Western Energy Imbalance Market Resource Sufficiency Evaluation Metrics Report covering Q3 2024

November 14, 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* (RSE). 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, impacts, and enhancements during the third quarter of 2024.

Report highlights

Resource sufficiency evaluation failures

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

Enhancements in determining uncertainty for pass-group

- **On June 25, 2024, the ISO made an improvement for determining the group of balancing areas passing the resource sufficiency evaluation in advance of the regressions for calculating uncertainty for the pass-group.**
- In some intervals, the regressions for calculating the uncertainty requirement for the pass-group must be performed before the final set of balancing areas in this group are known. An improvement in the process increased the consistency between (1) the group of balancing areas used to determine the regression coefficients for the pass-group and (2) the group of balancing areas whose forecast information gets combined with those coefficients to determine the uncertainty requirement.
- Following this enhancement, the set of balancing areas in the pass-group between the regression and current-forecast-information differed in around 6 percent of intervals, compared to around 18 percent of intervals prior to the enhancement.
- Additional improvements should still be considered to address any remaining inconsistency between these two sets of information.

Other enhancements

- **Phase 2 (track 2) of resource sufficiency evaluation enhancements was fully implemented by July 1, 2024.** This included the following enhancements.
    - On April 16, the ISO implemented the “failed-to-start” exemption for counting offline short-start resources in the capacity test.
    - On July 1, the ISO implemented changes to improve visibility around the priority of export tags that are submitted.

Assistance energy transfers

- **Ten balancing areas were opted in to assistance energy transfers (AET) during the third quarter.** Eight of these areas (Avangrid, California ISO, Idaho Power, NorthWestern Energy, NV Energy, PacifiCorp East, Public Service Company of New Mexico, and WAPA Desert Southwest) 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. The other two areas (PacifiCorp West and Portland General Electric) did not fail the resource sufficiency evaluation while participating in the program.

- **During the quarter, the Public Service Company of New Mexico (PNM) failed the resource sufficiency evaluation during 79 intervals while opted in to the assistance energy transfer option**. PNM received an additional 49 MW on average during these intervals (with a maximum of 973 MW).
- **Failures while opted in to the assistance energy transfer program were not highly coincident across balancing areas.** This indicates limited widespread reliance on assistance energy transfers during tight west-wide conditions.

Quantile regression method for calculating uncertainty

- **On August 14, 2024, the ISO made a change to the historical sample in which the regressions operate from.** Prior to August 14, the historical observations were selected from the previous 180 days. On August 14, the ISO changed the methodology to instead select the observations from two periods: (1) the previous 90 days and (2) the next 90 days minus one year. Symmetric sampling can improve the performance of the calculation, particularly during seasonal transition periods.

Demand response load adjustments in the resource sufficiency evaluation

- **Idaho Power submitted a -25 MW demand response load adjustment for 80 consecutive hours between July 8 and July 12, 2024.** This adjustment had no impact on Idaho Power passing or failing the resource sufficiency evaluation. WEIM entities are able to submit load forecast adjustments in the resource sufficiency evaluation to reflect demand response programs which could not be accounted for otherwise in the real-time market.

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 continues to recommend 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 the report

- Section 2 **summarizes the frequency and size of resource sufficiency evaluation failures.**
- Section 3 **summarizes the impact of advisory resource sufficiency evaluation runs**. This section describes improvements made for determining the group of balancing areas that pass the resource sufficiency evaluation in advance of the regressions for calculating uncertainty.
- Section 4 **provides an overview of the changes implemented as part of Phase 2 (track 2) of resource sufficiency evaluation enhancements.** This includes:
  - On April 16, 2024, the ISO implemented the "failed-to-start" exemption for counting offline short-start resources in the capacity test.
  - On July 1, 2024, the ISO implemented changes to improve visibility around the priority of export tags that are submitted.
- Section 5 **summarizes the use of assistance energy transfers (AET).** This section includes new analysis on AET costs as well as a review of widespread reliance on AET during tight west-wide conditions.
- Section 6 **summarizes uncertainty used in the flexible ramp sufficiency test.**
- Section 7 **summarizes demand-response-based load adjustments used in the resource sufficiency evaluation.**
- Section 8 **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 9 **summarizes WEIM import limits and transfers following a resource sufficiency evaluation failure.**
- Appendix A **provides a technical overview of the flexible ramp sufficiency and bid range capacity tests.**
- Appendix B **provides an overview of the mosaic quantile regression method for calculating uncertainty.**

DMM welcomes 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 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.[1] 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 2.1 through Figure 2.4 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.[2] Figure 2.5 through Figure 2.8 provide the same information for the downward direction. The dash indicates that the area did not fail the test during the month.

In the third quarter:

- Public Service Company of New Mexico (PNM) failed the upward flexibility test in around 1 percent of intervals.
- All other balancing areas failed each test type in less than one percent of intervals.

Figure 2.9 shows the change in the percent of intervals with an upward test failure from the third quarter of 2023 to the third quarter of 2024. Figure 2.10 shows the same information for downward test failures.

Figure 2.11 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 2.12 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.

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

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

Figure 2.1 Frequency of upward capacity test failures (percent of 15-minute intervals)

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

Figure 2.2 Average shortfall of upward capacity test failures (MW)

	Jul 2023	Aug 2023	Sep 2023	Oct 2023	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mar 2024	Apr 2024	May 2024	Jun 2024	Jul 2024	Aug 2024	Sep 2024
Arizona Publ. Serv.	—	—	—	58	—	160	—	—	—	—	—	—	—	—	—
Avangrid	—	—	190	—	—	—	—	—	—	—	—	—	396	—	—
Avista	—	—	—	2	13	—	31	9	—	—	—	—	11	—	—
BANC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BPA	118	—	73	—	—	—	176	—	—	—	—	—	—	—	—
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
El Paso Electric	20	8	6	18	—	—	—	—	4	3	15	14	27	17	12
Idaho Power	—	—	—	—	58	—	4	—	—	—	—	—	—	—	—
LADWP	10	18	—	—	—	10	71	1	—	19	6	—	54	61	—
NorthWestern En.	70	—	—	—	—	—	—	12	—	—	—	—	—	—	40
NV Energy	3	41	—	12	—	—	—	—	—	—	39	38	55	57	—
PacifiCorp East	116	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PacifiCorp West	—	26	—	—	—	—	51	8	—	25	8	—	—	—	—
Portland Gen. Elec.	24	—	0	17	228	—	—	—	—	—	9	12	10	—	—
Powerex	—	—	154	2	6	—	—	—	—	—	—	—	—	—	—
PSC of New Mexico	—	25	4	48	—	49	—	—	—	46	8	28	48	22	—
Puget Sound En.	29	28	48	48	89	41	78	15	52	53	18	—	71	27	—
Salt River Proj.	65	56	80	56	23	10	17	38	22	29	—	233	76	24	68
Seattle City Light	2	6	—	5	563	—	18	—	—	9	—	0	7	4	7
Tacoma Power	—	7	—	5	0	—	—	—	119	—	2	—	—	—	—
Tucson Elec. Pow.	54	—	—	12	—	—	—	—	—	—	—	—	16	—	8
Turlock Irrig. Dist.	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
WAPA DSW	18	4	13	7	282	78	—	—	1	—	5	6	7	13	—

Figure 2.3 Frequency of upward flexibility test failures (percent of 15-minute intervals)

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

Figure 2.4 Average shortfall of upward flexibility test failures (MW)

	Jul 2023	Aug 2023	Sep 2023	Oct 2023	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mar 2024	Apr 2024	May 2024	Jun 2024	Jul 2024	Aug 2024	Sep 2024
Arizona Publ. Serv.	—	88	—	—	102	23	27	55	65	35	83	—	208	33	—
Avangrid	20	26	138	60	8	7	12	20	30	19	15	20	273	—	17
Avista	—	—	—	21	15	—	66	—	14	—	—	—	8	—	—
BANC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BPA	114	44	41	5	—	—	153	73	—	5	9	47	49	43	32
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	388	—	—
El Paso Electric	19	34	9	17	10	13	9	24	23	17	17	14	10	15	21
Idaho Power	—	—	—	10	—	—	32	—	17	27	28	33	17	—	—
LADWP	51	102	14	—	—	69	26	—	52	200	50	48	32	67	74
NorthWestern En.	32	20	6	11	4	5	16	24	3	11	12	26	72	—	40
NV Energy	52	207	12	—	22	19	—	137	136	—	80	—	—	—	—
PacifiCorp East	36	—	—	—	—	—	—	—	—	27	44	—	—	27	—
PacifiCorp West	35	—	—	22	25	22	104	—	9	—	—	6	—	—	—
Portland Gen. Elec.	27	—	—	25	2	—	—	—	23	—	44	22	—	—	12
Powerex	—	—	—	—	—	—	106	—	—	—	—	—	1345	—	—
PSC of New Mexico	35	56	20	56	38	39	52	50	37	48	43	83	55	55	67
Puget Sound En.	55	43	18	86	42	27	29	16	71	12	17	22	53	45	—
Salt River Proj.	77	50	90	43	63	151	66	50	44	76	92	209	36	103	52
Seattle City Light	—	16	29	6	—	—	22	—	16	19	6	—	—	—	5
Tacoma Power	—	—	—	9	2	—	6	7	73	2	13	—	—	—	—
Tucson Elec. Pow.	35	21	—	13	13	55	6	13	—	10	25	—	12	15	28
Turlock Irrig. Dist.	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—
WAPA DSW	9	21	14	16	143	12	12	27	33	18	12	18	—	—	—

Figure 2.5 Frequency of downward capacity test failures (percent of 15-minute intervals)

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

Figure 2.6 Average shortfall of downward capacity test failures (MW)

	2023						2024								
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Arizona Publ. Serv.	—	—	—	—	—	176	18	16	9	100	—	—	—	—	69
Avangrid	—	—	—	—	93	—	—	—	—	—	—	—	—	—	—
Avista	—	—	—	—	—	—	—	—	264	—	—	—	—	—	—
BANC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BPA	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
El Paso Electric	15	2	18	—	—	—	4	—	7	6	10	20	5	15	6
Idaho Power	—	—	—	—	—	—	—	—	—	12	—	—	—	—	—
LADWP	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7
NorthWestern En.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
NV Energy	51	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PacifiCorp East	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PacifiCorp West	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Portland Gen. Elec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Powerex	15	—	—	—	—	—	—	—	—	25	—	—	—	—	—
PSC of New Mexico	—	—	72	—	—	—	—	—	—	—	—	—	5	—	—
Puget Sound En.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Salt River Proj.	39	—	13	46	—	—	—	20	2	21	33	—	—	14	—
Seattle City Light	—	12	15	—	15	3	1	—	—	—	—	—	8	—	—
Tacoma Power	1	—	4	—	—	—	—	—	—	—	—	2	2	0	—
Tucson Elec. Pow.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Turlock Irrig. Dist.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
WAPA DSW	13	11	7	6	2	—	—	—	—	—	—	—	7	—	—

Figure 2.7 Frequency of downward flexibility test failures (percent of 15-minute intervals)

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

Figure 2.8 Average shortfall of downward flexibility test failures (MW)

	2023						2024								
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Arizona Publ. Serv.	—	—	—	—	—	84	72	53	116	94	—	—	—	—	—
Avangrid	—	—	11	—	—	—	18	—	—	—	—	—	—	—	—
Avista	—	—	—	—	27	—	—	1	—	—	—	—	25	—	21
BANC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BPA	62	—	13	192	—	—	243	104	—	36	190	125	—	—	—
California ISO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
El Paso Electric	36	—	21	—	7	8	7	7	10	31	11	9	—	9	—
Idaho Power	—	—	17	—	4	—	—	—	3	89	—	—	—	—	—
LADWP	—	—	—	—	—	—	—	—	—	—	—	—	—	—	34
NorthWestern En.	—	15	2	—	—	—	22	—	31	—	21	8	84	8	4
NV Energy	120	10	75	59	156	—	—	—	94	23	—	279	—	—	—
PacifiCorp East	—	—	25	8	—	—	—	36	35	68	76	125	118	—	98
PacifiCorp West	—	—	51	—	6	—	—	—	30	—	—	—	—	—	—
Portland Gen. Elec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Powerex	85	—	67	421	—	160	—	84	2528	5	—	—	1225	620	—
PSC of New Mexico	15	123	72	36	20	44	55	37	21	42	59	9	109	14	82
Puget Sound En.	—	—	—	—	—	—	—	—	—	—	—	—	16	—	—
Salt River Proj.	172	—	—	—	41	1	44	27	62	36	59	23	—	—	—
Seattle City Light	7	10	21	—	45	8	64	4	9	37	—	5	9	11	—
Tacoma Power	2	—	5	—	2	—	—	2	—	—	—	—	—	—	—
Tucson Elec. Pow.	—	—	—	—	—	—	—	94	—	—	—	—	—	—	—
Turlock Irrig. Dist.	—	—	—	—	39	—	—	1	—	—	5	2	—	3	—
WAPA DSW	12	14	11	14	8	8	66	22	16	3	—	—	9	4	9

Figure 2.9 Change in percent of intervals with an upward resource sufficiency evaluation failure (Q3 2023 to Q3 2024)

	Flexibility test			Capacity test		
WEIM entity	**Q3 2023**	**Q3 2024**	**Difference**	**Q3 2023**	**Q3 2024**	**Difference**
Arizona Publ. Serv.	0.0%	0.0%	0.0%	0%	0%	0%
Avangrid	0.4%	0.1%	-0.3%	0.3%	0.0%	-0.2%
Avista	0%	0.0%	0.0%	0%	0.0%	0.0%
BANC	0%	0%	0%	0%	0%	0%
BPA	0.6%	0.2%	-0.3%	0.2%	0%	-0.2%
California ISO	0%	0.0%	0.0%	0%	0%	0%
El Paso Electric	1.1%	0.6%	-0.5%	0.3%	0.1%	-0.2%
Idaho Power	0%	0.0%	0.0%	0%	0%	0%
LADWP	0.1%	0.2%	0.1%	0.0%	0.1%	0.1%
NorthWestern En.	0.5%	0.2%	-0.3%	0.1%	0.1%	0.0%
NV Energy	0.1%	0%	-0.1%	0.0%	0.0%	0.0%
PacifiCorp East	0.1%	0.0%	0.0%	0.0%	0%	0.0%
PacifiCorp West	0.1%	0%	-0.1%	0.0%	0%	0.0%
Portland Gen. Elec.	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Powerex	0%	0.2%	0.2%	0.0%	0%	0.0%
PSC of New Mexico	0.5%	1.0%	0.5%	0.0%	0.1%	0.1%
Puget Sound En.	1.4%	0.3%	-1.0%	0.7%	0.1%	-0.6%
Salt River Proj.	1.7%	0.4%	-1.3%	1.3%	0.1%	-1.2%
Seattle City Light	0.2%	0.0%	-0.2%	0.3%	0.2%	-0.2%
Tacoma Power	0%	0%	0%	0.0%	0%	0.0%
Tucson Elec. Pow.	0.2%	0.3%	0.1%	0.1%	0.0%	-0.1%
Turlock Irrig. Dist.	0.0%	0%	0.0%	0.0%	0%	0.0%
WAPA DSW	0.4%	0%	-0.4%	0.6%	0.1%	-0.5%

Figure 2.10 Change in percent of intervals with a downward resource sufficiency evaluation failure (Q3 2023 to Q3 2024)

	Flexibility test			Capacity test		
WEIM entity	**Q3 2023**	**Q3 2024**	**Difference**	**Q3 2023**	**Q3 2024**	**Difference**
Arizona Publ. Serv.	0%	0%	0%	0%	0.1%	0.1%
Avangrid	0.0%	0%	0.0%	0%	0%	0%
Avista	0%	0.1%	0.1%	0%	0%	0%
BANC	0%	0%	0%	0%	0%	0%
BPA	0.1%	0%	-0.1%	0%	0%	0%
California ISO	0%	0%	0%	0%	0%	0%
El Paso Electric	0.3%	0.0%	-0.3%	0.1%	0.1%	-0.1%
Idaho Power	0.0%	0%	0.0%	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%	0.0%
NV Energy	0.1%	0%	-0.1%	0.0%	0%	0.0%
PacifiCorp East	0.0%	0.1%	0.0%	0%	0%	0%
PacifiCorp West	0.4%	0%	-0.4%	0%	0%	0%
Portland Gen. Elec.	0%	0%	0%	0%	0%	0%
Powerex	0.1%	0.4%	0.3%	0.0%	0%	0.0%
PSC of New Mexico	0.5%	0.3%	-0.2%	0.0%	0.0%	0.0%
Puget Sound En.	0%	0.0%	0.0%	0%	0%	0%
Salt River Proj.	0.0%	0%	0.0%	0.3%	0.1%	-0.2%
Seattle City Light	0.6%	0.2%	-0.4%	0.1%	0.1%	0.0%
Tacoma Power	0.0%	0%	0.0%	0.0%	0.0%	0.0%
Tucson Elec. Pow.	0%	0%	0%	0%	0%	0%
Turlock Irrig. Dist.	0%	0.0%	0.0%	0%	0%	0%
WAPA DSW	0.3%	0.1%	-0.2%	0.3%	0.0%	-0.3%

Figure 2.11 Upward capacity/flexibility test failure intervals by concurrence (July–September 2024)

