Western Energy Imbalance Market Resource Sufficiency Evaluation Metrics Report covering Q1 2024

May 1, 2024

Prepared by: Department of Market Monitoring

California Independent System Operator

1 Report summary

As part of the Western Energy Imbalance Market (WEIM) design, each balancing area is subject to a *resource sufficiency evaluation*. The evaluation is performed prior to each hour to ensure that generation capacity and flexibility in each area is sufficient without relying on transfers from other WEIM balancing areas. In this report, DMM provides additional information and analysis about resource sufficiency evaluation performance, accuracy, and impacts during the first quarter of 2024.

Report highlights

Mid-January cold weather event

- **Between January 13 and 15, balancing areas in the Pacific Northwest and Intermountain West regions experienced notably high loads, strained supply conditions, and an increase in resource sufficiency evaluation failures due to a cold weather event.** During this period, by opting in to Assistance Energy Transfers, three balancing areas achieved additional WEIM imports that would not have occurred otherwise.
- **Idaho Power adjusted the resource sufficiency evaluation load down 40 MW during 19 hours across January 14 and January 15 to account for non-participating demand response programs which otherwise could not be accounted for in the tests.** These adjustments allowed Idaho Power to pass the resource sufficiency evaluation in fifteen intervals that otherwise would have been failures.

Assistance Energy Transfers

- **Seven balancing areas were opted in to Assistance Energy Transfers during the first quarter: Avangrid, Idaho Power, NorthWestern Energy, NV Energy, PacifiCorp East, PacifiCorp West, and the California ISO.** Four of these areas (Avangrid, Idaho Power, NorthWestern Energy, and NV Energy) failed the resource sufficiency evaluation during at least one interval while opted in to the program, gaining access to additional WEIM supply that would not have been available otherwise.

Resource sufficiency evaluation failures

- **The frequency of capacity or flexibility test failures was low across most balancing areas for the quarter.** The WAPA Desert Southwest area failed the upward flexibility test in around 2.4 percent of intervals. The Public Service Company of New Mexico (PNM) area failed the upward flexibility test in around 1.6 percent of intervals. For all other balancing areas, failures for each test type and direction occurred in less than 1 percent of intervals.

Quantile regression approach for calculating uncertainty

This report includes an overview and analysis on the mosaic quantile regression method for calculating net load uncertainty in the flexible ramping test during the first quarter. Key findings of this analysis include the following:

- **Overall, the uncertainty values from the mosaic quantile regression approach were lower on average across most balancing areas compared to those calculated with the prior histogram approach.** However, results of the mosaic quantile regression approach vary more widely, with extremely high or low values in many hours. This variability — combined with the complexity of the mosaic quantile regression approach — can make it more difficult for WEIM balancing areas to plan for and meet flexibility test requirements without significant excess.

- **For the first and second intervals of each hour, the regressions for calculating the uncertainty requirement for the group of balancing areas that pass the resource sufficiency evaluation must be performed before the final composition of balancing areas in this group are known.** When the final composition of balancing areas in the pass-group differs, this can create swings in the calculated flexible ramping product uncertainty target. DMM has requested that the ISO consider options to resolve this timing issue.

Analysis for the quarter provided in this report are consistent with trends that have been highlighted in prior reports dating back to February 2023, when the mosaic quantile regression method was first implemented.

CAISO non-participating pump load

This report also highlights non-participating pump loads in the ISO balancing area that are not included in the ISO area resource sufficiency evaluation. Non-participating pump load is included in the ISO area real-time market requirement but is not included in the resource sufficiency evaluation. This can contribute to conditions in which the ISO passes the resource sufficiency evaluation while an Energy Emergency Alert is issued (such as during July 2023).

- **DMM recommends that the ISO and stakeholders consider whether non-participating pump load should be included in the resource sufficiency evaluation.** This would better align the conditions in the real-time market with the conditions considered in the resource sufficiency evaluation.

Organization of report

- Section 2 provides a special overview of resource sufficiency evaluation performance during the mid-January cold event.
- Section 3 provides an overview of Assistance Energy Transfers.
- Section 4 summarizes the frequency and size of resource sufficiency evaluation failures.
- Section 5 provides an overview and analysis on the quantile regression method for calculating uncertainty in the flexible ramp sufficiency test.
- Section 6 provides an overview of demand differences that can exist between the real-time market and resource sufficiency evaluation. CAISO non-participating pump load is included in the real-time market but not in the resource sufficiency evaluation.
- Section 7 summarizes WEIM import limits and transfers following a resource sufficiency evaluation failure.
- The appendix provides a technical overview of the flexible ramp sufficiency and bid range capacity tests.

DMM continues to welcome feedback on existing or additional metrics and analysis that WEIM entities and other stakeholders would find most helpful. Comments and questions may be submitted to DMM via email at DMM@caiso.com.

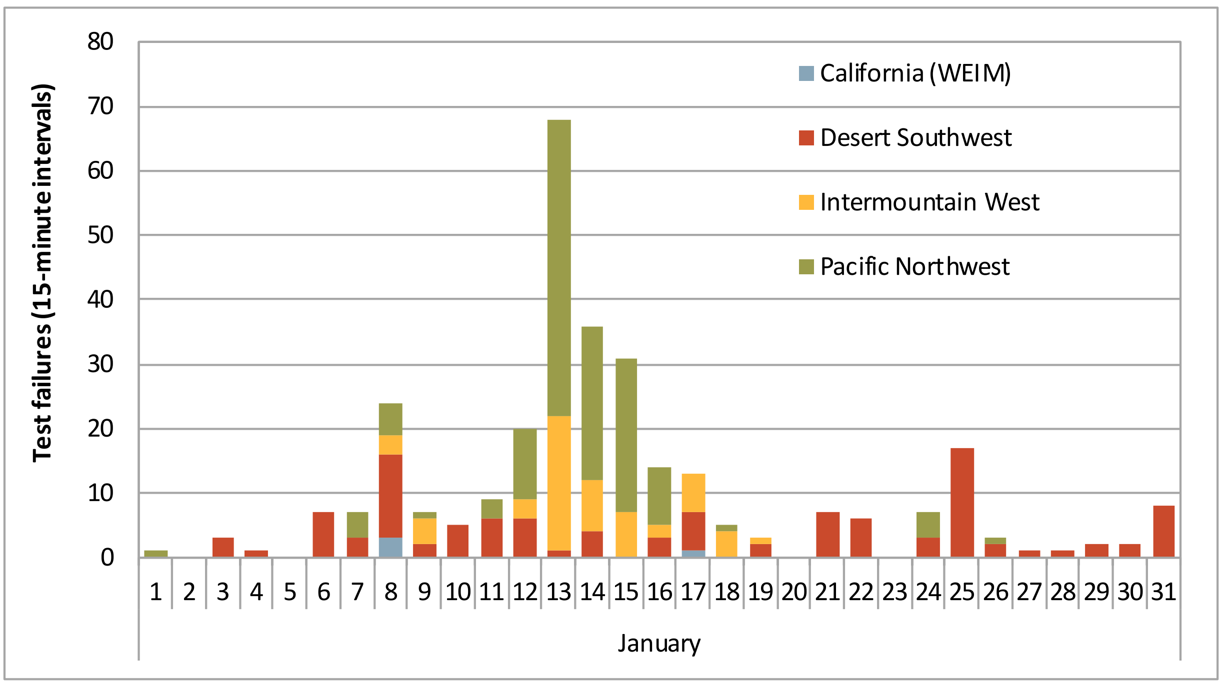
2 Resource sufficiency evaluation results during mid-January cold event

Between January 13 and January 15, WEIM balancing areas in the Pacific Northwest and Intermountain West regions experienced an extreme cold weather event.[1] For the balancing areas affected, this period was marked by notably high loads, strained supply conditions, and an increase in resource sufficiency evaluation failures. This section describes resource sufficiency evaluation results during this period.

Resource sufficiency evaluation failures and Assistance Energy Transfers

Figure 2.1 shows the number of upward resource sufficiency evaluation failures by region and day in January.[2] During the peak of the cold weather event (between January 13 and January 15), the frequency of resource sufficiency evaluation failures increased — particularly in the Pacific Northwest and Intermountain West regions. High loads associated with the winter event contributed to the resource sufficiency evaluation failures. Figure 2.2 summarizes the peak 5-minute market load for non-CAISO balancing areas in the WEIM for each day by region. Between January 12 and January 16, load for balancing areas in the Pacific Northwest and Intermountain West regions peaked at over 50,000 MW.

Figure 2.1 Upward resource sufficiency evaluation failures by region (January 2024)



[1] California ISO, *Winter Conditions Report for January 2024*, March 6, 2024: https://www.caiso.com/Documents/WinterMarketPerformanceReportforJan2024.pdf

[2] California (WEIM) includes BANC, LADWP, and Turlock Irrigation district. Desert Southwest includes Arizona Public Service, NV Energy, PNM, Salt River Project, El Paso Electric, Tucson Electric Power, and WAPA (DSW). Intermountain West includes Idaho Power, Northwestern Energy, PacifiCorp East, and Avista. Pacific Northwest includes Avangrid, BPA, PacifiCorp West, Portland General Electric, Powerex, Puget Sound Energy, Seattle City Light, and Tacoma Power. These regions reflect a combination of general geographic location as well as common price-separated groupings that can exist when a balancing area is collectively import or export constrained along with one or more other balancing areas.

Figure 2.2 Peak WEIM load by region (January 2024)

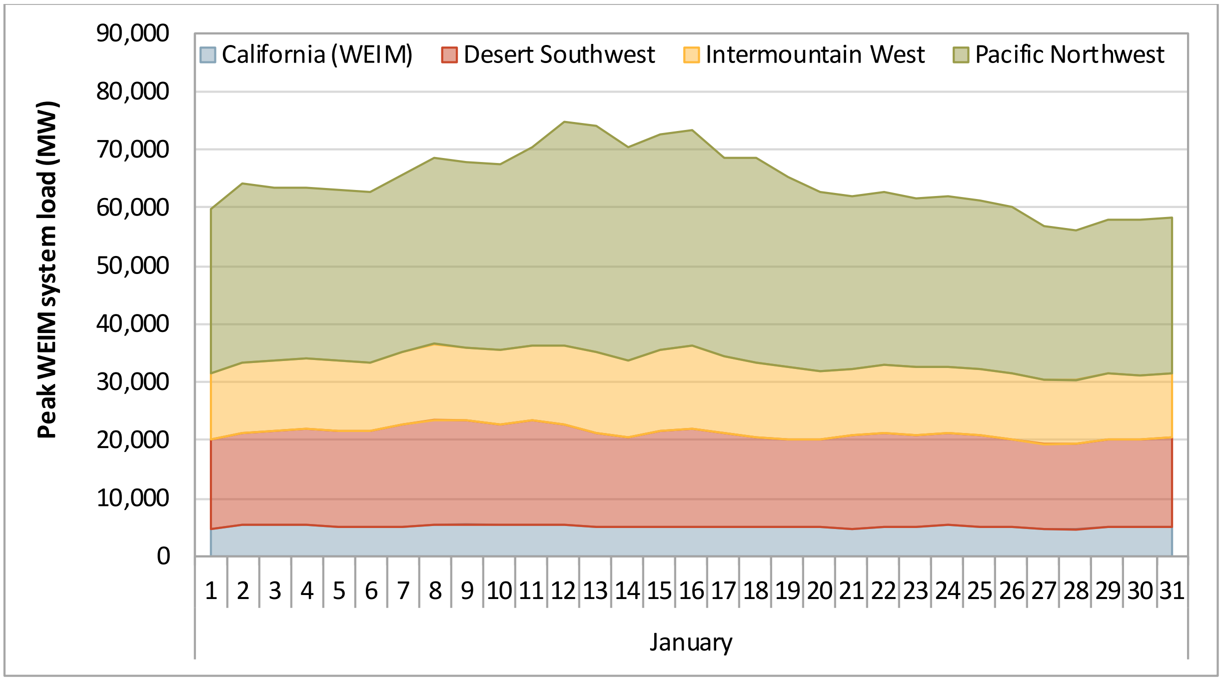
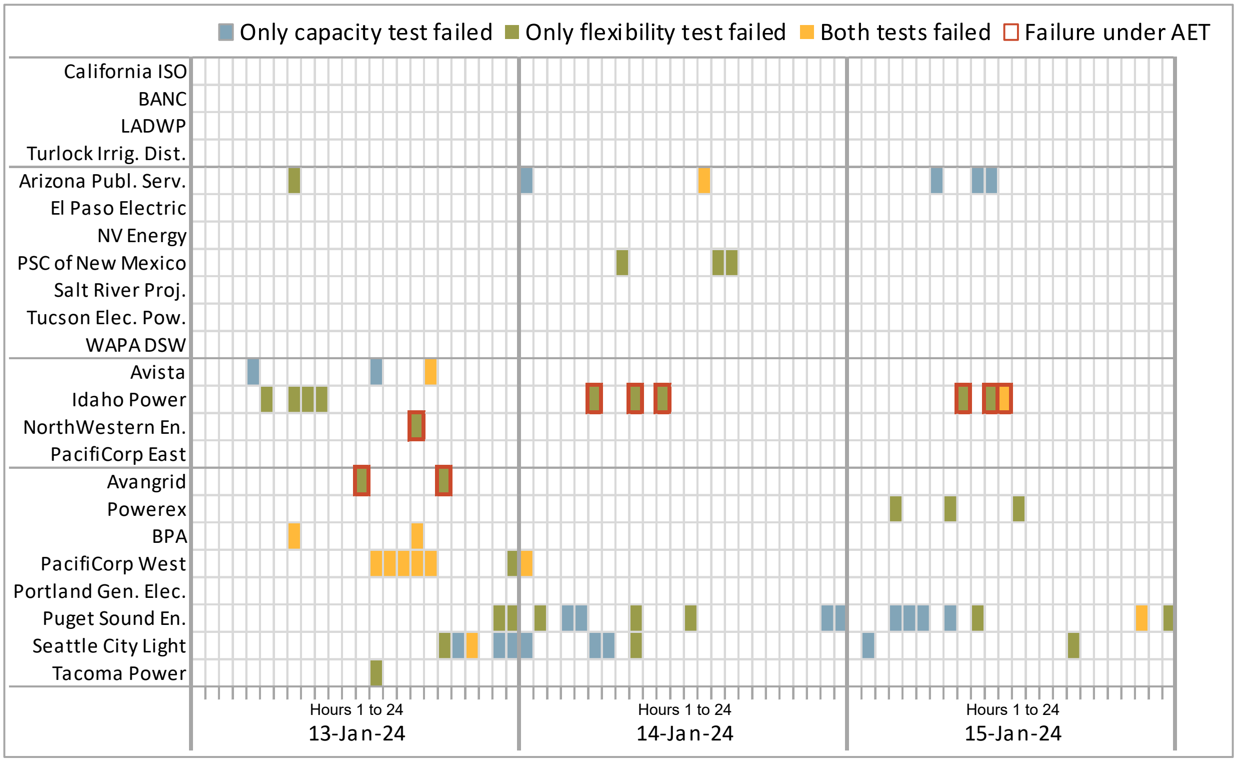


Figure 2.3 shows hours in which each WEIM entity failed the capacity test, flexibility test, or both tests in at least one interval between January 13 and January 15, 2024. During this period, 12 different balancing areas failed the resource sufficiency evaluation with most of the test failures occurring within the Pacific Northwest or Intermountain West regions. Idaho Power, PacifiCorp West, and Puget Sound Energy failed the test most frequently in this period, during roughly 28 intervals each across 7 or more hours. Seattle City Light failed the test during 18 intervals across 11 hours.

The red borders in Figure 2.3 indicate resource sufficiency evaluation failures in which the balancing area had elected to opt in to Assistance Energy Transfers (AET). AET gives balancing areas access to excess WEIM supply that may not have been available otherwise following an upward resource sufficiency evaluation failure.[3] During this period, six balancing areas were opted in to the program for at least one of the days — Avangrid, Idaho Power, NV Energy, NorthWestern Energy, PacifiCorp East, and PacifiCorp West — with three of these balancing areas experiencing a resource sufficiency evaluation failure while opted in. These three balancing areas were Avangrid, Idaho Power, and NorthWestern Energy. Assistance Energy Transfers allowed these balancing areas to achieve additional WEIM imports that otherwise would not have occurred following the resource sufficiency evaluation failure. Between January 13 and January 15, Idaho Power achieved as much as 176 MW in additional imports due to AET. NorthWestern Energy achieved as much as 158 MW during the same period. The following section provides more details on Assistance Energy Transfers as well as outcomes during the first quarter.

[3] Without AET, a balancing area failing either the upward flexibility or upward capacity test would have net WEIM imports limited to the greater of either the base transfer or the optimal transfer from the last 15-minute market interval.

Figure 2.3 Upward resource sufficiency evaluation failures (January 13-15, 2024)



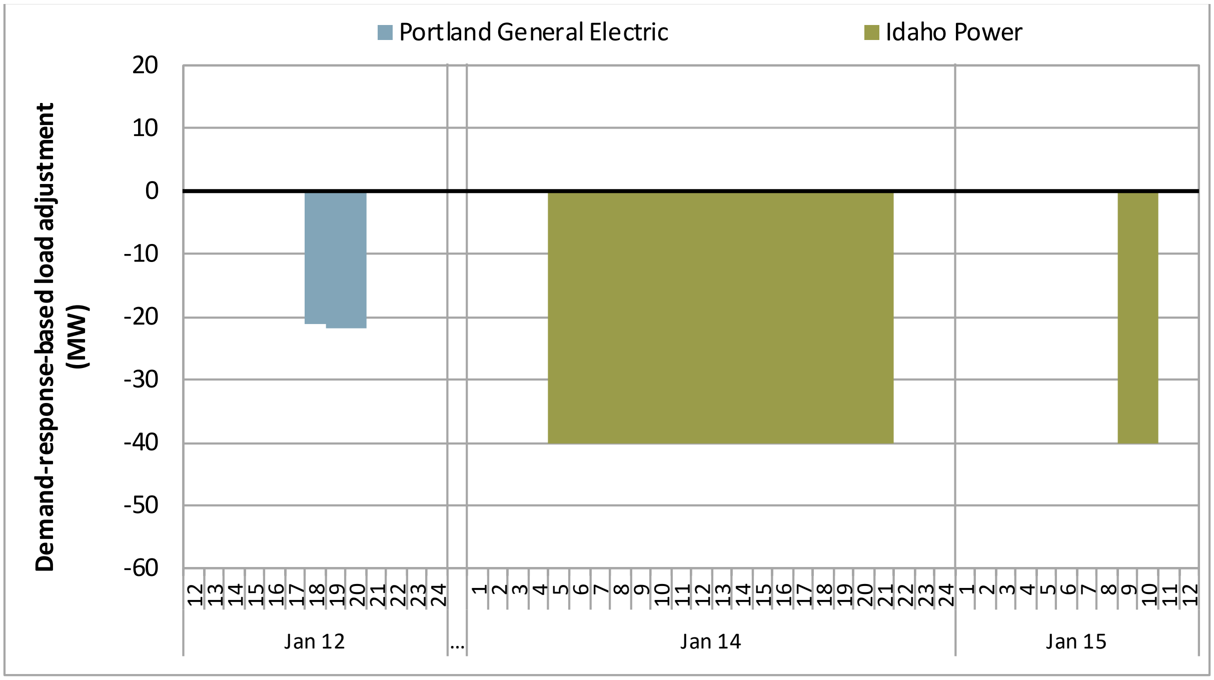
Demand-response based load adjustments in the resource sufficiency evaluation

WEIM entities can submit a load forecast adjustment in their resource sufficiency evaluation to reflect demand response programs which otherwise could not be accounted for in the real-time market.[4] This adjustment is included in both the capacity and flexibility tests, and impacts the load used in the requirement of both tests.

Around the mid-January cold event, two balancing areas used this feature to adjust the load forecast in the tests. Figure 2.4 shows all hourly demand-response-based load adjustments in the resource sufficiency evaluation that occurred during January. In particular, Idaho Power adjusted the resource sufficiency evaluation load down 40 MW during 19 hours across January 14 and January 15. These adjustments allowed Idaho Power to pass the resource sufficiency evaluation in fifteen intervals that would have instead been a failure had the demand response program not been accounted for in the test.

[4] The process in which non-participating demand-response schedules are submitted and incorporated in either the ISO-calculated forecast for WEIM demand or the resource sufficiency evaluation is expected to change as part of Resource Sufficiency Evaluation Phase 2 (track 3) enhancements. For more information, see the *Business Requirements Specification:* *https://www.caiso.com/Documents/BusinessRequirementsSpecification-WEIM-Resource-Sufficiency-Evaluation-Enhancements-Phase2-Redline.pdf*

Figure 2.4 Demand-response-based load adjustments included in the resource sufficiency evaluation (January 2024)



3 Assistance Energy Transfers

Assistance Energy Transfers (AET) give balancing areas access to excess WEIM supply that may not have been available otherwise following an upward resource sufficiency evaluation failure. Without AET, a balancing area failing either the upward flexibility or upward capacity test would have net WEIM imports limited to the greater of either the base transfer or the optimal transfer from the last 15-minute market interval. Balancing areas can voluntarily opt in to the AET program to prevent their WEIM transfers from being limited during an upward resource sufficiency evaluation failure, but will be subject to an ex-post surcharge. Balancing areas must opt in or opt out of the program in advance of the trade date.[5]

The Assistance Energy Transfer surcharge is applied during any interval in which an opt-in balancing area fails the upward flexibility or capacity test. The surcharge is calculated as the *applicable real-time assistance energy transfer* times the real-time bid cap.[6] The applicable AET quantity is based on the lesser of either (1) the tagged dynamic WEIM transfers or (2) the amount by which the balancing area failed the resource sufficiency evaluation. If the tagged dynamic WEIM transfers are less than the amount by which the balancing area failed the resource sufficiency evaluation, then the applicable AET quantity is also reduced by a credit. The credit is either upward available balancing capacity for WEIM entities or cleared regulation up for the ISO balancing area.

Opting in to the Assistance Energy Transfer program does not guarantee that the balancing area will achieve additional WEIM supply following a resource sufficiency evaluation failure (compared to opting out of the program). It only removes the import limit that would have been in place following a test failure, allowing the market to freely and optimally schedule WEIM transfers based on supply and demand conditions in the system. If the import limit following a test failure was set high such that it is not restricting the optimal solution, then opting in or opting out of the program will have no effect on WEIM import supply in that interval.

Table 3.1 shows the days in which a balancing area was opted in to Assistance Energy Transfers during the first quarter. Six balancing areas were opted in to the program on at least one day during this period: Avangrid, CAISO, Idaho Power, NorthWestern Energy, NV Energy, PacifiCorp East and PacifiCorp West.[7] Avangrid, NorthWestern Energy, and NV Energy were opted in to AET during all days of the first quarter.

Table 3.2 summarizes all balancing areas that were opted in to Assistance Energy Transfers on at least one day during the first quarter and its impact following a resource sufficiency evaluation failure. First, the table shows the number of 15-minute intervals in which a balancing area failed the resource sufficiency evaluation after opting in to AET. These are the intervals in which the WEIM import limit following the test failure was removed — giving the WEIM entity access to WEIM supply that may not have been available otherwise. Table 3.2 also shows the percent of failure intervals in the 5-minute market in which the balancing area achieved additional WEIM imports due to opting in to AET. The table also shows the average and maximum WEIM imports added in the 5-minute market because of AET.

---

5 Assistance Energy Transfer designation requests are submitted to Master File as *opt-in* or *opt-out* and include both a start and end date. The standard timeline to implement an opt-in or opt-out request is at least five business days in advance of the start date. An *emergency* opt-in request is also available, should reliability necessitate this, for two business days in advance of the start date. For more information, see: https://bpmcm.caiso.com/Pages/ViewPRR.aspx?PRRID=1525&IsDlg=0

6 The soft bid cap is $1,000/MWh and can increase to the hard bid cap of $2,000/MWh under certain conditions.

7 The CAISO balancing area can opt in to Assistance Energy Transfers based on upcoming system conditions and operator experience. For more information, see the Business Practice Manual for the Western Energy Imbalance Market, section 11.3.2: https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Energy%20Imbalance%20Market The CAISO area did not fail the resource sufficiency evaluation during the quarter.

