# DOE/OE Transmission Reliability Program

# Automatic Reliability Reports, Research and Implementation and Frequency Response Research and Analysis

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June 3-4, 2013
Washington, DC

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# Automatic Reliability Reports - GARR Project

- Field Test was on hold because of MISO other higher priorities
- University of Illinois continue with algorithms research, improvements, and validations
- Join meeting is set for July, 2014 for re-starting Field Test at MISO
- Review and deploy latest algorithms, visualization and automatic reports at MISO using their PMU data and infrastructure
- Execution of propose Field Test plan at MISO to get their feedback
- Risk - Additional Field Test delays because of MISO priorities

# Presentation Outline
# for Frequency Response Research & Analysis

- Overall Project Objectives
- Background, Frequency Response Reliability Issues, and Data Used
- Interconnections Frequency Response Trends: 1994-2008, 2009-2013
- Early Withdrawal of Primary Response, Reliability Impacts and sustainability performance Metrics
- Assessment of Statistical Methods for Estimating Interconnections Yearly Frequency Response.

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# Project Objectives

1. FY14 - Participation, research and support during NERC Frequency Response Standard Field Trial from 4Q2013 to 4Q2015 to validate, tune or propose modifications to standard parameters and processes

2. FY14 - Identify interconnections early withdrawal of Primary Frequency Response before Secondary Response, and research and define performance metrics for Primary Response Sustainability

3. FY14 - Research and evaluate statistical methods for grouping each interconnection yearly frequency events for estimating an adequate and industry acceptable estimate for Frequency Response

4. FY15 - Research and evaluate methods to estimate and define interconnections yearly Frequency Response Obligations (IFRO).

5. FY15 - Research to identify and measure interconnections interactions between Primary, Secondary and Tertiary Frequency Responses

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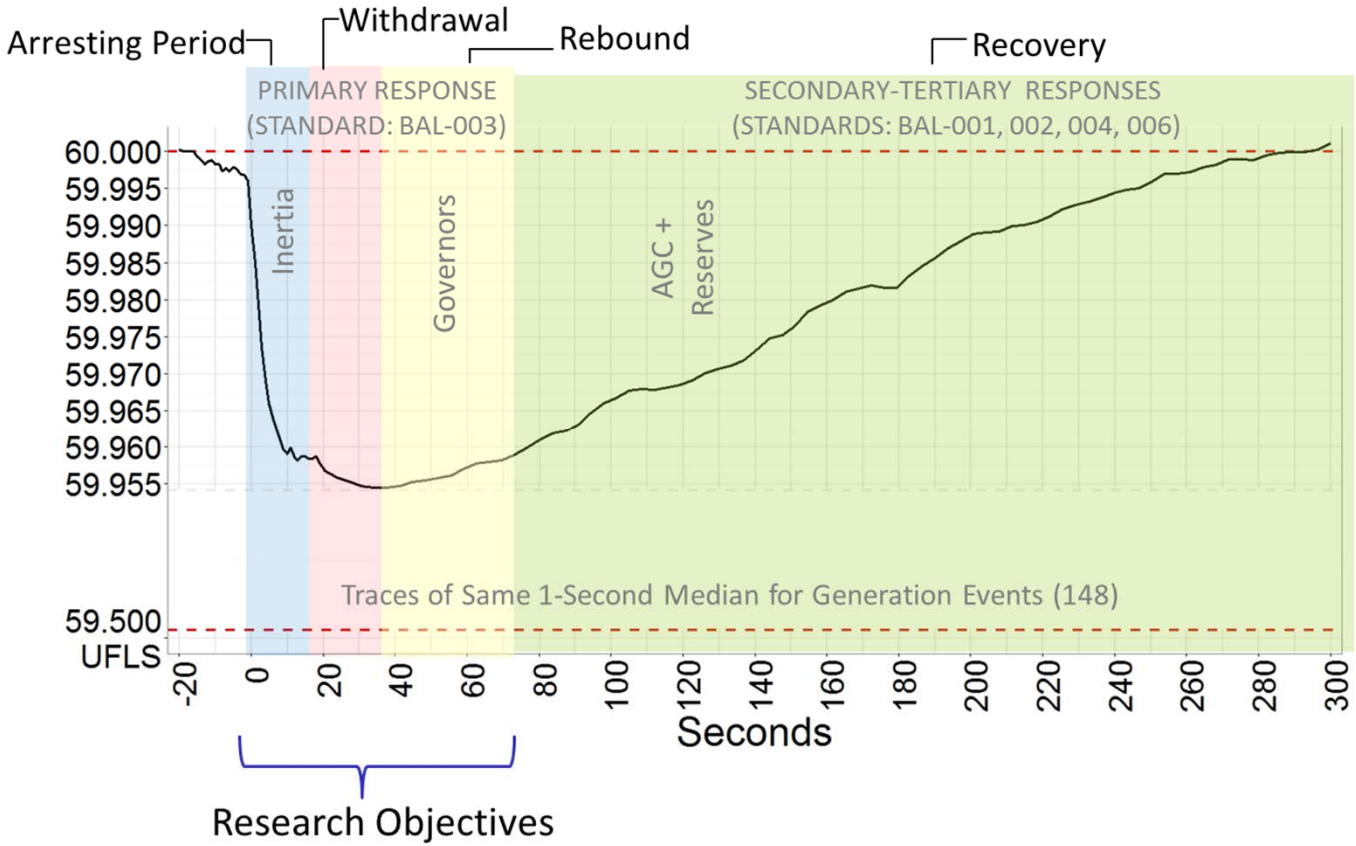
# Background and Field Trial Data Used