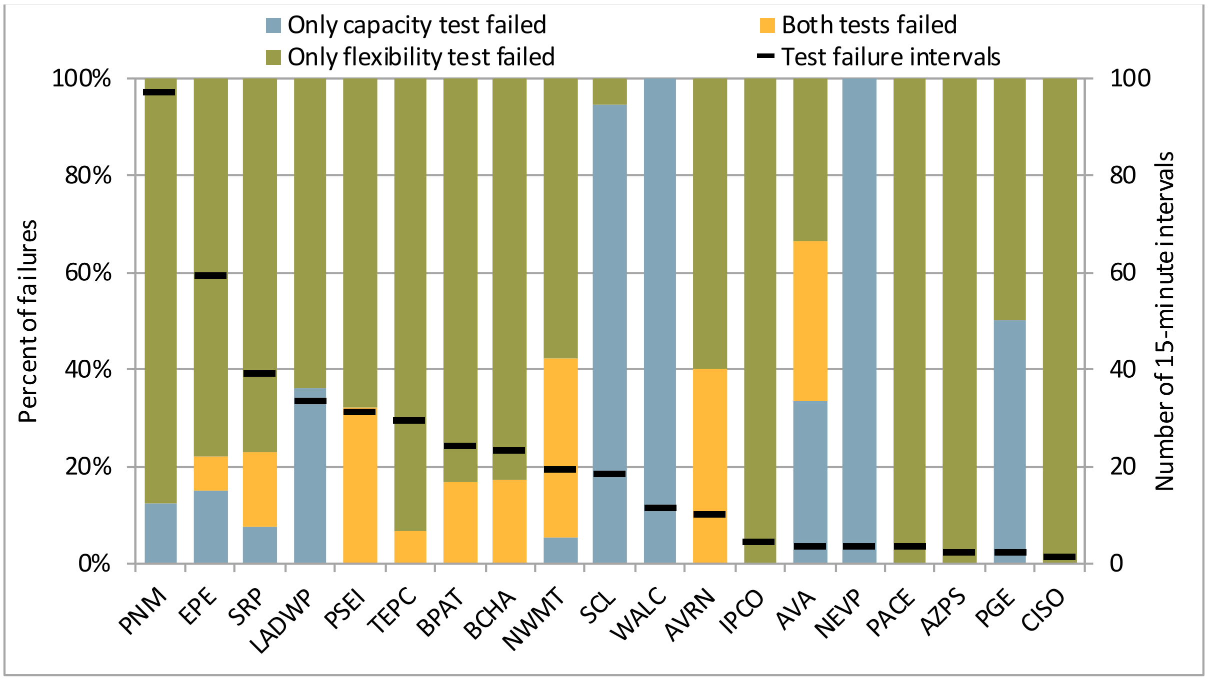
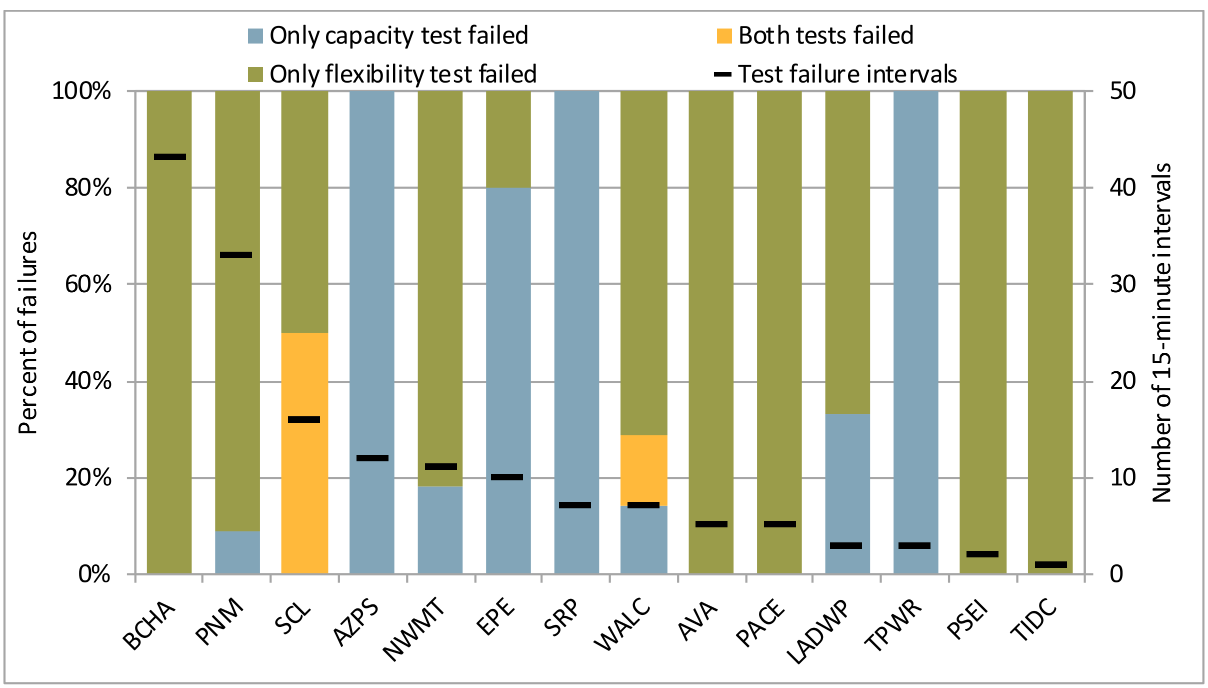


Figure 2.12 Downward capacity/flexibility test failure intervals by concurrence (July–September 2024)



3 Impact of advisory resource sufficiency evaluation runs

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 3.1 and Figure 3.2 summarize the *first* interval of each evaluation hour during the quarter and the frequency of a failure in the second (T-55) or final (T-40) resource sufficiency evaluation.[3] 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.

3 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 3.1 Upward resource sufficiency evaluation failures in first 15-minute interval of hour (July–September 2024)

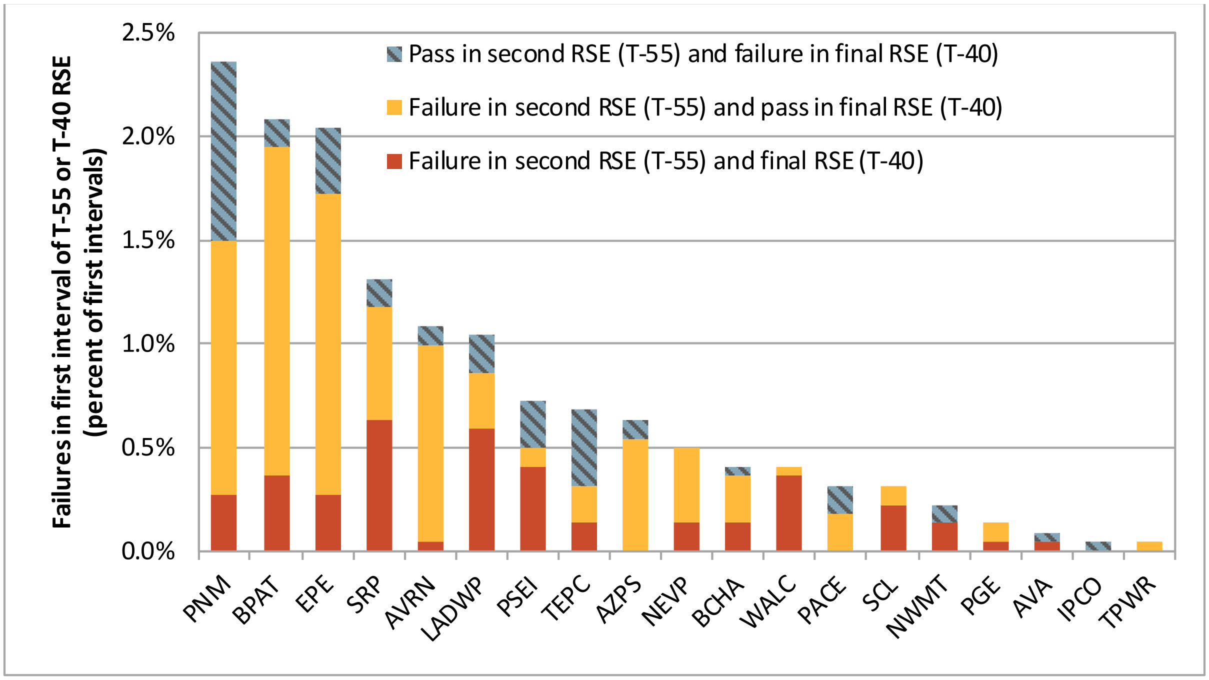
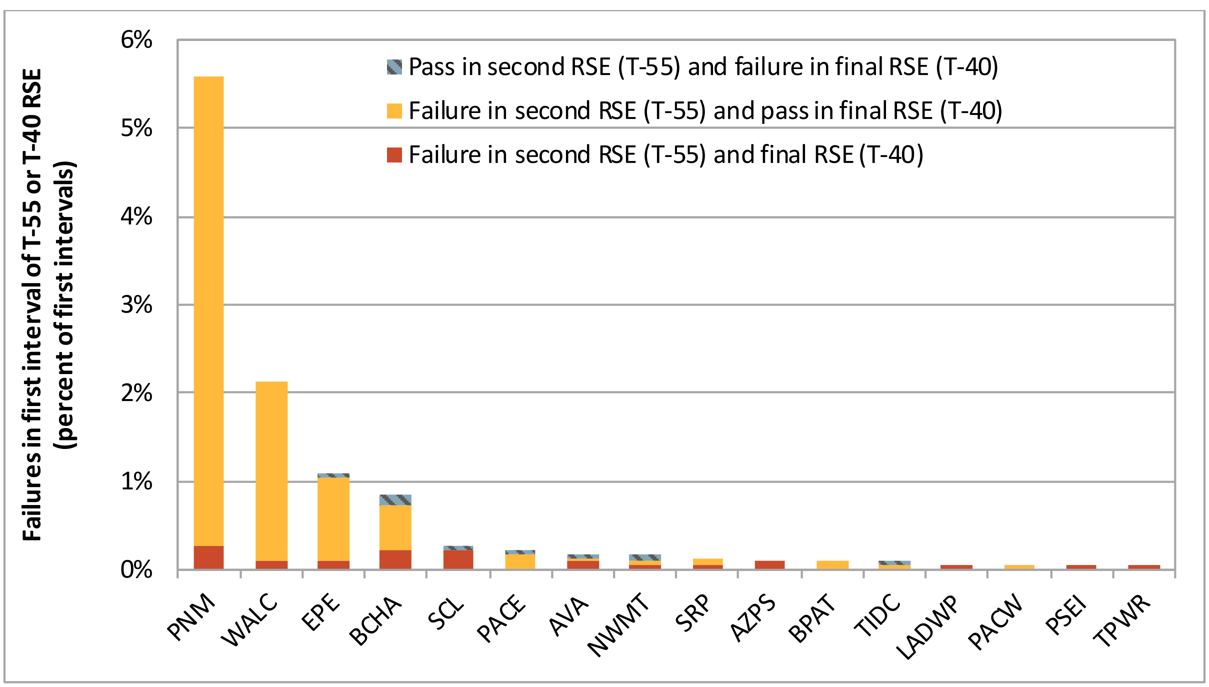


Figure 3.2 Downward resource sufficiency evaluation failures in first 15-minute interval of hour (July–September 2024)



Improvement for calculating uncertainty within the group of balancing areas that pass the tests

The ISO made improvements to the set of balancing areas considered in the pass-group for performing the regressions that estimate the relationship between forecast information and uncertainty.

As part of the enhancements implemented on February 1, 2023, uncertainty is calculated based on regression results that use historical data to predict uncertainty relative to load, solar, and wind forecasts. 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 in each interval so that it can perform the regression using historical data accordingly for that group.

To perform the regressions for the pass-group, the set of balancing areas in this group is sometimes estimated from preliminary test results based on information available at the time of this process. Then in the present, when the current forecast information is combined with the regression information to calculate uncertainty, a different set of balancing areas in the pass-group may be used based on changes in the results of the later resource sufficiency evaluation runs.

On June 25, 2024 the ISO made an improvement to the timing in which the resource sufficiency evaluation results are pushed in advance of the regressions that are performed to calculate pass-group uncertainty. In some intervals, the regressions for calculating the uncertainty requirement for the pass-group must be performed before the final set of balancing +areas in this group are known. The enhancement improved the consistency between (1) the group of balancing areas used to determine the regression coefficients for the pass-group and (2) the group of balancing areas whose forecast information gets combined with those coefficients to determine the uncertainty requirement.

Table 3.1 summarizes this inconsistency and the improvement made on June 25. The set of balancing areas in the pass-group for the current weather information that is ultimately combined with the regression results to calculate uncertainty and procure flexible capacity, 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. However, prior to June 25, *the regressions* were based on the results from the earliest resource sufficiency evaluation (T-75) to define the pass-group for the first interval of each hour, while the results from the second resource sufficiency evaluation (T-55) were used to define the pass-group for the second interval of each hour.

Starting on June 25, 2024 the set of balancing areas in the pass-group between the regression information and the current forecast information became more consistent. For the second interval of each hour, the regressions now use the results from the final resource sufficiency evaluation (consistent with forecast information). For the first interval of each hour, the regressions now use the results from the first or second resource sufficiency evaluation depending on the timing of various market processes (sometimes consistent with forecast information). DMM recommends that additional improvements be made to resolve inconsistencies in the set of balancing areas in the pass-group for the first interval of each hour.

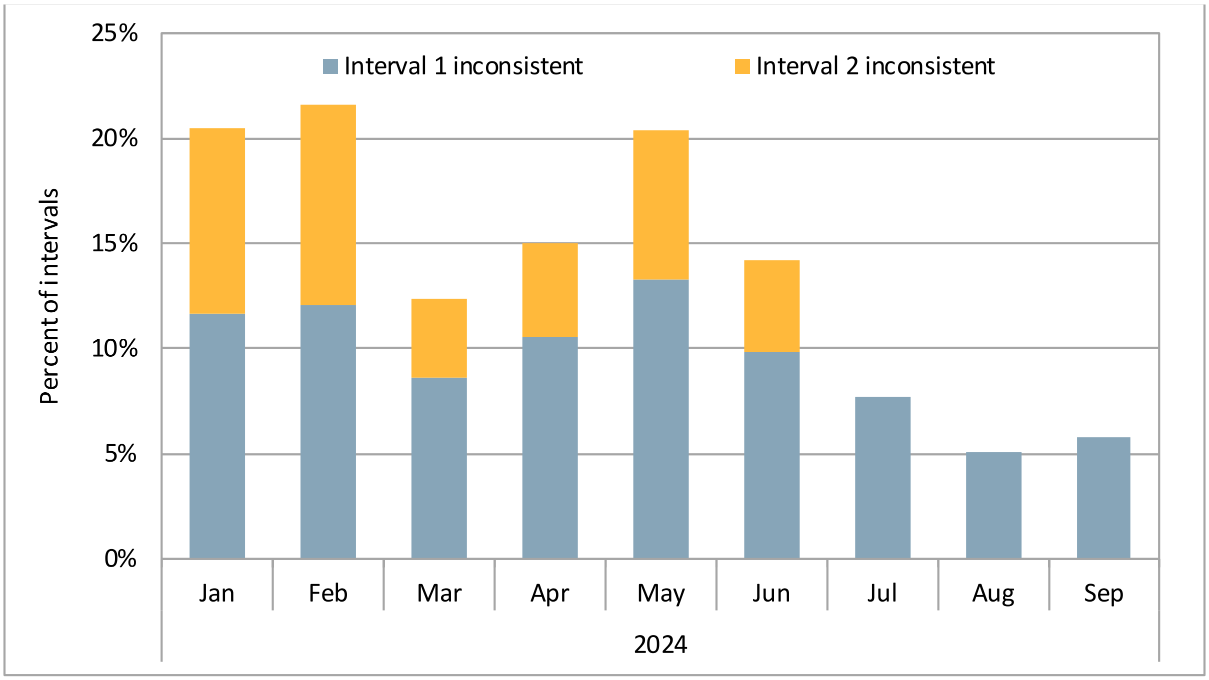
Table 3.1 Source of pass-group for calculating uncertainty and procuring flexible ramping capacity (prior to and after June 25, 2024)

15-minute market interval	Regression inputs and outputs		Current weather information for calculating uncertainty and flex ramp procurement
	(*prior to* June 25, 2024)	(*after* June 25, 2024)	
1	First run (T-75)	First run (T-75) or second run (T-55)	Second run (T-55)
2	Second run (T-55)	Final run (T-40)	Final run (T-40)
3	Final run (T-40)	Final run (T-40)	Final run (T-40)
4	Final run (T-40)	Final run (T-40)	Final run (T-40)

Using an inconsistent set 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 any of the historical data.

Figure 3.3 shows the percent of intervals by month in which the set of balancing areas in the pass-group differed between the regression information and current forecast information. The figure also shows whether it was the first or second interval of the hour that had the inconsistency. The enhancement removed the potential for inconsistency in interval 2 and improved the consistency in interval 1. Following the enhancements, the set of balancing areas in the pass-group differed in around 6 percent of intervals, compared to around 18 percent of intervals prior to the enhancements in 2024.

Figure 3.3 Percent of intervals in which the set of balancing areas in the pass-group differed between the current forecast information and regression information



4 Resource sufficiency evaluation enhancements Phase 2 (track 2)

Phase 2 (track 2) of resource sufficiency evaluation enhancements was fully implemented on July 1, 2024. This included the following enhancements:

- **On April 16, 2024, the ISO implemented the "failed-to-start" exemption for counting offline short-start resources in the capacity test.** Phase 1 of resource sufficiency evaluation enhancements excluded offline long-start resources from the capacity test. It also created a check to determine if offline short-start resources with commitment instructions during the resource sufficiency evaluation horizon *failed-to-start*. If a committed short-start resource had zero or negative telemetry at the time of the test, it was excluded from consideration in the capacity test. However, this incorrectly excluded some fast-start resources or resources with negative telemetry (particularly pump hydro resources) that could actually be available in the resource sufficiency evaluation horizon. The enhancement created a flag to exempt these resources from the failed-to-start rule. Short-start resources that can have zero or negative telemetry at the time of a resource sufficiency evaluation—but be available and online for the next interval—can request the exemption.[4]
- **On July 1, 2024, the ISO implemented changes to improve visibility around the priority of export tags that are submitted.** As part of the enhancements, low-priority exports need to be tagged as *Firm Provisional Energy* along with the priority type (Day-Ahead Lower Price Taker [DALPT], Real-Time Lower Price Taker [RTLPT], or Real-Time Economic [RTECON]) so that all parties understand the quality and firmness of the market award. During stressed system conditions, the enhancement allows operators to make curtailment decisions more effectively.

[4] Resources can request an exemption to the failed-to-start rule in the capacity test by submitting an updated Generator Resource Data Template (GRDT).

5 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 dynamic WEIM transfers or (2) the amount by which the balancing area failed the resource sufficiency evaluation. If the 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 5.1 shows the days in which a balancing area was opted in to receiving assistance energy transfers during the quarter. Ten 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, PNM, Portland General Electric, and WAPA Desert Southwest.[7] Avangrid, Idaho Power, NorthWestern Energy, NV Energy, PacifiCorp East, and PacifiCorp West were opted in to AET during all days during the quarter (92 days).

Table 5.2 summarizes all balancing areas that were opted in to assistance energy transfers on at least one day during the quarter and the subsequent 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. During the quarter, eight balancing areas (Avangrid, California ISO, Idaho Power, NorthWestern Energy, NV Energy, PacifiCorp East, PNM, and WAPA Desert Southwest)

[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

failed the resource sufficiency evaluation during at least one interval while opted in to the program. Table 5.2 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, maximum, and total WEIM imports added in the 5-minute market because of AET.

During the quarter, the Public Service Company of New Mexico (PNM) failed the resource sufficiency evaluation during 79 intervals while opted in to receiving assistance energy transfers. PNM achieved an additional 49 MW on average during these intervals (and maximum of 434 MW).

Table 5.3 summarizes the total cost from assistance energy transfers.[8] AET is settled during any interval in which the balancing area both opted in to receiving assistance energy transfers and failed the resource sufficiency evaluation. The applicable quantity that is settled for AET is based on the lower of the resource sufficiency evaluation insufficiency or the WEIM imports.[9] The price is the real-time bid cap, typically $1,000/MWh. Table 5.3 also shows the total cost per *WEIM imports added*. WEIM imports added are measured as net WEIM imports in the 5-minute market above what the limit would have been following the resource sufficiency evaluation failure without opting in to AET.

