Field Test Results
WECC-0115 BAL-002-WECC-2a
Request to Retire Requirement R2

Standard Drafting Team

March 5, 2019

Executive Summary

After doing a field test from May 1, 2017, through April 30, 2018, the WECC-0115 BAL-002-WECC-2a, Contingency Reserve, Request to Retire Requirement R2 Drafting Team (DT) concluded that, if Requirement R2 is retired, it is unlikely to have an adverse impact on reliability.

On May 6, 2015, WECC received Standard Authorization Request (SAR) WECC -0115 BAL-002-WECC -2a Contingency Reserve, Request to Retire Requirement R2 (R2) requesting retirement of R2 and its compliance elements. The SAR stated that on April 1, 2016, R2 would become redundant to BAL-003-1.1 Frequency Response and Frequency Bias Settings, Requirement R1.

From May 1, 2017, through April 30, 2018, WECC did a NERC-approved field test to find out the impact on reliability if R2 was retired.[1] A compliance waiver for R2 was granted beginning on May 1, 2017, and ending on May 1, 2019.

WECC required U.S. entities to provide data on the quantity of reserve carried during the field test period. This was done to enable WECC to see the impacts of the field test, as a condition to take part in the field test, and to meet conditions from NERC in approving WECC's request for a field test. The data showed no adverse impact to reliability if R2 is retired.

Project WECC-0115 will not be balloted until this report is presented for review to the WECC Ballot Pool and the requirements of the NERC Rules of Procedure, 6.3 Communication and Coordination for All Types of Field Tests and Data Analyses have been met by NERC.

[1] The field test was approved by NERC in late March 2017 and conducted per NERC Standards Processes Manual, Section 6.2, Field Tests and Data Analysis for Validation of Requirement.

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Introduction

On May 6, 2015, WECC received SAR WECC-0115 BAL-002-WECC-2a, Contingency Reserve requesting retirement of Requirement R2 (R2). The SAR was deemed complete the same day. The SAR asserted that on April 1, 2016, Requirement R2 would become redundant to BAL-003-1.1, Requirement R1, Frequency Response and Frequency Bias Setting.

On June 23, 2015, the WECC Standards Committee (WSC) approved the SAR after vetting by the WECC Operating Committee Steering Committee (OC) (June 9, 2015) and the Joint Guidance Committee (JGC) (May 27, 2015).

From October 22 through December 8, 2015, the project was posted once for comment, during which stakeholders were asked a question:

> Do you agree that WECC Regional Standard BAL-002-WECC-2,[2] Contingency Reserve, Requirement R2 should be retired as of the effective date of NERC Standard BAL-003-1[3] (BAL-003), Frequency Response and Frequency Bias Setting, Requirement R1?

Three entities responded to the posting and were in favor of retirement.[4] After a discussion with staff, the DT and WECC staff[5] agreed that a field test should be done to gauge the impact of retiring R2.

A NERC-approved field test was done from May 1, 2017, through April 30, 2018. The field test data is the foundation of this paper and was posted for comment as Posting 2 of this project. Posting 2 received three comments, one for retirement and two suggesting caution.

Field Test Description

Data Source and Description

The field test data was requested from each Balancing Authority (BA) and each Reserve Sharing Group (RSG) subject to R2. Data was received by WECC through an online WECC portal.

The data request included the following information:

[2] During this project, the BAL-002-WECC-2 designation changed to BAL-002-WECC-2a on January 24, 2017, in FERC Docket No. RD17-3-000. The BAL-003-1 designation changed to BAL-003-1.1 on November 13, 2015, in FERC Docket RD15-6-000.

[3] BAL-003-1, Frequency Response and Frequency Bias Setting is approved by FERC on March 24, 2014, and has an enforcement date of April 1, 2016.

[4] Xcel Energy, Bonneville Power Administration, and WECC.

[5] Steven Rueckert, WECC Director of Standards, and Phil O'Donnell, WECC Manager, Operations and Planning Audits and Investigations.

1. For any reportable Disturbance Control Standard (DCS)[6] event, the date and time of the event, the required amount of Contingency Reserves at the time of the event, the actual amount of Operating Reserves-Spinning at the time of the event, and the actual DCS performance.[7]
2. For all instances of a loss of resources 700 MW or greater, whether it is a reportable DCS event or not, the date and time of the event, the name of the resource(s), and the total MW loss.

Objective

The field test was designed to determine whether retirement of R2 would have any adverse impact on grid reliability. The test examined the impact on DCS performance and frequency response in the Western Interconnection.

Overview

The first metric, DCS performance, monitored the performance of each RSG, and each BA that was not a member of an RSG, for every reportable DCS event to see whether any were unable to meet the DCS recovery period for a DCS event. More information was requested from the participants to calculate the ratio for required contingency reserve to Operating Reserve-Spinning for each qualified event.

