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## Background

At its September 2010 meeting, the NERC Operating Committee (OC) requested the NERC Resources Subcommittee (RS) to draft a short “position paper” on Frequency Response. The paper was accepted by the NERC OC at their March 2011 meeting subject to minor edit changes. This document reflects the work of the NERC RS, OC and Industry comments.

The NERC Resources Subcommittee (RS) has been concerned with the trend in Frequency Response, particularly in the Eastern Interconnection, for several years. The RS initiated the Standards Authorization Request (SAR) for BAL-003 to put a measurement process in place so engineers can objectively analyze the adequacy of Frequency Response and underlying issues to enable informed decisions.

Most in the industry agree that there is adequate Frequency Response at this point in all Interconnections. For example, it would take a contingency on the order of 10,000 MW in the Eastern Interconnection to trigger the first general step of Under Frequency Load Shedding (UFLS). The intent of the SAR for the Frequency Response Standard is to have facts and an objective process in place to adjust regionally or turn things around globally if warning signs develop or if limits are approached.

## Focus of BAL-003

While it is true that generators are the primary source of Frequency Response, the focus of BAL-003 should not be generators alone. Assuming there is presently an acceptable amount of Primary Frequency Response, resources would be better applied by initially evaluating performance at the Balancing Authority level and address local action in Balancing Authority Areas where Frequency Response measured as low.

A generator-centric standard would be costly and likely take years to implement and does not recognize new resources which can also provide frequency response. The *Form EIA-860 Database Annual Electric Generator Report* for 2008 lists over 7000 generators 25 MW or larger in the US. This does not include combined generation plants with small units with capacity greater than 75 MW (plant level size is another requirement which bring small generation under NERC registry), which would also be subject to a generator-centric standard. Monitoring and validating performance of all these generators would be difficult at best.

## Target Minimum Frequency Response

The Frequency Response Standard drafting team is proposing a standard with performance goal that each Interconnection can withstand at least a severe N-2 event without encroaching upon the first tier of Under Frequency Load Shedding (UFLS). The Interconnection may include an additional safety margin in the standard’s contingency protection criteria. The process to identify the Interconnection N-2 protection criteria is expected to be administered centrally by the Interconnection or NERC working collaboratively with the NERC Operating and Planning Committees.

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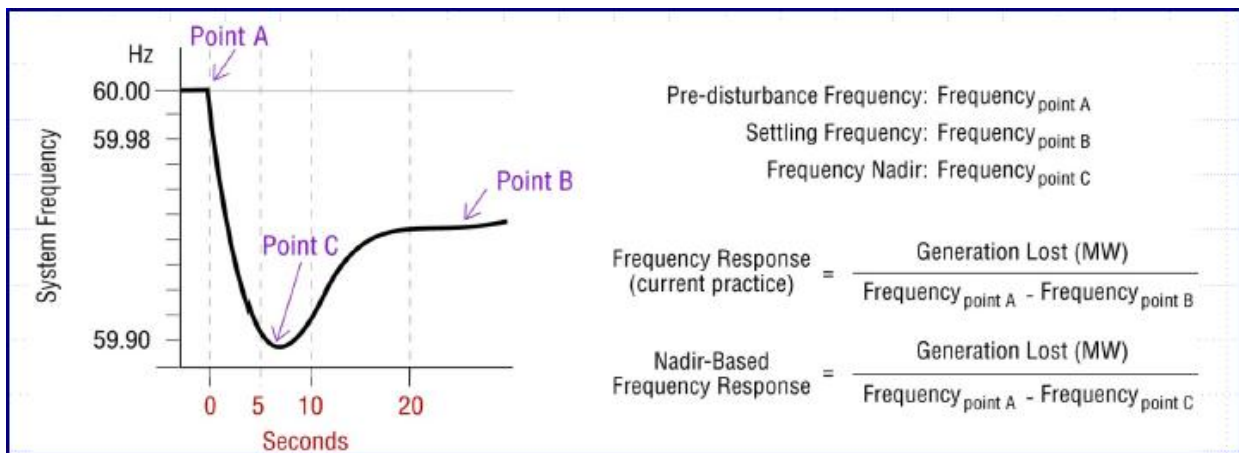
	Eastern	Western	Texas	HQ	
Starting Frequency	60	60	60	60	Hz
Highest UFLS*	59.6	59.5	59.3	58.5	Hz
Contingency Protection Criteria	4500	2740	2708	1700	MW
Frequency Response Obligation	1125	548	387	113	MW/0.1Hz

**Development of Frequency Response Obligation (Example)**

**Note:** The table above is illustrative. The values have not been fully vetted in the standards process. The obligation will likely include an additional safety margin to address the difference between Point A and Point C.

\*The Eastern Interconnection set point presented in the table is a compromise of the general first step of UFLS in the East (59.7Hz) and a special protection setting in Florida (59.7Hz). It is extremely unlikely there would be an event elsewhere in the Eastern Interconnection that would cause a “false trip” of the Florida UFLS.