Table 3.1 Assistance Energy Transfer opt-in designations by balancing area (January–March 2024)

BAA	Period opted in to Assitance Energy Transfers	Days opted in to AET
Avangrid	Jan. 1 - Mar. 31	91
California ISO	Mar. 4 - Mar. 5, Mar. 18 - Mar. 19, Mar. 25, Mar. 27	6
Idaho Power	Jan. 14 - Jan. 17	4
Northwestern Energy	Jan. 1 - Mar. 31	91
NV Energy	Jan. 1 - Mar. 31	91
PacifiCorp East	Jan. 15 - Jan. 16	2
PacifiCorp West	Jan. 15 - Jan. 16	2

Table 3.2 Resources sufficiency evaluation failures during Assistance Energy Transfer opt-in (January–March 2024)

BAA	RSE failures under AET (15-min. intervals)	Failure intervals with additional WEIM imports due to AET (percent)	Average WEIM imports added (MW)	Max WEIM imports added (MW)
Avangrid	12	25%	15	180
California ISO	0	N/A	N/A	N/A
Idaho Power	17	39%	20	176
Northwestern Energy	21	27%	22	158
NV Energy	3	33%	128	459
PacifiCorp East	0	N/A	N/A	N/A
PacifiCorp West	0	N/A	N/A	N/A

4 Frequency of resource sufficiency evaluation failures

This section summarizes the frequency and shortfall amount for bid-range capacity test and flexible ramping sufficiency test failures.[8] If a balancing area fails either (or both) of these tests, then transfers between that and the rest of the WEIM areas are limited.

Figure 4.1 through Figure 4.4 show the percent of 15-minute intervals in which each WEIM area failed the upward capacity or the flexibility tests, as well as the average shortfall of those test failures.[9] Figure 4.5 through Figure 4.8 provide the same information for the downward direction. The dash indicates that the area did not fail the test during the month.

In the first quarter:

- WAPA Desert Southwest failed the upward flexibility test in around 2.4 percent of intervals.
- Public Service Company of New Mexico (PNM) failed the upward flexibility test in around 1.6 percent of intervals.
- All other balancing areas failed each test type in less than one percent of intervals.

Figure 4.9 shows the change in the percent of intervals with an upward test failure from the first quarter of 2023 to the first quarter of 2024. Figure 4.10 shows the same information for downward test failures.

Figure 4.11 summarizes the overlap between failure of the upward capacity and the flexibility tests during the quarter. The black horizontal line (right axis) shows the number of 15-minute intervals with either a capacity or a flexibility test failure for each WEIM area. The areas are shown in descending number of failure intervals. The bars (left axis) show the percent of the failure intervals that meet the condition. Figure 4.12 shows the same information for the downward direction. Areas that did not fail either the capacity or the flexibility tests during this period were omitted from the figure. Across both directions, the flexibility test was more often the source of the resource sufficiency evaluation failure.

[8] Results in this section exclude known invalid test failures. These can occur because of a market disruption, software defect, or other errors.

[9] Results in these figures reflect the final resource sufficiency evaluation (40 minutes prior to the evaluation hour).

Figure 4.1 Frequency of upward capacity test failures (percent of 15-minute intervals)

	2023												2024		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Arizona Publ. Serv.	0.4	0.5	0.7	0.2	0.0	0.1	—	—	—	0.0	—	0.1	—	—	—
Avangrid				0.0	—	—	—	—	0.8	—	—	—	—	—	—
Avista	—	—	—	0.1	0.0	—	—	—	—	0.0	0.1	—	0.3	0.1	—
BANC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BPA	—	—	—	0.2	—	0.3	0.4	—	0.1	—	—	—	0.3	—	—
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
El Paso Electric				0.0	0.1	0.3	0.8	0.0	0.1	0.1	—	—	—	—	0.1
Idaho Power	—	—	—	0.0	0.1	—	—	—	—	—	0.1	—	0.0	—	—
LADWP	0.1	—	—	—	—	—	0.1	0.0	—	—	—	0.0	0.1	0.0	—
NorthWestern En.	0.3	0.1	—	—	—	—	0.3	—	—	—	—	—	—	0.1	—
NV Energy	—	—	—	—	0.0	—	0.0	0.0	—	0.0	—	—	—	—	—
PacifiCorp East	—	—	—	—	—	—	0.0	—	—	—	—	—	—	—	—
PacifiCorp West	0.1	0.1	—	—	—	—	—	0.1	—	—	—	—	0.8	0.0	—
Portland Gen. Elec.	—	0.0	0.0	0.1	0.4	0.1	0.0	—	0.0	0.0	0.6	—	—	—	—
Powerex	—	—	—	—	0.1	—	—	—	0.1	0.0	0.0	—	—	—	—
PSC of New Mexico	—	—	0.7	0.3	0.2	0.0	—	0.0	0.1	0.1	—	0.1	—	—	—
Puget Sound En.	—	0.0	0.2	—	0.1	0.5	1.5	0.5	0.2	0.7	1.0	0.2	0.8	0.1	0.2
Salt River Proj.	1.0	0.4	1.1	0.9	0.2	0.0	2.8	1.2	0.0	0.8	0.2	0.1	0.1	0.1	0.2
Seattle City Light	0.0	0.1	—	—	—	—	0.1	0.9	—	0.1	0.6	—	0.5	—	—
Tacoma Power	0.0	0.1	0.1	—	0.1	—	—	0.1	—	0.1	0.0	—	—	—	0.3
Tucson Elec. Pow.	0.1	0.0	—	—	—	—	0.3	—	—	0.2	—	—	—	—	—
Turlock Irrig. Dist.	—	—	—	0.0	—	—	0.1	—	—	—	—	—	—	—	—
WAPA DSW				2.3	0.8	0.7	1.1	0.6	0.1	0.3	0.4	0.1	—	—	0.1

Figure 4.2 Average shortfall of upward capacity test failures (MW)

	2023												2024		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Arizona Publ. Serv.	316	41	817	637	35	192	—	—	—	58	—	160	—	—	—
Avangrid				1	—	—	—	—	190	—	—	—	—	—	—
Avista	—	—	—	20	1	—	—	—	—	2	13	—	31	9	—
BANC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BPA	—	—	—	55	—	238	118	—	73	—	—	—	176	—	—
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
El Paso Electric				6	8	88	20	8	6	18	—	—	—	—	4
Idaho Power	—	—	—	23	12	—	—	—	—	—	58	—	4	—	—
LADWP	49	—	—	—	—	—	10	18	—	—	—	10	71	1	—
NorthWestern En.	56	68	—	—	—	—	70	—	—	—	—	—	—	12	—
NV Energy	—	—	—	—	53	—	3	41	—	12	—	—	—	—	—
PacifiCorp East	—	—	—	—	—	—	116	—	—	—	—	—	—	—	—
PacifiCorp West	9	84	—	—	—	—	—	26	—	—	—	—	51	8	—
Portland Gen. Elec.	—	38	13	1	19	12	24	—	0	17	228	—	—	—	—
Powerex	—	—	—	—	131	—	—	—	154	2	6	—	—	—	—
PSC of New Mexico	—	—	52	24	106	5	—	25	4	48	—	49	—	—	—
Puget Sound En.	—	15	22	—	26	45	29	28	48	48	89	41	78	15	52
Salt River Proj.	44	44	54	30	38	1	65	56	80	56	23	10	17	38	22
Seattle City Light	2	16	—	—	—	—	2	6	—	5	563	—	18	—	—
Tacoma Power	0	5	0	—	2	—	—	7	—	5	0	—	—	—	119
Tucson Elec. Pow.	65	1	—	—	—	—	54	—	—	12	—	—	—	—	—
Turlock Irrig. Dist.	—	—	—	2	—	—	8	—	—	—	—	—	—	—	—
WAPA DSW				133	74	5	18	4	13	7	282	78	—	—	1

Figure 4.3 Frequency of upward flexibility test failures (percent of 15-minute intervals)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
	2023												2024		
Arizona Publ. Serv.	0.9	1.8	2.5	1.1	0.2	0.1	—	0.0	—	—	0.2	0.1	0.2	0.1	0.5
Avangrid				1.0	0.7	0.1	0.2	0.0	0.9	0.1	0.1	0.2	0.2	0.1	0.1
Avista	—	0.0	0.0	0.2	0.2	0.0	—	—	—	0.1	0.1	—	0.1	—	0.1
BANC	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—
BPA	—	0.1	0.6	0.2	1.2	0.3	1.3	0.2	0.2	0.1	—	—	0.4	0.0	—
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
El Paso Electric				0.8	0.7	0.3	2.1	0.5	0.6	0.4	0.2	0.1	0.3	0.0	1.0
Idaho Power	0.0	0.1	0.3	0.3	0.5	0.1	—	—	—	0.1	—	—	1.1	—	0.1
LADWP	—	0.3	—	0.1	0.0	0.1	0.0	0.2	0.0	—	—	0.1	0.1	—	0.1
NorthWestern En.	0.3	0.1	0.2	0.8	0.3	0.2	1.0	0.4	0.2	0.2	0.0	0.1	0.5	0.1	0.0
NV Energy	0.1	0.3	0.0	0.1	0.1	0.0	0.1	0.2	0.1	—	0.1	0.0	—	0.1	0.0
PacifiCorp East	0.1	—	0.0	0.1	—	0.0	0.2	—	—	—	—	—	—	—	—
PacifiCorp West	0.1	0.1	—	0.1	0.6	0.0	0.2	—	—	0.0	0.0	0.1	1.0	—	0.1
Portland Gen. Elec.	0.0	0.1	0.0	0.1	1.5	0.7	0.1	—	—	0.6	0.0	—	—	—	0.0
Powerex	—	0.2	—	—	—	—	—	—	—	—	—	—	0.2	—	—
PSC of New Mexico	0.2	—	1.2	5.1	0.9	0.6	0.7	0.5	0.3	1.9	1.9	0.3	2.0	2.3	0.4
Puget Sound En.	—	0.1	0.8	0.2	1.0	0.6	2.6	1.3	0.2	1.3	1.9	0.5	0.8	0.1	0.2
Salt River Proj.	3.5	1.2	1.7	2.0	0.6	0.2	3.7	1.1	0.3	0.6	0.4	0.2	0.2	0.1	0.7
Seattle City Light	—	0.1	—	—	—	—	—	0.5	0.0	0.0	—	—	0.3	—	0.1
Tacoma Power	0.2	0.1	0.2	—	0.1	—	—	—	—	0.2	0.0	—	0.1	0.0	0.4
Tucson Elec. Pow.	0.3	0.3	0.3	0.1	0.1	—	0.2	0.3	—	0.1	0.2	0.1	0.0	0.2	—
Turlock Irrig. Dist.	—	—	—	0.0	—	—	0.1	—	—	—	—	—	—	—	—
WAPA DSW				2.7	0.7	0.8	0.3	0.6	0.2	0.3	0.5	0.1	1.1	2.5	3.5

Figure 4.4 Average shortfall of upward flexibility test failures (MW)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
	2023												2024		
Arizona Publ. Serv.	154	77	288	119	36	76	—	88	—	—	102	23	27	55	65
Avangrid				79	13	9	20	26	138	60	8	7	12	20	30
Avista	—	13	12	35	14	4	—	—	—	21	15	—	66	—	14
BANC	—	—	—	—	64	—	—	—	—	—	—	—	—	—	—
BPA	—	36	62	99	82	164	114	44	41	5	—	—	153	73	—
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
El Paso Electric				24	15	123	19	34	9	17	10	13	9	24	23
Idaho Power	5	51	28	42	24	46	—	—	—	10	—	—	32	—	17
LADWP	—	45	—	21	30	56	51	102	14	—	—	69	26	—	52
NorthWestern En.	44	16	40	14	33	11	32	20	6	11	4	5	16	24	3
NV Energy	60	69	29	164	59	24	52	207	12	—	22	19	—	137	136
PacifiCorp East	53	—	101	47	—	18	36	—	—	—	—	—	—	—	—
PacifiCorp West	14	79	—	30	146	2	35	—	—	22	25	22	104	—	9
Portland Gen. Elec.	39	16	9	61	49	37	27	—	—	25	2	—	—	—	23
Powerex	—	86	—	—	—	—	—	—	—	—	—	—	106	—	—
PSC of New Mexico	19	—	45	47	26	21	35	56	20	56	38	39	52	50	37
Puget Sound En.	—	45	46	29	59	48	55	43	18	86	42	27	29	16	71
Salt River Proj.	47	39	48	54	72	53	77	50	90	43	63	151	66	50	44
Seattle City Light	—	23	—	—	—	—	—	16	29	6	—	—	22	—	16
Tacoma Power	6	3	6	—	21	—	—	—	—	9	2	—	6	7	73
Tucson Elec. Pow.	67	28	31	36	30	—	35	21	—	13	13	55	6	13	—
Turlock Irrig. Dist.	—	—	—	1	—	—	12	—	—	—	—	—	—	—	—
WAPA DSW				71	122	21	9	21	14	16	143	12	12	27	33

Figure 4.5 Frequency of downward capacity test failures (percent of 15-minute intervals)

	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023	Jun 2023	Jul 2023	Aug 2023	Sep 2023	Oct 2023	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mar 2024
Arizona Publ. Serv.	—	—	0.6	—	—	—	—	—	—	—	—	0.8	0.1	0.0	0.1
Avangrid				—	—	—	—	—	—	—	0.3	—	—	—	—
Avista	—	—	—	0.0	—	—	—	—	—	—	—	—	—	—	0.1
BANC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BPA	—	0.1	—	0.2	0.1	—	—	—	—	—	—	—	—	—	—
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
El Paso Electric				0.2	0.1	0.3	0.2	0.1	0.2	—	—	—	0.2	—	0.4
Idaho Power	—	—	—	—	—	0.0	—	—	—	—	—	—	—	—	—
LADWP	0.1	—	—	—	—	0.0	—	—	—	—	—	—	—	—	—
NorthWestern En.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NV Energy	—	—	—	0.1	0.1	0.6	0.1	—	—	—	—	—	—	—	—
PacifiCorp East	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PacifiCorp West	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Portland Gen. Elec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Powerex	—	—	—	—	—	—	0.0	—	—	—	—	—	—	—	—
PSC of New Mexico	—	—	0.1	0.3	—	—	—	—	0.1	—	—	—	—	—	—
Puget Sound En.	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—
Salt River Proj.	0.4	1.5	0.2	0.3	0.6	0.4	0.7	—	0.1	0.1	—	—	—	0.1	0.1
Seattle City Light	—	0.1	—	—	—	—	—	0.3	0.1	—	0.1	0.2	0.0	—	—
Tacoma Power	—	0.2	0.1	—	—	—	0.0	—	0.0	—	—	—	—	—	—
Tucson Elec. Pow.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Turlock Irrig. Dist.	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—
WAPA DSW				0.2	—	0.8	0.1	0.4	0.5	0.2	0.2	—	—	—	—

Figure 4.6 Average shortfall of downward capacity test failures (MW)

	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023	Jun 2023	Jul 2023	Aug 2023	Sep 2023	Oct 2023	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mar 2024
Arizona Publ. Serv.	—	—	210	—	—	—	—	—	—	—	—	176	18	16	9
Avangrid				—	—	—	—	—	—	—	93	—	—	—	—
Avista	—	—	—	2	—	—	—	—	—	—	—	—	—	—	264
BANC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BPA	—	435	—	12	99	—	—	—	—	—	—	—	—	—	—
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
El Paso Electric				91	8	11	15	2	18	—	—	—	4	—	7
Idaho Power	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—
LADWP	16	—	—	—	—	19	—	—	—	—	—	—	—	—	—
NorthWestern En.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NV Energy	—	—	—	14	42	124	51	—	—	—	—	—	—	—	—
PacifiCorp East	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PacifiCorp West	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Portland Gen. Elec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Powerex	—	—	—	—	—	—	15	—	—	—	—	—	—	—	—
PSC of New Mexico	—	—	9	233	—	—	—	—	72	—	—	—	—	—	—
Puget Sound En.	—	—	—	—	26	—	—	—	—	—	—	—	—	—	—
Salt River Proj.	15	15	6	79	27	35	39	—	13	46	—	—	—	20	2
Seattle City Light	—	7	—	—	—	—	—	12	15	—	15	3	1	—	—
Tacoma Power	—	4	7	—	—	—	1	—	4	—	—	—	—	—	—
Tucson Elec. Pow.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Turlock Irrig. Dist.	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—
WAPA DSW				9	—	12	13	11	7	6	2	—	—	—	—

Figure 4.7 Frequency of downward flexibility test failures (percent of 15-minute intervals)

	2023												2024		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Arizona Publ. Serv.	0.9	0.5	2.1	0.7	1.2	0.1	—	—	—	—	—	0.3	0.1	0.1	0.2
Avangrid				0.1	—	—	—	—	0.1	—	—	—	0.1	—	—
Avista	—	—	0.1	0.1	0.1	—	—	—	—	—	0.1	—	—	0.0	—
BANC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BPA	—	0.0	0.1	0.6	5.5	0.0	0.4	—	0.0	0.2	—	—	0.4	0.1	—
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
El Paso Electric				0.2	0.9	1.9	0.5	—	0.3	—	0.2	0.3	0.3	0.2	0.4
Idaho Power	—	—	0.9	0.2	—	—	—	—	0.0	—	0.1	—	—	—	0.0
LADWP	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NorthWestern En.	—	0.0	—	—	0.2	0.2	—	0.1	0.0	—	—	—	0.2	—	0.1
NV Energy	0.1	0.1	0.1	0.0	0.1	0.4	0.1	0.1	0.0	0.1	0.1	—	—	—	0.1
PacifiCorp East	—	—	—	—	—	—	—	—	0.0	0.1	—	—	—	0.2	0.0
PacifiCorp West	—	—	—	0.0	0.2	0.0	—	—	1.1	—	0.1	—	—	—	0.2
Portland Gen. Elec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Powerex	0.1	0.1	—	0.2	—	—	0.0	—	0.2	0.1	—	0.1	—	0.1	0.4
PSC of New Mexico	0.0	—	0.4	1.6	2.1	—	0.1	0.4	1.1	0.4	0.2	0.2	0.9	0.9	0.4
Puget Sound En.	—	—	—	—	0.8	—	—	—	—	—	—	—	—	—	—
Salt River Proj.	1.4	3.3	1.0	0.3	0.1	0.1	0.1	—	—	—	0.1	0.0	0.1	0.1	0.7
Seattle City Light	0.1	0.2	0.0	0.3	0.0	0.3	0.4	1.1	0.2	—	0.8	0.2	0.2	0.1	0.1
Tacoma Power	—	0.2	0.1	—	—	—	0.0	—	0.1	—	0.0	—	—	0.0	—
Tucson Elec. Pow.	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—
Turlock Irrig. Dist.	0.1	0.1	0.1	0.1	0.4	—	—	—	—	—	0.1	—	—	0.0	—
WAPA DSW				2.7	0.5	0.7	0.1	0.2	0.6	0.8	0.2	0.1	0.3	0.1	0.0

Figure 4.8 Average shortfall of downward flexibility test failures (MW)

	2023												2024		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Arizona Publ. Serv.	46	45	49	33	64	14	—	—	—	—	—	84	72	53	116
Avangrid				13	—	—	—	—	11	—	—	—	18	—	—
Avista	—	—	16	12	29	—	—	—	—	—	27	—	—	1	—
BANC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BPA	—	72	78	102	741	27	62	—	13	192	—	—	243	104	—
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
El Paso Electric				8	15	30	36	—	21	—	7	8	7	7	10
Idaho Power	—	—	31	11	—	—	—	—	17	—	4	—	—	—	3
LADWP	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NorthWestern En.	—	17	—	—	39	16	—	15	2	—	—	—	22	—	31
NV Energy	83	104	90	22	13	96	120	10	75	59	156	—	—	—	94
PacifiCorp East	—	—	—	—	—	—	—	—	25	8	—	—	—	36	35
PacifiCorp West	—	—	—	6	44	7	—	—	51	—	6	—	—	—	30
Portland Gen. Elec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Powerex	23	30	—	48	—	—	85	—	67	421	—	160	—	84	2528
PSC of New Mexico	16	—	115	112	75	—	15	123	72	36	20	44	55	37	21
Puget Sound En.	—	—	—	—	38	—	—	—	—	—	—	—	—	—	—
Salt River Proj.	52	54	84	45	49	23	172	—	—	—	41	1	44	27	62
Seattle City Light	10	28	6	6	30	15	7	10	21	—	45	8	64	4	9
Tacoma Power	—	3	4	—	—	—	2	—	5	—	2	—	—	2	—
Tucson Elec. Pow.	—	—	—	—	—	—	—	—	—	—	—	—	—	94	—
Turlock Irrig. Dist.	6	6	14	8	4	—	—	—	—	—	39	—	—	1	—
WAPA DSW				55	8	16	12	14	11	14	8	8	66	22	16

Figure 4.9 Change in percent of intervals with an upward resource sufficiency evaluation failure (Q1 2023 to Q1 2024)

	Flexibility test			Capacity test		
WEIM entity	**Q3 2023**	**Q3 2024**	**Difference**	**Q3 2023**	**Q3 2024**	**Difference**
Arizona Publ. Serv.	1.7%	0.2%	-1.5%	0.5%	0%	-0.5%
Avangrid		0.1%			0%	
Avista	0.0%	0.1%	0.1%	0%	0.1%	0.1%
BANC	0%	0%	0%	0%	0%	0%
BPA	0.2%	0.1%	-0.1%	0%	0.1%	0.1%
California ISO	0%	0%	0%	0%	0%	0%
El Paso Electric		0.4%			0.0%	
Idaho Power	0.2%	0.4%	0.3%	0%	0.0%	0.0%
LADWP	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%
NorthWestern En.	0.2%	0.2%	0.0%	0.2%	0.0%	-0.1%
NV Energy	0.1%	0.0%	-0.1%	0%	0%	0%
PacifiCorp East	0.0%	0%	0.0%	0%	0%	0%
PacifiCorp West	0.0%	0.3%	0.3%	0.0%	0.3%	0.2%
Portland Gen. Elec.	0.1%	0.0%	0.0%	0.0%	0%	0.0%
Powerex	0.1%	0.1%	0.0%	0%	0%	0%
PSC of New Mexico	0.5%	1.6%	1.1%	0.2%	0%	-0.2%
Puget Sound En.	0.3%	0.4%	0.1%	0.1%	0.4%	0.3%
Salt River Proj.	2.1%	0.3%	-1.8%	0.8%	0.1%	-0.7%
Seattle City Light	0.0%	0.1%	0.1%	0.0%	0.2%	0.1%
Tacoma Power	0.2%	0.2%	0.0%	0.1%	0.1%	0.0%
Tucson Elec. Pow.	0.3%	0.1%	-0.2%	0.1%	0%	-0.1%
Turlock Irrig. Dist.	0%	0%	0%	0%	0%	0%
WAPA DSW		2.4%			0.0%	

Figure 4.10 Change in percent of intervals with a downward resource sufficiency evaluation failure (Q1 2023 to Q1 2024)

