October 4, 2018

VIA ELECTRONIC FILING

Mr. Patrick Wruck, Commission Secretary
British Columbia Utilities Commission
Box 250, 900 Howe Street
Sixth Floor
Vancouver, B.C.
V6Z 2N3

Re: Informational Filing Regarding BAL-001-2 (Errata to Include Attachment)

Dear Mr. Wruck:

The North American Electric Reliability Corporation ("NERC") hereby submits this informational filing regarding Reliability Standard BAL-001-2 (Real Power Balancing Control Performance), resulting from a directive by the Federal Energy Regulatory Commission ("FERC") in Order No. 810.[1] Reliability Standard BAL-001-2 is intended to ensure that Interconnection frequency is maintained within predefined frequency limits and improved upon the prior version of the standard by adding a frequency component to the measurement of a Balancing Authority ("BA") Area Control Error ("ACE") called the BA ACE Limit ("BAAL").

In approving Reliability Standard BAL-001-2, FERC directed NERC to submit an informational filing after implementation of the standard regarding potential impacts on System Operating Limit ("SOL") and Interconnection Reliability Operating Limit ("IROL") exceedances in the Western and Eastern Interconnections.[2] In particular, FERC stated:

> The Commission adopts the NOPR proposal regarding NERC's submission of an informational filing. …. Further, we find that the informational filing should encompass both the Western and Eastern Interconnections, as there were concerns about possible increases of SOL/IROL exceedances in both Interconnections.
>
> ….Therefore, we direct NERC to make an informational filing 90 days after the end of the two-year period following implementation that includes an analysis of data (all relevant events or a representative sample) on whether experience with the Balancing Authority ACE Limit in the first two years after approval has seen ACE swings and

[1] *Real Power Balancing Control Performance Reliability Standard*, Order No. 810, 151 FERC ¶ 61,048, 80 Fed. Reg. 22,395 (2015) ("Order No. 810").

[2] SOL is the value (such as MW, MVar, Amperes, Frequency or Volts) that satisfies the most limiting of the prescribed operating criteria for a specified system configuration to ensure operation within acceptable reliability criteria. An IROL is a SOL that, if violated, could lead to instability, uncontrolled separation, or cascading outages that adversely impact the reliability of the bulk power system.

> unscheduled power flows or inadvertent interchange that could cause SOL/IROL exceedances. However, if it is evident that during this two-year period the issues discussed above are creating SOL/IROL exceedances NERC should provide that information to the Commission, together with appropriate recommendations for mitigation, as this information becomes available. Further, NERC should also make the underlying data available to Commission staff upon request.[3]

The attached report presents NERC's analysis regarding whether experience with the BAAL has resulted in ACE swings and unscheduled power flows or inadvertent interchange that could cause SOL/IROL exceedances. To complete this analysis, NERC evaluated trends in frequency trigger limit exceedances, unscheduled flow mitigation hours in the Western Interconnection, transmission loading relief procedures in the Eastern Interconnection, frequency performance, and inadvertent interchange. Based on this analysis, NERC concludes that the BAAL has not resulted in an increase in SOL/IROL exceedances.

NERC is not requesting any action on the instant filing. This filing is for informational purposes only.

Respectfully submitted,

/s/ *Candice Castaneda*
Candice Castaneda

Counsel for North American Electric Reliability Corporation

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[3] Order No. 810, PP 36-38. FERC also directed NERC to revise the definition of Reporting ACE. NERC submitted this revised definition in *Notice of Filing of the North American Electric Reliability Corporation of Six NERC Glossary Definitions*, filed on June 8, 2016. This informational filing satisfies all outstanding directives in FERC Order No. 810.

NERC

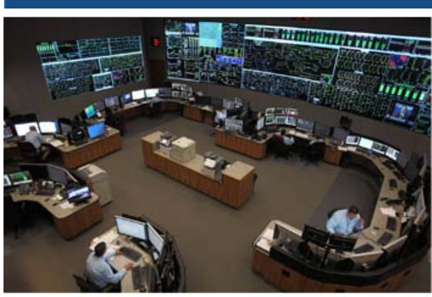
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Technical Report on NERC Standard BAL-001-2

Informational Filing in Compliance with FERC Order 810

September 2018

RELIABILITY | ACCOUNTABILITY

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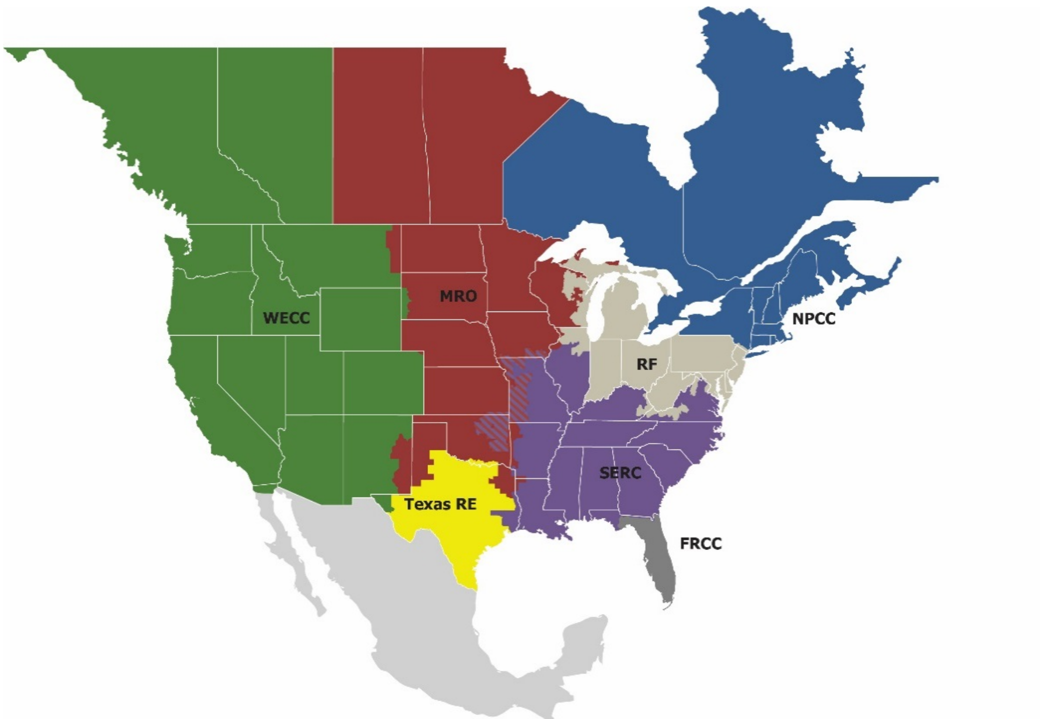
Preface

The vision for the Electric Reliability Organization (ERO) Enterprise, which is comprised of the North American Electric Reliability Corporation (NERC) and the seven 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.

The North American BPS is divided into seven 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.



FRCC	Florida Reliability Coordinating Council
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

In Order No. 810, the Federal Energy Regulatory Commission (FERC) accepted Reliability Standard BAL-001-2 (Real Power Balancing Control Performance).[1] Reliability Standard BAL-001-2 is designed to ensure that applicable entities maintain system frequency within narrow bounds around a scheduled value. The standard improved reliability by adding a frequency component to the measurement of a Balancing Authority (BA) Area Control Error (ACE). In approving the standard, FERC also directed NERC to submit an informational filing pertaining to the standard's potential impact.[2]

In particular, FERC stated the following:

> "The Commission adopts the NOPR proposal regarding NERC's submission of an informational filing. …. Further, we find that the informational filing should encompass both the Western and Eastern Interconnections, as there were concerns about possible increases of SOL/IROL exceedances in both Interconnections.
>
> ….Therefore, we direct NERC to make an informational filing 90 days after the end of the two-year period following implementation that includes an analysis of data (all relevant events or a representative sample) on whether experience with the Balancing Authority ACE Limit in the first two years after approval has seen ACE swings and unscheduled power flows or inadvertent interchange that could cause SOL/IROL exceedances. However, if it is evident that during this two-year period the issues discussed above are creating SOL/IROL exceedances NERC should provide that information to the Commission, together with appropriate recommendations for mitigation, as this information becomes available. Further, NERC should also make the underlying data available to Commission staff upon request."[3]

This report provides NERC's analysis of the issues in accordance with FERC's directive.