| Intercon | Eastern | | | | | Western | | | | | ERCOT | | | | | Quebec I. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | 2013 | 2012 | 2011 | 2010 | 2009 | 2013 | 2012 | 2011 | 2010 | 2009 | 2013 | 2012 | 2011 | 2010 | 2009 | 2013 | 2012 | 2011 |
| **Events** | 177 | 68 | 114 | 139 | 72 | 61 | 69 | 64 | 84 | 72 | 94 | 74 | 101 | 123 | 80 | 90 | 57 | 145 |

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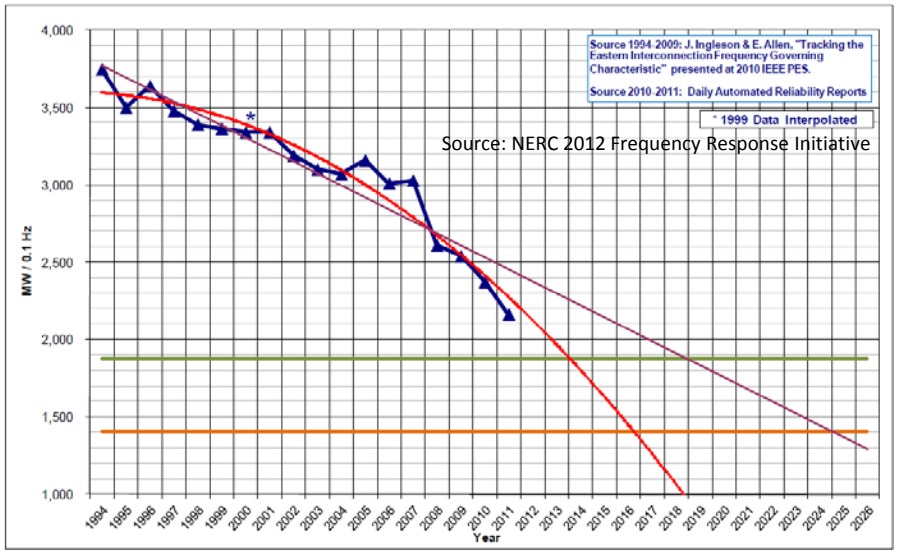
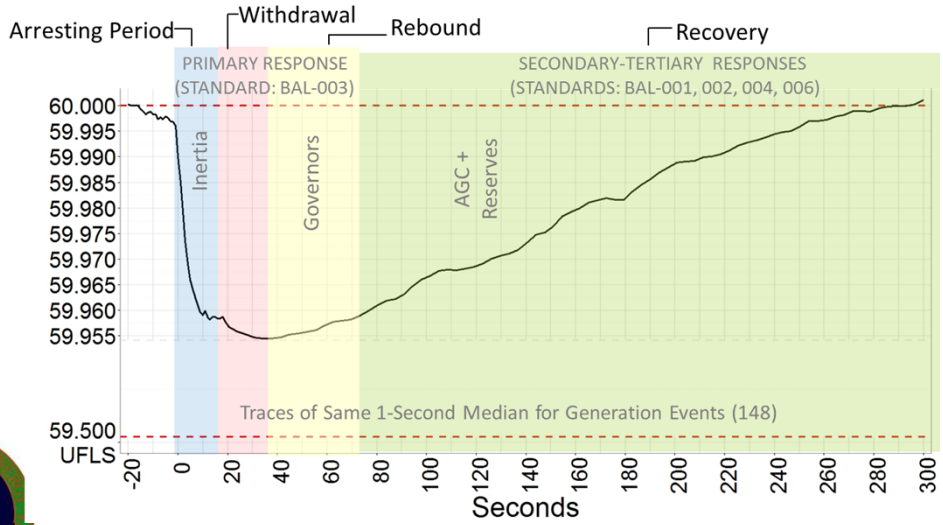
# Primary Frequency Response Reliability Issues




