Blackstart and Next-Start Resource Availability in the Texas Interconnection

FERC, NERC and Regional Entity Staff Study
December 2023

Regional Entities:

ACKNOWLEDGEMENT

This study results from the combined efforts of many dedicated individuals in multiple organizations across various jurisdictions. The joint study team consisted of individuals from the Federal Energy Regulatory Commission (FERC or the Commission), the North American Electric Reliability Corporation (NERC), Regional Reliability Entities: Midwest Reliability Organization (MRO), Northeast Power Coordinating Council (NPCC), ReliabilityFirst Corporation (ReliabilityFirst), SERC Corporation (SERC), the Texas Reliability Entity (Texas RE), and the Western Electricity Coordinating Council (WECC), all of whom are named in Appendix 1. They were assisted by other non-joint study team members within their respective organizations. This is a joint staff study, and does not speak for the Commission, NERC, or any of the Regional Entities. The joint study team would also like to acknowledge and thank the staff at the Public Utility Commission of Texas (PUCT) and the staff at the Railroad Commission of Texas (RRC) for their thoughtful review of the study. Additionally, the joint study team appreciates the feedback, cooperation, and involvement from the study participants in the development of this study.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This study of blackstart[1] and next-start resource availability in the Texas Interconnection during extreme cold weather conditions originated from Recommendation 26 of the November 16, 2021, *FERC- NERC- Regional Entity Staff Report: The February 2021 Cold Weather Outages in Texas and the South Central United States*.[2] In November 2022, Commission, NERC,[3] and Regional Entity[4] staff (collectively, the joint study team) initiated the recommended study, which focused on the availability of blackstart resources and next-start[5] resources and the Texas region's Independent System Operator's (ISO's)[6] procurement of blackstart resources for its blackstart system restoration[7] plan. The joint study team also assessed registered entities' blackstart resource testing, fuel-switching tests, fuel delivery infrastructure, fuel supply contracts, coordination between electric and natural gas entities, and blackstart and system restoration training practices and procedures. This joint study was not a compliance or enforcement initiative.

The joint study team makes several key findings, including that the ISO has defined procurement processes and procedures in place to secure blackstart resources, and that the ISO has verified, through simulations and models, the sufficiency of the blackstart resources in its blackstart system restoration plan. However, the fuel mix of the blackstart resources available to the ISO has limited fuel diversity and the ISO relies heavily on natural gas as fuel for its blackstart and next-start resources. Regarding training, the joint study team found that participants who perform additional testing of blackstart resources and restoration training use the knowledge gained from these activities to modify, update, and improve their blackstart system restoration plans.[8] The joint study team observed that the electric and natural gas industries are heavily reliant on one another to maintain reliable operations. For this reason, the joint study team concludes that having open lines of communication in place between the two industries in preparation for a blackstart system restoration scenario is necessary to facilitate timely restoration of the electric grid.

---

1 A generating unit and its associated set of equipment that has the ability to be started without support from the connected electric transmission system or is designed to remain energized without connection to the remainder of the system.

2 *See generally* 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 Pursuant to section 215 of the Federal Power Act (FPA), the Commission established a process to select and certify an Electric Reliability Organization (ERO), and subsequently certified NERC as the ERO. *See Rules Concerning Certification of the Electric Reliability Organization; and Procedures for the Establishment, Approval, and Enforcement of Electric Reliability Standards*, Order No. 672, 114 FERC ¶ 61,104, *order on reh'g*, Order No. 672-A, 114 FERC ¶ 61,328 (2006); *see also N. Am Elec. Reliability Corp.*, 116 FERC ¶ 61,062, *order on reh'g and compliance*, 117 FERC ¶ 61,126 (2006), *aff'd sub nom. Alcoa, Inc. v. FERC*, 564 F.3d 1342 (D.C. Cir. 2009); 16 U.S.C. § 824o(c).

4 Pursuant to section 215 of the FPA, the ERO may enter agreements to delegate authority to a Regional Entity for the purpose of proposing Reliability Standards to the ERO and enforcing Reliability Standards. 16 U.S.C. § 824o(e)(4); *see also* 18 C.F.R. § 39.8(a).

5 A next-start generating unit is the first generating unit in the cranking path to be energized using power from the blackstart generating unit. A cranking path is the portion of the electric transmission system that can be isolated and then energized to deliver electric power from a generation source to enable startup of one or more other generating units.

6 An ISO is an electric power transmission system operator which coordinates, controls, and monitors the operation of the electrical power system in a specific geographical area. For the purposes of this report, references to the ISO refer to the ISO serving most of Texas.

7 Restoration is 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.

8 In conducting the study, the joint study team gathered information from nine entities from both the electric and natural gas industries within the ISO (the participants).

From these findings, the joint study team identified best practices and opportunities for improvement in the participants' programs/procedures and developed associated recommendations, which are discussed in this report. These recommendations apply to both the electric and natural gas industries regarding practices, procedures, and methodologies aimed at improving blackstart system restoration overall, and blackstart capability planning and testing.

The joint study team recognizes that there is a need for a better understanding of the actions required to address a blackstart system restoration scenario and which electric and natural gas entities would need to take action in such a scenario. To that end, the joint study team highlights the need for the electric and natural gas industries to work together to develop a joint blackstart system restoration plan that considers extreme cold weather conditions and the mutual interdependence of these two complex and important industries. Other recommendations include approaches to improve electric and natural gas industry coordination and communication, mitigate the risks to the operability of blackstart resources, test blackstart resources, assess the validity of blackstart system restoration plans, incorporate a variety of options into blackstart system restoration plans, and the use of natural gas storage. The joint study team views the recommendations in this report as proactive, to help the entities responsible for blackstart system restoration preemptively plan for recovery from a blackout. While the recommendations in this report are voluntary and the report imposes no obligations beyond those required by the relevant Reliability Standards, the joint study team strongly urges that the report's recommendations and observed practices be implemented by the entities necessary for blackstart system restoration.

Recommendations

Blackstart restoration requires the electric and natural gas entities to work collaboratively across multiple jurisdictions and functional responsibilities, including but not limited to, transmission operators, generator operators, distribution providers, reliability coordinators, and natural gas producers, processors, and transporters. The joint study team makes the below recommendations to these entities as a whole, understanding that some entities may have a larger role than others in the development and implementation of a blackstart restoration plan.

1. **Entities responsible for developing and implementing a blackstart system restoration plan should:**

    a. **Examine the diversity of fuel, single points of failure,[9] 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. **[Section IV.B.]**

9 A single point of failure is a part of the system that, if it fails, will stop the entire system from working.

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,[10] high voltage direct current (HVDC) ties, variable frequency transformers,[11] block load transfers,[12] 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. **[Section IV.B.]**

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. **[Section IV.C.]**

d. **Implement a testing requirement for blackstart resources to perform alternate fuel[13] 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. **[Section IV.D.]**

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:**

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.**[14] 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

10 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.

11 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.

12 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.

13 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.

14 A blackout is the complete interruption of power in a given service area.

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. **[Section IV.C.]**

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.[15] 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. **[Section IV.C.]**

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.[16] 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. **[Section IV.C.]**

Observed Practices for Consideration

The joint study team observed that the participants have many practices and procedures pertaining to blackstart resource availability, testing, communication and coordination, and training, that serve to enhance their preparations for blackstart system restoration. While they may not be universally applicable, incorporating these observed practices where appropriate could add significant value and resilience to the electric grid. Examples of these beneficial practices observed by the joint study team include:

- Installing permanent winterization measures, where possible, to minimize the use of temporary measures, such as portable space heaters, at generating resources. Permanent mitigation could limit the amount of annual maintenance required. **[Section IV.B.]**

15 An island is an electrically isolated portion of an interconnection.

16 A curtailment is the reduction in the scheduled natural gas capacity or natural gas delivery.

- Periodically reviewing and identifying generating resources capable of operating in isochronous mode[17] when developing blackstart system restoration plans.[18] This information is critical in identifying the generating resources capable of controlling frequency within islands during blackstart system restoration. **[Section IV.B.]**

- Performing expanded testing, where feasible, to confirm the viability of blackstart capability through coordination between blackstart resources and transmission entities. Expanded testing could be used to confirm the viability of blackstart system restoration plans as well as to update system models and blackstart system restoration training programs.[19] **[Section IV.D.]**

The beneficial practices observed by the joint study team are discussed in greater detail in the relevant sections of the report.

17 In an isochronous mode, a generator's output is controlled to maintain a constant frequency, rather than voltage, by adjusting the speed of the generator in response to changes in the load demand. The speed governor of the generator is designed to respond quickly to changes in the load demand, ensuring that the frequency remains constant. Isochronous mode is typically used when a generator either stands alone or is the largest unit on a grid.

18 On October 12, 2023, the PUCT approved a revision to the ISO's practices and procedures, requiring that resource entities identify whether a physical resource has the potential capability to be called upon or used during a blackstart emergency or if it has the capability to operate in isochronous mode.

19 Expanded testing involves testing beyond the currently required blackstart testing (up to energizing a dead bus), including energizing the transmission line and the next-start generating unit, to ensure that the blackstart generating unit can energize additional equipment needed to restore the system as intended.

INTRODUCTION

On February 16, 2021, Commission, NERC, and Regional Entity staff began an inquiry into the operations of the bulk electric system during Winter Storm Uri. The scope of the inquiry included identifying commonalities with previous cold weather events and any lessons learned that NERC should incorporate in the development of cold weather Reliability Standards, and making recommendations to mitigate and recover from similar events in the future. This inquiry culminated in the issuance of a joint report on the February 2021 cold weather outages in Texas and the South-Central United States (2021 Cold Weather Report).[20]

The 2021 Cold Weather Report provided a comprehensive record of the electric industry's behaviors and practices during Winter Storm Uri and made 28 recommendations to improve electric generation and natural gas infrastructure, grid emergency operations, and seasonal preparedness for extreme cold weather. Based on the performance of the ISO's blackstart resources during Winter Storm Uri, the 2021 Cold Weather Report included Recommendation 26, suggesting a joint FERC-NERC-Regional Entity team study of blackstart resource availability in Texas during extreme cold weather conditions to enable the ISO to improve its blackstart system restoration plan.[21]

In November 2022, the joint study team began to examine the worst-case scenario for the ISO— the complete interruption of power, i.e., a blackout. Any blackout imposes profound effects upon industry, business, community, and life, which would be compounded during an extreme cold weather event. Being able to restore the system following a blackout is an important capability. Accordingly, FERC, NERC, and its Regional Entities have studied the matter and issued prior joint reports assessing the availability of blackstart and next-start resources in the event of a blackout.[22] Given that the possibility of a blackout exists, planning for such a high impact event must be approached holistically by all that would be impacted by such an event.

This joint study aims to improve the practices of blackstart and next-start resource entities as well as natural gas entities that would support blackstart system restoration by proposing observed practices and recommendations. The scope of the joint study focuses on: (1) the characteristics of blackstart and next-start resources relied upon in blackstart system restoration plans; (2) the characteristics of natural gas supply contracts and delivery infrastructure for the blackstart and next-start resources that are relied upon in blackstart system restoration plans; (3) the testing of blackstart resources and their fuel switching capabilities; and (4) the blackstart and system restoration operating personnel training practices, procedures, and resources.

---

20 *See generally* 2021 Cold Weather Report.

21 *Id.* at 236.

22 *See* FERC, NERC, and Regional Entity Staff, *Report on the FERC-NERC-Regional Entity Joint Review of Restoration and Recovery Plans* (Jan. 2016), https://www.ferc.gov/sites/default/files/2020-04/01-29-16-FERC-NERC-Report.pdf (January 2016 Report); *see also* FERC, NERC, and Regional Entity Staff, *Report on the FERC-NERC-Regional Entity Joint Review of Restoration and Recovery Plans* (May 2018), https://www.ferc.gov/sites/default/files/2020-05/bsr-report.pdf (May 2018 Report).

STUDY PROCESS AND DATA

The joint study team included subject matter experts from the Commission, NERC, and the Regional Entities, who collectively provided the necessary planning and operations expertise to conduct the study.[23]

During its assessment, the joint study team reviewed relevant reports and documentation provided by each participant and engaged in discussions with the participants, both on-site and virtual, to gain additional information and insights.

The process used to perform this study included four steps:

Step 1: Review of Relevant Literature
The joint study team identified, reviewed, and summarized relevant studies, reports, manuals, and references as background to aid in effectively structuring and performing this study.[24]

Step 2: Identify Participants
The joint study team designed participant identification criteria to best achieve the overall study goals of assessing blackstart and next-start resource availability, natural gas availability, and strategies to improve the reliability of these resources during extreme cold weather events and blackstart system restoration scenarios. The criteria included verifying whether and how participants conduct testing of blackstart capability under anticipated blackstart conditions. The joint study team used the following criteria to identify prospective participants in the ISO:

- Entities subject to Reliability Standard EOP-005-3 (System Restoration from Blackstart Resources)[25] that have documented blackstart and next-start resource procedures;
- Entities located within the ISO with different types of blackstart resources, including those with fuel switching capabilities;
- Entities with significant Bulk-Power System[26] responsibilities during blackstart system restoration;
- Entities that produce, process, and transport natural gas to blackstart and next-start resources;
- Entities that have experienced natural gas curtailments;
- Entities that have experience in identifying the priority facilities[27] within their service area and prioritizing those priority facilities in their blackstart system restoration plans; and

---

23 Appendix 1 lists the joint study team members.

24 Appendix 3 contains a summary of the literature reviewed, except for specific literature pertaining to the participants in order to protect the participants' identities.

25 *See* Reliability Standard EOP-005-3, available at https://www.nerc.com/pa/Stand/Reliability Standards/EOP-005-3.pdf.

26 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. *See* 16 U.S.C. § 824o(a)(1).

27 Facilities are a set of electrical equipment that operates in a single Bulk-Power System element. For the purposes of this report, priority facilities refer to the electric and natural gas facilities that are necessary for system restoration.

