FY12 DOE/CERTS Transmission Reliability R&D Internal Program Review

Reliability Standards Analysis and Assessment

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June 12-13, 2012

Washington, DC

CERTS
Consortium for Electric Reliability Technology Solutions

NERC
North American Electric Reliability Corporation

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Research Projects

Reliability Standards Analysis and Assessments

- Frequency Response Event Collection and Analysis
- NERC Interconnections 2011 Annual Grid Reliability Performance Analysis and Report

Reliability Standards Analysis and Assessment

- **Objective:**

  Support the NERC committees/groups (Resource Subcommittee and RS-Frequency Working Group) in the following ways:

  - Perform grid reliability metrics analysis using data collected in CERTS applications as requested by the RS
  - Analyze collected data to assess reliability performance at different levels – Interconnection, Reliability Coordinator, Balancing Authority
  - Perform analysis, testing, and monitoring of current and proposed reliability standards

Reliability Standards Analysis and Assessment

Major technical accomplishments that will be completed this year:

- **Frequency Response Event Collection and Analysis**
  - Continue to use the delta frequency methodology and the appropriate thresholds to detect, capture, and analyze significant frequency events and related metrics in support of NERC Frequency Response Standards development
- **NERC Interconnections 2011 Annual Grid Reliability Performance Analysis and Report**
  - Analyze 2011 Load-Generation control performance metrics for the Eastern, WECC, and ERCOT interconnections, and prepare report for the Resource Subcommittee

Frequency Response Event Collection and Analysis

Background

- Frequency Response is a measure of an Interconnection's ability to stabilize frequency immediately following the sudden loss of generation or load. It is a critical component to the reliable operation of the bulk power system, particularly during disturbances and restoration.
- The NERC Resources Subcommittee (RS) has been concerned with the trend in Frequency Response, particularly in the Eastern Interconnection, for several years. The RS initiated the Standards Authorization Request (SAR) for BAL-003 to put a measurement process in place so the adequacy of Frequency Response and the underlying issues can be objectively analyzed to enable informed decisions.
- In support of the NERC Resource Subcommittee (RS) for the implementation of Reliability Standard BAL-003, a frequency event identification methodology and criteria were researched and defined by CERTS-EPG for capturing significant frequency events for all NERC interconnections.
- NERC-RS requested EPG to use the defined methodology and 1-second Phasor data to identify, capture, analyze, and report all significant frequency events for all NERC interconnections; and, submit the captured events with corresponding plots to the RS Frequency Working Group on a monthly basis for selection as final candidate events that BAs will use to measure their yearly Frequency Response performance.

Frequency Response Event Collection and Analysis

Method of Analysis:

- *Delta Frequency Event Detection Methodology* - A frequency event is detected and captured if, during a 15-second rolling time window, the change in frequency exceeds the predetermined threshold (see following slide)
- All detected events and data are captured and analyzed to ensure data validity (see following sample data summary sheet)
- The loss of generation/load and the Frequency Response for the events are calculated using the following formula:

  Loss of generation/load (MW):

  MWLoss = Max(DeltaACE(BA))-Const*10*FreqBias*DeltaFreq

  Where the Constants are: EI & WECC = 0.6; ERCOT = 0.3; HQ = 0.1

  Frequency Response:

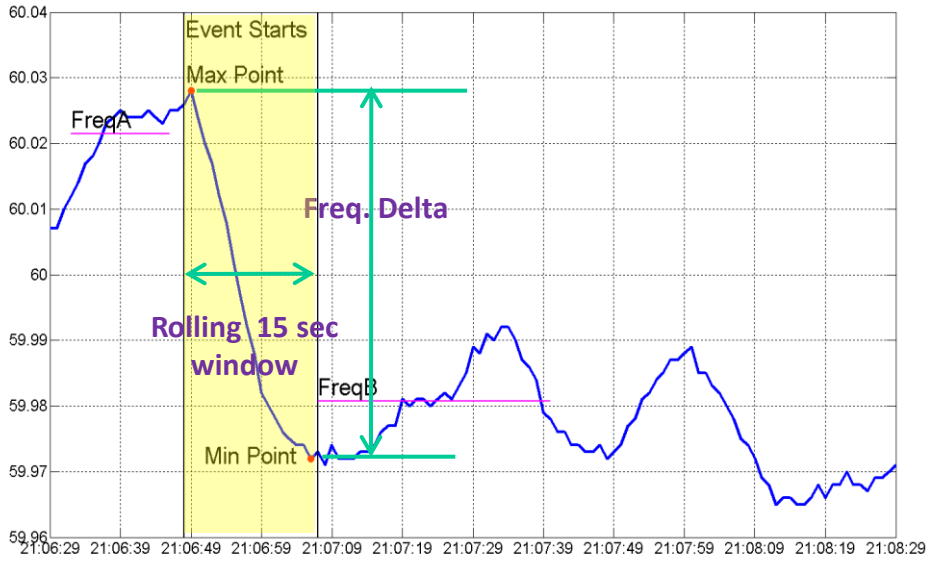
  Frequency Response = MWLoss/10*DeltaFreq

- Each event is presented in a frequency plot with all pertinent values related to the event identified and labeled (see following sample plot)

Frequency Event Detection Methodology

- **Delta Frequency Detection Methodology:**

  A frequency event is detected and captured if, during a 15-second rolling time window, the change frequency exceeds the established frequency threshold. The threshold for each Interconnection is shown in the table. The thresholds are being monitored and tuned to ensure the appropriate significant events are captured.



