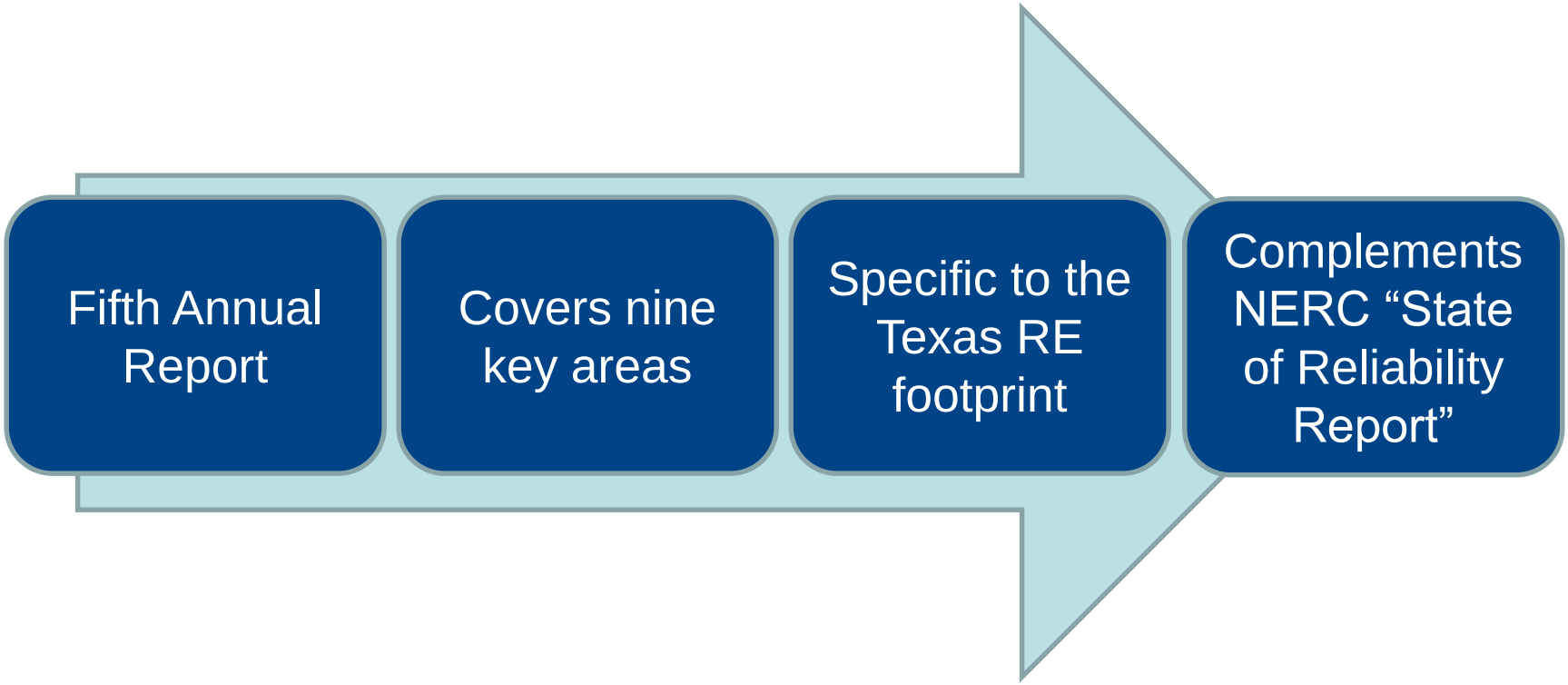
Annual Assessment of Reliability Performance

ROS Meeting

May 4, 2017

2016 Assessment of Reliability Performance



2016 Assessment of Reliability Performance

- Growth in renewable generation continues to be managed well
- Transmission outage rates remain stable and comparable to NERC-wide averages
- Frequency control metrics continue to be maintained at high levels
- Protection system misoperation rates are showing an improving trend
- Generation fleet metrics continue to meet or exceed NERC-wide fleet averages

2016 At A Glance

Record peak demand: 71,193 MW on August 11, 2016

Record instantaneous wind generation: 16,022 MW on December 25, 2016 @ 10:40

Peak hourly wind penetration: 47.5% of total energy on March 23, 2016 at 01:00

CPS-1: 176.6 for calendar year 2016 vs. 174.3 for calendar year 2015

Primary frequency response: 764 MW/0.1 Hz vs. NERC obligation of 381 MW/0.1 Hz

Protection system misoperation rate: 5.3% for 2016 vs. 7.0% for 2015

TADS 345 kV automatic outage rate per 100 miles: 2.78 for 2016 vs. 2.99 for 2015

GADS equivalent forced outage rate (EFOR): 5.75% for 2016 vs. 6.51% for 2015

2017 Focus Areas

Changing Resource Mix

- Modeling requirements
- Frequency and voltage ride-through capabilities
- Ramping variability
- Distributed generation
- Increased use of Generic Transmission Constraints

