NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Blackstart Resource Availability and Readiness in the Eastern and Western Interconnections

## NERC and Regional Entity Staff Study, FERC Staff Observation

November 21, 2025

RELIABILITY | RESILIENCE | SECURITY




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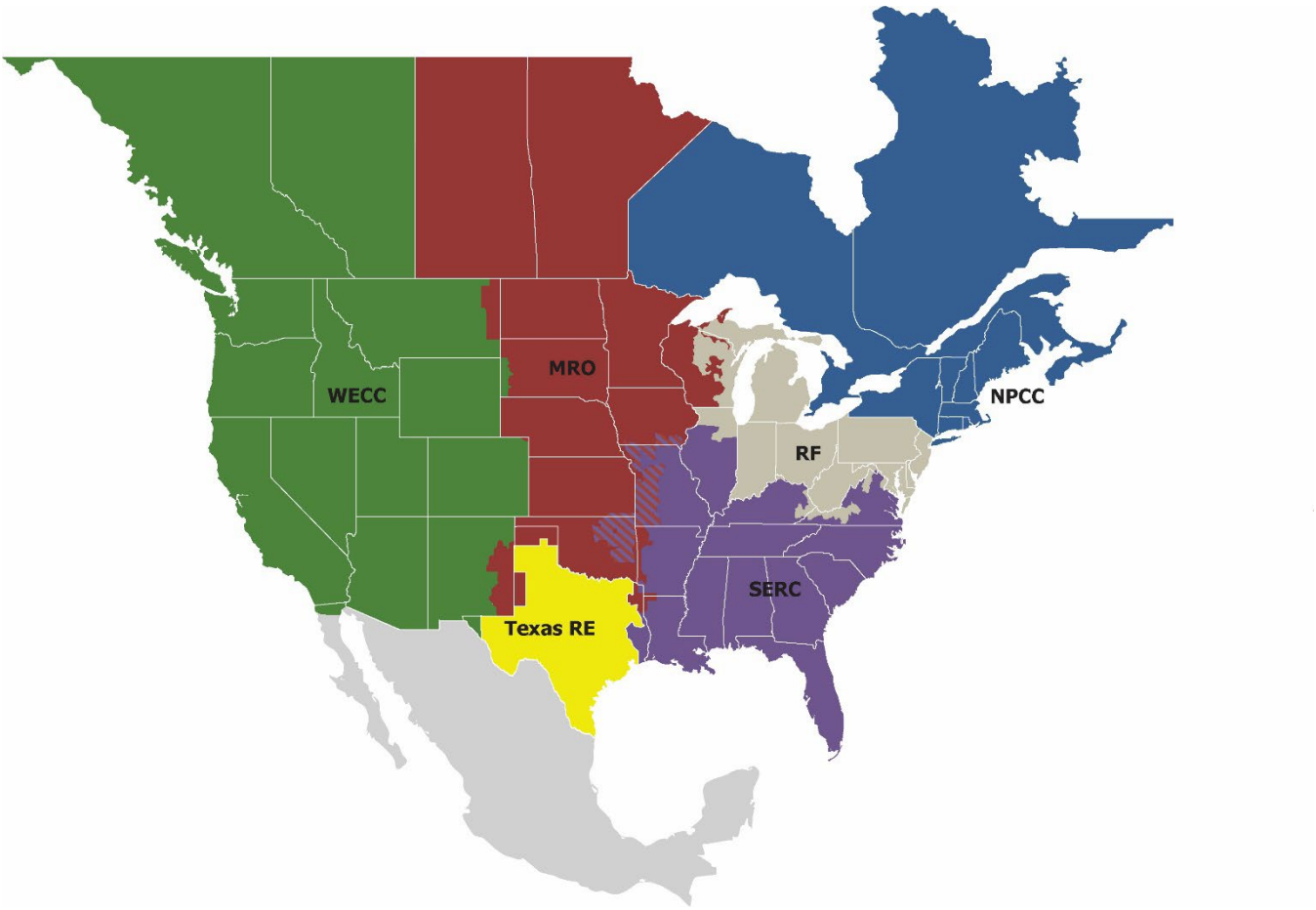
# Preface

Electricity is a key component of the fabric of modern society, and the Electric Reliability Organization (ERO) Enterprise serves to strengthen that fabric. The vision for the ERO Enterprise, which is comprised of NERC and the six Regional Entities, is a highly reliable, resilient, and secure North American bulk power system (BPS). Our mission is to assure the effective and efficient reduction of risks to the reliability and security of the grid.

Reliability | Resilience | Security
*Because nearly 400 million citizens in North America are counting on us*

The North American BPS is made up of six Regional Entities as shown on the map and in the corresponding table below. The multicolored area denotes overlap as some load-serving entities participate in one Regional Entity while associated Transmission Owners/Operators participate in another.

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|---|---|
| **MRO** | Midwest Reliability Organization |
| **NPCC** | Northeast Power Coordinating Council |
| **RF** | ReliabilityFirst |
| **SERC** | SERC Reliability Corporation |
| **Texas RE** | Texas Reliability Entity |
| **WECC** | WECC |

# Executive Summary

In October 2023, the Federal Energy Regulatory Commission (FERC), NERC, and Regional Entity staff jointly released a report regarding BPS operations during Winter Storm Elliott in December 2022.[1] That report presented 11 recommendations to improve electric generation and natural gas infrastructure for extreme cold weather reliability, grid emergency operations, and seasonal preparedness. In accordance with Recommendation 3 of the *Winter Storm Elliott Report*, NERC and Regional Entity staff in collaboration with FERC staff implemented this joint study of natural gas-fueled and dual-fuel blackstart resource (BSR) availability and readiness during extreme cold weather conditions in the U.S. portions of the Eastern and Western Interconnections (see **Figure E.1**). This study follows and builds upon *The February 2021 Cold Weather Outages in Texas and the South-Central United States* report[2] and Recommendation 26 from that same report, which resulted in a December 2023 study: *Blackstart and Next-Start Resource Availability in the Texas Interconnection* (Precedent Study). The Precedent Study included an assessment of blackstart and next-start resources following Winter Storm Uri in February 2021.[3] Neither study was a compliance or enforcement initiative.

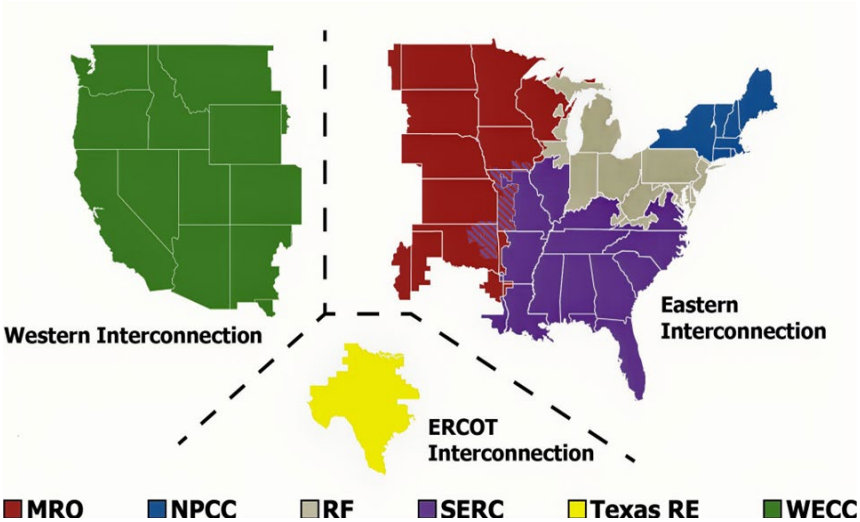


**Figure E.1: U.S. Portions of the Eastern, Western, and Texas Interconnections**

BSRs designated to be relied on during system restoration events throughout the Eastern and Western Interconnections are generally comprised of a diverse fuel mix. However, certain areas exhibit limited fuel diversity, relying predominantly on natural gas-fueled generation. Since approximately 77% of the BSRs in the U.S. portion of the Eastern Interconnection that experienced forced outages, derates, or failures to start during Winter Storm Elliott were natural gas fired,[4] this study focused on natural gas-fueled BSRs.

## Recommendations

The joint study team reaffirms the three identified recommendations from the FERC, NERC, and Regional Entity Staff Study, *Blackstart and Next-Start Resource Availability in the Texas Interconnection*, and asserts that they are applicable for the Western and Eastern Interconnection entities as well. Recognizing the evolving complexity of interdependent energy infrastructures, particularly during extreme cold weather conditions, the joint study team advances **nine**

[1] See *Inquiry into Bulk-Power System Operations During December 2022 Winter Storm Elliott Report* (October 2023), Winter Storm Elliott Report: Inquiry into Bulk-Power System Operations During December 2022 | Federal Energy Regulatory Commission (2023 Winter Storm Elliott Report).
[2] See FERC, NERC, and Regional Entity Staff, *The February 2021 Cold Weather Outages in Texas and the South Central United States* (Nov. 2021), https://www.ferc.gov/media/february-2021-cold-weather-outages-texas-and-south-central-united-states-ferc-nerc-and (2021 Cold Weather Report).
[3] See *Blackstart and Next-Start Resource Availability in the Texas Interconnection* (December 2023) FERC-NERC-Regional Entity Joint Blackstart and Next-Start Resource Availability Study in the Texas Interconnection | Federal Energy Regulatory Commission (Precedent Study).
[4] 2023 Winter Storm Elliott Report, pages 105–106: *"155 blackstart-designated generating units (119 of which were natural gas-fired)"*

**additional recommendations**. These new recommendations are designed to enhance cross-industry coordination, improve situational awareness, strengthen regulatory frameworks, and ensure the robustness of blackstart capabilities.

