

# RELIABILITY & SECURITY

Workshop - Salt Lake City, UT

March 26–27, 2024







# Cold Weather Events

March 26, 2024

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# What You Will Learn and Why it Matters

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- Learn the history of recent Cold Weather impacts on the BPS
- Understand the need and urgency for enforceable Cold Weather reliability standards

# Introduction



# Introduction

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- What is an Extreme Cold Weather Event?
- Cold Weather in the Western Interconnection
- Historic Cold Weather Events

# What is an Extreme Cold Weather Event?

- Cybersecurity and Infrastructure Security Agency (CISA)
  - Extreme Cold is temperatures that are lower than historical averages to the point that it creates a dangerous environment for people, animals, and critical infrastructure. What constitutes “extreme cold” can vary across the country, as some regions are less accustomed to winter weather and freezes.

# Average Winter Temperatures in the West

- Arizona: 43.6 °F
- California: 46.2 °F
- Colorado: 25.8 °F
- Idaho: 25.4 °F
- Montana: 21.2 °F
- Nevada: 32.2 °F
- Oregon: 34 °F
- New Mexico: 36.1 °F
- Utah: 28.2 °F
- Washington: 33 °F
- Wyoming: 21.2 °F

# Cold Weather Extremes in the West

- Arizona: -40 °F
- California: -45 °F
- Colorado: -61 °F
- Idaho: -60 °F
- Montana: -70 °F
- Nevada: -50 °F
- Oregon: -54 °F
- New Mexico: -50 °F
- Utah: -50 °F
- Washington: -48 °F
- Wyoming: -66 °F



# Historic Cold Weather Events

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December 1983	December 2006	January 2021
February 1989	January 2007	December 2022
December 1989	February 2008	?
January 1994	January 2010	
February 2003	February 2011	
January 2004	January 2014	
February 2006	January 2018	

# Event Comparison

Event Date/Duration	2011 Event/ Feb 1-5	2014 Event/ Jan 6-8	2018 Event/ Jan 15-19	2021 Event/ Feb 8-20	2022 Event/ Dec 21-26
Deviation from Average Daily Temperature	17 to 36 deg. Below average	20 to 30 deg. Below average	12 to 28 deg. Below average	40 to 50 deg. Below average	20 to 30 deg. Below average
Geographic Area of Event	Texas and Southwest US	Midwest, South Central, and East Coast	South Central US	Texas and Southcentral US	Central, Midwest and large parts of Southeast and Northeast US
Event Area Sq. Miles (approx.)	656,300	1,923,000	418,000	869,000	1,517,000
Unavailable Generation Due to Cold Weather at Worst Point (MW)	14,702	9,800	15,600	65,622	90,500
Causes of Unavailable Generation	Freezing Issues, Mechanical/ Electrical Issues, Natural Gas Fuel Issues	Freezing Issues (cold weather), Natural Gas Fuel Issues	Freezing Issues, Mechanical/ Electrical Issues, Natural Gas Fuel Issues	Freezing Issues, Mechanical/ Electrical Issues, Natural Gas Fuel Issues	Freezing Issues, Mechanical/ Electrical Issues, Natural Gas Fuel Issues
Energy Emergency Declared/ Highest Level	Yes/ EEA 3	Yes/ EEA 3	Yes/ EEA 2	Yes/ EEA 3	Yes/ EEA 3
Maximum Level of Firm Load Shed (MW)	5,411.60	300	0	23,418 (ERCOT 20,000, SPP 2,718, MISO South 700)	Over 5,400 Total (TVA over 3,000, DEC 1,000, SEP 961, LG&E/KU 317, DESC 94.7, Santee Cooper 86.4)
Overall Duration of Firm Load Shed	ERCOT: 7 hours, 24 minutes	3 hours	N/A	ERCOT: over 70 hours, SPP: over 4 hours, MISO South: over 2 hours	TVA: 7 hours, DEC: 3 hours, DEP: 2 hours, LG&E/KU: 4 hours, DESC and Santee Cooper: 9, and 17 min., respectively

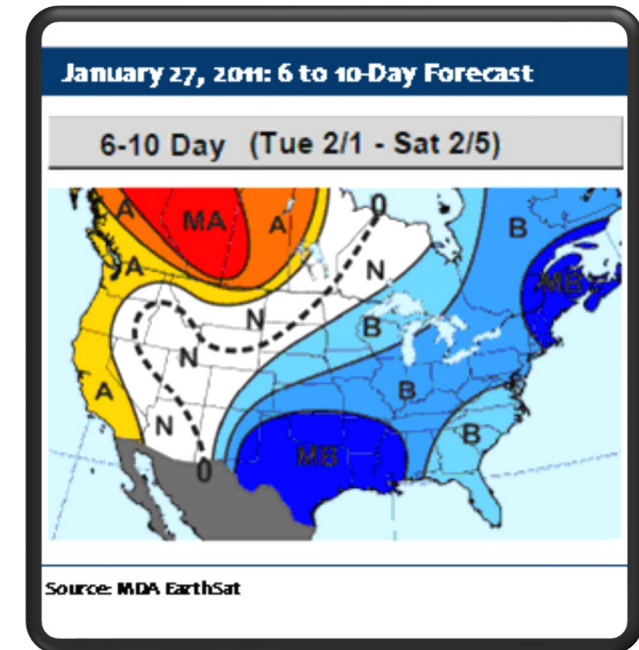
# Not Without Warning

A severe arctic cold front hit the central and northeastern United States and southern Canada on February 1, 2011, and lasted for several days. It was dubbed the “Groundhog’s Day Blizzard of 2011.”

**The front was not unexpected.**

About a week before the event, long-range forecasts predicted an outbreak of very cold temperatures for the first week of February, with wind, ice, and snow from Texas to Mississippi. Arctic air was expected to extend southward to the Gulf by February 2, bringing daytime highs to as low as 30 degrees below normal.

Sustained winds of 20–25 mph, with higher gusts, were also anticipated.



Color legend:

N = normal

B = below normal

MB = much below normal

SB = strong below normal

# Proper Preparations

**“By failing to prepare, you are preparing to fail.”**

Electric:

“Going into the February 2011 Storm, neither ERCOT nor the other electric entities that initiated rolling blackouts during the event expected to have a problem meeting customer demand.”

They all had adequate reserve margins, based on anticipated generator availability. But those reserves proved insufficient for the extraordinary amount of capacity that was lost during the event from trips, derates and failures to start.



# 2011 Southwest Cold Weather Event

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Between February 1-5, a significant winter storm caused a loss of power in the Southwestern United States that resulted in a loss of 56,344 MW and left 1.3 million customers without power and 225 tripped generators.

On February 14, FERC initiated an inquiry into the Southwest outages and service disruptions.

The inquiry had two objectives:

1. Identify the causes of the disruptions.
2. Identify any appropriate actions to prevent recurrence of the disruptions.

# Affected Entities

- ERCOT—A total of 210 individual generating units experienced either an outage, a derate, or a failure to start, leading to total load shed of 4,000 MW.
- Salt River Project—Lost 1,050 MW of generation and shed 300 MW of load, affecting some 65,000 customers.
- El Paso Electric—Lost approximately 646 MW of generation. It was forced to implement rotating load shedding totaling over 1,000 MW and affecting some 253,000 customers.