Essential Reliability Services

- Ramping
- Inertia

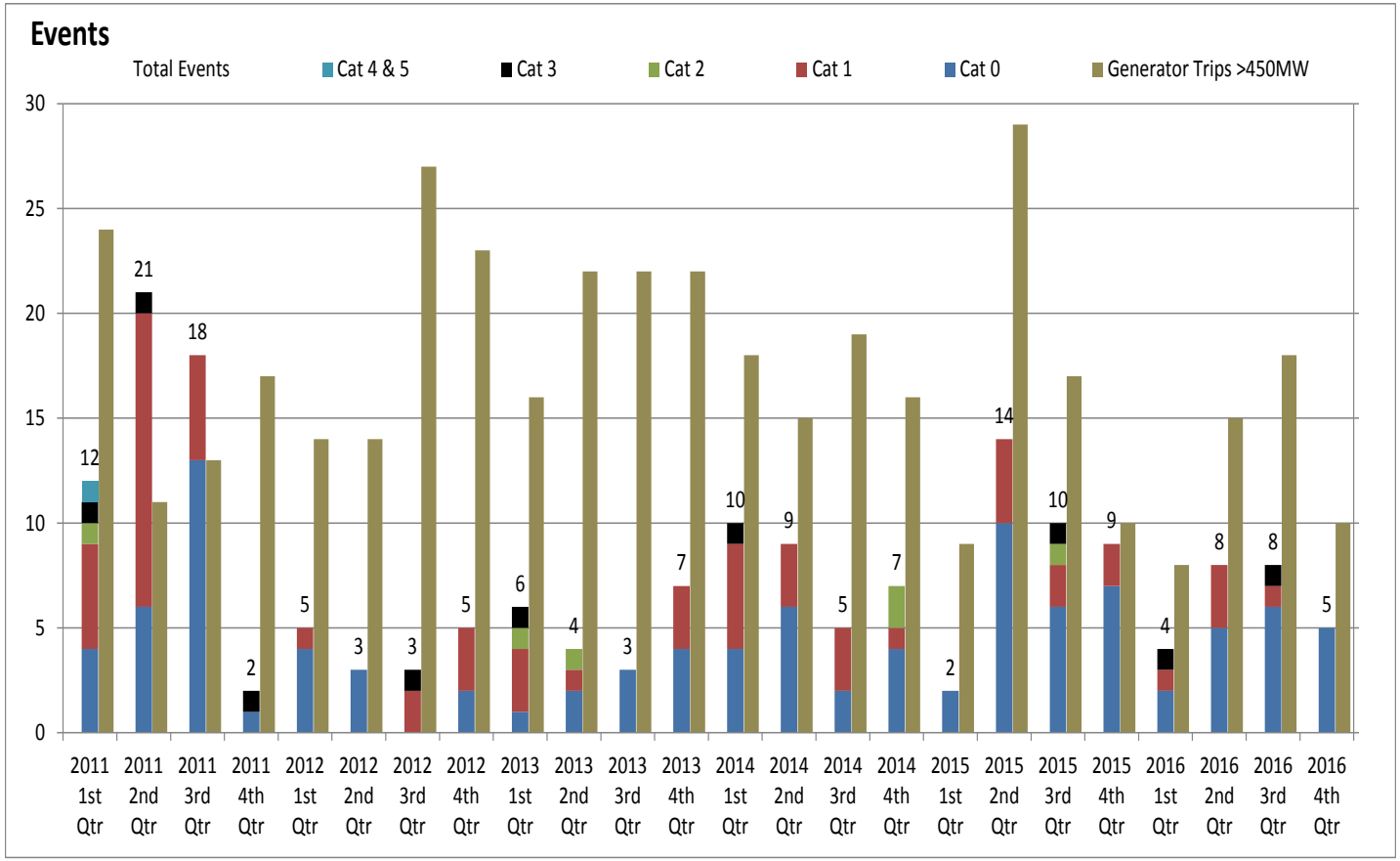
Cyber and Physical Security

Situational Awareness

Human Performance

Load serving capability of the Lower Rio Grande Valley area

System Events



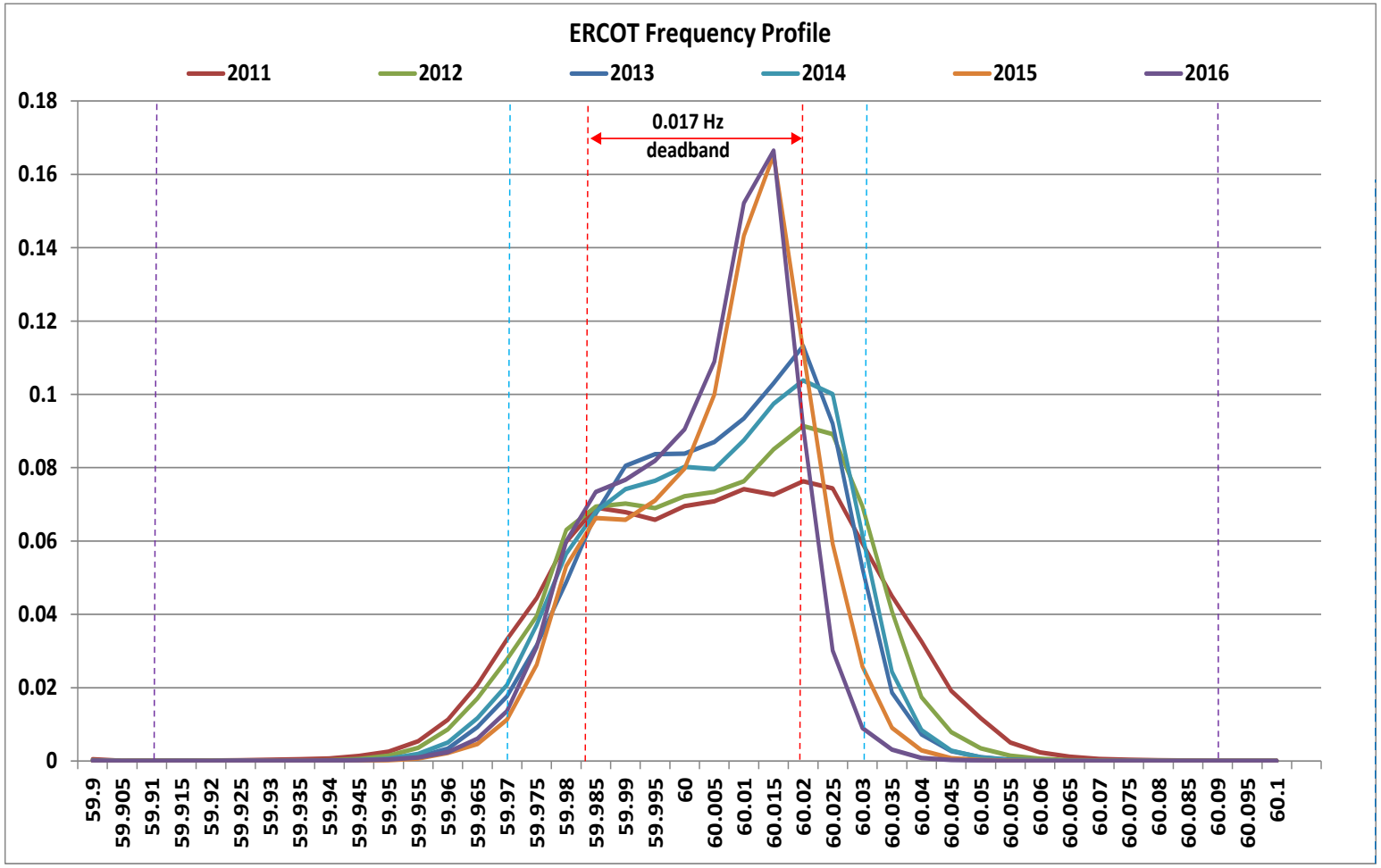
2016 Events in Brief

- Events reported: 72
- Protection system misoperations:132
- Generation forced outages: 1830
- 345kV transmission automatic outages: 409

