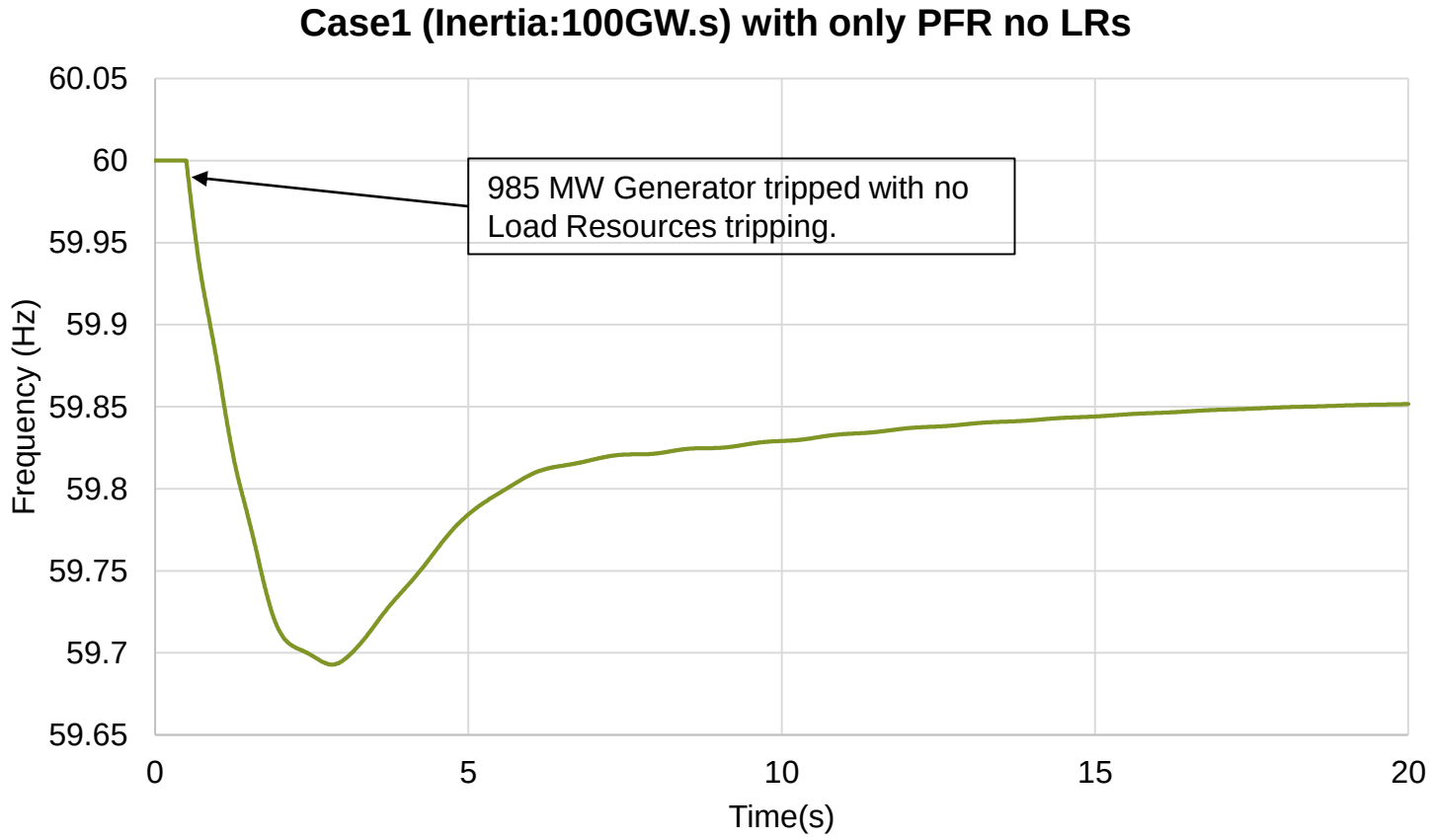
The Southern Cross Transmission Project

Frequency Deviation Review for PDCWG

November 8, 2017

Pattern Development