	Flexibility test			Capacity test		
WEIM entity	Q3 2023	Q3 2024	Difference	Q3 2023	Q3 2024	Difference
Arizona Publ. Serv.	1.2%	0.1%	-1.0%	0.2%	0.1%	-0.1%
Avangrid		0.0%			0%	
Avista	0.0%	0.0%	0.0%	0%	0.0%	0.0%
BANC	0%	0%	0%	0%	0%	0%
BPA	0.0%	0.2%	0.1%	0.0%	0%	0.0%
California ISO	0%	0%	0%	0%	0%	0%
El Paso Electric		0.3%			0.2%	
Idaho Power	0.3%	0.0%	-0.3%	0%	0%	0%
LADWP	0.0%	0%	0.0%	0.0%	0%	0.0%
NorthWestern En.	0.0%	0.1%	0.1%	0%	0%	0%
NV Energy	0.1%	0.0%	-0.1%	0%	0%	0%
PacifiCorp East	0%	0.1%	0.1%	0%	0%	0%
PacifiCorp West	0%	0.1%	0.1%	0%	0%	0%
Portland Gen. Elec.	0%	0%	0%	0%	0%	0%
Powerex	0.1%	0.2%	0.1%	0%	0%	0%
PSC of New Mexico	0.2%	0.8%	0.6%	0.0%	0%	0.0%
Puget Sound En.	0%	0%	0%	0%	0%	0%
Salt River Proj.	1.9%	0.3%	-1.6%	0.7%	0.0%	-0.7%
Seattle City Light	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
Tacoma Power	0.1%	0.0%	-0.1%	0.1%	0%	-0.1%
Tucson Elec. Pow.	0%	0.0%	0.0%	0%	0%	0%
Turlock Irrig. Dist.	0.1%	0.0%	-0.1%	0.0%	0%	0.0%
WAPA DSW		0.1%			0%	

Figure 4.11 Upward capacity/flexibility test failure intervals by concurrence (January–March 2024)

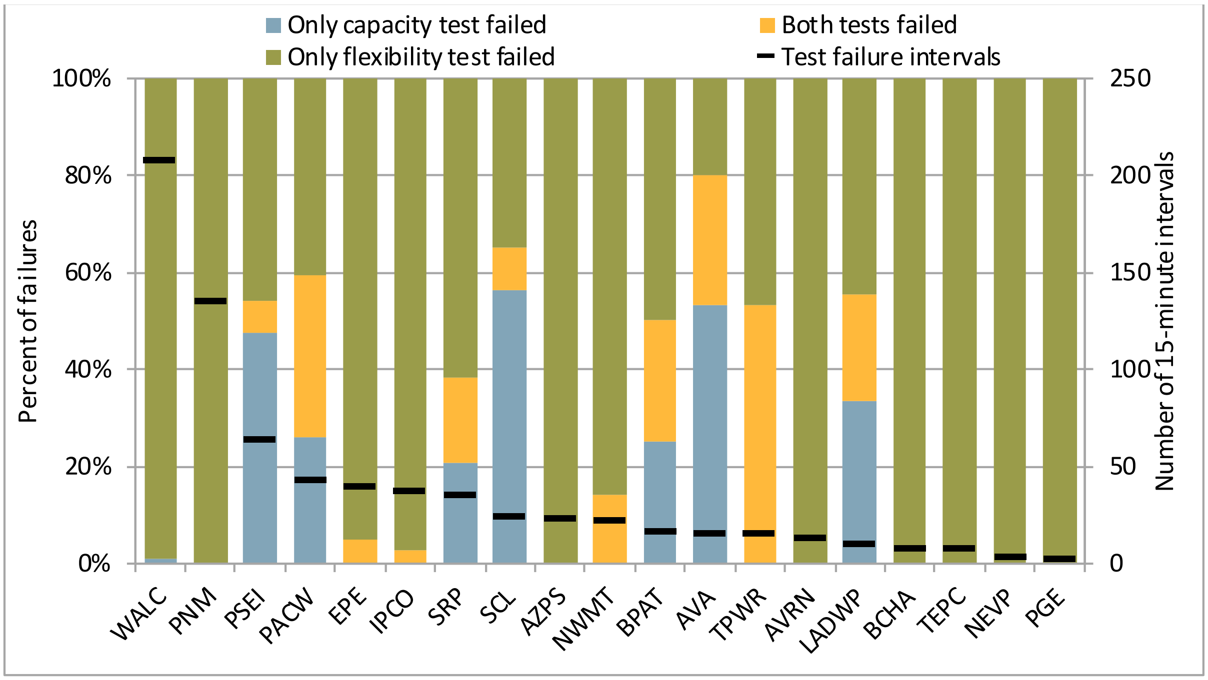
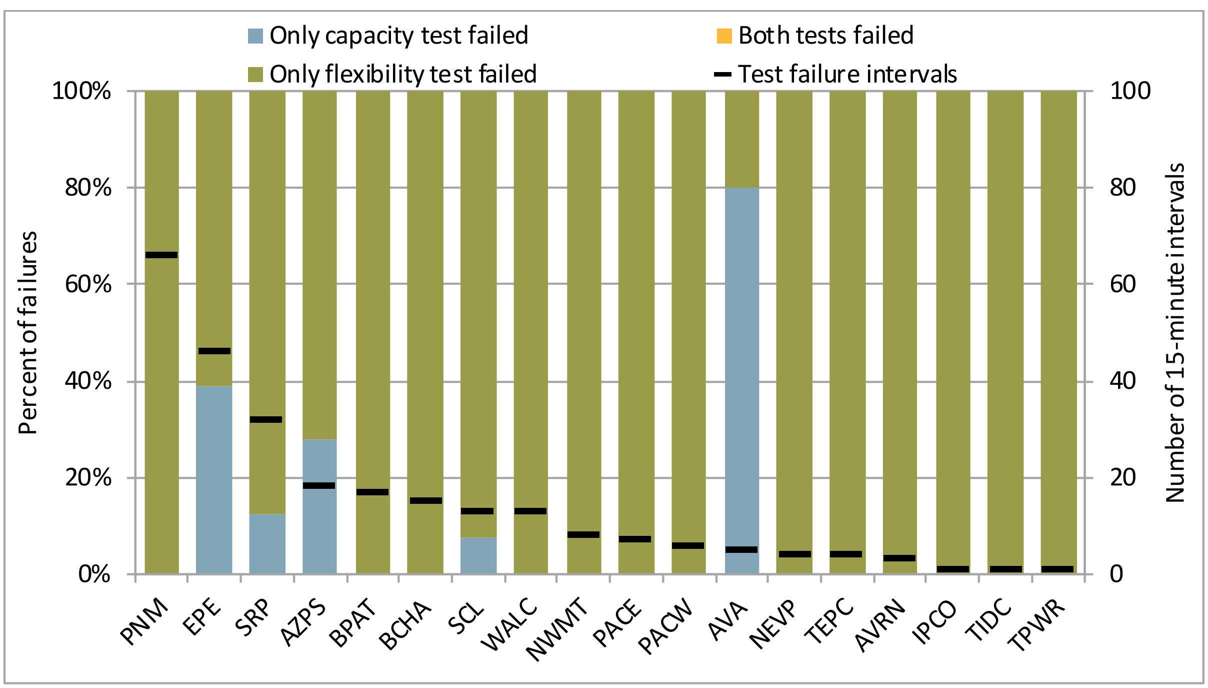


Figure 4.12 Downward capacity/flexibility test failure intervals by concurrence (January–March 2024)



Impact of earlier runs of the resource sufficiency evaluation on market results

There are three runs of the resource sufficiency evaluation, at 75 minutes (first run), 55 minutes (second run), and 40 minutes (final run) prior to each evaluation hour. The first and second runs are sometimes considered the *advisory runs*, with the results of the final evaluation at 40 minutes prior considered the *binding run*. The previous section summarized the frequency of resource sufficiency evaluation failures in the final run. However, the results in the earlier runs of the resource sufficiency evaluation can also impact binding market results in several key ways. These are discussed below.

Nodal flexible ramping capacity procurement in the first 15-minute interval of each hour

Flexible ramping product nodal procurement in the first 15-minute market interval of each hour is dependent on the second run of the resource sufficiency evaluation at 55 minutes prior to the evaluation hour.

The results of the resource sufficiency evaluation are used as an input for the flexible ramping product. As part of the enhancements implemented on February 1, the real-time market will enforce an area-specific uncertainty target for balancing areas that fail the resource sufficiency evaluation. This target can only be met by flexible capacity within that area. In contrast, flexible capacity for the group of balancing areas that pass the resource sufficiency evaluation are pooled together to meet the uncertainty target for the rest of the system.

Deliverable flexible capacity awards are produced through two deployment scenarios that adjust the expected net load forecast in the *following* interval by the lower and upper ends of uncertainty that might materialize. This ensures that upward and downward flexible capacity awards do not violate transmission or transfer constraints. A consequence of this is that binding flex ramp awards in the first 15-minute market interval of each hour are now dependent on the second run of the resource sufficiency evaluation at 55 minutes prior to the evaluation hour — based on the latest information available at the time of this market run.

Figure 4.13 and Figure 4.14 summarize the first interval of each evaluation hour during the quarter with a failure in the second (T-55) or final (T-40) resource sufficiency evaluation.[10] This reflects failure of *either* the flexibility or capacity test in the second or final run. The red and yellow bars show instances with a failure in the second evaluation (T-55), and whether the balancing area ultimately failed or passed in that interval based on the final evaluation results at 40 minutes prior to the hour. The dashed blue region instead shows cases in the first interval of the hour when the balancing area passed the second evaluation (T-55) but failed the final evaluation (T-40). In these intervals, the balancing area would have been included in the pass-group for the purpose of procuring flexible ramping capacity. The pass-group uncertainty requirement includes any diversity benefit of reduced uncertainty over a larger footprint.

---

[10] Areas that did not fail in the first interval of a resource sufficiency evaluation at T-55 or T-40 during this period were omitted from these figures.

Figure 4.13 Upward resource sufficiency evaluation failures in first 15-minute interval of hour (January–March 2024)

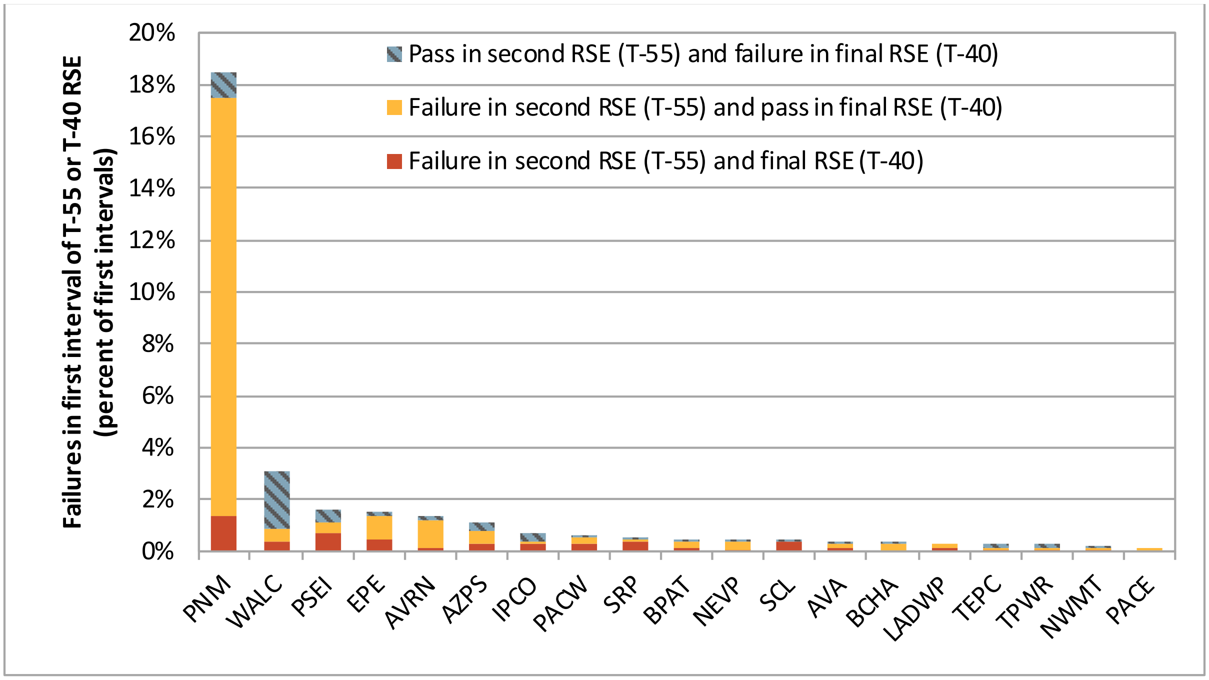
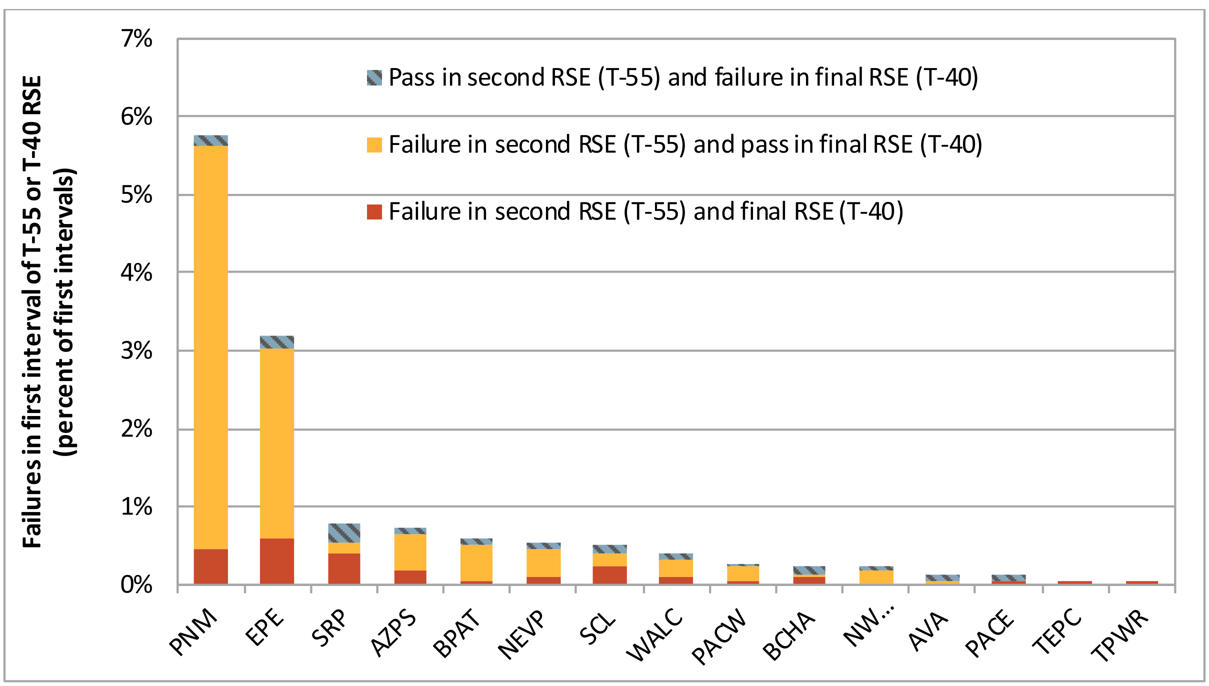


Figure 4.14 Downward resource sufficiency evaluation failures in first 15-minute interval of hour (January–March 2024)



Calculating uncertainty for balancing areas passing the resource sufficiency evaluation

Uncertainty estimates created for the group of balancing areas that pass the resource sufficiency evaluation in the *first and second* interval of each hour are based on earlier test results.

As part of the enhancements implemented on February 1, uncertainty is now calculated based on regression results that use historical data to predict uncertainty relative to load, solar, and wind forecasts.[11] Once all of the regressions are complete, the regression outputs can be combined with current forecast information to calculate uncertainty for each interval.

For a single balancing area that failed the resource sufficiency evaluation, these regressions can be performed in advance and local uncertainty targets can be readily determined based on current forecast information. However, for instead the group of balancing areas that pass the resource sufficiency evaluation (known as the pass-group), the regression procedure needs to first determine which balancing areas make up this group so that it can perform the regression using historical data accordingly for that group.

To perform the regressions to estimate the pass-group uncertainty, the composition of balancing areas in this group is based on earlier test results for the first and second 15-minute market interval of each hour. In the first interval, the results from the earliest resource sufficiency evaluation (T-75) is used to define the pass-group. In the second interval, the results from the second resource sufficiency evaluation (T-55) is used to define the pass-group. This is based on the latest information available at the time of this process.

However, the current weather information that is ultimately combined with the regression results to calculate uncertainty are instead consistent with the group of balancing areas in the pass-group for flexible ramping capacity procurement. This is based on the second run of the resource sufficiency evaluation (T-55) for interval 1, and the final resource sufficiency evaluation (T-40) for intervals 2 through 4. Table 4.1 summarizes this inconsistency by showing which resource sufficiency evaluation run is used for each interval and process.

Table 4.1 Source of pass-group for calculating uncertainty and procuring flexible ramping capacity

15-minute market interval	Current weather information for calculating uncertainty and flex ramp procurement	Regression inputs and outputs
1	Second run (T-55)	First run (T-75)
2	Final run (T-40)	Second run (T-55)
3	Final run (T-40)	Final run (T-40)
4	Final run (T-40)	Final run (T-40)

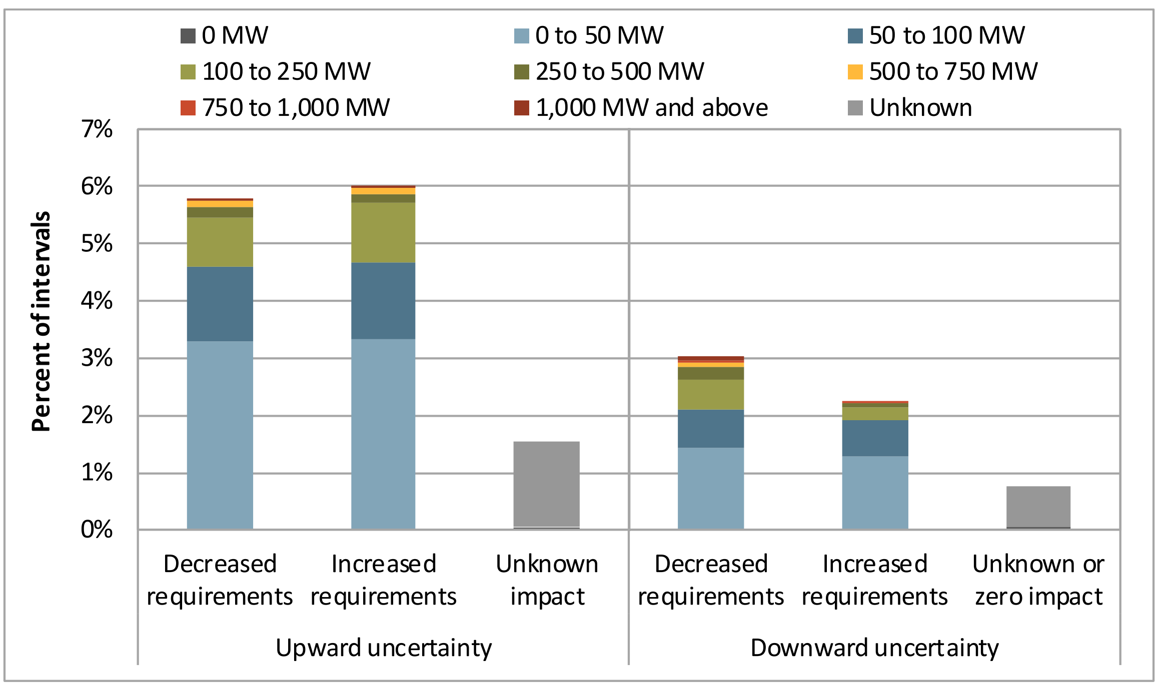
Using an inconsistent composition of balancing areas in the pass-group between the forecast and regression information can create significant swings in the calculated uncertainty for this group. For example, if you have a model to predict uncertainty based on forecast information of all but one balancing area passing the test (based on earlier test results), but then combine this with current forecast information of all balancing areas (based on later test results), then the calculated uncertainty can be disconnected from forecasted conditions in the system. DMM has requested that the ISO consider options to resolve inconsistencies in the composition of balancing areas in the pass-group.

[11] The calculation of uncertainty is described in more depth in the following section.

During about 18 percent of intervals during the quarter, the composition of balancing areas in the pass-group between the current forecast information and regression information were inconsistent for either upward or downward uncertainty. Figure 4.15 summarizes the impact of this inconsistency on pass-group uncertainty requirements in cases when the composition of balancing areas differed between the two sets of data. Figure 4.15 shows the percent of intervals in which the market uncertainty requirements (with inconsistent balancing areas in the pass-group) were higher or lower than counterfactual uncertainty requirements with a consistent composition of balancing areas in the pass-group.[12] These results are shown separately for the following categories to highlight the impact of this inconsistency on uncertainty requirements.

- **Decreased requirements** indicate that market uncertainty requirements for the pass-group were lower as a result of inconsistent balancing areas in the pass-group.
- **Increased requirements** indicate that market uncertainty requirements for the pass-group were higher as a result of inconsistent balancing areas in the pass-group.
- **No impact** indicates that uncertainty requirements were capped by thresholds in a way that resulted in the same uncertainty requirements.
- **Unknown impact** indicates that there was an inconsistent composition of balancing areas in the pass-group but data was not available to calculate the impact.

Figure 4.15 Impact of pass-group inconsistency on uncertainty requirements (January–March 2024)



[12] This analysis accounts for any thresholds that capped or would have capped calculated uncertainty requirements.

Additional impacts of earlier resource sufficiency evaluation failures on market results

Each real-time market run will use the latest resource sufficiency evaluation results available to optimize resources and energy transfers in the WEIM accordingly. This includes future advisory intervals that can be impacted by earlier runs of the resource sufficiency evaluation. In particular, the hour-ahead market includes resources and transfers in the WEIM footprint with transfer limits potentially impacted from test failures from the first run of the resource sufficiency evaluation at 75 minutes prior to the evaluation hour.

5 Net load uncertainty in the resource sufficiency evaluation

Net load uncertainty is included in the requirement of the flexible ramp sufficiency test (flexibility test) to capture additional flexibility needs that may be required in the evaluation hour due to variation in either load, solar, or wind forecasts. This calculation was adjusted on February 1 using a method called *mosaic quantile regression*. This section summarizes how uncertainty is currently calculated, the results of the uncertainty calculation, and how it compares with actual error between forecasts used in the tests and in the real-time market.

Calculating net load uncertainty in the resource sufficiency evaluation

Histogram method

Uncertainty used in the resource sufficiency evaluation was previously calculated by selecting the 2.5th and 97.5th percentile of observations from a distribution of historical net load forecast errors. This is known as the *histogram method*. The historical error observations in the distribution were the difference between binding 5-minute market net load forecasts and corresponding advisory 15-minute market net load forecasts.[13] Prior to February 1, 2023, the weekday distributions used data for the same hour from the previous 40 weekdays, while weekend distributions instead used same-hour observations from the previous 20 weekend days. The histogram approach did not factor in any current load, solar, or wind forecast information. Under this approach, uncertainty could have been set by historical outlier observations uncorrelated with current market conditions, such as an extreme historical observation in which wind forecasts were significant while wind forecasts in the evaluation hour were minimal.

Mosaic quantile regression method

The calculation for net load uncertainty was adjusted on February 1, 2023 as part of flexible ramping enhancements. The uncertainty was adjusted to incorporate current load, solar, and wind forecast information using a method called *mosaic quantile regression*.

Regression is a statistical method used to study the relationship between two or more variables, such as the relationship between the load or renewable forecasts (independent variables) and uncertainty (dependent variable). Ordinary Least Squares is widely used to estimate the *mean* relationship between these variables (i.e., the average value of the dependent variable as a function of the independent variable). In contrast, quantile regression is a variation of regression that is useful when interested in the relationship between the independent variable(s) and different *percentiles* of the dependent variable. For example, the relationship between the load or renewable forecasts and the 97.5th percentile of uncertainty.

