NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Project 2017-01 BAL-003 SDT Phase II White Paper

Considerations of Revisions to Address Project Deliverables

January 6, 2021

RELIABILITY | RESILIENCE | SECURITY




3353 Peachtree Road NE
Suite 600, North Tower
Atlanta, GA 30326
404-446-2560 | www.nerc.com

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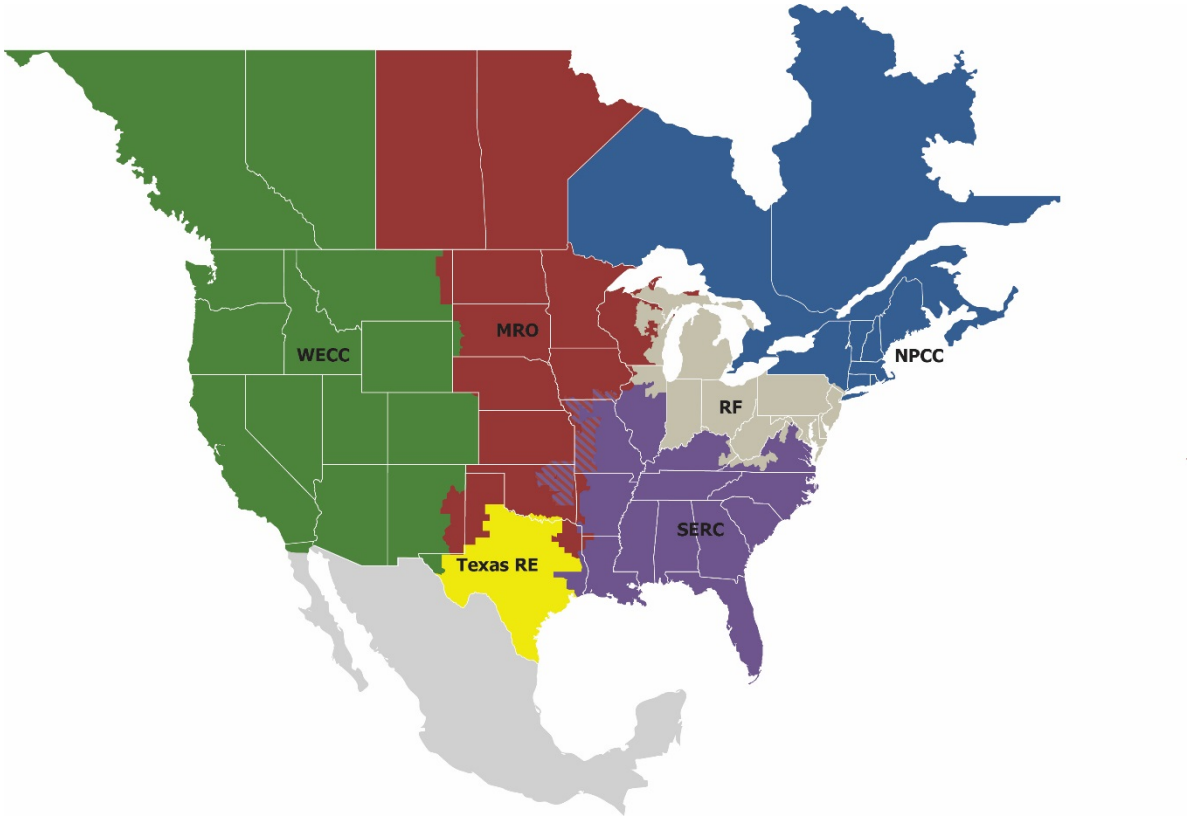
Preface

Electricity is a key component of the fabric of modern society and the Electric Reliability Organization (ERO) Enterprise serves to strengthen that fabric. The vision for the ERO Enterprise, which is comprised of the North American Electric Reliability Corporation (NERC) and the six Regional Entities (REs), is a highly reliable and secure North American bulk power system (BPS). Our mission is to assure the effective and efficient reduction of risks to the reliability and security of the grid.

Reliability | Resilience | Security
Because nearly 400 million citizens in North America are counting on us

The North American BPS is divided into six RE boundaries as shown in the map and corresponding table below. The multicolored area denotes overlap as some load-serving entities participate in one Region while associated Transmission Owners/Operators participate in another.



MRO	Midwest Reliability Organization
NPCC	Northeast Power Coordinating Council
RF	ReliabilityFirst
SERC	SERC Reliability Corporation
Texas RE	Texas Reliability Entity
WECC	Western Electricity Coordinating Council

Executive Summary

The Project 2017-01 Standard Authorization Request (SAR), under Phase II, directs the standard drafting team (SDT) to consider assigning responsibilities under BAL-003 to different or additional applicable entities, address Real-time operations of the grid, and address measurement concerns, among other things.

The SDT discussed several different options while trying to address the concerns raised in the SAR. These options include potentially adding additional Balancing Authority (BA) requirements to address Real-time primary Frequency Response reserves, modification to existing BA requirements on performance measurements, and adding Generator Owner (GO) and Generator Operator (GOP) requirements for operational and responsive control. These options are detailed in this White Paper.

The SDT is soliciting industry feedback to narrow in on industry's concerns or support of a modification to BAL-003. To facilitate an understanding with industry as to what the SDT has discussed, this paper lays out multiple options. These options are all viable for modifying BAL-003; however, there are certain items that are either mutually inclusive or mutually exclusive, so the final set of requirements proposed for BAL-003 will depend on comments received from industry so the SDT can assess next steps for Project 2017-01, Phase II.

As an initial step, the SDT determined that the BA performance requirement must remain in place for multi-BA Interconnections. While the measurement methodology might change, a requirement on the BA will not be removed. The BAs (or Reserve Sharing Groups, if applicable) have ultimate responsibility for ensuring ***all*** reserve requirements are met at the BA level and that there is not another NERC Registered Entity that is in the position to ensure resources are scheduled to provide the needed service.

While some entities have argued that the generators are the ultimate source of the response, the SDT notes that the GOs and GOPs are not able to ensure that any single generator will be committed and dispatched in such a way to allow the generator to respond to an event. This responsibility is that of the BA alone. Therefore, the ultimate responsibility lies with the BA to ensure sufficient Frequency Responsive Reserves are available, just as it is the BA's responsibility to ensure that sufficient Contingency Reserves and Regulating Reserves are available.

The SDT seeks industry feedback on the following proposed requirements:

- New BA requirement – requires Operational Planning process to address Frequency Responsive Reserves
- New BA requirement – specify minimum governor settings ***or*** request governor settings from the GO
    - If the BA specifies a governor requirement, then an additional requirement for a process to allow for exceptions would also be recommended by the SDT.
- New GO requirement – Ensure the governor settings meet the BA specification set above
- New GOP requirement – Ensure the unit is operating with the governor and outer loop controls that are responsive or the BA has been notified that it is not responsive.