**Primary Frequency Response Reliability Issues:**

- Decline of interconnections Frequency Response since 1994
- Impact on Frequency Response of intermittent renewables integration
- Impact on Reliability of early withdrawal of Primary Frequency Response (sustainability)

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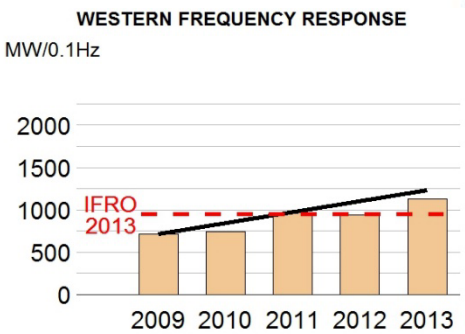
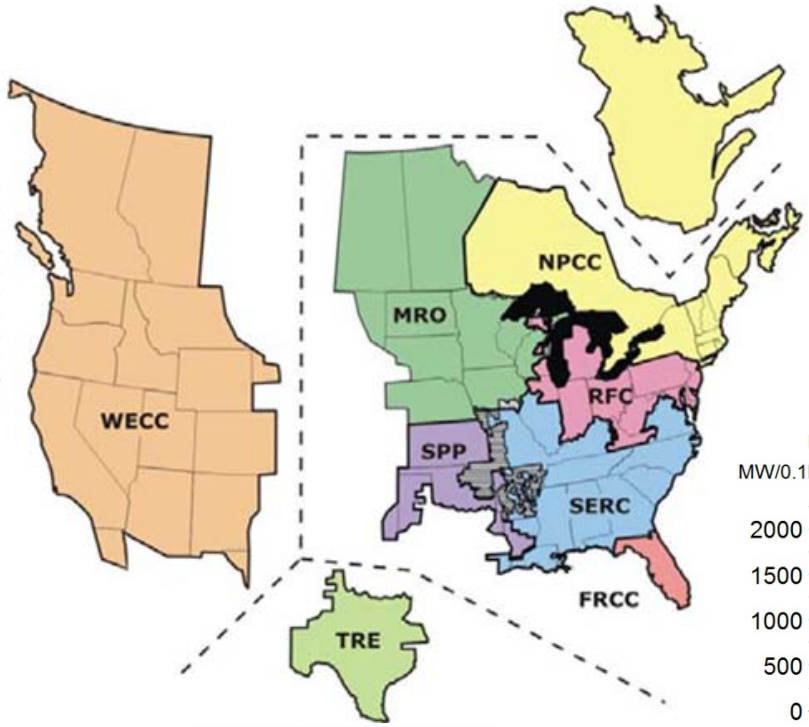
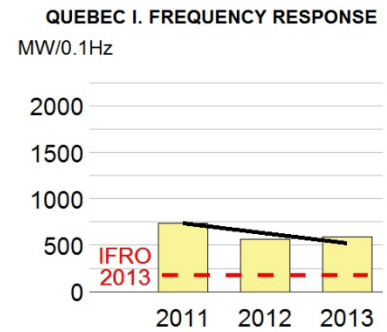
# Interconnections 2009-2013 Frequency Response Trends During BAL-003 Field Trial

