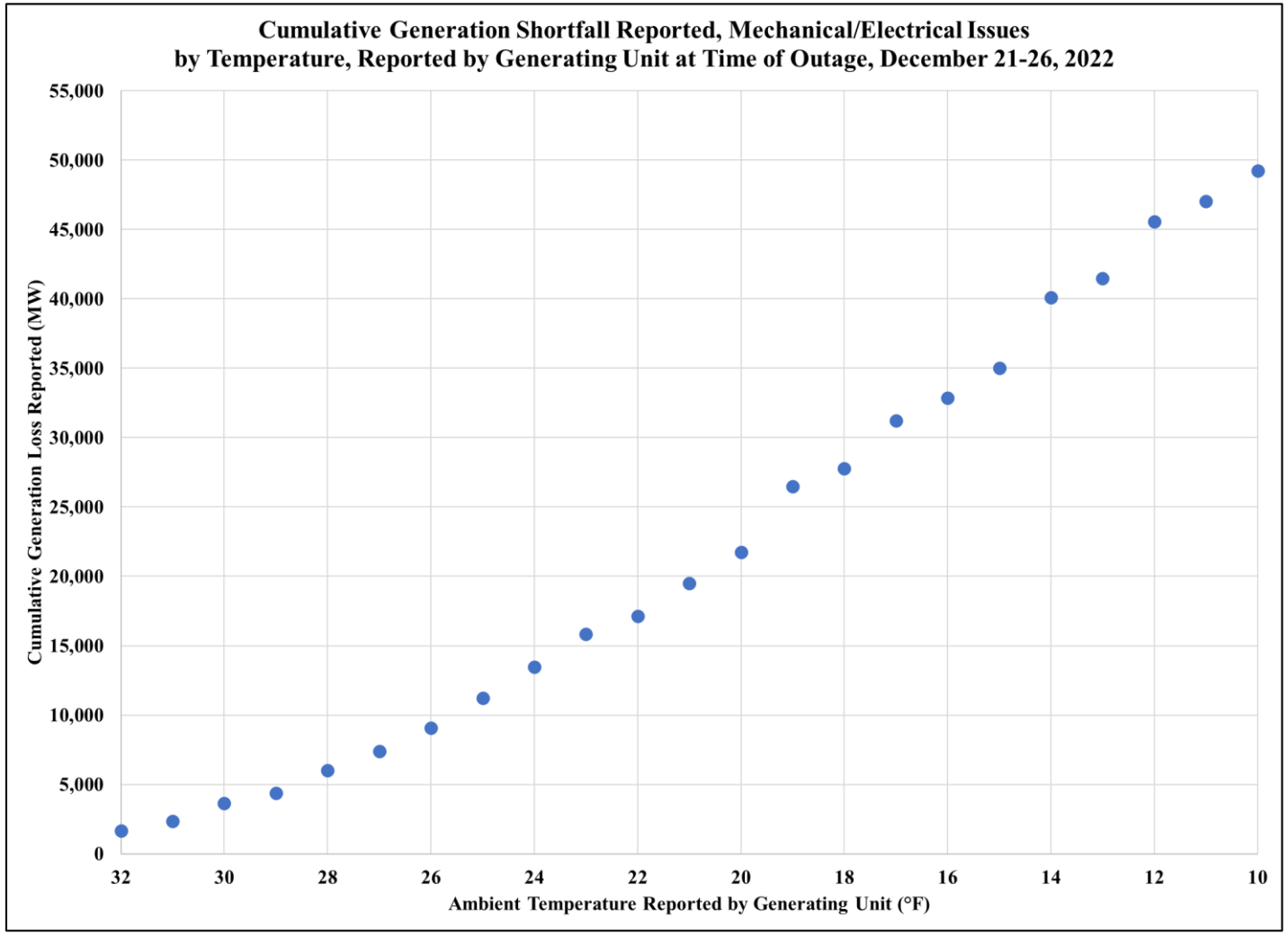
Key Findings

- 55 percent of the generating unit outages, derates, and failures to start, were caused by:
  - Freezing Issues (31 percent)
  - Fuel Issues (24 percent)
    - Natural Gas Fuel Issues were 20 percent of all causes and other fuels were 4 percent)
- 41 percent indicated by Generator Owners to be caused by Mechanical/Electrical Issues, but the team found them to be correlated with subfreezing temperatures