The SDT considered a generator performance requirement, and that is discussed in detail within this White Paper. If a Frequency Response performance requirement is determined to be proposed for the generators, the SDT believes it would be appropriate for the BAs to calculate the response for each generator within the Balancing Authority Area (BAA), similar to the process found in the BAL-001-TRE-2, Requirement R2.

Reading through this White Paper should help with understanding the reasoning behind the SDT's current position. The SDT looks forward to feedback from industry participants.

Introduction

Background

The issues related to Reliability Standard BAL-003-1.1 were laid out concisely in the SAR. Those issues were grouped into two phases (see SAR excerpts below). The first phase, Phase I, addressed primarily administrative issues. The second phase, Phase II, addresses more complex issues, which contain both administrative and technical elements.

Excerpts from SAR

Phase I

- *Revise the IFRO calculation in BAL-003-1 due to issues identified in the 2016 Frequency Response Annual Analysis (FRAA) Report, such as the Interconnection Frequency Response Obligation (IFRO) values with respect to Point C and varying Value B;*
- *Reevaluate the interconnections' Resource Contingency Protection Criteria;*
- *Reevaluate the frequency nadir point limitations (currently limited to t0 to t+12);*
- *Review and modify as necessary Attachment A of the Reliability Standard to remove administrative tasks and provide additional clarity, e.g., related to Frequency Response Reserve Sharing Groups (FRSG) and the timeline for Frequency Response and Frequency Bias Setting activities; and*
- *Make enhancements to the BAL-003-1.1 FRS Forms that include, but may not be limited to, the ability to collect and submit FRSG performance data.*

In addition to fixing the inconsistencies outlined above, the SDT may separate the administrative and procedural items and propose they be reassigned to an alternative process subject to Electric Reliability Organization (ERO) and North American Electric Reliability (NERC) Operating Committee (OC) approval.

Phase II

- *Both the IFRO calculations and the allocation of IFROs to reliability entities are retrospective (up to 2 years). The review should determine if there are alternate methodologies which consider characteristics affecting Frequency Response (e.g., load response, mix and type of generation, BAA footprint changes) to make allocation as equitable as possible;*
- *Although BAs and FRSGs are responsible for coordination and/or management of Frequency Response from both resources and loads, response from resources is not addressed. The review should determine if additional reliability entities should have responsibility (e.g., GOPs) for provision of generator governor response; and*
- *Review the measurement methodology of Frequency Response (both System and equipment level):*
    - *The FRM should be reviewed to ensure that over-performance by one entity does not negatively impact the evaluation of performance by another.*

All the items in Phase I were addressed in the balloted and approved Reliability Standard BAL-003-2. Although the needed modifications to accommodate FRSG reporting were included in Phase I, additional improvements to the submittal process to further simplify reporting (possibly eliminating mandatory use of the prescribed Excel spreadsheets) were deferred to Phase II.

To clarify the issues needing to be addressed in Phase II, the SDT held a technical conference via WebEx in March of 2019. Here are the questions posed for discussion during the conference and the findings presented by the SDT.

March 2019 Technical Conference

Questions Posed

- What improvements are needed based on Interconnections' performance under the existing BAL-003-1.1?
- Do reliability needs dictate separate measures for Arresting, Stabilizing (current method), and Recovering periods?
- Do the use and application of adjustments (e.g., non-conforming load, dynamic schedules, etc.) need more clarification? Do we need to add other adjustments?
- What are the pitfalls of delta NAI to measure FRM? Are there viable alternatives?
- How can we best simplify the data collection and submittal process?
- Should measurement also include a prospective Frequency Response Reserve (FRR) requirement?
- What areas of historical performance indicate a need for improvement?
- We have seen an improvement in B space with either no change or slight improvement in C space (FRAA Report)?
- Interconnection nadirs (C point) are constant or increasing?
- Particularly, in light of a changing resource mix, what areas of performance in the future need to be addressed?

Findings presented

Findings presented at the conference in response to the questions posed were:

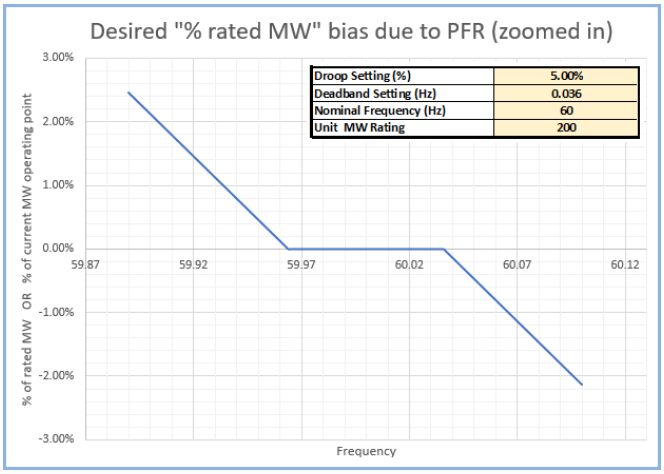
- Although not statistically significant, interconnection performance is stable or slightly improved over the last 4 years (the 2020 FRAA is consistent with the previous 4 years).
- Although the expected future changes in resource mix (driven predominantly by inverter-based resources) will cause changes in the profile over the response period, there is no clear evidence of a reliability need for separate measures (Arresting, Stabilizing, Recovery).
- Clarification of application of adjustments is not needed, but consideration of other adjustments has been made. The administrative burden associated with each (e.g., adjustments for schedule ramping would require coordination of the data submittals of all such schedules between the respective BA partners) precludes the value those identified to date.
- Although the use of NAI (even with existing adjustments) does have limitations and cause inequities for some BAs, no adequate alternative has been identified.
- Data collection and submittal can significantly be simplified. Prototype examples of the submittal forms and corresponding example calculation methods have been developed and are being vetted by the SDT and interested observers.

Other Considerations

This section will provide considerations of other pertinent issues discussed by the SDT during the consideration of the various options for GO/GOP requirements as part of the standard. After describing these other factors, attention will be given to establishing a direction for the SDT with respect to this matter.

Measurement Accuracy

Discussion of the measurement accuracy issues is applicable for interconnection regions where the governor droop and deadband settings are set to 5% droop and +/- 0.036 Hz deadband. Typical non-revenue metering equipment often is known to be 1% accurate. Most sudden imbalance conditions in the Eastern Interconnection do not result in low frequency excursions dropping below 59.9 Hz. The chart below shows the expected % change of facility-rated megawatt (MW) for frequency excursions exceeding the deadband. Notice that the 2% change value occurs at a frequency beyond the majority of the observed frequency excursion limits of the Eastern Interconnection. This results in the situation where the attempted measurement of the frequency responsiveness of many generators in the Eastern Interconnection can be unsuccessful due to the measurement inaccuracies of the equipment in use. Certainly, this can be remedied with projects to use measurement equipment with better accuracy, yet this solution is not without cost and effort. Observed frequency excursions in the Western Interconnection are larger than those in the Eastern Interconnection, so measurement accuracy is a smaller factor in the ability to see the facility response.



