

2019 ASSESSMENT OF RELIABILITY PERFORMANCE



TEXAS RE
Ensuring electric reliability for Texans

SUMMARY REPORT
MAY 2020



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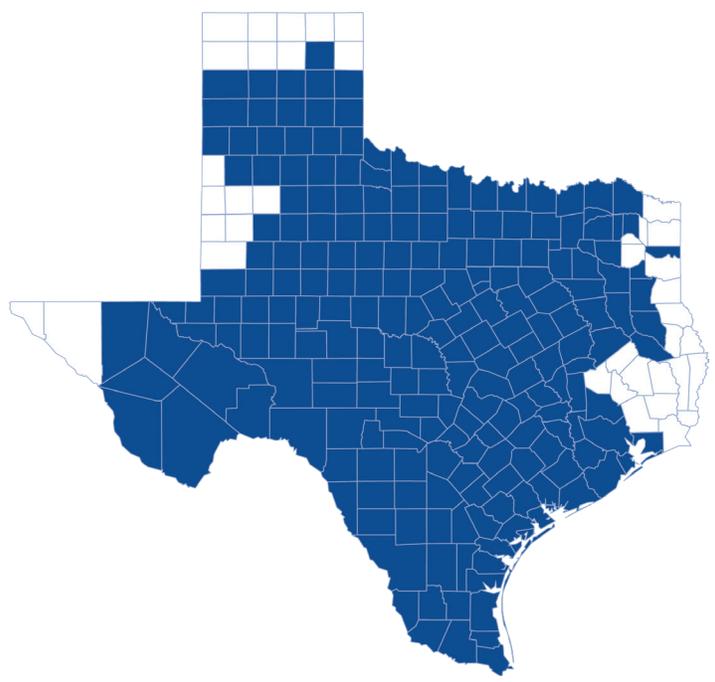
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INTRODUCTION



Texas RE periodically assesses and reports on the reliability and adequacy of the bulk power system (BPS) within the Texas Interconnection. The Assessment of Reliability Performance annually compiles analyses for the previous year and this document is a summary version of [2019's report](#).

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.

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.

DATA SOURCES

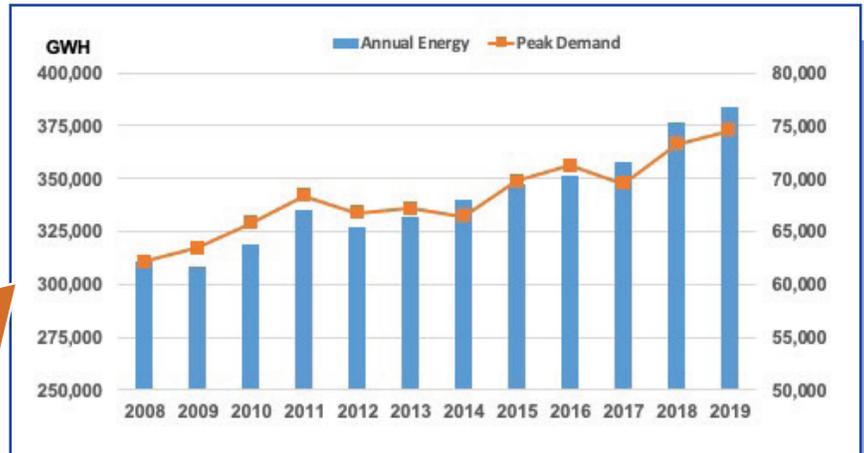
TADS Transmission Availability Data System	GADS Generation Availability Data System	DADS Demand Response Availability Data System	MIDAS Misoperation Information Data Analysis System
EVENT REPORTS OE-417, NERC EOP-4 & NERC Event Analysis Process reports	Frequency Control Performance and Primary Frequency Response (Source)	ERCOT ISO Data and Reports	



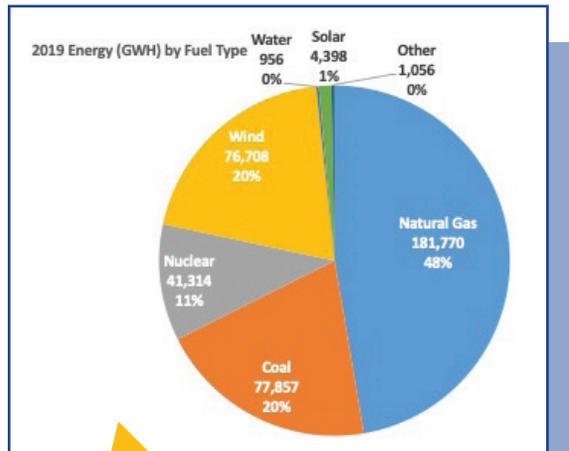
DEMAND AND ENERGY

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SUMMER ALL-TIME PEAK DEMAND:
74,533 MW
on 8/12/2019

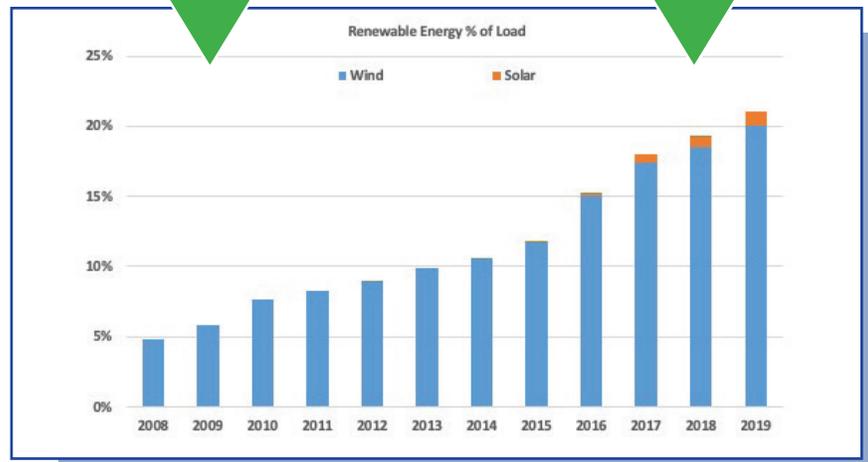


RECORD ENERGY USAGE FOR 2019:
at over
376,800 GWH



PEAK HOURLY RENEWABLE PENETRATION:
57% on
11/26/2019

RENEWABLE ENERGY SERVED:
21.1% of total energy served in 2019

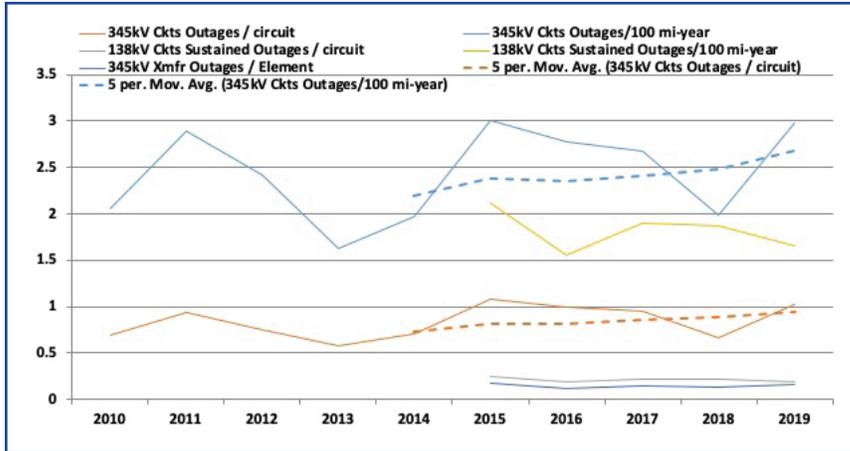


ALL-TIME PEAK HOURLY WIND GENERATION:
19,580 MW
on 1/21/2019

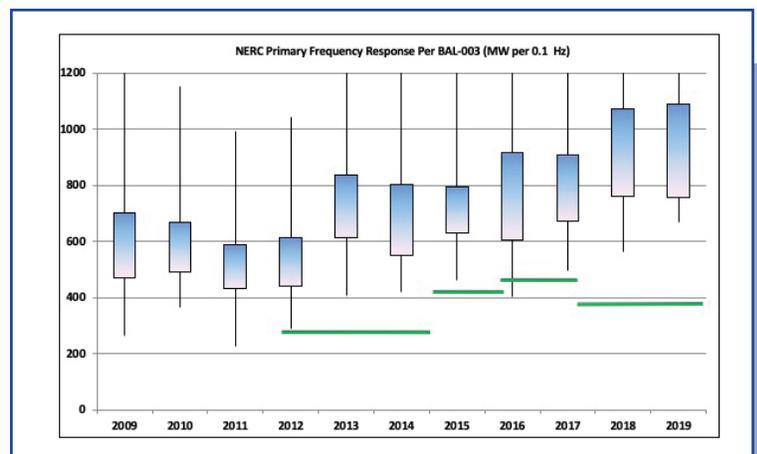
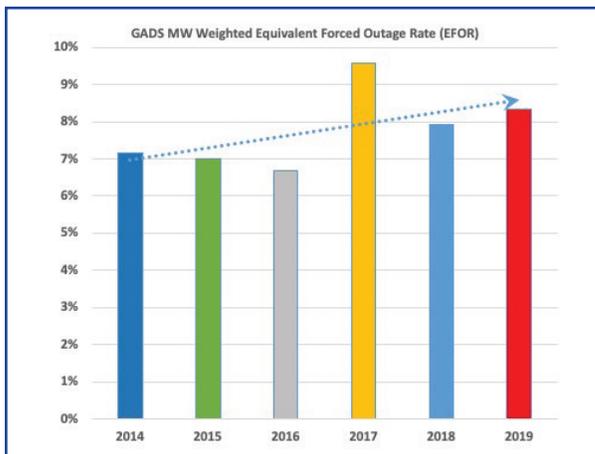


