WestConnect Regional Transmission Planning

2018-19 Planning Cycle

Scenario Assessment Report

Approved by WestConnect Planning Management Committee on

June 19, 2019

Contents

1.0 Background & Purpose

The purpose of this report is to summarize scenario assessments performed during WestConnect's 2018-19 Regional Transmission Planning Process ("Planning Process"). The Planning Subcommittee ("PS") developed this report to document the assumptions, study methods, and findings from the scenario assessments.

The 2018-19 WestConnect Regional Planning Study Plan ("Study Plan") was approved by the PMC on March 14, 2018. The Study Plan identifies the scope and schedule of activities to be conducted during the planning cycle. In addition to describing the Base Case planning assessments used to identify regional transmission needs, the Study Plan also describes information-only scenario studies that look at alternate but plausible futures. Scenarios represent futures or system conditions with resource, load, and public policy assumptions that are different in one or more ways than what is assumed in the Base Cases.

Members or stakeholders propose scenarios for consideration in the WestConnect planning process through an open submittal window, as outlined in the WestConnect Business Practice Manual. WestConnect held the open window from December 1, 2017 through January 5, 2018. Several proposed scenarios were received and subsequently reviewed by the PS during public meetings on January 19, 2018 and on February 13, 2018. During the meetings, the PS discussed the proposed scenarios, member feedback, and the number of scenarios that would be appropriate to study. These conversations led to the inclusion of two scenarios in the final Study Plan: a Load Stress scenario and a CAISO Export Stress scenario. Both scenarios are reliability assessments. The purpose of the Load Stress scenario is to test the robustness of the Base Transmission Plan against significant unforeseen load growth. The intent of the CAISO Export scenario is to evaluate the reliability of the WestConnect regional system during conditions in which physical power flows from the CAISO to WestConnect during CAISO overgeneration conditions.

2.0 Study Scope

The PS finalized the study scopes and developed the models required to complete the two scenario assessments. The table below summarizes each scenario and the core questions that the studies were designed to investigate.

Table 1: Scenario Case Descriptions & Core Questions

Scenario	Description of Case	Core Questions to Investigate
Load Stress	The WestConnect-approved 2028 Heavy Summer Base Case conforming loads were scaled for each TOLSO based on feedback received during the scenario development process and the generation-load gap was filled with existing generator capacity not already dispatched in the Base Case. In one area,	How robust is the Base Transmission Plan when peak load is higher than expected?

Scenario	Description of Case	Core Questions to Investigate
	renewable capacity was added and dispatched to meet the load increase.	
CAISO Export	Using the WestConnect-approved 2028 Production Cost Model ("PCM"), a power flow snapshot was developed based on system conditions identified for Hour 15 on June 18th. This hour was selected by the PS during the [January 15, 2019, meeting] as a system condition representative of high CAISO export to WestConnect. The CAISO export to WestConnect was approximately 6,280 MW during that hour. [1]	During high export conditions from the CAISO to WestConnect, how reliable is the WestConnect regional transmission system?

The PS decided to perform both steady-state and transient stability contingency analysis on the scenarios. These assessments were performed using reliability standards adopted by the North American Electric Reliability Corporation TPL-001-4 Table 1 (P0 and P1) and TPL-001-WECC-CRT-3.1 (Transmission System Planning Performance WECC Regional Criterion), and supplemented with any more stringent Transmission Owner with Load Serving Obligations ("TOLSO") planning criteria based on TOLSO member feedback.

Contingency definitions for the steady-state contingency analysis were limited to N-1 contingencies for elements 230kV and above, generator step-up ("GSU") transformers for generation with at least 200 MW capacity, and member-requested N-2 contingencies. All bulk electric system (BES) branches and buses in the WECC model were monitored with violation reports filtered to exclude branch flows that increased less than 1% and voltage decline less than 0.5%.

The following contingencies were evaluated in the transient stability simulations for both scenario Base Cases:

1) Tripping one Palo Verde generator and its GSU transformer with fault on the Palo Verde 500kV bus
2) Tripping Daniel Park-Comanche 345kV Lines 1 & 2 with fault at the Comanche 345kV bus
3) Fault on Missile Site 345kV Bus, loss of Missile Site – Harvest Mi & Missile Site – Daniels Park 345kV Lines, and loss of Limon and Missile Site Wind Generation

[1] The CAISO Export to WestConnect interface was defined using all monitored "seam" branches between the CAISO and WestConnect Load Areas in the PCM. The flow on unmonitored and non-BES "seam" branches was not included in the interface definition.