The second metric watched system performance for any loss of resources greater than 700 MW and for any adverse impact on frequency response.[8] Data for this metric was collected using the same information used by NERC to collect information to perform analysis on interconnection frequency response analysis for the NERC State of Reliability and Frequency Response Annual Analysis reports.

Field Test Analysis and Results

BAL-002-WECC-2a, Requirement R2 was intended to do two things: 1) to aid in frequency recovery (through governor action) for large generation loss events across the Western Interconnection, and 2) to provide a part of the Contingency Reserves (on-line generation minus 10-minute response) for generation trip events within the BA or RSG if the party is an RSG member. With the implementation of new standards and a change of generation resources in the Western Interconnection, the SAR was based on the presumptions that BAL-002-WECC-2a, Requirement R2 became redundant as of the

[6] "The reliability standard that sets the time limit following a Disturbance within which a BA must return its Area Control Error to within a specified range." NERC Glossary of Terms Used in Reliability Standards (Glossary).

[7] During the field test, only the DCS responsible entity was asked to provide data during DCS events. Entities that did not have a reportable DCS event were not requested to provide data.

[8] The DT noted that the WECC Interconnection Frequency Response Obligation (IFRO) is roughly -840 MW per 0.1 HZ. The 700-MW loss was chosen as a more conservative number than the IFRO and represents a value large enough to cause a significant frequency excursion. For an example, see Frequency Response Analysis Tool, Dmitry Kosterev, Bonneville Power Administration, 2014. https://www.wecc.org/Reliability/Frequency%20Response%20Analysis%20-%20Dmitry%20Kosterev.pdf

April 1, 2016, effective date of BAL-003-1.1 Frequency Response and Frequency Bias Setting, and that, with its retirement, neither interconnection frequency performance metrics nor DCS performance would degrade.

With the implementation of BAL-003-01.1, frequency response became measurable, and the field test gave entities a compliance waiver for WECC BAL-002-WECC-2a Requirement R2, thus splitting DCS and frequency response. Entities were responsible for ensuring both reliability performance metrics were met. On that basis, the data captured from the field test was used with interconnection frequency response performance data to assess any impact to individual DCS performance as well as overall interconnection frequency performance.

Data Description

Data from the field test covered 66 DCS events. During each of those events, entities provided data to help assess DCS performance. This data included Contingency Reserve Obligation, Required Spin (assuming no compliance waiver), Actual Spin, and whether Area Control Error recovery was met to successfully pass the DCS event. See Table 1 for the data set collected.

Table 1—DCS Event Field Test Data

Entity #	Reported MW Loss	DCS Event	Contingency (Cont.) Reserve Obligation	Required Spin	Actual Spin	Pass(x)	Cont./Spin (Pre-Contingency Value)
Entity 3	530	Yes	585	293	878	x	150.09%
Entity 3	480	Yes	585	293	1165	x	199.15%
Entity 5	341	Yes	2624	1312	5595	x	213.22%
Entity 5	309	Yes	2528	1264	4095	x	161.99%
Entity 5	310	Yes	2830	1415	4428	x	156.47%
Entity 5	294	Yes	2992	1496	4010	x	134.02%
Entity 5	480	Yes	2349	1174.5	4360	x	185.61%
Entity 5	375	Yes	3068	1534	4986	x	162.52%
Entity 5	393	Yes	3106	1553	3989	x	128.43%
Entity 5	587	Yes	2373	1187	4483	x	188.92%
Entity 5	628	Yes	3124	1562	4201	x	134.48%
Entity 5	388	Yes	3211	1606	4217	x	131.33%
Entity 5	838	Yes	2988	1494	4223	x	141.33%
Entity 5	353	Yes	3234	1617	4658	x	144.03%
Entity 2	655	Yes	656	328	552	x	84.26%
Entity 5	356	Yes	3646	1823	5956	x	163.36%
Entity 5	619	Yes	3732	1866	6193	x	165.94%
Entity 2	430	Yes	468	234	417	x	89.11%
Entity 5	513	Yes	3514	1757	6063	x	172.54%
Entity 5	519	Yes	2823	1412	6001	x	212.58%
Entity 5	748	Yes	3688	1844	6271	x	170.04%