# Event Report Findings

Many generators failed to adequately apply and institutionalize knowledge and recommendations from previous severe winter weather events, especially as to winterization of generation and plant auxiliary equipment.

The reason blackouts had to be initiated was that over 29,000 MW of generation that was committed in the day ahead market or held in reserve either tripped, was derated, or failed to start.

Transmission operators and distribution providers generally did not identify natural gas facilities such as gathering facilities, processing plants or compressor stations as critical and essential loads.

# Recommendations not Followed

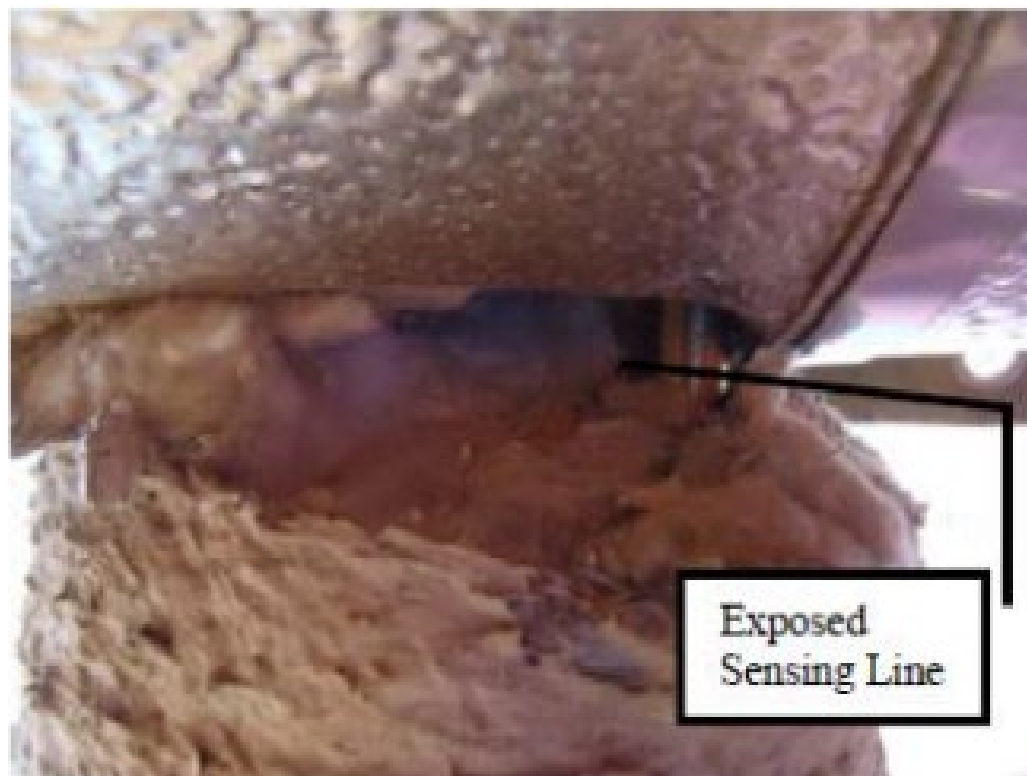
- Despite the recommendations of the PUCT in its report on the 1989 event, most of the problems generators experienced in 2011 resulted from failures of the same type of equipment that failed in the earlier event. In many cases, these failures were experienced by the same generators.
- Of the over 56 units and 16,805 MW of generating capacity that became unavailable during the December 1989 event, 43 units (representing 13,606 MW of capacity) are still in service in 2011. Twenty-six of those units, representing 5,654 MW of capacity, experienced problems again during the February 2011 cold weather event.



# Gas-Electric Interdependency

- The task force examined data from numerous electric and gas entities to gauge the severity that shortfalls in one commodity had on the other during the February event. Materials received from natural gas producers indicate that the rolling blackouts (or customer curtailments) in ERCOT were a significant cause, from 29 to 27%, respectively, of production shortfalls in the Permian and Fort Worth Basins.
- Gas shortfalls caused problems for some generators in Texas, although not nearly to the extent as did direct weather-related causes such as equipment failure from below-freezing temperatures

# Typical Problem Areas



**Gap in insulation**



**Exposed valves emerge from thermal insulation and are not heat traced.**

# Typical Problem Areas

**Frozen Valves:**  
Inspect and maintain thermal  
insulation on all units.



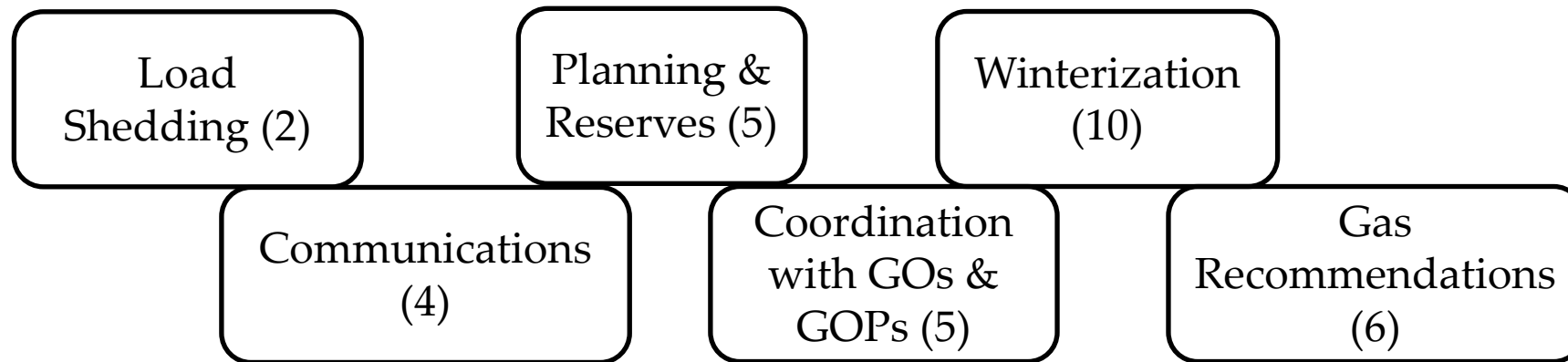
Removal of insulating blanket in summer, failure to reinstall for winter.



Low wind break

# Recommendations

- On August 16, 2011, 26 electrical recommendations and six gas recommendations were issued.





# 2014 Polar Vortex

- In early January 2014, the Midwest, South Central, and East Coast regions of North America experienced a weather condition known as a polar vortex, where extreme cold weather conditions occurred in lower latitudes than normal, resulting in temperatures 20 to 30°F below average.
- Some areas faced days that were 35°F or more below their average temperatures. These temperatures resulted in record high electrical demand for these areas on January 6 and again on January 7, 2014.

