NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Background: Industry Advisory

Reliability Risk — Interconnection Frequency Response – (Revision 1)

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NERC, working through the Resources Subcommittee, has identified a trend of natural interconnection frequency response deficiencies during the course of the last several years, as exhibited during multiple loss of resource (generation) events. These results reveal an ongoing trend with a potential for inherent risk and substantial consequences to the bulk power system (BPS). During analysis of these events, the balancing authorities (BAs) involved did not have adequate responsive resources with sufficient operating margins in service to arrest frequency decline at a more acceptable level. To promptly arrest system frequency decline following an event and to ensure reliable operations, each BA must provide primary frequency response from the generation and dispatch levels it scheduled for the loss of generation (or other significant changes resulting in change in frequency) anywhere in the interconnection.

Trends in frequency response of the Eastern Interconnection demonstrate the decline in performance and the associated reliability risk. Figure 1 shows the decline from 1994 through 1998[1]; Figure 2 shows more recent yearly trending. Individual events during load ramping have resulted in Eastern Interconnection Frequency Response less than 1,000 MW/0.1 Hz.

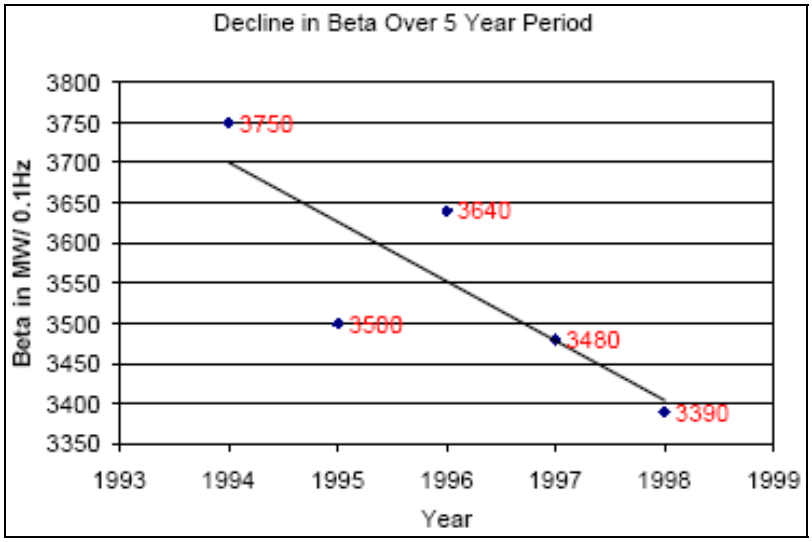

Figure 1 — Eastern Interconnection Frequency Decline[2]

[1] Decline of 72 MW/0.1 Hz/year from the Ingleson- Nagle study.
[2] For purposes of these figures, Beta or β refers to frequency response.

