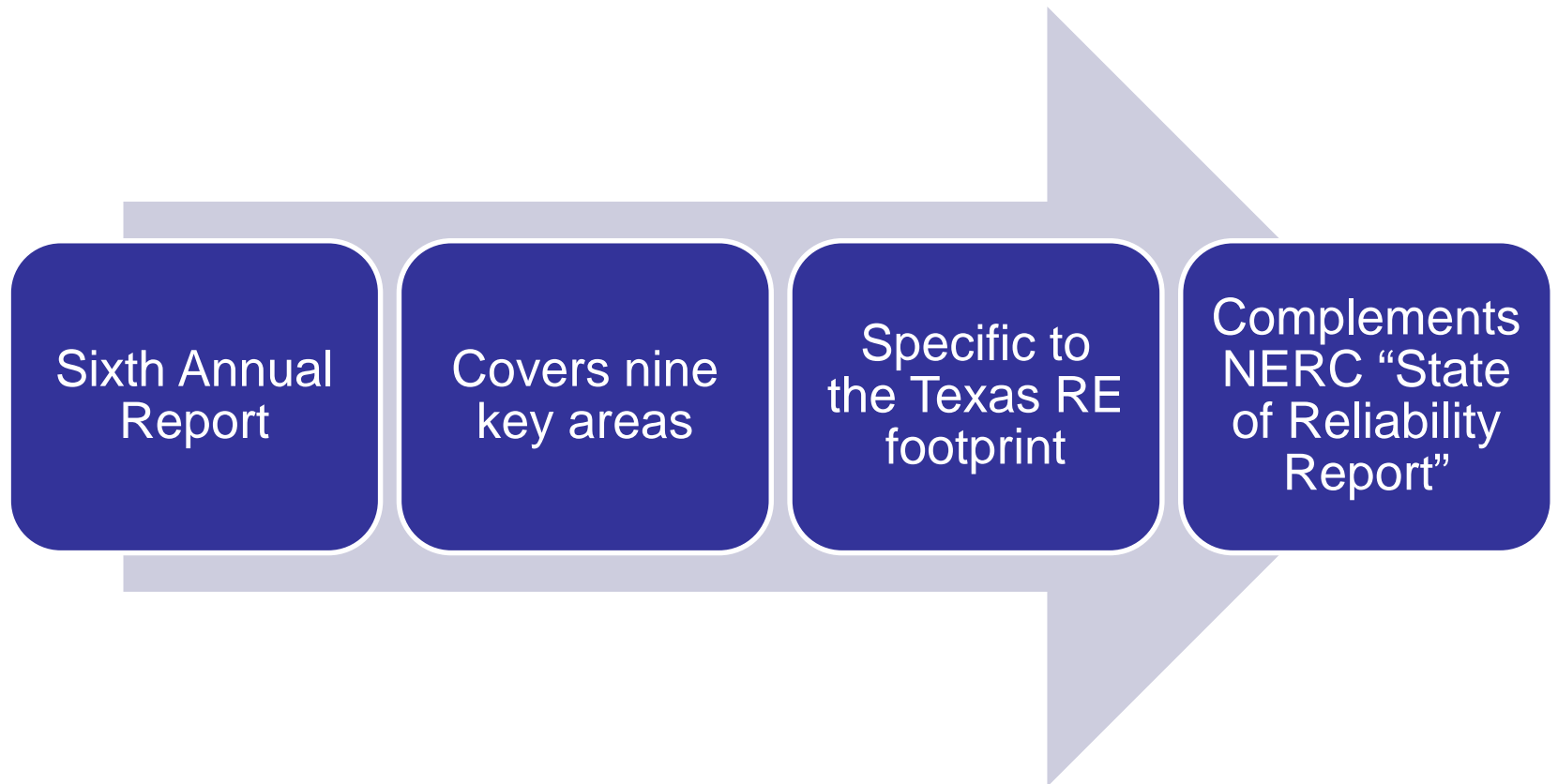




Annual Assessment of Reliability Performance

ROS Meeting
May 3, 2018

2017 Assessment of Reliability Performance



2017 Assessment of Reliability Performance

System Inertia is showing a downward trend

Growth in Renewable Generation continues to be managed well

Frequency control metrics continue to be maintained at high levels

Protection system misoperation rates increased in 2017

Transmission outage rates remain stable

2017 at a Glance

Peak hourly demand: 69,531 MW on July 28, 2017

Peak hourly wind generation: 16,035 MW on November 17, 2017 at 22:00

Peak hourly wind penetration: 53.7% of total energy on October 27, 2017 at 03:00

CPS-1: 174.9 for calendar year 2017 vs. 176.6 for calendar year 2016

Primary frequency response: 759 MW/0.1 Hz vs. NERC obligation of 381 MW/0.1 Hz

Protection system misoperation rate: 7.3% for 2017 vs. 5.3% for 2016

TADS 345 kV automatic outage rate per 100 miles: 2.68 for 2017 vs. 2.78 for 2016

GADS equivalent forced outage rate (EFOR): 7.33% for 2017 vs. 5.75% for 2016

2018 Focus Areas

Resource Adequacy

- Impact of generation retirements and resource mix changes on system inertia, ramping, and frequency response
- Distributed energy resource effects on demand, ramping, and voltage control

