2025 Assessment of Reliability Performance

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June 3, 2026

Antitrust Admonition

Because this event brings together market participants who may be viewed as actual or potential competitors, we must be mindful to conduct it in a manner that is consistent with the antitrust and competition laws. Participants should not disclose non-public, proprietary, or competitively sensitive information.

Attendees should exercise independent judgment and avoid even the appearance of discussions of agreements or concerted actions that may be viewed as restraining competition. Any questions on Texas RE's Antitrust Compliance Corporate Policy may be directed to Texas RE's General Counsel.

Upcoming Events at Texas RE

June 23, 2026

Integration of Large Loads

June 30, 2026

Regional Risk Series: Supply Chain

July 13, 2026

Artificial Intelligence in Energy

Upcoming Events at Texas RE

Public

August 19, 2026

Winter Weatherization Workshop

September 16, 2026

Q3 MRC and Board Meetings

November 4, 2026

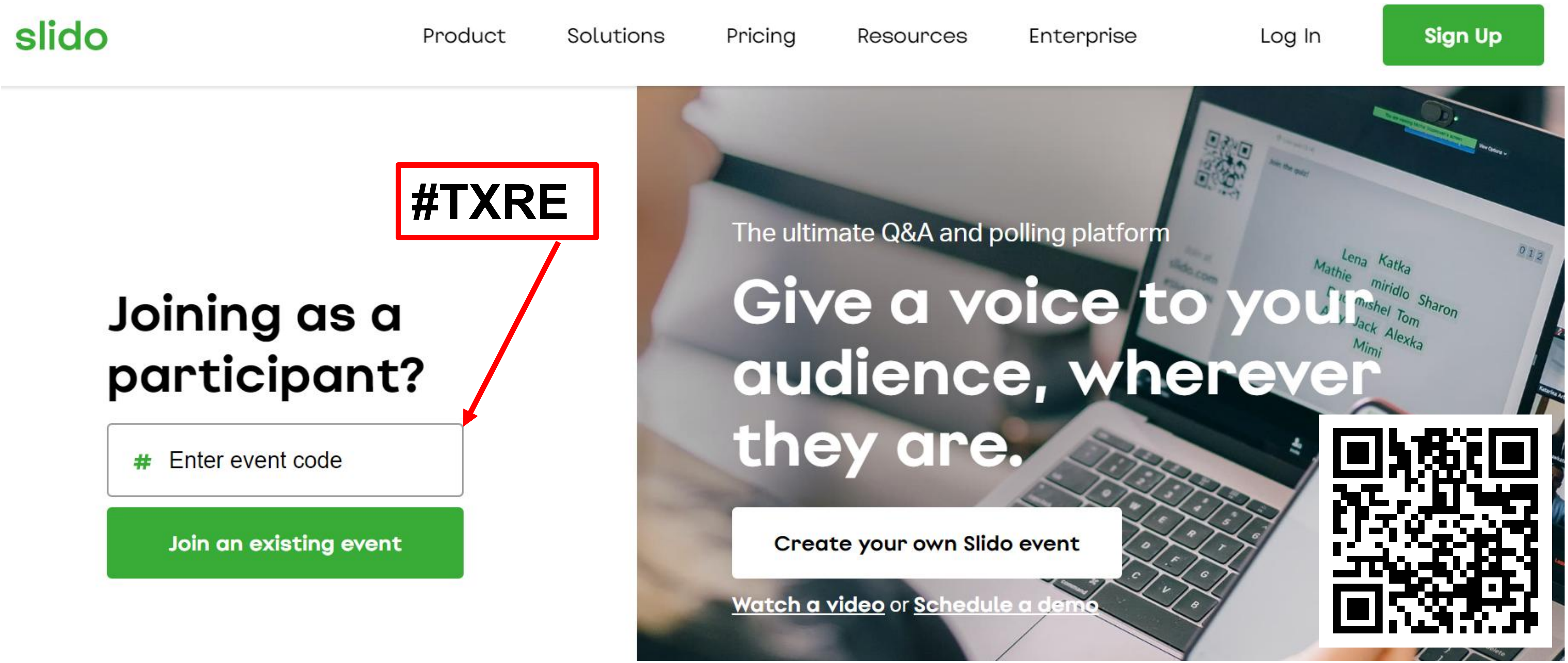
Fall Standards, Security, & Reliability Workshop

Upcoming ERO Enterprise Events

Date	Event
June 23-25, 2026	WECC Reliability Fundamentals
July 13, 2026	Technical Talk with RF
July 29, 2026	SERC IBR Seminar #3

Slido.com

Public



Assessment of Reliability Performance

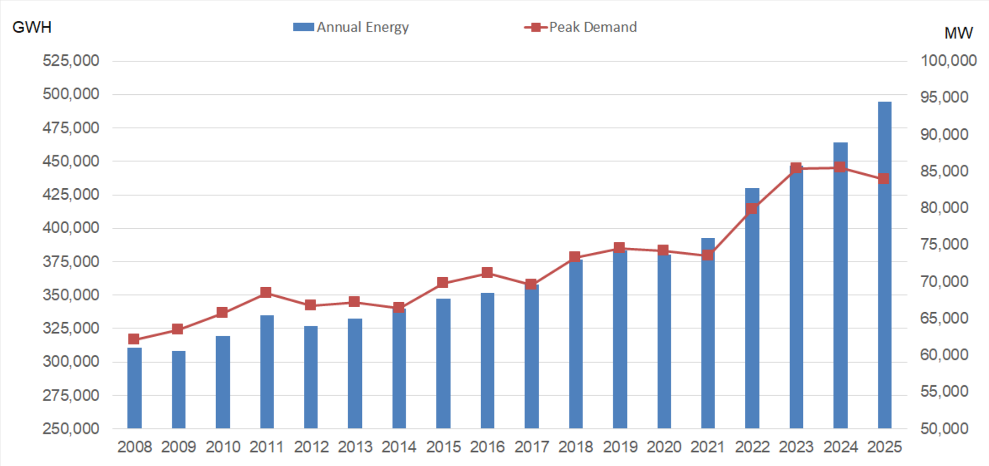
2025 RELIABILITY PERFORMANCE ASSESSMENT

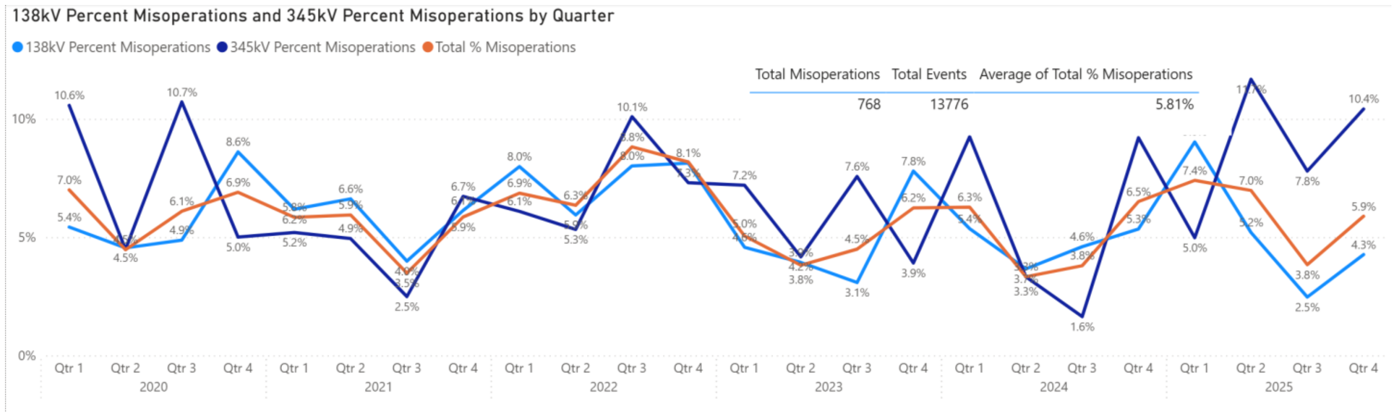
June 2026

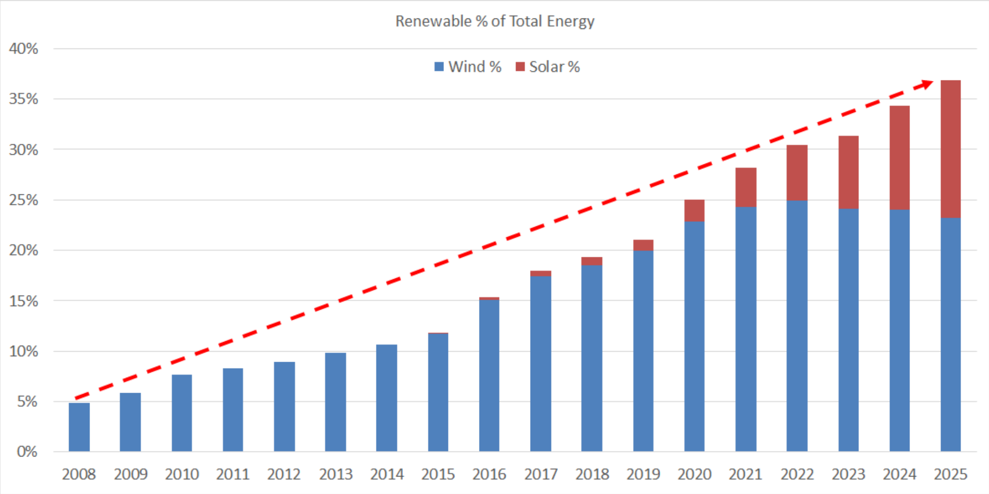
Performance Analysis and Key Risk Areas

- Grid Transformation
  - Resource Adequacy and Performance
  - Bulk Power System Planning
  - Protection and Control Systems
  - Situational Awareness Challenges
  - Human Performance
  - Changing Resource Mix
- Resilience to Extreme Events
- Cyber and Physical Security
- Critical Infrastructure Interdependencies