- **Recommendation 1:** Entities responsible for the development of system restoration plans and the selection of BSRs should consider reviewing and revising (as needed) internal processes to ensure that the selection and qualifications of BSRs include the consideration of currently effective NERC Reliability Standard EOP-012-3 operational data[5] and capability under R2 or R3, as it pertains to blackstart service/capabilities, extreme cold weather preparedness, and operations. These entities should consider implementing more frequent (perhaps annual, preseason) assessments or validation of blackstart capabilities of BSRs to ensure operational readiness for each winter season.
- **Recommendation 2:** Entities responsible for BSRs should ensure that the blackstart procedures contain specific extreme cold weather preparatory actions and considerations to help operators successfully perform in extreme cold weather conditions.
- **Recommendation 3:** Entities responsible for, or capable of, providing blackstart service should systematically evaluate and identify generator cold weather critical components, including those components only used during system restoration.
- **Recommendation 4:** Entities responsible for development of system restoration plans should evaluate their restoration plans and the BSR capabilities and procedures to ensure that restoration plans consider and manage fuel availability risk under extreme cold weather conditions for blackstart service of designated BSRs.

  a. Entities responsible for the implementation of system restoration plans with identified dual-fuel-capable BSRs should evaluate and establish/strengthen their documented requirements for a minimum amount of onsite or readily available backup fuel to successfully implement the plan.
- **Recommendation 5:** Entities responsible for the development and implementation of emission/environmental regulation waiver requests, as applicable, should evaluate the existing emission/environmental regulation waiver request processes and procedures to ensure that they will work during a system blackout and make sure that BSRs will be available when called upon. This waiver evaluation process should consider the entirety of the restoration plan beyond BSRs and establish clearly defined waiver triggers.

  a. Emission/environmental waiver processes or procedures should consider requests to applicable air emission regulatory jurisdictions, which could include situations in which BSR(s) may be located in a different state (with a different environmental regulator outside the impacted area) and/or neighboring Reliability Coordinator area.
- **Recommendation 6:** The joint study team reaffirms Recommendation 2 from the Precedent Study, emphasizing its continued relevance.[6] Given the multijurisdictional nature of the Eastern and Western Interconnections encompassing multiple states and energy regulatory authorities, the joint study team recommends that each individual entity with system restoration plan requirements proactively collaborate, based on its regional electric system restoration assessments. These entities should also develop joint blackstart system restoration plans to address electric and natural gas system identified interdependency risks.

  a. The joint study team recommends that subject matter experts (SME) from the electric and natural gas industries evaluate the potential impact of a wide-area electric blackout on natural gas system functionality, consequent impacts on electric system restoration, and potential single points of failure, as pertains to individual Transmission Operator area system restoration plans. These SMEs should also help

[5] List of operating parameters, capabilities, and other important factors is provided in Requirement 1.
[6] See Precedent Study report, page 6.

develop system restoration plans that include solutions to resolve identified issues. It is recommended that such restoration plans include the following:

i. Distinguishing between critical customer loads and system restoration critical loads, which includes natural gas supply, processing, storage, and delivery facilities; and

ii. Requiring Transmission Owners/Operators with natural gas-fueled BSRs in their system restoration plans to jointly work with natural gas transmission and delivery facility owners to identify necessary natural gas supply route(s) supporting BSRs. It is recommended that these Transmission Owners/Operators also identify the source of the natural gas supply (including storage).

- **Recommendation 7:** Dual-fuel BSRs should identify, mitigate, and communicate the residual risk related to their primary and alternate fuel supply availability and deliverability during a blackout scenario to the entities responsible for the applicable system restoration plans.

  a. BSR owners should evaluate primary and backup communication methods with fuel suppliers and delivery entities (e.g., trucking or barge delivery of alternate fuels). This communication should include the identification of critical communication infrastructure that supports both the natural gas system and alternate fuel delivery necessary for BSR participation in restoration in the event of a blackout.

- **Recommendation 8:** Entities responsible for developing and implementing a system restoration plan should:

  a. Consider incorporating a periodic (e.g., annual or pre-season) startup test with alternate fuel for dual-fuel BSRs that indicate capability to start on an alternate fuel into dual-fuel BSR testing requirements. When possible and practical, entities should look for opportunities to perform these tests during extreme cold weather to verify performance in cold conditions.

  i. Tabletop exercises in lieu of winter tests (where winter tests are not feasible or practical) are acceptable to identify extreme cold weather-related gaps in blackstart startup and operating procedures.

  b. Consider implementing fuel switching BSR testing to confirm the capability and time required to switch between primary and alternate fuel for an extreme cold weather blackstart event.

  c. Consider including specific identified extreme cold weather considerations and actions in their system restoration plan to help operators perform successfully in cold weather conditions.

- **Recommendation 9:** To strengthen the effectiveness of system restoration preparatory efforts, the joint study team recommends enhancements to existing simulator-based training to focus on system restoration during extreme cold weather operations.

# Introduction

On December 28, 2022, FERC, NERC, and Regional Entity staff began an inquiry into the operations of the Bulk Electric System (BES) and the supporting natural gas infrastructure in the U.S. Eastern Interconnection during Winter Storm Elliott. The event occurred between December 21 and 26, 2022, causing significant generation loss and unprecedented firm load shed within the Eastern Interconnection. The investigation resulted in the report titled, *Inquiry Into Bulk-Power System Operations During December 2022 Winter Storm Elliott*,[7] issued in October 2023.

The 2023 *Winter Storm Elliott Inquiry Report* provided a detailed assessment of electric and natural gas system performance during extreme cold weather across the Eastern Interconnection. Building on insights from prior events like Winter Storm Uri, the report underscored the urgent need to enhance BSR readiness. It revealed that more than 150 blackstart-designated generating units—representing approximately 19,000 MW—experienced outages during the Winter Storm Elliott event,[8] raising serious concerns about their ability to fulfill their critical role in grid restoration following a blackout. In response to observed challenges, including blackstart units failing to operate as expected, the report recommended that the ERO Enterprise, in collaboration with FERC, conduct a comprehensive study of blackstart generator availability and readiness under extreme cold weather conditions across both the Eastern and Western Interconnections. This initiative aims to improve restoration planning and ensure that designated BSRs can reliably support grid recovery during future extreme cold weather events.

Recommendation 3 of the Elliott report[9] states the following:

- A joint NERC-Regional Entity team, collaborating with FERC staff, should study the overall availability and readiness of blackstart units to operate during extreme cold weather conditions. This study should cover all portions of the U.S. not already studied, and should incorporate existing literature, studies, reports, and other analyses as to the availability and readiness of blackstart units. The scope of the study should include, among other things:
  - an evaluation of existing blackstart restoration plans, including a review of potential single points of failure related to natural gas system dependence;
  - an evaluation of the sufficiency of existing blackstart availability, readiness, and testing criteria, including whether unscheduled, unannounced, or criteria-based testing (e.g., those used in ERCOT) would improve reliability during extreme cold weather events;
  - the need for ensuring that generating units with dual-fuel capability providing blackstart service have appropriate fuel storage (as determined by the Balancing Authority);
  - the need to require blackstart generators to test their fuel switching capabilities seasonally;
  - the need to require additional fuel storage due to import constraints;
  - the need for Transmission Operators to incorporate generating units' extreme cold weather preparations into the qualification process for certifying generators as blackstart units; and,

[7] This report, https://www.ferc.gov/media/winter-storm-elliott-report-inquiry-bulk-power-system-operations-during-december-2022, states that at the worst point of the event, a total of over 127,000 MW of generation was unavailable, including unplanned outages, derates, failures to start, and generation already out of service. This represented 18 percent of the U.S. portion of the anticipated resources in the Eastern Interconnection. Firm load shed to maintain system reliability during the event exceeded 5,400 MW. This was the largest controlled firm load shed recorded in the history of the Eastern Interconnection.

[8] 2023 Winter Storm Elliott Report, page 19 – "Over 150 blackstart-designated generating units, totaling 19,000 MW, incurred outages during the Event, 119 of which were natural gas-fueled generating units (accounting for just under 75 percent of all MW of blackstart-designated generation outages)."

[9] Id. at 135

- any other subject areas identified as areas of substantial interest or concern in the report issued as a result of ongoing efforts to study blackstart unit availability and readiness in ERCOT.

On August 5, 2024, the NERC and Regional Entity joint study team comprising the ERO Enterprise initiated this study,[10] focused on natural-gas-fired BSRs (including units that are dual-fuel capable) since natural gas units represented the large majority of freezing issues during Winter Storm Elliott. This report notes similarities to the recommendations of the blackstart study of the Texas Interconnection [11] and identifies new observations and recommendations designed to further enhance cross-industry coordination, improve situational awareness, strengthen regulatory frameworks, and ensure the robustness of blackstart capabilities.

[10] ERO Enterprise to Perform Blackstart Study of Eastern, Western Interconnections as Recommended by Winter Storm Elliott Report
[11] This report is located at: https://www.ferc.gov/media/ferc-nerc-regional-entity-joint-blackstart-and-next-start-resource-availability-study-texas.

# Chapter 1: Study Process and Data

The ERO Enterprise supplied SMEs as team members to provide necessary planning and operational expertise to conduct the study.[12] FERC staff members collaborated with the team. The joint study team identified and reviewed prior blackstart studies, reports, and other references to inform the study.[13]

The joint study team designed participant identification criteria to best achieve the study goals of assessing blackstart availability, natural gas availability, and strategies to improve the reliability of these resources during extreme cold weather events and blackstart system restoration scenarios. The joint study team used the following criteria to identify prospective participants:

- Entities with natural-gas-fueled and dual-fueled BSRs subject to NERC Reliability Standard EOP-005-3: System Restoration from Blackstart Resources[14]
- Entities subject to NERC Reliability Standard EOP-006-3: System Restoration Coordination[15]
- Entities with facilities and operational responsibilities across multiple sectors/segments (midstream and downstream) within the natural gas supply chain

The topics surveyed included fuel contracts, fuel switching, maintenance, coordination between BSRs and their fuel suppliers, procedures, and training as well as BSR designation requirements. Three natural gas industry organizations were asked to participate in the study, focusing on the natural gas supply chain operations. The joint study team asked natural gas entity participants to provide an overview of their organization's operations during extreme cold weather events and wide-area blackout scenarios.

The joint study team adapted the surveys from the Precedent Study for this geographically expanded study to ensure consistency with the Precedent Study. Each Regional Entity requested and collected comprehensive survey responses from selected entities within its footprint and reviewed the responses. The Regional Entities then integrated and summarized all responses from the Eastern and Western Interconnection study areas and aligned observations, recommendations, and observed practices for consideration specific to the study scope. The joint study team pursued further information and clarification from survey participants as needed.

The Precedent Study is the only similarly identified precursor to this study. However, a literature review also identified various papers, documents, and studies addressing aspects of blackstart service.[16] The Precedent Study assessed one Reliability Coordinator's (RC) area restoration plan specific to the Texas Interconnection. This study assessed the coordination of all 11 U.S. RCs in the Eastern and Western Interconnections, surveyed Transmission Owners/Transmission Operators across the same Interconnections and investigated the availability and readiness of the BSRs upon which system restoration plans rely. The increased scope of this study versus the Precedent Study necessitated a selective approach to obtain electric and natural gas entity participants.

[12] Significant overlap exists between this team and that of the December 2023 blackstart study as well as of those teams investigating and issuing reports on Winter Storm Uri, Winter Storm Elliott, and Winter Storms Gerri and Heather. Appendix A lists the ERO Enterprise SMEs and FERC collaboration team members.
[13] Appendix B contains a list of literature reviewed prior to and during the conduct of the study.
[14] This NERC Reliability Standard is located at: https://www.nerc.com/pa/Stand/Reliability%20Standards/EOP-005-3.pdf.
[15] This NERC Reliability Standard is located at: https://www.nerc.com/pa/Stand/Reliability%20Standards/EOP-006-3.pdf.
[16] See Appendix B.

