TEXAS RE

Ensuring electric reliability for Texans

2018 Assessment of Reliability Performance

Summary Report

June 2019

Table of Contents

Read the full report here.

Introduction

Texas RE periodically assesses and reports on the reliability and adequacy of the bulk power system (BPS) within its region. This document is a summary of the 2018 Assessment of Reliability Performance for the Texas Interconnection.

The goals of this report are to paint the overall BPS reliability picture with historical context, identify current and future risk areas, and prioritize and create actionable results for reliability improvement. This report provides insight into areas where reliability goals can be more effectively achieved by addressing key measurable components of BPS reliability. Additionally, this report aligns data and facts reported from multiple sources with full information transparency. The key findings and observations can serve as inputs to process improvements, event analyses, reliability assessments, and critical infrastructure protection.

Data sources for this report include:

1. Transmission Availability Data System (TADS)
2. Generation Availability Data System (GADS)
3. Demand Response Availability Data System (DADS)
4. Misoperation Information Data Analysis System (MIDAS)
5. Event Reports
6. Frequency Control Performance and Primary Frequency Response

Texas RE's Mission:

To assure efficient and effective reduction of risks to the reliability and security of the bulk power system within the ERCOT Interconnection.

2018 at a Glance: Demand and Energy

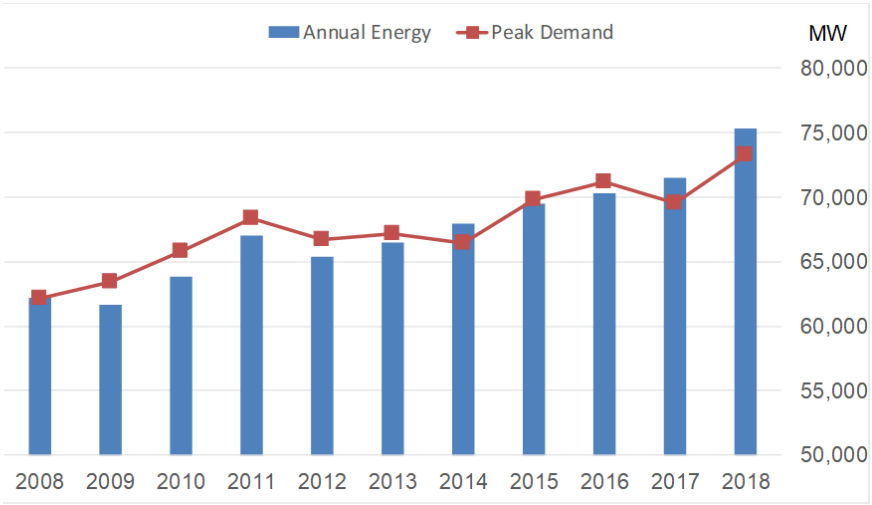
Summer all-time peak hourly demand: 73,264 MW on 7/19/2018

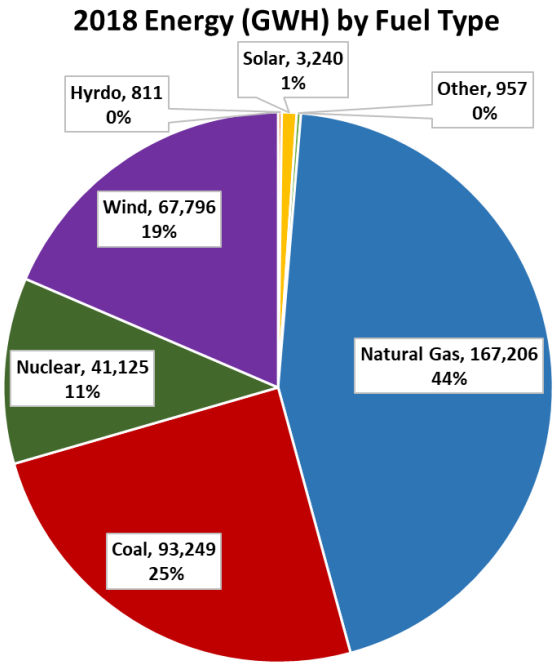
Winter all-time peak hourly demand: 65,724 MW on 1/17/2018

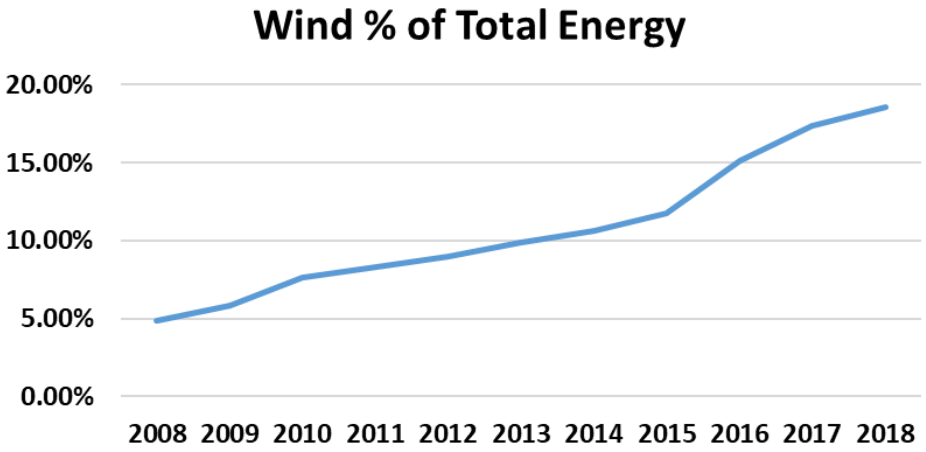
Renewable energy was 19.3% of total energy for calendar year 2018

All-time peak hourly wind generation: 19,019 MW on 12/14/2018 at 3:00 a.m.

Peak hourly renewable penetration: 54.03% on 12/27/2018 at 4:00 a.m.







2018 at a Glance: Reliability

Control Performance Standard 1 (CPS1): 175.7 for calendar year 2018 versus 174.9 for calendar year 2017

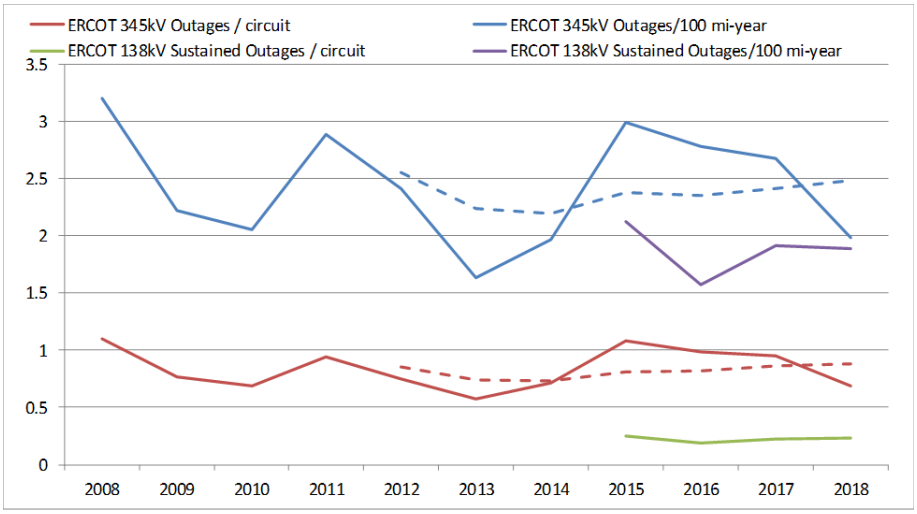
Primary Frequency Response: 895.2 MW/0.1 Hz versus NERC obligation of 381 MW/0.1 Hz