Weak grid areas in the Interconnections

- Panhandle
- West Texas
- Lower Rio Grande Valley

Resilience and recovery

Cyber and physical security

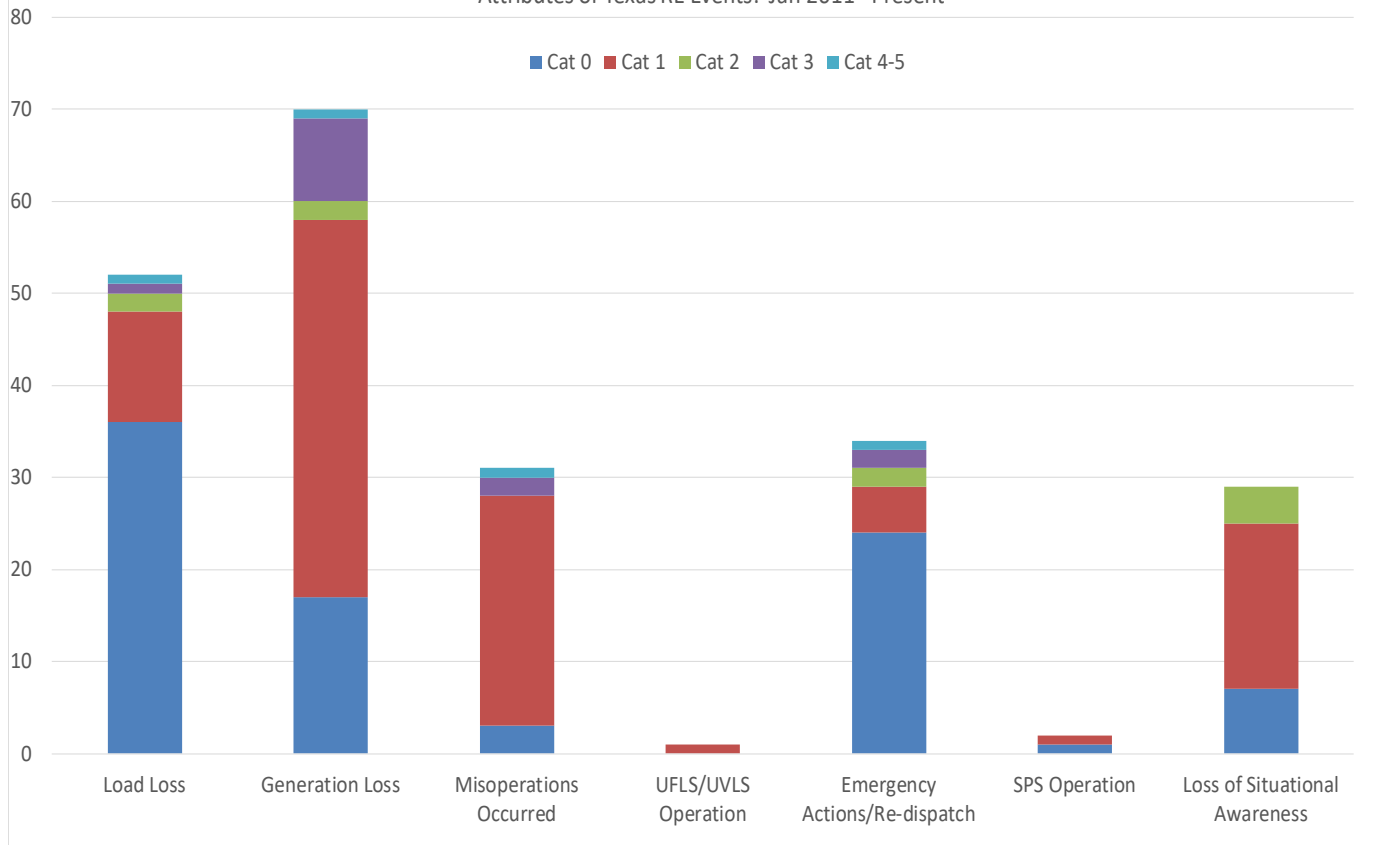
Human Performance

Situational Awareness

System Events

Attributes of Texas RE Events: Jan 2011 - Present

■ Cat 0 ■ Cat 1 ■ Cat 2 ■ Cat 3 ■ Cat 4-5



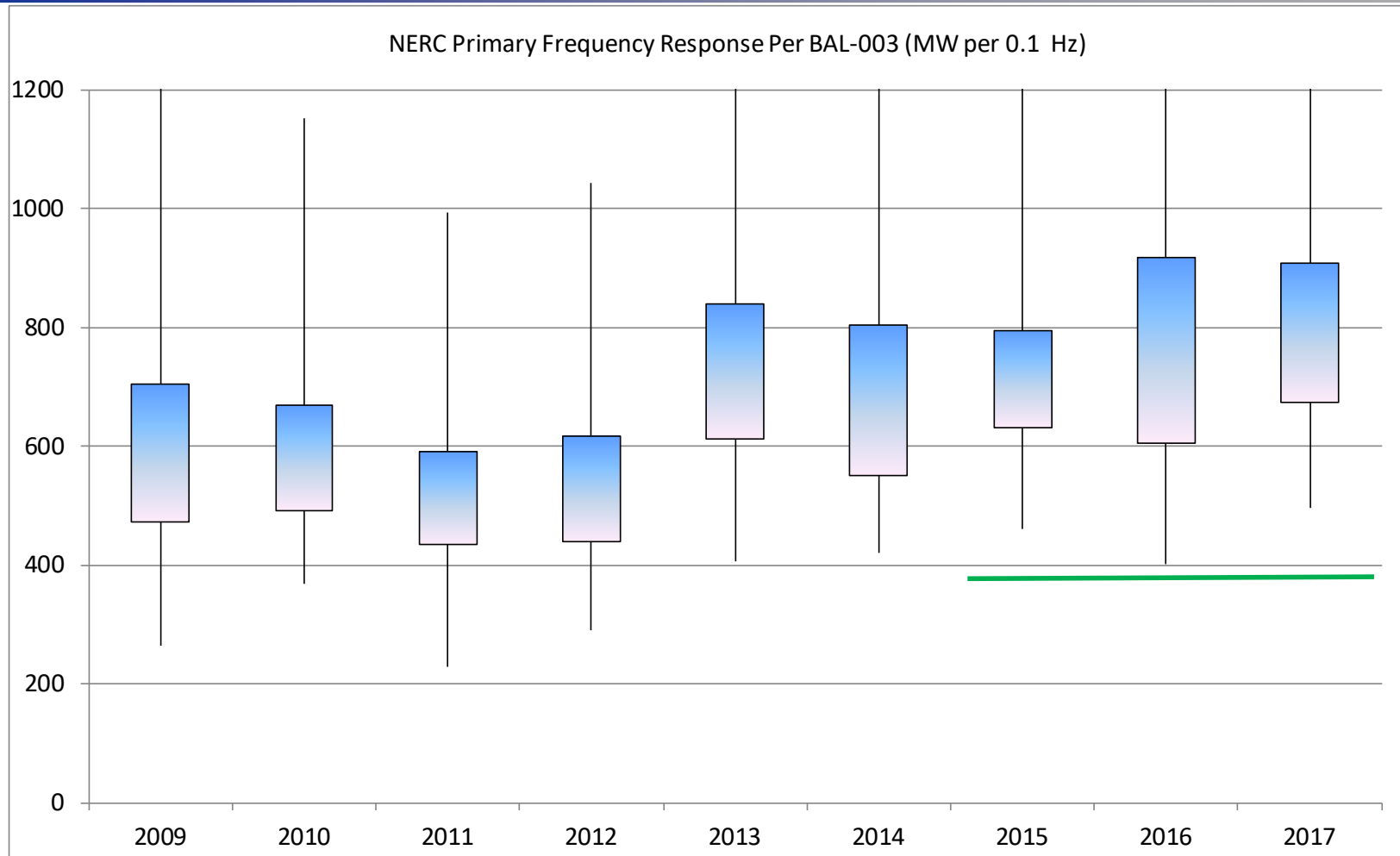
2017 Events in Brief

- Events reported: 64
- Protection system misoperations: 183
- Generation forced outages: 1816
- 345 kV transmission automatic outages: 407