Delta Methodology		
Interconnections	Freq. Delta for Significant Events Identified with (mHz)	Time Window (second)
Eastern	40	15
Western	70	15
ERCOT	90	15
Quebec	300	15

Sample Frequency Event Data Sheet

NERC INTERCONNECTIONS APRIL, 2012 FREQUENCY EVENTS – SUMMARY DATA

EASTERN

Event Time				Event Frequency Data						Interconnection	CERTS	NERC-SA
UTC (t-0) Date / Time (MM/DD/YY HH:MM:SS)	Local Time (t-0) Date / Time (MM/DD/YY HH:MM:SS)	Day	Time Zone Pull Dn	A Value Freq Error (from 60)	A Value (t-16 to t-0) average	B Value (t+20 to t+52) average	Hz Delta B-A	Point C (w/in 8 sec after t-0)	delta from A_{ave}	Bias Setting MW/0.1 Hz	Estimated Loss MW	Estimated Loss MW
04/01/2012 4:00:19	04/01/2012 0:00:19	Sun	EDT	0.009	60.009	59.952	-0.057	59.971	-0.038	6349	656	1000
04/05/2012 0:03:15	04/04/2012 20:03:15	Wed	EDT	0.008	60.008	59.944	-0.065	59.954	-0.054	6349	967	1129
04/14/2012 17:46:50	04/14/2012 13:46:50	Sat	EDT	0.010	60.010	59.940	-0.069	59.937	-0.073	6349	1079	1800
04/16/2012 11:17:10	04/16/2012 7:17:10	Mon	EDT	-0.027	59.973	59.933	-0.041	59.937	-0.036	6349	1443	1040
04/27/2012 12:19:33	04/27/2012 8:19:33	Fri	EDT	0.026	60.026	59.971	-0.055	59.988	-0.038	6349	799	NA
04/30/2012 14:02:41	04/30/2012 10:02:41	Mon	EDT	-0.004	59.996	59.939	-0.057	59.939	-0.057	6349	1855	1237
05/01/2012 3:27:27	04/30/2012 23:27:27	Mon	EDT	0.023	60.023	59.976	-0.047	59.979	-0.044	6349	1142	NA

WESTERN

Event Time				Event Frequency Data						Interconnection	CERTS	NERC-SA
UTC (t-0) Date / Time (MM/DD/YY HH:MM:SS)	Local Time (t-0) Date / Time (MM/DD/YY HH:MM:SS)	Day	Time Zone Pull Dn	A Value Freq Error (from 60)	A Value (t-16 to t-0) average	B Value (t+20 to t+52) average	Hz Delta B-A	Point C (w/in 8 sec after t-0)	delta from A_{ave}	Bias Setting MW/0.1 Hz	Estimated Loss MW	Estimated Loss MW
04/03/2012 17:26:01	04/03/2012 10:26:01	Tue	PDT	-0.014	59.986	59.946	-0.040	59.916	-0.070	2024	438	NA
04/04/2012 16:25:09	04/04/2012 9:25:09	Wed	PDT	0.014	60.014	59.953	-0.061	59.921	-0.093	2024	323	789
04/06/2012 16:38:18	04/06/2012 9:38:18	Fri	PDT	0.024	60.024	59.930	-0.095	59.870	-0.155	2024	820	1400
04/11/2012 14:54:44	04/11/2012 7:54:44	Wed	PDT	-0.022	59.978	59.936	-0.042	59.914	-0.064	2024	633	NA
04/12/2012 14:08:34	04/12/2012 7:08:34	Thu	PDT	0.013	60.013	59.966	-0.047	59.945	-0.068	2024	390	NA
04/20/2012 22:36:51	04/20/2012 15:36:51	Fri	PDT	0.037	60.037	59.912	-0.125	59.848	-0.189	2024	1022	NA

ERCOT

Event Time				Event Frequency Data						Interconnection	CERTS	NERC-SA
UTC (t-0) Date / Time (MM/DD/YY HH:MM:SS)	Local Time (t-0) Date / Time (MM/DD/YY HH:MM:SS)	Day	Time Zone Pull Dn	A Value Freq Error (from 60)	A Value (t-16 to t-0) average	B Value (t+20 to t+52) average	Hz Delta B-A	Point C (w/in 8 sec after t-0)	delta from A_{ave}	Bias Setting MW/0.1 Hz	Estimated Loss MW	Estimated Loss MW
04/02/2012 22:54:33	04/02/2012 17:54:33	Mon	CDT	0.004	60.004	59.862	-0.142	59.842	-0.162	653	2139	850
04/03/2012 7:07:47	04/03/2012 2:07:47	Tue	CDT	0.012	60.012	59.898	-0.114	59.874	-0.138	653	1558	NA
04/04/2012 10:16:20	04/04/2012 5:16:20	Wed	CDT	0.029	60.029	59.955	-0.074	59.947	-0.083	653	590	NA
04/04/2012 12:17:27	04/04/2012 7:17:27	Wed	CDT	-0.012	59.988	59.850	-0.137	59.833	-0.155	653	1558	NA
04/07/2012 16:02:38	04/07/2012 11:02:38	Sat	CDT	0.014	60.014	59.936	-0.078	59.926	-0.088	653	583	NA
04/18/2012 13:16:08	04/18/2012 8:16:08	Wed	CDT	-0.004	59.996	59.935	-0.061	59.890	-0.106	653	689	NA
04/19/2012 21:08:31	04/19/2012 16:08:31	Thu	CDT	-0.018	59.982	59.914	-0.067	59.890	-0.091	653	667	NA
04/20/2012 3:41:14	04/19/2012 22:41:14	Thu	CDT	0.021	60.021	59.946	-0.074	59.930	-0.091	653	562	NA
04/23/2012 1:17:01	04/22/2012 20:17:01	Sun	CDT	0.021	60.021	59.946	-0.075	59.923	-0.098	653	791	NA
04/29/2012 0:56:35	04/28/2012 19:56:35	Sat	CDT	0.000	60.000	59.921	-0.079	59.907	-0.093	653	653	NA