- Entities that have performed blackstart resource testing under actual or anticipated conditions (e.g., expanded testing beyond the currently required blackstart testing).

The joint study team identified nine entities as prospective participants and requested their participation. The study participants were, without exception, exemplary in their cooperation with the joint study team. The participants shared relevant details about their blackstart and next-start resources, recent changes to blackstart and next-start readiness strategies and operating procedures,[28] the characteristics of fuel supply contracts and delivery infrastructure for blackstart and next-start resources, the characteristics of natural gas fuel availability, recent changes to blackstart testing, blackstart resources' fuel switching capabilities, and blackstart operating personnel training practices. The joint study team commends the participants for their contributions to the study.

The joint study team sent a study request letter to each prospective participant, outlining the information needed for the study.[29] The letter asked the participants to provide or make available for review and discussion documentation pertaining to:

- Criteria for the selection of current and future blackstart resources (e.g., size, fuel type, locations, limitations);
- Current and future cranking paths[30] due to changes in blackstart and next-start resources;
- Provisions for alternate cranking paths if the primary cranking path is unavailable;
- Operating issues associated with blackstart resources pertaining to fuel type and other factors;
- Results of testing current blackstart and next-start resources, cranking paths, and backup generators, and the lessons learned from such testing;
- Current winter weatherization procedures involving blackstart and next-start resources;
- Blackstart operating personnel training practices and procedures;
- Any reports or other documents that have already been produced in these areas that may be beneficial for the joint study team to review; and
- Any additional documents or information identified by the joint study team.

The joint study team reviewed the responses before the participant engagements to aid in identifying specific areas of interest for each participant in the study. The joint study team selected electric and natural gas entities to participate in the study. All nine study participants were located solely in the state of Texas; therefore, the blackstart and next-start resources discussed below are largely reliant on intrastate pipelines for their natural gas supply.

---

28 An operating procedure is 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).

29 A copy of the request letter is attached as Appendix 2.

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

Step 3: Assess Blackstart and Next-Start Resource Availability, Strategies to Improve the Reliability of these Resources, Testing Practices, and Blackstart Operating Personnel Training, Practices, and Resources

The joint study team identified specific areas of focus to aid in identifying and understanding recent changes to blackstart and next-start resources, participants' strategies to improve the reliability of these resources in extreme cold weather events and blackstart system restoration scenarios, and the options for expanded testing and training beyond what is currently required. The areas of focus included, but were not limited to:

- Assessing blackstart and next-start resources in blackstart system restoration plans;
- Assessing blackstart and next-start resources capability and availability to improve the readiness of these resources in extreme cold weather events and blackstart system restoration scenarios;
- Analyzing the natural gas fuel availability to blackstart and next-start resources;
- Evaluating fuel supply contracts and constraints, and the fuel delivery infrastructure to blackstart and next-start resources, including intrastate pipelines;
- Assessing the monitoring and control of system conditions during testing, training, and actual events; and
- Reviewing the communication and coordination involved during testing, training, and actual events.
- The joint study team shared these focus areas with participants to enable the joint study team to perform a consistent, efficient, and thorough assessment of all participants within the scope of review.

Step 4: Document Observed Practices for Consideration and Develop Recommendations

Upon completion of the participant engagements, based on the data reviewed and other input shared by participants, the joint study team documented observed practices for consideration and developed recommendations in several areas, as described below.[31] The joint study team identifies the applicable entities for each recommendation in this report. Nevertheless, the joint study team did not identify applicable entities within the observed practices for consideration below. The joint study team believes that entities should determine whether to implement these observed practices for consideration if feasible for their operations.

31 For the purposes of this report, observed practices for consideration refer to actions currently being performed by at least some of the participants in this study, whereas recommendations refer to actions that are not currently being performed or could be enhanced.

ASSESSMENT

Overview

NERC Reliability Standard EOP-005-3 requires that transmission operators develop and implement a blackstart system restoration plan. Under this Standard, the blackstart system restoration plan must include: (1) strategies for system restoration that are coordinated with the reliability coordinator's strategy for restoring interconnections; (2) a description of how off-site power will be maintained during system restoration; (3) procedures for restoring interconnections with other transmission operators; (4) the identification of blackstart resources and their characteristics; (5) the identification of cranking paths, initial switching requirements, and units to be started; (6) the identification of acceptable operating voltage and frequency limits during system restoration; (7) operating processes to reestablish connections with the transmission operator's system; (8) operating processes to restore loads required to restore the system; and (9) operating processes for transferring operations back to the balancing authority. Nevertheless, the blackstart system restoration plan outlined in Reliability Standard EOP-005-3 does not fully account for the interdependencies of the electric and natural gas industries.

The joint study team finds that an important takeaway from this study is the need for the electric and natural gas entities necessary for blackstart system restoration to work together to develop a joint blackstart system restoration plan. The joint study team believes that this plan can be developed by the electric and natural gas industries coordinating to ensure that both industries are available to support one another during blackstart system restoration. The development of such a plan will require a high level of communication and collaboration between the industries to identify the infrastructure necessary to keep both the electric and natural gas industries operational.

During the participant engagements, the joint study team observed a comprehensive range of approaches regarding the availability of blackstart and next-start resources, natural gas delivery infrastructure, natural gas supply contracts, electric and natural gas industry coordination and communication, fuel-switching, testing and validation of blackstart system restoration plans, and blackstart operating personnel training practices and procedures. The sections below discuss the joint study team's observations pertaining to: (1) blackstart and next-start generating resources relied upon in blackstart system restoration plans; (2) natural gas supply contracts and delivery infrastructure for blackstart and next-start generating resources that are relied on in blackstart system restoration plans; (3) blackstart testing and fuel-switching capabilities; and (4) blackstart and system restoration operating personnel training practices and procedures. The sections below also detail the joint study team's relevant recommendations and observed practices for consideration.

Blackstart and Next-Start Generating Resources Relied Upon in Blackstart System Restoration Plans

INTRODUCTION

The joint study team assessed the ISO's procurement process for blackstart resources and ways to optimize the selected blackstart resources in the event of a blackout.[32] To better understand the factors that potentially affect the resources' availability, the joint study team examined the participants' blackstart and next-start resources, including the types and characteristics of the resources and how the participants ensure adequate primary and on-site alternate fuel. Further, the joint study team considered the participants' maintenance practices applied to blackstart and next-start resources and associated on-site fuel facilities.

Although the ISO stated that it has seen a decrease over time in the total number of blackstart-capable resources applying to be contracted blackstart resources, the ISO confirmed through simulations and modeling that it has procured enough blackstart resources to facilitate a blackstart system restoration.[33] Most years, there is not much change in the ISO's selected blackstart resource mix from the previous procurement cycle. While the resource mix does not have much variety from year to year, some selected blackstart resources are able to connect to adjacent interconnections.[34] Some participants reported that they currently, or with modifications, could be capable of connecting to neighboring entities and adjacent interconnections, which could add resilience and contingency measures to the ISO's current blackstart system restoration plan.

OBSERVATIONS

Characteristics of Participants and Decisions Surrounding Current Blackstart and Next-Start Resources

Most of the blackstart resources in the ISO's blackstart system restoration plan use natural gas as their primary fuel. Some of these resources are dual-fuel capable, with distillate oil mainly used as the alternate fuel. Currently, none of the blackstart resources in the ISO's blackstart system restoration plan are wind or solar resources. The participants have taken some precautions to ensure that their blackstart and next-start resources have reliable and consistent access to fuel during a system disturbance, other extreme conditions, or a blackout, including the following:

- Some participants with dual-fuel capable blackstart resources have procured on-site alternate fuel sufficient to run their resources for a limited period (e.g., 72 to 96 hours at maximum output) to mitigate the loss of their primary fuel.
- Some participants secure firm natural gas supply and transportation contracts to increase the likelihood of fuel availability.

32 Background on the strategies for assessing the need for and procurement of blackstart resources, along with examples, can also be found in the original restoration and recovery assessment. *See* January 2016 Report at 20-23.

33 The simulations and models assume that there is an uninterrupted supply of natural gas to blackstart and next-start resources during a blackout.

34 An interconnection is 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.

- Some participants noted that they remotely monitor their alternate fuel levels and replenish alternate fuel when the levels get too low, both prior to the expected need for alternate fuel and immediately after an event.

- Some participants use no-notice transportation service[35] offered by intrastate[36] natural gas pipelines when needed for the operation of their blackstart resources.

As found in the January 2016[37] and May 2018[38] Reports, the joint study team finds that maximizing the use of dual-fuel blackstart resources mitigates the risk that a blackstart resource will not be available if one fuel is in short supply or otherwise unavailable, as may be the case in extreme cold weather. While the diversity of fuel for blackstart resources may be limited in the ISO, blackstart system restoration plans can be improved by including some degree of fuel-source diversity or some degree of fuel assurance for the selected blackstart resources.

During a blackstart system restoration scenario, coordination between electric entities is essential, including mutual knowledge of the operations each entity must perform to maintain frequency as electrical islands are built. Typically, blackstart resources within an island operate in isochronous mode (or speed-control), which ensures that the frequency is maintained constant regardless of the load on the system, while other units in the island operate in droop speed control[39] to maintain voltage and share loading. One transmission participant stated that there is no verified list of generating resources capable of operating in isochronous mode that the ISO or other entities could call upon in the event that a contracted blackstart resource becomes unavailable. This entity also reported that operating in isochronous mode is uncommon to some entities, and the entity has experienced challenges with generating resources unfamiliar with operating in this mode. Some transmission participants reported that they maintain a list of additional blackstart-capable resources within their footprints that they can contact should they need assistance. Further, the ISO plans to maintain a list of blackstart-capable units that it can reach out to beyond those specifically contracted in its blackstart system restoration plan to assist if contracted blackstart resources become unavailable.

Characteristics of the Blackstart Procurement Process

The ISO is the entity responsible for the Texas Interconnection's blackstart resource procurement process. Recently, the ISO's blackstart commitment cycle was lengthened from two to three years. This change was based on feedback from entities stating that the longer commitment cycle provides the contracted blackstart resources with more certainty and reduces the frequency that blackstart system restoration plans must be updated.

At the beginning of each procurement cycle, the ISO issues a request for proposals to provide blackstart service, and interested generating units submit a proposal. Once the ISO receives proposals, it uses a software optimization tool to assess the ISO's blackstart system restoration needs. The tool uses an algorithm to find multiple solutions, producing a

35 No-notice transportation service allows entities to receive natural gas without nominations, but at a premium price. A nomination is a request to move a specified amount of natural gas from one location to another on a certain date, usually under a specific contract with a pipeline.

36 Intrastate refers to activity occurring within a single state whereas interstate refers to activity occurring between states or across state boundaries. Interstate natural gas pipelines carry natural gas across state boundaries. Natural gas pipelines operate within a single state's borders and link natural gas producers to local markets and the interstate pipeline network.

37 *See* January 2016 Report at 27.

38 *See* May 2018 Report at 23.

39 Droop speed control is a generator control mode used where the power output of the generator changes to maintain voltage as the frequency changes. In isochronous mode, a generator maintains a constant frequency, whereas droop speed control allows for a frequency change to maintain voltage in response to changes in load.

list of the interested generating resource entities that would meet the restoration needs of the ISO's service area.[40] The ISO then manually reviews the list of blackstart resources produced by the optimization tool to make a final selection of blackstart resources for the procurement cycle. Next-start resources and natural gas producers, processors, and transporters are not consulted, nor do they have an opportunity to provide feedback to the ISO regarding the ISO's procurement process. Transmission entities are consulted by the ISO on the selection of blackstart resources. One transmission participant stated that even though they are consulted, they only have a limited amount of input and would like more involvement in the ISO's blackstart resource selection process. This participant reported that they have valuable experience that could be beneficial to the ISO when selecting its blackstart resources.

At the time of this study, the ISO's procurement process did not include a requirement for blackstart resources to have dual-fuel capability, although some of the contracted units did have this capability. The ISO has indicated that it will require that each selected blackstart resource maintain a contracted amount of on-site alternate fuel to run its resource for a minimum of 72 hours at maximum output in its next procurement cycle starting in 2024.[41] If the ISO is unable to procure enough supply that meets this minimum requirement, the ISO can exempt a blackstart resource from the requirement in order to meet blackstart system restoration needs.

Participants reported two issues that may be limiting participation of blackstart-capable resources within the ISO's service area: (1) some blackstart-capable entities do not apply due to the increased burden associated with providing blackstart service[42] and (2) participants' interpretation of the blackstart procurement documentation varied, which could lead to confusion and inconsistency in the responses to the ISO's request for proposals for blackstart service. Defining pertinent terms within the procurement process documentation and streamlining the administrative tasks within the ISO's blackstart procurement process could be beneficial to securing increased participation from blackstart-capable resources.

Winterization Measures, Practices, and Inspections

Many of the region's current winterization[43] measures that are applicable to all generating resources, including blackstart and next-start resources, were created by the Texas Legislature after Winter Storm Uri.[44] As a result of the legislation, the PUCT developed requirements that all generating resources within the ISO's service area be physically

---

40 The tool simulates restoration of peak load and determines the facilities necessary to accomplish system restoration. Some of the factors used in this tool include proximity to load centers, priority loads and gas pipelines, availability of the transmission network, and proximity to nuclear generating units.

41 Under the ISO's new regulations, each generation resource that is selected to provide blackstart services to the region must be able to use alternate fuel for blackstart service. Additionally, each generation resource selected by the ISO will be required to maintain a contracted amount of alternate fuel to run its blackstart resource(s) for a minimum of 72 hours at the maximum output.

42 Some of these burdens, as reported by participants, include heightened compliance requirements (e.g., NERC Reliability Standards) and the ISO's request for proposal process, which some participants characterized as cumbersome. For example, some participants reported that, coupled with other issues, the ISO's blackstart procurement process takes longer than it should because the entity bids and selection paperwork require physical signatures from personnel that then have to be scanned in before being sent back to the ISO.