RELIABILITY

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PRIMARY FREQUENCY RESPONSE:
 918 MW/0.1Hz for
 for 2019 vs. NERC
 Obligation of
 381 MW/0.1Hz



	2019	2018
CONTROL PERFORMANCE STANDARD 1 (CPS1)	174.8	175.7
TADS 345kV CIRCUIT AUTOMATIC OUTAGE RATE PER 100 MILES	2.97	1.98
PROTECTION SYSTEM MISOPERATION RATE	6.3%	7.3%
GADS EQUIVALENT FORCED OUTAGE RATE (EFOR) (MW WEIGHTED)	7.6%	6.1%



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2019 FOCUS AREAS

Texas RE continually evaluates risks to grid reliability in the Texas Interconnection through long-term and seasonal reliability assessments, event analyses, situational awareness, tracking reliability indicators, real-time performance monitoring, and planning observations. The 2019 Assessment of Reliability Performance report provides a high-level overview of the data collected in the ERCOT Interconnection in 2019. It includes:

- Overview of 2019's numbers
- Associated historical data
- The current state of the Texas Interconnection
- Observations for the future of Texas RE's region

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

EVENT ANALYSIS

RESOURCE ADEQUACY AND PERFORMANCE

SYSTEM RESILIENCE

CHANGING RESOURCE MIX

HUMAN PERFORMANCE

BULK POWER SYSTEM PLANNING

LOSS OF SITUATIONAL AWARENESS

PROTECTION SYSTEM MISOPERATIONS

PHYSICAL AND CYBER SECURITY

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, gives target values, and assesses the current state of each.

	Improving	Stable or No Change	Monitoring	Actionable
Key Performance Indicator with Description	2019 Performance & Trend Results			
<p>Resource Adequacy Measures potential resource adequacy issues by analysis of planning reserve margin and energy emergency alerts.</p>			<ul style="list-style-type: none"> • Future planning reserve • Two EEA Level 1 Alerts 	<ul style="list-style-type: none"> • Sufficient operating reserves maintained during summer peak
<p>Transmission Performance Measures transmission performance by analysis of transmission outage rates and Interconnection Reliability Operating Limit (IROL) exceedances.</p>			<ul style="list-style-type: none"> • Increasing 345kV circuit outage rate 	<ul style="list-style-type: none"> • 0 IROL exceedances • Reduced transmission outages on extreme days
<p>Resource Performance Measures generation performance by analysis of generator outage rates, primary frequency response, and balancing contingency events.</p>			<ul style="list-style-type: none"> • Increasing gas generator EFOR 	<ul style="list-style-type: none"> • Primary frequency response • Demand response performance
<p>Changing Resource Mix Measures potential issues related to the changing resource mix by analysis of system inertia and ramping.</p>			<ul style="list-style-type: none"> • Increasing solar ramp rates 	<ul style="list-style-type: none"> • Stable inertia trends
<p>Misoperation Rate Measures protection system performance by analysis of protection system misoperations.</p>			<ul style="list-style-type: none"> • Increasing rate in AC systems 	<ul style="list-style-type: none"> • Improving trend in setting errors
<p>Human Performance Measures protection system misoperations caused by human error.</p>			<ul style="list-style-type: none"> • Repeated errors resulting in protection system misoperations 	<ul style="list-style-type: none"> • Significant reduction in generation human error outages
<p>Situational Awareness Measures situational awareness by analysis of state estimator convergence rates, event analysis, and telemetry performance.</p>			<ul style="list-style-type: none"> • Four loss of EMS events 	<ul style="list-style-type: none"> • State estimator convergence rate

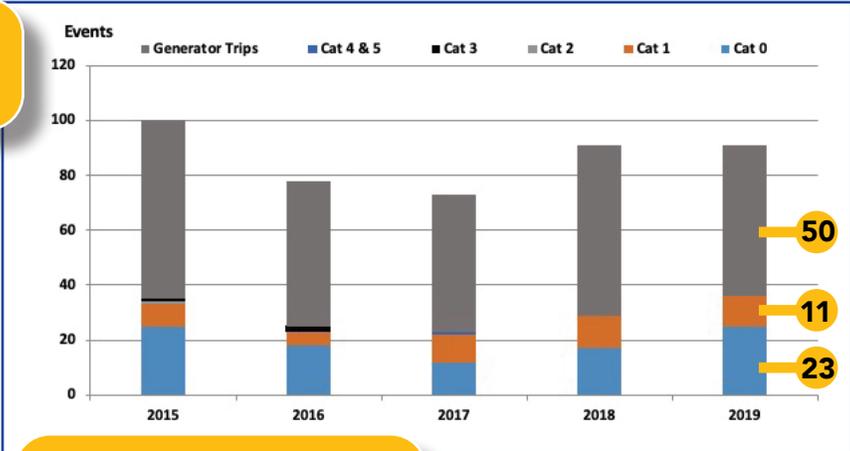
EVENT ANALYSIS



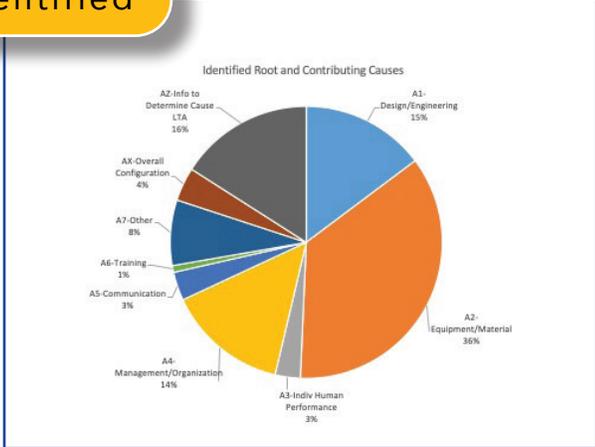
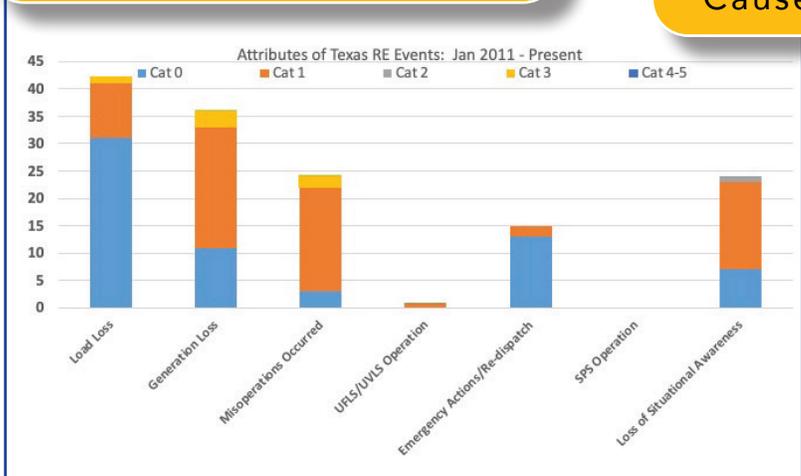
In 2019, Texas RE analyzed 84 BPS events; on par with the events reported per year during the preceding four years. In total, 433 events were reviewed between 2015 and 2019. Of the 302 root and contributing causes identified, the "Equipment/Material" category occurred most frequently with 36 percent of all identified causes. "Design/Engineering" was second with 15 percent, followed closely by "Management/Organization" with 14 percent. The number of Category 1 events has been stable over the last five years.

- 433 Events Analyzed
- Over 270 Event Reports

- Qualified event attributes dominated by:**
- Generation Loss
 - Protection System Misoperations
 - Loss of Situational Awareness



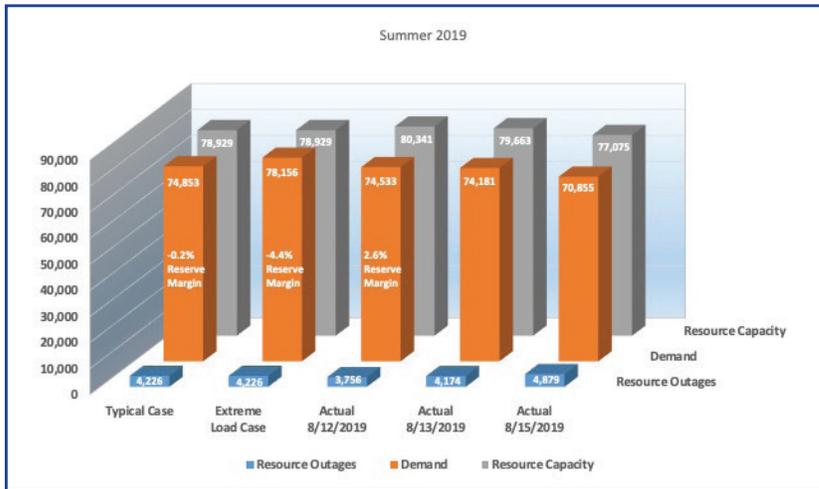
302 Root & Contributing Causes Identified