# Cold Weather

**Table 1: Average vs. Observed High Temperatures (Fahrenheit)**

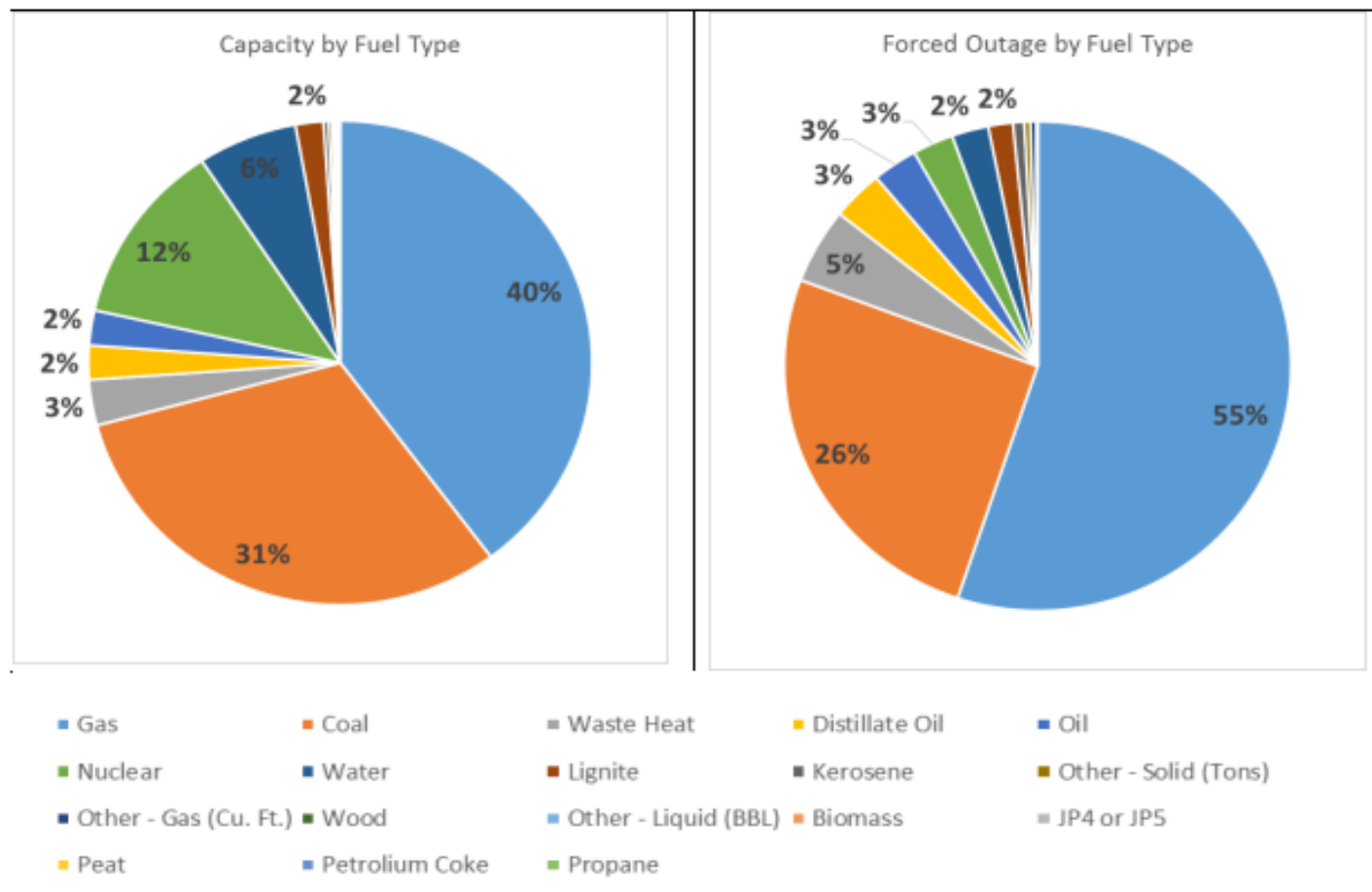
	Minneapolis, MN	Chicago, IL	St. Louis, MO	Dallas, TX	Columbus, OH	Indianapolis, IN	Columbia, SC	Washington DC	New York, NY
<b>Avg. High/Low<sup>3</sup></b>	24/8	32/19	40/23	56/37	36/23	35/21	55/35	43/29	38/27
<b>Observed 5-Jan-14</b>	-2/-20	31/-1	33/1	60/22	55/27	35/5	50/37	42/31	40/27
<b>Observed 6-Jan-14</b>	-12/-23	-1/-15	2/-7	33/14	33/-7	5/-15	60/21	49/11	55/19
<b>Observed 7-Jan-14</b>	5/-15	5/-11	22/-14	47/22	11/-7	8/-14	30/15	21/6	19/4
<b>Observed 8-Jan-14</b>	4/-11	15/-2	32/15	49/38	26/10	25/6	46/18	31/13	22/9

# Record Winter Peak Loads

**Table 2: Historic Winter Peak Loads vs. Polar Vortex Loads by Percentage<sup>4</sup>**

	MISO	PJM	NYISO	ISO-NE	South-eastern RC	TVA	VACS RC	SPP	ERCOT	FRCC
Previous Winter peak (% of previous peak)	99,855	136,675	25,541	22,818	46,259	43,384	42,983	32,635	57,265	36,926
6-Jan-14	109,307 (109.5%)	131,142 (95.5%)	23,197 (90.8%)	18,500 (81.1%)	44,871 (97.0%)	43,277 (99.8%)	50,659 (117.9%)	36,602 (112.2%)	56,031 (97.8%)	30,231 (81.9%)
7-Jan-14	104,746 (104.9%)	140,510 (103.5%)	25,738 (100.8%)	21,300 (93.3%)	48,279 (104.4%)	44,285 (102.1%)	44,654 (103.9%)	36,079 (110.6%)	57,277 (100.0%)	35,638 (96.5%)
8-Jan-14	100,154 (100.3%)	133,288 (98.1%)	24,551 (96.1%)	20,800 (91.2%)	47,005 (101.6%)	39,820 (91.8%)	43,203 (100.5%)	31,944 (97.9%)	45,281 (79.1%)	29,251 (79.2%)

# Generator Outage by Fuel Type



**Figure 13: Percentage of Net Dependable Capacity by Fuel Type (left); Percentage of Capacity Lost During Polar Vortex by Fuel Type (right) in Eastern and ERCOT Interconnections**



# Observations

- Generation facilities have made improvements in their winter preparation activities since February 2011; however, every extreme event provides insight for future improvements.
- Proactive communication and coordination between the RCs and within the RC areas helped ensure appropriate situational awareness was maintained and facilitated rapid response as needed.
- Planned and forced generation outages in some Regions exceeded the worst-case assumptions used in seasonal assessments. These assumptions warrant further review; in particular, the assumptions for generating unit forced and planned outage rates.