43 Winterization is 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.

44 *See* 16 Tex. Admin. Code §25.55 (2021); see also 16 Tex. Admin. Code § 3.66 (2022) (mandating critical/priority gas facilities in Texas to weatherize based on facility-specific factors, to ensure sustained operations during a weather emergency); 16 Tex. Admin. Code §25.55 (2022) (requiring generation entities and transmission service providers within the ISO to maintain weatherization preparation standards for the winter and summer seasons, while also mandating the ISO to conduct on-site inspections of every generation and transmission facility in its footprint).

inspected every three years for extreme weather preparedness, including cold weather readiness.[45] In addition to the PUCT requirements, the ISO requires all generating resources, including blackstart and next-start resources, to attest to the completion of winterization measures annually, by early fall. The ISO reported that since Winter Storm Uri it has been physically inspecting blackstart and next-start resources more frequently and plans to continue this activity.

As a result of Winter Storm Uri, one generating unit participant updated its entire winterization process. The updates included identifying components critical to maintaining operation, performing heat trace audits, insulation inspections and repairs, a review of previous cold weather events, inventory and testing of cold weather equipment, cold weather safety training, various operator checklists, and increased operator rounds to inspect equipment based on ambient temperature forecasts. Another participant reported that it performs checks of the natural gas infrastructure at the location where the natural gas pipeline enters the site of the blackstart resource.

One generating unit participant found that increasing glycol levels in its heating systems helped to prevent freezing issues, with no impact on its summer operations. Additionally, this participant found that ammonia was one of the required operating chemicals depleted earliest during extreme cold weather; thus, this participant now replenishes ammonia prior to the winter season. Another generating unit participant reported incorporating additives in its tanks of alternate fuel to prevent gelling[46] in the winter months. This participant also analyzes its on-site alternate fuel ahead of the winter season to ensure that it is still within specifications.

After Winter Storm Uri, one transmission operator participant reported that it increased staffing to account for the challenges and need for manpower during a large-scale extreme cold weather event. This participant also modified its winterization procedures to include reviews of prior events, increase the number of pre-winter inspections, and ensure that repairs are completed in a timely manner.

One gas supply participant reported that because of its experience during Winter Storm Uri, it added additional insulation to exposed equipment, updated winterization checklists, and performed more proactive inspections and verifications of equipment before, during, and after extreme cold weather. This participant initiated outreach to electric utilities regarding priority load[47] designations for its natural gas infrastructure and to facilitate a more open dialog between the electric and natural gas industries. Lastly, this participant activates a “ride out team” for forecasted extreme cold weather events to increase the number of staff at facilities that are typically unmanned.

All participants mentioned that restoring the system after a blackout is predicated on the availability of blackstart resources. To ensure that blackstart resources are available, especially during extreme cold weather, blackstart resources should consider implementing more robust winterization measures than those required of non-blackstart resources (see, e.g., Observed Practices for Consideration section below).

45 *See* 16 Tex. Admin. Code §25.55(d) (2022).

46 Fuel gelling is 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.

47 Priority load is the specific load identified in a system restoration plan, whose prolonged interruption may have an undesirable impact on health, safety, and the environment, and are thus, targeted for early restoration.

Blackstart Resources – Characteristics of Primary and Alternate Fuel

Most of the generating unit participants use natural gas as the primary fuel for their blackstart resources. Natural gas from processing plants or natural gas storage facilities is transported via intrastate pipelines to blackstart resources. One generating unit participant's blackstart resources can be supplied by multiple pipelines, affording redundancy on the loss of supply from one pipeline. Another generating unit participant reported that it experiences fuel switching limitations, such as being required to run on primary fuel prior to being able to switch to an alternate fuel, and the need for external power sources to start the blackstart resource on alternate fuel.

Generating unit participants with dual-fuel capability reported that they typically use distillate oil as their alternate fuel. This alternate fuel is generally delivered via trucks. Some participants reported that they have the ability to remotely monitor on-site alternate fuel levels available to their blackstart resources. This provides additional situational awareness and facilitates the scheduling of alternate fuel deliveries. One generating unit participant stated that it promptly replenishes its alternate fuel following an event to ensure restoration needs can be met and continuity of operations.

Multiple generating unit participants noted that if the blackstart or next-start resource is operating on alternate fuel, that fuel is commonly consumed faster than it can be replenished. As a result, blackstart resources may be forced off-line until the alternate fuel is replenished, which could delay system restoration. Some participants reported that they have made modifications to speed up the alternate fuel replenishment process. One generating unit participant improved the speed of its refueling process by modifying its delivery ramps to allow multiple trucks to replenish alternate fuel simultaneously.

Although the ISO's upcoming blackstart procurement cycle will require applicants to have 72 hours of on-site alternate fuel, it does not specify how quickly alternate fuel should be replenished while operating on the alternate fuel. Having clearly defined requirements for how quickly alternate fuel should be replenished will remove any ambiguities in the interpretation of the ISO's 72-hour fuel requirement and improve blackstart resources' preparedness in the event that their primary fuel becomes unavailable. Notably, some generating unit participants already exceed this requirement. One generating unit participant reported that it has an internal storage requirement to maintain 96-hours of alternate fuel.

Tracking Cold Weather Issues – Winterization and Remote Monitoring

Several generating unit participants reported that they added remote temperature monitoring and alarming to critical areas and equipment within their generating plants. Instead of operators periodically checking those areas and equipment (e.g., every two hours), remote temperature monitoring allows operators to remotely monitor and continuously receive alarms through Supervisory Control and Data Acquisition (SCADA)[48] if the temperature reaches certain thresholds. These participants also reported that they find it advantageous to have access to this advanced monitoring remotely because of the ease it provides in identifying and addressing issues. One participant increased its real-time monitoring capabilities for heat tracing,[49] on-site alternate fuel quantities, and natural gas supply pressure. The joint study team finds remote monitoring beneficial, as it provides continuous updates of blackstart related equipment, improves situational awareness, and reduces the need for visual inspections. This frees up staff to focus on monitoring other equipment or system conditions, especially during extreme cold weather or a blackstart system restoration scenario.

---

48 SCADA is a remote control and telemetry system used to monitor and control facilities.

49 Heat tracing is the application of a heat source to pipes, lines, and other equipment which, in order to function properly, must be kept from freezing.

One generating unit participant reported that it has an ongoing effort to minimize the use of temporary winterization measures. As one example, portable space heaters are often used to prevent freezing of equipment during the winter season. Temporary heaters require extension cords to reach certain areas, which presents a safety issue (trip hazard) and requires the deployment, positioning, and storage of the heater seasonally. Therefore, the participant is in the process of making modifications to permanently install the space heaters to be turned on as needed. As another example, this participant is ending the practice of using temporary shelters and wind breaks and installing permanent ones. This reduces the chance that temporary mitigation steps are missed year to year, which could impact blackstart resource availability.

A generating unit participant reported that it contracts with a third-party to perform audits of the heat trace and insulation on its blackstart resources. This entity uses the audit results to make recommended improvements and to develop periodic maintenance checklists for its operators.

Consideration of Alternative Resources for Blackstart Restoration – Batteries, Adjacent Interconnections

The ISO explained that its blackstart system restoration plan does not currently incorporate the use of batteries. The joint study team notes that other entities outside of the ISO use batteries for various emergency related purposes and blackstart assistance.[50] Batteries can be used as backup power systems to energize critical equipment at generating plants and critical natural gas infrastructure, and as an alternative to or in combination with on-site backup diesel generators. The team believes that with ongoing improvements in battery technology, batteries could make valuable contributions in emergency operations by providing support early in the blackstart system restoration as a power source, as a controllable load, and as a tool to maintain frequency and voltage.[51] Although batteries could be valuable contributions, the expected life and storage capability and thus duration of a battery varies depending on its age, type, designated purpose, state of charge at the time of the event, as well as other factors.[52] Further, changing or modifying the battery's use, cycle frequency, charge/discharge parameters or rate, will affect the life of the battery and its capabilities.[53] Entities should consider these parameters and capabilities for all batteries currently installed and those installed in the future when including batteries in blackstart system restoration plans.

The joint study team's literature review[54] indicates that additional connections to the Eastern and Western Interconnections could enable the ISO to increase its ability to import power when its system is stressed during emergencies and extreme cold weather events.[55] The ability to use or build off the strength of a neighboring entity could add resiliency and contingency measures to the ISO's current blackstart system restoration plan. One transmission participant noted that during system restoration after a hurricane, blocks of load were transferred from a neighboring entity to its system through the temporary establishment of connections to facilitate a temporary block load transfer.

---

50 *See IID Demonstrates Battery's Emergency Black Start Capability*, Imperial Irrigation District (May 2017), https://www.iid.com/Home/Components/News/News/557/30.

51 The joint study team also finds that the use of inverter-based resources and the advancements in grid forming technology could aid in blackstart system restoration. Grid forming is a technology that gives inverter-based resources the ability to operate in isochronous mode. *See* NERC, *Grid Forming Functional Specifications for BPS-Connected Battery Energy Storage Systems*, at v-vi (Sept. 2023), https://www.nerc.com/comm/RSTC_Reliability_Guidelines/White_Paper_GFM_Functional_Specification.pdf.

52 *See* NERC, *Energy Storage: Impacts of Electrochemical Utility-Scale Battery Energy Storage Systems on the Bulk Power System*, at xi (Feb. 2021), https://www.nerc.com/pa/RAPA/ra/Reliability Assessments DL/Master_ESAT_Report.pdf.

53 *Id.* at xi-xii.

54 Appendix 3 contains a summary of the literature reviewed.

55 *See* 2021 Cold Weather Report at 235.

This allowed loads that were impacted by the hurricane to be restored faster than would have otherwise been possible. Another participant reported that, with some modifications to its transmission system, it could electrically connect to adjacent interconnections through electrical bypasses or variable frequency transformers. This participant reported that this could allow for the almost immediate creation of stable islands to significantly increase the pace of system restoration. Another transmission participant noted that it has electrical ties with Mexico that could be used to a greater degree during emergencies and other extreme cold weather events. The participant explained that Mexico has provided load and frequency support when needed via verbal agreement, but has no contract that specifies the level of support. Another generating unit participant explained that, because of its electrical proximity, in the event of a blackout, it can connect and use power from an adjacent interconnection to start its blackstart resource.[56] Once the blackstart resource is operational, the blackstart resource can switch back to the impacted interconnection and provide blackstart services.

Recommendation 25 of the 2021 Cold Weather Report[57] suggested that the ISO evaluate the reliability benefits of additional links to adjacent interconnections, as they could provide significant reliability benefits for blackstart system restoration. To this end, the ISO reported that it is engaging with two universities to study the incorporation of DC ties and temporary alternating current (AC) ties for block load transfers to adjacent interconnections into blackstart system restoration.

CONCLUSIONS

The joint study team observes that the ISO has strategies and processes in place for selecting blackstart resources for blackstart system restoration. The ISO considers many factors in its selection of blackstart resources, such as fuel supply, locational diversity, and the ability to prove through testing or simulation that the contracted blackstart resources are capable of meeting the blackstart system restoration needs. The joint study team concludes that the ISO should also consider studying blackstart related risks within islands to better understand the individual risks posed to each island identified in the blackstart system restoration plan. The joint study team identifies additional risks and limitations affecting blackstart resources that could be further considered during the ISO's blackstart procurement process, including:

- Natural gas supply disruption risks due to the loss of supply from production facilities and the loss of natural gas infrastructure necessary for the processing and transportation of natural gas to blackstart resources.
- Natural gas curtailment risks due to blackstart resources lacking firm natural gas supply or firm pipeline transportation contracts, or connecting to a single pipeline.
- Fuel switching limitations, such as blackstart units being required to run on their primary fuel prior to being able to switch to an alternate fuel, and the need for external power sources or utility-supplied electricity to start the blackstart resource on the alternate fuel.

The joint study team finds that that the first three of these limitations – loss of natural gas infrastructure, lack of firm natural gas supply or firm pipeline transportation contracts, and blackstart resources' inability to switch to operating on an alternate fuel – can be single points of failure that would need to be accounted for in the ISO's procurement process and its blackstart system restoration plan.

---

56 This assumes that the adjacent interconnection is unaffected by the blackout.

57 *See* 2021 Cold Weather Report at 235.

The joint study team determines that one solution to address the lack of fuel diversity is to increase the number of generating resources responding to the ISO's request for proposal to provide blackstart service. A larger response to the request for proposal by generating resources would provide the ISO with more options for fuel diversity and locational advantages, such as close proximity to natural gas pipelines and natural gas storage when selecting blackstart resources. This could lead to a more resilient blackstart system restoration plan.

In addition, an increase in the number of physical inspections of blackstart and next-start resources prior to the winter season could help entities be better prepared for extreme cold weather events. The joint study team endorses the ISO's increased physical inspections of its blackstart and next-start resources since Winter Storm Uri. The joint study team finds that a frequency increase in the number of ISO-led inspections could help entities identify problems quicker to ensure that they are addressed before the following winter.

While blackstart resource options like fuel diversity may be limited in this region, reliance on a single fuel source, such as natural gas without natural gas storage or firm supply and transportation contracts, could cause significant issues during blackstart system restoration. The ISO should, therefore, consider (1) prioritizing blackstart and next-start resources with access to multiple natural gas pipelines and (2) incorporating the use of non-fuel energy resources and enhanced or expanded connections to neighboring interconnections in its blackstart system restoration plans. Non-fuel energy resources could include connections to neighboring entities or adjacent interconnections through bypasses, DC ties, or variable frequency transformers that provide opportunities for blackstart system restoration in addition to the use of existing blackstart resources. Also, the ISO could consider a study on additional restoration methods, such as the use of distributed energy resources and batteries to stabilize and balance the frequency of individual islands during restoration. Furthermore, to help mitigate the ISO's risks in the coordinated restoration of blackstart resources, the joint study team concludes that a list of generating resources that have the capability of operating in isochronous mode should be included in all blackstart system restoration plans to help the ISO identify resources to initiate blackstart system restoration.[58]

RECOMMENDATIONS

- **Entities responsible for developing and implementing a blackstart system restoration plan should:**
    - **Examine the diversity of fuel, single points of failure, 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.
    - **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, high voltage direct current (HVDC) ties, variable frequency transformers, block load transfers, and non-fuel energy

58 During restoration, electrical islands are typically in a fragile state due to the lack of adequate system inertia provided by synchronous generating units connected to the grid. Therefore, nominal disturbances could cause generating units (blackstart and other generating resources) to trip off and force a restart of the restoration process. Therefore, generating units operating in isochronous mode will maintain the frequency and stability of islands critical to the restoration process.