4) Fault on Laramie River 345kV Bus, loss of Laramie River – Ault 345kV Line, & loss of Laramie River #3 Generation

5) Palo Verde – Colorado River 500kV Line, Fault at Colorado River

6) Palo Verde – Colorado River 500kV Line, Fault at Palo Verde

7) Hassyampa – North Gila 500kV Line, Fault at Hassyampa

8) Hassyampa – North Gila 500kV Line, Fault at North Gila

The dynamic data needed to support the transient stability simulations was sourced from the WestConnect 2028 Heavy Summer Base Case.

System performance issues impacting or between more than one TOLSO Member system were identified for further review by the PS. Local issues were reported and provided to members for informational purposes. The local issues were not the focus of this assessment.

3.0 Load Stress Scenario

3.1 Assumptions, Modeling and Study Techniques

The Load Stress Study was designed to tests the robustness of the Base Transmission Plan against increases in system load. The Load Stress Base Case was developed by scaling load conditions modeled in the 2028 Heavy Summer Base Case to higher load levels as specified by TOLSOs during the case development phase. The generation-load gap created by the load increase was filled with existing generator capacity not already dispatched in the Base Case, with one expectation. In the PNM area renewable capacity was added and dispatched to meet the load increase. The transmission topology did not change from the Base Case and reflected the 2018-19 Base Transmission Plan additions. Detailed load, import, and generator dispatch assumptions are provided in the table below.

Table 2: High Load Stress Scenario Assumptions for WestConnect Region

	2028 Heavy Summer Base Case	2028 Load Stress Scenario	Change
Load (MW)[2]	65,274	69,348	Increased 6.24%
Import/Export (MW)	Export: 2,438	Export: 1,853	Decreased 24.0%
Generation Dispatch (MW)	Thermal: 53,179 Hydro: 6,902	Thermal: 55,596 Hydro: 7,022	Increased 5.15%

[2] *Represents the system coincident peak for a heavy summer conditions between the hours of 1500 to 1700 MDT during the months of June – August.*

	2028 Heavy Summer Base Case	2028 Load Stress Scenario	Change
	Wind/Solar: 5,637 Other: 1,994 Total: 67,712	Wind/Solar: 6,350 Other: 2,233 Total: 71,200	
Transmission	2018-19 Base Transmission Plan		No change

After case development was completed, the reliability assessment described in Section 2.0 was performed.

3.2 Study Results

Results from the assessment are provided in Appendix A. The results include 15 voltage issues on multi-owner systems. The multi-owner issues that were identified were geographically isolated issues. None of the multi-owner issues indicate deficiencies in the Base Transmission Plan. There were single-owner system issues, all of which the PS determined to be local issues and not regional in nature.

3.3 Summary of Findings

The Load Stress scenario did not materially impact regional-level flows. Average branch loading increased by roughly 1% when compared to the 2028 Heavy Summer Case. Contingency analysis identified few multi-owner voltage issues. These multi-owner issues are informational, radial in nature, and do not indicate deficiencies in the Base Transmission Plan. Therefore, the study results indicate that the Base Transmission Plan is sufficiently robust under higher than expected load conditions.

4.0 CAISO Export Stress Scenario

4.1 Assumptions, Modeling and Study Techniques

The CAISO Export Stress scenario tests the reliability of the WestConnect regional system under a condition in which power flows from the CAISO region into WestConnect. Today and historically, net flow is almost always from WestConnect into the CAISO. This is especially true on the major interfaces between California and Arizona, including Path 46 (West of River) and Path 49 (East of River), which flow in the east-to-west direction. As the CAISO adds more solar onto its system, certain conditions cause the CAISO system to have more generation than it needs, particularly in light-load conditions in the spring and fall. This creates the opportunity for economic (transactional) exports out of the CAISO into WestConnect, as well as physical exports of power (i.e., actual power flow, which are different than energy transactions).