The standard assumes that the given Interconnection is at the nominal value of 60 Hz at the time of the event. The target Frequency Response Obligation (FRO) is based on points A and B of the frequency excursion. The contingency protection criteria have a safety margin to address the difference between Points B and C. The graph below depicts a disturbance with a depiction of points A, B, C. C point is the lowest frequency value measured within 10 seconds.



**Typical Frequency Excursion<sup>1</sup>**

<sup>1</sup> “Use of Frequency Response Metrics to Assess the Planning and Operating Requirements for Reliable Integration of Variable Renewable Generation”, Lawrence Berkeley National Laboratory, December 2010.

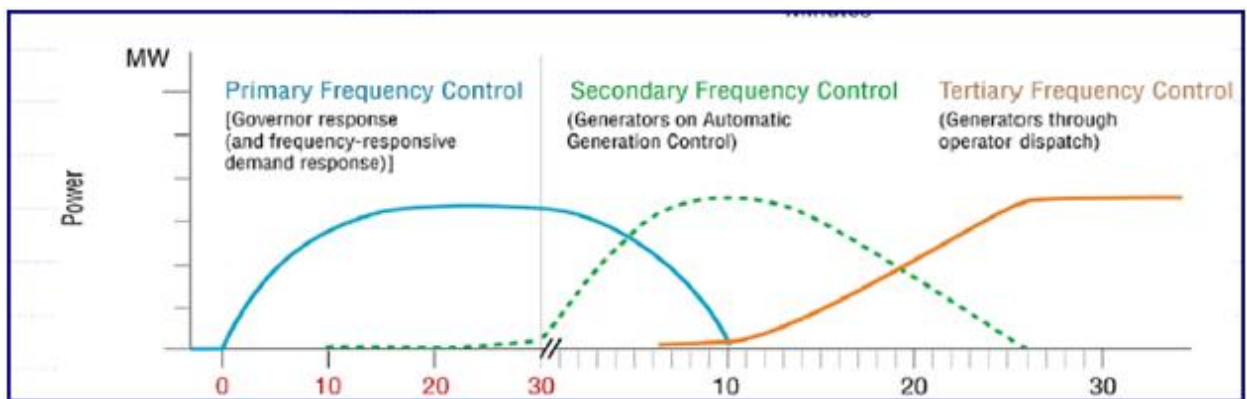
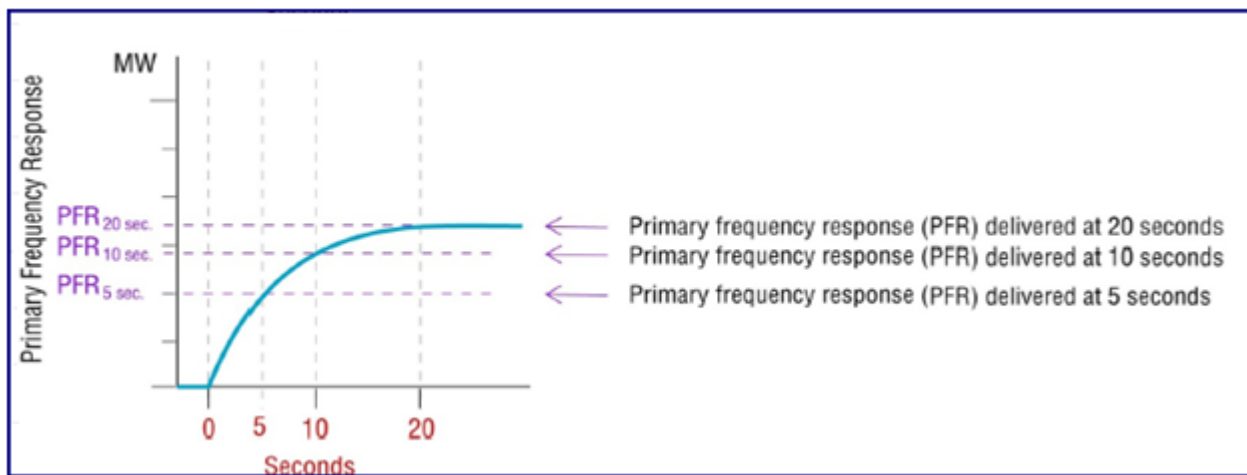
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It is expected the data collected in BAL-003 will be used by planners to validate models and test the adequacy of their respective Interconnection's Contingency Protection Criterion.

Once the Frequency Response Obligations have been vetted, it would not be difficult to set Red-Yellow-Green risk levels at the Balancing Authorities (BAs) to communicate to the industry the state of Frequency Response and to better target mitigating actions.