2016 Key Events

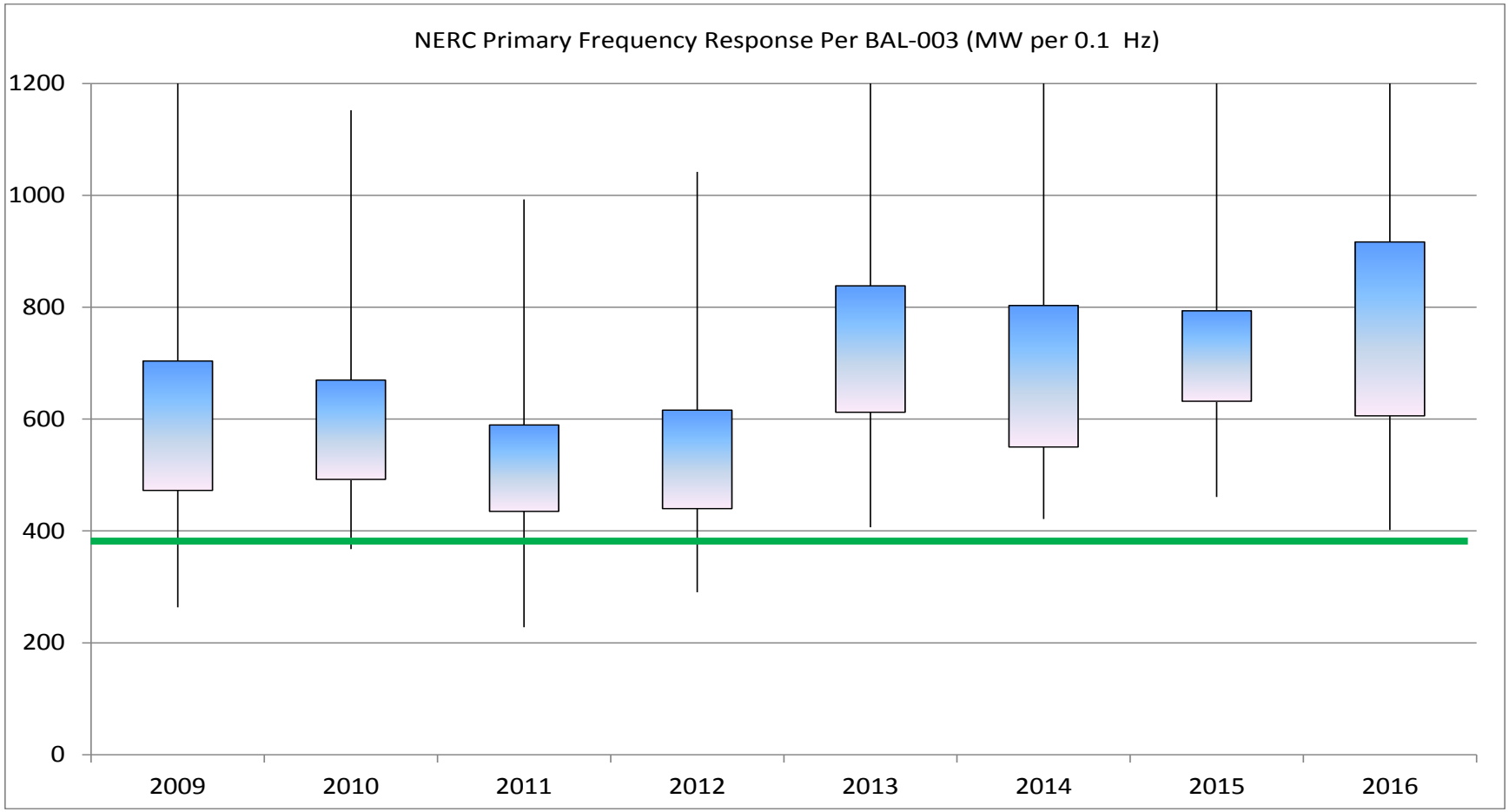
- 7/7/2016 ERCOT loss of EMS
- 7/10/2016 Multiple generation loss
- 10/3/2016 Valley public appeals
- Multiple wind generation loss events

Frequency Control



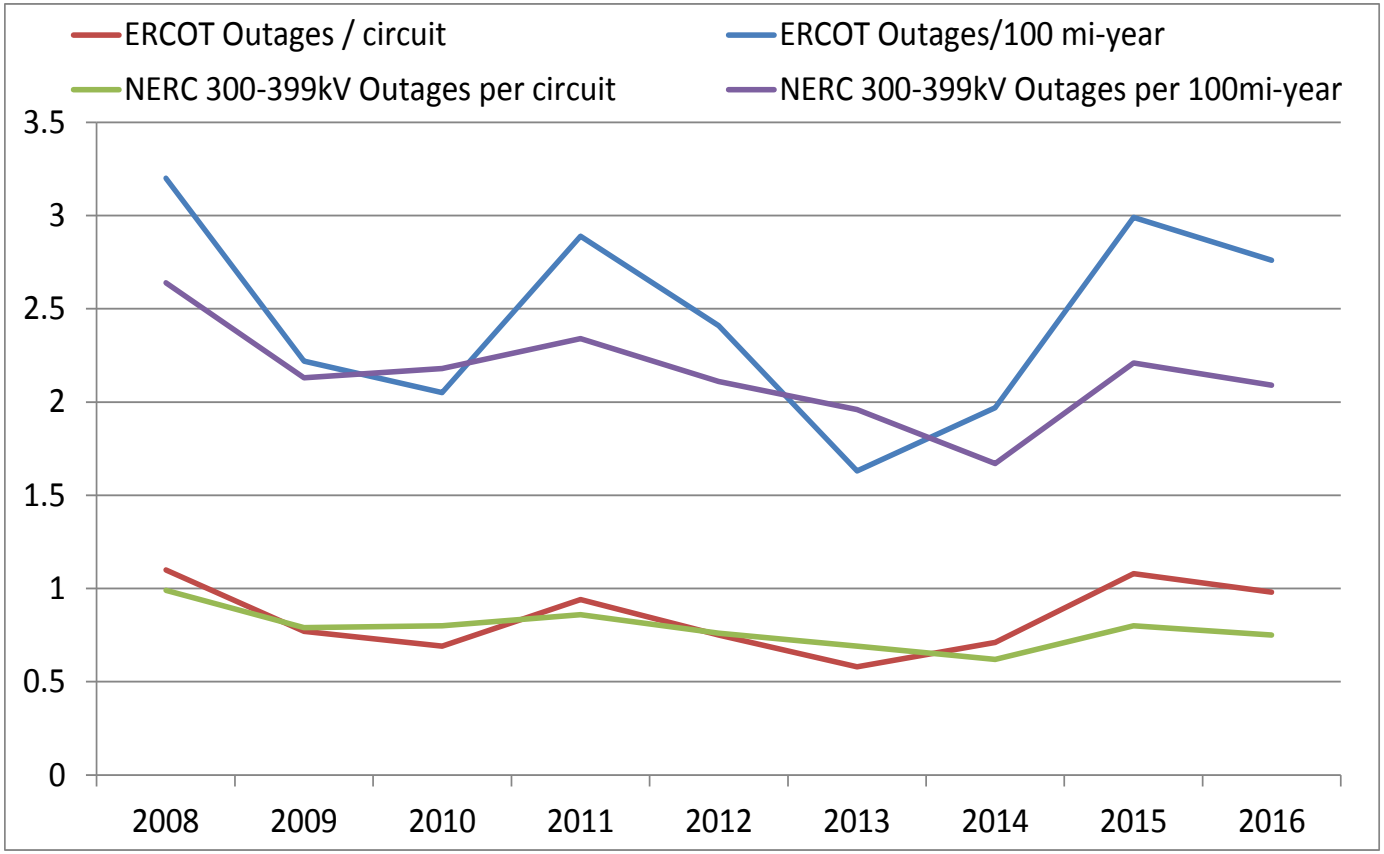
- Blue dashed lines are the Epsilon-1 value of 30 mhZ used for calculation of CPS-1
- Based on one-minute PI data

