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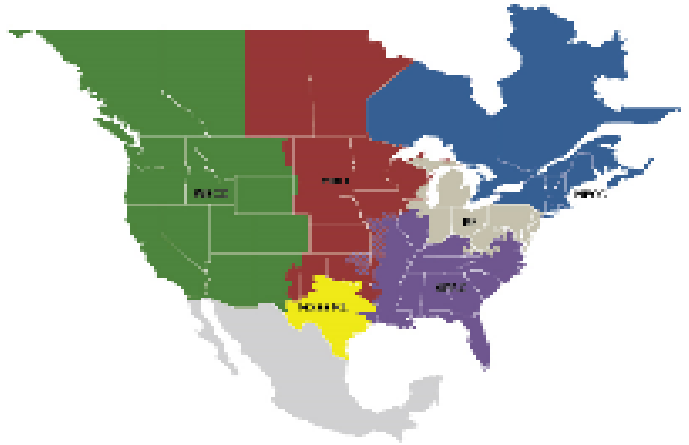


The February 2021 Cold Weather Outages in Texas and the South Central United States

FERC, NERC and Regional Entity Joint Staff Report

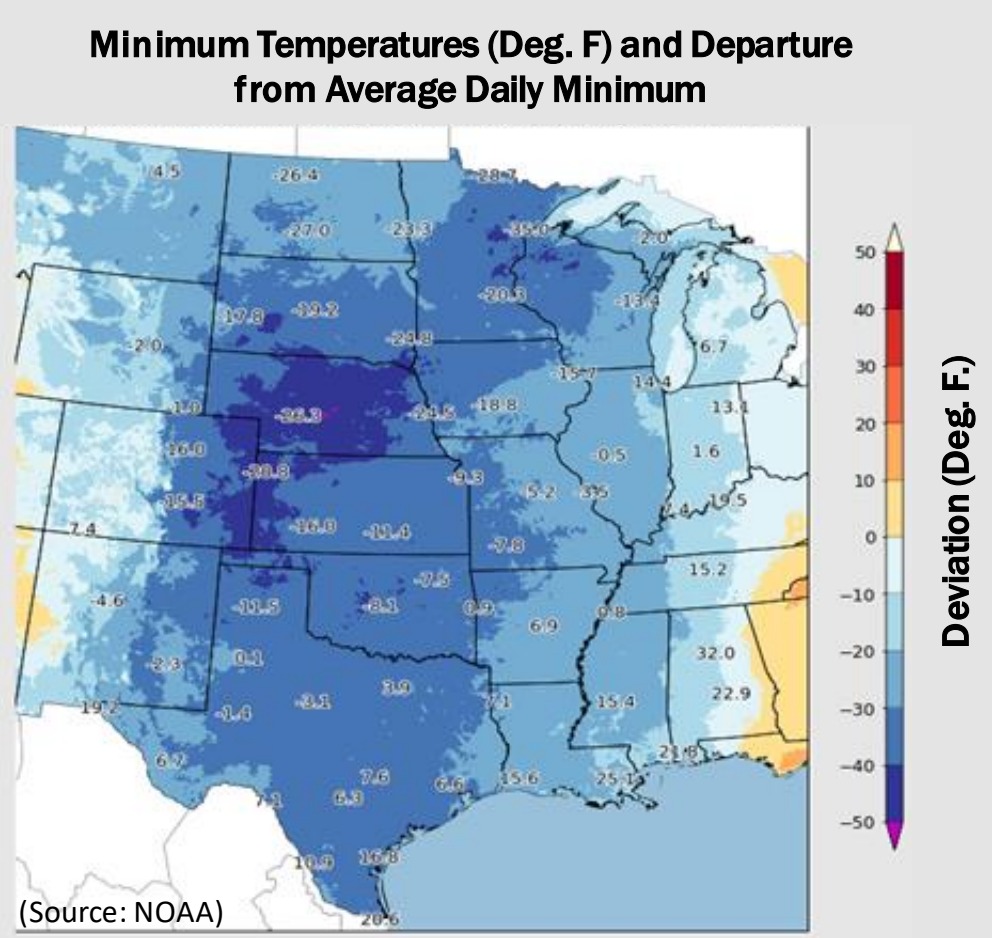
November 2021

This report was prepared by the staff of the Federal Energy Regulatory Commission in consultation with staff from the North American Electric Reliability Corporation and its Regional Entities. This report does not necessarily reflect the views of the Commission.

February 2021 Event Bottom Line

- During the week of February 14, 2021, for over two consecutive days, ERCOT averaged 34,000 megawatts (MW) of generation outages, nearly half of ERCOT's 2021 all-time winter peak load of 69,871 MW.
- Largest firm load shed event in U.S. history (23,418 MW), third largest in quantity of outaged MW of load (August '03 and August '96 blackouts).
- Fourth event in the past 10 years which jeopardized bulk-power system reliability due to unplanned generating unit outages which escalated due to cold weather.

Severe Cold and Freezing Precipitation Have Happened Before in Texas and South Central U.S.



- Comparing 1983, 1989, 2011, 2018 and 2021 cold weather conditions
- In every event, average daily temperatures fell below freezing in Dallas, Houston, and Jackson, for at least 3 days.
- 1983 was colder than 2021 on multiple days in Dallas, Houston and Jackson, MS, and 1989 was still coldest recorded winter for Houston and Galveston; 14 days below freezing over 2-3 weeks.
- 1983, 2011 and 2018 events all had significant freezing precipitation, like 2021.

Precipitation Comparison for Prior Events

Cold Weather Event	Precipitation Summary
1983	December 15-16: Severe cold and snow storm (8+ inches) in northern Texas; multiple cold fronts occurred in north Texas through the end of December, with sub-freezing temps and snow lasting throughout the month.
1989	December 21-24: Three severe cold fronts move into Texas; precipitation was minimal with a narrow band of snow north of Austin, Texas. Overall, precipitation was not much of a factor in the southern plains during this cold weather event of 1989
2011	February 1-3: Widespread heavy snow with blizzard conditions, combined with significant freezing rain and sleet ranging from northern Texas through the upper Midwest and into New England; snowfall amounts of 10-20 inches were recorded from the Midwest to New England along with high winds; Snowfall in northern Texas was 1-4 inches, with a few smaller areas in north Texas having up to 8 inches.
2018	January 14-17: Winter Storm Inga brought snow and ice to parts of the Midwest, South and Eastern U.S. on January 14-17. The upper Midwest experienced 2-5 inches of snow and the Gulf States from Texas to Alabama experienced 1-2 inches of snow accumulation and icy conditions.
2021	February 11-19: The southern plains experienced three waves of precipitation during a 7 day period; February 11-12: Freezing rain and snow in Texas and severe heavy rain in Louisiana and Mississippi; February 14-16: Heavy freezing rain and snow hits the southern plain states combined with severe cold temps; February 17-19: Addition snow and freezing rain occur across the southern plain states with Oklahoma and Arkansas receiving significant accumulations of snow and ice.