At a Glance

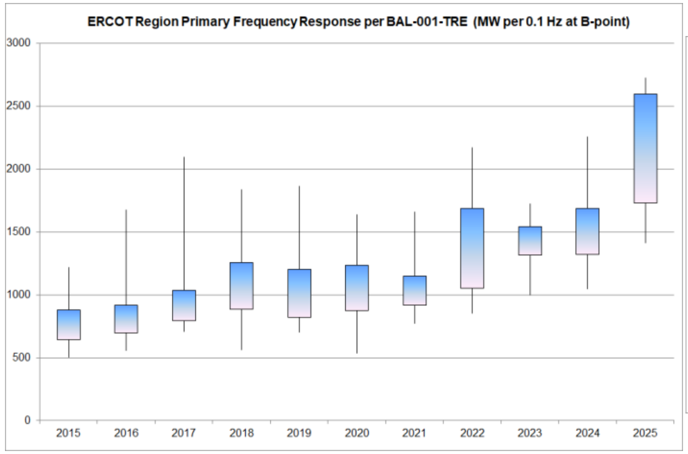


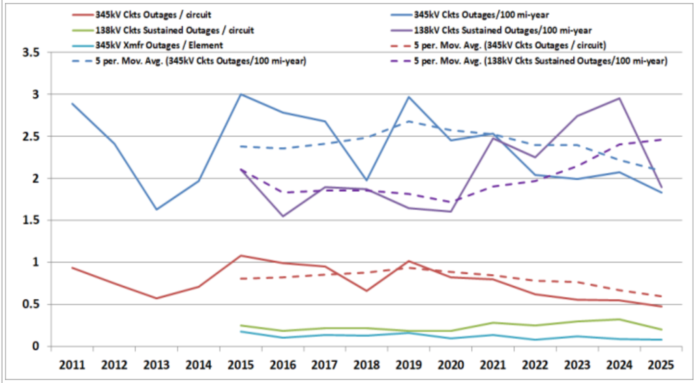




	2025	2024
Control Performance Standard (CPS 1)	177.2	175.5
TADS 345 kV Circuit Automatic Outage Rate per 100 miles	1.83	2.06
Protection System Misoperation Rate	6.0%	4.6%
GADS Equivalent Forced Outage Rate (EFOR) Unweighted	12.7%	10.1%

- **Summer Hourly Peak: 83,876 MW on 8/18/2025**
- **Winter Hourly Peak: 80,376 MW on 2/20/2025**
- **Peak Hourly Renewable Gen: 46,115 MW on 6/21/2025**
- **Renewable Energy %: 37.0% for 2025**
- **Peak Hourly Renewable Penetration: 75.6% on 3/2/2025**





2025 Year in Review

Operational Successes and Challenges

- Winter Storm Enzo and Kingston, new winter peak demand record set in February 2025
- Moderate summer, no major events or disturbances
- New west Texas Interconnection Reliability Operating Limits (IROLs) implemented
- Generation/Transmission metrics affected by extended forced outages
- Continued improvement in Primary Frequency Response (PFR), however increase in IBR oscillation events noted

Risk Mitigation Efforts

- Significant efforts in large load integration drove many activities
- Successful implementation of real-time co-optimization
- Initial NOGRR/PGRR approved for Battery Energy Storage System (BESS) Advanced Grid Support
- Implementation of NERC energy assessment process
- Ongoing efforts to reduce risks from inverter-based resources (IBRs)

Reliability Performance Metrics

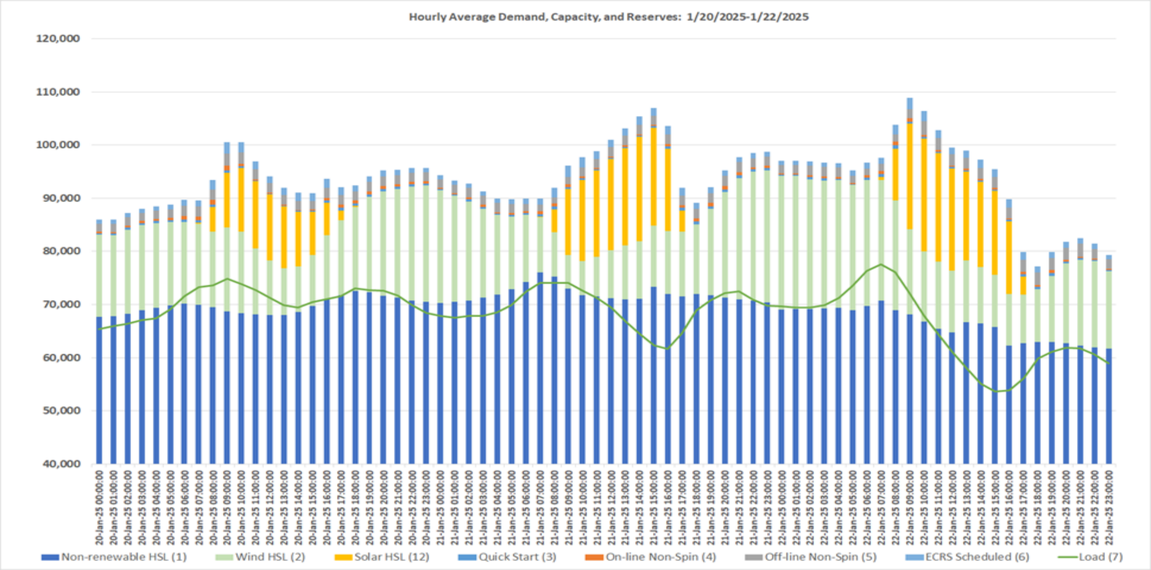
Improving	Stable or No Change	Monitoring	Actionable
Improving trend compared to previous four years or improved event performance of observed conditions	Minimal or no change compared to previous four years	(Declining trend compared to previous four years or specific negative event performance issues	Declining trend for two or more consecutive years or significant negative event performance

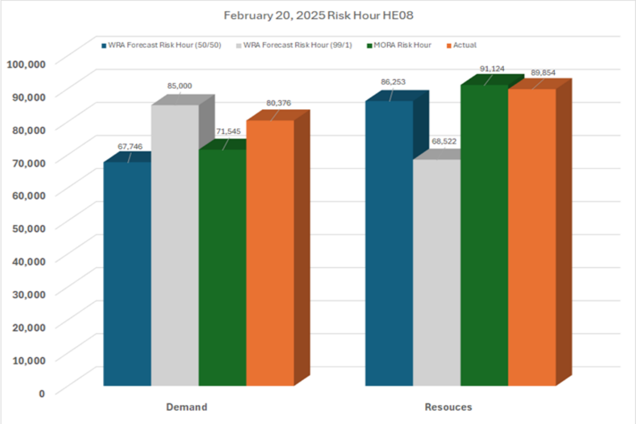
Key Performance Indicator with Description	2025 Performance & Trend Results
Resource Adequacy Measures potential resource adequacy issues by analysis of planning reserve margin and energy emergency alerts	Future reserve margins impacted by growth in large computational loads
	Resource weatherization resulted in sustained performance during cold weather events
Transmission Performance Measures transmission performance by analysis of transmission outage rates and Interconnection Reliability Operating Limits (IROL) exceedances	345 kV & 138 kV transmission outage rates improved in 2025
	IROL Exceedances
Resource Performance Measures generation performance by analysis of generator outage rates, primary frequency response, and balancing contingency events	Resource outages/gas restrictions during cold weather EFOR increased in 2025, long term rate increase
	Primary frequency response continues to improve No balancing contingency event failures
Grid Transformation Measures potential issues related to grid transformation by analysis of system inertia and ramping	Solar ramp magnitudes continue to increase Voltage ride through for IBRs
	Potential reliability impacts from operational characteristics of large computational loads
Protection System Performance Measures Protection System performance by analysis of Protection System Misoperations	Overall misoperation rate increased in 2025 Miisoperation count from incorrect settings stable
	Misoperation rate increased in 2025, remains less than overall NERC Misoperation rate
Human Performance Measures transmission outages, generation outages, and Protection System Misoperations caused by human error	Reduction in transmission and generation outage rates from human error
	Human error primary causal factor in Misoperations and events
Situational Awareness Measures situational awareness by analysis of state estimator convergence rates, event analysis, and telemetry performance	Five loss of situational awareness events (down from eight in 2024)
	State estimator convergence rate remained stable

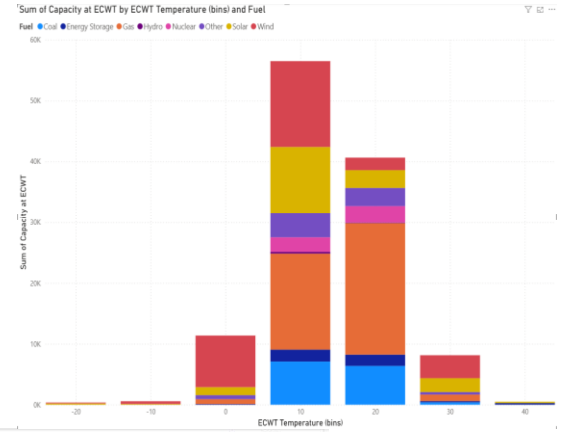
Performance Metrics

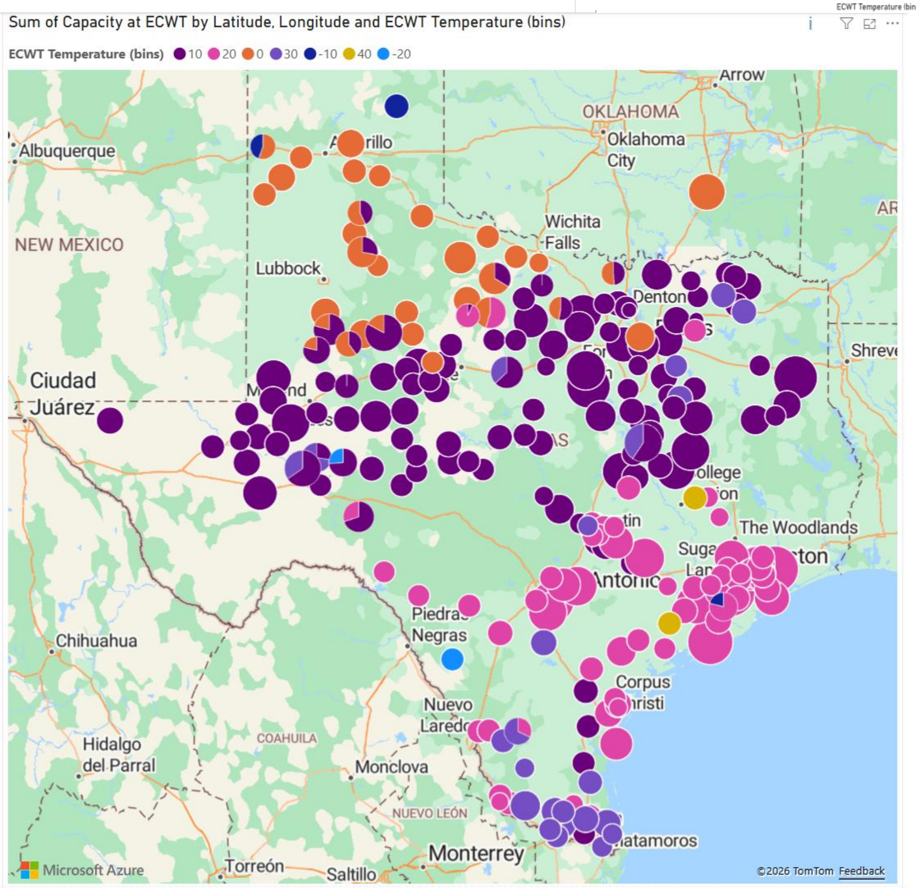
- Ongoing projected resource deficiencies and negative reserve margins noted in future years due to integration of large loads
- Minimal impacts on generator availability during cold weather events
- Continued improvement in frequency response due to integration of battery energy storage
- Solar down-ramp magnitude continues to increase
- Inverter-based resource and large load voltage ride-through continues to be a point of emphasis
- Misoperation rates improving but human performance continues to be primary causal factor in both misoperations and system events
- Improved transmission outage metrics in 2025 due to fewer severe weather events
- Coal fleet forced outage metrics decline