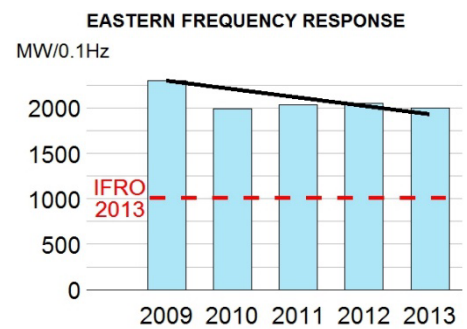



Rate per Year= 104 MW/0.1Hz



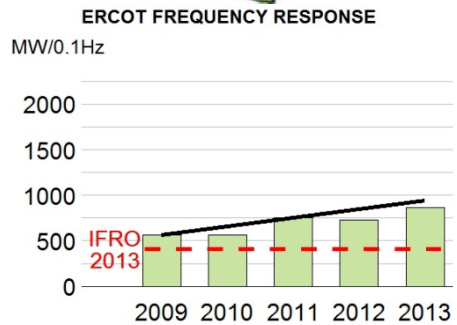




Rate per Year= -69 MW/0.1Hz




Rate per Year= -74 MW/0.1Hz

| FREQUENCY RESPONSE (FR) YEARLY RATES 1994-2008 and 2009-2013 | | |
|---|---|---|
| Intercon. (Rate Change %) | FR Decline Rate 1994-2008 [MW/0.1Hz] Per Year | FR Rate 2009-2013 [MW/0.1Hz] Per Year |
| Eastern (12%) | -82 | -74 |
| Western (159%) | -61 | 104 |
| ERCOT (163%) | -48 | 76 |
| Quebec I. (NA) | NA | -69 |




Rate per Year= 76 MW/0.1Hz

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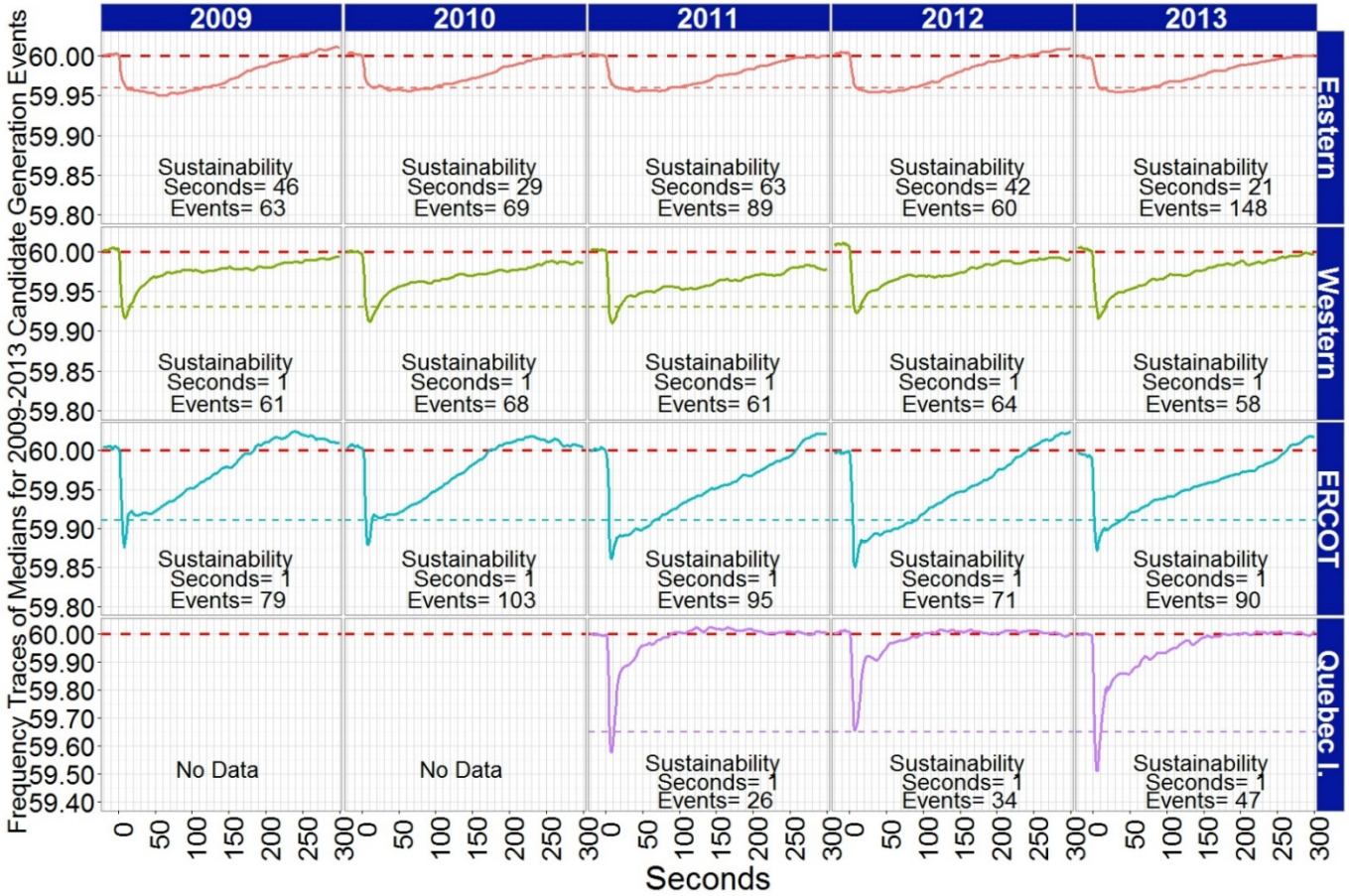
# Early Withdrawal of Primary Response, and Sustainability Performance Metrics (SM1, SM2)