(Source: NOAA)

Wind Comparison for Prior Events

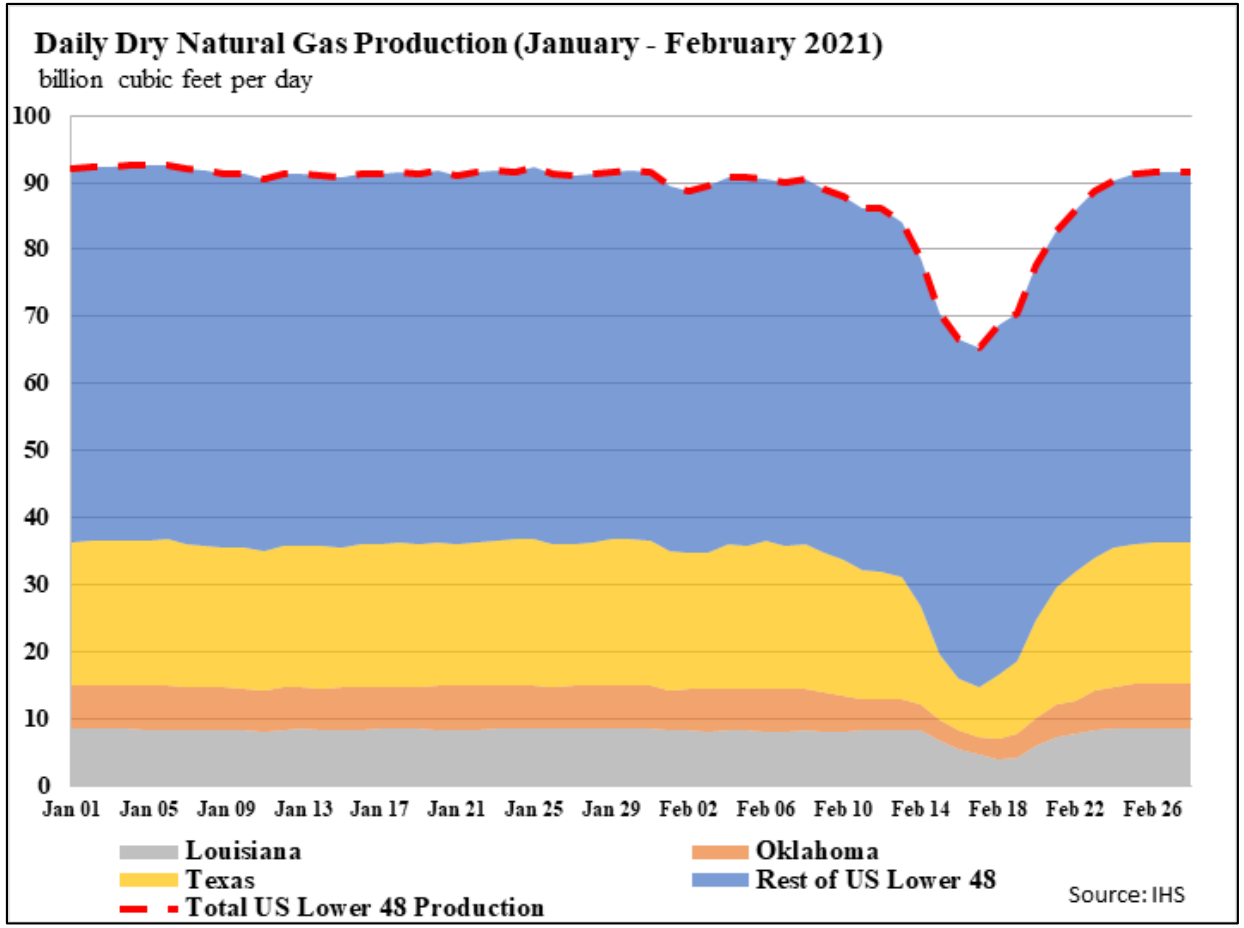
Cold Weather Event ->	1983		1989		2011		2018		2021	
	Avg.	Gust	Avg.	Gust	Avg.	Gust	Avg.	Gust	Avg.	Gust
Dallas	19	34	16	34	18	31	17	32	7	21
Houston	13	25	13	28	16	29	10	25	19	38
Lake Charles	12	20	15	28	14	29	5	18	16	41
Little Rock	14	34	7	15	13	24	13	25	6	16
Jackson	12	23	17	22	10	23	10	25	6	19

- All five severe cold weather events possessed moderate wind conditions for the majority of the above locations in south central U.S. and Texas
- Average wind speeds for each of the five locations across all five events ranged from 10 to 15 mph.
- Average wind gusts for each of the five locations across all five events ranged from 22 to 30 mph.
- Substantial wind conditions are likely to occur during extreme cold weather events. This condition warrants that infrastructure/facility freeze protection measures should also be protected to mitigate the risks caused by accelerated heat loss due to wind.

(Source: NOAA)