Entity #	Reported MW Loss	DCS Event	Contingency (Cont.) Reserve Obligation	Required Spin	Actual Spin	Pass(x)	Cont./Spin (Pre-Contingency Value)
Entity 5	630	Yes	3024	1512	6680	x	220.90%
Entity 2	**442**	**Yes**	**538**	**269**	**231**	**x**	**42.97%**
Entity 5	506	Yes	3610	1805	6703	x	185.68%
Entity 5	760	Yes	3742	1871	6133	x	163.90%
Entity 5	522	Yes	3612	1806	5698	x	157.75%
Entity 5	1061	Yes	3791	1896	6799	x	179.35%
Entity 5	411	Yes	2964	1482	5358	x	180.77%
Entity 5	1882	Yes	2497	1249	4952	x	198.32%
Entity 5	486	Yes	3536	1768	5855	x	165.58%
Entity 5	475	Yes	3422	1711	6647	x	194.24%
Entity 5	723	Yes	3006	1503	8401	x	279.47%
Entity 5	796	Yes	3293	1647	5844	x	177.47%
Entity 5	492	Yes	3174	1587	5111	x	161.03%
Entity 5	460	Yes	5129	2565	9318	x	181.67%
Entity 5	398	Yes	5614	2807	11920	x	212.33%
Entity 5	1150	Yes	5231	2616	13142	x	251.23%
Entity 5	1699	Yes	6028	3014	9288	x	154.08%
Entity 5	786	Yes	5874	2937	9350	x	159.18%
Entity 5	479	Yes	5155	2578	14798	x	287.06%
Entity 3	538	Yes	585	293	1329	x	227.23%
Entity 5	714	Yes	5869	2935	11056	x	188.38%
Entity 5	656	Yes	6090	3045	14291	x	234.66%
Entity 5	760	Yes	5517	2759	8679	x	157.31%
Entity 3	790	Yes	790	395	1607	x	203.42%
Entity 2	496	Yes	573	286	379	x	66.15%
Entity 5	1046	Yes	8090	4045	12613	x	155.91%
Entity 5	493	Yes	7099	3550	12659	x	178.32%
Entity 5	651	Yes	3351	1676	5962	x	177.92%
Entity 1	388	Yes	1040	520	979	x	94.13%
Entity 4	851	Yes	2181	1091	1091	x	50.02%
Entity 1	970	Yes	1037	519	1151	x	110.99%
Entity 4	1059	Yes	1175	588	600	x	51.06%
Entity 3	582	Yes	790	395	924	x	116.96%
Entity 2	**800**	**Yes**	**565**	**283**	**234**	**x**	**41.44%**
Entity 1	471	Yes	1040	520	1359	x	130.67%
Entity 1	699	Yes	1041	521	1426	x	136.98%
Entity 4	**817**	**Yes**	**1543**	**772**	**768**	**x**	**49.77%**
Entity 5	1026	Yes	2832	1416	6038	x	213.21%
Entity 5	850	Yes	2741	1371	6543	x	238.71%

Entity #	Reported MW Loss	DCS Event	Contingency (Cont.) Reserve Obligation	Required Spin	Actual Spin	Pass(x)	Cont./Spin (Pre-Contingency Value)
Entity 5	660	Yes	2691	1346	5911	x	219.66%
Entity 1	500	Yes	1040	520	1589	x	152.79%
Entity 5	506	Yes	3206	1603	5893	x	183.81%
Entity 5	707	Yes	3056	1528	5952	x	194.76%
Entity 1	322	Yes	1020	510	1454	x	142.55%
Entity 4	866	Yes	1186	593	672	x	56.66%

All 66 events had a 100 percent pass rate showing no degradation to DCS performance. With the BAL-002-WECC-2a R2 compliance waiver in effect, entities carried and deployed enough reserves for post disturbance Area Control Error (ACE) recovery. Also, Spinning Reserve more than the required 50 percent was carried during all but three events. Of the remaining 63, on average, the entity was carrying 166.38 percent Spinning Reserve as opposed to the 50 percent Spinning Reserve required by the standard. In the remaining three events, the entities carried an average of 5.3 percent less Spinning Reserve than mandated.[9]

Western Interconnection frequency performance was assessed to further determine the impact of the field test on the Interconnection. Frequency performance data was collected for the 32 events having a verified resource loss of more than 700 MW.

According to NERC, Essential Reliability Services (ERS) Measure 4[10] is a comprehensive set of Frequency Response measures capturing speed of Frequency Response and response withdrawal at all relevant time frames:

- Point A to C frequency response in MW/0.1 Hz;
- Point A to B frequency response in MW/0.1 Hz (similar to Adequate Level of Reliability (ALR)-12);
- C:B Ratio;
- C:C′ Ratio; and
- Three time-based measures: t0 to tC, tC to tC′, and t0 to tC′.

