TEXAS RE

2023 Reliability Performance and Regional Risk Assessment

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May 30, 2024

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Upcoming Texas RE Events

June 3, 2024

History & Introduction to Texas RE

June 4, 2024

Registration & Certification

June 5, 2024

Intro to Align

Upcoming ERO Enterprise Events

May - July, 2024

GADS Wind & Solar Template and Application Training

June 5, 2024

NERC Certification & Certification Review Process

June 10, 2024

Technical Talk with RF

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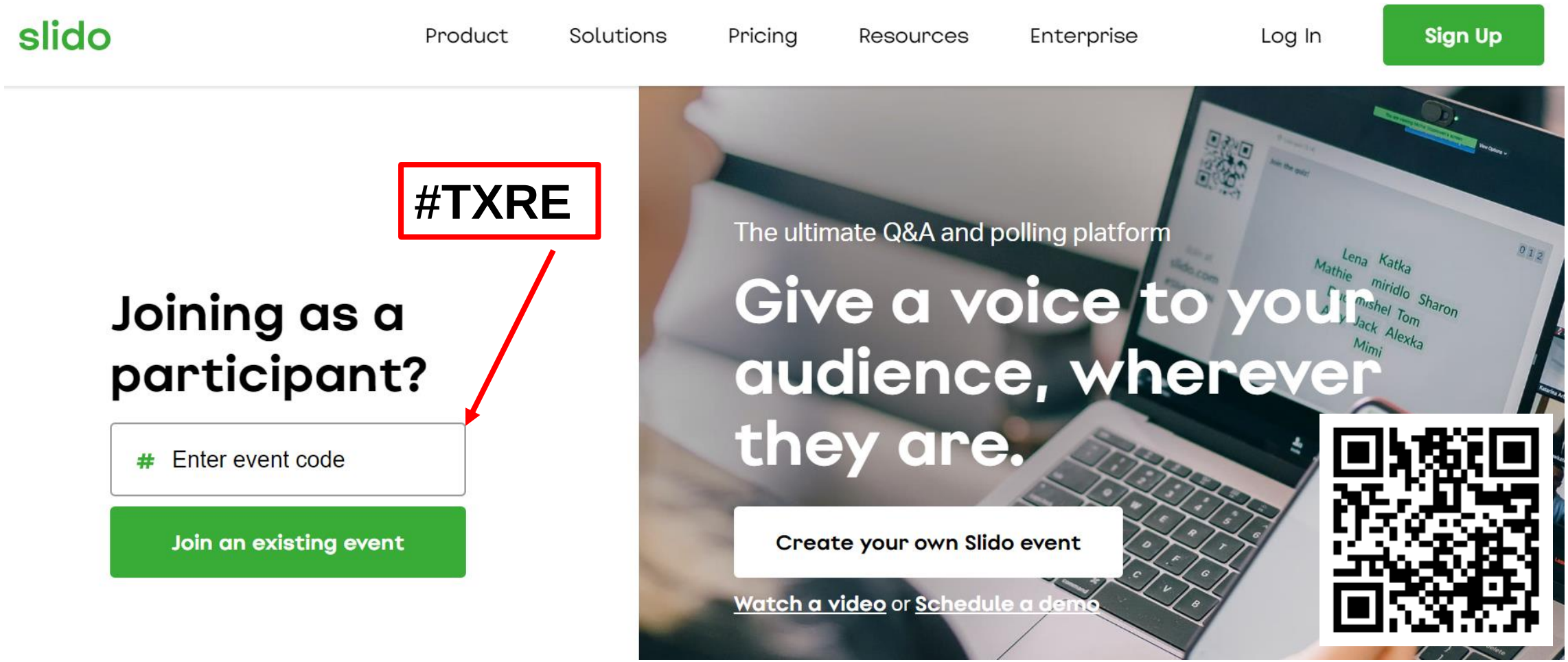
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2023 Reliability Performance and Regional Risk Assessment

2023 TEXAS RE RELIABILITY PERFORMANCE AND REGIONAL RISK ASSESSMENT

MAY 2024

Performance Analysis and Key Risk Areas

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

2023 Reliability Performance Metrics

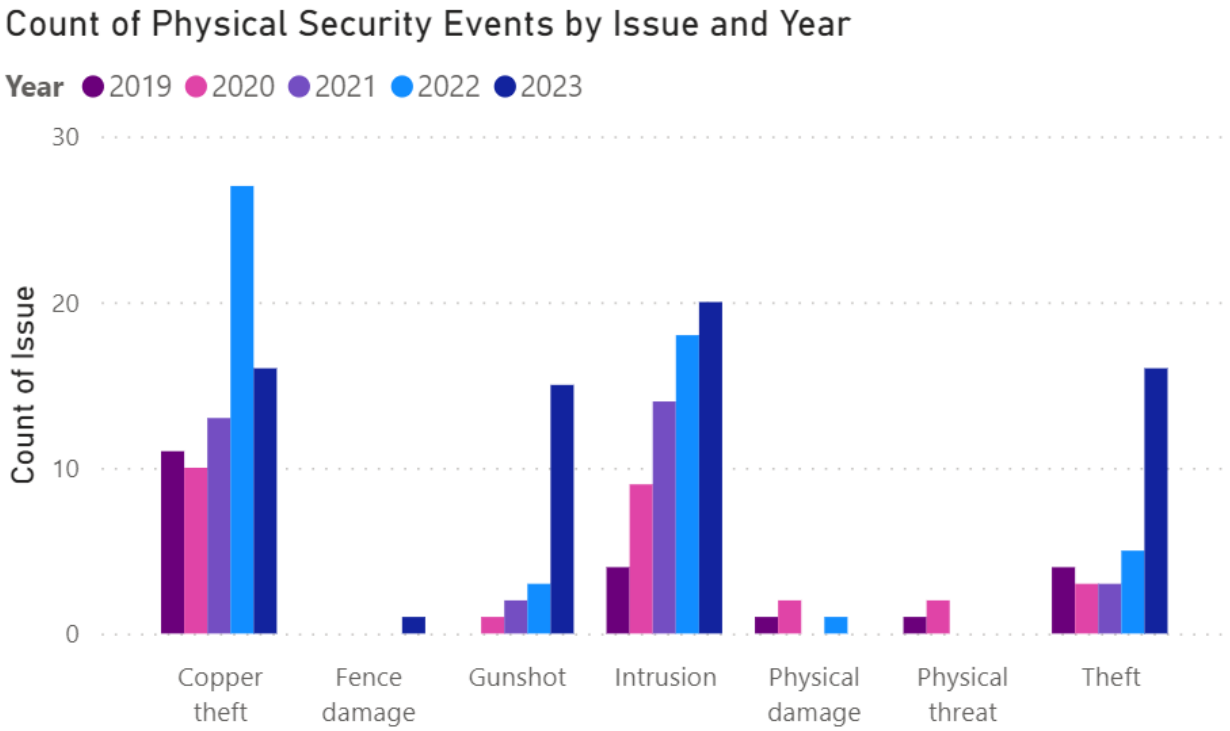
Improving	Stable or No Change	Monitoring	Actionable
(Improving trend compared to previous 4 years or improved event performance or observed conditions)	(Minimal or no change compared to previous 4 years)	(Declining trend compared to previous 4 years or specific negative event performance issues)	(Declining trend for two or more consecutive years or significant negative event performance)

Key Performance Indicator with Description	2023 Performance & Trend Results
Resource Adequacy Measures potential resource adequacy issues by analysis of planning reserve margin and energy emergency alerts	Reserve margins show sufficient resource capacity Extreme event scenarios highlight risk areas Resource weatherization
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 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 Long term increase in EFOR rates Primary frequency response 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 Synchronous generator retirements Voltage ride through for inverter-based resources Decrease in average system inertia levels
Protection System Performance Measures Protection System performance by analysis of Protection System Misoperations	Misoperations due to incorrect settings decreased in 2023 Misoperation rate decreased in 2023, 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	Four loss of situational awareness events State Estimator convergence rate