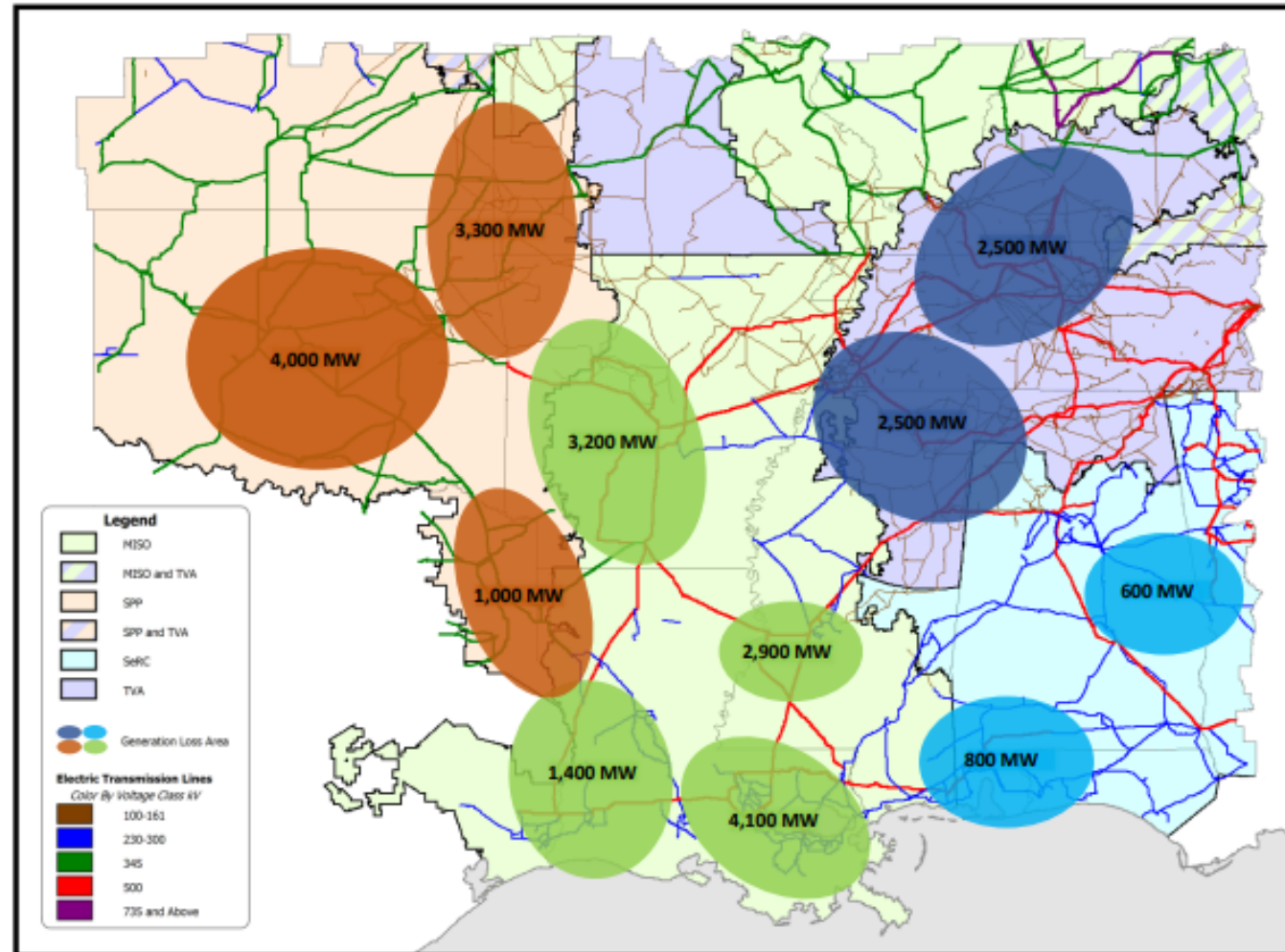
# Recommendations

- 10 Recommendations were made for this event.
  - Examine and review the natural gas supply issues encountered during the event.
  - Review and update power plant weatherization programs because of lessons learned from this event.
  - Continue or consider implementing a program of periodic site reviews of generation facilities' winter preparation.
  - Continue to improve operations management awareness of the fuel status of all generators, including improved awareness of pipeline system conditions.
  - Industry should work to identify and protect against outages that occurred within the cold weather design basis of the plant.

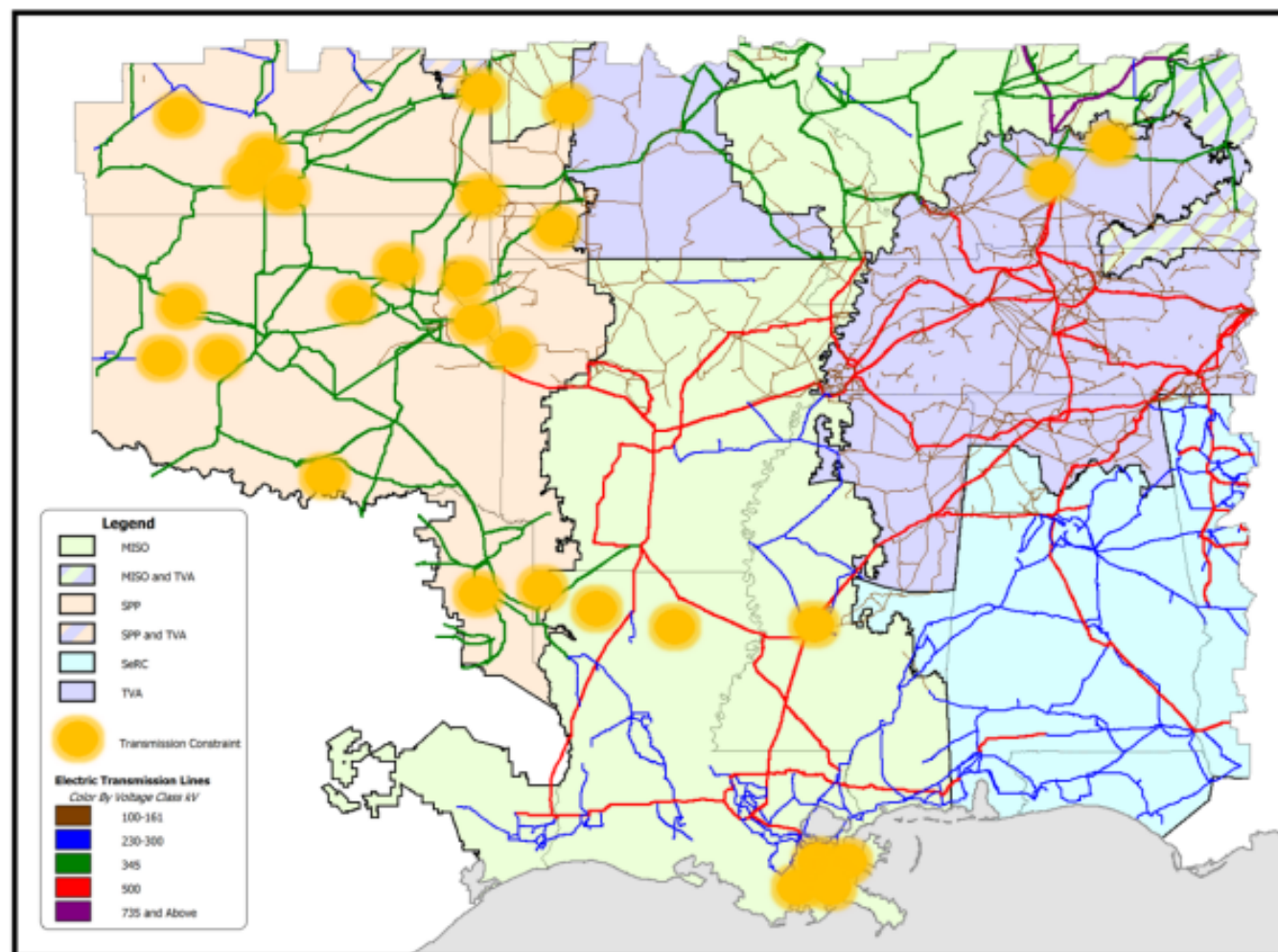
# 2018 The South-Central U.S. Cold Weather Event