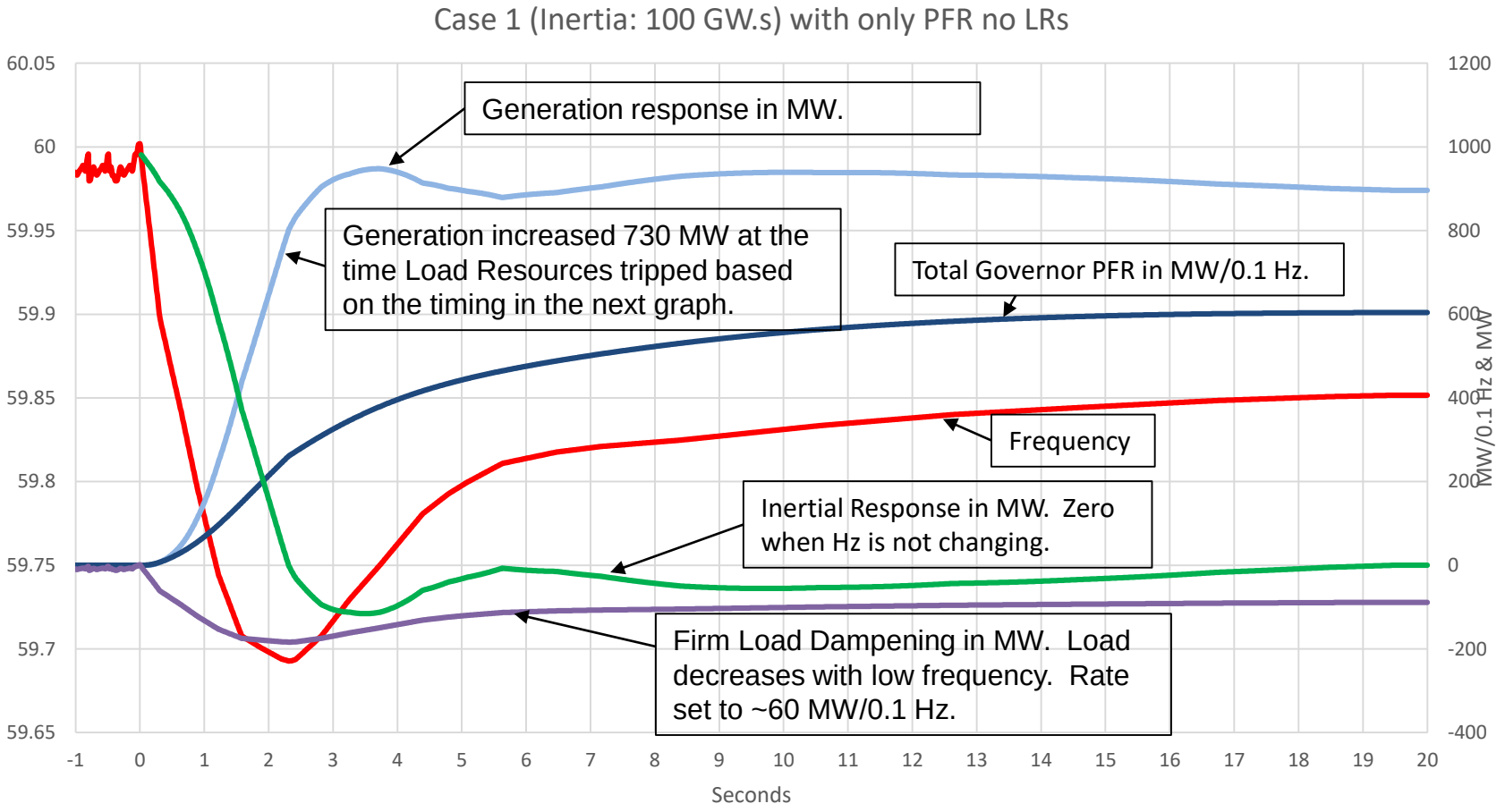
PDCWG/ERCOT Overshoot Study



	Inertia	Load	Wind	PFR Needed	LR Needed
*Case1	100GW.s	24.4GW	9.7GW	1150	2638