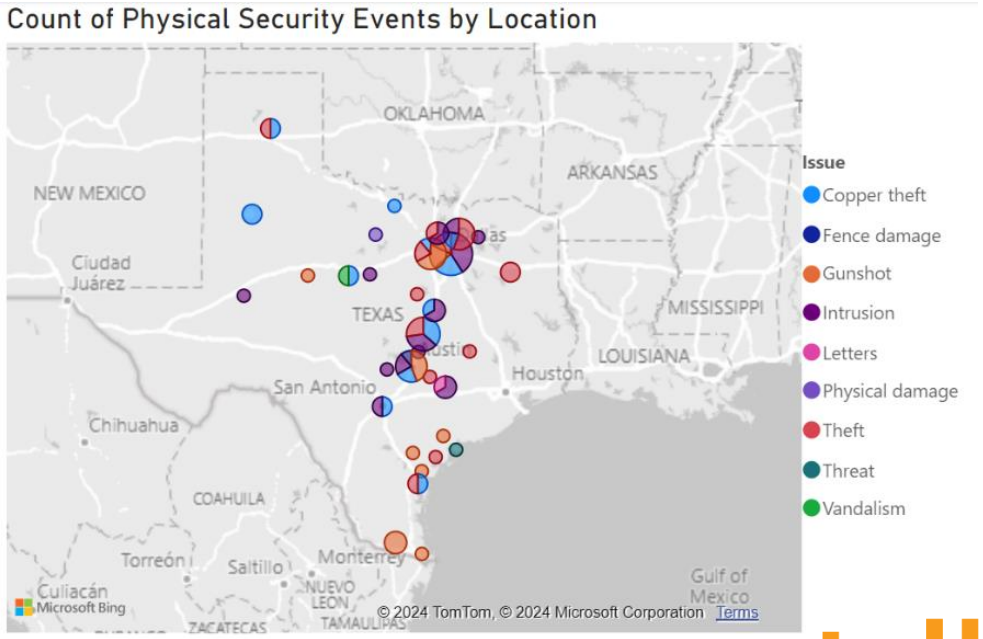
Performance Metrics

- Improvements noted in resource weatherization and cold weather resiliency
- Solar down-ramp magnitude continues to increase, creating periods with potential energy adequacy shortfalls
- Inverter-based resource ride-through continues to be a major risk point of emphasis
  - Performance requirement changes in progress through NERC/ERCOT committees
- Misoperation rates improving but human performance continues to be primary causal factor in both misoperations and system events
- Conventional generation fleet outage rates improved in 2024, but long-term outage rates continue to trend higher

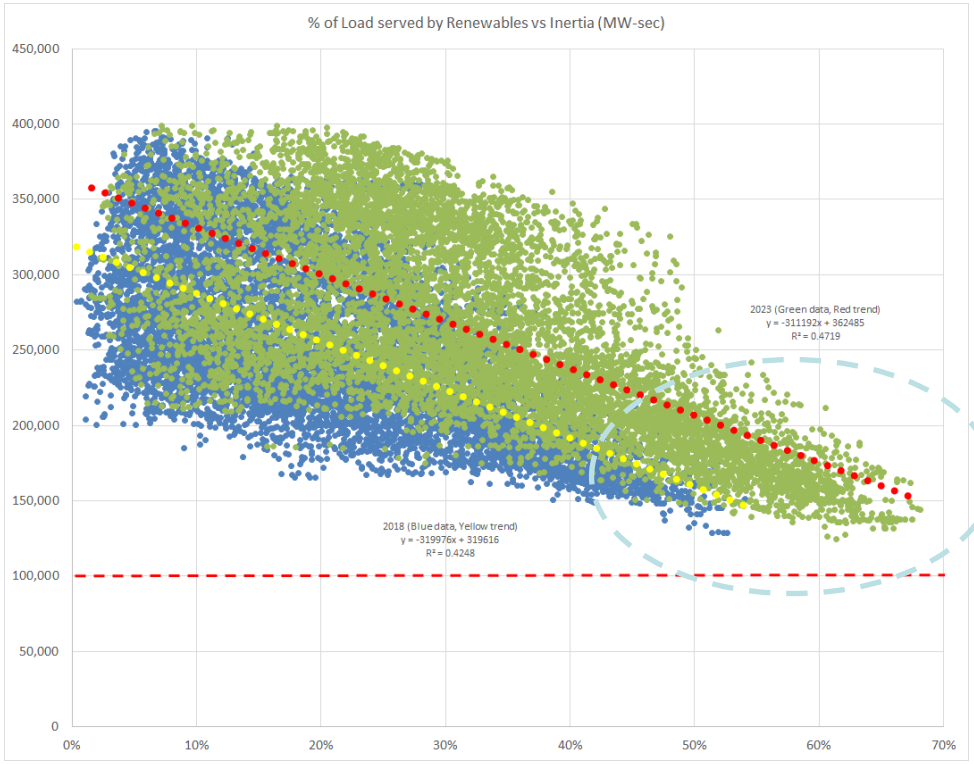
2023 Physical Security

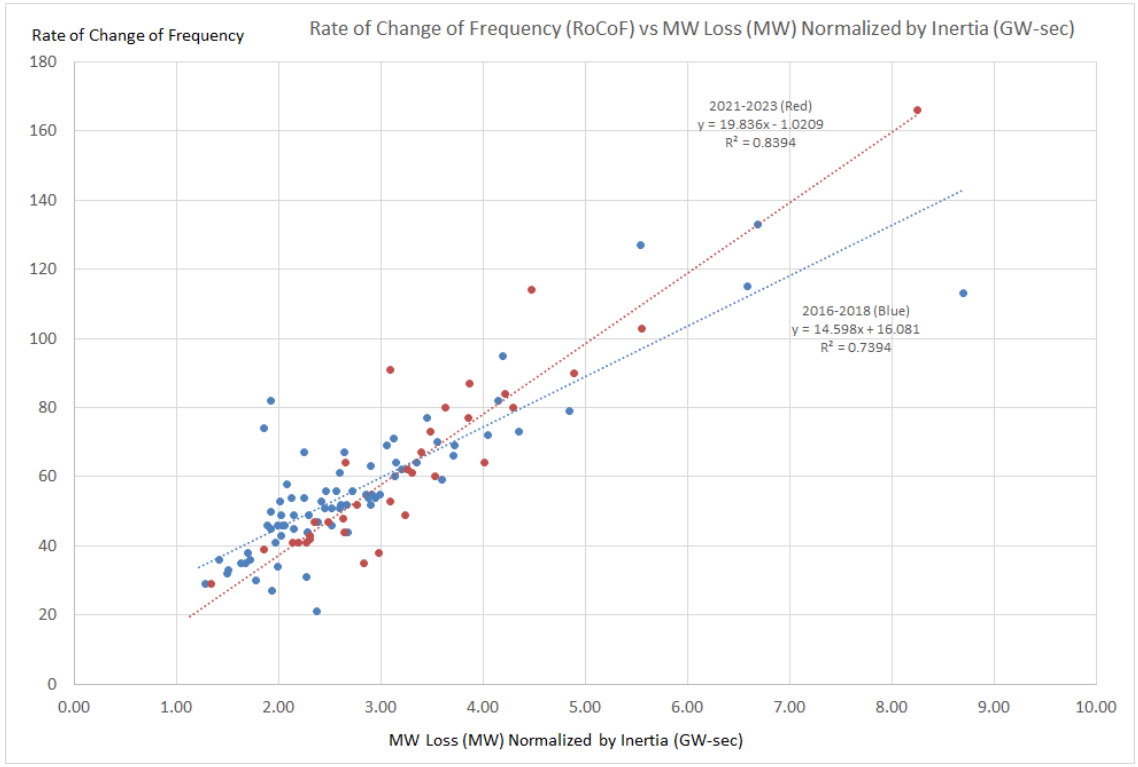


- **Significant increase in ballistic events in 2023 compared to prior years. Trend also observed nation-wide**
- **Significant increase in theft events**