The CAISO Export Stress scenario was based on conditions observed in the WestConnect 2028 Base Case economic model. The modeling results were filtered for hours in which there were power flows from the

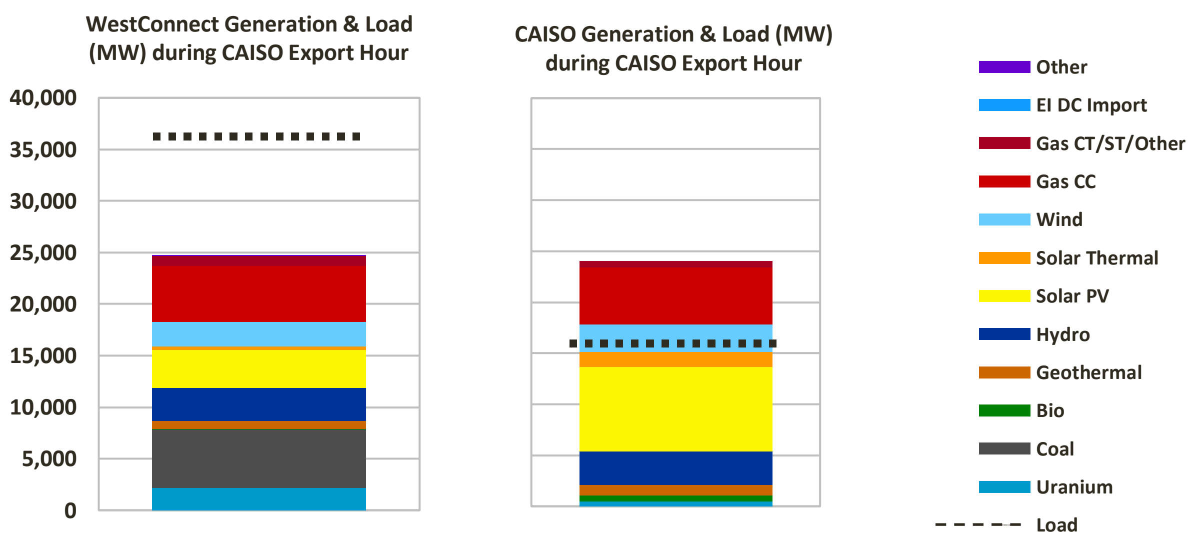
CAISO into WestConnect. In total, the export condition was observed in 13% of the hours in the study 2028 year. The PS focused on a review of hours in which both (1) exports from the CAISO to WestConnect are high, and (2) flows west-to-east across Path 49 and Path 46 are high. The following table identifies the condition selected by the PS for study: Hour 15 of June 18th. During this condition, flows from the CAISO to WestConnect are 6,284 MW and flows on Path 46 and Path 49 are in the west-to-east direction at 4,231 MW and 5,463 MW, respectively.[3]

Table 3: June 18th Hour 15 Flows from the CAISO to WestConnect

		Flow (MW)		
Date	Hour	P46 [E->W]	P49 [E->W]	CAISO Export to WC (Approx.)
6/18/2028	15	-4,231	-5,463	6,284

The simulated WestConnect and the CAISO load levels and generation dispatch are summarized in the figures below. The gap between the load and the top of the generation stack represents imports into the given region. When the stack is above the load level, this represents exports.

Figure 1: WestConnect & the CAISO Load & Generation During Selected CAISO Export on June 18th Hour 15



The transmission topology did not change from the Base Case assessments and reflects the 2018-19 Base Transmission Plan additions. The seed case was the approved WestConnect 2028 Heavy Summer Base Case. The load, imports, and generator dispatch assumptions are provided below.

[3] Not that the interface between the CAISO and WestConnect was defined as all monitored seam branches between the CAISO and WestConnect Load Areas. This means that branches between WestConnect loads in California and the CAISO were included in the interface. Non-bulk system branches and unmonitored branches were not included in the seam.

Table 4: CAISO Export Scenario Assumptions for WestConnect Region

	2028 Heavy Summer Base Case	2028 CAISO Export Scenario	Delta
Load (MW)	65,274[4]	35,872[5]	Decreased 54.96%
Import/Export (MW)	Export: 2,438	Import: 7,273	Switch from net export to net import (354.67% change)
Generation Dispatch (MW)	Thermal: 53,179 Hydro: 6,902 Wind/Solar: 5,637 Other: 1,994 Total: 67,712	Thermal: 18,621 Hydro: 3,187 Wind/Solar: 6,120 Other: 671 Total: 28,599	Decreased 42.24%
Transmission	2018-19 Base Transmission Plan		No change

After initial case development was completed, the reliability assessment described in Section 2.0 was performed.