2025 Winter Storms and Generator Weatherization



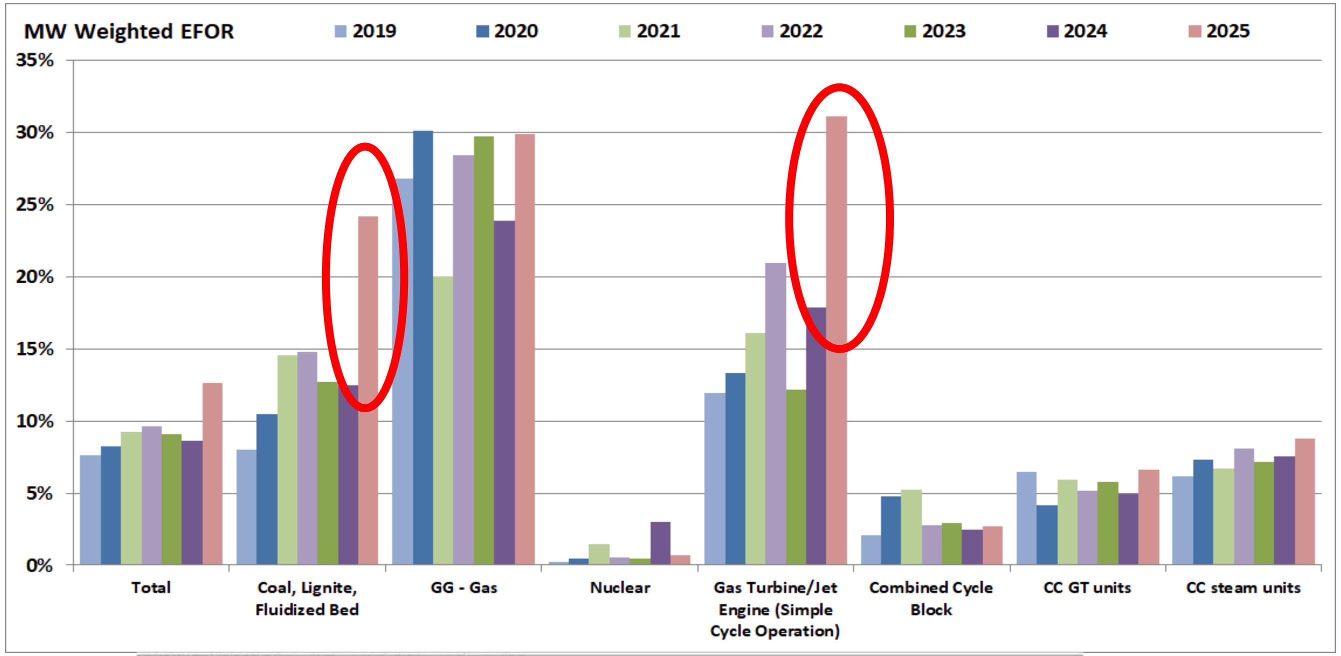


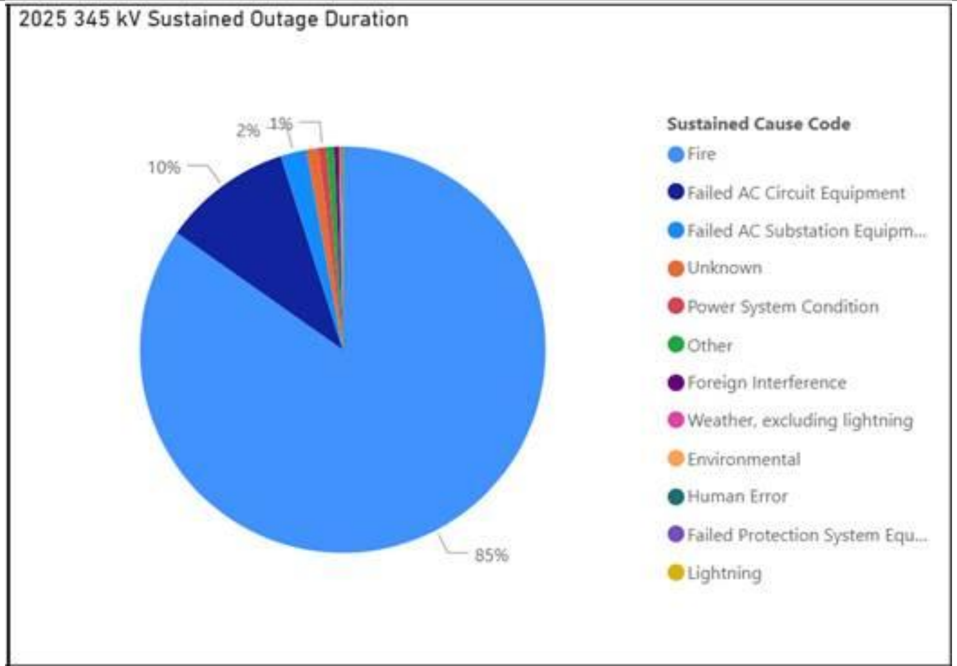




- New all-time winter peak record of 80,376 MW set during winter storm Kingston
- Approximately 15,000 MW of incremental outages combined between both storms; primarily wind icing, gas restrictions, and emissions
- NERC Extreme Cold Weather Temperature (ECWT) data collection
- EOP-012 constraint declarations
  - 38 constraints on 70 units
  - Wind blade/solar panel icing
  - Wind cold weather packages
  - Combustion turbine inlet air icing

Forced Outage Metrics Impacted by Extended Outages



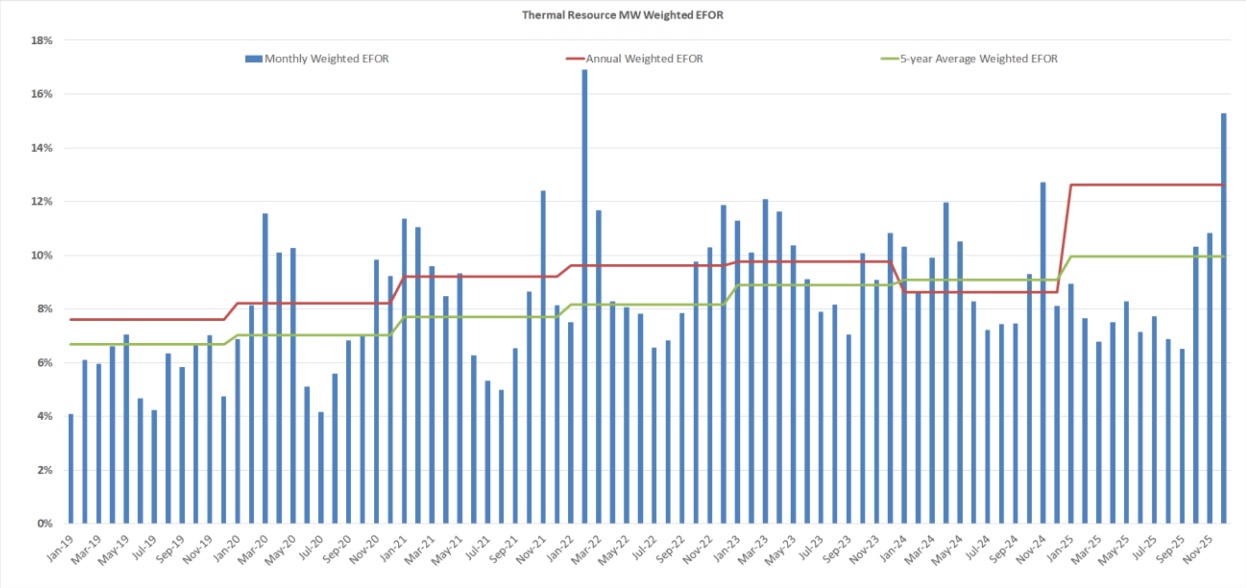


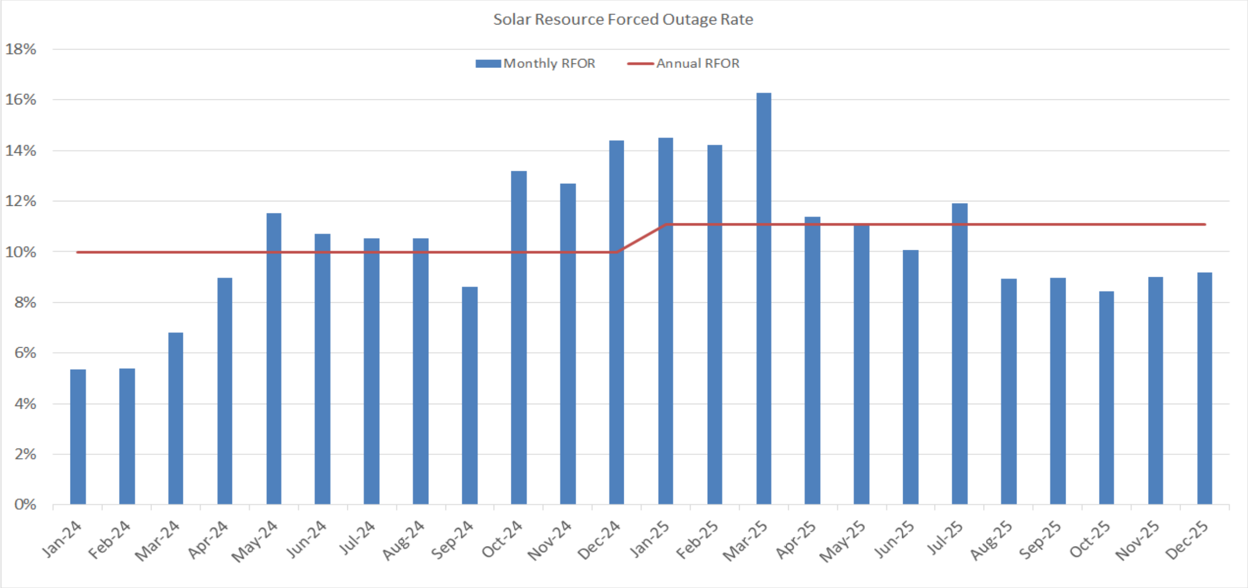
Significant increases in Equivalent Forced Outage Rate (EFOR) for coal and gas turbine/jet engine units in 2025