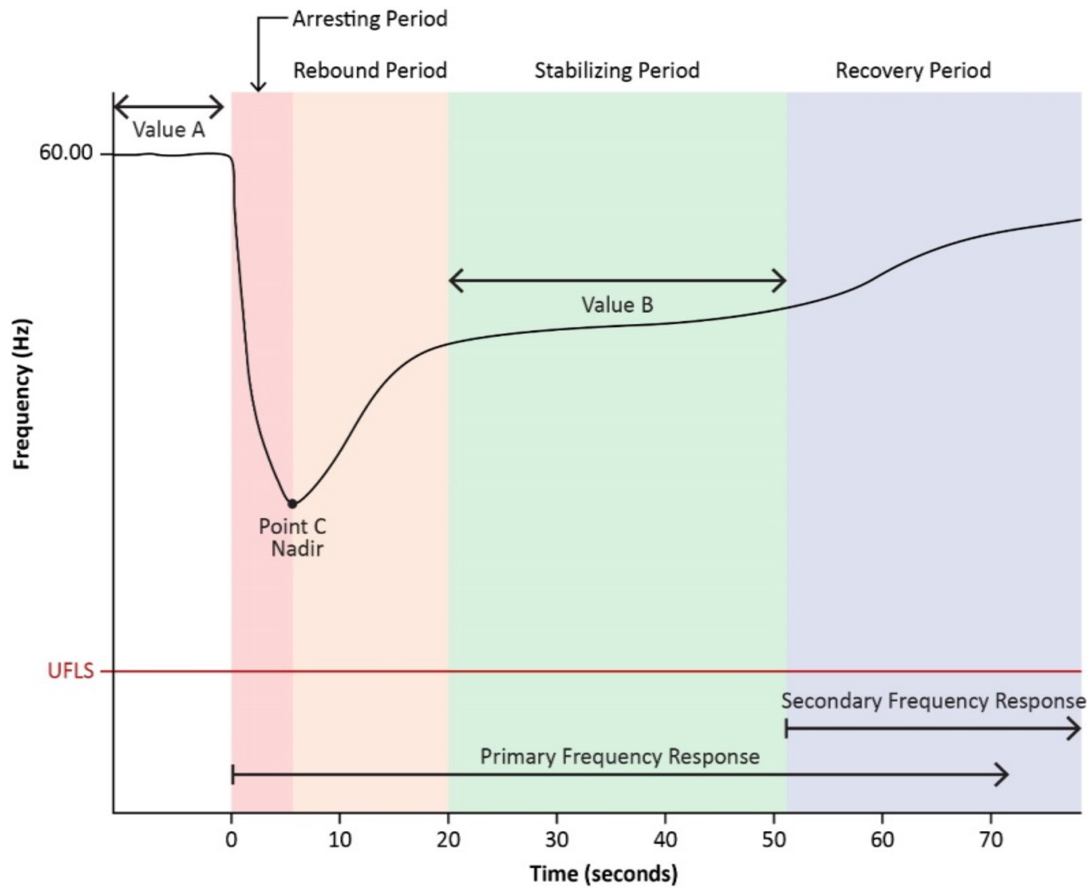
Figure 1 shows a frequency deviation due to a loss of generation resource and the methodology for calculating frequency response. The event starts at time t0. Value A is the average frequency from t-16 to t-2 seconds, Point C is the lowest frequency point observed in the first 12 seconds, and Value B is the

[9] This analysis does not speculate on why reporting entities carried more reserve than required. It only notes that excess reserves were carried.

[10] Please note that, although similar in title, *NERC's Essential Reliability Services (ERS) Measure 4* (page 8) is different from *NERC's State of Reliability Report, Metric M-4* (page 9).

average from t+20 to t+52 seconds. Point C′ occurs when the frequency after 52 seconds falls below either the Point C (12 seconds) or average Value B (20–52 seconds), as illustrated below.

Figure 1—Frequency Deviation due to Loss of Generation Resource



Per the NERC State of Reliability Report, Metric M-4 has two parts of interest: 1) performance of the Western Interconnection to arrest the frequency decline after a loss-of-generation event to prevent activation of underfrequency load shedding (UFLS), and 2) performance of the Western Interconnection to stabilize quickly at a high enough frequency to successfully respond to a second frequency event, should one occur.[11]

- Arresting Period: In 2017, the Western Interconnection experienced an event in which the Point C nadir was 59.697 Hz, resulting in a Point C to UFLS margin of 0.197 Hz, the smallest margin since a 0.171-Hz event in 2014. The resource MW losses for these two events were 2,685 MW and 2,826 MW, respectively. This is more than double the mean resource MW loss for each year, and larger than the Resource Contingency Criteria of 2,626 MW, which is defined in the 2016

[11] NERC State of Reliability, June 2018, Appendix E: Frequency Response Statistics and Essential Reliability Services, DADS Metric 4: Performance—Demand Response Events by Month—Dispatched vs. Realized, page 112. https://www.nerc.com/pa/RAPA/PA/Performance%20Analysis%20DL/NERC_2018_SOR_06202018_Final.pdf

Frequency Response Annual Analysis and used to calculate 2017 IFRO. Over the 2013–2017 operating years, the Western Interconnection trend was neither statistically improving nor declining. This indicates that the BAL-002-WECC-2a field test did not adversely impact Western Interconnection arresting period frequency performance.