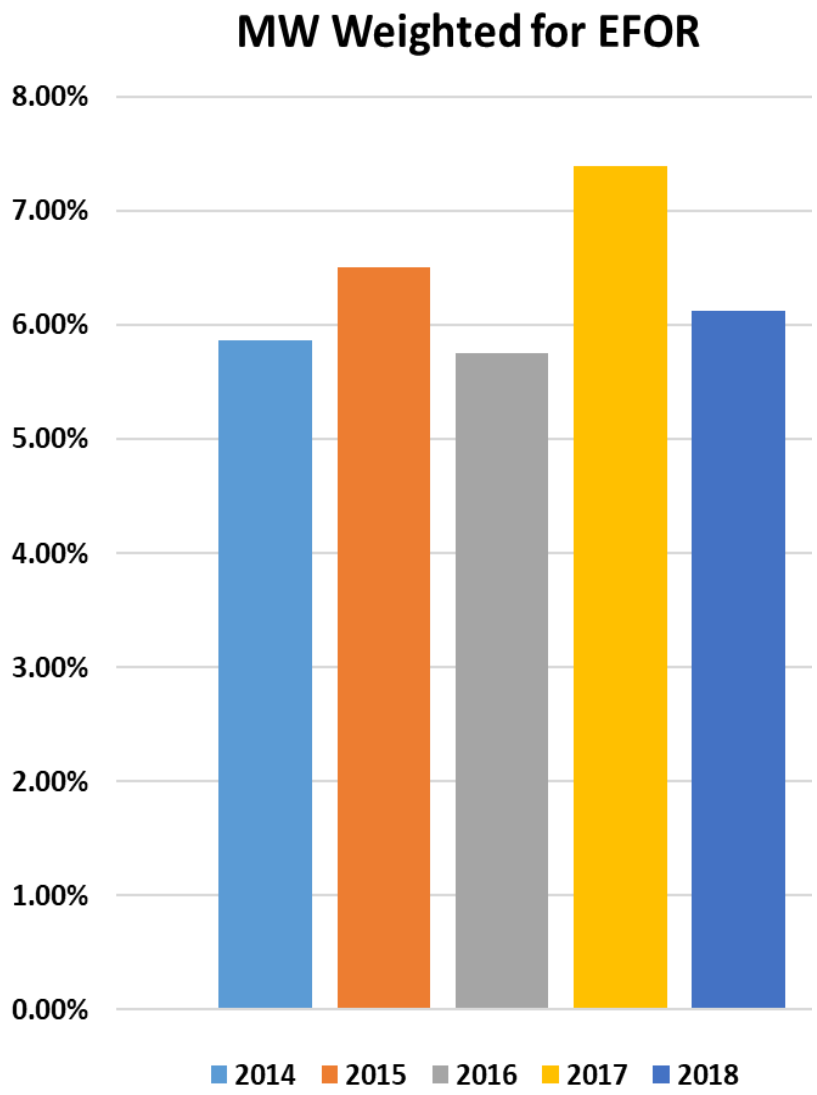
TADS 345 kV circuit automatic outage rate per 100 miles: 1.98 for 2018 versus 2.68 for 2017

Protection system misoperation rate (>100 kV): 7.1% for 2018 versus 6.5% for 2017

GADS EFOR (MW Weighted): 6.12% for 2018 versus 7.39% for 2017

Automatic Outage Metrics 2008-2018





2018 Focus Areas

Texas RE continually evaluates risks to system reliability within the ERCOT Interconnection through long-term and seasonal reliability assessments, events analysis, situational awareness, tracking reliability indicators, real-time performance monitoring, and planning observations. Texas RE developed the 2018 Assessment of Reliability Performance report to provide a high-level overview of the data collected in the region. This report provides:

- 2018 data at a high level
- Associated historical data
- Analysis of 2018 and other historical data as an indicator of the current state of the Texas Interconnection
- Observations that help connect the state of the region today to the future

To gauge reliability of the ERCOT Interconnection and turn that data into actionable information, Texas RE assesses data and historical trends in eight focus areas:

Performance Metrics

Texas RE utilizes key performance indicators to evaluate how effectively the region is meeting targeted electric reliability objectives. The table below describes these indicators, how they are measured, target values, and an assessment of the current state of each.

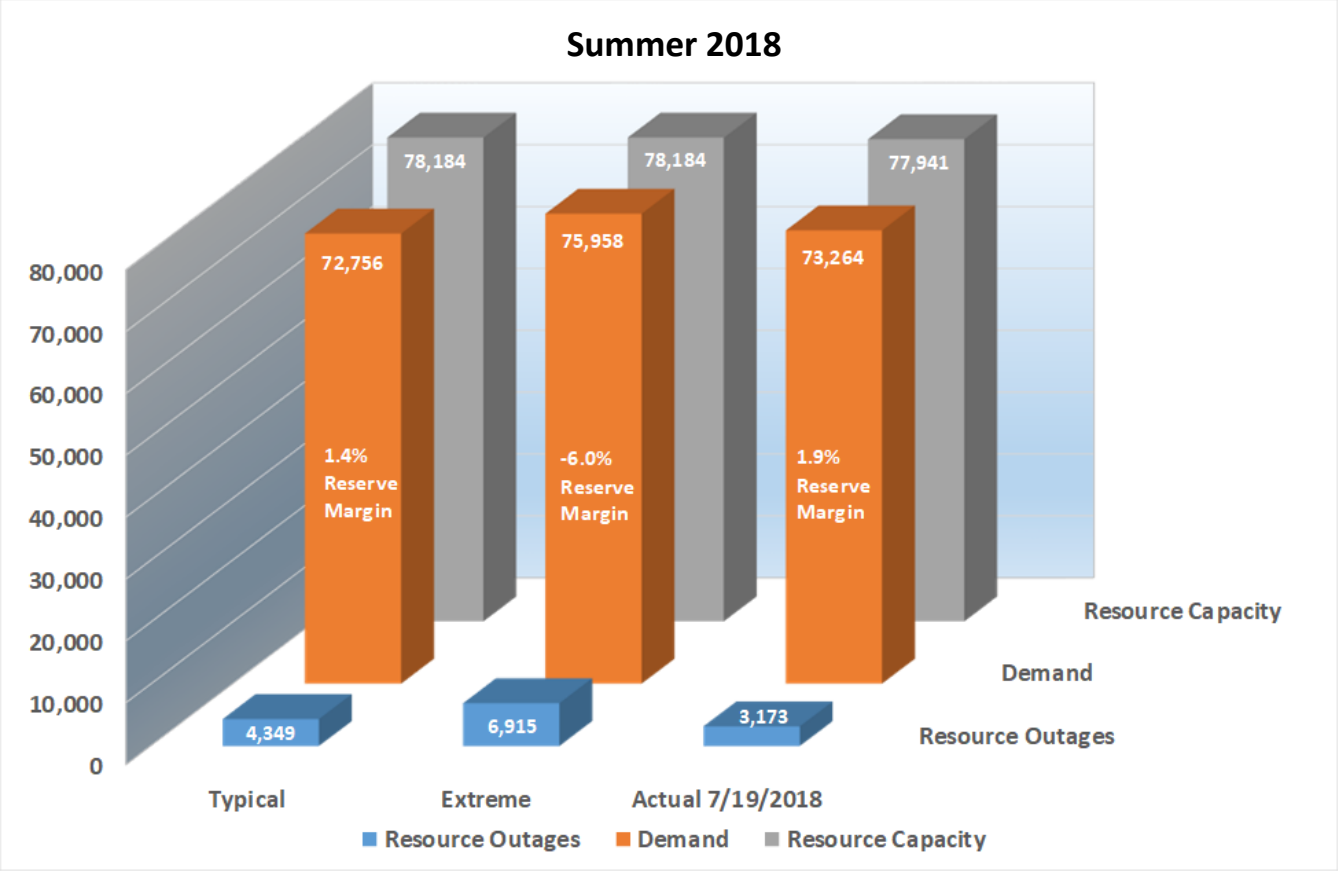
Key Performance Indicator	Negative Trend *	Stable Trend *	Positive Trend *
Resource Adequacy	Planning reserve margin Natural gas curtailments	Sufficient operating reserves maintained during summer and winter peaks	
Transmission Performance		Outage rates per circuit & per 100 miles 0 IROL exceedances	
Resource Performance	Inverter generation low voltage ride-through	EFOR rates No Balancing Contingency event failures	Primary frequency response
System Inertia	Negative inertia trend during minimum load hours	Stable trend during other hours	
Misoperation Rate	Increased rate in 2018		5-year overall improving trend
Human Performance		Stable trend in generation HP errors	Improving trend in transmission and misoperation HP errors
Situational Awareness	7 Loss of EMS events in 2018	State Estimator convergence rate	