RESOURCE ADEQUACY

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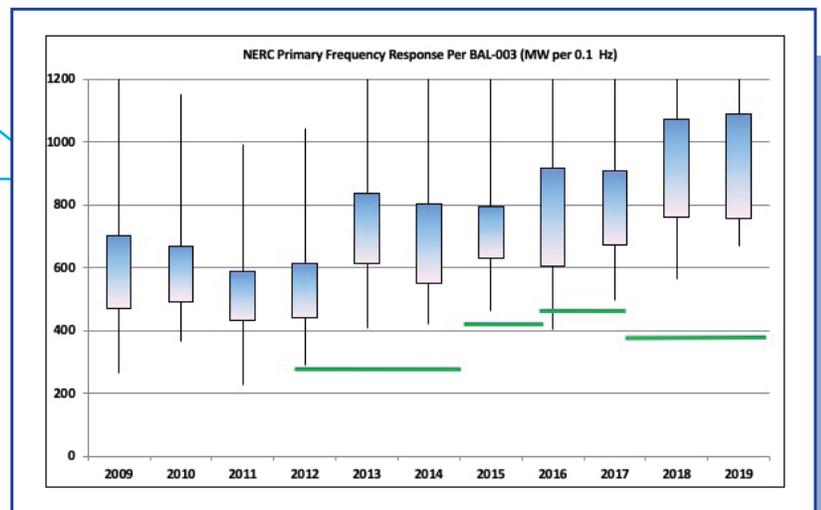


Projected Peak 74,853 MW
Actual Hourly Peak 74,533 MW

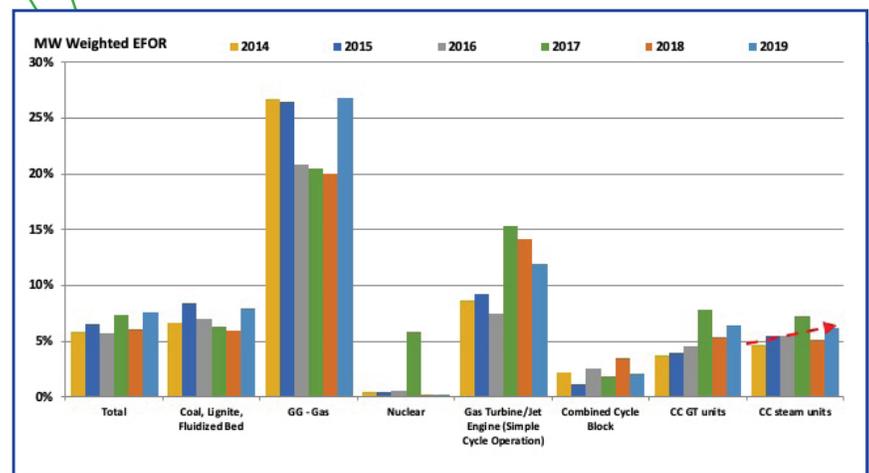
Wind % at Peak 11.9%
Max Hourly Wind 19,580 MW
Max Hourly Wind % 57.5%

Advisories (PRC < 3,000) 29
Watches (PRC < 2,500) 2
EEA (PRC < 2,300) 2

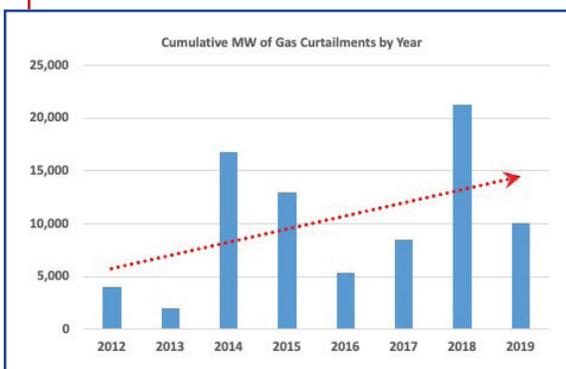
Primary frequency response continues to be maintained at high levels.



EFOR rates for gas fleet is showing a long-term increasing trend.



Gas curtailments decreased in 2019 due to the mild winter but show an increasing trend over time.



Sufficient operating reserves were maintained during summer and winter peak hours in 2019; however, two level 1 Energy Emergency Alerts (EEAs) were necessary in August 2019.

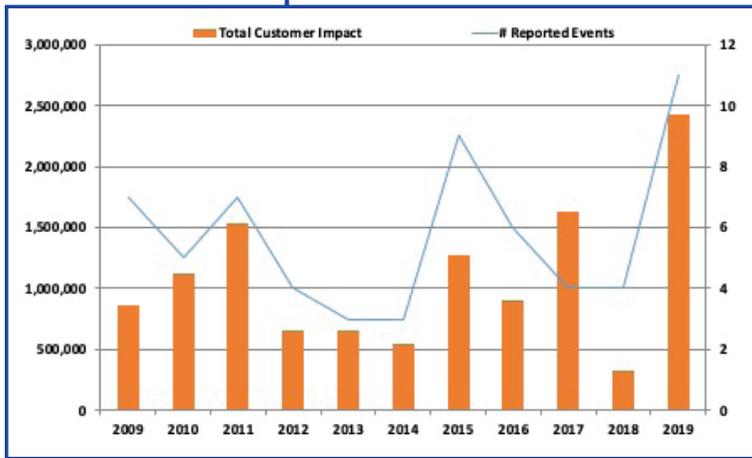
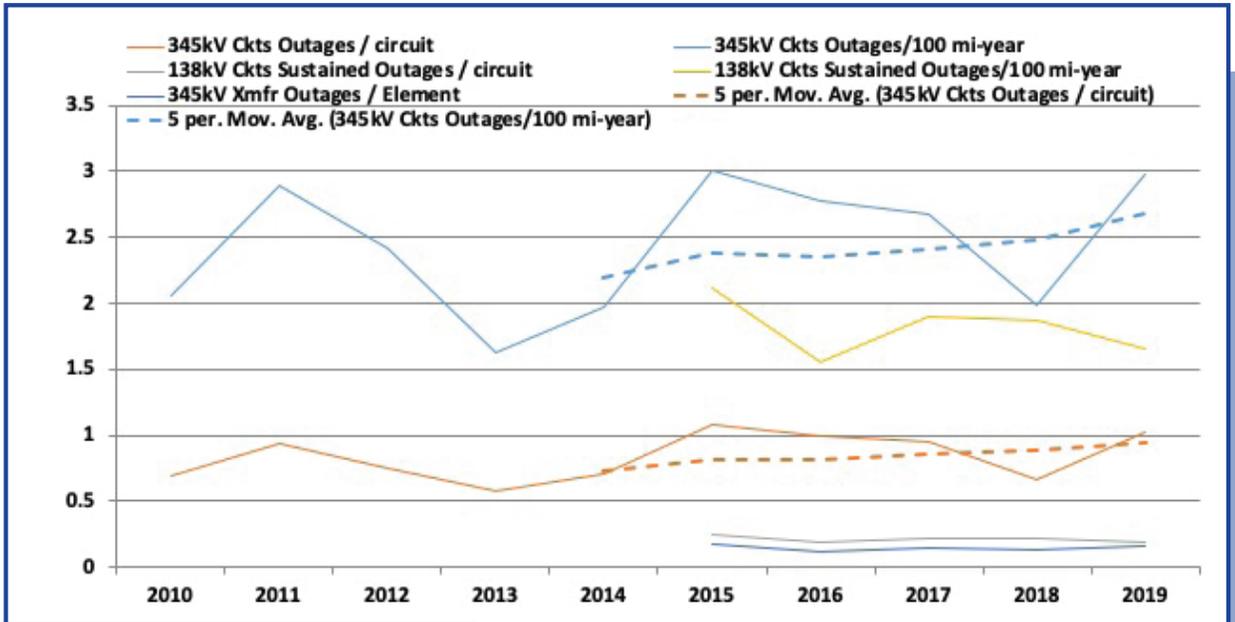
The cumulative generation capacity impacted by natural gas fuel curtailments decreased in 2019 when compared to previous years primarily due to a milder winter with relatively few severe cold weather days.