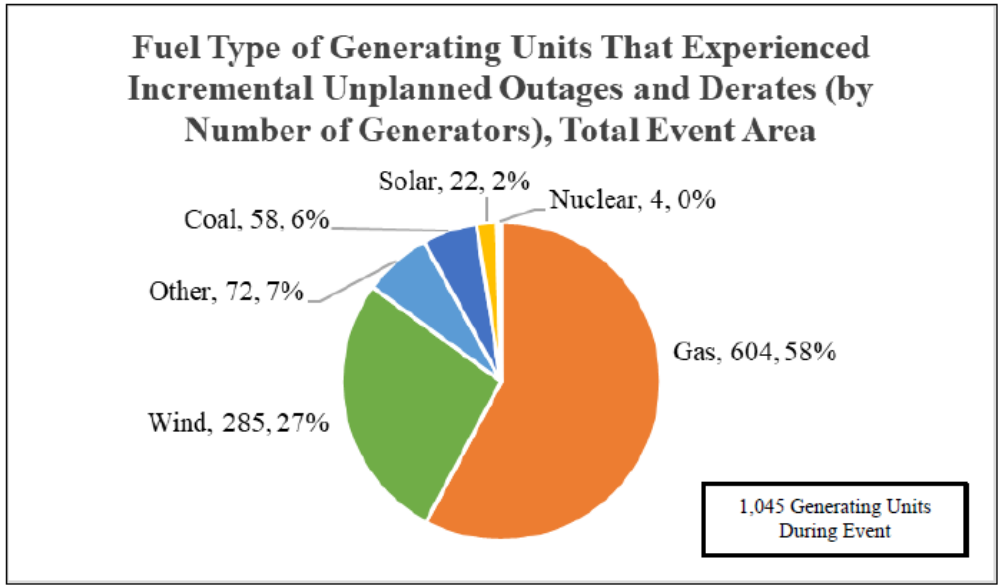
Effect on Natural Gas System

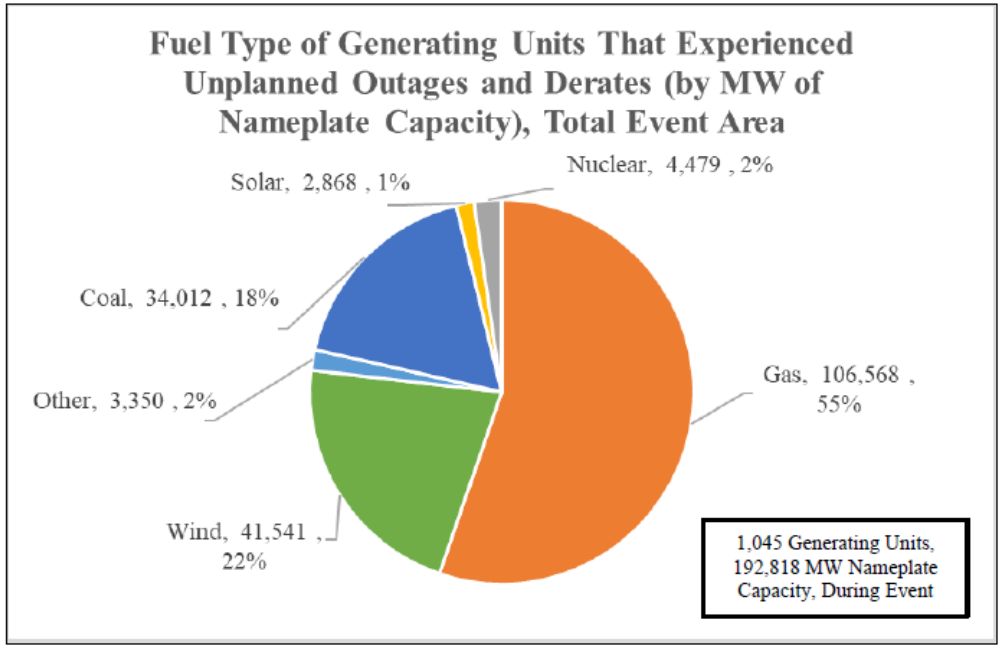
- Largest U.S. monthly decline of natural gas production on record.
- Between February 8 and 17, the total natural gas production in the U.S. Lower 48 fell by 28 percent, while Texas production declined 70.1 percent (as compared to January average).
- Most producing regions of the U.S. saw a sharp decline and recovery.



Unprecedented Electric Generation Shortfalls Due to Cold Weather Conditions

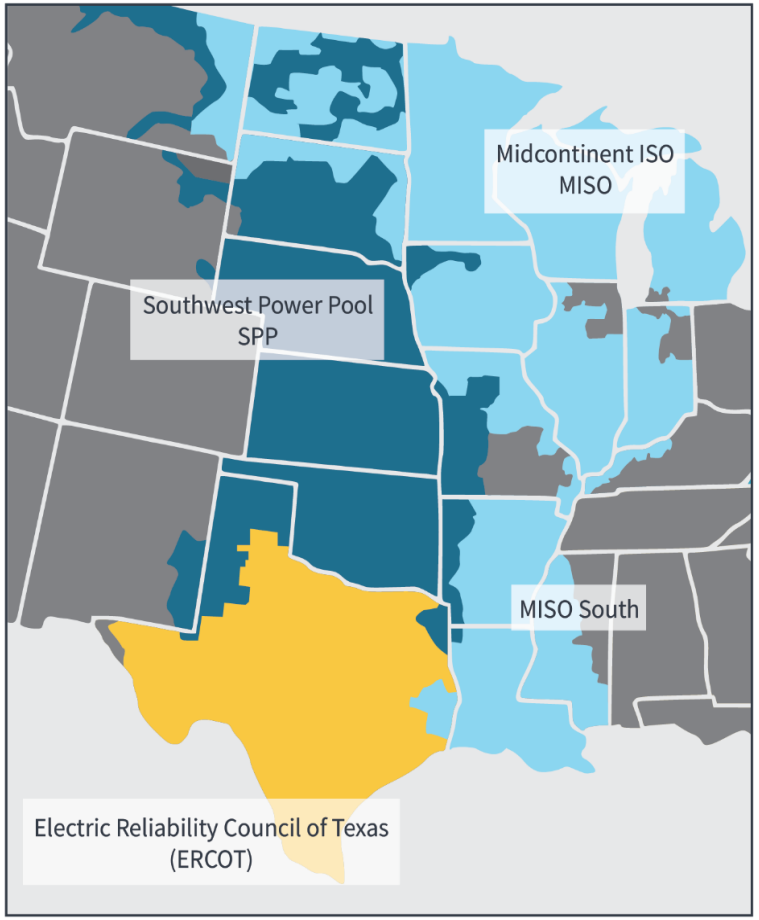
- 1,045 individual generating units experienced 4,124 outages, derates or failures to start, of which 604 (58 percent of all units by number of generators) were natural gas-fired generators.
- Fuel type breakdowns by both number of generators and MW of capacity provided for comparison