Table 5.1 Assistance energy transfer opt-in designations by balancing area (July–September 2024)

Balancing area	Period opted in to receiving assistance energy transfers	Days opted in to AET
Avangrid	Jul. 1 - Sep. 30	92
California ISO	Jul. 3, Jul. 8 - Jul. 11, Jul. 22 - Jul. 24, Aug. 5 - Aug. 7, Sep. 4 - Sep. 6, Sep. 9 - Sep 10	16
Idaho Power	Jul. 1 - Sep. 30	92
NorthWestern Energy	Jul. 1 - Sep. 30	92
NV Energy	Jul. 1 - Sep. 30	92
PacifiCorp East	Jul. 1 - Sep. 30	92
PacifiCorp West	Jul. 1 - Sep. 30	92
PNM	Jul. 8 - Sep. 23	78
Portland General Electric	Jul. 4 - Jul. 10, Aug. 5 - Aug. 7	10
WAPA Desert Southwest	Jul. 8 - Sep. 30	85

8 Information is based on settlement values available at the time of drafting. Updates can occur regularly within the settlements timeline, starting with T+9B (trade date plus nine business days) and T+70B, as well as others up to 36 months after the trade date.

9 If the 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.

Table 5.2 Resources sufficiency evaluation failures during assistance energy transfer opt-in (July–September 2024)

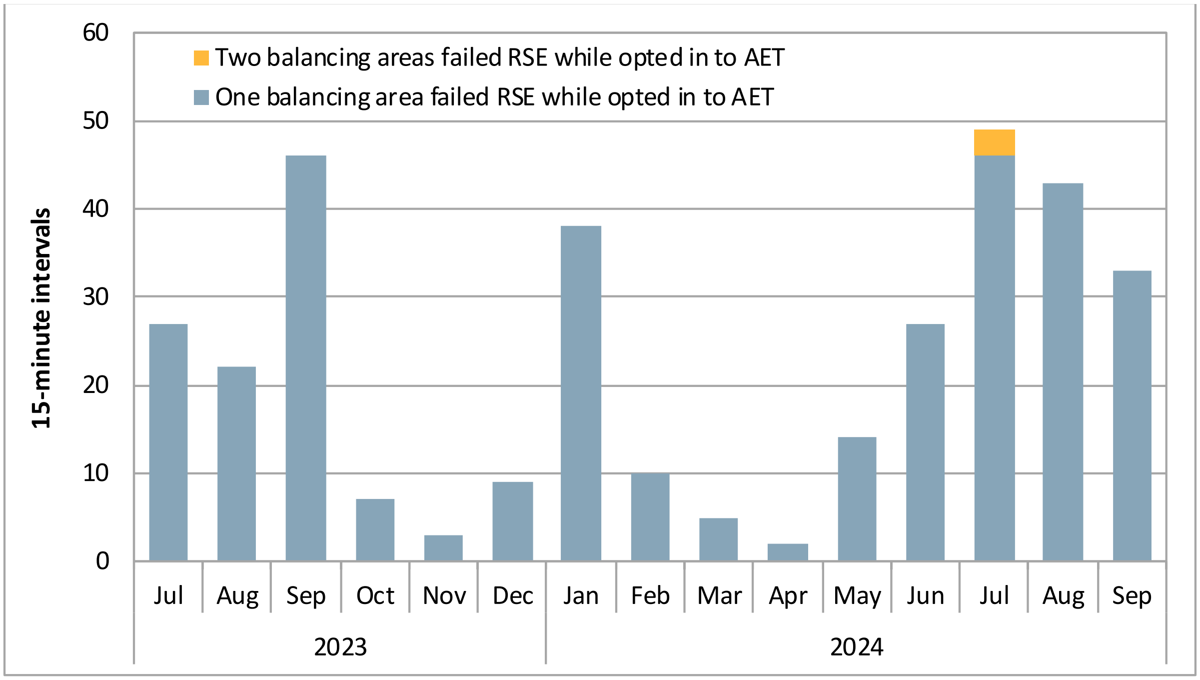
Balancing area	Days opted in to AET	RSE failures under AET (15-min. intervals)	Percent of failure intervals with additional WEIM imports due to AET	Average WEIM imports added (MW)	Max WEIM imports added (MW)	Total WEIM imports added (MWh)
Avangrid	92	10	33%	23	151	58
California ISO	16	1	0%	0	0	0
Idaho Power	92	4	33%	11	42	11
NorthWestern Energy	92	19	40%	14	157	65
NV Energy	92	3	56%	104	336	78
PacifiCorp East	92	3	33%	61	203	45
PacifiCorp West	92	0	N/A	N/A	N/A	N/A
PNM	78	79	41%	49	434	973
Portland General Electric	10	0	N/A	N/A	N/A	N/A
WAPA Desert Southwest	85	9	56%	99	277	223

Table 5.3 Cost of assistance energy transfers (July–September 2024)

Balancing area	RSE failures under AET (15-min. intervals)	Total WEIM imports added (MWh)	Total cost of assistance energy transfers	Total cost per added WEIM imports
Avangrid	10	58	$8,223	$143
California ISO	1	0	$97,020	*
Idaho Power	4	11	$7,408	$645
NorthWestern Energy	19	65	$217,427	$3,352
NV Energy	3	78	$41,983	$539
PacifiCorp East	3	45	$6,963	$153
PacifiCorp West	0	N/A	N/A	N/A
PNM	79	973	$870,527	$895
Portland General Electric	0	N/A	N/A	N/A
WAPA Desert Southwest	9	223	$22,913	$103

WEIM entities have expressed concern that leaning on assistance energy transfers may cause multiple balancing areas to procure less in advance, therefore exacerbating more-widespread scarcity conditions. If multiple balancing areas are frequently failing the resource sufficiency evaluation at the same time while opting in to receiving assistance energy transfers, that can be an indicator of extensive reliance on AET during tight west-wide conditions. If individual balancing areas are instead failing the resource sufficiency evaluation in isolated non-coincident events while opting in to receiving AET, that can reflect more localized and varied issues at the balancing area level. Figure 5.1 shows intervals when at least one balancing area failed the resource sufficiency evaluation while opted in to receiving AET. The blue bars indicate that only one balancing area failed the resource sufficiency evaluation while opted in to AET. The yellow bars indicate that two balancing areas failed the RSE while opted into AET. There were no cases with three or more balancing areas. Failures while opted in to receiving AET were not highly coincident across balancing areas.

Figure 5.1 Frequency of coincident resource sufficiency evaluation failures while opted in to receiving assistance energy transfers



6 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, 2023 using a method called *mosaic quantile regression*. Details on the calculation are included in Appendix B. This section summarizes 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.

Symmetric sampling to calculate net load uncertainty

The regressions use a distribution of historical forecast observations from 180 days, separate for each balancing area and hour to calculate uncertainty. Prior to August 14, 2024, the historical observations were selected from the previous 180 days. On August 14, 2024, the ISO changed the methodology to instead select the observations from two periods (1) the previous 90 days and (2) the next 90 days minus one year.[10] This is known as symmetric sampling.

The intent of this change was to improve the performance of the calculation, particularly during transition periods (for example, from spring to summer or summer to fall). By including historical observations from the following 90 days of the previous year, the historical data used to estimate uncertainty can be better representative of seasonal conditions in the present.

Uncertainty is calculated by first running a regression on historical data to determine the relationship between forecast information and uncertainty—and then second, by combining current forecast information with the resulting regression coefficients to estimate uncertainty in the present. Table 6.1 and Table 6.2 show the average upward and downward uncertainty in the seven days before and after the switch to symmetric sampling. This uncertainty was calculated using a constant average forecast over the two-week period in combination with the actual regression coefficients before and after the change. This better captures the change in net load uncertainty associated with the change to the underlying historical data rather than natural variation in the current real-time forecast. On average, upward uncertainty for Salt River Project increased by 10 percent while upward uncertainty for PacifiCorp East increased by 7 percent.

[10] Changes to Net-Demand Uncertainty Requirement Calculation Methodology in Flexible Ramping Product effective trade date 8/14/24: https://www.caiso.com/notices/changes-to-net-demand-uncertainty-requirement-calculation-methodology-in-flexible-ramping-product-effective-trade-date-8-14-24

Table 6.1 Average upward uncertainty requirement prior to and after change to symmetric sampling (calculated from constant average forecast)

Entity	Backward 180-day sampling (August 7 to August 13, 2024)	Symmetric 90-day sampling (August 14 to August 20, 2024)	Difference (MW)	Difference percent
Salt River Proj.	148	162	14	10%
PacifiCorp East	366	393	27	7%
Portland Gen. Elec.	145	154	9	6%
NV Energy	261	276	16	6%
Arizona Publ. Serv.	225	238	13	6%
PSC of New Mexico	145	151	6	4%
WAPA DSW	26	27	1	4%
LADWP	166	172	6	4%
Puget Sound En.	120	124	4	3%
Turlock Irrig. Dist.	8	8	0	2%
NorthWestern En.	53	53	0	1%
Tucson Elec. Pow.	115	115	0	0%
California ISO	1,084	1,063	-22	-2%
Idaho Power	143	139	-4	-3%
Seattle City Light	19	18	-1	-3%
Avangrid	274	262	-12	-4%
Powerex	126	120	-7	-5%
BPA	288	273	-16	-5%
El Paso Electric	48	44	-4	-8%
PacifiCorp West	112	102	-10	-9%
BANC	48	43	-4	-9%
Avista	69	62	-7	-10%
Tacoma Power	10	9	-1	-12%

Table 6.2 Average downward uncertainty requirement prior to and after change to symmetric sampling (calculated from constant average forecast)

Entity	Backward 180-day sampling (August 7 to August 13, 2024)	Symmetric 90-day sampling (August 14 to August 20, 2024)	Difference (MW)	Difference percent
NorthWestern En.	75	79	5	6%
Salt River Proj.	174	183	9	5%
Seattle City Light	19	20	1	5%
Powerex	139	144	5	4%
Turlock Irrig. Dist.	9	9	0	3%
PacifiCorp East	570	580	9	2%
WAPA DSW	29	29	0	1%
BANC	45	45	0	0%
Puget Sound En.	152	152	-1	-1%
LADWP	175	172	-4	-2%
El Paso Electric	45	43	-2	-4%
Tucson Elec. Pow.	98	93	-6	-6%
Tacoma Power	10	9	-1	-6%
NV Energy	256	241	-15	-6%
Idaho Power	164	152	-12	-7%
Portland Gen. Elec.	156	143	-13	-8%
PacifiCorp West	147	135	-12	-8%
California ISO	763	695	-68	-9%
Avista	96	88	-9	-9%
PSC of New Mexico	172	156	-16	-9%
Arizona Publ. Serv.	241	219	-22	-9%
Avangrid	220	196	-24	-11%
BPA	311	252	-60	-19%

Thresholds for capping uncertainty

Uncertainty calculated from the quantile regressions is 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 updated each day and pulled for each hour from the 1st and 99th percentile of net load error observations from the 180-day period.[11] 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 6.1 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. Averaging across all balancing areas, the thresholds capped the calculated upward uncertainty in around 12 percent of intervals and the calculated downward uncertainty in around 11 percent of intervals. In the large majority of cases with capped uncertainty, 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

[11] The histogram threshold also uses symmetric sampling, from historical observations from the previous 90 days as well as the next 90 days minus one year.

regression would be negative. Figure 6.2 shows the percent of test intervals in which the quantile regression uncertainty was set near zero by this threshold during the quarter.

Figure 6.1 Quantile regression uncertainty capped by mosaic or histogram thresholds (July–September 2024)

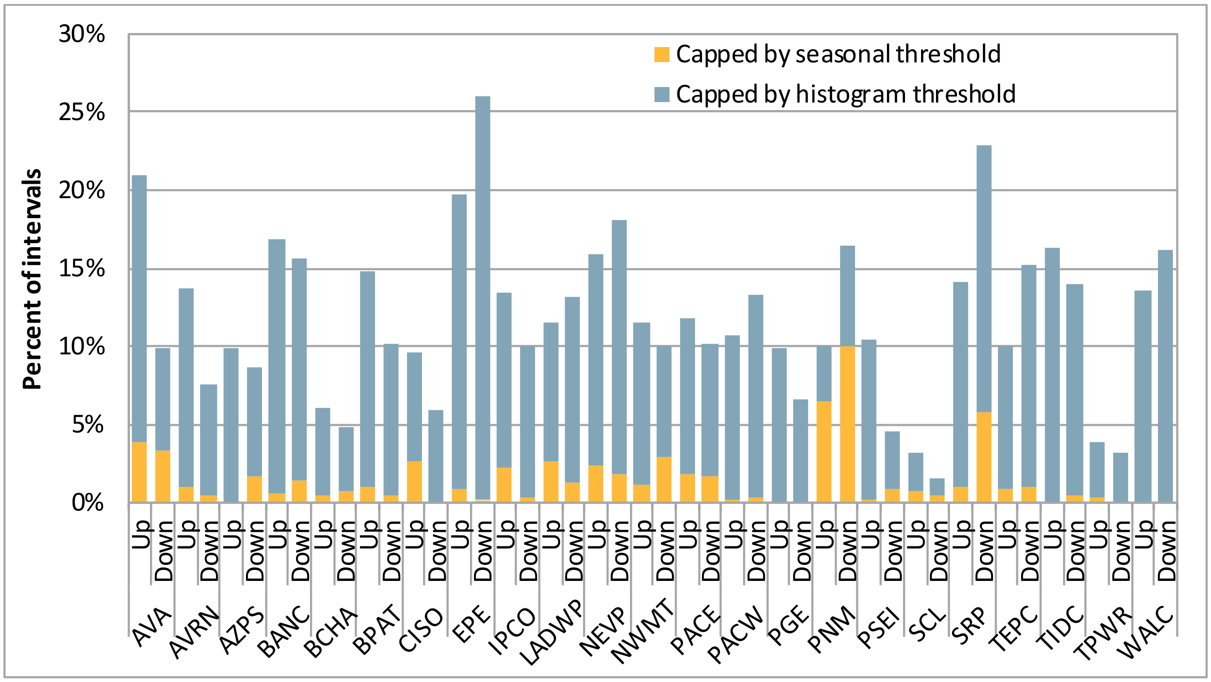
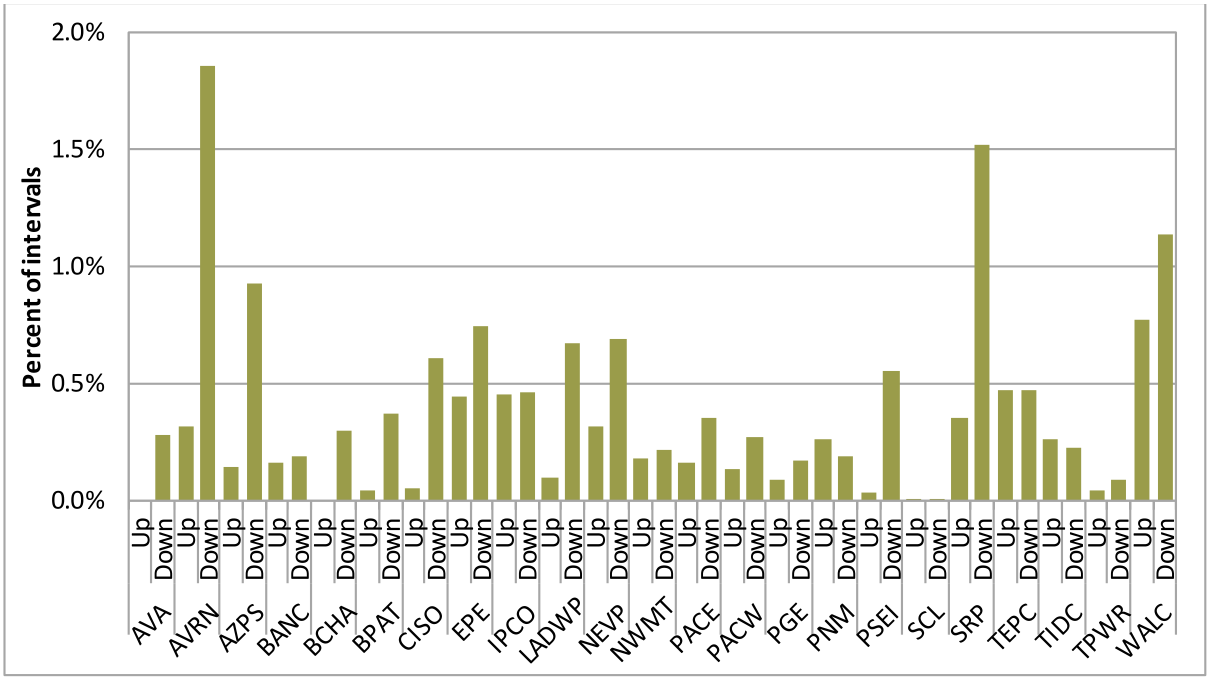


Figure 6.2 Quantile regression uncertainty set near zero by mosaic threshold (July–September 2024)



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.[12]

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.[13]

---

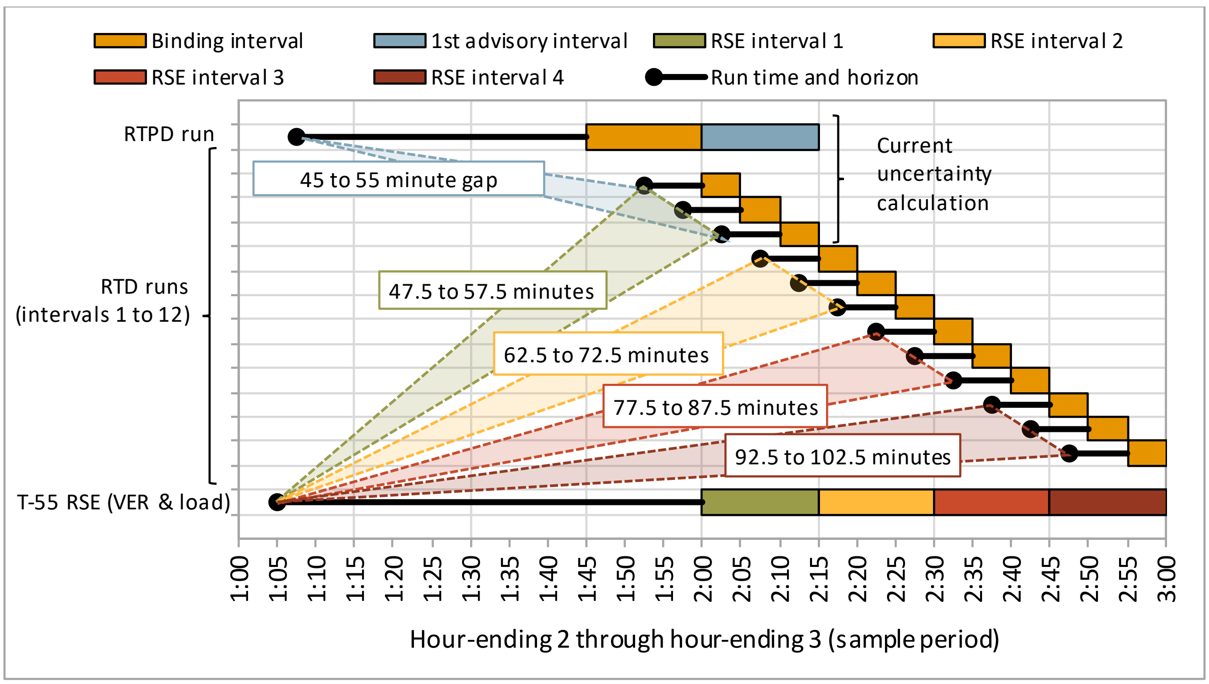
12 A balancing-area-specific flexible ramping product uncertainty requirement will be enforced for any balancing area that failed the resource sufficiency evaluation.