ADDITIONAL HIGHLIGHTS FOR 2019 INCLUDE:

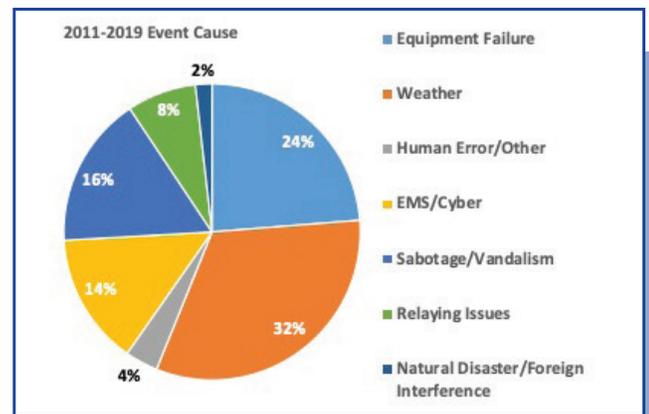
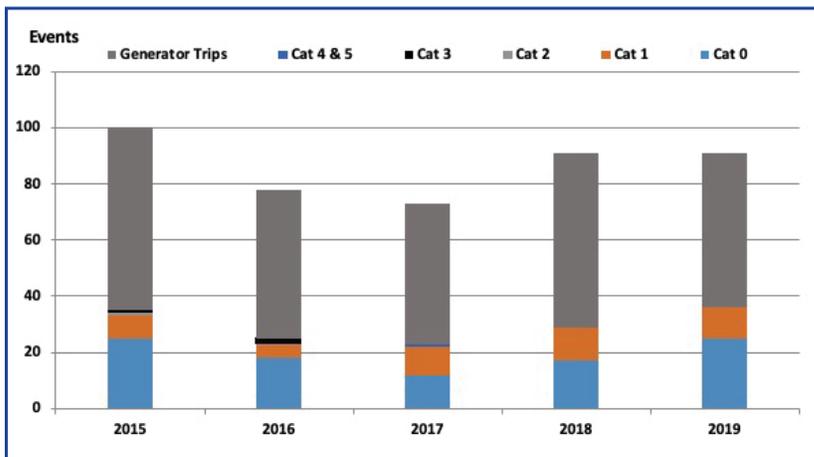
- Demand response played a key role during the two EEA level 1 events in August 2019.
- Primary Frequency Response achieved a median value of 918 MW/0.1 Hz versus the NERC obligation of 381 MW/0.1 Hz.
- GADS EFOR (MW Weighted) was 7.6 percent for 2019 versus 6.1 percent for 2018.
- No Reportable Balancing Contingency event recovery failures occurred in 2019.
- No Reportable Balancing Contingency events greater than the Most Severe Single Contingency (MSSC) occurred in 2019.

ADDITIONAL AREAS OF CONCERN INCLUDE:

- Gas generator EFOR rates are trending upward as the fuel mix shifts more to predominately gas-fired mix.
- The MW-Weighted EFOR for 2019 was higher than the five-year moving average. Long-term trends also indicate a gradual increase in EFOR rates.
- From January 2019 through December 2019, there were 2,122 immediate forced outage events (totaling 122,471 hours) with a cumulative outage capacity of 405,724 MW, and a median capacity of 171 MW per event.



Major storms caused an increase in distribution customer outages in 2019.



Equipment failure and weather continue to drive major events.

No category 2 or higher events in 2019.

The BPS withstood several events in 2019 with losses of multiple elements, but had no IROL exceedances. 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 continued to dominate the sustained outage duration, accounting for 86 percent of the 345 kV sustained outage duration and 75 percent of the 138 kV sustained outage duration.

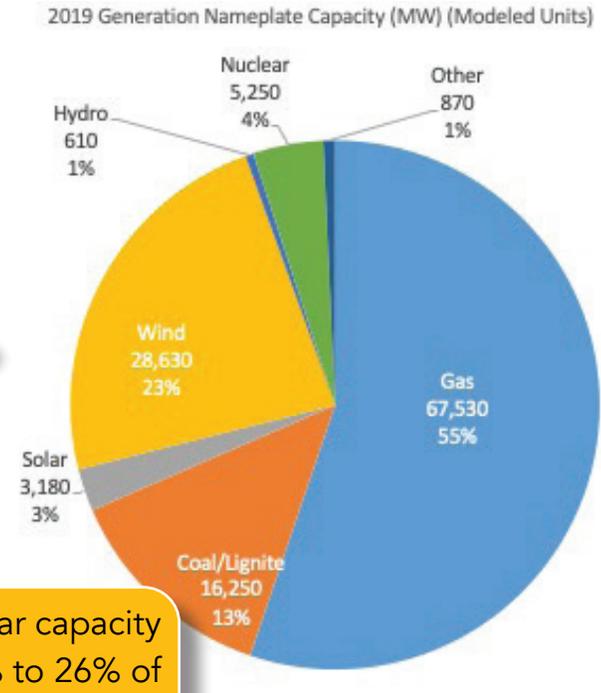
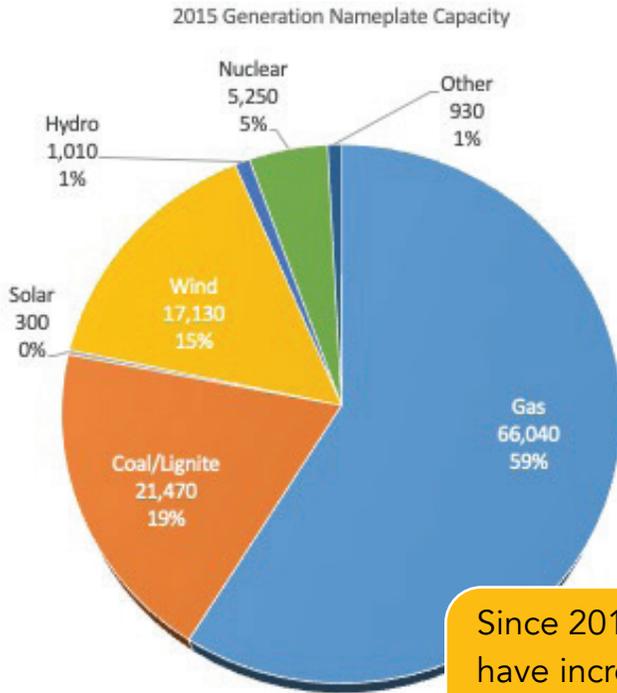
2019 HIGHLIGHTS FROM THE ANALYSIS OF RESILIENCE INCLUDE:

- The BPS was able to withstand several events in 2019 that involved the loss of multiple transmission and generation facilities.
- 138 kV circuit outages rates per element remained stable in 2019 when compared to previous years and the five-year average rates.
- Transmission system performance on extreme days improved in 2019 when compared to extreme days in 2017-2018.
- For the 345 kV circuit outages in 2019, 20 percent of the sustained automatic outage events and 70 percent of the sustained outage duration involved failed circuit equipment.
- For the 138 kV circuit outages in 2019, failed substation equipment and failed transmission circuit equipment dominated the sustained outages, accounting for 30 percent of the outage events and 75 percent of the outage duration.

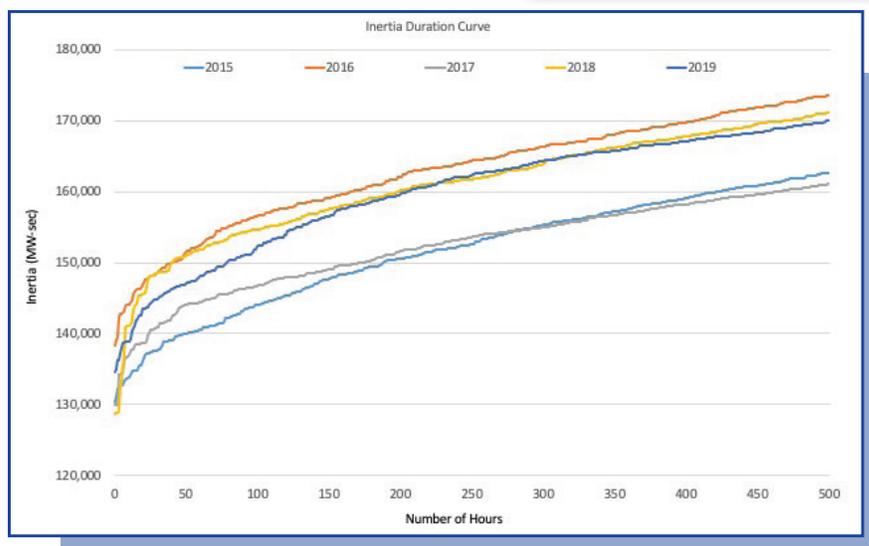
ADDITIONAL AREAS OF CONCERN INCLUDE:

- Protection system misoperations and wind generator ride-through issues continue to be a main causal factor in system events.
- 345 kV circuit outage rates increased in 2019, but remained within the five-year average. Long-term trends are indicating an increasing trend in outage rates per circuit and per 100 miles of line for the 345 kV system.

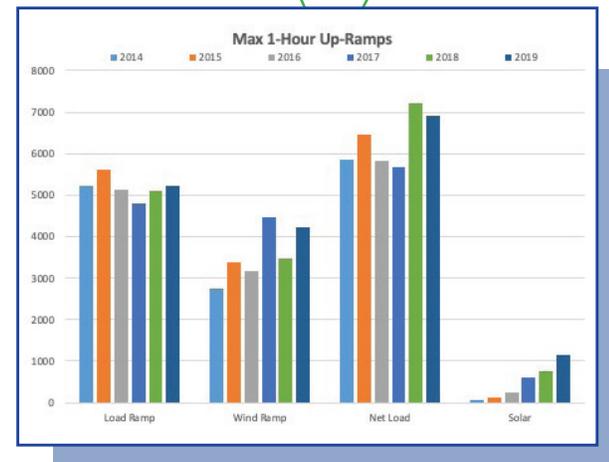
CHANGING RESOURCE MIX



Since 2015, wind and solar capacity have increased from 15% to 26% of generation capacity while coal has reduced from 19% to 13%.



There is a long-term increasing trend in the maximum one-hour up ramp magnitudes for net load and solar generation.



In 2019, 1,665 MW of fossil generation was retired while 2,563 MW of renewable generation was approved for commercial operation. Inertia data shows risk of approaching critical inertia level is less than 50 hours per year.

CHANGING RESOURCE MIX

Today’s resource mix continues to evolve with the addition of inverter-based generation resources, improving energy storage techniques, and government policies that encourage renewable generation. Transmission Planners, Balancing Authorities, asset owners, and system operators of the BPS may not have sufficient time to develop and deploy plans addressing reliability considerations that result from the rapidly evolving resource mix.