# Chapter 2: Assessment

## Overview

NERC Reliability Standard EOP-005-3 requires that each Transmission Operator (TOP) develop a system restoration plan that must be submitted to and approved by its respective RC. This plan is intended for implementation following a system disturbance that causes a partial or full loss of BES functionality. The standard requires the TOP, where applicable, to use BSRs to supply initial energization to begin the process of restoring portions of the system that have lost power. The plan must include strategies, agreements, procedures, and operating processes to restore the BPS following a wide-area blackout and identify the necessary BSR(s) to initiate the restoration.

Similar to the Precedent Study approach, through entity engagement, additional literature review, and SME input and collaboration, the joint study team identified a wide range of practices and challenges related to the BSRs and system restoration readiness. Specifically, the joint study team examined the following:

- BSRs relied upon for system restoration plans
- Fuel supply contracts and delivery infrastructure supporting those BSRs
- Maintenance, testing, and fuel-switching capabilities of BSRs
- Training practices for personnel responsible for operating BSRs and executing system restoration

The following sections summarize the team's observations, highlight notable practices, and present recommendations for enhancing resilience in capabilities and future restoration efforts.

## Blackstart Resources Relied Upon in System Restoration Plans

### Introduction

The joint study team evaluated the vast majority of the natural gas (including dual-fuel capable) BSRs for availability and readiness during extreme cold weather conditions. The study included reviews of fuel storage for units with dual-fuel capability, fuel switching capability, and potential emissions issues that might limit the runtime of a BSR resource. The joint study team also examined whether maintenance checklists and procedures exist to prepare for and execute steps necessary for system restoration specifically during extreme cold weather.

The joint study team approached these issues from the perspective of the BSR role within the TOP and higher-level RC restoration plans as well as from the perspective of the individual BSR capabilities.

### Observations

#### *Consideration of Fuel-Related Single Point of Failure*

Approximately half of the BSRs surveyed have dual-fuel capabilities with one-third of these identifying distillate oil or fuel oil as their alternate fuel. The majority of all dual-fuel BSRs surveyed noted the use of at least two suppliers for alternate fuel to support diversity of acquisition.

The joint study team examined RC criteria for the amount of alternate or backup fuel readily available, the associated unit runtime available through the available fuel, and requirements for fuel-assured BSRs in RC recovery plans. The joint study team observed varied approaches to backup fuel levels and runtime requirements from the RC level. The team found that certain RCs have established unique runtime requirements for BSRs that address fuel risks and runtime risks. Of the 11 RC entities surveyed, only three indicated that they have criteria for how much backup fuel must be available and minimum runtime duration. The survey responses included identified runtime criteria related to fuel inventory requirements. These requirements range from 12 to 16 hours of runtime on backup fuel.

Approximately one-third of participants reported having onsite storage capability. However, most RCs just monitor stored fuel levels and replenishment arrangements through surveys to maintain situational awareness rather than stipulating a minimum required level.

### *Blackstart Resource Selection and Qualification Process*

The joint study team observed that clear criteria did not exist in system restoration plans to establish how long a BSR can sit idle in sub-freezing temperatures before requiring additional protective measures for a successful cold start. This information would allow TOPs to prioritize implementation of system restoration plans. NERC Reliability Standard EOP-012-3 requires cold weather preparedness plans to address the operating capability of generating units in extreme cold weather; however, it does not specifically address the impact of a loss of power supply to protective measures of BSRs that would result from a blackout in extreme cold weather conditions.

### *Critical Loads and Critical Components to Support Cold Weather Blackstart Resource Startup and Operation*

Similar to the observations and findings in the Precedent Study,[17] the joint study team believes that distinguishing between customer critical loads and system restoration critical loads that support BSRs is important. Examples of system restoration critical loads could include natural gas supply, processing, storage, and delivery facilities.

The surveys did not explicitly request information regarding BSRs' generator cold weather critical components[18] that are required to support starting and operating BSRs during a system restoration event. However, the joint study team's review of the currently effective NERC Reliability Standard EOP-012-3 and its development record identified a potential reliability gap related to the applicability of the generator cold weather critical component definition as it pertains to the blackstart service-specific component or system. Therefore, the joint study team believes there is a need to systematically assess (and ensure fit for purpose) each BSR's generator cold weather critical components required to support starting and operating BSRs during a system restoration event.

### *Planned Mitigation for Blackstart Resource Fuel Emission Restriction*

The joint study team requested information on possible environmental restrictions and their mitigation when entities use alternate fuel. Entities reported that federal and state environmental agencies generally set criteria for generator emissions that use distillate oil as the alternate fuel, including byproduct limits for opacity, particulates, nitrogen oxides (NOx), sulfur dioxide ($SO_2$), volatile organic compounds, and other air pollutants. One participant noted the purchase of ultra-low-sulfur diesel (ULSD) at 15 parts per million (ppm) sulfur content (compared to low-sulfur diesel (LSD) having 500 ppm) as a mitigating strategy for meeting environmental restrictions.

Some Generator Operators (GOP) apply for emission waivers if needed after the occurrence of a system emergency resulting in an emission exceedance, and others indicate that no notifications are required for system emergencies. Two RCs have established procedures to coordinate emissions waivers with air emissions regulators (state and federal), prior to the grid emergency, to release them from environmental constraint obligations during an emergency, while one RC notes that its TOPs will coordinate emission issues with regulatory agencies. One RC coordinates with the Department of Energy should a 202(c)-emergency order be needed to operate a generation resource.

### *Blackstart Resource Retirements and Emerging Technologies*

The team also reviewed the recent New York Power Authority (NYPA) report that highlights the public policy-driven resource loss, including natural gas-fueled blackstart capable resources.[19] While the loss of the resources essential for

[17] See Precedent Study report, page 24.
[18] See Glossary of Terms Used in NERC Reliability Standards https://www.nerc.com/pa/Stand/Glossary%20of%20Terms/Glossary_of_Terms.pdf.
[19] See New York Power Authority (NYPA) Small Natural Gas Power Plant Transition Plan, May 9, 2025 - https://edge.sitecorecloud.io/newyorkpowe85b6-nypad19c-prod795c-a32e/media/Feature/nypa-sites/small-natural-gas-media/SNGPP-Transition-Plan.pdf.

system restoration may not be solely policy-driven (e.g., economics) throughout the Eastern Interconnection and Western Interconnection, the NYPA report recognizes the need to identify solutions for the replacement of critical blackstart ancillary service, including the benefit of diversification and new emerging technologies in enhancing the resilience of restoration plans. In the planned retirement discussions between the NYPA, New York Independent System Operator (NYISO), and Consolidated Edison on potential reuse of the sites for battery energy storage systems (BESS), it is important to maintain blackstart capability either at these sites or other electrically feasible locations. The NYPA report (footnote 36) states, "Some of NYPA's small power plants in New York City are equipped to help turn the power system back on after a blackout. NYPA expects to work with the NYISO and Consolidated Edison on how that 'black start' capability will be replaced by other resources, including the Champlain Hudson Power Express."[20] While using an import capability as an alternate blackstart source brings different risk, not the least of which is resource availability at the sending end during the time of a wide-area cold snap, for example, it diversifies the overall restoration plan risk by managing single point of failure concerns.

## Conclusions

This review did not include a comprehensive risk analysis of system restoration plans. The joint study team surveyed selected entities responsible for system restoration plans and BSRs to ensure that facilities are staffed and adequately prepared to support system restoration in extreme cold weather conditions. The joint study team identified a need to incorporate cold weather and a single-point-of-failure risk mitigation into their strategies. This is a similar finding to the Precedent Study.[21] Flexibility may exist outside of formal plans that may provide added assistance.[22] Other resources such as hydro, diesel, and BESS technology BSRs may provide diversity and other risk-mitigating benefits (non-fuel requirements, remote operation) in cold weather system restoration situations.[23]

The joint study team observed that entities' BSR design, selection, or qualification processes could be strengthened by incorporating an evaluation of cold weather capabilities, as outlined in NERC Reliability Standard EOP-012-3 Requirement 1.2.[24]

There is no consistent and uniform requirement across the Eastern and Western Interconnections that exists for the amount of onsite alternate fuel that needs to be maintained to support implementation of a restoration plan. While many surveyed BSRs possess dual-fuel capabilities and maintain diverse fuel supply arrangements, there is no standardized industry criterion for onsite alternate fuel quantities or contracting practices. This risk evaluation should be undertaken by each entity responsible for the development of their respective restoration plan.

NERC Reliability Standard EOP-012-3 requirements have led to industry efforts for improved cold weather preparedness and cold weather operating procedures for generation resources, including BSRs. Nevertheless, the standard does not explicitly address the effects of extreme cold weather on starting BSRs during a system blackout. As such, the joint study team believes that more work is needed to incorporate specific cold weather preparation activities into checklists and procedures to successfully prepare, start, and operate BSRs without external power from the grid during extreme cold weather.

## Recommendations

- **Recommendation 1:** Entities responsible for the development of system restoration plans and the selection of BSRs should consider reviewing and revising (as needed) internal processes to ensure that the selection and qualifications of BSRs include the consideration of currently effective NERC Reliability Standard EOP-012-

[20] See https://www.nema.org/docs/default-source/council-documents-library/chpe-rec-presentation.pdf?sfvrsn=3896a25e_3.
[21] See Recommendations 1a and 1b of the Precedent Study report.
[22] See Precedent Study report, pages 19–20.
[23] Additional restoration plan options may include "use of electrical bypasses, high voltage direct current (HVDC) ties, variable frequency transformers, block load transfers" – See Recommendation 1b of the Precedent Study.
[24] This NERC Reliability Standard is located at: https://www.nerc.com/pa/Stand/Reliability%20Standards/EOP-012-3.pdf.

3 operational data[25] and capability under R2 or R3, as it pertains to blackstart service/capabilities, extreme cold weather preparedness, and operations. These entities should consider implementing more frequent (perhaps annual, preseason) assessments or validation of blackstart capabilities of BSRs to ensure operational readiness for each winter season.

- **Recommendation 2:** Entities responsible for BSRs should ensure that the blackstart procedures contain specific extreme cold weather preparatory actions and considerations to help operators successfully perform in extreme cold weather conditions.
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- **Recommendation 4:** Entities responsible for development of system restoration plans should evaluate their restoration plans and the BSR capabilities and procedures to ensure that restoration plans consider and manage fuel availability risk under extreme cold weather conditions for blackstart service of designated BSRs.

  a. Entities responsible for the implementation of system restoration plans with identified dual-fuel-capable BSRs should evaluate and establish/strengthen their documented requirements for a minimum amount of onsite or readily available backup fuel to successfully implement the plan.

- **Recommendation 5:** Entities responsible for the development and implementation of emission/environmental regulation waiver requests, as applicable, should evaluate the existing emission/environmental regulation waiver request processes and procedures to ensure that they will work during a system blackout and make sure that BSRs will be available when called upon. This waiver evaluation process should consider the entirety of the restoration plan beyond BSRs and establish clearly defined waiver triggers.

  a. Emission/environmental waiver processes or procedures should consider requests to applicable air emission regulatory jurisdictions, which could include situations in which BSR(s) may be located in a different state (with a different environmental regulator outside the impacted area) and/or neighboring Reliability Coordinator area.