2017 Key Events

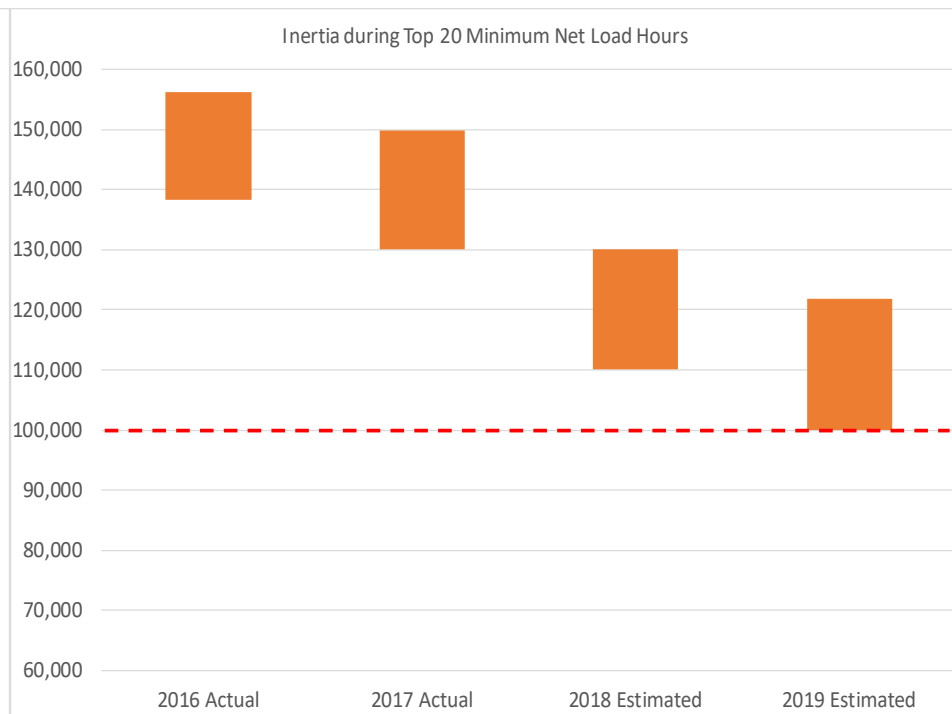
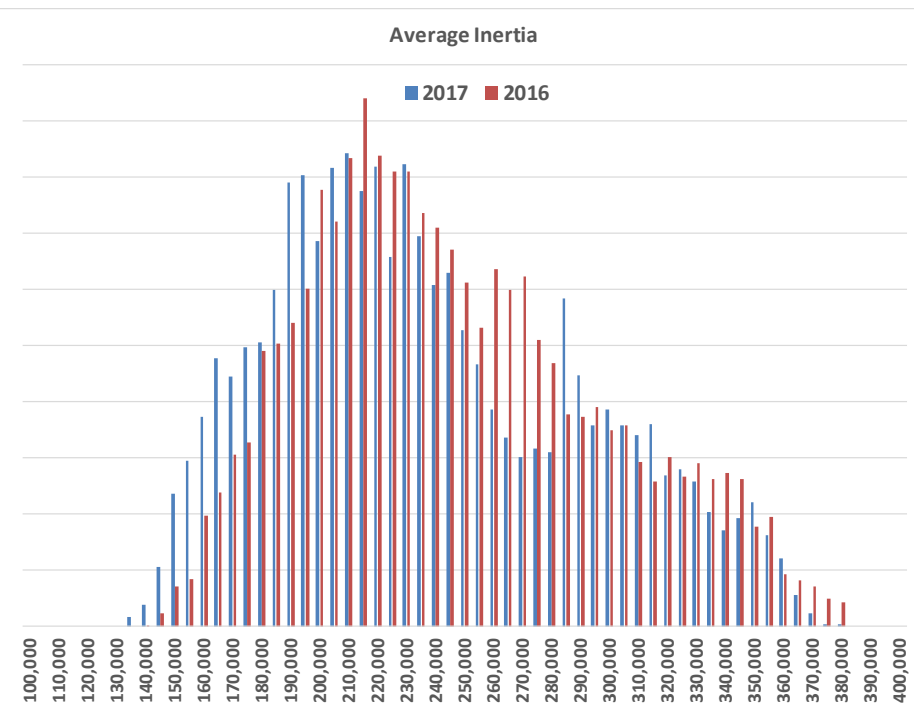
- 3/15/2017 Multiple generation loss
- 5/4/2017 Loss of EMS event
- 8/21/2017 Solar eclipse
- 8/25/2017 Hurricane Harvey