- Stabilizing Period: The mean frequency response in 2017 of 1,836 MW/0.1 Hz was the highest of all years evaluated in this report. The Western Interconnection had no events in 2017 in which its interconnection frequency response measure (IFRM) was below its IFRO, including the event noted above, wherein the Point C nadir to UFLS margin was less than 0.200 Hz. Frequency response over the 2013–2017 operating years indicated that the Western Interconnection experienced significant improvement during the stabilizing period. This indicates that the BAL-002-WECC-2a field test did not adversely impact Western Interconnection stabilizing period frequency performance.

Figure 2—Table 2.1 from NERC 2018 State of Reliability Report, June 2018

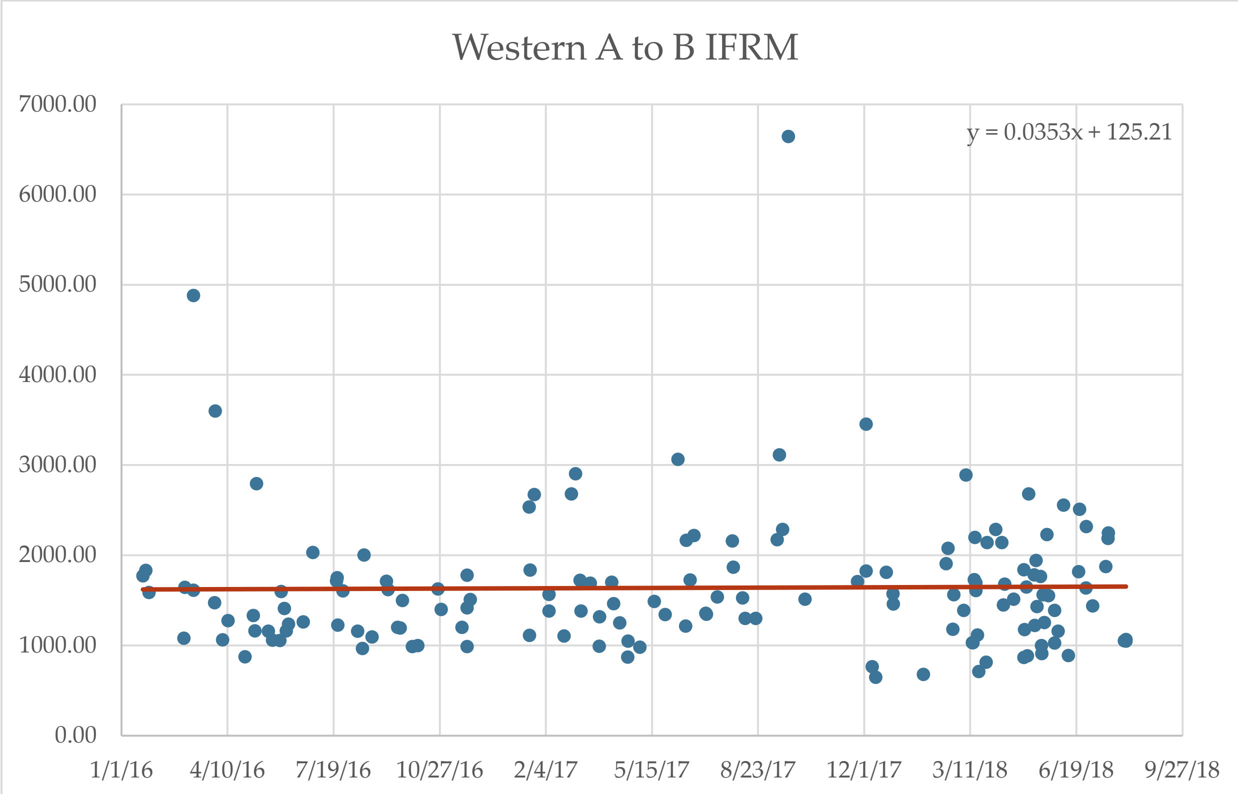
Table 2.1: Interconnection Performance Summary Statistics

Interconnection	2017 OY Largest Resource Loss		2017 OY Lowest A-B IFRM Performance		2013–2017 OY Arresting Period Performance Trend	2013–2017 OY Stabilizing Period Performance Trend
	MW Loss	UFLS Margin (Hz)	MW Loss	UFLS Margin (Hz)		
Eastern	1,661	0.453	511	0.472	Improving	No Change
Texas	1,219	0.433	369	0.603	Improving	Improving
Quebec	954	0.873	314	1.199	Improving	No Change
Western	2,776	0.210	383	0.450	No Change	Improving

Below is a summary of Western Interconnection frequency performance metrics:

1. A to B frequency response shows the effectiveness of primary frequency response in stabilizing frequency after a large frequency excursion. This measure is the conventional means of calculating Frequency Response as the ratio of net MW lost to the difference between Point A and Point B frequency values.