# Interconnections Primary Response 2009 to 2013 Sustainability Condition Identification

**Sustainability Seconds:** Delay in seconds before generator governors start controlling




**Observation:** Eastern is the Only Area with Identifiable Sustainability Condition

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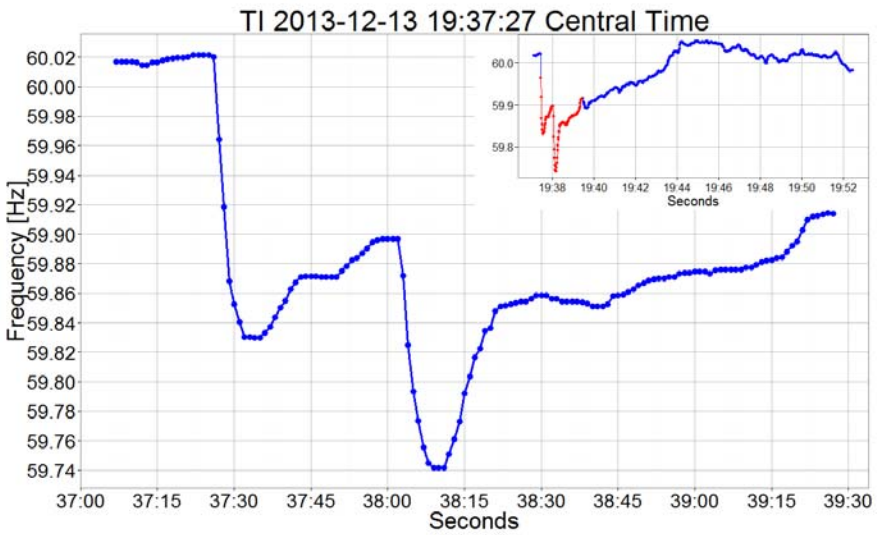
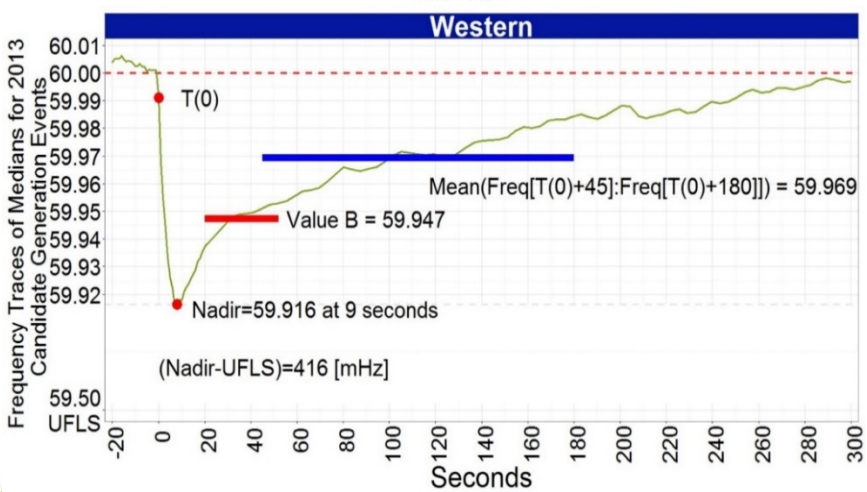
# Reliability Risks for Early Withdrawal and Sustainability Condition Identification Metric




**Risks for Early Withdrawal of Frequency Response:**

- Interconnections frequency could go closer to UFLS levels if consecutive events occur during periods of early withdrawal. For 2013 there were about 1 and 2 percent of events with consecutive events for ERCOT and Hydro Quebec respectively
- Early withdrawal could impact Secondary Response by extending the time for reaching pre-event frequencies within the 15-minutes require by BAL-002 (DCS)