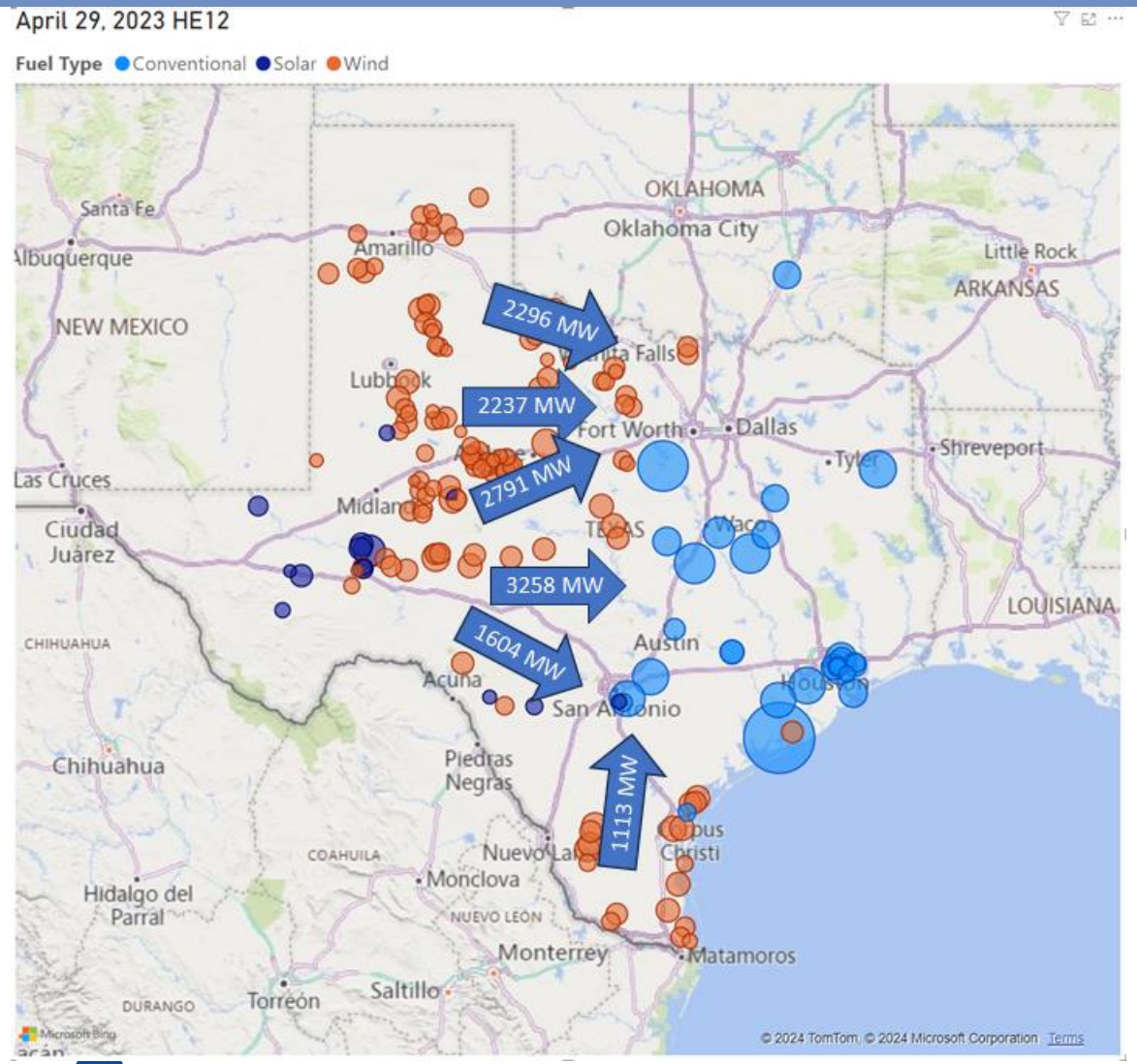
2023 Inertia





- 100 GW-sec critical inertia level used in ERCOT Operations
- Continued shift in inertia levels as resource mix changes
- Lowest hourly inertia level of 124.3 GW-sec in 2023
- Gradual increase noted in Rate-of-Change-of-Frequency measured during generation loss events

2023 High Renewable Hour

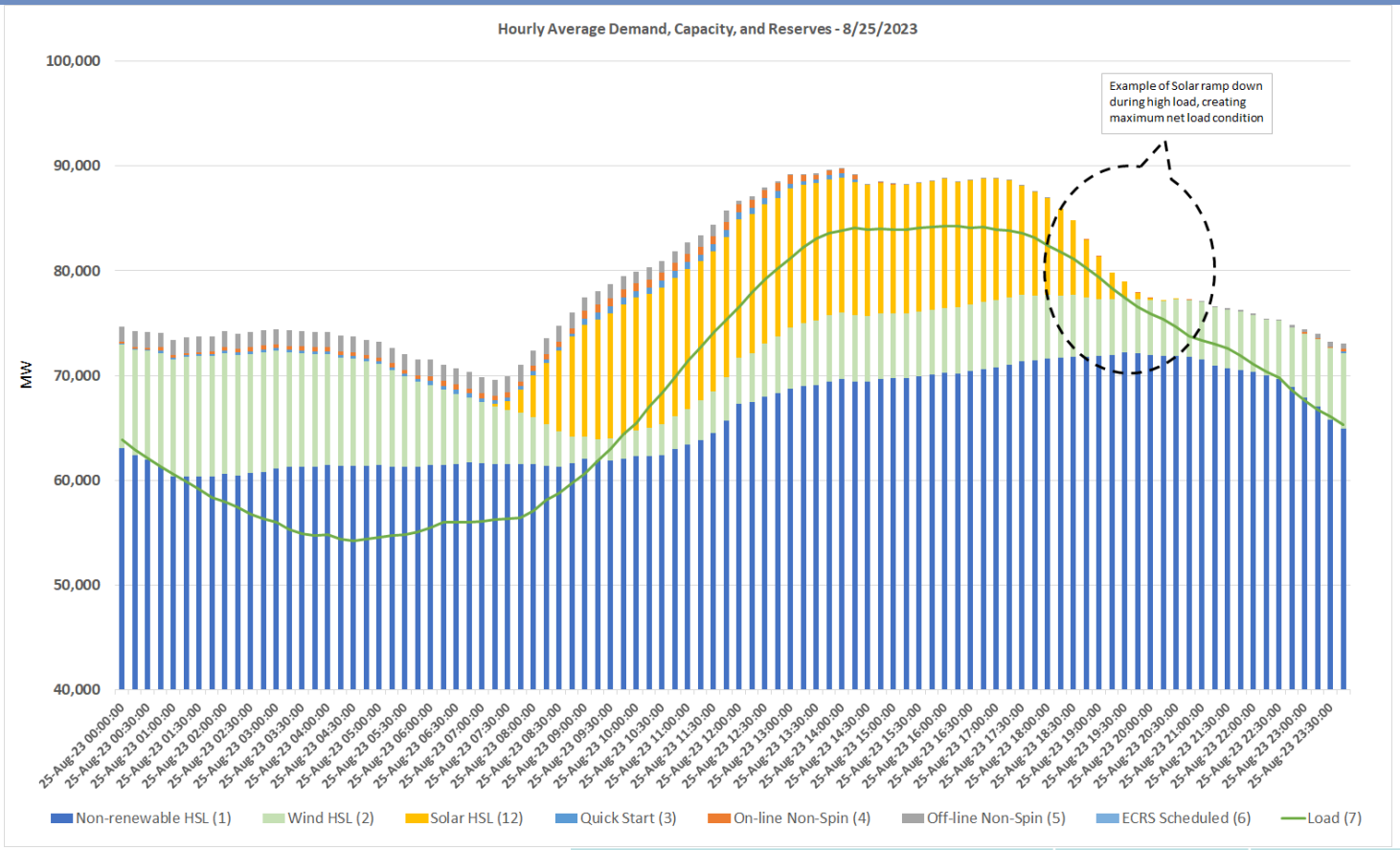


Snapshot of highest renewable penetration period: 4/29/2023 HE12

No synchronous generation online in West Texas, Panhandle, or Lower Rio Grande Valley