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.

OBSERVED PRACTICES FOR CONSIDERATION

- Incorporating additional remote monitoring capabilities, such as temperature, gas pressures, and alternate fuel levels, to provide operational data and alert operators to any potential issues.

- Installing permanent winterization measures, where possible, to minimize the use of temporary measures, such as portable space heaters, at generating resources. Permanent mitigation could limit the amount of annual maintenance required.

- Performing local checks on natural gas infrastructure owned by the gas supplier at the blackstart resource to verify its operational readiness. Relay any issues identified to the gas supplier for corrective action.

- Considering the impacts of extreme cold weather on the operability and performance of backup batteries located on key communication paths and at critical transmission substations, and how battery life is impacted by cold weather.

- Periodically reviewing and identifying generating resources capable of operating in isochronous mode when developing blackstart system restoration plans. This information is critical in identifying the generating resources capable of controlling frequency within islands during blackstart system restoration

Fuel Supply Contracts and Delivery Infrastructure for Blackstart and Next-Start Generating Resources

INTRODUCTION

The joint study team assessed the information provided regarding fuel supply contracts and the natural gas supply infrastructure that generation participants rely on for fuel delivery to their blackstart and next-start resources. Where applicable, the joint study team examined the sources of electricity that enable natural gas infrastructure to deliver fuel to blackstart and next-start resources. The joint study team also reviewed recent trends regarding fuel delivery and the impact of federal, state, and local regulations to understand how generation participants prioritize the delivery of natural gas to gas-fired blackstart and next-start resources among other end-user priorities. Lastly, the joint study team reviewed whether multiple blackstart and next-start generating resources are dependent on a single natural gas pipeline.

The electric and natural gas industries heavily rely on one another to maintain operations, especially in the case of blackstart system restoration. Similar to findings outlined in the North American Energy Standards Board's (NAESB)

July 2023 Gas Electric Harmonization Forum Report (July 2023 Report),[59] many participants reported that the current level of communication and collaboration between the electric and intrastate natural gas industries is insufficient. To increase the amount of visibility into the natural gas industry, the ISO stated that it is considering establishing a "gas desk"[60] to help it better understand and incorporate risks from the natural gas industry into its day-to-day operations as well as blackstart system restoration plan.

Many participants stated that they use internal priority designation levels to help them determine which priority electrical loads are vital to blackstart system restoration. Nevertheless, one participant reported potential challenges during blackstart system restoration due to restoration plans not identifying which loads are priority at different stages of the blackstart system restoration process.

OBSERVATIONS

Identification of Priority Loads for Blackstart System Restoration

One transmission participant reported that it is more difficult without documentation supporting self-designations, to evaluate the priority of each load. Priority facilities such as natural gas compressor stations, processing plants and gathering facilities, water treatment plants, and hospitals currently self-designate as priority loads via "self-designation priority load forms" in accordance with 16 Tex. Admin. Code §§ 3.65 and § 25.25.[61] However, transmission participants mentioned that they do not directly receive documentation supporting each facility's designation. One transmission participant reported that its distribution level Cooperative members are responsible for managing the list of priority load designations and provide this list to the transmission participant. This participant also stated that after Winter Storm Uri, its priority load list increased tenfold from approximately 200 to over 2,000 facilities that self-designated as priority loads.

Many transmission participants indicated that they separately assign internal priority levels to each self-designated priority load in addition to and instead of relying solely on the self-designation priority load forms. Some transmission participants suggested contacting self-designating entities about the priority of their loads to collect more information on the facilities connected to the load. By speaking directly with these entities, the participants could better determine the appropriate internal priority level assigned to each load. One transmission participant stated that it ranks priority loads within its blackstart system restoration procedures. In doing so, this participant has highlighted natural gas facilities that are near cranking paths as being particularly important during a blackstart system restoration scenario. Another transmission participant reported that it is unaware of which loads within its service area the PUCT, RRC, or ISO consider a priority at different stages of the blackstart system restoration process. This participant stated that it would be helpful to know ahead of time which facilities will have priority immediately after the blackout occurs, in two hours, 24 hours, 48 hours, and so on, to better facilitate blackstart system restoration.

---

59 *See Gas Electric Harmonization Forum Report, NAESB*, at 55-56 (July 28, 2023), https://www.naesb.org/pdf4/geh_final_report_072823.pdf (Recommendation 15); *see also* Natural Gas Policy Act (NGPA) § 311(a)(2) (an intrastate pipeline that is not under the Commission's Natural Gas Act (NGA) jurisdiction becomes subject to NPGA § 311(a)(2) if it sells or transports gas to an NGA pipeline, or to a local distribution company that itself takes service from a NGA pipeline)).

60 A gas desk stores information that could provide situational awareness that ties the natural gas and electric infrastructure together at their common point of operation.

61 *See* 16 Tex. Admin. Code § 3.65 (2021) (defining the types of natural gas facilities that are critical/priority gas suppliers and customers); *see also* 16 Tex. Admin. Code § 25.25 (2021) (requiring critical/priority natural gas facilities to provide critical/priority customer information to the utility from which it receives electric delivery services and incorporate this information into its restoration plans).

One gas participant reported that it contacts the 19 distribution service providers[62] that provide electricity to its natural gas infrastructure, annually and prior to potential events, to ensure that all necessary infrastructure is classified and treated as a priority load.

Coordination Between Entities for Blackstart System Restoration

The electric and natural gas industries are heavily reliant on one another to maintain operations; in most cases, natural gas cannot be produced, processed, or transported without electricity, and most blackstart and next-start resources within the ISO operate with natural gas as their primary fuel. The electric and natural gas entities could work collaboratively to identify and map the electric and natural gas facilities critical to the operation of individual blackstart and next-start resources. This identification would encompass all electric and natural gas facilities required to move natural gas from the source of the natural gas supply to the blackstart and next-start resources (e.g., natural gas compressor stations and electrical substations) and identify single points of failure. Such collaborative identification would facilitate an understanding of the needs and priorities of electric and natural gas infrastructure while also ensuring that fuel is delivered to blackstart and next-start resources during blackstart system restoration or an extreme cold weather event.

Mapping

Many generating unit and transmission participants discussed information sharing barriers, specifically regarding a map of critical electric and natural gas infrastructure that was developed after Winter Storm Uri by the PUCT. As of May 19, 2023, through the passage of SB 1093 in the Texas Legislature,[63] view-only access to applicable portions of this map could be provided to electric utilities, transmission and distribution utilities, electric cooperatives, municipally owned utilities, operators of gas supply chain facilities, and operators of gas pipeline facilities upon request.[64] Although access to this critical infrastructure mapping is now permissible upon entity request, it is unclear how this information on critical electric and natural gas infrastructure will be used to develop a joint blackstart system restoration plan that incorporates the needs of both the electric and natural gas industries.

Additionally, according to participants, once access to this map of critical electric and natural gas infrastructure is established, this information could be utilized to better inform more specific priorities in a transmission entity's blackstart system restoration plan. This would help to ensure that natural gas is available to blackstart and next-start resources during a blackstart system restoration scenario. Developing blackstart system restoration plans that include the electric and natural gas infrastructure will require a high degree of collaboration between the electric and natural gas industries to identify the infrastructure needed to keep both industries operational; many participants view this critical electric and natural gas infrastructure map as an important part of the collaboration between industries.

Natural gas coordination and communication

Several generating unit participants noted that coordination and communication with the region's natural gas entities could be improved. Natural gas participants also indicated that they were open to better and more frequent communication. Many participants – both generating units and natural gas participants - reported that they

62 A distribution service provider owns and operates, for compensation, the equipment and facilities used to transmit and/or distribute electricity.

63 *See* Texas Senate Bill No. 1093 (2023) (mandating that each electric utility, transmission and distribution utility, electric cooperative, and municipally owned utility provide its service area boundary map to the PUCT).

64 An entity must make a request to the Texas Electricity Supply Chain Security and Mapping Committee to receive view-only access to the map.

do not know the proper person to contact during emergency situations, including extreme cold weather, when communication is most needed. A few generating unit participants noted that they have direct contact with natural gas suppliers' trade desks and intrastate gas pipeline operators that communicate issues that those suppliers experience, but this communication is seldom outside of an emergency. Only one generating unit participant reported more regular, daily communications with gas suppliers and intrastate gas pipelines. This participant stated that its natural gas supply contract specifically defines communication capabilities and requirements during weekends, holidays, and emergencies. This participant also reported that it has contractual agreements with natural gas suppliers to communicate force majeure events in writing.[65] One generating unit participant reported that after Winter Storm Uri it added a force majeure events clause to the terms of its natural gas contracts for its blackstart resources because of its understanding that the risk of curtailment is greater than previously thought. This added clause requires the natural gas supplier to immediately submit, in writing, the *force majeure* notification so that the participant has greater insight into the availability of natural gas and can make other fuel arrangements as needed for continued operations.

A generating unit participant reported that it has a close relationship with its natural gas supplier and a designated representative to address fuel supply issues pertaining to its blackstart resources. One generating unit participant stated that it communicates daily its projected hourly usage to its natural gas suppliers to enhance the supplier's natural gas supply forecasts. Prior to Winter Storm Uri, this participant obtained additional natural gas on an as-needed basis in real-time, resulting in a need to reach out to multiple natural gas suppliers during periods of low liquidity. Since Winter Storm Uri, this participant now secures gas before long holiday weekends, when natural gas markets typically have low liquidity, to ensure that its generation resources, including blackstart and next-start resources, will be operational if needed.

Generating unit and transmission participants also expressed a concern that more coordination and planning between electric and intrastate natural gas entities is needed for blackstart system restoration scenarios. These participants reported a lack of shared operational information across the electric and natural gas industries that would be useful for a comprehensive study of risk during emergency or extreme cold weather scenarios. Even when gas entities do share information, one participant noted that natural gas entities sometimes report information about intrastate compressor station outages without clearly identifying the station in question. Furthermore, these intrastate natural gas entities have no obligation to share specific operational data with electric entities. This contrasts with interstate pipelines that, as required by the Commission's regulations, post information about gas flows, available capacity, and various notices on their public, electronic bulletin boards on a daily basis.[66] Interstate pipelines can share other, non-public operational information with electric transmission operators through the terms of FERC Order No. 787 in an effort to promote grid reliability.[67] Order No. 787 does not apply to intrastate pipelines and any communication of operational information is voluntary and at the natural gas entity's own discretion.

65 The phrase force majeure refers to an 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.

66 *See* 18 C.F.R. § 284.13(d).

67 *See Communication of Operational Information Between Natural Gas Pipelines and Electric Transmission Operators*, Order No. 787, 145 FERC ¶ 61,134 at PP 1-7 (2013), *order on reh'g*, Order No. 787-A, 147 FERC ¶ 61,228 (2014) (providing interstate natural gas pipelines and public utilities that own, operate, or control facilities used for the transmission of electric energy in interstate commerce with the authority to share non-public, operational information with each other for the purpose of promoting reliable service or operational planning on the public utility's or pipeline's system); *see also* 18 C.F.R. § 38.2 (detailing that the communications and information sharing are voluntary); 18 C.F.R. § 284.12(b)(4).

The joint study team found that the lack of adequate information exchange between electric and natural gas entities regarding natural gas availability and the status of specific intrastate natural gas infrastructure is a risk to the ISO's operational activities in maintaining the reliability of the bulk electric system, especially during emergencies such as a blackstart system restoration scenario. NAESB's July 2023 Report recommended that the Commission direct NAESB to revise its business practice standards related to the natural gas pipeline informational website posting data to enable the data to become routinely accessible to bulk electric system operators as soon as the data is reported and available, as well as promoting transparency between the natural gas and electric industries.[68] Nevertheless, the joint study team believes it is important to reiterate the need for this type of operational information sharing between the electric and natural gas industries. Emergency situations, such as extreme cold weather events, have shown how both industries can exacerbate each other's operational risks. The joint study team finds that further coordination and planning are necessary to ensure both industries remain operational during extreme cold weather events and blackstart system restoration scenarios.

Blackstart Resource - Fuel Contracts and Fuel Storage

The different natural gas procurement strategies provide varying levels of priority and commitment in adverse conditions, with firm natural gas supply and transportation contracts ensuring priority over interruptible contracts. One generating unit participant spoke to the value of firm supply and transportation contracts to ensure natural gas would flow to its blackstart and next-start resources. However, firm natural gas supply and transportation contracts were not always available to all study participants (e.g., during force majeure events). One generating unit participant reported that one of its blackstart resources does not have firm natural gas transportation contracts because the pipeline that services its plant only offers firm contracts to retail load, which does not include the blackstart resource. Another generating unit participant stated that it generally contracts for enough transportation capacity to run its blackstart resources at full capacity. However, this participant included a caveat that one of its blackstart resources does not have firm natural gas transportation contracts because the pipeline that services the plant did not offer firm contracts until recently.