HYDRO QUEBEC

Event Time				Event Frequency Data						Interconnection	CERTS	NERC-SA
UTC (t-0) Date / Time (MM/DD/YY HH:MM:SS)	Local Time (t-0) Date / Time (MM/DD/YY HH:MM:SS)	Day	Time Zone Pull Dn	A Value Freq Error (from 60)	A Value (t-16 to t-0) average	B Value (t+20 to t+52) average	Hz Delta B-A	Point C (w/in 8 sec after t-0)	delta from A_{ave}	Bias Setting MW/0.1 Hz	Estimated Loss MW	Estimated Loss MW
04/12/2012 17:12:52	04/12/2012 13:12:52	Thu	EDT	-0.017	59.983	60.105	0.122	60.455	0.472	420	-489	NA
04/23/2012 12:27:24	04/23/2012 8:27:24	Mon	EDT	0.004	60.004	59.940	-0.064	59.690	-0.314	420	366	NA

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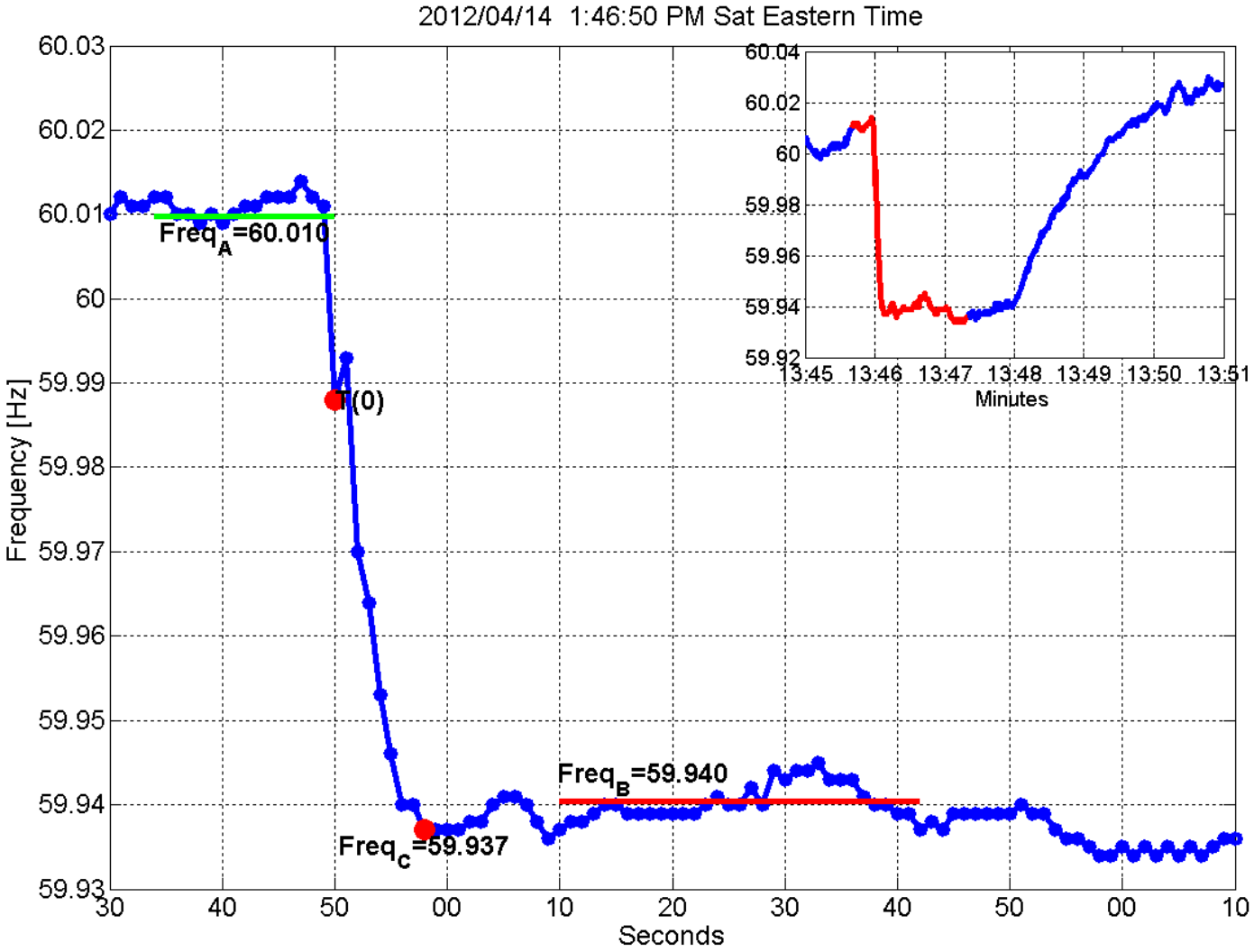
Page 7

Sample Frequency Event Plot



Frequency Response Event Collection and Analysis

Results and Conclusion:

- A monthly report summarizing the frequency events collected with the corresponding plots is prepared, analyzed and submitted to the NERC RS-FWG
- These monthly summary reports are posted at the NERC RS website under "Candidate Frequency Events".
- The NERC RS-FWG reviews the submitted summary reports at their Quarterly meetings and jointly select the final candidate events that BAs will use to measure their yearly Frequency Response performance.
- The current process and methodology have been accepted and approved by the NERC RS as being effective in identifying candidate events for the implementation of Reliability Standard BAL-003

Next Steps:

- EPG will continue to work closely with CERTS and the NERC RS-FWG to detect, capture and analyze all significant frequency events for all interconnections
- The current methodology and thresholds will continued to be monitored and refined/modified as necessary

EPG wants to acknowledge the collaborative effort of Mr. Carlos Martinez at Advanced Systems Researchers in the preparation and production of the monthly summary reports

NERC Interconnections 2011 Annual Reliability Performance Analysis

Background

- Currently EPG uses the NERC ACE and Frequency data to generate and distribute an automated Interconnections Daily Reliability Report to the FERC/NERC authorized users
- On an annual basis, EPG uses the same NERC ACE and Frequency data to analyze several key grid reliability metrics and prepare a grid performance summary report for submittal to the NERC Resource Subcommittee for their review and assessment of the reliability performance at the interconnection level