The chosen regression method is a two-step procedure to forecast the lower and upper extremes of net load uncertainty that might materialize. The initial quantile regressions determine the relationship between the forecasts (load, solar, and wind) and the extremes of each type of uncertainty (load, solar, and wind). In a simple linear regression, the relationship between the dependent variable Y and the independent variable X takes the basic form of $Y = bX$ where the outcome of the regression, b, explains how much Y changes for every one unit increase in X (e.g., if b is two, then Y is predicted to be twice X). For calculating uncertainty as a function of the forecast, the quantile regressions are instead defined in the quadratic form ($Y = aX^2 + bX + c$). The initial regressions are shown below in

[13] In comparing the 15-minute observation to the three corresponding 5-minute observations, the minimum and maximum net load errors were used as a separate observation in the distribution.

Equation 5.1 for upward net load uncertainty.[14]

Equation 5.1 Initial quantile regressions for upward net load uncertainty

$$
\begin{aligned}
Load\ uncertainty^{max} &= a_l^{97.5}(load)^2 + b_l^{97.5}(load) + c_l^{97.5} + \varepsilon \qquad (\tau = 0.975)\\
Solar\ uncertainty^{min} &= a_s^{2.5}(solar)^2 + b_s^{2.5}(solar) + c_s^{2.5} + \varepsilon \qquad (\tau = 0.025)\\
Wind\ uncertainty^{min} &= a_w^{2.5}(wind)^2 + b_w^{2.5}(wind) + c_w^{2.5} + \varepsilon \qquad (\tau = 0.025)
\end{aligned}
$$

Dependent variable: load, solar, and wind uncertainty — minimum or maximum difference between binding 5-minute market forecasts and advisory 15-minute market forecasts in each 15-minute market interval

Independent variable: advisory 15-minute market forecasts for load, solar, and wind in each interval

Error term (ε): variation in dependent variable that is not explained by independent variable

Quantile parameter (τ): determines the level of the quantile regression being estimated (high: 97.5th percentile, low: 2.5th percentile)

The uncertainty regressions use a distribution of historical forecast observations from the previous 180 days — separate for each balancing area, hour, and day type (weekday or weekend/holiday). For the resource sufficiency evaluation, uncertainty in the distributions is the difference between binding 5-minute market forecasts and corresponding advisory 15-minute market forecasts.[15] The outcome of these regressions are the coefficients *a*, *b*, and *c*, that define the relationships between the forecasts and the extreme end of uncertainty that might materialize.[16] These coefficients can then be combined with the historical 15-minute forecast data to create a distribution of predicted values for load, solar, and wind uncertainty, which is needed for the second step of the calculation. This is shown below in Equation 5.2 for upward net load uncertainty.

Equation 5.2 Predicted values for upward net load uncertainty

$$
\begin{aligned}
\hat{L}_Q^{97.5} &= a_l^{97.5}(load)^2 + b_l^{97.5}(load) + c_l^{97.5}\\
\hat{S}_Q^{2.5} &= a_s^{2.5}(solar)^2 + b_s^{2.5}(solar) + c_s^{2.5}\\
\widehat{W}_Q^{2.5} &= a_w^{2.5}(wind)^2 + b_w^{2.5}(wind) + c_w^{2.5}
\end{aligned}
$$

Predicted values: predicted 97.5th percentile of load uncertainty and 2.5th percentile of solar and wind uncertainty based on regression coefficients and historical distribution

Regression coefficients: parameters "a", "b", and "c" that define the relationship between the forecasts and the extreme end of uncertainty that might materialize

---

14 Equations 1 to 5 are for calculating *upward* net load uncertainty. *Downward* net load uncertainty is instead based on the lower end of load uncertainty, and upper end of solar and wind uncertainty that might materialize.

15 In comparing the 15-minute observation to the three corresponding 5-minute observations, the maximum load errors and minimum wind and solar errors are used to calculate upward net load uncertainty. Or, minimum load errors, and maximum wind and solar errors for downward net load uncertainty.

16 The coefficient *c* is also known as the intercept. It shows the value of the dependent variable when all independent variables are equal to zero.

The *mosaic* element of the regression combines the predicted forecasts above with the histogram method. For the histogram estimates, the 180-day distributions are again used to calculate the lower and upper ends of uncertainty, based on the 2.5th and 97.5th percentiles in the distribution. The combination of the predicted values and the histogram extremes in the mosaic variable are intended to capture the incremental weather effect of using predicted information relative to the histogram approach. Here, the calculation modifies the histogram net load by adding the predicted values and subtracting the histogram outcomes for each uncertainty type individually.[17] This is shown below in Equation 5.3 for upward net load uncertainty:

Equation 5.3 Mosaic variable for upward net load uncertainty

$$mosaic^{97.5} = NL_H^{97.5} + \left(\left(\hat{L}_Q^{97.5} - L_H^{97.5}\right) - \left(\hat{S}_Q^{2.5} - S_H^{2.5}\right) - \left(\widehat{W}_Q^{2.5} - W_H^{2.5}\right)\right)$$

Upward mosaic variable: intermediate variable for final regression

97.5th percentile of net load uncertainty from histogram

Predicted values: predicted load, solar, and wind uncertainty from initial quantile regressions (using historical distribution)

Load, solar, and wind uncertainty from histograms

Once the mosaic variable is calculated for each interval in the distribution, the software runs a final regression to predict net load uncertainty. Again, the quantile regression method looks for the extreme values of the data (at the 2.5th and 97.5th percentiles) such that the output reflects the upper and lower boundaries of the future uncertainty. Therefore, the predicted values obtained from the quantile regression models are expected to estimate the range in which net load uncertainty is likely to materialize. The final regression is shown in Equation 5.4 below:

Equation 5.4 Mosaic regression for upward net load uncertainty

$$Net\ load\ uncertainty^{max} = a_m^{97.5}(mosaic^{97.5})^2 + b_m^{97.5}(mosaic^{97.5}) + c_m^{97.5} + \varepsilon \qquad (\tau = 0.975)$$

Dependent variable: net load uncertainty — maximum difference between binding 5-minute market forecasts and advisory 15-minute market forecasts in each 15-minute market interval

Independent variable: mosaic variable in each 15-minute market interval (from previous step)

Error term (ε): variation in dependent variable that is not explained by independent variable

Quantile parameter (τ): determines the level of the quantile regression being estimated (high: 97.5th percentile)

Once all of the regressions are complete, the regression output coefficients can be combined with current forecast information to calculate uncertainty for each interval. For the flexibility test, this forecast information is the same load, solar, and wind forecasts which are considered in the resource sufficiency evaluation for calculating ramping capacity and test requirements. The latest forecasts at the

[17] The mosaic variable can be thought of as the modified net load.

time of the second pass of the resource sufficiency evaluation at 55 minutes prior to the evaluation hour are held constant for the final test at 40 minutes prior to the hour. The final equations for combining the current forecast information with the regression coefficients and histogram extremes to calculate upward uncertainty for each interval are shown in Equation 5.5 below.

Equation 5.5 Calculation of upward uncertainty from current forecast information

$$\hat{L}^{97.5}_{current} = a^{97.5}_{l}(load_{current})^2 + b^{97.5}_{l}(load_{current}) + c^{97.5}_{l}$$
$$\hat{S}^{2.5}_{current} = a^{2.5}_{s}(solar_{current})^2 + b^{2.5}_{s}(solar_{current}) + c^{2.5}_{s}$$
$$\hat{W}^{2.5}_{current} = a^{2.5}_{w}(wind_{current})^2 + b^{2.5}_{w}(wind_{current}) + c^{2.5}_{w}$$

$$mosaic^{97.5}_{current} = NL^{97.5}_{H} + \left(\left(\hat{L}^{97.5}_{current} - L^{97.5}_{H}\right) - \left(\hat{S}^{2.5}_{current} - S^{2.5}_{H}\right) - \left(\hat{W}^{2.5}_{current} - W^{2.5}_{H}\right)\right)$$

$$Net\ load\ uncertainty^{97.5}_{current} = a^{97.5}_{m}\left(mosaic^{97.5}_{current}\right)^2 + b^{97.5}_{m}\left(mosaic^{97.5}_{current}\right) + c^{97.5}_{m}$$

The performance of the mosaic quantile regression method depends on whether there is a meaningful relationship between net load uncertainty, and the mosaic variables created from historical and predicted values. DMM has published a more detailed review of the mosaic quantile regression approach.[18] DMM finds that the regression model has limited predictive capability for forecasting net load uncertainty.

Thresholds for capping uncertainty

Uncertainty calculated from the quantile regressions are capped by the lesser of two thresholds. The thresholds are designed to help prevent extreme outlier results from impacting the final uncertainty. The *histogram* threshold is pulled for each hour from the 1st and 99th percentile of net load error observations from the previous 180 days.[19] The seasonal threshold is updated each quarter and is calculated based on the 1st and 99th percentile using observations over the previous 90 days. Here, each hour is calculated separately, and the greatest upward and downward uncertainty across all hours sets the seasonal threshold for each hour of the same direction.

Figure 5.1 shows the percent of test intervals in which the upward or downward uncertainty calculated by the quantile regression was capped by either the seasonal or histogram threshold during the quarter. Across all balancing areas, the thresholds capped the calculated upward uncertainty in around 12 percent of intervals and the calculated downward uncertainty in around 10 percent of intervals. In the large majority of cases, the *histogram* threshold capped the uncertainty.

A threshold is also in place that sets the *floor* for uncertainty at 0.1 MW in both directions. The upward and downward uncertainty is therefore set near zero when the uncertainty calculated from the quantile regression would be negative. Figure 5.2 shows the percent of test intervals in which the quantile regression uncertainty was set near zero by this threshold during the quarter.

---

[18] Department of Market Monitoring, *Review of mosaic quantile regression for estimating net load uncertainty*, November 20, 2023: http://www.caiso.com/Documents/Review-of-the-Mosaic-Quantile-Regression-Nov-20-2023.pdf

[19] The histogram threshold is updated every day. The distributions are separate for each hour and day type (weekday or weekend/holiday).

Figure 5.1 Quantile regression uncertainty capped by mosaic or histogram thresholds (January–March 2024)

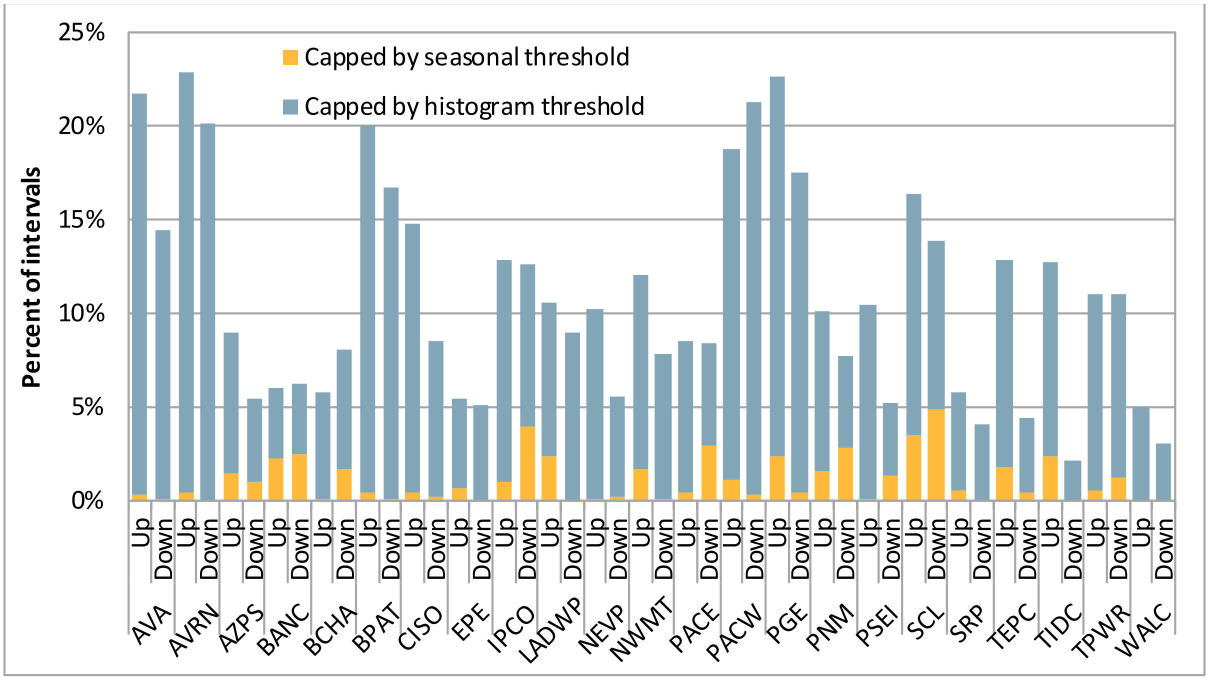
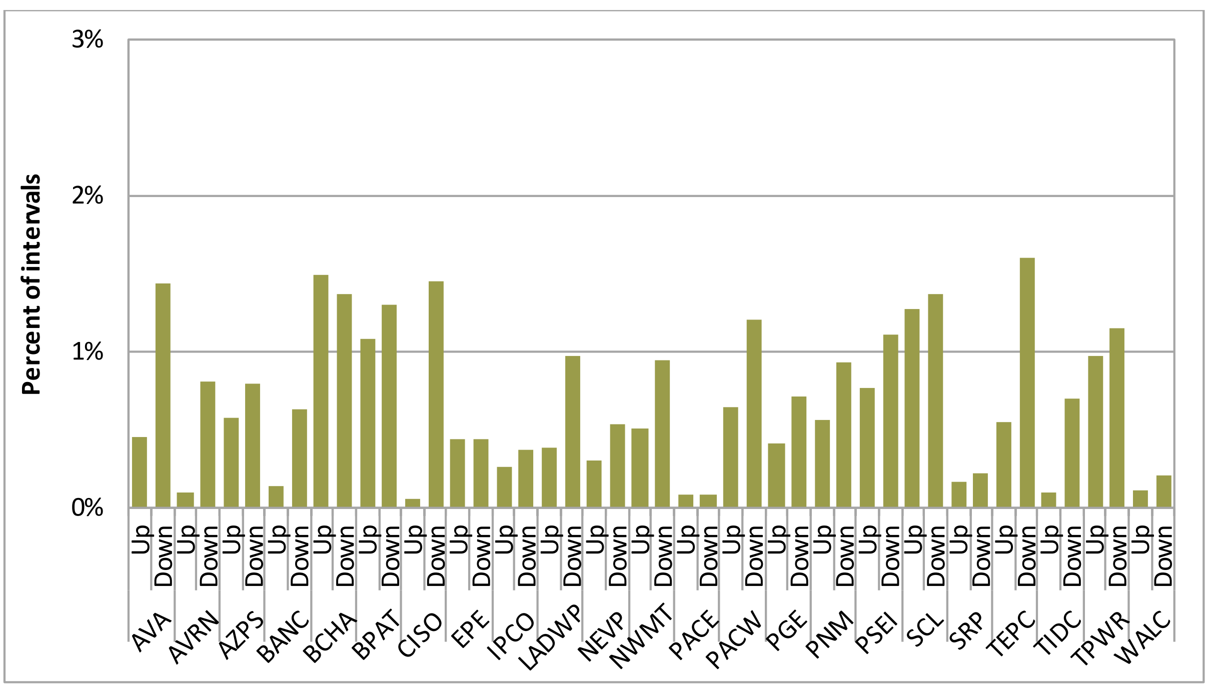


Figure 5.2 Quantile regression uncertainty set near zero by mosaic threshold (January–March 2024)



Using uncertainty from the flexible ramping product in the resource sufficiency evaluation

The calculation of uncertainty in the flexibility test continues to be measured similarly to the 15-minute market flexible ramping product — based on the difference between binding 5-minute market forecasts and corresponding advisory 15-minute market forecasts. The quantile regression uses the historical sample of 5-minute and 15-minute market observations to create hourly coefficients that define the relationship between the forecasts and uncertainty. The resource sufficiency evaluation and flexible ramping product uncertainty calculations for a single balancing area use the same hourly coefficients, but are combined with the current forecast information for each time horizon.[20]

The calculated uncertainty is based on the 2.5th and 97.5th percentile for downward and upward uncertainty, respectively. The 95 percent confidence interval for the uncertainty requirement in the flexible ramping product was designed to capture the upper end of uncertainty needs, such that it could be optimally relaxed based on the trade-off between the cost of procuring additional flexible ramping capacity and the expected cost of a power balance constraint relaxation. In the resource sufficiency evaluation, this trade-off is not considered, and the upper end of uncertainty is instead required in full to pass both tests. DMM has asked the ISO and stakeholders to consider whether the 95 percent confidence interval, or another, is most appropriate for the tests.[21]

Further, the resource sufficiency evaluation occurs in a different timeframe than the 15-minute market. Figure 5.3 illustrates the current uncertainty calculation — based on net load error between an advisory 15-minute market interval and corresponding binding 5-minute market intervals — as well as how it compares with the timeframe of the resource sufficiency evaluation. The current uncertainty calculation captures 45 to 55 minutes of potential uncertainty from the 15-minute market run to three corresponding 5-minute market runs. In contrast, when comparing the variable energy resource (VER) and load forecast values used in each interval of the resource sufficiency evaluation to corresponding 5-minute intervals, there exists a larger gap for uncertainty to materialize.[22]

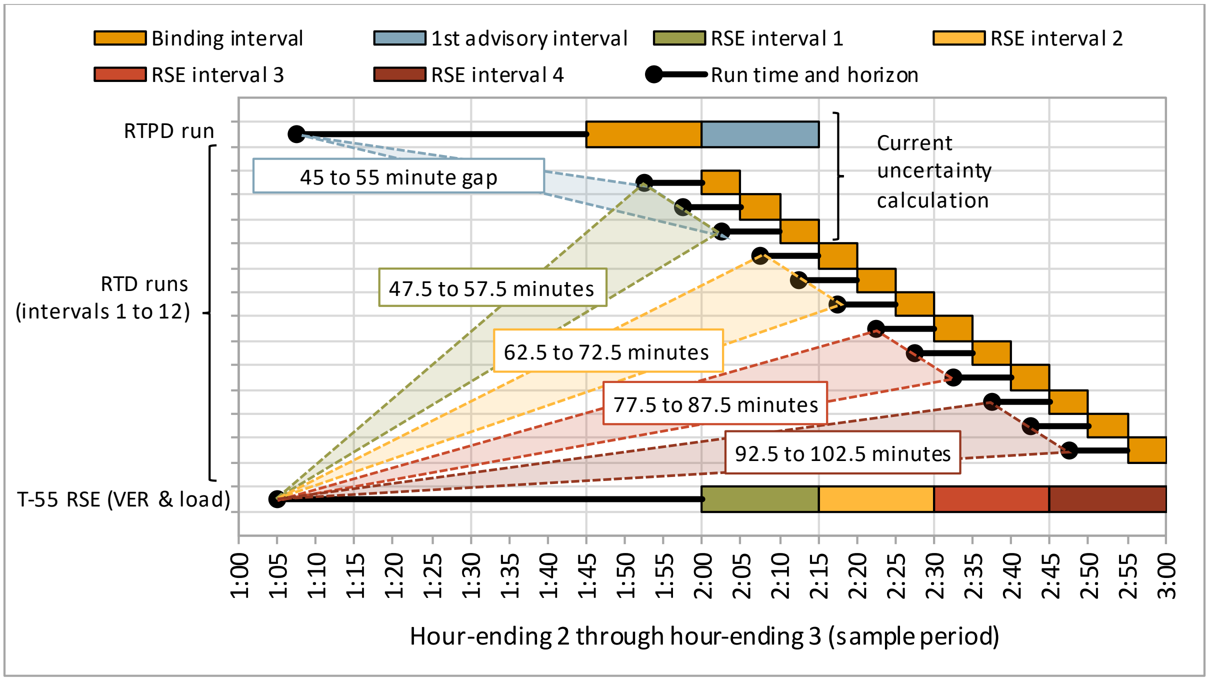
In comparing the first 15-minute test interval to corresponding 5-minute market intervals, the timeframe and potential for net load uncertainty is similar to the timeframe of the 15-minute market flexible ramping product uncertainty calculation. In the later test intervals, the gap between the predicted forecasts at the time of the resource sufficiency evaluation and the real-time forecasts widens, reaching above 100 minutes.

[20] A balancing-area-specific flexible ramping product uncertainty requirement will be enforced for any balancing area that failed the resource sufficiency evaluation.

[21] Department of Market Monitoring, *Comments on EIM Resource Sufficiency Evaluation Enhancements Issue Paper*, September 8, 2021: http://www.caiso.com/Documents/DMM-Comments-on-EIM-Resource-Sufficiency-Evaluation-Enhancements-Issue-Paper-Sep-8-2021.pdf

[22] The figure shows the resource sufficiency evaluation run time at 55 minutes prior to the hour. While the financially binding test is run at 40 minutes prior to the hour, the VER and load forecasts used in the final test are pulled from the advisory test performed at T-55.

Figure 5.3 Comparison of current uncertainty calculation to the timeframe of the RSE



Results of quantile regression uncertainty in the resource sufficiency evaluation

Figure 5.4 summarizes the histogram uncertainty (pulled from the 2.5th and 97.5th percentile of observations in the hour from the previous 180 days) and the final uncertainty from the mosaic quantile regression during the quarter for the ISO area. The green and blue lines show the *average* upward and downward uncertainty from each method, while the areas around the lines show the minimum and maximum amount over the quarter (range of uncertainty in each interval). The dashed red and yellow lines in Figure 5.4 show the average histogram and seasonal thresholds, respectively, during the quarter.

Figures covering the same information for all WEIM entities are provided further below.

Overall, the uncertainty outcomes from the mosaic quantile regression approach were often comparable to those calculated with the prior histogram approach. The mosaic quantile regression approach tends to be somewhat lower on average across most hours and balancing areas. However, results of the mosaic quantile regression approach vary more widely.