During extreme cold weather and blackstart system restoration events, intrastate natural gas supply and transportation agreements may not be sufficient to provide blackstart and next-start resources with natural gas. Even for entities holding firm transportation contracts, those contracts may not be reliable during a complete blackout when nomination and scheduling platforms may be offline.[69] To account for such extreme conditions, several generating unit participants reported that, when necessary, they rely on no-notice transportation service, which allows entities to receive natural gas at generating plants to meet unexpected demand without the need for nominations, but at a premium price that is settled on the date of the natural gas receipt. One generating unit participant has formalized its no-notice gas agreements with its natural gas supplier to mitigate disruptions in natural

68 *See Gas Electric Harmonization Forum Report*, NAESB, at 17-19, 55-56 (July 28, 2023), https://www.naesb.org/pdf4/geh_final_report_072823.pdf (Recommendation 1 states that, "[t]he FERC should direct NAESB to revise its business practice standards related to the timely reporting of natural gas pipeline informational website posting data…to enable the data and any subsequent amendments to become routinely accessible to [b]ulk [e]lectric [s]ystem operators as soon as such data [is] reported and available" and Recommendation 15 details that, "[a]pplicable state authorities should consider establishing informational posting requirements for intrastate natural gas pipelines to enhance transparency for intrastate natural gas market participants regarding operational capacity data, similar to the reporting and posting requirements mandated by the FERC for interstate natural gas pipeline as part of 18 CFR §284.13. In instances where state authorities lack enabling authority to take such actions, the FERC should adopt regulations to achieve identical outcomes within its authority.").

69 A nomination is a request to move a specified amount of gas from one location to another on a specified date.

gas supplies.[70] Another generating unit participant stated that it has an interruptible agreement for no-notice gas that allows it to inject or withdraw gas on any given day by paying a fee. One natural gas participant indicated that if a blackstart or next-start resource does not have a contract in place for natural gas, even during an extreme cold weather event or blackstart system restoration scenario, its only recourse is an executive order from the appropriate state authorities and jurisdictional entities to supply natural gas to these resources. Formalizing no-notice intrastate natural gas supply and transportation agreements, or something equivalent where available, may increase the likelihood that natural gas supplies to blackstart and next-start resources will be available during extreme cold weather events.

During a blackstart system restoration scenario, the production and processing of natural gas may be impacted by the loss of electricity from the grid to the natural gas infrastructure. Intrastate natural gas production and processing facilities are predominantly reliant on electricity from the grid. Some natural gas participants noted that only a limited number of its facilities have back-up power that could be used to keep the facility operational in the event of a blackout. Thus, the supply of natural gas could be limited or non-existent, highlighting the importance of fuel storage. To restore the electrical system in the absence of natural gas production and processing, blackstart and next-start resources would rely on on-site alternate fuel (most have at least three days' worth), or natural gas already in storage (assuming it is deliverable). One gas participant reported that backup generators at natural gas storage facilities, as well as along the natural gas transportation pipelines, could be used to power the natural gas infrastructure necessary for moving natural gas to blackstart and next-start resources during blackstart system restoration. One generating unit participant reported that it found natural gas storage to be particularly useful during Winter Storm Uri. After Winter Storm Uri, this participant started purchasing more natural gas storage contracts, some of which can serve its blackstart resources to ensure access to natural gas when needed.

One generating unit participant reported that it receives alternate fuel (distillate fuel oil) deliveries from two different suppliers for redundancy (a primary and a backup) to increase the likelihood that its blackstart resources will have fuel in an extreme cold weather event. This participant's alternate fuel is delivered to its blackstart resources by truck. As such, these alternate fuel deliveries can be impacted during extreme cold weather if there are staffing issues at the alternate fuel company's site or hazardous road conditions. This participant noted that it takes anywhere from 7 to 20 days to get its alternate fuel replenished; thus, it has taken steps to ensure ample alternate fuel is on-site and routinely schedules fuel deliveries.

Another generating unit participant, an independent power producer operating under a tolling arrangement,[71] reported that the blackstart resource's operational decisions, including when to run and what fuel to use, are made by a third party. Therefore, the participant has little to no information regarding its primary or alternate fuel contracts. This participant also has no say in how much, if any, alternate fuel is kept on-site.

---

70 A no-notice gas agreement is a partial solution as it does not guarantee natural gas in the event of an operational flow order (OFO) because the pipeline may not have the capacity to provide the no-notice gas. An OFO is a mechanism to protect the operational integrity of the pipeline. It requires shippers to balance their natural gas supply with their customers' usage.

71 An independent power producer is an entity that owns or operates an electric generating facility that is not included in an electric utility's rate base. Some independent power producers operate under tolling arrangements where they contract with another entity to convert that entity's fuel into electricity.

Blackstart and Next-Start Fuel Supply Related Coordination

Following the winter storm in 2011, the ISO created a blackstart coordination group comprised of several natural gas entities working on bolstering communication and coordination related to the natural gas fuel supply to blackstart and next-start resources.[72] Some study participants mentioned that there is restricted access to this group's meetings due to confidentiality issues and the discussion of proprietary and Critical Energy Infrastructure Information.[73]

As noted above, the ISO informed the joint study team that it is considering adding a "gas desk" in its control room to monitor the supply of natural gas to power plants across its footprint. The ISO reported that fuel risks and natural gas curtailment impacts could be better understood through collaboration in the operational space between electric and natural gas entities and with additional data from natural gas entities. Nevertheless, many participants stated that natural gas entities are reluctant to share operational data, citing competition in the intrastate gas market as an impediment. Gas participants mentioned concerns with confidentiality and the scope of the "gas desk." One gas participant opined that the scope of the ISO's "gas desk" should be limited to the sharing of natural gas infrastructure outage related information, because it does not see the relevance of additional information, such as total gas flows, to the "gas desk's" activities.

The joint study team found in its literature review that ISO-New England (ISO-NE) has an electronic bulletin board containing information that could be used as an example in the development of a Gas Utilization Tool to visualize natural gas infrastructure.[74] A Gas Utilization Tool is also referenced in NERC's fuel assurance guidelines.[75] The NAESB report also highlighted that there may be existing tools in place that entities could take advantage of, such as natural gas pipeline electronic bulletin board data, that would increase situational awareness and visibility into the natural gas industry.[76] Nevertheless, the joint study team finds that the ISO should consider evaluating the activities of ISOs/regional transmission organizations (RTOs) in other regions and other entities that already have practices in place to assess operational data from the natural gas industry to determine whether ideas gleaned from their practices regarding assessment and use of operational data from the natural gas industry can be applied in the ISO's footprint.

---

72 *See* FERC and NERC Staff, *Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011* (Aug. 2011), https://www.ferc.gov/sites/default/files/2020-05/ReportontheSouthwestColdWeatherEventfromFebruary2011Report.pdf.

73 Critical Energy Infrastructure Information within the Texas Interconnection is defined as the specific engineering, vulnerability, or detailed design information concerning proposed or existing system infrastructure that: (1) relates to details about the production, generation, transportation, transmission, or distribution of energy; (2) could foreseeably be useful to a person planning an attack on the ISO's system infrastructure; (3) is exempt from mandatory disclosure under the Freedom of Information Act, 5 U.S.C. § 552, and has not been disclosed to the public through lawful means; and (4) does not simply give the general location of the ISO's system infrastructure.

74 *See* Technical Conference, Sept. 8, 2022, New England Winter Gas-Electric Forum, Docket No. AD22-9-000 (Sept. 8, 2022), Tr. 85-86, https://www.ferc.gov/media/transcript-docket-no-ad22-9-000 (ISO-NE uses pipeline information that is publicly available through electronic bulletin boards that they then put into their Gas Utilization Tool).

75 *See* NERC, *Reliability Guideline: Natural Gas and Electrical operational Coordination Considerations*, at 11 (Mar. 2023), https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability Guideline - Gas and Electric Operational Coord Considerations.pdf.

76 *See Gas Electric Harmonization Forum Report, NAESB*, at 21 (July 28, 2023), https://www.naesb.org/pdf4/geh_final_report_072823.pdf.

Legislature Set Prioritization of Natural Gas

Prior to Winter Storm Uri, natural gas utilities were allowed to file a curtailment plan, specific to its operations, for approval by the RRC.[77] If a plan was not filed with the RRC, natural gas utilities had to follow the order of priority outlined in 16 Tex. Admin. Code §7.305, which did not list generation resources in the order of priority. In February 2021, the RRC issued an emergency order in response to Winter Storm Uri, which temporarily modified the natural gas utility curtailment standards to ensure the protection of natural gas to human needs customers and generation resources.[78]

In April 2022, the RRC permanently adopted a new curtailment standard that set priorities for natural gas supplies and transportation during natural gas curtailments.[79] This new curtailment standard specifies the prioritization of natural gas for intrastate pipelines by natural gas utilities,[80] with residential customers having priority over all else, including blackstart and next-start resources. It also specifies that firm deliveries to all generation resources could be curtailed, without distinguishing between blackstart and non-blackstart resources. Curtailment of the natural gas supply and transportation services to blackstart and next-start resources could impact the availability of electricity to critical natural gas infrastructure (e.g., natural gas compressor stations), thereby impeding blackstart system restoration and subsequently the restoration of electricity to residential customers.

CONCLUSIONS

Electric and natural gas industries are heavily reliant on one another to maintain operations during blackstart system restoration, even more so during extreme cold weather events. As such, collaboration is needed between the two industries for a timely, efficient, and effective system restoration. The current level of communication and collaboration between the two industries must be improved to plan for a blackstart system restoration scenario. The joint study team believes that there is a need for the electric and natural gas industries to work together to develop a joint blackstart system restoration plan to ensure that both industries are available to support one another during a blackstart system restoration scenario. The electric and natural gas industries should work collaboratively to develop a synchronized blackstart system restoration plan that incorporates the needs of both industries. The blackstart system restoration plan should prioritize the natural gas infrastructure required to supply natural gas to the blackstart and next-start resources within each restoration island, as well as the sequence and timing for energizing critical electrical substations and natural gas infrastructure to help ensure a more synchronized blackstart system restoration between the electric and natural gas industries. Furthermore, the joint study team finds that further work by the ISO's blackstart coordination group could increase collaboration across the electric and natural gas industries, especially relating to natural gas fuel supply to blackstart and next-start resources, if participation and access to the group were expanded to include all entities that are necessary to in the blackstart system restoration process.

Participants' use of internal priority designation levels is beneficial, as it helps the entities determine which priority loads are paramount to blackstart system restoration. System restoration could be improved if load priority at different stages of blackstart system restoration were identified. The joint study team concludes that natural gas supply to blackstart and next-start resources must be a priority as these resources are needed not only to restore the Bulk-Power

---

77 *See* 16 Tex. Admin. Code §7.305 (2002).

78 *See RRC*, Emergency Order (Feb. 21, 2021), available at: https://rrc.texas.gov/media/cw3ewubr/emergency-order-021221-final-signed.pdf.

79 *See* 16 Tex. Admin. Code §7.455(c) (2022).

80 *See* 16 Tex. Admin. Code § 3.65 (2021) (defining the types of natural gas facilities that are critical/priority gas suppliers and customers); *see also* 16 Tex. Admin. Code § 25.25 (2021); 16 Tex. Admin. Code §7.455(c) (2022).

System but to subsequently energize critical natural gas infrastructure. The joint study team finds that the RRC should consider revising its curtailment list to prioritize the natural gas supply to blackstart and next-start resources to help improve the speed of restoring service to residential customers. In addition, the joint study team concludes that it is important for blackstart and next-start resources to understand the order and amount of natural gas supply and transportation curtailments due to contracts and priority designations that may impact their operations.

Furthermore, similar to the findings outlined in the May 2018 Report,[81] the joint study team concludes that the reliance on a single fuel type without firm fuel arrangements could impact the availability of blackstart and next-start resources during a scenario when natural gas is curtailed. In addition, the joint study team determines that having blackstart and next-start resources in close proximity to natural gas infrastructure, including natural gas storage facilities, limits the amount of coordination required to supply fuel to blackstart and next-start resources. As was found in the May 2018 Report,[82] the joint study team finds that the reliance on single and dual-fuel blackstart resources without fuel storage capacity or fuel assurance could cause issues during a blackstart system restoration scenario.

As discussed in the recommendations below, the joint study team believes that the ISO would benefit from incorporating the use of natural gas storage in blackstart system restoration plans to supply fuel to blackstart and next-start resources to add more fuel supply options during blackstart system restoration. The joint study team agrees with the NAESB Report regarding the benefit of conducting a study on whether natural gas storage facilities are sufficient to address natural gas supply shortfalls during extreme cold weather events. However, the joint study team also sees an immediate need for the use of natural gas storage in blackstart system restoration plans, and implementation should not be delayed until the completion of a study.[83] The joint study team believes that an exorbitant amount of planning and coordination would be needed to enable the production and processing of natural gas to continue during a blackout. Therefore, stored natural gas could improve the availability of blackstart and next-start resources. Nevertheless, there will still be a high level of planning and coordination necessary to ensure that this natural gas in storage is deliverable to the blackstart and next-start resources. The use of natural gas storage that is deliverable to blackstart resources could help mitigate the risk of the natural gas system being unavailable to blackstart units in the event of a blackout or extreme cold weather event.

The ISO's plan to create a "gas desk" should help the ISO better understand and incorporate the risks posed by natural gas infrastructure on electric reliability. The joint study team believes that the ISO, with collaboration and input from the natural gas entities, should clearly define the scope of the "gas desk" and consider evaluating activities of ISO/RTOs in other regions, such as ISO-NE, that already have practices in place to assess operational data from the natural gas industry to determine whether any ideas can be applied to the Texas Interconnection. The joint study team concludes that a more detailed plan from the ISO, with collaboration and input from the natural gas entities, on the scope of the "gas desk," including how operational natural gas data would be used and protected, could help facilitate more collaboration and sharing of data from natural gas entities. In addition, the joint study team believes that the use of a specific tool that allows for visualization of natural gas infrastructure and outreach to other ISO/RTOs could improve situational awareness and coordination between electric and natural gas entities regarding blackstart and related activities.

81 *See* May 2018 Report at 26.

82 *See id*. at 25-26.

83 *See Gas Electric Harmonization Forum Report*, NAESB, at 63 (July 28, 2023), https://www.naesb.org/pdf4/geh_final_report_072823.pdf (Recommendation 18).