4.2 Study Results

Results from the assessment are provided in Appendix B. The results include 6 branch overloads and 9 voltage issues on multi-owner transmission. The thermal branch overloads were located in the Colorado and Wyoming area. Single-system issues were reviewed and the PS determined that these single-system issues were not regional in nature.

4.3 Summary of Findings

The case development was successful in that a CAISO export condition was identified in the WestConnect 2028 Economic Base Case, and this condition was replicated in reliability models in terms of load, generation dispatch, and system flows. Reliability analysis of the condition identified several multi-owner voltage issues that can be easily addressed through system adjustments. The analysis also identified a few thermal overloads in the Colorado area, but these issues are remote from the CAISO-WestConnect interface(s) and are caused by flows occurring in entirely new directions than what is

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[4] *Represents the system coincident peak for a heavy summer conditions between the hours of 1500 to 1700 MDT during the months of June – August.*

[5] *Note that this load forecast is based on 1-in-2 load forecasts contained in the production cost model. The 2028 Heavy Summer Base case is based on 1-in-10 load forecasts. This discrepancy accounts for a portion of the load differential between the two cases.*

observed historically. At a high-level, the scenario does not significantly stress the regional transmission system beyond levels identified in the Base Cases and the regional system is robust during CAISO export conditions.

5.0 Appendix A: Load Stress Reliability Assessment Results

Issues are related to facility loadings or voltage. Transmission elements are typically rated in Amps, transformers in MVA, and voltage in per-unit (pu).

Table 5: Load Stress Reliability Assessment Contingency Analysis

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
Load Stress	PNM's WESTMESA - SANDIA 345 kV Line #1	PNM	MONTANOT - CLAREMNT 115kV Line #1	801.3 Amp	783.19 Amp	Line Overload	PNM: PNM has plans to uprate this line segment in the 10-year planning horizon.
		PNM	PRAGER - MONTANOT 115kV Line #1	929.34 Amp	893.64 Amp	Line Overload	PNM: PNM has plans to uprate this line segment in the 10-year planning horizon.
Load Stress	APS's CACTUS - PPAPSN 230 kV Line #1	APS	CACTUS - OCO N 230kV Line #1	1081.27 Amp	1034.21 Amp	Line Overload	APS: APS has conceptual projects identified to address this overload
		APS	OCO C - OCO N 230kV Line #1	1603.31 Amp	1596.5 Amp	Line Overload	APS: APS has conceptual projects identified to address this overload
Load Stress	SRP's HASSYAMP - MESQUIT2 500 kV Line #1	SRP	MESQUIT1 500/230kV Transformer #1	1597.11 MVA	1593 MVA	Transformer Overload	SRP: Four of the five are the Mesquite 500/230kV xfmrs (loss of one overloads the other if too much generation is on) which is mitigated by a RAS (loss of one of the xfmrs will trip Mesquite Solar gen).
Load Stress	SRP's MESQUITE 500/230 kV Transformer #2	SRP	MESQUIT1 500/230kV Transformer #1	1597.09 MVA	1593 MVA	Transformer Overload	SRP: Four of the five are the Mesquite 500/230kV xfmrs (loss of one overloads the other if too much generation is on) which is mitigated by a RAS (loss of one of the xfmrs will trip Mesquite Solar gen).
Load Stress	SRP's HASSYAMP - MESQUIT1 500 kV Line #1	SRP	MESQUIT2 500/230kV	1596.65 MVA	1593 MVA	Transformer Overload	SRP: Four of the five are the Mesquite 500/230kV xfmrs (loss of one overloads the other if too much generation is on) which is