Response to Order No. 810 Directive

Analysis of whether experience with the Balancing Authority ACE Limit (BAAL) in the first two years after approval of the standard has resulted in ACE swings and unscheduled power flows or inadvertent interchange that could cause SOL/IROL exceedances.

NERC concludes that, based on the analysis of data two years prior to and two years after the implementation of Reliability Standard BAL-001-2, the BAAL has not resulted in an increase in SOL/IROL exceedances. This analysis was based on NERC's evaluation of trends in frequency trigger limit exceedances, unscheduled flow mitigation hours (in the Western Interconnection), transmission loading relief procedures (in the Eastern Interconnection), frequency performance, and inadvertent interchange.

[1] Real Power Balancing Control Performance Reliability Standard, Order No. 810, 151 FERC ¶ 61,048 (2015).

[2] Order No. 810, at P 2 (directing, "analysis of data on whether experience with the Balancing Authority ACE Limit in the first two years after approval has seen ACE swings and inadvertent interchange and unscheduled power flows that could cause system operating limit (SOL) and interconnection reliability operating limit (IROL) exceedances."); *and id.*, n. 4–5 (noting, "Inadvertent interchange is '[t]he difference between the Balancing Authority's Net Actual Interchange and Net Scheduled Interchange. (IA – IS).' NERC Glossary of Terms Used in Reliability Standards (NERC Glossary) at 42." Adding, "Unscheduled power flows generally refers to power flows that result from the law of physics that causes power from a given source to flow over all possible paths to its destination.").

[3] Order No. 810, PP 36-38.

Introduction

The purpose of Reliability Standard BAL-001-2 is to assure reliability by maintaining Interconnection frequency within predefined frequency limits. This standard defined a new requirement, known as the BAAL, which replaced prior Reliability Standard BAL-001-1 Requirement R2 known as Control Performance Standard 2 (CPS2).[4] Compliance with the BAAL requires the BA to balance its resources and demand in real-time so that the clock-minute average of its reporting ACE does not exceed its clock-minute BAAL for more than 30 consecutive clock minutes.

The NERC Operating Committee (OC) endorsed a BAAL field trial that was subsequently approved by the NERC Standards Committee in June of 2005. The field trial began in the Eastern Interconnection in July of 2005. The Electric Reliability Council of Texas (ERCOT) Interconnection was added to the field trial in December of 2009, followed by the Western Interconnection in March of 2010, and the Québec Interconnection in September of 2010. The field trial ended for participating BAs upon the effective date of Reliability Standard BAL-001-2. Reliability Coordinators for all Interconnections monitored the performance of BAs participating in the field trial and held monthly field trial conference calls.

The following provide a background on the development of the BAAL, an overview of the BAAL field trial, and the analysis method used to satisfy the directive set forth in FERC Order 810.

Development of the BAAL

Control Performance Standard 1 (CPS1)

The foundation of the NERC Balancing Standards are the Real Power Balancing Control Performance requirements found in Reliability Standard BAL-001-2. The standard includes two requirements: CPS1 and BAAL. The predecessor to BAAL was CPS2. CPS1 assigns each Balancing Authority a share of the responsibility for control of steady-state Interconnection frequency. The amount of responsibility is directly related to Balancing Authority Frequency Bias. CPS1 measures ACE variability in combination with the Interconnection's frequency error in one-minute averages over a rolling one-year period and is derived from frequency-based statistical theory.

BAAL versus CPS2

CPS2 was designed to limit a BA's unscheduled power flows but was not designed to address Interconnection frequency. It measures the ability of a BA to maintain its 10-minute average ACE within a fixed limit of plus or minus a MW value called L_{10}. To be compliant, a BA needed to demonstrate that its average ACE value during a consecutive 10-minute period was within the L_{10} bound for at least 90 percent of all 10-minute periods over a one-month period. While this metric did require the BA to correct its ACE to not exceed specific bounds, it failed to recognize the positive or negative impact of that action on Interconnection frequency. The BAAL requirement provided dynamic limits that are BA and Interconnection specific. These ACE values are based on identified Interconnection Frequency Trigger Limits (FTLs) to ensure the Interconnection returns to a reliable state when an individual BA's ACE or Interconnection frequency deviates into a region that contributes too much risk to the Interconnection. The intent of BAAL was to replace and improve upon CPS2, which is not dynamic, is not based on Interconnection frequency and allows for a Balancing Authority's ACE value to be unbounded for a specific amount of time during a calendar month.

BAAL Analysis Methods

The purpose of this analysis is to use historic data to determine whether the implementation of BAAL control, in lieu of CPS2, has contributed in an increase in ACE swings, unscheduled power flows, or inadvertent interchange that could cause an increase in SOL/IROL exceedances. The time period evaluated includes two years prior to and two years after the implementation of BAAL. The analysis focuses on identifying trends in the number and duration of FTL

[4] Unless otherwise designated, all capitalized terms shall have the meaning set forth in the *Glossary of Terms Used in NERC Reliability Standards*, available at http://www.nerc.com/files/Glossary_of_Terms.pdf.

exceedances, unscheduled flow (USF) mitigation hours in accordance with the Western Interconnection Unscheduled Flow Mitigation Plan (WIUFMP), transmission loading relief (TLR) occurrences in accordance with Reliability Standard IRO-006-EAST-2, frequency performance, and inadvertent interchange. Particular attention is given to the multi-BA Western and Eastern Interconnections.

Frequency Trigger Limit (FTL) Exceedance Analysis

This analysis focuses on the one-minute frequency performance in the two multi-BA Interconnections, Western and Eastern, two years before and two years after the implementation of Reliability Standard BAL-001-2 as it relates to exceeding the FTLs. Under BAAL control, ACE swings could be more likely at the BA level when Interconnection frequency exceeds the FTLs due to BAAL allowing BA ACE to exceed the L10 boundaries used under its predecessor CPS2. The purpose of this analysis is to determine whether FTL exceedances have increased since the implementation of BAL-001-2 and BAAL.

Unscheduled Flow (USF) Mitigation and Transmission Loading Relief (TLR) Analysis

The WIUFMP is used to mitigate flows on Qualified Paths to reliable levels during real-time operations. Transmission Operators of Qualified Paths may use the WIUFMP to reduce flows on Qualified Paths. The purpose of this analysis is to determine whether conclusive evidence exists that transmission constraints and USF mitigation hours increased in the Western Interconnection as a direct result of BAAL implementation.

The NERC TLR Procedure is an Eastern-Interconnection-wide process that allows Reliability Coordinators to mitigate potential or actual operating security limit violations while respecting transmission service reservation priorities. The purpose of this analysis is to determine whether conclusive evidence exists that transmission constraints and TLR occurrences increased in the Eastern Interconnection as a direct result of BAAL implementation.

Frequency Performance and Inadvertent Interchange

Interconnection frequency can become more variable or noisy for a wide spectrum of issues, including congestion, multiple transmission line operations, generation losses, or general control issues. Adverse frequency control impacts due to the implementation of BAAL could be reflected in an increase in frequency variability, measured by RMS1. The purpose of this analysis is to determine whether conclusive evidence exists that frequency variability increased as a direct result of BAAL implementation.

Inadvertent Interchange is the difference between the BA's net actual interchange and its net scheduled interchange. BAs calculate and report Inadvertent Interchange for both On-Peak and Off-Peak periods. Adverse frequency control impacts due to the implementation of BAAL could be reflected in an increase in inadvertent interchange. The purpose of this analysis is to determine whether conclusive evidence exists that BA inadvertent interchange accumulations increased as a direct result of BAAL implementation.

Chapter 1: BAAL Field Trial

Below is a brief summary of observations, by Interconnection, during the BAAL Field Trial.