Key Findings
Freezing and Mechanical/Electrical Issues

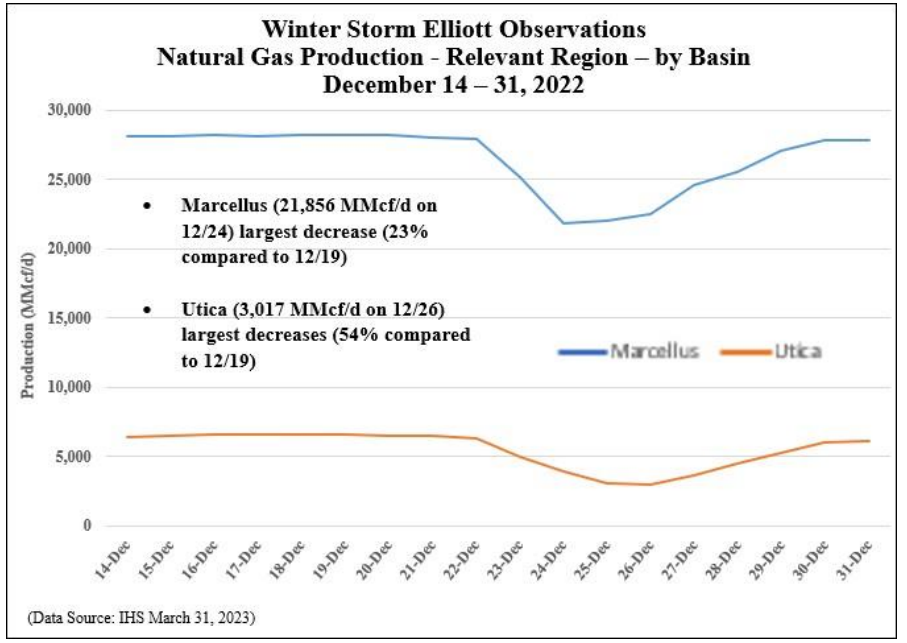
- Those that were attributed to having "Mechanical/Electrical Issues" increased with decreasing ambient temperatures
- Of those generating unit outages, derates, and failures to start that were attributed to having "Freezing Issues" nearly 80% occurred at ambient temperatures that were above their documented minimum operating temperatures.

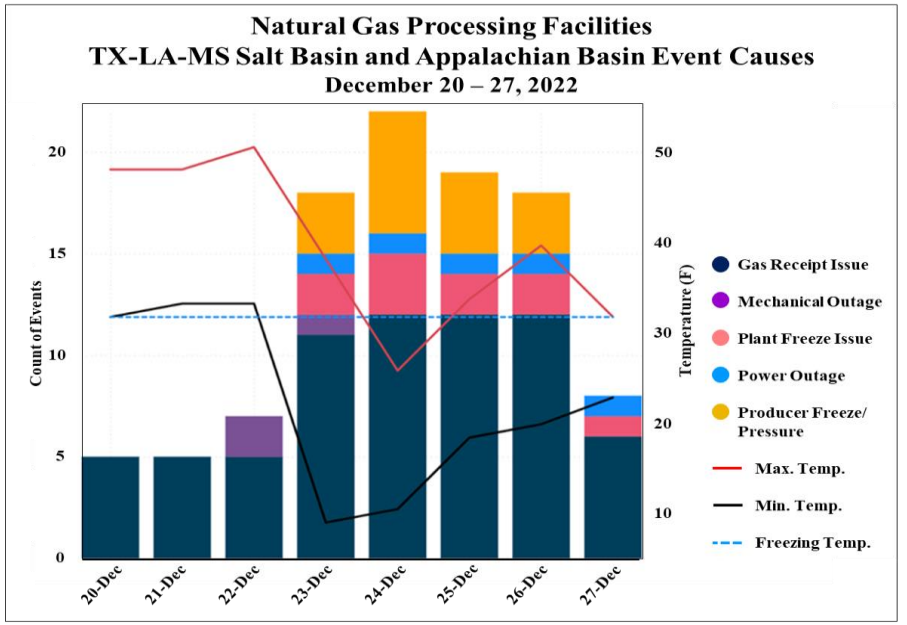


Key Findings
Natural Gas Fuel Issues

Major Cause: Natural Gas Infrastructure Reliability Issues During Extreme Cold Weather

- Production Infrastructure
  - Wellhead freeze-offs, other equipment freezing
  - Poor road conditions due to storm/cold weather, preventing maintenance
- Processing Facility Operating Issues
  - Reduction in receipt (production) volume
  - Producer freeze and pressure issues
  - Processing plant disruptions and outages caused by freezing and mechanical issues