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
			Transformer #2				mitigated by a RAS (loss of one of the xfmrs will trip Mesquite Solar gen).
Load Stress	SRP's MESQUITE 500/230 kV Transformer #1	SRP	MESQUIT2 500/230kV Transformer #2	1596.63 MVA	1593 MVA	Transformer Overload	SRP: Four of the five are the Mesquite 500/230kV xfmrs (loss of one overloads the other if too much generation is on) which is mitigated by a RAS (loss of one of the xfmrs will trip Mesquite Solar gen).
Load Stress	SRP's BRANDOW - KRY-EAST 230 kV Line #1	SRP	PAPAGOBT - KYR-EAST 230kV Line #1	1985.33 Amp	1934.88 Amp	Line Overload	SRP: SRP's latest TPL assessment says that we will upgrade the line, but since this is far into the future the mitigation has not been fully vetted. If we upgrade everything (conductor, line drops, crossbay) the new ratings go up to 3896A (1552.06 MVA) continuous and 4480A (1784.71 MVA) emergency.
Load Stress	NVE's LENZIE - NWEST 500 kV Line #1	NVE	MEAD N - ARDEN 230kV Line #1	891.83 Amp	868.03 Amp	Line Overload	NVE: The rating is limited be a jumper at Mead, which is to be replaced by WALC in 2019; after that rating will be 1080 Amps (conductor) that would mitigate this overload
Load Stress	NVE's NWEST 500/230/34.5 kV 3WT #1	NVE	MEAD N - ARDEN 230kV Line #1	890.91 Amp	868.03 Amp	Line Overload	NVE: same as above
Load Stress	NVE's ARDEN - TOLSON 230 kV Line #1	NVE	TOLSON 230/138kV Transformer #1	383.24 MVA	382 MVA	Transformer Overload	NVE: Magnolia 230/138 XF #2 (in-service 2020), will mitigate; also can be mitigated by adjusting TOL XF taps (up, to reduce Q)
Load Stress	LADWP's RIVER - HAYNES 230 kV Line #1	LADWP	VELASCO - HAY N 230kV Line #1	1603.22 Amp	1599.01 Amp	Line Overload	LADWP: Mitigated by turning on shunt caps at Gramercy and Wilmington 138 kV buses.
Load Stress	LADWP's TOLE - HOLYWD_F 230 kV Line #3	LADWP	TOLHOL11 - HOLYWD_E 230kV Line #1	983.82 Amp	896.15 Amp	Line Overload	LADWP: Mitigated by increasing Pgen at Scattergood Unit 4 and adjusting the Inyo phase shifter.

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
Load Stress	CSU's KELKER - FRTRANGE 230 kV Line #1	CSU	KELKER N - RD_NIXON 230kV Line #1	961.23 Amp	943.84 Amp	Line Overload	
Load Stress	AEPCO's APACHE - BUTERFLD 230 kV Line #1	AEPCO	KARTCHNR 115kV Bus	0.8724 pu	0.8999 pu	Low Voltage	
Load Stress	WAPA's GAVLINWA - PINPK 230 kV Line #1	APS	GAVILNPK 230kV Bus	0.8556 pu	0.8999 pu	Low Voltage	
		WAPA	GAVLINWA 230kV Bus	0.8557 pu	0.8999 pu	Low Voltage	
Load Stress	LADWP's ADELANTO - TOLUCA 500 kV Line #1	LADWP	SYLMAR S 230kV Bus	0.945 pu	0.9499 pu	Low Voltage	LADWP: Mitigated by adjusting the basin shunts.
		LADWP	WLMNTNLD 138kV Bus	0.9429 pu	0.9499 pu	Low Voltage	LADWP: Mitigated by adjusting the basin shunts.
		LADWP	SYLMAR1 230kV Bus	0.9449 pu	0.9499 pu	Low Voltage	LADWP: Mitigated by adjusting the basin shunts.
		LADWP	SYL PF BUS 1 230kV Bus	0.9462 pu	0.9499 pu	Low Voltage	LADWP: Mitigated by adjusting the basin shunts.
		LADWP	SYL PF BUS 2 230kV Bus	0.9454 pu	0.9499 pu	Low Voltage	LADWP: Mitigated by adjusting the basin shunts.
Load Stress	Multiple LADWP (BARRENRD - ROSAMOND & ROSAMOND - HSKLLYCYN)	LADWP	ROSAMOND 230kV Bus	0.9465 pu	0.9499 pu	Low Voltage	LADWP: Mitigated by adjusting the Sylmar filter banks and in basin shunts.
		LADWP	SO_PPA_21SUB 230kV Bus	0.9498 pu	0.9499 pu	Low Voltage	LADWP: Mitigated by adjusting the Sylmar filter banks and in basin shunts.
Load Stress	EPE's PICANTE - AMRAD 345 kV Line #1	EPE	CHAPARAL - ORO_GRAN 115kV Line #1	622.22 Amp	602.45 Amp	Line Overload	EPE: An expected line rating uprate for this line by Summer of 2020 will eliminate this issue. TSGT: If TSGT saw a sudden increase in loads forecasted for this area, TSGT would plan for these issues. This issue does not appear in TSGT's 10-year TPL study.