Primary Frequency Response



- 2016 average recovery time from a generation loss event was 5.3 minutes

Transmission Outage Rates (> 200 kV)

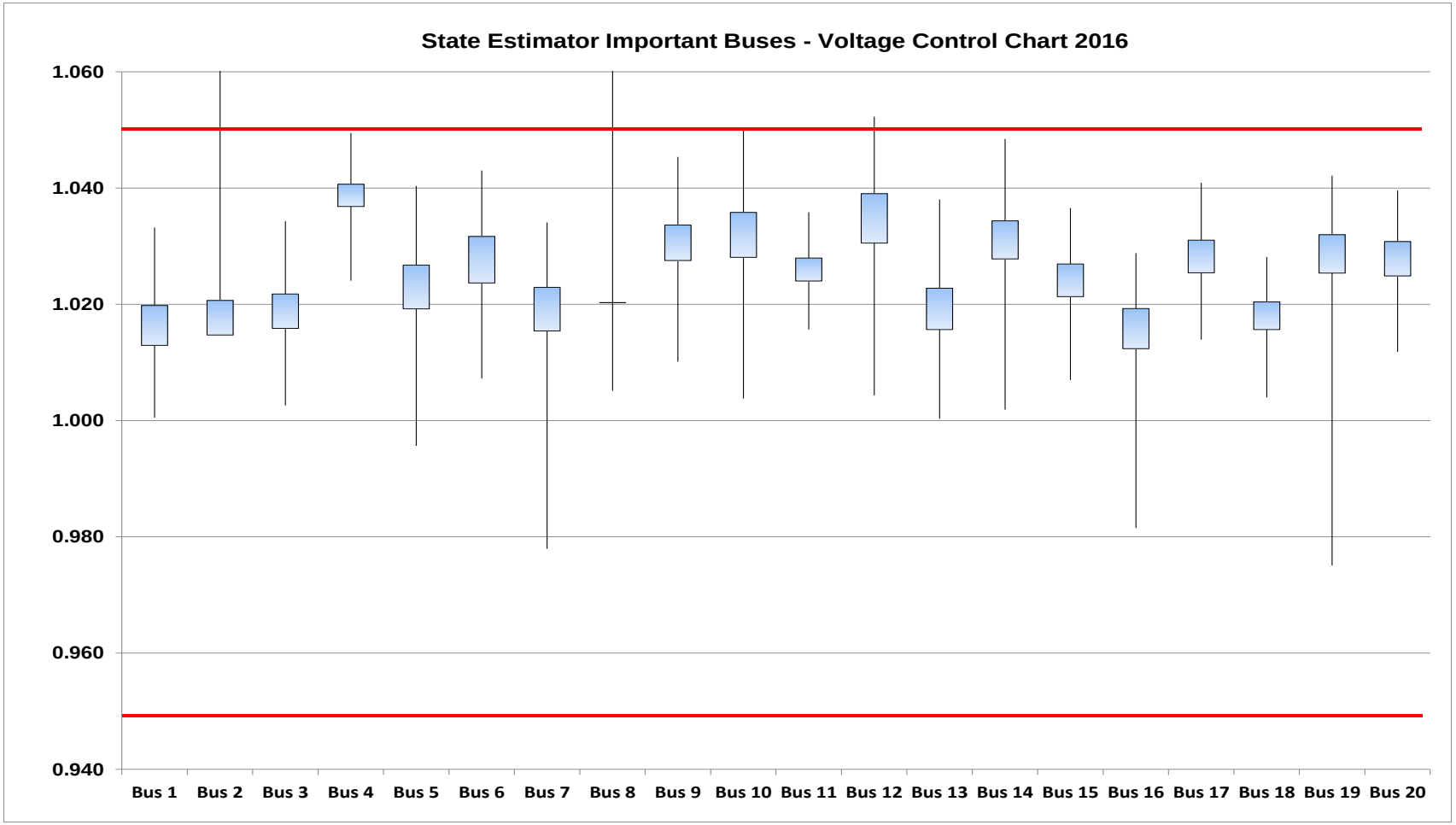


2016 Transmission Performance in Brief

- 345kV circuits: 424
- 345kV circuit miles: 15,025
- 345kV circuit outages: 413
- 345kV circuit outage duration: 2,617 hrs
- 345kV transformer outage duration: 3,829 hours

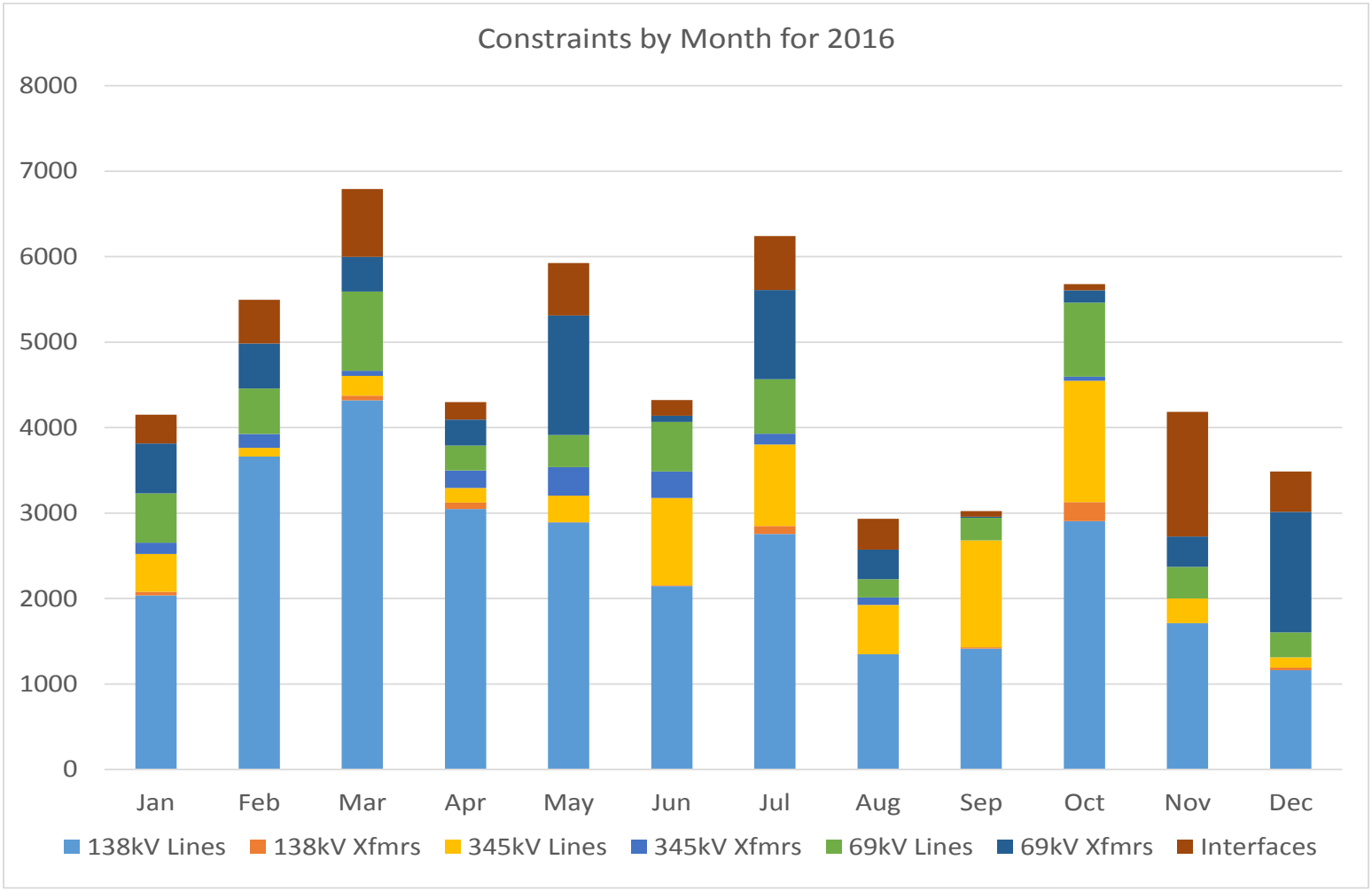
- 138kV circuits: 1768
- 138kV circuit miles: 21,032
- 138kV circuit sustained outages: 352
- 138kV circuit outage duration: 8,582 hrs