Eastern Interconnection

Number of Participating Balancing Authorities

Under a phased implementation, the field trial began in the Eastern Interconnection in July of 2005, and seven BAs that represented approximately 60 percent of the non-coincident peak demand in the Interconnection were operating under the field trial by the end of that year. After the initial field trial implementation, BAs were added to the field trial while others had been consolidated into larger BA Areas. This resulted in eleven BAs operating under the field trial, which represented approximately 75 percent of the non-coincident peak demand in the Interconnection.

Frequency Performance

There was an improvement in frequency performance in the Eastern Interconnection under the field trial, including a notable reduction in the total minutes of frequency beyond the FTL.

Unscheduled Flow Events

Throughout the duration of the field trial, no BA, Reliability Coordinator, or other participating reliability entity cited problems with unscheduled flows associated with operation of BAAL.

Western Interconnection

Number of Participating Balancing Authorities

The Western Interconnection began its participation in the BAAL field trial on March 1, 2010. Initially 26 out of 37 BA Areas participated in the field trial; another BA was later added, bringing the total number of BAs to 27 out of 38. The participating BA Areas represented approximately 90 percent of the non-coincident peak Demand in the Interconnection.

Frequency Performance

The Western Interconnection observed that the average one-minute frequency error increased from 10 mHz in 2009 to 18 mHz in 2013. The largest annual frequency error increase, from 10 mHz to 14 mHz, occurred between 2009 and 2010 when the field trial was first implemented. The Western Interconnection Epsilon1 frequency target is 22.8 mHz.

Unscheduled Flow Events

The hours of coordinated operations of the phase shifters increased during the field trial period. However, due to changing seasonal patterns, a changing resource mix, unusual operating conditions, and other events, it was not possible to conclusively associate the increased hours of phase shifter operations with the field trial. Additional information can be found in the WECC Performance Working Group report[5], approved by the WECC Operating Committee in March 2015.

Single BA Interconnections: ERCOT

Of the Interconnections in North America, two Interconnections have only one BA: ERCOT and Québec. ERCOT joined the BAAL field trial in December 2009, and Québec joined the field trial in September 2010. While ERCOT was already under a waiver from CPS2 since 2002, Québec chose not to request a waiver from CPS2 while operating under the field trial. As single BA Interconnections, ERCOT and Québec were affected differently than most BAs by the BAAL requirement.

[5] https://www.wecc.biz/Reliability/RBC%20Field%20Trial%20Report%20Approved%203-25-2015.pdf

Both single BA Interconnections found that currently implemented control methods were sufficient to easily meet the requirements specified by BAAL, and the BAs' only challenge was to implement the performance measurement to assure they could meet any audit and reporting requirement associated with BAAL.

Standard Drafting Team Conclusions

The BAL-001 Standard Drafting Team reached the following general conclusions from the field trial:[6]

- In the Eastern Interconnection, field trial participants observed an increase in System Operator understanding of Interconnection frequency control and improved timely response to significant ACE and frequency deviations. This led to a reduction in both the magnitude and duration of large frequency deviations on the Eastern Interconnection.
- One of the primary concerns of the standard drafting team when initiating the field trial was how replacement of CPS2 by BAAL would affect transmission constraints.
  - **Eastern Interconnection:** No case of an increase in the occurrence or magnitude of transmission constraints was identified and attributed to BAAL during the field trial.
  - **Western Interconnection:** During the field trial there were transmission constraints; however, there was no conclusive evidence that these transmission constraints were a direct result of BAAL.
- BAAL, in conjunction with NERC Standard BAL-003-1.1 Frequency Response and Frequency Bias Setting, meets the requirements set forth in Paragraph 355 of FERC Order No. 693.

[6] On the ERCOT and Hydro Québec single-BA interconnections, BAAL reduces to the FTL, and managing to the FTL has had no adverse impact on transmission reliability. While FTL replaces CPS2 in the Hydro Québec Interconnection, it is a whole additional constraint on the ERCOT Interconnection, which has operated since 2003 under a waiver from CPS2.

Chapter 2: FTL Exceedance Data

The BAAL method established FTLs that are used to determine each BA's BAAL control limits during both low and high frequency in accordance with Reliability Standard BAL-001-2. The FTL_{Low} is the Low Frequency Trigger Limit (calculated as Fs - 3Ɛ1) and FTL_{High} is the High Frequency Trigger Limit (calculated as Fs - 3Ɛ1) where Epsilon1 (Ɛ1) is the predefined targeted frequency boundary for each Interconnection.

This analysis focuses on the one-minute frequency performance in the two multi-BA Interconnections, Western and Eastern, two years before and two years after the implementation of Reliability Standard BAL-001-2 as it relates to exceeding the FTLs. Under BAAL control, ACE swings could be more likely at the BA level when Interconnection frequency exceeds the FTLs due to BAAL allowing BA ACE to exceed the L10 boundaries used under its predecessor CPS2. See Reliability Standard BAL-001-2 for more information on these calculation methods.[7] The purpose of this analysis is to determine whether FTL exceedances have increased since the implementation of BAL-001-2.

Note that two minor changes occurred in the calculation of FTL_{Low} and FTL_{High} and subsequently $BAAL_{Low}$ and $BAAL_{High}$ from the BAAL Field Trial methods to those of the BAL-001-2 standard that became effective in July 2016. The two changes are as follows and are reflected in the data analysis that follows in this chapter:

- The current standard uses scheduled frequency (Fs) in the calculations, taking into account the effect of time error corrections, whereas the field trial used only 60 Hz, and,
- The current standard uses 3Ɛ1 in the calculation of FTLs whereas the field trial used slightly smaller constants (i.e., 50 mHz in the EI and 68 mHz in the WI). This resulted in a slight increase of 4 mHz in both the FTL_{Low} and FTL_{High} for both the EI and WI).

Table 2.1 shows the FTL values for Eastern and Western Interconnection before and after the July 2016 implementation of BAAL.

Table 2.1: FTLs Before and After BAAL Implementation						
Eastern Interconnection						
	Before July 2016			After July 2016		
	Fs = 60 Hz	Fs = 59.98 Hz	Fs = 60.02	Fs = 60 Hz	Fs = 59.98 Hz	Fs = 60.02
FTL_{High} (Hz)	60.05	60.05	60.05	60.054	60.034	60.074
FTL_{Low} (Hz)	59.95	59.95	59.95	59.946	59.926	59.966
Western Interconnection						
	Before July 2016			After July 2016		
	Fs = 60 Hz	Fs = 59.98 Hz	Fs = 60.02	Fs = 60 Hz	Fs = 59.98 Hz	Fs = 60.02
FTL_{High} (Hz)	60.068	60.068	60.068	60.0684	60.0484	60.0884
FTL_{Low} (Hz)	59.932	59.932	59.932	59.9316	59.9116	59.9516

Figure 2.1 (Western Interconnection FTL Exceedances) and **Figure 2.2** (Eastern Interconnection FTL Exceedances) show the monthly total number of FTL exceedance minutes and the number of monthly events where an FTL limit was exceeded by multiple consecutive minutes. FTL_{Low} and FTL_{High} exceedance data are shown on separate graphs. The exceedance events are categorized into four duration groups: events less than 10 minutes, events between 10 and 20 minutes, events between 20 and 30 minutes, and events greater than 30 minutes. One-minute frequency data was compiled for the time period from July 1, 2014, through June 30, 2018, reflecting two years before and two years

[7] https://www.nerc.com/pa/Stand/Reliability%20Standards/BAL-001-2.pdf

after implementation of Reliability Standard BAL-001-2.[8] The red vertical line on the x-axis denotes the implementation of the standard on July 1, 2016.

