Challenges and Solutions for System Operations with high share of RE– ERCOT (Texas)

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ERCOT

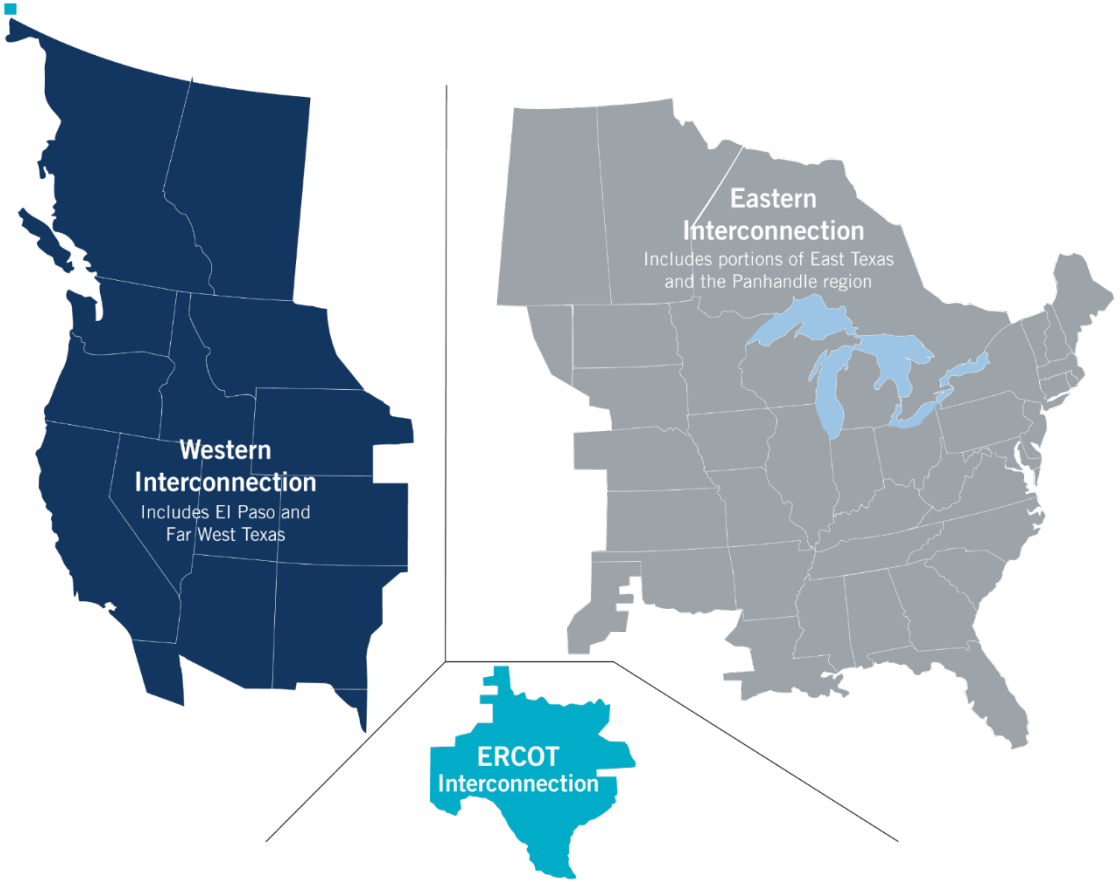
Outlines

- Background information of ERCOT
- Renewable Integration Practices and Solutions at ERCOT
- Future Challenges Associated with High Penetration of Renewables

What is ERCOT?

The Texas Legislature restructured the Texas electric market in 1999 and assigned ERCOT four primary responsibilities:

- **System Reliability**
- **Competitive Wholesale Market**
- **Open Access to Transmission**
- **Competitive Retail Market**



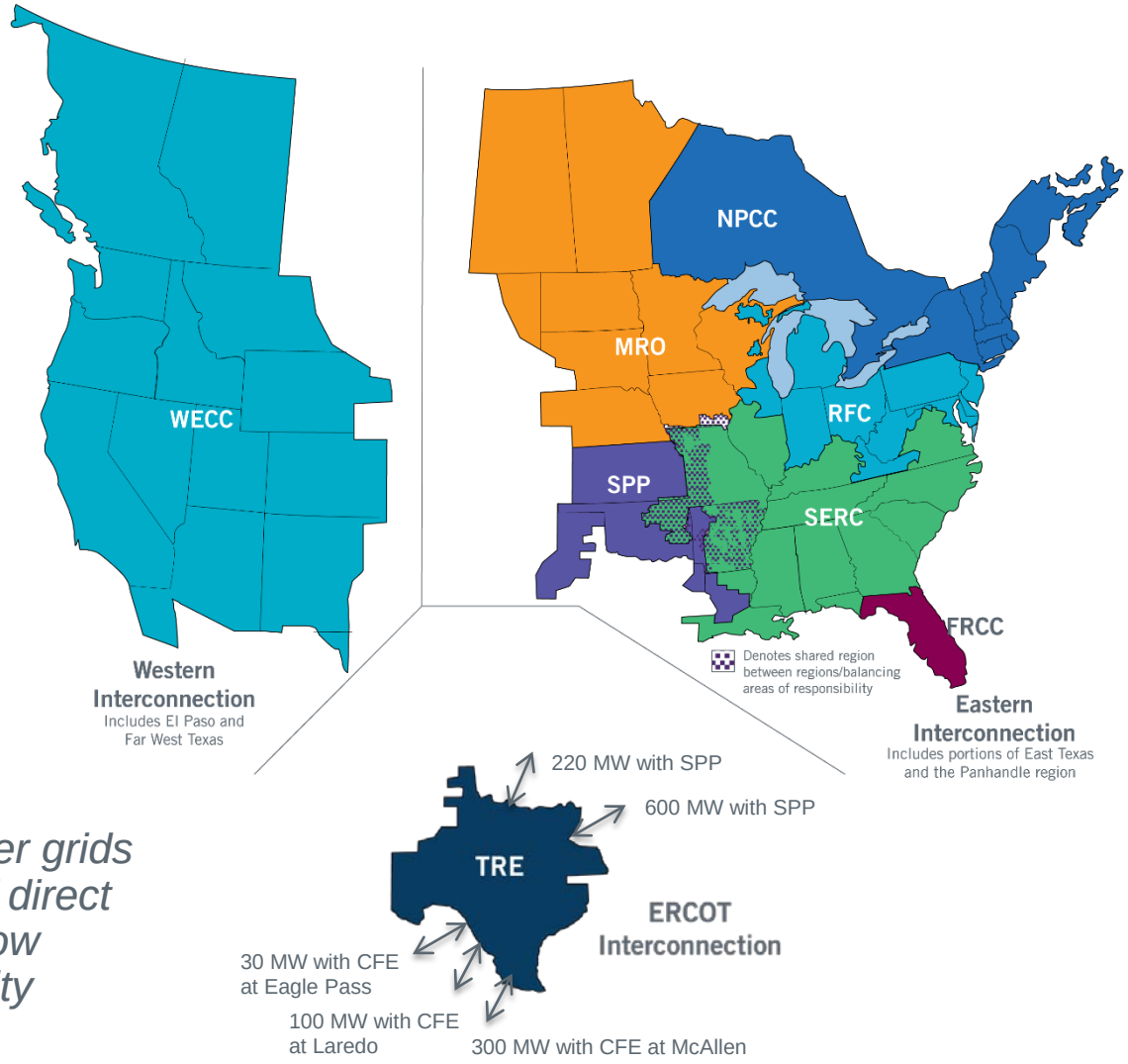
ERCOT is a nonprofit organization and regulated by the Public Utility Commission of Texas, with oversight by the Texas Legislature.

ERCOT is not a market participant and does not own generation or transmission/distribution wires.

The ERCOT Region

The interconnected electrical system serving most of Texas, with limited external connections

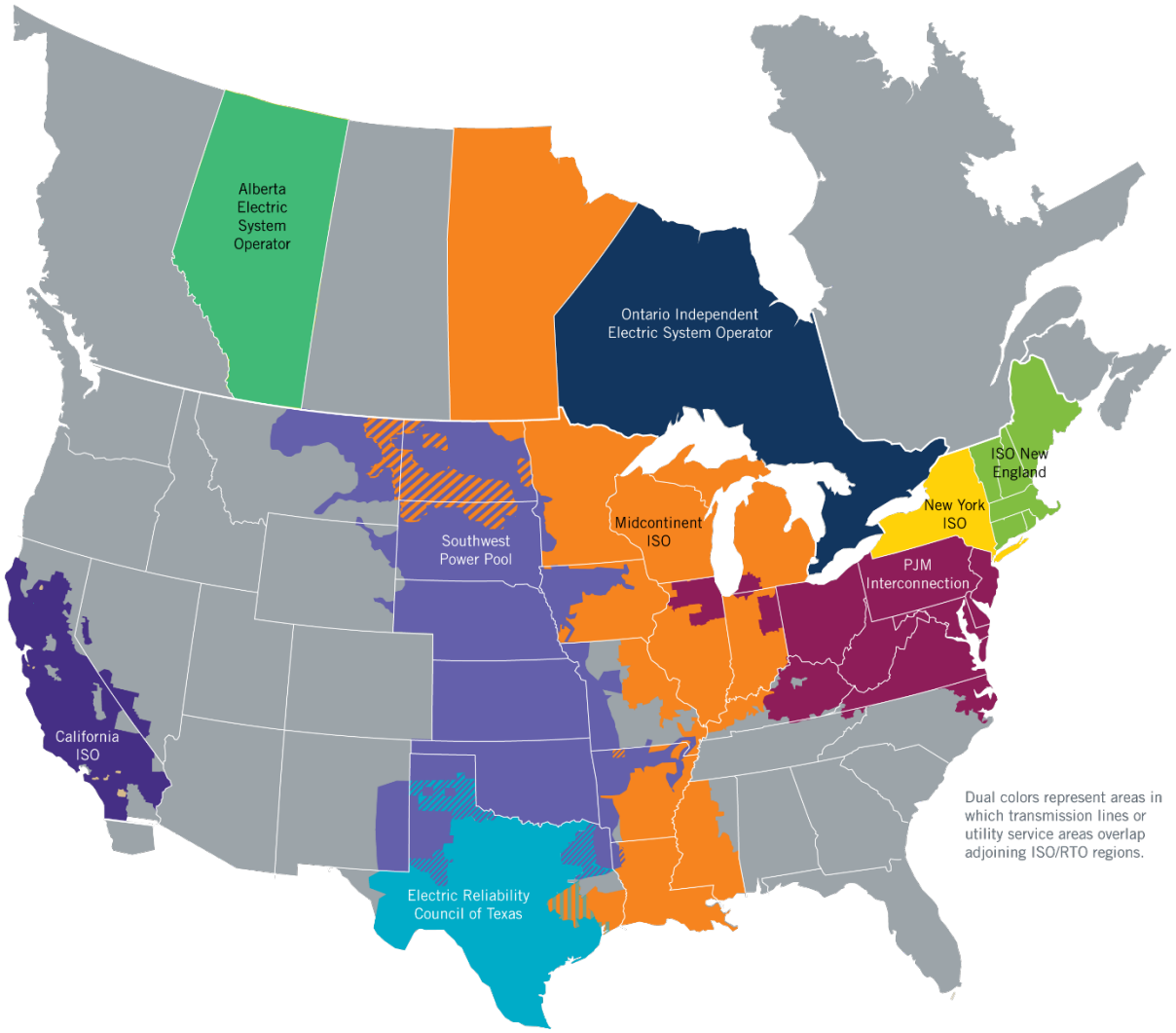
- 90% of Texas electric load; 75% of Texas land
- 71,110 MW peak, August 11, 2016
- More than 46,500 miles of transmission lines
- 570+ generation units



ERCOT connections to other grids are limited to ~1250 MW of direct current (DC) ties, which allow control over flow of electricity

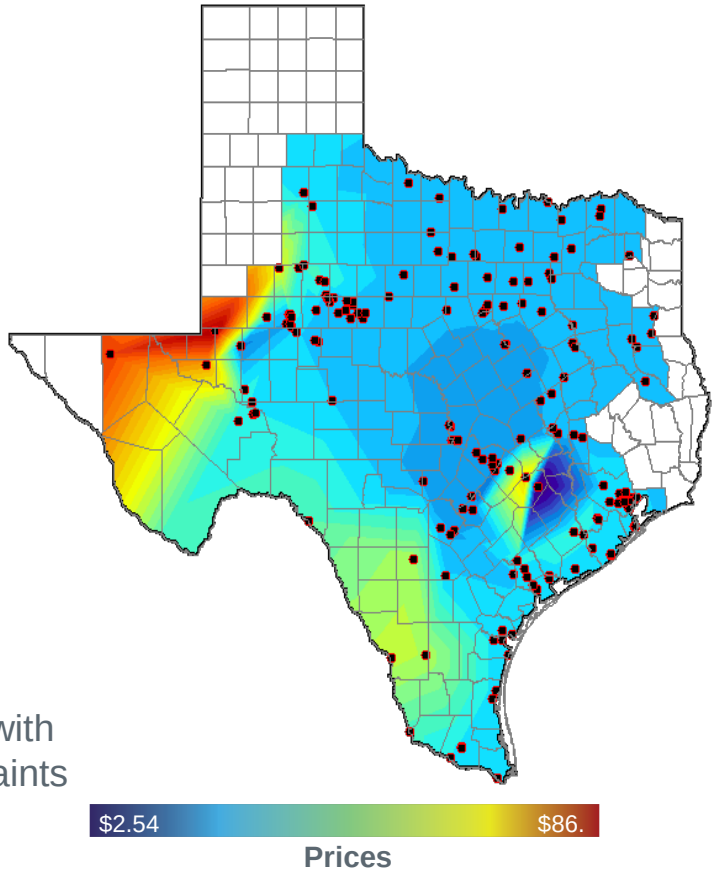
ISOs and RTOs

- ERCOT is one of nine **independent system operators** and **regional transmission organizations** in the U.S. and Canada.
- Together, ISO/RTOs serve about two-thirds of electric consumers in the U.S. and more than half of consumers in Canada.



Energy Market

- Market participants bring generation on-line; ERCOT may start additional generation needed to maintain reliability.
- Market participants submit offers for generation output.
- ERCOT clears the market every five minutes, using the generation with the lowest bids to serve the load, subject to transmission constraints.
- Prices received by generators signal whether more or less output is needed from generators in that area at that time.
- In general, the set of generator output levels produced by this process is the lowest cost way that doesn't overload the transmission system to meet the system load for each five minute interval.
- ERCOT clears market every five minutes, using the generation with the lowest bids to serve the load, subject to transmission constraints
- Ancillary Service is procured in Day-Ahead Market



Current Records

Peak Demand Record: 71,110 MW

- Aug. 11, 2016, 4-5 p.m.

