Forward Looking Frequency Trends, A Brief for Regulators and Policymakers

ERS Framework[1] Measures 1, 2, and 4: Forward Looking Frequency Analysis

Regulators and policymakers should be aware of impacts to bulk power system (BPS) reliability that occur due to policy decisions that influence the resource mix. This document addresses the manner in which frequency support is being assessed and managed by the smaller Interconnections, and the benefit, particularly for the larger Interconnections, of forecasting future trends.

Frequency support is the response of generators and loads to maintain the system frequency in the event of a system disturbance. Frequency support is provided through the combined interactions of synchronous inertia (traditionally from conventional generators and motors) and frequency response (from a wide variety of generators and loads). Working in a coordinated way, these characteristics arrest and eventually stabilize frequency. A critical issue is to stabilize the frequency before it falls below underfrequency load shedding values or rises above overfrequency relay trip settings.

It is important to understand that inertia and frequency response are properties of the Interconnection (not to each balancing area individually) and these properties have different characteristics for each Interconnection. For example, if changes to the resource mix alter the relative amounts of synchronous inertial response or frequency response, various mitigation actions are possible (such as obtaining faster primary frequency response from other generators or loads) to maintain or improve frequency support.

The frequency measures are intended to monitor and identify trends in frequency response performance as the generation mix continues to change. The holistic frequency measure, called Measure 4 in ERSWG reports, tracks phases of frequency performance after disturbance events in each Interconnection (initial frequency rate of change, arresting phase, and recovery phase). Other measures look at components of this coordinated frequency response, such as the amount of synchronous inertial response (SIR, Measure 1) and the initial rate of change in frequency following the largest contingency event (RoCoF, Measure 2).

As previously reported in the separate brief on historical frequency trends, changes in frequency measures are being carefully analyzed by using historical data. The NERC Resources Subcommittee is monitoring historical trends and reporting on these results in the annual NERC State of Reliability (SOR) report.

However, it is also prudent to forecast future trends to anticipate changes and provide additional time to plan and implement changes. Projecting future frequency support characteristics requires modeling of the future state of the Interconnection by using reasonable assumptions and scenarios. This forward-looking analysis will be performed as part of the NERC reliability assessment process and included in the NERC Long Term Reliability Assessment (LTRA) report.

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[1] Essential Reliability Services Working Group, Measures Framework Report, November 2015

Hydro Québec (HQ) and ERCOT are smaller Interconnections that consist of a single balancing area. In ERCOT, approximately 20 percent of the installed generation capacity is from wind resources (as of the end of 2016), and there are times when wind generation is serving up to 50 percent of ERCOT's total system load. In HQ, the majority of the generation capacity comes from hydro resources which, in general, have lower inertia in comparison to coal and combined cycle units of the same MW size. Consequently, these two Interconnections are actively addressing issues with lower system inertia and experience faster frequency declines after large contingency events.

Both HQ and ERCOT have requirements and practices in place to ensure sufficient frequency performance. They have similar approaches for ensuring sufficient primary frequency response (PFR). Both ERCOT and HQ require PFR capability to be enabled on all online generators that are over 10 MW in size and connected at the transmission level, and all online generators are expected to respond to disturbance events when they have the available operating range to do so. Both also have approaches for procuring additional frequency response reserves when needed (ERCOT through the ancillary service market, and HQ through bilateral contracts). Interestingly, up to a half of ERCOT's primary frequency reserve can be provided by load resources with this very fast response considered to be a valuable form of fast frequency response (FFR). HQ obtains a different form of FFR through use of a "synthetic inertia" option from wind turbines.

On the other hand, the two Interconnections have different strategies to ensure reliable operation during low system inertia conditions. ERCOT has studied the performance of their Interconnection across a range of SIR levels, implemented a control room tool to provide operator awareness, and determined the amounts and types of additional frequency response reserves to be obtained for various operating conditions. HQ has establish operating criteria based on comprehensive studies of their system while considering different load/generation levels, contingency sizes and locations, effects of synchronous reserves, load behaviors, etc. They then operate their system so as to ensure that the maximum generation trip will not result in underfrequency load shedding based on the actual topology of their network for both day-ahead and hour-ahead generation dispatches.

In comparison to HQ and ERCOT, the Eastern Interconnection (EI) and Western Interconnection (WI) are physically much larger systems with lower penetrations of non-synchronous generation as a percentage of system load and very large numbers of diverse generation resources. Therefore, rather than conduct studies that cover all possible inertia conditions, as in the cases of HQ and ERCOT, it is most practical to forecast future trends using EI and WI planning cases and modeling methods. The Eastern Interconnection Planning Collaborative (EIPC) and Western Electricity Coordinating Council (WECC) will lead this effort for the EI and the WI, respectively. The current proposal is to repeat the forward looking frequency response studies every two to three years using the five-year future planning cases.

For Further Information

For more details, see Chapter 1 of the ERS Whitepaper on Sufficiency Guidelines, the Brief for Regulators and Policymakers on Historical Frequency Trends, or the detailed Technical Brief on these topics. The historical and forward looking frequency trends will be discussed annually in the NERC State of Reliability (SOR) report and Long Term Reliability Assessment (LTRA) report, respectively.