**Based on a statistical five-year regression*

Key Findings: Reserve Margins

1. Planning reserve margins are historically low going into 2019

While sufficient operating reserves were maintained during summer and winter peak hours in 2018, the cumulative generation capacity impacted by natural gas fuel curtailments increased significantly when compared to previous years—primarily due to several severe cold weather periods in January 2018. Seasonal Equivalent Forced Outage Rates (EFOR) also indicate a higher risk of forced outages during winter periods. These risks need to continue to be proactively managed by ERCOT through multiple winter preparation audits for at-risk generation sites.



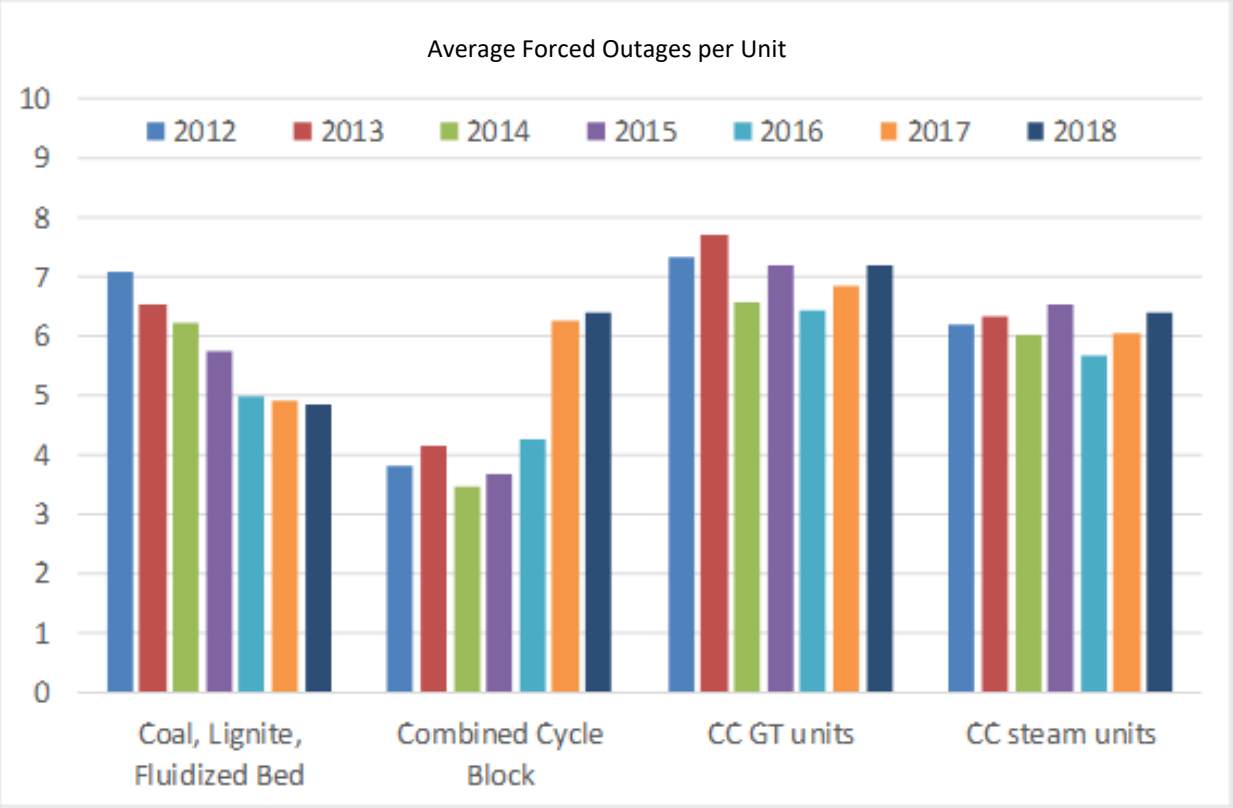
Additional risk factors within the ERCOT Interconnection include:

- The traditional methods of assessing resource adequacy may not accurately or fully reflect the new resource mix's ability to supply energy and reserves for all operating conditions.
- Forecasting BPS resource requirements to meet customer demand is becoming more difficult due to the penetration of distributed energy resources (DER), which can mask the customer's electric energy use and the operating characteristics of distributed resources without sufficient visibility.