The integration of new technologies and distributed energy resources (DERs) are affecting availability as well as the ability of operators to see and control resources within their area.

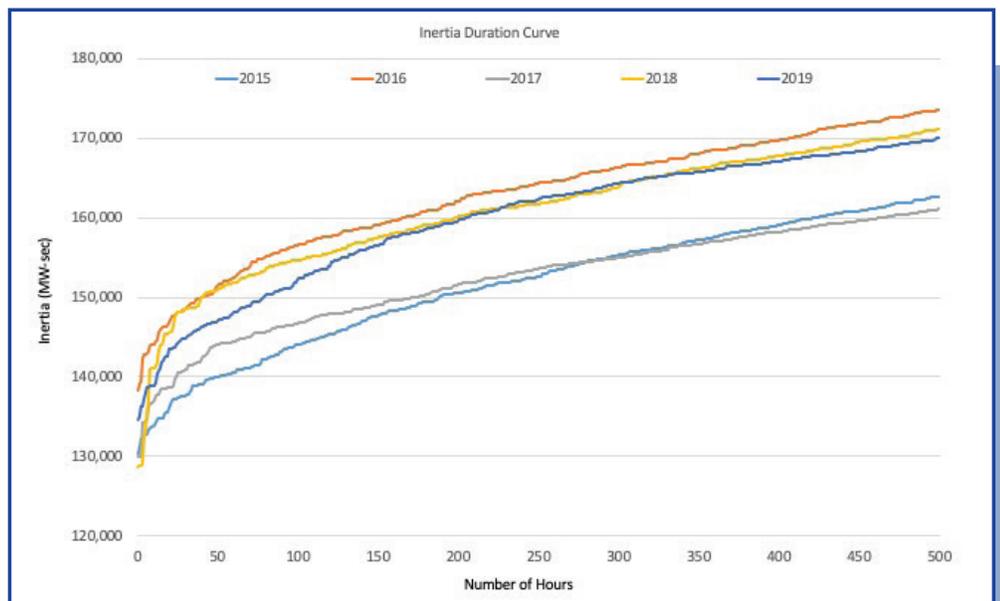
2019 HIGHLIGHTS FROM THE ANALYSIS OF CHANGING RESOURCE MIX INCLUDE:

- Average synchronous inertia across most operating hours continued to increase in 2019 when compared to previous years. This is even after the retirement of additional large coal units.
- Primary and secondary frequency response for the generation fleet continues to exceed NERC requirements.

AREAS OF CONCERN INCLUDE:

- Over 1,660 MW of coal and natural gas capacity was retired or mothballed in 2019. The system added over 2,700 nameplate MW capacity from new units or upgrades, over 90 percent of which was renewable generation.
- There is a long-term increasing trend in the maximum one-hour up ramp magnitudes for net load and solar generation. Solar ramp rates are currently not accounted for in security-constrained economic dispatch.
- Low voltage ride-through issues for wind turbines continue to occur during transient voltage disturbances on the transmission system.

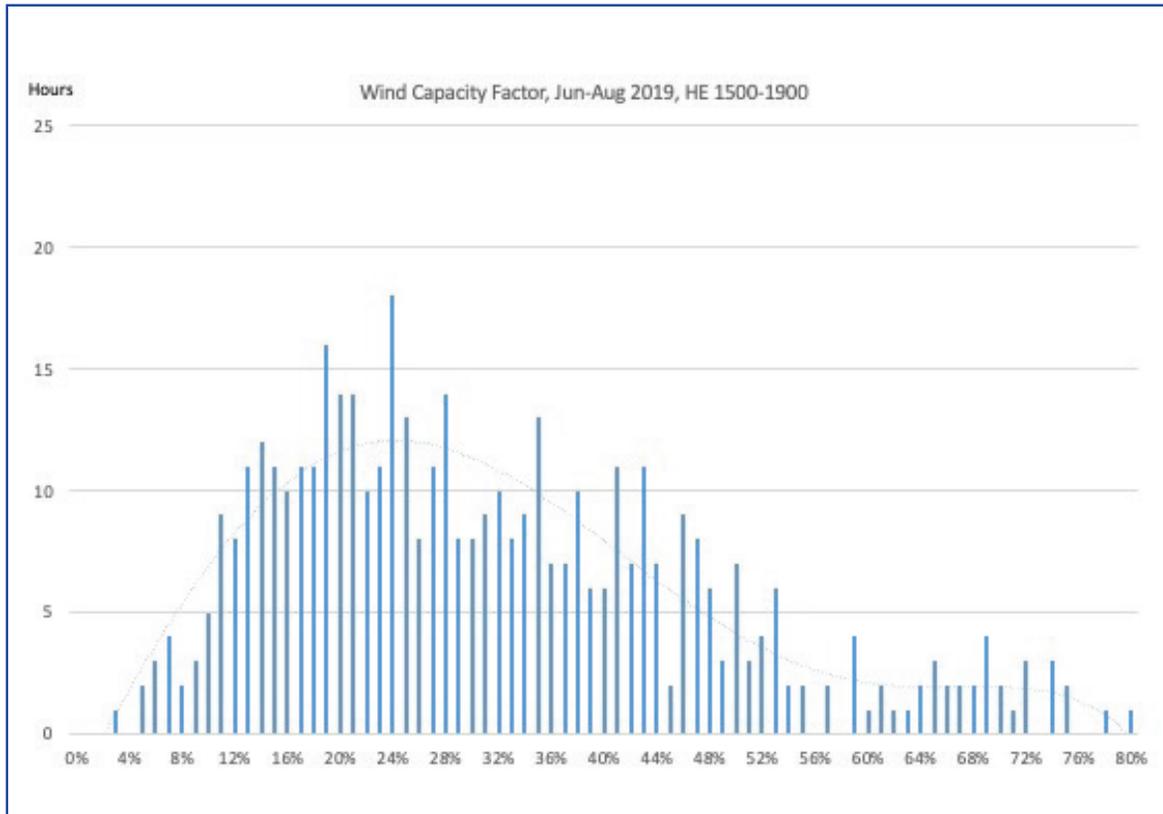
Overall system inertia increased in 2019 compared to 2018 in spite of the retirement of additional large coal units. The minimum hourly inertia level in 2019 was 134.6 GW-s, on March 27, 2019 at 1:00 a.m., when the IRR penetration level was 50.2 percent and system load was 29,426 MW (net load of 14,645 MW).



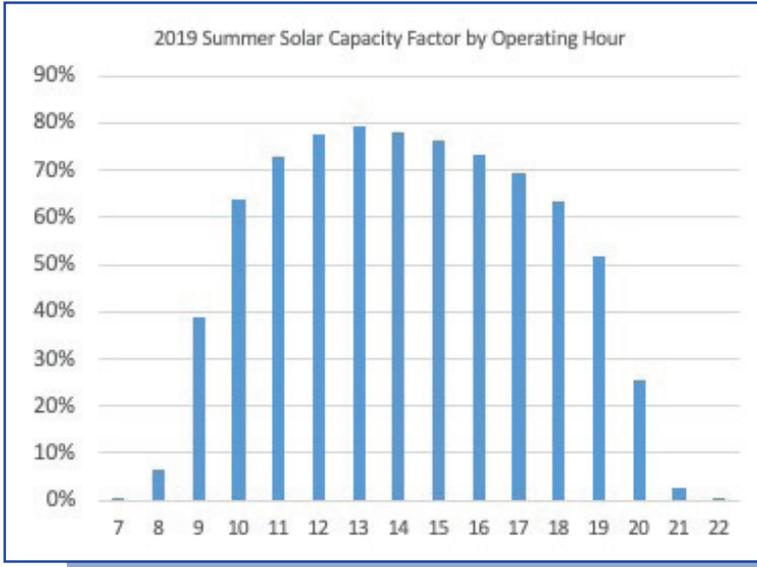


CHANGING RESOURCE MIX

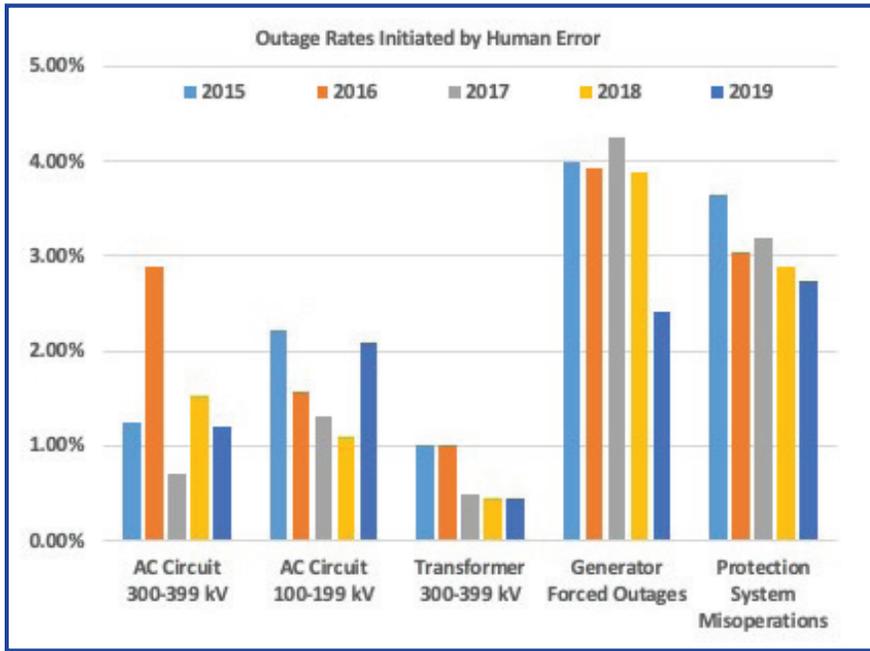
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Wind generation capacity factor calculations during summer peak hours ranged from 3 percent to 73 percent with an average value of 21 percent. Solar generation capacity factor calculations during summer peak hours averaged 68 to 75 percent.

