# Resource sufficiency tests in the energy imbalance market

May 20, 2021

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# 1 Summary

As part of the energy imbalance market, each area including the 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 includes 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 ramping sufficiency test (sufficiency 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 bid range capacity test or flexible ramping sufficiency test in the upward direction, energy imbalance market transfers into that area cannot be increased.[1]

In January 2021, the ISO held a workshop to review the design of the resource sufficiency evaluation and its application to the ISO during the August heatwave.[2] The ISO identified two errors in the way the bid range capacity test was implemented:

- Resource derates and outages were not accounted for resulting in higher resource capacity relative to actual availability. This affected both the ISO and energy imbalance market areas.
- Mirror resources were incorrectly included for the ISO, impacting net scheduled interchange and the capacity test requirement.[3] This only affected the ISO.

The ISO corrected both of these issues effective February 4, 2021. The ISO has also proposed to add net load uncertainty to the requirement of the bid range capacity test as part of a package of market enhancements for Summer 2021 Readiness.[4]

- Section 1 of this report continues with key findings, recommendations, and an overview of the tests.
- Section 2 of this report provides analysis of the impact of both the implementation errors and proposed changes on the bid range capacity test for all energy imbalance market areas across 2020.
- Section 3 of this report provides insight and analysis surrounding the ISO's resource sufficiency evaluation during the August heatwave.
- Section 4 of this report provides two examples for each EIM area including a specific period that particularly highlights the impact of the errors and the addition of uncertainty for that area.

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1 If an area fails the upward test, net EIM imports (negative) during the hour cannot exceed the lower of either the base transfer or optimal transfer from the last 15-minute interval prior to the hour.

2 *Resource Sufficiency Evaluation*, January 13, 2021. http://www.caiso.com/InitiativeDocuments/Presentation-MarketEnhancements-Summer2021ReadinessJan13,2021Workshop.pdf

3 Mirror resources are import and export schedules into or out of an EIM area to model power flow from the EIM area perspective at ISO intertie scheduling points. This allows the market to solve for both the California ISO and adjacent EIM areas simultaneously.

4 *Market Enhancements for Summer 2021 Readiness*, March 19, 2021. http://www.caiso.com/InitiativeDocuments/FinalProposal-MarketEnhancements-Summer2021Readiness.pdf .

## 1.1 Key findings and recommendations

Key findings and recommendations in this report include the following:

**The ISO would have failed the bid range capacity test in 20 intervals during the August heatwave had the bid range capacity test been functioning correctly.** With uncertainty added to the requirement, the ISO would have failed the capacity test during 27 intervals during this period.

**The inclusion of derated or outage capacity in the capacity test overestimated available capacity across the EIM, allowing almost all EIM areas to pass capacity tests when there should have been some additional test failures.** Had the bid range capacity test been functioning correctly, transfers into the NV Energy, Puget Sound Energy, and Salt River Project would have been capped in a significantly greater number of intervals during 2020. The potential impact of correcting the test would have been even greater in these areas than in the CAISO area. Most other EIM areas would have failed the tests during a limited number of intervals.

**Additional failures of the capacity test can have a significant impact on average prices.** If a balancing area fails the upward capacity or sufficiency test, the market software will constrain import transfer capability, which can affect the ability for the area to balance load as there is less flexibility to import from neighboring areas. For this reason, 77 percent of power balance constraint relaxations across all EIM areas during 2020 occurred after failing the capacity or sufficiency test. This can result in local prices being set at power balance constraint penalty parameters. On March 20, 2021 the penalty parameter for an under-supply infeasibility was scaled up to $2,000/MWh as part of FERC Order 831 compliance.

**DMM recommends that the ISO consider eliminating some additional capacity from the bid range capacity test, which is unavailable because of various operating limitations and independent from any displacement from energy imbalance market transfers.** This would make the test more accurate. Some examples of constrained capacity in this category include a maximum or fixed exceptional dispatch issued by grid operators, a long start time beyond the horizon of the real-time market, or ramp-constrained capacity immediately following an outage.

## 1.2 Overview of bid range capacity and flexible ramping sufficiency test

### Flexible ramping sufficiency test overview

The flexible ramping sufficiency test is performed every hour and ensures 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. The test requires balancing areas to show sufficient ramping capability from the start of the hour to each of the four 15-minute intervals within the hour. If an area fails the upward sufficiency test, EIM transfers into that area cannot be increased.[5] Similarly, if an area fails the downward sufficiency test, transfers out of that area cannot be increased.