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
		EPE	ALA_5 115kV Bus	0.8993 pu	0.8999 pu	Low Voltage	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		EPE	AMRAD 115kV Bus	0.8933 pu	0.8999 pu	Low Voltage	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		EPE	AMRAD 345kV Bus	0.897 pu	0.8999 pu	Low Voltage	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		EPE	HOLLOMAN 115kV Bus	0.8819 pu	0.8999 pu	Low Voltage	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		EPE	LARGO 115kV Bus	0.8888 pu	0.8999 pu	Low Voltage	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		EPE	MAR 115kV Bus	0.888 pu	0.8999 pu	Low Voltage	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		EPE	WHITE_SA 115kV Bus	0.8938 pu	0.8999 pu	Low Voltage	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		TSGT	ALAMOGPG 115kV Bus	0.8768 pu	0.8999 pu	Low Voltage	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
		TSGT	BLAZER_T 115kV Bus	0.8521 pu	0.8999 pu	Low Voltage	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		TSGT	C_CANYON 115kV Bus	0.845 pu	0.8999 pu	Low Voltage	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		PNM	ALAMOGCP 115kV Bus	0.8769 pu	0.8999 pu	Low Voltage	EPE, PNM, & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		PNM	GAVILAN 115kV Bus	0.8402 pu	0.8999 pu	Low Voltage	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		PNM	RUIDOSO 115kV Bus	0.8431 pu	0.8999 pu	Low Voltage	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		PNM	TULAROSA 115kV Bus	0.8626 pu	0.8999 pu	Low Voltage	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
		EPE	AMRAD 345kV Bus	Δ -12.91%	-8%	High % V Decrease	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		EPE	AMRAD_B 345kV Bus	Δ -13.25%	-8%	High % V Decrease	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		EPE	ALA_5 115kV Bus	Δ -12.02%	-8%	High % V Decrease	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		EPE	HOLLOMAN 115kV Bus	Δ -14.18 %	-8%	High % V Decrease	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		EPE	MAR 115kV Bus	Δ -13.55 %	-8%	High % V Decrease	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		EPE	WHITE_SA 115kV Bus	Δ -12.25 %	-8%	High % V Decrease	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		TSGT	BLAZER_T 115kV Bus	Δ -15.98 %	-8%	High % V Decrease	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		TSGT	C_CANYON 115kV Bus	Δ -16.49 %	-8%	High % V Decrease	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
		TSGT	JARILLA1 115kV Bus	Δ -11.82 %	-8%	High % V Decrease	EPE & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		PNM	ALAMOGCP 115kV Bus	Δ -14.43 %	-8%	High % V Decrease	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		PNM	GAVILAN 115kV Bus	Δ -16.64 %	-8%	High % V Decrease	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		PNM	RUIDOSO 115kV Bus	Δ -16.55 %	-8%	High % V Decrease	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.
		PNM	TULAROSA 115kV Bus	Δ -15.27 %	-8%	High % V Decrease	EPE, PNM & TSGT: This result is consistent with the Base Case. As load increases more voltage support is needed.

6.0 Appendix B: CAISO Export Reliability Assessment Results

Issues are related to facility loadings or voltage. Transmission elements are typically rated in Amps, transformers in MVA, and voltage in per-unit (pu).