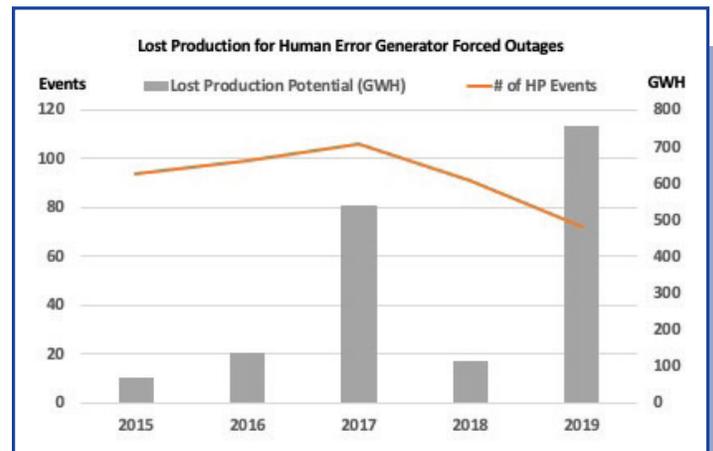


HUMAN PERFORMANCE



2019 HIGHLIGHTS FROM THE ANALYSIS OF HUMAN PERFORMANCE INCLUDE:

- Outage rates for Protection System Misoperations caused by human error are showing an improving, downward trend.
- Generator forced outage rates caused by human error decreased in 2019 compared to previous years.



AREAS OF CONCERN INCLUDE:

- Causal analysis of human errors in Protection System Misoperations shows repeated issues due to lack of adequate error-checking processes and procedures.
- Human performance remains the primary causal factor in misoperations, primarily due to incorrect settings and/or as-left errors.

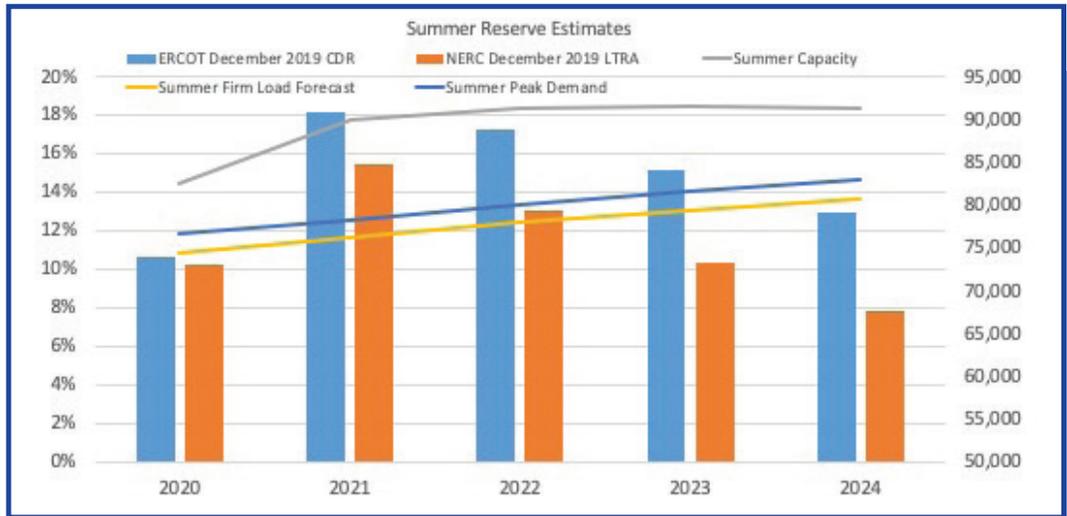


BULK POWER SYSTEM PLANNING

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The NERC Long Term Reliability Assessment (LTRA) shows a planning reserve margin below the 13.75 percent target for four of the next five years. The ERCOT Capacity Demand Reserves (CDR) shows a planning reserve margin below the 13.75 percent target for only two of the next five years. While both of these reports are focused on the long-term planning reserve margins, the results will differ due to data collection dates and forecasting of load.

ERCOT had 1,510 MW of non-modeled generation capacity and 638 MW of distributed generation resources (DGR) at the end of 2019 that had provided data for mapping capacity to their modeled loads.

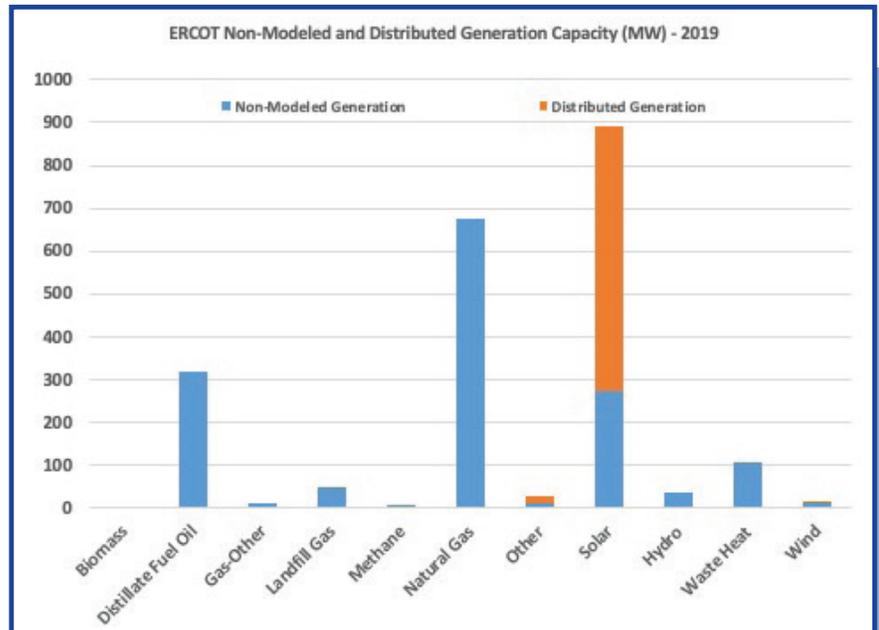


2019 HIGHLIGHTS FROM THE ANALYSIS OF BULK POWER SYSTEM PLANNING INCLUDE:

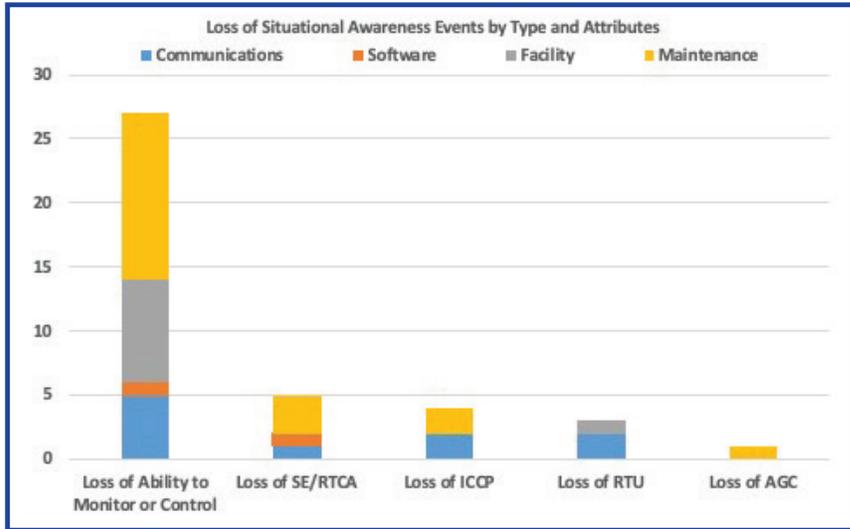
- Summer Peak: Actual 74,533 MW vs. projected 74,853 MW
- Winter Peak: Actual 60,646 MW vs. projected 61,780 MW
- Peak hourly wind generation: 19,580 MW on January 21, 2019
- Peak hourly renewable penetration: 57.5 percent on November 26, 2019

AREAS OF CONCERN INCLUDE:

- Planning reserve margins in the five-year planning horizon continue to show several years below the reference reserve margin level of 13.75 percent.
- West Texas load growth continues to grow at rates of 5-7 percent per year. Transmission entities in the area are implementing upgrades to keep up with this growth rate.
- As of December 2019, ERCOT projections indicate utility-scale solar generation will increase 273 percent to over 8,500 MW and wind generation will increase 41 percent to more than 33,700 MW during the next two years (based on current signed generation interconnect agreements with financial security). During the same period, only 640 MW of new gas units are projected. The growth rate in renewable generation will continue to test ERCOT's ability to maintain adequate system inertia and ancillary services.