## Observed Practices for Consideration

- One participant stated that it provides cold weather attributes (winter combustion tuning and fuel gelling prevention) within its cold weather blackstart procedures.
- Some participants stated that they have established requirements related to fuel assurance for BSRs to successfully implement their system restoration plans.[26]

[25] List of operating parameters, capabilities, and other important factors is provided in Requirement 1.

[26] Examples include:

- PJM Manual 36: System Restoration Revision 35, June 15, 2025: https://www.pjm.com/-/media/DotCom/documents/manuals/m36.pdf; Attachment A, and Manual 12: PJM Manual 12: Balancing Operations - https://www.pjm.com/-/media/DotCom/documents/manuals/m12.pdf; Section 4.5
- ERCOT Nodal Protocols, Section 8: Performance Monitoring: https://www.ercot.com/files/docs/2022/12/09/08-060125_Nodal.docx; Section 8.1.1.2.1.5, part 1(g); and Section 3: Management Activities for the ERCOT System - https://www.ercot.com/files/docs/2024/06/28/03-060125_Nodal.docx, part 3.14.2
- ISO-New England Operating Procedure No. 11 Blackstart Resource Administration (OP-11), September 12, 2023 - https://www.iso-ne.com/static-assets/documents/rules_proceds/operating/isone/op11/op11_rto_final.pdf; Section II.1 - Eligibility Requirements for Providing Blackstart Service

The NERC Electric Gas Working Group, under the Reliability and Security Technical Committee, has also developed a guideline that focuses more broadly on fuel assurance risk but also identifies the need for consideration of restoration-specific fuel assurance risk. See NERC *Reliability Guideline: Fuel Assurance and Fuel-Related Reliability Risk Analysis for the Bulk Power System*, September 2023, Appendix C, Step 3 and Appendix D : https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Fuel_Assurance_and_Fuel-Related_Reliability_Risk_Analysis_for_the_Bulk_Power_System.pdf.

- One participant has implemented centralized ordering of alternate fuel for all its facilities to maintain awareness and availability of its generation fleet's capability. Another participant noted that the oil inventory maintained on site allows for multiple days of operations of BSRs.

# Fuel Supply Contracts and Delivery Infrastructure for Blackstart Resources

## Introduction

The joint study team notes that the electric and natural gas systems have a strong interdependence for reliable operations, which the Precedent Study report also confirmed.[27] The joint study team examined the characteristics of fuel contracts used to procure natural gas and alternate distillate or fuel (oil) for BSRs.

The joint study team further evaluated the awareness and practices of natural gas entities, including those involved in natural gas gathering, production, transportation and storage as well as Local Distribution Company (LDC) services. The joint study team surveyed natural gas entities' operations and potential impacts on BSR startup and electric system restoration. Where applicable, the joint study team examined the sources of electricity that enable natural gas providers to deliver fuel to BSRs and the fuel delivery risks, to understand what commercial priorities exist for both electric and natural gas systems. Furthermore, the joint study team investigated whether priorities need to change in the case of a wide-area blackout to ensure that BSRs perform effectively and that both the electric and natural gas services are normalized as quickly as possible.

Some BSRs relying on natural gas fuel supplies connected behind a city gate served by an LDC may have less fuel supply availability risks compared to those connected directly to interstate pipelines.

Natural gas may be available to BSRs as a result of the loss of the firm natural gas customer load during a wide-area blackout. However, since this decrease of natural gas customer load is uncertain, the availability of non-firm natural gas for BSRs cannot be assured. Some surveyed participants secure firm natural gas supply and transportation contracts to reduce the fuel availability risk. However, a significant number of BSRs surveyed indicated that they do not secure firm natural gas supply and transportation contracts, meaning that they will be a lower-priority customer with a higher risk of being unable to obtain natural gas during a cold weather wide-area blackout scenario.

The joint study team surveyed BSRs identified in individual system restoration plans to examine whether multiple BSRs within a restoration plan have a single point of failure related to fuel supply (e.g., common natural gas pipeline) that would compromise implementation of the plan. The joint study team found that a limited number of entities have criteria for multiple natural gas connections to address the single-point-of-failure fuel supply risk. The joint study team reviewed communication plans for fuel suppliers during abnormal situations, such as a blackstart scenario. Finally, the joint study team considered natural gas entity cold weather measures and mitigations employed to increase the reliability of natural gas supply.

## Observations

### *Blackstart Resource–Natural Gas Fuel Risk*

The joint study team has identified risks and operational vulnerabilities associated with BSRs. These include natural gas curtailment risks due to BSRs lacking firm natural gas supply or firm pipeline transportation contracts. Of the 79 entities that responded, 42% indicated that they do not have firm fuel supply and/or transportation contracts.

[27] See Precedent Study report, page 29.

Many of the participating entities that identified underperformance as a fuel supply risk attributed it to an expectation of force majeure.[28] Natural gas suppliers might invoke force majeure when, for instance, extreme cold conditions cause wellheads to "freeze off," limiting production.

One surveyed natural gas participant indicated that it has backup generators available at compressor stations that are natural gas-fired reciprocation units, meaning that they do not require electricity from the BES to start. Another participant noted that some natural gas compressor stations contain backup diesel generators while others require electric power. One participant stated that it considers pre-positioning additional backup power generators at key transmission or storage compressor stations in advance of significant weather events to mitigate the risk of local or regional power outages.

The participating entities noted that these actions are aimed at maintaining a reliable natural gas supply despite the potential loss of internal communications within the natural gas company and providing continuity of delivery service irrespective of any level of communication with the electric system. One natural gas transportation and storage participant stated that during extreme cold weather, it staffs its compressor stations and key pipeline control locations to ensure continuing service in the event of communication problems or other trouble. Ninety-seven percent of its mainline compressor stations use natural gas-fired compression and are equipped with backup generation power by diesel or natural gas. This entity's stations can run on battery backup for up to 36 hours before a pneumatic backup controller would come into service as communication to the station would simultaneously fail. Further, this entity takes measures to ensure that valves at compressor stations have heat blankets to help them remain operable in the event of extreme cold weather.

With the continuing trend of reliance on natural gas, it is critical that industry maintain the integrity of the dual-fuel capability of BSRs.

### *Blackstart Alternate Fuel Risk*

The joint study team observed that alternate fuel risk mitigation strategies vary across participants. About half of the BSRs surveyed have alternate fuel capability as well as different approaches to ensuring the availability of alternate fuel. There is not a consistent approach to having firm or non-firm contracts in place for alternate fuel. Onsite storage is the most common means of access to alternate fuel. One entity noted that it pre-purchases alternate fuel from a neighboring facility and maintains a dedicated storage tank onsite.

Participants' responses indicated reliance on different land-based alternate fuel delivery methods—truck, train, or pipeline; another noted the option to have alternate fuel delivered by ship at some locations. Several participants identified delivery nonperformance as a risk for alternate fuel with road conditions mentioned as a potential cause. Transportation availability, transportation personnel, and supply disruption at fuel oil terminals are listed as potential risks during extreme cold weather events. Most oil transportation services are provided by a third party. Most participants have not researched how a blackout might impact the ability of their alternate fuel supplier to replenish fuel used during blackstart conditions. A few participants employ multiple suppliers within an area to mitigate delivery issues. One participant uses weather forecasts to determine when to order additional onsite alternate fuel to mitigate possible delivery issues due to road conditions.

### *Blackstart Resource – Fuel Contracts and Fuel Storage*

Approximately half of BSR participants in this study utilize firm fuel supply contracts with the other half buying fuel from the spot market for primary fuel needs. Some participants noted that they employ a hybrid approach, projecting an amount of fuel to be obtained through firm contract and purchasing any additional fuel needed in the spot market if the need materializes, such as an extreme cold weather event.

[28] Force majeure is any event beyond the reasonable control of, and that occurs without the fault or negligence of, an entity whose performance is prevented by the occurrence of such event.

Participants reported that operating restrictions, if noted, focus mainly on limited storage capability or the limited availability of demineralized water. Participants noted that a limited supply of demineralized water can impact the availability of blackstart combustion turbines. Such units require demineralized water for NOx control, and without it, they may be unable to operate within environmental permit limits. These participants stated that if the water system is not properly winterized, it is susceptible to freezing, further jeopardizing unit availability during restoration.

### *Delivery Priorities for Blackstart Scenarios*

The joint study team observed that current natural gas regulatory frameworks, industry business practices, and operational procedures do not permit flexibility to prioritize natural gas services for BSRs during system restoration. This is similar to the finding and Recommendation 3 of the Precedent Study.[29] While securing firm natural gas supply and transportation contracts remains a mitigation strategy to reduce fuel availability risk, enhancing electric service prioritization to critical natural gas infrastructure during cold weather blackstart scenarios would further strengthen system resilience and reliability to support fuel availability and deliverability during electric system restoration. Pipeline operators and natural gas utilities serving BSRs will, on a best-effort basis, endeavor to support these critical resources within the framework of their existing policies and procedures. To ensure efficient recovery from a blackout, electric and natural gas entities must strengthen their coordination and jointly develop comprehensive restoration plans.

### *Communication Risks*

Electric entities surveyed reported that the current level of communication and collaboration with natural gas suppliers is generally limited to daily operations. Several noted “heightened” or “constant” communication with fuel suppliers in advance of and during extreme cold weather. Some electric and gas participants have initiated discussions about the electric power supply to critical gas transportation infrastructure. The joint study team recognizes the importance of effective communication between the electric and natural gas systems—not only for routine operations, but also for initiative-taking planning and coordinated response during abnormal events, such as system restoration relying on BSRs with particular emphasis on cold weather scenarios.

Survey results identify the most common communication channels between primary fuel suppliers and BSRs to be traditional landlines, email, web chat sessions, and internal web products. Only one BSR indicated that it maintains satellite backup communications with its primary fuel suppliers. The surveys associated with this study noted that communication channels between BSRs and their alternate fuel suppliers are heavily concentrated on email and traditional landline interactions that are prone to failure during a wide-area blackout. Communication with the transporters of primary and alternate fuels tends to mirror that with the supplier. The joint study team did not survey or assess periodic testing of communication channels or analysis of communication failure points for the wide-area blackout scenario.

## Conclusions

The joint study team concludes that delivery risks associated with the interdependence of the electric and natural gas industries, including BSR priority delivery of natural gas and delivery of electricity to critical natural gas infrastructure, could be simultaneously addressed if the two industries collaborate on a joint extreme cold weather system restoration plan.

Several participants indicated that, during a blackout, it is generally assumed that natural gas supply and transportation would likely be available during the initial stages of system restoration to support BSRs. RCs and TOPs are considering various fuel-related risk mitigation approaches to diversify single points of failure utilizing natural gas at the time, particularly for events during the heating season.[30] However, the joint study team has not conducted or identified any existing analysis for this assumption and believes that further coordination is required between the electric and natural gas industries to understand and manage risks related to fuel availability during a blackout.