Weekend Record: 68,413 MW*

- Saturday, July 29, 2017, 4-5 p.m.

Winter Peak Record: 59,650 MW

- Jan. 6, 2017, 6-7 p.m.

Wind Generation Records (instantaneous)

- Output: 16,141 MW
  - March 31, 2017, 8:56 p.m.
- Penetration (load served): 50%
  - March 23, 2017, 3:50 a.m.
  - Total Load = 28,780 MW

Recent Monthly Peak Demand Records

2017

- January: 59,650 MW (Jan. 6, 6-7 p.m.)
- April: 53,420 MW (April 28, 4-5 p.m.)
- May: 59,244 MW (May 26, 4-5 p.m.)
- June: 67,617 MW (June 23, 4-5 p.m.)
- July: 68,799 MW (July 20, 4-5 p.m.)*

2016

- August: 71,110 MW *(All-time record)*
- September: 66,949 MW (Sept. 19, 4-5 p.m.)
- October: 59,864 MW (Oct. 5, 4-5 p.m.)
- December: 57,932 MW (Dec. 19, 7-8 a.m.)

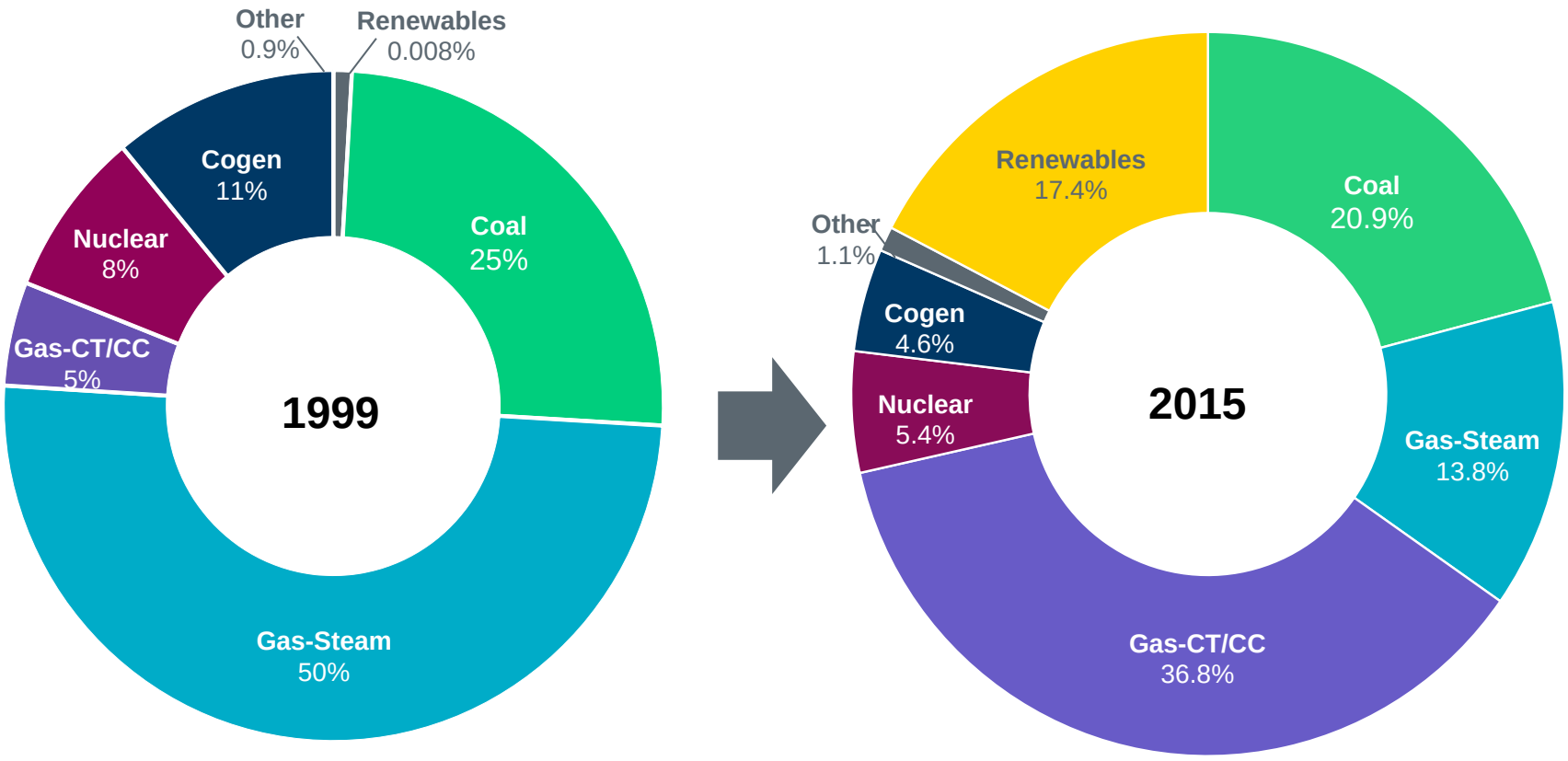
2015

- July: 67,650 MW (July 30, 4-5 p.m.)

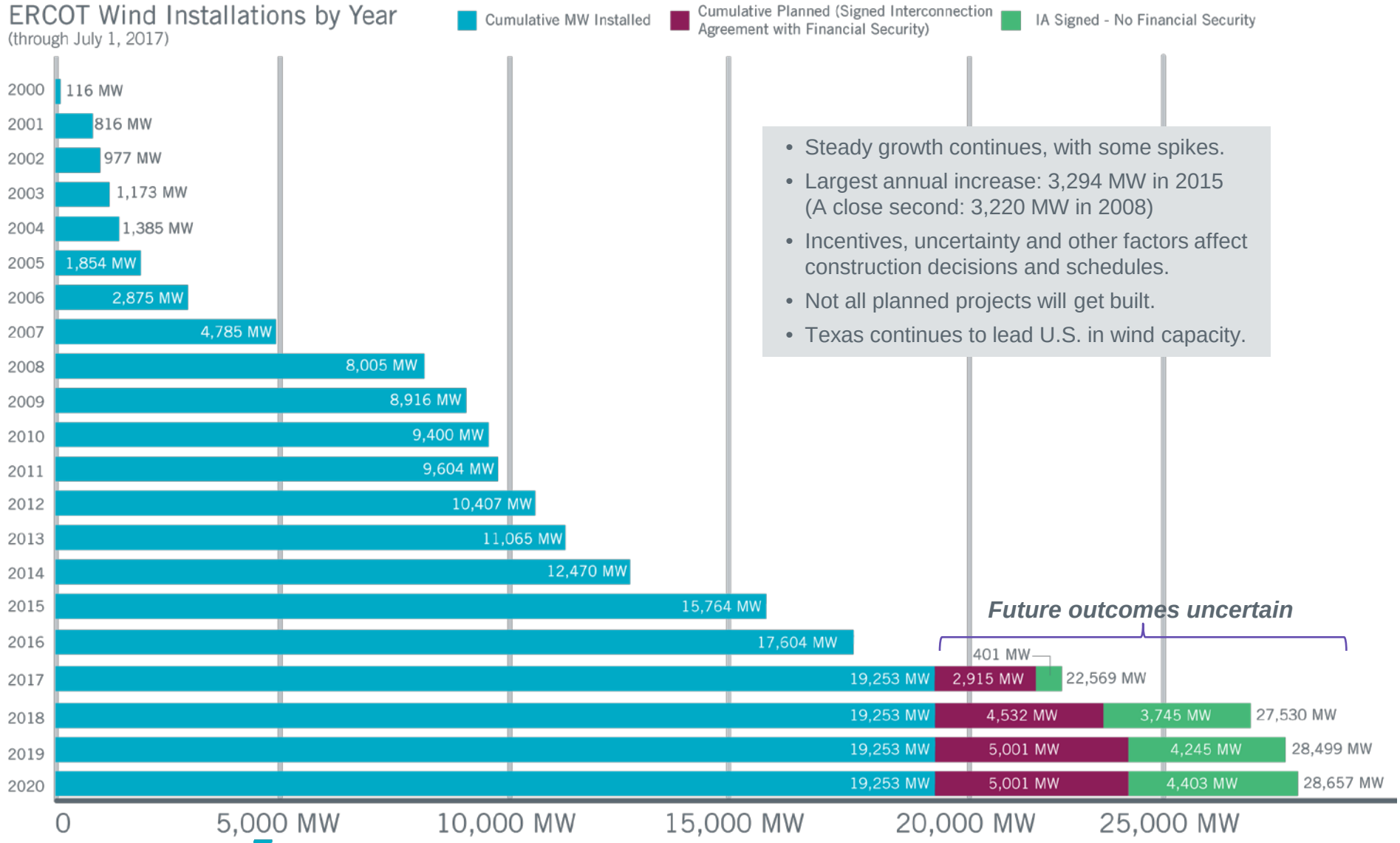
*Preliminary operating data

Annual Energy and Peak Demand (2005-2016)

Changing Resource Mix – Installed Capacity (MW)

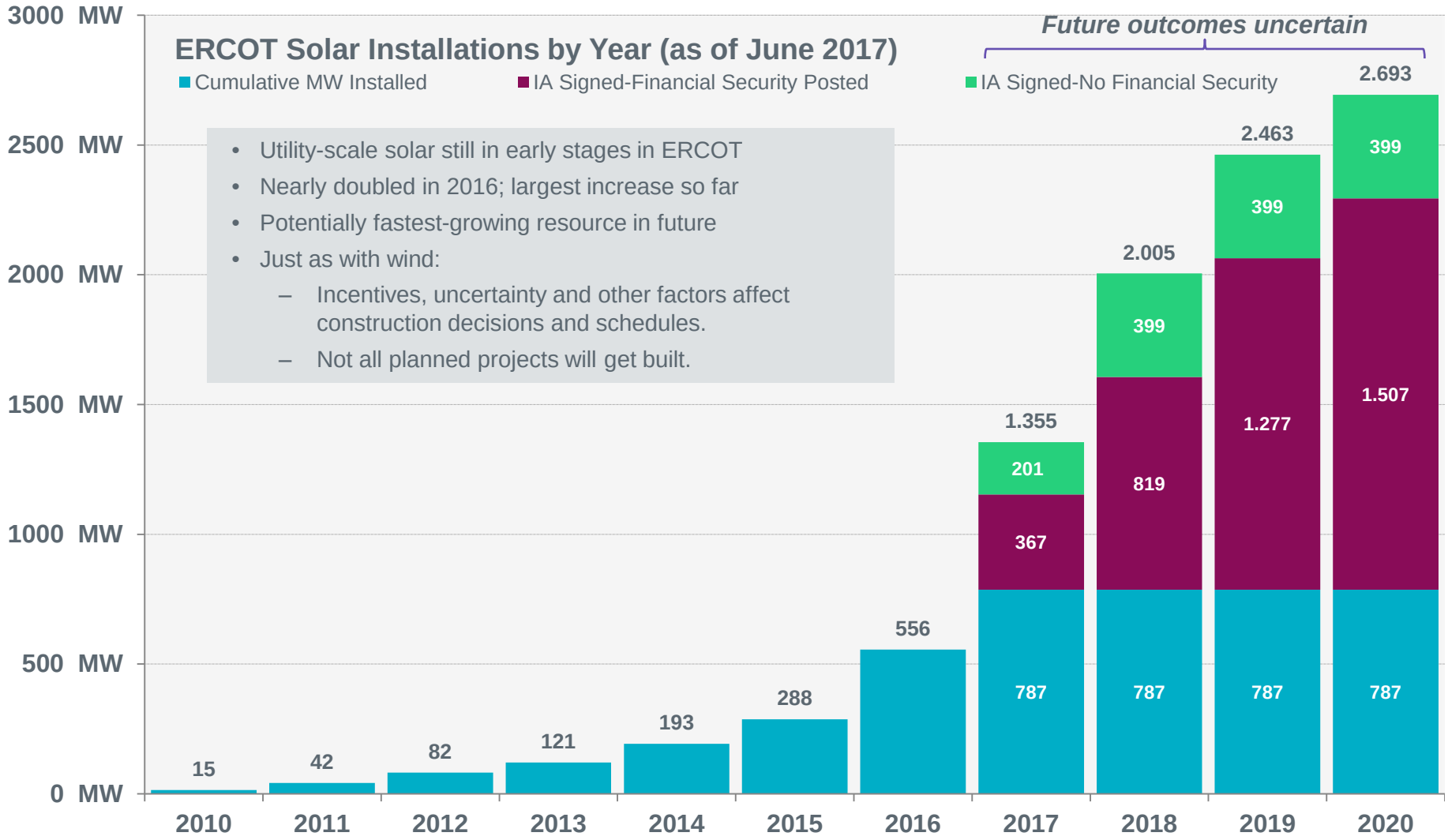


Wind Generation Capacity – June 2017



- Steady growth continues, with some spikes.
- Largest annual increase: 3,294 MW in 2015 (A close second: 3,220 MW in 2008)
- Incentives, uncertainty and other factors affect construction decisions and schedules.
- Not all planned projects will get built.
- Texas continues to lead U.S. in wind capacity.

Utility Scale Solar Generation Capacity – June 2017



The data presented here is based upon the latest registration data provided to ERCOT by the resource owners and can change without notice. Any capacity changes will be reflected in current and subsequent years' totals. Scheduling delays will also be reflected in the planned projects as that information is received. This chart reflects planned units in the calendar year of submission rather than installations by peak of year shown.