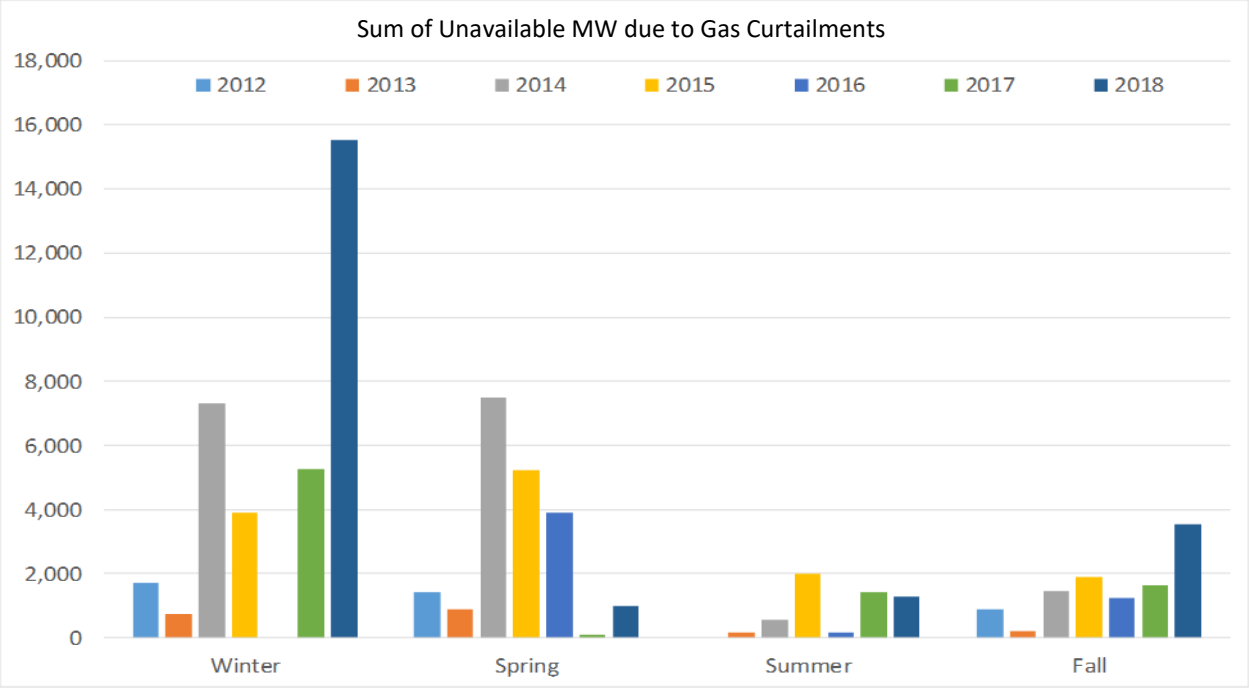
- Conventional steam resources that operate infrequently due to economics may not operate reliably when dispatched for short peak-demand periods during seasonally hot or cold temperatures.
- Historic methods of assessing and allocating ancillary services such as regulation, ramping, frequency response, and voltage support may not ensure essential reliability services (ERS) or sufficient contingency reserves are available at all times during real-time operations.
- Fuel constraints and environmental limitations may not be reflected in resource adequacy assessments.

From January 2018 through December 2018, there were 2,026 immediate forced outage events with a median outage capacity of 171 MW per event. The majority of the immediate forced outage events occurred due to boiler control or other control system issues, blade path temperature spreads, fuel piping, human error, and vibration issues.

2018 Fossil Unit Forced Outages Major System	Number of Forced Outage Events	Total Duration (hours)	Total Capacity (MW)	Median Duration per Event (hours)	Median Capacity per Event (MW)	Average Duration per Event (hours)	Average Capacity per Event (MW)
Boiler System	199	9,941.8	72,873.2	8.8	300.0	49.9	366.2
Balance of Plant	399	12,481.1	84,564.3	4.9	170.0	31.3	211.9
Steam Turbine/ Generator	1,091	35,929.3	178,597.3	3.6	157.5	32.9	163.7
Heat Recovery Steam Generator	92	5,647.6	18,962.9	21.8	185.0	61.4	206.1
Pollution Control Equipment	31	938.0	4,431.0	5.3	57.0	30.3	142.9
External	114	54,371.7	18,432.9	15.3	102.7	476.9	161.7
Regulatory, Safety, Environmental	14	182.8	1,471.6	13.9	85.0	13.1	105.1
Personnel/Procedure Errors	78	376.6	19,627.7	2.3	182.0	4.8	251.6
Other	8	168.0	247.0	1.8	46.8	21.0	30.9



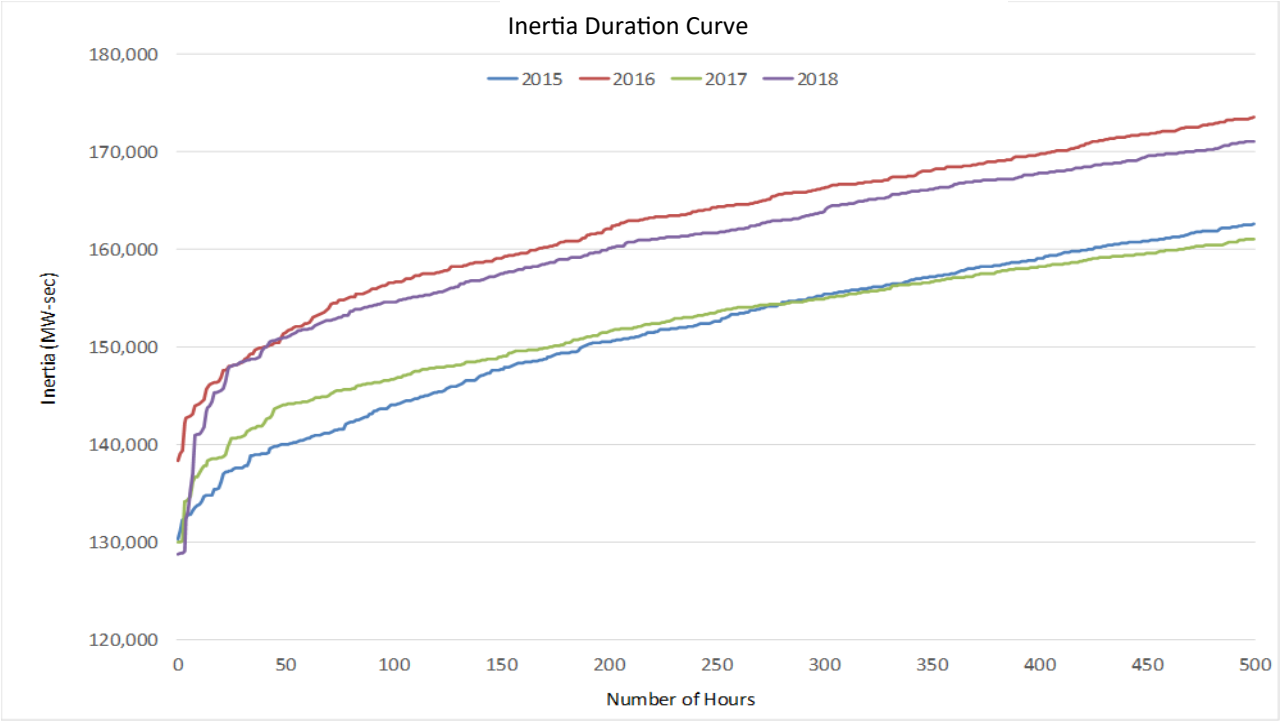
There was a significant increase in unavailable generation capacity due to natural gas fuel curtailments in 2018, with most of the curtailment occurring in January during the previously mentioned extreme cold events.