NERC Interconnections 2011 Annual Reliability Performance Analysis

Method of Analysis:

- The following reliability metrics were analyzed for the year 2011 and compared to the previous years to determine the trends and level of performance at the interconnection level.
  - Control Performance Metrics (Load-Generation Resource Adequacy)
    - CPS1 and CPS2 (Primary Control Performance)
      - CPS1 threshold: >100% compliance
      - CPS2 threshold: >90% compliance
    - Epsilon (Secondary Control Performance)
      - Thresholds: Eastern: 18 mHz; Western: 23 mHz; ERCOT: 30 mHz
  - Frequency Performance During Morning/Evening Peaks
  - Frequency/Load Events
    - Number of events with 1-minute frequency delta exceeding the following thresholds:
      - Eastern and Western Interconnections: 35 mHz
      - ERCOT Interconnection: 70 mHz
  - FTL (Frequency Trigger Alarms)
    - Number of Events when Frequency > FTL Low/High Limits:
      - FTL High Limit: Eastern – 60.05 Hz; Western – 60.07 Hz; ERCOT – 60.068 Hz
      - FTL Low Limit: Eastern – 59.95 Hz; Western – 59.93 Hz; ERCOT – 59.932 Hz

NERC Interconnections 2011 Annual Reliability Performance Analysis

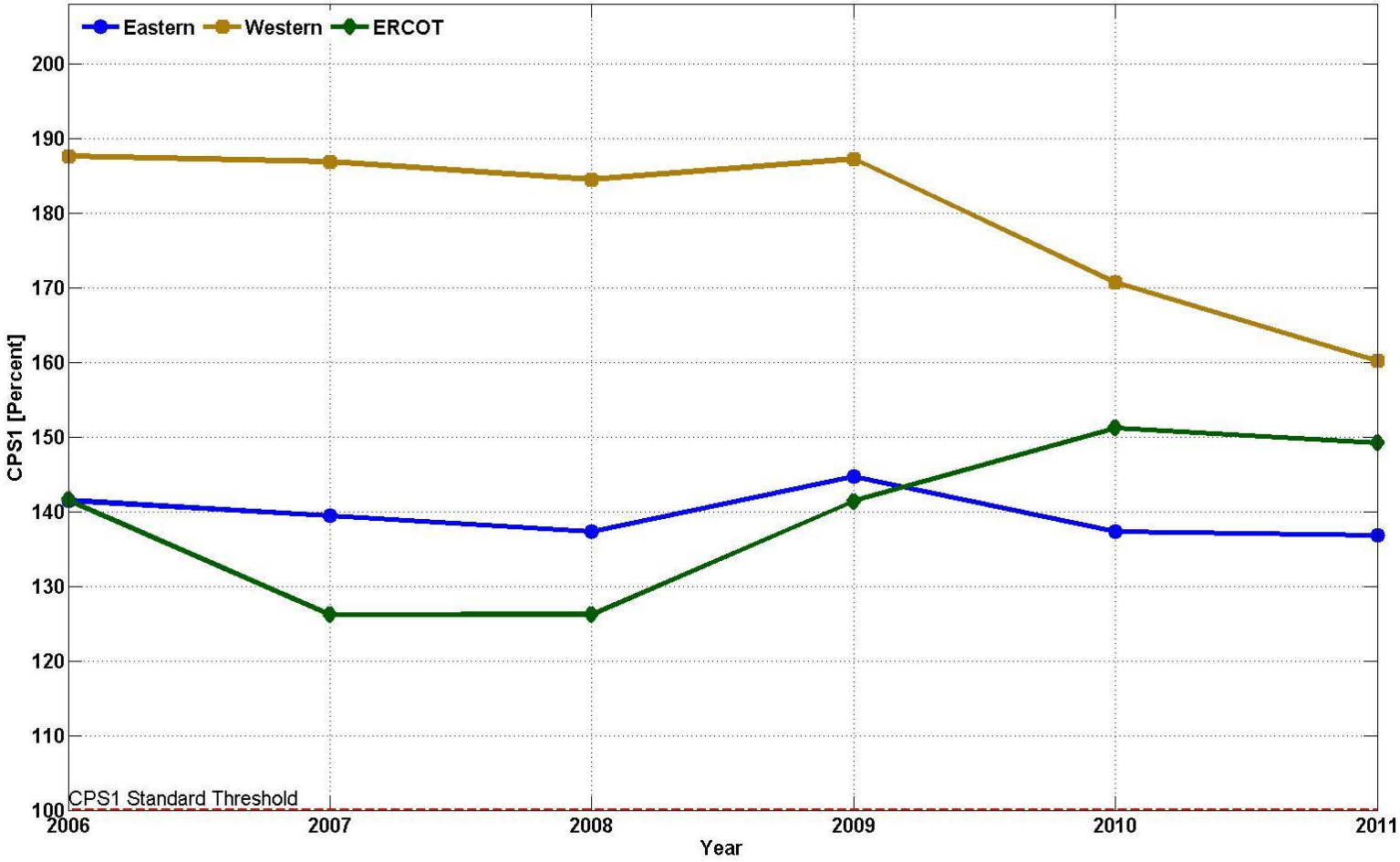
Results and Conclusion:

