NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Compliance Application Notice — 0040

BAL-003 R2 and R5 Frequency Bias Calculation

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Primary Interest Groups
Compliance Enforcement Authority (CEA)[1]
NERC
Regional Entity (RE)
Balancing Authority (BA)

Issue: What is the proper approach for calculating the Frequency Bias Setting?
For the purpose of aiding a CEA, this CAN provides guidance regarding the proper approach to determine Frequency Bias contribution of Area Control Error (ACE).

Background
There is often confusion in the Industry when discussing Frequency Bias and Frequency Response. Even though there are similarities between the two terms, Frequency Bias (B) is not the same as Frequency Response (Greek letter beta β).

Frequency Response, defined in the NERC Glossary, is the mathematical expression of the net change in a Balancing Area's actual net interchange for a change in interconnection frequency. It is a fundamental reliability service provided by a combination of governor and load response. Frequency Response represents the actual MW primary response contribution to stabilize frequency following a disturbance.

The Frequency Bias Setting creates an adjustment of the ACE calculation to prevent the Automatic Generation Control (AGC) system from withdrawing primary Frequency Response when tie line flows change as the generation within the Balancing Authority responds to a frequency excursion caused by loss of generation or load. The Frequency Bias Setting is a mathematical approximation of β used in the ACE equation to represent the expected Frequency Response of the generation and load within a Balancing Authority Area. It is represented in the ACE equation as the letter B and is expressed as a negative number of megawatts of response per tenth Hertz change in frequency.

The ACE equation is:

$$ACE = (Ni_A - Ni_S) - 10B(f_A - f_S) - I_{ME}$$

Where:

- Ni_A is Actual Net Interchange
- Ni_S is the Scheduled Net Interchange

[1] Compliance Enforcement Authorities include ERO auditors, investigators, enforcement personnel or any person authorized to assess issues of concern, potential non-compliance, and possible, alleged or confirmed violations of NERC Reliability Standard requirements.

- f_A is the actual frequency
- f_S is the scheduled frequency (normally 60 Hz)
- B is the Frequency Bias
- $10B(f_A-f_S)$ is the frequency bias contribution term; the factor 10 converts the bias setting (B) from MW/0.1 Hz to MW/Hz
- I_{ME} is meter error correction estimate; this term should normally be very small or zero.

The **conventional** calculation of ACE takes into account the direction of the flow by using positive (out of the BA) or negative (into the BA) numbers (however, it should be noted that not all entities honor this convention, and deviations from this convention should not be seen as violations of the standard). It should be noted that both the Frequency Bias Setting and the actual Frequency Response are negative values. This is important when considering the phrase in BAL-003 Requirement (R) 2: "*…establish and maintain a Frequency Bias Setting that is as close as practical to, or greater than, the Balancing Authority's Frequency Response.*" In this requirement, "greater than" refers to the magnitude of the **absolute value** of the Frequency Bias Setting and the Balancing Authority's Frequency Response.

The term 10 B (f_A-f_S) *is* the Frequency Bias contribution. The factor 10 converts the bias setting (B) from megawatts per tenth Hertz to megawatts per Hertz (since f_A and f_S are measured in Hertz). The Frequency Bias contribution in the ACE calculation is a negative number that represents the frequency response obligation of the BA to support interconnection frequency. In the event of a loss of generation, subtracting this term from the difference between actual interchange and scheduled interchange adjusts the ACE such that the AGC of those entities responding to the disturbance will not attempt to return actual interchange to its pre-disturbance value, but instead continue to export in support of interconnection frequency.

If the absolute value of the Frequency Bias term is less than the actual Frequency Response for the BA, some of the primary Frequency Response will be withdrawn through AGC action, reducing overall frequency support. Ideally, the Frequency Bias should be as close as possible to the actual Frequency Response of the BA. However, in practical terms, it is better to be over-biased than under-biased (i.e., providing more frequency support, rather than less); hence the establishment of a "minimum" Frequency Bias Setting based on 1% of peak load in BAL-003 R5.

When determining a fixed Frequency Bias Setting as described in R2.1, the first step for a BA is to analyze its Frequency Response to a number of disturbances. A list of on-peak events that can be analyzed for the determination of a fixed-bias setting is provided annually by the NERC Resources Subcommittee at the end of each year. Other tools that sample frequency change and analyze the change in Tie Line deviation throughout the year during on-peak periods may also be used in this analysis.

When determining a variable Frequency Bias Setting as described in R2.2, the BA analyzes its resources to determine an appropriate method for modeling the Frequency Response attributed to its load and the Frequency Response attributed to its generation (usually based on generator output, droop characteristic, and governor deadband). This model is then used to calculate a variable Frequency Bias Setting based on current system conditions (e.g., load, generation, governor characteristics, and frequency).