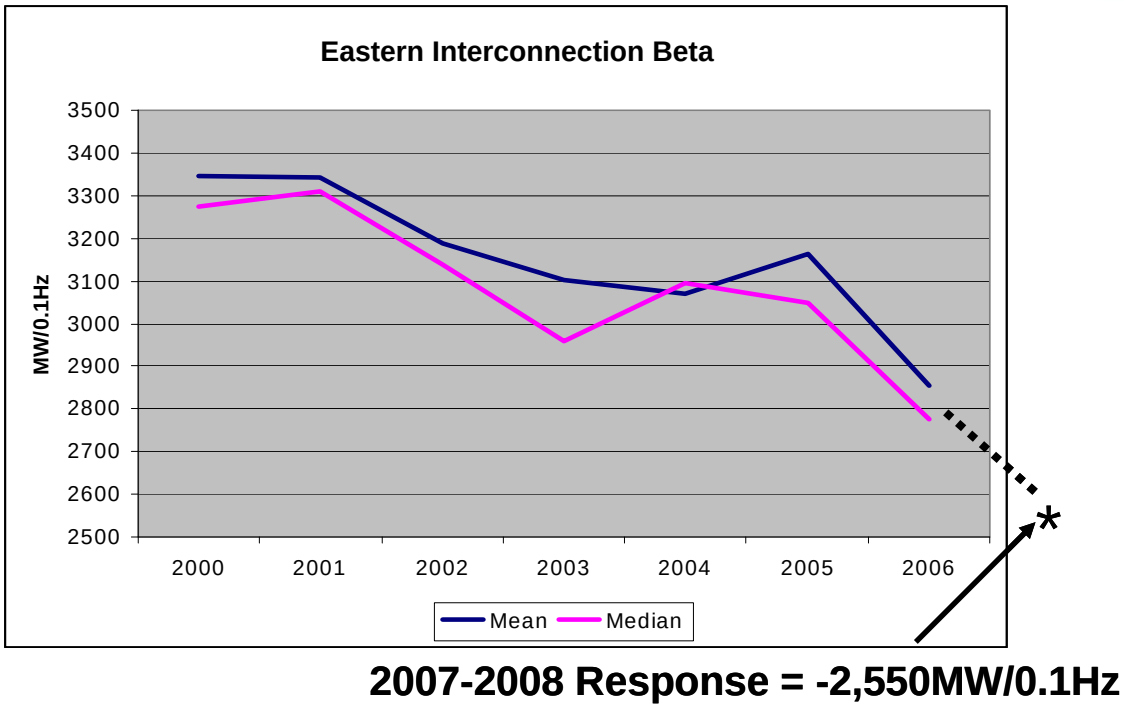

Figure 2 — Recent Eastern Interconnection Frequency Response[3]

A typical frequency response excursion is shown in Figure 3[4], including the longer-term recovery attributable to automatic generator control (AGC) action by the BAs.

Three key points used to describe such a disturbance can be seen on the typical frequency response shown in Figure 3. Point A is the pre-disturbance frequency, typically close to 60 Hz. Point C is the maximum excursion point, while point B is the steady-state interconnection's frequency following the event. It is important to remember primary frequency response (primary control actions) will not return frequency to the normally scheduled value of 60 Hz, but is expected to stabilize frequency.

[3] 2007-2008 Response = -2,550 MW/0.1 Hz per Ingleson and Ellis/NERC Resources Subcommittee/Virginia Tech analyses.
[4] NERC Reference Document: Understand and Calculating Frequency Response, June 2008

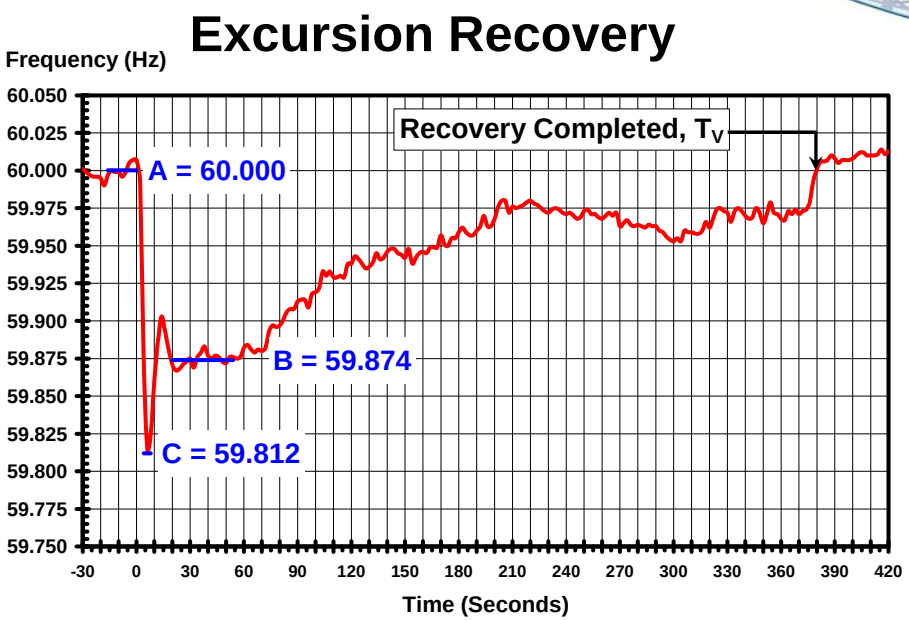

Figure 3 — Typical Frequency Excursion

By comparison, the shapes of the typical frequency responses of the Eastern, Western and Texas Interconnections (Figures 4 through 6) give additional insight to the severity of the problems being encountered. Please note that the Quebec Interconnection data and graph are not available and, consequently, are not represented in this advisory. However, with the exception of the Quebec Interconnection, the remaining provinces of Canada are part of the Eastern and Western Interconnections. Additionally, portions of Mexico are interconnected to the Western and Texas Interconnections.