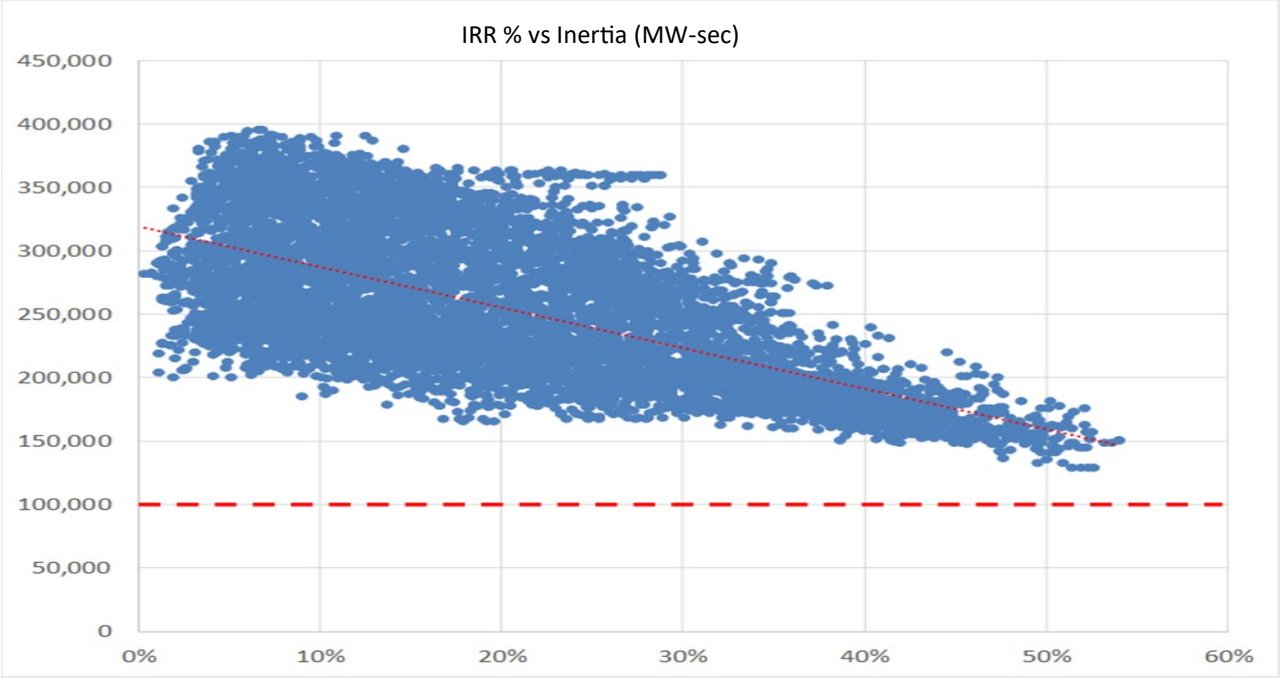


Key Findings: System Inertia

2. System inertia trends are mixed

Overall system inertia increased in 2018 compared to 2017 in spite of the retirement of several large coal units. However, during low load conditions the minimum inertia levels continue to decline. The change in system inertia is an indicator for the changing resource mix. As traditional turbine generators are replaced, inertia will need to be carefully managed by ERCOT.