Table 6: CAISO Export Reliability Assessment Contingency Analysis

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
CAISO Export	WAPA's ROGSWAPA - PINPK 230 kV Line #2	WAPA	ROGSWAPA - PINPK 230kV Line #1	1221.58 Amp	1079.39 Amp	Line Overload	
CAISO Export	WAPA's ROGSWAPA - PINPK 230 kV Line #1	WAPA	ROGSWAPA - PINPK 230kV Line #2	1221.58 Amp	1079.39 Amp	Line Overload	
CAISO Export	PSCO's COMANCHE 345/27 kV GSU #U1	BEPC	DAVEJOHN - SAWMILLCK 230kV Line #1	1254.56 Amp	1199.88 Amp	Line Overload	PSCo: Results are due to loss of large generator in power flow model, which does not accurately reflect governor action of other generation units.
			SAWMILLCK - LAR.RIVR 230kV Line #1	1238.63 Amp	1199.88 Amp	Line Overload	BEPC: The noted overload on the LRS-Sawmill Crk-DJ 230 kV line for the n-1 outage of a LRS or Comanche unit is due to the additional wind that PacifiCorp has added around DJ. The overload would be mitigated pre-contingent via the WECC Unscheduled Flow Mitigation plan.
CAISO Export	BEPC's MBPP-1 345/24 kV GSU #1	BEPC	DAVEJOHN - SAWMILLCK 230kV Line #1	1204.87 Amp	1199.88 Amp	Line Overload	BEPC: The noted overload on the LRS-Sawmill Crk-DJ 230 kV line for the n-1 outage of a LRS or Comanche unit is due to the additional wind that PacifiCorp has added around DJ. The

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
							overload would be mitigated pre-contingent via the WECC Unscheduled Flow Mitigation plan.
CAISO Export	BEPC's MBPP-2 345/24 kV GSU #1	BEPC	DAVEJOHN - SAWMILLCK 230kV Line #1	1245.52 Amp	1199.88 Amp	Line Overload	BEPC: The noted overload on the LRS-Sawmill Crk-DJ 230 kV line for the n-1 outage of a LRS or Comanche unit is due to the additional wind that PacifiCorp has added around DJ. The overload would be mitigated pre-contingent via the WECC Unscheduled Flow Mitigation plan.
			SAWMILLCK - LAR.RIVR 230kV Line #1	1229.74 Amp	1199.88 Amp	Line Overload	BEPC: The noted overload on the LRS-Sawmill Crk-DJ 230 kV line for the n-1 outage of a LRS or Comanche unit is due to the additional wind that PacifiCorp has added around DJ. The overload would be mitigated pre-contingent via the WECC Unscheduled Flow Mitigation plan.
CAISO Export	WAPA's BONANZA - CRAIG 345 kV Line #1	DG&T	RANGELY - CALAMRDG 138kV Line #1	730.9 Amp	489.49 Amp	Line Overload	PSCo & TSGT: CAISO Export round trip resulted in unprecedented west-east flows through Colorado. The WECC TOT1A path limit is not defined in this direction due to the unrealistic nature of these flows. Additional local studies may be needed should the flows in the scenario occur in Base Case studies.
		TSGT	MEEKER - W.RV.CTY 138kV Line #1	692.49 Amp	476.94 Amp	Line Overload	PSCo & TSGT: CAISO Export round trip resulted in unprecedented west-east flows through Colorado. The WECC TOT1A path limit is not defined in this direction due to the unrealistic nature of these flows. Additional local studies may be needed should the flows in the scenario occur in Base Case studies.

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
			W.RV.CTY - CALAMRDG 138kV Line #1	701.18 Amp	476.94 Amp	Line Overload	PSCo & TSGT: CAISO Export round trip resulted in unprecedented west-east flows through Colorado. The WECC TOT1A path limit is not defined in this direction due to the unrealistic nature of these flows. Additional local studies may be needed should the flows in the scenario occur in Base Case studies.
		LADWP	INT PF BUS 2 345kV Bus	1.05 pu	1.05 pu	High Voltage	
CAISO Export	PSCO's HOPKINS - MALTA 230 kV Line #1	PSCO	HOPKINS - BASALT 115kV Line #1	493.59 Amp	461.88 Amp	Line Overload	PSCo: CAISO Export round trip resulted in unprecedented west-east flows through Colorado. Additional local studies may be needed should the flows in the scenario occur in Base Case studies.
CAISO Export	PSCO's HDNWEST - FOIDELCK 230 kV Line #1	PSCO	HOPKINS - BASALT 115kV Line #1	478.41 Amp	461.88 Amp	Line Overload	PSCo: CAISO Export round trip resulted in unprecedented west-east flows through Colorado. Additional local studies may be needed should the scenario become plausible.
CAISO Export	WAPA's WCANON - PONCHABR 230 kV Line #1	PSCO	PONCHA - SMELTER 115kV Line #1	306.86 Amp	301.23 Amp	Line Overload	PSCo: CAISO Export round trip resulted in unprecedented west-east flows through Colorado. Additional local studies may be needed should the flows in the scenario occur in Base Case studies.
CAISO Export	WAPA's SANJNPS - WATRFLW 345 kV PST #2	WAPA	SANJN PS - WATRFLW 345kV PST #1	388.04 MVA	360 MVA	PST Overload	WACM: Overloads on Phase Shifting Transformers. Change angles on transformers at Waterflow and at Shiprock.
CAISO Export	WAPA's SANJNPS -	WAPA	SANJN PS - WATRFLW 345kV PST #2	387.84 MVA	360 MVA	PST Overload	WACM: Overloads on Phase Shifting Transformers. Change angles on transformers at Waterflow and at Shiprock.