[5] If an area fails the upward sufficiency test, net EIM imports (negative) cannot exceed the lower of either the base transfer or optimal transfer from the last 15-minute interval. Similarly, if an area fails the downward sufficiency test, net EIM exports are capped at the higher of either the base transfer or optimal transfer from the last 15-minute interval

The requirement for the flexible ramping sufficiency test is calculated as the forecasted change in load plus the uncertainty component minus two discounts, diversity benefit and flexible ramping credits. The diversity benefit reflects that system-level flexible ramping needs are typically smaller than the sum of the individual balancing area flexible ramping needs because of reduced uncertainty across a larger footprint. As a result, balancing areas receive a prorated diversity benefit discount based on this proportion. In addition, credits reflect the ability to reduce exports to increase upward ramping capability or reduce imports to increase downward ramping capability. Further, the reduction in the sufficiency 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.

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

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

Forecasted component

Uncertainty component

Discounts: diversity benefit and credit reduction capped by transfer capability

The uncertainty component used currently in the flexible ramping sufficiency test is calculated from the 2.5th percentile (downward requirement) and 97.5th percentile (upward requirement) of historical net load error observations.[6] As part of the flexible ramping product refinements stakeholder initiative, the uncertainty component is expected to be enhanced prior to fall 2021 to scale and account for net load currently in the system.[7]

The flexible ramping capacity used to meet the requirement is calculated across all resources from both economic energy bids as well as fixed changes in schedules or renewable forecasts from the previous hour to the next. Here, all resource constraints are considered (including start-up times, ramp rates, exceptional dispatches, derates, etc.) as well as ancillary service schedules.

### Bid range capacity test overview

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. If an area fails the capacity test, it will automatically fail the flexible ramping sufficiency test in the same direction.

The requirement for the bid range capacity test is calculated as the load forecast plus export base schedules minus import and generation base schedules. Further, an additional component is added to the requirement to account for historical intertie deviations. If the requirement is positive, then the area must show sufficient incremental bid range capacity to meet the requirement and if the requirement is

[6] Net load error in the 15-minute market is calculated from the difference between binding net load forecasts in the 5-minute market and the advisory net load forecast in the 15-minute market. Weekdays use data for the same hour from the last 40 weekdays. For weekends, the last 20 weekend days are used.

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

negative, then sufficient decremental bid range capacity must be shown. For non-ISO energy imbalance market areas, the export, import, and generation schedules used in the requirement are the base schedules submitted as part of the hourly resource plan. For the ISO, the "base" schedules used in the requirement are the advisory schedules from the last binding 15-minute market run.

$$Requirement = \underbrace{Load}_{\text{Forecasted load}} + \underbrace{Export_{base} - Import_{base} + Generation_{base}}_{\text{Intertie and generation base schedules}} + \underbrace{Intertie\ Deviation}_{\text{Additional requirement to account for historical inter-tie deviation}}$$

The bid range capacity used to meet the meet the requirement is calculated relative to the base schedules. Incremental bid-in generation capacity is calculated as the range between the generation base schedule and the economic maximum, accounting for upward ancillary services. After the fixes implemented in early February 2021, derates are also accounted for. 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. Since the bid range capacity is calculated relative to the base schedules, the upward capacity test can also be expressed as follows:

$$\underbrace{Generation_{maximum} + Net\ Import_{maximum}}_{\text{Upward capacity}} \geq \underbrace{Load\ + Intertie\ Deviation}_{\text{Requirement}}$$

### Proposed change to bid range capacity test

The ISO has proposed to add net load uncertainty to the requirement of the bid range capacity test as part of a package of market enhancements for Summer 2021 Readiness.[8] The ISO intends to add adjusted uncertainty, which is uncertainty net of the diversity benefit. The uncertainty component is similar to that used in the flexible ramping sufficiency test, based on the 97.5$^{th}$ and 2.5$^{th}$ percentile of historical net load error observations for the upward and downward tests, respectively.

As discussed in the sufficiency test overview, the uncertainty component is expected to be enhanced prior to fall 2021 to scale and account for net load currently in the system.[9] Unlike the flexible ramping sufficiency test, credits (net EIM exports in the upward test and net EIM imports in the downward test) will not be used in the capacity test to prevent double counting of internal capacity. For example, net EIM exports are supported by internal capacity, which is already accounted for in the capacity test by the generation base schedules and bid range.