- In general, average temperatures remained at or above-freezing for the deep south into Monday January 15; however, as arctic high pressure moved from the northern plains to the central and eastern U.S. on January 15-17, it resulted in average temperatures well below freezing for areas including parts of the plains, the Mississippi Valley, and Tennessee.
- This cold front was forecast several days in advance. On Friday, January 12, at 3 p.m., the National Weather Service issued its “US Hazards Outlook” covering the period that included January 15 to 19.
- It predicted that an “arctic air mass” would reach the eastern half of the U.S. by January 17 and “last for several days,” bringing “much below normal temperatures,” with “maximum and minimum temperatures 12 -28 degrees [Fahrenheit] below normal.”

# Generator Outages and Derates



# Transmission Constraints





# Findings

- The South-Central U.S. Cold Weather BES event of January 17, 2018, was caused by failure to properly prepare or “winterize” the generation facilities for cold temperatures.
- Gas supply issues contributed to the event, and natural-gas-fired units represented at least 70% of the unplanned generation outages and derates.
- The generation outages during the peak hour ending 8:00 a.m. CST on January 17 created an “N-many” BES condition, and led the affected entities to transfer power from distant generation into the affected region to cover energy demands and provide reserves. These large power transfers resulted in wide-area BES transmission-constrained conditions in four RC footprints.
- MISO’s five- to three-day-out load forecasts for MISO South were significantly lower than the actual peak load on January 17, and less accurate than adjacent RCs’ forecasts for the same period.

# Recommendations

- 13 Recommendations were made based on the report findings
- **Recommendation 1:**
  - The Team recommends a three-pronged approach to ensure Generator Owners/Generator Operators, Reliability Coordinators and Balancing Authorities prepare for cold weather conditions:
    - 1) development or enhancement of one or more NERC Reliability Standards,
    - 2) enhanced outreach to Generator Owners/Generator Operators, and
    - 3) market (Independent System Operators/Regional Transmission Organizations) rules where appropriate

❖ April 2023, EOP-011-2, TOP-003-5, and IRO-010-4 became enforceable.

# Recommendations

## Recommendation 9:

- Transmission Owners and Transmission Operators, as part of establishing facility ratings and System Operating Limits, respectively, should conduct analysis that delineates different summer and winter ratings, for both normal and emergency conditions.
- The established facility ratings and associated System Operating Limits should consider, at a minimum, ambient temperature conditions that would be expected during high summer load and high winter load conditions, respectively.
- These ratings and limits should be provided to the Reliability Coordinator and other applicable entities for use in tools for operation, such as Energy Management System and Real-Time Contingency Analysis applications.

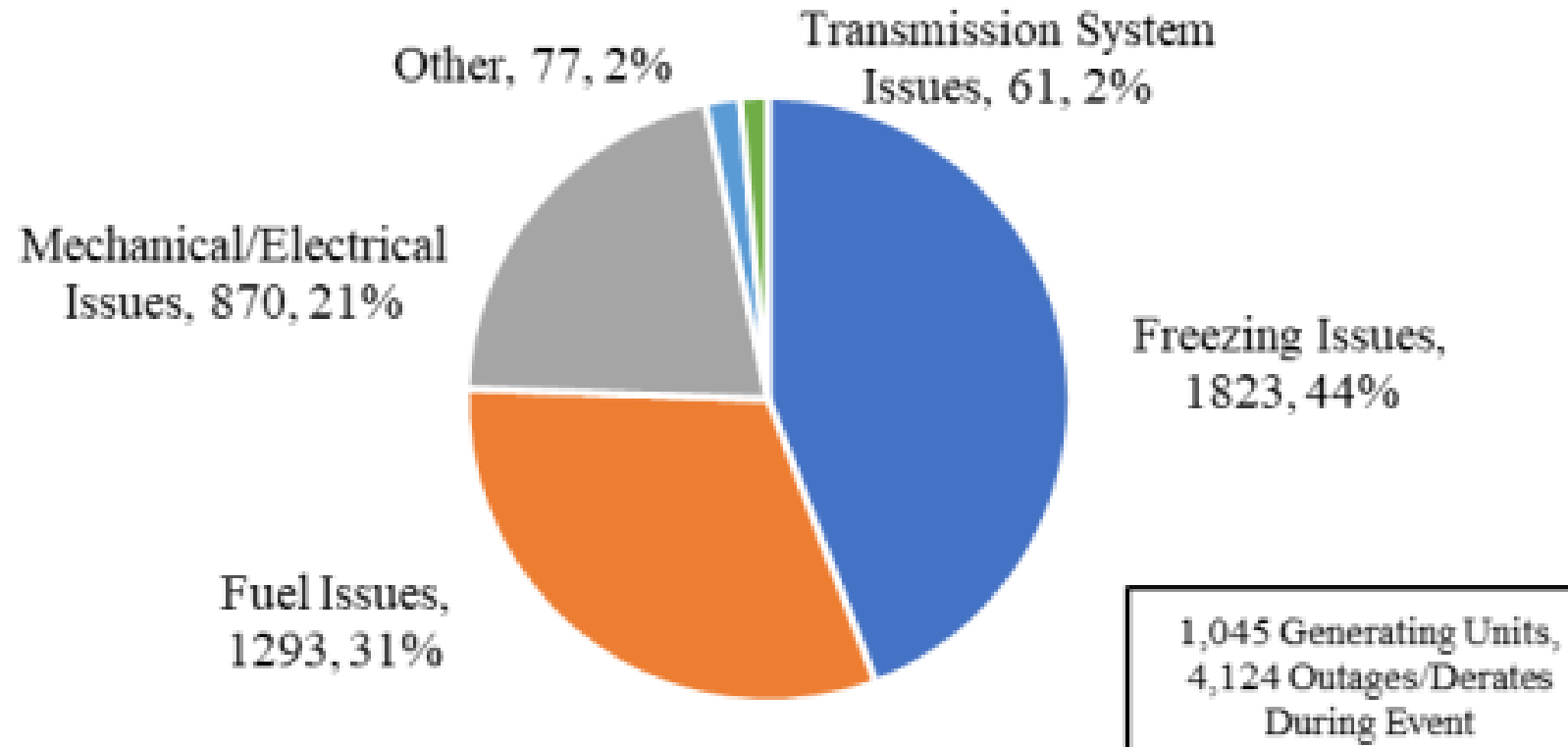
# 2021 Cold Weather Outages in Texas and South-Central U.S.