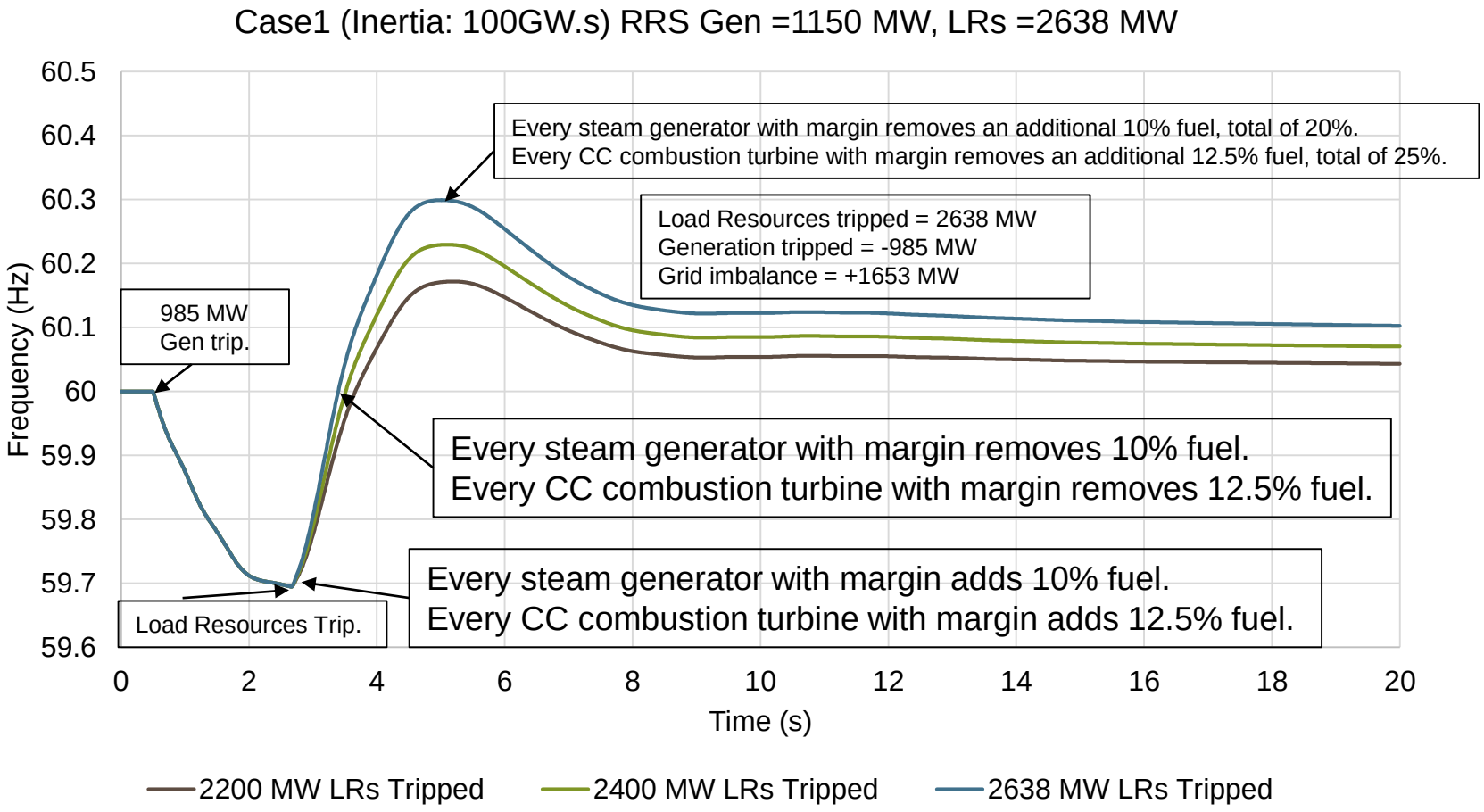
Pattern Development

PDCWG/ERCOT Overshoot Study
Generator Response, Load Dampening & Inertial Response of 985 MW Generator Trip, No LRs