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

Further, the resource sufficiency evaluation occurs in a different timeframe than the 15-minute market. Figure 6.3 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.[14]

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.

Figure 6.3 Comparison of current uncertainty calculation to the timeframe of the RSE



[14] 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.

Results of quantile regression uncertainty in the resource sufficiency evaluation

Figure 6.4 through Figure 6.26 show 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 for all balancing areas during the third quarter. 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 show the average histogram and seasonal thresholds, respectively, during the quarter.

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, including periods with zero uncertainty.

Figure 6.4 Arizona Public Service resource sufficiency evaluation uncertainty requirements (July–September 2024)

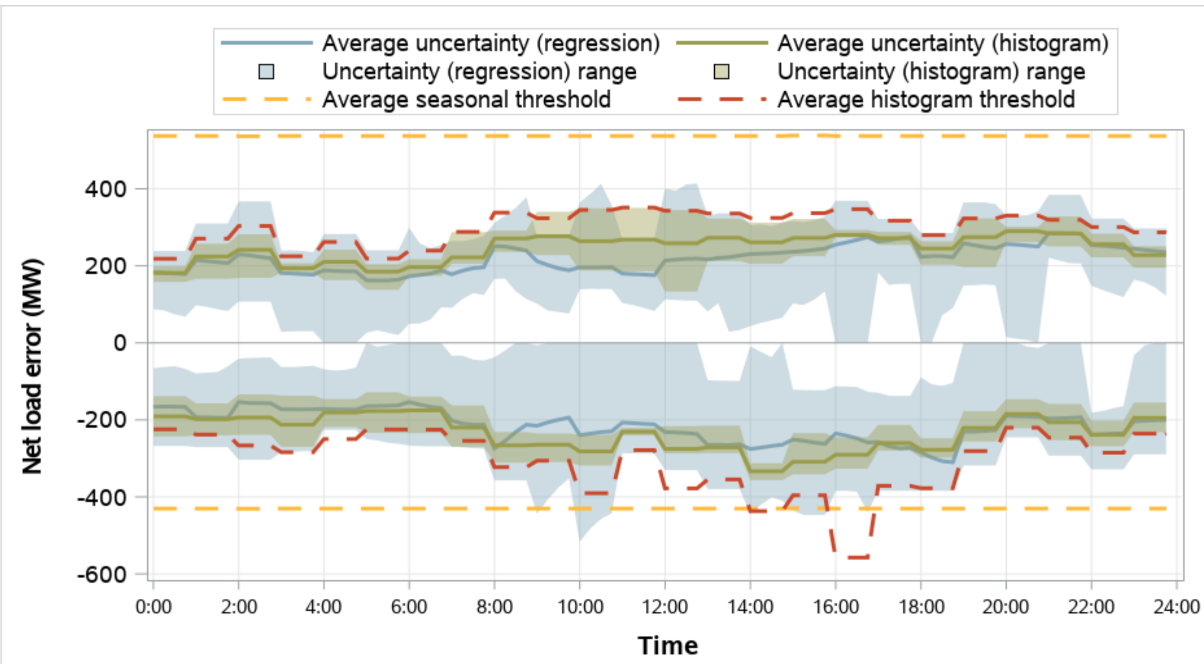


Figure 6.5 Avangrid resource sufficiency evaluation uncertainty requirements (July–September 2024)

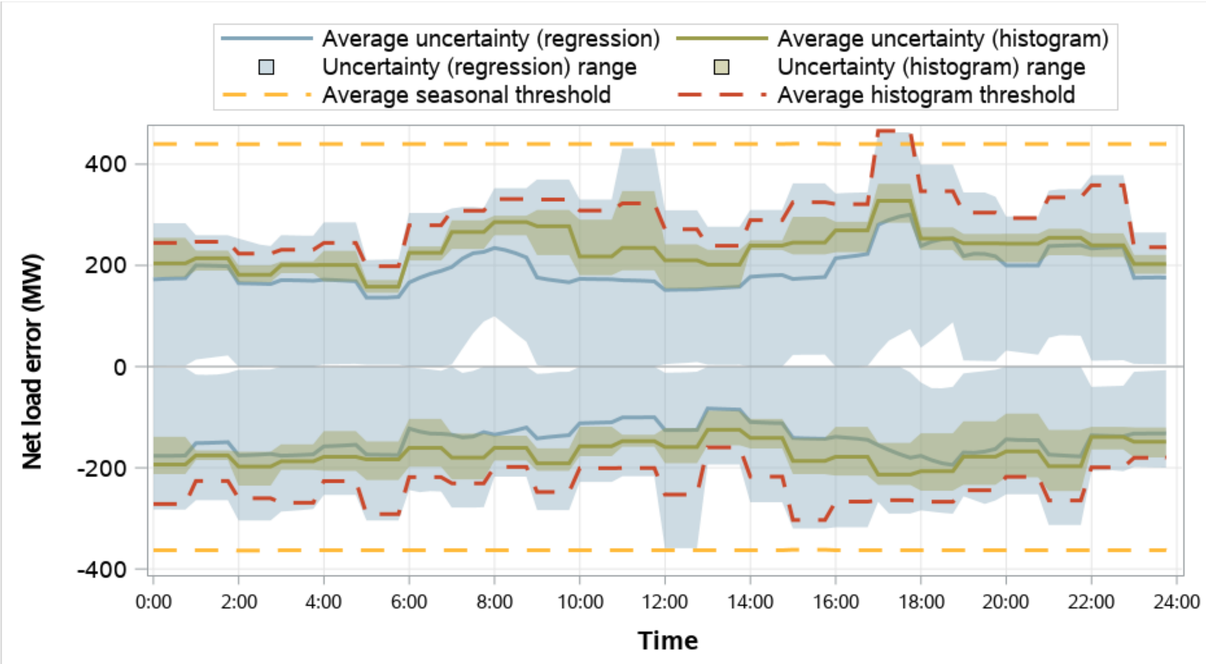


Figure 6.6 Avista resource sufficiency evaluation uncertainty requirements (July–September 2024)

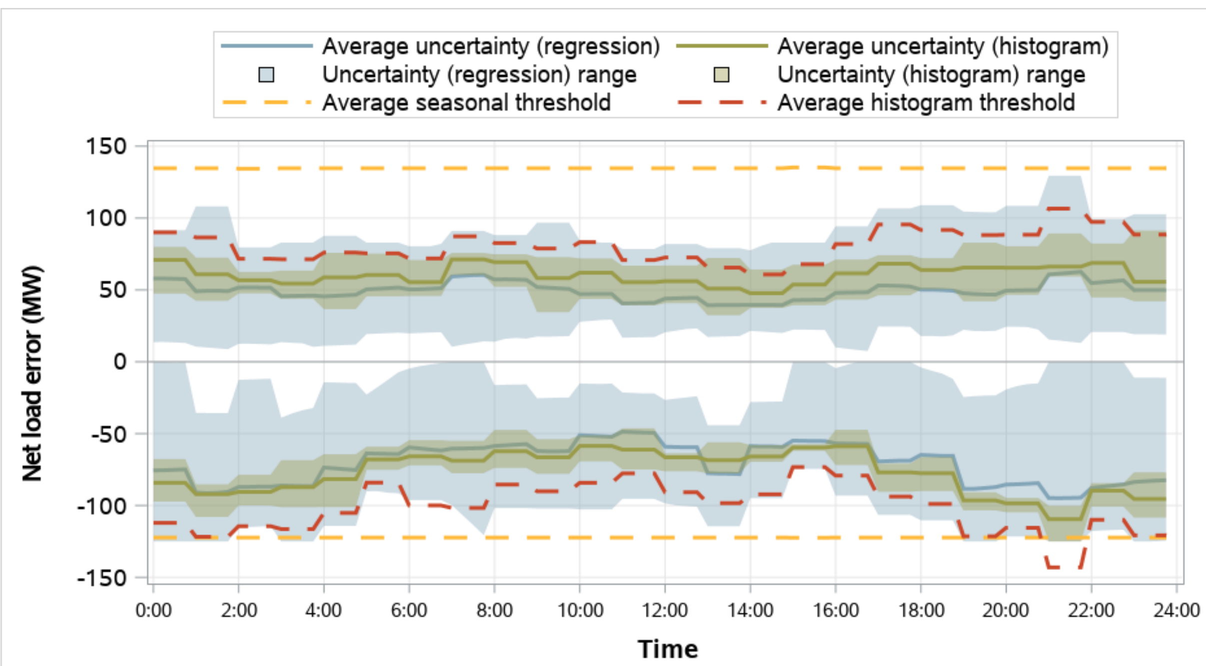


Figure 6.7 BANC resource sufficiency evaluation uncertainty requirements (July–September 2024)

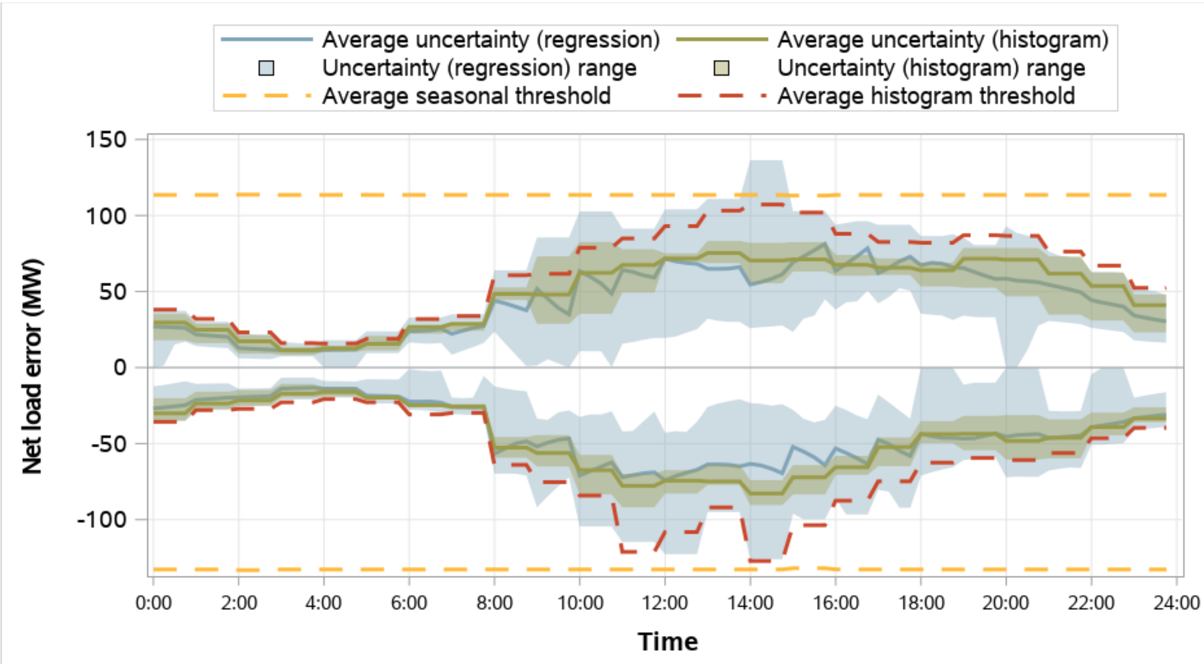


Figure 6.8 BPA resource sufficiency evaluation uncertainty requirements (July–September 2024)

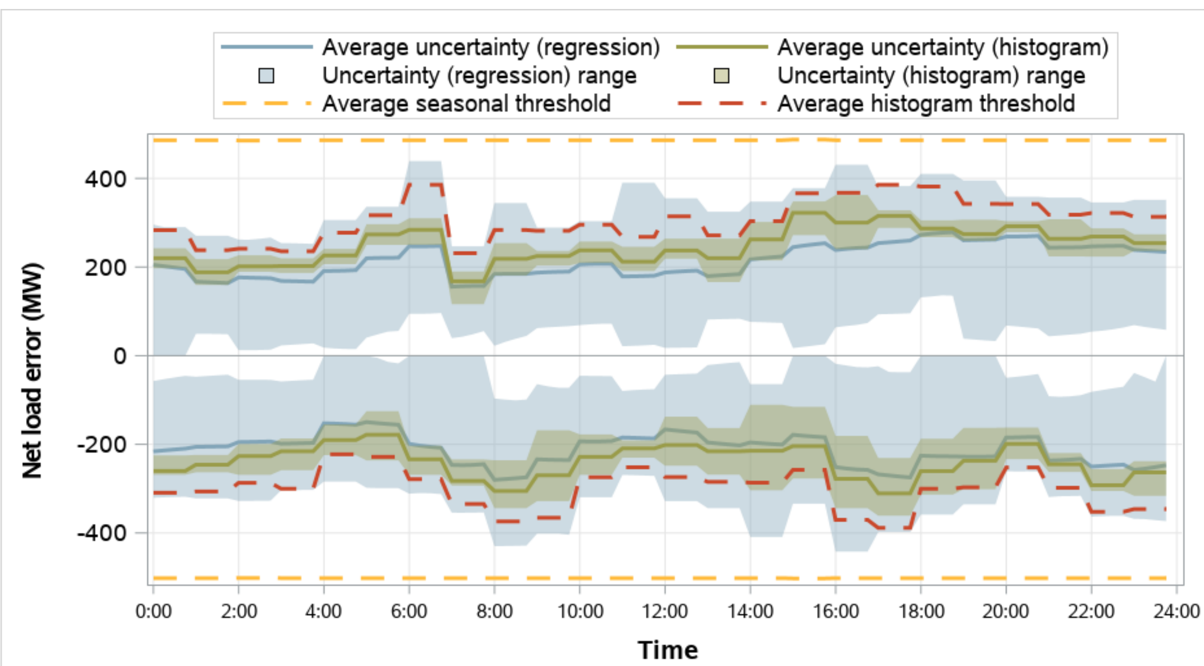


Figure 6.9 California ISO resource sufficiency evaluation uncertainty requirements (July–September 2024)

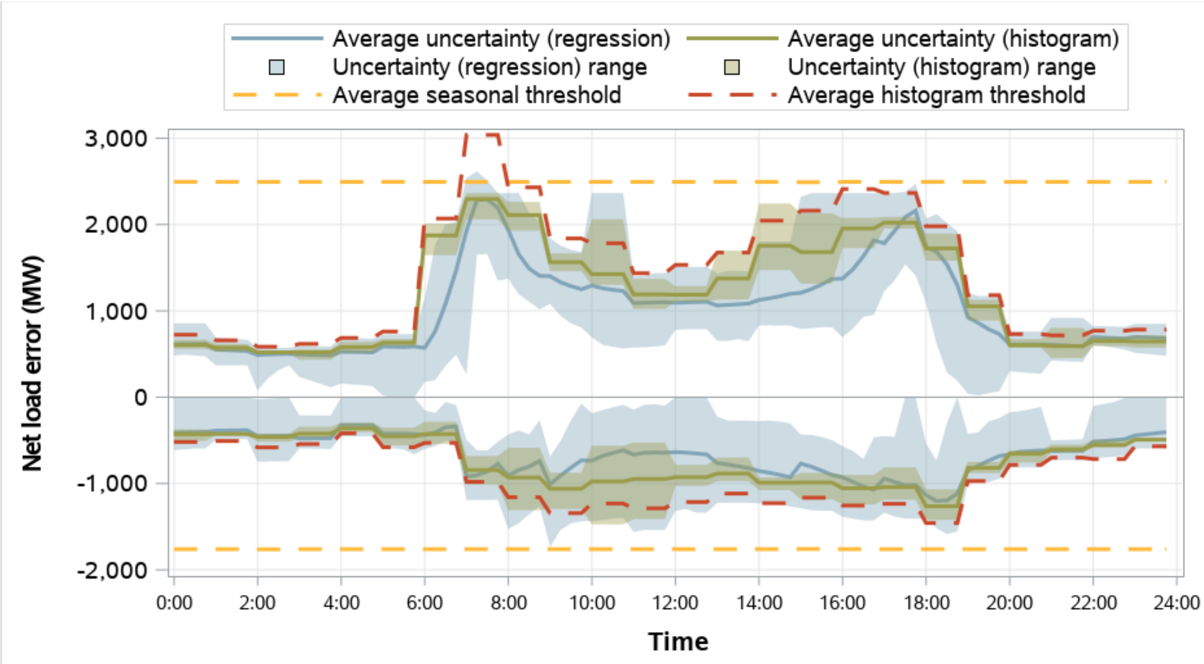


Figure 6.10 El Paso Electric resource sufficiency evaluation uncertainty requirements (July–September 2024)

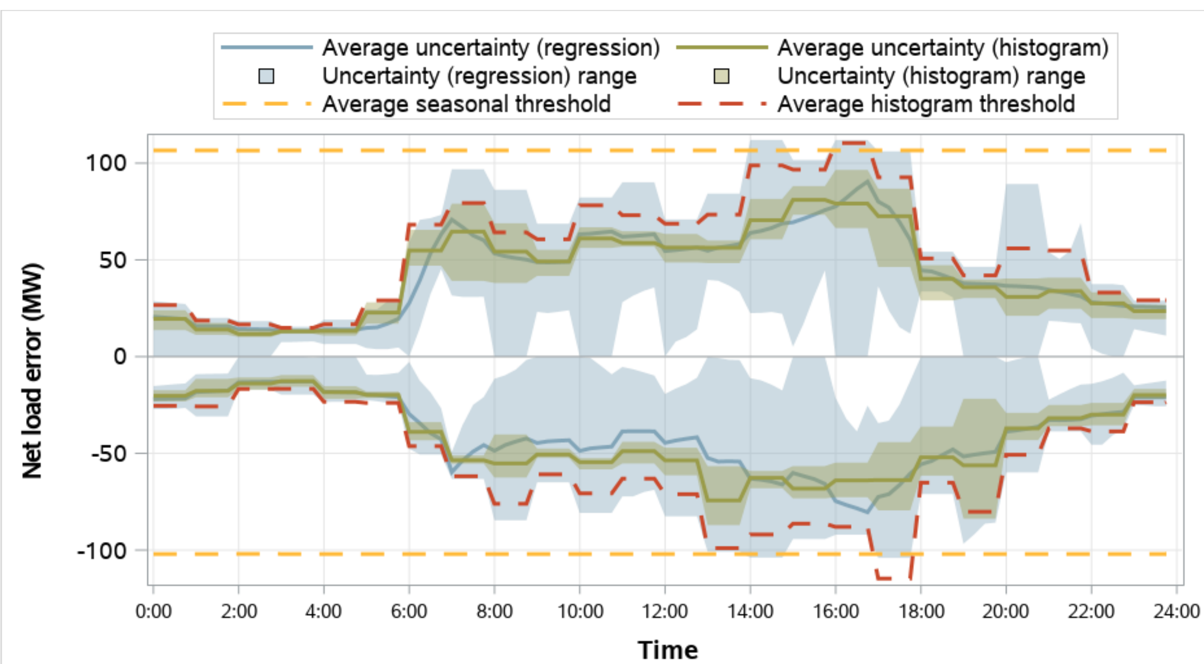


Figure 6.11 Idaho Power resource sufficiency evaluation uncertainty requirements (July–September 2024)