Primary Frequency Response



- 2017 average recovery time from a generation loss event was 5.8 minutes

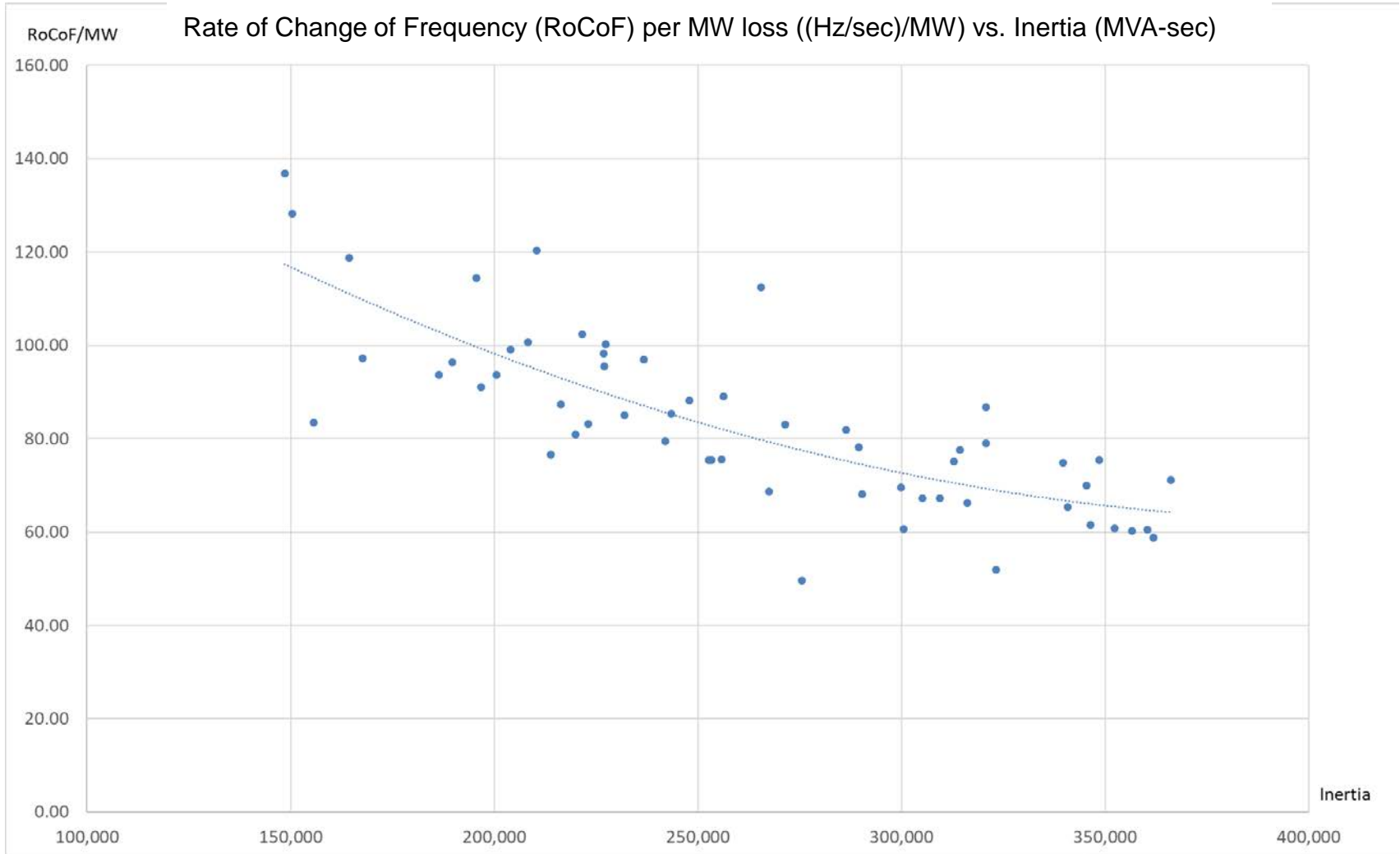
Inertia



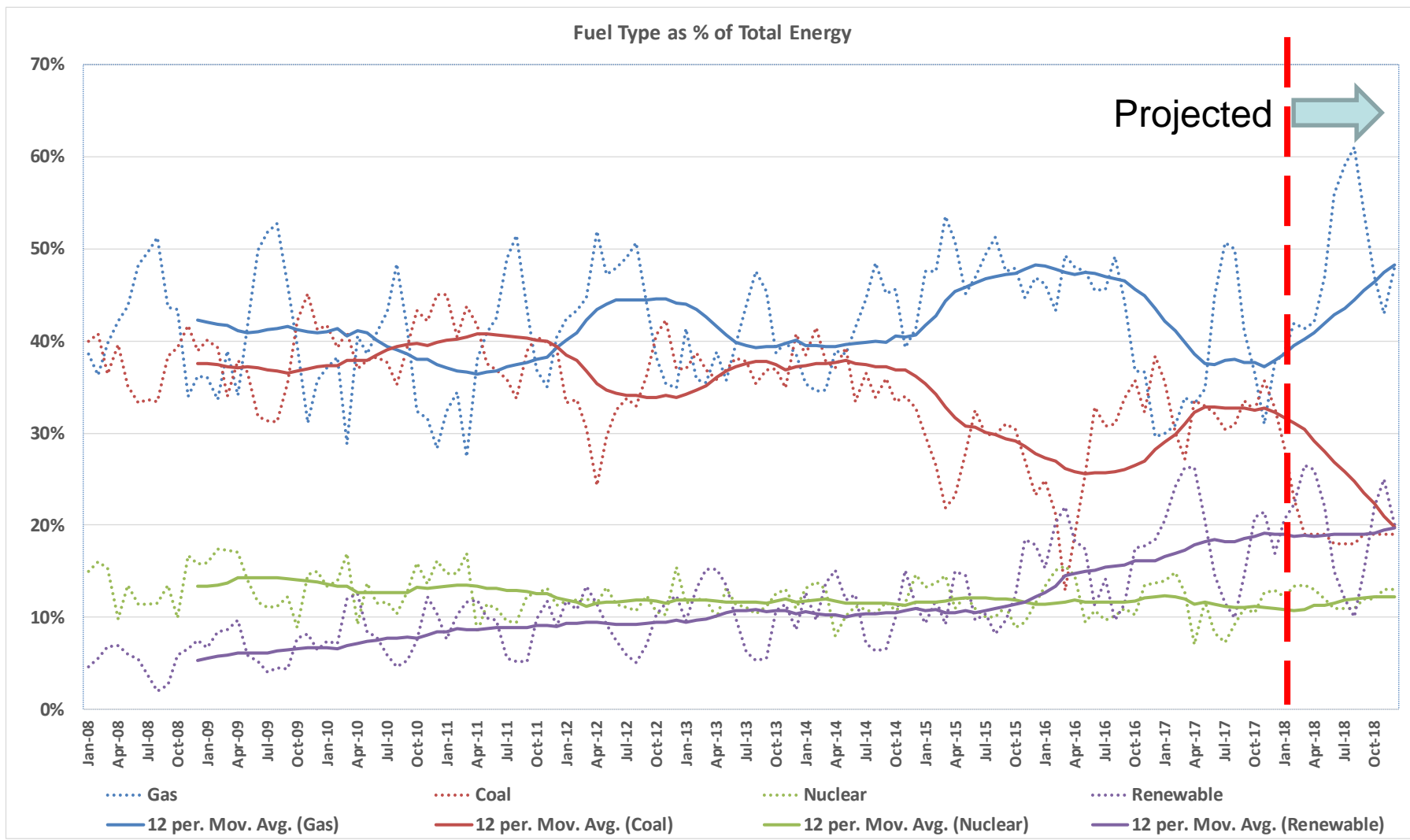
The minimum hourly inertia level in 2017 was 130.0 GW-s, on October 27, 2017 at 03:00 a.m., when the intermittent renewable resources (IRR) penetration level was 53.7% and system load was 28,443 MW (net load of 13,178 MW).

Year	Minimum Inertia (GW-s)	Load (MW)	Net Load (MW)	IRR %
2015	130.3	27,798	20,569	26.1%
2016	138.4	26,839	14,797	44.9%
2017	130.0	28,443	13,178	53.7%

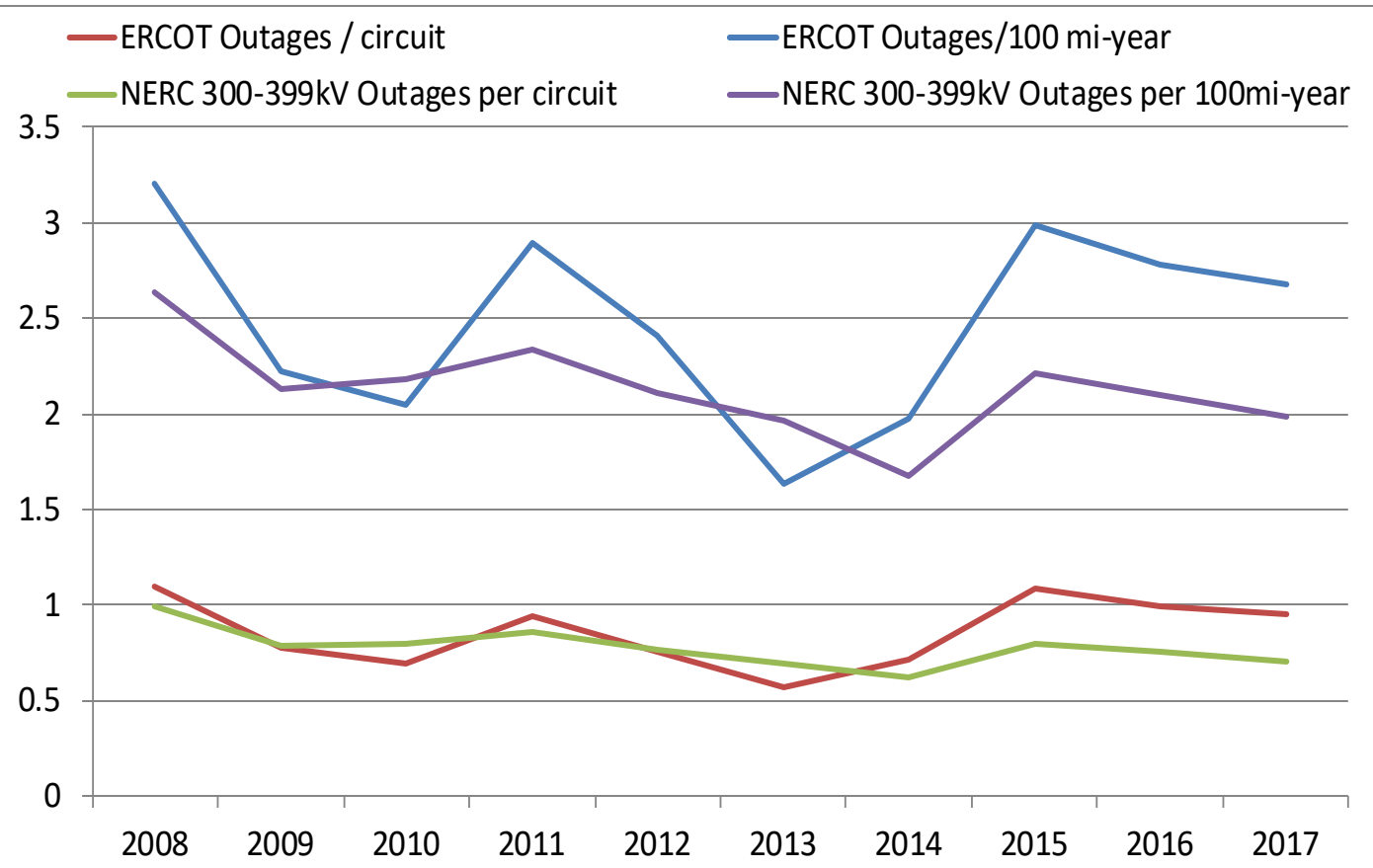
Rate of Change of Frequency vs. Inertia



Resource Mix Changes – Energy by Fuel Type



Transmission Outage Rates (>200 kV)