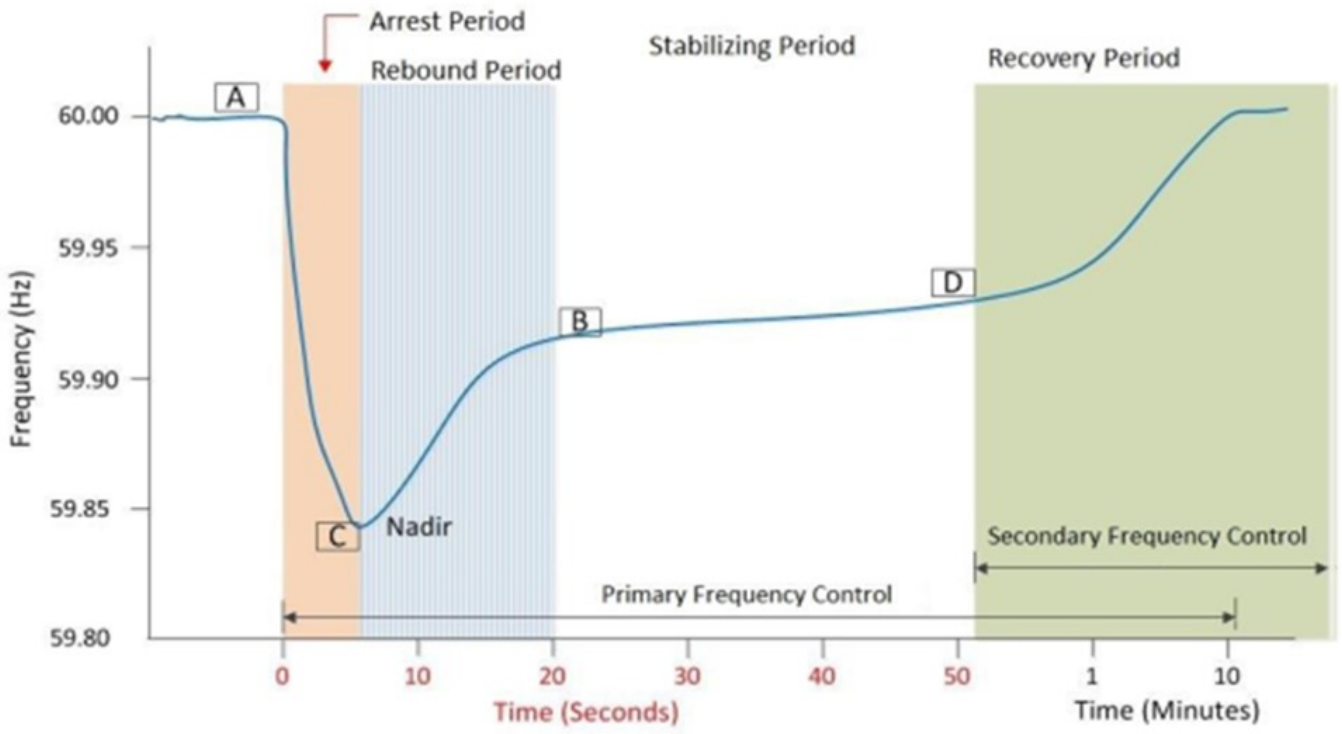




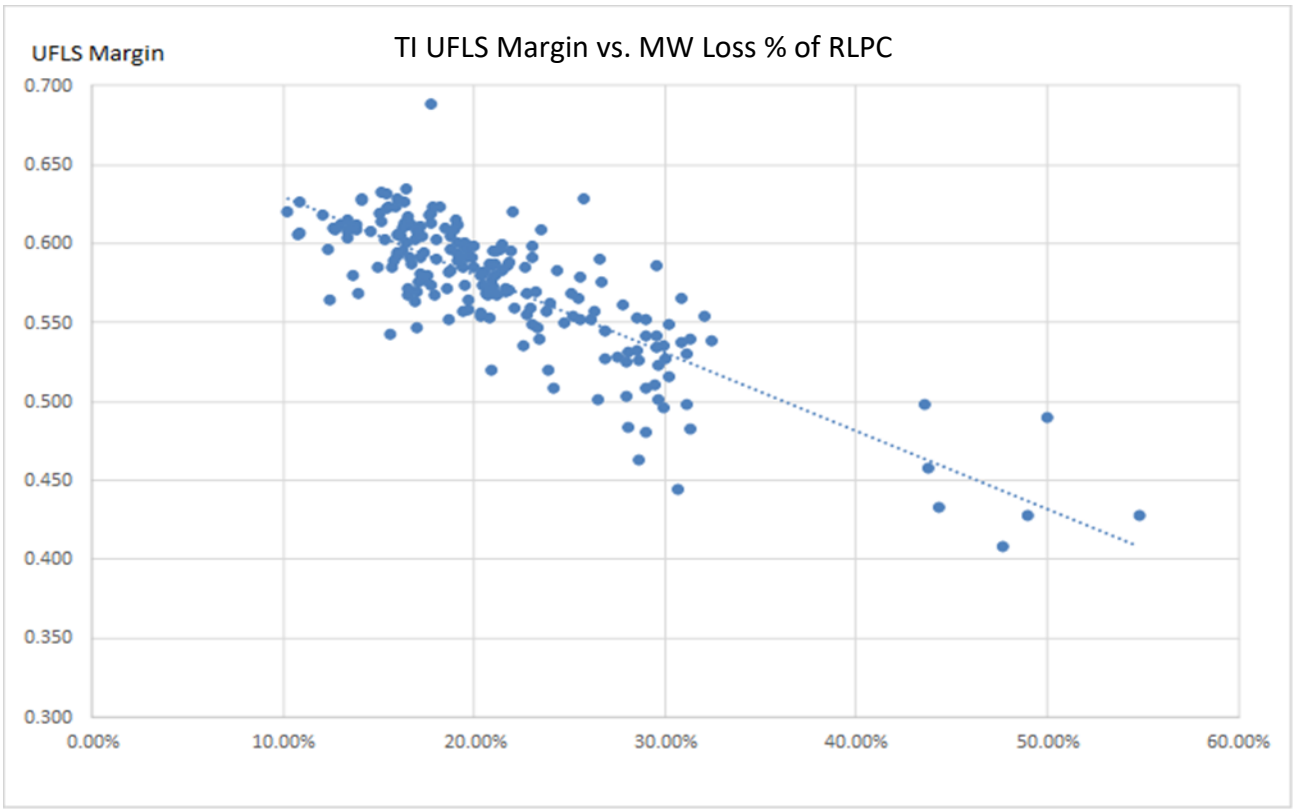
Key Findings: Frequency Response

3. Primary frequency response continues to improve

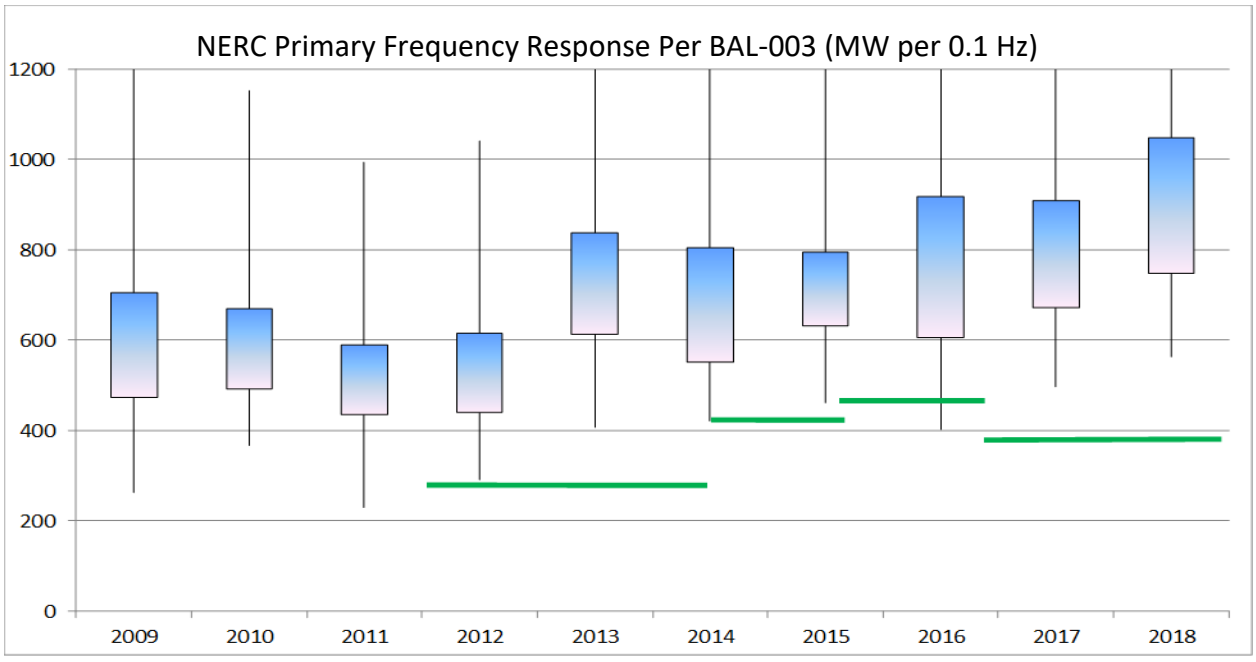
Primary frequency response (PFR) is the immediate increase or decrease in power output provided by generating units/facilities in response to Frequency Deviations. It is the goal of PFR to detect and immediately rebound, stabilize, and recover from frequency variations before a critical imbalance is reached.



The Nadir, or C-Point frequency, is an indicator of the system imbalance created by the unit trip and is a combination of synchronous inertial response and governor response. Normalizing the unit MW loss by inertia can provide insight into how the Nadir can vary under different inertia conditions for the same MW loss value. The figure on the next page shows the margin to the first step of underfrequency load shed (UFLS) protection plotted against the generation MW loss value normalized by the Resource Loss Protection Criteria (RLPC) for the Interconnection. This analysis not only shows the historic performance for how the Nadir is affected by different MW loss and inertia conditions, but may also be used as a possible predictive tool.



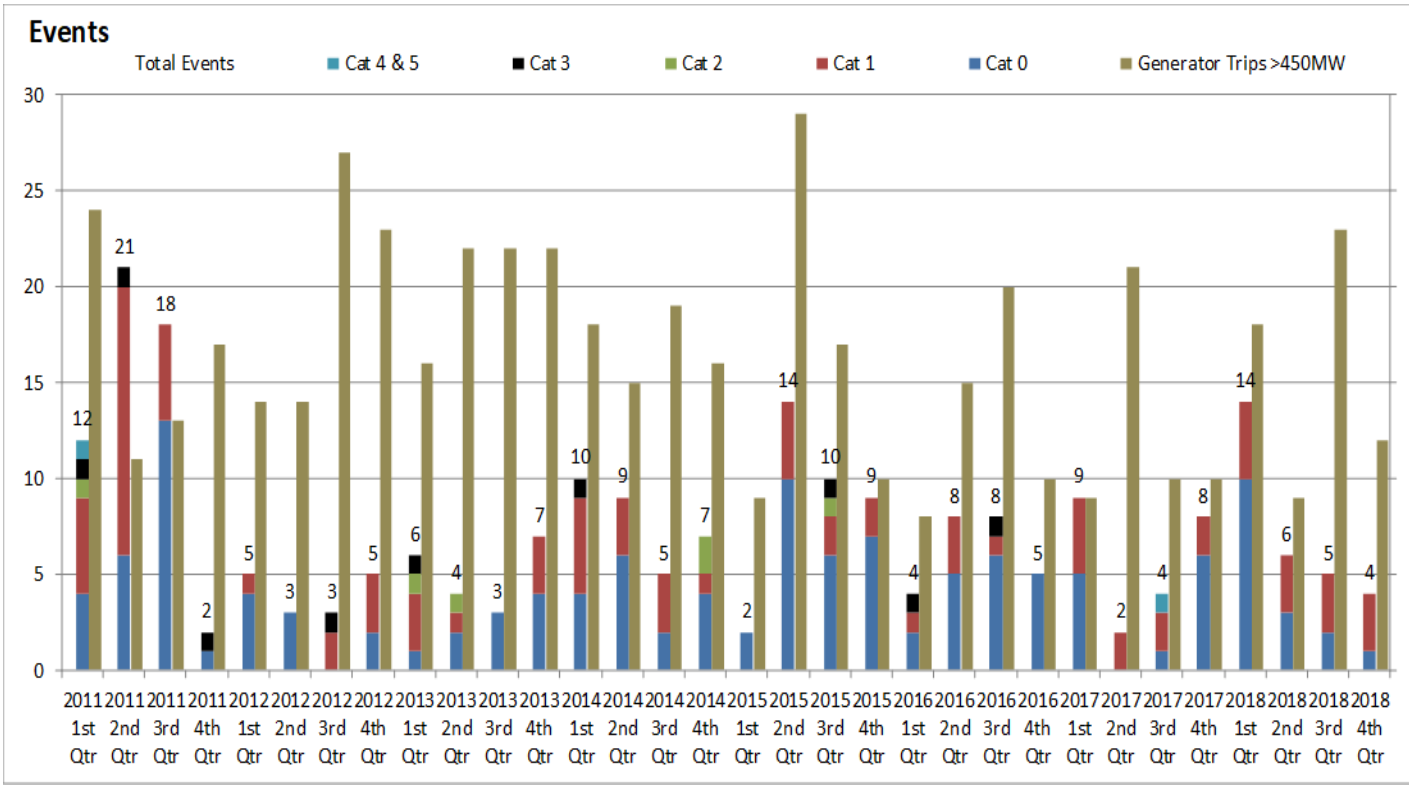
The median primary frequency response for the region as measured by BAL-003 events improved significantly in 2018. Analysis improved the understanding of the correlations between system inertia, rate-of-change of frequency, and the Nadir point during frequency disturbances. The frequency Control Performance Standard (CPS) metrics for the region remain stable.