Observed frequency excursions

Resource Variability

As mentioned in previous sections, there is **variability in the capability and ability** of existing types of resources to provide primary frequency response due to the modes of operation of those facilities and other important process control constraints. A **generic requirement** which covers existing resource types, therefore, will present GOs with the need for changes in equipment, control modes, efficiencies, and revenue opportunities. In areas where the existing frequency responsiveness is adequate, an application of additional regulations for existing resources may not be warranted. Generic standard requirements for new resource development are more appropriate than detailed, specific requirements. Providing **specific requirements** for certain resource types has the potential to influence, dis-incent, or incent other resource developments in delivering Frequency Response.

Fast Frequency Response

The requirements for fast frequency responsive resources should take into consideration the speed of response characteristics of those resources in comparison to other resources. Certainly, the droop setting controls the

sensitivity of the unit response, and equal sharing of the burden for providing more or less MW for a given frequency excursion will occur given that the excursion lasts long enough for the slowest response timing. If, however, future generating unit resource types with fast Frequency Response become so populous that the MW response needed for arresting and correcting the frequency excursion is available from those fast responding units, the burden would probably not be shared equally with slower responding units even though the droop settings match. At the same time, however, it is understood that those resource types can play an important role during the arresting phase of the frequency excursion.

Frequency Response from New Generation Resources

Provided the trends in the frequency excursion characteristic curve in an interconnection are not markedly showing deterioration coupled with the existing acceptability of the current response, perhaps engaging new generation resources to match the response exhibited by the existing fleet of generators will provide sufficient responsiveness in the future.

The ability to provide sustained Frequency Response from certain types of renewable resources is not guaranteed. Factors include variability in wind speed for wind; operation at maximum power output for wind, solar, steam turbines, and combustion turbines (CTs); intermittent cloud cover for solar; and the current state of charge for battery systems.

The possibility of insufficient Frequency Response stemming from the replacement of traditional synchronous generators (rotating machines) with static-power-conversion-based generation causes focus to be directed towards obligations placed on the new generation to address the issue at the time of the addition of the new resource. The Federal Energy Regulatory Commission (FERC) Order 842 partially addresses this. Interconnection agreements for future resources can specify that all new resources be provisioned with this ability and adequately programmed (controlled) to deliver Frequency Response during normal operation. This ability to have automatic frequency regulation included in the functionality is similar to requiring generating facility equipment to have reactive power production capability, which permits it to deliver automatic voltage regulation (AVR). These provisions, where used and followed, may obviate the need for any additional regulations for GO/GOPs. The adequacy of the existing Frequency Response for the Eastern, Western, and Quebec Interconnections should be considered carefully before new regulation is applied for all generation in each of these interconnections. The frequency excursion characteristics vary from Interconnection to Interconnection.

2017 & 2019 Generator Governor Survey Reports

NERC has performed generator surveys related to frequency response in 2017 and 2019.

These surveys appear to show that generator response to frequency events has increased, although it is still less than expected. It is believed that this increase has been driven due to increased awareness in the industry of the need for frequency response, including efforts by some Balancing Authorities to work with generators to improve response.

TRE Solution

The Texas region has addressed frequency excursion control ability through regional standards specifying governor settings, governor in-service requirements, initial/sustained Frequency Response performance, and credits for load used as a resource (early load shed schemes), and now is developing fast Frequency Response market products.

Market Based Solutions

Many discussions of the growing penetration and density of inverter-based intermittent renewable resources and a forecast of its possible (negative) impact on Frequency Response assumes there is no capability for renewables to provide Frequency Response. This ability may flourish through market requirements and payment for Frequency Response. Market factors would incent the entities to operate these types of resources at less than the maximum available power if properly compensated. Market-driven Frequency Response provision mechanisms can be

developed. These market-based solutions are possibilities instead of provisioning using reliability standard requirements. Both can achieve power injection/withdrawal as needed to regulate the frequency. High-speed power injection and load rejection contracts can arrest frequency declines when dispatched well before the underfrequency load shedding (UFLS) frequency set points in each region. All characteristics of Frequency Response could be incentivized to ensure additional system reliability. BAs may consider acquiring additional Frequency Response through various market means and some resources may elect to participate in market options.

Section 1: Overview of Possible New/Modified Requirements

The rationale for new requirements for both BAs and GOs/GOPs is to have matching requirements for each: one for the operational planning window, one for Real-time status monitoring, and one for performance. The reliability need for each time frame and each functional entity is under much debate.

Existing Requirements

No changes to existing bias setting or measurement reporting requirements.

New/Modified BA Requirements

New BA requirements **may** require a BA to explicitly address planning for Frequency Response reserves in next-day operational planning, develop methods to explicitly monitor Frequency Response reserves in Real-time, and demonstrate Frequency Response reserve maintenance after-the-fact.

Frequency Response Reserves Operational Planning

Explicitly address maintaining Frequency Response reserves in operational plans/procedures.
(See Detail in Chapter 2, R3)

Real-Time Frequency Response Reserves Monitoring

Require BAs to explicitly monitor Frequency Response Reserves in Real-time and to have and meet Real-time targets (static or dynamic). (No formal requirement has been drafted in this paper.)

Real-Time Frequency Response Reserves Performance

Additionally, consideration of an after-the-fact metric on performance (how well did the BA follow its plan?).
(No formal requirement has been drafted in this paper.)

New GO/GOP Requirements

New GO/GOP requirements may require a GO/GOP to explicitly document and communicate Frequency Response capability, develop methods to explicitly monitor and communicate Frequency Response capability in Real-time, and demonstrate Frequency Response performance after-the-fact.

Frequency Responsive Capability

Simple documentation of existence of Frequency Response capability and settings (if capable).

Communication to BA

What information (e.g., just settings or, additionally, actual current capability) should be reported to BA? What mechanism should be used for reporting? And in what periodicity should that information be communicated? All aspects are interrelated (e.g., a one-time settings communication does not need inter-control center communications protocol (ICCP) transfer, but Real-time ramp/headroom capability may).

Is this (could this be) covered by data collection requirements in other standards?

Frequency Responsive Performance

A possible requirement to assess unit performance and meet minimal performance targets.

Administrative Changes

Reporting of data has been reduced to only data needed for multi-BA calculation apportionment and actual required performance metrics. Background data collection, analysis, and calculations are not required to be reported, but prototype calculation methods and tools are developed to provide guidance for users.