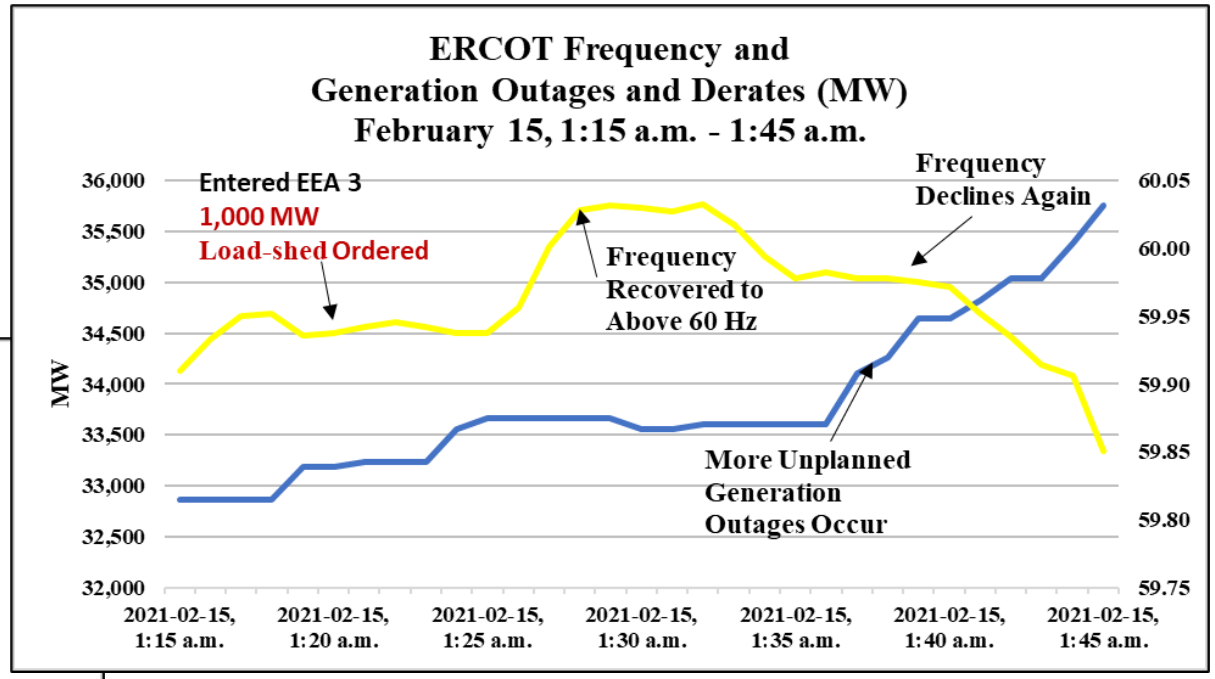


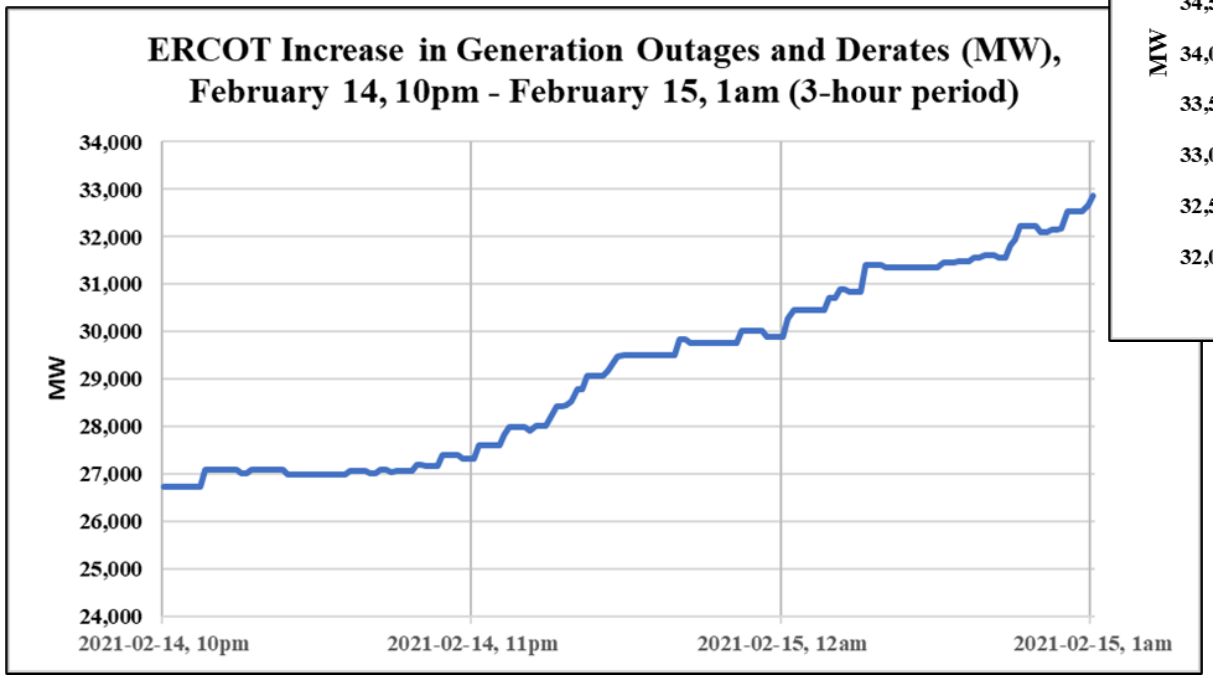
Generation Shortfalls Led to Energy Emergency Firm Load Shed in ERCOT, SPP, and MISO

- Affected Balancing Authorities (BAs) declared Energy Emergencies and ordered firm load shed at different points of time, in total 23,418 MW, during severely cold weather to avoid entire system blackouts:
  - ERCOT BA: nearly three consecutive days and at its worst point, 20,000 MW,
  - SPP BA: over four hours total and at its worst point, 2,718 MW, and
  - MISO BA (MISO South): over two hours and at its worst point, 700 MW.

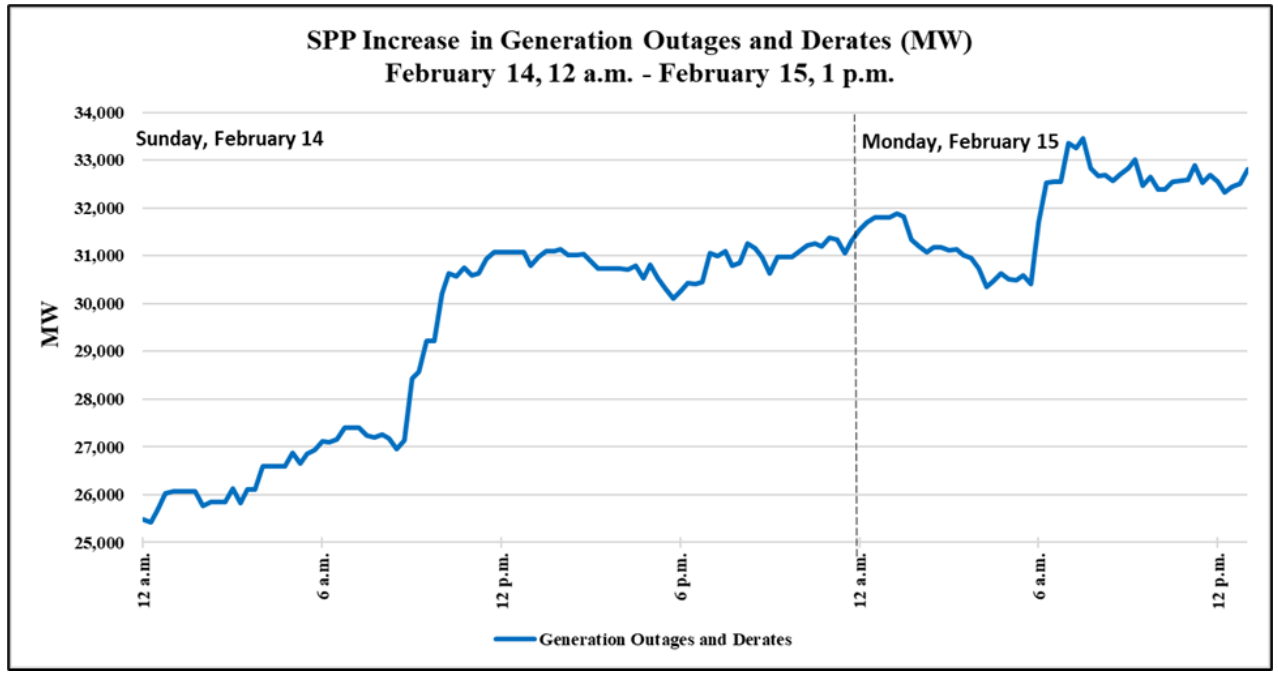


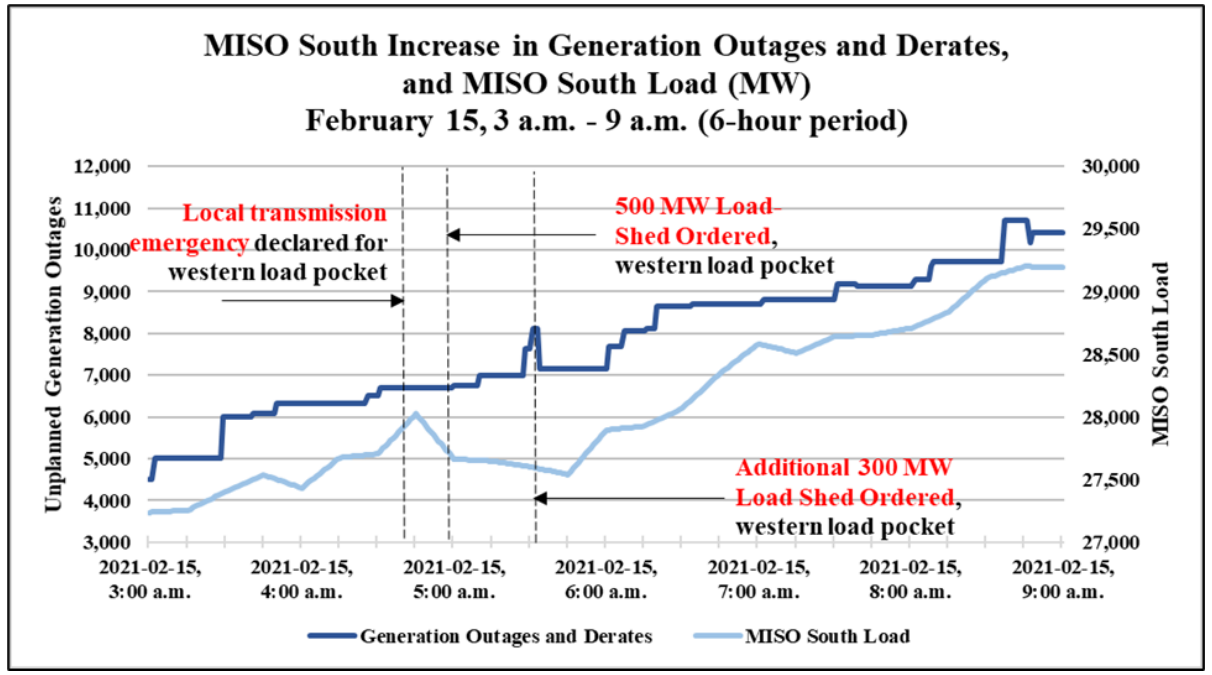
Periods of Large Increases in Generation Outages and Derates: **ERCOT**