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[8] *Market Enhancements for Summer 2021 Readiness*, March 19, 2021. http://www.caiso.com/InitiativeDocuments/FinalProposal-MarketEnhancements-Summer2021Readiness.pdf .

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

## 1.3 Description of unavailable capacity the ISO should consider eliminating

DMM recommends that the ISO consider eliminating additional capacity from the bid range capacity test, specifically capacity which is unavailable because of various operating limitations independent of any displacement from energy imbalance market transfers. In other words, this is capacity that is restricted by intertemporal and resource-level constraints that exist regardless of how EIM transfers positioned the resource.

Some examples of constrained capacity in this category include the following:

- **A maximum or fixed exceptional dispatch issued by grid operators**. In this case, a resource is ordered to maintain a fixed operating level or not to exceed an operating level, and its energy award is constrained by the market optimization accordingly. The capacity between the exceptional dispatch and the maximum capacity should be considered unavailable regardless of EIM participation and therefore omitted from the capacity test.
- **A long start time beyond the horizon of the real-time market**. In this case, a long-start resource is committed outside of the real-time market. Here, the ability for this resource to turn on and generate at maximum capacity is not dependent on EIM transfers, but on start times, ramp times, and commitment decisions prior to the real-time market run. Therefore, capacity which is unavailable because of intertemporal constraints associated with bringing this resource online should be omitted from the capacity test.
- **Ramp-constrained capacity immediately following an outage**. In this case, a resource returning online immediately following an outage is subject to intertemporal constraints before it can return to maximum output. Since the outage reflects a physical limitation that is independent of EIM transfers, the start-up and ramp constraints associated with bringing the resource to maximum capacity should be accounted for in the capacity test.

# 2 Impact of errors and proposed changes on bid range capacity test

The ISO identified two errors in the way the bid capacity test was implemented:

- Resource derates and outages were not accounted for resulting in higher resource capacity relative to actual availability. This affected both the ISO and energy imbalance market areas.
- Mirror resources were incorrectly included for the ISO, impacting net scheduled interchange and the capacity test requirement.[10] This affected only the ISO.

First, Figure 2.1 shows the number of original upward capacity test failures (15-minute market intervals) during 2020.[11] Capacity test failures were very low across all energy imbalance market areas including the ISO, which did not fail the capacity test at all during the summer. The inclusion of derated or outage capacity in the capacity test overestimated available capacity across the EIM, allowing many passed capacity tests which should have been failures. Figure 2.2 summaries the impact of the two implementation errors by showing the number of additional upward capacity test failures that would have occurred in 2020 had these errors not existed.

The bid range capacity test and flexible ramping sufficiency test have the same effective outcome. If either test fails, EIM transfers are capped for that interval and cannot be increased. Therefore, Figure 2.3 shows the additional upward capacity test failures with the errors fixed excluding instances when the upward flexible ramping sufficiency test also failed. These amounts therefore summarize the impact of the errors on the market during 2020 by showing additional intervals when EIM transfers should have been capped. In particular, EIM imports into NV Energy should have been capped during 2020 in 391 additional 15-minute market intervals. EIM imports into Puget Sound Energy should have been capped in 345 additional intervals. EIM imports into Salt River Project should have been capped in 170 additional intervals.

The ISO corrected both of these errors effective February 4, 2021. The ISO has also proposed to add net load uncertainty to the requirement of the bid range capacity test as part of a package of market enhancements for Summer 2021 Readiness.[12] The ISO intends to implement adjusted uncertainty, which is uncertainty net of the diversity benefit.[13] This is similar to that used in the flexible ramping sufficiency test.

Figure 2.4 estimates the impact of adding *adjusted uncertainty* to the upward bid range capacity test requirement by summarizing additional capacity test failures in 2020 with both the implementation errors fixed and adjusted uncertainty added. Figure 2.5 shows the same information, except without intervals in which the flexible ramping sufficiency test also failed in that interval. After adjusting for the implementation error and adding uncertainty, EIM imports into NV Energy would have been capped

[10] Mirror resources are import and export schedules into or out of an EIM area to model power flow from the EIM area perspective at ISO intertie scheduling points. This allows the market to solve for both the California ISO and adjacent EIM areas simultaneously.

[11] Intervals in which an energy imbalance market entity is entirely disconnected from the market (market interruption) are removed from the analysis in this section.

[12] *Market Enhancements for Summer 2021 Readiness*, March 19, 2021. http://www.caiso.com/InitiativeDocuments/FinalProposal-MarketEnhancements-Summer2021Readiness.pdf .