[29] Precedent Study report, page 7 and 28

[30] https://techevaluate.com/if-the-u-s-power-grid-is-down-will-natural gas-still-work/

## Recommendations

- **Recommendation 6:** The joint study team reaffirms Recommendation 2 from the Precedent Study, emphasizing its continued relevance.[31] Given the multijurisdictional nature of the Eastern and Western Interconnections encompassing multiple states and energy regulatory authorities, the joint study team recommends that each individual entity with system restoration plan requirements proactively collaborate, based on its regional electric system restoration assessments. These entities should also develop joint blackstart system restoration plans to address electric and natural gas system identified interdependency risks.

  a. The joint study team recommends that SMEs from the electric and natural gas industries evaluate the potential impact of a wide-area electric blackout on natural gas system functionality, consequent impacts on electric system restoration, and potential single points of failure, as pertains to individual Transmission Operator area system restoration plans. These SMEs should also help develop system restoration plans that include solutions to resolve identified issues. It is recommended that such restoration plans include the following:

    i. Distinguishing between critical customer loads and system restoration critical loads, which includes natural gas supply, processing, storage, and delivery facilities; and

    ii. Requiring Transmission Owners/Operators with natural gas-fueled BSRs in their system restoration plans to jointly work with natural gas transmission and delivery facility owners to identify necessary natural gas supply route(s) supporting BSRs. It is recommended that these Transmission Owners/Operators also identify the source of the natural gas supply (including storage).

- **Recommendation 7:** Dual-fuel BSRs should identify, mitigate, and communicate the residual risk related to their primary and alternate fuel supply availability and deliverability during a blackout scenario to the entities responsible for the applicable system restoration plans.

  a. BSR owners should evaluate primary and backup communication methods with fuel suppliers and delivery entities (e.g., trucking or barge delivery of alternate fuels). This communication should include the identification of critical communication infrastructure that supports both the natural gas system and alternate fuel delivery necessary for BSR participation in restoration in the event of a blackout.

## Observed Practices for Consideration

- One natural gas participant indicated that it could move natural gas through its system despite electrical blackout conditions and switch to natural gas storage if the supply is interrupted. This operability is maintained by the following:
  - Compressor stations utilizing on-site fuel and/or pipeline gas to continue operations during a power outage
  - Battery backup supporting up to 36 hours for certain delivery facilities
- Another natural gas participant stated that it designs its natural gas control system with auxiliary power and multiple forms of data communication to maintain operations during blackout events.
- One natural gas participant noted that it plans to use cell phones and short-range radio with satellite options for voice communication during blackout events.
- Another natural gas entity mentioned having onsite local backup generation to maintain operations of critical gas infrastructure during wide area electric outages.

[31] See Precedent Study report, page 6.

# Maintenance, Testing, and Fuel-Switching Capabilities

## Introduction

Maintaining robust maintenance programs and procedures for BSRs is essential to ensuring grid resilience and effective and timely recovery from a major system blackout. BSRs are tasked with the critical function of initiating system restoration when the grid experiences a complete or partial blackout. Since blackstart mode of operation is extremely rare and would be implemented under stressful and unpredictable conditions in an actual event, consistent maintenance programs are critical to their successful performance when they are needed. Preventive maintenance helps identify and address vulnerabilities before they become operational failures during emergencies.

Equally important are rigorous and standardized testing requirements. Regular testing verifies that BSRs can start, operate, and energize portions of the grid as designed. Testing also ensures that personnel are familiar with startup procedures. Testing expected capabilities helps validate BSRs' operational readiness and ensures situational awareness of operators that will rely on these resources to execute system restoration plans. Without proper testing, assumptions about blackstart capability may go unchallenged, leaving the system exposed to restoration delays or failures. Together, strong maintenance and testing programs form the backbone of a reliable blackstart strategy, reinforcing confidence in the grid's ability to recover from extreme events.

## Observations

### *Maintenance Programs, Procedures, and Checklists*

Most BSR participants reported using plant-specific pre- and post-season winterization checklists, and the majority also maintain checklists tailored for extreme cold weather conditions. However, some participants noted that their blackstart procedures and checklists do not explicitly incorporate extreme cold weather considerations as these are addressed separately through dedicated winterization procedures.

### *Startup and Fuel Switching Tests for Dual-Fuel Blackstart Resources*

Most participants with dual-fuel capabilities indicated that they conduct their blackstart startup tests by using their primary fuel. However, only a small number of dual-fuel startup capable BSR participants reported actually performing a startup test using alternate fuel**.** Approximately two-thirds of the participants stated in their responses that they can operate on alternate fuel without unit derate. Similar to the Precedent Study, at least one BSR in this study requires startup on natural gas before it can transfer and operate on its alternate fuel. Some of the surveyed BSRs stated they use onsite auxiliary diesel generators to initiate the startup process.

Some participants surveyed stated that they have fuel switching capabilities. The joint study team did not quantify how many survey participants perform fuel switching testing as part of the survey process.

## Conclusions

The joint study team believes that it is critical to periodically test and verify all design capabilities, including startup on primary fuel, startup on alternate fuel, and fuel switching to ensure continued functionality. While the joint study team recognizes that there may be limitations to conducting startup tests on alternate fuels (e.g., financial considerations or environmental constraints), it is essential that entities responsible for restoration planning evaluate the need for such testing. This evaluation should be based on each area's specific risk profile and tolerance and should be reflected in their procedures and processes through the appropriate testing requirements.

## Recommendations

- **Recommendation 8:** Entities responsible for developing and implementing a system restoration plan should:

  a. Consider incorporating a periodic (e.g., annual or pre-season) startup test with alternate fuel for dual-fuel BSRs that indicate capability to start on an alternate fuel into dual-fuel BSR testing requirements. When

possible and practical, entities should look for opportunities to perform these tests during extreme cold weather to verify performance in cold conditions.

i. Tabletop exercises in lieu of winter tests (where winter tests are not feasible or practical) are acceptable to identify extreme cold weather-related gaps in blackstart startup and operating procedures.

b. Consider implementing fuel switching BSR testing to confirm the capability and time required to switch between primary and alternate fuel for an extreme cold weather blackstart event.

c. Consider including specific identified extreme cold weather considerations and actions in their system restoration plan to help operators perform successfully in cold weather conditions.

### Observed Practices for Consideration

- Several participants stated that they use cold weather checklists to prepare for the cold weather season. The participants reported that some of these practices could be beneficial in a cold weather blackout scenario by doing the following:
  - Keeping personnel both safe and functioning during extreme cold weather by providing cold weather gear (gloves, hardhat liners, winter boots, tools, etc.) and using the check-in or buddy system during equipment walkdowns
  - Verifying equipment functionality during extreme cold weather
  - Stocking winter consumables, ensuring that snow removal equipment is ready, and securing doors, windows, and equipment enclosures
  - Increasing the frequency of operator walkdowns based on cold weather temperature range
- Several participants noted that they incorporated pre- and post-event cold weather lessons learned into maintenance checklists that help them better prepare for extreme cold weather.

## Blackstart Resource and System Restoration Operating Personnel Training Practices

### Introduction

BSR procedures play a vital role in the successful implementation of restoration plans. Restoration begins with the startup of the first resource capable of re-energizing the grid. BSR blackstart procedures outline the steps required for designated entities to start their units independently without relying on external grid power. These procedures must account for a wide range of operating conditions as blackouts can occur at any time. BSR personnel undergo regular training to ensure that they can execute these procedures effectively and without delay. Entities tasked with developing and implementing restoration plans should include clear requirements for designated BSRs to be incorporated within their blackstart procedures.

The joint study team reviewed the participants' survey responses regarding personnel training practices and procedures, in particular those that support blackstart operation under extreme cold weather conditions. Responses included training practices related to the BSR startup and energization of associated cranking path as well as operability of required substations. Surveys also captured responses related to simulator training and simulations to support TOP or higher-level RC restoration plans. The surveys also gathered information related to whether strategies for power importation from outside the restoration footprint are considered. Finally, the joint study team inquired whether entities evaluate training and/or actual events to develop lessons learned and integrate them into operating procedures in a timely fashion.

## Observations

### *Training – Blackstart Restoration and Extreme Cold Weather*

BSR participants indicated that extreme cold weather plans and training exist predominantly independently of blackstart procedures and training. These entities reported that BSRs are typically governed by plans for extreme cold just like any other resource. One participant stated that relative to blackstart in extreme cold weather, the ambient conditions should not affect the blackstart operation since the winter weather freeze plan will have already been initiated to cover freeze protection.

Multiple participants stated that cold weather-related training typically occurs in advance of expected winter seasonal peak periods with the majority having been performed in the fall. This training includes cold weather operating procedures, winterization plans for the facilities, and NERC Reliability Standard EOP-012-3 requirements.[32] BSR participants stated that their blackstart training typically occurs on an annual basis, but a small number of participants reported conducting blackstart training biannually.

### *Substation Operability*

Through survey questions, the joint study team assessed substation operability considerations in support of system restoration plans and procedures. Surveyed entities state that substation control system batteries are designed and sized to operate between 4 and 70 hours. Most are designed for an eight-hour operation during a blackout scenario. Some TOP/Transmission Owners (TO) report having portable generators and battery trailers available for deployment. One respondent asserts that its RC requires that all substation facilities identified in the restoration path have backup generation to provide substation control system power during a blackout event. Extreme cold weather may affect substation battery performance and should be considered in system restoration plans and associated training activities.

### *Blackstart Simulator Training*

A majority of the participants involved in the system restoration plan implementation conduct actual simulator training to support restoration plans rather than simulation drills and desktop exercises. Some participating utilities noted that simulator training is not conducted at the TO/TOP level. When that is the case, they stated that they do participate in restoration plan simulator training with their RCs. However, there was no indication that these simulations included extreme cold weather scenarios.

### *Power Import Option Included in Restoration Plan*

Participants indicated that power importation from adjacent systems is generally not incorporated into system restoration plans. Nonetheless, multiple entities noted that, depending on the severity and scope of the blackout, the feasibility of importing power may be assessed and potentially utilized to restore the system.

Several participants reported that they require BSRs not located within the TOP's system to implement their system restoration plan. These TOP participants stated that they consequently rely on their RCs to coordinate the importation of power from neighboring systems as specified in the RCs' restoration plans.

### *Lessons Learned Development and Integration for Continuous Improvement*

Entities responsible for training personnel to implement blackstart and system restoration plans and procedures generally conduct lessons learned activities following training as well as following actual events to improve the processes. All participating RCs indicated that they reviewed the Precedent Study, and some mentioned implementing changes to testing, plans, and requirements based on findings and recommendations of that report, such as occasionally inviting system operators to attend BSR tests.