Periods of Large Increases in Generation Outages and Derates: **SPP and MISO South**

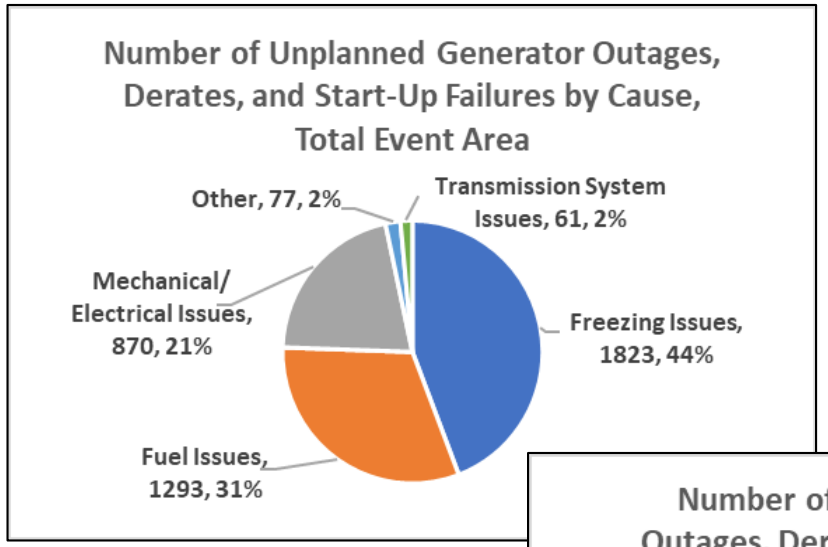


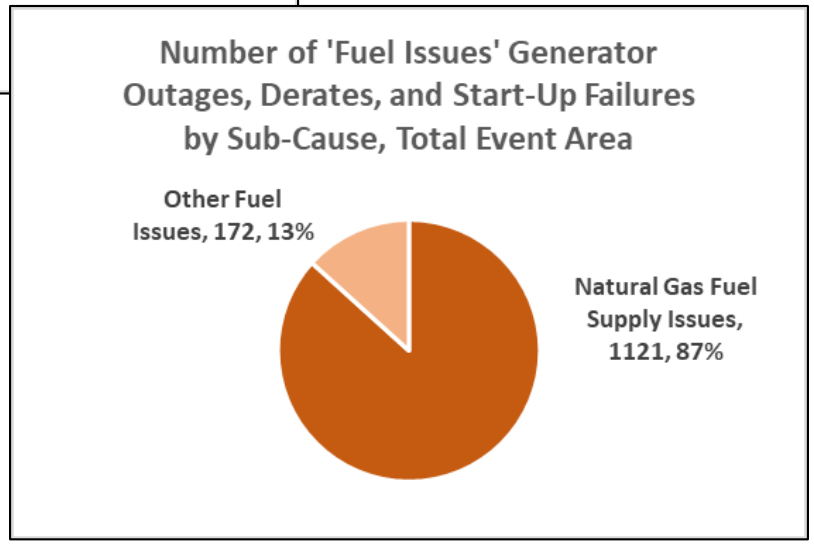


Causes of Generation Shortfalls

- 75 percent of the generating unit outages, derates, and failures to start, were caused by:
  - Freezing Issues (44 percent)
  - Fuel Issues (31 percent).

- Out of outages and derates caused by Fuel Issues, 87 percent were caused by:
  - Natural Gas Fuel Supply issues (27% of total outages)





Causes of Generation Shortfalls
Freezing Issues

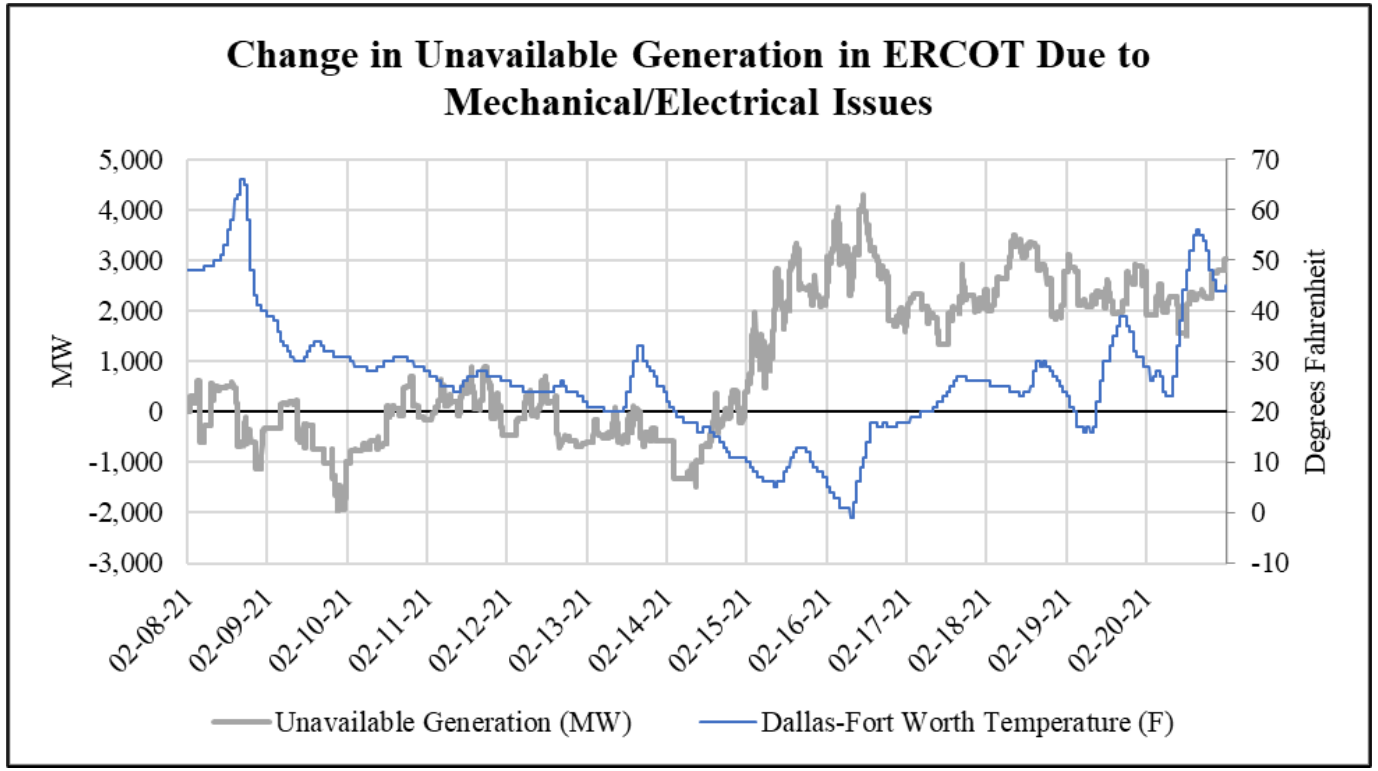
- **Freezing Issues** – generating units:
  - Frozen instrumentation (transmitters, sensing lines)
    - 34.5% ERCOT, 55% MISO South, 14.7% SPP
  - Icing on wind turbine blades
    - 32 percent in both ERCOT and SPP
- Protecting transmitters, sensing lines and instrumentation, as well as wind turbine blades against icing, could have cut the MW of generating units experiencing freeze-related outages:
  - by 67 percent in ERCOT,
  - by 47 percent in SPP, and
  - by 55 percent in MISO South.