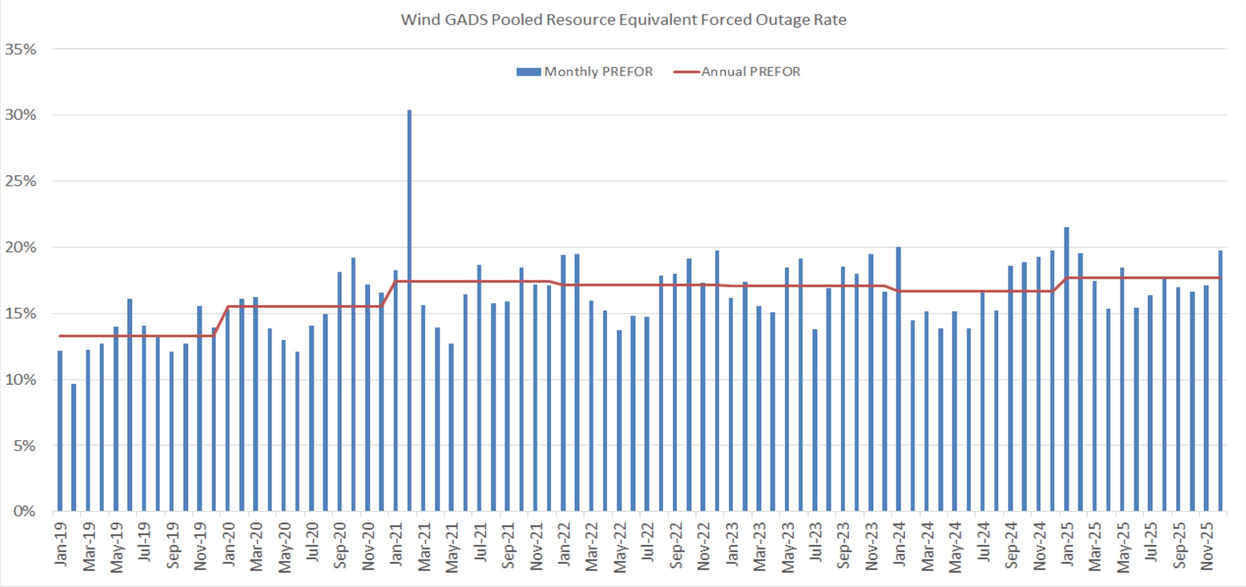
- Coal rate driven by extended outages on two units, one for 14 consecutive months and another for 12 months (ongoing)
- Gas turbine/jet engine rate driven by extended outages (three months or longer) on nine units

A single fire-related substation equipment failure accounted for 85 percent of the 345 kV circuit outage duration in 2025 (circuit and associated 345 kV auto remain out ~ 18 months)

Generation Forced Outage Rates



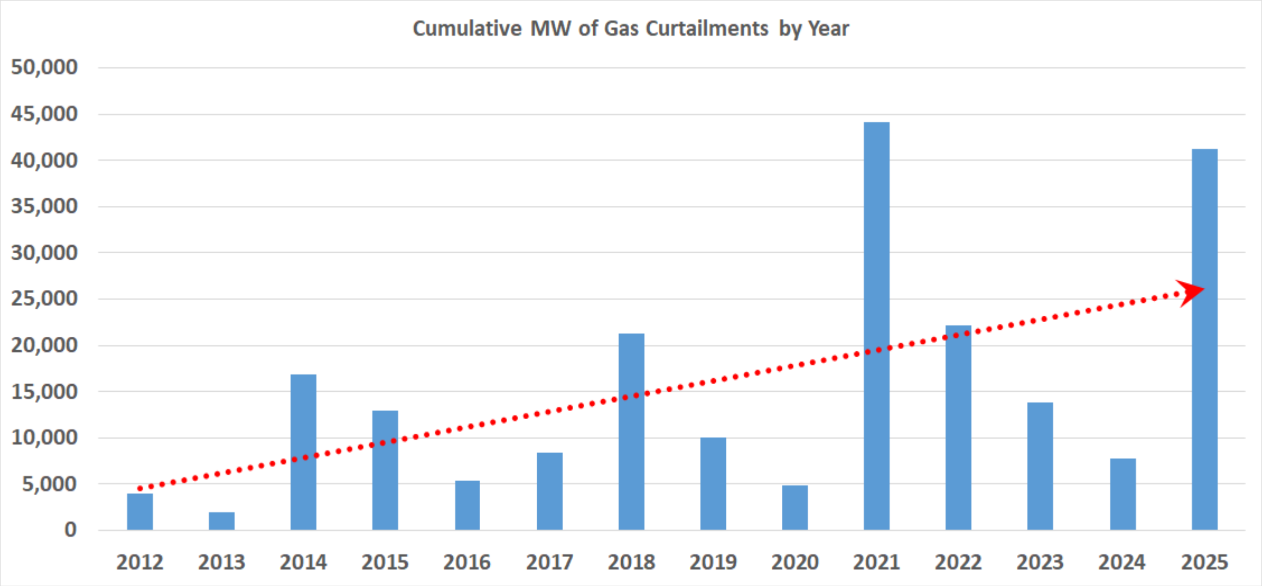


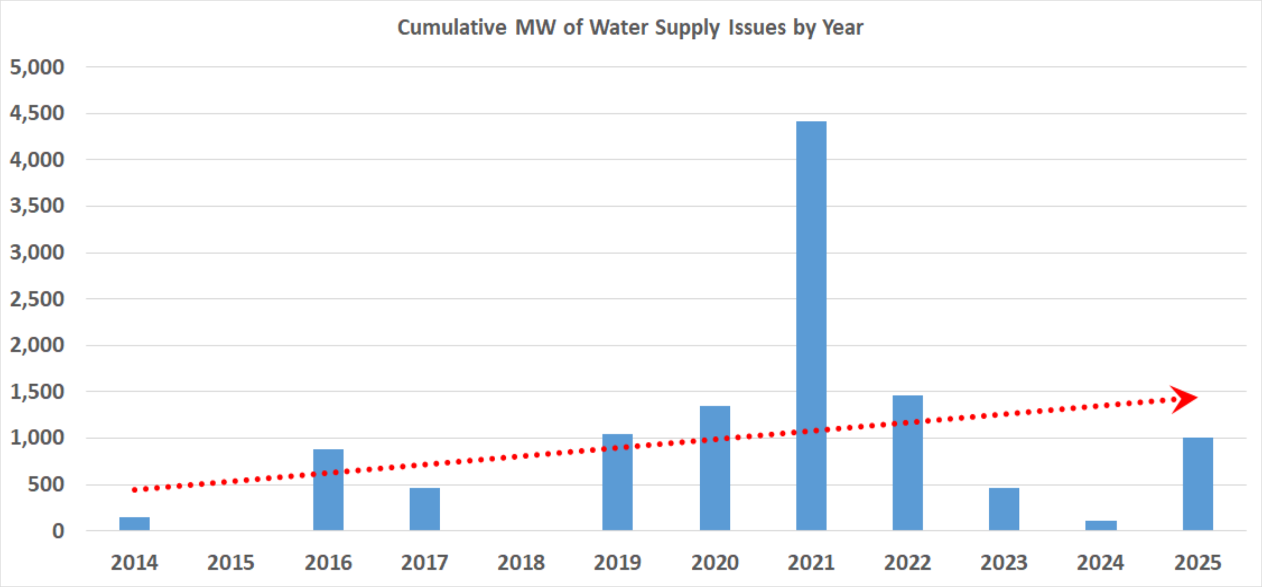


Wind and solar forced outage rates remained stable

Conventional generation forced outage rates impacted by extended outages

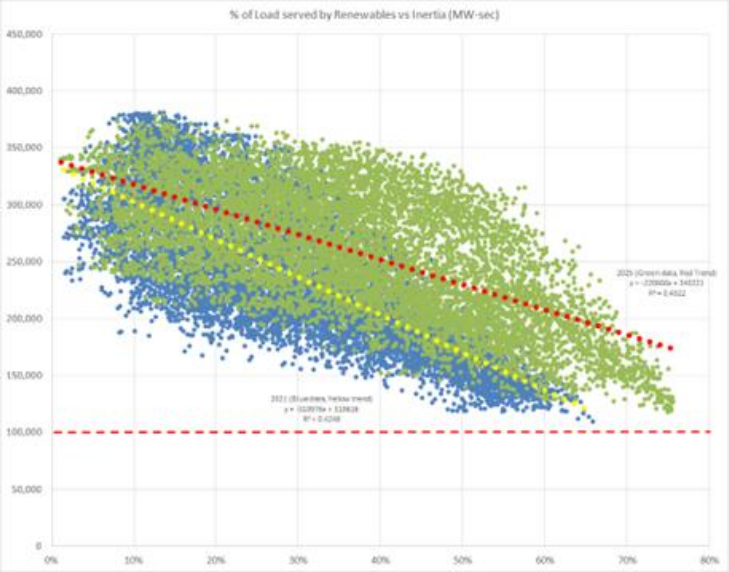
Infrastructure Interdependencies

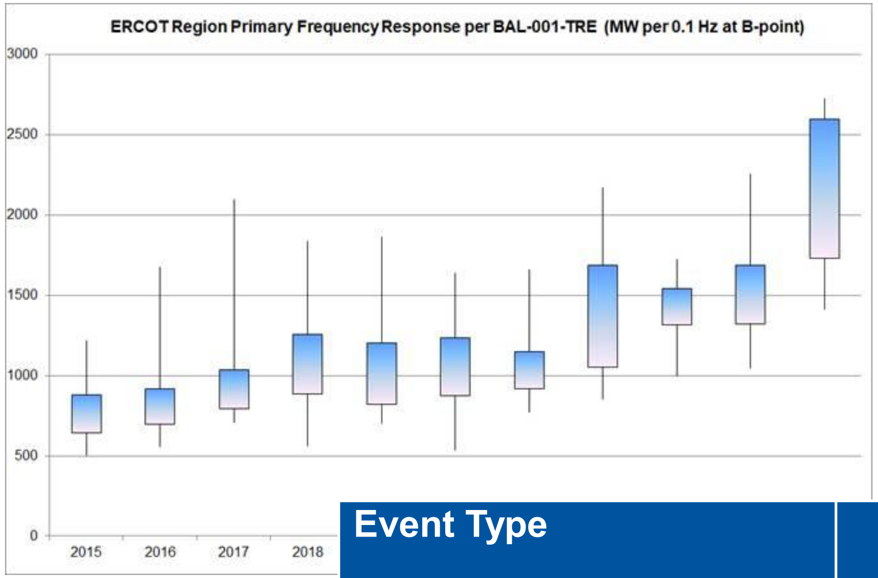




- Cumulative MW impact from gas curtailments increased significantly in 2025
- Larger than normal increase during summer and fall months
- Maximum single-day natural gas curtailment impact recorded for 2025 on 9/22/2025, with an associated cumulative impact of 2,644 MW
- No loss of Supervisory Control and Data Acquisition (SCADA) or Energy Management System (EMS) events in 2025 due to external communication provider issues