[32] NERC Reliability Standard EOP-012-3 is located at: https://www.nerc.com/pa/Stand/Reliability%20Standards/EOP-012-3.pdf.

### Conclusions

Ensuring that substation personnel are trained on local restoration plans and practices including the implementation of TOP instruction(s) during a blackout which will increase situational awareness and efficient restoration efforts.

### Recommendations

- **Recommendation 9:** To strengthen the effectiveness of system restoration preparatory efforts, the joint study team recommends enhancements to existing simulator-based training to focus on system restoration during extreme cold weather operations.

### Observed Practices for Consideration

- One BSR participant indicated that it reviews and updates its training program for its cold weather procedures twice a year, once in preparation for winter and again after winter once the winterization measures are removed. This improves BSR personnel's readiness and demonstrates a learning organization.
- While some entities have requirements to witness BSR tests, one entity suggested, for training and educational purposes, that system operators may find value in attending BSR tests, as scheduling and location allows.
- Field and plant personnel involved in restoration plan efforts have benefited from observing or participating in a blackstart system restoration simulation or tabletop exercise.

## Final Conclusion

This study and subsequent report emphasize the critical importance of ensuring BSR availability and readiness during extreme cold weather events, particularly given the interdependence between electric and natural gas systems. While many entities have adopted strong practices for extreme cold weather preparedness and blackstart operations, the study highlights several areas where further improvements are recommended. Based on the conclusions of this study these areas include the following:

- Enhancing fuel assurance
- Strengthening BSR cold weather preparedness and operational readiness
- Ensuring that restoration plans incorporate resource selection processes that account for cold weather-related risks
- Improving communication capabilities with fuel suppliers
- Integrating cold weather specific restoration training

The joint study team reaffirms the value of cross-industry collaboration to address shared vulnerabilities and to develop coordinated restoration strategies. The recommendations outlined in this report aim to bolster the resilience of system restoration plans, with a particular focus on BSR performance under extreme cold weather conditions.

# Appendix A: Joint Study Team Members List

| Joint Study Team Members List | | |
|---|---|---|
| **Name** | **Title** | **Entity** |
| David Till (Co-Lead) (retired) | Principal, Engineering & Security Integration | North American Electric Reliability Corporation (NERC) |
| Darrel Richardson (retired) | Principal Technical Advisor. Power Risk and Strategic Management (PRISM) | North American Electric Reliability Corporation (NERC) |
| Jack Gibfried | Engineer - Power Systems Modeling and Analysis, Engineering & Security Integration | North American Electric Reliability Corporation (NERC) |
| Scott Barfield-McGinnis | Principal Technical Advisor, Power Risk and Strategic Management (PRISM) | North American Electric Reliability Corporation (NERC) |
| Chanel Chasanov (Observer) | *Former Attorney-Advisor at FERC | Federal Energy Regulatory Commission (FERC) |
| Ashly Smith (Observer) | Electrical Engineer | Office of Energy Infrastructure Security Federal Energy Regulatory Commission (FERC) |
| Donald V. Gerkin Jr. (Observer) | Electrical Engineer | Office of Energy Infrastructure Security Federal Energy Regulatory Commission (FERC) |
| Ray Orocco-John (Observer) | Engineer | Federal Energy Regulatory Commission (FERC) |
| Robert Clark (Observer) | Engineer | Federal Energy Regulatory Commission (FERC) |
| Mark A. Tiemeier | Director, Power System Risk Management | Midwest Reliability Organization (MRO) |
| Eric Graftaas | Principal Power Systems Engineer | Midwest Reliability Organization (MRO) |
| David Kuyper | Power Systems Engineer II | Midwest Reliability Organization (MRO) |
| Andrey Oks | Director, Operations Coordination | Northeast Power Coordinating Council, Inc (NPCC) |
| Ryan McSherry | Manager, Operations Coordination | Northeast Power Coordinating Council, Inc (NPCC) |
| Lacy Skinner | Senior Engineer, Operations Coordination | Northeast Power Coordinating Council, Inc (NPCC) |
| Dwayne Fewless (Co-lead) | Principal Analyst, Operational Analysis & Awareness | ReliabilityFirst (RF) |
| Dave Krueger | Senior Program Manager, Operations | SERC Reliability Corporation |
| Mark Henry | Chief Engineer and Director, Reliability Outreach | Texas Reliability Entity (TRE) |
| Bert Peters | Senior Reliability Specialist | Western Electricity Coordinating Council (WECC) |
| W. Curtis Crews | Senior Technical Advisor | Western Electricity Coordinating Council (WECC) |

# Appendix B: Summary of Literature


1. Inquiry into Bulk-Power System Operations During December 2022 Winter Storm Elliott Report (October 2023), Winter Storm Elliott Report: Inquiry into Bulk-Power System Operations During December 2022 | Federal Energy Regulatory Commission (2023 Winter Storm Elliott Report)
2. FERC, NERC, and Regional Entity Staff, The February 2021 Cold Weather Outages in Texas and the South Central United States (Nov. 2021), https://www.ferc.gov/media/february-2021-cold-weather-outages-texas-and-south-central-united-states-ferc-nerc-and (2021 Cold Weather Report)
3. Blackstart and Next-Start Resource Availability in the Texas Interconnection (December 2023) FERC-NERC-Regional Entity Joint Blackstart and Next-Start Resource Availability Study in the Texas Interconnection | Federal Energy Regulatory Commission
4. O'Brien J.G., M. Cassiadoro, T. Becejac, G.B. Sheble, J.D. Follum, U. Agrawal, and E.S. Andersen, et al. 2022. **Electric Grid Blackstart: Trends, Challenges, and Opportunities**,Pacific Northwest National Laboratory. https://www.pnnl.gov/publications/electric-grid-blackstart-trends-challenges-and-opportunities-0, April 16, 2022
5. ERCOT Nodal Protocols, Section 8: Performance Monitoring, June 1, 2025 - https://www.ercot.com/files/docs/2022/12/09/08-060125_Nodal.docx
6. ERCOT Nodal Protocols, Section 3: Management Activities for the ERCOT System, June 1, 2025 - https://www.ercot.com/files/docs/2024/06/28/03-060125_Nodal.docx
7. ISO New England Operating Procedure No. 11 Blackstart Resource Administration (OP 11), September 12, 2023 - https://www.iso-ne.com/static-assets/documents/rules_proceds/operating/isone/op11/op11_rto_final.pdf
8. PJM Manual 36: System Restoration Revision: 35, June 15, 2025 - https://www.pjm.com/-/media/DotCom/documents/manuals/m36.pdf
9. PJM Manual 12: Balancing Operations Revision: 55, June 18, 2025 - https://www.pjm.com/-/media/DotCom/documents/manuals/m12.pdf
10. MISO's Tariff - https://www.misoenergy.org/legal/rules-manuals-and-agreements/tariff/
    a. Attachment NN – ATC - https://docs.misoenergy.org/miso12-legalcontent/Schedule_33_-_ATCLLC_Formula_Rate_Template_Protocols_for_Blackstart_Resource_Service.pdf
    b. https://docs.misoenergy.org/miso12-legalcontent/Attachment_NN_-_ATCLLC_Attachment_A_to_the_Blackstart_Resource_Agreement.pdf
11. Blackstart Service Business Practice Manual BPM-022-r16 Effective Date: MAR-07-2025 - Business Practices Manuals
12. NERC Reliability Guideline: Fuel Assurance and Fuel-Related Reliability Risk Analysis for the Bulk Power System, September 2023 - https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Fuel_Assurance_and_Fuel-Related_Reliability_Risk_Analysis_for_the_Bulk_Power_System.pdf
13. New York Power Authority (NYPA) Small Natural gas Power Plant Transition Plan, May 9, 2025 - https://edge.sitecorecloud.io/newyorkpowe85b6-nypad19c-prod795c-a32e/media/Feature/nypa-sites/small-natural-gas-media/SNGPP-Transition-Plan.pdf
14. If the U.S. Power Grid Is Down, Will Natural gas Still Work?, John Mortensen - https://techevaluate.com/if-the-u-s-power-grid-is-down-will-natural gas-still-work/
15. Electric Grid Blackstart: Trends, Challenges, and Opportunities - https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-32773.pdf
16. Blackstart Resources Availability (BRAv) - https://www.ferc.gov/sites/default/files/2020-04/bsr-report.pdf

# Appendix C: Request Letter for Participation

MONTH DD, 2024
Dear Name:

FERC, NERC, and Regional Entity staff jointly released the *Inquiry into Bulk-Power System Operations During December 2022 Winter Storm Elliott*[33] in October 2023. Among the report's 11 recommendations to improve electric generation and natural gas infrastructure for cold weather reliability, grid emergency operations, and seasonal preparedness were several recommendations for further study. In accordance with Recommendation 3, NERC and Regional Entity staff, collaborating with FERC staff, are implementing a joint study of blackstart unit availability and readiness during cold weather conditions in the U.S. portions of the Eastern and Western Interconnections.[34]

The joint study will evaluate a representative sample of Transmission and Generator Operators' blackstart and grid restoration plans, procedures, and resources that would be used to help restore the electricity grid of the respective Reliability Coordinator and Interconnection in the event of a blackout. The study will focus on natural gas-fueled and dual-fueled blackstart units, which were most challenged in the Winter Storm Elliott event.[35] As an entity with bulk power system significance and representative operating characteristics that may be beneficial to this analysis, we are requesting Company A's participation in this review. Additionally, other entities with other representative characteristics (e.g., fuel suppliers) will also be asked to participate to achieve a more comprehensive review.

The joint study team plans, via outreach with industry entities, to gain an understanding of:[36]

- Characteristics of blackstart generation resources relied on in system restoration plans for the U.S. portions of the Eastern and Western Interconnections, including, where applicable:
  - Winter weatherization measures
  - Primary fuel provisions (e.g., commodity supply and delivery contracts, characteristics of delivery, and on-site infrastructures for use of fuel)
  - Backup/alternate fuel provisions (e.g., commodity supply and delivery contracts, characteristics of delivery, and on-site infrastructures for use of fuel), including fuel storage provisions
  - Maintenance practices applied to blackstart resources and associated on-site fuel to ensure resource operability when needed
  - Energy storage resources (non-fuel) that may be associated with blackstart plans and procedures

[33] Report is available at https://www.ferc.gov/media/winter-storm-elliott-report-inquiry-bulk-power-system-operations-during-december-2022.
[34] See Report, Recommendation 3, at pp 135–136 (recommending that a joint NERC-Regional Entity team, collaborating with FERC staff, should study the overall availability and readiness of blackstart units to operate during cold weather conditions. This study should cover all portions of the U.S. not already studied (i.e., the Eastern and Western Interconnections), and should incorporate existing literature, studies, reports, and other analyses as to the availability and readiness of black start units and provided suggested scope for the study).
[35] See Report p. 135: natural gas blackstart units accounted for just under 75 percent of all generation lost by blackstart designated units during the event.
[36] Relevant documents and information may be requested for review during the entity outreach.