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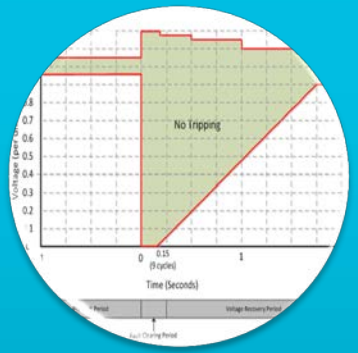
Renewable Integration at ERCOT



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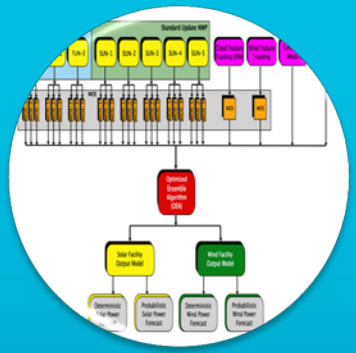
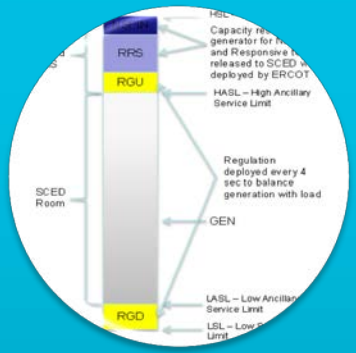


2. Renewable Forecast



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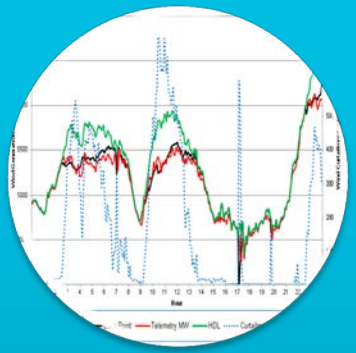


4. Real-time Operations

IRR (Intermittent Renewable Resources)

Interconnection Requirements

- Frequency Response (governor actions)
- Reactive Capability and Voltage Ride-through
- Ramp Rate Limitation

System Impacts

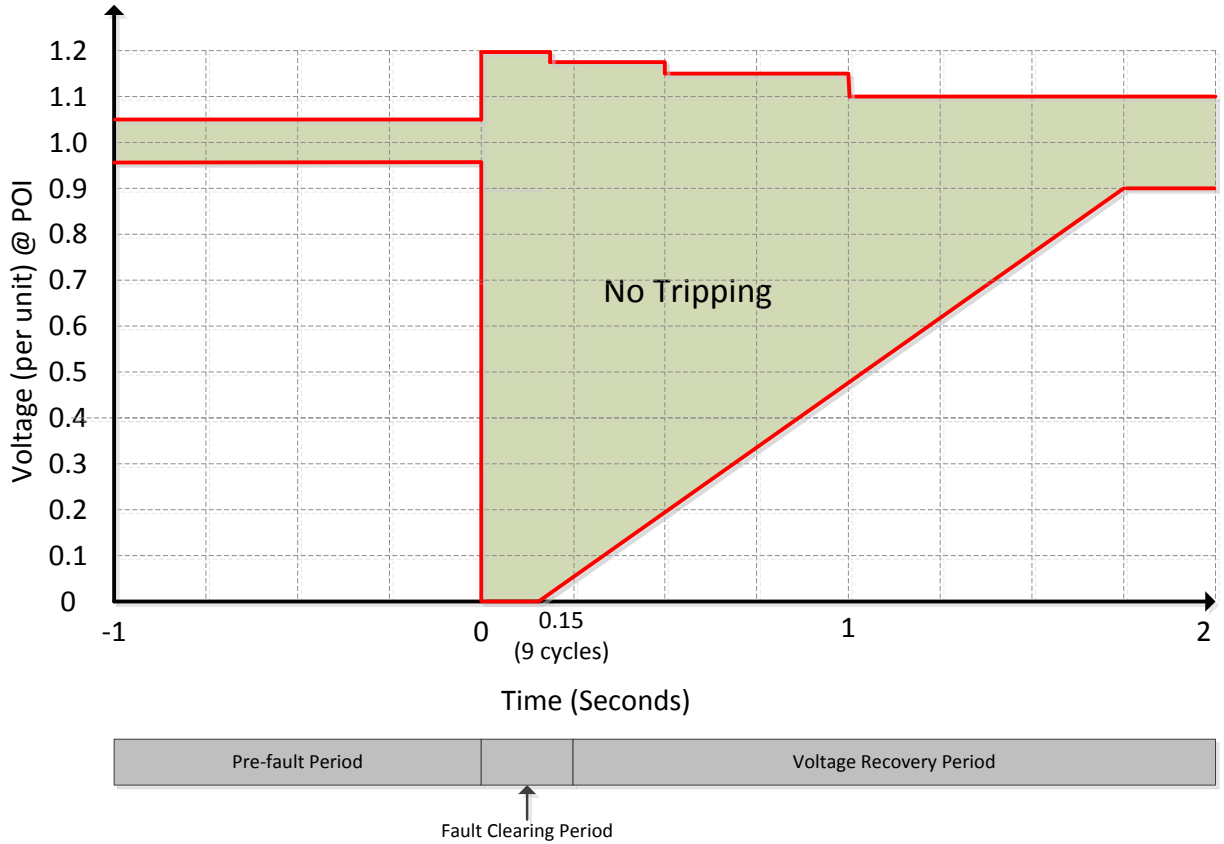
- Short Circuit Ratio
- Primary Frequency Response
- Secondary Frequency Response
- Large Wind Ramp

Integrating Renewables – Frequency Control

- All generation in ERCOT is required to provide governor response with a 5% droop setting with a deadband of 17 mHZ.
- Renewable resources started to assist in frequency control (by having an automatic response to frequency deviations) after 2010.
  - NERC's BAL-001-TRE regional standard was implemented starting April 1, 2015. This reduced Governor Dead-band for most resources including renewables from 36mHz to 17 mHZ.

Voltage Ride-through Requirements

- Renewable resources that interconnected after 2008 are required to ride through i.e. stay online during abnormal disturbances in voltage and frequency.



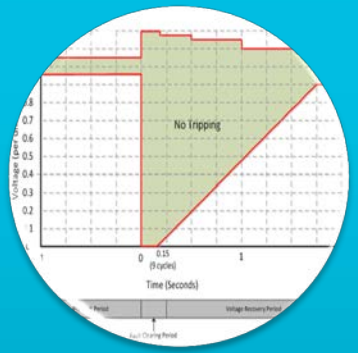
Ramp Rate Limitation

- Renewable resources that were installed after 2009 are required to implement controls which limit per minute ramping to **20%** of the unit's nameplate rating.

6.5.7.10 Intermittent Renewable Resource Ramp Rate Limitations

1) Each Intermittent Renewable Resource (IRR) that is part of a Standard Generation Interconnection Agreement (SGIA) signed on or after January 1, 2009 shall limit its ramp rate to **20% per minute of its nameplate rating (MWs)** as registered with ERCOT when responding to or released from an ERCOT deployment.
2) The requirement of paragraph (1) above does not apply during a Force Majeure Event or during intervals in which a decremental deployment instruction coincides with a demonstrated decrease in the available IRR.
3) Each IRR that is part of an SGIA signed on or before December 31, 2008 and that controls power output by means other than turbine stoppage shall limit its ramp rate to 20% per minute of its nameplate rating (MWs) as registered with ERCOT when responding to or released from an ERCOT deployment.

Renewable Integration at ERCOT



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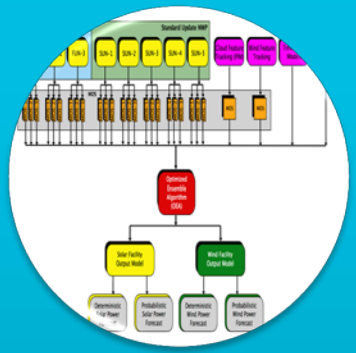

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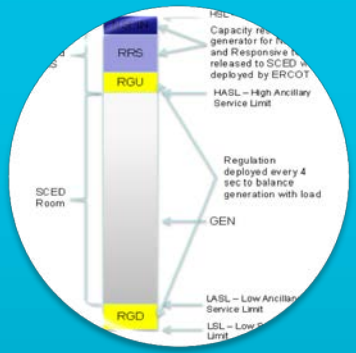

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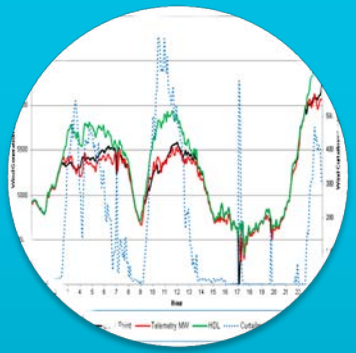


4. Real-time Operations

Generic Wind Forecasting Approach

Macro Weather Models

Wind Models

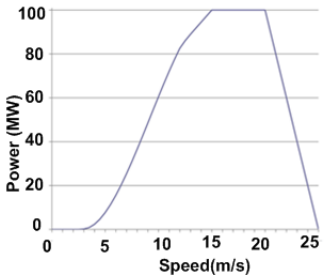
Turbine Power Models

Wind Power Forecast by Plant

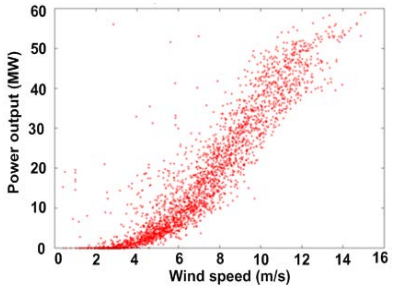
Weather

Power curves and availability of turbines

Hypothetical Power Curve



Actual Wind Farm Power



Wind Generation Forecast

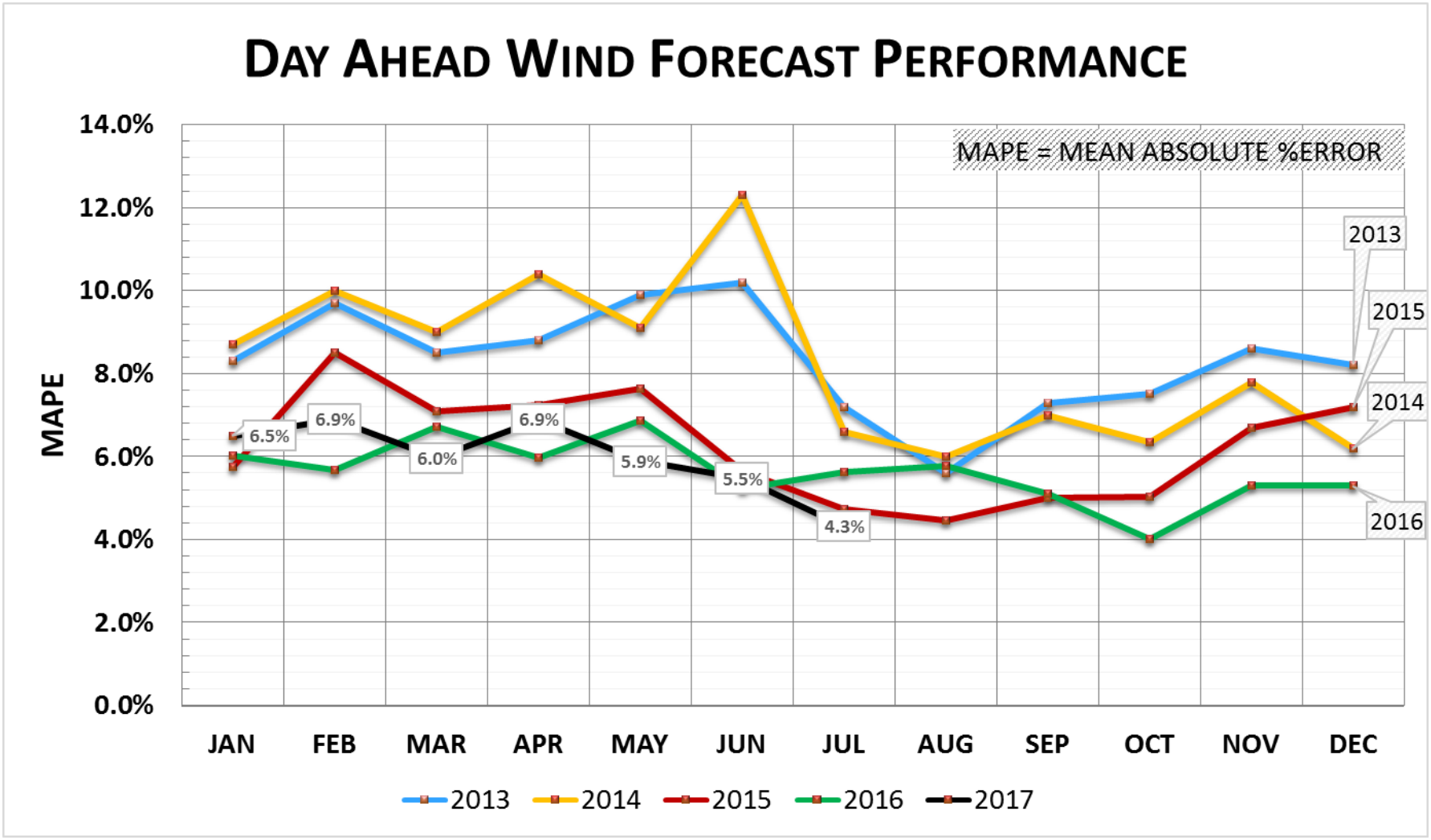
- Wind Forecast Vendor computes a Short Term Wind Power Forecast (STWPF) for all Wind-powered Generation Resources (WGR) in ERCOT for a rolling 168 hour timeframe.

- This process uses information from multiple systems, including:
  - RARF (Resource Asset Registration Form) (ex. site geo-location, met tower geo-location)
  - EMS (Energy Management System) (ex. Resource Status, telemetered site specific meteorological data)
  - Outage Scheduler (ex. WGR derate start/stop dates, derate values)

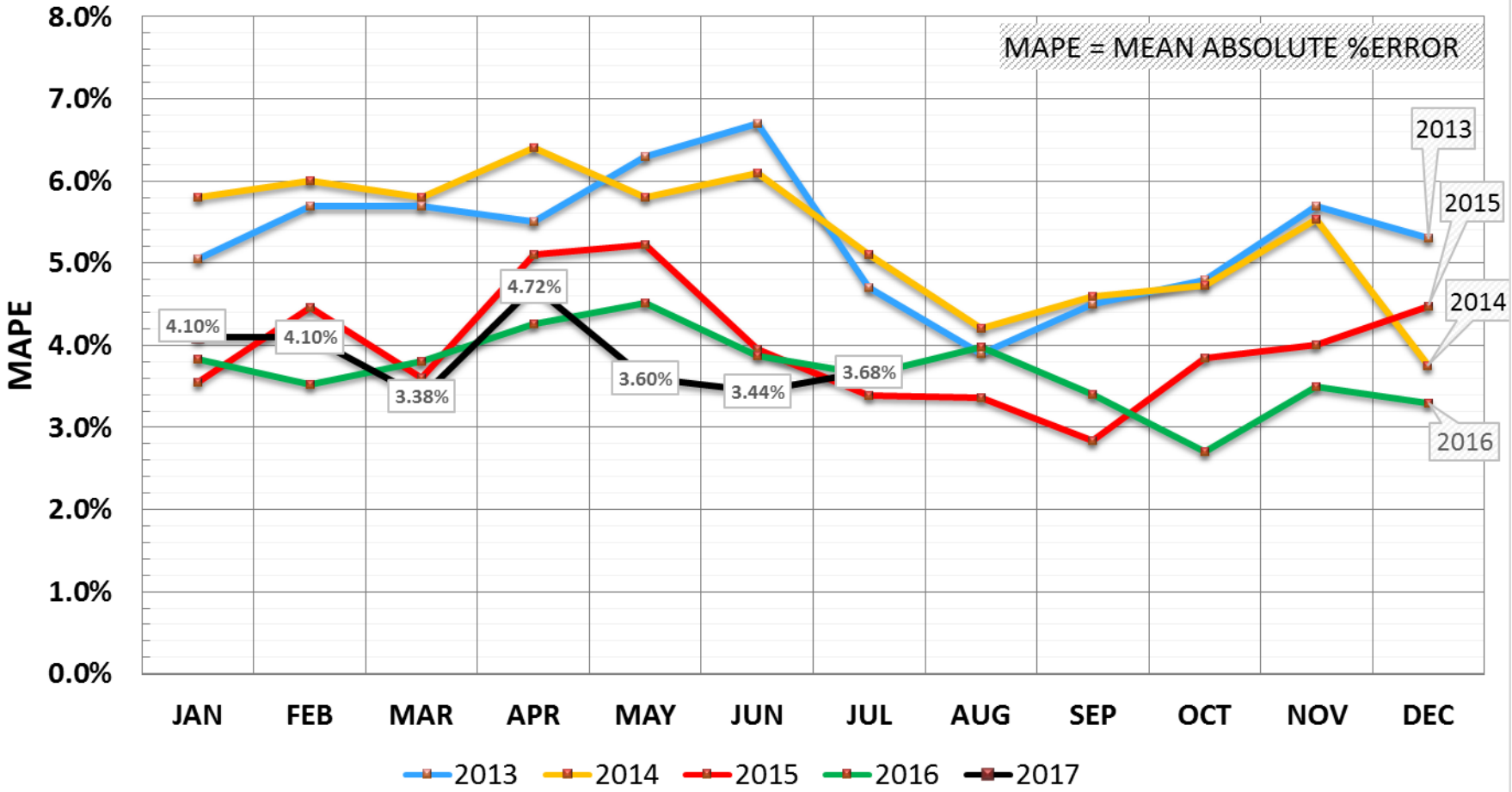
- When submitting COPs, Wind QSEs must use this STWPF for the applicable 168 hours timeframe. (COP HSL must be <= STWPF.)
  - Note that NPRR 785, upon approval will only require Wind QSEs to update a COP only when wind farm operating conditions dictate COP HSL to be lower STWPF.