**Sustainability Condition Identification Metric:**

$$\boldsymbol{SM_1 = Sustainability\ Metric \quad = Mean\left(Freq_{(T0+45)}\ to\ Freq_{(T0+180)}\right) - FreqValueB\ [mHz]}$$

(a negative $\boldsymbol{SM_1}$ metric could indicate early withdrawal of primary frequency response)

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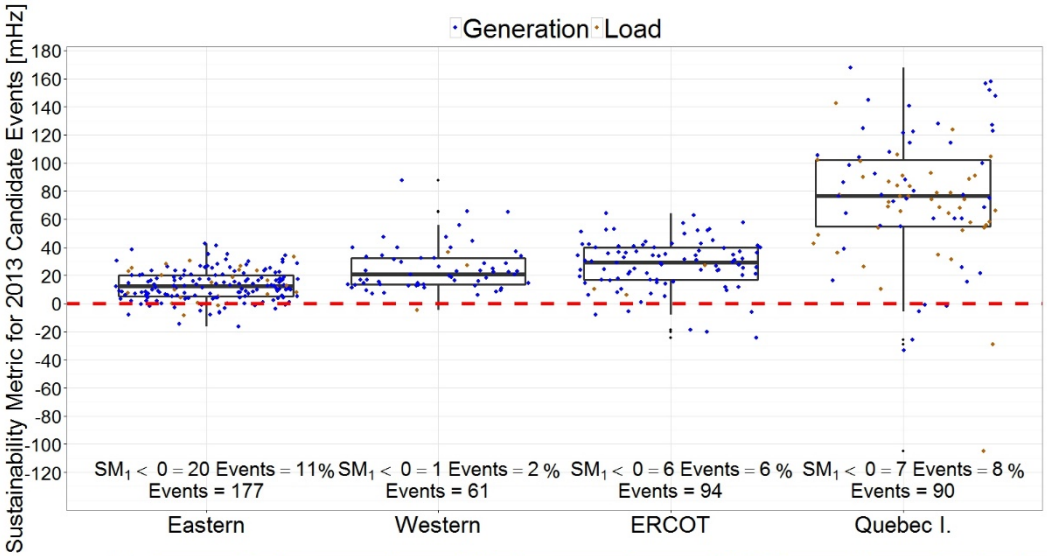
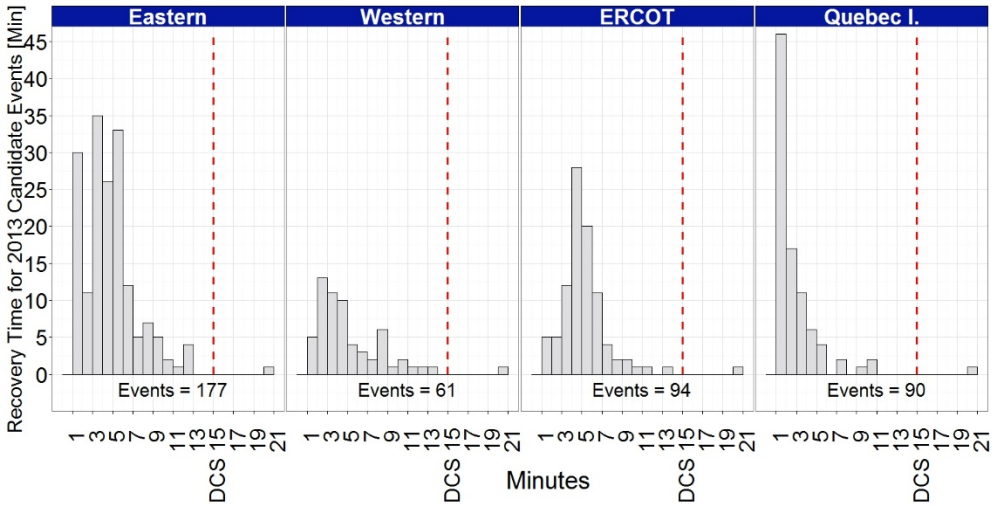
# 2013 Sustainability Metric (SM1) Statistics, and Impact on Frequency Recovery Time




## Sustainability Metric Statistics:

- 11, 2, 6, 8 percent of events show early withdrawal for E, W, T, Q
- Early withdrawal occur each time there are two consecutive events
- Lesser probability of early withdrawn conditions for smaller interconnections
- SM2 (Risk Metric) indicate higher reliability risk for smaller interconnections