ERCOT load: 40,227 MW
Net load: 12,823 MW
Inertia level: 144,227 MW-sec
Wind generation: 21,104 MW
Solar generation: 6,300 MW
Renewable penetration: 68.1%
Total curtailments: 8,320 MW
System Lambda: -$1

2023 Solar and Net Load Ramping



- **Conventional resources must have sufficient ramping capability to maintain the generation-load balance when intermittent renewables have large up or down ramps**
- **Solar and net load ramp rates continue to increase, causing non-spin and other reserve deployments during sunset hours**

Ramping Variability 2023	Load	Wind Gen	Solar Gen	Net Load
Maximum One-Hour Increase	5,721 MW	6,020 MW	7,572	12,119
Maximum One-Hour Decrease	-4,919 MW	-5,256 MW	-7,524	-8,971

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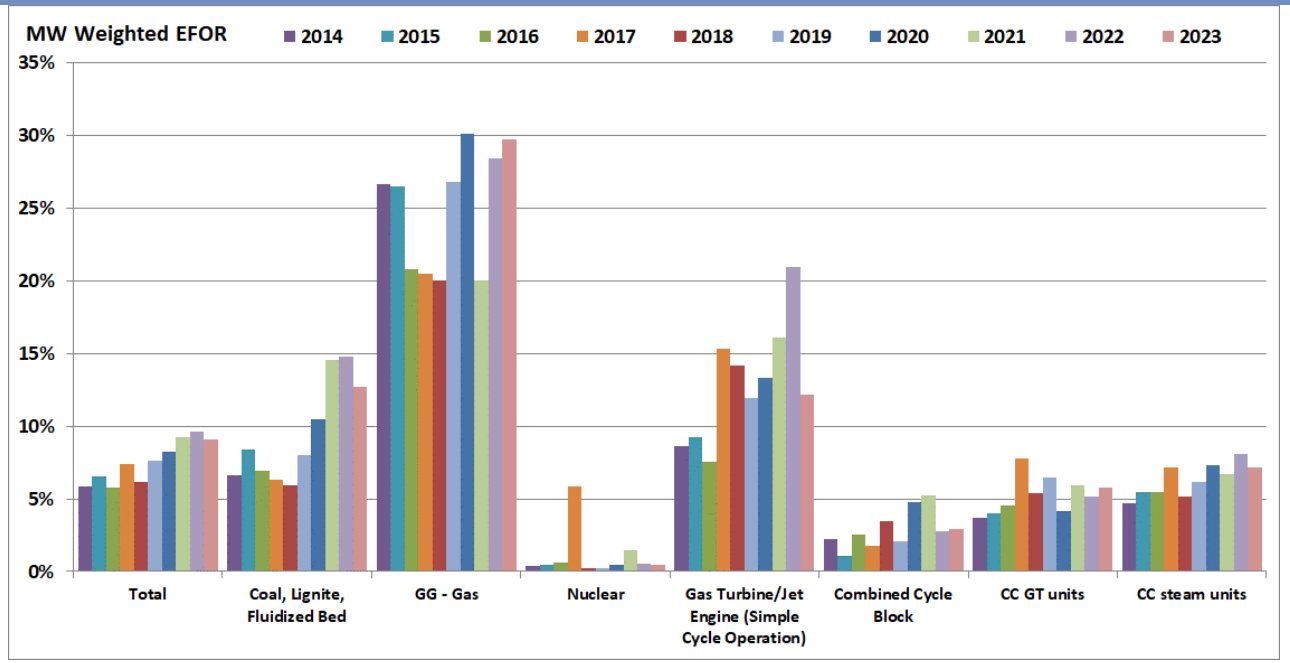
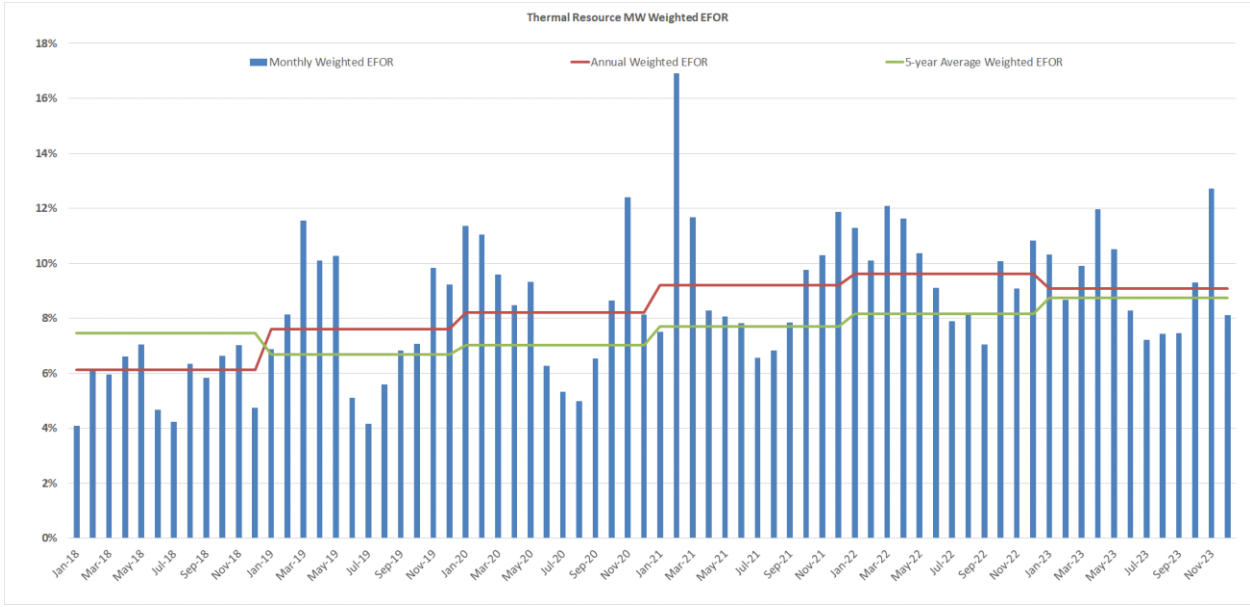
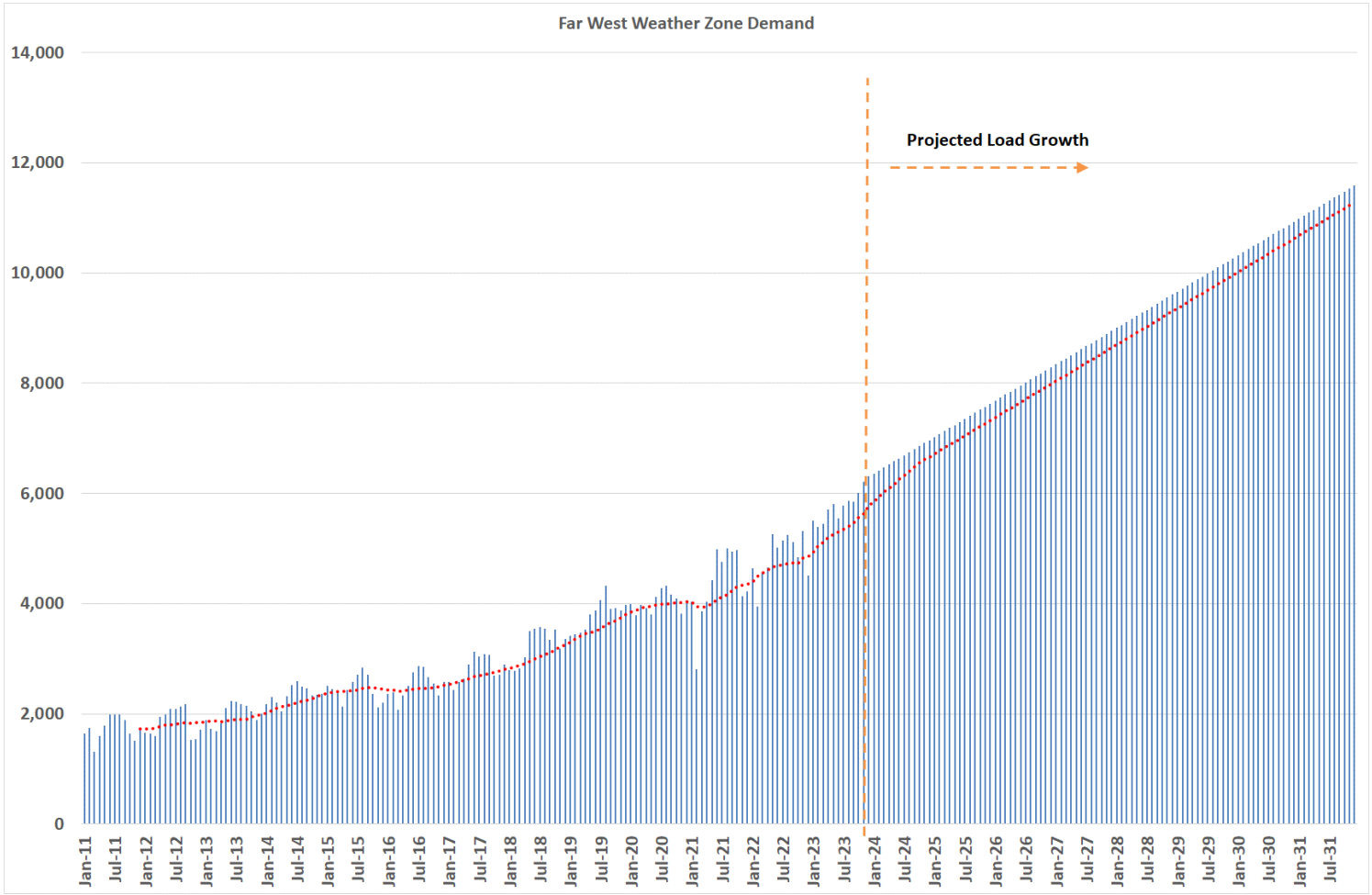
2023 Generator Outage Rates