### Obtaining Frequency Response

What are the attributes of Frequency response? The desired support is a resultant change in power or load to arrest declining frequency and restore system frequency to a stable value above point C. The response to arrest frequency deviation is automatic and provided by direct measurement of frequency or rotation of the turbine. The expected response needs to be delivered within cycles to seconds of the frequency deviation and continued delivery until the disturbance is arrested and Automatic Generation Control acts to restore ACE. Graphic below shows frequency response delivered within 20 seconds and maintained. Graphics below<sup>2</sup> show primary response measure and the second graph shows the interrelationship of primary, secondary, and Tertiary Frequency Control.



<sup>2</sup> "Use of Frequency Response Metrics to Assess the Planning and Operating Requirements for Reliable Integration of Variable Renewable Generation", Lawrence Berkeley National Laboratory, December 2010.

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Order No. 693 directed NERC to modify BAL-003 to identify methods of obtaining Frequency Response. A simple approach to achieve this objective is to allow BAs to obtain response by participation in a Reserve Sharing Group (RSG) similar to the acquisition of contingency reserves. Performance could be aggregated similar to the Disturbance Control Standard. Grouping BAs may work to improve some BA response. Frequency response of the Interconnection is used by all BAs when their respective load or generation disturbance event happens.

Additionally, there appears to be an existing mechanism through transmission tariffs and markets. Regulation and Frequency Response is an approved ancillary service. The FERC has also previously given the Transmission Provider authority to determine the amount and location of required ancillary services and if necessary sanction the overutilization of such services. BAL-003 could be used to objectively determine the need for additional services. Tariffs are not the only solutions to obtain frequency response. Europe and the state of Texas have also put in grid code requirements that generation must meet which includes frequency response.

Presently, the bulk of Frequency Response must come from generators and may change as alternative methods and devices provide this same service. This means Balancing Authorities will need a rational frequency response service verification standard that couples to any performance obligation in BAL-003.

### Field Test

Assuming BAL-003 will be a Balancing Authority-centric standard, there are several reasons why a field Test is needed, including:

- The drafting team is proposing to adjust the floor for Bias to address concerns raised in the 2003 Blackout Report. Control theory says frequency performance improves if Bias Setting and natural Frequency Response are nearly equal. Still, the interaction between Bias and actual performance may cause unexpected interactions that negatively impact frequency performance.
- The event selection and measurement processes have not been tested and could have flaws.
- In the past, NERC Frequency-Response Characteristic surveys have been used to measure frequency response throughout the continent; however, these surveys had limited accuracy. The drafting team is evaluating other more technically-based approaches to evaluate risk and performance obligations. This evaluation will be done in parallel with the Field Test.

The Frequency Response Standard drafting Team is recommending the use of the 2011 Bias calculation data (events from 2010 frequency excursions as the basis) as a field test. Keep in mind that the trial is recommending the reduction of Bias floor to 0.8% of peak load or true natural response whichever is the larger absolute value for the field trial Bias setting.

### Summary Points

- Frequency response is an important reliability function. In the event of generation loss, it assists in arresting the frequency decline as frequency deviates from nominal, and adds stability.
- The Interconnections appear to have sufficient Frequency Response at this time.
- An overly stringent standard will increase customer costs for marginal increases in reliability.

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- BAL-003 should also enable a process for review to bring more Frequency Responsive resources to bear when the Interconnection is stressed or during islanding and blackstart operations. Regions have the authority to develop local standards should they choose to have a more stringent standard, or if there is something unique about the Region that requires more response.
- Similar to the Control Performance Standard, BAL-003 should be “tunable” such that the Interconnection target response can be adjusted as the industry learns more.
- To expedite the standard, there should be a field trial using a defined set of 2010 frequency excursions as a basis for an objective Bias calculation for 2011 and allow analysis of data. An improved standard could be deployed in 2012.
- If Frequency Response is a priority issue, NERC and the FERC should develop a standard to assure is performance and they should take a leadership role to encourage Smart Grid technologies to include Frequency Response as one of the services provided.

### **Future Work (Generator Control)**

- Generators or other sources of Frequency Response that utilize a step response once frequency crosses their governor dead-band can cause instability during island and blackstart operation. Dead-bands act as filters to prevent generation response and to some extent oscillatory behavior with electrically close generation. The droop curve will drive the unit to a power level based on the difference in reference once the signal exceeds the dead-band – this sudden jump in power is the step function
- Black start plans should consider generator Frequency Response performance in determining black start and cranking path generators.
- Outer Loop MW control and the early withdrawal of Frequency Response is also a reliability concern. Generators that do not sustain Frequency Response during the frequency recovery period should be studied to determine the root cause of the early withdrawal. It is suspected that contributing factors are improper implementation of desired (set point) generation overruling frequency based generation at the generator. Market design, rules or tariffs that incent generators to remain on an exact MW schedule at all times should be changed to acknowledge the obligation to support frequency.
- Interconnections need specific guidelines for droop settings and allowable dead-bands. The droop settings should not have step changes at the dead-bands. Interconnections with low or marginal Frequency Response will need to have a closely coupled generator verification standard.