*Note that for a WGR going through commissioning process, ERCOT will start providing STWPF to the QSE once WGR receives approval to Generate into the ERCOT Grid (Part II of the Commissioning check list)

Wind Forecast Performance (Day-Ahead)



Wind Forecast Performance (Hour-Ahead)



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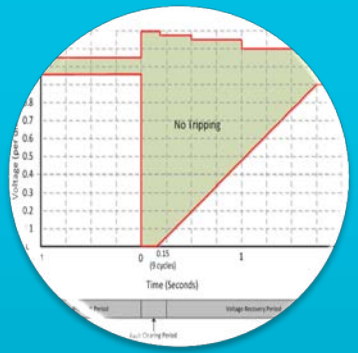

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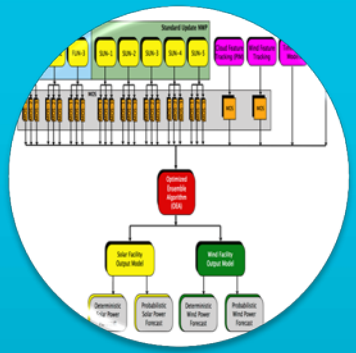

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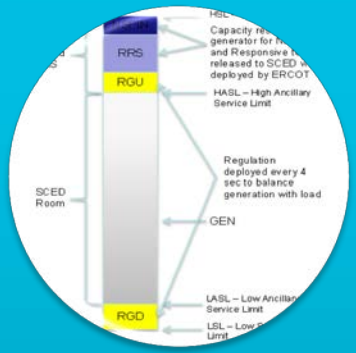

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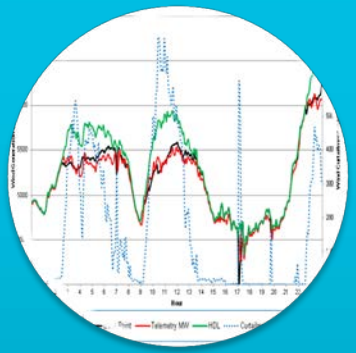
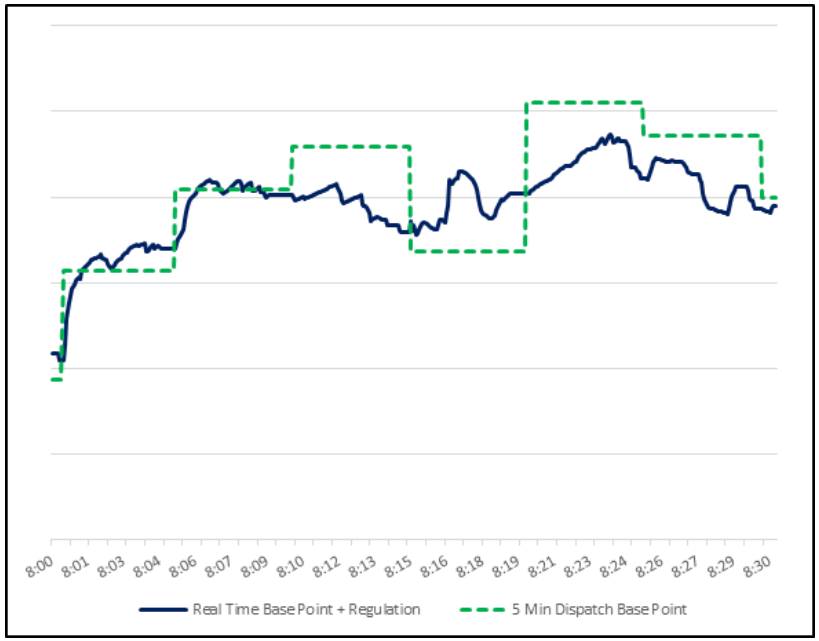


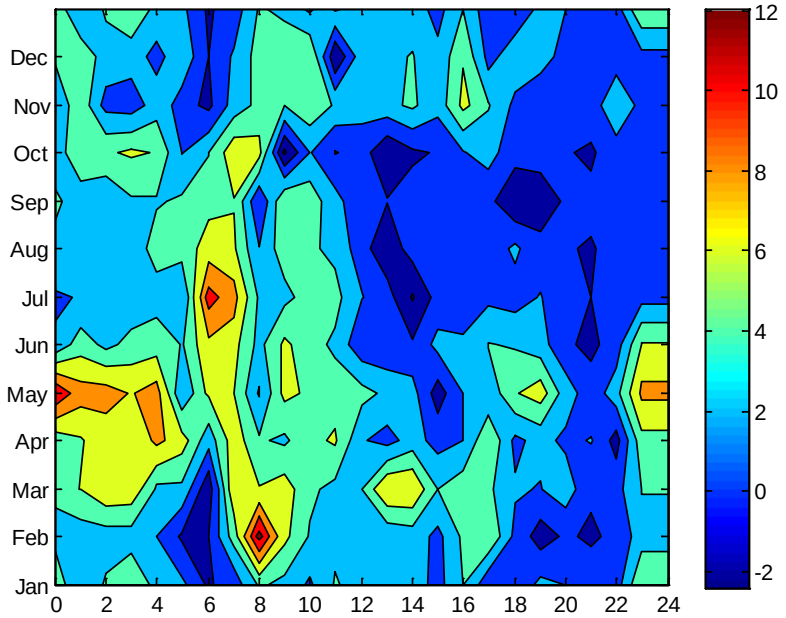
4. Real-time Operations

Ancillary Services – Regulation Service

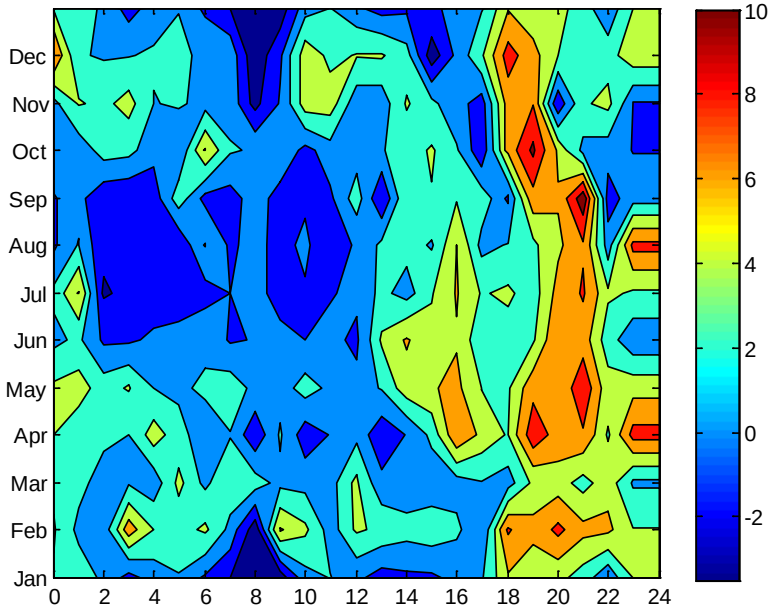
- SCED sends dispatch instruction every 5 minutes.
- LFC sends Regulation signals to generation resources every 4 second service to move up or down to maintain frequency at nominal.



Impact of Wind Generation on Regulation Services



Regulation-Up



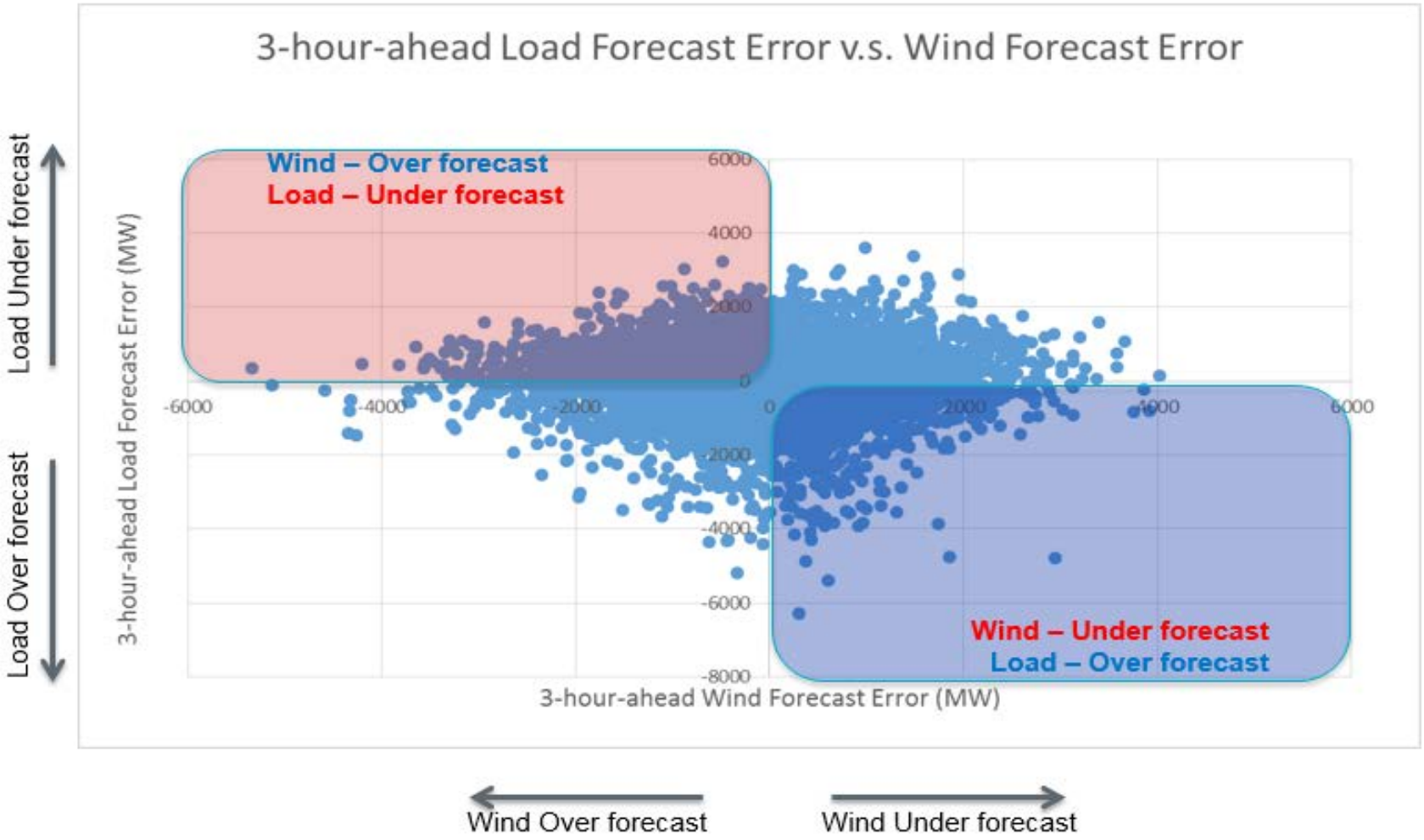
Regulation-Down

Incremental MW adjustment to Regulation Requirement, per 1000 MW of Incremental Wind Generation Capacity, to Account for Wind Capacity Growth

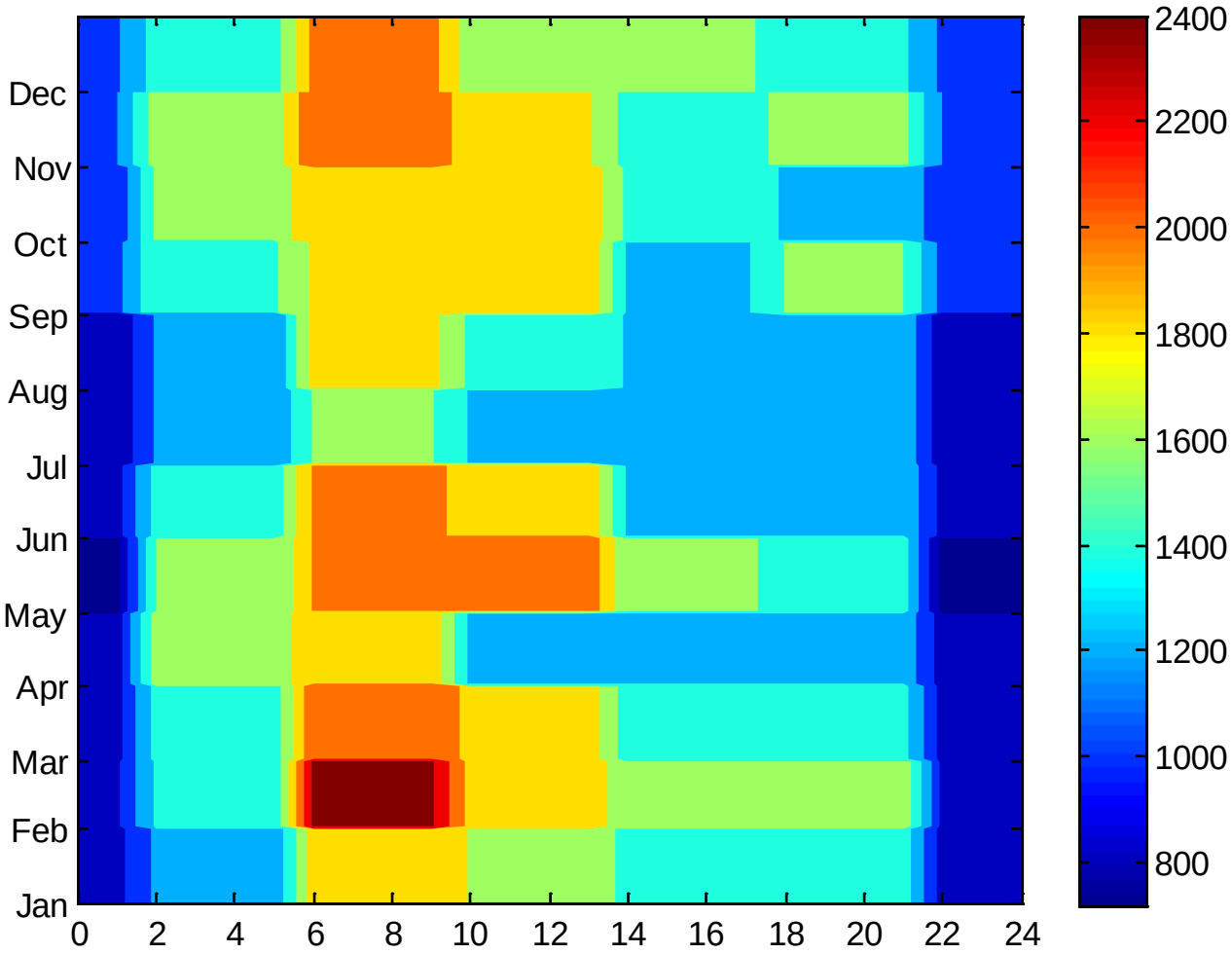
Ancillary Services – Non-Spinning Reserve Service (NSRS)