Figure 5.4 California ISO resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

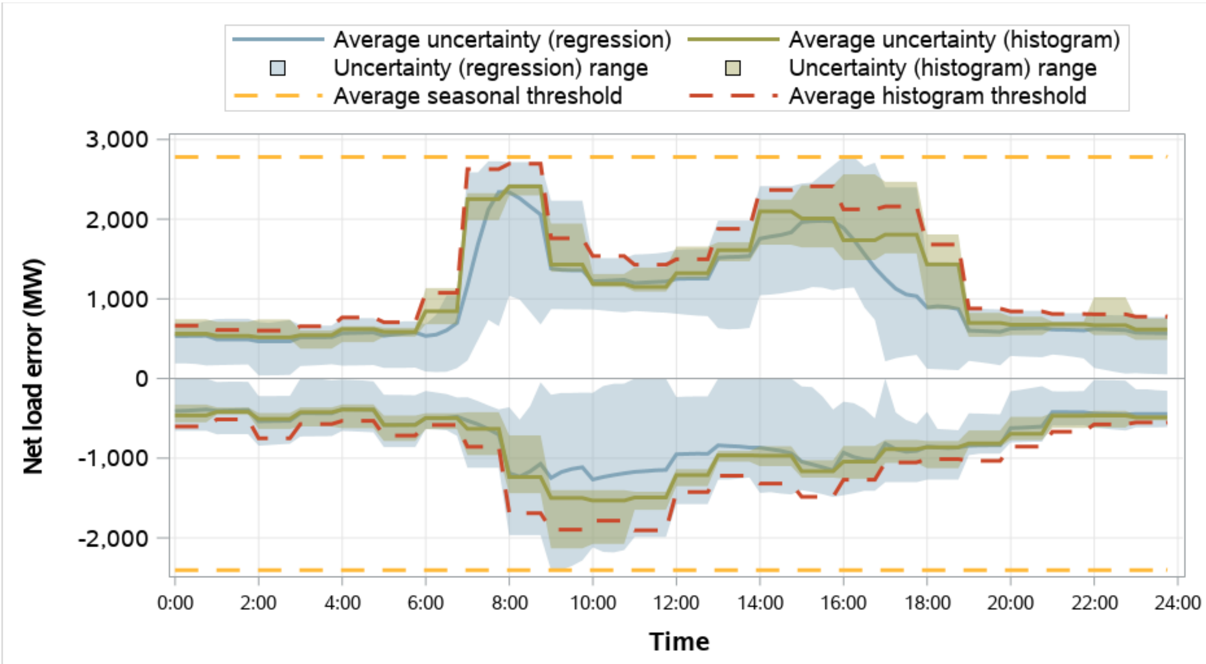


Figure 5.5 Arizona Public Service resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

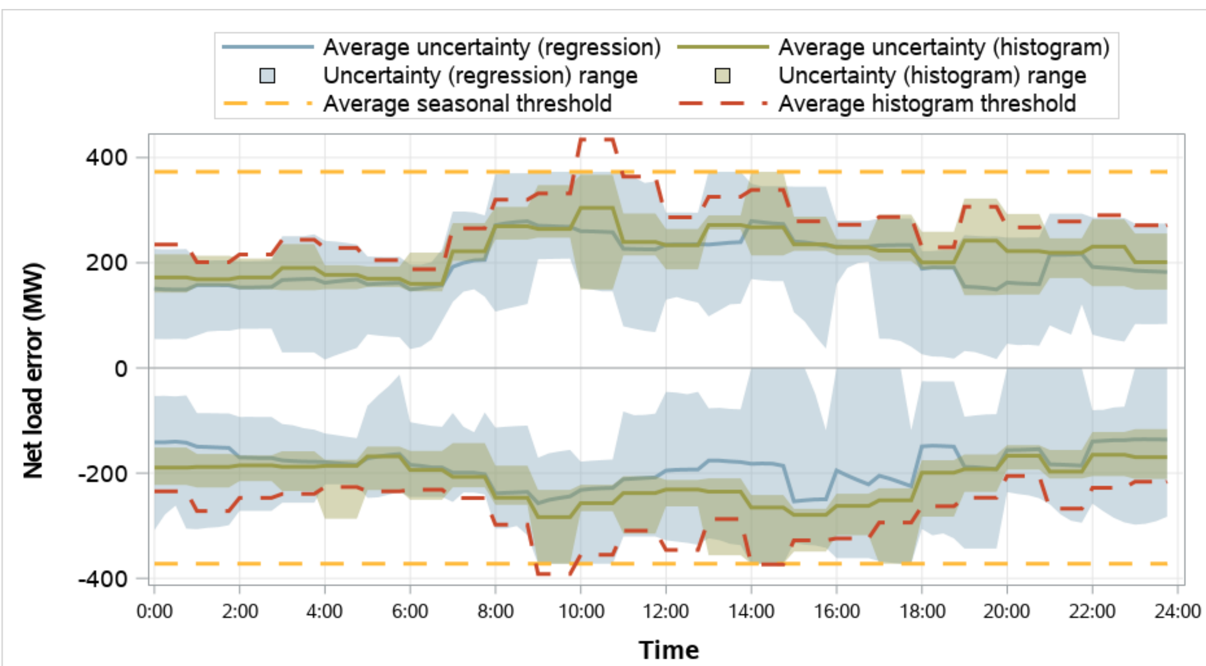


Figure 5.6 Avangrid resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

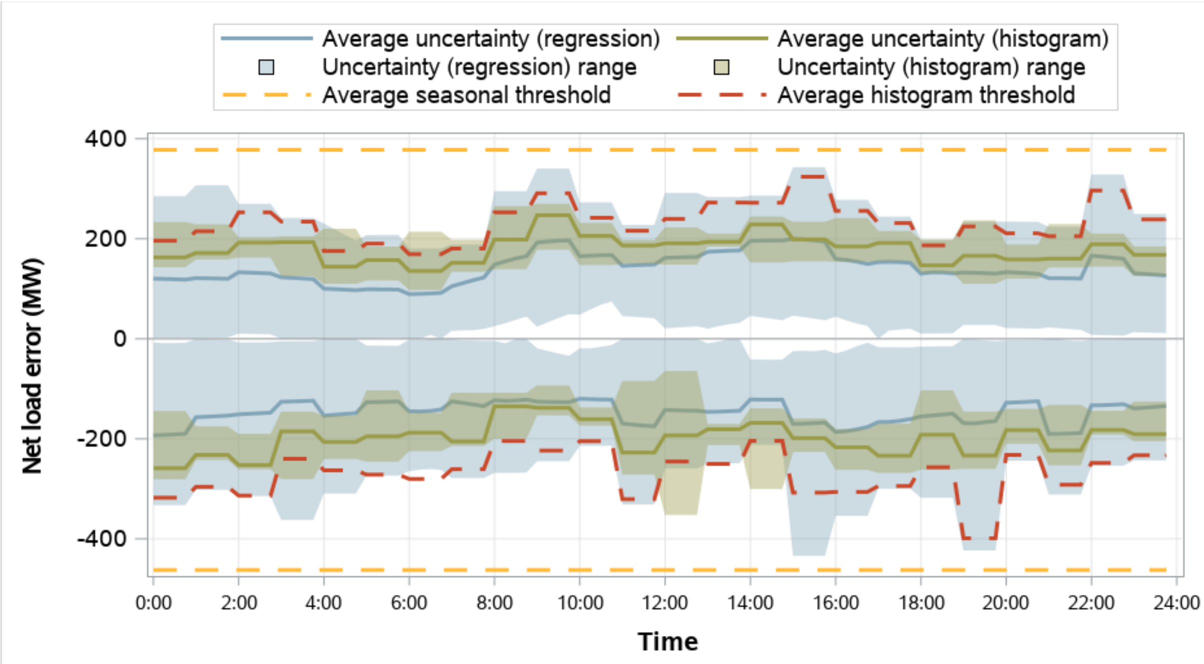


Figure 5.7 Avista resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

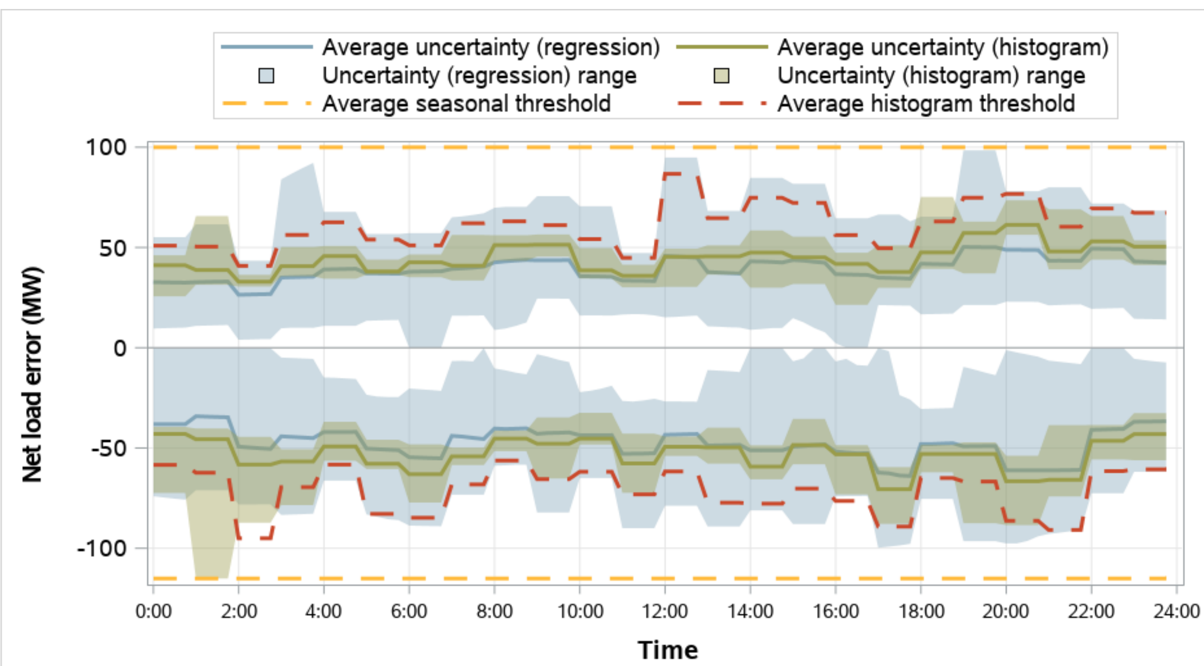


Figure 5.8 BANC resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

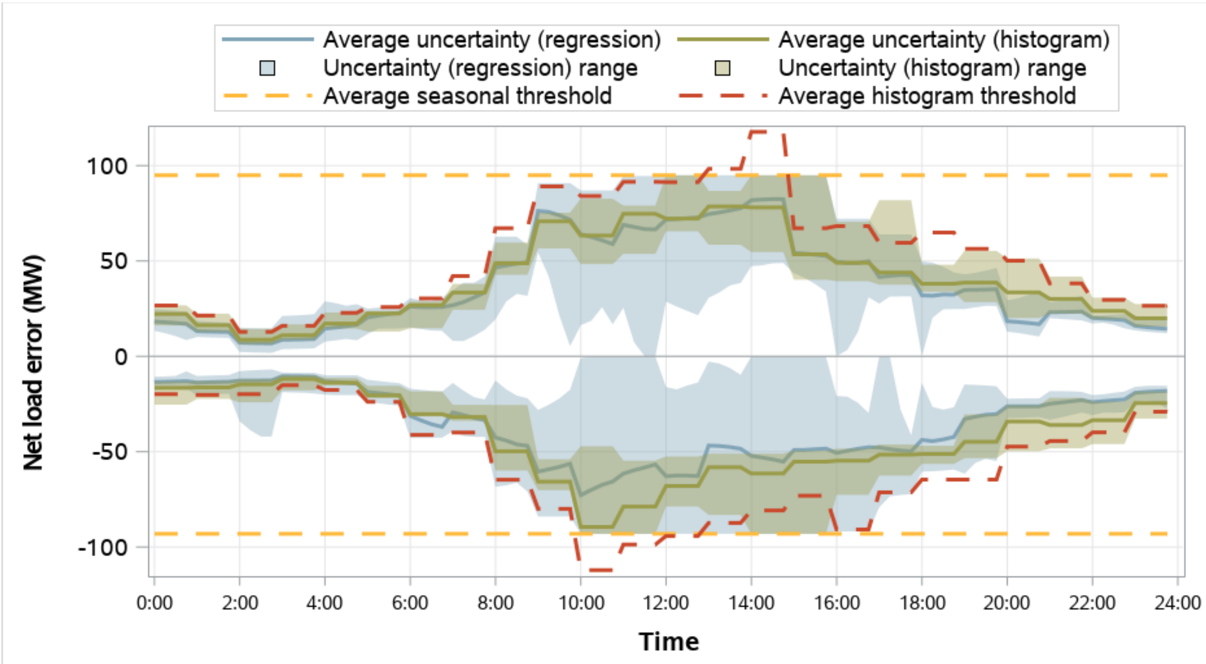


Figure 5.9 BPA resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

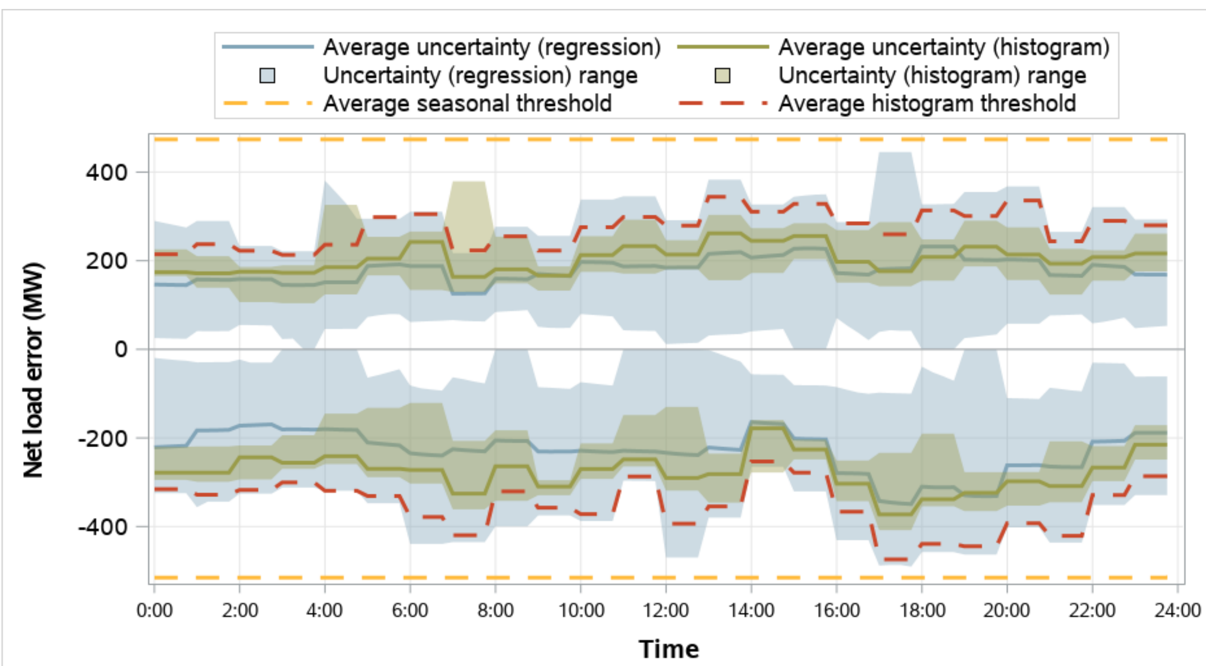


Figure 5.10 El Paso Electric resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

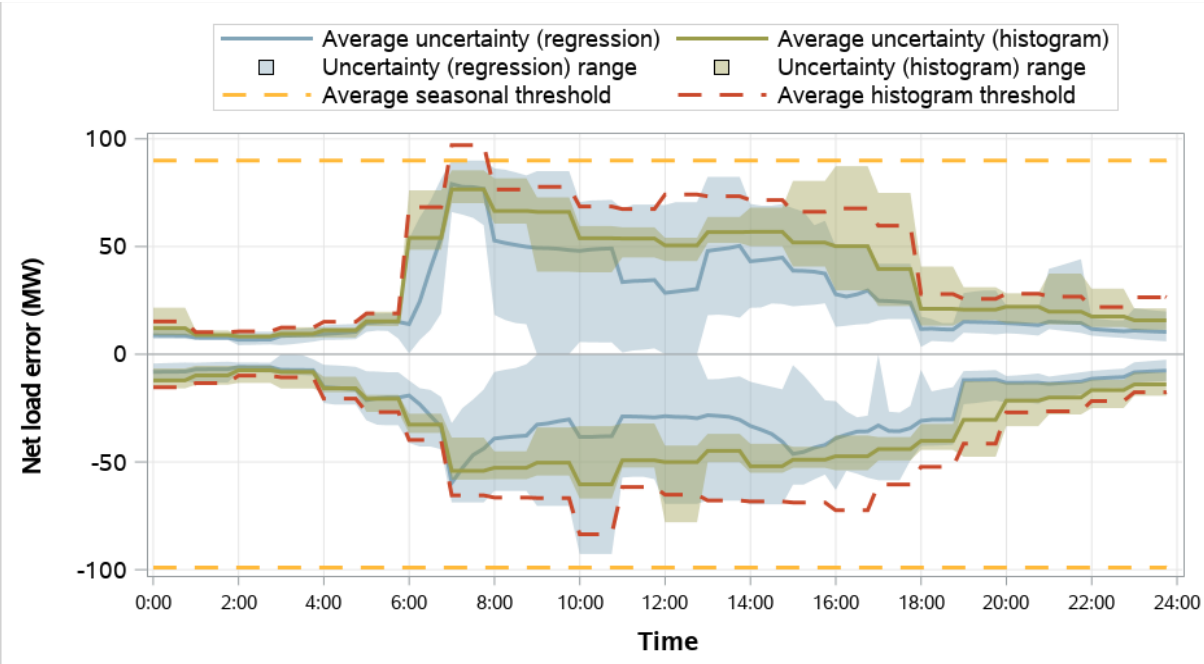


Figure 5.11 Idaho Power resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

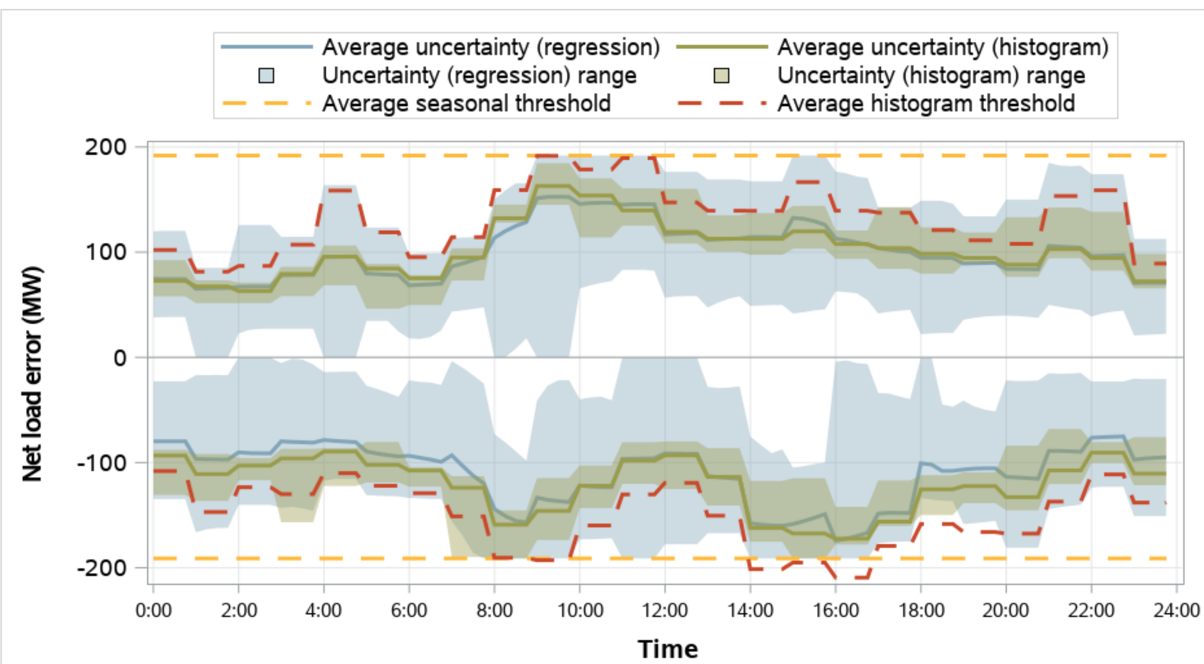


Figure 5.12 LADWP resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

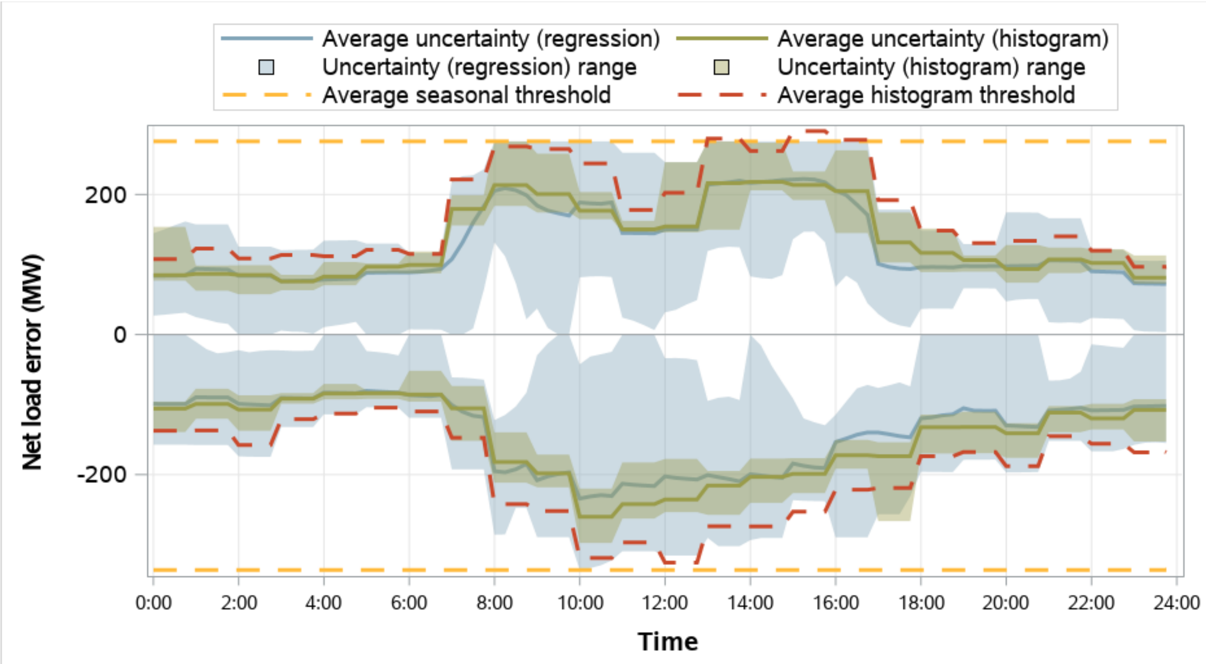


Figure 5.13 NorthWestern Energy resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