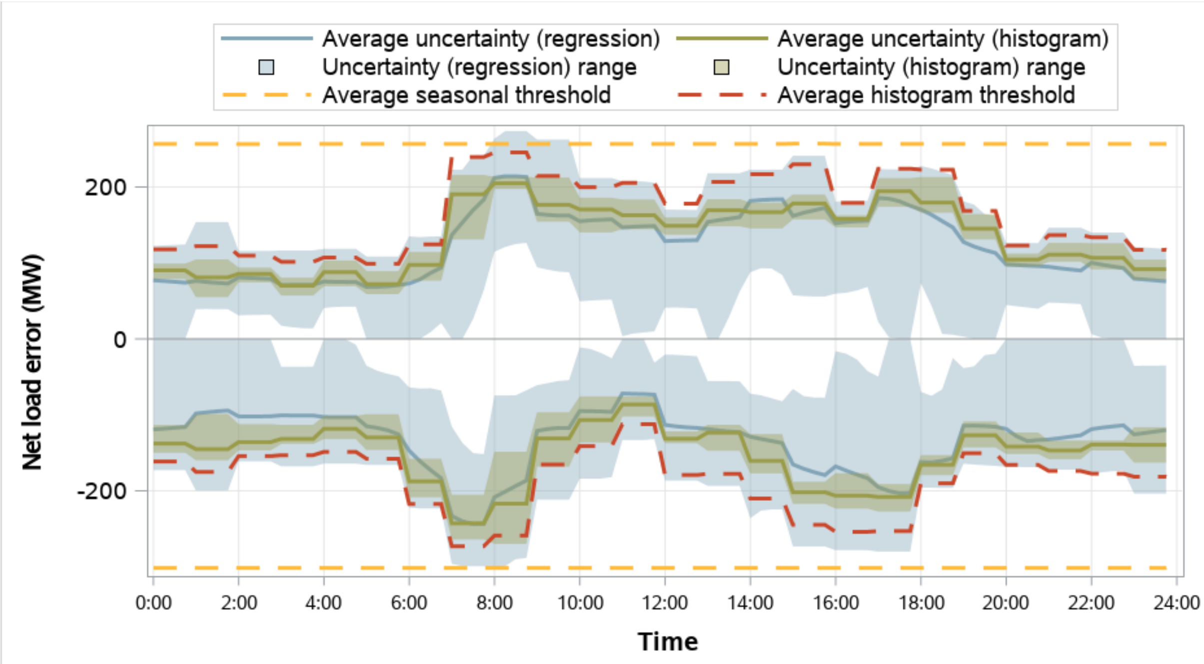


Figure 6.12 LADWP resource sufficiency evaluation uncertainty requirements (July–September 2024)

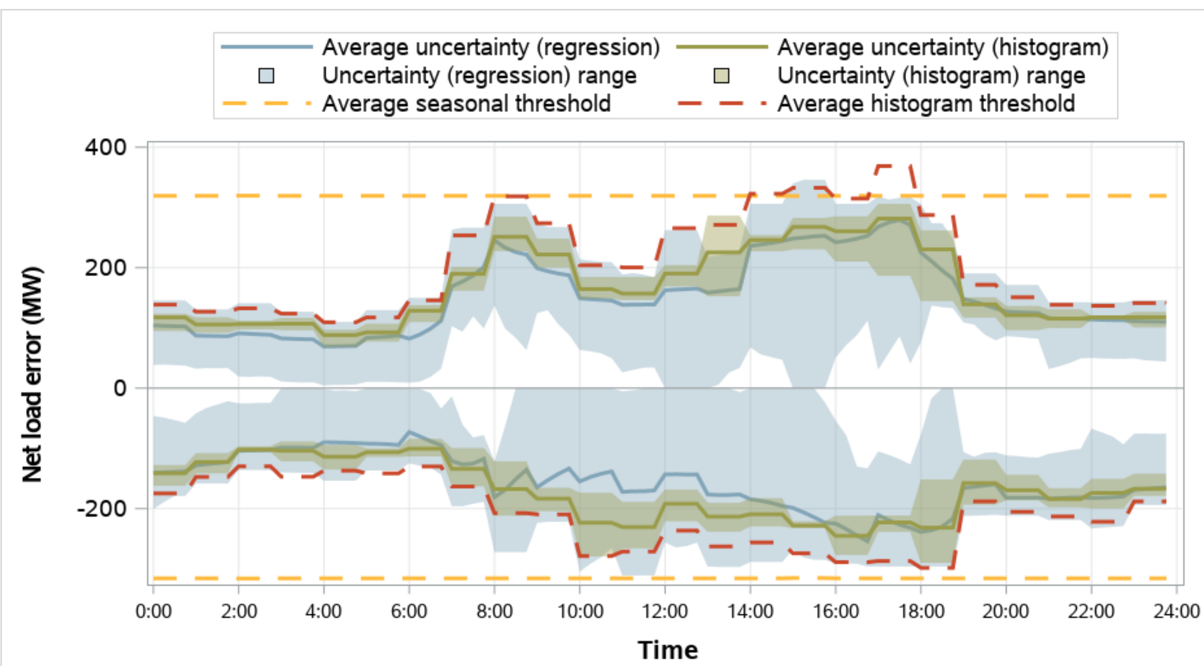


Figure 6.13 NorthWestern Energy resource sufficiency evaluation uncertainty requirements (July–September 2024)

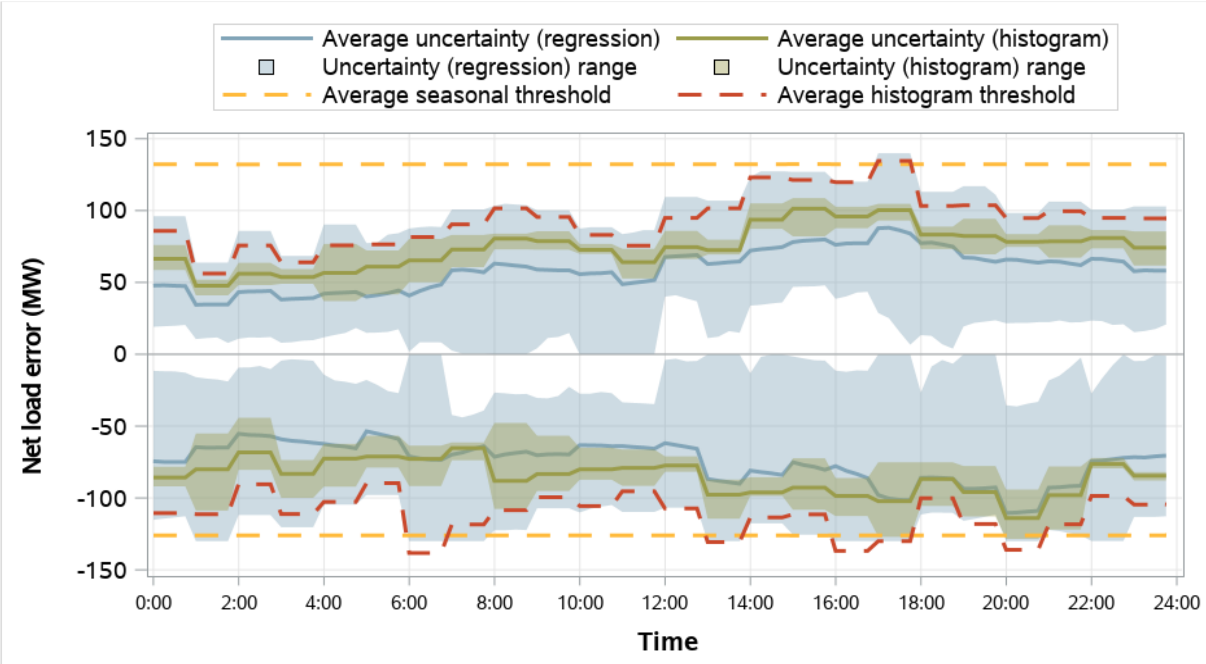


Figure 6.14 NV Energy resource sufficiency evaluation uncertainty requirements (July–September 2024)

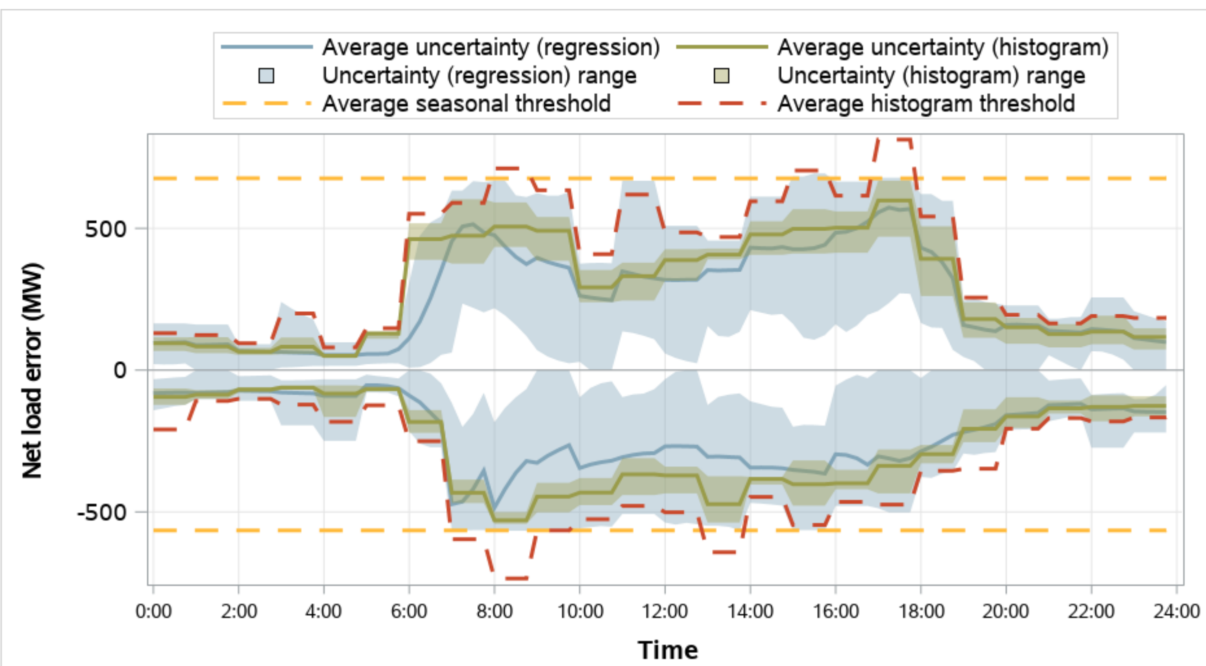


Figure 6.15 PacifiCorp East resource sufficiency evaluation uncertainty requirements (July–September 2024)

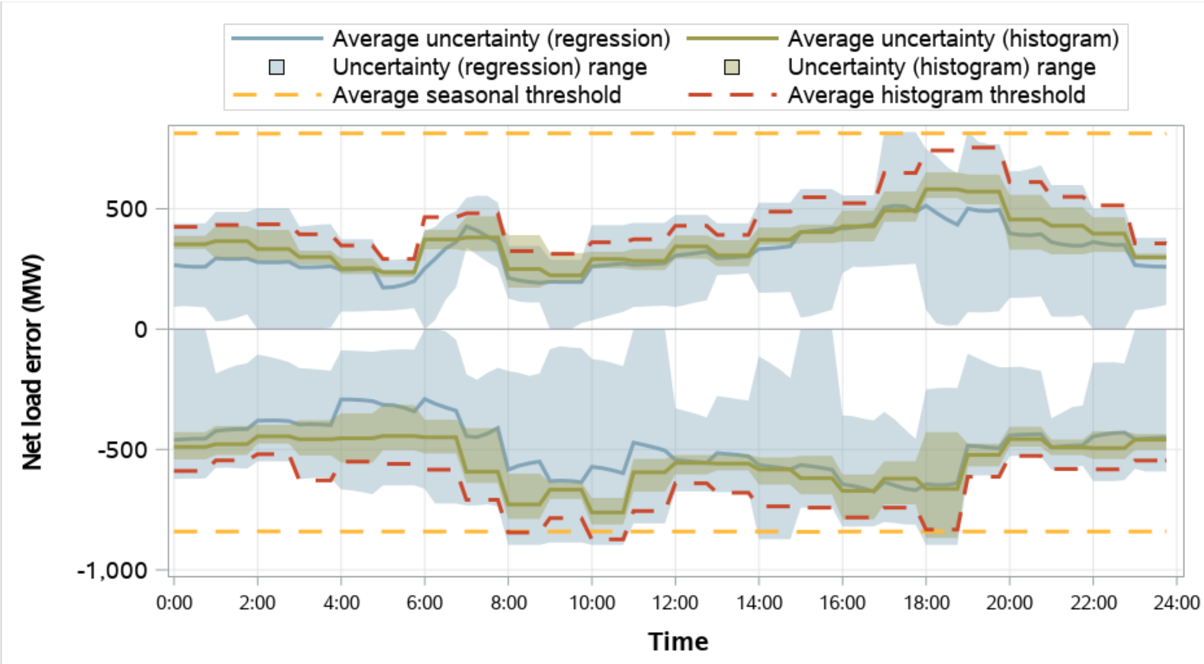


Figure 6.16 PacifiCorp West resource sufficiency evaluation uncertainty requirements (July–September 2024)

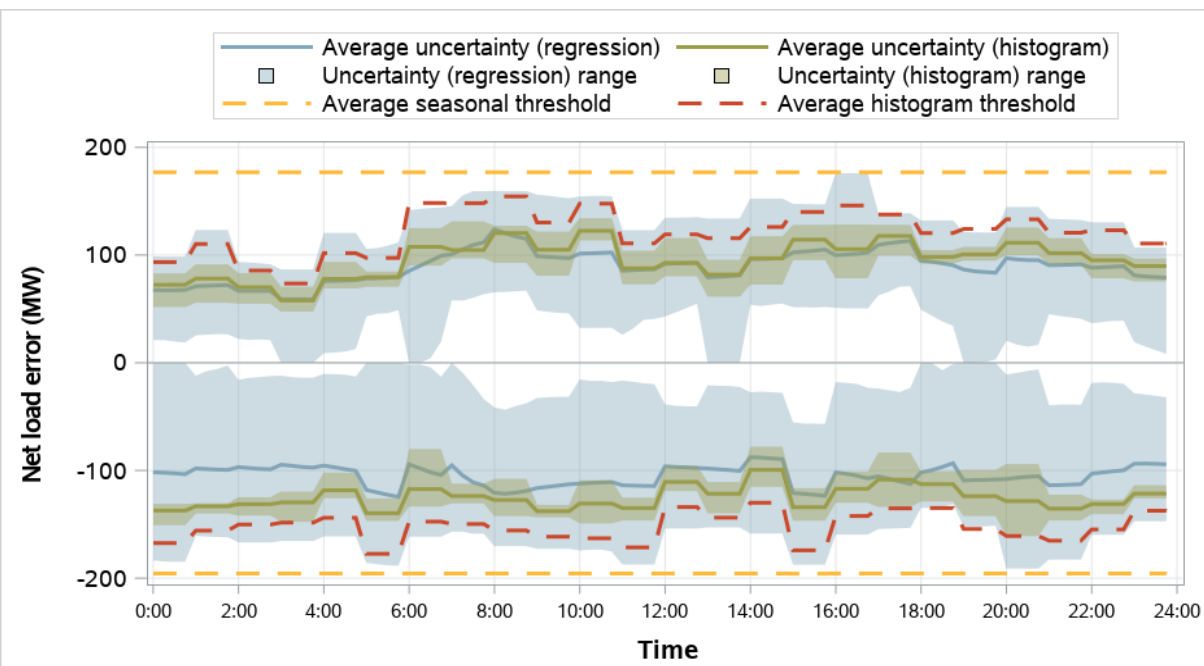


Figure 6.17 Portland General Electric resource sufficiency evaluation uncertainty requirements (July–September 2024)

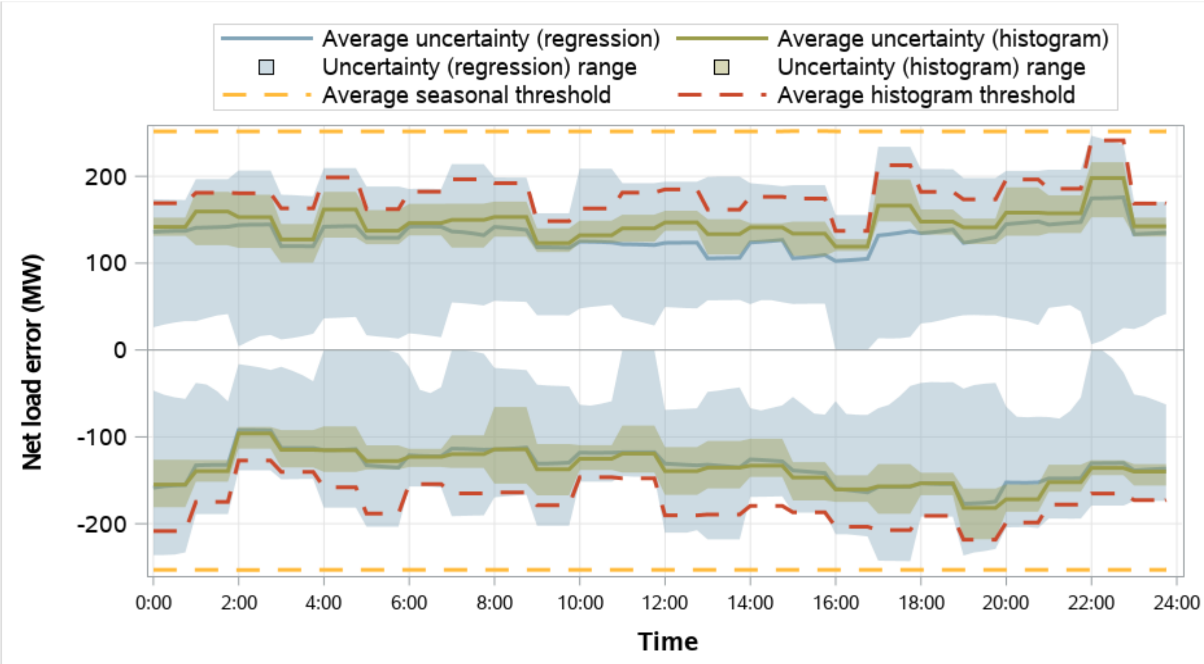


Figure 6.18 Powerex resource sufficiency evaluation uncertainty requirements (July–September 2024)