2025 Inertia, Frequency Response, and Oscillation Events

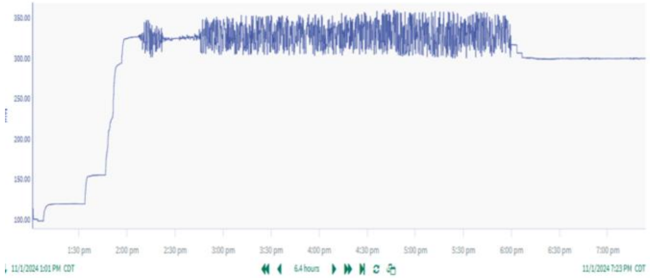


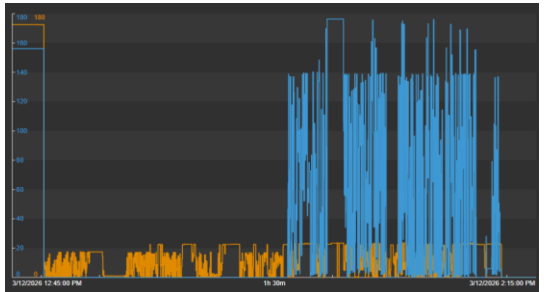


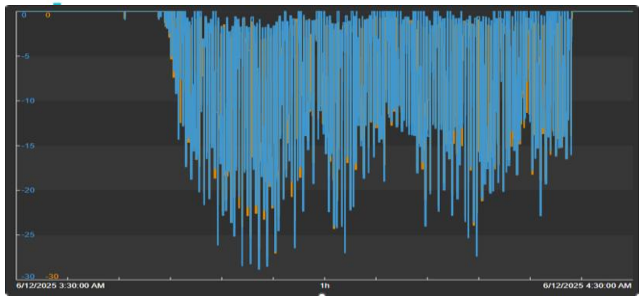
Year	Count of Hours Renewable % > 70%
2023	1
2024	39
2025	163
2026 YTD	253

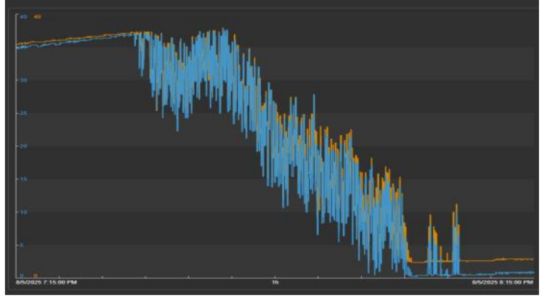
Event Type	# of events in 2024	# of events in 2025
Large load Oscillation	1	1
IBR Oscillation Events	35	24

- Lowest hourly inertia level of 118.3 GW-sec in 2025
- Low inertia hours have shifted to mid-day due to solar generation
- Frequency response continues to improve due to higher levels of Primary Frequency Response (PFR) capacity from integration of batteries
- Increasing number of oscillation events noted in 2025 due to IBRs and large loads

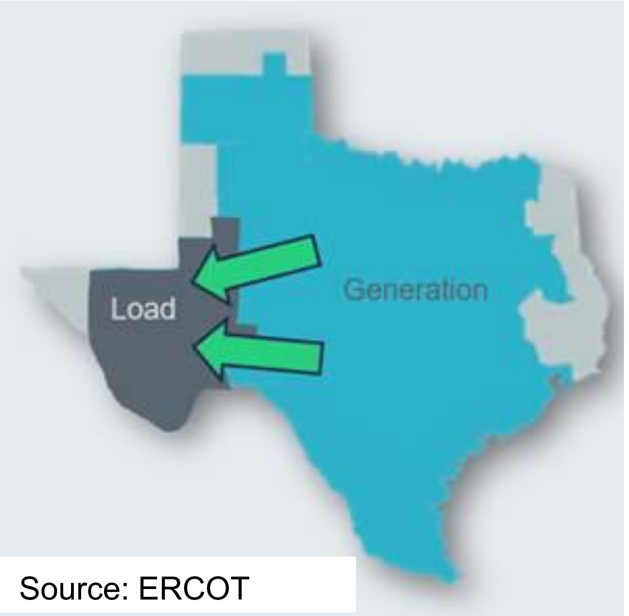




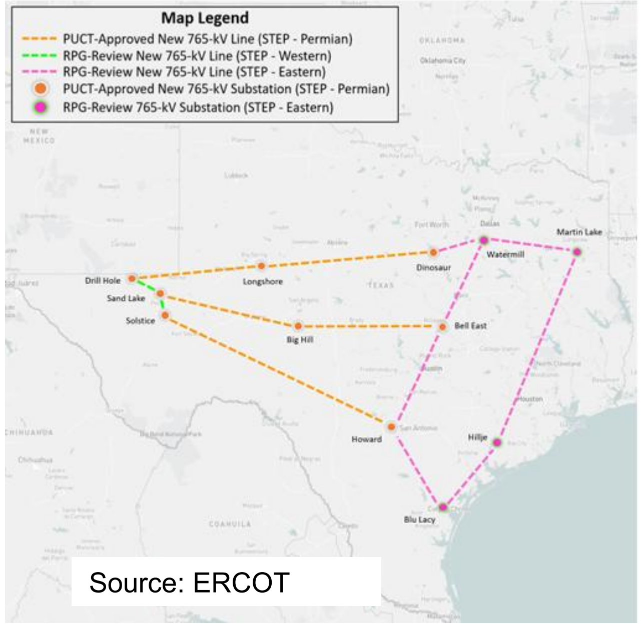




West Texas IROLs, 765 kV Activities, Transmission Growth



Source: ERCOT

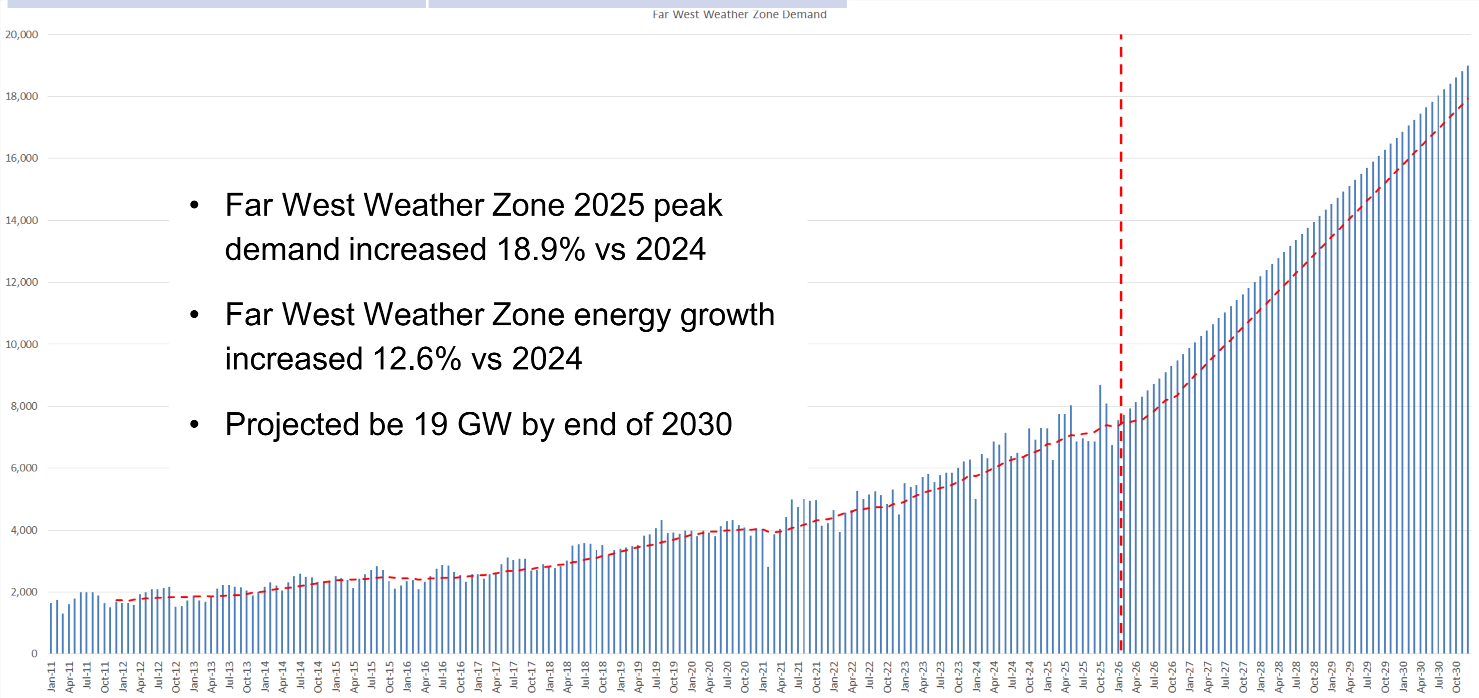


Source: ERCOT

TPIT Projects Completed in 2025	
Tier 1	6
Tier 2	13
Tier 3	31
Tier 4	133

TADS Circuit Miles Added in 2025	
138 kV	528.0
345 kV	300.2
345/138 kV Xfmrs	2

- Approval of 765 kV STEP plan Phase 1
- Additional 765 kV projects endorsed by ERCOT Board in December
- Two west Texas Generic Transmission Constraints (GTCs) identified