- Long-term trends show increasing outage rates for conventional units
- Coal unit outage rate remains high
- CC fleet trends also increasing



2023 West Texas Load Growth

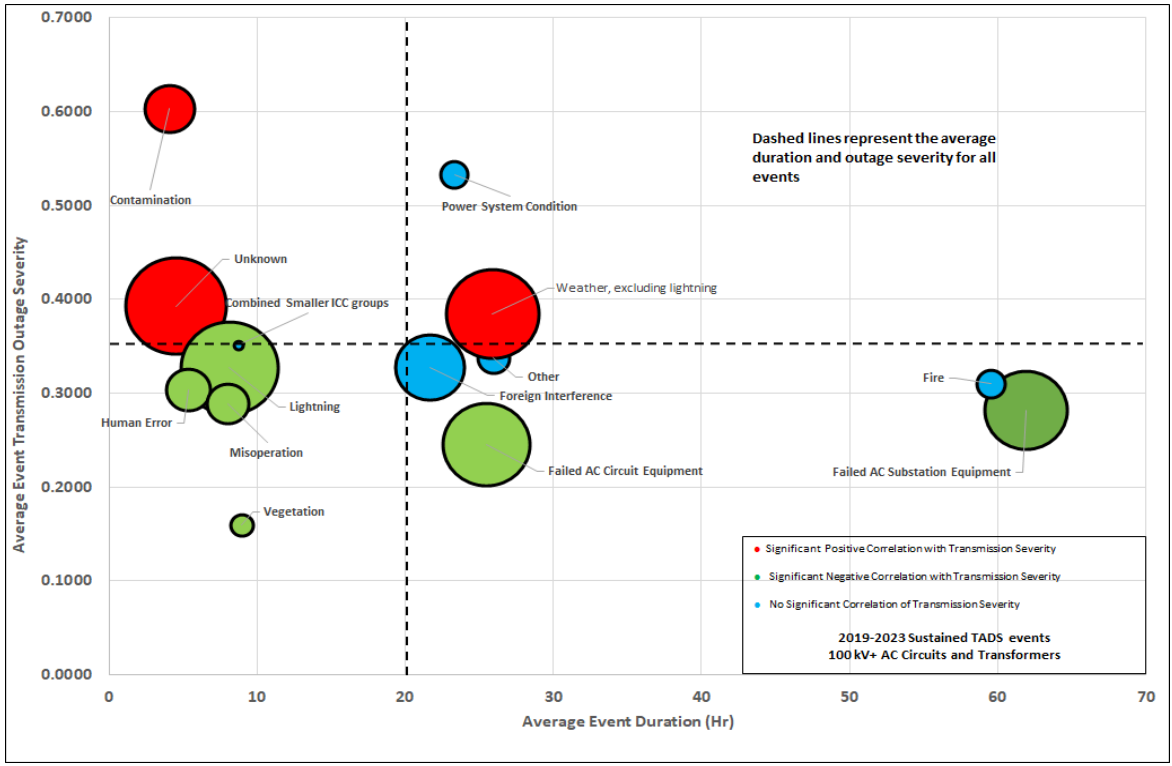


- Permian Basin load projections over 11.9 GW by 2030
- Both oil and gas demand in addition to large flexible loads
- $4.3B in approved projects completed since 2014
- $1.12B in projects currently under review

2023 Resilience and Extreme Day Analysis

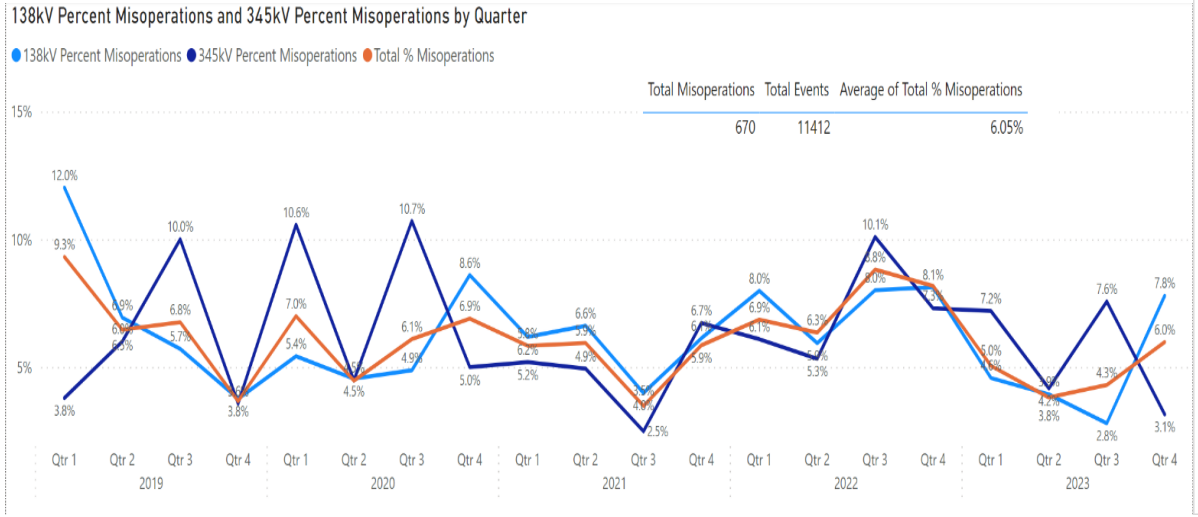
Generation and Transmission outage severity and duration continues to be driven by weather and failed equipment