- Non-spinning Reserve Service
  - 30 minute product that can be provided by unloaded capacity, offline Generators, and Load Resources
  - Wind power and load forecast error is one of the inputs used for calculating the requirement for this service
  - The net forecast error uncertainty that NSRS will be used to mitigate will depend on the risk of net load ramp.
  - During higher net load ramp risk hours, we procure NSRS to cover up to 95th percentile of net forecast uncertainty.
  - During low net load ramp risk hours, we may only procure NSRS to cover 70th percentile of net forecast uncertainty.

Forecast Errors in 2016



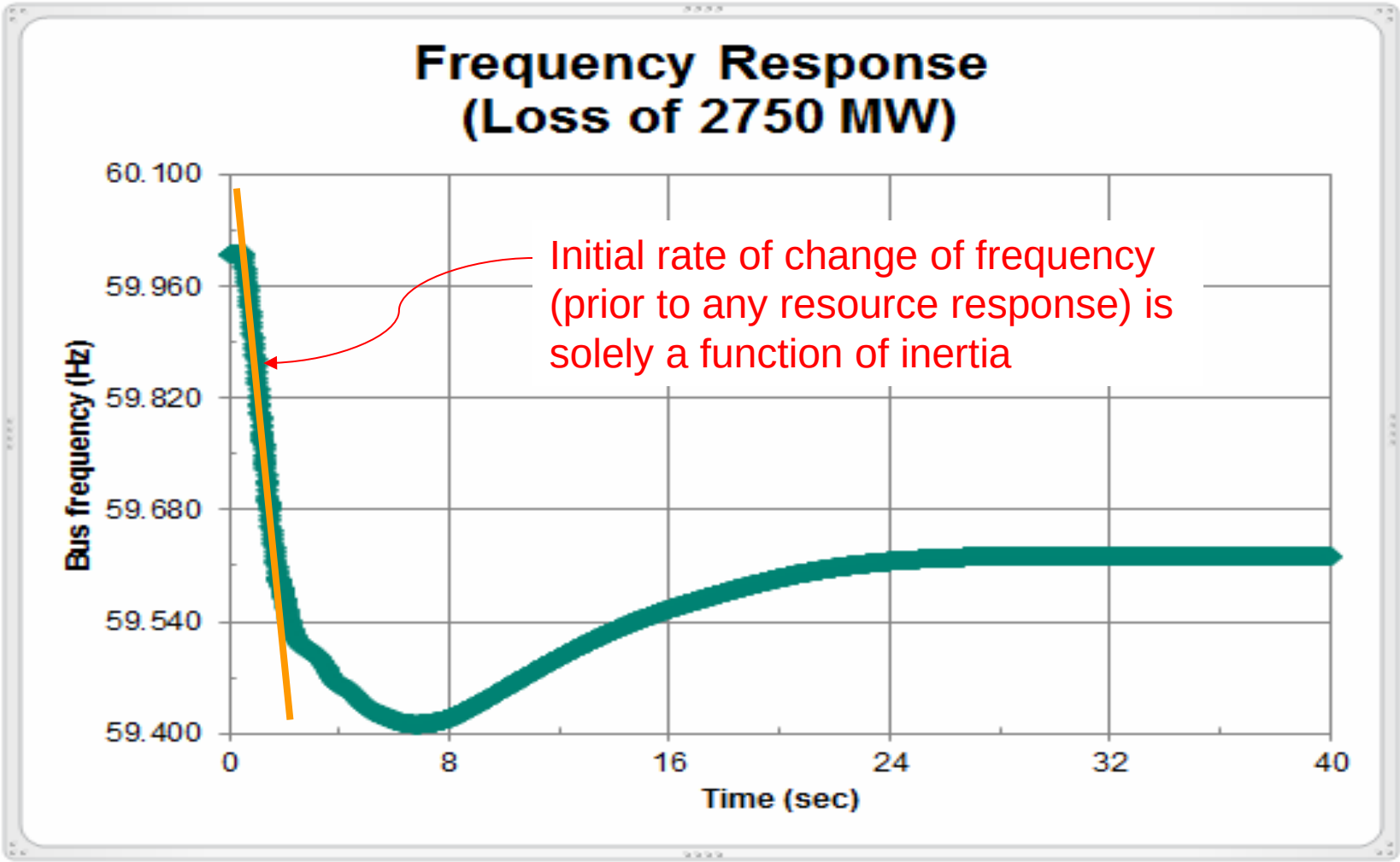
Minimum NSRS Requirement in 2017



Ancillary Services – Responsive Reserves

- Responsive Reserves are procured to ensure sufficient capacity is available to respond to frequency excursions due to unit trips
  - Capacity reserved from generators to provide governor response
  - Up to 50% of Responsive requirement can be provided by Load Resources on under-frequency relays (to trip when frequency decreases to 59.7 Hz for .5s)
- Since 2015, the Responsive Reserve procurement is based on expected system inertia.

Inertial Effect



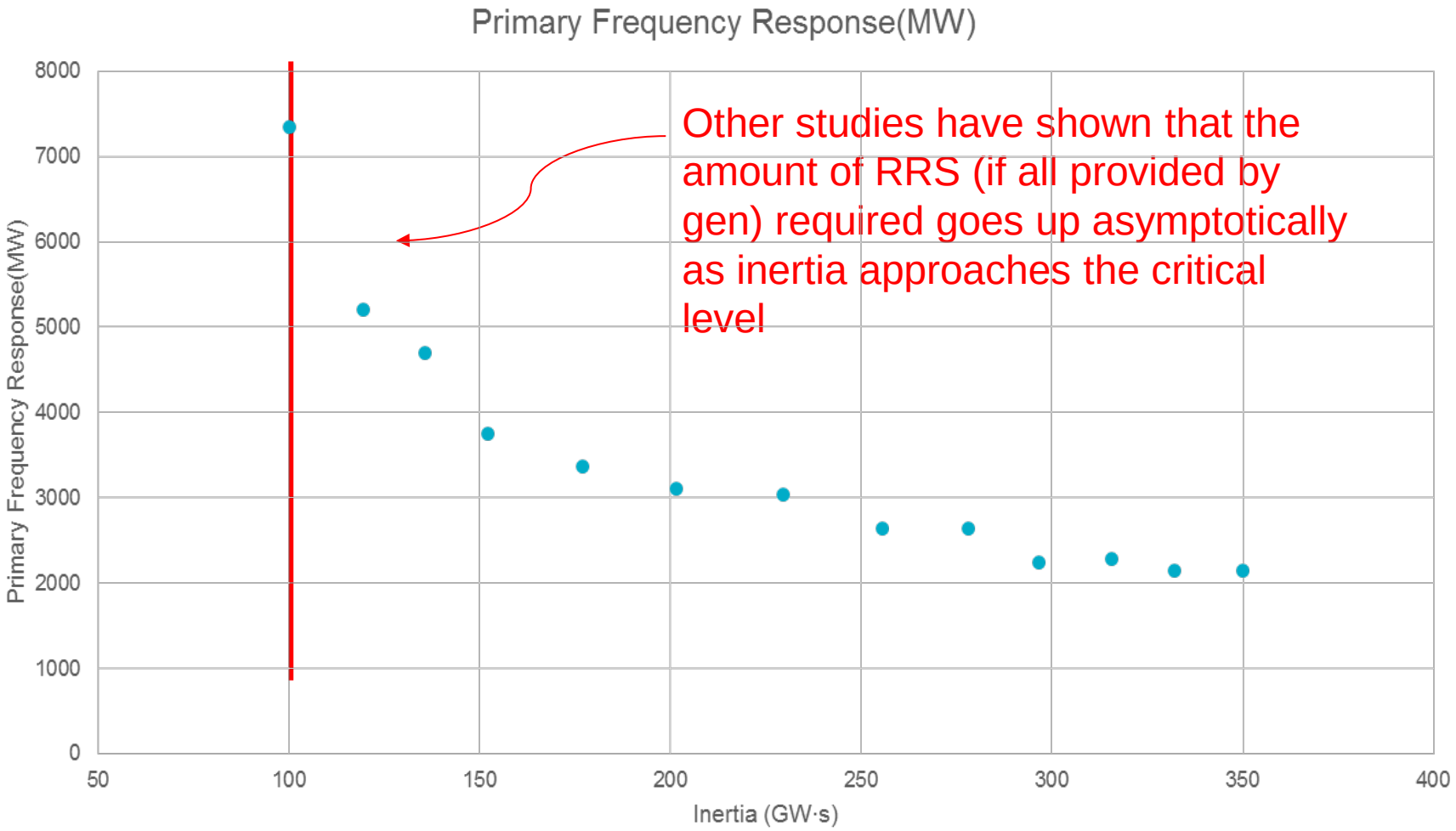
Frequency Response Times

- Load Resources providing RRS have underfrequency relays that respond in about 0.5s after the frequency drops below the trigger level (currently 59.7Hz)
- Governors of thermal generating units begin to respond “immediately” but will take 1-3 seconds to provide significant response (requires more steam or more combustion)

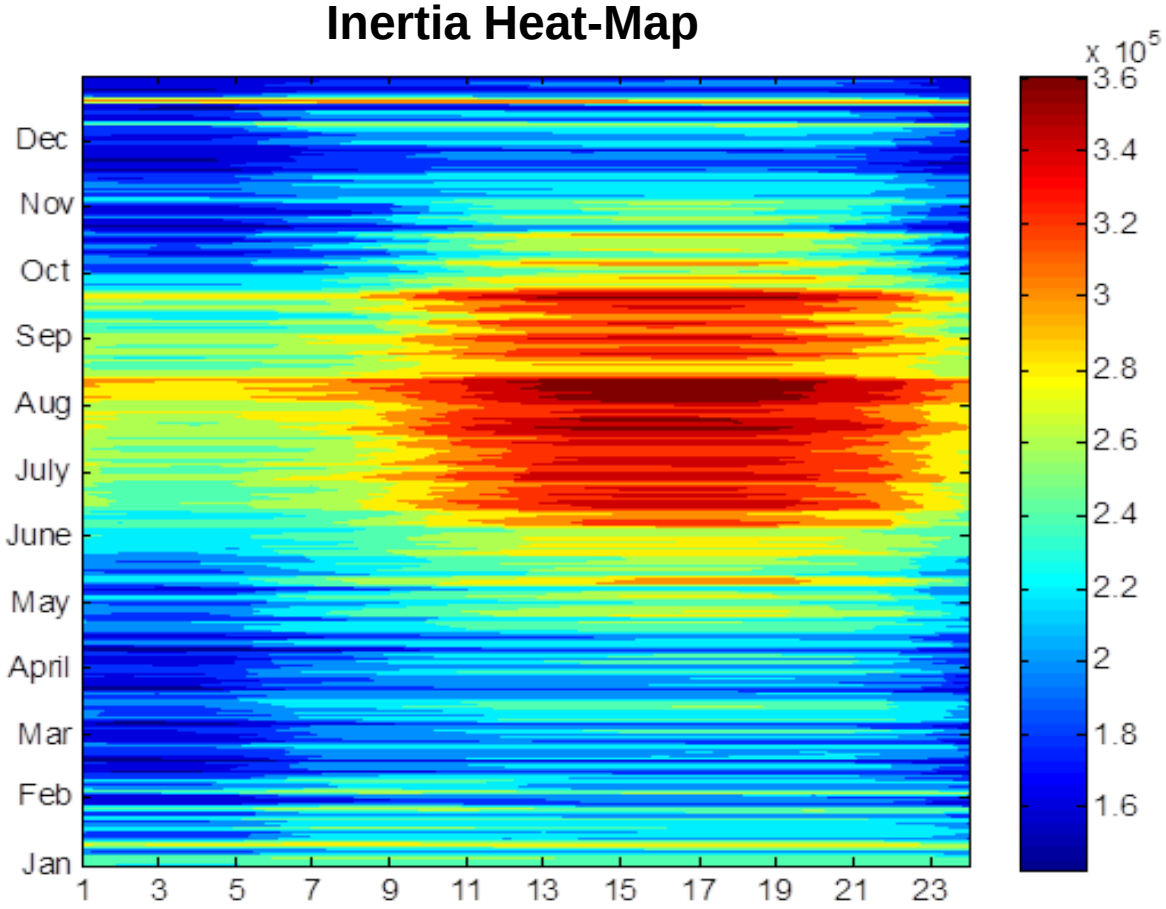
Current RRS Studies

	Case1	Case2	Case3	Case4	Case5	Case6	Case7	Case8	Case9	Case10	Case11	Case12	Case13
Inertia (GW·s)	100	119.5	135.5	152	177	201.5	229.5	255.5	278	296.5	315.5	332	350
PFR Requirement (no LRs)	7350	5200	4700	3750	3370	3100	3040	2640	2640	2240	2280	2140	2140
LRs /PFR	2.35:1	2.2:1	2.0:1	1.5:1	1.4:1	1.3:1	1.25:1	1.13 :1	1.08:1	1.0:1	1.0:1	1.0:1	1.0:1
PFR Min	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150
LRs	2638	1841	1740	1699	1586	1500	1512	1319	1380	1090	1130	990	990
Combined Total	3788	2991	2890	2849	2736	2650	2662	2469	2530	2240	2280	2140	2140