LOSS OF SITUATIONAL AWARENESS



LOSS OF SITUATIONAL AWARENESS EVENTS ARE BROKEN DOWN INTO SEVERAL CATEGORIES BY THE CAUSE OF THE EVENT. THESE ARE:

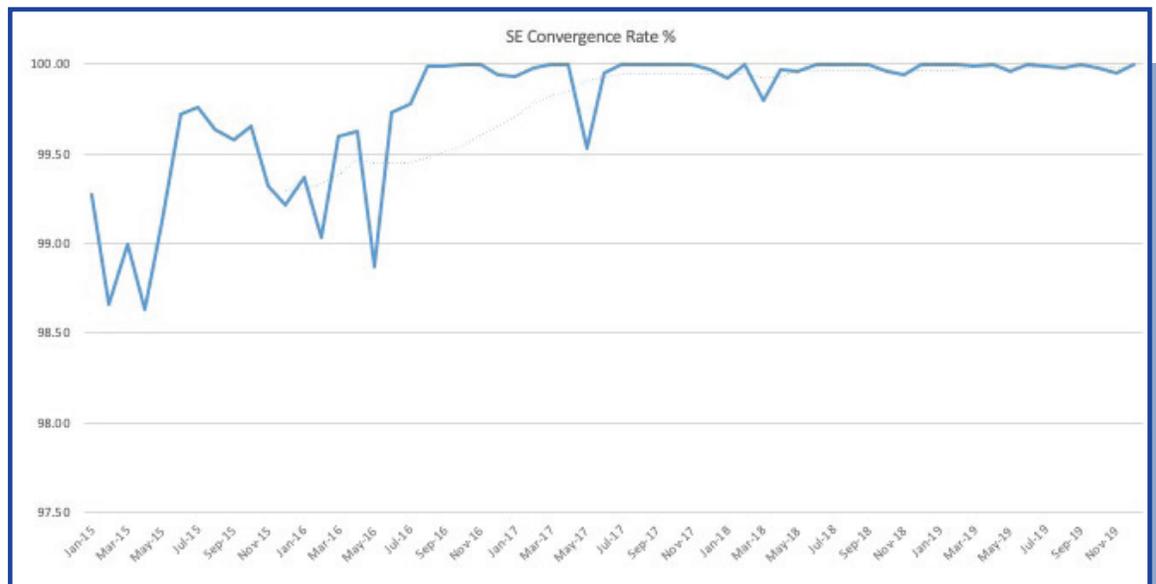
- Loss of ability to monitor or control
- Loss of state estimator (SE) or real-time contingency analysis (RTCA)
- Loss of inter-control center communication protocol (ICCP) links
- Loss of remote terminal units (RTUs)
- Loss of automatic generation control (AGC)

2019 HIGHLIGHTS FROM THE ANALYSIS OF LOSS OF SITUATIONAL AWARENESS INCLUDE:

- Convergence rates for ERCOT’s State Estimator continue to surpass the goal of 97 percent, exceeding 99.99 percent in 2019.
- Telemetry availability rates remain stable at approximately 97 percent overall.
- Telemetry accuracy metrics are showing an improving trend.

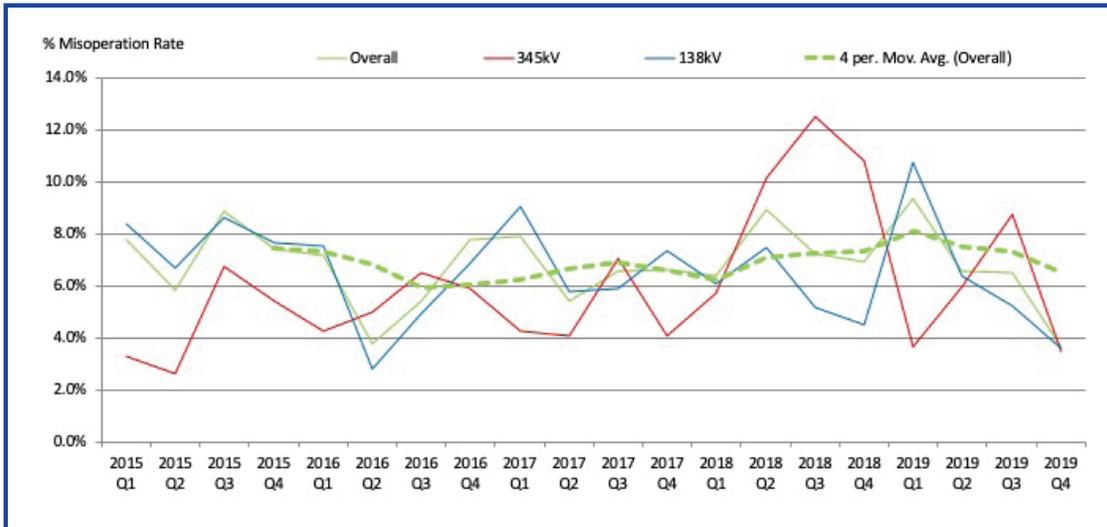
AREAS OF CONCERN INCLUDE:

- A total of four (two Category 1) loss of SCADA or EMS events were reviewed in 2019 at Transmission Operators control facilities. Total duration was approximately six and a half hours.



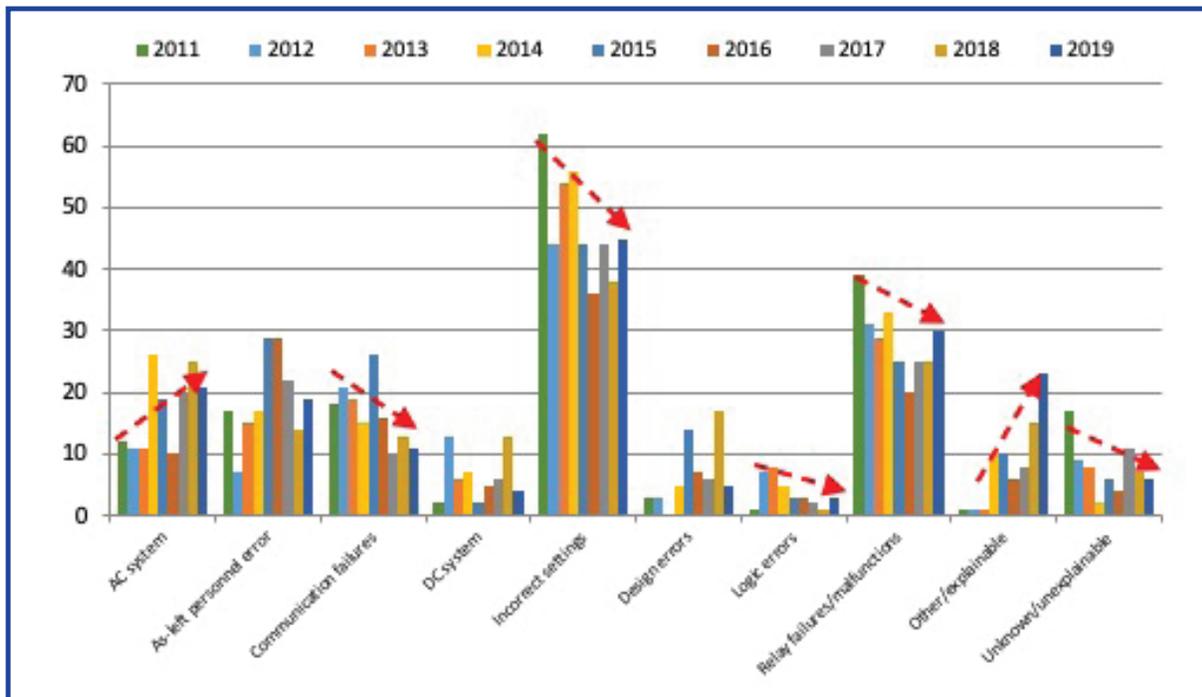


PROTECTION SYSTEM MISOPERATIONS



2019 HIGHLIGHTS FROM THE ANALYSIS OF REPORTED PROTECTION SYSTEM MISOPERATIONS INCLUDE:

- There is a positive downward trend in the number of misoperations occurring each year, indicating fewer incorrect settings, communication failures, and relay failures.
- The overall Protection System Misoperation rate decreased in 2019 to 6.3 percent versus 7.3 percent for 2018.



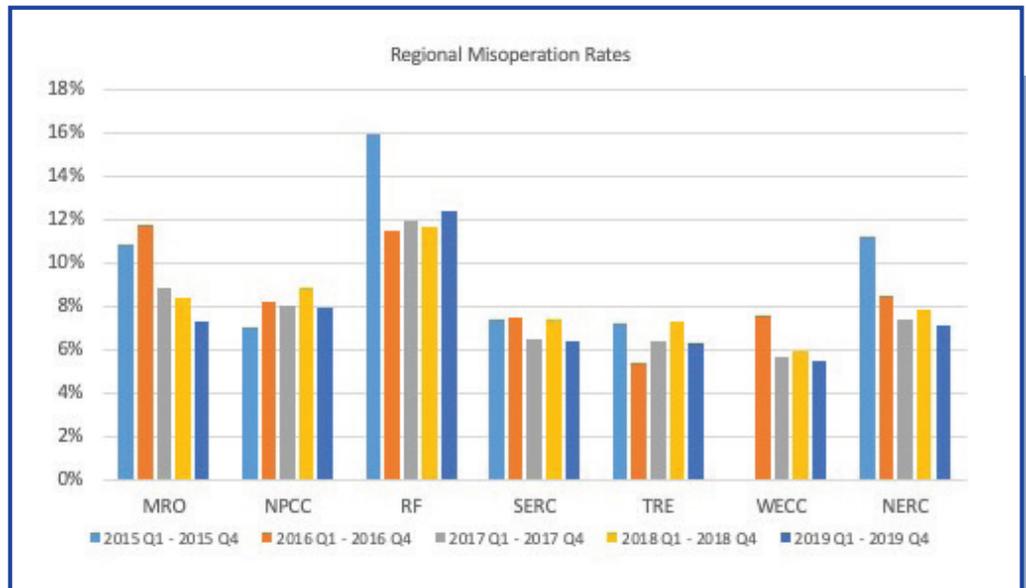
PROTECTION SYSTEM MISOPERATIONS

AREAS OF CONCERN INCLUDE:

- Incorrect settings, logic, and design errors remained the largest cause of misoperations, accounting for 32 percent of misoperations in 2019.
- Multiple system events occurred in 2019 where Protection System Misoperations expanded the magnitude of the transmission elements outaged or caused loss of generation or load.