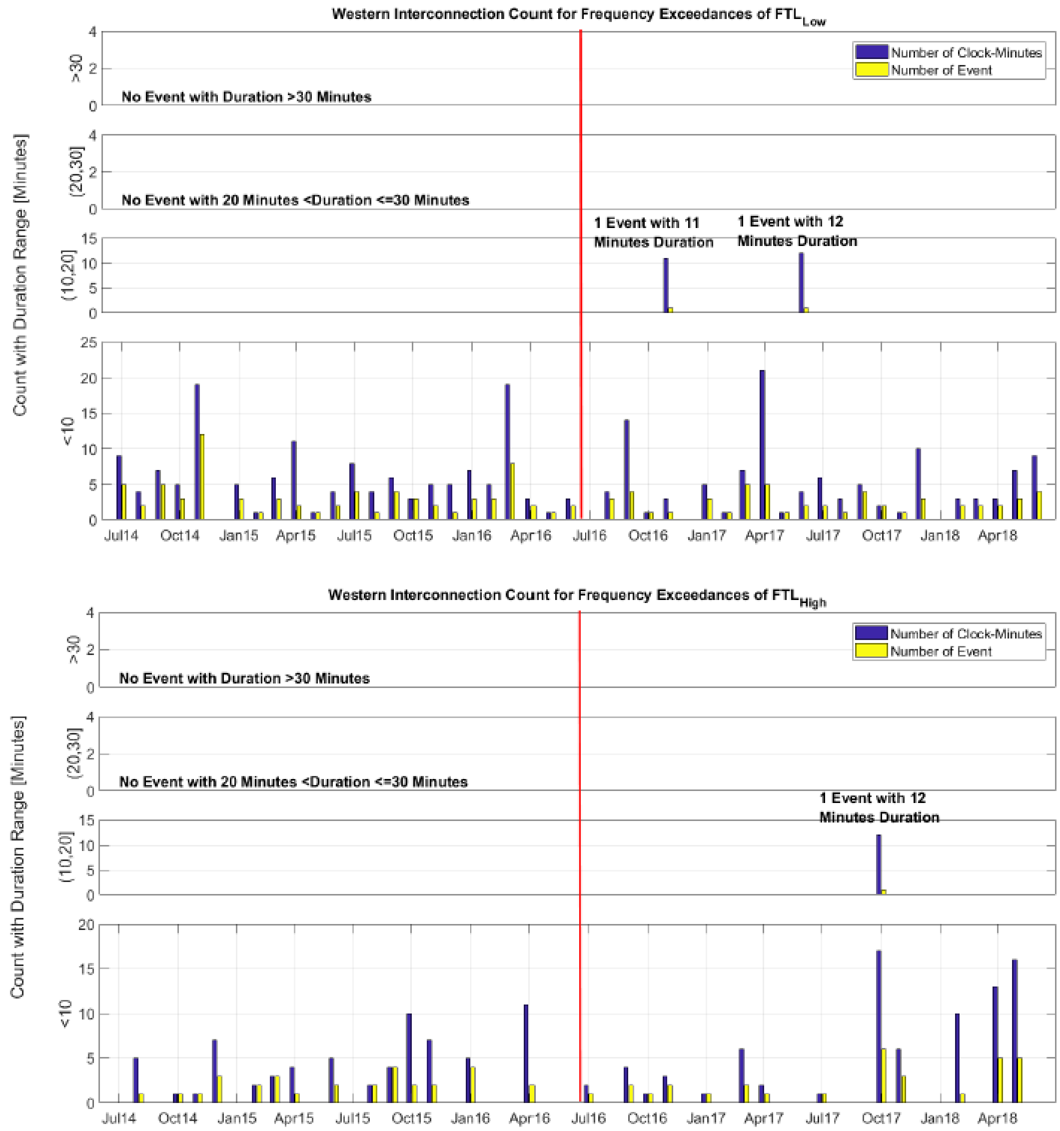


Figure 2.1: Western Interconnection FTL Exceedances

Western Interconnection observations for both total monthly FTL exceedance minutes and the number of events include the following:

- During November 2016, there is one FTL_{Low} event with an 11-minute duration that occurred when a market software issue resulted in undesirable unit commitment outputs from a Balancing Authority's security-constrained economic dispatch unit commitment software. This caused a reduction in generation output.[9]

[8] The data used in this chapter was compiled and analyzed by the Electric Power Group (EPG) using FNet frequency data from the University of Tennessee at Knoxville (UTK).

[9] https://www.nerc.com/pa/rrm/ea/Lessons%20Learned%20Document%20Library/LL20170401_Dispatched_Reduction_in_Generation_Output_Causes_Frequency_Deviation.pdf

- During June 2017, there is one FTL_{Low} event with a 12-minute duration that occurred when a high voltage DC transmission line tripped and resulted in remedial action scheme (RAS) operations.
- During October 2017, there is one FTL_{High} event with a 12-minute duration that occurred when the Western Interconnection separated between Canada and the United States following a 500 kV transmission line fault that resulted in RAS operations.
- There is no event with a duration greater than 20 minutes.

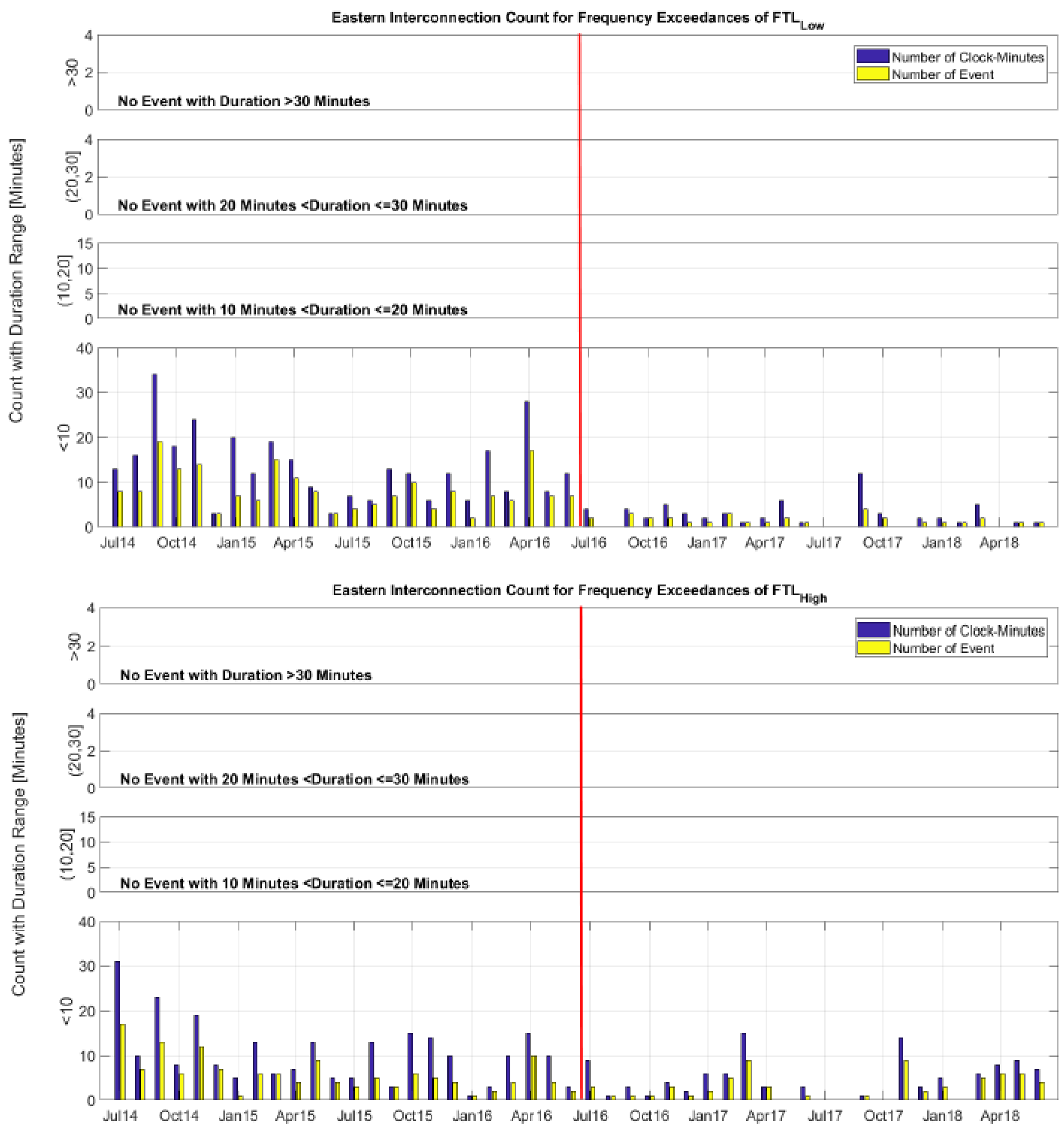


Figure 2.2: Eastern Interconnection FTL Exceedances

The Eastern Interconnection had no event with a duration greater than 10-minutes.