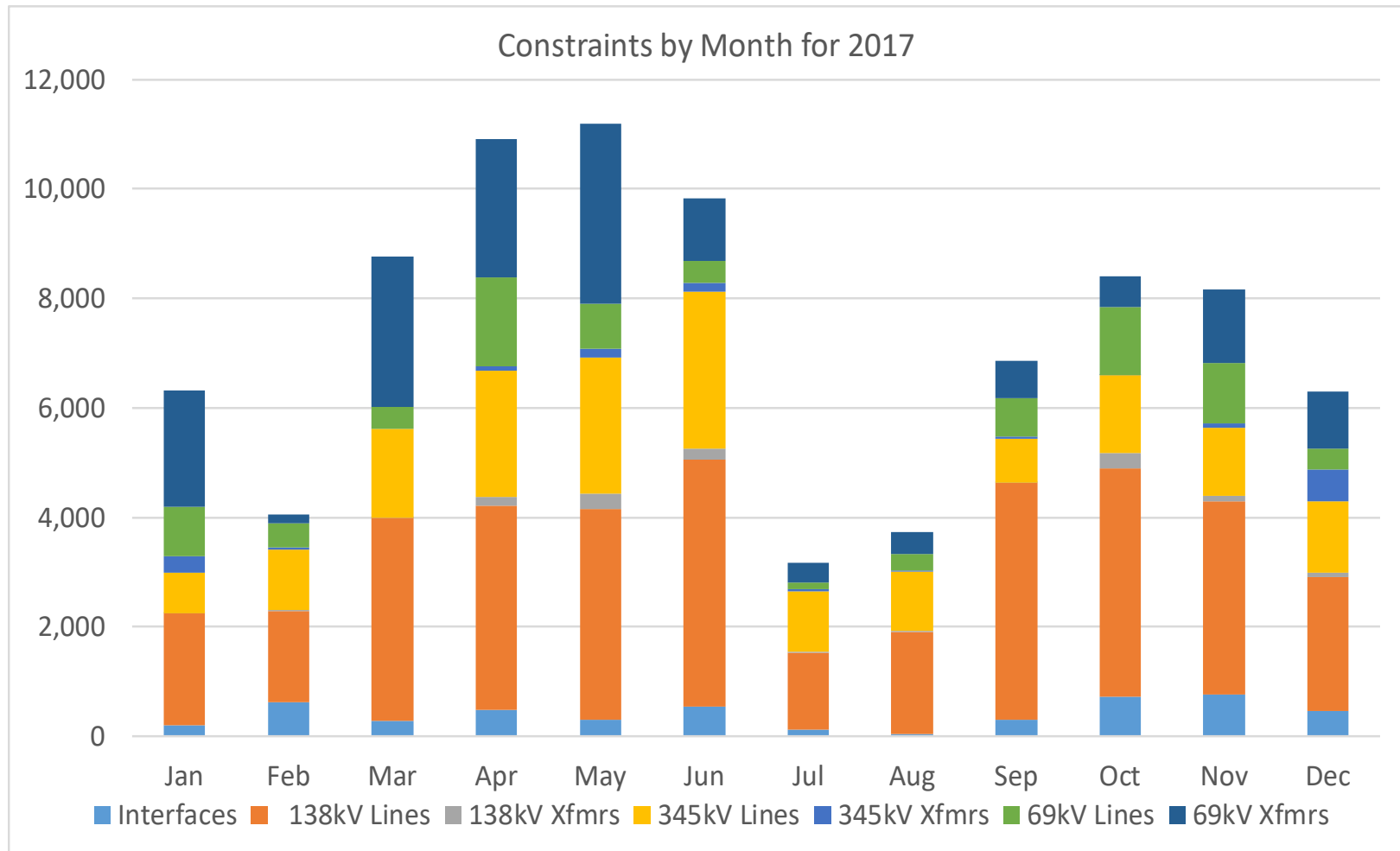


2017 Transmission Performance in Brief

- 345 kV circuits: 433
- 345 kV circuit miles: 15,263
- 345 kV circuit outages: 407
- 345 kV circuit outage duration: 5,840 hrs
- 345 kV transformer outage duration: 12,818 hours

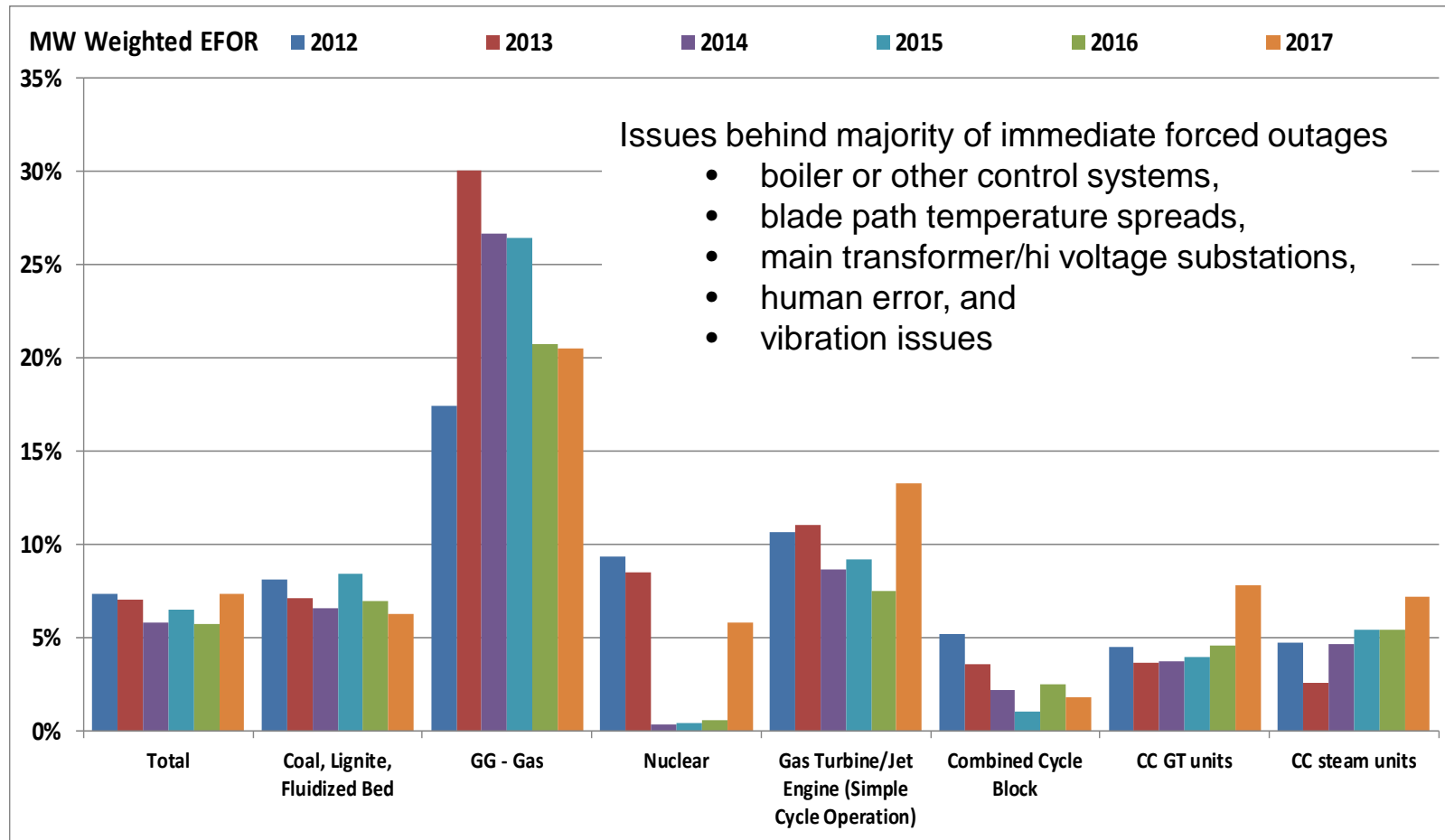
- 138 kV circuits: 1856
- 138 kV circuit miles: 21,516
- 138 kV circuit sustained outages: 406
- 138 kV circuit outage duration: 10,785 hrs