Pattern Development

985 MW Generator Trip Followed By LR Tripping PDCWG – ERCOT Frequency Overshoot Study March 8, 2017



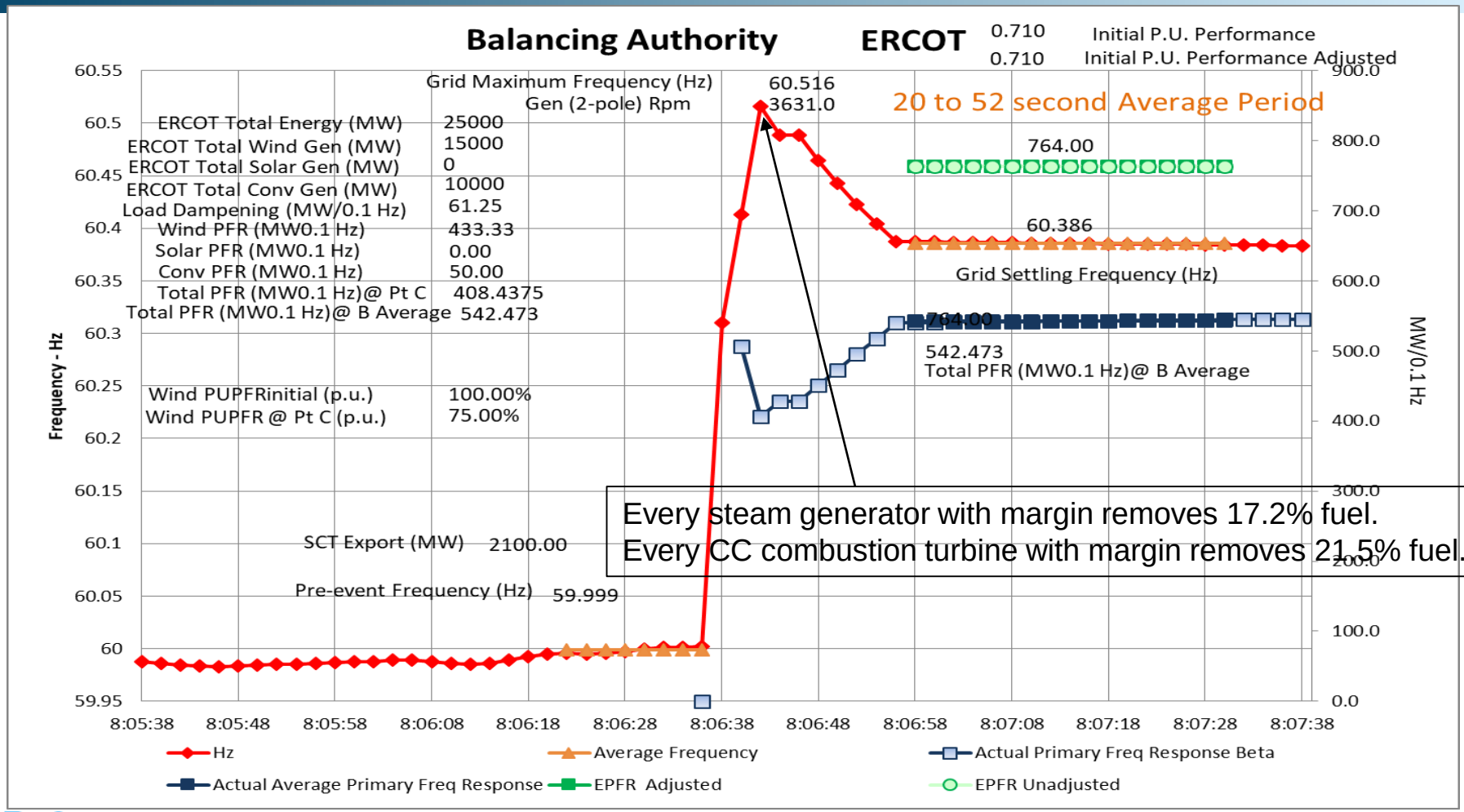
Pattern Development

PDCWG/ERCOT Overshoot Observations 985 MW Generator Trip Followed by 2638 MW of Load Resources Tripping

- Normal Event with just the 985 MW generator tripping.
- Event with 2638 MW of Load Resources tripping had these observations:
  - Generators first increase output in response to the low frequency adding fuel.
  - In 2.17 seconds generators increase output 730 MW helping to stabilize frequency at 59.695 Hz.
  - With 2638 MW of Load Resources tripped, frequency begins to increase rapidly and Generators begin decreasing fuel as frequency quickly returns to 60 Hz. For conventional generators, fuel is still being burned, energy generated during these next 0.74 seconds. Due to the time lag in generator response it is unlikely that the 730 MW of PFR has been removed by the time frequency returns to 60 Hz.
  - For the grid Load Imbalance when the LRs tripped: 2685 MW – 985 MW + 730 MW = 2430 MW imbalance.
  - With this imbalance, frequency continues to 60.299 Hz causing generators to continue decreasing fuel.
  - Conventional generator fuel change during event:
    - Increase 10% fuel for 5% droop and 12.5% for 4% droop. Frequency at 59.695 Hz.
    - Decrease 10% fuel for 5% droop and 12.5% for 4% droop. Frequency back to 60 Hz.
    - Decrease 10 % fuel for 5% droop and 12.5% for 4% droop. Frequency at 60.299 Hz. Total 20% and 25% change.