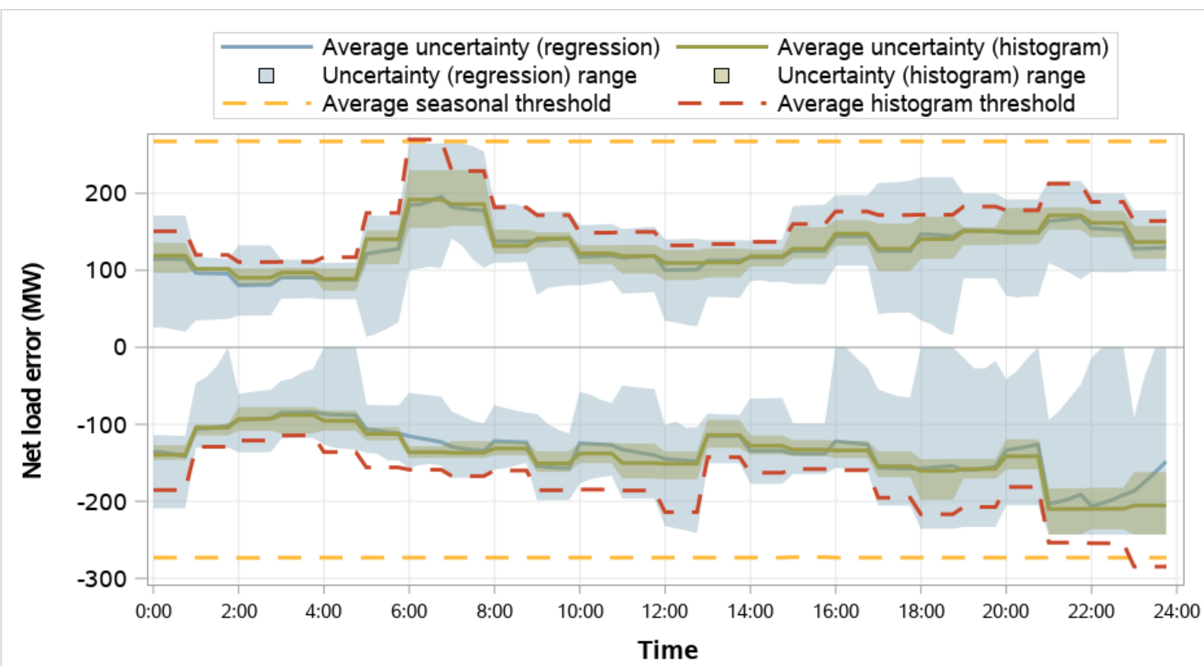


Figure 6.19 PNM resource sufficiency evaluation uncertainty requirements (July–September 2024)

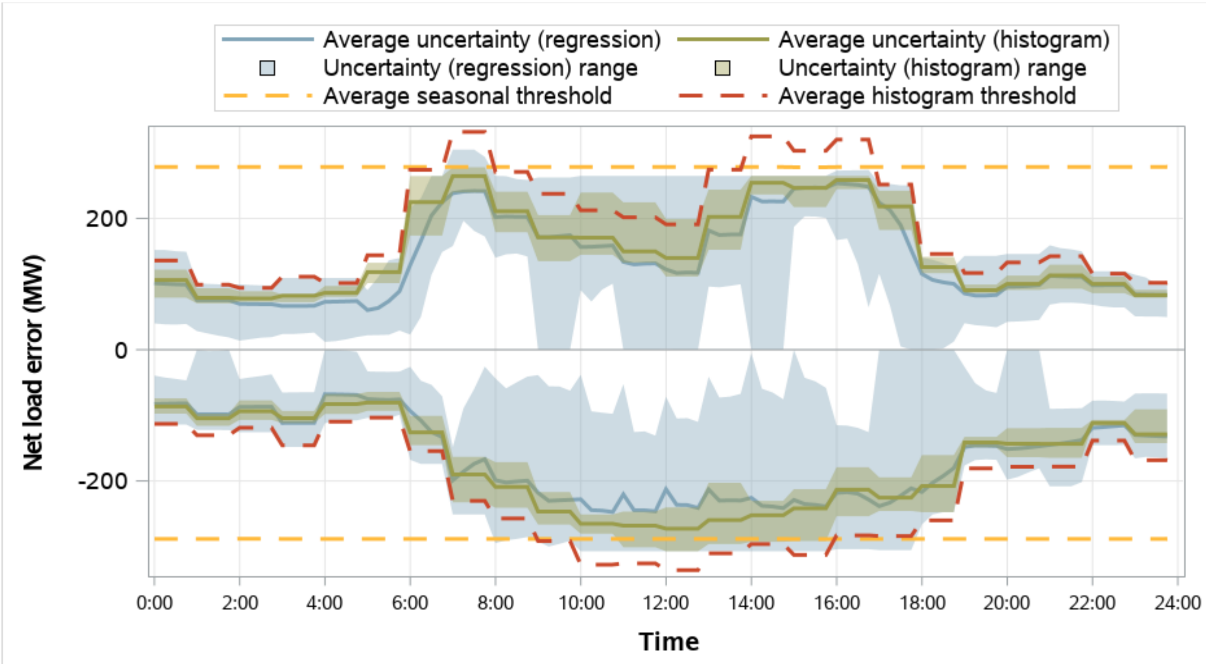


Figure 6.20 Puget Sound Energy resource sufficiency evaluation uncertainty requirements (July–September 2024)

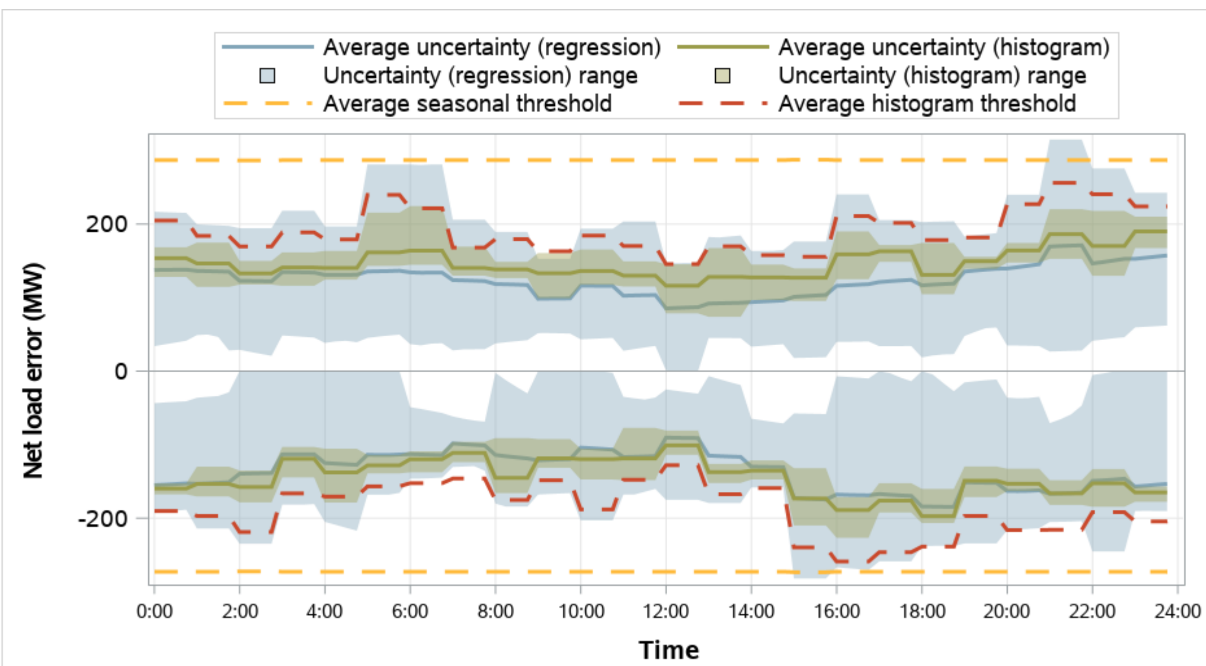


Figure 6.21 Salt River Project resource sufficiency evaluation uncertainty requirements (July–September 2024)

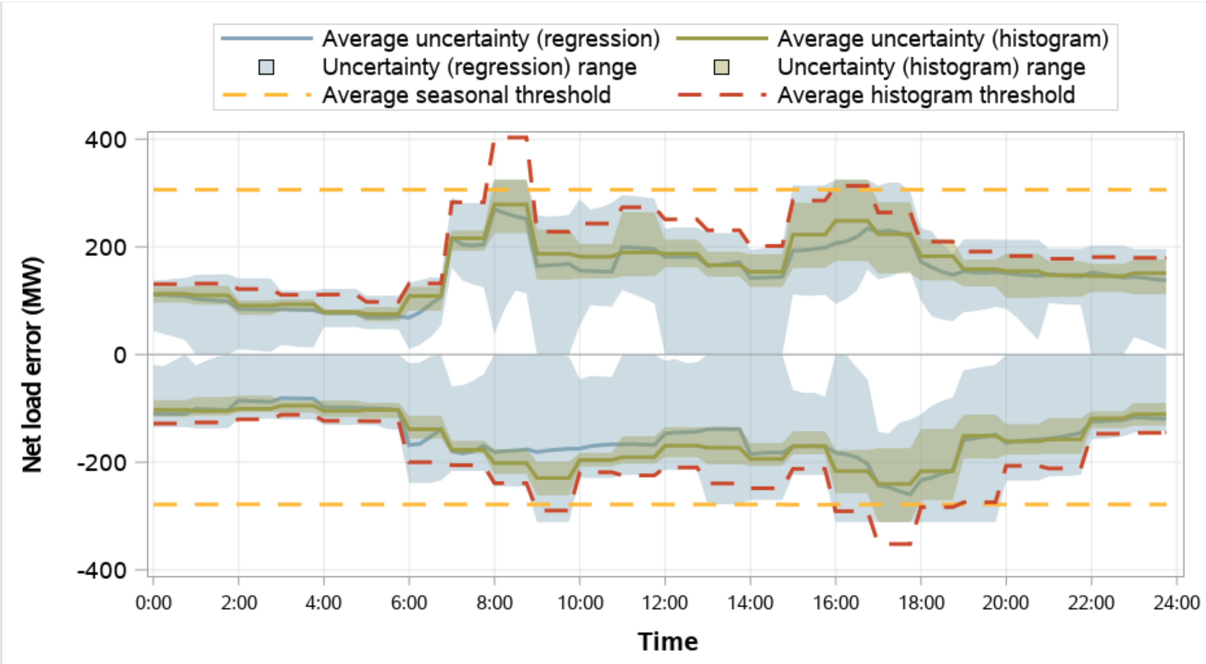


Figure 6.22 Seattle City Light resource sufficiency evaluation uncertainty requirements (July–September 2024)

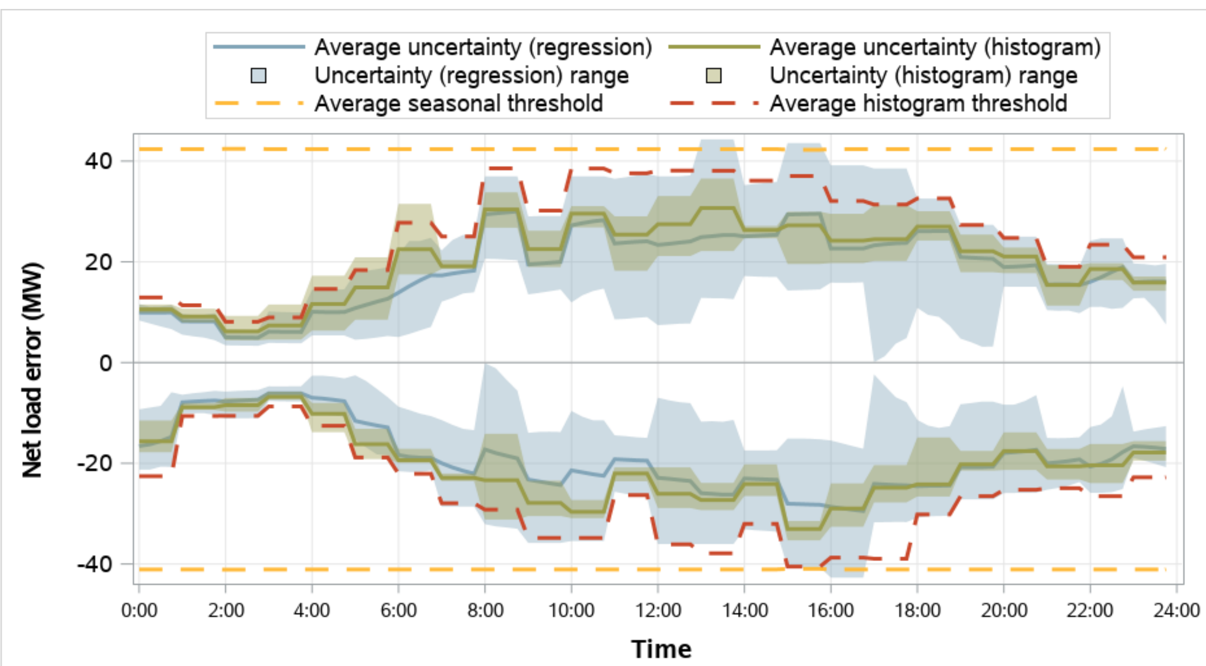


Figure 6.23 Tacoma Power resource sufficiency evaluation uncertainty requirements (July–September 2024)

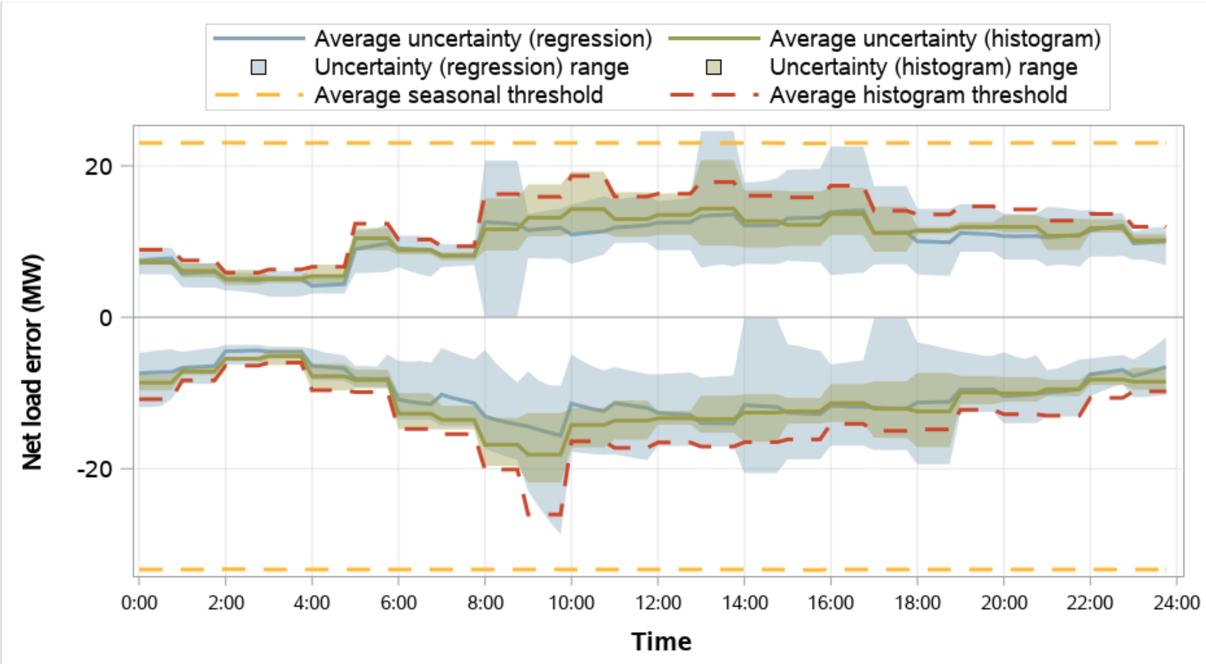


Figure 6.24 Tucson Electric Power resource sufficiency evaluation uncertainty requirements (July–September 2024)

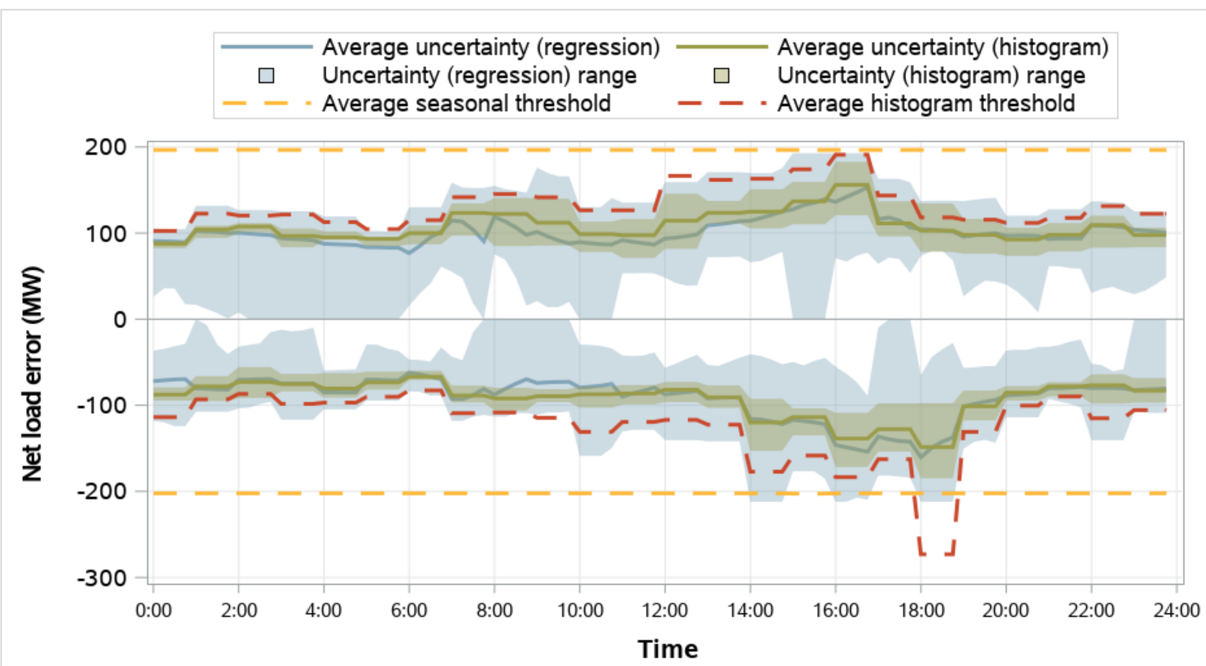


Figure 6.25 Turlock Irrigation District resource sufficiency evaluation uncertainty requirements (July–September 2024)