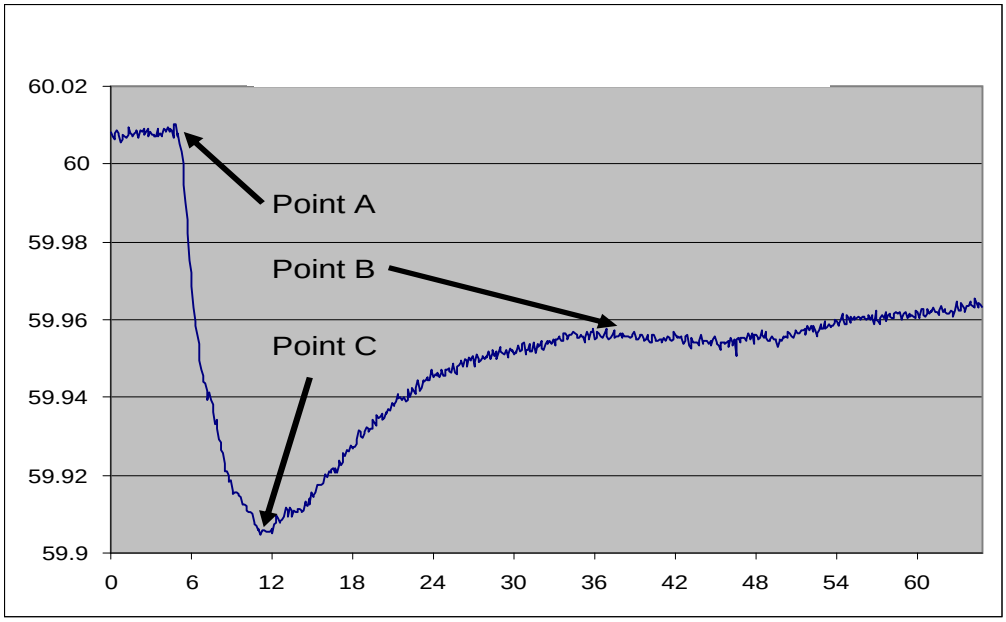

Figure 4 — Typical Western Interconnection Frequency Excursion

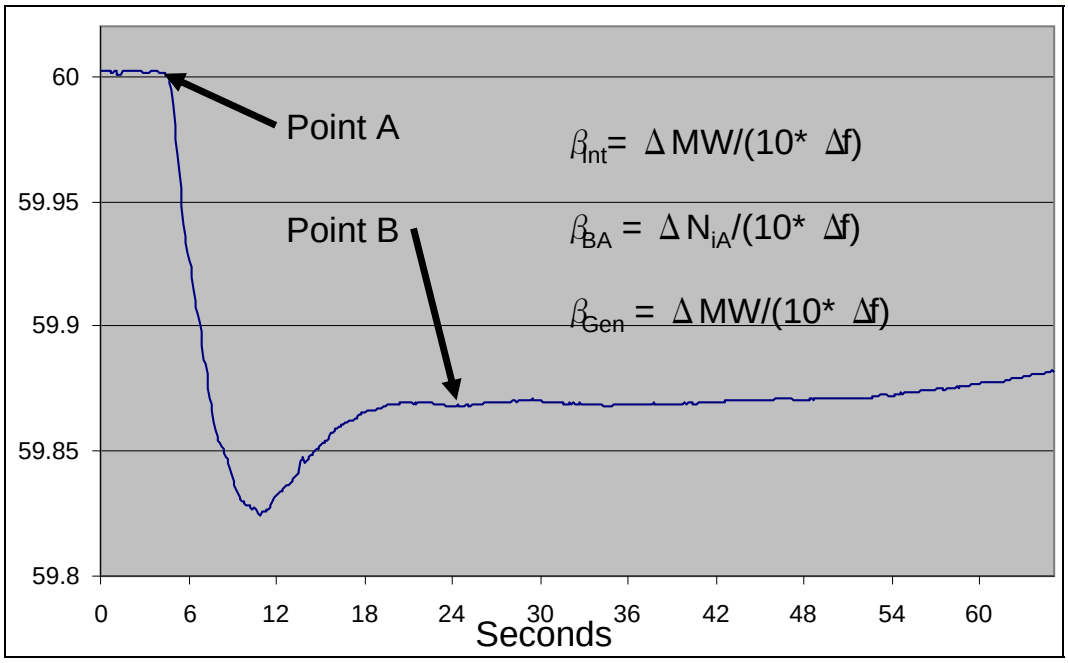

Figure 5 — Typical Texas Interconnection Frequency Excursion

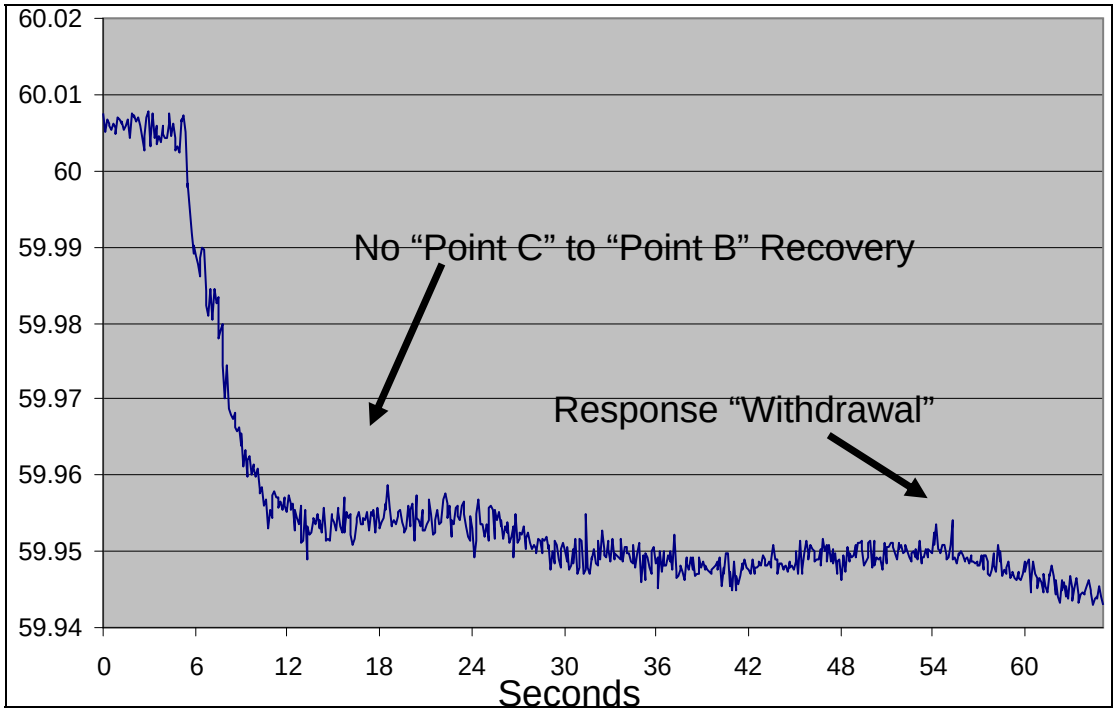

Figure 6 — Typical Eastern Interconnection Frequency Excursion

Addressing these trends is a multi-faceted problem that requires significant effort by the electricity sector to ensure the continued reliability of the North American bulk power system.

Related Reliability Standards in Effect

BAL-003 (Frequency Response and Bias) R2, R3, and R5 outline the requirements for frequency bias setting and its relationship with frequency response. These requirements provide:

- **R2.** Each Balancing Authority shall establish and maintain a Frequency Bias Setting that is as close as practical to, or greater than, the Balancing Authority's Frequency Response. Frequency Bias may be calculated several ways**:**
    - **R2.1.** The Balancing Authority may use a fixed Frequency Bias value which is based on a fixed, straight-line function of Tie Line deviation versus Frequency Deviation. The Balancing Authority shall determine the fixed value by observing and averaging the Frequency Response for several Disturbances during on-peak hours.
    - **R2.2.** The Balancing Authority may use a variable (linear or non-linear) bias value, which is based on a variable function of Tie Line deviation to Frequency Deviation. The Balancing Authority shall determine the variable frequency bias value by analyzing Frequency Response as it varies with factors such as load, generation, governor characteristics, and frequency.
- **R3.** Each Balancing Authority shall operate its Automatic Generation Control (AGC) on Tie Line Frequency Bias, unless such operation is adverse to system or Interconnection reliability.
- **R5.** Balancing Authorities that serve native load shall have a monthly average Frequency Bias Setting that is at least 1% of the Balancing Authority's estimated yearly peak demand per 0.1 Hz change.
    - **R5.1.** Balancing Authorities that do not serve native load shall have a monthly average Frequency Bias Setting that is at least 1% of its estimated maximum generation level in the coming year per 0.1 Hz change.