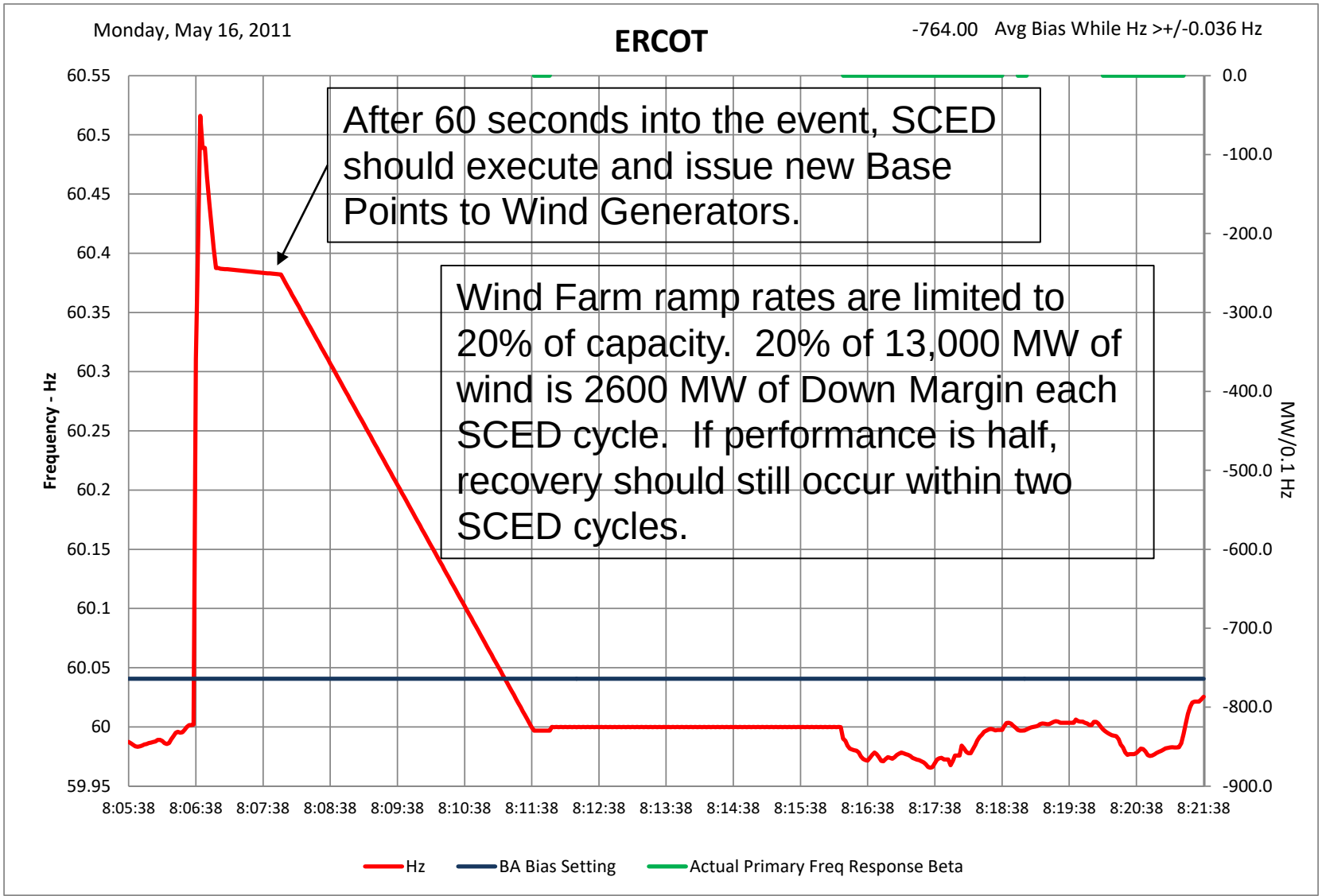
Pattern Development

ERCOT Frequency during 2100 MW Export Tripping of both poles during High Wind Low Load – NERC N-2 Event: Planning Standard TPL P7



Pattern Development

Recovery After Loss of DC Tie



2100 MW Export Trip Observations

- Frequency burden on generators through their governor action should be less risky than during the PDCWG/ERCOT Frequency overshoot study due to the single direction of frequency movement.
- Frequency higher than PDCWG/ERCOT Overshoot study but less total frequency movement. 17.2% compared to 20% in study and 21.5% compared to 25% in study.
- Load Imbalance in PDCWG/ERCOT Overshoot study was 2430 MW compared to DC Tie trip of 2100 MW.
- Speed of delivery of PFR by governors is extremely important to minimize peak frequency.
- **Primary Frequency Response definition Nodal Protocols.**
  - The immediate proportional increase or decrease in real power output provided by All-Inclusive Generation Resources and Controllable Load Resources 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.

Pattern Development

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