RECOMMENDATIONS

- **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:**

    - **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.** 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 black start 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.

    - **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. 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.

- **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. 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.

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

    - **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 and in the event of a blackout, which may be necessary to start system restoration.

OBSERVED PRACTICES FOR CONSIDERATION

- Considering all service offerings from natural gas suppliers, such as no-notice gas and natural gas storage, to enhance fuel assurance and add flexibilities if one type of service is unavailable or curtailed. Entities should also define any limitation on service offerings under certain conditions.

- Contracting where possible for firm natural gas supply and firm natural gas transportation to blackstart and next-start resources to increase the likelihood of fuel availability during natural gas curtailments.

- Developing an alternate fuel replenishment plan for blackstart resources, particularly for the replenishment of alternate fuel following blackstart resource testing and/or use of alternate fuel. This plan would add certainty that alternate fuel is available when needed.

- Defining, through established procedures, operating agreements, or contracts, the communication responsibilities and capabilities between electric and natural gas entities during emergency scenarios, weekends, and holidays.

Expanded Testing and Fuel-Switching Capabilities

INTRODUCTION

The joint study team assessed the participants' testing of blackstart capability using both primary and alternate fuels, including the participant's efficiency and preparedness to switch from primary to alternate fuel during blackstart testing. The joint study team also assessed the ability of participants to perform blackstart and fuel-switching tests without utility-supplied electricity sources.

All owners and operators of blackstart resources, as part of their role in providing blackstart services, are required to perform periodic testing of the blackstart resources to verify their capability, with the requirements for such testing set out in Reliability Standard EOP-005-3 and the ISO's protocols. Some owners of blackstart resources test their blackstart resources more frequently than required, and some voluntarily perform expanded blackstart testing that exceeds the testing requirements.

OBSERVATIONS

Expanded Testing of Blackstart and Next-Start Resources

As noted above, all owners and operators of blackstart resources, as part of their role in providing blackstart services, are required to perform periodic testing of the blackstart resources to verify capability. Each blackstart resource selected by the ISO must successfully pass a basic blackstart test (annually),[84] line energization test (every three years),[85] load carrying test (every three years),[86] and a next-start generating unit test (every five years).[87] All owners of blackstart resources test their units at least once every three years, consistent with Reliability Standard EOP-005-3. Some of the participants exceed the testing requirements and test annually as well as perform voluntary expanded blackstart testing.

Participants reported that next-start resources are not contracted through the ISO's blackstart procurement process and are not obligated to participate in expanded testing of blackstart resources. However, many could easily participate in expanded testing because in many situations the blackstart and next-start resources are located in close proximity. Although this configuration provides operational advantages such as increased feasibility of expanded testing, and improved coordination and communication during blackstart system restoration, overreliance on such resources could be detrimental since both resources may rely on a single fuel source (e.g., the same gas pipeline) for operations. In such a scenario, a disruption in fuel supply would render both resources unavailable. One transmission participant reported that it does its own studies on the procured blackstart and next-start units to determine viability and the impact on its transmission system. This participant stated that it would like to have more input in the blackstart procurement process.

Fuel Switching: Alternate Fuel Testing

A blackstart resource's ability to switch to alternate fuel would add resilience to the ISO's blackstart system restoration plan, especially in the event that its primary fuel becomes unavailable. One generating unit participant reported that as a part of its pre-winter testing, its blackstart resource starts on alternate fuel to ensure it would be operational during an extreme cold weather event. This participant noted that it takes about an hour for it to switch from the primary to alternate fuel if its blackstart resource is already on-line because the blackstart resource must cool down before fuel switching can occur. After Winter Storm Uri, this participant updated its emergency operating procedures to include preemptively starting its blackstart resource on alternate fuel prior to a cold weather event since its primary fuel is typically curtailed during emergencies and extreme cold weather events. This participant also actively tracks any lessons learned during blackstart testing on alternate fuel and incorporates those lessons into its operating procedures.

One generating unit participant reported that it performs a test of its blackstart resource on alternate fuel with the complete removal of external power sources, i.e., utility-supplied electricity. Such a test could better prepare operators and possibly uncover hurdles that could be addressed during testing instead of during an actual blackstart

84 The basic blackstart test assesses a blackstart resource's ability to start itself or start from a normally open interconnection to another provider not inside the ISO's interconnection, without support from the ISO's system.

85 The line energizing test reviews a blackstart resource's ability to energize enough transmission to deliver the resource's output to loads that the ISO's restoration plan requires the blackstart resource to supply.

86 The load carrying test assesses the stability of the blackstart resource while supplying restoration power to load that is not identified as auxiliary load of the resource and is allowed to be auxiliary load of adjacent facilities.

87 The next-start resource test reviews the ability of a blackstart resource to startup the next-start generating unit's largest required motor while continuing to remain stable, and control voltage and frequency.

system restoration scenario. Another generating unit participant reported that it cannot start its blackstart unit without utility-supplied electricity, but it is capable of connecting to multiple interconnections to be supplied with this needed electricity for operability. One generating unit participant reported that it is unable to start its blackstart resource on alternate fuel (distillate oil) without first starting the blackstart resource using its primary fuel (natural gas). While it takes less than five minutes and a low consumption of natural gas to start and switch to alternate fuel, the engineering and design of its blackstart resource renders it unable to start up exclusively on alternate fuel.

One generating unit participant noted that it could start up its blackstart resource exclusively on alternate fuel, or switch to alternate fuel while its blackstart resource is already running on primary fuel. Since Winter Storm Uri, this participant started doing internal blackstart testing to provide additional practice for its operating personnel. This participant reported that it usually performs two to three additional blackstart tests per year, and newly hired personnel participate in these blackstart tests. One generating unit participant reported that it performs periodic fuel switching tests to identify and correct any issues that may arise and negatively impact its blackstart resources in the event of an extreme cold weather event. These periodic tests are performed once a month during the winter season and quarterly otherwise. This participant stated that it gained valuable knowledge through this additional testing, which it may not have gained otherwise.

At the time of this study, the ISO did not require blackstart resources to demonstrate, through testing, their ability to start up using alternate fuel. Going forward, the ISO stated that it plans to include a requirement in its request for proposal for blackstart resources to test their ability to start up using alternate fuel.

CONCLUSIONS

While the joint study team finds that expanded blackstart testing could provide significant additional insight into and validation of an entity's blackstart system restoration plan, it imposes additional burdens, and may not be feasible or advisable in certain situations including situations that would require shedding residential customer load. Accordingly, the joint study team recommends that entities consider voluntary expanded blackstart testing where feasible to confirm viability of blackstart capability. Entities could gain valuable experience and insight from voluntarily expanding testing and performing fuel-switching tests, which could be used to update and refine their operating procedures. Furthermore, blackstart and next-start resources in close proximity should consider performing voluntary expanded testing where feasible. While a blackout could occur at any time, blackouts become more problematic for blackstart system restoration when coupled with extreme cold weather. Therefore, to properly simulate a blackout in extreme cold weather, blackstart resources should perform fuel switching tests in actual cold weather, when feasible. Such testing could show how long it takes a blackstart resource to heat up and be operational when needed, and whether the blackstart resource experiences any fuel gelling issues. The joint study team finds these to be important elements that entities can use to better prepare for blackstart system restoration scenarios in the event of extreme cold weather.

The joint study team concurs with the ISO's plan to require fuel switching tests of blackstart resources and encourages the ISO to consider implementing testing requirements for blackstart resources to perform startup tests solely on alternate fuel and with the complete removal of any utility-supplied electricity sources. In addition, the joint study team concludes that the ISO should implement and clarify testing requirements for blackstart resources to perform startup tests solely on alternate fuel with the complete removal of any utility-supplied electricity sources. These tests would better prepare blackstart resources for blackstart system restoration scenarios and help ensure that blackstart resources can start on alternate fuel or without utility-supplied electricity during a blackout.

RECOMMENDATION

- **Entities responsible for developing and implementing a blackstart system restoration plan should:**
    - **Implement a testing requirement for blackstart resources to perform alternate fuel 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.

OBSERVED PRACTICES FOR CONSIDERATION

- Conducting fuel switching and alternate fuel tests periodically on blackstart resources during normal operations and in actual cold weather to practice fuel switching and ensure functionality of blackstart resources.

- Performing expanded testing, where feasible, to confirm the viability of blackstart capability through coordination between blackstart resources and transmission entities. Expanded testing could be used to confirm the viability of blackstart system restoration plans as well as to update system models and blackstart system restoration training programs.

Blackstart and System Restoration Operating Personnel Training Practices, and Procedures

INTRODUCTION

The joint study team assessed the participants' blackstart operating personnel training practices and procedures. The purpose of the assessment is to better understand the recent blackstart system restoration trends pertaining to training practices and procedures during, or as a result of, extreme cold weather conditions. The joint study team examined the ISO-led blackstart simulator trainings, entity-specific trainings, and operating procedures that incorporated lessons learned since Winter Storm Uri to assess participants' preparedness for extreme cold weather.

The ISO considers many different real-world conditions, including actual electrical system topology,[88] in its annual joint blackstart simulation training.[89] Some participants stated that they perform additional, internal blackstart simulation trainings outside of the ISO's annual blackstart simulation training. Lastly, several participants reported that it has been helpful to track and document issues that occur during testing, trainings, and events, to ensure that they are promptly addressed and that the issues do not recur.

88 Electrical system topology is defined by the connectivity among power system components such as generators, power transformers, transmission lines, loads, etc.

89 The ISO invites generation and transmission entities within the ISO's blackstart system restoration plan to participate in the ISO's annual joint blackstart simulation training.

OBSERVATIONS

ISO's Blackstart Simulations and Training

The Reliability Standards require all generating unit and transmission participants to attend an annual ISO-led blackstart training simulation.[90] During the annual training, electric entity personnel are typically on-site with ISO staff experiencing and responding to the same blackstart system restoration scenario. Since the participants may not have interactions outside of an actual event, the annual ISO-led blackstart simulation training facilitates interaction and dialogue between entities. Due to the COVID-19 pandemic, the ISO modified its annual blackstart simulation training during 2021 and 2022 to include a hybrid option (in person and virtual). Some generating unit and transmission participants reported that the hybrid training option was helpful in simulating a more realistic blackstart system restoration scenario because the communications mirrored that of an actual event. Other participants stated that they preferred to be in-person for the annual ISO-led blackstart simulation training because they were able to meet parties with whom they would interact during an actual event.

Generating unit and transmission participants reported that the ISO uses actual system topology rather than a generic system in blackstart training simulations. These participants stated that use of actual system topology assisted in gaining familiarity with the blackstart system restoration plan. While the ISO incorporates cold load pickup[91] into its simulation, its simulator does have limitations. Transmission participants stated that cold load pickup in the ISO's simulator takes about 30 minutes, and may not reflect load characteristics that would be experienced during a blackstart restoration scenario, particularly if the blackout occurs during extreme cold weather. The ISO also incorporates lessons learned from past events to provide operators with experience from real-world scenarios. Also, the ISO noted that while its annual joint blackstart simulation trainings discuss Underfrequency Load Shedding (UFLS) concepts as well as adding and shedding load, a specific training that focuses exclusively on UFLS/ Undervoltage Load Shed (UVLS) during a blackstart system restoration scenario would be helpful.

The ISO informed the joint study team that it is continually pursuing opportunities to enhance its simulation capabilities to allow for a more realistic blackstart simulation training. One gas participant reported that the ISO is planning to incorporate gas entities into its annual blackstart simulator training; this participant plans to attend future ISO-led trainings. One transmission participant suggested that next-start resources, which are critical to the restoration process, should also participate in the annual ISO led blackstart restoration simulation training. The joint study team agrees with the ISO's plan to expand participation to entities outside the electric industry and believes it should also expand it to include other entities that would have a role in blackstart system restoration, such as next-start resources.

Participants' Internal Blackstart Simulations and Training

Some generating unit and transmission participants reported that not only do they participate in the annual ISO-led blackstart simulation trainings, but they perform additional internal blackstart simulation trainings. Another generating unit participant reported that its internal blackstart trainings consist of an actual blackstart resource test that is used for practice in preparation for the ISO's certification testing. Additionally, one transmission participant

90 Reliability Standard EOP-005-3, Requirements R10 and R16.

91 Cold load pick up is an overcurrent condition that occurs when a distribution circuit is reenergized following an extended outage. This is because the load has reached a "cold" state before being reenergized due to an extended lack of power supply. For instance, during restoration, when residential load is re-energized, it results in a sharp increase in load, which is challenging to manage.

reported that restoring priority loads are a specific objective in its internal blackstart trainings. Another transmission entity stated that its internal blackstart training occurs annually with participation from its transmission and distribution personnel. Some transmission participants found it beneficial to incorporate injects,[92] such as extreme cold weather scenarios, into their internal blackstart restoration trainings. Doing so has allowed these participants to address specific communication issues, improve situational awareness, and practice pre-event preparations for cold weather. Multiple transmission participants reported that they emphasize cold load pick up in their internal blackstart trainings because of the attention to detail required by operators in managing high currents produced during cold load pickup. Internal blackstart simulator trainings can manipulate a distribution feeder's megawatt loading to simulate a field crew isolating sections of the feeder to address cold load pick up.

One transmission participant noted that its internal blackstart system restoration plan includes a list of blackstart-capable resources beyond those included in its blackstart system restoration plan. One gas participant reported that, although it does not currently have a specific blackstart system restoration plan, its emergency response plan addresses various emergency scenarios when the plan would be activated, including a blackout. This gas participant noted that it provides training to its personnel on this emergency response plan annually.

The joint study team collected perspectives on the categories of personnel that are useful to include in participants' training activities. Some participants indicated that it has been helpful to include both transmission and distribution system operators as well as field personnel in their internal blackstart restoration trainings. Consistent with Reliability Standard EOP-005-3, one transmission entity reported that its field personnel participate in cold weather trainings annually and blackstart restoration trainings every two years. Also, generation dispatchers are invited to this participant's internal blackstart trainings and are actively involved in the simulation. This array of roles provides the generation dispatchers with further insight into the blackstart and next-start resources within the transmission participant's service area.