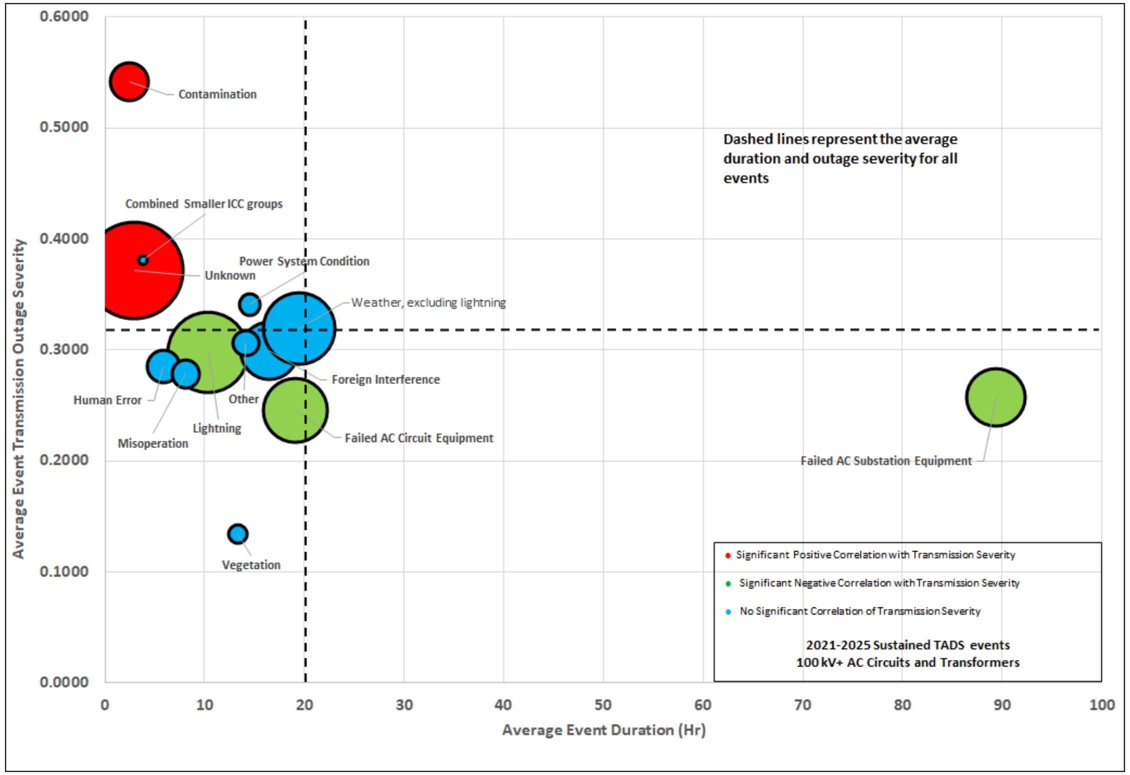


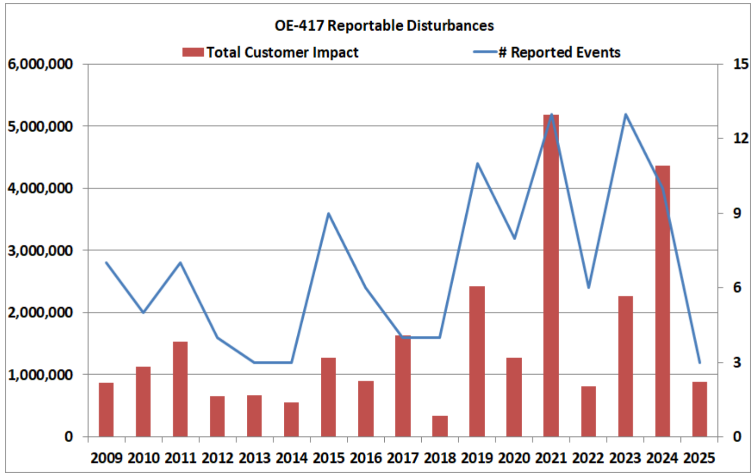
- Far West Weather Zone 2025 peak demand increased 18.9% vs 2024
- Far West Weather Zone energy growth increased 12.6% vs 2024
- Projected be 19 GW by end of 2030

Resilience and Extreme Day Analysis

- Generation and Transmission outage severity and duration continues to be driven by weather and failed equipment
- PUCT BlackStarTX exercise
- FERC Blackstart report for Eastern and Western Interconnections

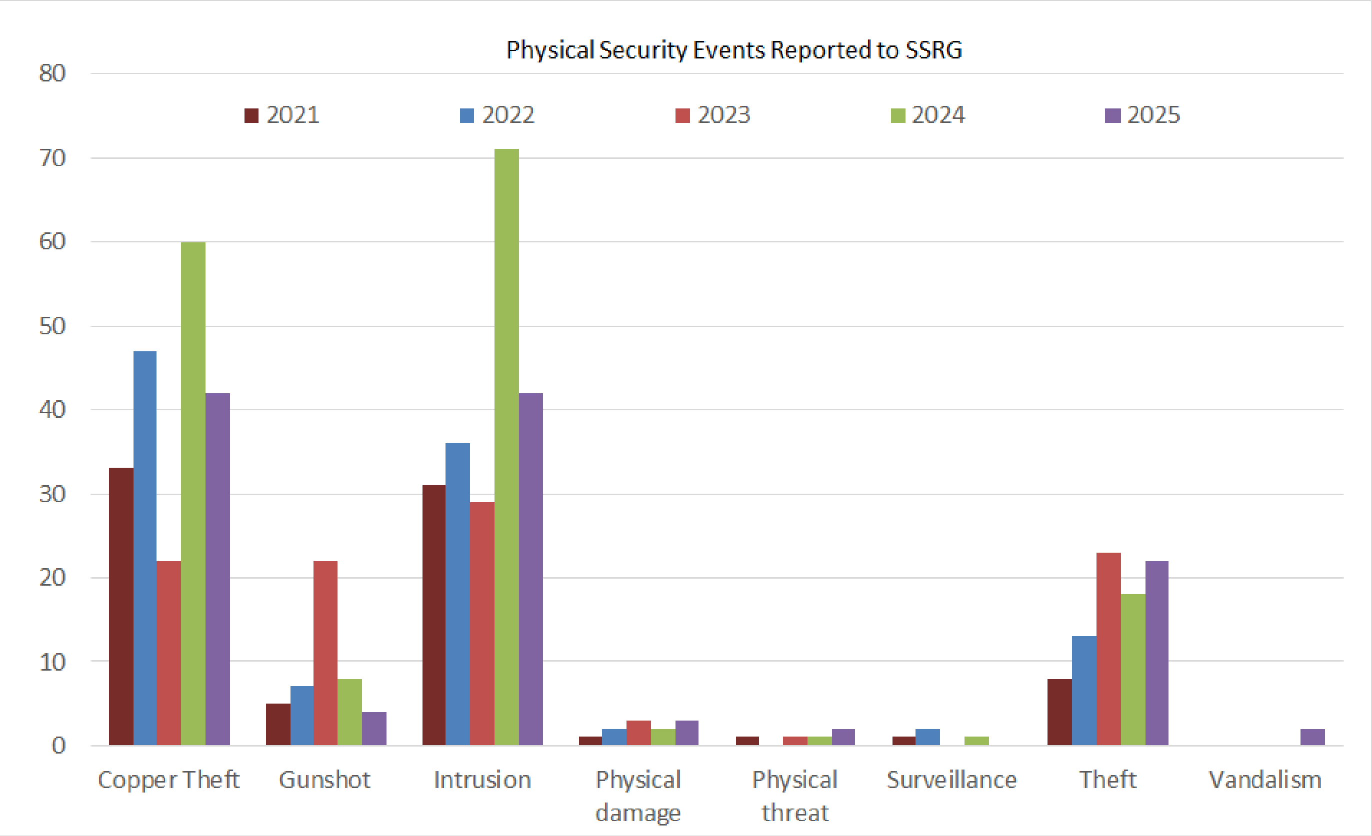
Generation Extreme Day Analysis	Number of Generation Outage Events on Extreme Day	Leading Causes for Extreme Day	Cumulative Outage Duration on Extreme Day	Cumulative MW Impact on Extreme Day	Cumulative GWh Impact on Extreme Day
8/27/2017	41	Weather	22,798 hours	10,107 MW	2,917.5 GWH
1/16/2018	84	Balance of Plant/Fuel	2,891 hours	11,893 MW	517.8 GWh
5/11/2019	36	Turbine Generator	1,626 hours	6,449 MW	282.5 GWh
7/1/2020	44	Auxiliary systems	3,352 hours	8,251 MW	247.9 GWh
2/15/2021	187	Weather	6,937 hours	35,241 MW	1,204.1 GWh
12/23/2022	164	Weather	2,180 hours	23,163 MW	321.8 GWh
1/30/2023	65	Turbine Generator/Fuel	2,745 hours	9,327 MW	332.4 GWH
1/15/2024	92	Fuel, Weather	916 hours	10,200 MW	89.6 GWH
1/6/2025	74	Fuel, Weather	4,687 hours	9,884 MW	283.2 GWH





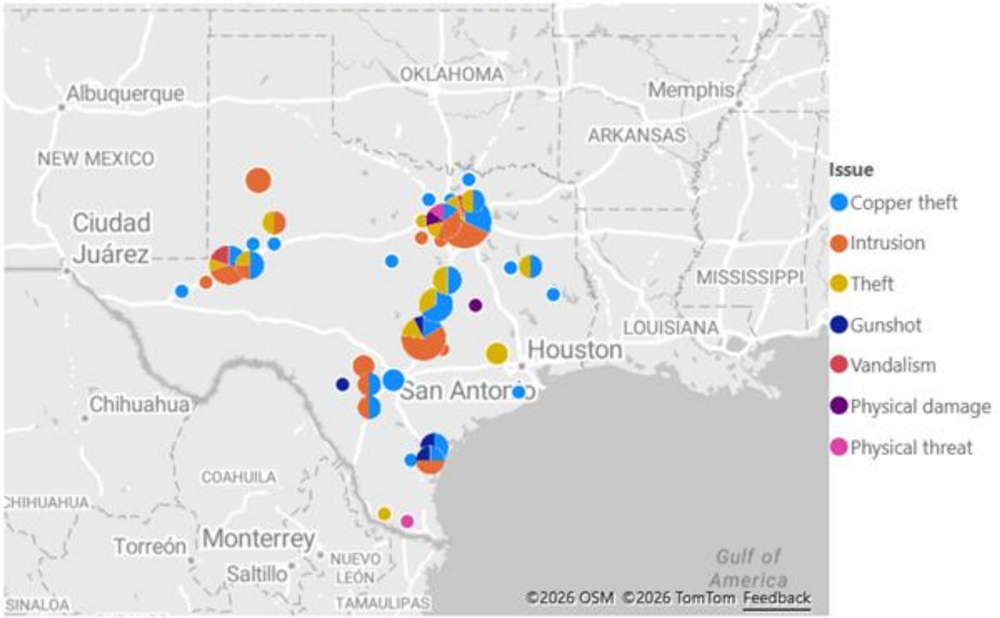
Large drop in customer outages due to fewer severe weather events