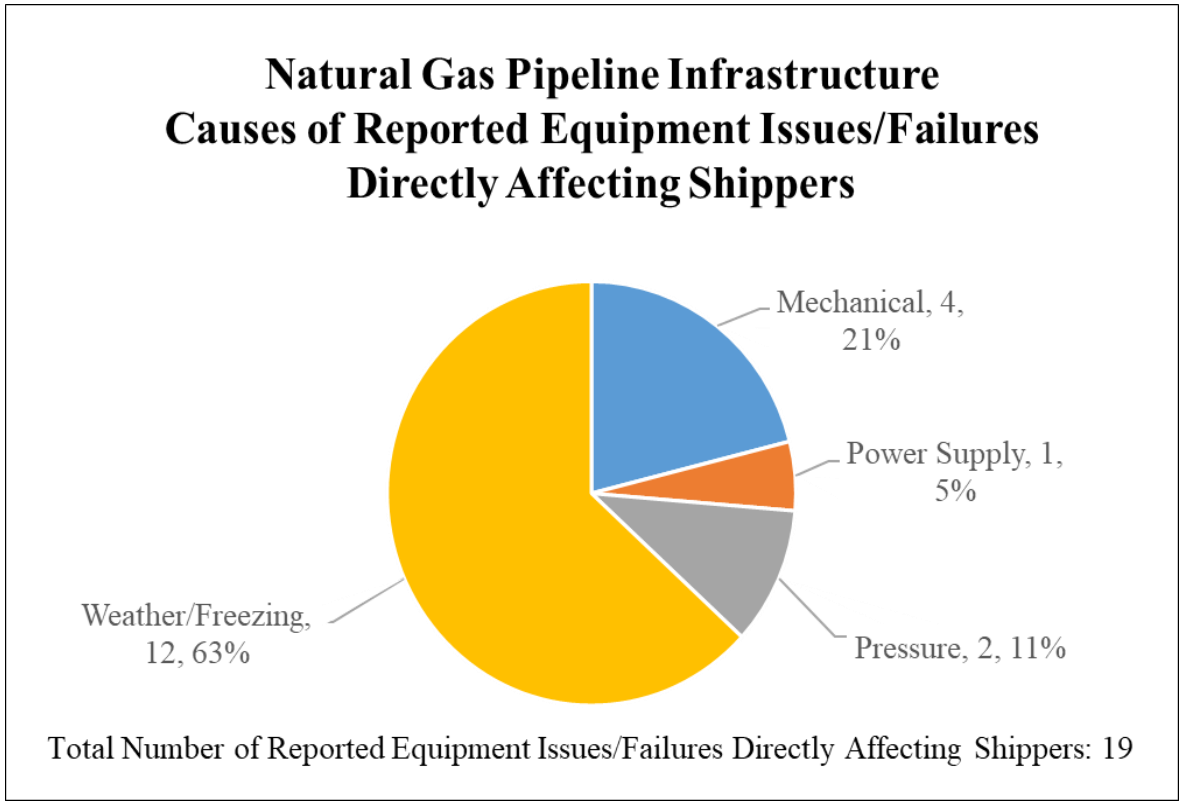


Key Findings
Natural Gas Fuel Issues

Major Cause: Natural Gas Infrastructure Reliability Issues During Extreme Cold Weather

- Pipeline Infrastructure
  - Equipment issues directly affecting shippers (e.g., end-users such as generating units, LDCs):
    - Weather/freezing issues (majority)
    - Mechanical issues
  - Interstate pipelines mitigated other equipment issues to avoid impacts to shippers.

- 63 natural gas-fired generating unit outages/derates, totaling 10,038 MW, were due to firm gas transportation curtailments during the Event.



Key Findings

Electricity Demands Exceeded Grid Operators' Forecasts

- The majority of the BAs' short-range forecasts of peak electricity demands underestimated load on December 23 and December 24.*
- One BA's underestimation was as much as 11.6% for their "Day-Ahead" forecast for December 23.
- Two BAs' underestimations were as much as 5.0% for their "Day-Ahead" forecasts for the December 24.

	Peak Load Forecasts for Friday, December 23		Peak Load Forecasts for Saturday, December 24	
	Underestimation		Underestimation	
Forecasts Produced ->	2 Days-Ahead	Day-Ahead*	2 Days-Ahead	Day-Ahead*
Total Load Forecast Underestimation (MW) for Grid Entities' Footprints Combined	23,047	17,773	13,316	10,033
Average Percent Forecast Underestimation for Core Entity Footprints Combined	8.8%	6.8%	5.1%	3.9%

*Many BAs target their respective "Day-Ahead" peak load forecast errors to be within 2 – 3 percent of actual peak loads.