Increasing RRS as Inertia Approaches Critical

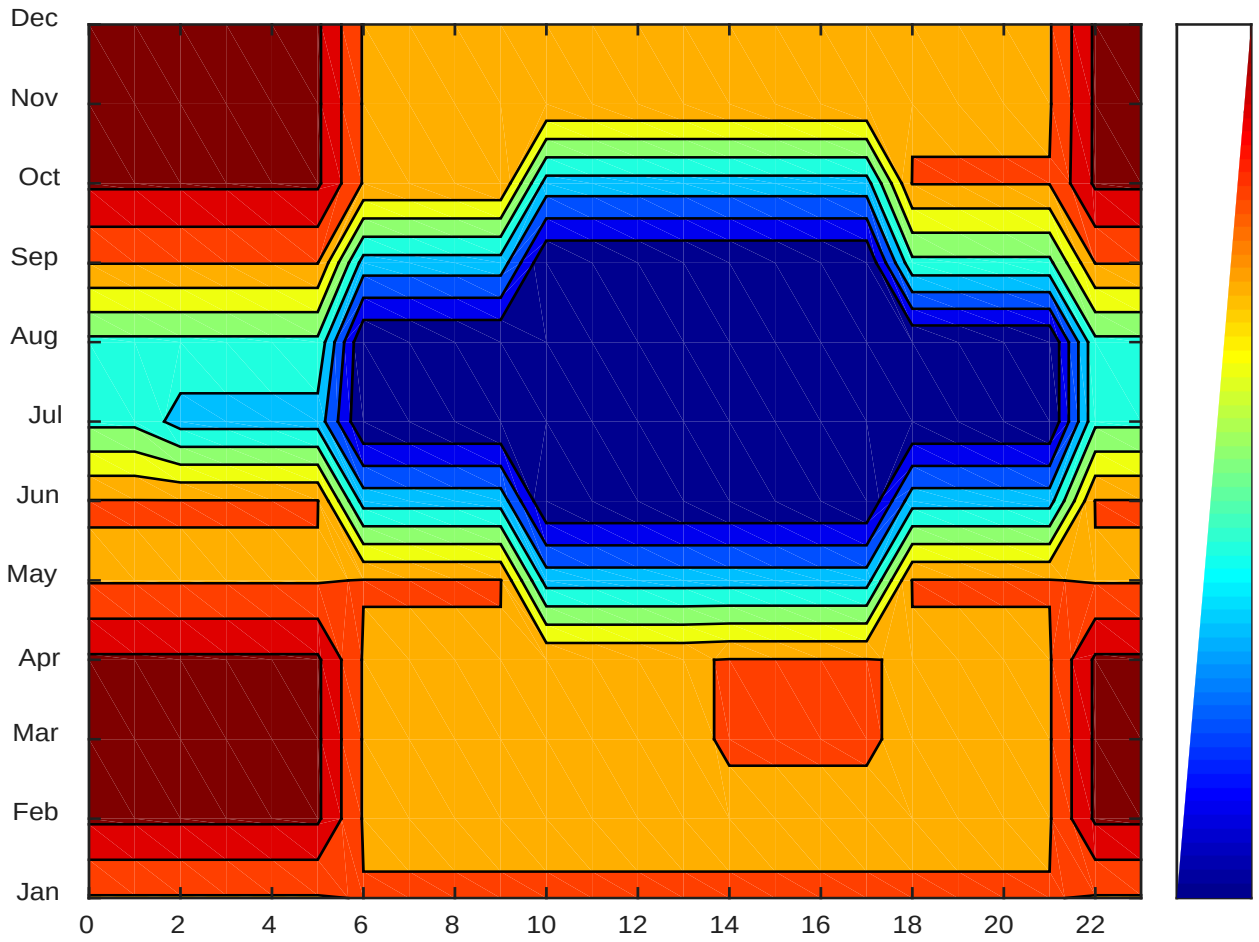


2016 Inertia



Minimum inertia being observed in 2016 is 142.9 GW·s, in 2017 this number dropped to 134 GW·s

Minimum RRS Requirement (MW) in 2017



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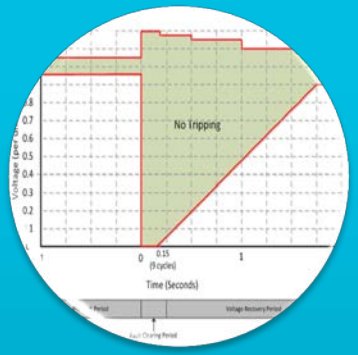

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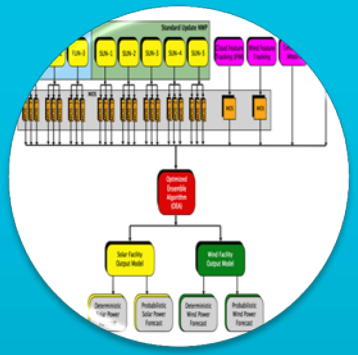

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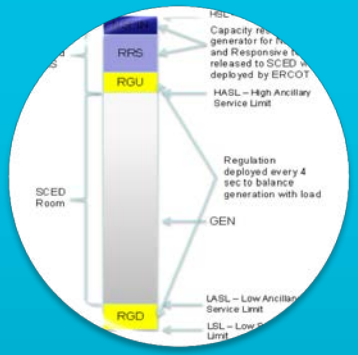
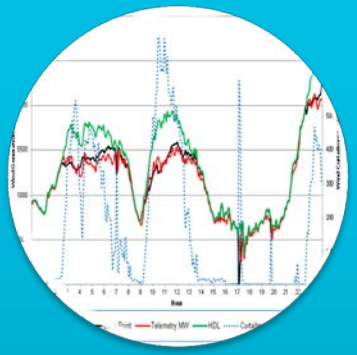
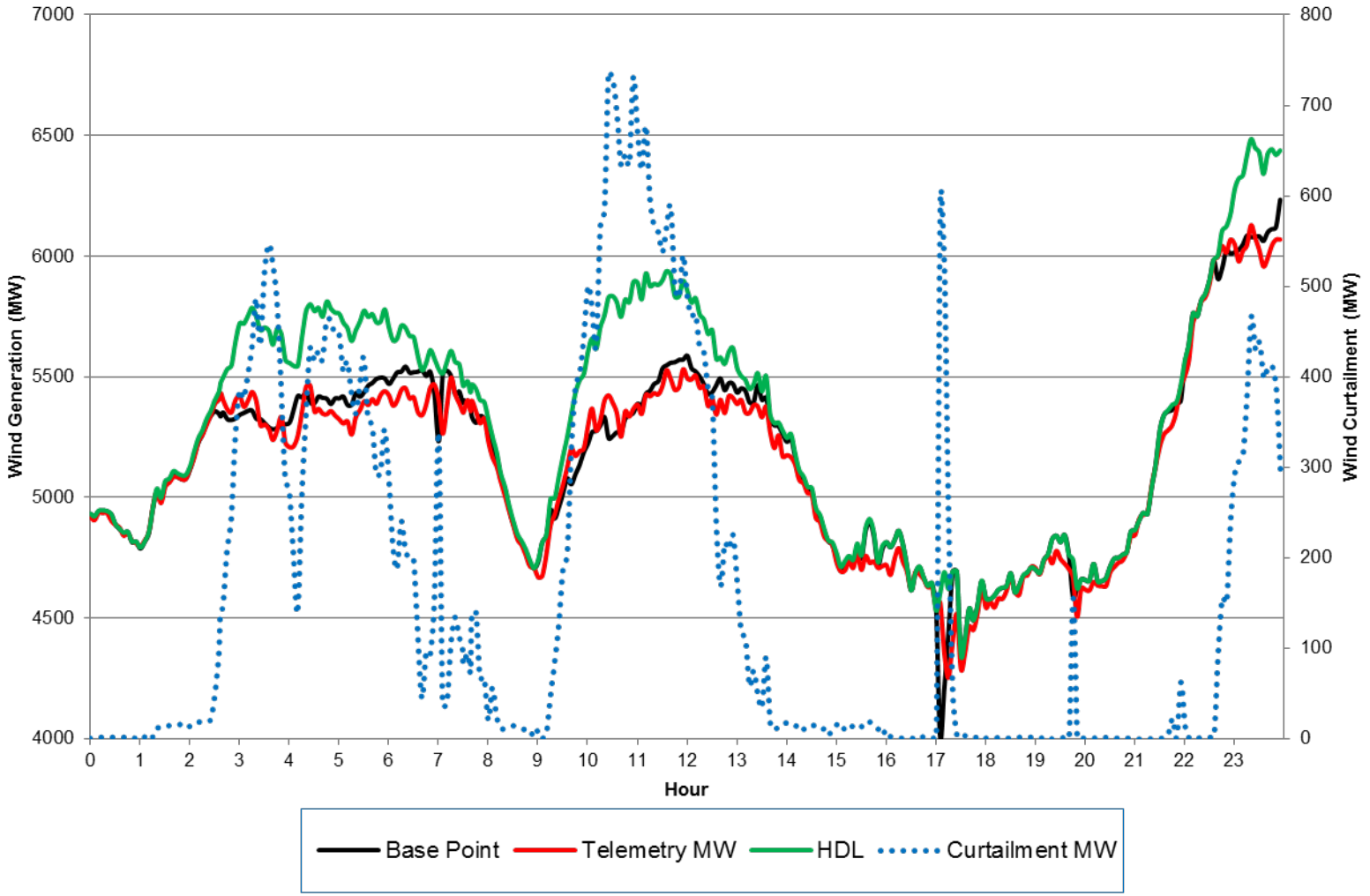