Key Findings: Protection System Performance

4. System resilience during transmission and generation outages was impacted by Protection System performance

The BPS withstood several events in 2018 with losses of multiple elements, but no IROL exceedances. 345 kV and 138 kV transmission circuit outage rates remained stable and there were no Category 2 or higher events. However, Protection System misoperations magnified the impact of several system events, causing the loss of additional transmission elements as well as generation resources.

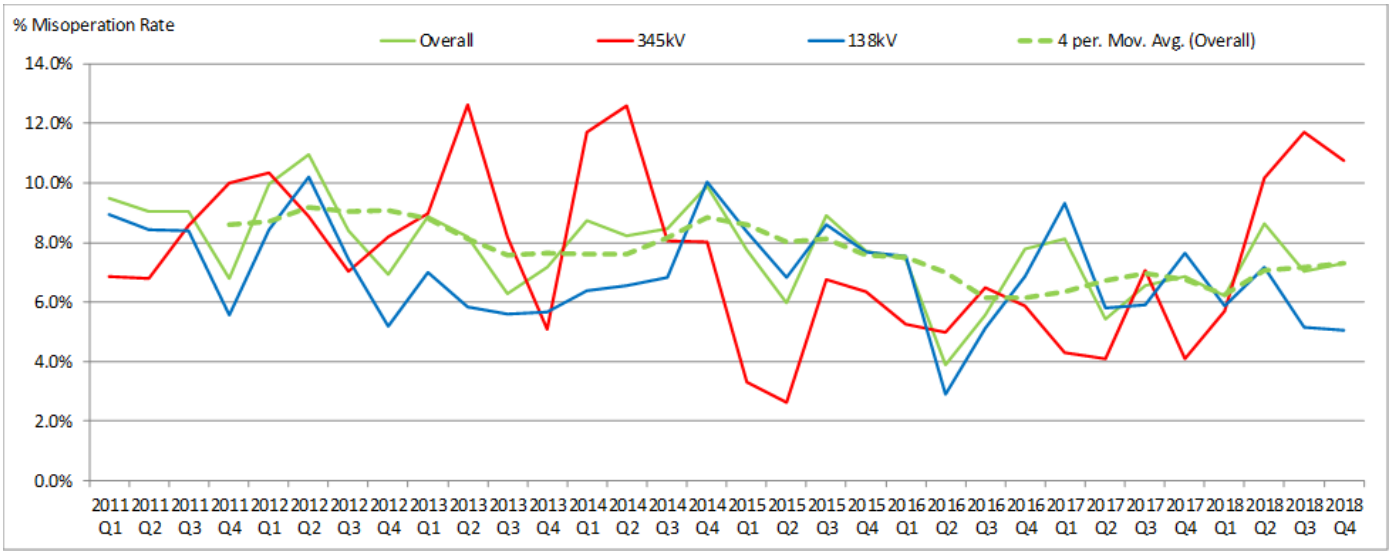


Failed transmission circuit and substation equipment dominated the sustained outage duration, accounting for 81 percent of the 345 kV sustained outage duration and 85 percent of the 138 kV outage duration. During one system event, the voltage collapsed in a local area following a transmission line fault, resulting in the loss of fourteen 138 kV and 69 kV lines and 140 MW of load.

Key Findings: Misoperations

5. The five-year average Protection System Misoperation rate is stable

The five-year average misoperation rate has stabilized at 7.0 percent. The misoperation rate increased from 6.5 percent in 2017 to 7.1 percent in 2018.



Human performance remains the primary causal factor in misoperations, primarily due to incorrect settings and/or as-left errors. The following list provides examples of common actual human error-related misoperations since 2015 in the ERCOT Interconnection.

Occurrences	Misoperations
17	Incorrectly wired CTs or PTs (polarity, ratio, etc.)
17	Field settings did not match the issued settings
15	Field wiring did not match the engineering drawings
9	Zero-sequence polarization vs. negative sequence polarization
9	Modeling
8	CTs left in the shorted or open position
8	Pilot relaying disabled on one end of the line
3	Cut-off switches left in wrong position
2	Relay firmware versions not current, or different on each end of a line

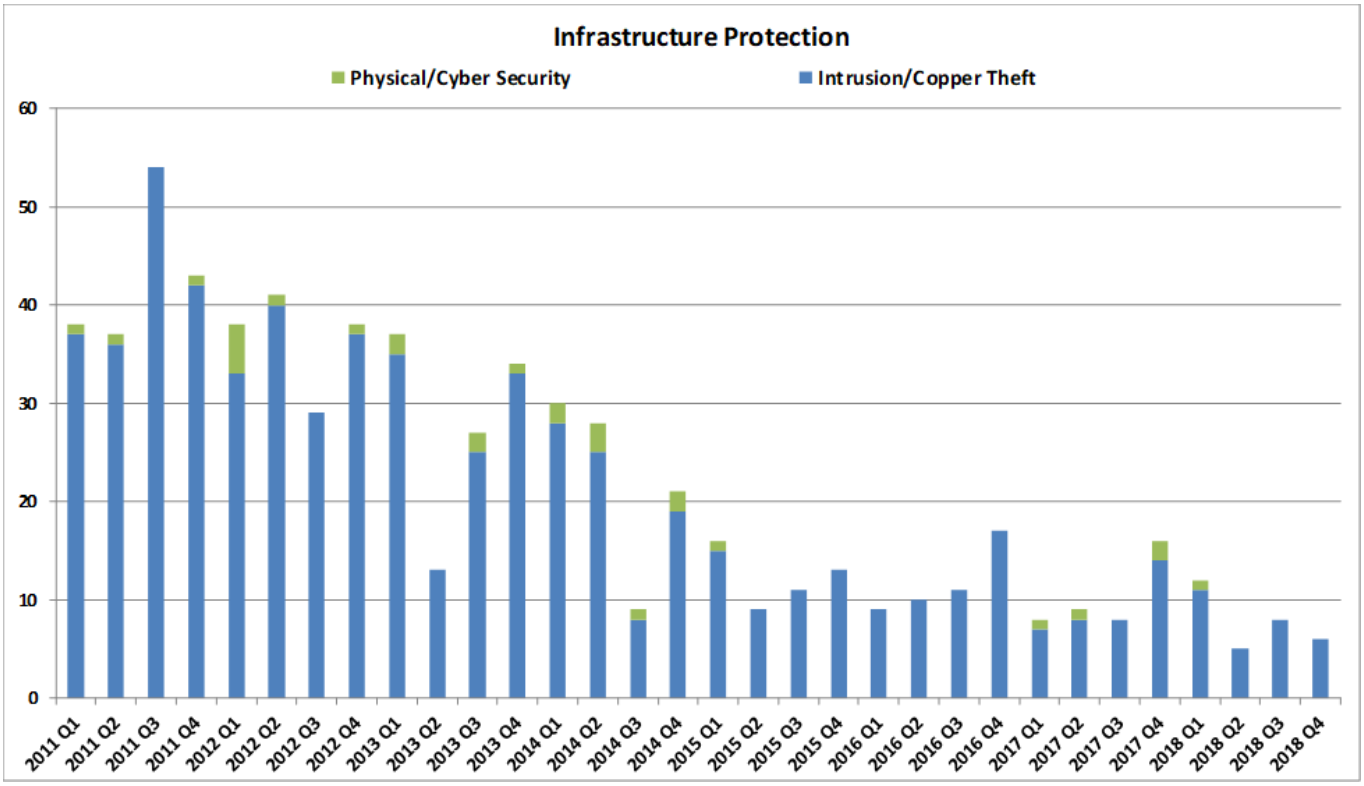
Eliminating these common human error related misoperations would create a significant reduction in the overall misoperation rate.