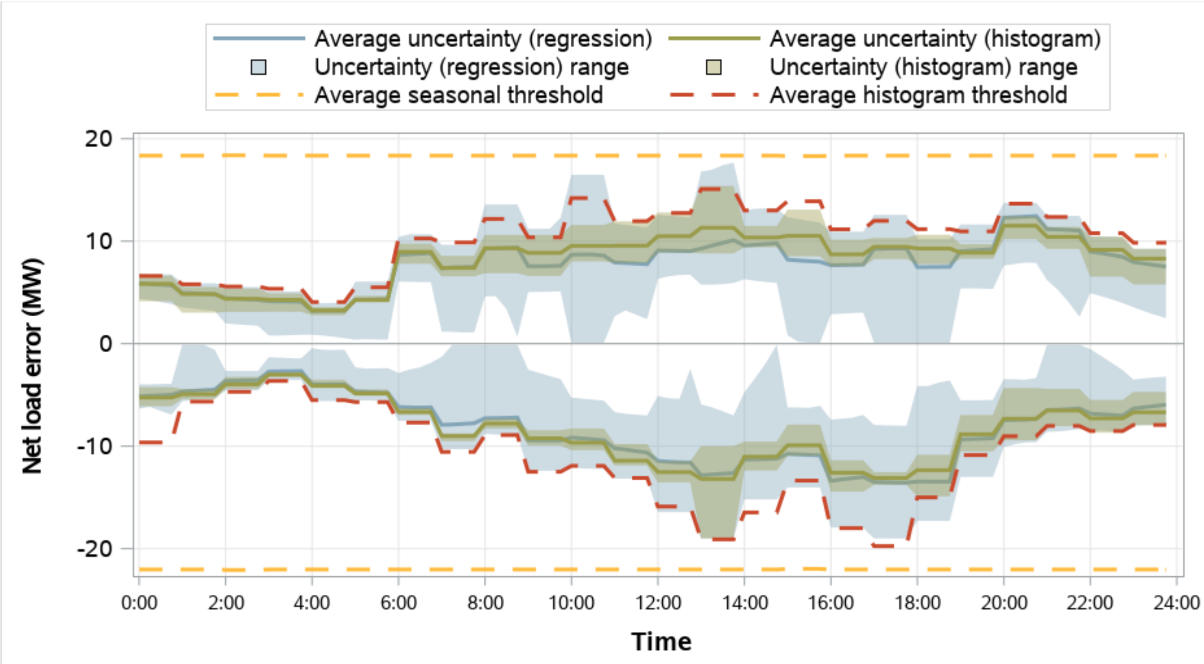
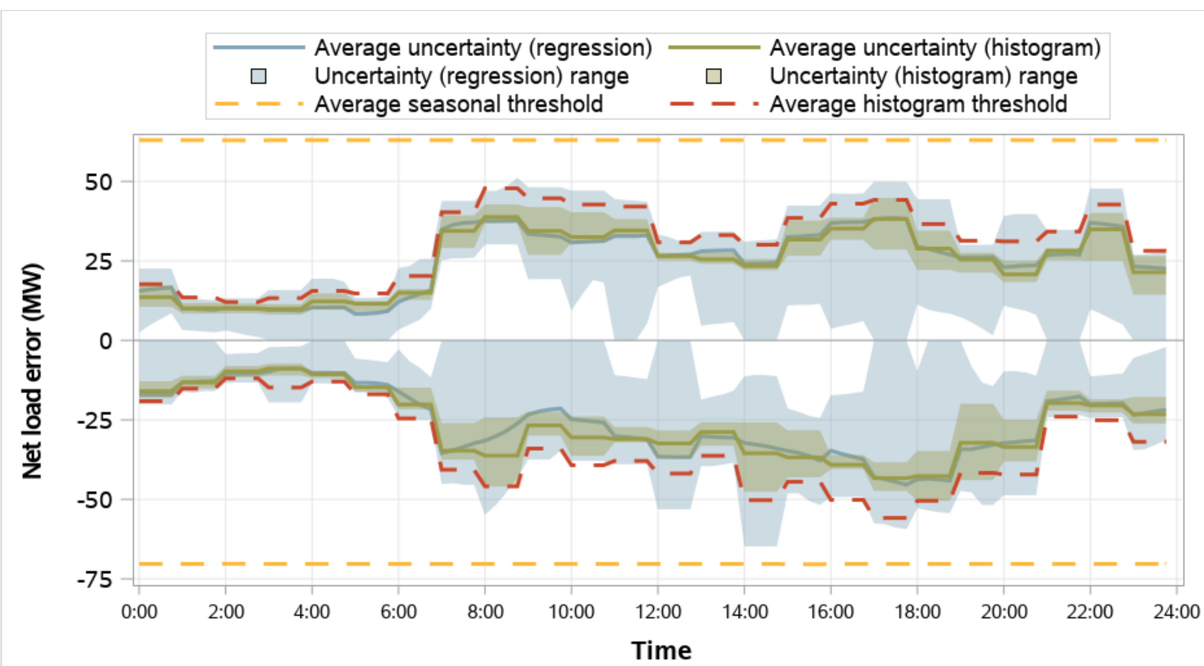


Figure 6.26 WAPA Desert Southwest resource sufficiency evaluation uncertainty requirements (July–September 2024)



Performance measurements of quantile regression uncertainty

Table 6.3 summarizes the average requirements calculated using both the histogram and mosaic quantile regression methods. The blue cells highlight balancing areas and directions in which the calculated uncertainty from the regression method was less than the histogram method, while the orange regions highlight that the regression method had greater calculated uncertainty. On average across all hours, the uncertainty calculated from the regression method was less than the histogram method for almost all of the WEIM entities.

Table 6.4 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.[15] 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.[16] The calculated uncertainty from the mosaic regression covered between 75 and 91 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 6.5 shows the same information as Table 6.4, except with requirements calculated from the histogram method. Coverage from the histogram method was more than the regression method for most balancing areas.

15 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.

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

Table 6.3 Average uncertainty requirements in the resource sufficiency evaluation (July–September 2024)

	Upward uncertainty			Downward uncertainty		
Balancing area	**Histogram**	**Mosaic**	***Difference***	**Histogram**	**Mosaic**	***Difference***
Arizona Public Service	247.2	220.3	-27.0	-235.4	-215.6	19.8
Avangrid	233.3	193.4	-39.8	-172.9	-144.2	28.6
Avista	60.8	49.6	-11.1	-77.0	-70.8	6.3
BANC	49.1	44.6	-4.5	-46.2	-42.3	3.8
Bonneville Power Admin.	248.2	215.1	-33.1	-240.1	-212.6	27.5
California ISO	1,214.6	1,036.3	-178.3	-749.7	-665.0	84.6
El Paso Electric	43.6	43.4	-0.2	-42.4	-40.0	2.4
Idaho Power	135.3	124.5	-10.8	-152.4	-134.0	18.4
LADWP	168.6	152.2	-16.3	-171.7	-156.9	14.8
NorthWestern Energy	74.7	59.3	-15.3	-85.4	-75.1	10.3
NV Energy	293.5	258.8	-34.6	-261.2	-219.1	42.1
PacifiCorp East	363.4	324.3	-39.1	-552.1	-490.1	62.1
PacifiCorp West	95.5	89.3	-6.1	-125.2	-105.0	20.1
Portland General Electric	146.4	131.7	-14.7	-137.2	-133.7	3.6
Powerex	132.7	129.2	-3.5	-140.6	-134.6	6.0
PNM	153.3	139.2	-14.1	-174.8	-166.0	8.8
Puget Sound Energy	147.2	124.2	-22.9	-145.1	-136.8	8.3
Salt River Project	161.2	151.2	-10.0	-159.2	-150.6	8.6
Seattle City Light	20.4	18.8	-1.6	-20.7	-18.8	1.8
Tacoma Power	10.6	10.1	-0.5	-11.1	-10.1	1.0
Tucson Electric Power	108.5	102.2	-6.4	-92.6	-91.5	1.1
Turlock Irrigation District	8.3	7.8	-0.5	-8.4	-8.2	0.1
WAPA Desert Southwest	24.9	25.1	0.1	-26.7	-25.8	0.8

Table 6.4 Actual net load error versus regression uncertainty requirements (July–September 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	84%	172.5	269.0	13%	73.9	3%	93.5
Avangrid	89%	163.4	179.3	6%	51.4	5%	53.3
Avista	87%	50.1	72.4	10%	17.7	4%	22.4
BANC	87%	44.5	42.4	7%	19.5	7%	19.6
Bonneville Power Admin.	90%	207.3	225.3	6%	70.7	4%	62.0
California ISO	88%	830.0	876.9	7%	326.7	5%	238.3
El Paso Electric	88%	40.6	44.2	7%	15.5	5%	20.4
Idaho Power	89%	127.8	134.4	7%	37.9	4%	39.6
LADWP	91%	150.7	161.3	6%	59.7	4%	39.3
NorthWestern Energy	89%	59.1	76.3	6%	19.3	5%	31.5
NV Energy	85%	224.7	268.4	12%	92.9	4%	103.7
PacifiCorp East	88%	346.0	474.8	9%	106.7	3%	131.1
PacifiCorp West	90%	95.8	101.0	5%	28.8	5%	33.8
Portland General Electric	88%	124.3	143.2	7%	35.7	5%	41.0
Powerex	88%	130.5	135.6	6%	41.2	6%	49.4
PNM	88%	130.4	174.5	9%	65.0	3%	45.6
Puget Sound Energy	90%	114.7	148.7	6%	46.7	4%	48.1
Salt River Project	75%	109.1	187.5	21%	83.3	3%	81.3
Seattle City Light	91%	18.9	18.9	4%	7.0	5%	5.8
Tacoma Power	90%	10.1	10.2	5%	2.7	6%	3.3
Tucson Electric Power	90%	94.2	100.8	5%	29.2	5%	50.1
Turlock Irrigation District	87%	8.1	8.0	6%	2.7	7%	4.0
WAPA Desert Southwest	84%	24.5	27.2	9%	9.1	7%	10.5

Table 6.5 Actual net load error versus histogram uncertainty requirements (July–September 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	87%	195.4	288.7	11%	73.1	2%	100.0
Avangrid	92%	202.3	204.8	4%	79.5	3%	74.2
Avista	91%	60.4	78.2	7%	22.7	2%	25.2
BANC	89%	50.0	45.9	6%	22.9	5%	23.2
Bonneville Power Admin.	92%	237.8	251.5	4%	94.7	3%	70.7
California ISO	92%	996.8	974.5	5%	367.2	3%	236.0
El Paso Electric	89%	40.8	46.5	7%	15.6	4%	24.7
Idaho Power	92%	136.0	152.6	5%	42.8	3%	43.5
LADWP	93%	164.5	177.1	4%	62.2	3%	45.1
NorthWestern Energy	92%	73.7	86.6	4%	24.2	4%	36.7
NV Energy	89%	253.9	315.7	8%	94.8	3%	127.9
PacifiCorp East	92%	380.5	536.5	7%	141.0	2%	147.5
PacifiCorp West	92%	100.7	120.4	3%	37.9	4%	38.8
Portland General Electric	90%	137.5	147.0	5%	45.8	5%	42.8
Powerex	89%	133.9	140.2	6%	40.0	5%	49.7
PNM	90%	142.2	184.8	7%	72.7	3%	50.4
Puget Sound Energy	93%	136.2	156.6	4%	59.7	3%	52.4
Salt River Project	78%	119.0	196.3	20%	84.1	2%	107.1
Seattle City Light	93%	20.5	20.7	3%	7.0	4%	6.6
Tacoma Power	92%	10.6	11.2	4%	2.7	4%	3.7
Tucson Electric Power	91%	99.6	102.0	4%	32.4	5%	52.6
Turlock Irrigation District	89%	8.6	8.3	5%	2.8	6%	4.1
WAPA Desert Southwest	85%	24.1	27.8	8%	9.4	7%	11.7

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 6.27 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 6.28 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 6.27 Megawatt change in upward quantile regression uncertainty between T-75 and T-55 resource sufficiency evaluation runs (July–September 2024)

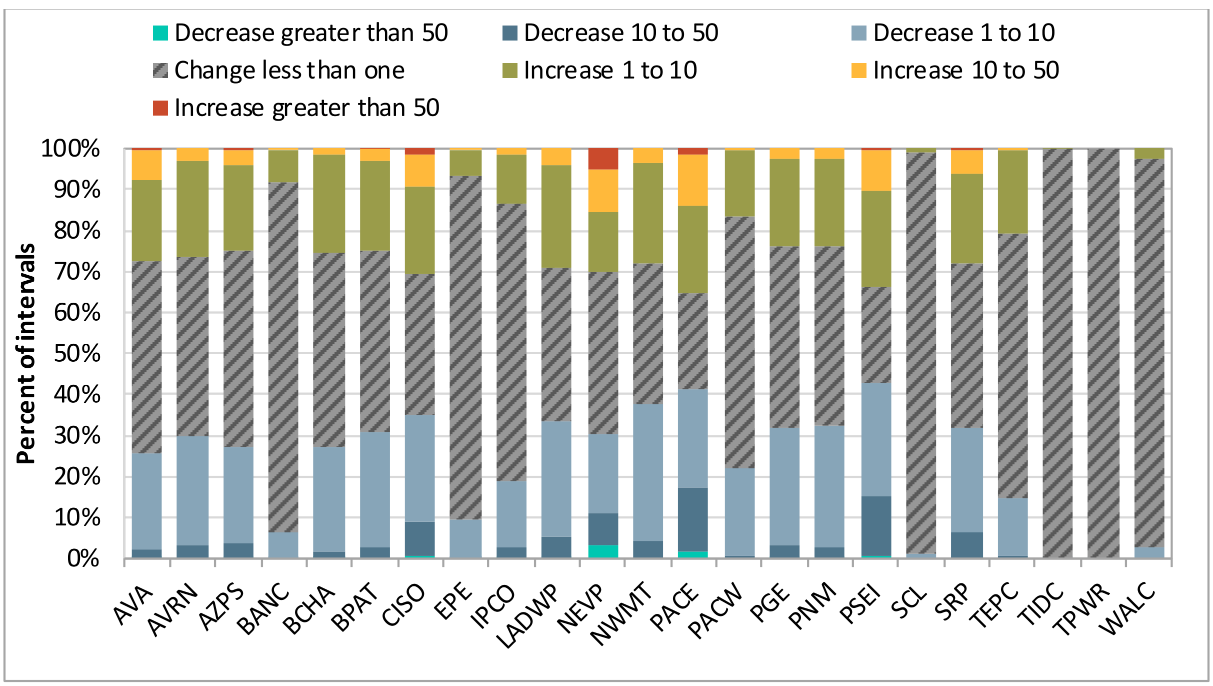
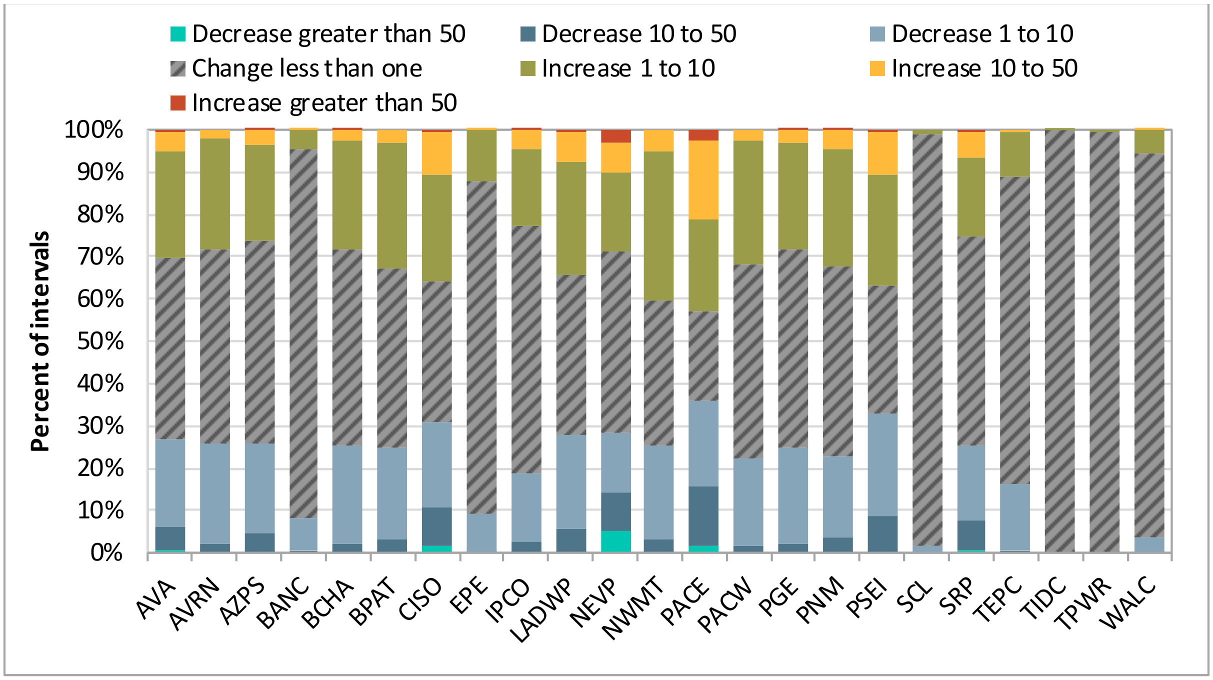


Figure 6.28 Megawatt change in downward quantile regression uncertainty between T-75 and T-55 resource sufficiency evaluation runs (July–September 2024)



7 Demand-response-based load adjustments in the resource sufficiency evaluation

WEIM entities are able to submit load forecast adjustments in the resource sufficiency evaluation to reflect demand response programs which could not be accounted for otherwise in the real-time market. This adjustment is included in both the capacity and flexibility tests, and impacts the load used in the requirements of both tests.

The adjustments can be entered as positive or negative. A negative adjustment reflects a lower load forecast as a result of a demand response program. This will decrease the requirement for the upward capacity and flexibility tests, but will increase the requirement for the downward tests. The adjustments can also be entered as a positive load adjustment. This can reflect additional demand because of expected pre-cooling or post-demand-response event increases (sometimes referred to as snapback).

Idaho Power submitted a -25 MW demand-response-based load adjustment for 80 consecutive hours between July 8 and July 12, 2024. This adjustment had no impact on Idaho Power passing or failing the resource sufficiency evaluation.

Figure 7.1 shows hourly demand-response-based load adjustments for all other balancing areas during July. Figure 7.2 shows the same information for all balancing areas during August and September. The feature to adjust the load forecast in the tests based on a demand response program was used by six balancing areas during the quarter: Arizona Public Service, BANC, Idaho Power, NV Energy, PacifiCorp East, and Portland General Electric. Table 7.1 summarizes the use of these adjustments during the quarter.

During the quarter, these adjustments had no impact on any balancing area passing or failing the resource sufficiency evaluation.