Data Collection

A modified spreadsheet form to report needed data for pro rata calculations has been prepared.

Form Replacement

Prototype forms to replace Form 1 and Form 2 have been developed

Section 2: Balancing Authority Requirements Options

Overview

The current Reliability Standard BAL-003-1.1 requires a BA to achieve a median performance on events selected through the frequency event selection process. This process could be thought of as a "past" performance metric since any failure to meet the standard would not be identified until well after the compliance period has passed. This allows the BA to adopt a "wait and see" approach, and puts the interconnection in an assumed state of reliability without any required planning to meet those objectives.

The following requirement was modeled after Reliability Standard VAR-001, Requirement R2, with the intent to move the BA to a forward-looking assessment of available frequency responsive reserves. This is not intended to require the BA to monitor these reserves in Real–time, but simply support a process to evaluate the available Frequency Response in the Operations Planning Horizon, including Real-time operations. While this does not necessarily guarantee performance during an event, it does reduce the risk that a BA might operate in a state with inadequate Frequency Response.

The SDT is proposing a governor (or equivalent control) setting requirement for generating resources connected to the interconnected transmission system. The intent of such a requirement is to:

- Ensure every generating resource is capable of responding to frequency deviations;
- Ensure the BA is aware of the droop and deadband characteristics of the generating resource; and
- Ensure the BA is aware of generating resource operating position and available frequency response.

It has been proposed that a new version, a proposed BAL-003-3, specify the required droop and deadband settings for each generating resource. After careful deliberation, the SDT does not believe it is appropriate to apply a single droop and deadband setting specification to each generating resource. The SDT is proposing that the BA specify the droop and deadband settings and develop an appropriate process for allowing exemptions to the BA's droop and deadband settings. This process should include exemptions for the governor operating requirement.

The requirement to ensure adequate Frequency Response falls upon the BA. Frequency Response is like other types of Operating Reserve in that a certain amount is necessary to maintain reliability. In the case of Operating Reserve, the BA can choose to carry Operating Reserve on the most effective and efficient resources, while ensuring that there is adequate Operating Reserve in total for the BA. In the same manner, Frequency Response can be procured and dispatched in the most efficient manner across the BA's entire generating fleet while providing the necessary reliability. Therefore, the SDT elected not to pursue a specific GOP requirement to provide Frequency Response for selected events. Just as there are efficiency and reliability reasons to carry Operating Reserve on specific generating resources, the same logic applies to Frequency Response. Reliability is better served by an analytical approach to provisioning Frequency Response than by requiring each generating resource to provide it at any time for any Frequency Deviation.

Frequency Response is largely determined by the generating resource's operating point and governor droop and deadband settings. Generating resource types each have unique operating and performance characteristics. For example, when specifying droop, on a hydro generator the control output that changes is gate position. However, a 5% gate change does not equate to a 5% power output change. The same issue applies with Combustion Turbines (CT) and throttle position. The issue becomes more complicated with combined cycle power plants. Generally, the steam turbine does not have a speed governor. Its output varies based on the heat generated (and power) of the CT. In specifying a 5% power droop, if the governor is set to 5%, actual observed power droop is likely to be different. The SDT is proposing that the BA specify droop and deadband settings, which can be based on the BA's and generating resource's operating needs and capabilities.

There will be instances where a generating resource is not capable, or it is not desirable to provide Frequency Response. In order to address these cases, the BA shall develop a process that can be applied to determine if a generating resource can be exempted from the requirement to have a governor operating when connected to the interconnected system.

Knowledge of governor status and settings allows the BA to determine the amount of Frequency Response available for any given operating point. With that information, the BA can make the appropriate dispatch decisions to ensure reliability while using the most economic generating resources available. The proposed requirements and the associated justifications describe a coordinated approach to this.

Operational Planning – Process

BA-R3

Each Balancing Authority shall develop and implement an Operating Process, reviewed and maintained at least annually, as part of its Operating Plan to schedule frequency responsive resources sufficient to maintain interconnection frequency equal to or greater than its Frequency Responsive Reserve Obligation.

BA-M3

Each Balancing Authority shall have evidence of scheduling frequency responsive resources based on their assessments of the system. For the operations planning time horizon, Balancing Authorities shall have evidence of assessments used as the basis for how resources were scheduled.

Justification

NERC performed off-peak dynamics analyses of the recommended IFROs for the Eastern, Western, and Texas Interconnections to determine if those levels of primary generator frequency response (PGFR) are adequate to avoid tripping of the first stage of regionally approved UFLS systems in the interconnection. Each of the interconnections prepared light load cases as the starting root case for each of the analyses. In each case, the dynamic governor or load responses of the PGFR of the interconnection closely matched the recommended IFRO value for the prescribed resource loss. All three simulations did not model automatic generation control (AGC), which typically starts to influence PGFR in the 30-45 second timeframe. In all three interconnections analyzed, frequency remained above the highest UFLS set point even with Interconnection PGFR degraded to the IFRO value. The FRAA report presents further analysis of each interconnection for each year.

While the Frequency Response Measure is calculated in MW/.1Hz, the total Frequency Responsive Reserves for each BA should be based on risk associated with anticipated frequency excursions for the applicable interconnection. The responsible entity should have a process to determine the amount of Frequency Responsive Reserves it will plan to have available.

PGFR references and identified risk from the 2012 FRI Report are shown in **Figure 0.1** below as an example.