Table 2.2 shows the average change of monthly frequency exceedances of the FTL bands for both Eastern Interconnection and Western Interconnection before July 2016 and after the July 2016 implementation of reliability standard BAL-001-2.

Table 2.2: Monthly Changes in FTL Exceedances				
		Before July 2016	After July 2016	Difference
Eastern Interconnection				
FTL Band Range (mHz)		100 (59.95-60.05)	108 (59.946-60.054)	8
Average monthly number of clock-minutes	FTL_{Low}	13	3	-10
	FTL_{High}	10	4	-6
Average monthly number of events	FTL_{Low}	8	1	-7
	FTL_{High}	6	3	-3
Maximum event Duration (minutes)	FTL_{Low}	10	6	-4
	FTL_{High}	6	5	-1
Western Interconnection				
FTL Band Range (mHz)		136 (59.932-60.068)	136.8 (59.9316-60.0684)	0.8
Average monthly number of clock-minutes	FTL_{Low}	6	6	0
	FTL_{High}	3	4	1
Average monthly number of events	FTL_{Low}	3	2	-1
	FTL_{High}	1	1	0
Maximum event Duration (minutes)	FTL_{Low}	9	12	3
	FTL_{High}	9	12	3

The key findings for the Eastern and Western Interconnection include the following:

- For the Eastern Interconnection, beginning in July 2016, the number of clock-minutes and number of events with operation outside the FTL bounds decreased significantly.
- For the Western Interconnection, the monthly average number of exceedances showed no significant change for both FTL_{Low} and FTL_{High}.
- The maximum FTL exceedance event duration decreased for Eastern Interconnection.
- The maximum FTL exceedance event duration increased for Western Interconnection due to the aforementioned transmission events.

Conclusion: Analysis of the FTL exceedances and events in the Western and Eastern Interconnections over the two year period before and after implementation of BAAL found no evidence that would suggest that the implementation of BAAL resulted in an increase in FTL exceedances.

Chapter 3: Mitigation of SOL/IROLs

Western Interconnection Unscheduled Flow Mitigation Plan (WIUFMP)

The purpose of the Western Interconnection Unscheduled Flow Mitigation Plan (WIUFMP)[10] is to mitigate flows on Qualified Paths to reliable levels during real-time operations. This is accomplished in two primary ways: the first is by the use of Qualified Controllable Device(s) that can change flow dynamics within the interconnection, and the second is by the use of curtailments.

The Commission approved regional Reliability Standard IRO-006-WECC-2[11] (Qualified Transfer Path Unscheduled Flow (USF) Relief) and the associated implementation plan (violation severity levels and violation risk factors by Letter Order[12]) on May 13, 2014. Reliability Standard IRO-006-WECC-2 standard became effective on July 1, 2014.

The following provides the process for the use of the WIUFMP and reflects modifications made in June 2013.

Transmission Operators of Qualified Paths may use the WIUFMP to reduce flows on Qualified Paths. The process has four steps:

Step 1: The Transmission Operator advises their RC of the situation and their intended actions.

Step 2: To the most practical possible extent, the Transmission Operator uses their own equipment to reduce unscheduled flows on the Qualified Path. PacifiCorp R.S. 439 Rev. 2b WECC Unscheduled Flow Mitigation Plan v. 3.1.0 Effective On: January 1, 2016, Page 4, "The Qualified Path Operator and their RC shall communicate periodically and as necessary regarding system status, Qualified Controllable Device positioning, the termination of, or taking additional steps in the WIUFMP based on current and anticipated system conditions."

Step 3: The Transmission Operator requests the coordinated operation of Qualified Controllable Devices to mitigate unscheduled flows on the Qualified Path. This request shall remain active for four (4) consecutive hours unless terminated or advanced to Step 4 by the Transmission Operator of the Qualified Path. To continue beyond the fourth consecutive hour, the Transmission Operator must re-issue the request before the completion of the third hour of the event or the event will automatically terminate at the completion of the fourth consecutive hour.

Step 4: The Transmission Operator requests curtailments in conjunction with the coordinated operation of Qualified Controllable Devices to mitigate unscheduled flows on the Qualified Path. Each hour is deemed to be a separate event for WIUFMP curtailment purposes. Therefore, Transmission Operators must re-issue a curtailment mitigation request for each hour that mitigation is desired.

[10] https://www.wecc.biz/Reliability/12c-FERC%20Accepted%20WIUFMP%202016%2003%2011.pdf
[11] https://www.nerc.com/_layouts/15/PrintStandard.aspx?standardnumber=IRO-006-WECC-2&Title=Qualified%20Transfer%20Path%20Unscheduled%20Flow%20(USF)%20Relief%20&Jurisdiction=United%20States
[12] https://www.nerc.com/FilingsOrders/us/FERCOrdersRules/Letter%20Order%20Approving%20IRO-WECC.pdf

Table 3.1 provides a list of the Qualified Paths under WIUFMP. **Table 3.2** and **Figure 3.1** show the number of unscheduled flow (USF) mitigation hours by path from 2014 through 2017. This historical data demonstrates that a downward trend of USF mitigation hours was seen during the last two years of the BAAL field trial and continued after the implementation of Reliability Standard BAL-001-2 in July 2016.

Table 3.1: List of Qualified Paths as of January 26, 2012

Path Code	Path Oper	Qualified Transfer Path	Qualifying Direction
66	**CISO**	**California–Oregon Intertie** Malin–Round Mt. 500-kV lines 1 and 2 Captain Jack–Olinda 500-kV line	**CCW** (North–South)
22	**APS**	**Four Corners–Central Arizona** Four Corners–Moenkopi 500-kV line Four Corners–Cholla 345-kV lines 1 and 2	**CW** (East–West)
23	**APS**	**Four Corners 345/500-kV Transformer** with Four Corners Unit 5 Out-of-Service OR at Greatly Reduced Output	**CW** (Low–High)
30	**WACM**	**TOT 1A Transmission Path** Hayden–Artesia 138-kV Meek–Rangely 138-kV Bears Ears–Bonanza 345-kV	**CW** (East–West)
31	**WACM**	**TOT 2A Transmission Path** Hesperus–Glade Tap 115-kV line Lost Canyon–Shiprock 230-kV line Waterflow–San Juan 345-kV line	**CW** (North–South)
36	**WACM**	**TOT 3 Transmission Path** Laramie River–Ault 345-kV line Laramie River–Story 345-kV line Archer–Ault 230-kV line Sidney–Spring Canyon 230-kV line Sidney–Sterling 115-kV line Cheyenne–Owl Creek 115-kV line Cheyenne–Ault 230-kV line	**CW** (North–South)

Table 3.2: WI Total USF Hours by Qualified Path

	Path 22	Path 23	Path 30	Path 31	Path 36	Path 66	Path 30/66	Path 31/30	Path 36/66	All
2014	0	0	301	82	324	1,491	11	2	53	2,264
2015	0	0	184	124	124	332	5	1	0	770
2016	19	0	211	118	313	548	25	13	80	1,327
2017	0	0	99	96	168	551	0	13	18	955