- Control Performance Metrics:
  - Interconnections CPS1 and CPS2 Trend:
    - All three Interconnections operated above CPS1 threshold
    - Eastern and Western operated below CPS2 threshold; ERCOT operated above CPS2 threshold
    - Graph for 6 years attached
  - Epsilon Performance:
    - All 3 interconnections operated within their thresholds but showed a slight increasing trend
- Frequency Performance During Morning/Evening Peaks
  - Western – Lowest and highest frequencies increased (see following slide)
  - Eastern – No noticeable changes
  - ERCOT – Lowest and highest frequencies decreased
- Frequency/Load Events (see following slide)
  - Number of events exceeding the thresholds decreased between 2011 & 2010 for Western and ERCOT
  - Number of events exceeding the thresholds increased for the Eastern for the last 3 years
- FTL (Frequency Trigger Alarms)
  - Number of Events when Frequency > FTL Low/High Limits (see following slide):
    - FTL Low limit - Eastern and Western decreased from 2010; ERCOT increased from 2010
    - FTL High limit – Eastern and ERCOT decreased from 2010; Western increased from 2010

Next Steps:

- Submitted Report with summary analysis to RS
- Continue to monitor and perform interconnection reliability performance analysis and present results to the RS

Interconnections CPS1 6-Year Trend



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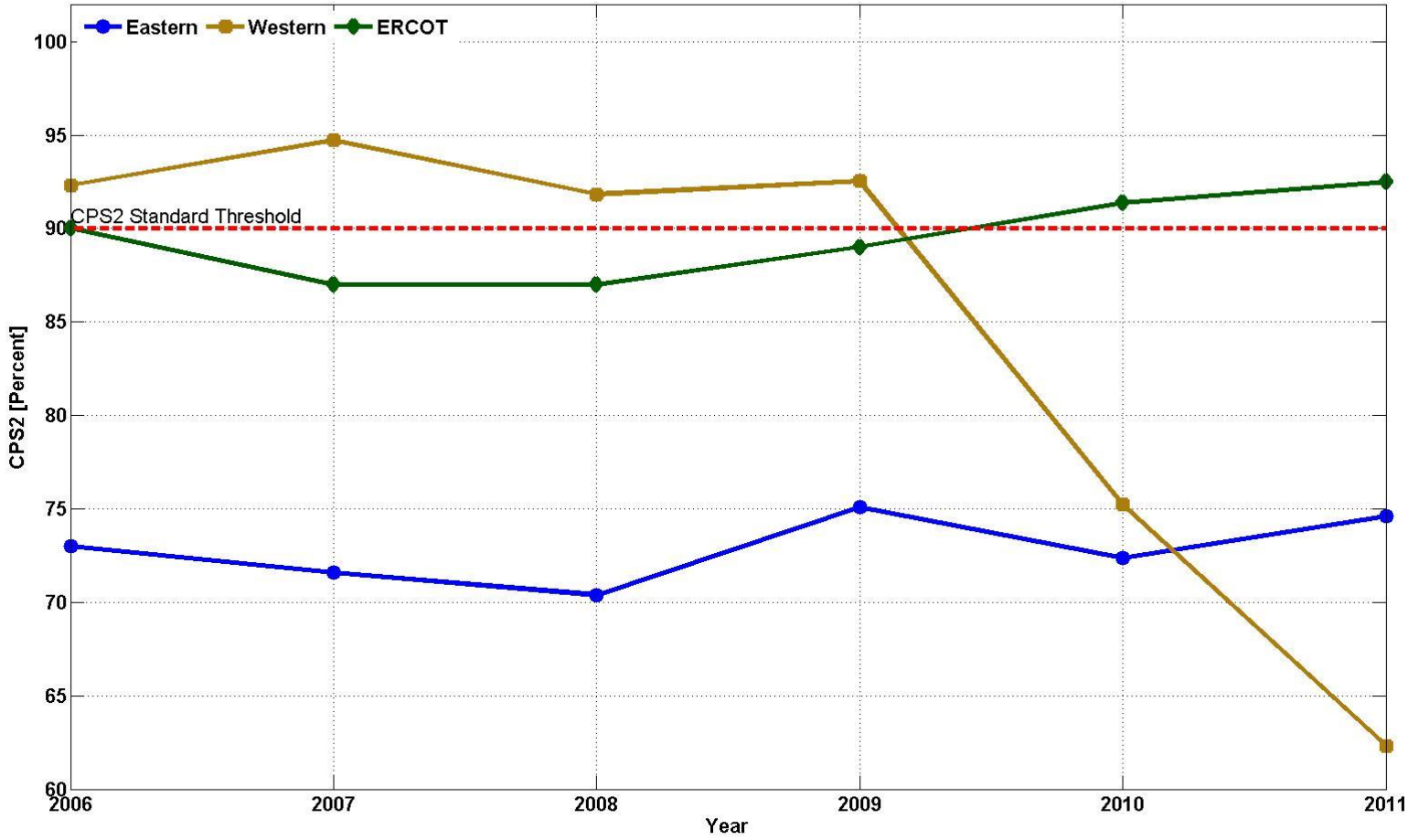
Interconnections CPS2 6-Year Trend