Transmission Constraints



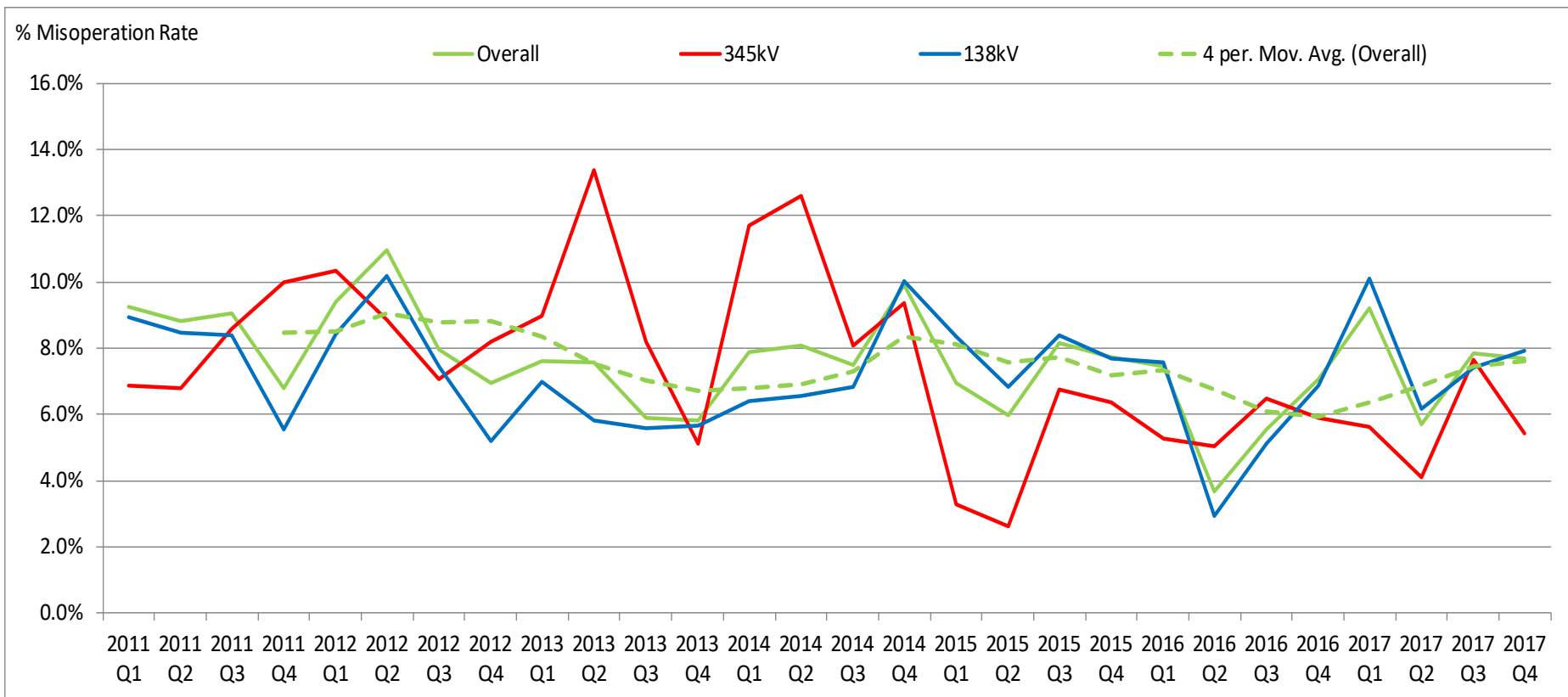
Count represents the number of RTCA intervals showing a basecase or post-contingency exceedance

Generation Equivalent Forced Outage Rates



- Equivalent Forced Outage Rate (EFOR) measures the rate of forced outage events
- ERCOT units only, based on GADS submittal data (no wind, or units under 50 MW in 2012)

Protection System Misoperations

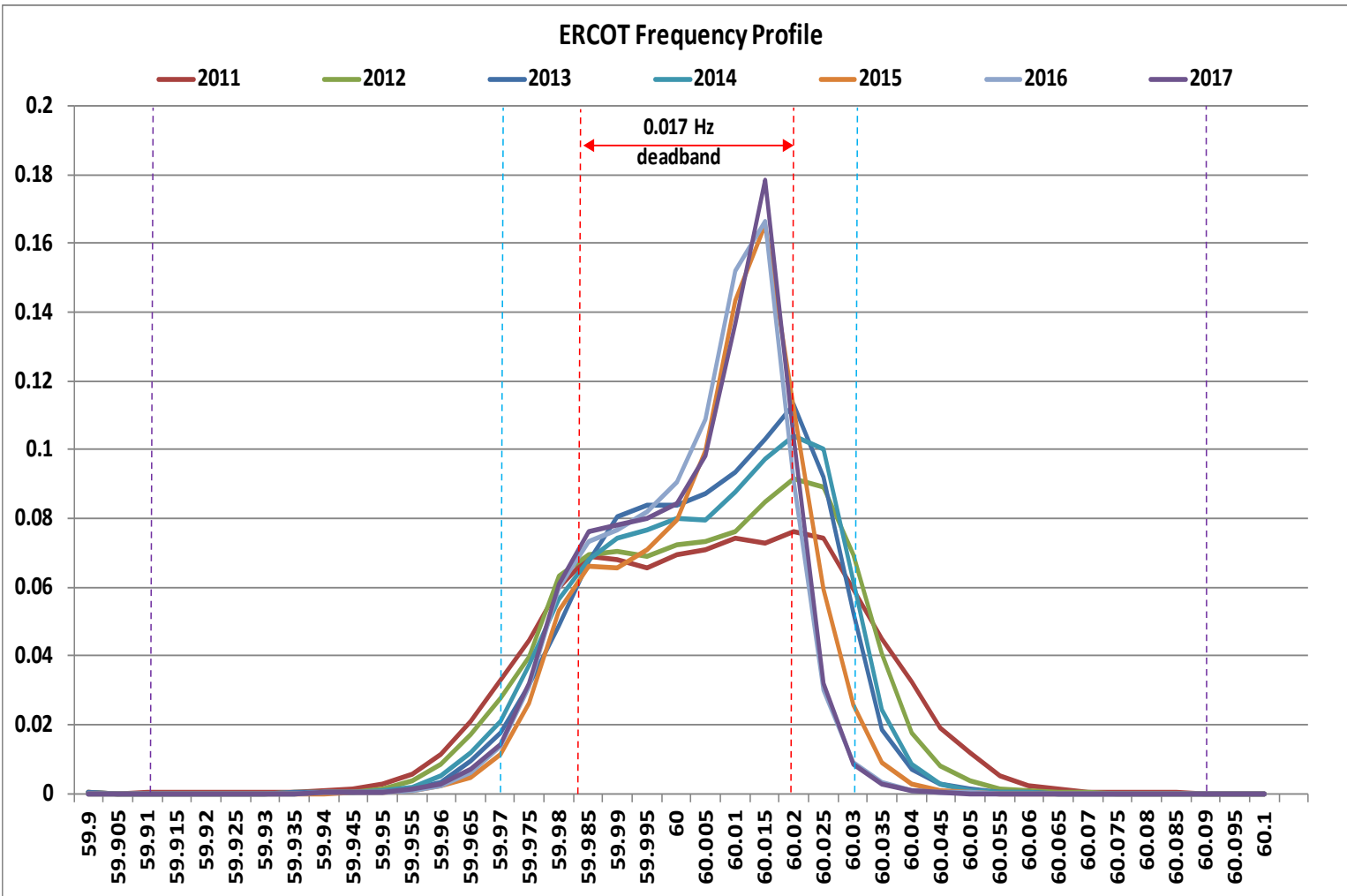


In 2017, three main categories accounted for 68% of the total misoperations: incorrect settings/logic/design (34%), as-left personnel errors (14%), and relay failures (20%).