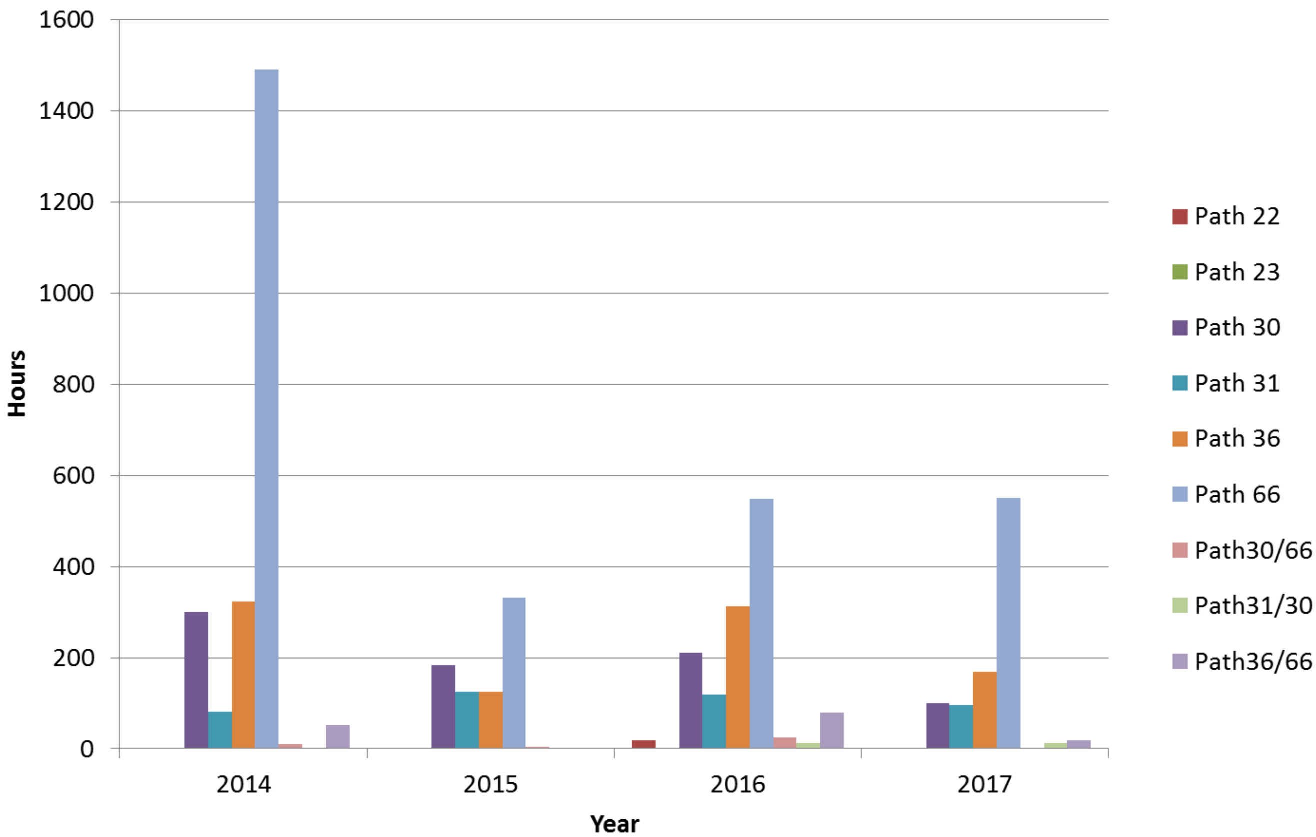


Figure 3.1: Total Yearly Qualified Path Hours

As reflected in **Table 3.2** and **Figure 3.1**, the USF mitigation hours for Path 66 were significantly higher in 2014 than 2015 through 2017. This was due to line deratings as a result of equipment maintenance that included a phase shifting transformer used for USF mitigation.

The BAAL field trial in the Western Interconnection began on March 1, 2010. SOL exceedances, USFs, and mitigation actions during the field trial were examined by WECC subcommittee and working group experts. Some of their findings are as follows:[13]

- SOL exceedances caused by unplanned derating of path SOL, redispatch of generation resources, or an increase in scheduled path use can be mitigated by re-dispatch of generation that reduced BA ACE.
- SOL exceedances caused by unscheduled flows on the path can be mitigated by the use of phase-shifting transformer tap position changes. There is evidence that phase-shifting transformer tap position changes reduce unscheduled flow.
- SOL exceedances caused by a combination of unscheduled flow and BA ACE contribution to unscheduled flow on the path can be mitigated by redispatch of generation resources with the RC requesting a BA to reduce its ACE to less than its L10 and reducing its scheduled path use.

[13] https://www.wecc.biz/Reliability/RBC%20Field%20Trial%20Report%20Approved%203-25-2015.pdf

The hours of coordinated operations of the phase shifters increased during the BAAL field trial period; however, due to changing seasonal patterns, a changing resource mix, unusual operating conditions, and other events, it is not possible to conclusively associate the increased hours of phase shifter operations with BAAL operation. Based on the Western Interconnection field trial, there were transmission constraints and many other attributing factors to the monitoring criteria; however, there was no conclusive evidence that these transmission constraints and USF were a direct result of BAAL.

Eastern Interconnection Transmission Loading Relief (TLR)

The NERC TLR Procedure is an Eastern Interconnection-wide process that allows Reliability Coordinators to mitigate potential or actual operating security limit violations while respecting transmission service reservation priorities. A TLR log contains the details of TLR incidents reported by Reliability Coordinators who are required to complete the logs whenever they invoke TLR Level 2 or above.

NERC Reliability Standard IRO-006-5 – Reliability Coordination – Transmission Loading Relief[14] and IRO-006-EAST-1 Transmission Loading Relief Procedure for the Eastern Interconnection[15] provide information regarding the use of TLRs. **Table 3.3** shows the TLR levels and corresponding Reliability Coordinator actions.[16]

Table 3.3: Transmission Loading Relief Levels

TLR Level	Reliability Coordinator Action	Comments
1	**Notify** Reliability Coordinators of potential System Operating Limit (SOL) or Interconnection Reliability Limit (IROL) violations.	
2	**Hold** Transfers at present level to prevent SOL or IROL violations.	Of those transactions at or above the Curtailment Threshold, only those under existing Transmission Service reservations will be allowed to continue, and only to the level existing at the time of the hold. Transactions using Firm Point-to-Point Transmission Service are not held. See Attachment 1 to IRO-006, Section 2.2.
3a	**Reallocation** of Transmission Service by curtailing Interchange Transactions using Non-firm Point-to-Point Transmission Service to allow Interchange Transactions using higher priority Transmission Service.	Curtailment follows Transmission Service priorities. Higher priority transactions are enabled to start by the Reallocation process. See Attachment 1 to IRO-006, Section 2.3 and Section 6.0.
3b	**Curtail** Interchange Transactions using Non-firm Point-to-Point Transmission Service to mitigate an SOL or IROL violation.	Curtailment follows Transmission Service priorities. There are special considerations for handling Transactions using Firm Point-to-Point Transmission Service. See Attachment 1 to IRO-006, Section 2.4 and Section 7.0.
4	**Reconfigure** transmission system to allow Transactions using Firm Point-to-Point Transmission Service to continue.	There may or may not be an SOL or IROL violation. There are special considerations for handling Interchange Transactions using Firm Point-to-Point Transmission Service. See Attachment 1 to IRO-006, Section 2.5.

14 https://www.nerc.com/pa/Stand/Reliability%20Standards/IRO-006-5.pdf
15 https://www.nerc.com/pa/Stand/Reliability%20Standards/IRO-006-EAST-1.pdf
16 https://www.nerc.com/pa/rrm/TLR/Pages/TLR-Levels.aspx

Table 3.3: Transmission Loading Relief Levels		
TLR Level	**Reliability Coordinator Action**	**Comments**
5a	**Reallocation** of Transmission Service by curtailing Interchange Transactions using Firm Point-to-Point Transmission Service on a pro rata basis to allow additional Interchange Transactions using Firm Point-to-Point.	Attempts to accommodate all Transactions using Firm Point-to-Point Transmission Service, though at a reduced ("pro rata") level. Pro forma tariff also requires curtailment/ REALLOCATION on pro rata basis with Network Integration Transmission Service and Native Load. See Attachment 1 to IRO-006, Section 2.6, and Section 6.0.
5b	**Curtail** Interchange Transactions using Firm Point-to-Point Transmission Service to mitigate an SOL or IROL Violation	Pro forma tariff requires curtailment on pro rata basis with Network Integration Transmission Service and Native Load. See Attachment 1 to IRO-006, Section 2.7.
6	**Emergency Procedures**	Could include demand-side management, re-dispatch, voltage reductions, interruptible and firm load shedding. See Attachment 1 to IRO-006, Section 2.8.
0	**TLR Concluded**	**Restore** transactions. See Attachment 1 to IRO-006, Section 2.9.