- Characteristics of fuel supply contracts and delivery infrastructure for the above-identified blackstart generation resources, including:
  - Energy sources relied on for delivery of primary and alternate fuels to blackstart generation resources (e.g., electricity sources to natural gas compressors)
  - Where applicable, sources of electricity relied on for natural gas and backup/alternate fuel infrastructure delivery to blackstart resources
  - Whether multiple blackstart resources are dependent on a single natural gas pipeline
  - How delivery of natural gas and backup/alternate fuel is prioritized among other end-user delivery priorities to ensure delivery of fuel to blackstart resources
- Testing blackstart and fuel-switching capabilities, including:
  - Testing of blackstart capability from both primary and backup/alternate fuels
  - Testing of capability to switch from primary to backup/alternate fuel during blackstart testing
  - Removal of any utility-supplied electricity sources for backup/alternate fuel provisions for the test
- Blackstart operating personnel training practices, procedures, and resources, including for:
  - Generator Operators, including plant operations personnel
  - Transmission Operator and system operator personnel
- Review of recent reports and literature pertaining to blackstart resource availability

In addition to the information specified above, entities are encouraged to provide any information or documents that may be helpful to the study. We understand and appreciate the sensitive nature of this information, particularly related to fuel supply arrangements. All information provided will be kept confidential with any references anonymized and not attributable to a specific organization.

This effort represents an important step in protecting reliability by gauging the level of preparation and the ability to restore the bulk power system quickly and efficiently. The study team aims to gather and analyze the results for this joint review by the end of 2024 and issue a report with recommendations to improve reliability in the first quarter of 2025.

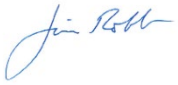
In anticipation of Company A's participation, we thank you, and your regional representatives will work closely with you to ensure this project is conducted as a partnership with minimal disruption to your organization. Please contact your regional representative from the list below with any questions or comments that you might have.

Contacts for this study:

- Mark Tiemeier, MRO
- David Till, NERC
- Lacy Skinner, NPCC
- Dwayne Fewless, ReliabilityFirst
- Dave Krueger, SERC
- Mark Henry, Texas RE
- Bert Peters, WECC

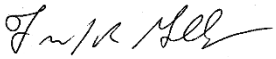
Sincerely,

**The ERO Enterprise CEOs**


Jim Robb, NERC


Sara Patrick, MRO


Charles Dickerson, NPCC


Tim Gallagher, RF


Jason Blake, SERC


Jim Albright, Texas RE


Melanie Frye, WECC

# Appendix D: Glossary of Terms and Acronyms Used in This Study

**Alternate Fuel:** known as non-conventional and advanced fuels, are fuels derived from sources other than natural gas.

**Balancing Authority:** The responsible entity that integrates resource plans ahead of time, maintains demand and resource balance within a Balancing Authority Area, and supports interconnection frequency in real-time.

**Blackout:** The complete interruption of power in a given service area.

**Blackstart Capable Resource:** An electric generating unit that is capable of being started without electrical energy being supplied from the power transmission or distribution system. This resource is not contracted by the entity responsible for blackstart procurement.

**Blackstart Resource (BSR):** A generating unit(s) and its associated set of equipment which has the ability to be started without support from the System or is designed to remain energized without connection to the remainder of the System, with the ability to energize a bus, meeting the Transmission Operator's restoration plan needs for real and reactive power capability, frequency and voltage control, and that has been included in the Transmission Operator's restoration Plan.

**BSR Cold Weather Critical Components:** Any generating unit component or system, or associated Fixed Fuel Supply Component, that is under the Generator Owner's control, and is susceptible to freezing issues, the occurrence of which would likely lead to a Generator Cold Weather Reliability Event. This definition excludes any component or system or associated Fixed Fuel Supply Component located inside a permanent building with a heating source that regularly maintains the space at a temperature above 32 degrees Fahrenheit (0 degrees Celsius).

**Blackstart Service:** An ancillary service provided by a resource that is able to start without support of the grid.

**Bulk Electric System (BES):** All transmission elements operated at 100 kV or higher and real power and reactive power resources connected at 100 kV or higher. This does not include facilities used in the local distribution of electric energy. The NERC Glossary of Terms contains the list of inclusions and exclusions.

**Bulk-Power System (BPS):** All facilities and control systems necessary for operating an interconnected electric energy transmission network (or any portion thereof) and electric energy from generation facilities needed to maintain transmission system reliability. The term does not include facilities used in the local distribution of electric energy.

**Cold Load Pickup:** An overcurrent condition that takes place when a distribution circuit is re-energized following an extended outage. It is "cold load" because the power supply has been unavailable for a period of time, so the load has reached a "cold" state before re-energizing.

**Control Center:** One or more facilities hosting operating personnel that monitor and control the bulk electric system in real-time to perform the reliability tasks, including their associated data centers, of: (1) a reliability coordinator, (2) a Balancing Authority, (3) a Transmission Operator for transmission Facilities at two or more locations, or (4) a Generator Operator for generation facilities at two or more locations.

**Cranking Path:** A portion of the electric transmission system that can be isolated and then energized to deliver electric power from a generation source to enable the startup of one or more other generating units.

**Customer Critical Load:** A customer for whom electric service is considered crucial for the protection or maintenance of public safety, including but not limited to hospitals, police stations, fire stations, and critical water and wastewater facilities.

**Disturbance:** (1) An unplanned event that produces an abnormal system condition. (2) Any perturbation to the electric system. (3) The unexpected change that is caused by the sudden failure of generation or interruption of load.

**Dual-fuel:** Operates using two different fuel types, typically natural gas and (fuel/distillate) oil. This dual capability allows the generator to switch between the two fuels, providing flexibility and reliability during power outages or fuel shortages.

**Emergency:** Any abnormal system condition that requires automatic or immediate manual action to prevent or limit the failure of transmission facilities or generation supply that could adversely affect the reliability of the Bulk-Power System.

**Extreme Cold Weather:** Abnormally low temperature conditions, including freezing precipitation, that jeopardizes the reliable operation of the Bulk-Power System and the natural gas system, similar to the February 2021 winter weather event during Winter Storm Uri and the December 2023 winter weather event during Winter Storm Elliott.

**Facility:** A set of electrical equipment that operates in a single bulk electric system element (e.g., a line, a generator, a shunt compensator, transformer, etc.).

**Firm Load:** That portion of the demand that a power supplier is obligated to provide except when system reliability is threatened or during emergency conditions.

**Force Majeure Event:** Any event beyond the reasonable control of, and that occurs without the fault or negligence of, an entity whose performance is prevented by the occurrence of such event.

**Forced Outage:** (1) The removal from service availability of a generating unit, transmission line, or other facility for emergency reasons. (2) The condition in which the equipment is unavailable due to unanticipated failure.

**Fuel Assurance**: Proactively taking steps to identify fuel arrangements or other alternatives that would provide confidence such that fuel interruptions are minimized to maintain reliable BPS performance during both normal operations and credible disruptive events.

**Fuel Gelling:** A problem caused by the effects of temperature on paraffin, a component of diesel fuel. Although fuel gelling can occur year-round, it is most prevalent in the winter when temperatures start to drop, and diesel fuel starts to solidify. Fuel gelling often impacts engine performance and results in downtime.

**Generator Operator (GOP):** The entity that operates generating unit(s) and performs the functions of supplying energy and interconnected operations services. The generator operator is responsible for having procedures for each blackstart resource.

**Generator Owner (GO):** The entity that owns and maintains generating facility(ies).

**Heat Tracing:** The application of a heat source to pipes, lines, and other equipment which, in order to function properly, must be kept from freezing.

**Independent System Operator (ISO):** An electric power transmission system operator which coordinates, controls, and monitors the operation of the electrical power system in a specific geographical area.

**Interconnection:** A geographic area in which the operation of Bulk-Power System components is synchronized such that the failure of one or more of such components may adversely affect the ability of the operators of other components within the system to maintain reliable operation of the facilities within their control.

**Island, Electrical:** An electrically isolated portion of an interconnection. The frequency in an electrical island must be maintained by balancing generation and load in order to sustain operation.

**Load:** An end-use device or customer that receives power from the electric system.

**Load Shed:** The reduction of electrical system load or demand by interrupting the load flow to major customers and/ or distribution circuits, normally in response to system or area capacity shortages or voltage

control considerations. In cases of capacity shortages, load shedding is often performed on a rotating basis, systematically and in a predetermined sequence.

**Natural gas Curtailment:** A reduction in the scheduled natural gas capacity or natural gas delivery.

**Next-start Resource**: A next-start generating unit is the first generating unit in the cranking path to be energized using power from the blackstart generating unit.

**Operating Procedure:** A document that identifies specific steps or tasks that should be taken by one or more specific operating positions to achieve specific operating goal(s). The steps in an operating procedure should be followed in the order in which they are presented and should be performed by the position(s) identified.

**Peak Load (or Peak Demand):** (1) The highest hourly integrated net energy for load within a balancing authority area occurring within a given period (e.g., day, month, season, or year). (2) The highest instantaneous demand within the balancing authority area.

**Precedent Study**: Blackstart and Next-Start Resource Availability in the Texas Interconnection.

**Priority Facilities:** For the purposes of this report, priority facilities refer to the electric and natural gas facilities that are necessary for system restoration.

**Real-time:** Bulk-Power System conditions, characteristics, and/or data representing what actually occurred at specific times or timeframes during an event.

**Regional Entity:** An independent entity with delegated authority from NERC to propose and enforce Reliability Standards and to otherwise promote the effective and efficient administration of Bulk-Power System reliability.

**Reliability Coordinator (RC):** The NERC recognized entity that is the highest level of authority who is responsible for the reliable operation of the bulk electric system, has the wide area view of the bulk electric system, and has the operating tools, processes, and procedures, including the authority to prevent or mitigate emergency operating situations in both next-day analysis and real time operations.

**Reliability Standard:** A requirement, approved by the United States Federal Energy Regulatory Commission under this Section 215 of the Federal Power Act, or approved or recognized by an applicable governmental authority in other jurisdictions, to provide for reliable operation [Reliable Operation] of the bulk-power system [Bulk-Power System]. The term includes requirements for the operation of existing bulk-power system [Bulk-Power System] facilities, including cybersecurity protection, and the design of planned additions or modifications to such facilities to the extent necessary to provide for reliable operation [Reliable

Operation] of the bulk-power system [Bulk-Power System], but the term does not include any requirement to enlarge such facilities or to construct new transmission capacity or generation capacity.

**Restoration:** The process of returning generators and transmission system elements and customer load to reestablish an electric system in a stable and orderly manner in the event of a partial or total shutdown of the system.

**Single Points of Failure:** A part of the system that, if it fails, will stop the entire system from working.

**System Operator:** An individual at a control center of a balancing authority, transmission operator, or reliability coordinator who operates or directs the operation of the bulk electric system in real-time.