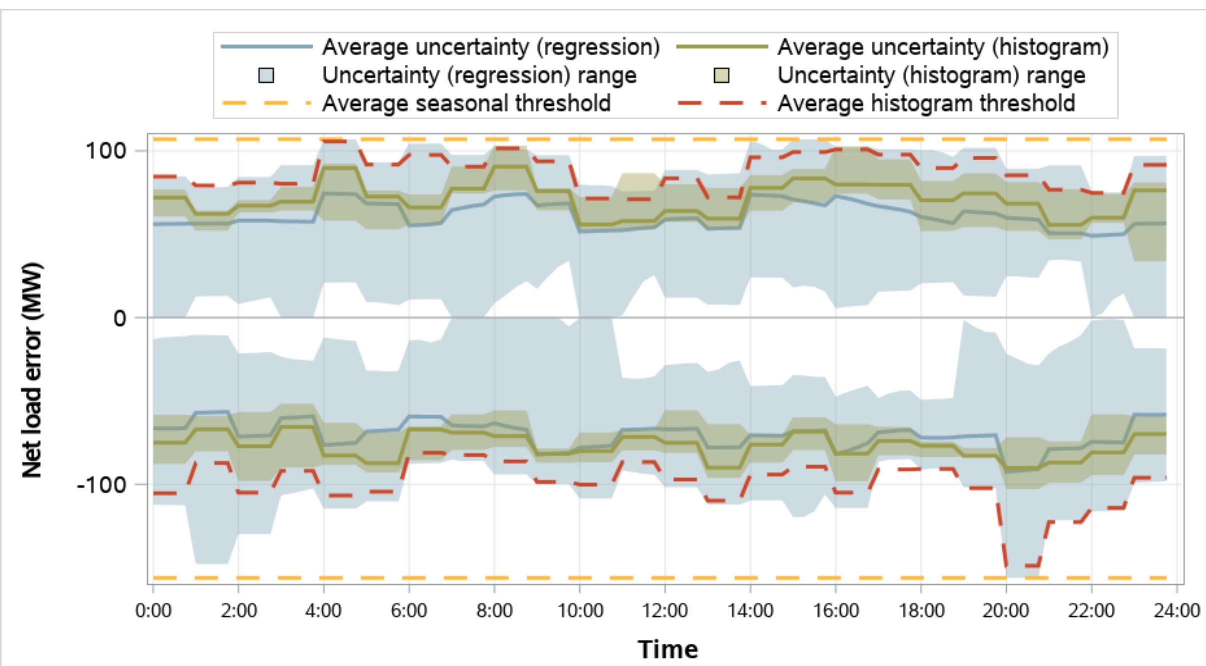


Figure 5.14 NV Energy resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

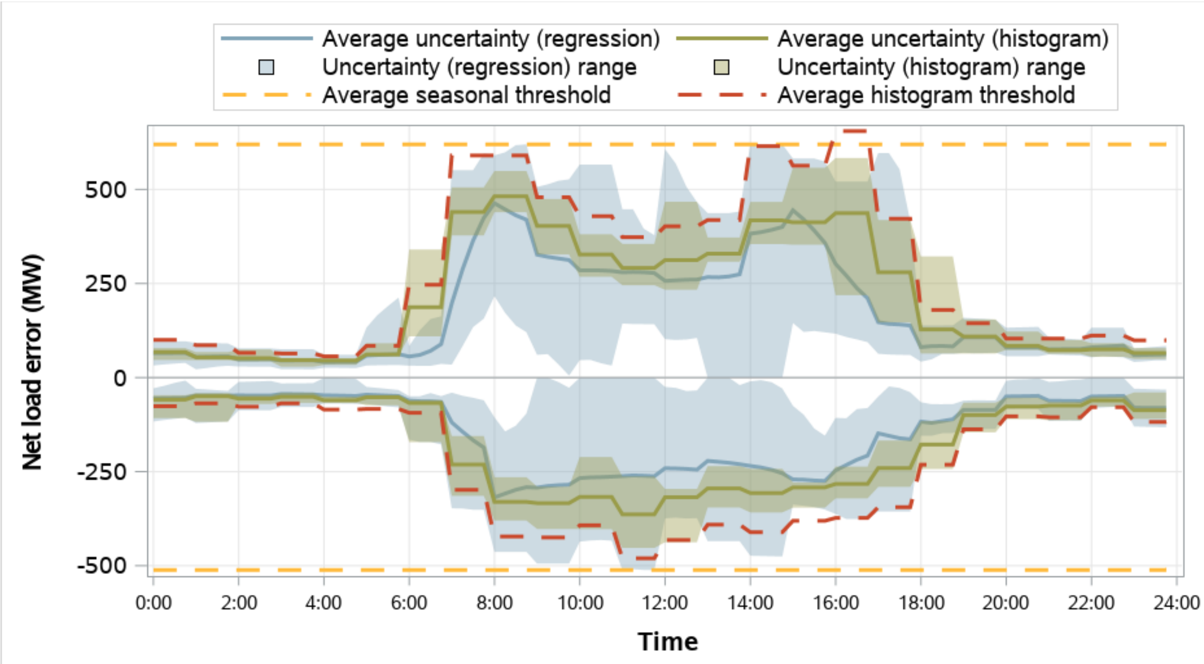


Figure 5.15 PacifiCorp East resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

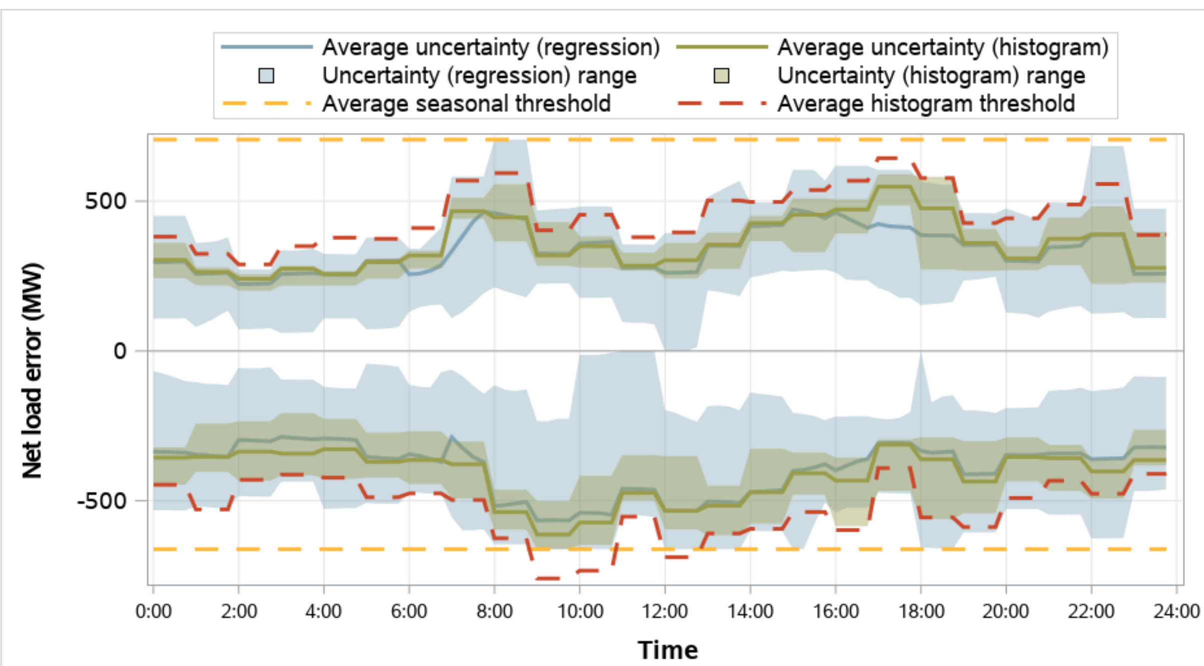


Figure 5.16 PacifiCorp West resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

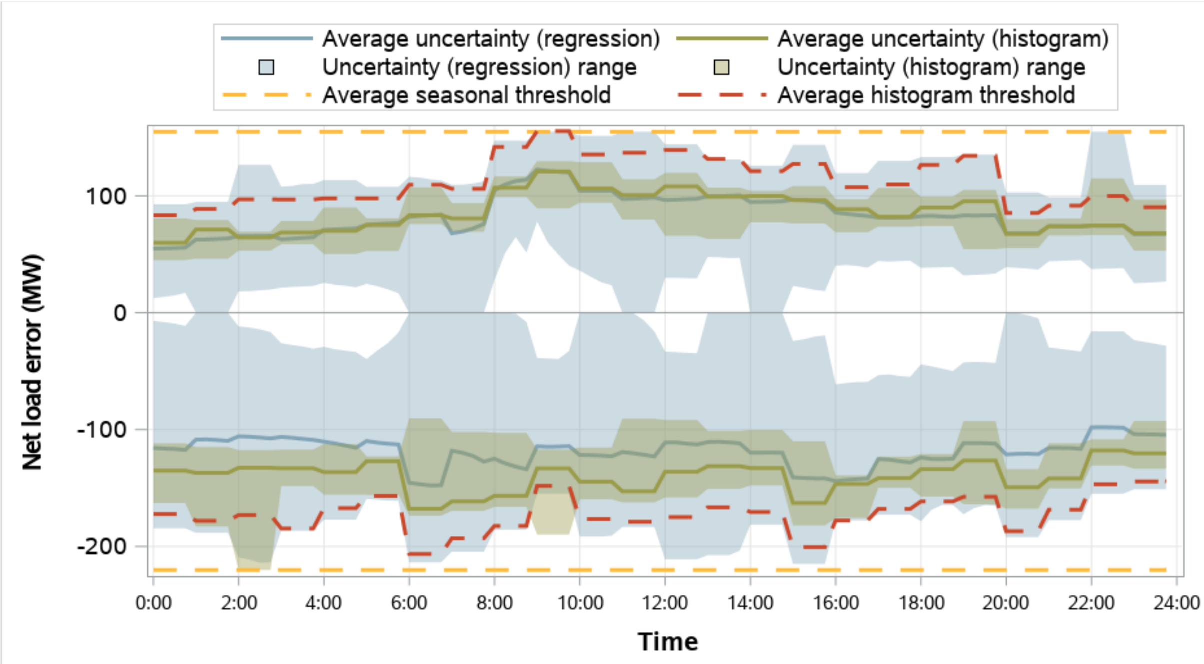


Figure 5.17 Portland General Electric resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

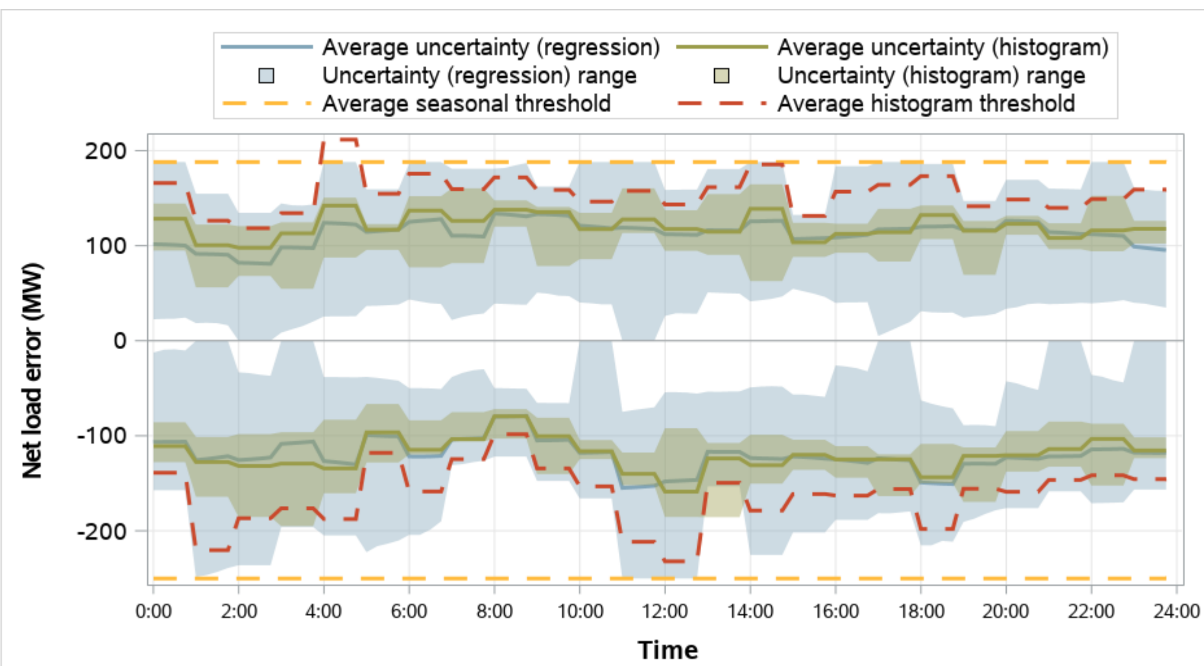


Figure 5.18 Powerex resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

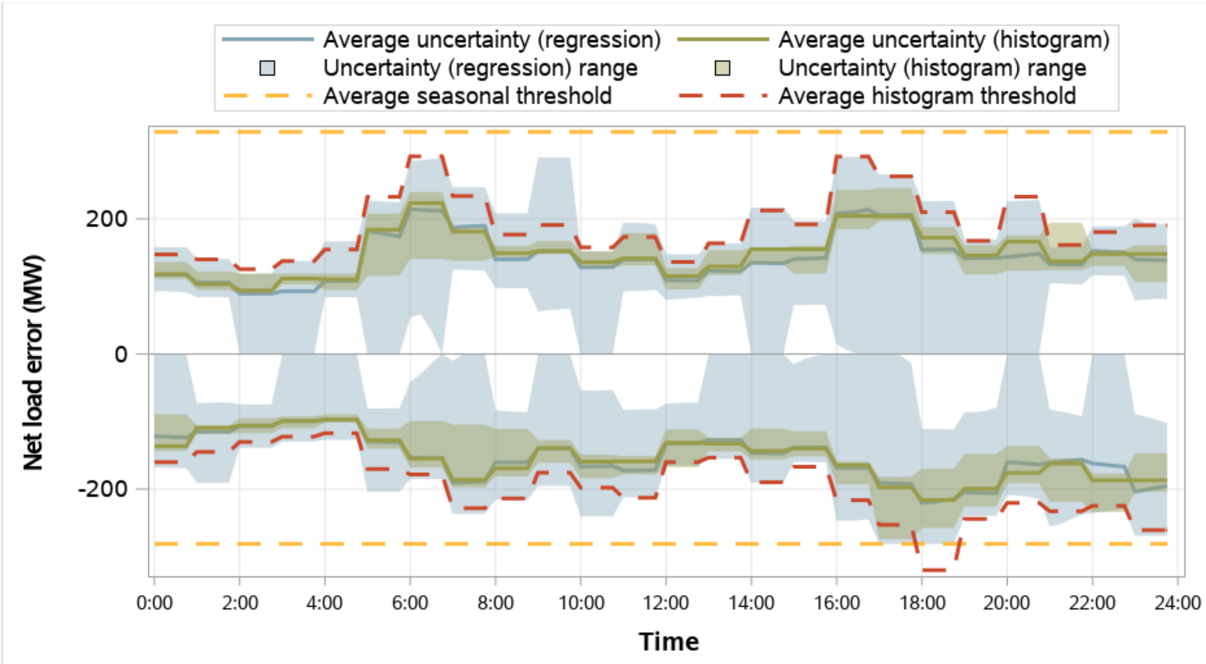


Figure 5.19 PNM resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

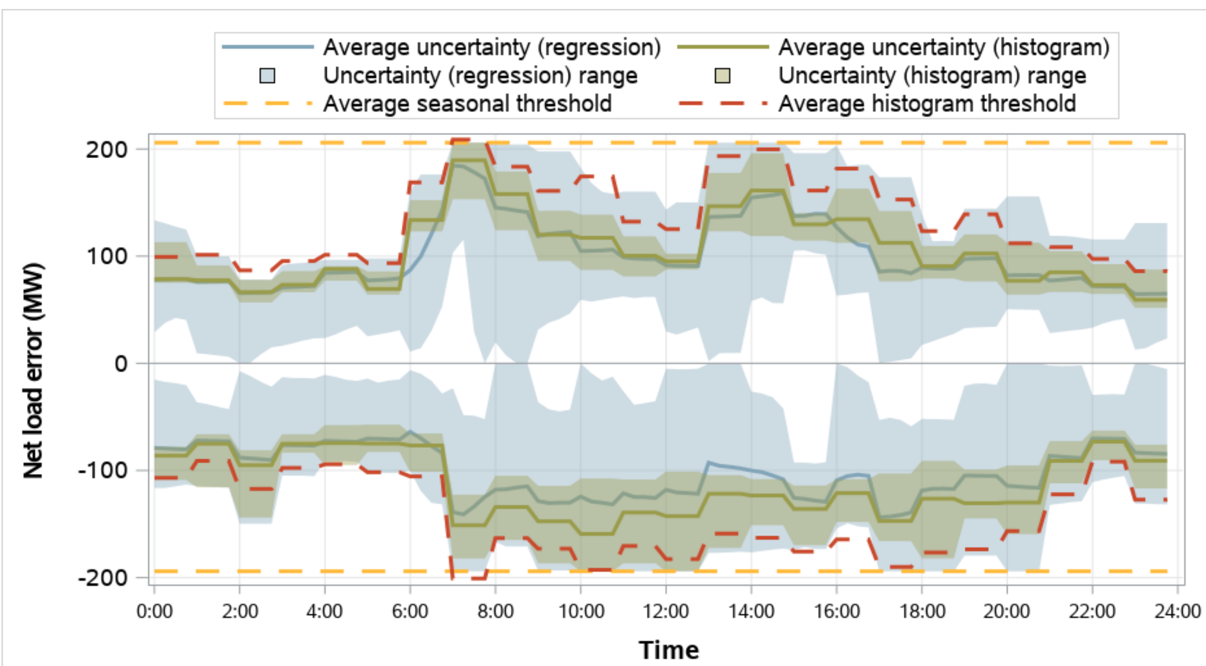


Figure 5.20 Puget Sound Energy resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

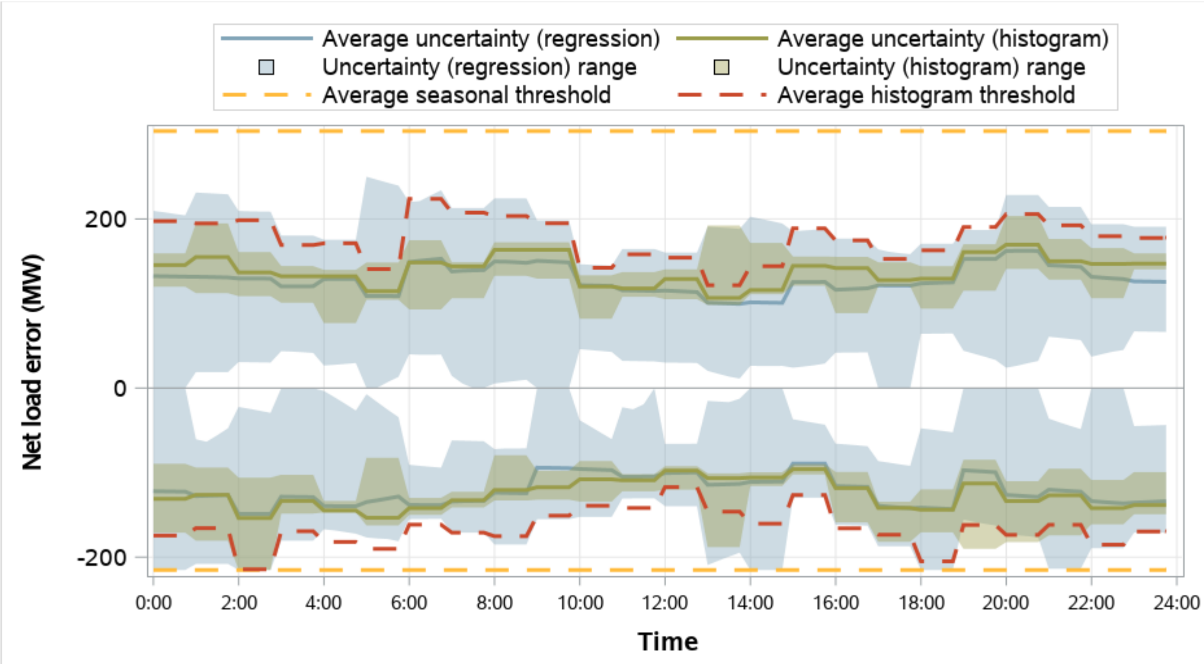


Figure 5.21 Salt River Project resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

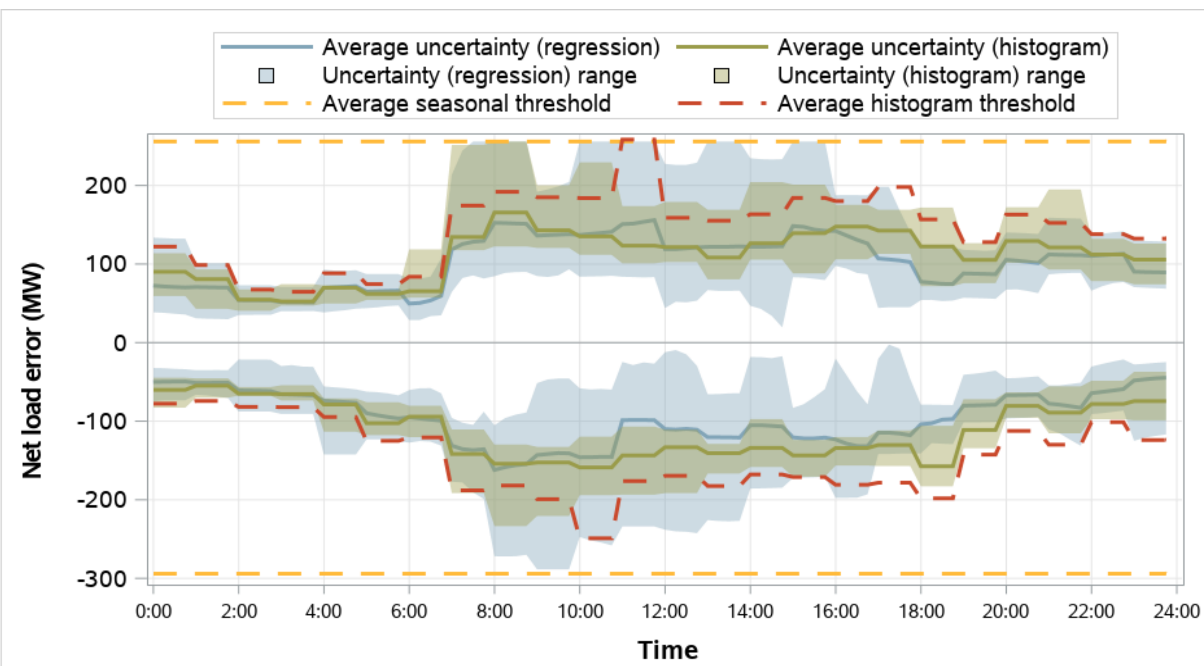


Figure 5.22 Seattle City Light resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

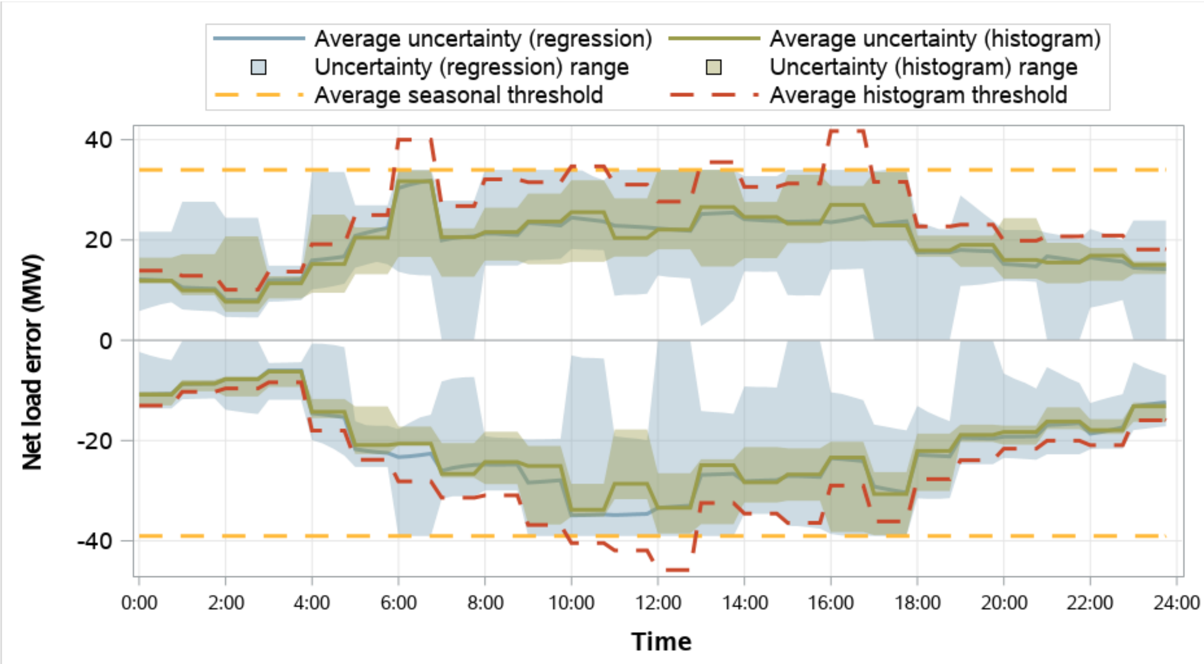


Figure 5.23 Tacoma Power resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