Table 3.4 and **Figure 3.5** show the number by month and time range of the TLR issuances for the Eastern Interconnection for 2014 through 2017. This data shows a downward trend in TLR issuances. This TLR downward trend has been examined by many utility/subcommittee/working group industry experts including the Operating Reliability Subcommittee. Some of the contributing factors include:

- Operations Planning enhances seasonal coordinated operational studies.
- Coordinated RTO/ISO level congestion management processes (i.e. Locational Marginal Pricing, Market Flows Calculation, Security Constrained Unit Commitment and Security Constrained Economic Dispatch, etc.).
- The IDC/SDX Calculated Frequency and Real Time Data Exchange Operations Tool which runs every 5 minutes for real-time current hour calculations and every 15 minutes for next hour calculations.
- Data is exchanged every 5-15 minutes to IDC for TLR purposes.
- SOL/IROLs are mitigated via established local procedures.

Table 3.4: Eastern Interconnection Total TLRs													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
2014	94	95	71	37	53	80	53	43	67	25	61	68	**747**
2015	79	85	37	41	31	48	45	27	17	46	17	23	**496**
2016	19	40	35	30	41	31	45	39	29	19	22	22	**372**
2017	12	14	42	18	23	25	6	7	18	36	18	24	**243**

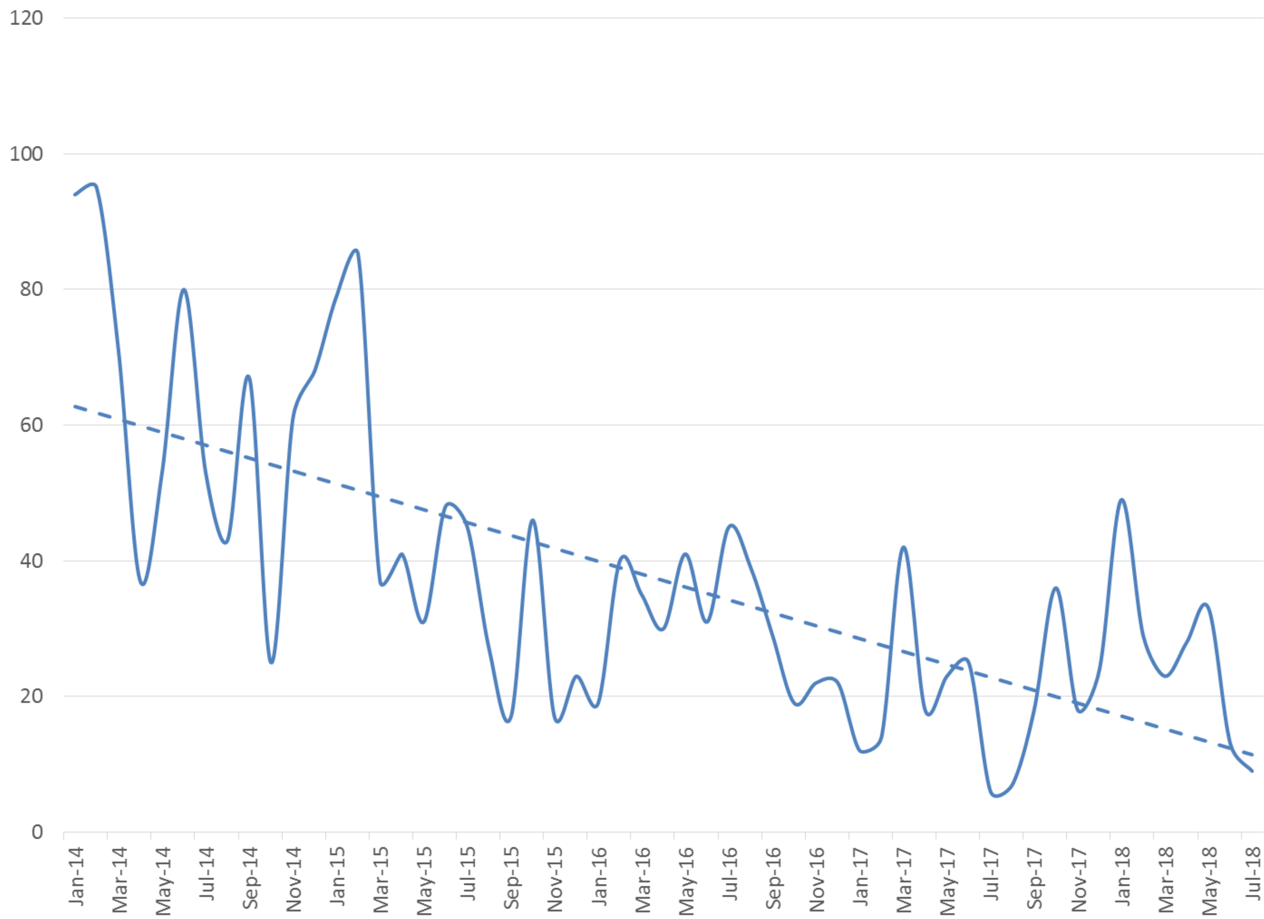


Figure 3.2: Eastern Interconnection Total Monthly TLRs

Historic TLR data from 2014 through the first two quarters of 2018 shows a downward trend in the issuance of TLR procedures and suggests that the replacement of CPS2 by BAAL caused no increase in the number or magnitude of transmission constraints due to unscheduled flow on the Eastern Interconnection.

Conclusion: Analysis of the USF mitigation hours in the Western Interconnection and TLR occurrences in the Eastern Interconnection over the period from 2014 through the first two quarters of 2018 found no evidence that would suggest that the implementation of BAAL resulted in an increase in either.

Chapter 4: Frequency Performance and Inadvertent Interchange

Frequency Performance

The foundation of the NERC Balancing Standards is the Control Performance Standard CPS1 found in Reliability Standard BAL-001-2. CPS1 is based on the variability of the one-minute averages of frequency deviation from schedule. Scheduled frequency is normally 60 Hz except during Time Error Corrections.

NERC posts the target frequency annual frequency variation in each Interconnection as "Epsilon 1." Epsilon 1 is the target root-mean-square (RMS) value of the one-minute averages of frequency deviation. CPS1 gives each Balancing Authority a portion of Interconnection performance based on its size through the BA Frequency Bias Setting (FBS) component of the calculation.

NERC and its Resources Subcommittee track the daily RMS1 values of frequency deviation as a fundamental indicator of Interconnection reliability over time. Frequency can become more variable or noisy for a wide spectrum of reliability issues, including congestion, multiple transmission line operations, generation losses, or general control issues. All of these problems cause more frequency variability.

Adverse frequency control impacts due to the implementation of BAAL, including increased movement of Inadvertent Interchange, would be reflected in an increase in RMS1.

The summary frequency performance data shown in **Table 4.1** and the graph shown in **Figure 4.1** demonstrate an improvement in the daily frequency performance in the Texas, Western, and Eastern Interconnections since the implementation of BAL-001-2 on July 1, 2016.