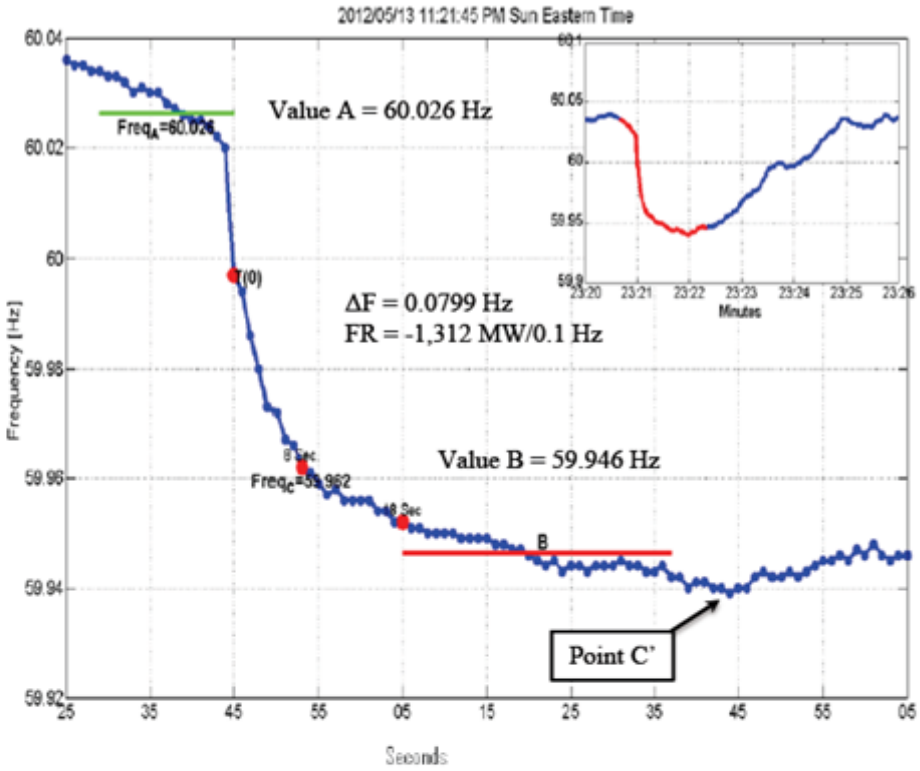


Fig. 24. PGFR Characteristic 11:21 pm Sunday 1,049 MW Resource Loss.

The measurement of Value B (20 to 52 seconds) does not capture the lowest frequency. That frequency point is the true frequency event nadir, hereafter referred to as Point C' ("Point C Prime"), and is normally equal to Point C for events that do not exhibit the so-called "lazy L" effect. It is important that the phenomenon be recorded and trended to determine if it is improving or deteriorating.

NERC Recommendation – Measure and track frequency response sustainability trends by observing frequency between T+45 seconds and T+180 seconds. Calculating a pair of indices comparing that value to both Point C and Value B provides for gauging sustainability. A later alternative comprises the use of arrested PGFR as the PGFR measure.

"NERC should embark immediately on the development of a NERC Frequency Response Resource Guideline to define the performance characteristics expected of those resources for supporting reliability. That guideline should address appropriate parameters for the following:

Figure 0.1: Excerpt from FRI Report October 2012

While these studies assure us that our past performance in each interconnection has been sufficient, they do not necessarily represent the changing resource mix and the potential future performance. This also covers a gap where the BA is required to plan for and carry Contingency Reserves but where those reserves may not be frequency responsive, making them irrelevant to stabilizing the system immediately after a resource loss. In addition to this standard, the Operating Reserve Reliability Guideline should be updated with examples on how to calculate Frequency Response similar to the Electric Reliability Council of Texas (ERCOT) approach with BAL-001-TRE. With the time it takes to modify a standard to address these potential issues in the future, the timing is right to address these known risks now before the interconnections approach a more critical situation.

Operational Planning – Settings

BA-R4

Each Balancing Authority shall specify a minimum droop and deadband setting for the resources located within its boundaries and provide those minimum settings to the Generator Owner.

R4.1

Each Balancing Authority shall provide a copy of the minimum droop and deadband settings to its Reliability Coordinator and adjacent Balancing Authorities within 30 calendar days of a request.

BA-M4

Each Balancing Authority shall have evidence that it specified resource droop, deadband, or equivalent control settings to its resources.

- Each Balancing Authority shall have evidence that the frequency control specifications were provided to its Reliability Coordinator and adjacent Balancing Authorities within 30 calendar days of a request. Evidence may include but is not limited to emails, website postings, and meeting minutes.

Justification

The intent of these proposed requirements is to assist the BA in developing criteria for determining compliance with Requirement R3.

This model is different than the other ancillary services products currently obtained and utilized by BAs to ensure reliability services are available, and it may negatively impact other possible sources of Frequency Response due to lack of compensation. There is also some concern about how generators will be compensated for changes required by its BA, and that the process could be manipulated by a BA by assigning response to certain generators and then limiting dispatch of those generators. But this model simplifies the modeling and operational analysis and allows BAs to require specific settings.

Operational Planning – Exemptions

BA-R5

Each Balancing Authority shall specify the criteria that will exempt generators from:

1. Following the recommended governor droop and deadband settings;
2. Having its governors in service and not blocked; and
3. Having to make associated notifications on governor status changes.

If a Balancing Authority determines that a generator has satisfied the exemption criteria, it shall notify the associated Generator Operator.

BA-M5

Each Balancing Authority shall have evidence of documenting criteria for generator exemptions and documentation of notifications to exempted resources.

Justification

The previous Requirement R4, sets the expectations for resources, and R5 addresses the known limitations that prevent every resource from providing Frequency Response. Requirements R4 and R5 support Requirement R3, which is ultimately needed to comply with Requirement R1. This exemption process should identify resource types that have known mechanical or safety limits to performing Frequency Response. This process also completes the communication loop between the BA and GOP. Other standards are being discussed for the GOP's requirement to perform.

Section 3: Generator Owner/Generator Operator Requirements Options

Overview

Considerable discussion has occurred in recent years of possible requirements for the GO/GOP in the NERC functional model related to improving the ability to control the frequency of an Interconnection during system disturbances. The Frequency Response provided by connected generation and loads during the first minute(s) following a sudden, unplanned upset between the balance of generation and load plays a vital role in arresting the change in system frequency that results from the imbalance.

This section will address four options for engaging the GO/GOP in system frequency management, which is currently required of the BA through the BAL family of NERC Reliability Standards. Since the BA is tasked with frequency control, BA knowledge of the expected Frequency Response that should occur for disturbances can provide confidence in its ability to meet the frequency control obligations. While presenting various methods for this engagement, the following will be discussed:

- the present and forecasted system need for changes in the GO/GOP Frequency Response performance;
- the level of engagement of GO/GOP for delivering Frequency Response – adequacy issues;
- the changing mix of generating facility resource types, their operating/response characteristics, and their impact on Frequency Response in relation to system inertia and reserves;
- information/communication-based requirements versus measured performance requirements; and
- the ability to use market products for soliciting/ensuring adequate provision of Frequency Response.

Changes in the resource mix of electric power generating facilities tend to change the grid dynamics relative to frequency control capability. Lower system inertia results in increased rate-of-change-of-frequency when sudden imbalances in generation and load occur. Each interconnection currently maintains adequate and substantial margin between automatic UFLS set-points and the lowest frequencies experienced in recent years. Many new resource types can be controlled such that they can provide Frequency Response. Many existing synchronous resource types have been modified in the past decade to provide reliable Frequency Response. The present and forecasted system need for Frequency Response and the response capability of resources are closely related issues.

Options that the SDT has discussed include:

1. Copy all BAL-001-TRE performance requirements, including the requirement for the BA to calculate the response for all generators within their BA footprint. (***Option 1*** below.)
2. Create GO/GOP performance requirements with the GO/GOP responsible for the calculation of the performance. (***Option 2*** below.)
3. Limit the GO/GOP requirements to just “Operate with the Governor in Service” and “Notify if out of service” only. (***Option 3*** below.)
4. Create requirements for the GO/GOP to provide the droop, deadband and other requested data to the BA. (***Option 4*** below.)
5. A combination of 3 and 4 above

Each possible method of addressing the GO/GOP in frequency control through the regulatory process that has been discussed by the BAL-003 SDT under Project 2017-03 will be examined and evaluated in this document.