Questions?

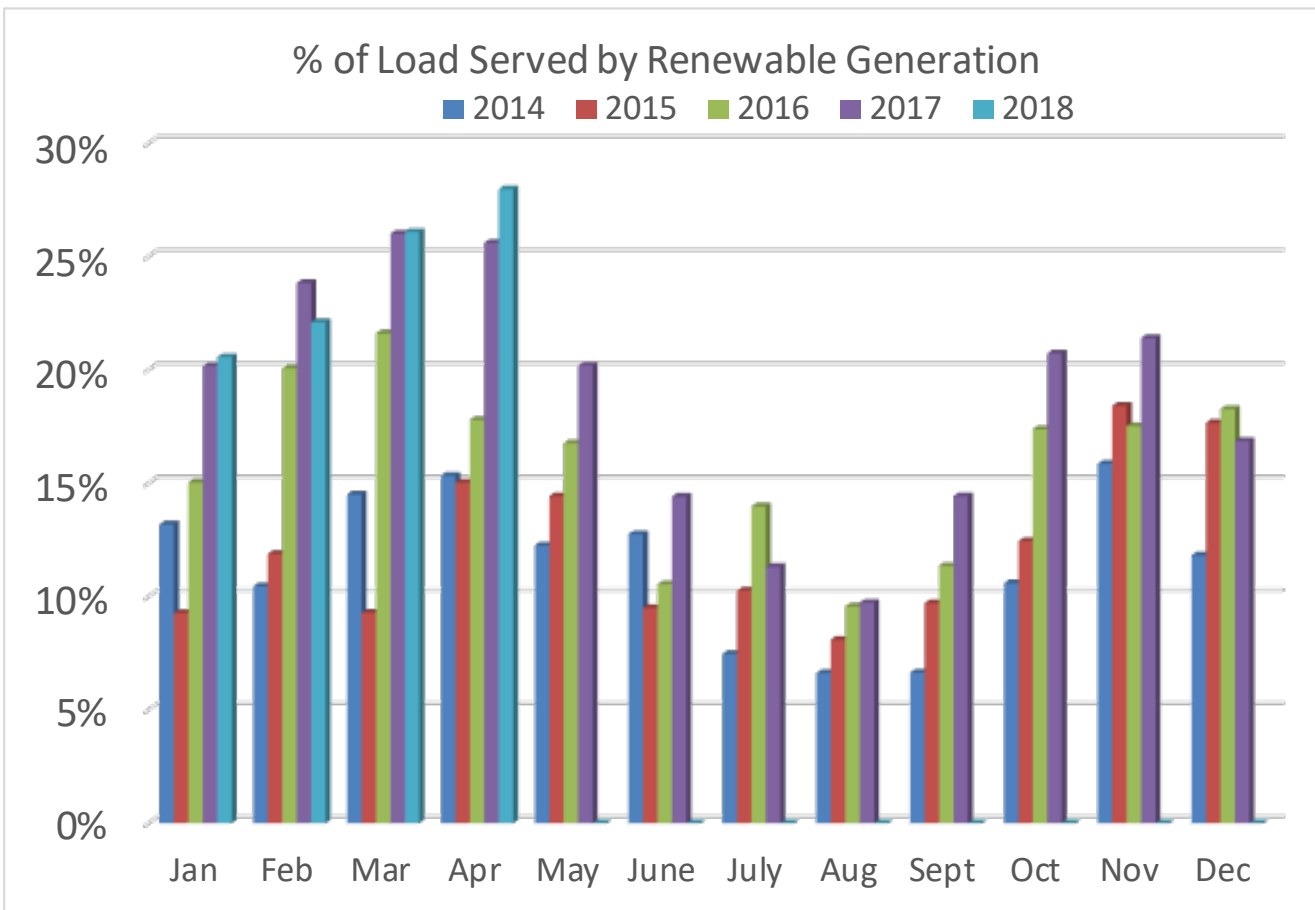


Frequency Control



- Blue dashed lines are the Epsilon-1 value of 30 mHz used for calculation of CPS-1
- Based on one-minute PI data

Renewable Generation Growth

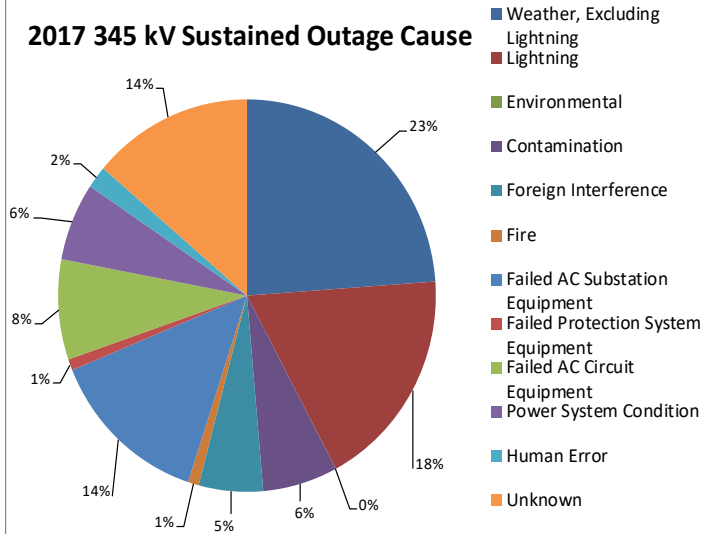


Renewable generation (wind + solar) produced 18.7% of the ERCOT total energy for calendar 2017

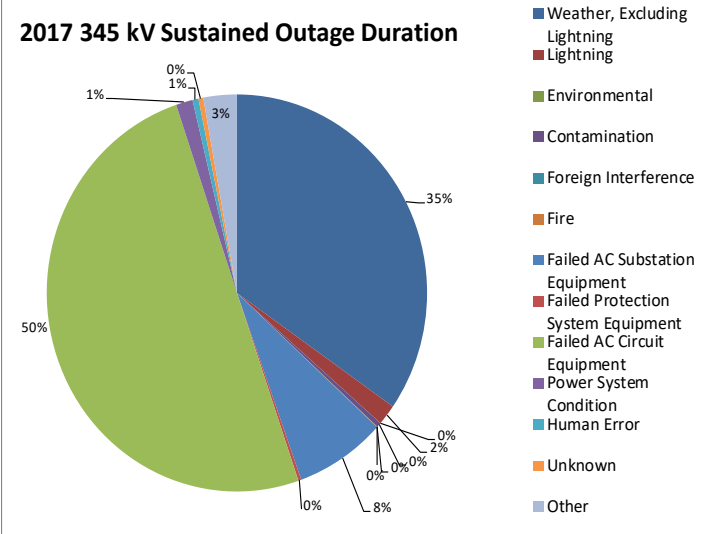
- ERCOT projections indicate solar generation will increase to over 2,300 MW and wind generation will increase to over 25,900 MW over the next two years based on current signed generation interconnect agreements with financial security