Table 4.1: Interconnection Frequency Performance Data

	Texas Target Ɛ1 = 0.0300 Hz		Western Target Ɛ1 = 0.0228 Hz		Eastern Target Ɛ1 = 0.0180 Hz	
	Median Daily RMS1	Mean Daily RMS1	Median Daily RMS1	Mean Daily RMS1	Median Daily RMS1	Mean Daily RMS1
2014 Q1–4	0.0180	0.0181	0.0175	0.0176	0.0145	0.0145
2015 Q1–4	0.0151	0.0151	0.0176	0.0177	0.0135	0.0134
2016 Q1–4	0.0145	0.0146	0.0177	0.0178	0.0142	0.0141
2017 Q1–4	0.0149	0.0150	0.0172	0.0172	0.0138	0.0138
2018 Q1-–	0.0144	0.0146	0.0163	0.0165	0.0139	0.0139

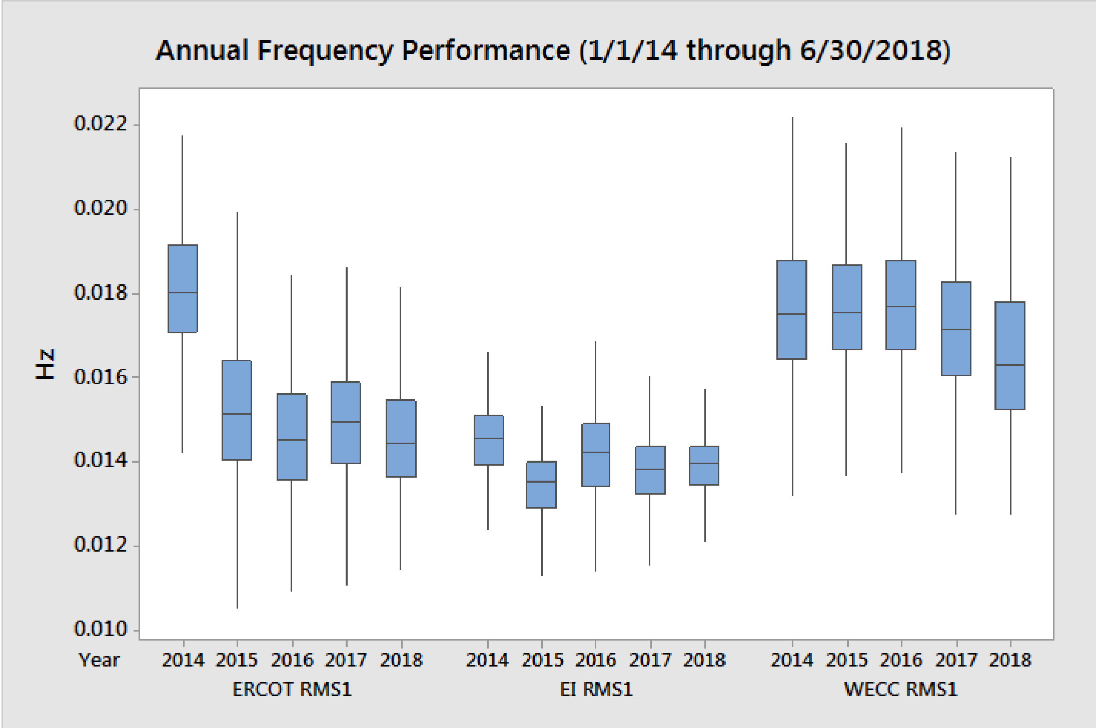


Figure 4.1: RMS1 Annual Frequency Performance

The Texas Interconnection had a reduction in median daily RMS1 each year from 2014 (0.0180 Hz) through the first two quarters of 2018 (0.0144 Hz) with the exception of 2017 (0.0149 Hz), which had a slight increase. The general reduction in RMS1 over the period also reflect the implementation of a regional frequency response standard, BAL-001-TRE-1, which went into effect in two phases beginning April 2015. BAL-001-TRE-1 was fully effective in October 2015 and required all generators to have a working governor and tightened deadband settings.

The Western Interconnection had slight increases in median daily RMS1 from 2014 (0.0175 Hz) through 2016 (0.0177 Hz) followed by significant decreases in 2017 (0.0172 Hz) and the first two quarters of 2018 (0.0163 Hz). The mean daily RMS1 also decreased from 2016 (0.0172 Hz) through the first two quarters of 2018 (0.0165 Hz).

The Eastern Interconnection median daily RMS1 varied slightly within a range of 0.6 mHz each year from 2014 through the first two quarters of 2018. While the median daily RMS1 was slightly higher in the first two quarters of 2018 (0.0139 Hz) as compared to 2017 and 2016 (0.0138 and 0.0142 Hz, respectively), there was a noticeable reduction in variability as shown in the box and whisker plots in **Figure 4.1**.

Both the Western and Eastern Interconnections had slight increases in the median and mean daily RMS1 in 2016. In addition to the implementation of Reliability Standard BAL-001-2 and BAAL in July 2016, the minimum bias settings for both Interconnections were also reduced in April 2016 in accordance with Reliability Standard BAL-003-1.1. This change resulted in a temporary increase in frequency variability for both Interconnections in April 2016, which would be reflected in the 2016 RMS1 performance shown in **Table 4.1** and **Figure 4.1**.

Conclusion: Analysis of the frequency data for the Texas, Western, and Eastern Interconnections over the period from 2014 through the first two quarters of 2018 found no evidence that would suggest that the implementation of BAAL resulted in a decrease in frequency performance.

Inadvertent Interchange

Inadvertent interchange is the difference between a BA's net actual Interchange and net scheduled interchange. BAs calculate and record hourly inadvertent interchange, which includes all ac and dc tie lines that connect to its adjacent BAs in the same Interconnection and interchange served by jointly owned generators for on-peak and off-peak periods. All BAs reconcile their monthly inadvertent interchange with adjacent BAs using agreed-to accounting data with like MWh values and opposite signs. The sign (+ or -) indicates the direction of the monthly net inadvertent interchange flows. The monthly inadvertent interchange for each BA is recorded in the NERC Inadvertent Interchange Reporting Tool.

A BA's on-peak and off-peak monthly inadvertent interchange is added to the accumulated balances from the previous month. It is the responsibility of each BA to minimize accumulated inadvertent interchange balances. When a BA's accumulated inadvertent balances exceed a predetermined threshold, depending on Interconnection, the BA should start a form of inadvertent payback method that includes a target of driving their balance down towards zero in accordance with the North American Energy Standards Board requirements. Additional information can be found in the Reliability Guideline Inadvertent Interchange, which was approved by the NERC Operating Committee.[17]

The NERC Inadvertent Interchange Working Group monitors the monthly and accumulated inadvertent interchange for each BA to identify trends at the BA and Interconnection levels. Table 4.2 shows quarterly aggregated inadvertent interchange data for the BAs in the Eastern and Western Interconnections. Adjacent BAs reconcile their monthly inadvertent interchange with like values but opposite signs. The data shown in Table 4.2 is the sum of the absolute values of accumulated inadvertent for all BAs in the given Interconnection.

Table 4.2: Quarterly Inadvertent Interchange Accumulations

	Jun 16	Nov 16	Feb 17	May 17	Aug 17	Nov 17	Feb 18	Apr 18
Eastern Interconnection								
Ave Absolute On Peak Inadvertent	37,606	31,152	29,347	25,710	19,836	16,606	14,135	11,349
Median Absolute On Peak Inadvertent	1475	545	648	1262	953	693	784	703
Ave Absolute Off Peak Inadvertent	16,075	15,331	16,783	13,565	9,363	6,005	4,474	3,107
Median Absolute Off Peak Inadvertent	1,684	487	573	1,080	1,078	1,264	787	717
Western Interconnection								
Ave Absolute On Peak Inadvertent	649	1,031	851	1,337	1,277	1,603	1,596	1,536
Median Absolute On Peak Inadvertent	156	316	163	414	247	532	411	520
Ave Absolute Off Peak Inadvertent	869	1041	459	908	819	560	417	526
Median Absolute Off Peak Inadvertent	173	380	137	404	274	171	114	178

Conclusion: If BAAL operation was resulting in increased inadvertent interchange, it would be evident in the quarterly on-peak and off-peak accumulations shown in Table 4.2. The Eastern Interconnection shows a declining trend in accumulated inadvertent interchange due at least in part to the efforts of the Inadvertent Interchange Working Group to monitor and assist BAs in reducing their accumulations. The Western Interconnection uses automated time error correction and manages inadvertent interchange balances in accordance with Regional standard BAL-004-WECC-2. As with the Eastern Interconnection, the aggregated data for the Western Interconnection does not show evidence of an increasing inadvertent trend that could be due to BAAL operation.

[17] https://www.nerc.com/comm/OC_Reliability_Guidelines_DL/Reliability_Guideline_Inadvertent_Interchange_v1.1_20171213.pdf