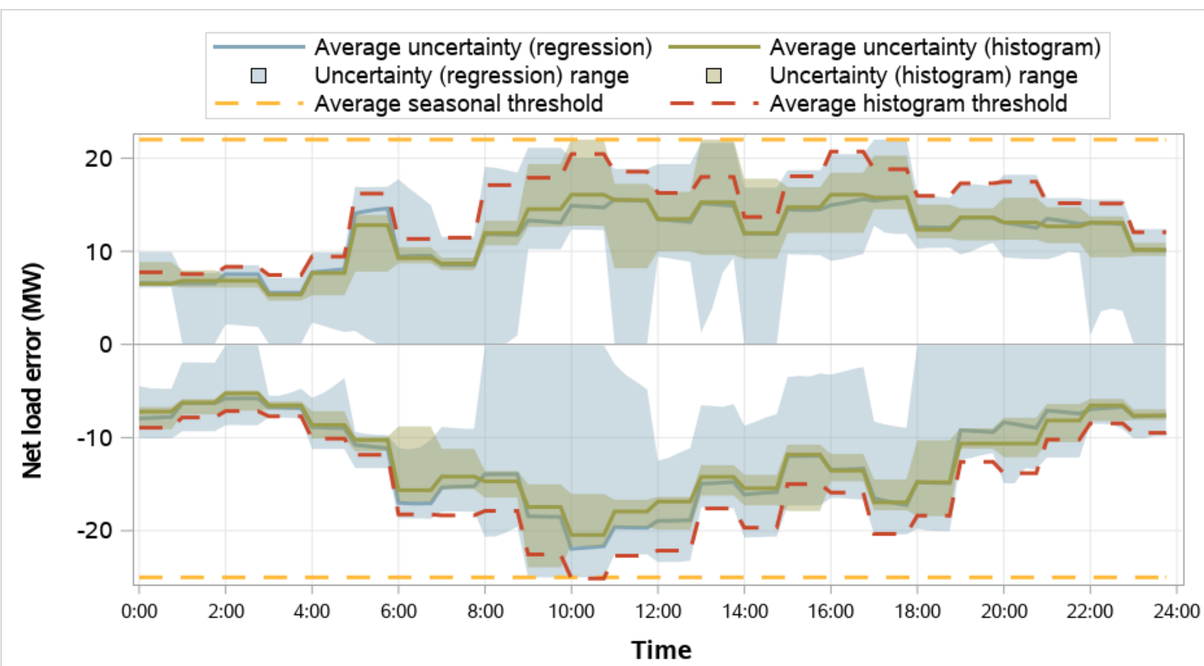


Figure 5.24 Tucson Electric Power resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

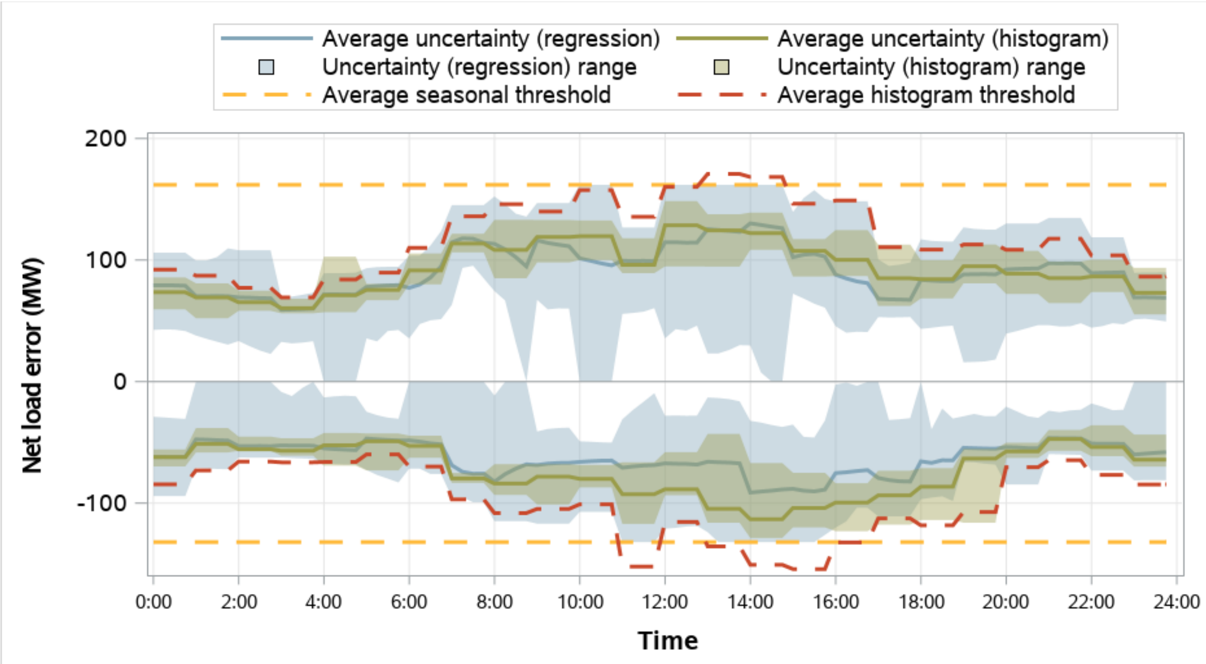


Figure 5.25 Turlock Irrigation District resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)

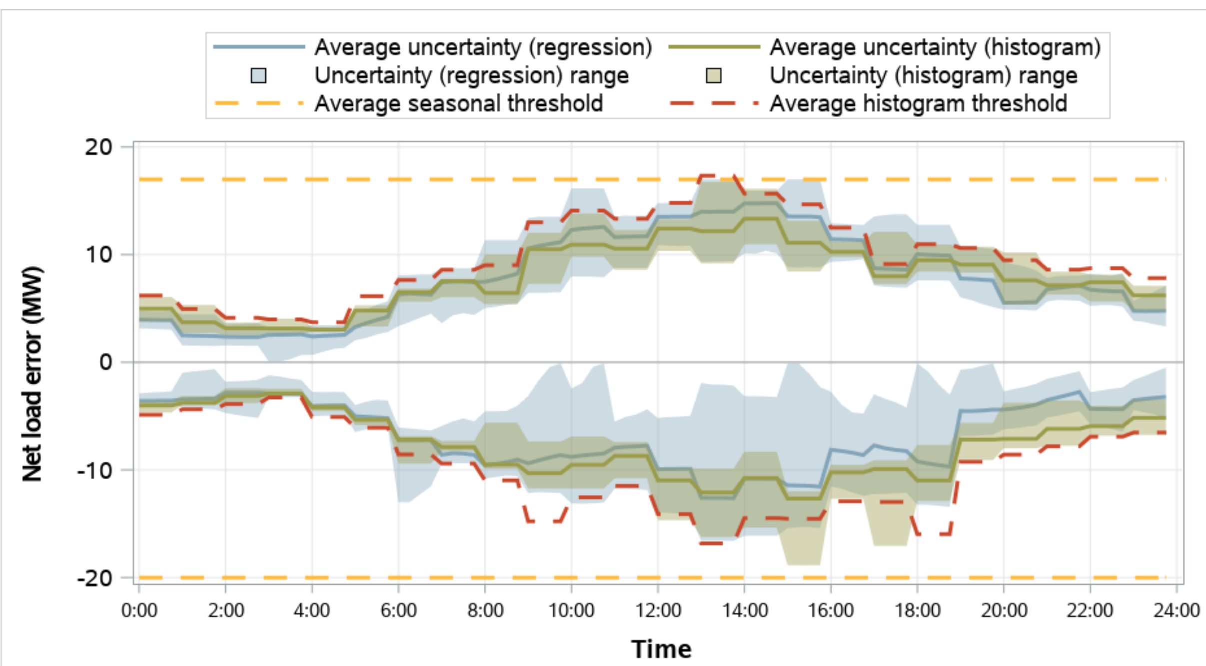
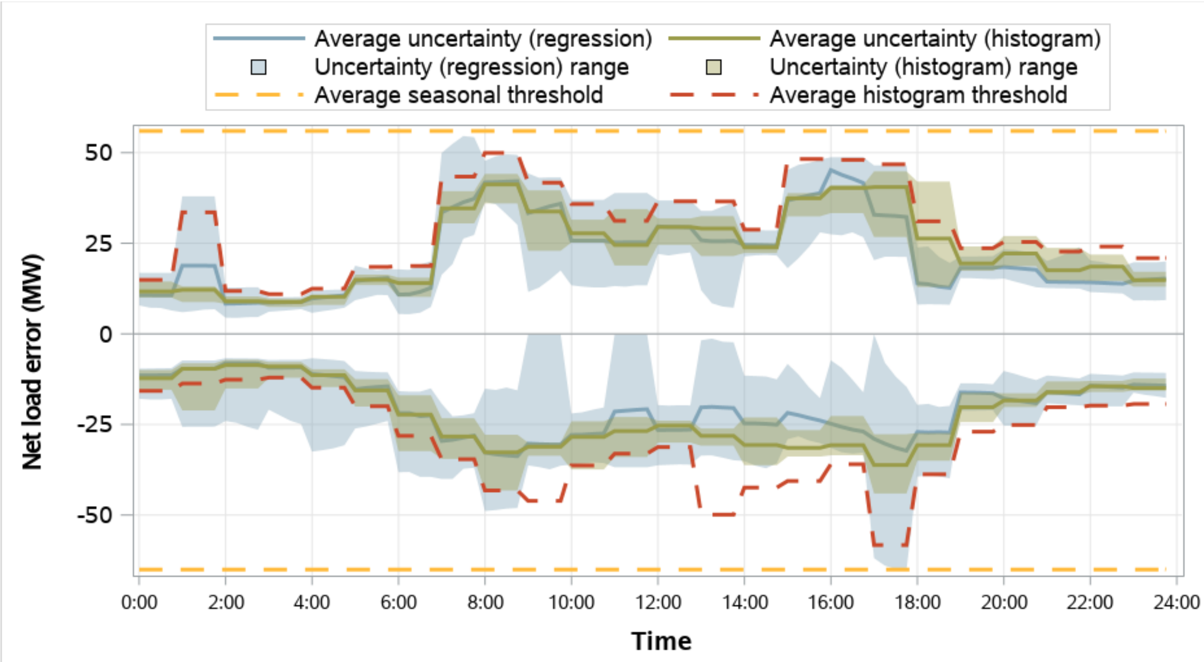


Figure 5.26 WAPA Desert Southwest resource sufficiency evaluation uncertainty requirements (weekdays, January–March 2024)



Performance measurements of quantile regression uncertainty

Table 5.1 summarizes the average requirements calculated using both the histogram and mosaic quantile regression methods. On average across all hours, the uncertainty calculated from the regression method was less than the histogram method for most of the WEIM entities. The exceptions were Seattle City Light and Tacoma Power where uncertainty from the regression method was higher than the histogram method on average for downward uncertainty.

Table 5.2 summarizes the *actual net load error* — as measured by the difference between binding 5-minute market net load forecasts and *net load forecasts in the resource sufficiency evaluation* — and how that compares to the mosaic regression uncertainty requirements for the same interval.[23] The left side of the table summarizes the closeness of the actual net load error to the uncertainty requirements when the actual net load error was within (or covered) by the upward and downward requirements.[24] The calculated uncertainty from the mosaic regression covered between 78 and 90 percent of actual net load errors across all balancing areas. The right side of the table summarizes when the actual net load error instead exceeded upward or downward uncertainty requirements.

Table 5.3 shows the same information except with requirements calculated from the histogram method. Coverage from the histogram method was more than the regression method for most balancing areas.

23 In comparing the 15-minute resource sufficiency evaluation forecasts to the three corresponding 5-minute forecasts, all three observations of error were used as a separate observation for calculating coverage, closeness, and exceedance.

24 To the extent that the actual net load error averages around zero MW, this measurement largely matches the upward and downward uncertainty requirements.

Table 5.1 Average uncertainty requirements in the resource sufficiency evaluation (January–March 2024)

	Upward uncertainty			Downward uncertainty		
Balancing area	**Histogram**	**Mosaic**	***Difference***	**Histogram**	**Mosaic**	***Difference***
Arizona Public Service	221.4	198.5	-22.9	-223.2	-192.4	30.9
Avangrid	177.6	140.9	-36.7	-190.2	-140.5	49.7
Avista	44.3	39.8	-4.4	-53.5	-48.2	5.3
BANC	41.0	37.9	-3.2	-42.0	-35.5	6.6
Bonneville Power Admin.	200.6	176.7	-23.9	-265.1	-220.2	44.9
California ISO	1,189.8	1,046.9	-142.8	-839.2	-742.1	97.1
El Paso Electric	35.8	27.2	-8.6	-32.5	-24.0	8.4
Idaho Power	101.9	100.4	-1.5	-120.0	-109.1	10.8
LADWP	137.6	129.6	-8.0	-149.4	-138.0	11.4
NorthWestern Energy	71.5	61.5	-10.0	-75.7	-67.6	8.1
NV Energy	214.9	176.2	-38.7	-178.7	-144.2	34.5
PacifiCorp East	352.0	337.0	-15.0	-405.7	-385.7	19.9
PacifiCorp West	83.7	81.1	-2.6	-137.7	-115.9	21.8
Portland General Electric	115.4	109.2	-6.2	-119.8	-119.0	0.8
Powerex	147.7	141.5	-6.3	-151.6	-148.2	3.4
PNM	106.7	99.8	-6.9	-114.8	-99.7	15.1
Puget Sound Energy	136.6	126.2	-10.3	-126.7	-120.4	6.3
Salt River Project	109.6	100.2	-9.4	-110.0	-93.3	16.7
Seattle City Light	19.8	18.7	-1.1	-21.0	-21.3	-0.3
Tacoma Power	11.9	11.5	-0.4	-12.1	-12.3	-0.2
Tucson Electric Power	92.8	89.3	-3.5	-71.6	-59.9	11.6
Turlock Irrigation District	7.9	7.8	-0.1	-7.7	-6.4	1.3
WAPA Desert Southwest	23.0	21.6	-1.4	-22.5	-21.2	1.3

Table 5.2 Actual net load error versus regression uncertainty requirements (January–March 2024)

	Actual net load error falls within calculated uncertainty requirements			Actual net load error exceeds ...			
				upward requirement		downward requirement	
Balancing area	Percent of intervals	Distance to up requirement (MW)	Distance to down requirement (MW)	Percent of intervals	Amount (MW)	Percent of intervals	Amount (MW)
Arizona Public Service	86%	188.1	205.0	10%	185.3	4%	68.9
Avangrid	88%	131.7	150.0	6%	47.4	6%	75.2
Avista	88%	43.5	46.1	6%	15.9	6%	18.9
BANC	84%	36.2	35.9	7%	23.5	9%	18.5
Bonneville Power Admin.	86%	192.1	209.6	8%	85.6	7%	86.9
California ISO	87%	885.9	915.6	7%	269.8	6%	339.6
El Paso Electric	83%	27.5	23.4	7%	12.8	11%	10.9
Idaho Power	85%	109.2	100.8	6%	41.0	9%	40.0
LADWP	85%	135.4	133.6	7%	49.4	8%	53.5
NorthWestern Energy	89%	59.8	70.6	7%	22.4	4%	28.2
NV Energy	78%	132.0	175.2	18%	172.8	4%	47.9
PacifiCorp East	90%	352.3	376.8	5%	94.2	5%	99.4
PacifiCorp West	86%	95.4	105.5	8%	40.3	6%	33.6
Portland General Electric	86%	118.9	112.6	5%	46.3	9%	43.6
Powerex	86%	145.5	150.3	7%	53.8	6%	48.7
PNM	84%	104.8	97.2	7%	41.1	9%	36.7
Puget Sound Energy	88%	123.0	127.6	6%	44.8	6%	42.5
Salt River Project	88%	102.0	92.7	6%	47.6	6%	29.0
Seattle City Light	80%	19.4	20.9	11%	14.7	9%	9.5
Tacoma Power	82%	12.0	12.1	10%	6.4	8%	4.2
Tucson Electric Power	84%	78.8	72.0	8%	33.7	9%	26.0
Turlock Irrigation District	87%	7.4	6.9	6%	3.3	7%	2.7
WAPA Desert Southwest	85%	23.0	19.8	6%	10.4	9%	9.5

Table 5.3 Actual net load error versus histogram uncertainty requirements (January–March 2024)

	Actual net load error falls within calculated uncertainty requirements			Actual net load error exceeds ...			
				upward requirement		downward requirement	
Balancing area	Percent of intervals	Distance to up requirement (MW)	Distance to down requirement (MW)	Percent of intervals	Amount (MW)	Percent of intervals	Amount (MW)
Arizona Public Service	90%	210.7	232.7	9%	170.3	2%	77.7
Avangrid	92%	170.0	199.3	4%	83.7	4%	104.2
Avista	91%	47.3	50.9	5%	22.1	4%	21.6
BANC	88%	39.9	41.5	6%	25.5	6%	19.6
Bonneville Power Admin.	88%	213.9	253.4	6%	103.7	6%	98.3
California ISO	91%	1,036.7	983.3	5%	312.1	4%	315.9
El Paso Electric	91%	37.4	30.5	4%	14.8	4%	13.3
Idaho Power	87%	110.2	111.6	5%	44.9	8%	42.2
LADWP	89%	143.6	142.2	6%	56.8	6%	54.2
NorthWestern Energy	91%	68.9	78.7	5%	25.6	4%	33.5
NV Energy	83%	165.0	216.4	14%	180.2	3%	44.6
PacifiCorp East	92%	367.3	394.9	4%	107.0	4%	108.8
PacifiCorp West	89%	96.5	125.5	7%	44.9	4%	39.8
Portland General Electric	88%	124.7	111.6	5%	48.4	8%	51.1
Powerex	89%	148.7	152.1	5%	49.4	5%	46.6
PNM	88%	110.6	111.0	5%	43.2	7%	42.4
Puget Sound Energy	90%	132.0	132.4	5%	49.3	5%	43.0
Salt River Project	91%	111.6	108.7	4%	49.7	4%	30.1
Seattle City Light	80%	20.6	20.4	11%	14.4	8%	9.1
Tacoma Power	82%	12.2	11.9	9%	5.9	8%	4.2
Tucson Electric Power	89%	82.5	81.9	6%	34.9	6%	24.7
Turlock Irrigation District	90%	7.6	8.0	5%	3.9	5%	2.8
WAPA Desert Southwest	88%	24.5	20.9	5%	10.8	7%	9.7

Variability of quantile regression uncertainty

Prior to February 2023, uncertainty used in the resource sufficiency evaluation was known in advance of the trade date based on the lower and upper percentiles of observations over the historical period for the same hour (*histogram approach*). Under this approach, the uncertainty was also the same in each interval for the evaluation hour. The *mosaic quantile regression* approach combines regression results with current load, solar, and wind forecast information to calculate uncertainty in each 15-minute interval of the evaluation hour. With this approach, the regression coefficients for individual balancing areas are known in advance, but the exact uncertainty is dependent on current forecast information. A natural consequence of this is that calculated uncertainty has greater variability and is more difficult to predict in advance.

Changes in uncertainty between resource sufficiency evaluation runs

Figure 5.27 shows the difference in the calculated upward uncertainty from the first run of the resource sufficiency evaluation at 75 minutes prior to the evaluation hour, to the second run of the resource sufficiency evaluation at 55 minutes prior to the evaluation hour. Figure 5.28 shows the same information for downward uncertainty. Load and renewable forecasts are held fixed between the second (T-55) and final (T-40) resource sufficiency evaluations such that uncertainty is also unchanged between these runs. Therefore, these figures summarize how effective the T-75 uncertainty is in predicting the final uncertainty used in the resource sufficiency evaluation. The dashed gray region shows effectively no difference from the first resource sufficiency evaluation (less than one MW change). The regions above or below this show increased or decreased uncertainty relative to the T-75 results. The uncertainty difference from the first run of the resource sufficiency evaluation was typically less than 10 MW. More significant increases in the uncertainty requirement also occurred in rare instances and may lead to unexpected resource sufficiency evaluation failures.

Figure 5.27 Megawatt change in upward quantile regression uncertainty between T-75 and T-55 resource sufficiency evaluation runs (January–March 2024)

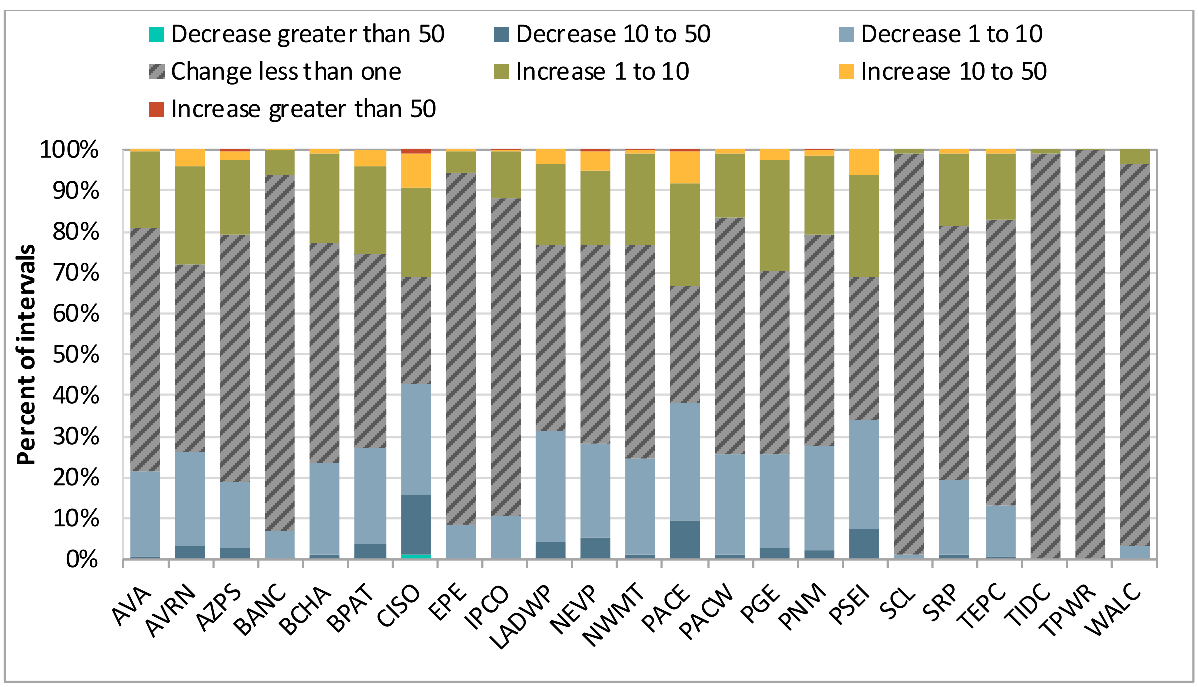
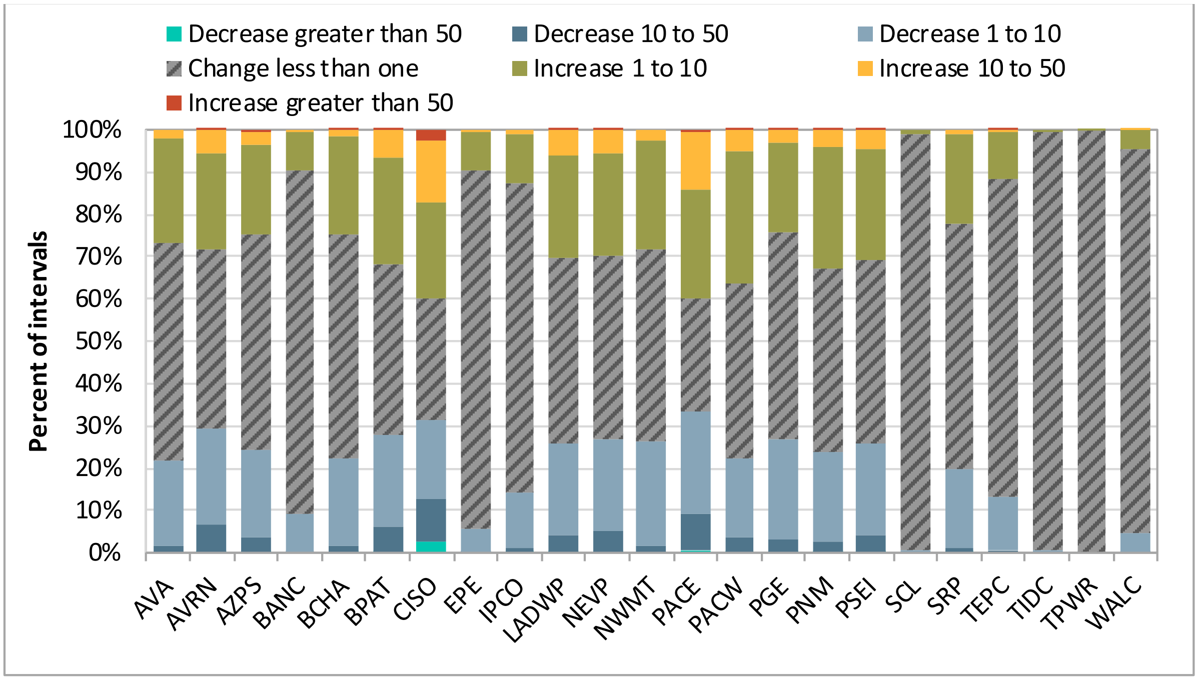