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- In the early morning of February 15, 2021, an arctic front moving through Texas and the South-Central U.S. began to take its toll.
- As temperatures dropped, more and more generating units throughout Texas failed in ERCOT.
- The same front led generating units to fail to a lesser extent in the South-Central U.S. footprints of Midcontinent Independent System Operator (MISO) South and Southwest Power Pool (SPP).

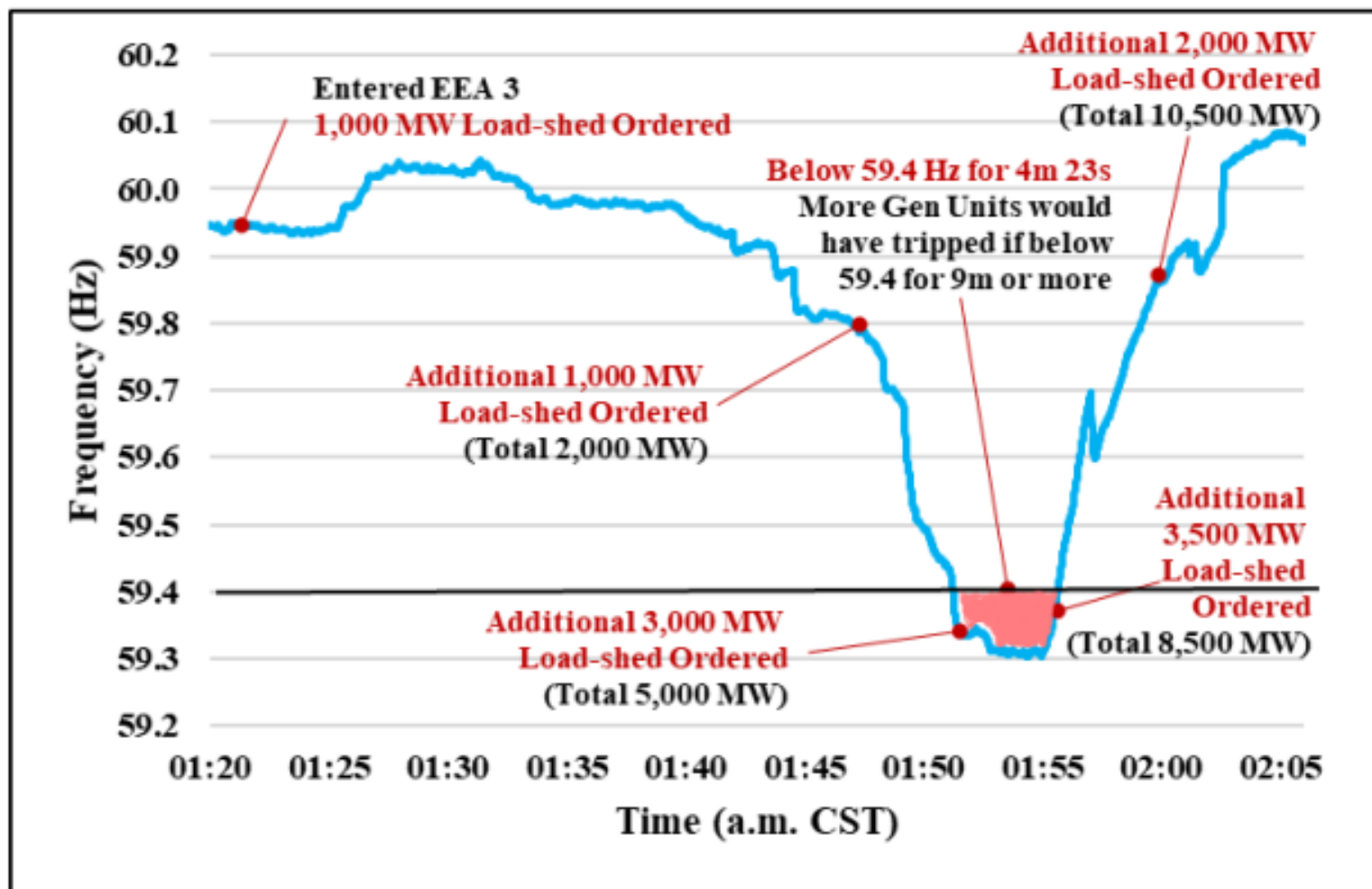
# Generation

**Number of Incremental Unplanned Generator Outages, Derates, and Start-Up Failures by Cause, Total Event Area**





# February 15 Load Shed



Courtesy of NERC February 2021 Cold Weather Outages in Texas and the South Central United States

# Natural Gas

## Processing Facility Event Causes on February 14

	Natural Gas Infrastructure Condition	Result	Facility Event Causes
<b>Freezing Temperature and Weather Conditions</b> (85% of Plant Disruptions)	Reduced Gas Receipts from Production/Gathering Facilities	Processing Facility Disruption	73%
	Freezing Issues at Processing Facilities	Processing Facility Disruption	12%
<b>Loss of Power</b> (15% of Plant Disruptions)	Processing Facilities - Loss of Power Supply or curtailment	Processing Facility Disruption	15%
<b>Other Issues</b>	Mechanical Failures - Non-Weather Related	Processing Facility Disruption	0%
<b>Total</b>			100%

*\*There were a total of 34 causes of processing plants events occurring on February 14.*

# Findings

- Despite several prior recommendations by FERC and NERC that generating units take actions to prepare for the winter (and providing detailed suggestions for winterization), as well as annual reminders via Regional Entity workshops,
  - 49 generating units in SPP (15%, 1,944 MW of nameplate capacity),
  - 26 in ERCOT (7%, 3,675 MW), and
  - Three units in MISO South (4%, 854 MW), still did not have any winterization plans, and 81% of the freeze-related generating unit outages occurred at temperatures above the unit's stated ambient design temperature.
- Generating units that experienced freeze-related outages above the unit's stated ambient design temperature represented about 63,000 MW of nameplate capacity.

# Recommendations

Recommendation Topic	#	Timeframe for Implementation <sup>367</sup>
<b>Key Recommendations</b>		
Cold Weather Critical Components	1a,b	2023-2024
Account for Effects of Precipitation and Wind	1c	2023-2024
Corrective Action Plans for Freeze-Related Causes	1d	2022-2023
Annual Training on Cold Weather Plans	1e	2022-2023
Operate to Specified Ambient Temperature, Weather	1f	2022-2023
Generator Capacity to Rely Upon during Cold Weather	1g	2023-2024
Generator Compensation Opportunities for Investments	2	2022-2023
Generator Winter Readiness Technical Conference	3	2022-2023
Freeze Protection Inspection and Maintenance Timing	4	2022-2023
Natural Gas Facility Cold Weather Preparedness Plans	5	2022-2023

28 Recommendations were made with implementation time frames, which are being tracked by FERC and NERC.

EOP-012-1 Effective date October 1, 2024.

EOP-012-2 Effective date October 1, 2024?