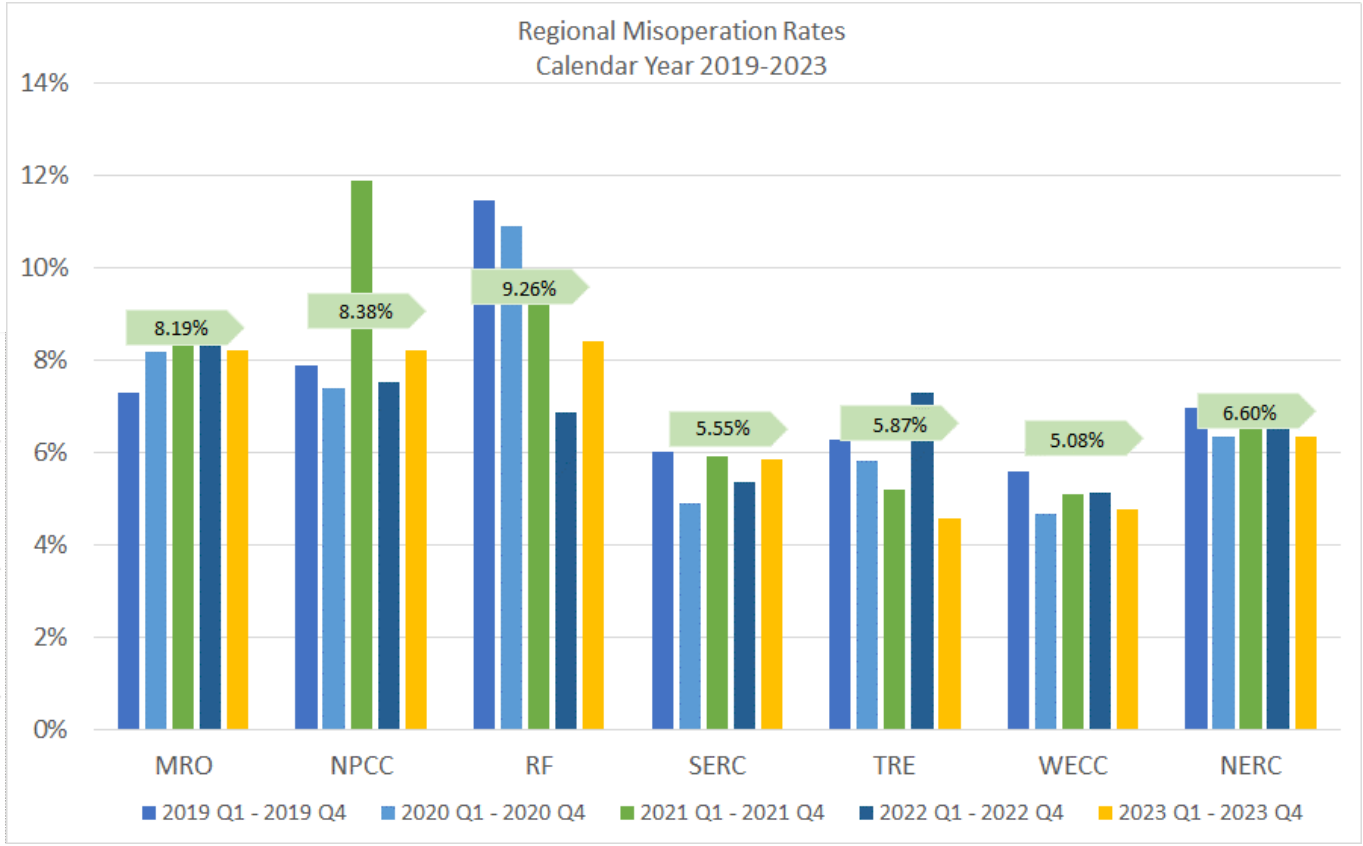
Generation Extreme Day Analysis	Number of Generation Outage Events on Extreme Day	Leading Causes for Extreme Day	Cumulative Outage Duration on Extreme Day	Cumulative MW Impact on Extreme Day	Cumulative GWh Impact on Extreme Day
8/27/2017	41	Weather	22,798 hours	10,107 MW	2,917.5 GWH
1/16/2018	84	Balance 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



2023 Protection System Misoperation

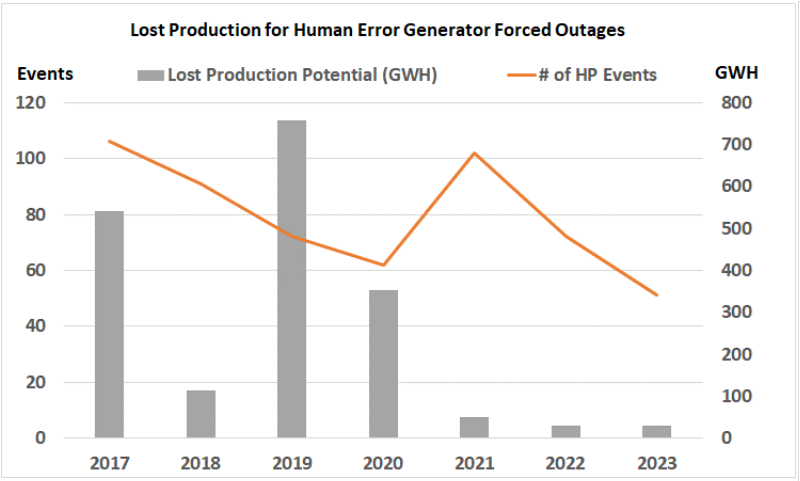
- **Overall Misoperation rate trending lower, from 6.4% in 2019 to 4.6% in 2023**
- **Incorrect settings, logic, and design errors remain the largest cause**