Causes of Generation Shortfalls
Natural Gas Fuel Supply Issues

- **Natural Gas Fuel Supply Issues** root cause: natural gas production declines at wellheads, gathering, and processing facilities, due to:
  - Wellhead shut-ins to prevent freezing issues 18.0 percent
  - Freezing issues (wellhead, midstream, roads) 25.3 percent
  - Power outages 21.5 percent
- Natural gas production facility loss of power was primarily due to weather-related power line outages and firm load shed.
- The percentage of production declines caused by power outages on February 14, which only included part of ERCOT's load shed (18 percent), varied little from the overall Event, (21.5 percent), and the day of maximum production decline, February 17, (21.5 percent).

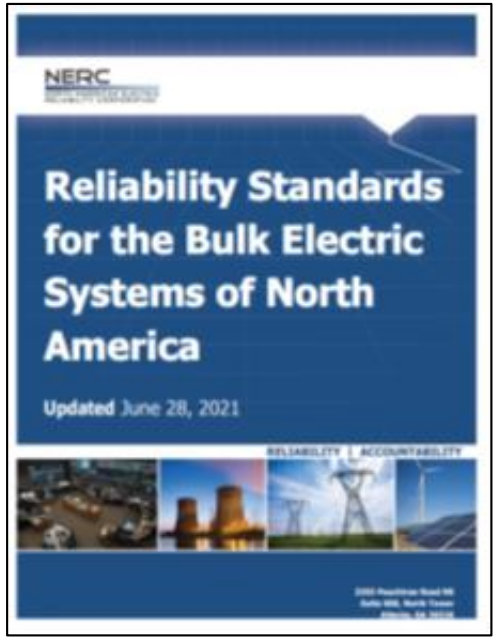
Causes of Generation Shortfalls
Freezing Issues

- Additional 21 percent above the 44 percent caused by freezing (shown on slide 9) were attributed to "mechanical/electrical" issues, but were related to cold—as temperatures decreased, these outages increased



Recommendations
Generator Cold Weather Reliability Standards

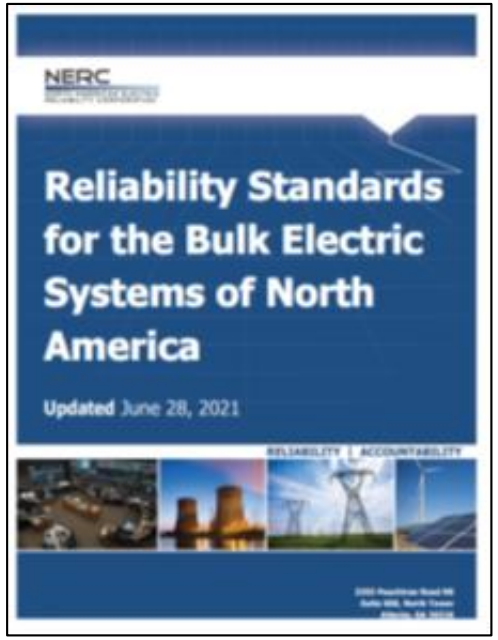
- New or revised Reliability Standards for:
  - To require GOs to identify cold-weather-critical components and systems for each generating unit, defined as those which are susceptible to freezing or otherwise failing due to cold weather, and which could cause the unit to trip, derate or fail to start (1a, see Report page 184 for full text)
    - Support was combined with 1b, see next slide
    - Phase 1 already defined GCWCC and GCWCC also included in R1 (in connection with 20 mph wind speed) and R3.2 (plan shall include "documentation identifying" GCWCC)



These recommendations are above and beyond the NERC Reliability Standards revisions to address cold weather. See 176 FERC ¶ 61,119 (August 2021).

Recommendations
Generator Cold Weather Reliability Standards

- New or revised Reliability Standards for:
  - To require GOs to identify and implement freeze protection measures for the cold-weather-critical components and systems
  - GO should consider previous freeze-related issues and any mitigation taken in response.
  - At an interval of time . . . the GO should analyze whether the list of identified cold-weather-critical components and systems remain accurate, and whether any additional freeze protection measures are necessary (1b, see Report page 184 for full text)



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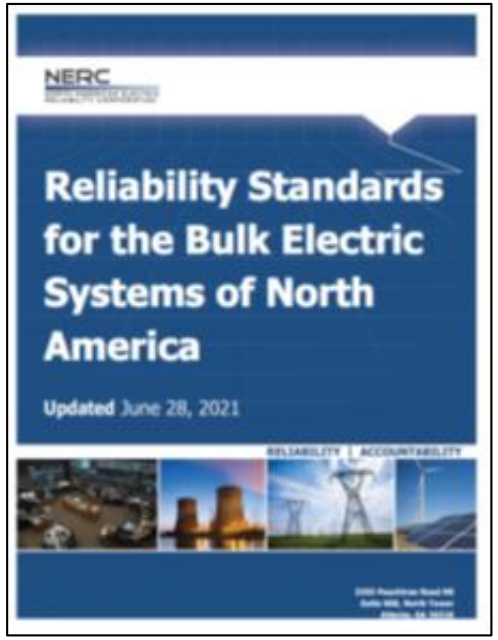
Recommendations
Generator Cold Weather Reliability Standards

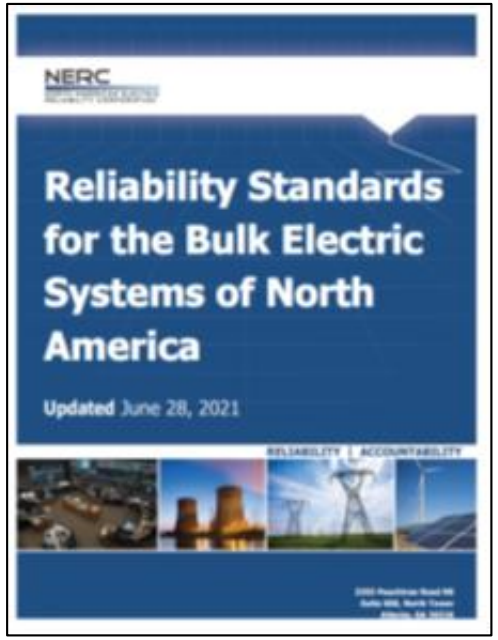
- Cold-weather-critical components and systems (continued)



- Both 2011 and 2018 report in addition to this Report found that certain equipment more frequently contributed to outages: frozen sensing lines, frozen transmitters, frozen valves, frozen water lines, and wind turbine icing.
- Post-2018-report Standards required plans to include freeze protection measures but did not require GOs to implement any specific freeze protection measures
- CWCC responsible for over 68GW outages in ERCOT, 27 GW in SPP and 21 GW in MISO South in 2021.