Figure 3—A to B IFRM



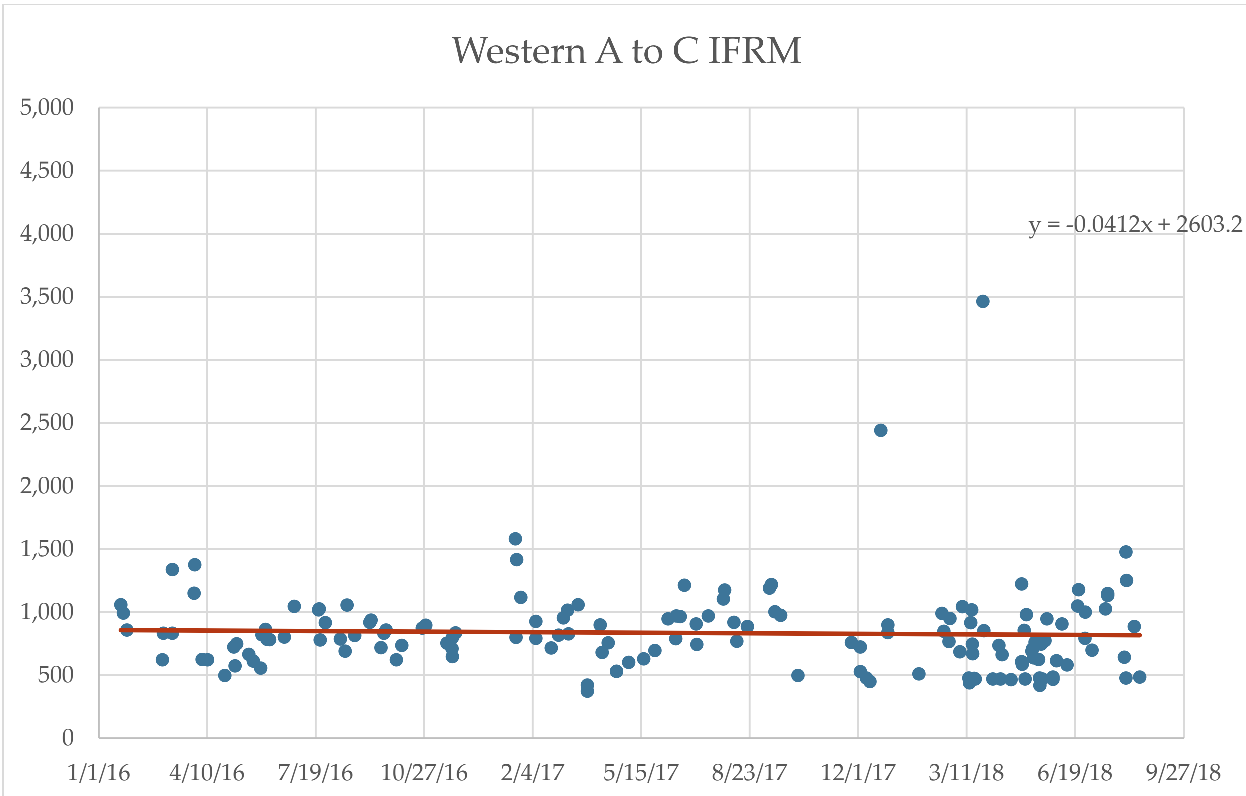
An increasing trend indicates that frequency response is improving. The Western Interconnection A to C metric shows no degradation.

For Example:

- 60.0 Hz pre-event (A frequency), Loss of 1,000 MW, 59.9 Hz primary frequency response (B frequency)
  - A to B Measure = 1,000 MW/0.1 HZ
- 60.0 Hz pre-event (A frequency), Loss of 1,500 MW, 59.9 Hz primary frequency response (B frequency)
  - A to B Measure = 1,500 MW/0.1 HZ
  - A to B measure increases, showing that larger loss of resource results in same post-event disturbance
- 60.0 Hz pre-event (A frequency), Loss of 1,000 MW, 59.92 Hz primary frequency response (B frequency)
  - A to B Measure = 1,250 MW/0.1 HZ
  - A to B measure increases, showing that the same loss in resource results in higher post-event (primary frequency response measure)

2. A to C frequency response shows the impacts of inertial response, load response (load damping), and initial governor response. Governor response is triggered immediately after frequency exceeds a pre-set deadband; however, depending on generator technology, full governor response may require up to 30 seconds to be fully deployed. This measure is calculated as the ratio of net megawatts lost to the difference between Point A and Point C frequency values.

Figure 4—A to C IFRM



An increasing trend indicates that frequency response is improving. The Western Interconnection A to C metric shows no degradation.