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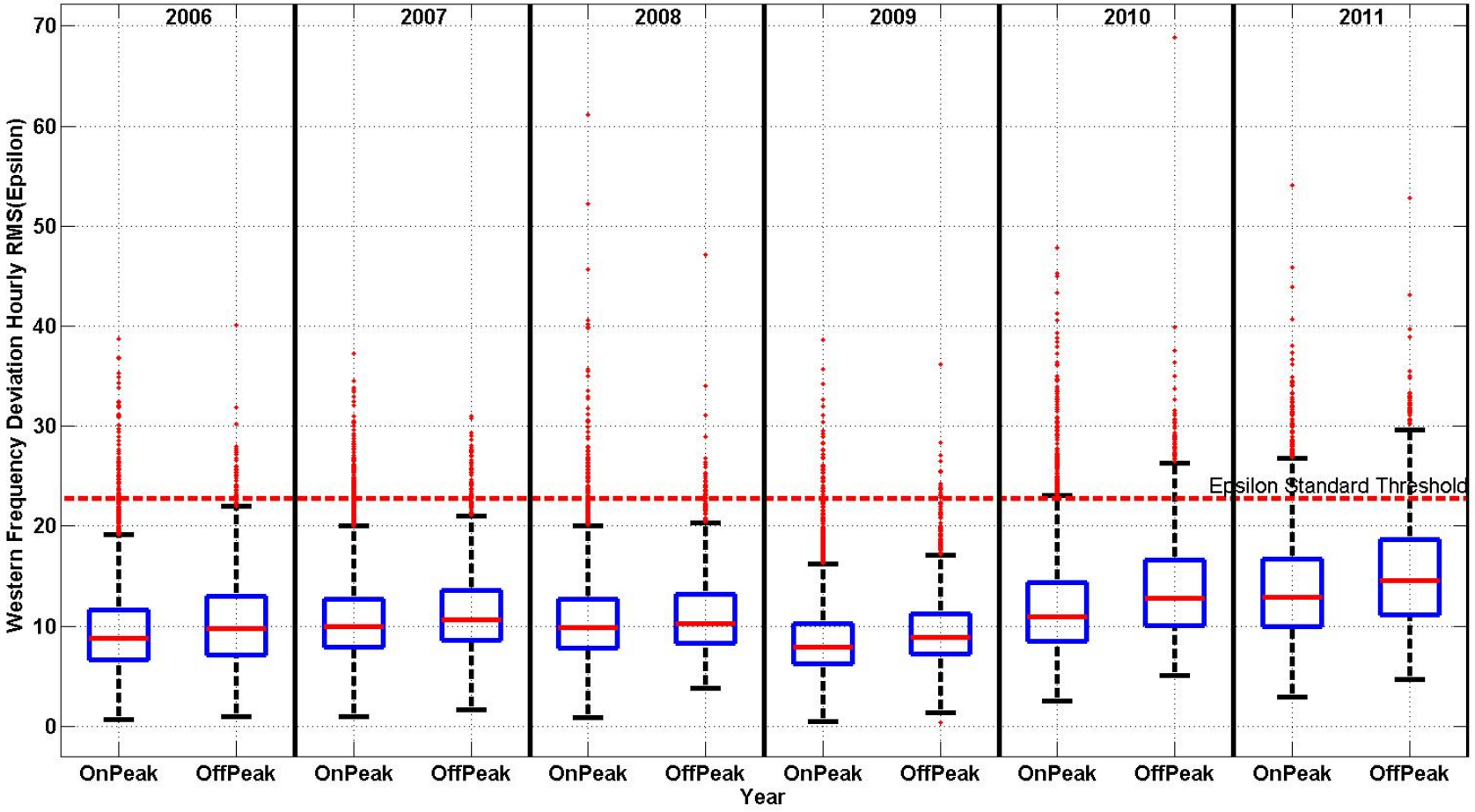
Interconnections Epsilon 6-Year Trend



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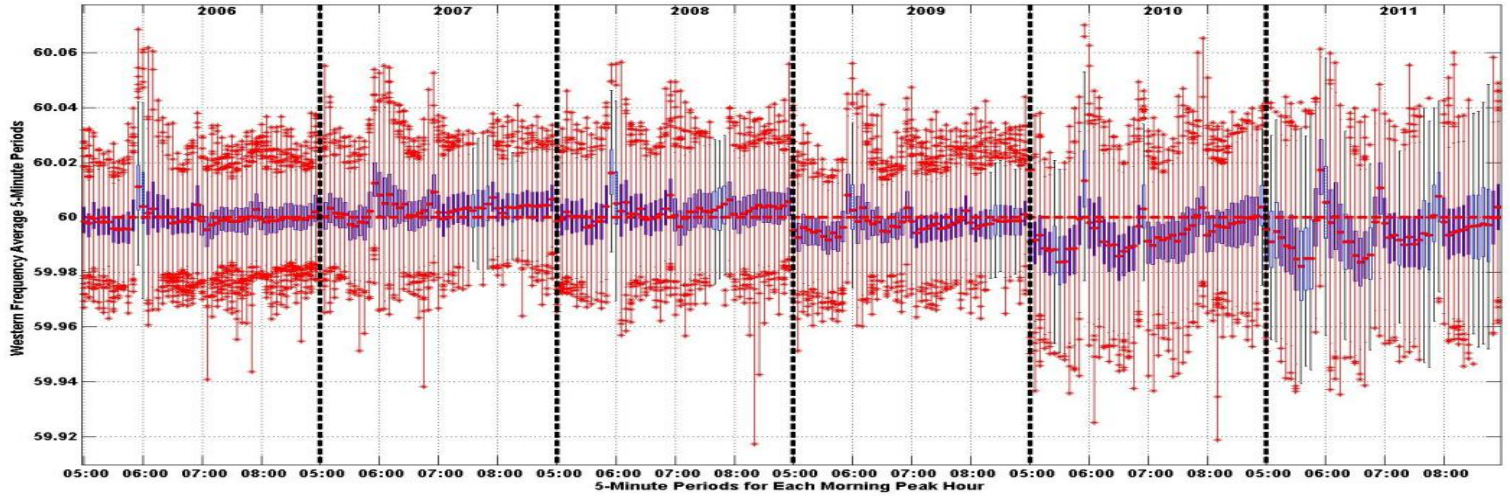
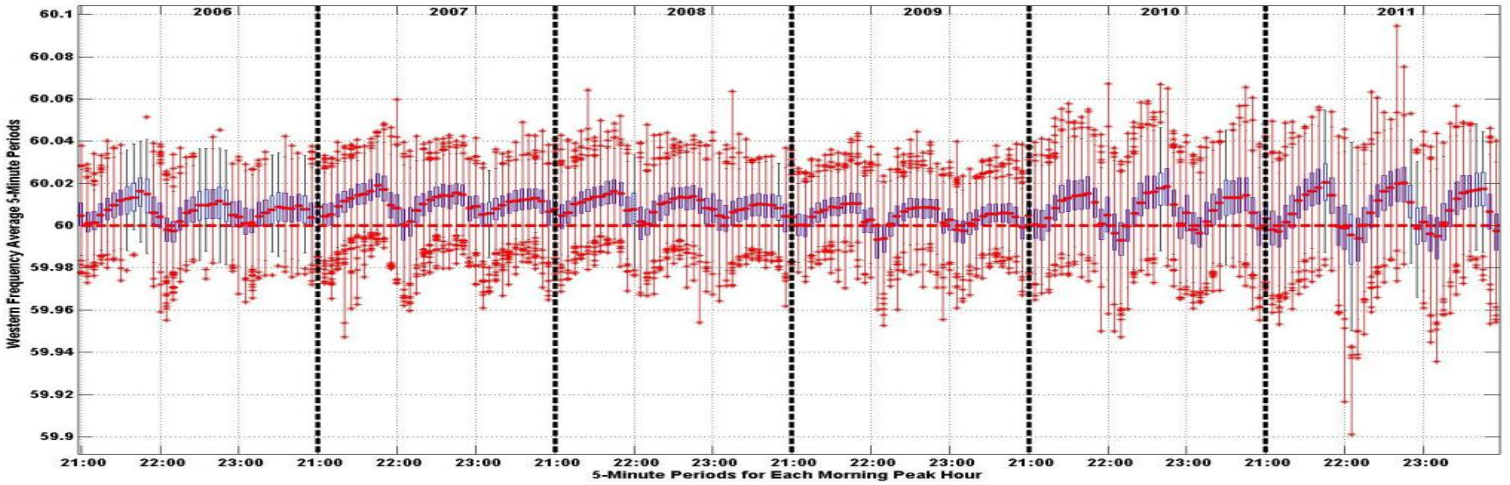
Frequency Performance During Morning/Evening Peaks