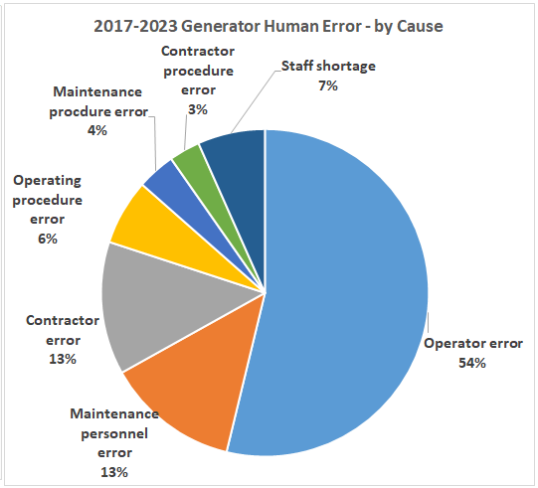


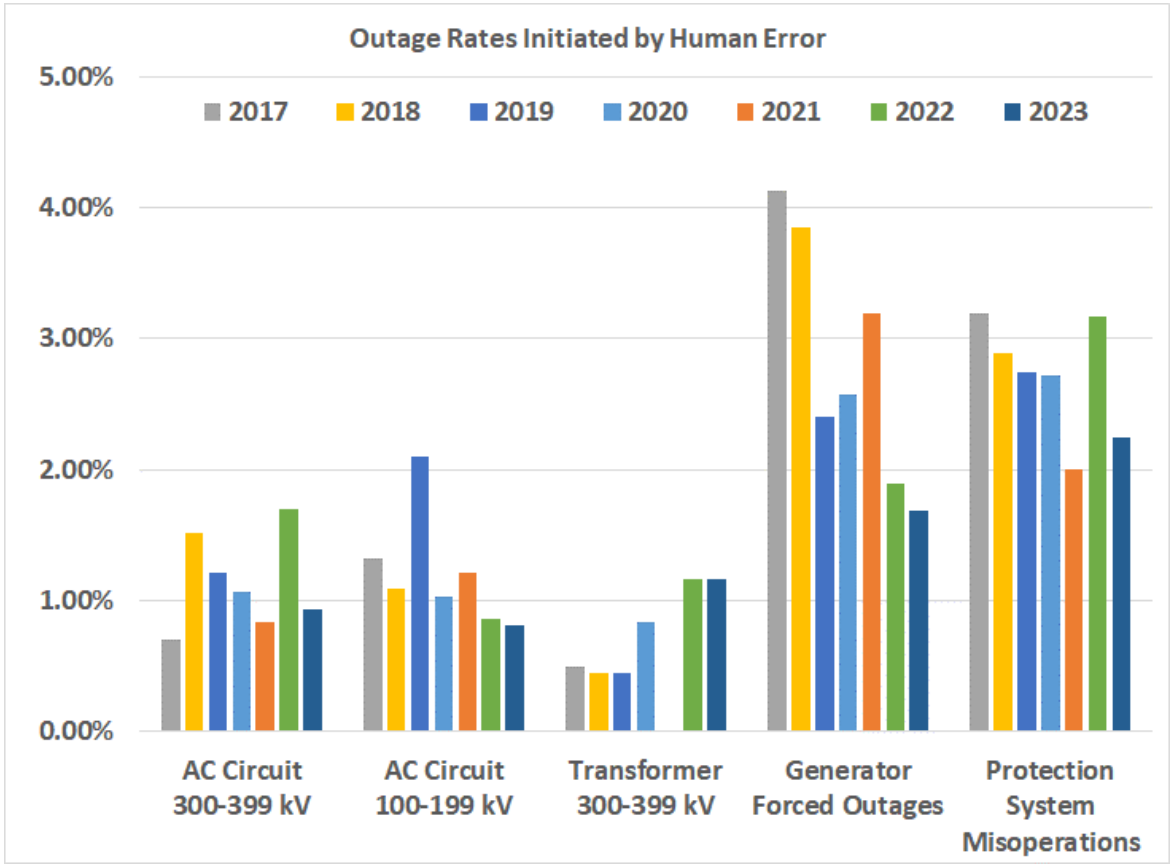


2023 Human Performance

- Human performance remains primary causal in Protection System Misoperations
- 53% of event root and contributing cause related to human or organizational performance