# 2022 Winter Storm Elliott

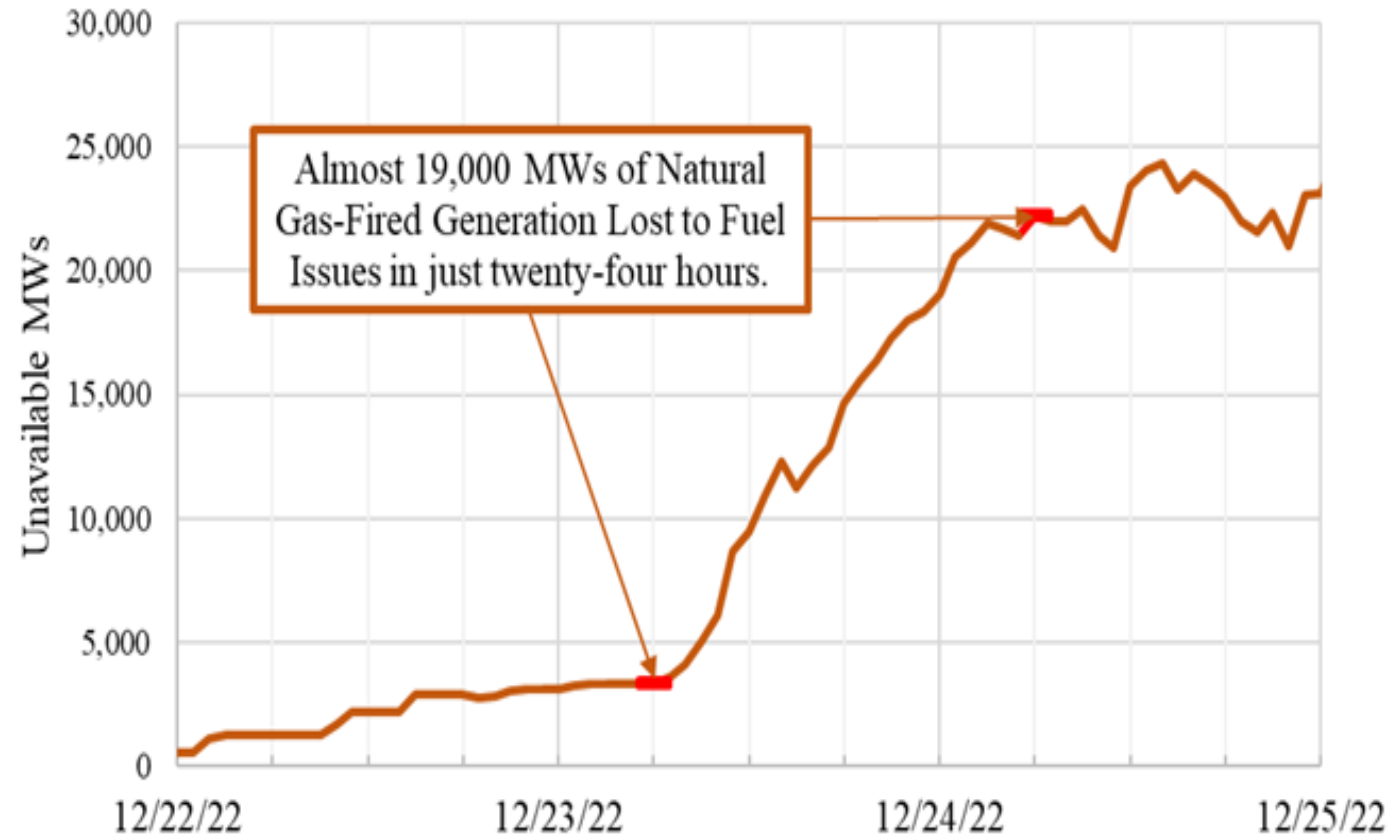
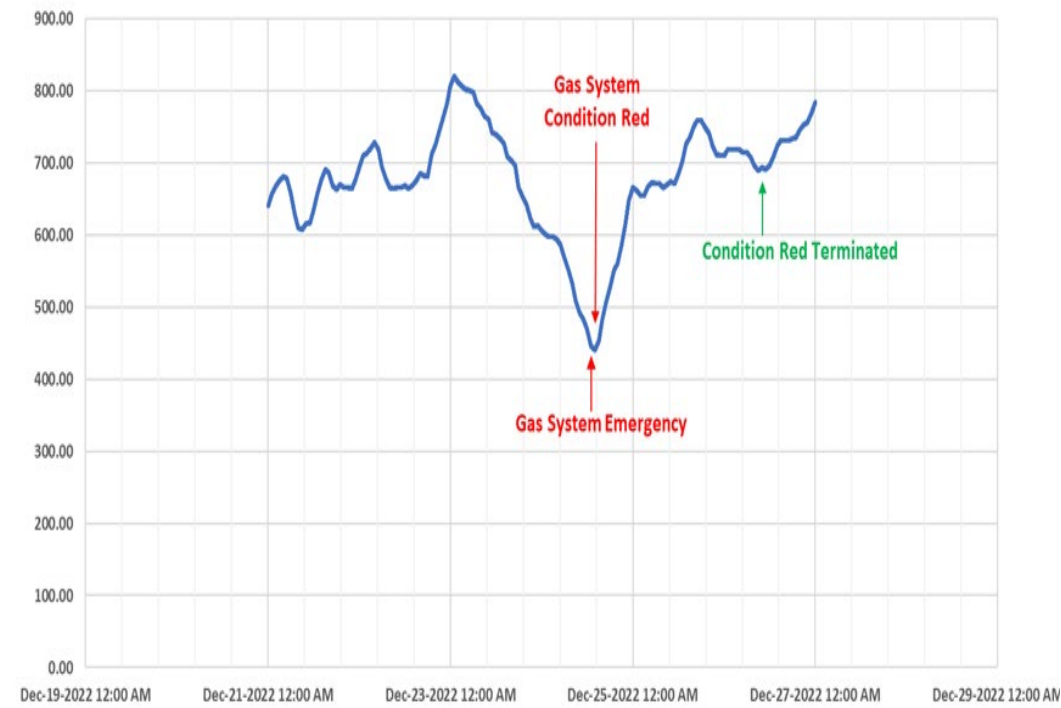
- The extreme cold weather event occurring between December 21 and 26, 2022 (Winter Storm Elliott) affected the reliability of the BES and the supporting natural gas infrastructure in the U.S. Eastern Interconnection.
- During the event, 1,702 individual BES generating units in the Eastern Interconnection experienced 3,565 unplanned outages, derates, or failures to start. Each unit could, and often did, have multiple outages from the same or different causes. At the worst point of the event, there were 90,500 MW of coincident unplanned generating unit outages, derates, and failures to start.
- Including generation that was already out of service, over 127,000 MW of generation was unavailable, representing 18% of the U.S. portion of the anticipated resources in the Eastern Interconnection.

# 2022 Winter Storm Elliott

- 96% of all outages, derates, and failures to start were attributed to three causes:
  - Freezing Issues (31%),
  - Fuel Issues (24%) and
  - Mechanical/ Electrical Issues (41%).
- Of those outages, derates, and failures to start, 55% were caused by either Freezing Issues or Fuel Issues. Natural Gas Fuel Issues (a subset, but the majority, of Fuel Issues) were 20% of all causes, and issues with other fuels were 4%.