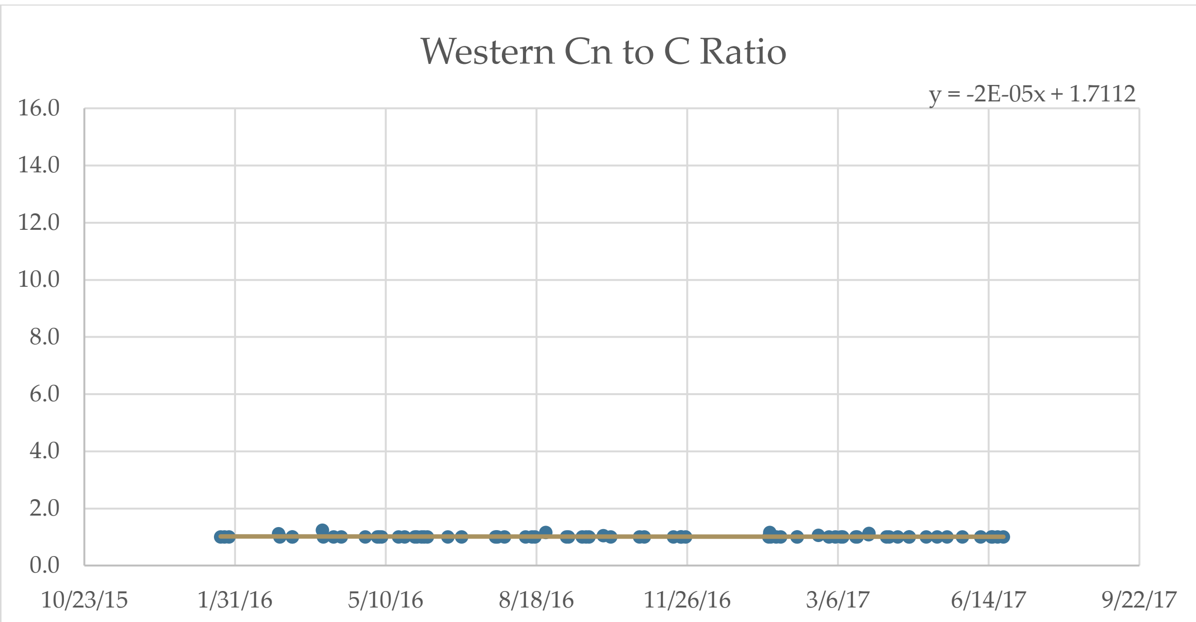
For Example:

- 60.0 Hz pre-event (A frequency), Loss of 1,000 MW, 59.85 Hz lowest frequency (C frequency)
  - A to C Measure = 667 MW/0.1 HZ
- 60.0 Hz pre-event (A frequency), Loss of 1,500 MW, 59.85 Hz lowest frequency (C frequency)
  - A to C Measure = 1,000 MW/0.1 HZ
  - A to C measure increases, representing that larger loss of resource results in same post-event disturbance

- 60.0 Hz pre-event (A frequency), Loss of 1,000 MW, 59.90 Hz lowest frequency (C frequency)
    - A to C Measure = 1,000 MW/0.1 HZ
    - A to C measure increases, representing that the same loss in resource results in higher post-event (primary frequency response measure)

3. Cn to C is the ratio between the absolute frequency minimum (Point Cn) caused by governor withdrawal and the initial nadir (Point C). This metric measures withdrawal of primary frequency response. A response greater than 1.0 indicates withdrawal. A declining trend is an indication of improving primary frequency response. The Western Interconnection has shown no indications of response withdrawal.