Key Findings: CIP Protection

6. Critical Infrastructure protection analysis is hampered by lack of data.

Intentional damage, destruction, or disruption to facilities can cause localized to extensive interconnection-wide BPS disruption—potentially for an extended period. Exploitation of cybersecurity vulnerabilities can potentially result in loss of control or damage to BPS-related voice communications, data, monitoring, protection and control systems, or tools. Successful exploitation can damage equipment, causing loss of situational awareness and—in extreme cases—can result in degradation of reliable operations to the BPS, including loss of load.

Regional Entities lack accurate, readily available information to analyze the BPS risk from physical and cyber security issues outside of compliance-related activities. Reports made by entities to the Electricity Information Sharing and Analysis Center (E-ISAC) are not available to Texas RE. The main data sources available for analysis of infrastructure protection issues (i.e., reports made to the Reliability Coordinator for substation intrusions and copper theft) only cover physical security. This data set is not comprehensive and the observed decline in intrusion and copper theft reports lacks credibility to suggest lower BPS physical security risk by itself. Critical infrastructure Standard compliance monitoring results and E-ISAC reports over the past five years indicate an increased risk.



Recommended Focus Areas for 2019

Resource Adequacy

A. Impact of generation unit retirements and resource mix changes
B. Distributed energy resource effects on demand, ramping, and voltage control

Resource adequacy needs to look beyond the calculation of reserve margins to also encompass ancillary services, voltage control, and system ramping capability.

The rate of change of the resource mix continues to increase. There are potentially increasing risks to the BPS as conventional synchronous generation is retired and replaced with renewable, distributed, or asynchronous resources. Uncoordinated integration of inverter-based technology may result in common-mode failures.

The increased dependency on natural gas as the predominant fuel source will begin to present more challenges to real-time operations. Natural gas fuel supplies and deliverability can have a significant impact on reliability and must be studied to identify necessary mitigation strategies. Situational awareness should now include gas sources, pipeline status, gas compressor station locations and failures, and deliverability issues.

Bulk Power System Planning

A. Planning reserve margins
B. Weak grid areas in the Interconnection

Anticipated reserve margins are projected to continue to decline in the short-term planning horizon as fossil-fueled units retire or are mothballed due to economic conditions.

Weak grid characteristics, including lack of local synchronous generation combined with a lack of local load, can lead to grid strength challenges such as low short-circuit strength and voltage instability.

The generation modeling information necessary to perform transient and small-signal stability studies appears to be incomplete. Non-representative wind plant control system models in the Panhandle and Valley areas have limited the accuracy of instability studies as well as studies for the interaction and performance of the control systems. Modeling of large-scale solar inverter systems also needs validation.

Changing Resource Mix

Changes in system inertia and its corresponding effects on rate-of-change of frequency and the nadir frequency point will continue to be monitored as the resource mix continues to change in 2019.

The effects from the changing resource mix on ancillary services, voltage support, and ramping will also continue to be monitored. Several proposed NERC Standards changes and NERC guideline efforts are underway to provide guidance and requirement language to better incorporate inverter-based generation technology into the grid. These efforts will continue to be monitored and supported throughout 2019.

Resilience and Recovery

In 2017, Hurricane Harvey demonstrated the impact that extreme natural events can have on the resilience of the BPS, from equipment damaged by high winds and flooding to disruption of the operating infrastructure that the BPS depends on. Hurricane impacts in Florida and the Eastern Interconnection reinforced this point in 2018. The BPS is becoming more dependent on other sectors such as telecommunications for visibility and control. Coordination between sectors should be enhanced to mitigate vulnerabilities that significantly impact the reliability and resilience of the BPS because system resilience not only includes the electric infrastructure, but fuel sources and fuel delivery infrastructure, data and voice communications systems, water supplies, etc. Recovery of those much needed infrastructure resources will be monitored, as needed, in 2019.

Cyber and Physical Security

Critical Infrastructure Protection (CIP) will continue to remain a priority for NERC and Texas RE for the foreseeable future. Cyber threats are becoming more sophisticated and increasing in number. Exploitation of cyber vulnerabilities can result in loss of control or damage to utility voice communications, data, monitoring, protection and control systems, and tools. The potential for cyber or physical attack on natural gas infrastructure highlights the need for increased coordination among pertinent ISACs and the industry to improve response and recovery times due to the interdependency of the gas and electric system. Interdependency and increased reliance on third-party service providers, cloud-based services, and the supply chain expands the attack surface and associated risk for potential cyber vulnerabilities.

Situational Awareness

Data is needed to understand the performance of and risks to the BPS. This includes information regarding DER. Data is needed from multiple sources and larger areas to identify and manage risks. It is important that data requirements include: (1) the data needed from DER, including any necessary aggregated forms of data; (2) status of infrastructure on which operators rely (e.g., gas infrastructure, data and voice telecommunications systems); (3) logistics for how the data will be exchanged; (4) the frequency of the data updates; and (5) security and confidentiality measures for protecting necessary data.

From 2013-2018, there were a total of 31 loss of EMS/SCADA events reported in the ERCOT Interconnection. Loss of EMS or SCADA events will continue to be of concern due to their impact on visibility and situational awareness for System Operators. Accuracy and availability of telemetry is a key issue for situational awareness for System Operators as well as the proper functioning of Real-Time Assessment and Operational Planning Analysis tools.

Human Performance

Skilled workers and technical expertise are vital to the reliable operation of the BPS. Human performance issues manifest themselves in a number of ways, particularly in the areas of Protection System Misoperations, loss of EMS events, asset management, and maintenance. Turnover of experienced workers, lack of adequate training programs, inadequate management oversight and controls, and ineffective corrective actions can lead to severe events or disruptions on the BPS.

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