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
	WATRFLW 345 kV PST #1						
CAISO Export	SRP's WESTWING - PERKINS 500 kV Line #1	SRP	PERKINS 500kV Bus	1.158 pu	1.155 pu	High Voltage	SRP: The line reactor at Perkins on the Perkins – Mead 500kV line is off in the base case. This reactor is normally in-service. Modeling the line reactor as in-service mitigates the high voltage concern.
CAISO Export	IPA's MWC345 - INTERMT 345 kV Line #1	IPA	INTERMT 345kV Bus	1.052 pu	1.05 pu	High Voltage	LADWP: Mitigated by adjusting the Intermountain filter banks.
			INTERMTX 345kV Bus	1.052 pu	1.05 pu	High Voltage	LADWP: Mitigated by adjusting the Intermountain filter banks.
			INTERMTY 345kV Bus	1.052 pu	1.05 pu	High Voltage	LADWP: Mitigated by adjusting the Intermountain filter banks.
		LADWP	INT PF BUS 1 345kV Bus	1.052 pu	1.05 pu	High Voltage	LADWP: Mitigated by adjusting the Intermountain filter banks.
			INT PF BUS 2 345kV Bus	1.053 pu	1.05 pu	High Voltage	LADWP: Mitigated by adjusting the Intermountain filter banks.
			INT PF BUS 3 345kV Bus	1.052 pu	1.05 pu	High Voltage	LADWP: Mitigated by adjusting the Intermountain filter banks.
			INT PF BUS 4 345kV Bus	1.052 pu	1.05 pu	High Voltage	LADWP: Mitigated by adjusting the Intermountain filter banks.
			SOL2SUB 345kV Bus	1.052 pu	1.05 pu	High Voltage	LADWP: Mitigated by adjusting the Intermountain filter banks.
			SOL1SUB 345kV Bus	1.052 pu	1.05 pu	High Voltage	LADWP: Mitigated by adjusting the Intermountain filter banks.
CAISO Export	LADWP's MARKETPL -	LADWP	MARKETPL 500kV Bus	1.101 pu	1.1 pu	High Voltage	LADWP: Mitigated by turning on the line reactor from McCullough 500 kV to Victorville 500 kV.

Base Case PF	Disturbance(s) [Multiple if affected elements were the same]	Affected Element					Comment
		Owner/ Operator	Affected Element	Value under (Worst) Disturbance	Limit	Issue	
	MCCULLGH 500 kV Line #1		MKTPSVC 500kV Bus	1.101 pu	1.1 pu	High Voltage	LADWP: Mitigated by turning on the line reactor from McCullough 500 kV to Victorville 500 kV.
			COPPMTN3 500kV Bus	1.102 pu	1.1 pu	High Voltage	LADWP: Mitigated by turning on the line reactor from McCullough 500 kV to Victorville 500 kV.
CAISO Export	LADWP's INTERMT - INTPFBUS1 345 kV Line #1	LADWP	INT PF BUS 2 345kV Bus	1.051 pu	1.05 pu	High Voltage	LADWP: This element is a Filter Bank. This is not a credible contingency.
			SOL1SUB 345kV Bus	1.05 pu	1.05 pu	High Voltage	LADWP: This element is a Filter Bank. This is not a credible contingency.