Apart from the language of the requirements themselves, the Federal Energy Regulatory Commission (FERC) made clear its expectation concerning the application of BAL-003. In particular, in Order No. 693, FERC stated that "The purpose of BAL-003-0 is to ensure that a balancing authority's frequency bias setting is accurately calculated to match its actual frequency response."[5] FERC also went on to say that:

> "Requirement R2 states that the frequency bias setting should be as close as practical to, or greater than, the balancing authority's frequency response. That is the Requirement concerning the relationship between frequency response and

[5] Order No. 693 at P357.

> frequency bias, with Requirement R5 and R5.1 providing minimum frequency bias values for specific types of balancing authorities. The three Requirements do not conflict. A balancing authority must use a frequency bias of at least one percent and they must have a frequency bias that is as close as practical to, or greater than, the balancing authority's actual frequency response[6]."

Most significantly, FERC also stated its understanding is BAL-003 established a performance requirement for entities to ensure their actual frequency response met the 1 percent threshold, and frequency bias was adjusted to closely match actual frequency response. In particular, FERC stated:

> "We understand that the present Reliability Standard sets the required frequency response of the balancing authorities to be approximately one percent or greater by requiring that the frequency bias shall not be less than one percent and that the frequency bias be as close as practical to, or greater than, the actual frequency response[7]."

This understanding was not challenged on rehearing.

NERC, through its standard development process, has also provided an interpretation of BAL-003. This interpretation has been approved by FERC and is included with the standard.

BAL-003-0 — Frequency Response and Bias — Requirement 2 requires a BA to analyze its response to frequency excursions as a first step in determining its frequency bias setting. The BA may then choose a fixed bias (constant through the year) per Requirement 2.1, or a variable bias (varies with load, specific generators, etc.) per Requirement 2.2.

BAL-003-0 — Frequency Response and Bias — Requirement 5 sets a minimum contribution for all BAs toward stabilizing interconnection frequency. The 1 percent bias setting establishes a minimum level of automatic generation control action to help stabilize frequency following a disturbance. By setting a floor on bias, Requirement 5 also helps ensure a consistent measure of control performance among all BAs within a multi-BA interconnection.

Spot Checks of BAL-003 Requirements

To begin to address the declining trend in interconnection frequency response, NERC Compliance Staff included a requirement in the 2010 Compliance Monitoring Enforcement Program (CMEP) Implementation Plan that the Regional Entities conduct spot checks of all BAs under BAL-003 - Frequency Response and Bias. For purposes of conducting the required spot checks, NERC has directed the Regional Entities to review each BA's frequency bias setting practices to ensure compliance with the applicable requirements of BAL-003. In particular, the Regional Entities will look to ensure each BA:

- Reviews its frequency bias setting annually and recalculates the setting to reflect any change in frequency response

[6] Order No. 693 at P370.
[7] Order No. 693 at P373.

- establishes and maintains a frequency bias setting that is as close as practical to, or greater than, its frequency response
- has a monthly average frequency bias setting that is at least 1 percent of its estimated yearly peak demand per 0.1 Hz change.

As a result of this spot check initiative, NERC will collect data concerning each BA's actual frequency response during the course of the spot checks in order to determine possible causes of the continued decline in Interconnection frequency response. NERC and the Regional Entities will utilize the data collected in the spot checks to aid in formulating future actions. This data will also further assist the industry in identifying the root causes of the decline in frequency response and implement operational changes necessary to preserve BPS reliability.

These BAL-003 spot checks are part of a broader set of activities NERC and the Regional Entities will undertake to address the declining frequency response issue. Additional activities include efforts to further study the issue, educate the industry about the importance of frequency response, and develop more explicit frequency response reliability standard requirements. This combination of activities is intended to improve frequency response performance, reverse the trend of declining interconnection frequency response, and lead to a more robust and reliable BPS.

Please note that all inquiries regarding this advisory can be addressed to the following NERC Staff.

Contact:

Michael Moon
Director, Compliance Operations
609-524-7028 (office)
609-651-9693 (mobile)
michael.moon@nerc.net

Bob Cummings
Director, Events Analysis
609-524-7025 (office)
609-947-0103 (mobile)
Bob.Cummings@nerc.net

To report any incidents related to this alert, contact:
ES-ISAC 24-hour hotline
609.452.1422
esisac@nerc.com

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