Figure 5—Cn to C Ratio



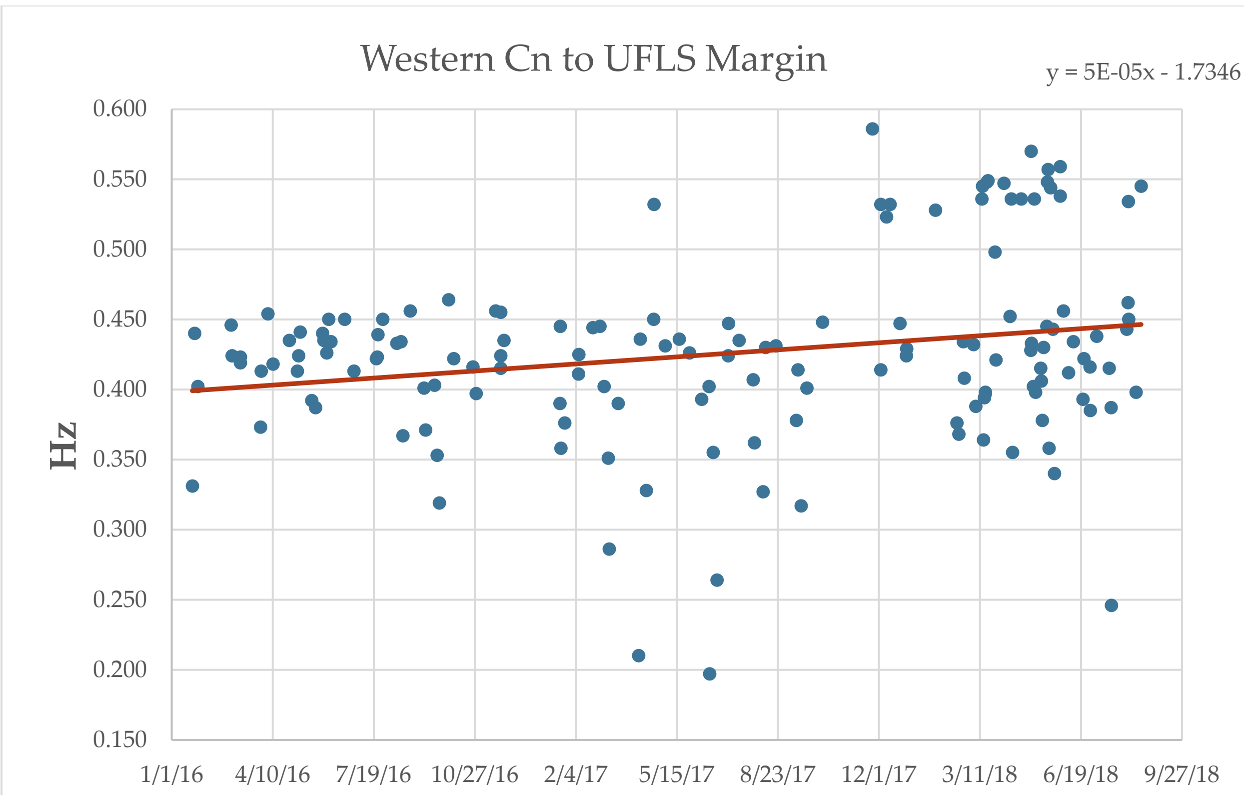
When this white paper was drafted, Cn data was only publicly available through August 2017. However, in addition to trended data, the NERC Frequency Response Annual Analysis, published November 2018, also shows that the Western Interconnection continues to experience no frequency response withdrawal during the BAL-002-WECC-2a field test.

Figure 6—Table 2.2 from NERC 2018 Frequency Response Annual Analysis, November 2018

Table 2.2: Statistical Analysis of the Adjustment for C' Nadir (BC'adj)						
Interconnection	Number of Events Analyzed	C' Lower than B	C' Lower than C	Mean Difference	Standard Deviation	BC'ADJ (95% Quantile)
Eastern	112	66	34	0.005	0.003	0.006
Western	86	45	0	N/A	N/A	N/A
ERCOT	143	61	2	N/A	N/A	N/A
Québec	135	31	12	-0.019	0.028	-0.004

4. Cn to UFLS ratio measures the margin between the frequency nadir and the first step in UFLS.

Figure 7—Cn to UFLS margin



The trend does show a statistical increase in UFLS margin. It should also be noted that the magnitude of the resource loss has a direct impact on Interconnection performance calculation as measured by IFRMs and Point C to UFLS margins. During 2017 and 2018, there were three events in which the resource loss was 2,776 MW, 2,685 MW, and 2741 MW; more than double the mean resource MW loss for each year and larger than the defined Resource Contingency Criteria of 2,626 MW.[12]

One event occurred on April 6, 2017, 11:00 p.m. PDT when the field test was not in effect, and the other two events on June 16, 2017, at 5:14 a.m. PDT and July 18, 2018, at 5:30 p.m. PDT when the field test was in effect. All events, however, had comparable results and significant UFLS margin before and after the field test. Also, all three events had an IFRM that exceeded the IFRO.

Per the WECC Off-Nominal Frequency Load Shedding Plan (UFLSP), load shedding occurs sequentially in five blocks with a minimum separation of 0.1 Hz between steps. UFLS entities taking part in the UFLS plan (aka, Coordinated Plan) are required to shed their first block of load as soon as frequency has declined to 59.5 Hz.[13]

[12] See the 2017 Frequency Response Annual Analysis https://www.nerc.com/comm/OC/BAL0031_Supporting_Documents_2017_DL/2017_FRAA_Final_20171113.pdf

[13] "UFLS Entities participating in the Coordinated Plan are required to shed their first block of load as soon as frequency has declined to 59.5 Hz, with additional minimum requirements for further load shedding steps (as set forth in the accompanying table)." WECC Off-Nominal Frequency Load Shedding Plan, Coordinated Plans, para. 1a, page 8, December 5, 2012.

WECC receives data used in its analyses from a wide variety of sources. WECC strives to source its data from reliable entities and undertakes reasonable efforts to validate the accuracy of the data used. WECC believes the data contained herein and used in its analyses is accurate and reliable. However, WECC disclaims any and all representations, guarantees, warranties, and liability for the information contained herein and any use thereof. Persons who use and rely on the information contained herein do so at their own risk.