3. Ancillary Services

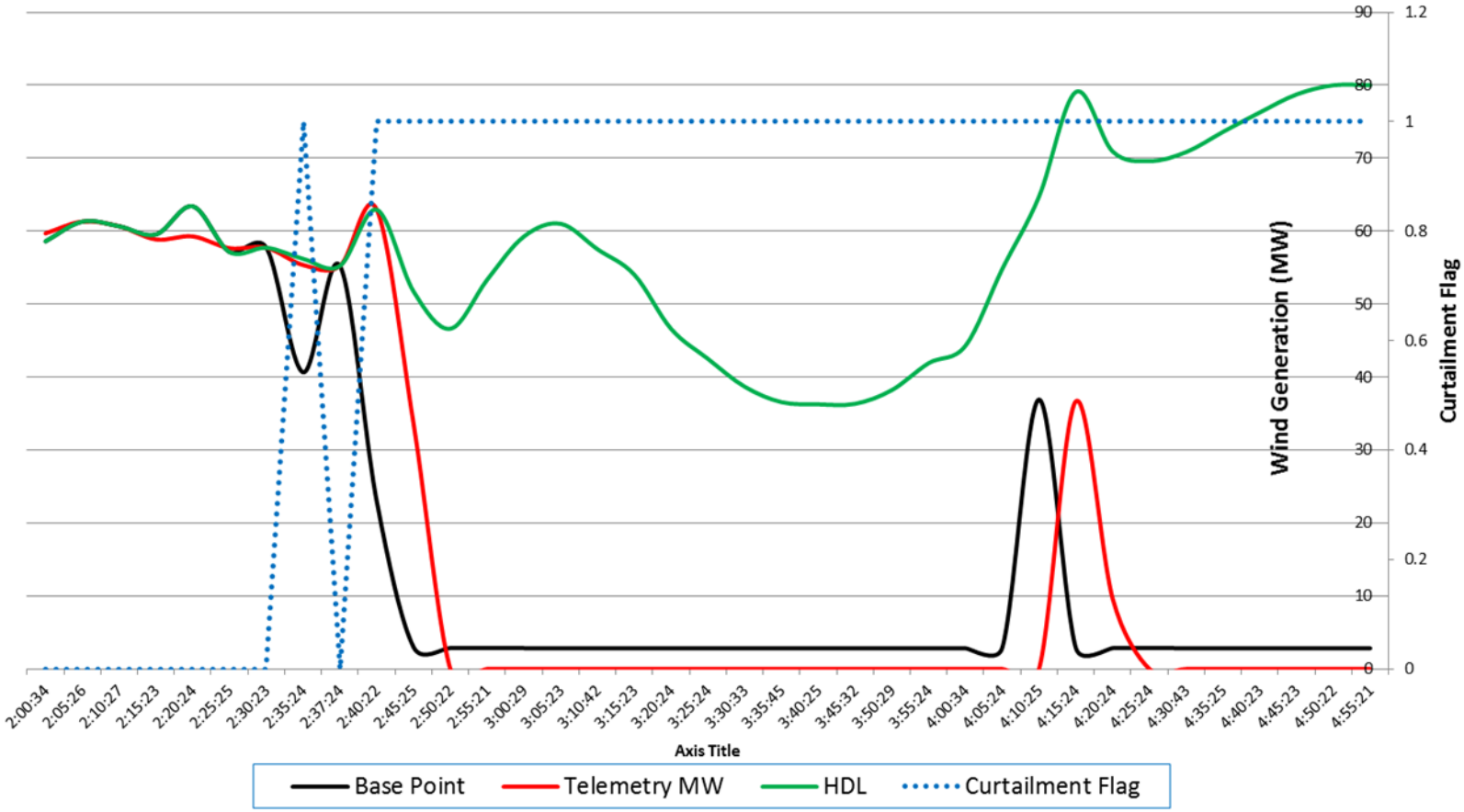


4. Real-time Operations

Real Time System Wide Wind Generation Curtailment

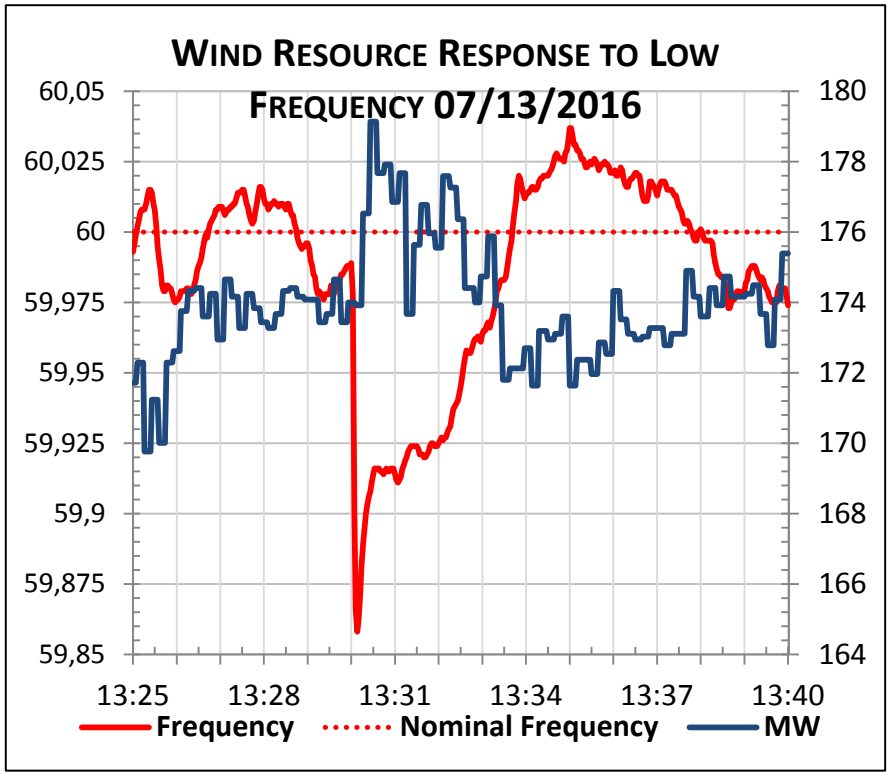


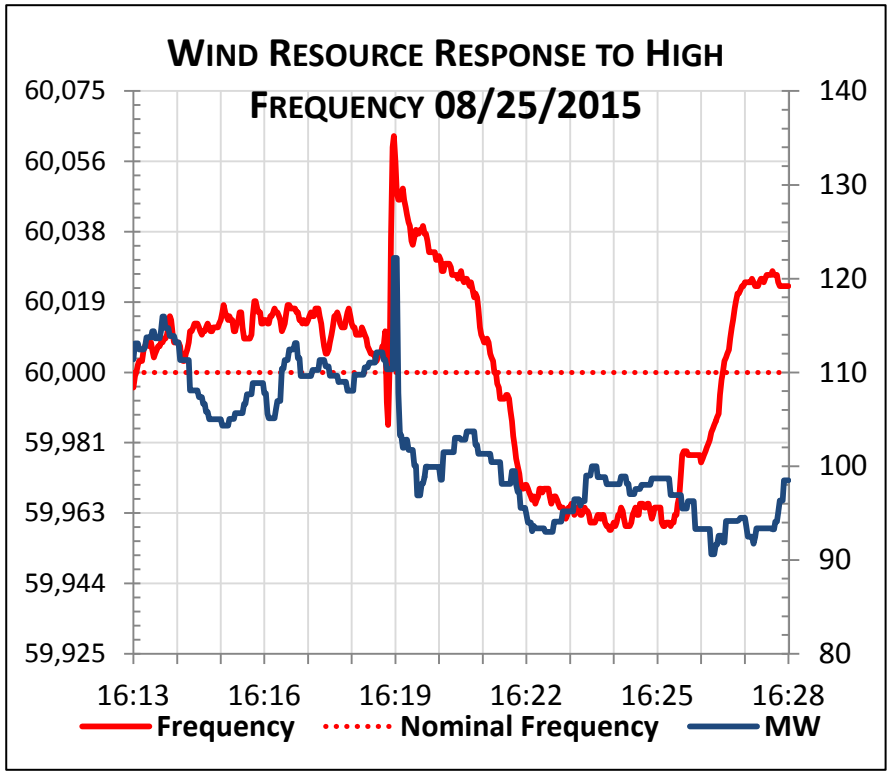
Real Time Curtailment of single WGR



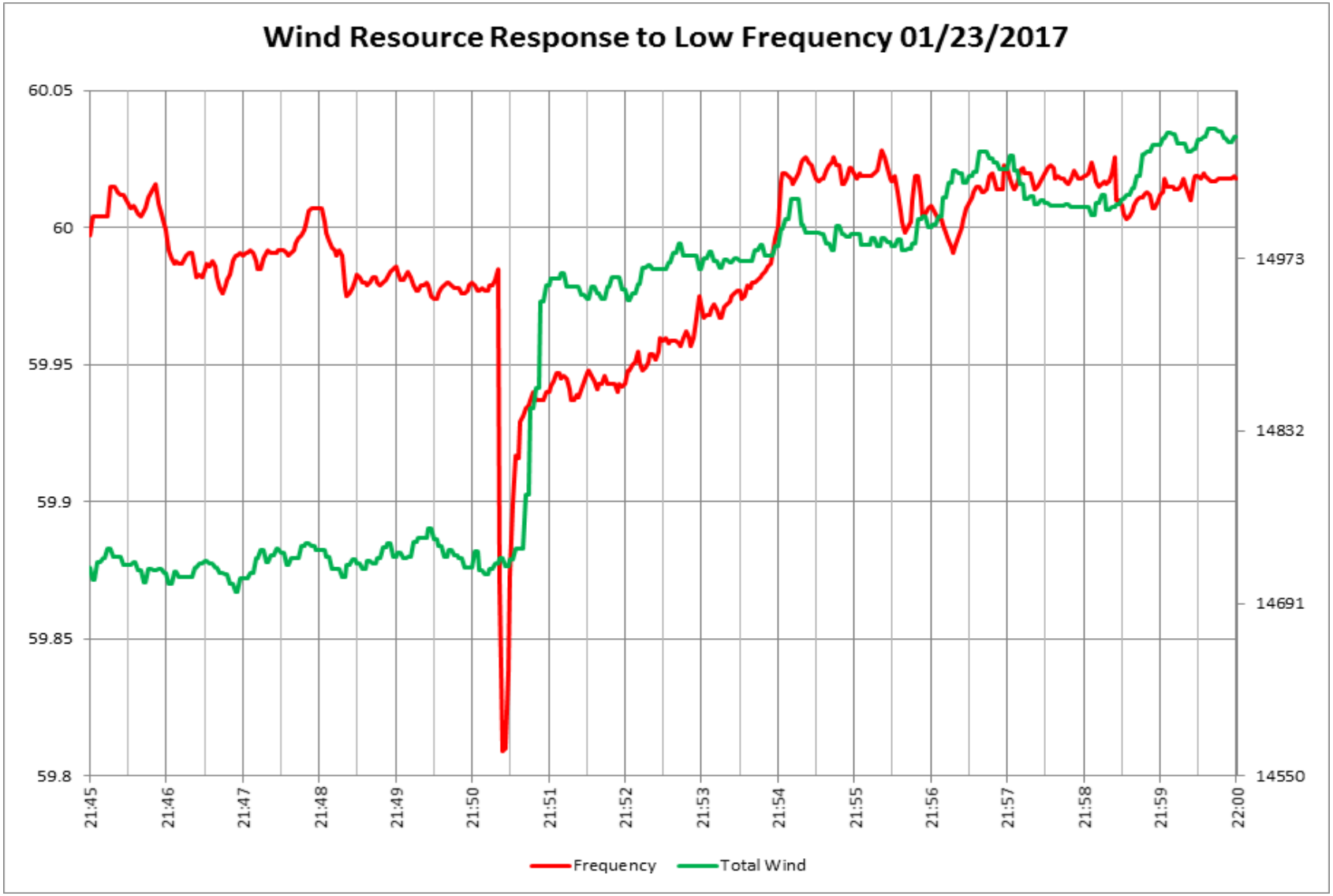
Integrating Renewables – Frequency Control

- Renewable resources started to assist in frequency control (by having an automatic response to frequency deviations) after 2010.