2025 Physical Security

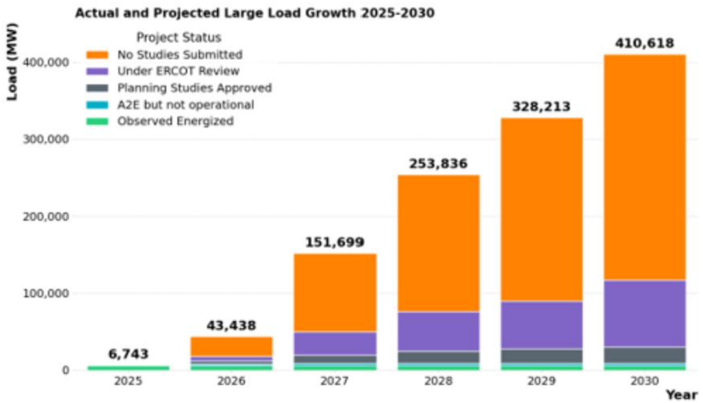


Significant Events

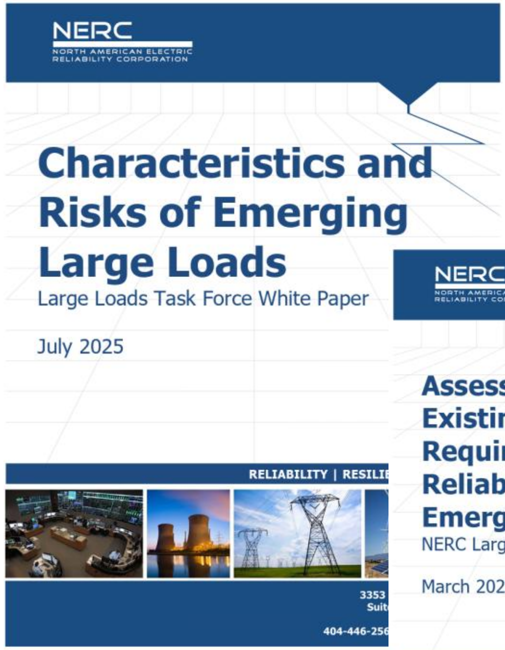
- Gunshot damage to wind plant pad-mount transformer
- Multiple individuals showed up at a solar site for employment, apparent victims of an employment scam
- Individuals attempted to enter a wind plant facility with instructions to work on a bitcoin mining unit, which the site did not possess

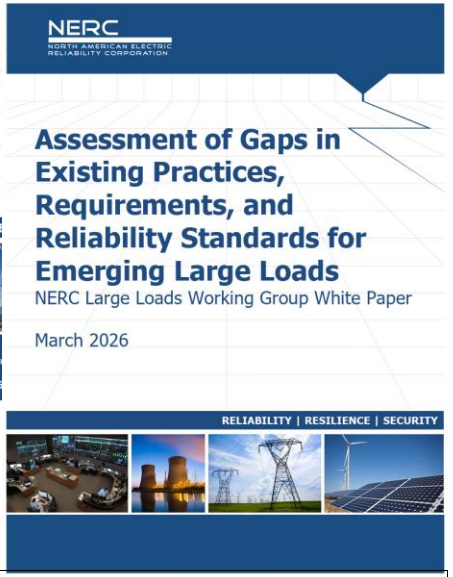


Large Load Integration Efforts



Project Status	2025	2026	2027	2028	2029	2030
No Studies Submitted	0	25,253	101,702	177,879	238,188	293,651
Under ERCOT Review	0	6,478	30,539	51,315	61,966	86,605
Planning Studies Approved	30	3,181	10,739	15,923	19,040	21,343
A2E but not operational	935	2,748	2,941	2,941	3,241	3,241
Observed Energized	5,778	5,778	5,778	5,778	5,778	5,778
Total (MW)	**6,743**	**43,438**	**151,699**	**253,836**	**328,213**	**410,618**





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Incident Review
Voltage-Sensitive Crypto Load Reductions

Primary Takeaways

Recent Electric Reliability Council of Texas (ERCOT) load-loss events highlight the unique and sensitive ride-through characteristics of crypto-mining facilities. As these facilities rely heavily on constant-power electronic supplies, cooling equipment, and single-phase devices that respond to normally cleared transmission faults, they experience load drops within milliseconds of a voltage sag. Restoration times vary widely depending on equipment configuration and the level of manual intervention required.

Understanding these behaviors is essential for assessing grid impacts, interpreting event data, and developing appropriate ride-through expectations and mitigation strategies for large electronic loads (LEL) operating in the bulk power system (BPS).

Overview of Crypto-Mining Facility

Crypto-mining facilities are specialized, industrial-scale data centers that house powerful computers (miners) for the purpose of solving complex problems. Solving these problems may then produce new digital tokens that are distributed per the protocols used by that currency.

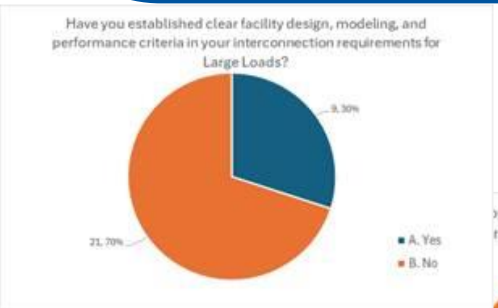
The facilities differ from other data center facilities, such as cloud computing and AI data centers, in that they typically do not have uninterruptible power supply (UPS) systems or backup generators. As a result, crypto facilities have different ride-through characteristics than other types of data centers.

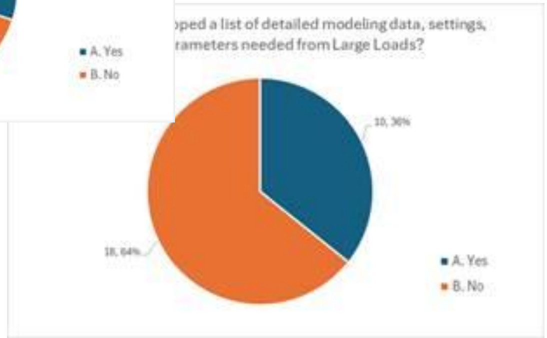
Crypto-mining facilities depend on a large number of constant-power electronic power supplies that are highly sensitive to voltage drops. When the voltage dips below a certain threshold, the miners shut down almost instantly, causing a rapid loss of load. During a voltage depression or sag, the nature of the constant power supply means that, during a voltage depression, the amount of current drawn will be inversely proportional to the reduction in voltage. For example, if the voltage dropped to 0.8 per unit (p.u.), the current would need to increase by 1.25 p.u. Depending on how heavily loaded the circuits are, the voltage depression could result in overloads and possible protective actions and potentially trigger local protection systems.

Once the voltage recovers, crypto-mining facilities go through a multistage restoration process, which includes stabilizing the power supply, booting the operating system, initializing the mining software, recognizing hash boards, and normalizing the cooling system. Consequently, restoration times can vary greatly—from just a few minutes to significantly longer—depending on the type of equipment, the cooling system, and whether manual resets are required. Unlike traditional data centers, crypto-mining facilities do not return to full load almost immediately; instead, their ramp-up process is gradual and predictable, reducing the chances of rapid spikes in demand on the grid.

Regulatory Item	Description
PGRR122	Reliability Performance Criteria for Loss of Load
PGRR136	Large Load Interconnection Study Scope Documentation
PGRR138	Large Load Interconnection Study Review and Approval Process
PGRR141	Large Load Interconnection Study Reform for Substantiated Load
PGRR144	Dynamic Model Submission and Review Requirements for Large Loads including Large Electronic Loads
PGRR145	Batch Zero Process for Large Load Interconnections
NOGRR282	Large Electronic Load Ride-Through Requirements
NPRR1308	Large Electronic Load Ride-Through Requirements
NPRR1325	Batch Zero Process for Large Load Interconnections
NERC Rules of Procedure	Definition of Computational Load and Computational Load Entity
NERC Rules of Procedure	Registration Criteria for Computational Load Entity
NERC Project 2026-02	Standards Authorization Request to create requirements for Computational Load Entities

- **NERC whitepapers on Risks of Emerging Large Loads and Assessment of Gaps in Existing Requirements for Large Loads**
- **Incident Review on Voltage-Sensitive Crypto Loads**
- **NERC Level 2 Alert and future Level 3 Alert**
- **ERCOT market rule changes and batch study process**
- **Future NERC large load registration criteria**





Inverter-Based Resource Risk Mitigation Efforts

185 FERC ¶ 61,042
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

18 CFR Part 40

[Docket No. RM22-12-000; Order No. 901]

Reliability Standards to Address Inverter-Based Resources

(Issued October 19, 2023)

IBR Standards filed in 2025	
Energy Assurance with Constrained Resources	BAL-007-1
Modeling Framework for IBRs	IRO-010-6 MOD-032-2 TOP-003-8
System Model Validation with IBRs	MOD-033-3
Verification of Generator Models	MOD-026-2
ERCOT Market Rule Changes	
Advanced Grid Support Requirements for Inverter-Based ESRs	NOGRR272
Advanced Grid Support Requirements for Inverter-Based ESRs	PGRR121

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This is a Compliance Monitoring and Enforcement Program (CMEP) Practice Guide. It is developed exclusively by the ERO Enterprise under its obligations for independence and objectivity. This CMEP Practice Guide is intended for use by ERO Enterprise Staff to support consistency as they perform CMEP activities. This CMEP Practice Guide is posted publicly solely to provide transparency.

ERO Enterprise CMEP Practice Guide:

Application of the Registration Criteria for Category 2 Generator Owner and Generator Operator Inverter-Based Resources
Version 1: January 31, 2025

Background

In support of successful implementation of and compliance with the North American Electric Reliability Corporation (NERC) Reliability Standards, the Electric Reliability Organization (ERO) Enterprise[1] adopted the Compliance Guidance Policy.[2] The Compliance Guidance Policy outlines the purpose, development, use, and maintenance of guidance for implementing Reliability Standards. According to the Compliance Guidance Policy, Compliance Guidance includes two types of guidance – Implementation Guidance and Compliance Monitoring and Enforcement Program (CMEP) Practice Guides.[3]

Purpose

As part of its Inverter-Based Resources (IBR) Strategy, NERC is dedicated to identifying and addressing challenges associated with inverter-based resources as the penetration of these resources continues to increase. An ERO analysis identified a reliability gap associated with the increasing integration of IBRs on the grid with a significant level of Bulk Power System (BPS) connected IBR owners and operators currently not meeting the criteria thresholds required to register with NERC, and, as such, not required to adhere to NERC Reliability Standards. In response, the Federal Energy Regulatory Commission (FERC) issued an order directing NERC to identify and register owners and operators of unregistered BPS connected IBRs that in aggregate have a material impact on BPS reliability.[4] Working closely with industry and stakeholders, NERC is executing a FERC-approved work plan to achieve the identification and registration directive by 2026.

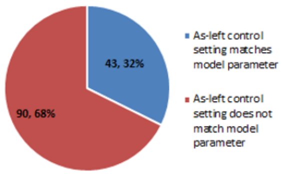
The NERC Registry Criteria contained in the NERC Rules of Procedure (ROP), Appendix 5B, Statement of Compliance Registry Criteria[5] was revised and approved by FERC on June 27, 2024.[6] The revisions created changes to the Generator Owner (GO) and Generator Operator (GOP) functional criteria for which owners and operators of non-BES IBRs must register with NERC as GO Category 2 and GOP Category 2.[7]

[1] The ERO Enterprise consists of NERC and the six Regional Entities.
[2] The ERO Enterprise Compliance Guidance Policy is located on the NERC website at: https://www.nerc.com/pa/comp/guidance/Documents/Compliance%20Guidance%20Policy.pdf
[3] Implementation Guidance provides a means for Registered Entities to develop examples or approaches to illustrate how Registered Entities could comply with a standard that are vetted by industry and endorsed by the ERO Enterprise. CMEP Practice Guides differ from Implementation Guidance in that they address how ERO Enterprise CMEP staff executes compliance monitoring and enforcement activities, rather than examples of how to implement the standard.
[4] FERC Docket RD22-4-000
[5] https://www.nerc.com/AboutNERC/Pages/Rules-of-Procedure.aspx
[6] https://elibrary.ferc.gov/eLibrary/filelist?accession_number=20240627-3033&optimized=false
[7] Note that the existing GO and GOP registration criteria specific to owners and operators of resources that meet the NERC definition of Bulk Electric System (BES) is unchanged but is now categorized as GO Category 1 and GOP Category 1.