Voltage Control (345 kV)



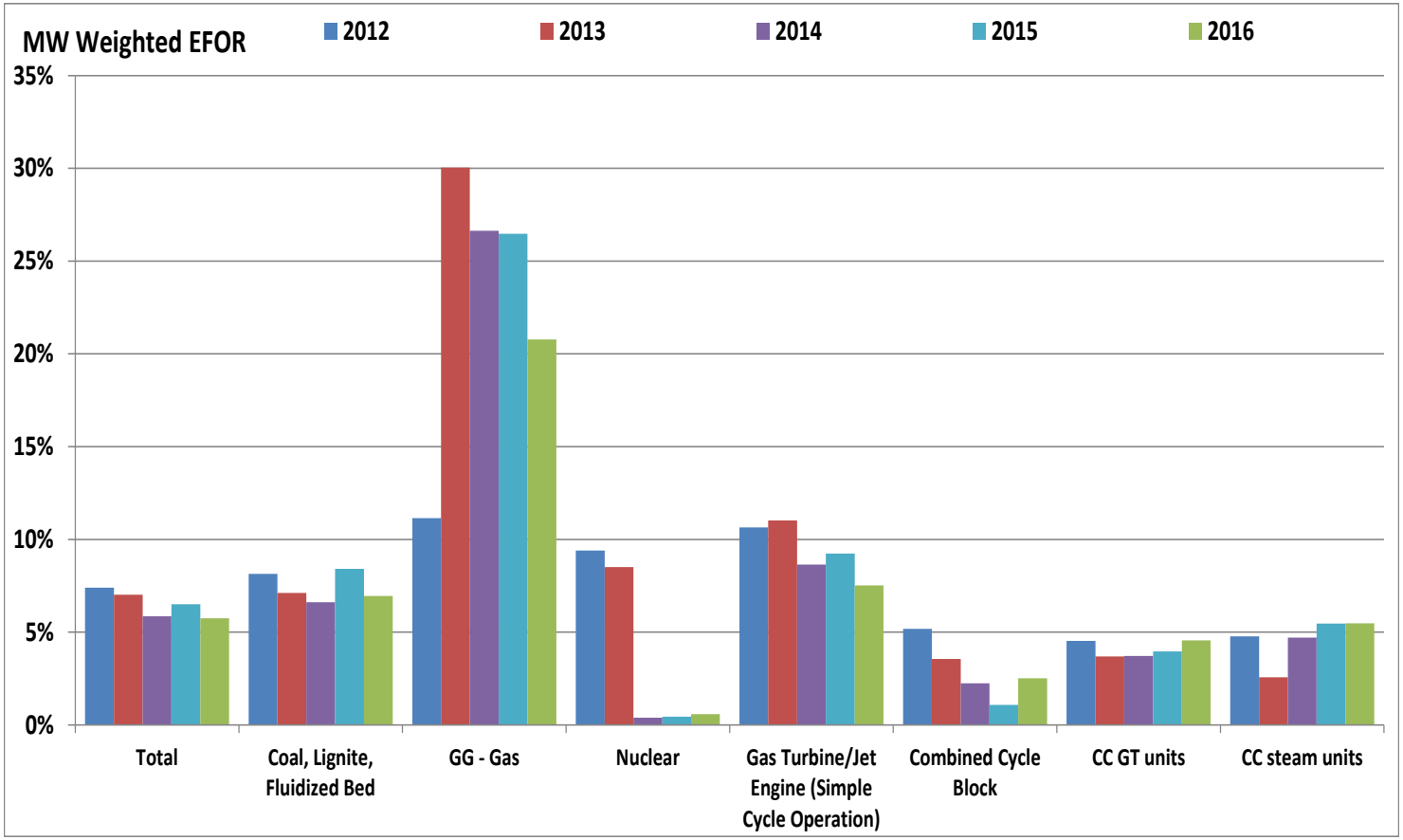
- One hour average PI data for 20 345kV buses

