Inertia Monitoring and Changes to Frequency Response Reserves At ERCOT

Nitika Mago
Supervisor, Operations Analysis
ERCOT

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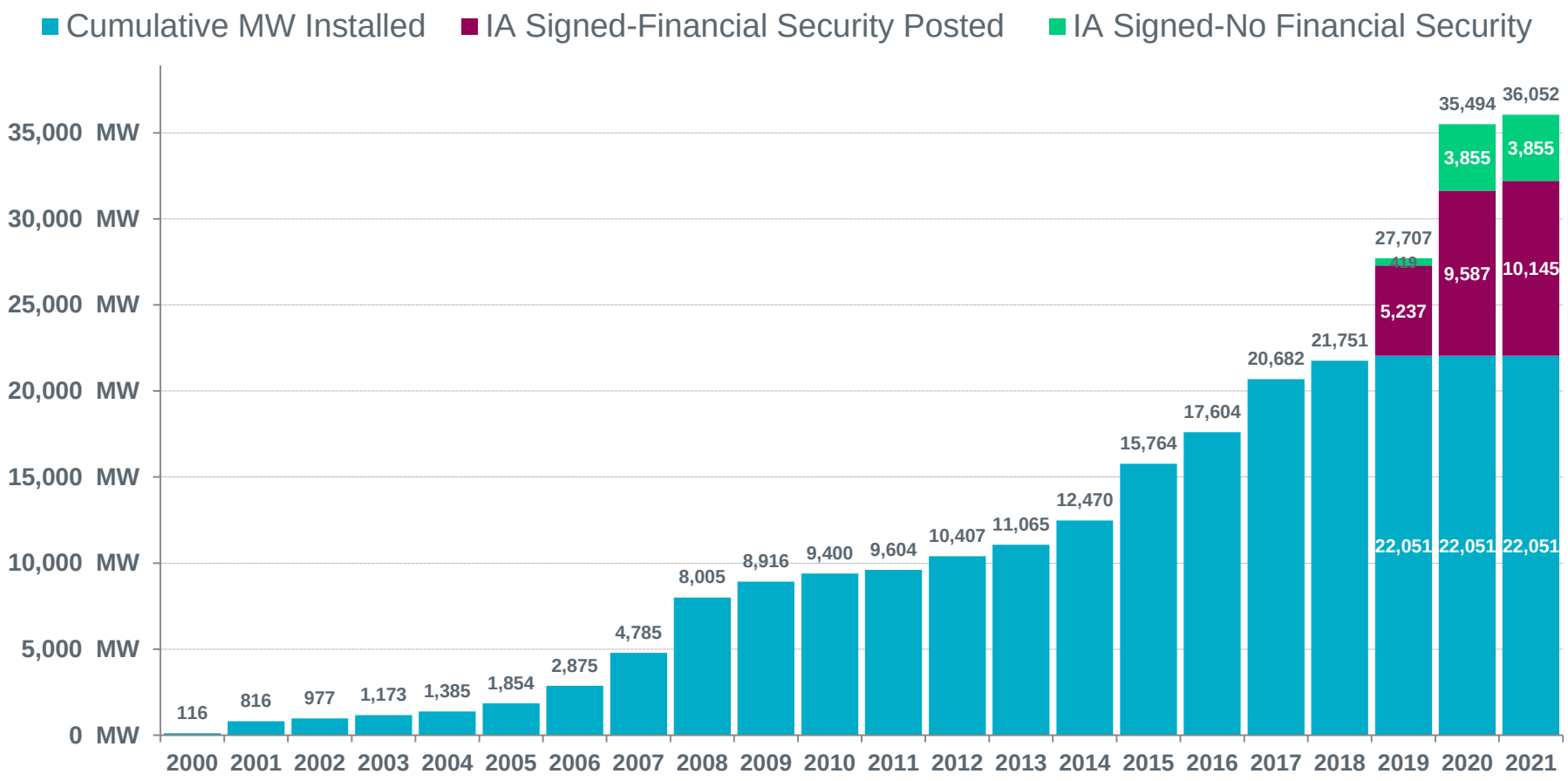
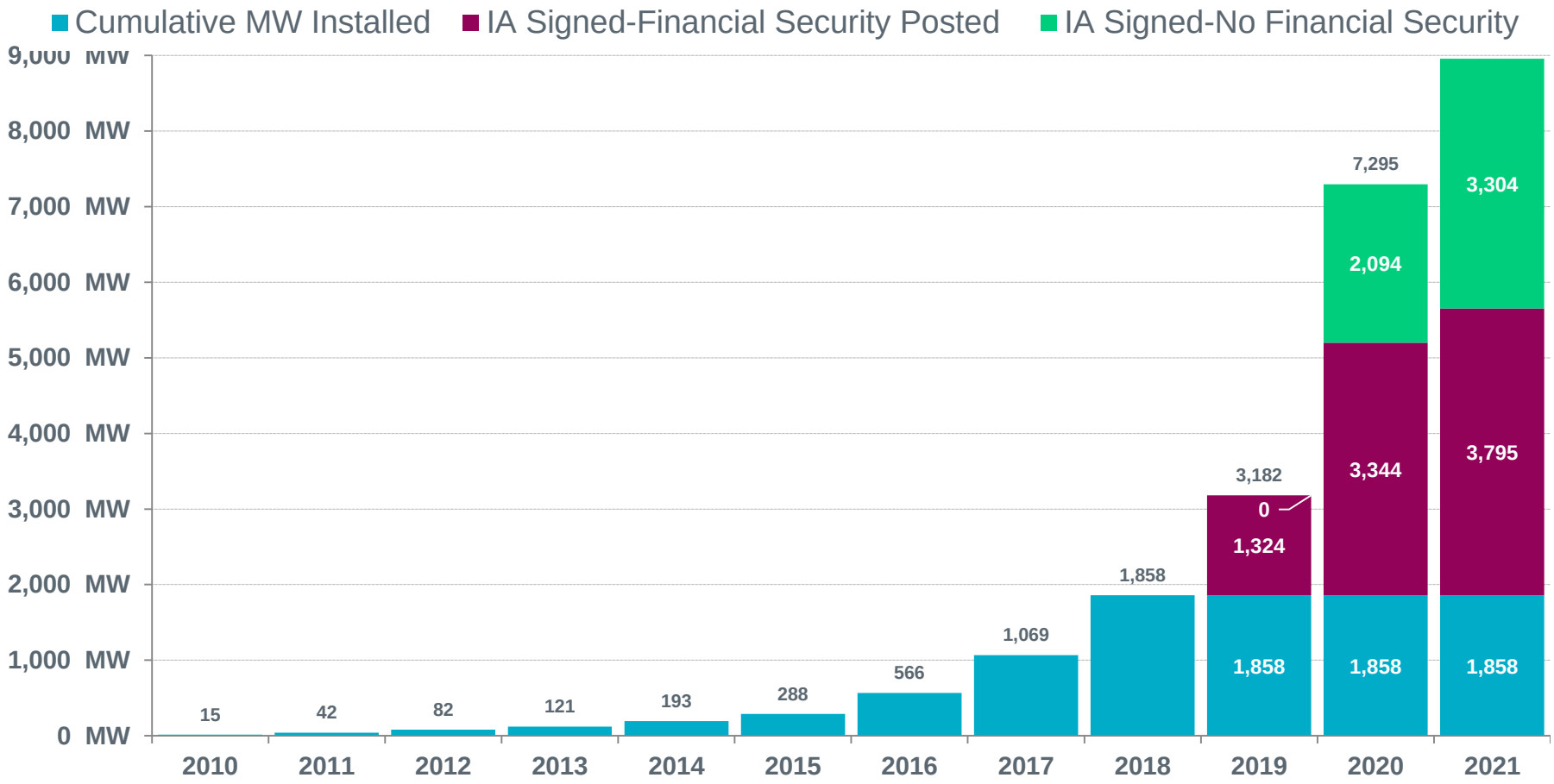
ERCOT Wind Additions by Year (as of Apr 30, 2019)



Notes:
- The data presented here is based upon the latest information provided to ERCOT by resource owners and developers and can change without notice.
- Installed capacities are the original nameplate rating of the generation facilities, and do not reflect retirements or rating changes over time due to facility expansions or repowering.

ERCOT Solar Additions by Year (as of Apr 30, 2019)



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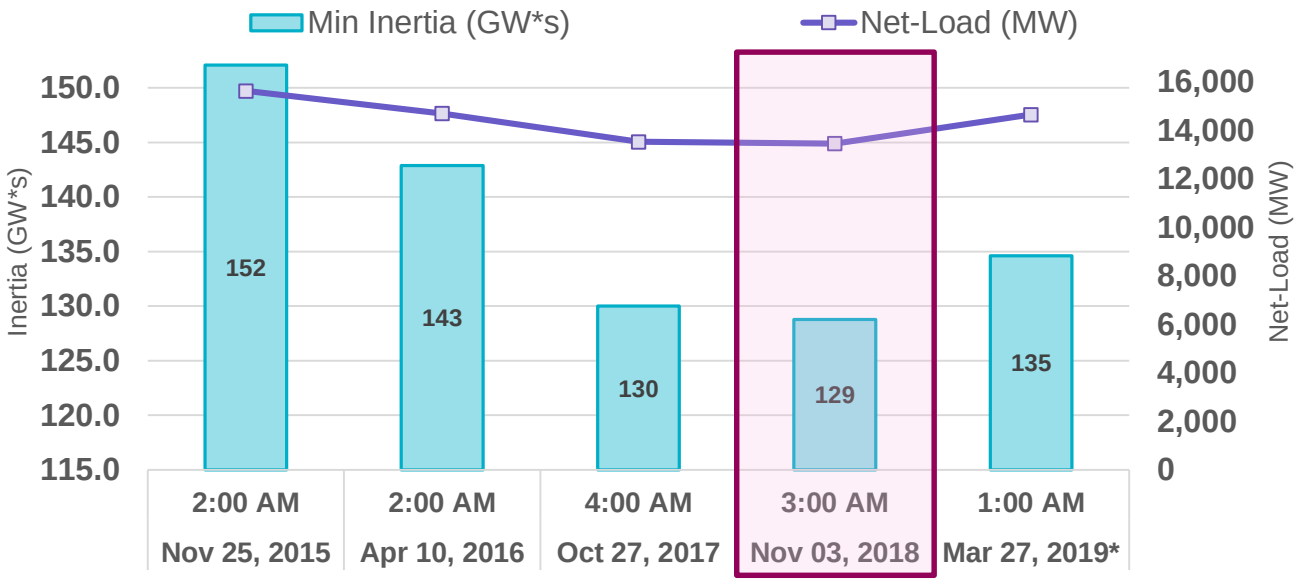
ERCOT Minimum Inertia (as of Apr 30, 2019)

- ERCOT's minimum system inertia is trending downward. This trend is directly attributive to decline in ERCOT's net-load (Load – Wind – Solar).

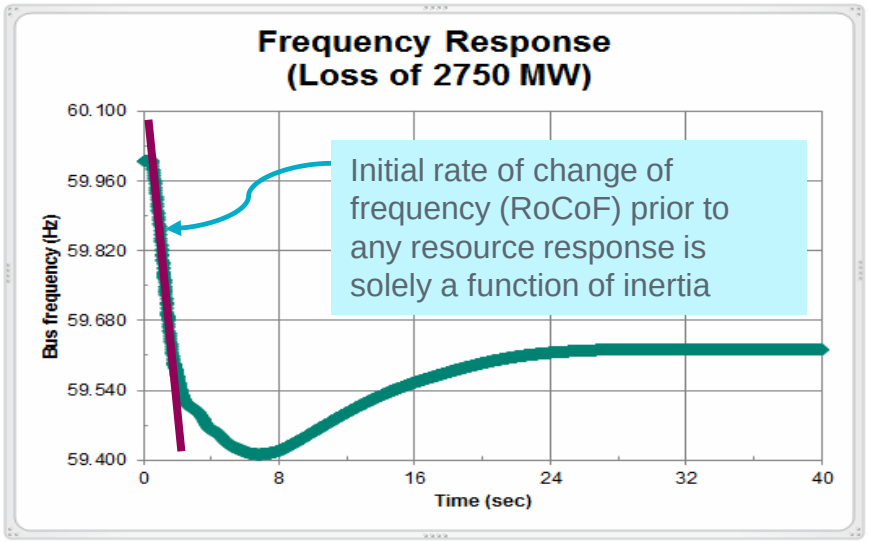


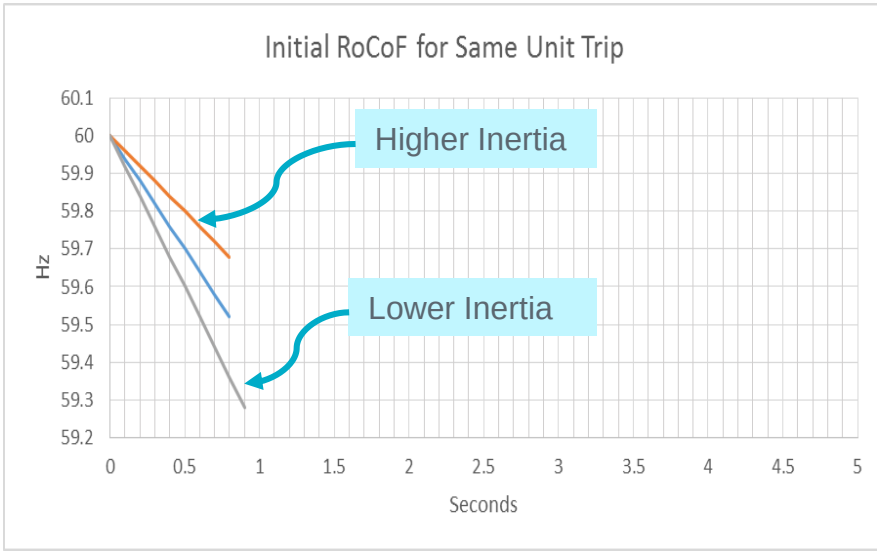
	System Inertia (GW·s)	Load (MW)	Wind Gen (MW)	Net Load (MW)
Nov 25, 2015 @02:00	152	26599	10977	15622
Apr 10, 2016 @02:00	143	26783	12091	14692
Oct 27, 2017 @04:00	130	28763	15236	13527
Nov 03, 2018 @03:00	129	28412	14960	13452
Mar 27, 2019* @01:00	135	29426	14781	14645

*Partial year. Jan thru April data used for 2019.

Inertia Background

- Only synchronous machines provide inertia to the system
- Everything else provides a response, but does not provide system inertia
- Following a unit trip, initial rate of change of frequency (RoCoF) prior to any resource response is solely a function of inertia.
  - Lower the system inertia faster the decline of frequency for the same size unit trip.





Frequency Response at ERCOT

- ERCOT procures Responsive Reserve Ancillary Service (RRS) to ensure sufficient capacity is available to respond to frequency excursions during unit trips.

- ERCOT' s RRS requirements are established based on historic system inertia and studies conducted per design criteria established to meet NERC's BAL-003 Interconnection Frequency Response Obligation.
  - Must plan not to activate Under Frequency Load Shed (UFLS) at 59.3 Hz for loss of 2750 MW of generation.
  - RRS design criteria includes 0.1 Hz margin on UFLS frequency setting.

- ERCOT's Frequency response reserve is provided by two types of resources
  - Capacity reserved from online Generation Resources
    - Governors of thermal generating units or Governor like response from curtailed renewable generating units begin to respond "immediately". Both set will take a few seconds to provide significant response
  - Load Resources with high-set under-frequency relays that respond in about 0.5s after the frequency drops below 59.7 Hz.

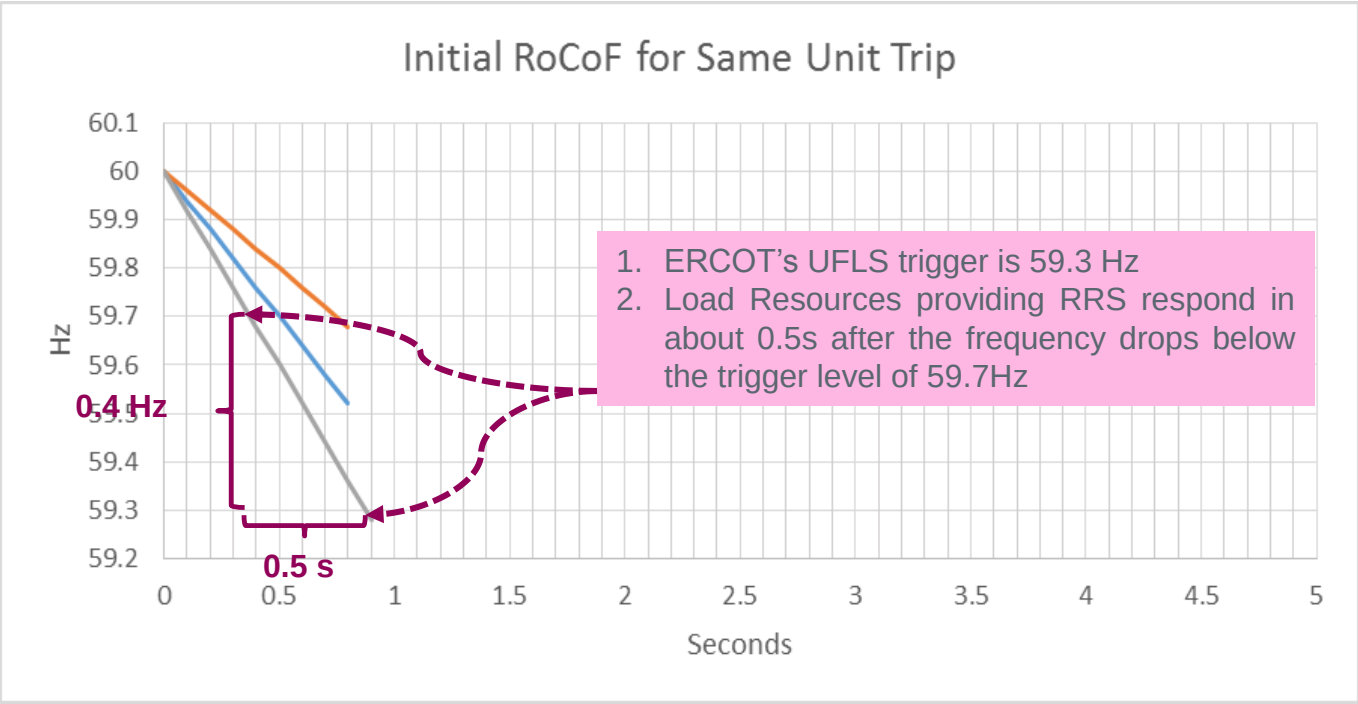
Two Inertia related Frequency Response Concerns

1. ERCOT must maintain at least a “Critical Inertia” level in Real Time based on the current operation practices and characteristics of frequency responsive resources.

2. ERCOT’s frequency response reserve requirements increase exponentially as inertia approaches “Critical Inertia” levels.

Critical Inertia Concept

- "Critical Inertia" is the level of inertia which causes the frequency to drop below the Under Frequency Load Shed (UFLS) trigger before the "fastest" resources can provide sufficient frequency response for the loss of 2750 MW generation.

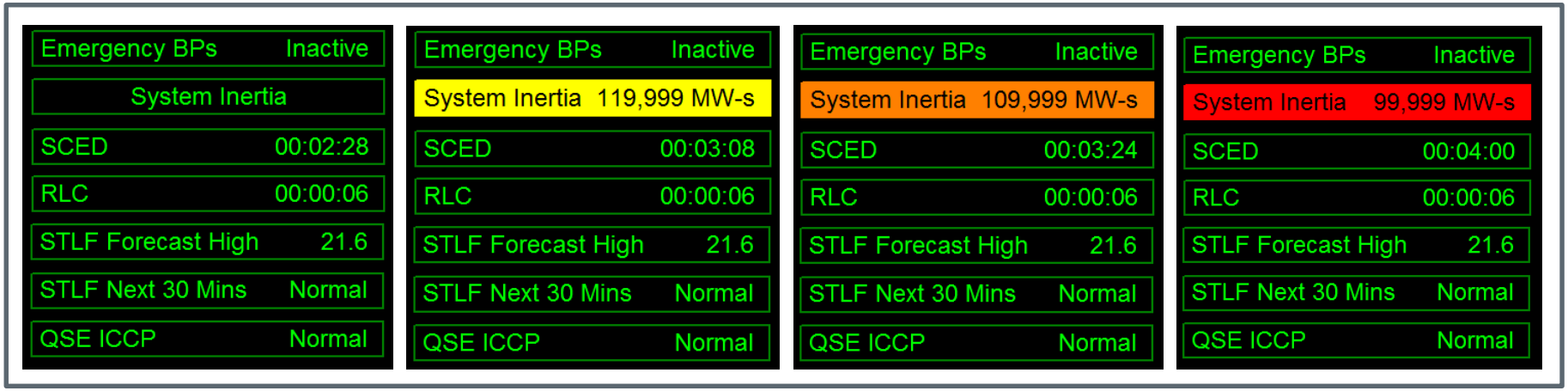


Current Critical Inertia for ERCOT

- Currently, ERCOT's Critical Inertia appears to be **around 100 GW*s.**
  - Simulations show that at inertia levels at or above 94 GW*s the "fastest" resources will have sufficient time to respond before frequency hits UFLS trigger (59.3 Hz) for the loss of 2750 MW generation.
  - Simulation results have also shown wide-area voltage oscillations at inertia below this level (This is a separate but somewhat related issue as identified in the Panhandle region as weak grid).

Maintaining Critical Inertia

- ERCOT Control Room actively monitors system inertia in Real Time. Visual alarms are raised alarms when inertia gets close to critical levels.



- As inertia approaches critical levels, ERCOT System Operators may take actions to bring additional synchronous generation resources with sufficient inertia online.

Fast Frequency Response

- Nodal Protocol Revision Request (NPRR) 863 was approved on February 13, 2019.
- This NPRR introduces a framework for Fast Frequency Response (FFR) as a subset in ERCOT's frequency responsive reserves.

Fast Frequency Response (FFR) From NPRR 863

The automatic self-deployment and provision by a Resource of their obligated response **within 15 cycles after frequency meets or drops below a preset threshold (59.85 Hz)** or a deployment is response to an ERCOT Verbal Dispatch Instruction (VDI) within 10 minutes. Resources capable of automatically self-deploying and providing their full Ancillary Service Resource Responsibility within 15 cycles after frequency meets or drops below a preset threshold and **sustaining a full response for at least 15 minutes** may provide Responsive Response Service (RRS).

A Resource providing RRS as FFR that is deployed shall not recall its capacity until system frequency is greater than 59.98 Hz.

Once recalled, a Resource providing FRS as FFR must restore their full RRS Ancillary Service Resource Responsibility within 15 minutes after cessation of deployment or as otherwise directed by ERCOT.

- ERCOT is currently in process of implementing software system changes related to FFR.

Benefits of FFR

- Inclusion of FFR-capable Resources into RRS would allow ERCOT to procure fewer quantities of RRS while still meeting the same reliability objective.

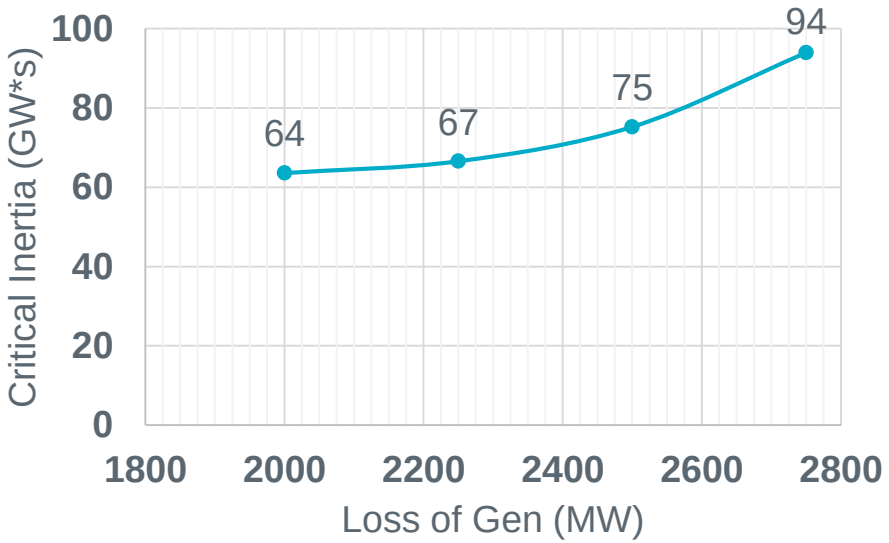
- Inclusion of FFR-capable Resources in RRS could reduce critical inertia.

	No FFR	525 MW FFR (59.8 Hz,15 cycles)
0.42s LR Response Time	94 GW*s	87 GW*s

Other Ideas to Mitigate Critical Inertia

- ERCOT's Critical Inertia is sensitive to other parameters such as
  1. Faster Response from LRs
  2. Changes to UFLS Settings
  3. Critical Contingency

	UFLS @59.3Hz	UFLS @59.1Hz
0.42s LR Response Time	94 GW*s	71 GW*s
0.25s LR Response Time	68 GW*s	52 GW*s



- Each one of the above brings in a different level of implementation cost and complexity. Adoption of one or more of these or something else is still being discussed.

Summary

- ERCOT's minimum system inertia is trending downward as a result of decline in ERCOT's net-load (Load – Wind – Solar).

- ERCOT's Critical Inertia System Operating Limit is currently around 100 GW*s.
- ERCOT is monitoring system inertia in Real Time. ERCOT System Operators may take actions in Real Time to maintain Critical Inertia levels.

- ERCOT's frequency response reserve, RRS will include Fast Frequency Response (FFR) as a subset. FFR will help mitigate Critical Inertia level.

- ERCOT studies have identified other changes that have the potential to further lower ERCOT's Critical Inertia and widen ERCOT's System Operating Limit. Discussions are still in flight on what additional changes might be adopted in this context.

QUESTIONS?

EMAIL ADDRESS: nmago@ercot.com

References

- Inertia: Basic Concepts and Impacts on the ERCOT Grid
- Synchronous Inertial Response (SIR) Workshop
- Synchronous Inertial Response (SIR) Workshop II