Examples

As an example, consider a case of three Balancing Authorities in an interconnection: Entity A, Entity B, and Entity C. If Entity B suffers a loss of generation and frequency declines, the primary Frequency Response of the generation in Entities A and C will cause an increase in generation to stabilize and support the interconnection frequency and, thereby, increase flow out of their Balancing Authority Area to the interconnection. However, because this increased flow is in excess of their scheduled interchange, their ACE would show a positive value (indicating over-generation), and their AGC systems would normally react by calling for a decrease in generation without the Frequency Bias term in the ACE equation. The Frequency Bias term in the ACE equations counteracts the increased flows (up to the value of the Frequency Bias term), thereby stopping the AGC system from decreasing generation, which allows the primary Frequency Response to continue to be supplied to the interconnection.

As an example of the opposite scenario, when Entity A has a disturbance in its Balancing Authority Area, Entities B and C respond to support interconnection frequency to the level of their frequency response obligation, represented by the Frequency Bias Setting in their ACE calculation. Assume Entity A has a disturbance in its balancing area, such as a generator outage, resulting in a loss of 1,000 MW. For Entity A, the disturbance will show an Interchange error of negative 1,000 MW from the outage, its actual net interchange will be reduced by 1,000 MW, and ACE will be negative (-1,000 MW). Entities B and C would provide some outflow to stabilize frequency at a point below 60Hz. Frequency would not return to 60Hz until Entity A replaced the lost 1,000 MW.

The minimum Frequency Bias Setting (in absolute value), in accordance with BAL-003 R5 should be calculated as 1% of the entity's projected peak load. For example, if an entity's peak load is project to be 30,000 MW, its minimum Frequency Bias Setting would be -300 MW/0.1 Hz (30,000 x 0.01 = 300).

Compliance Application

BAL-003 provides, in pertinent part:

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 in several different 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.*
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> ***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.*

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.*

CEAs should be aware that the BA may select a fixed Frequency Bias Setting (constant through the year) per BAL-003 R2.1 or a variable Frequency Bias Setting (which varies with load, dispatch, and other factors) per BAL-003 R2.2.

Regardless of whether a registered entity uses a fixed or variable Frequency Bias Setting, the Frequency Bias Setting must meet the 1% criteria specified in R5 and R5.1. The determined value must be compared to the minimum Frequency Bias Setting prescribed in BAL-003 R5. The CEA is to verify that the BA used in its ACE equation a Frequency Bias Setting based on the largest of:

- the absolute value of their estimated Frequency Response, or
- for BAs serving native load, the absolute value of 1% of their projected peak demand for the coming year, or
- for BAs that do not serve native load, the absolute value of 1% of their maximum expected generation level for the coming year per 0.1 Hz change.

Effective Period for CAN

This CAN is effective upon posting as final on the NERC Web site, and is to be used by CEAs to assess compliance from the posting date forward, regardless of the start date of any non-compliance or Possible Violation. It supersedes all prior communications and will remain in effect until such time that a future version of a FERC or other applicable government authority approved standard or interpretation becomes effective and addresses the specific issue contained in this CAN.

For any enforcement action in process and for audits that have been initiated,[2] a CEA will apply the appropriate discretion, including consideration of the specific facts and circumstances of the non-compliance, in determining whether to assess compliance pursuant to this CAN.

Evidence of Compliance

A CEA is to obtain reasonable assurance of the entity's compliance by assessing the calculations used to determine their Frequency Response to interconnection frequency deviations. For fixed Frequency Bias Settings, the CEA should verify that the data used to estimate Frequency Response used data from on-peak periods, and that it produced a value representative of actual Frequency Response. For variable Frequency Bias Settings, the CEA should verify that the assumptions used in developing the Frequency Response model are reasonable, and that the Frequency Bias Setting appropriately takes into account current conditions such that the resultant Frequency Bias Setting is representative of actual Frequency Response.

CEAs are also to verify the entity correctly evaluated Frequency Bias Setting as an **absolute value**, and the entity determined its Frequency Bias Setting as the greater of its estimated Frequency Response or the minimums established in Requirement R5.

[2] "Initiated" means that a registered entity has received notification of the upcoming audit.

CEAs may request evidence of all steps in the calculation, including any events[3] that occurred in past year to determine its Frequency Bias.

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This document is designed to convey compliance monitoring instruction to achieve a measure of consistency among auditors and Compliance Enforcement Authorities. It is not intended to establish new requirements under NERC's Reliability Standards or to modify the requirements in any existing NERC Reliability Standard. Compliance will continue to be assessed based on language in the currently enforceable NERC Reliability Standards. This document is not intended to define the exclusive method an entity must use to comply with a particular standard or requirement, or foreclose a registered entity's demonstration by alternative means that it has complied with the language and intent of the standard or requirement, taking into account the facts and circumstances of a particular registered entity. Implementation of information in this document is not a substitute for compliance with requirements in NERC's Reliability Standards.

[3] NERC Technical Document "Balancing Frequency and Control," January 26, 2011.