Recommendations
Generator Cold Weather Reliability Standards

- New or revised Reliability Standards for:
  - To revise EOP-011-2, R7.3.2 to require GOs to account for the effects of precipitation and the accelerated cooling effect of wind when providing temperature data (1c, see Report page 186 for full text)
    - 7.3.2 requires GO to include minimum design temperature, historical operating temperature or performance temperature determined by engineering analysis.
    - 2011 report identified accelerated rate of heat loss caused by wind as factor in event outages
    - 81 percent of generating unit outages in 2021 occurred at ambient temperatures above stated design criteria



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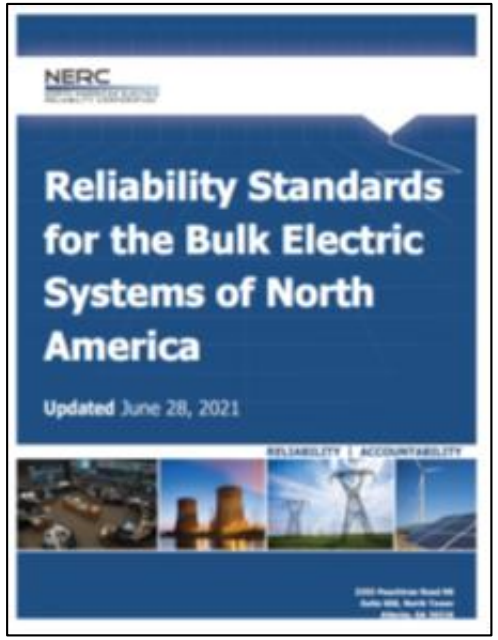
Recommendations
Generator Cold Weather Reliability Standards

- New or revised Reliability Standards for:
  - To provide greater specificity about the relative roles of the GO, GOP and BA in determining the generating unit capacity that can be relied upon during "local forecasted cold weather" (1g, see Report page 190 for full text)
    - TOP-003, effective April 2023, will require TOPs and BAs to include in data specs requests for "provisions for notification of [the generating unit's status] during locally forecasted cold weather," including the unit's "capability and availability, fuel supply and inventory concerns, fuel switching capability, and environmental constraints," and minimum temperature, based on one of three options (R1.3.1 and 1.3.2)



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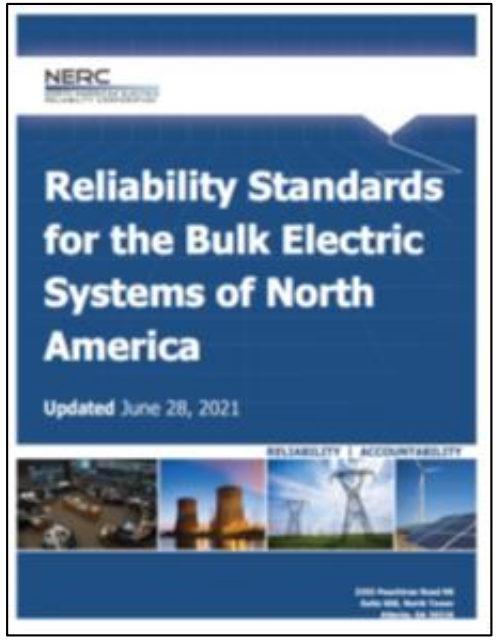
Recommendations
Generator Cold Weather Reliability Standards

- 1g, continued:
  - EOP-012 R3 requires GO to include in its plan similar elements, such as capability and availability, fuel supply and inventory concerns, fuel switching capability, and environmental constraints," and minimum temperature, but with a key difference: it lacks the "local forecasted cold weather" language—is more static, less adjusted to real time
  - The "intent behind [TOP-003 local forecasted cold weather language] is to prevent grid operators from being surprised when large numbers of generating units that had committed to run are unable to do so during cold weather events." p.189
  - 1g "attempts to eliminate doubt about which entity is responsible to provide info or act on info" Id.



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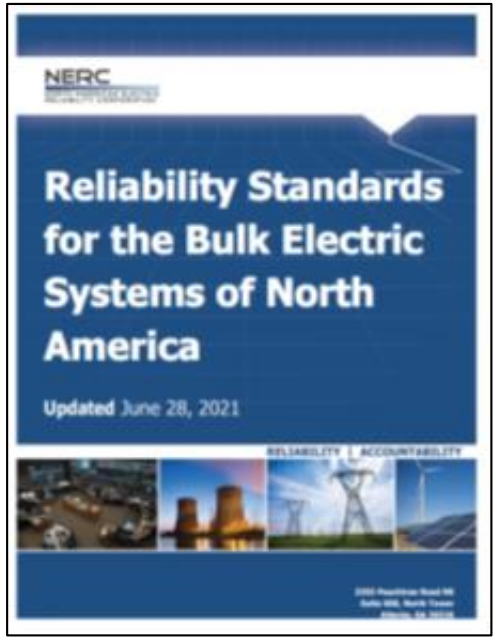
Recommendations
Generator Cold Weather Reliability Standards

- 1g, continued:

  GO/GOPs to provide BA with total percentage of generating unit's capacity that it reasonably believes the BA can rely on during the local forecasted cold weather

  - Based on GO's understanding of "full reliability risks related to contracts and other arrangements made to obtain natural gas commodity and transportation" (p.190)-quote refers to Key Rec. 8, which begins on p. 204 and has good info about the contractual arrangements of units that had outages
  - While the rec focuses on reliability risks related to natural gas, TOP-003-5 includes operating limitations beyond fuel—encourage SDT to require GOs to include all limitations in % calculation

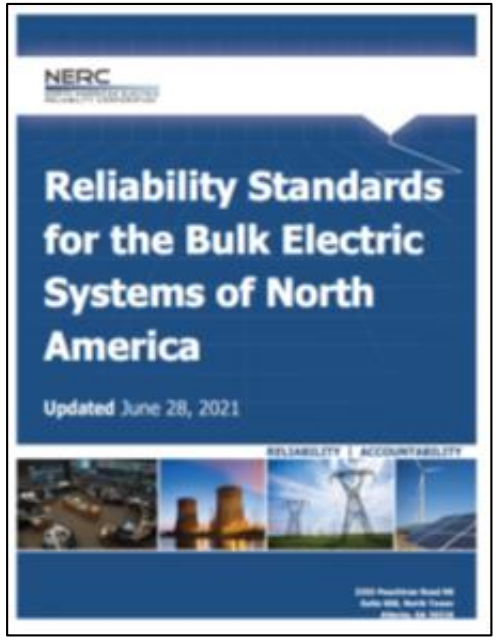


Recommendations
Generator Cold Weather Reliability Standards

- 1g, continued:

BA should be required to use data provided by GO/GOP, combined with its evaluation, based on experience, to calculate % capacity that it reasonably believes it can rely on during the local forecasted cold weather and share with RC

  - Neither BA's nor GO/GOP's calculations should be "strict liability" numbers—intent is NOT to say that if GO/GOP doesn't meet the percentage, or BA predicts wrong %, they have violated Standard.
  - Intent is a "good faith, reasonable estimate," based on:
    - information about historical temperature capability, fuel limitations, environmental limitations, and contractual provisions for fuel," for GO/GOPs, or
    - "experience with [units], the [pipelines serving units], and [weather predictions]," for BAs