Similarities to Past Extreme Cold Weather Events

	2011 Event	2014 Event	2018 Event	2021 Event	2022 Event
Significant levels of incremental unplanned electric generating unit losses with top causes found to be mechanical/electrical, freezing, and fuel issues.	✓	✓	✓	✓	✓
Significant natural gas production decreases occurred, with some areas of the country more severely affected.	✓			✓	✓
Short-range forecasts of peak electricity demands were less than actual demands for some BAs in event area.	✓		✓	✓	✓
Significant natural gas LDC outages or near miss	✓				✓

Recommendations

- 11 recommendations

- Categories of recommendations include improvements to:
  - Generator Cold Weather Reliability
  - Natural Gas Infrastructure Cold Weather Reliability
  - Gas-Electric Coordination Cold Weather Reliability
  - Electric Grid Operations Cold Weather Reliability

- Where appropriate, recommendations have recommended timeframes for implementation/initiation

Improvements to Generator Cold Weather Reliability

1. Findings support (a) the need for prompt NERC development and implementation of remaining recommended revisions to Reliability Standards from 2021 Key Rec. 1 to strengthen generators' ability to maintain extreme cold weather performance; (b) the need for robust ERO monitoring of implementation of currently-effective and approved cold weather Reliability Standards, to determine if reliability gaps exist.

   - Near-term action: NERC should identify the generating units that are the highest risk and perform cold weather verifications of these generating units.

2. NERC should initiate a technical review, to be performed by an independent subject-matter expert team, of causes of cold-related mechanical/electrical generation outages to identify preventive measures and determine if additional Standards are needed.

3. NERC and its Regional Entities, with Commission staff engagement, should initiate a study modeled after the 2021 Report Rec. 26/ERCOT black start unit availability study, to assess readiness of other blackstart units to operate during cold weather conditions, including recommended actions for improvement, (if necessary).

Implement Robust Monitoring: By Q3, 2024

Verify Highest Risk Units: By Q4, 2023

Initiate Technical Review By: By Q1, 2024

Initiate Study(s): By Q1, 2024

Improvements to Natural Gas Infrastructure Cold Weather Reliability

4. LEGISLATION by Congress and state legislatures (and/or regulation by entities with jurisdiction over natural gas infrastructure reliability) IS NEEDED to establish reliability rules for natural gas infrastructure necessary to support the grid and natural gas LDCs that address the following needs:

   a) the need for natural gas infrastructure reliability rules, from wellhead through pipeline, requiring cold weather preparedness plans, freeze protection measures, and operating measures for when extreme cold weather periods are forecast, and during the extreme cold weather periods,

   b) the need for situational awareness of natural gas infrastructure reliability, by establishing regional natural gas communications coordinators (similar to a Reliability Coordinator for the electric grid) to communicate timely operational information at all levels of the natural gas supply chain, in advance of and throughout the extreme cold weather period to maintain regional natural gas situational awareness, and communicate potential issues to and from electric grid reliability entities (e.g., BA, RC), and

   c) the need for designation of critical natural gas infrastructure loads for protection from load shed.

Improvements to Gas-Electric Coordination Cold Weather Reliability

5. Commission should consider obtaining a one-time report from FERC-jurisdictional natural gas entities, describing their vulnerability to extreme cold weather events, and how they are trying to minimize these vulnerabilities.
6. Near-Term Action: NAESB should convene natural gas and electric grid operators, and LDCs to identify improvements in communication during extreme cold weather events to enhance situational awareness across natural gas supply chain.
7. Initiate study(s) by an independent research group to analyze whether additional natural gas infrastructure, including interstate pipelines and storage, is needed to support the reliability of the electric grid and meet the needs of LDCs. The study would include information about the cost of the infrastructure buildout.

Consider Reporting: By Q3, 2024

Identify Improvements: By Q2, 2024

Initiate Study(s): By Q1, 2024

Improvements to Electric Grid Operations Cold Weather Reliability

8. BAs should improve their short-term load forecasts for extreme cold weather periods by implementing report-identified sound practices and sharing those and newly-identified sound practices with peers for continuous improvement across electric grid.

Implement/ Confirm Sharing: By Q4, 2023

9. BAs should assess whether new processes or changes to existing ones, such as multi-day risk assessment processes, advance or multi-day reliability commitments, are needed to address anticipated capacity shortages or transmission system-related reliability problems during well-forecast extreme cold weather events.

Consider Process Changes: By Q4, 2023

10. Resource planners and entities that serve load should sponsor joint-regional reliability assessments of electric grid conditions that could occur during extreme cold weather periods, which can be used in power supply planning to reduce the risk of firm load shed.

Initiate Reliability Assessments: By Q4, 2024

11. NERC should initiate a study to be performed by an independent subject-matter expert team, to examine potential stability risks on December 23-24 for periods of decreased frequency and low responsive reserves during Winter Storm Elliott, to identify enhanced operator tools for situational awareness and mitigation.

Initiate Study: By Q1, 2024

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

December 2022 Winter Storm Elliott Grid Operations: Key Findings and Recommendations

FERC, NERC, and Regional Entity Joint Staff Inquiry

Please note: this presentation is not the report. The report will be published soon, and we encourage everyone to read it.

CLOSING

Thank you all for attending this event!

Your feedback is very important to us. Please provide your feedback using the link: https://www.surveymonkey.com/r/VSZD5FG or QR Code below: