Primary Frequency Response (PFR)/Fast Frequency Response(FFR) Assessment

ERCOT Future Ancillary Service Team

ERCOT FAST Workshop

March 28, 2014

Background and Purpose

- Background:
  - The Future Ancillary Service Team (FAST) has discussed concepts and proposals for a new framework for Ancillary Services in ERCOT.
  - ERCOT was asked in the FAST working sessions to provide an indication of the quantities that might be required for the proposed Ancillary Services.
- Purpose:
  - To “estimate” the PFR/FFR needs (in terms of MW) under different system conditions.
  - This results of this assessment only provide a reference for ERCOT FAST consideration. The assumptions made in this assessment were based on the proposed AS framework and should not be used for other purposes.

Definition

- Primary Frequency Response (PFR):
  - The immediate proportional increase or decrease in real power output provided by a Resource and the natural real power dampening response provided by Load in response to system frequency deviations. This response is in the direction that stabilizes frequency.
- Fast Frequency Response (FFR):
  - A response from a resource that is automatically self-deployed and provides a full response within 30 cycles after frequency meets or drops below a preset threshold.
  - Two FFR subgroups:
    - FFR1: trigger frequency at 59.8 Hz
    - FFR2: trigger frequency at 59.7 Hz
- **PFR and FFR help to stabilize the frequency but do not recover the frequency back to nominal frequency.**

Study Assumptions and Criteria

- Study Assumptions
  - Only PFR units provided governor response
  - Non-PFR units were assumed at their physical limit, no headroom to provide governor response.
  - Load damping was assumed as 2%/Hz based on PDCWG data
  - No Wind Dynamic Model
  - Two subgroups of FFR service, at different frequency thresholds
    - FFR1: 59.8 Hz, FFR2: 59.7 Hz
- Study Criteria and contingency
  - Freq nadir >= 59.4 Hz, losing two STPs
  - Freq overshoot <=60.5 Hz, losing one unit and triggering all FFR deployments
- Study Cases
  - Multiple system conditions

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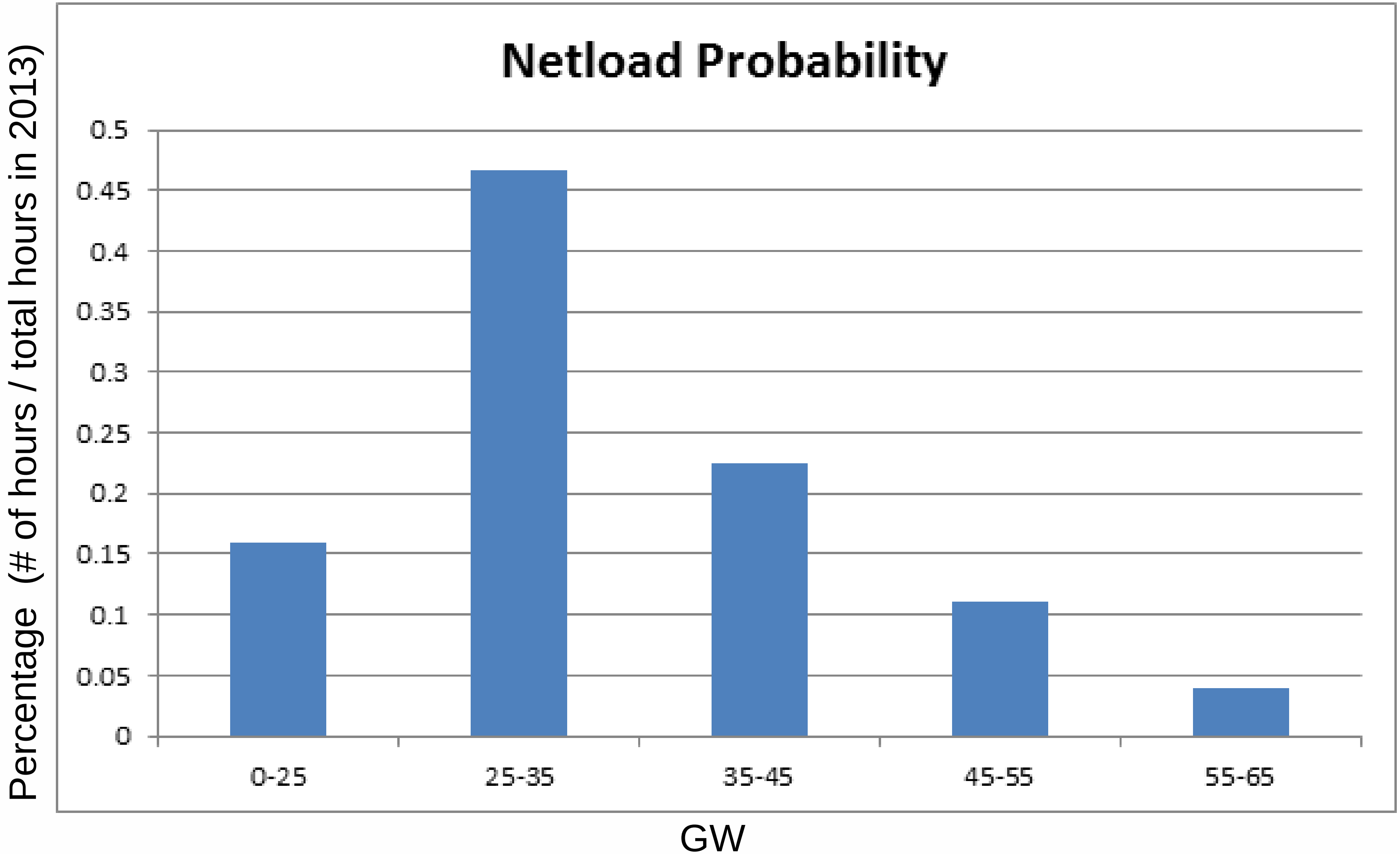
2013 Net Load (= load - wind)



Selected Study Cases

Case	Date/Time	Load (MW)	Wind Output (MW)	PRC* (MW)	Wind Penetration **	Net Load (MW)	System Inertia*** (GW-Second)
1	08072013 17:00	67,148	2,398	4,105	3.57%	64,750	372
2	02132014 19:00	36,460	1,188	5,062	3.26%	35,272	236
3	01132014 03:00	24,857	7,196	5,812	28.95%	17,661	174

*PRC: Physical Reserve Capacity

**Wind Penetration = Wind output / Load

***System Inertia (GW-second) = Sum of (Machine MVA * H) / 1000

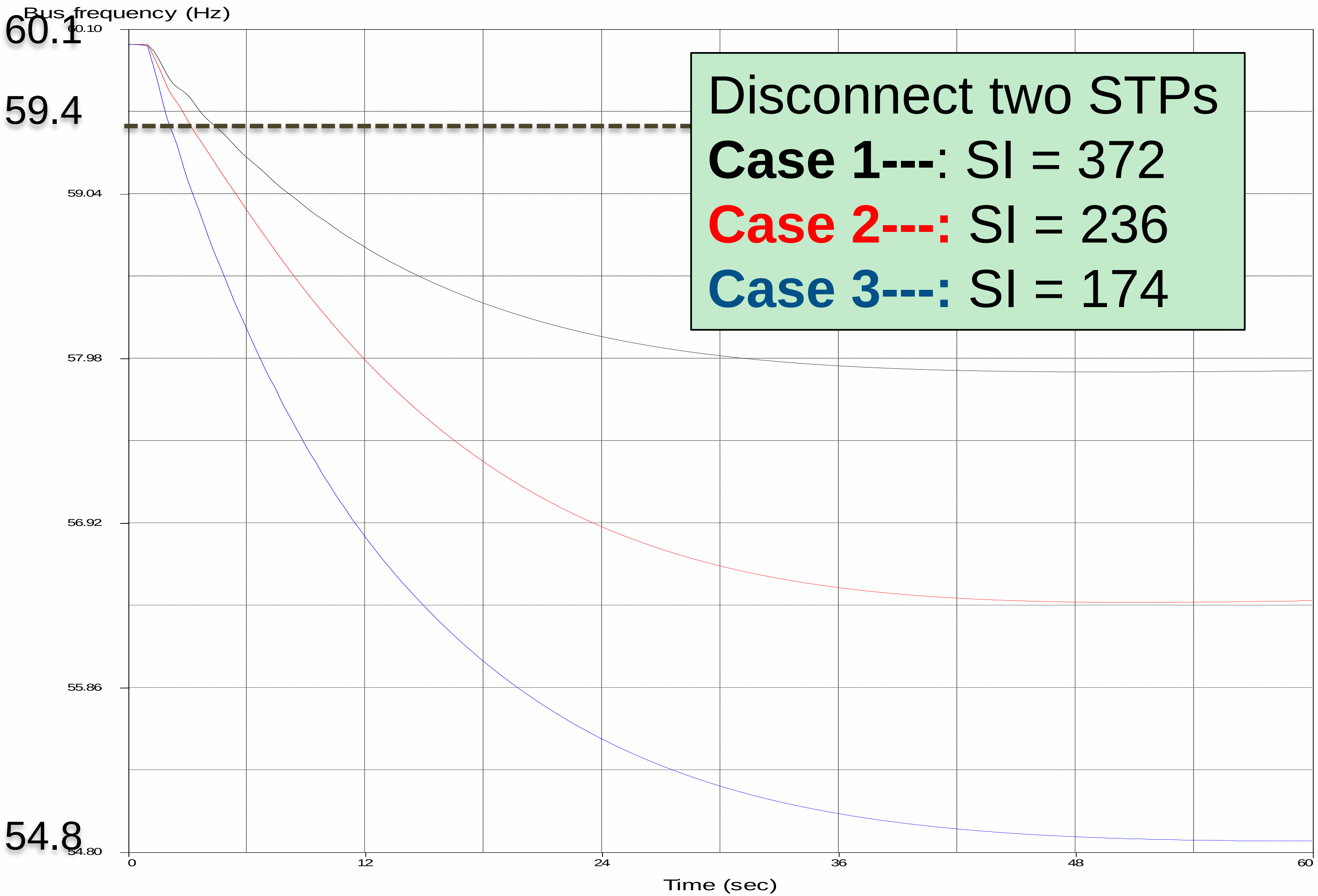
Study Approach

- Detailed dynamic simulations were performed in this assessment to evaluate the system frequency response in the first 20~30 seconds following a frequency events.
- This assessment included the impact of the following proposed Ancillary Services.
  - Synchronous Inertial Response
  - Primary Frequency Response
  - Fast Frequency Response

Questions to Answer

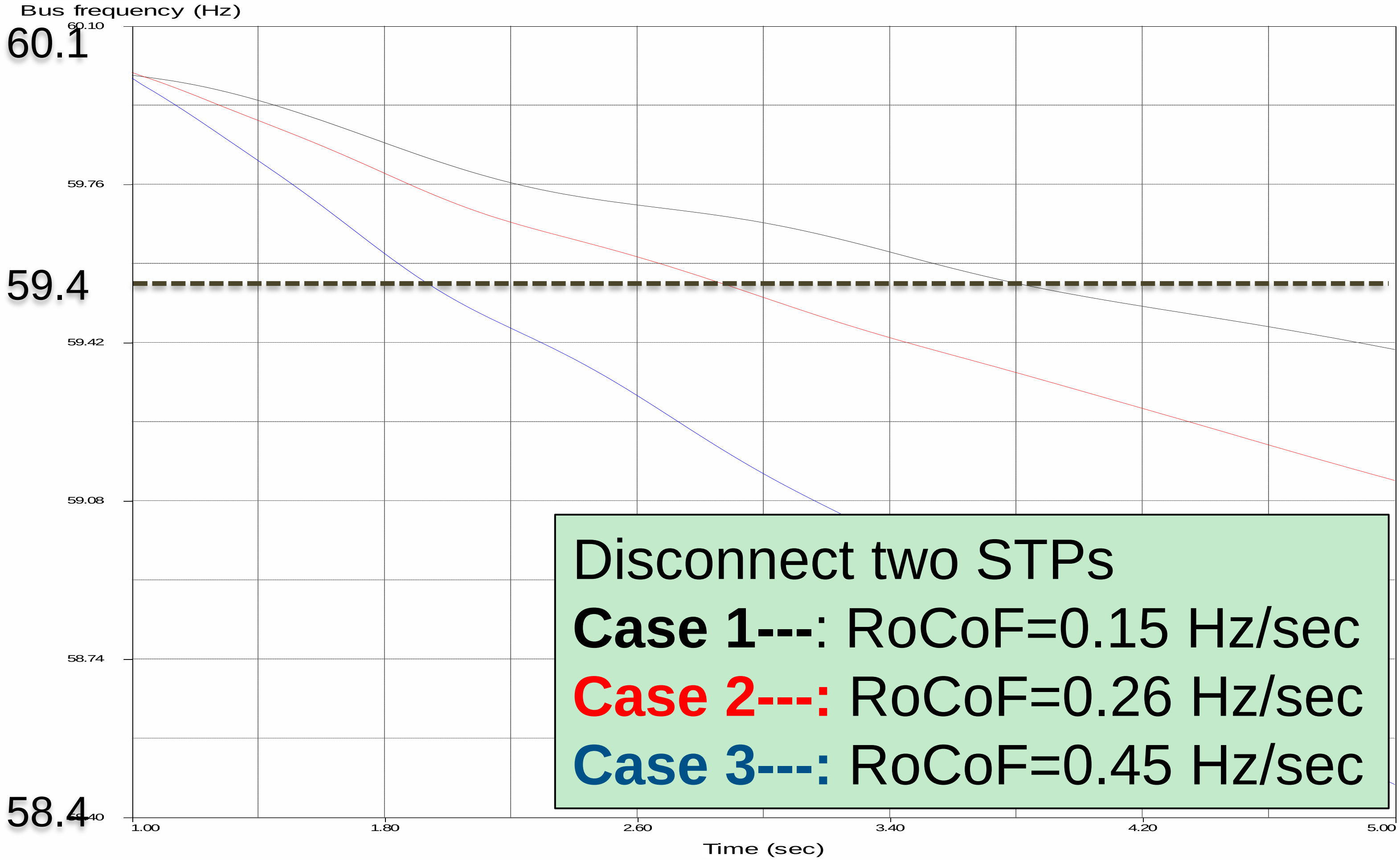
- Why do we need PFR and FFR?
- Do the PFR and FFR requirements vary with system conditions?
- What are the preliminary estimated requirements for PFR and FFR?
- What is the relationship between PFR and FFR?

Test 1: No PFR, No FFR, System Inertia (SI) Only



SI (GW-second): 1 > 2 > 3

Test 1: No PFR, No FFR, System Inertia Only



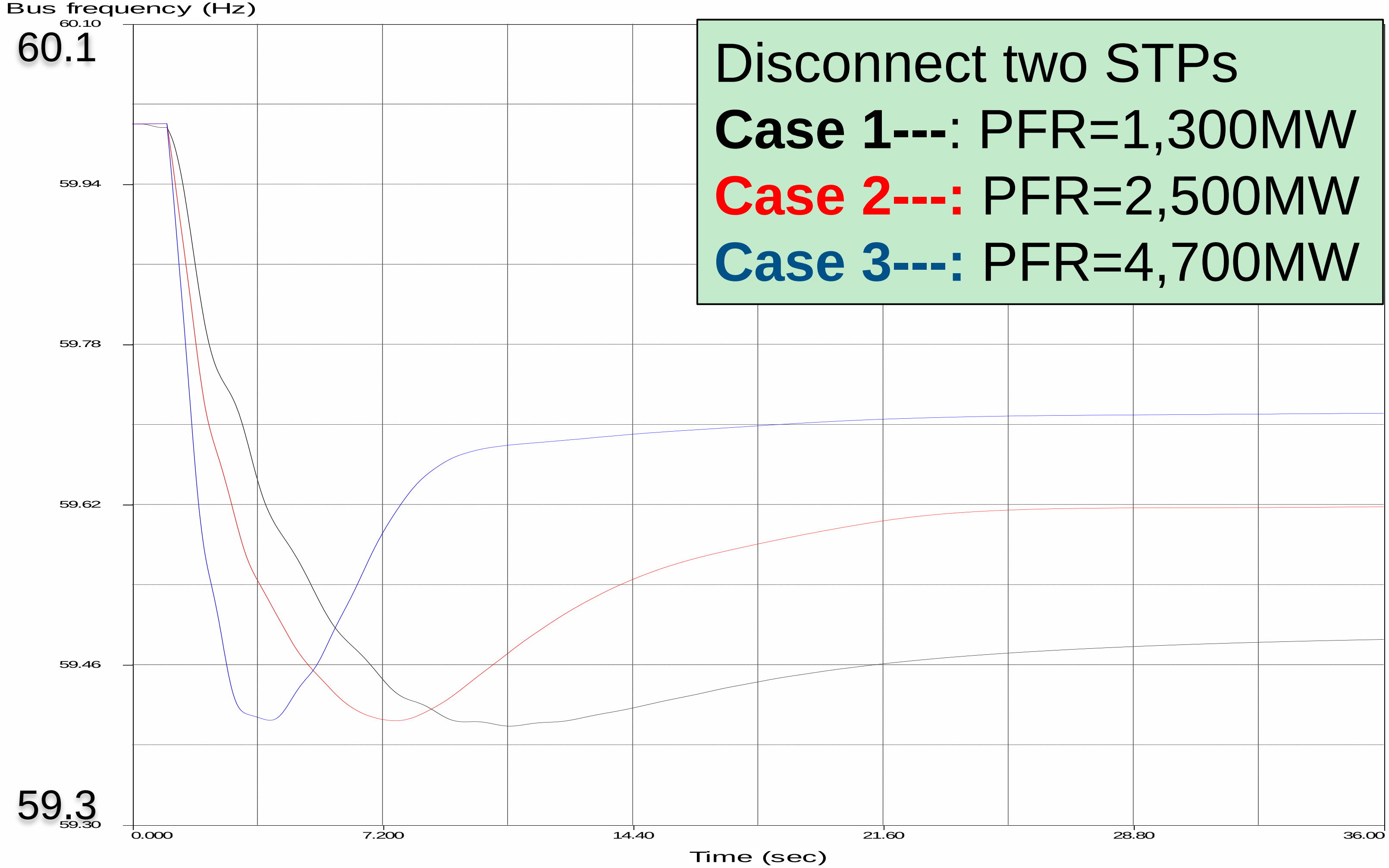
RoCoF: Rate of Change of Frequency

RoCoF (Hz/sec): 1 < 2 < 3

Test 2: Minimum PFR Needs

- Test: all three cases
- Target:
  - Frequency nadir >= 59.4 Hz with the loss of two STP units
- Assumptions
  - Only PFR units provided governor response
  - Non-PFR units were assumed at their physical limit, no headroom to provide governor response.
  - Load damping was assumed as 2%/Hz based on PDCWG data
  - No Wind Dynamic Model
  - No FFR

Test 2: Simulation Results



PFR: 3 > 2 > 1

Test 3: Minimum FFR Needs

- A minimum PFR capacity is required to identify the minimum FFR needs.
- Criteria to determine the minimum PFR
  - Potential # of FFR deployments in a year
  - Frequency nadir >= 59.7 Hz with the loss of one generation unit
- Results: a minimum of 1,400 MW of PFR was needed

Date/Time	Load (MW)	PFR (MW)	Frequency Nadir (hz)	Generation Loss (MW)
08072013 17:00	67,148	1,400	59.70	1,350
02132014 19:00	36,460	1,400	59.70	950
01132014 03:00	24,857	1,400	59.70	350

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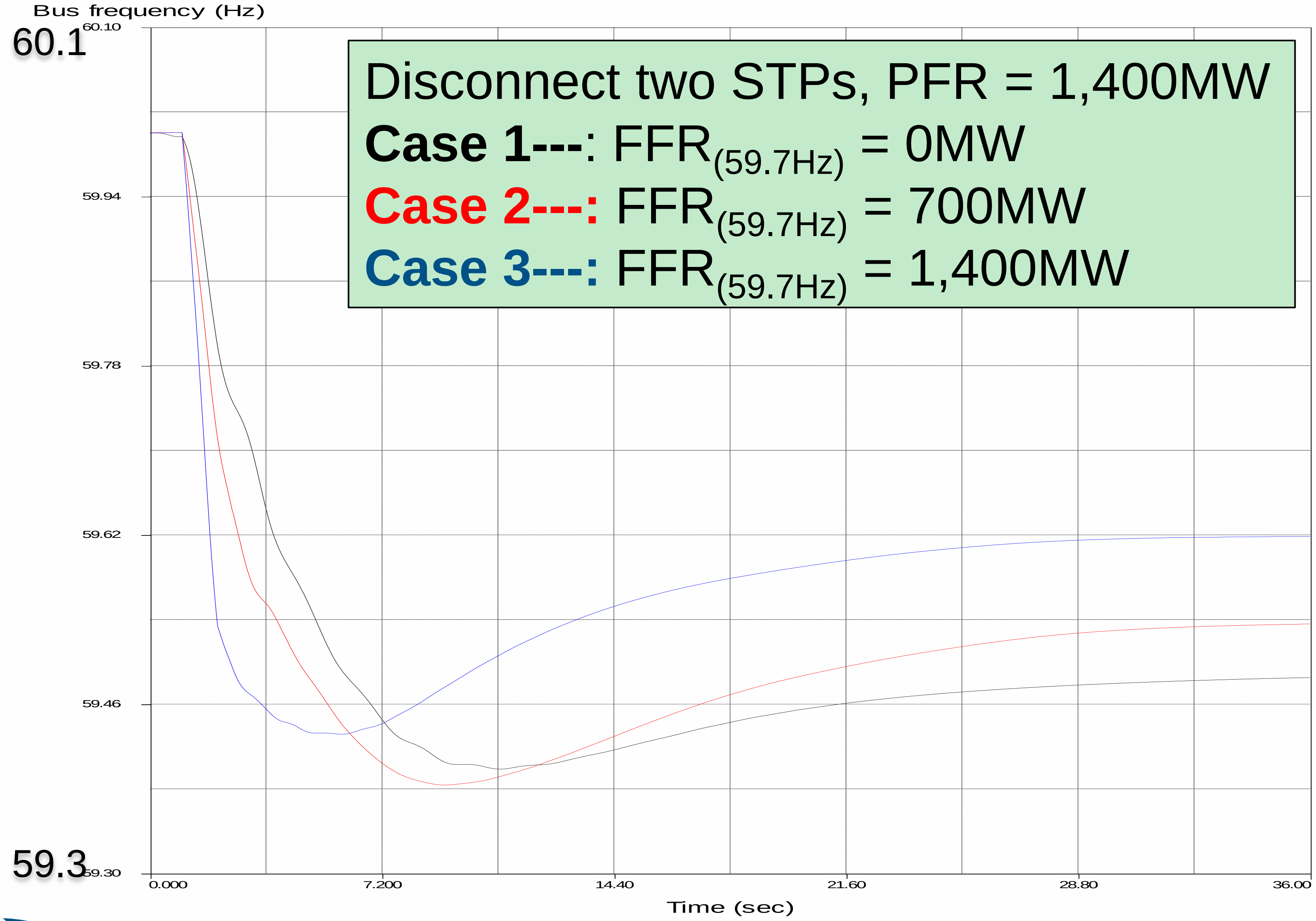
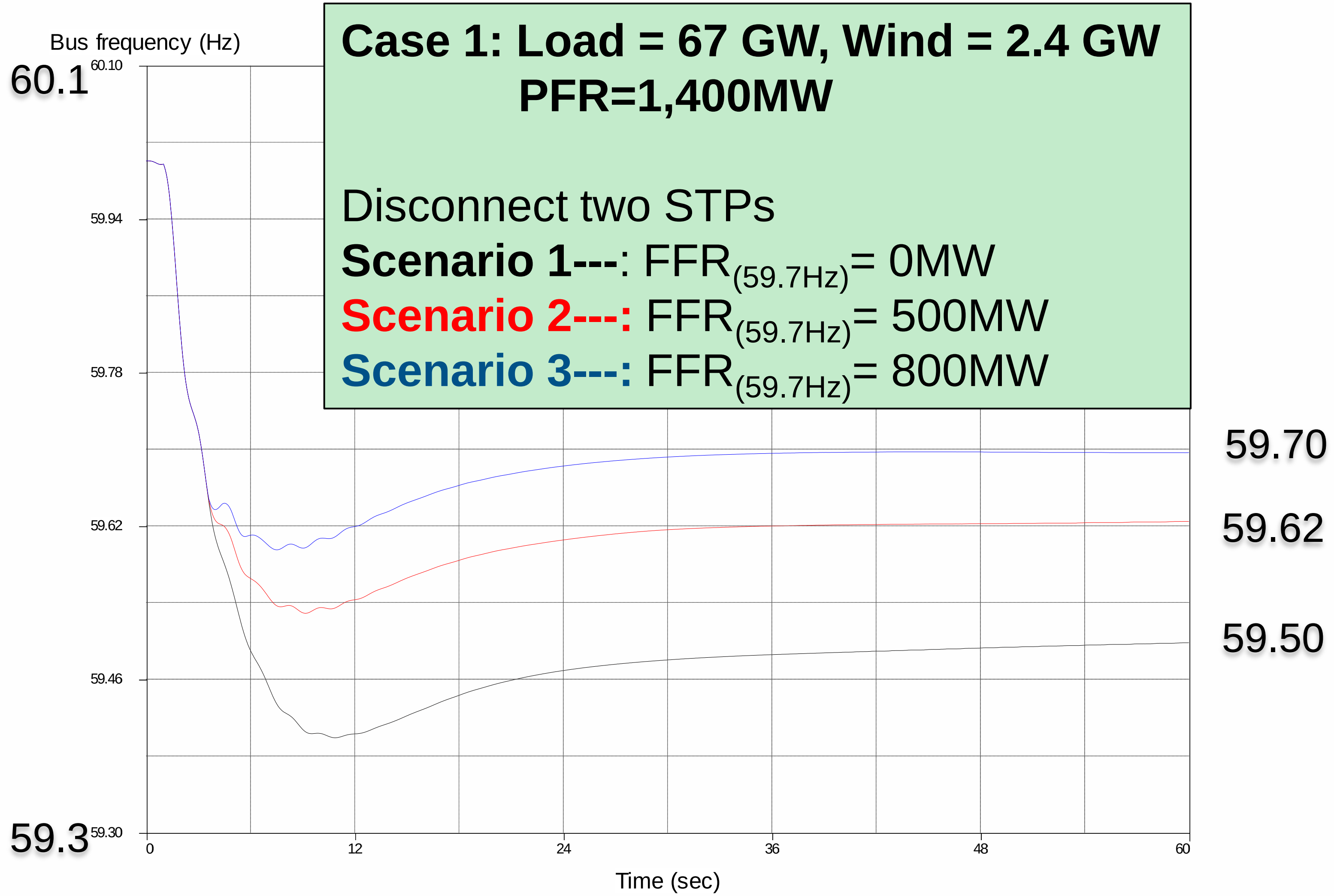
Test 3: Simulation Results



Test 4: FFR Impact at High Load

- What is the FFR contribution at high load?
  - Having only PFR in the high load condition results in a low post-disturbance frequency (Point B).
    - May require additional regulation and contingency reserve to recover the frequency back to 60 Hz.

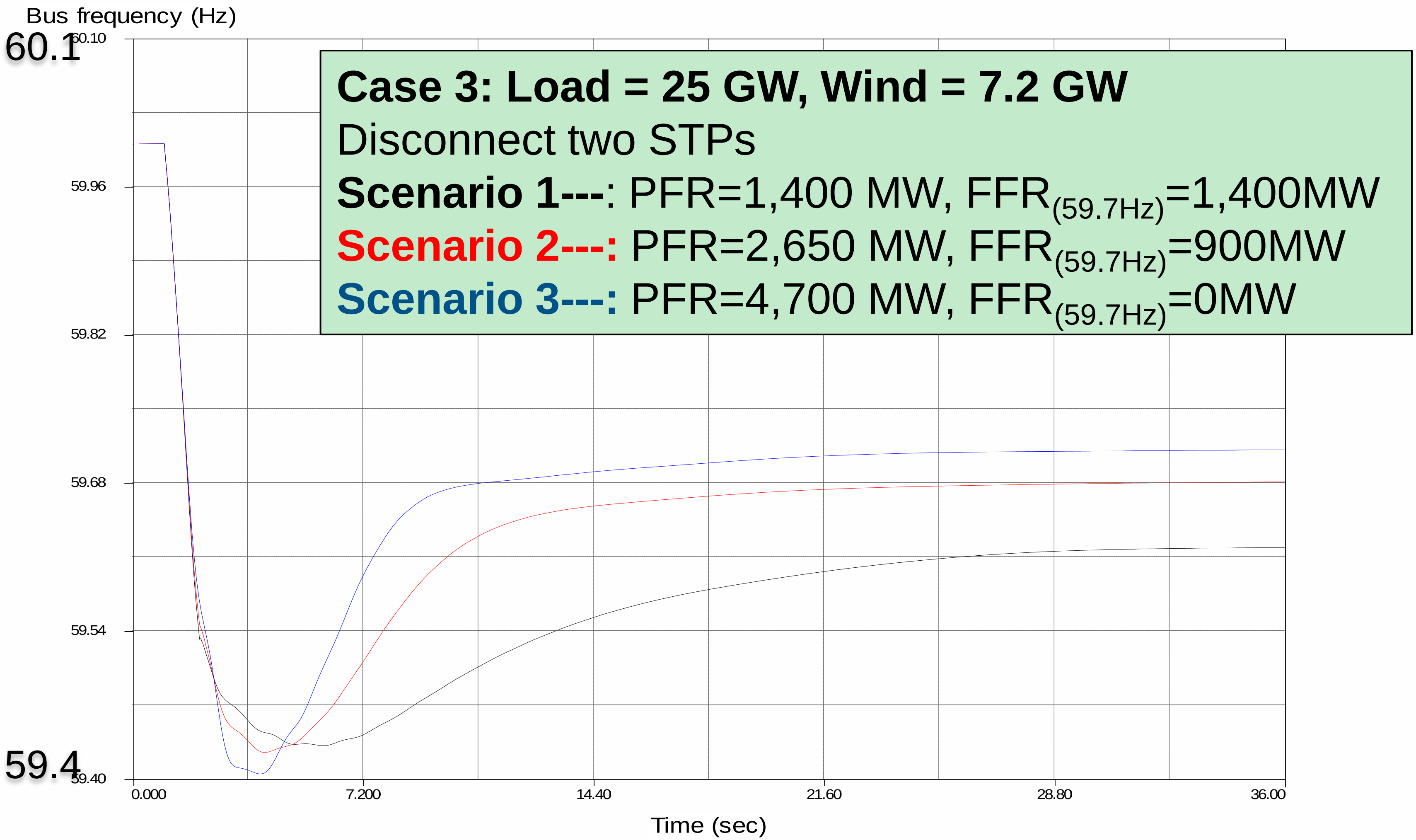
Test 4: FFR Impact at High Load



Test 5: PFR/FFR Substitution

- Test: all three cases
- Target:
  - Obtain sufficient PFR + $FFR_{(59.8Hz)}$ + $FFR_{(59.7Hz)}$
  - Frequency nadir >= 59.4 Hz with the loss of two STP units
- Assumptions
  - Only PFR units provided governor response
  - Non-PFR units were assumed at their physical limit, no headroom to provide governor response.
  - Load damping was assumed as 2%/Hz based on PDCWG data
  - No Wind Dynamic Model

Test 5: Simulation Results for Case 3



Case 3: 1 MW FFR ≈ 2.35 MW PFR

Answers to Questions

- Why do we need PFR and FFR?
  - To maintain adequate frequency response following an event.
- Do the PFR and FFR requirements vary with system conditions?
  - Yes, PFR/FFR requirements vary with system conditions.
- What are the preliminary estimated requirements for PFR and FFR?
- What is the relationship between PFR and FFR?

Case	Net Load (GW)	PFR_{min} (MW)	FFR_{min} (MW)	PFR/FFR Substitution*
1	65	1,400	0	0
2	35	1,400	700	1.5
3	18	1,400	1,400	2.35

* PFR MWs that can be “replaced by” 1 MW FFR, based on the assumptions in the Case