The regional Protection System Misoperation rate continues to meet or exceed the rate for NERC and other regions.

Protection System Misoperations were a contributing factor in several key system events in 2019. In all of these events, the misoperations expanded the magnitude of the transmission elements outaged or caused loss of generation or load.

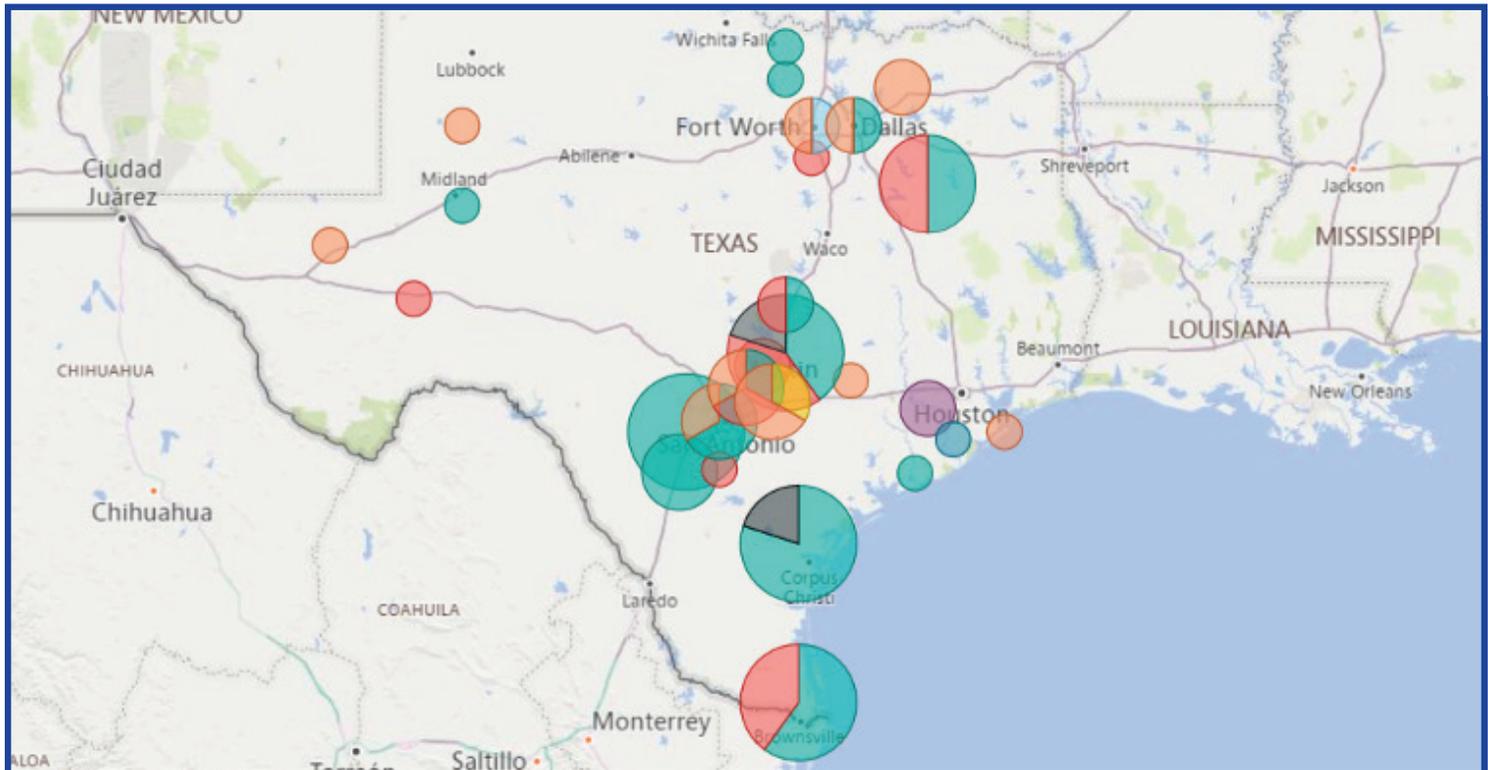
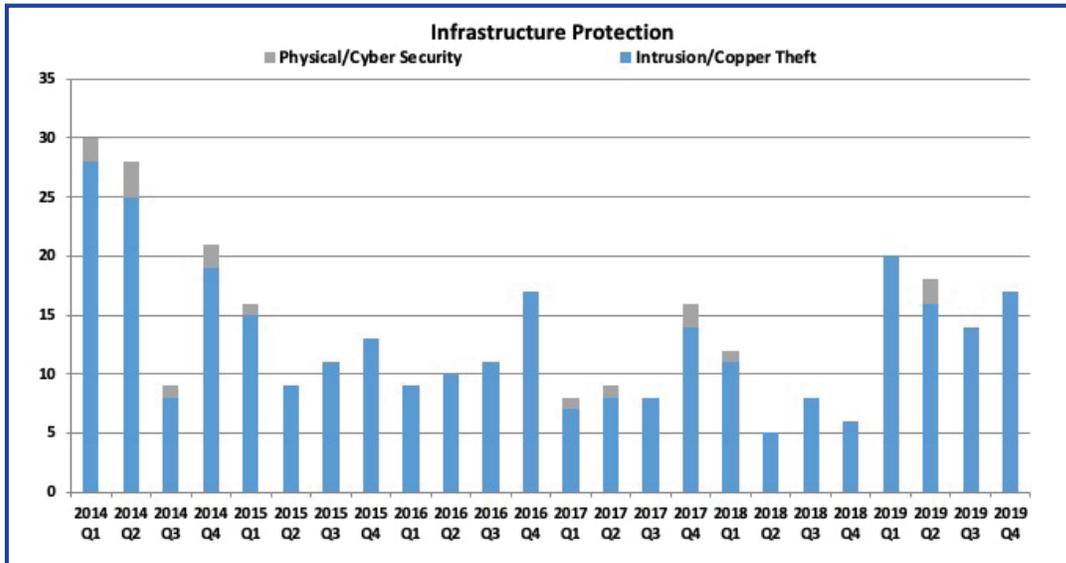


- On April 11, 2019, a 345 kV line protective relay misoperated due to an incorrect setting of a ground overcurrent protective function, resulting in the loss of 664 MW of generation.
- On August 10, 2019, a 345 kV line protective relay failed and misoperated for a fault and caused the loss of a generation facility, resulting in the loss of 1,244 MW of generation.
- On August 21, 2019, a fault occurred on a 345 kV line. The misoperation occurred at a nearby wind generation facility due to an incorrect setting of a ground distance protective function, causing the loss of 160 MW of generation. A second misoperation occurred on a nearby 138 kV line due to an incorrect setting of a ground overcurrent function. Mutual coupling effects were not properly accounted for in the relay setting calculation.
- On October 6, 2019, a fault occurred on a 138 kV capacitor bank. The capacitor bank protection failed to trip due to an incorrect setting of an overcurrent element. The delayed clearing time caused low voltages throughout the area and resulted in the loss of multiple generation facilities, totaling 1,100 MW of generation.

PHYSICAL AND CYBER SECURITY

2019 HIGHLIGHTS FROM THE ANALYSIS OF PHYSICAL AND CYBER SECURITY EVENTS INCLUDE:

- Substation intrusions reported through ERCOT channels are low risk, with vandalism and copper theft being the most common.



RECOMMENDED FOCUS AREAS FOR 2020

CRITICAL INFRASTRUCTURE INTERDEPENDENCIES

- Gas-electric relationships
- Situational awareness of gas system issues, including pipeline status, gas compressor station locations and failures, and deliverability issues
- Electric-communication system relationships

RESOURCE ADEQUACY

- Continuing impact of generation unit retirements and resource mix changes
- Assess renewable resource impact on system ramping capability
- Distributed energy resource effects on demand, ramping, and voltage control

BULK POWER SYSTEM PLANNING

- Planning reserve margins
- Weak grid areas of the interconnection

CHANGING RESOURCE MIX

- Increasing use of stability-related generic transmission constraints due to renewable resources
- Accurate dynamic and steady-state modeling of renewable generation
- Low voltage and low frequency characteristics of inverter-based resources
- Stability modeling challenges with inverter-based resources

RESILIENCE DURING MAJOR SYSTEM EVENTS

CYBER AND PHYSICAL SECURITY

HUMAN PERFORMANCE



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