[13] The diversity benefit reflects that system-level flexible ramping needs are typically smaller than the sum of the individual balancing area flexible ramping needs because of reduced uncertainty across a larger footprint. The diversity benefit is a prorated discounted based on this proportion.

during 2020 in 909 additional 15-minute market intervals. EIM imports into Puget Sound Energy would have been capped in 688 additional intervals. EIM imports into Salt River Project would have been capped in 450 additional intervals. EIM imports into the ISO would have been capped in 18 additional intervals.

Failures of the capacity or sufficiency test are important because these outcomes limit transfer capability. Constraining import transfer capability because of failing either test in the upward direction can affect the ability for an area to balance load, as there is less flexibility to import from neighboring areas. This can result in local prices being set at power balance constraint penalty parameters. For this reason, 77 percent of power balance constraint relaxations across all EIM areas during 2020 occurred after failing the capacity or sufficiency test. On March 20, 2021 the penalty parameter for an under-supply infeasibility was scaled up to $2,000/MWh as part of FERC Order 831 compliance. As a result, even a short period with pricing at the $2,000 cap can significantly increase average prices for that area.

**Figure 2.1 Original capacity test failures (15-minute intervals)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| California ISO | 0 | 0 | 0 | 4 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Arizona PS | 0 | 0 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 9 |
| BANC | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1 | 0 |
| Idaho Power | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NV Energy | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 6 | 0 |
| PacifiCorp East | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| PacifiCorp West | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| Portland GE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Powerex | 12 | 6 | 8 | 6 | 10 | 0 | 0 | 0 | 2 | 2 | 3 | 0 |
| Puget Sound En | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Salt River Project | | | | 7 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 0 |
| Seatle City Light | | | | 0 | 4 | 0 | 6 | 2 | 0 | 0 | 0 | 0 |

2020

**Figure 2.2 Additional capacity test failures with errors fixed (15-minute intervals)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| California ISO | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 3 | 0 | 0 | 0 |
| Arizona PS | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 5 | 1 | 0 |
| BANC | 0 | 1 | 0 | 0 | 0 | 4 | 5 | 8 | 5 | 6 | 3 | 0 |
| Idaho Power | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| NV Energy | 0 | 2 | 1 | 4 | 63 | 53 | 172 | 283 | 95 | 69 | 33 | 8 |
| PacifiCorp East | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 13 | 1 | 0 | 0 | 0 |
| PacifiCorp West | 0 | 1 | 2 | 0 | 0 | 3 | 2 | 0 | 0 | 7 | 1 | 2 |
| Portland GE | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 2 | 11 | 9 | 1 | 0 |
| Powerex | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Puget Sound En | 0 | 5 | 2 | 0 | 2 | 77 | 164 | 79 | 28 | 20 | 1 | 0 |
| Salt River Project | | | | 8 | 2 | 1 | 11 | 51 | 55 | 61 | 52 | 0 |
| Seatle City Light | | | | 0 | 1 | 0 | 0 | 7 | 6 | 5 | 2 | 0 |

2020

**Figure 2.3 Additional capacity test failures with errors fixed *excluding sufficiency test failures* (15-minute intervals)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| California ISO | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 1 | 0 | 0 | 0 |
| Arizona PS | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| BANC | 0 | 1 | 0 | 0 | 0 | 4 | 5 | 6 | 5 | 6 | 3 | 0 |
| Idaho Power | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| NV Energy | 0 | 0 | 1 | 1 | 27 | 16 | 76 | 138 | 56 | 48 | 20 | 8 |
| PacifiCorp East | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 13 | 1 | 0 | 0 | 0 |
| PacifiCorp West | 0 | 1 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 7 | 1 | 2 |
| Portland GE | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 2 | 7 | 9 | 1 | 0 |
| Powerex | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Puget Sound En | 0 | 4 | 2 | 0 | 2 | 71 | 146 | 71 | 28 | 20 | 1 | 0 |
| Salt River Project | | | | 5 | 2 | 1 | 7 | 29 | 39 | 47 | 40 | 0 |
| Seatle City Light | | | | 0 | 1 | 0 | 0 | 7 | 5 | 2 | 2 | 0 |