Figure 5.28 Megawatt change in downward quantile regression uncertainty between T-75 and T-55 resource sufficiency evaluation runs (January–March 2024)

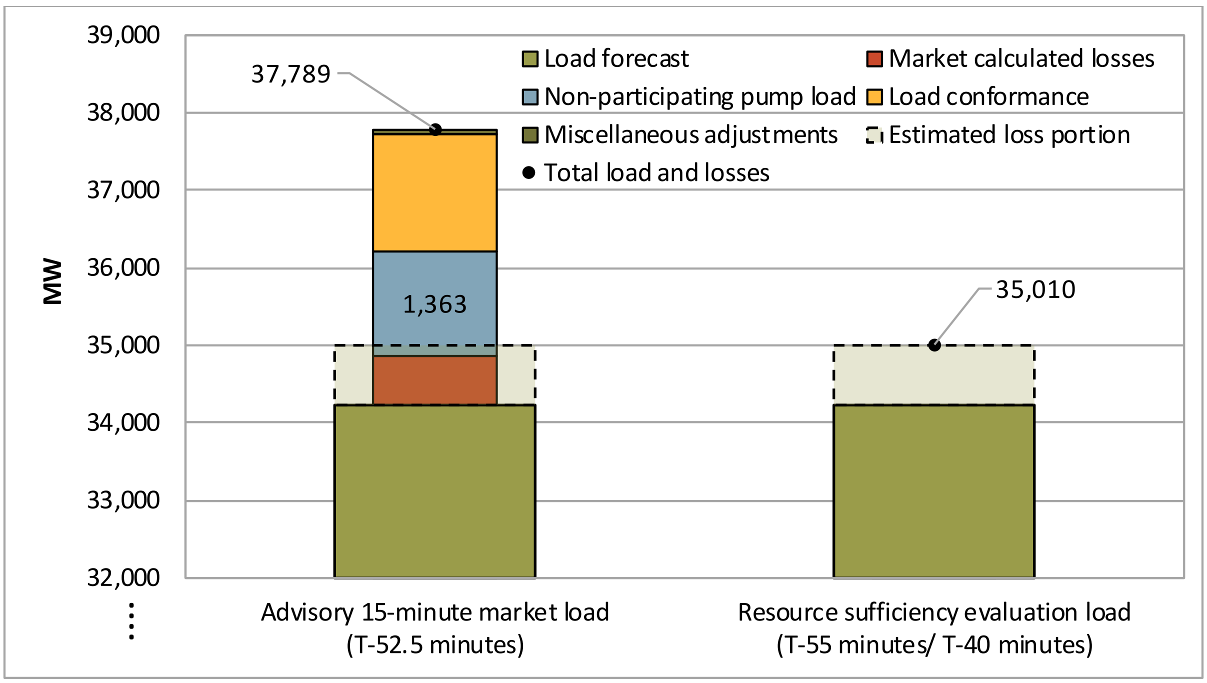


6 Additional demand in the real-time market compared to the resource sufficiency evaluation

The real-time market and resource sufficiency evaluation use different measurements for the total load. The resource sufficiency evaluation uses the raw (or initial) real-time load forecast directly in the requirement for both the capacity and the flexibility test. However, in the real-time market, the software adds operator load conformance, adds non-participating pump load, removes the portion that is estimated to be from losses, and finally recalculates the losses in the market.[25]

This is illustrated below in Figure 6.1 for the ISO area during an example interval. The example compares the total load and losses between the resource sufficiency evaluation with a corresponding advisory interval from the latest 15-minute market run.[26] In this example, the raw load forecast used in both cases (35,010 MW) was identical based on the timing of when the two market processes were run.

Figure 6.1 Example — difference between load used in the real-time market and in the resource sufficiency evaluation (CAISO, July 20, 2023. Hour-ending 23. Interval 1.)



The potential inclusion of load conformance was discussed as part of a resource sufficiency evaluation enhancements stakeholder process. In this process, the ISO confirmed no changes in the tests to account for load conformance, following findings that the use of load conformance does not regularly benefit any balancing area from passing the resource sufficiency evaluation.[27]

---

[25] The total load also adjusts for a few other miscellaneous components that cannot be accounted for elsewhere. The amounts here are typically small.

[26] Load and renewable forecasts are held fixed between the second run of the resource sufficiency evaluation (T-55) and final run (T-40).

[27] California ISO, EIM Resource Sufficiency Evaluation Enhancements Phase 2 Straw Proposal, July 1, 2022: http://www.caiso.com/InitiativeDocuments/StrawProposal-WEIMResourceSufficiencyEvaluationEnhancementsPhase2.pdf

Non-participating pump load within the ISO balancing area is not counted in the resource sufficiency evaluation. This is pumping load that is bid and scheduled as non-participating load in the day-ahead market and included as a component of the total load in the real-time market optimization. This pumping load can be significant (above 1,000 MW).

Non-participating pump load is included in the real-time market but not in the resource sufficiency evaluation. This can create differences in the conditions observed between both processes. This can also be a factor in hours during which the ISO passes the resource sufficiency evaluation while an Energy Emergency Alert is issued.

Other factors can also contribute to this outcome. First, rapidly evolving and declining conditions might prompt an EEA, but may not be observed by the resource sufficiency evaluation based on the latest information in advance of the evaluation hour. Also, real-time low priority and economic exports that clear the hour-ahead scheduling process would be included in the real-time market as additional demand but are no longer counted as such in the resource sufficiency evaluation because of enhancements implemented on July 1, 2023.

DMM recommends that the ISO and stakeholders consider whether non-participating pump load should be included in the resource sufficiency evaluation. This would better align the conditions in the real-time market with the conditions considered in the resource sufficiency evaluation.

7 WEIM import limits following test failure

This section summarizes the import limits that are imposed when a WEIM entity fails either the bid-range capacity or the flexible ramping sufficiency test in the upward direction.

Balancing areas can voluntarily opt in to receiving assistance energy transfers. When a balancing area opts in to the program, their WEIM transfers will not be affected by any limits that would exist following an upward resource sufficiency evaluation failure — allowing the market to freely and optimally schedule WEIM transfers based on supply and demand conditions in the system. The import limits summarized in this section cover both balancing areas that opted out or opted in to the assistance energy transfer program. For balancing areas that opted in to the program, these limits reflect what would have been in place had the balancing area not opted in.

When either test fails in the upward direction, imports will be capped at the greater of (1) the base transfer or (2) the transfer from the last 15-minute market interval. Figure 7.1 summarizes the import limits after failing either test by the source of the limit. The black horizontal line (right axis) shows the number of 15-minute intervals with either a capacity or a flexibility test failure, while the bars (left axis) show the percent of failure intervals in which the WEIM import limit was capped by either the base transfer or the last 15-minute market transfer.

Figure 7.1 Upward capacity/flexibility test failure intervals by source of import limit (January–March 2024)

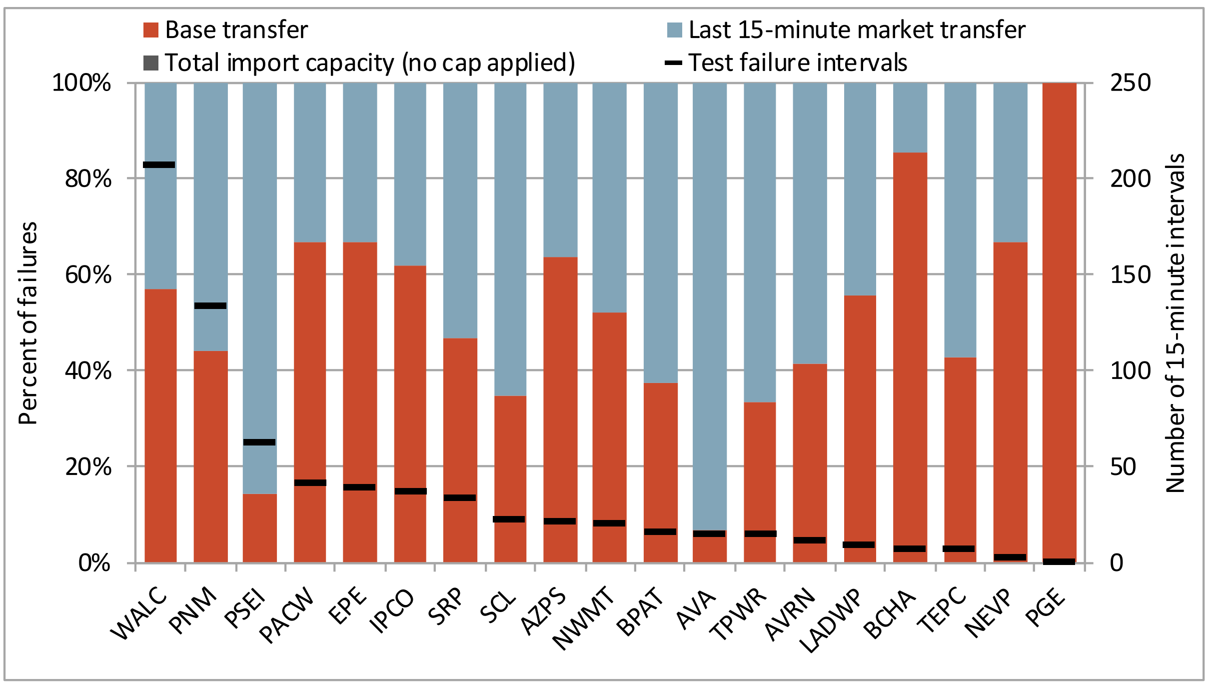


Figure 7.2 summarizes dynamic WEIM import limits above base transfers after failing either test in the upward direction.[28] From this perspective, the incremental WEIM import limit after a test failure is set

[28] Test failure intervals in which an import limit was not imposed because it was at or above the unconstrained total import capacity were excluded from this summary.

by the greater of (1) zero or (2) the transfer from the last 15-minute market interval minus the current base transfer. Therefore, the dynamic import limits show the incremental flexibility available through the WEIM after a resource sufficiency evaluation failure. The black horizontal line (right axis) shows the number of 15-minute intervals with an import limit imposed after a test failure. Areas without any upward test failures during the quarter were excluded.

Figure 7.2 Upward capacity/flexibility test failure intervals by dynamic import limit (January–March 2024)

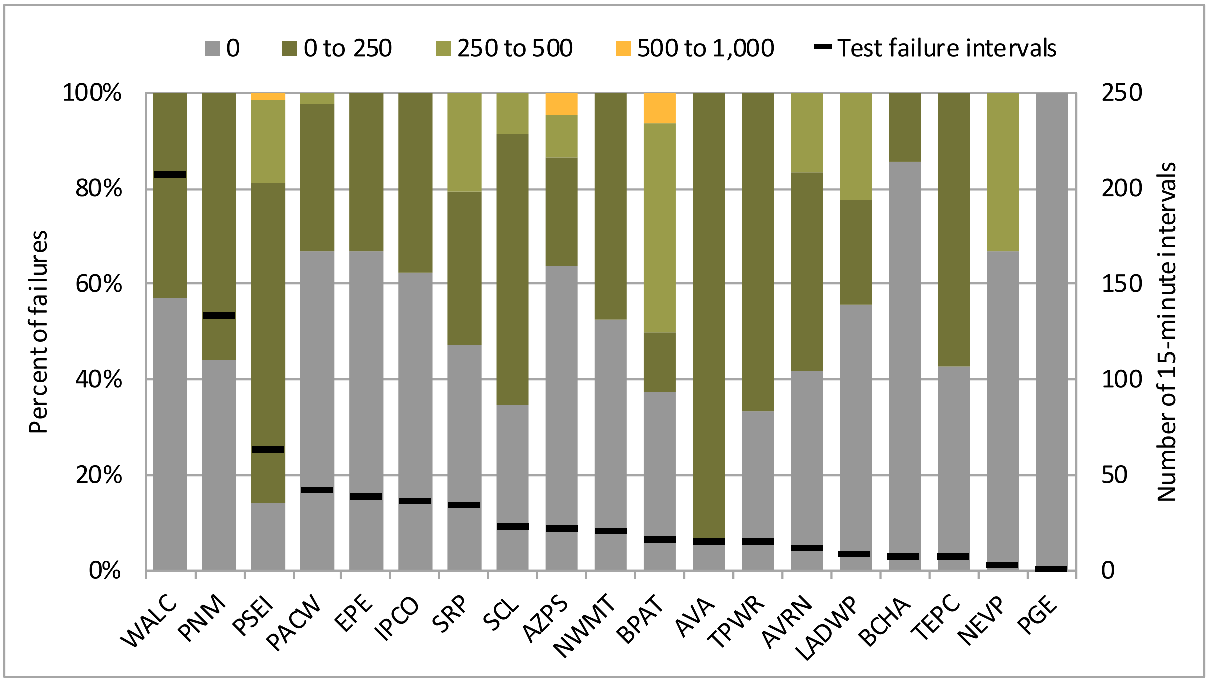
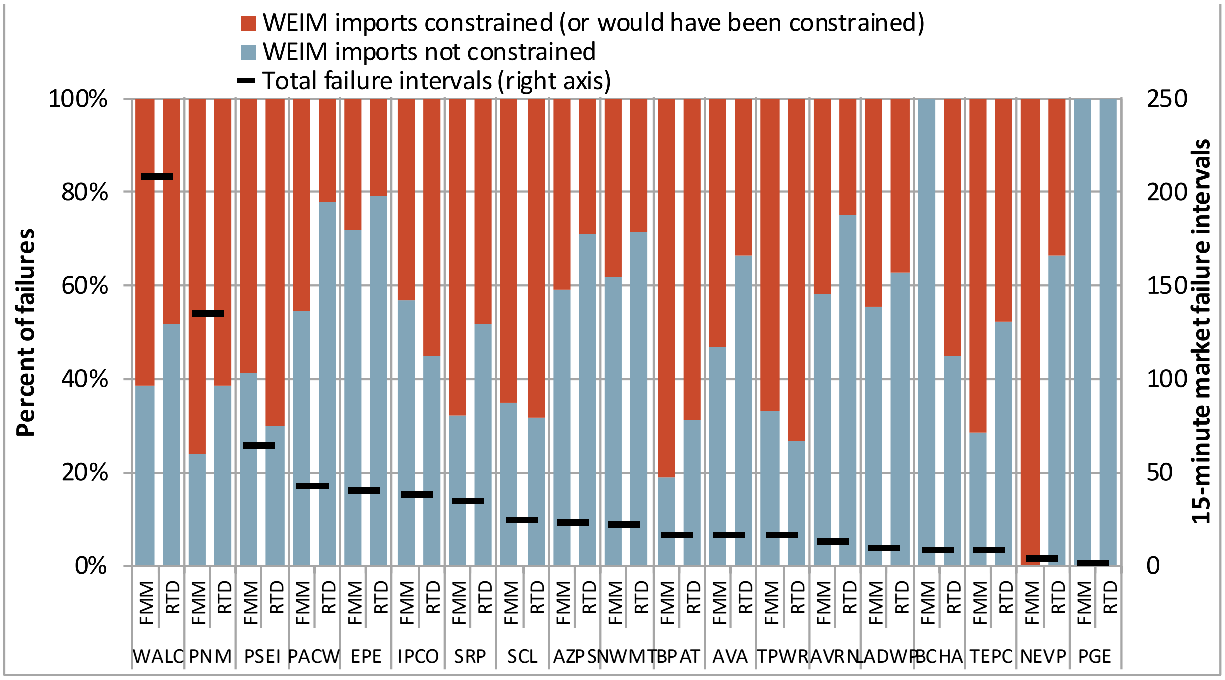


Figure 7.3 summarizes whether the import limit that was imposed after failing either test in the upward direction impacted market transfers (or would have impacted market transfers had the balancing area not opted in to the assistance energy transfer program).[29] The black horizontal line (right axis) shows the number of 15-minute market intervals with either a capacity or flexibility test failure. The blue bars (left axis) show the percent of failure intervals in which the resulting transfers – after failing the resource sufficiency evaluation – were *below* the import limit that was imposed (or would have been imposed for opt-in balancing areas). In all other failure intervals (red bars), the resulting transfers were either constrained to the limit imposed after failing the test or would have been constrained by the limit without an opt-in designation. These results are shown separately for the 15-minute (FMM) and 5-minute (RTD) markets.

[29] Test failure intervals in which an import limit was not imposed because it was at or above the unconstrained total import capacity were excluded from this summary.

Figure 7.3 Percent of upward failure intervals in which WEIM imports were constrained or would have been constrained by test failure limits (January–March 2024)



Appendix – Overview of the flexible ramp sufficiency and capacity tests

As part of the Western Energy Imbalance Market (WEIM) design, each balancing area (including the California ISO) is subject to a resource sufficiency evaluation. The evaluation is performed prior to each hour to ensure that generation in each area is sufficient without relying on transfers from other balancing areas. The evaluation is made up of four tests: the power flow feasibility test, the balancing test, the bid range capacity test, and the flexible ramp sufficiency test.

The market software automatically limits transfers into a balancing area from other WEIM areas if a balancing area fails either of the following two tests:

- **The bid range capacity test (capacity test)** requires that each area provide incremental bid-in capacity to meet the imbalance between load, intertie, and generation base schedules.
- **The flexible ramp sufficiency test (flexibility test)** requires that each balancing area has enough ramping flexibility over an hour to meet the forecasted change in demand as well as uncertainty.

If an area fails either the flexible ramp sufficiency test or bid range capacity test in the *upward* direction, WEIM transfers into that area cannot be *increased*.[30] Similarly, if an area fails either test in the *downward* direction, transfers out of that area cannot be *increased*.

Bid range capacity test

The *bid range capacity test* requires that each area provide incremental (or decremental) bid-in capacity to meet the imbalance between load, intertie, and generation base schedules. Equation A.1 shows the different components and mathematical formulation of the bid range capacity test. As shown in Equation A.1, the requirement for the bid range capacity test is calculated as the *load forecast* plus *export base schedules* minus *import and generation base schedules*. Intertie uncertainty was removed on June 1, 2022.

Equation A.1 Bid range capacity test requirement

$$Requirement = \underbrace{Load}_{\text{Load forecast}} + \underbrace{Export_{base} - Import_{base} - Generation_{base}}_{\text{Intertie and generation base schedules}}$$

If the requirement is positive, then the area must show sufficient incremental bid range capacity to meet the requirement, and if the requirement is negative, then sufficient decremental bid range capacity must be shown.

The bid range capacity used to the meet the requirement is calculated relative to the base schedules. For the California ISO balancing area, the "base" schedules used in the requirement are the advisory schedules from the last binding 15-minute market run. For all other WEIM areas, the export, import, and generation schedules used in the requirement are the base schedules submitted as part of the hourly

---

[30] If an area fails either test in the upward direction, net WEIM imports during the interval cannot exceed the greater of either the base transfer or optimal transfer from the last 15-minute market interval.

resource plan. Since the bid range capacity is calculated relative to the base schedules, the upward capacity test can generally be expressed as shown in Equation A.2.[31]

Equation A.2 Bid range capacity test reformulation

$$\underbrace{Generation_{maximum} + Net\ Import_{maximum}}_{\text{Upward capacity}} \geq \underbrace{Load}_{\text{Load forecast (requirement)}}$$

Incremental bid-in generation capacity is calculated as the range between the generation base schedule and the economic maximum, accounting for upward ancillary services and any de-rates (outages). Other resource constraints including start-times and ramp rates are not considered in the capacity test; 15-minute dispatchable imports and exports are included as bid range capacity.

Flexible ramp sufficiency test

The *flexible ramp sufficiency test* requires that each balancing area has enough ramping resources to meet expected upward and downward ramping needs in the real-time market without relying on transfers from other balancing areas. Each area must show sufficient ramping capability from the start of the hour to each of the four 15-minute intervals within the hour.

Equation A.3 shows the different components and formulation of the flexible ramp sufficiency test requirement. The requirement for the flexible ramp sufficiency test is calculated as the *forecasted change in load* plus the *uncertainty component* minus two components: (1) the *diversity benefit* and (2) *flexible ramping credits.* Any undersupply infeasibility in the last 15-minute market interval is also accounted for in the flexibility test requirement since June 1, 2022.

Equation A.3 Flexible ramp sufficiency test requirement

$$Up\ Requirement = \Delta Load + Up\ uncertainty - \min\begin{bmatrix} Net\ import\ capability, \\ Diversity\ benefit + Up\ credit \end{bmatrix} + Undersupply\ infeasibility$$

$$Down\ Requirement = \underbrace{-\Delta Load}_{\text{Change in load forecast}} + \underbrace{Down\ uncertainty}_{\text{Net load uncertainty}} - \underbrace{\min\begin{bmatrix} Net\ export\ capability, \\ Diversity\ benefit + Down\ credit \end{bmatrix}}_{\text{Discounts: diversity benefit and credit reduction capped by transfer capability}} - \underbrace{Undersupply\ infeasibility}_{\text{Undersupply infeasibility in last 15-minute market interval, excluding imbalance conformance}}$$

The diversity benefit reflects that system-level flexible ramping needs are typically smaller than the sum of the needs of individual balancing areas because of reduced uncertainty across a larger footprint. As a result, balancing areas receive a prorated diversity benefit discount based on this proportion.

[31] DMM has identified cases when the existing incremental approach for the capacity test relative to base schedules does not equal maximum capacity expected under a total approach. The incremental bid-range capacity can be positive only. If maximum capacity at the time of the test run is below base schedules, this difference will not be accounted for in the test. For more information, see DMM's *Comments on EIM Resource Sufficiency Evaluation Enhancements Issue Paper,* September 8, 2021: https://stakeholdercenter.caiso.com/Common/DownloadFile/25df1561-236b-4a47-9b1c-717b4a9cf9f0

The flexible ramping credits reflect the ability to reduce exports from a balancing area to increase upward ramping capability, or to reduce imports to increase downward ramping capability.

As shown in Equation A.3 above, the reduction in the flexibility test requirement because of any diversity benefit or flexible ramping credit is capped by the area's net import capability for the upward direction, or net export capability for the downward direction.

Last, as part of phase 1 of *resource sufficiency evaluation enhancements*, the flexibility test requirement now includes any undersupply infeasibility (power balance constraint relaxation) from the 15-minute market solution immediately prior to the resource sufficiency evaluation hour. This amount excludes any operator imbalance conformance.

Since February 1, 2023, the uncertainty component used in the flexible ramp sufficiency test is calculated using a regression method which considers forecasted net load currently on the system.[32] The measured uncertainty reflects extreme historical net load errors (95 percent confidence interval) adjusted to reflect forecasted conditions. The net load error observations used to calculate uncertainty in the resource sufficiency evaluation are measured from the difference between (1) binding 5-minute market net load forecasts and (2) the corresponding advisory 15-minute market net load forecast.

[32] California ISO, *Flexible Ramping Product Refinements Final Proposal*, August 31, 2020: http://www.caiso.com/InitiativeDocuments/FinalProposal-FlexibleRampingProductRefinements.pdf