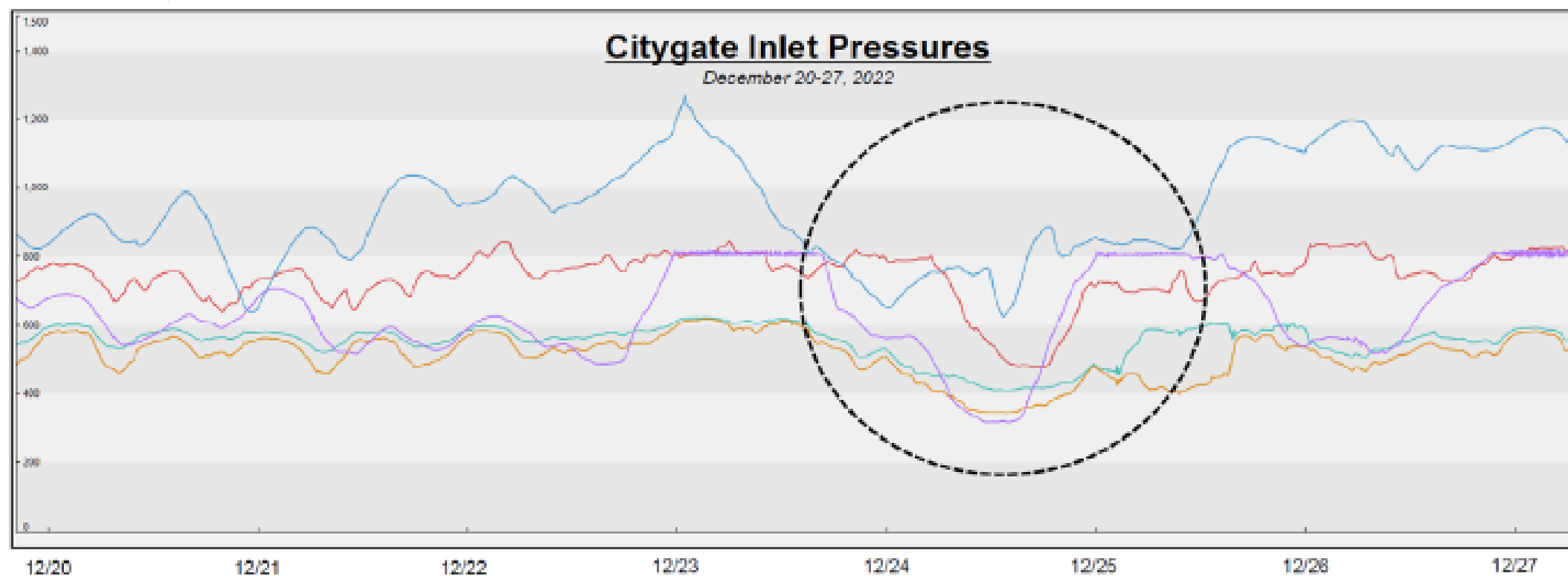


# Natural Gas Impact



# Natural Gas Impact

Figure 66: Con Edison Citygate Inlet Pressures, December 20 - 27, 2022



# Blackstart Generators

- Of significant concern is that blackstart-designated generating units totaling **19,000 MW** experienced forced outages, derates or failures to start during the Event.
- It is, therefore, disconcerting that generation loss due to the unavailability of blackstart-designated units coincided with the arrival of extreme cold weather conditions and the corresponding acceleration of generation loss throughout the bulk electric system.

# Mechanical/Electrical Issues

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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.

# Natural Gas Fuel Issues

- 63 natural gas-fired generating unit outages/derates, totaling 10,038 MW, were due to firm gas transportation curtailments during the Event.
- Equipment issues directly affecting shippers (e.g., end-users such as generating units, LDCs):
  - Weather/freezing issues (majority)
  - Mechanical issues

# Electricity Demands Exceeded Grid Operators' Forecasts

- The majority of the BAs' shortrange 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.



# Recommendations

- The report contains 11 recommendations that address improvements to Cold Weather Reliability for Generators, Natural Gas Infrastructure Grid Operations, and Gas-Electric Coordination.
- In concert with effective implementation of the 2021 Report recommendations, the implementation of these recommendations is aimed at addressing the recurrence of the generating unit outages and natural gas infrastructure issues that have adversely affected reliability in winter storms Uri and Elliott.

# Winter Storm Elliott—Recommendation 1 b

Recommendation 1(b): Findings from the Report support the need for robust monitoring by NERC and the Regional Entities of compliance with the currently effective and approved generator cold weather Reliability Standards, to determine if reliability gaps exist. NERC should identify the generating units that are at the highest risk during extreme cold weather and work with the Regional Entities (and Balancing Authorities, if applicable) to perform cold weather verifications of those generating units until all of the extreme cold weather Standards proposed by the 2021 Report are approved and effective. (Verify highest risk units by Q4 2023; implement by Q3 2024)

# Determining Potential Generators Posing Risk

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- NERC dependent on assistance from Regional Entities
- Data sources used
  - NERC Alert cold weather preparations for extreme weather events
  - Generation type and location
  - GADS outage data

# Cross Departmental Team

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- Curtis Crews—Senior Technical Advisor—Entity Monitoring
- Greg Park—Senior Risk Analysis Specialist—Risk Analysis & Data Services
- Curtis Holland—Senior Reliability Specialist—Operations Analysis
- Fahad Ansari—Senior Technical Advisor—Oversight Planning
- Dave Grover—Senior Reliability Engineer—Operations Analysis
- James Hanson—Manager—Operations Analysis

# Additional Information Requested

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- Questions were developed touching on:
  - Incomplete essential actions tied to NERC Alert
  - Cold weather readiness processes and procedures
  - Cold weather maintenance and training
  - Units involved in cold weather events—what was learned
  - Freeze protection measures for units with ECWT above 32 degrees
  - How freeze protection measures are monitored

# Contact with Selected Entities

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- Held webinars with entities explaining the effort
  - Why
  - Selection process
  - Review of questions
- Helped throughout the response period

# Responses Received

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- Internal team reviewed responses
  - Identified where follow up was necessary to understand approach
  - Identified responses exhibiting stand out practices
  - Identified responses where improvements could be made
- Held follow up calls with entities to address questions from initial responses
- Identified generating stations to perform on-site verifications



# Feedback from Effort

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- Individual feedback to selected entities
  - Observation sheet
    - Areas of strength
    - Opportunities for improvement
- General audience
  - Provide observations to NERC for ERO-wide presentation
  - Regional presentations

# Continued Efforts—Recommendation 1c

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1(c) Generator Owners/Operators should assess their own freeze protection measure vulnerability, and NERC or the Regional Entities should perform targeted cold weather verifications pursuant to a risk-based approach.

# References

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- [NERC Information on Cold Weather Preparation and BPS Impacts](#)
- [NERC Major Event Reports](#)



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**[www.wecc.org](http://www.wecc.org)**