Transmission Constraints



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

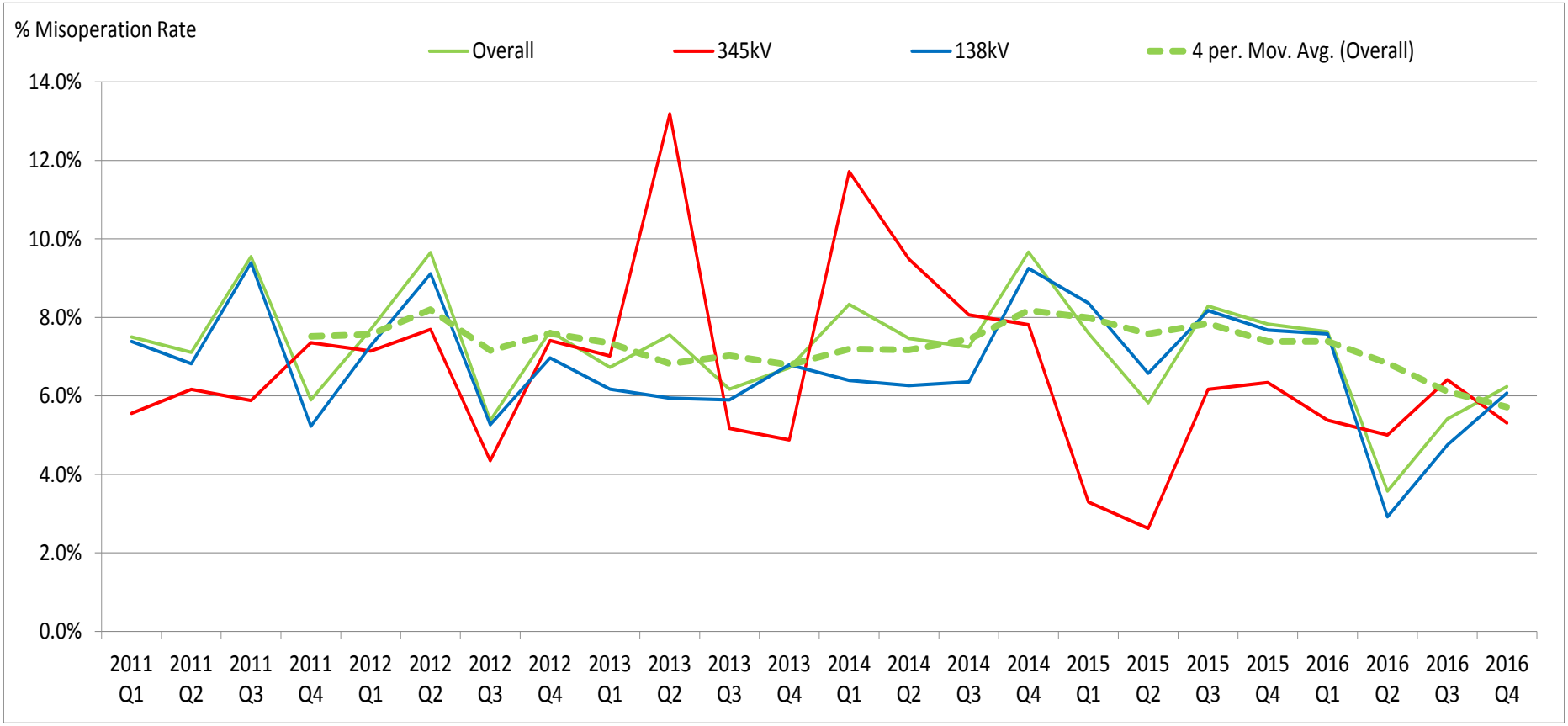
Generation Equivalent Forced Outage Rates



NERC 2011-2015 Fleet Avg EFOR	
Unweighted	18.8%
MW Weighted	14.6%

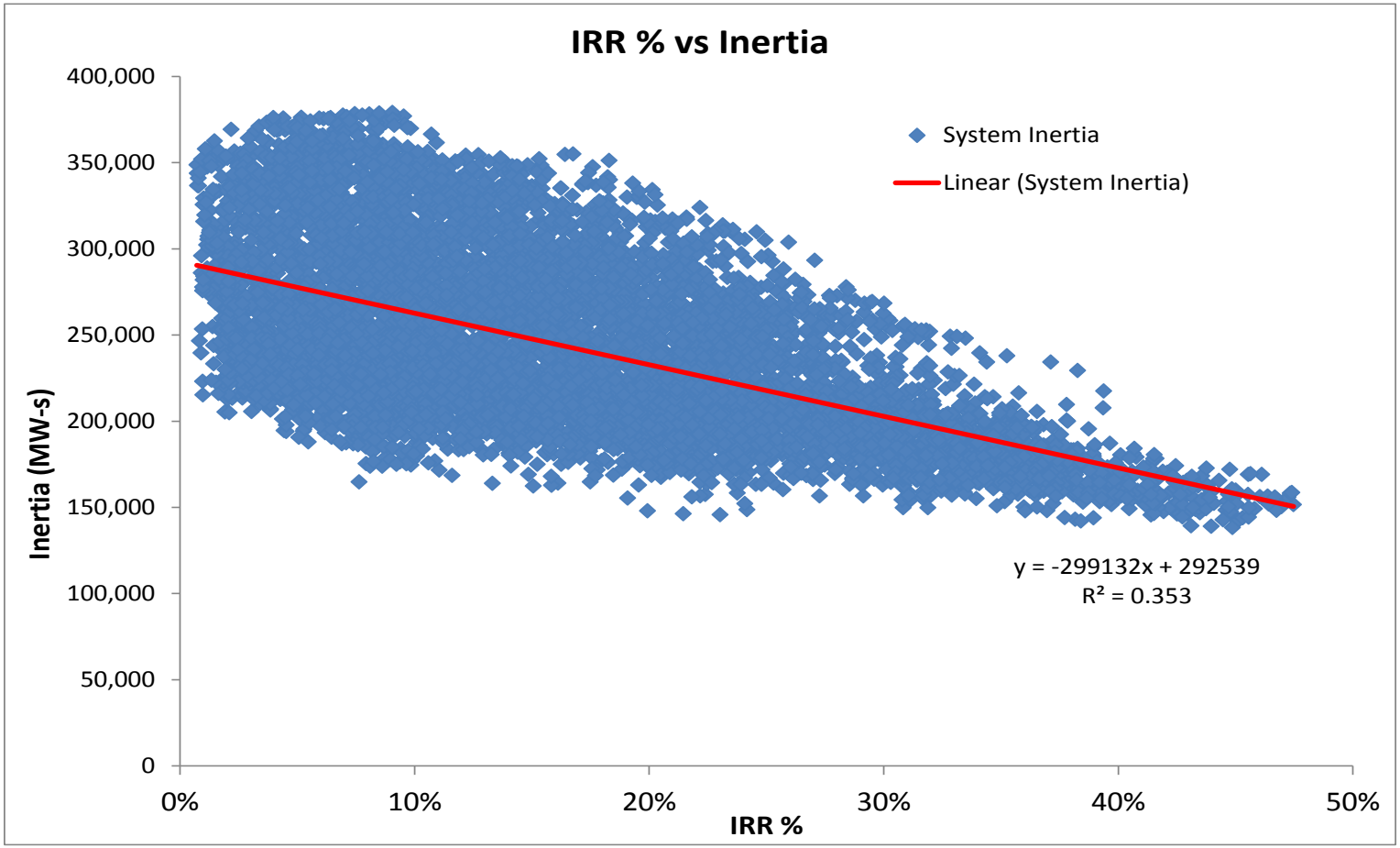
- EFOR: Equivalent Forced Outage Rate. Measures the rate of forced outage events
- ERCOT units only, based on GADS submittal data (no wind, or units under 50 MW in 2012)