Transmission Outages by Cause and Duration

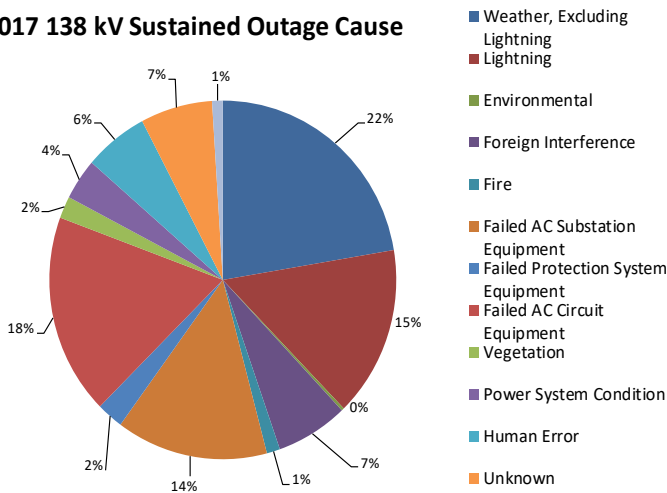
2017 345 kV Sustained Outage Cause



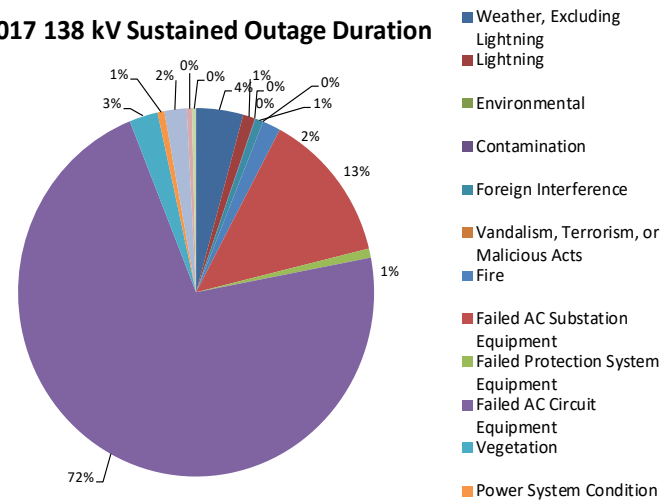
2017 345 kV Sustained Outage Duration



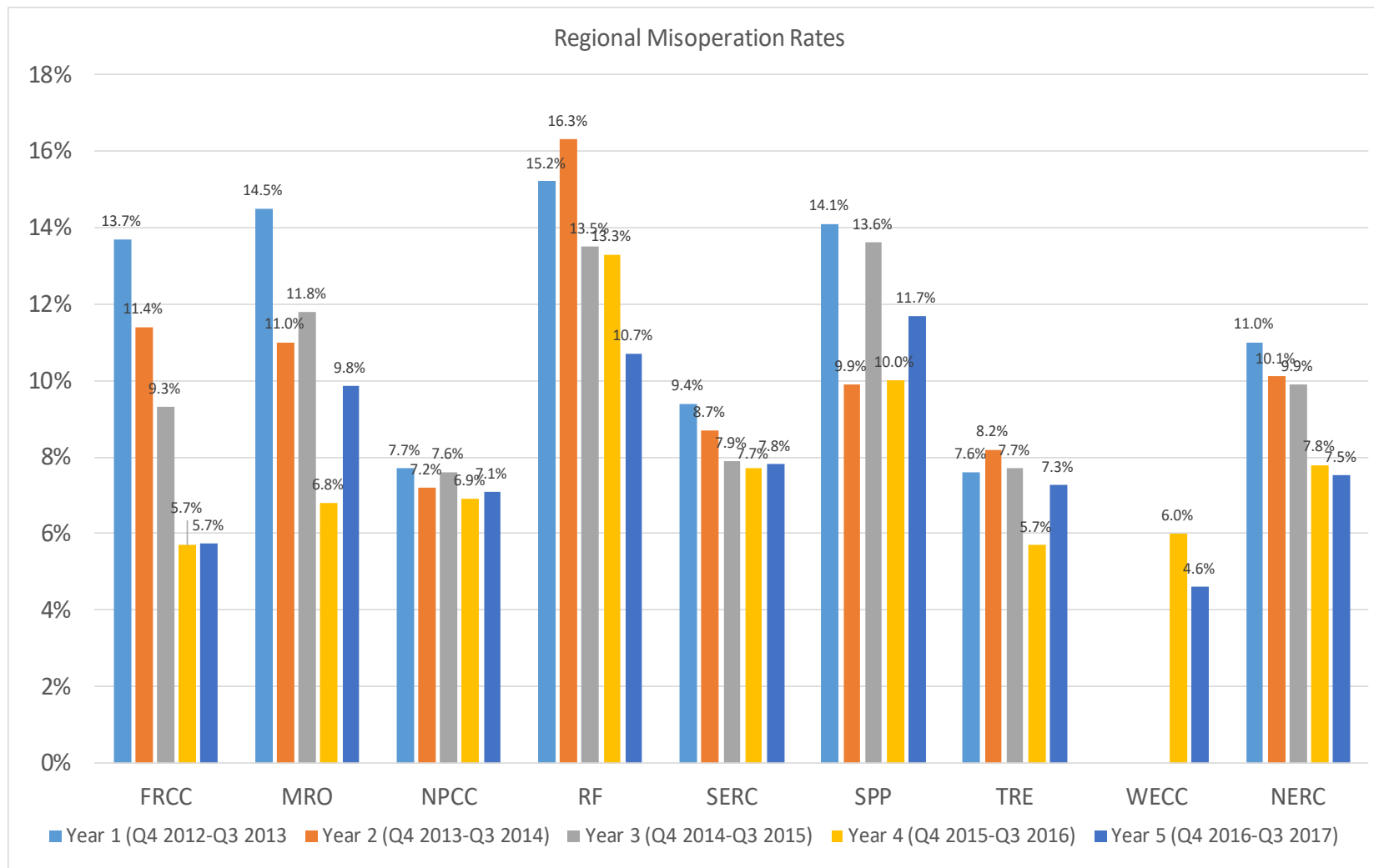
2017 138 kV Sustained Outage Cause



2017 138 kV Sustained Outage Duration

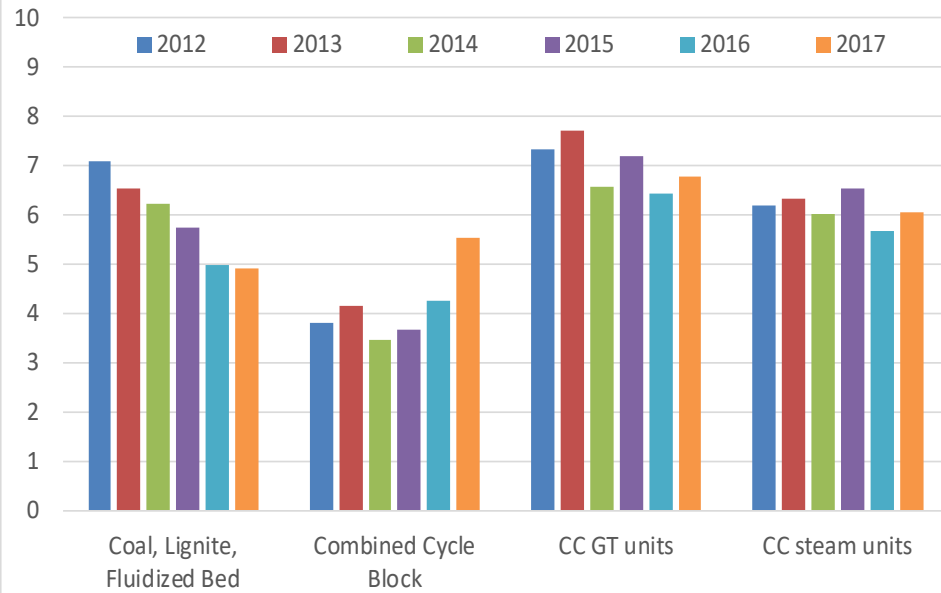


Protection System Misoperation Rates by Region



Generation Forced Outage Rates

Average Forced Outages per Unit



The majority of the immediate forced outage events occurred due to boiler control or other control system issues, blade path temperature spreads, main transformer or other high voltage substation events, human error, and vibration issues.

Average Unavailability from Forced Outages