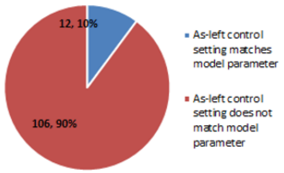
REL

- Increased reliance on IBRs to meet load
- FERC Order 901 projects
- NERC Alert on IBR model quality
- ERCOT market rules for Advanced Grid Support
- Category 2 IBR registration initiative

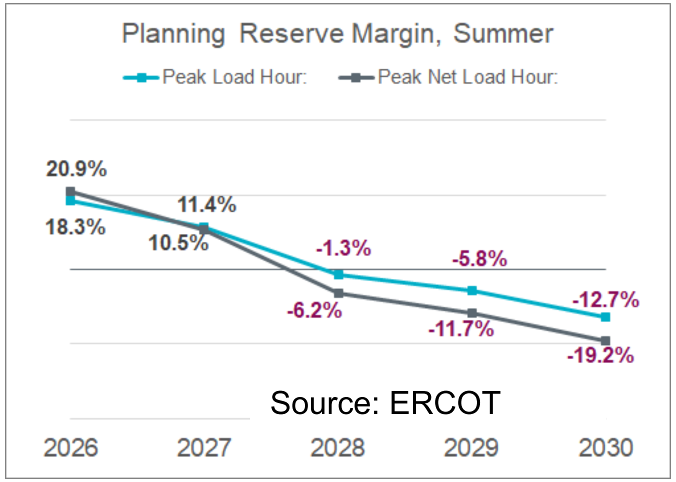
Low Voltage Threshold Settings Model vs Reported	# of Facilities	%
As-left control setting matches model parameter	43	32%
As-left control setting does not match model parameter	90	68%
Total	133	100%

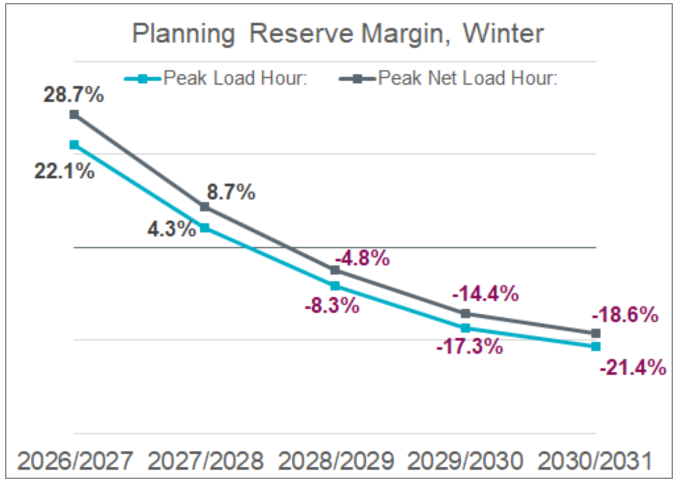


Frequency Deadbands Model vs Reported	# of Facilities	%
As-left control setting matches model parameter	12	10%
As-left control setting does not match model parameter	106	90%
Total	118	100%



Energy Assessment and Resource Adequacy





Texas Energy Fund Projects

Projects Approved	3,564 MW
Projects Under Study/Due Diligence	5,420 MW

Base-Case Summary of Results	2026*	2027	2029
EUE (MWh)	11,090	5,864	17,053
NEUE (ppm)	18.95	8.70	18.84
LOLH (hours per Year)	1.57	0.94	3.64

* Provides the 2024 ProbA Results for Comparison

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Limited Disclosure

Modeling and Studies Team (MAST) Strategy

Dec 2025

Purpose and Scope

This document describes the Reliability Assessments execution strategy for MAST.

Strategic Objectives

MAST's strategic objective is to analyze and highlight for the stakeholders, wide-area system risks beyond energy deficiency and resource adequacy in NERC's Long-term Reliability Assessments. This includes transmission assessments, weak grid, undamped oscillations, voltage and dynamic stability risks etc. The MAST team will enhance Electric Reliability Organization's (EROs) capabilities to assess such risks in a timely manner and bring them to the forefront so that appropriate steps can be taken to address risks.

Resources and Capabilities

NERC and Regional Entities will ensure appropriate resources are available to perform MAST activities. This includes:

- Appropriate personnel and staffing
- Analysis software and tools
- Required datasets

MAST will form appropriate sub-teams to scope and perform workplan activities. MAST and/or sub-teams will identify the appropriate software, database and technology capabilities that will be needed to perform the reliability assessments and other activities.

Data Requirements

MAST will establish data requirements for each of its assessments. This includes:

- Forecast data
- Model data
- Appropriate base-cases

MAST with the participation of Regional Entities define data requirements for each of its reliability assessments. Such requirements will be appropriately communicated to the relevant entities that will have the responsibility to supply the required information.

NERC and Regional Entities will establish appropriate checks to ensure that data are accurate and reflects the most up-to-date information.

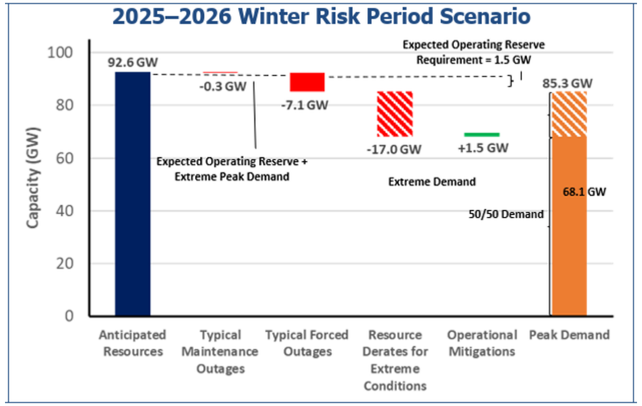
Workplan Development and Implementation Process

MAST will utilize NERC's Risk Management Process to assess, highlight and communicate key reliability risks. The strategy will involve periodic review of risk reports from NERC and each of the Regional Entities. Reliability Risks that have been identified by each of the risk reports (or majority of the risk reports) will drive the prioritization for MAST activities.

RELIABILITY | RESILIENCE | SECURITY

DRAFT

- Energy assessment pilot study completed
- Probabilistic approach to energy adequacy
- Texas Energy Fund projects
- NERC Transmission assessment strategy



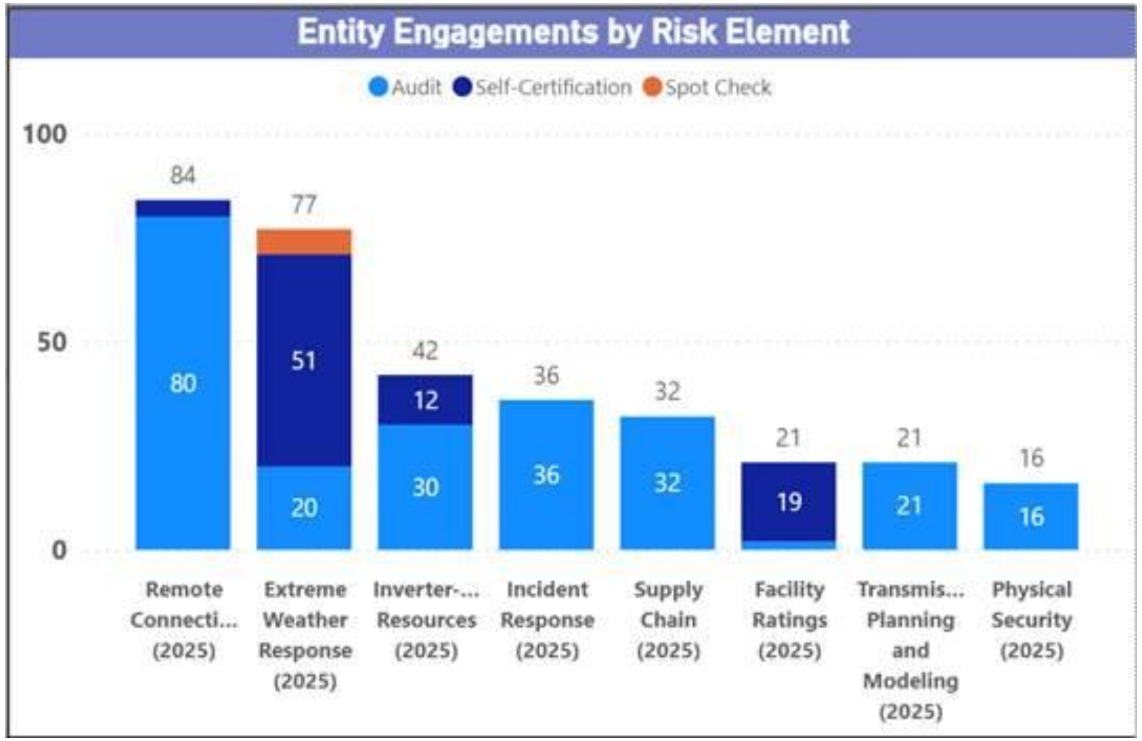
New Resources Approved for Commercial Operation in 2025

Fuel Type	Total MW	Average # Days to Connect (from FIS to COD)	Median # Days to Connect	Minimum # Days to Connect	Maximum # Days to Connect
Battery	6,291	625	479	200	1,535
Solar	5,998	845	714	330	1,829
Fuel Oil	439	75	75	34	115
Wind	1,463	1,119	844	692	2,858

Risk Focus Area Follow-up and Outreach

2025 Risk and CMEP IP Focus Areas
Inverter-Based Resource Ride Through
Provision of Essential Reliability Services from a Changing Resource Mix
Energy Availability
Inaccurate Resource Modeling
Remote Access
Supply Chain
Physical Security
Extreme Weather & Resource Weatherization
Facility Ratings
Gas Supply Chain Restrictions During Cold Weather
Integration of Large Loads
Artificial Intelligence

- **28 Talk with Texas RE webinars and NSRF presentations on risk focus area topics**
- **Winter Weatherization Workshop**
- **Evolving Grid Workshop**
- **NERC Alert issued on large loads**
- **Multiple entity engagements (~ 330)**



Questions?

TEXAS RE
Ensuring electric reliability for Texans