Internal Blackstart Operating Procedures and Lessons Learned

All generating unit and transmission participants reported that they update their internal procedures annually. One generating unit participant reported that it maintains a contact list of plant personnel within its operating procedures as well as on a third-party cloud-based system to ensure that the contact list is easily accessible remotely. Prior to an event, this participant circulates the contact list with a schedule detailing roles and responsibilities to its personnel. This participant also found it beneficial for the contact list and roster to be distributed as part of meeting invites during an emergency event, such as extreme cold weather, so that participants in these meetings are aware of who is on shift during the event and how best to contact the relevant personnel.

Another generating unit participant reported that it uses a notice-of-change form for its blackstart procedures. Through this notice-of-change form, all personnel certify that they have reviewed the changes in blackstart procedures, which are also documented in operator logs. This process ensures that personnel are aware of any changes to blackstart operating procedures that could affect their work. One generating unit participant noted that its personnel review all blackstart procedures following procedure revisions to help ensure that personnel are aware of changes that could affect operations in the event of an extreme cold weather event or blackstart system

92 An "inject" is the simulation of a scenario that is outside the anticipated sequence of events. For example, an inject during blackstart system restoration simulation could include the hypothetical loss of communications or the forced outage of a high voltage facility. The participants must factor in the complication in their response to the simulation scenario.

restoration scenario. Furthermore, another generating unit participant stated that changes to its internal operating procedures are accompanied by personnel trainings on these changes to ensure that personnel are not only aware of the changes but understand how the new procedures would work and the potential impacts on operations from these changes.

All of the generating unit and transmission participants reported that they incorporate lessons learned into their operating procedures and internal blackstart trainings. One generating unit participant stated that it incorporates and implements lessons learned from prior events into its plant-specific winterization procedures within two months of an event. Another generating unit participant reported incorporating more frequent trainings for its personnel after discovering opportunities for improvement during Winter Storm Uri. This participant found it helpful to hold annual lessons learned meetings with personnel to update its internal operating procedures and blackstart trainings. As part of its lessons learned process, one generating unit participant documented approximately 100 issues experienced by its blackstart resource during Winter Storm Uri. After the event, the entity reviewed the documented list and made modifications to prevent recurrence during future cold weather events. One gas participant stated that, after Winter Storm Uri, it updated its winterization procedures by identifying potential issues every year beginning in August so that lessons learned can be incorporated into the procedures prior to winter.

Training on Alternate Communication Methods

Most of the generating unit and transmission participants reported that they have various means of communication should the phone lines go down during an emergency or blackstart system restoration scenario. Many participants noted that they have satellite phones or have access to the Government Emergency Telecommunications Service (GETS)[93] to maintain communication when needed.[94] One gas participant stated that it also has access to Wireless Priority Service (WPS)[95] to allow personnel to make calls when a major incident prevents wireless phone lines from operating. However, an employee must first have access before receiving training on how to use these services.

CONCLUSIONS

The ISO has simulations and trainings in place for its blackstart resource and blackstart system restoration personnel. The ISO could gain valuable insight by inviting natural gas entities and next-start resources to participate in its ISO-led blackstart restoration simulation trainings. Doing so could help improve blackstart coordination and communication for all entities in the event of an emergency or blackstart system restoration scenario. Furthermore, the joint study team concludes that simulating real-world conditions, including extreme cold weather, and incorporating lessons learned into simulations is beneficial as it better prepares entities for an actual event. In addition, where feasible, generating unit entities should test the blackstart resources during cold weather periods, and incorporate injects, such as the removal of equipment that may be affected during cold weather. These tests could provide lessons learned specific to cold weather that could be incorporated into operational procedures. The joint study team also finds that tracking lessons learned during an event and incorporating the lessons learned into entity-specific trainings may help entities better prepare for emergencies and blackstart system restoration scenarios. Additionally,

---

93 A program run by the U.S. Department of Homeland Security, Office of Emergency Communications. This program prioritizes calls over wireline networks. See Government Emergency Telecommunications Service, Federal Communications Commission (July 5, 2023), https://www.fcc.gov/general/government-emergency-telecommunications-service.

94 Reliability Standard COM-001-3 (Communications), available at https://nerc.com/pa/Stand/Reliability Standards/COM-001-3.pdf.

95 For GETS program users to received priority access over cellular communication networks, they must use the WPS program. GETS and WPS can be used in combination.

entities could gain valuable insight and experience by completing additional blackstart simulation trainings outside of the ISO-led simulation training, such as the ISO's computer-based trainings, which could help ensure that operators are well versed in the entity's internal blackstart system restoration plan. The joint study team understands the benefit of internal blackstart simulations and trainings, including how these activities could prepare both electric and natural gas entities to conduct island-specific restoration. Such island specific training can identify where communication and coordination between the electric and natural gas entities in the restoration process is needed to facilitate a coordinated blackstart system restoration. In addition, the joint study team concludes that entities should perform island-specific restoration trainings that include transmission, distribution and generation operators, and natural gas entities within respective islands to help facilitate a coordinated blackstart system restoration. Furthermore, the joint study team finds that more frequent trainings on alternate communication methods could better prepare entities for emergency situations, including extreme cold weather. Also, tracking and documenting issues that occur during testing, trainings, and events, ensure that these issues are promptly addressed and that the issues do not recur.

Lastly, the joint study team concludes that identifying blackstart-capable resources beyond those included in an entity's blackstart system restoration plan provides the ISO with flexibility and redundancy. This could help mitigate the impact of blackstart resources becoming unavailable during restoration. Documenting blackstart-capable resources in an entity's internal blackstart system restoration plan also makes operators aware of those units and their capabilities in the event of a blackstart system restoration scenario.

OBSERVED PRACTICES FOR CONSIDERATION

- Training personnel regularly on the use of alternate communication methods to better prepare for emergency scenarios, including extreme cold weather, when common carrier and wireless communication networks may be compromised.

- Including natural gas entities and next-start resources to participate in the annual ISO-led joint blackstart restoration simulation trainings to improve blackstart coordination and communication in the event of an emergency or extreme cold weather.

- Completing internal blackstart trainings, in addition to the ISO-led blackstart training, to ensure that transmission operators are well versed in the blackstart system restoration plan.

- Involving field personnel in cold weather trainings and blackstart restoration trainings to improve generating and transmission entities' response during an emergency or extreme cold weather event. Involving newly hired personnel in blackstart testing will help familiarize them with the internal operating procedures.

- Tracking and documenting issues that occur during testing, training, and events to ensure that they are promptly addressed, and the issues do not reoccur. Incorporating any lessons learned into procedures to prevent known issues from recurring in extreme cold weather scenarios.

- Maintaining a list of blackstart-capable resources not identified in blackstart system restoration plans that could be used during an emergency or extreme cold weather conditions if other blackstart resources are unavailable. These blackstart-capable units would add resiliency, flexibility, and redundancy to blackstart system restoration plans.

FINAL CONCLUSION

The observed practices for consideration and recommendations noted above apply to both the electric and natural gas industries necessary to blackstart system restoration regarding practices, procedures, and methodologies aimed at improving blackstart system restoration overall, as well as blackstart capability planning and testing. In addition, the joint study team highlights the need for the electric and natural gas industries to work together to develop a joint blackstart system restoration plan that considers extreme cold weather conditions and the mutual interdependence of these two complex and important industries. While the recommendations in this report are voluntary and impose no obligations beyond those required by the relevant Reliability Standards, the joint study team strongly urges that the report's recommendations and observed practices for consideration be implemented in the Texas Interconnection, as well as other regions of the country with a similar blackstart resource mix.

APPENDICES

APPENDIX 1 - JOINT STUDY TEAM MEMBERS LIST

Federal Energy Regulatory Commission:

Chanel Chasanov (Co-Lead)
Robert Clark (Co-Lead)
Coboyo Bodjona
Norris Henderson*
David Huff
Ray Orocco-John
Jeffrey Fang
Heather Polzin

Midwest Reliability Organization:

Mark Tiemeier

North American Electric Reliability Corporation:

Kiel Lyons
David Till

Northeast Power Coordinating Council, Inc.:

Ryan McSherry
Andrey Oks

ReliabilityFirst:

Derek Kassimer**
Dwayne Fewless

SERC Reliability Corporation:

Dave Krueger

Texas Reliability Entity, Inc.:

Mark Henry (Co-Lead)
David Penney

Western Electricity Coordinating Council:

Curtis Holland
Bert Peters

*Contributed to portions of the study; a former FERC employee.
**Contributed to portions of the study; a former ReliabiltiyFirst employee.

APPENDIX 2 - REQUEST LETTER FOR PARTICIPATION

On November 16, 2021, the Commission posted to its web site the *FERC-NERC- Regional Entity Staff Report: The February 2021 Cold Weather Outages in Texas and the South Central United States* ("Report").[96] Among the Report's 28 recommendations made to improve electric generation and natural gas infrastructure cold weather reliability, grid emergency operations and seasonal preparedness for cold weather, it made several recommendations for further study. In accordance with Recommendation 26, Commission staff, in collaboration with NERC and Regional Entity staff, is implementing a joint study of blackstart availability in the ISO's Interconnection during cold weather conditions.[97]

The joint staff study will evaluate a representative sample of transmission and generator operators' blackstart and grid restoration plans, procedures, and resources which, in the event of a blackout,[98] would be used to aid in restoring the ISO's electricity grid. The evaluation will include review of provisions for blackstart generation resources and for next-start generating units, for cases where restoration depends on startup of those generating units. 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) may also be asked to participate to achieve a more comprehensive review.

The joint staff study team plans, via outreach with a select sample of industry entities, to gain understanding of:[99]

- characteristics of blackstart and next-start generation resources relied upon in system restoration plans for the ISO's Interconnection, including, where applicable:
    - winter weatherization measures
    - primary fuel provisions (commodity supply and delivery contracts, characteristics of delivery and on-site infrastructures for use of fuel)
    - alternate fuel provisions (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 (e.g., gelling prevention) to ensure resource operability when needed.
    - energy storage resources (non-fuel) that may be associated with blackstart plans and procedures

---

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

97 *See* Report, Recommendation 26, at pp 236-238 (recommending that a joint FERC-NERC-Regional Entity study blackstart unit availability in the [ISO's] footprint during cold weather conditions, and providing suggested scope for that study).

98 During the February 2021 cold weather event, while there were rotating outages of electricity to customers (manual firm load shed) in Texas which subsequently required restoration when grid conditions improved, [the ISO's] Interconnection did not incur a blackout that would have depended on the use of blackstart generating units to restore power to its electricity grid. See Report at 10, 157, and 236.

99 Relevant documents and information may be requested for review during the entity outreach, such as through on-site visits.

- characteristics of fuel supply contracts and delivery infrastructure for the above-identified blackstart and next-start generation resources, including:
    - energy sources relied on for delivery of primary and alternate fuels to blackstart and next-start generation resources (e.g., electricity sources to natural gas compressors)
    - where applicable, sources of electricity relied on for natural gas and alternate fuel infrastructure delivery to blackstart and next-start resources
    - whether multiple blackstart and next-start resources are dependent on a single natural gas pipeline
    - how delivery of natural gas and alternate fuel is prioritized among other end-user delivery priorities to ensure delivery of fuel to blackstart and next-start resources
- testing blackstart and fuel-switching capabilities, including:
    - testing of blackstart capability from both primary and alternate fuels
    - testing of capability to switch from primary to alternate fuel during blackstart testing
    - removal of any utility-supplied electricity sources for alternate fuel provisions for the test
- blackstart operating personnel training practices, procedures, and resources, including for:
    - generator operators, including plant operations personnel
    - transmission 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.

This collaborative assessment by the Commission, NERC and the Regional Entities is an important step in protecting reliability by gauging the level of preparation and the ability to restore the Bulk-Power System quickly and efficiently. We plan to gain insights and make recommendations to benefit reliability across industry. In anticipation of Company A's participation, we thank you and will work closely with you to ensure this project is conducted as a partnership with minimal disruption to your organization. My staff will contact you at your earliest convenience regarding any questions or concerns that you may have about this joint staff review.

APPENDIX 3 - SUMMARY OF LITERATURE REVIEW

October 2023 –Joint FERC-NERC Regional Entity Report on the Inquiry into Bulk-Power System Operations During December 2022 Winter Storm Elliott

In December 2022, Winter Storm Elliott impacted the reliability of the bulk electric system and the supporting natural gas infrastructure in the Eastern Interconnection. It was also the fifth event in the past 11 years in which unplanned cold weather-related generation outages jeopardized grid reliability. The report included recommendations for another joint study to look into the availability and readiness of blackstart units that are selected to operate during cold weather conditions. It was noted that these studies should cover all portions of the United States not already studied, with a focus on the Eastern and Western Interconnections. The report recognized that the availability and readiness of blackstart units is paramount to the reliability of the grid during extreme cold weather conditions.

September 2023—NERC's White Paper on Grid Forming Functional Specifications for Bulk-Power System Connected Battery Energy Storage Systems

In September 2023, NERC released a white paper on the advancements in grid forming technology and its applicability to inverter-based resources in the Bulk-Power System. NERC reports that grid forming technology is needed for inverter-based resources to maintain stable operations. NERC states that grid forming functionality is a prerequisite for an inverter-based resource to provide blackstart service and that the technological advances and future research efforts in this field could help in the development and adoption of grid forming technology in blackstart applications.

July 2023 – NAESB Gas Electric Harmonization Forum Report

In July 2022, FERC and NERC wrote a letter encouraging NAESB to expeditiously convene a forum to discuss gas electric coordination, to address activities described in Key Recommendation 7 of the 2021 Cold Weather Report. As a result, NAESB reconvened its Gas Electric Harmonization (GEH) Forum. The resulting report contains twenty recommendations for action that the industry, FERC, the National Association of Regulatory Utility Commissioners (NARUC), state public utility commissions, applicable state authorities, and the Department of Energy could take to address recurring challenges stemming from natural gas-electric infrastructure interdependency.