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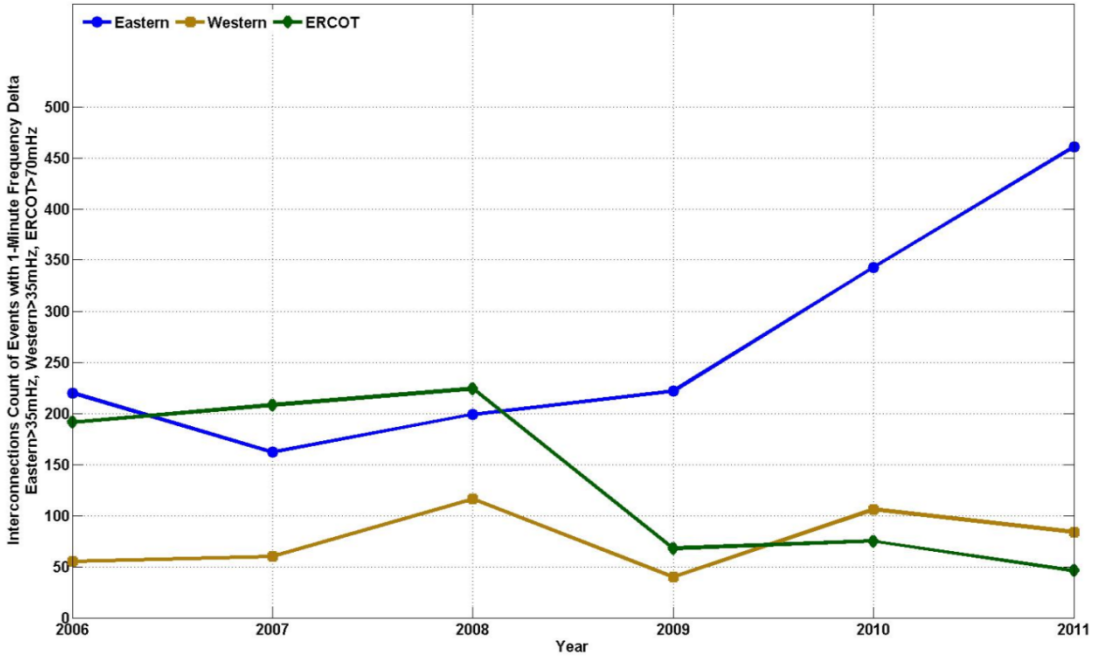
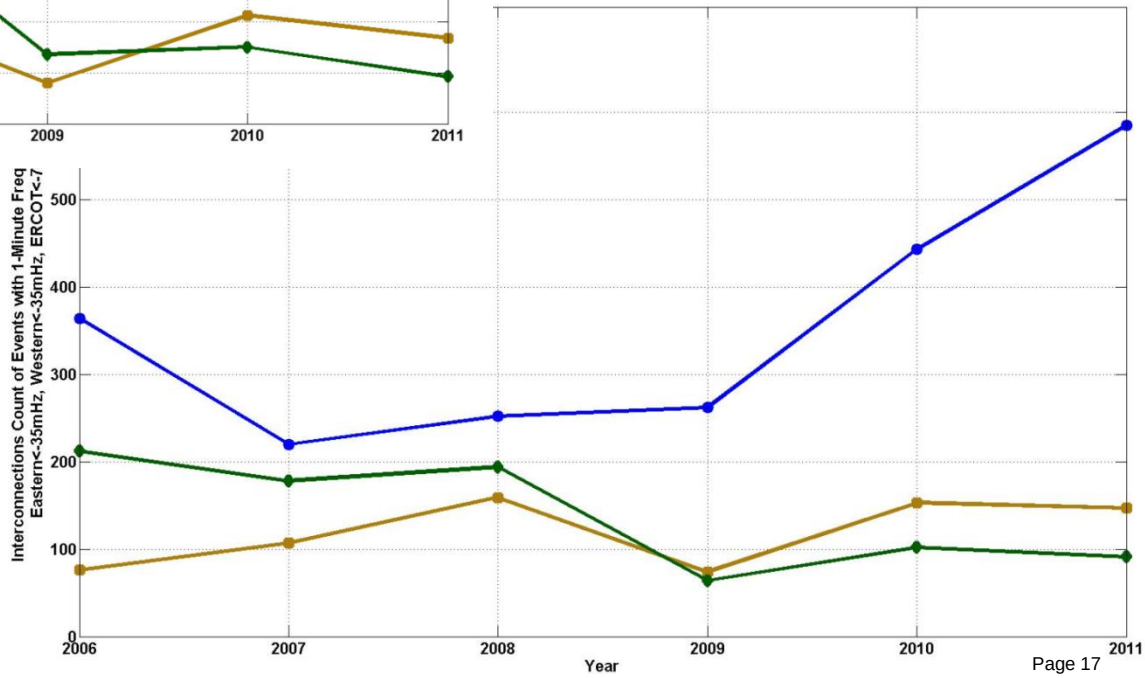
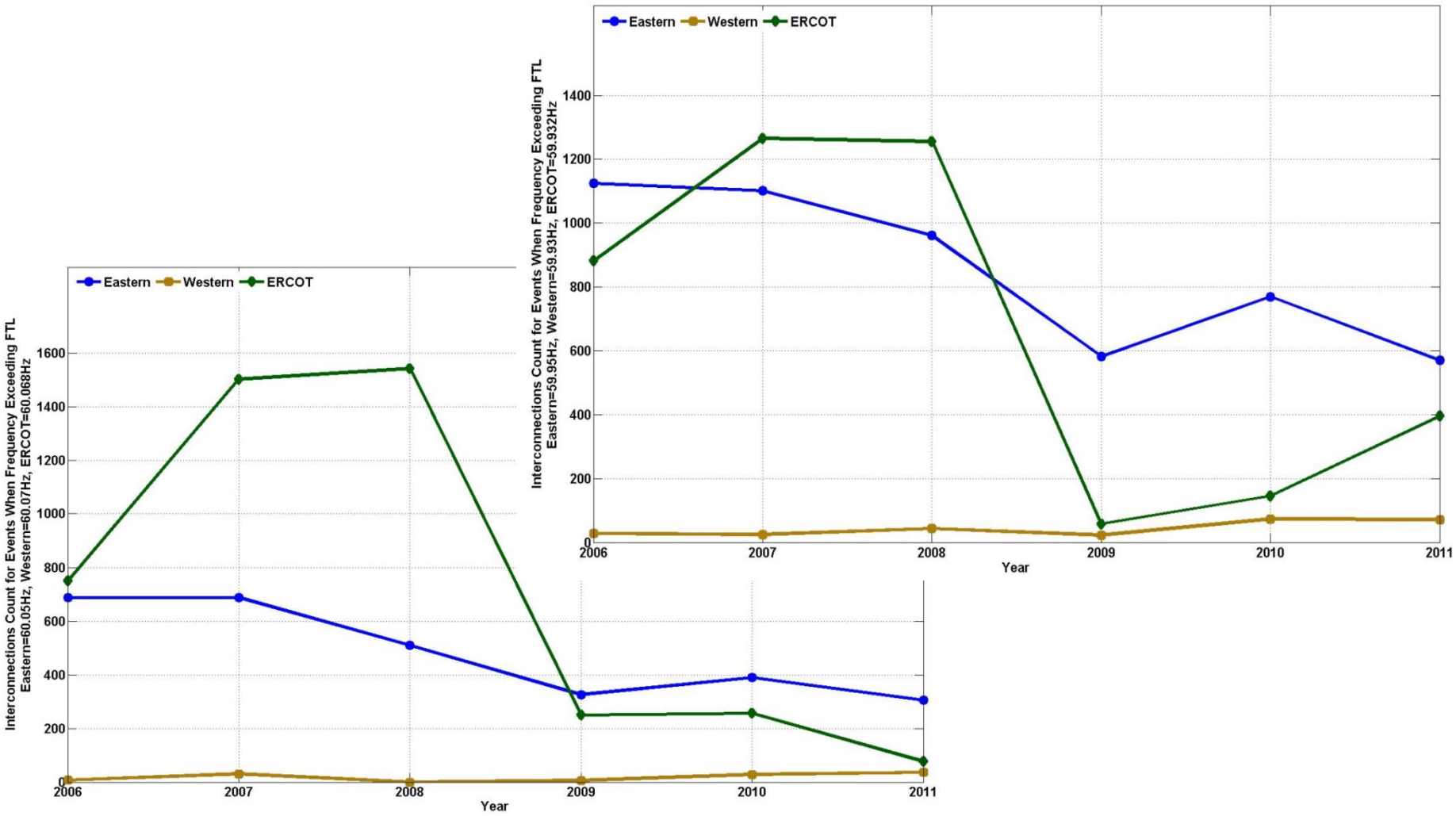
Frequency Events Exceeding the Thresholds





Frequency Trigger Alarms Trend



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Summary

Accomplishments:

- **Frequency Response Event Collection and Analysis**
  - EPG has effectively detected, captured, and analyzed all candidate frequency events for the NERC RS in support of the implementation of Reliability Standard BAL-003
- **NERC Interconnections 2011 Annual Reliability Performance Analysis & Report**
  - The 2011 Annual Grid Reliability Performance Report for the Eastern, WECC, and ERCOT interconnections has been completed and submitted to the NERC Resource Subcommittee

Risks and Challenges:

- The ability to get quality data reliably
- Continue to gain the confidence of the electric industry experts in our ability to provide support on analysis and reporting in the development of grid reliability standards. We can accomplish this by continuing to work closely with NERC RS and the standards draft teams

Next Steps:

- DOE's continuing support of this activity is critical to continue to research and analyze reliability performance and proposed standards in light of changing resource mix, smart grid technologies, and integration of intermittent renewables.

Q & A

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