Figure 7.1 Demand-response-based load adjustments included in the resource sufficiency evaluation — excluding Idaho Power (July 2024)

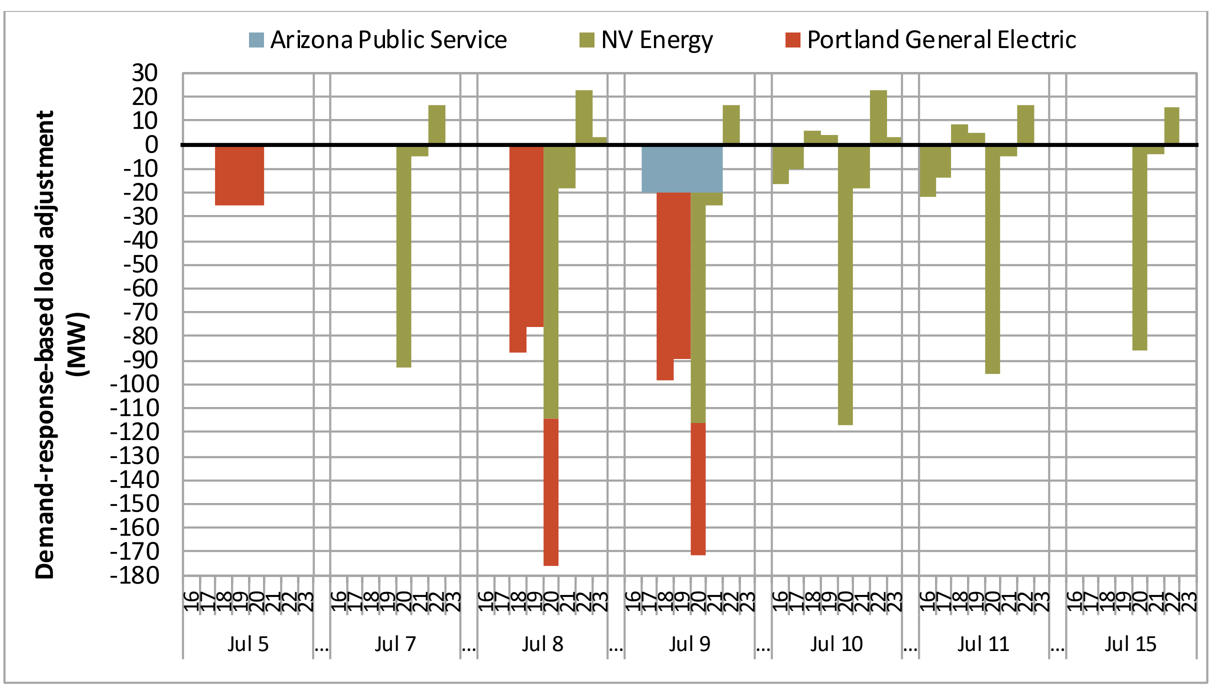


Figure 7.2 Demand-response-based load adjustments included in the resource sufficiency evaluation (August–September 2024)

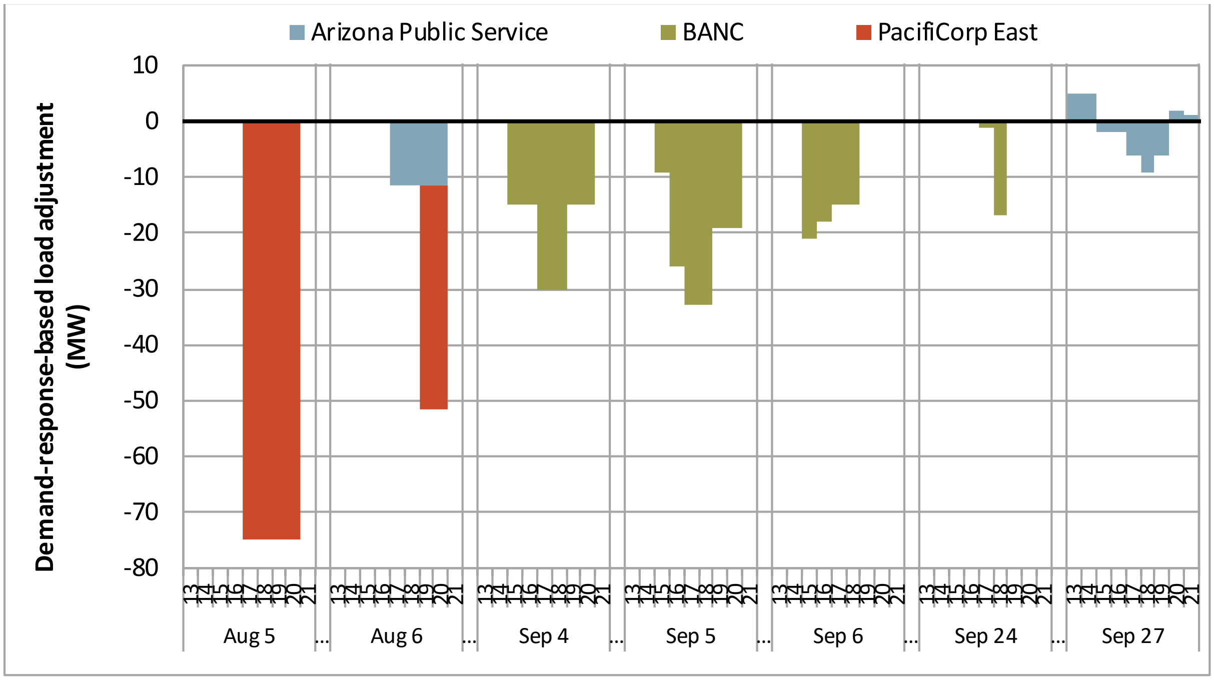


Table 7.1 Summary of demand-response-based load adjustments in the resource sufficiency evaluation (July–September, 2024)

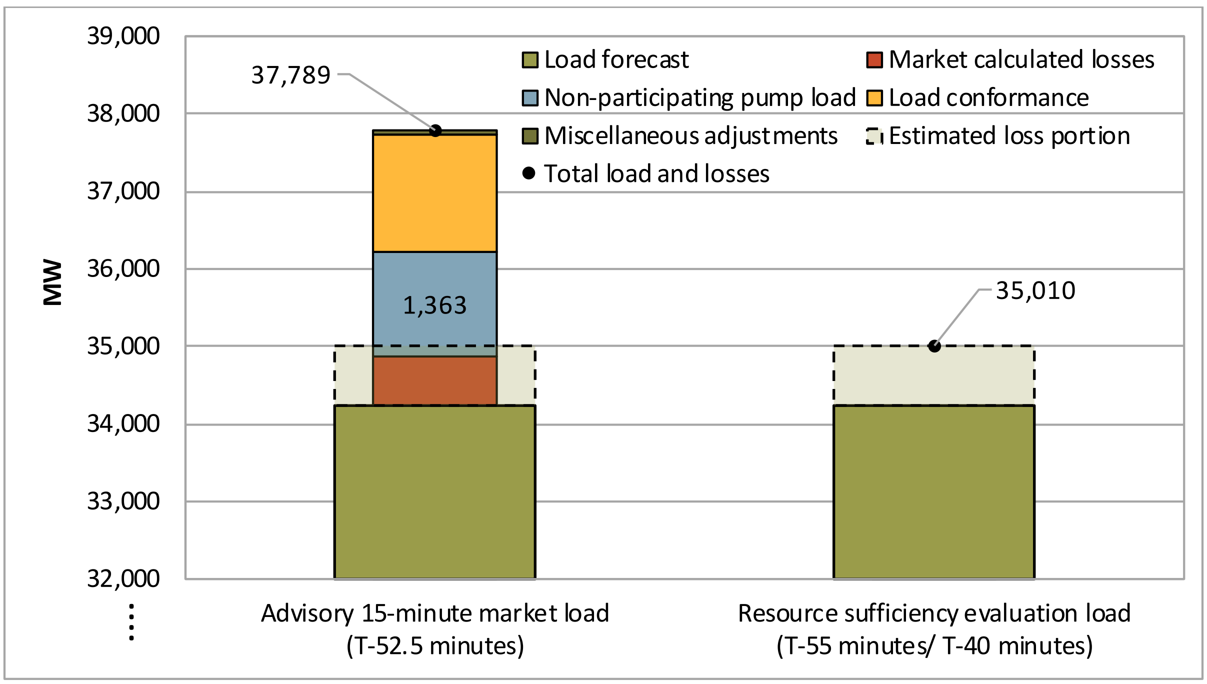
	Negative **demand-response-based load adjustment**				***Positive*** **demand-response-based load adjustment**			
Balancing area	**Total hours**	**Percent of hours**	**Average adjustment**	**Lowest adjustment**	**Total hours**	**Percent of hours**	**Average adjustment**	**Highest adjustment**
Arizona Public Service	16	0.7%	-10.9	-20	7	0.3%	2.2	5
BANC	18	0.8%	-19.2	-33				
Idaho Power	80	3.6%	-25.0	-25				
NV Energy	16	0.7%	-44.9	-117	12	0.50%	11.9	23
PacifiCorp East	6	0.3%	-63.3	-75				
Portland General Electric	9	0.4%	-55.8	-87				

8 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.[17]

This is illustrated below in Figure 8.1 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.[18] 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 8.1 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.[19]

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

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

[19] *EIM Resource Sufficiency Evaluation Enhancements Phase 2 Straw Proposal*, California ISO, 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 (EEA) 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.

9 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 9.1 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. In some cases, the import limit after failing the test (i.e., the greater of the base transfer or last 15-minute interval transfer) is at or above the unconstrained total import capacity. In these cases, the import limit imposed after failing the test has no impact.

Figure 9.1 Upward capacity/flexibility test failure intervals by source of import limit (July–September 2024)

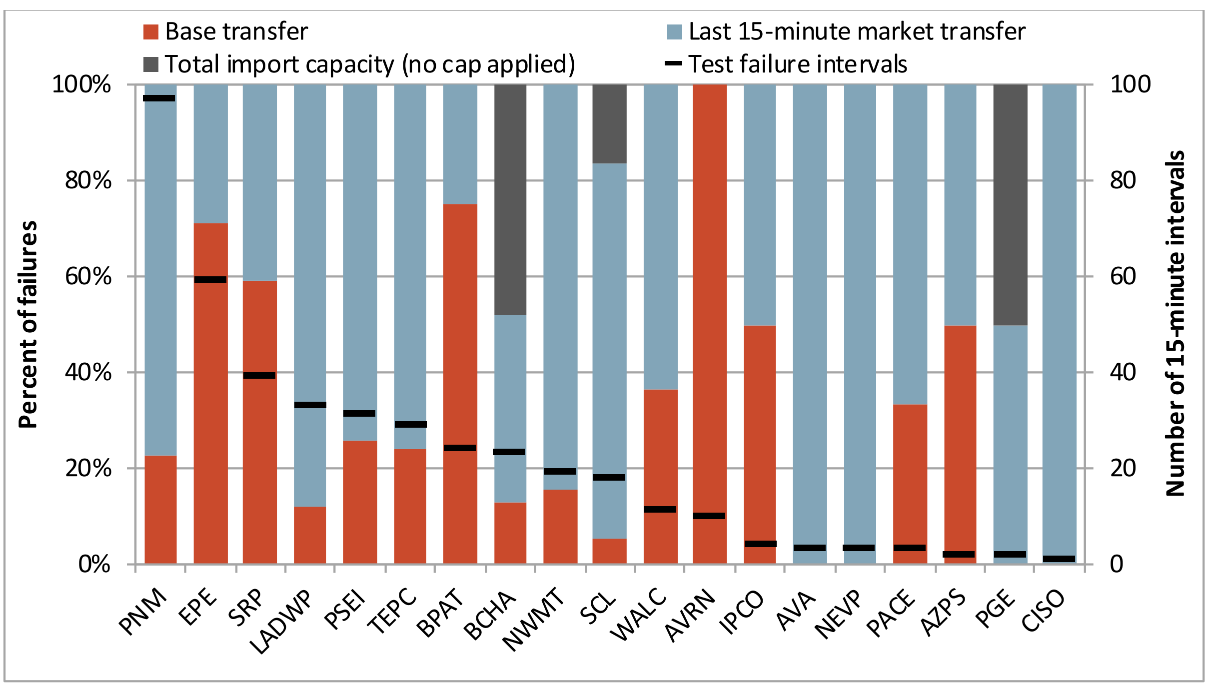
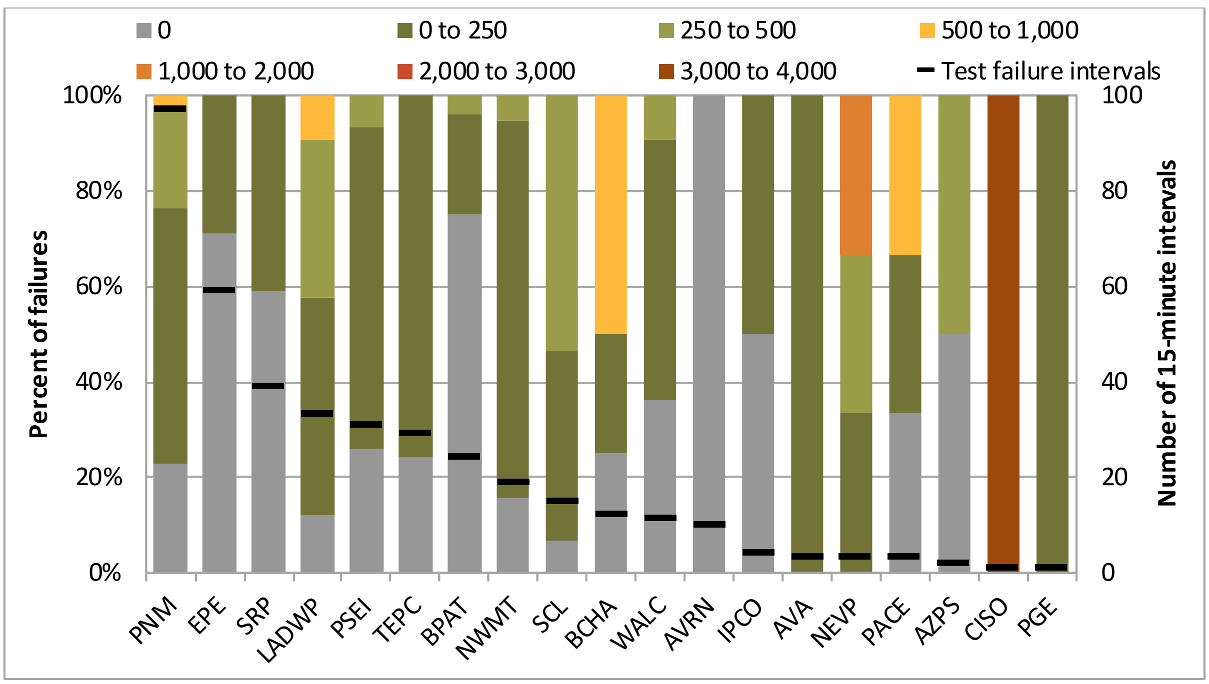


Figure 9.2 summarizes dynamic WEIM import limits above base transfers after failing either test in the upward direction. [20] From this perspective, the incremental WEIM import limit after a test failure is set by the greater of (1) zero or (2) the transfer from the last 15-minute market interval minus 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.

The California ISO balancing area failed the resource sufficiency evaluation in one interval on July 23, 2024, while opted in to receiving assistance energy transfers (AET). The import limit that would have been imposed (without AET) was around 3,280 MW, set by the level of WEIM imports in the last 15-minute market interval. WEIM transfers into the California ISO balancing area in the peak hours are typically higher in the 15-minute market relative to the 5-minute market because of consistently higher imbalance conformance adjustments entered by operators. Here, the optimal transfer increases as the optimization solves for load plus imbalance conformance. This can set a higher import limit than would have existed otherwise. In this case, 5-minute market WEIM imports were significantly below the import limit that would have been imposed without the opt-in designation such that assistance energy transfers had no impact.

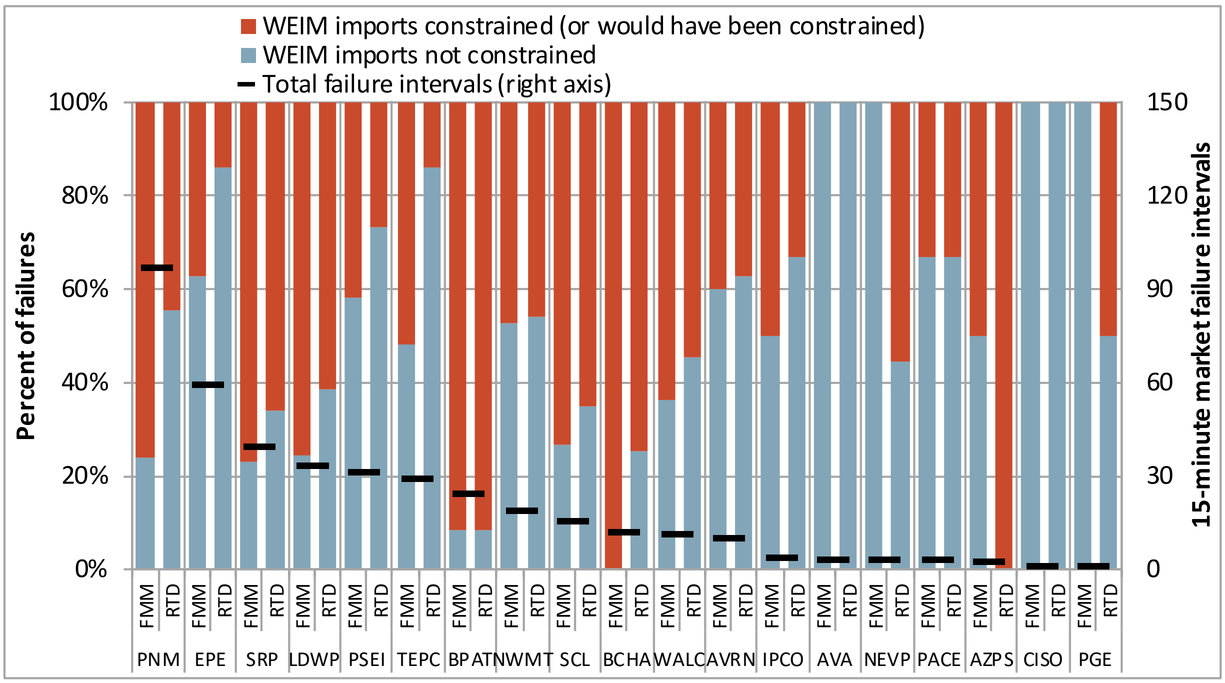
Figure 9.2 Upward capacity/flexibility test failure intervals by dynamic import limit (July–September 2024)



[20] 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 9.3 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).[21] 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.

Figure 9.3 Percent of upward failure intervals in which WEIM imports were constrained or would have been constrained by test failure limits (July–September 2024)



[21] 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.

Appendix A – 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*.[22] 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

[22] 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. [23]

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

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

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

Change in load forecast

Net load uncertainty

Discounts: diversity benefit and credit reduction capped by transfer capability

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.

---

[23] 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.[24] 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.

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

Appendix B – Calculating net load uncertainty in the tests

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.[25] 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 Equation B.1 for upward net load uncertainty.[26]

[25] 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.

[26] 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.

Equation B.1 Initial quantile regressions for upward net load uncertainty

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

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 180 days, separate for each balancing area and hour. As of August 14, 2024, the historical observations are from two combined periods: (1) the previous 90 days, and (2) the next 90 days minus one year.[27] 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.[28] 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.[29] 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 B.2 for upward net load uncertainty.

Equation B.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

[27] Changes to Net-Demand Uncertainty Requirement Calculation Methodology in Flexible Ramping Product effective trade date 8/14/24: https://www.caiso.com/notices/changes-to-net-demand-uncertainty-requirement-calculation-methodology-in-flexible-ramping-product-effective-trade-date-8-14-24

[28] 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.

[29] 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.[30] This is shown below in Equation B.3 for upward net load uncertainty:

Equation B.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 B.4 below:

Equation B.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

[30] 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 B.5 below.

Equation B.5 Calculation of upward uncertainty from current forecast information

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

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

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

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.[31] DMM finds that the regression model has limited predictive capability for forecasting net load uncertainty.

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