Resource Frequency Response Performance Requirement

The Project 2017-01 SDT has discussed whether it would be appropriate for GO/GOP requirements to replace the current BA requirement due to comments received during the SAR process. During discussions, the SDT determined:

1. The largest BAs in the Eastern and the Western Interconnections are responsible for determining the commitment and dispatch levels of unassociated generation within their footprint during Real-time operations. Therefore, without a BA requirement to ensure the generation fleet is committed and dispatched in a manner to allow response, the GO/GOP would be at risk of meeting a requirement that would replace the current BA requirement while the generation could be committed and/or dispatched such that all available generation meets the performance requirement but the interconnection fails to have sufficient response.
2. Allocating the IFRO to GO/GOPs would either require a Real-time allocation process to address units on and off-line or be likely to aggravate minimum load/generation balancing issues already seen at times as GO/GOPs would need to keep some generation online to provide the required response.

For these reasons, the SDT determined that a GO/GOP requirement could not replace the existing BA requirement. Instead, any GO/GOP requirement would have to be in addition to the existing BA requirement. Therefore, the SDT has focused its discussions in this direction.

This possible set of requirements would be like some or all of those that exist today in the Texas Reliability Entity (TRE) regional standard, BAL-001-TRE-2. Individual resources, whether a single generating unit or an aggregated group of resources such as a wind farm, would be measured against an expected level of response during identified frequency events to determine if the resources are responding.

For ease of understanding and reference, a summary of the pertinent TRE requirements is provided:

- R2 – BA calculates the Frequency Response (both initial and sustained) for each generator;
- R6 - GO must set controls to meet three criteria: droop, deadband and slope;
- R7 – GO shall operate the generator with the governor in-service unless there is a valid reason for it to be out-of-service and the GOP has been notified.
- R8 – GOP will notify the BA within 30 minutes of change in status of the governor.
- R9 – GO will meet 12 month rolling average initial Frequency Response performance of 0.75 based on participation in at least 8 events.
- R10 – GO will meet 12 month rolling average sustained Frequency Response performance of 0.75 based on participation in at least 8 events.

The SDT notes that the TRE standard does not have a BA performance requirement. However, ERCOT, as the registered BA, does have a performance requirement under the NERC BAL-003 standard.

Discussion of the Different Options

Option 1 – Performance Requirement BA Calculation

Under Option 1 above, the SDT discussed the benefits, possible hurdles and perceived negatives associated with the potential requirements structure. These are listed below:

Benefits

- The requirements are relatively clear and understood.
- Data available from TRE shows the process provides an adequate level of reliability.
- Expectation that the amount of Frequency Response seen would remain steady or increase regardless of changes in the generation mix.

Possible Hurdles

- Data transfer rates between generators and BAs in many areas may not be sufficient to allow the BA to make the calculation. (ERCOT uses a 1-second data transfer rate compared to 2-to-6 seconds in other BAs).
- Calculation process may be onerous for smaller BAs.
- Generators may incur expenses to address performance requirements with no clear process for compensation.
- Interconnection size may impede the ability to identify a significant number of events that exceed the deadband.

Negatives

- For BAs with large geographic areas, Frequency Deviations across the system may cause complications for the calculation process.
- Potential for penalizing GO/GOP when more than adequate response across the BA and interconnection is provided (even if the BA and GO/GOP are the same entity).
- Compliance burden may be greater than the potential reliability benefit by placing a compliance obligation on all GO/GOP when over multiple years actual response comes from 50 percent or fewer of units.
- Mandatory performance without clear compensation may negatively impact development of alternative providers of Frequency Response.

Option 2 – Performance Requirement GO Calculation

Under Option 2, the identified list of benefits, possible hurdles and negatives are much the same. The main differences would be related to the data transfer rate and geographic issues and depends on whether the BA, or the GO, would be responsible for calculations. Regardless, the larger number of entities involved in the calculation process would likely increase the administrative burden of the process.

Benefits

- Clear and relatively easy to understand.
- Data available showing experience in TRE to support adequacy of the process.

- Increased Frequency Response.
- May provide reliability value if proven to be needed.

Possible Hurdles

- Calculation process may be onerous for smaller GO/GOPs.
- Generators may incur expenses to address performance requirements with no clear process for compensation.
- Data needed to make the calculation at the GO/GOP level may require significant modifications to data collection at the plant level.
- Interconnection size may impede the ability to identify a significant enough number of events that exceed the deadband.

Negatives

- Large number of entities required to have the data necessary for the calculation, and maintaining trained individuals to perform the calculation may cause the process to be administratively burdensome.
- Potential for penalizing GO/GOP when more than adequate response across the BA and interconnection is provided (even if the BA and GO/GOP are the same entity).
- Compliance burden may be greater than the potential reliability benefit by placing a compliance obligation on all GO/GOPs when, over multiple years, the actual response comes from 50 percent or fewer of units.
- Mandatory performance without clear compensation may negatively impact development of alternative providers of Frequency Response.

BAL-001-TRE-1 became effective on April 1, 2014. Under the standard, a generator must participate in a minimum of 8 frequency events to have a measurable performance obligation. As of August 1, 2020, approximately 20 percent of the generators in the TRE footprint have been scored on 8 or more events. Of the remaining generators, 24.3 percent have received a score in less than 8 events and 55.7 percent have not received a score in any event; therefore, at this time they do not have an official compliance obligation for performance. All generators have an obligation under the standard to have the required settings in place, regardless of event participation.

Option 3 – Resource Governor In-service Requirement

This possible requirement for the GO/GOP for frequency control can be compared with Reliability Standard VAR-002, which is concerned with voltage control. Reliability Standard VAR-002, in paraphrase, obligates the GO or GOP to:

- operate each generator with the automatic voltage regulator in-service and controlling voltage;
- maintain the voltage or reactive schedule provided by the TOP;
- modify voltage when instructed or provide an explanation for not being able to do so;
- notify the TOP of AVR, PSS, or voltage controlling device status changes;
- notify the TOP of reactive capability status changes;
- provide GSU and Aux transformer tap settings, ranges, and transformer impedance data to the TOP and TP;
- modify GSU transformer tap settings, if possible, at the request of the TOP; and

- follow alternate directions by the TOP, or be exempted due to being in startup, shutdown, or testing mode.