Protection System Misoperations



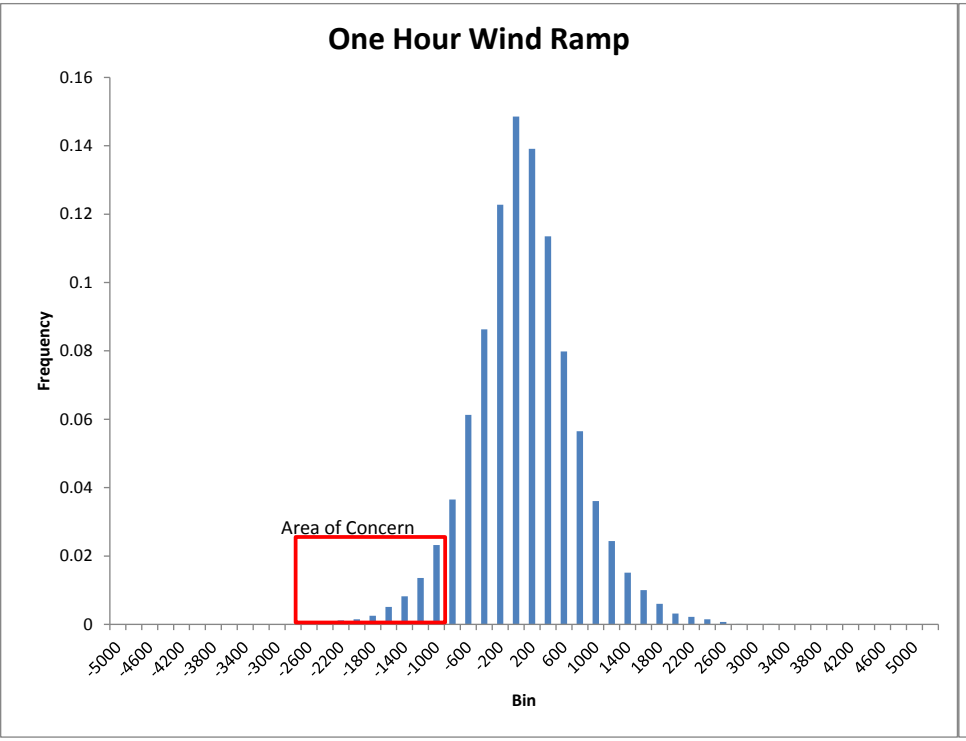
- Significant decrease in misoperations due to incorrect settings in 2016
- Noted increase in misoperations due to As-left Personnel Error

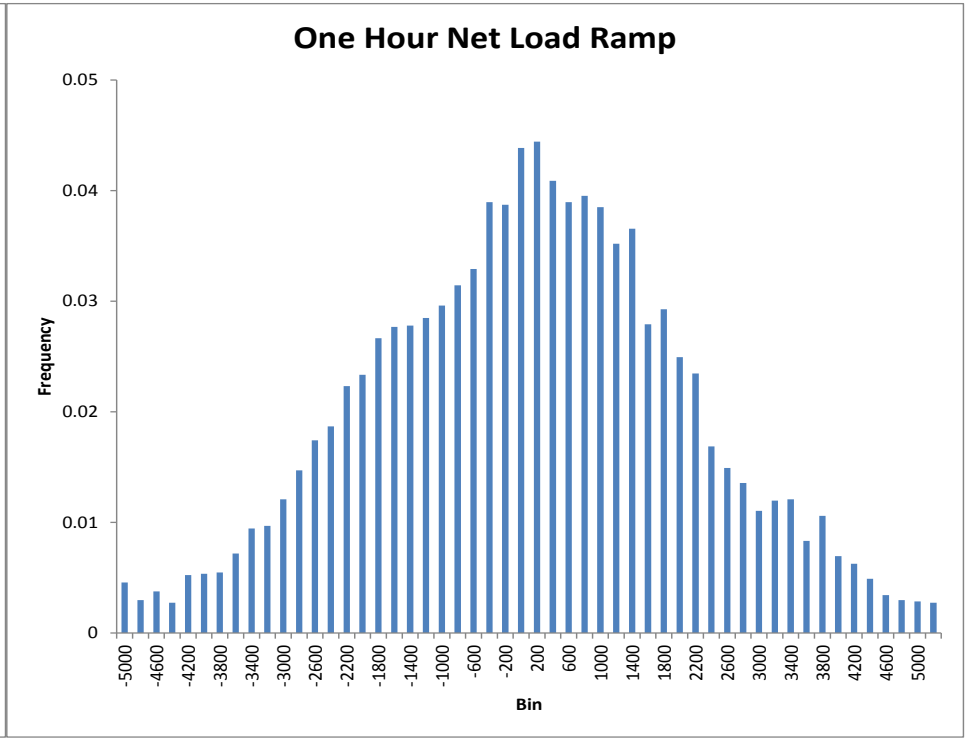
Emerging Issues - Inertia



- Plot of Inertia vs. Percentage of load served by Intermittent Renewable Resources (IRRs)
- Based on one-hour PI data