**System Restoration Critical Loads:** System restoration critical loads refer to the essential electric and natural gas facilities, known in some reports as priority facilities, that are necessary for the restoration of the electric system following a partial or total shutdown. These are the loads that must be prioritized and restored during the system restoration process to ensure the bulk electric system can return to a stable and orderly state. Critical loads support the operation of generators, transmission system elements, and other infrastructure vital for reestablishing reliable power delivery, enabling the coordinated recovery of the broader system.

**System Restoration Plan:** A plan required to allow for restoring the transmission operator's system following a disturbance in which one or more areas of the Bulk-Power System shuts down and the use of blackstart resources is required to restore the shut-down area to a state whereby the choice of the next load to be restored is not driven by the need to control frequency or voltage regardless of whether the blackstart resource is located within the transmission operator's system.

**Transmission Operator (TOP):** The entity responsible for the reliability of its "local" transmission system and that operates or directs the operations of the transmission facilities. The transmission operator is required to have a restoration plan.

**Transmission Owner (TO):** The entity that owns and maintains transmission facilities.

**Transmission Service Provider (TSP):** The entity that administers the transmission tariff and provides transmission services to customers under applicable transmission service agreements.

**Weatherization/Winterization:** The specific freeze protection and cold weather preparedness plans implemented to help facilities function during extreme cold ambient temperatures and extreme cold weather events at their locations. For the purposes of this report, winterization and weatherization are used interchangeably.

# Appendix E: Observed Practices for Consideration

- One participant stated that it provides cold weather attributes (winter combustion tuning and fuel gelling prevention) within its cold weather blackstart procedures.
- Some participants stated that they have established requirements related to fuel assurance for BSRs to successfully implement their system restoration plans.[37]
- One participant has implemented centralized ordering of alternate fuel for all its facilities to maintain awareness and availability of its generation fleet's capability. Another participant noted that the oil inventory maintained on site allows for multiple days of operations of BSRs.
- One natural gas participant indicated that it could move natural gas through its system despite electrical blackout conditions and switch to natural gas storage if the supply is interrupted. This operability is maintained by the following:
  - Compressor stations utilizing on-site fuel and/or pipeline gas to continue operations during a power outage
  - Battery backup supporting up to 36 hours for certain delivery facilities
- Another natural gas participant stated that it designs its natural gas control system with auxiliary power and multiple forms of data communication to maintain operations during blackout events.
- One natural gas participant noted that it plans to use cell phones and short-range radio with satellite options for voice communication during blackout events.
- Another natural gas entity mentioned having onsite local backup generation to maintain operations of critical gas infrastructure during wide area electric outages.
- Several participants stated that they use cold weather checklists to prepare for the cold weather season. The participants reported that some of these practices could be beneficial in a cold weather blackout scenario by doing the following:
  - Keeping personnel both safe and functioning during extreme cold weather by providing cold weather gear (gloves, hardhat liners, winter boots, tools, etc.) and using the check-in or buddy system during equipment walkdowns
  - Verifying equipment functionality during extreme cold weather
  - Stocking winter consumables, ensuring that snow removal equipment is ready, and securing doors, windows, and equipment enclosures

[37] Examples include:

- PJM Manual 36: System Restoration Revision 35, June 15, 2025 – https://www.pjm.com/-/media/DotCom/documents/manuals/m36.pdf; Attachment A, and Manual 12: PJM Manual 12: Balancing Operations - https://www.pjm.com/-/media/DotCom/documents/manuals/m12.pdf; Section 4.5
- ERCOT Nodal Protocols, Section 8: Performance Monitoring - https://www.ercot.com/files/docs/2022/12/09/08-060125_Nodal.docx; Section 8.1.1.2.1.5, part 1(g); and Section 3: Management Activities for the ERCOT System - https://www.ercot.com/files/docs/2024/06/28/03-060125_Nodal.docx, part 3.14.2
- ISO-New England Operating Procedure No. 11 Blackstart Resource Administration (OP-11), September 12, 2023 - https://www.iso-ne.com/static-assets/documents/rules_proceds/operating/isone/op11/op11_rto_final.pdf; Section II.1 - Eligibility Requirements for Providing Blackstart Service

The NERC Electric Gas Working Group, under the Reliability and Security Technical Committee, has also developed a guideline that focuses more broadly on fuel assurance risk but also identifies the need for consideration of restoration-specific fuel assurance risk - See NERC Reliability Guideline: Fuel Assurance and Fuel-Related Reliability Risk Analysis for the Bulk Power System, September 2023, Appendix C, Step 3 and Appendix D – https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Fuel_Assurance_and_Fuel-Related_Reliability_Risk_Analysis_for_the_Bulk_Power_System.pdf.

  - Increasing the frequency of operator walkdowns based on cold weather temperature range

- Several participants noted that they incorporated pre- and post-event cold weather lessons learned into maintenance checklists that help them better prepare for extreme cold weather.
- One BSR participant indicated that it reviews and updates its training program for its cold weather procedures twice a year, once in preparation for winter and again after winter once the winterization measures are removed. This improves BSR personnel's readiness and demonstrates a learning organization.
- While some entities have requirements to witness BSR tests, one entity suggested, for training and educational purposes, that system operators may find value in attending BSR tests, as scheduling and location allows.
- Field and plant personnel involved in restoration plan efforts have benefited from observing or participating in a blackstart system restoration simulation or tabletop exercise.

# Appendix F: Recommendations from Blackstart and Next-Start Resource Availability in the Texas Interconnection

The Precedent Study report[38] provides the following recommendations:

1. Entities responsible for developing and implementing a blackstart system restoration plan should:
    a. **Examine the diversity of fuel, single points of failure,[39] fuel arrangements, and other limitations of each blackstart resource.** Fully understanding the types of fuel arrangements would provide entities with insight into the likelihood of the blackstart resource being available during an emergency or blackstart system restoration scenario. Assessing the additional limitations of blackstart resources would help entities prepare for, mitigate, and respond to blackstart system restoration scenarios.
    b. **Evaluate and incorporate, where feasible, a wide variety of options into their blackstart system restoration plans.** For example, entities should consider the use of electrical bypasses,[40] high-voltage direct current (HVDC) ties, variable frequency transformers,[41] block load transfers,[42] and non-fuel energy resources (e.g., inverter-based resources and batteries). During a blackstart system restoration scenario, these alternatives could provide entities with other options beyond a reliance on traditional blackstart resources. Having these options available during a blackstart system restoration scenario would add diversity and resilience, particularly if natural gas to blackstart and next-start resources is limited or unavailable. While the preceding list encompasses examples that entities could use, it is not exclusive, and entities should perform their own study of alternatives.
    c. **Incorporate off-site natural gas storage in blackstart system restoration plans.** Doing so could provide entities with more fuel supply options during blackstart system restoration. The natural gas supply chain may be severely stressed or completely unavailable during a blackstart system restoration scenario. Stored natural gas may increase the likelihood of blackstart and next-start resources being able to secure fuel more quickly and reliably in the event of a blackout, which may be necessary to start system restoration.
    d. **Implement a testing requirement for blackstart resources to perform alternate fuel[43] startup tests completely on alternate fuel.** Performing these alternate fuel startup tests would confirm that dual-fuel capable blackstart resources are able to start on alternate fuel during a blackout when no other external electricity sources are available and primary fuel is unavailable. Additionally, these requirements should be clearly defined so that the blackstart resources are able to perform these tests effectively.
2. The appropriate state and other authorities with jurisdiction should facilitate and moderate engagement among the entities responsible for developing and implementing a blackstart system restoration plan, including but not limited to, electric generation owners and operators, electric transmission owners and operators, electric distribution owners and operators, and natural gas supply chain owners and operators to:

[38] See Precedent Study report, pages 5–7.
[39] A single point of failure is a part of the system that, if it fails, will stop the entire system from working.
[40] An electrical bypass is an alternative power supply path in an electrical circuit. It can be used to reroute power in case of an emergency or power failure.
[41] Variable frequency transformers are double fed electric machines that are used to transmit electricity between two (asynchronous or synchronous) alternating current frequency domains. A variable frequency transformer behaves as a continuously adjustable phase-shifting transformer that controls the power flow between two networks.
[42] A transfer system that isolates a group of loads from the control area in which they normally are served and then connects them to another control area.
[43] For the purposes of this report, alternate fuel refers to the backup fuel stored on-site at the blackstart resource. In the ISO, this alternate fuel is typically distillate oil.

a. **Assess the impact of a blackout on the natural gas supply chain with a focus on natural gas availability to blackstart and next-start resources.**[44] This assessment could help the electric and natural gas industries better understand what is required in a blackstart system restoration scenario and which electric and natural gas entities are responsible for blackstart system restoration. This assessment should include the impact on the natural gas supply chain and evaluate the impact on the availability of natural gas to blackstart and next-start resources. The availability of natural gas will impact the blackstart and next-start resources' performance and restoration capabilities during a blackstart system restoration scenario. Furthermore, this assessment should determine the resilience of the electrical system based on the risk of the natural gas system not being available. In addition, such an assessment could determine the impact to the natural gas system in the event of a blackout, particularly during an extreme cold weather event. This assessment could help blackstart resources understand the effects of a rapid degradation of the natural gas system. In Texas, this assessment should expand upon the critical infrastructure mapping that was developed by the PUCT and RRC after Winter Storm Uri. Results of the assessment could aid in further collaboration between the electric and natural gas industries, and drive potential changes to the blackstart procurement process, including which units are selected to be blackstart resources and their fuel procurement requirements.

b. **Develop a coordinated blackstart system restoration plan that incorporates the needs of both the electric and natural gas industries.** The electric and natural gas entities necessary for blackstart system restoration should work collaboratively to develop this blackstart system restoration plan. In Texas, this coordinated blackstart system restoration plan should further distinguish the critical load designations developed by the PUCT and RRC after Winter Storm Uri to account for the loads critical for blackstart system restoration. The blackstart system restoration plan should prioritize the natural gas infrastructure required to supply natural gas to the blackstart, next-start, and other essential resources necessary for blackstart system restoration within each restoration island.[45] Additionally, this plan should prioritize the sequence and timing for energizing critical electrical substations and natural gas infrastructure. This plan could help ensure a more synchronized blackstart system restoration between the electric and natural gas industries.

3. **The appropriate state and other authorities with jurisdiction over developing and defining natural gas curtailment plans and standards should evaluate elevating the priority of natural gas supply and transportation to blackstart and next-start resources.** The curtailment of natural gas to these resources could lead to their unavailability.[46] The joint study team finds that this evaluation would help entities ensure that natural gas supplies are prioritized and thus, available to blackstart and next-start resources when natural gas fuel supplies are limited.

[44] A blackout is the complete interruption of power in a given service area.
[45] An island is an electrically isolated portion of an interconnection.
[46] A curtailment is the reduction in the scheduled natural gas capacity or natural gas delivery.