Whereas the requirements of Reliability Standard VAR-002 apply to the AVR equipment located at generating facilities for the purpose of voltage control, possible requirements of a proposed BAL-003-3 could apply to the turbine/plant control systems to promote system frequency control and stability. These requirements could take the form of the following:

- operate each governor/speed/frequency/MW set point controller with the primary frequency regulator in-service and controlling frequency;
- maintain the scheduled frequency using a proportional control with percent droop and frequency deadband; settings (see the next section for a discussion of specifying and/or reporting the settings between the GO/GOP and the BA);
- provide an explanation to the BA for not being able to contribute to frequency control;
- notify the BA of frequency controlling device status changes;
- provide the in-service frequency controlling device settings to the BA;
- modify the in-service frequency controlling device settings, if possible, at the request of the BA; and
- follow alternate directions by the BA, or be exempted due to being in startup, shutdown, or testing modes.

FERC Order 842 requires minimum interconnection requirements for new units/facilities, including the installation, maintenance, and operation of a functioning governor. The first bullet above is akin to that part of FERC Order 842. There is significant debate about whether, given the current state of acceptable frequency responsiveness, new resource requirements to provide Frequency Response will provide adequate ability to arrest and correct future frequency disturbances.

In the above-bulleted list of possible GO/GOP requirements, several are informational in nature, where the GO/GOP is providing information to the BA on the ability to control frequency (providing an explanation of not being able to control frequency, notifying due to status changes, etc.). Where the BA wants this information to use for a reliability purpose, the BA may require it through the data specifications developed under Reliability Standard TOP-003. Considering a GO/GOP requirement to provide information that has not previously been required (by Reliability Standard TOP-003) raises the question of whether the information will be used for any purpose.

This requirement is one which can be "coupled" with new BA requirements for having a Frequency Response reserve plan, knowing the Frequency Response reserves available. Although traditional generation does not have on/off switches for governors, differing vastly from AVR control modes, improper settings can defeat an otherwise responsive governor. A turbine control system may not have system frequency (speed) built into the governor during on-line operation. Examples of this are steam valve position and hydro wicket gate position regulators. Solar and wind generating facilities often operate at the maximum power operating point and, therefore, are unable to provide any additional response for underfrequency disturbances. Additionally, the variability of the power source for these types of facilities prevents certainty of the 100% availability for Frequency Response. Certain steam turbine driven generators operate with the turbine steam valves in a wide-open position which will prevent additional generation from being available for underfrequency events. Some CT controllers run fuel control at a maximum exhaust temperature mode which may prevent additional generation from being available for underfrequency events.

Modes of Operation

The following is a discussion of the ability to implement possible requirements (“Options”) outlined above and provides considerations relevant to each. Operating each governor or equivalent controller with the primary

frequency regulator in-service and controlling frequency, in most cases, should not be a difficult proposition due to the following characteristics of most control systems:

- A frequency-dependent bias component exists in the control equipment functionality; and
- In-service/out-of-service control switches or variable parameter settings permit the tuning and detuning of the responsiveness of the frequency-dependent bias component.

There could, however, be other important process elements or operating modes which may serve to eliminate, either partially or wholly, the ability of this frequency-dependent bias component from providing the desired Frequency Response during frequency disturbances. These include, but are not limited to:

- The importance of and focus given to reactor controls at nuclear generating stations.
  - Some controls on these units have shown the ability to provide Frequency Response, while others intentionally have detuned the controls by various methods to prevent their operation, thereby increasing the stability of the reactor control.
- Current, widely-used modes of operation for wind, solar, CTs, and steam turbines may permit or may restrict responsiveness. These modes include:
  - operation at the maximum power point (solar, wind, batteries, steam turbines, CTs, etc.);
  - operating at the minimum power point in the control continuum;
  - CT running at the maximum allowable exhaust temperature limit; and
  - coal-fired unit on the verge of coal requirement switching point to change load levels.

Prescribed changes to the modes of operation would be necessary in these instances to permit the existing equipment to provide Frequency Response. Maintaining the scheduled frequency using frequency-dependent bias components with specified limits to the sensitivity settings has been shown to be possible where generating units are not constrained by other operational limitations. A discussion of the sensitivity settings (droop, deadband) is part of the next section of this document.

Resource Frequency Response Communication Requirement

Option 4 – Notifications and Governor Settings

Notifications by the GO/GOP to the BA could be provided to indicate the ability of a unit, or change in the ability of a unit, to provide Frequency Response. For each unit, operational experience and certain test results can provide this intelligence which can be conveyed to the BA for use in frequency response reserve planning. Many generating units will have known operating conditions where Frequency Response can be expected. Additionally, operating conditions resulting in no Frequency Response are often known. Real-time determination and communication of these instances would prove to be more challenging in some cases, as there may be difficulty or uncertainty in incorporating all aspects of unit operating conditions into the logic used to indicate the expected responsiveness. Where on/off switches are used in control systems for the frequency responsive component of the control, changes to the set points of the control can easily be communicated to the BA.

Providing the in-service frequency controlling device settings to the BA is expected to be a one-time event as these settings are not often modified. Modifying these settings is possible and are recommended to be changed while the controller is not in service. Requiring a unit to be offline for these changes impacts the speed in which changes can be implemented. Consideration should be given to the variation in droop and deadband settings of governor primary frequency control settings for all generating units in each interconnection. A coordinated approach for contributions from each facility during Frequency Disturbances is desired. A secondary effect of any changes to the droop and

deadband settings could cause the model verification performed as part of Reliability Standard MOD-027 to become invalid, and this would trigger a requirement to re-verify that model.

Exceptions to any prescribed Frequency Response requirement for the GO/GOP need to be considered and permitted for certain situations. These include unique unit attributes allowed for alternate directions by the BA, being in startup, shutdown, or testing modes, or other individual peculiarities or anomalies that exist with a generating facility. These types of exceptions are analogous to voltage schedule adherence exceptions which are allowed under Reliability Standard VAR-002. Communication and discussion of these exceptions should be expected between the GO/GOP and the BA.

Consideration of Real-time Information

Generating units providing Real-time information to BAs on the available Frequency Response capability would provide valuable transparency to the expected Frequency Response. The SDT has discussed a BA requirement (see Section 1: New/Modified BA Requirement) to calculate and have available a set amount of Frequency Response reserves in Real-time. A requirement for the generating units to provide information to the BA on the capability would be a direct complement to this requirement. No BA requirement for Real-time Frequency Response reserves determination was drafted.

Communication of Governor Settings

Areas the SDT has been discussing around the topic of Real-time status, availability, and expected droop and deadband settings are:

- Requirement to provide the data;
- Settings to be provided, or prescribed; and
- What parameters should to be communicated.

Requirement to provide the data – Options 4(a) and 4(b)

The requirements for providing Frequency Response data to the BA should be considered for all generating resources including but not limited to generators, non-synchronous machines, and storage.