February 2021 – Winter Storm Uri and the November 2021 Joint FERC-NERC-Regional Entity Report

In February 2021, Winter Storm Uri led to the largest controlled firm load shed event in U.S. history, with over 4.5 million people losing power and at least 210 people losing their lives during the event. Shortly thereafter, the Commission, along with NERC and the Regional Entities, initiated a joint staff inquiry into Winter Storm Uri that resulted in the issuance of a joint report in November 2021. The November 2021 report included recommendations for further joint studies to look into the reliability of certain resources during extreme cold weather events as well as Reliability Standard enhancements to improve extreme cold weather operations, preparedness, and coordination. Recommendation 25 suggested that the ISO conduct a study to evaluate the benefits of additional links between the ISO's Interconnection and other interconnections that could provide additional reliability benefits. Recommendation 26 suggested that a joint FERC-NERC-Regional Entity team study blackstart unit availability in the ISO's footprint during cold weather conditions.

Recommendations 25 and 26 both arose from observations about the performance of Texas blackstart units during Winter Storm Uri. During Winter Storm Uri, the ISO had 28 (primary and alternate) blackstart resources within its footprint (100 percent using natural gas as their primary fuel, while some had an alternate fuel as well). The

November 2021 report concluded that the high percentage of Texas blackstart units that were unavailable during Winter Storm Uri was a cause for concern, especially given that the ISO cannot rely on imports to restore the system in the event of a blackout. Thus, the recommendation for a study under Recommendation 26 was developed to help the ISO improve the reliability of their restoration plan.

Report on Energy Storage and the Impact of Battery Energy Storage Systems on the Bulk-Power System from February 2021

In February 2021, NERC released a report on the impact of battery energy storage systems on the Bulk-Power System. NERC found that with the increase in inverter-based resources, there has been an increase in the application of battery energy storage systems on the Bulk-Power System. NERC stated that battery energy storage systems are capable of complementing inverter-based resources by providing some of the essential reliability services that are important to maintaining Bulk-Power System reliability. Further, battery energy storage systems provide elements of grid support to support new peaking conditions. NERC determined that advances in technology, decreasing costs, and changes to FERC and other market rules will promote battery energy storage system growth, which will enhance grid reliability.

Report on the FERC-NERC Regional Entity Joint Review of Restoration and Recovery Plans from May 2018

The objective of this study was to assess the current state of blackstart resource availability and registered entities' strategies for replacement of blackstart resources and verify whether and how registered entities conduct testing of blackstart resources under anticipated blackstart conditions, including identifying methods and practices that could be used to improve other registered entities' blackstart system restoration plans and trainings. The report found that although some participants experienced a decrease in the availability of blackstart resources due to the retirement of blackstart-capable units over the past decade, there were sufficient blackstart resources in the entities' blackstart system restoration plans, as well as comprehensive strategies for mitigating against the loss of any additional blackstart resource going forward. The report also concluded that participants that performed voluntary expanded testing of blackstart capability, including testing energization of the next-start generating unit, gained valuable knowledge that was used to modify, update, and improve blackstart system restoration plans and blackstart system restoration drills. The report provided recommendations for industry-wide considerations regarding practices, procedures, and methodologies aimed at improving blackstart system restoration overall, and blackstart planning and testing. The report also noted beneficial practices employed by individual participants.

IID Demonstrates Battery's Emergency Blackstart Capability – Press Release from May 16, 2017

This press release describes a battery energy storage system installation commissioned by Imperial Irrigation District (IID) in California. The system is a 33-megawatt (MW), 20megawatt-hour (MWh) lithium-ion battery energy storage system that went on-line in October 2016. IID's energy storage system was created to increase voltage stability, balance power, mitigate large fluctuations of energy, and deliver blackstart power restoration capabilities to IID's nearby El Centro gas generation plant. On May 10, 2017, the energy storage system successfully supplied electricity to start IID's 44-MW combined-cycle natural gas turbine at the El Centro Generating Station. While energy storage system provided El Centro with startup power, it also converted the power to allow the generator to synchronize. Thus, in the event of a future blackout, IID can employ its battery energy storage system to produce electricity to startup its power plants thereby increasing the resiliency of IID's grid.

Report on the FERC-NERC Regional Entity Joint Review of Restoration and Recovery Plans from January 2016

In September 2014, FERC, NERC, and its Regional Entities initiated a joint staff review to assess entities' plans for restoration and recovery of the Bulk-Power System following a widespread outage or blackout. The objective of the review was to assess and verify the electric industry's Bulk-Power System recovery and restoration planning, and to test the efficacy of related Reliability Standards in maintaining and advancing reliability in that respect. The report concluded that the study participants had blackstart system restoration plans that, for the most part, were thorough and highly detailed. The report determined that the reviewed plans required the identification and testing of blackstart resources, identification of primary and alternate cranking paths, and periodic training and drilling on the restoration process under a variety of outage scenarios. The report also found that each study participant had full time personnel dedicated to the roles and responsibilities outlined in their respective response and recovery plans. The report provided recommendations for improving blackstart system restoration, cyber incident response, and recovery planning and readiness. The report also noted beneficial practices employed by individual participants.

Hitachi Energy's Sharyland Railroad DC Tie in Texas

The Sharyland Railroad DC tie enables power exchanges between the ISO's Interconnection and the Mexican national grid. HVDC technology enables bi-directional power flow between both grids, thereby allowing each grid to rely on the others in times of emergencies, extreme cold weather, or peak demand. The Sharyland interconnection is an essential installation because even though the American and Mexican power networks have the same fundamental power frequencies, they operate independently and thus, could have different frequency and voltage variations. The Sharyland's power converters ensure that power moving in either direction is synchronized with the power network into which it is flowing.

The Laredo Variable Frequency Transformer Project in Texas

The Laredo variable frequency transformer established an asynchronous transmission link between Texas and Mexico's Comisión Federal de Electricidad. This variable frequency transformer technology provided a controlled transmission path between Texas and Mexico's electrical grids, allowing a power exchange that was previously impractical and risky due to asynchronous boundaries. GE Energy's variable frequency transformer technology is an alternative to back-to-back high voltage DC convertors by allowing customers to control power between two asynchronous grids with less risk compared to conventional technologies. The Laredo variable frequency transformer provides Texas with the highest degree of flexibility by allowing the scheduling of power transfers in high load periods, while maintaining a reliable power supply.

The ISO's Blackstart Working Group

The ISO states that their blackstart working group is responsible for planning blackstart services and suggesting improvements to the blackstart process. The group reviews the ISO's blackstart plan, individual blackstart resource startup procedures, cranking paths, and individual transmission service provider blackstart plans. They also discuss topics such as backup communication, sync scope installation, blackstart related operating procedures, compliance issues. The blackstart working group reports its activities to the ISO's reliability and operations subcommittee on a regular basis. Any member or prospective member of the blackstart working group must sign the appropriate Non-Disclosure Agreement and receive approval from the ISO.

ISO-NE Real-Time Maps and Charts and Electronic Bulletin Boards (EBBs)

ISO-NE provides a wide variety of viewable and downloadable public data to market participants and other interested stakeholders. Real-time maps, graphs, and data tables for power system conditions, system load, resource mix, load forecast, system demand forecasts and reports are provided in these public websites.[100] ISO-NE also has an electronic bulletin board (EBB); the EBB is a communication system that allows registered users to view timely information about available capacity and react by entering data, requesting new data, and/or requesting files to be transferred.

100 *See Real-Time Maps and Charts, ISO New England*, https://www.iso-ne.com/isoexpress/web/charts (last visited July 6, 2023).

APPENDIX 4 - GLOSSARY OF TERMS AND ACRONYMS USED IN THIS STUDY

Alternating Current (AC): Electric current that changes periodically in magnitude and direction with time. In power systems, the changes follow the pattern of a sine wave having a frequency of 60 cycles per second in North America.

Asynchronous: In AC power systems, two systems are asynchronous if they are not operating at exactly the same frequency. Two systems may also be considered asynchronous if, at potential interconnection points, there is a significant difference in phase angle between their respective voltage waveforms.

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: A generating unit(s) and its associated set of equipment that 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.

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

Blackstart System Restoration Scenario: The complete interruption of power in a given service area. This can also be referred to as a blackout.

Block Load Transfer: A transfer system that isolates a group of load from the control area in which they normally are served and then connects them to another control area.

Bulk Electric System: 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; it can be found at: https://www.nerc.com/pa/Stand/Glossary%20of%20Terms/Glossary_of_Terms.pdf .

Bulk-Power System: 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.

Demand: (1) The rate at which electric energy is delivered to or by a system or part of a system, generally expressed in kilowatts or megawatts, at a given instant or averaged over any designated interval of time; or (2) the rate at which energy is being used by a customer.

Direct Current (DC): Electric current that is steady and does not change in either magnitude or direction with time. DC is also used to refer to voltage and, more generally, to smaller or special purpose power supply systems utilizing direct current either converted from AC, from a DC generator, from batteries, or from other sources such as solar cells.

DC Tie: Any non-synchronous transmission interconnection.

Distribution Provider: Provides and operates the "wires" between the transmission system and the end-use customer.

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.

Droop Speed Control: A control mode used for generators where the power output of the generator changes as the frequency changes.

Electrical Bypass: An alternative path for certain frequencies in an electrical circuit. It can be used to reroute power away from one or more components without interrupting the power supply to a particular structure.

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.

Expanded Testing: Expanded testing involves testing beyond the currently required blackstart testing (up to energizing a dead bus), including energizing the transmission line and the next-start generating unit, to ensure that the blackstart generating unit can energize equipment needed to restore the system as intended.

Extreme Cold Weather Event: 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.

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 (or Firm Demand): 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 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.

Gas Desk: A gas desk stores information that could provide situational awareness that ties the natural gas and electric infrastructure together at their common point of operation.

Gas Utilization Tool (GUT): A specific tool to visualize natural gas infrastructure.

Generator Operator: 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: 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 Power Producer (IPP): Any entity that owns or operates an electricity generating facility that is not included in an electric utility's rate base. This term includes, but is not limited to, co-generators and small power producers and all other non-utility electricity producers, such as exempt wholesale generators, who sell electricity.

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.

Interstate: Activity occurring between states or across state boundaries. Interstate natural gas pipelines carry natural gas across state boundaries.

Intrastate: Activity occurring exclusively within a single state. Intrastate natural gas pipelines operate within a single state's borders and link natural gas producers to local markets and the interstate pipeline network.

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.

Isochronous Mode: In an isochronous mode, a generator's output is controlled to maintain a constant frequency, rather than voltage, by adjusting the speed of the generator in response to changes in the load demand. The speed governor of the generator is designed to respond quickly to changes in the load demand, ensuring that the frequency remains constant. Isochronous mode is typically used when a generator either stands alone or is the largest unit on a grid.

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.

Nomination(s): A request to move a specified amount of gas from one location to another on a certain date. This request may be made prior to the day of gas flow or at specific times during the flow day.

No-notice Gas: Allows entities to receive gas without nominations, but at a premium price.

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.

Off-Line: The status of a resource that is not synchronously interconnected to the Bulk-Power System.

On-Line: The status of a resources that is synchronously interconnected to the Bulk-Power System.

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.

Operational Flow Order (OFO): A mechanism to protect the operational integrity of the pipeline. It requires shippers to balance their natural gas supply with their customers' usage.

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.

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

Priority Load: Specific load identified in a system restoration plan, whose prolonged interruption may have an undesirable impact on health, safety, and the environment, and are thus, targeted for early restoration. Priority load may include off-site power for nuclear generating stations (to maintain safe shutdowns), cranking power to certain generating units, power to natural gas infrastructure, power to pumping stations for oil pipelines, military installations and flood water control installations, power to hospitals, and other emergency operations.

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.

Regional Transmission Organization (RTO): An electric power transmission system operator that coordinates, controls, and monitors a multi-state electric grid.

Reliability Coordinator: 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 and enforced by FERC under Section 215 of the Federal Power Act, or approved or recognized by an applicable governmental authority in other jurisdictions, to provide for the reliable operation of the Bulk-Power System.

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.

Spot Market: A short-term market in which energy is sold or purchased for immediate delivery.

Supervisory Control and Data Acquisition (SCADA): A system of remote control and telemetry used to monitor and control the transmission system

Synchronize: The process of bringing two electrical systems together by closing a circuit breaker at an interface point when the voltages and frequencies are properly aligned.

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 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.

Tolling Arrangement: A contract arrangement under which a raw material or intermediate product stream from one company is delivered to the production facility of another company in exchange for the equivalent volume of finished products and payment of a processing fee. In the context of an electrical generator, the generator itself is the "production facility," the "raw material" is fuel, and the "finished product" is electricity.

Transmission Operator: 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: The entity that owns and maintains transmission facilities.

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

Underfrequency Load Shedding (UFLS): A method used to balance generation and load when a system event, such as the loss of a large generating unit or multiple generating units occurs, causing a significant drop in frequency throughout an interconnection or islanded area. Generally, this can be looked at as an automatic response associated with a decline in frequency to rebalance the system.

Undervoltage Load Shedding (UVLS): A method that trips load offline to prevent or avoid voltage collapse scenarios which can lead to cascading outages, through the use of specific voltage settings – not frequency settings. When predetermined voltage levels and timing requirements are met, a signal is sent to open designated circuit breakers shedding load to improve system voltage.

Utility-supplied Electricity: The electricity sources external to the generation resource.

Variable-Frequency Transformer: A double fed electric machine that is used to transmit electricity between two (asynchronous or synchronous) alternating current frequency domains. The variable frequency transformer behaves as a continuously adjustable phase-shifting transformer that allows control over the power flow between two networks.

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.