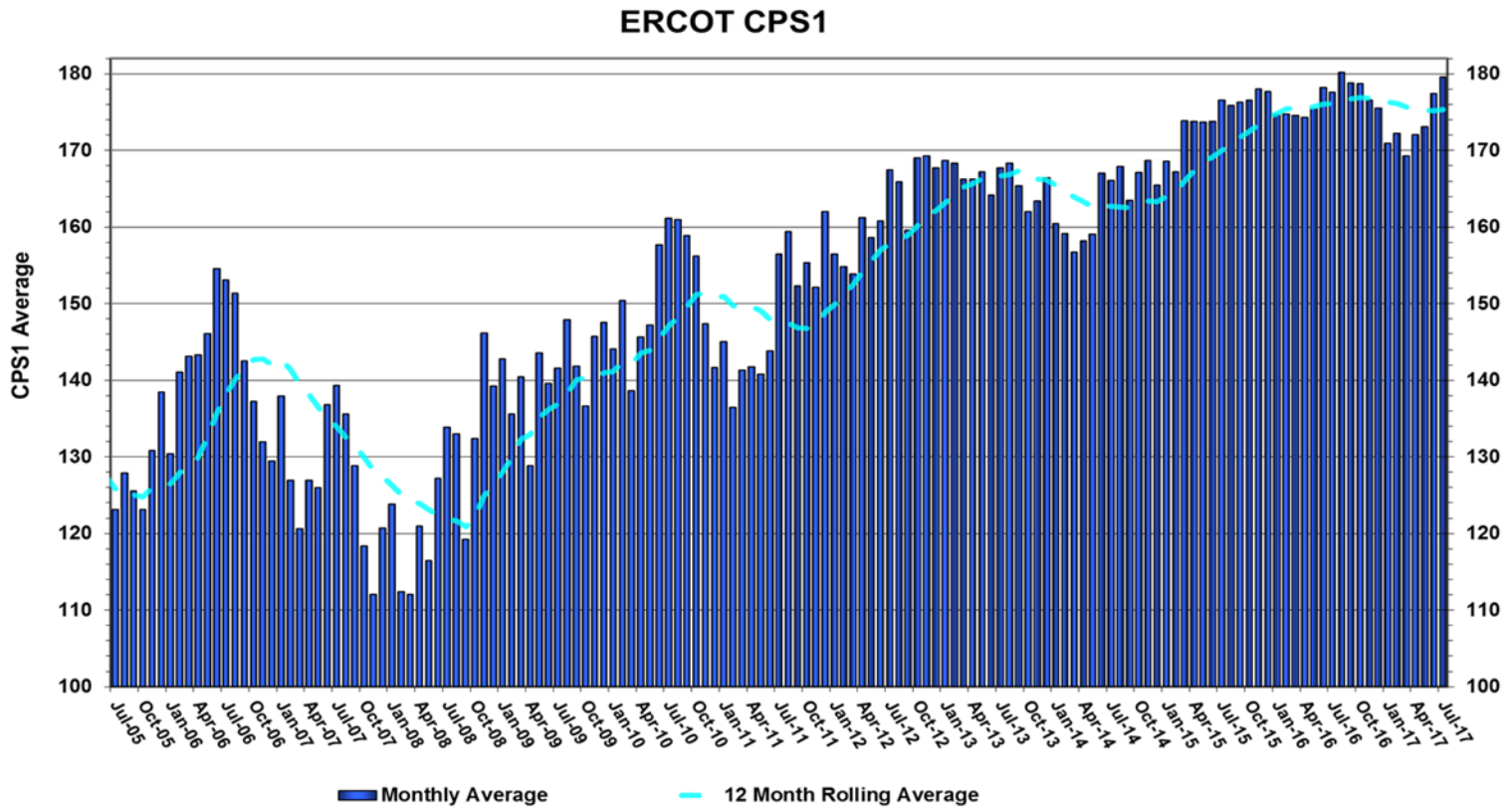


Integrating Renewables – Frequency Control

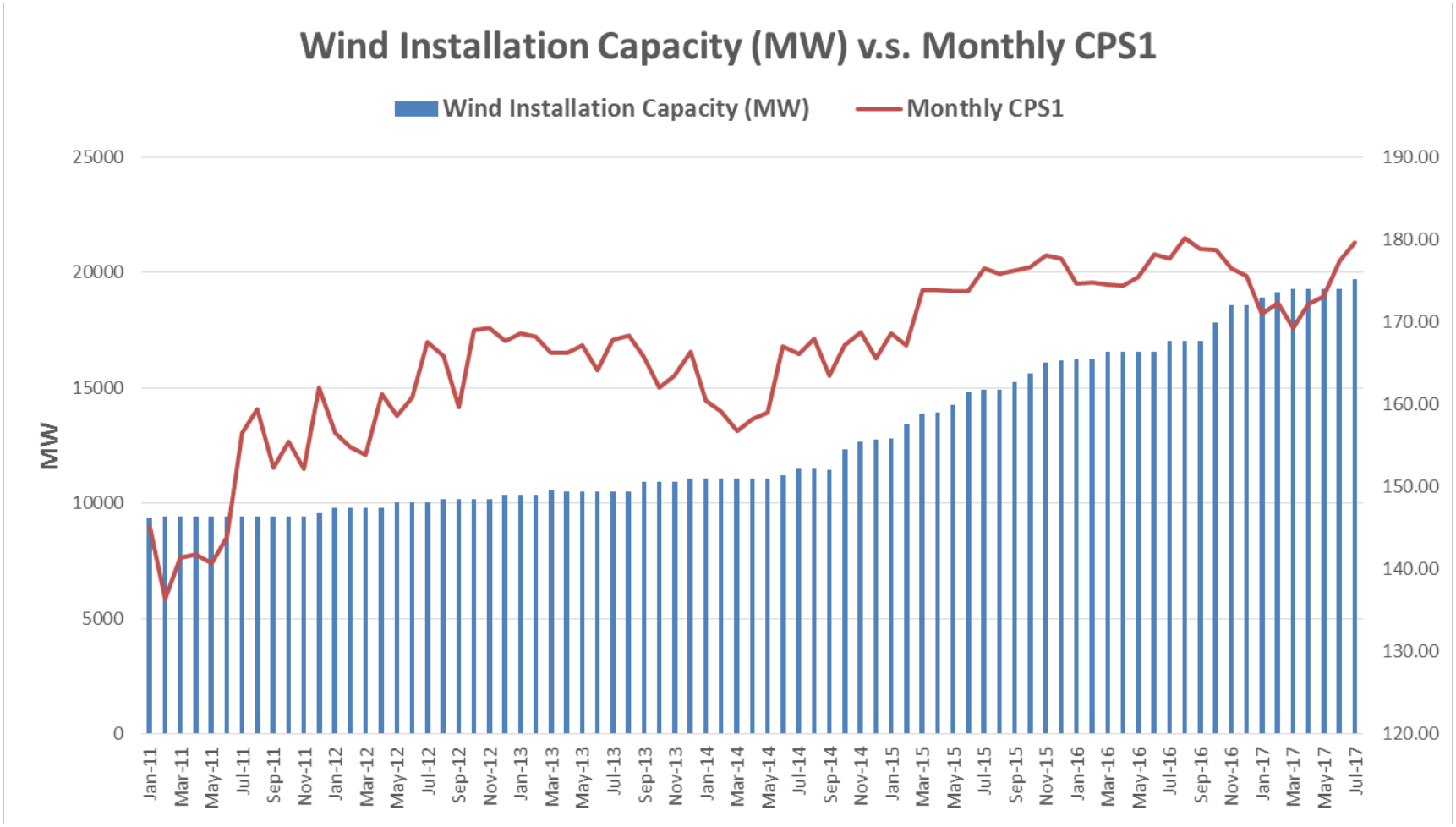


Primary Frequency Response

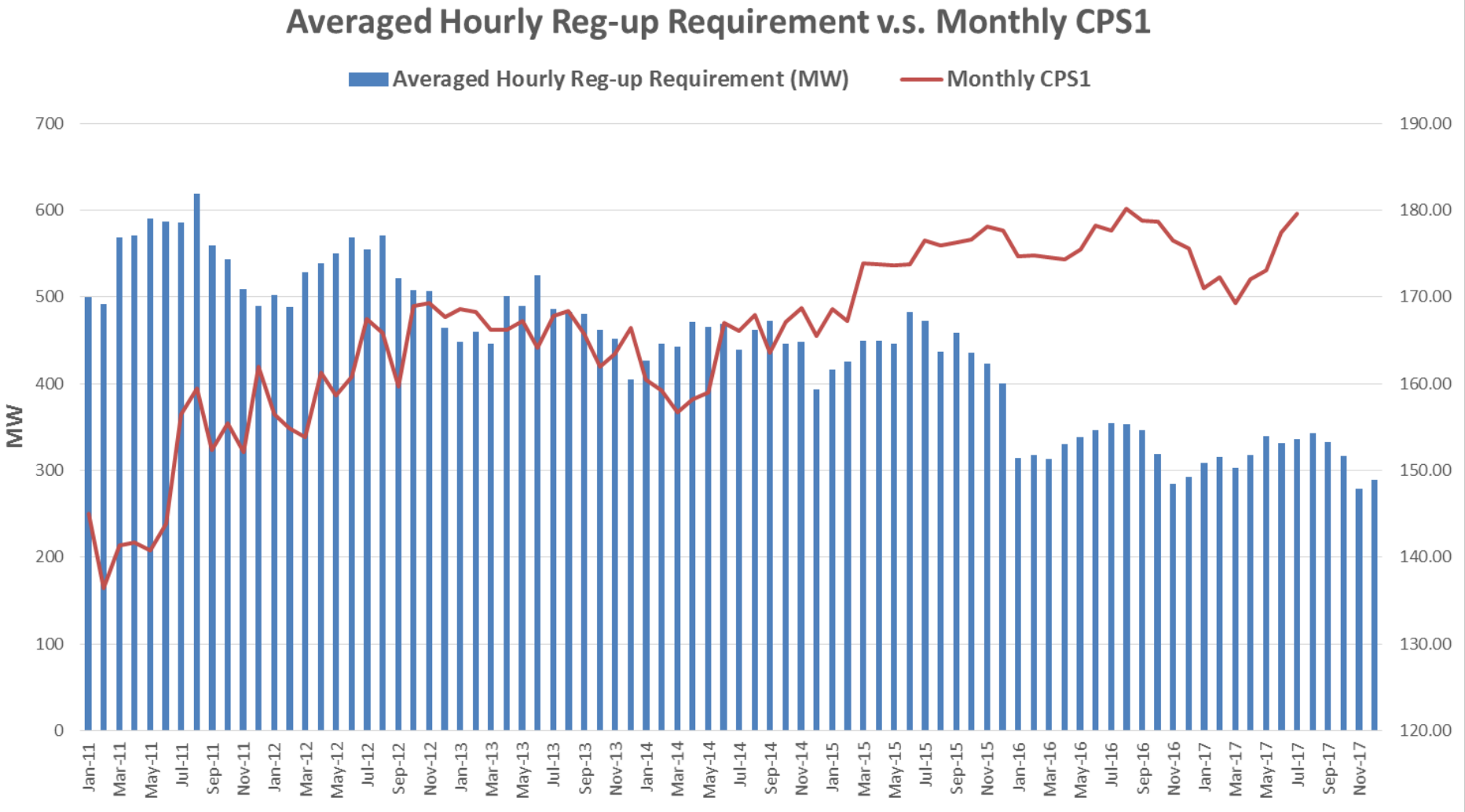
- Wind farms are required to provide primary frequency response to frequency deviations from 60 Hz.



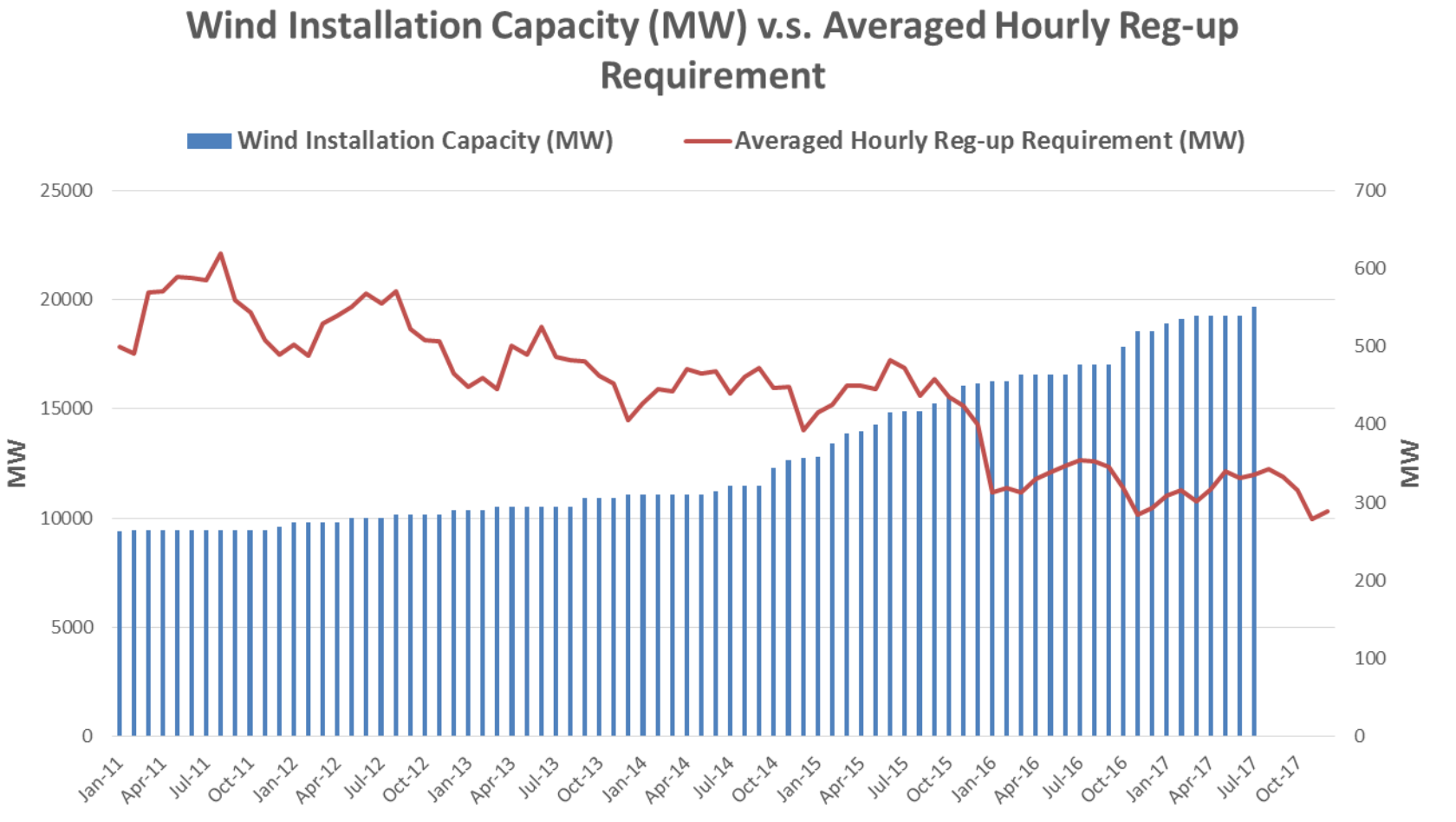
Trend of Monthly CPS1



Regulation-Up Requirements vs CPS1



Wind Installed Capacity vs. Reg-Up Requirement

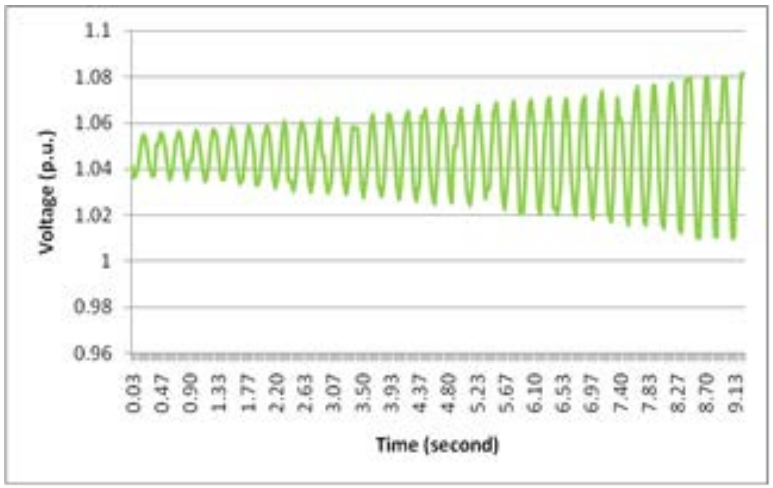


Outlines

- Background information of ERCOT
- Renewable Integration Practices and Solutions at ERCOT
- Future Challenges Associated with High Penetration of Renewables

Integrating Wind on Weak Grids

As more renewables integrate into locations that are further away from load centers in Texas, the certain generation intensive pockets in the ERCOT grid are vulnerable to system strength issues that hinder continued reliable operations during abnormal system conditions.

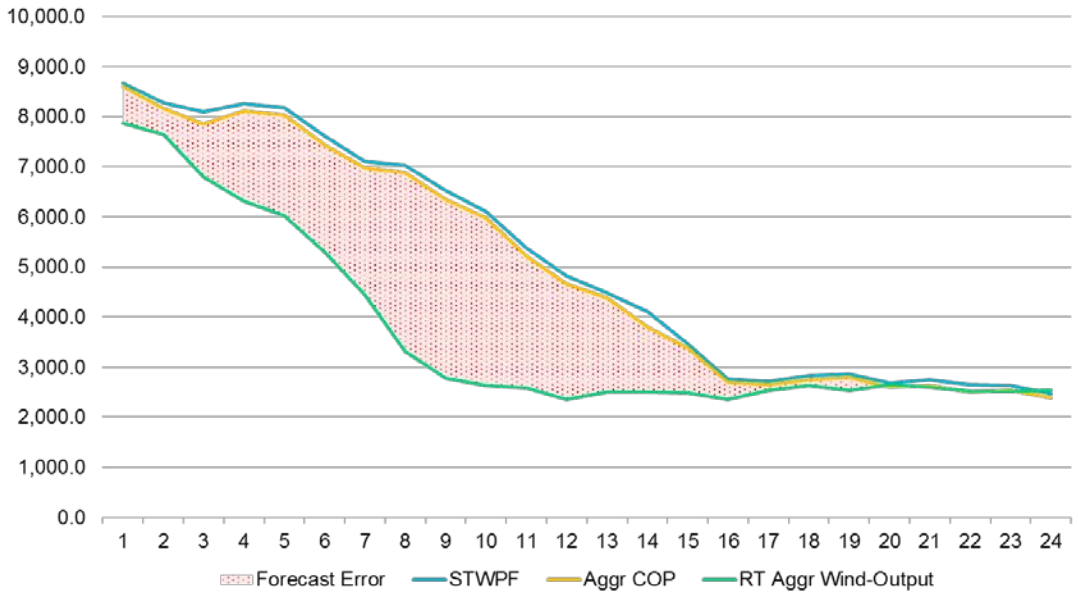


– A Generic Transmission Constraint is being used to maintain generation levels in the Texas Panhandle region such that Weighted Short Circuit Ration of the area is greater than or equal to 1.5. [2015]

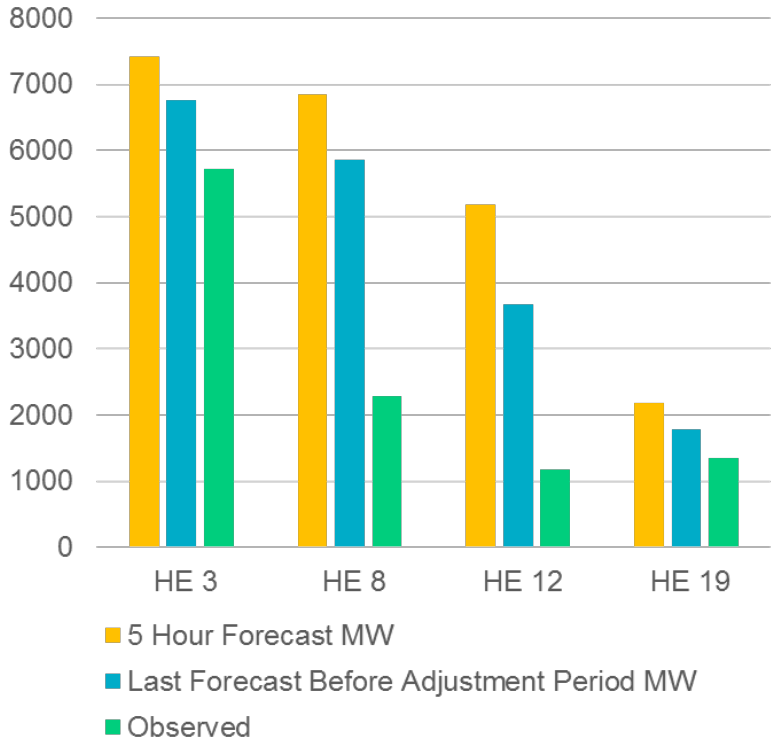
- Texas Panhandle has ~2.9 GW of renewables operational to date; the region has very little load and primarily exports energy into the rest of the ERCOT grid; the region is expecting another 2.4 GW of renewables to interconnect by 2018.
- Studies indicate that abnormal disturbances which occur when the Weighted Short Circuit Ration of the Texas Panhandle region is below a certain threshold, can cause oscillations and cascading over-voltages in region.

– Additional tools are being deployed to the Control Room to more efficiently monitor system strength of the Panhandle region and Panhandle export in Real Time. [2016]

Extreme Weather Condition Forecast



West Wind Hour Ahead Summary



West Wind

Low-Inertia Condition

- Procure RRS from earlier and/or faster responding resources
- Distribute RRS across a larger number of generators (results in faster aggregate response)
- Procure RRS from resources having relatively more inertia
- Synchronous Condensers provide inertia that needs to be included in calculation of inertia on system and may already be needed to resolve system strength issues; do not inject uneconomic MW into market
- “Synthetic Inertia” from inverter-based resources may help lower Critical Inertia Level because of faster response (but do not provide inertia to meet that requirement once it is set)

Questions?