## Impact on Freq. Recovery Time:

- Definition - Recovery Time, duration in minutes from start of event until frequency reaches pre-event frequency or 60.00 Hz
- For the majority of the events, all four interconnections recover frequency during the first 5 minutes
- Only about 2-4 percent of events recover
- Its frequency

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# FY14 Deliverables, Risk Factors, Follow-On Work

**FY14 Deliverables:**

- Final report for NERC Staff and Reliability Subcommittees including research results, validations, and recommendations for a metric indicating sustainability conditions (SM1), and a second metric indicating reliability risk (SM2) originated by sustainability conditions.
- Algorithms and associate database structures and software for real-time implementation of sustainability alarming and tracking

**Risk Factors:**

- Data quality and time skews between SCADA and Phasor data used, increases substantial development time for alignment and filtering
- Unreliable and inaccurate generation or load MW loss during frequency events, originates larger discrepancies and debates for assessing final results
- Delay from stakeholders feedback from review of preliminary report could delay deliverables

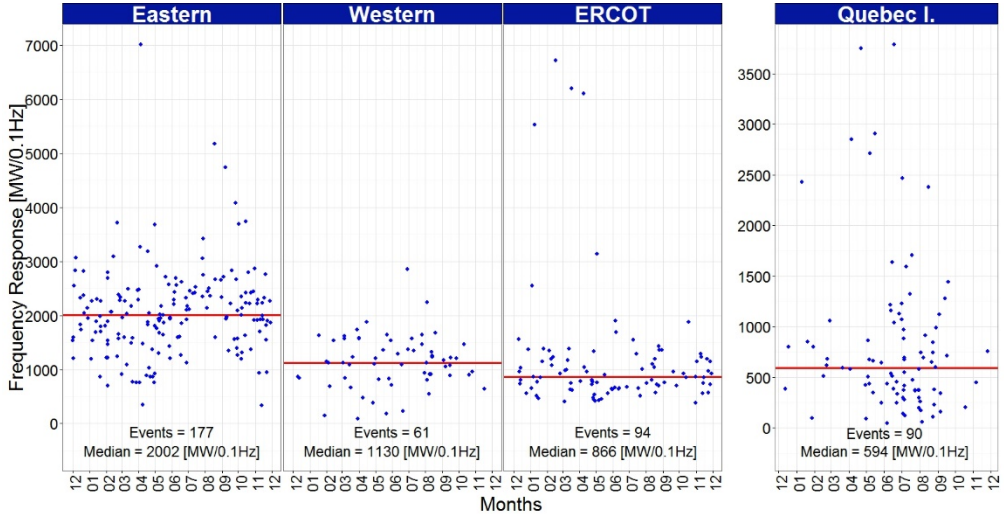
**Follow-on Work to Consider for FY15:**

This project will be completed during FY15. For completing the project we will:

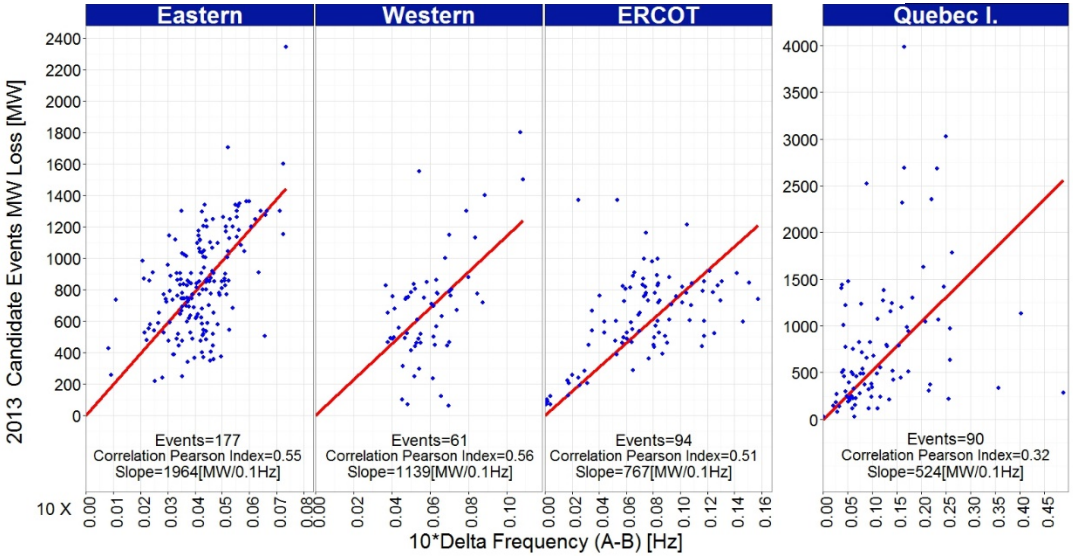
- Research and evaluate the risk for reaching UFLS under sustainability conditions, and identify and validate a corresponding performance metric
- Research, define and validate a composite sustainability performance metric including SM1 and SM2 and other risk metrics. Working jointly with NERC Staff and Reliability Subcommittees