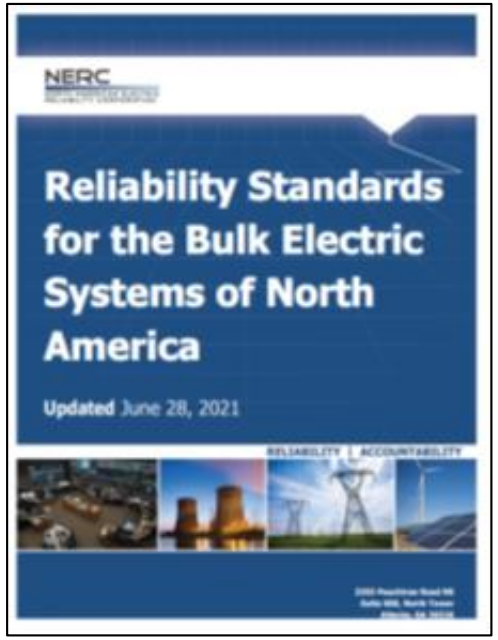


Recommendations
Generator Cold Weather Reliability Standards

- 1g, continued:

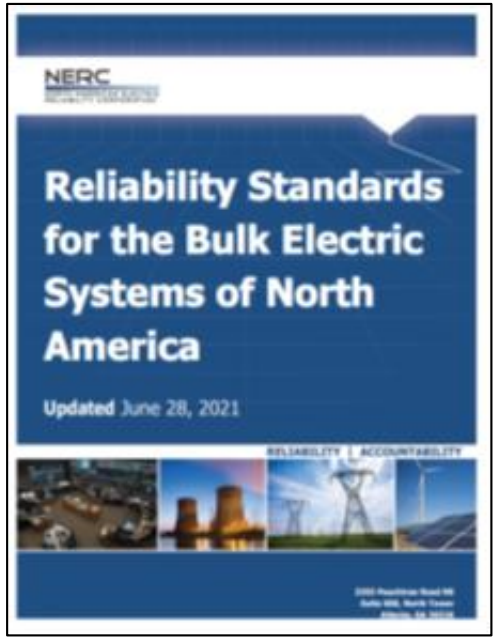
BA should be required to use its calculation of the % of generating unit capacity that it reasonably believes it can rely on during the local forecasted cold weather to:

  - Perform its TOP-003-5 R2 [data spec] "analysis functions and real-time monitoring," and
  - "Manage generating resources in its BA Area to address . . fuel supply and inventory concerns" as part of its EOP-011-2 R2.2.3.2 Capacity and Energy Emergency Operating Plans [fuel supply/inventory concerns to be considered such plans]
  - Overall intent of rec is to prevent grid operators from being surprised when large numbers of units that had committed to run are unable to do so during extreme weather



Recommendations
Grid Emergency Operations Preparedness

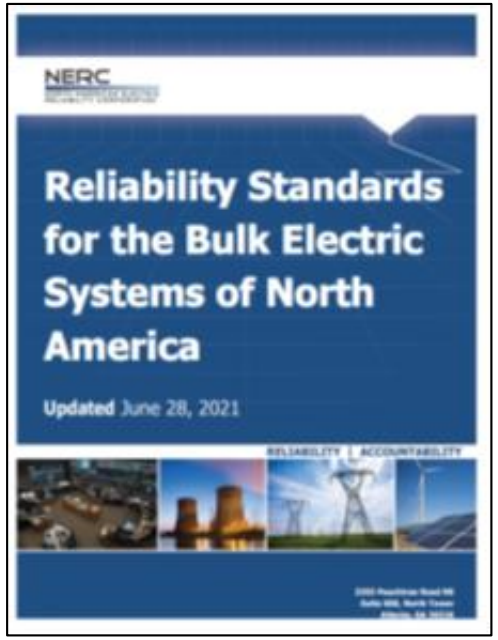
- New or revised Reliability Standards :
  - To require BA's operating plans (for contingency reserves [BAL-002-3] and to mitigate capacity and energy emergencies [EOP-011-1]) to prohibit use for demand response of critical natural gas infrastructure loads (1h, see Report page 208 for full text)
    - critical natural gas infrastructure loads are natural gas infrastructure loads which, if deenergized, could adversely affect provision of natural gas to BES natural gas-fired generating units, thereby adversely affecting BES reliability. See rec. 28
    - not an absolute prohibition on natural gas infrastructure as demand response



These recommendations are above and beyond the NERC Reliability Standards revisions to address cold weather. See 176 FERC ¶ 61,119 (August 2021).

Recommendations
Grid Emergency Operations Preparedness

- New or revised Reliability Standards :
  - To protect critical natural gas infrastructure loads (CNGIL) from manual and automatic load shedding (1i, see Report page 208-9 for full text)
    - Require BAs'/TOPs' provisions for manual load shedding to include processes for identifying and protecting CNGIL
    - Require BAs'/TOs'/PCs'/TPs' provisions and programs for manual and automatic load shedding to protect *identified* CNGIL from manual and automatic load shedding by load shed entities (incl. TOPs, TOs and DPs) within their footprints
    - Require load shed entities to distribute criteria to NG infrastructure entities and request ID of CNGIL, and require load shed entities to incorporate *identified* CNGIL into plans/procedures for protection against load shed



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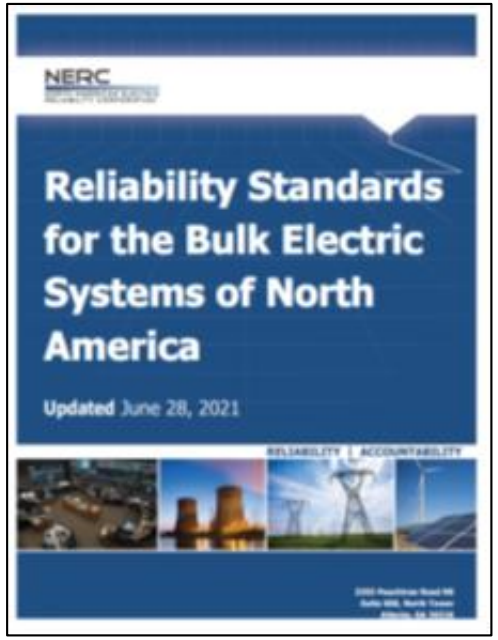
Recommendations
Grid Emergency Operations Preparedness

- New or revised Reliability Standards :
  - To protect critical natural gas infrastructure loads (CNGIL) from manual and automatic load shedding (1i, see Report page 208-9 for full text)
    - Most of the natural gas production and processing facilities surveyed were not identified as critical load or otherwise protected from manual load shedding
    - From early February 15 through February 18 implementation of manual firm load shed by ERCOT operators to preserve BES reliability partially contributed to the decline in production of natural gas (see slide 13)



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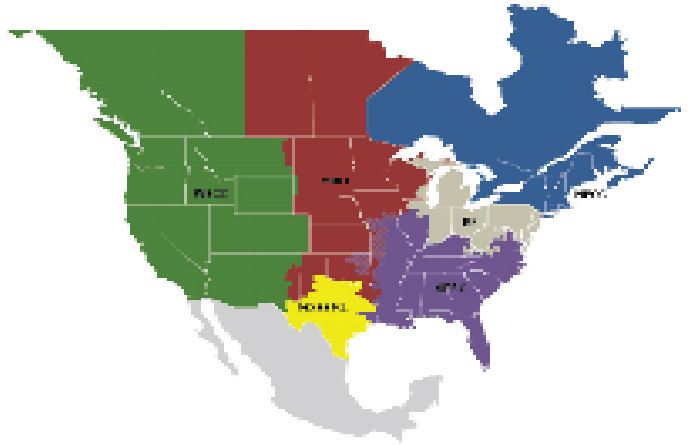

The full report can be found at:

https://www.ferc.gov/media/february-2021-cold-weather-outages-texas-and-south-central-united-states-ferc-nerc-and