Options discussed by the SDT for a requirement to provide Real-time Frequency Response data were:

Option 4(a): Add a new BA requirement in Reliability Standard BAL-003.

Option 4(b): Provide recommendation for information to be provided under Reliability Standard TOP- 003.

Settings to be provided, or prescribed

Options discussed by the SDT on the droop and deadband settings information to be provided were:

1. The droop and deadband settings can be specified to the generator by the BA.
2. The GO would communicate the current droop and deadband settings of the unit to the BA.

Discussion of options: 4(a) and 4(b)

Under Option 4(a), a new requirement would be added to Reliability Standard BAL-003 for the BA to provide the specified Frequency Response communications to the GO. The BA would be able to set the required droop and deadband for all resources (see Section 2, BA R4). BAs would need to determine if they required the “default” deadband (no greater than 36 MHz), and droop (no greater than 5%), or if there were different settings that would be appropriate. It will also need to be determined if a resource type would drive the Frequency Response setting and

an exception process would need to be considered for resources unable to provide Frequency Response (See Chapter 2, BA R5).

Benefits

- Ensures the BA knows what to expect from all generators in its footprint;
- Allows BAs to set requirements aligned with ensuring adequate Frequency Response capability is available on the system; and
- Would minimize the information that would need to be provided in Real-time from the GO to the BA.

Possible Hurdles

- Requires BAs to put processes in-place to define the required droop and deadband settings;
- Could require measurable staff support to respond to generator inquires and potential discrepancies between generator capabilities and requirements.

Negatives

- Potential concerns over large discrepancies between BAs on requirements for droop and deadband settings; and
- Potential concerns over fairness between all generators in a given BA, and potentially different settings or exemptions between resource types.

Under Option 4(b), the GO would communicate to the BA the current droop and deadband settings of the unit. There would not be a set droop or deadband expectation for the resources. Rather, this would ensure the transparency of the resource capability and operations. The Frequency Response communications from the GO/GOP to the BA would be managed under the existing (or modified) TOP-003 Reliability Standard. A benefit to this method is that existing processes and data exchange can be used to provide the additional data. A hurdle to this method may be that a new SAR for modification to the existing TOP-003 Reliability Standard may be needed to allow for this data to fit within the requirements. Adding data requirements without a clear understanding of how this data will be used by the BA does not fulfill the contemplated requirements for the BA documented in Sections 1 and 2.

Benefits

- Would allow the BA to have situational awareness of available Frequency Response reserves; and
- Minimal cost to implement communication of the droop and deadband settings.

Possible Hurdles

- This information is already being communicated to the Transmission Planner as part of the Reliability Standard MOD-027 data; and
- Determination needs to be made as to whether this data would be usable by the BA, or if this data would not be valid for Real-time awareness and reserve calculations.

Negatives

- Potential to have significant data exchange requirements between the generator and BA; and
- While increasing visibility, this requirement would not necessarily increase Frequency Response.

Section 4: Summary of Options for Requirements

Balancing Authority Requirements

R3 – Operational Planning process to schedule adequate Frequency Response reserves

A. **BA-R3:** Each Balancing Authority shall develop and implement an Operating Process, reviewed and maintained at least annually, as part of its Operating Plan to schedule frequency responsive resources sufficient to maintain interconnection frequency equal to or greater than it's frequency responsive reserve obligation.

R4 - Governor Settings

A. **BA-R4:** BA specifies minimum Governor Settings in its appropriate data specification (droop, deadband, and operating mode) for Generators within BA Footprint.

B. **BA-R4.1** Each Balancing Authority shall provide a copy of the minimum droop and deadband settings to its Reliability Coordinator and adjacent Balancing Authorities within 30 calendar days of a request.

To be able to plan and schedule sufficient Frequency Response reserves, BAs will need actual governor settings from each generator in their footprint. Where should any potential request for data (droop, deadband, and operating mode) from the GO/GOP to the BA be addressed?

R5 - Governor Setting/Operation Exemption

A. **BA R5:** The Balancing Authority specifies exemption process for governor settings (droop, deadband, and operating mode) in BA R4.

Generator Owner/Operator Requirements

Option 1 – Performance Requirement BA Calculation

Requirements similar to BAL-001-TRE where the local BA performs the generator performance calculations.

Option 2 – Performance Requirement GO Calculation

Requirements similar to BAL-001-TRE where the GO/GOP performs the generator performance calculations.

Option 3 – Resource Governor In-service Requirement

Requirements similar to VAR-002 for voltage control equipment applied to the turbine/plant speed / MW/frequency control systems. These requirements may take the form of the following:

- operate each governor/speed/frequency/MW set point controller with the primary frequency regulator in-service and controlling frequency;
- maintain the scheduled frequency using a proportional control with percent droop and frequency deadband; settings (see the next section for a discussion of specifying and/or reporting the settings between the GO/GOP and the BA);

- provide an explanation to the BA for not being able to contribute to frequency control;
- notify the BA of frequency controlling device status changes;
- provide the in-service frequency controlling device settings to the BA;
- modify the in-service frequency controlling device settings, if possible, at the request of the BA; and
- follow alternate directions by the BA, or be exempted due to being in startup, shutdown, or testing modes.

Option 4 – Notifications and Governor Settings

This possible requirement would require

- notifications by the GO/GOP to the BA could be provided to indicate the ability of a unit, or change in the ability of a unit, to provide Frequency Response
- Providing the in-service frequency controlling device settings to the BA. Two methods of this communication are being considered:
  a. The droop and deadband settings can be specified to the generator by the BA.
  b. The GO would communicate the current droop and deadband settings of the unit to the BA.

Conclusion and Recommendations

Conclusion

Various methodologies are available for the establishment of systems to arrest, stabilize, and restore to normal any sudden imbalances in generation and load which manifest themselves in Frequency Disturbances. This White Paper has investigated several methods as possible approaches that are detailed in Chapters 2 and 3. Additionally, other relevant considerations including varying existing resource capabilities, new technology capabilities, existing Frequency Response adequacy measures, projected Frequency Response adequacy estimations, and market solutions have been presented.

Recommendations

The SDT recommends a four-layered approach to provide for the adequacy of Frequency Response resources:

1. Require BAs to gather information on a GO's ability to provide Frequency Response, where needed, to permit improved Frequency Response reserves planning.
2. Limit the GO/GOP national standard requirement for frequency control to one that is similar to the existing GO/GOP requirement for the provision of voltage control for resources with the ability to perform the function.
3. Allow the provisions contained with the FERC Order 842, coupled with Interconnection Agreements for future connected resources, to procure and establish additional frequency responsiveness. New resources with this capability included in the functionality allow for marketplace solutions.
4. Permit the establishment of market incentives for areas/regions where additional reserve is desired.