# Research, Analysis and Evaluation of Statistical Methods for Estimating Interconnections Yearly Frequency Response

# Evaluation of Median and Regression Methods for Estimating 2013 Frequency Response




Median Frequency Response Evaluation




Regression Frequency Response Evaluation

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# Accuracy Comparison of Median-Regression Methods for Estimating Yearly Frequency Response

| Intercon. | Year | Frequency Response Estimation | | Methods' RMSE | | Pearson Correlation Index |
|---|---|---|---|---|---|---|
| | | Median [MW/0.1Hz] | Regression [MW/0.1Hz] | Median [MW/0.1Hz] | Regression [MW/0.1Hz] | |
| Eastern | 2013 | 2002 | 1964 | 827 | 831 | 0.55 |
| | 2012 | 2052 | 1856 | 744 | 742 | 0.45 |
| | 2011 | 2035 | 2090 | 674 | 668 | 0.57 |
| | 2010 | 1986 | 1970 | 777 | 778 | 0.56 |
| | 2009 | 2300 | 2278 | 626 | 625 | 0.63 |
| Western | 2013 | 1130 | 1139 | 492 | 492 | 0.56 |
| | 2012 | 941 | 936 | 588 | 589 | 0.47 |
| | 2011 | 970 | 1105 | 402 | 414 | 0.80 |
| | 2010 | 745 | 771 | 402 | 399 | 0.70 |
| | 2009 | 713 | 538 | 386 | 443 | 0.27 |
| ERCOT | 2013 | 866 | 767 | 1177 | 1207 | 0.51 |
| | 2012 | 728 | 730 | 820 | 820 | 0.25 |
| | 2011 | 755 | 717 | 349 | 354 | 0.59 |
| | 2010 | 562 | 559 | 160 | 160 | 0.76 |
| | 2009 | 564 | 437 | 163 | 202 | 0.71 |
| Quebec I. | 2013 | 594 | 524 | 799 | 821 | 0.32 |
| | 2012 | 560 | 423 | 962 | 1001 | 0.54 |
| | 2011 | 732 | 718 | 1082 | 1087 | 0.37 |

**Assessment and Recommendation:**

- The median shows the lowest RMSE for 13 of 18 Frequency Response estimates for all 2013 interconnection events
- Eastern and Western have a moderate MWLoss-Delta (A-B) correlation, ERCOT has moderate to weak correlation, and Hydro Quebec has very weak correlation
- Based on research results presented and because the median consistency and simplicity, is recommended continuing using the Median for estimating Frequency Response for BAL-003

**Convention:** Green color indicates the lowest RMSE. Red color indicates weak correlations

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# FY14 Deliverables, Risk Factors and Follow-On Work

**FY14 Deliverables:**

Final report for NERC Staff and Reliability Subcommittees including research results, validations, and recommendations for an accurate and appropriate statistical method for estimating interconnections and Balancing Authorities yearly Frequency Response for the BAL-003 standard.

**Risk Factors:**

- Data quality and time skews between SCADA and Phasor data used, increases substantial development time for alignment and filtering
- Unreliable and inaccurate generation or load MW loss during frequency events, originates larger discrepancies and debates for assessing final results
- Delay from stakeholders feedback from review of preliminary report could delay deliverables

**Follow-on Work to Consider for FY15:**

The project will be completed during FY15. For completing the project we will:

- Research and validate alternate methods for estimating interconnections and Balancing Authorities yearly Frequency Response Obligation (IFRO) for the BAL-003 standard
- Complete the research to identify and measure interconnections interactions between Primary, Secondary and Tertiary Frequency controls
- Compare the Median and Regression methods for estimating yearly Frequency Response with alternate methods such as: winsorized-mean, bootstrapping percentile 50, and trimean

# QUESTIONS
# and ANSWERS