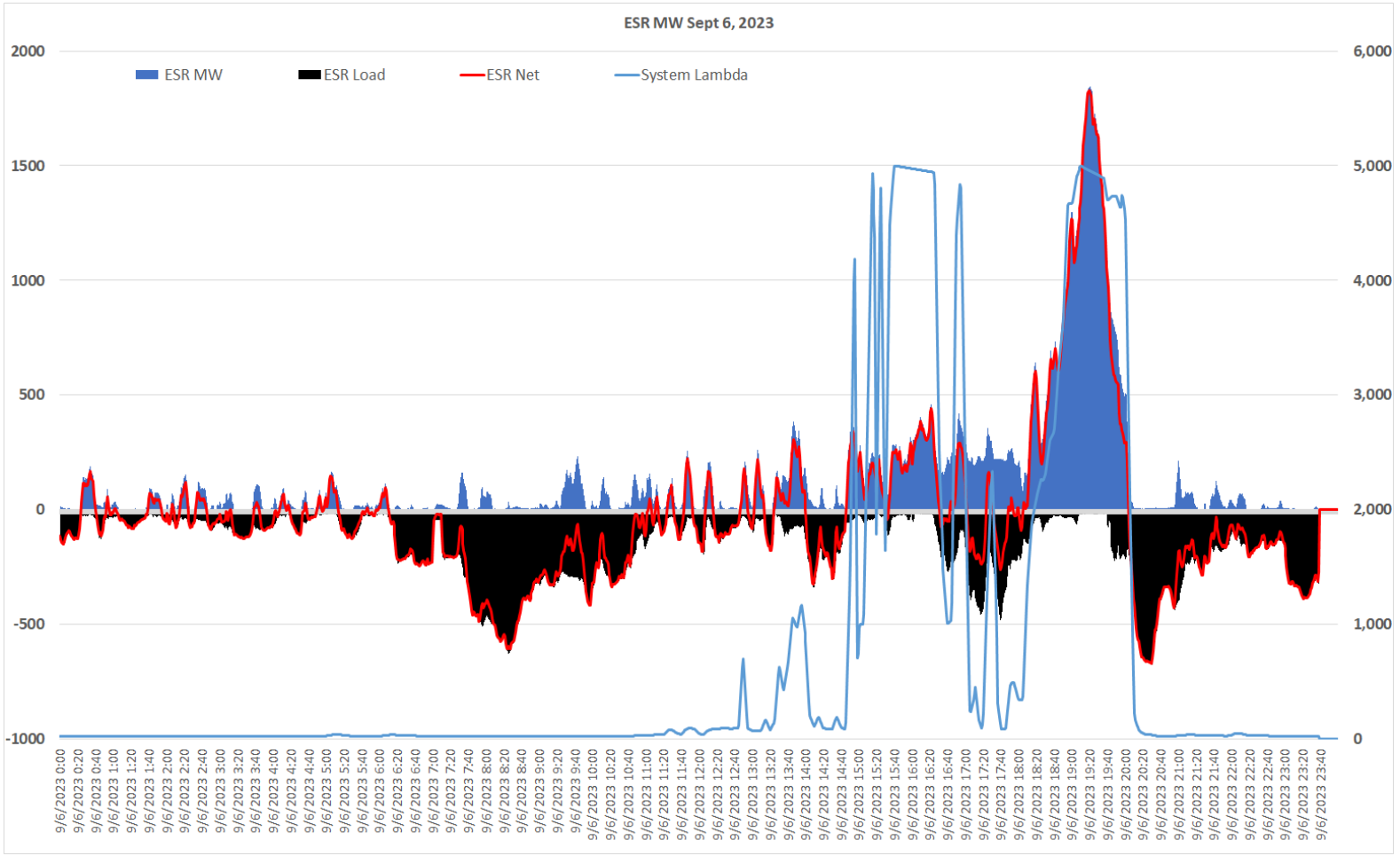




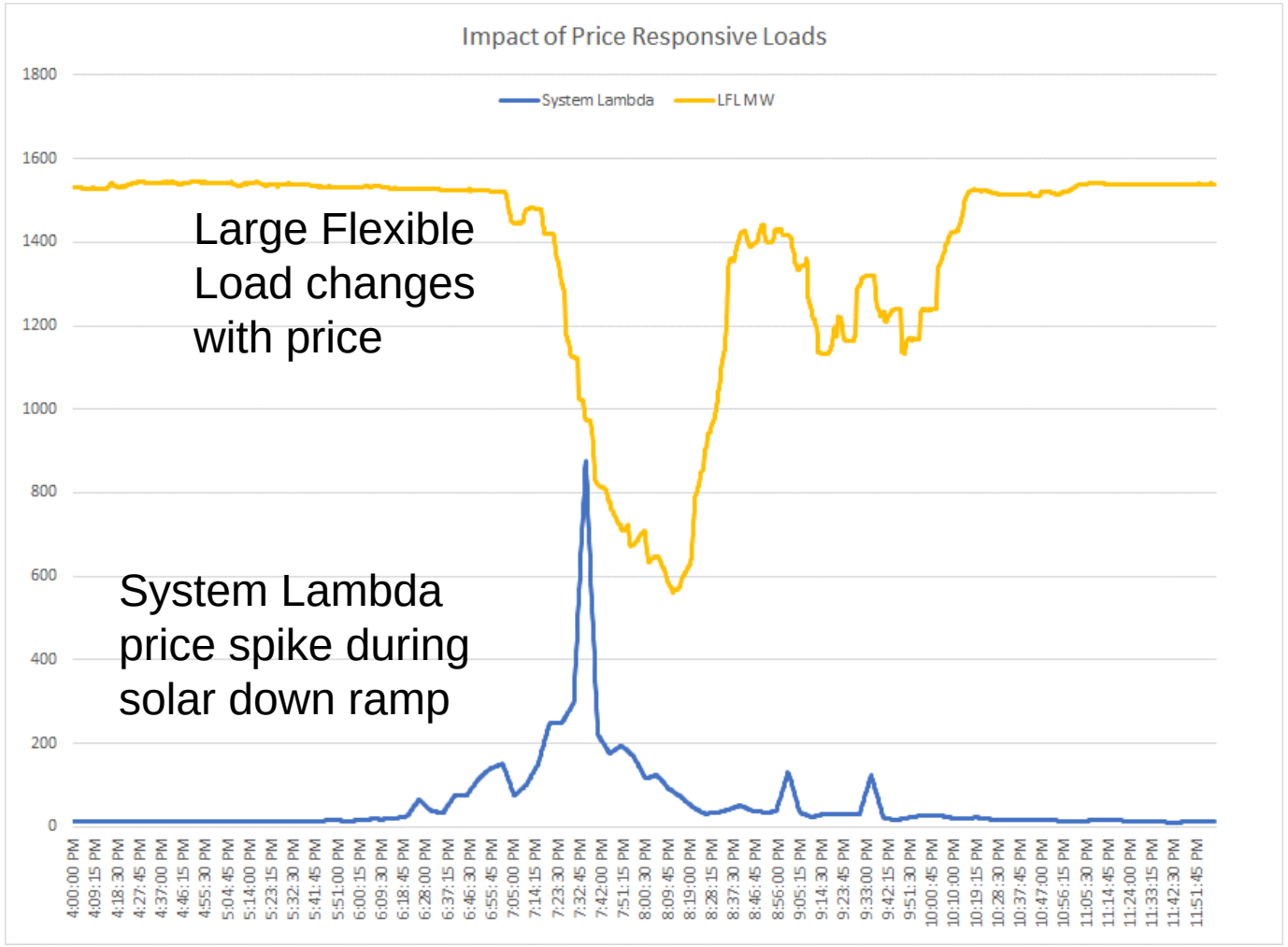
2023 Energy Storage

Energy Storage

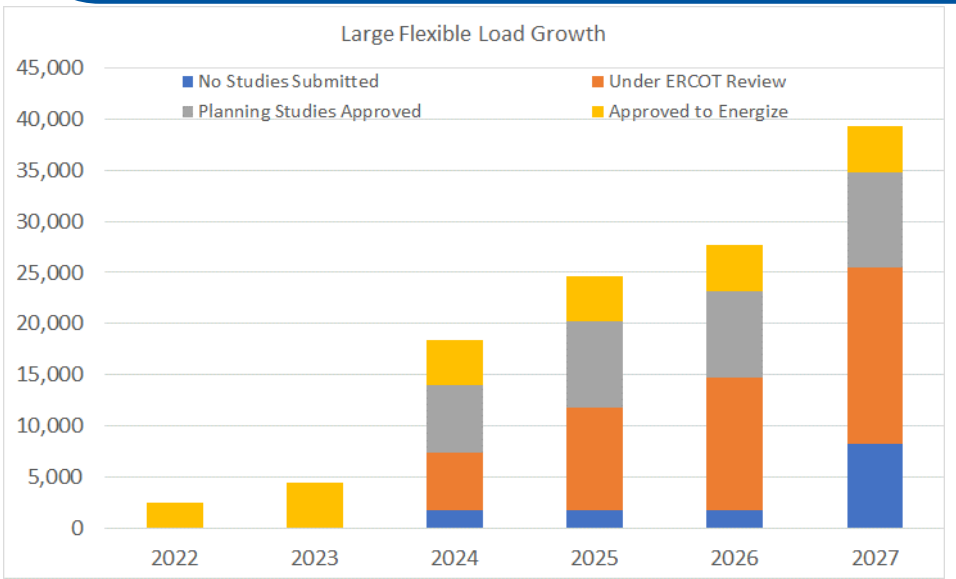
- Batteries providing increasing quantities of ancillary services
- Some issues noted with incorrect telemetry
- Multiple PFR failures
- Battery injection during events has provided valuable MW



2023 Large Flexible Loads



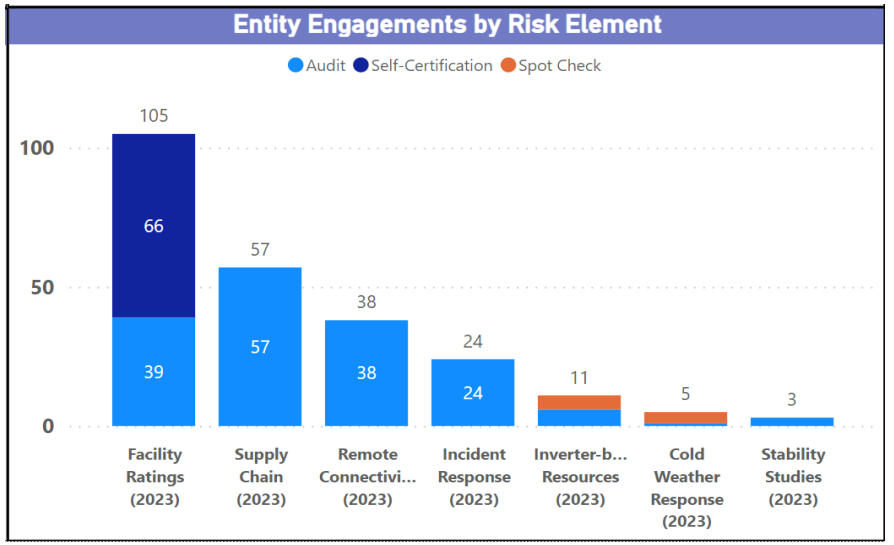
- Price-responsive load introducing errors in load forecasts
- Regulation exhaustion during large load swings
- Significant increases in Large Flexible Loads projected
- Most do not meet NERC registration criteria
- Issues with long-range planning models



2023 Risk Focus Area Follow-up and Outreach

2023 Risk and CMEP IP Focus Areas
Inverter-Based Resource Ride Through
Provision of Essential Reliability Services from a Changing Resource Mix
Energy Reliability Planning
Inaccurate Resource Modeling
Equipment Failures/Misoperations
Remote Access
Supply Chain
Physical Security
Extreme Weather & Resource Weatherization
Facility Ratings
Gas Supply Chain Restrictions during Cold Weather
Malware
Loss of Situational Awareness

- **Fourteen Talk with Texas RE webinars on risk focus-area topics**
- **Winter Weatherization Workshop**
- **Two NERC Alerts issued**
- **Multiple entity engagements on remote connectivity, supply chain, modeling standards, facility ratings, and cold weather standards**



2024 Risk Focus Areas

	Likelihood	Consequence
Inverter-Based Resource Ride Through	Likely	Major
Provision of Essential Reliability Services from a Changing Resource Mix	Unlikely	Moderate
Energy Availability	Possible	Major
Inaccurate Resource Modeling	Possible	Moderate
Disorganized Integration of Large Flexible Loads	Unlikely	Moderate
Remote Access	Possible	Moderate
Supply Chain	Possible	Major
Physical Security	Likely	Moderate
Extreme Weather & Resource Weatherization	Possible	Major
Facility Ratings	Unlikely	Moderate
Gas Supply Chain Restrictions during Cold Weather	Possible	Major

Risk Focus Areas for 2024

- **Continuous Evaluation of Emerging Risks**
- **Priorities based on Likelihood and Impact**
- **Major Areas**
  - **IBR Ride-Through**
  - **Physical Security**
  - **Remote Access Threats and Vulnerabilities**
  - **Gas-Electric Interdependencies**
  - **Supply Chain**
- **New for 2024: Integration of Large Flexible Loads**

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Ensuring electric reliability for Texans