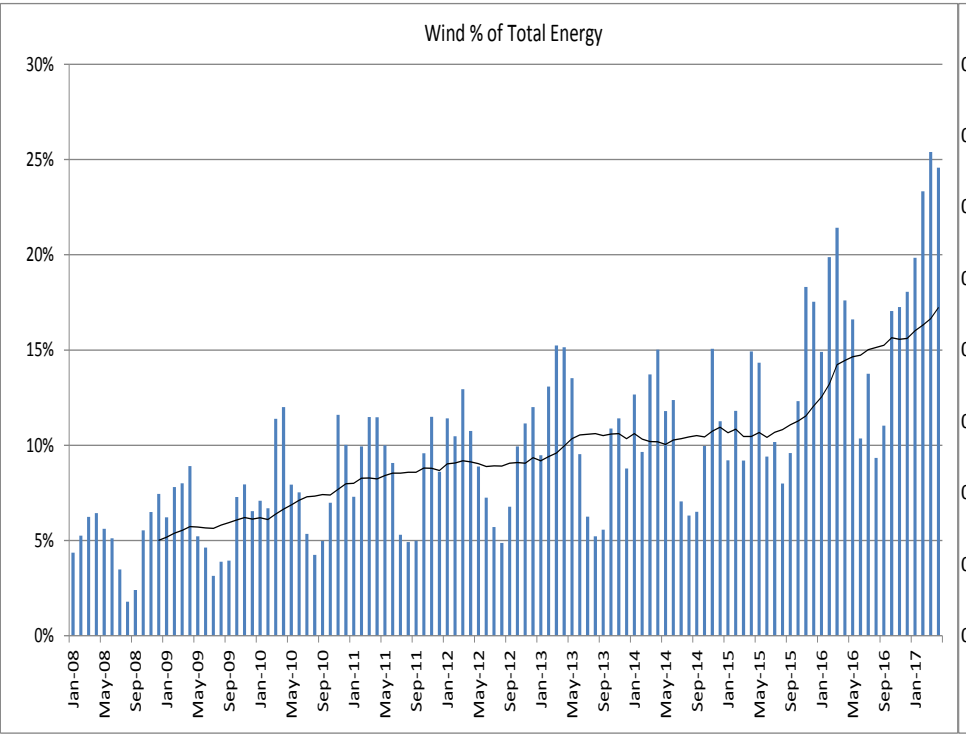
Emerging Issues - Ramping

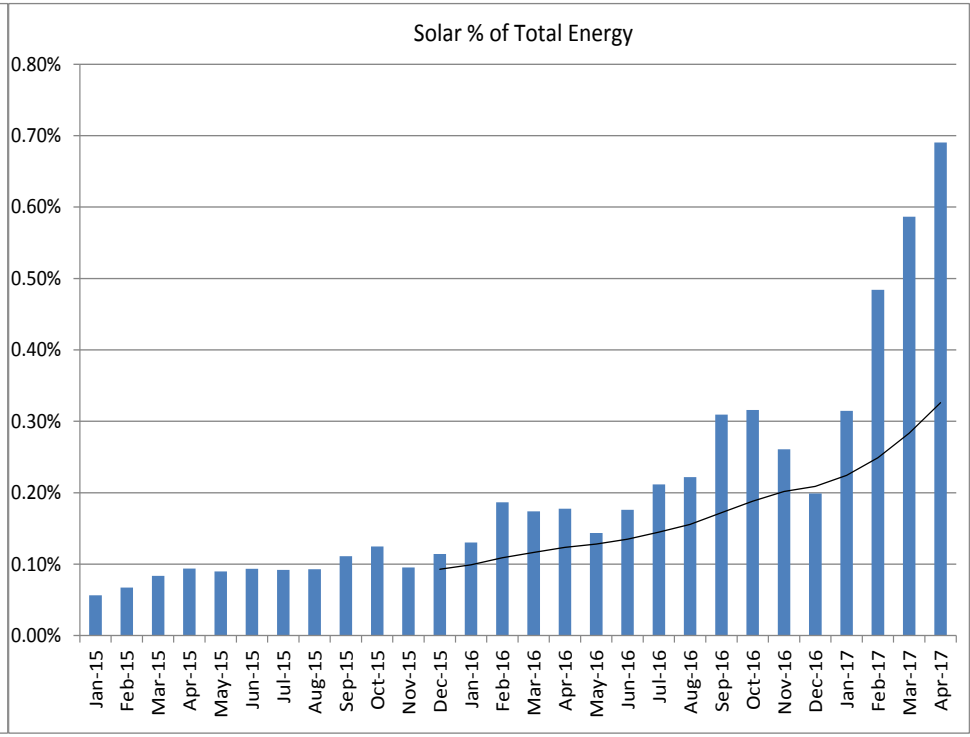




- Frequency plots of one-hour net wind ramp and one-hour net load ramp
- Based on one-hour PI data

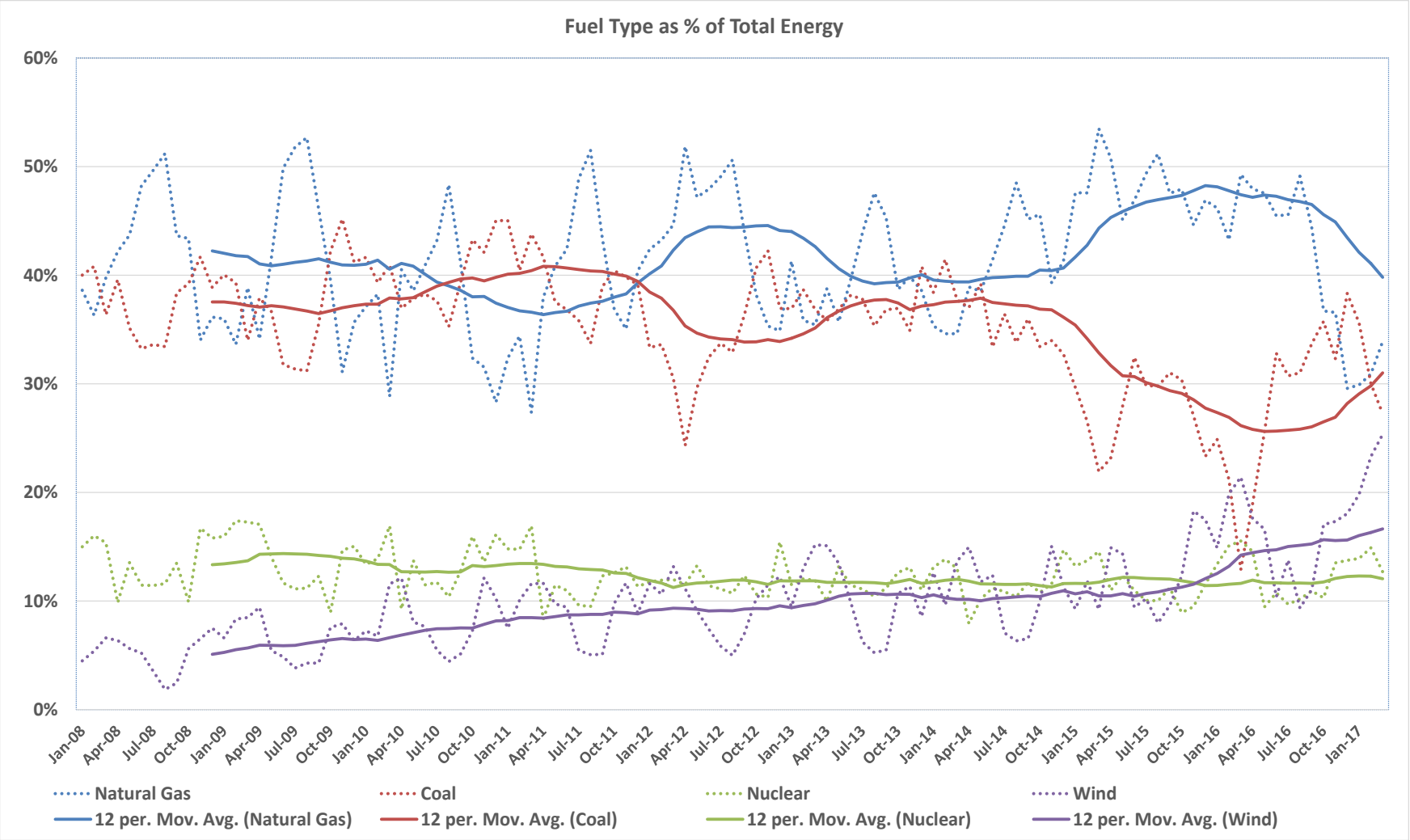
Renewable Generation Growth





- ERCOT projections indicate solar generation will increase to over 1,650 MW and wind generation will increase to over 23,400 MW over the next two years based on current signed generation interconnect agreements with financial security

Resource Mix Changes – Energy by Fuel Type



Questions?