2020

**Figure 2.4 Additional capacity test failures with errors fixed plus adjusted uncertainty (15-minute intervals)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| California ISO | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 6 | 2 | 0 | 0 |
| Arizona PS | 2 | 4 | 5 | 0 | 11 | 2 | 5 | 1 | 2 | 25 | 13 | 34 |
| BANC | 0 | 1 | 0 | 0 | 0 | 7 | 13 | 14 | 14 | 10 | 3 | 1 |
| Idaho Power | 0 | 0 | 0 | 0 | 0 | 35 | 16 | 20 | 4 | 0 | 0 | 0 |
| NV Energy | 0 | 4 | 1 | 11 | 118 | 93 | 282 | 481 | 205 | 144 | 59 | 11 |
| PacifiCorp East | 0 | 0 | 1 | 0 | 0 | 8 | 16 | 62 | 10 | 11 | 0 | 0 |
| PacifiCorp West | 8 | 4 | 4 | 0 | 2 | 13 | 17 | 6 | 0 | 36 | 15 | 25 |
| Portland GE | 1 | 0 | 4 | 0 | 1 | 0 | 50 | 33 | 41 | 51 | 9 | 2 |
| Powerex | 14 | 3 | 3 | 5 | 13 | 4 | 0 | 0 | 9 | 5 | 2 | 0 |
| Puget Sound En | 5 | 10 | 27 | 0 | 7 | 135 | 293 | 131 | 61 | 49 | 11 | 0 |
| Salt River Project | | | | 29 | 9 | 3 | 50 | 104 | 144 | 131 | 94 | 1 |
| Seatle City Light | | | | 0 | 8 | 0 | 7 | 15 | 12 | 8 | 4 | 6 |

2020

**Figure 2.5 Additional capacity test failures with errors fixed plus adjusted uncertainty *excluding sufficiency test failures* (15-minute intervals)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| California ISO | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 2 | 0 | 0 | 0 |
| Arizona PS | 0 | 2 | 3 | 0 | 11 | 2 | 5 | 1 | 1 | 17 | 6 | 30 |
| BANC | 0 | 1 | 0 | 0 | 0 | 7 | 13 | 12 | 14 | 10 | 3 | 1 |
| Idaho Power | 0 | 0 | 0 | 0 | 0 | 32 | 15 | 19 | 4 | 0 | 0 | 0 |
| NV Energy | 0 | 0 | 1 | 3 | 73 | 45 | 173 | 305 | 147 | 107 | 44 | 11 |
| PacifiCorp East | 0 | 0 | 1 | 0 | 0 | 7 | 16 | 61 | 10 | 7 | 0 | 0 |
| PacifiCorp West | 7 | 4 | 1 | 0 | 2 | 13 | 17 | 5 | 0 | 34 | 14 | 25 |
| Portland GE | 1 | 0 | 3 | 0 | 1 | 0 | 45 | 31 | 34 | 50 | 9 | 2 |
| Powerex | 10 | 3 | 3 | 5 | 9 | 1 | 0 | 0 | 7 | 4 | 2 | 0 |
| Puget Sound En | 5 | 8 | 27 | 0 | 7 | 126 | 275 | 123 | 61 | 45 | 11 | 0 |
| Salt River Project | | | | 18 | 9 | 3 | 37 | 74 | 120 | 111 | 77 | 1 |
| Seatle City Light | | | | 0 | 8 | 0 | 6 | 15 | 11 | 3 | 2 | 6 |

2020

# 3 CAISO resource sufficiency evaluation during the August heatwave

### Bid range capacity tests

The CAISO balancing area passed the bid range capacity test (capacity test) in all hours on August 14 and 15, including during intervals when the area experienced high levels of scarcity in the real-time energy market and curtailed load. The CAISO balancing area failed the flexible ramping sufficiency tests during some high demand intervals on August 14 and 15 including some intervals when load was being curtailed, but passed in other high demand intervals.

The fact that the CAISO system passed during periods of real-time scarcity and load curtailment on August 14 and 15 has led to a closer examination of these results and the underlying methodologies. This section provides additional context and analysis of the ISO's resource sufficiency evaluation on August 14 and 15.

Figure 3.1 shows 15-minute and 5-minute market energy imbalance market imports coming into the ISO on August 14. The shaded regions illustrate three critical periods on this day. The red line shows the intervals in which the ISO failed the upward sufficiency test, limiting transfers to the transfer level of the last binding 15-minute interval. The ISO did not fail the capacity test during any interval on this day.

Figure 3.2 shows the same information for August 15. For this day, the ISO failed the flexible ramping sufficiency test throughout the twenty-minute period in which the ISO curtailed load. Similar to the previous day, the ISO passed the capacity test during all intervals.

**Figure 3.1 Limits on EIM imports into CAISO due to resource sufficiency test failure (August 14, 2020)**

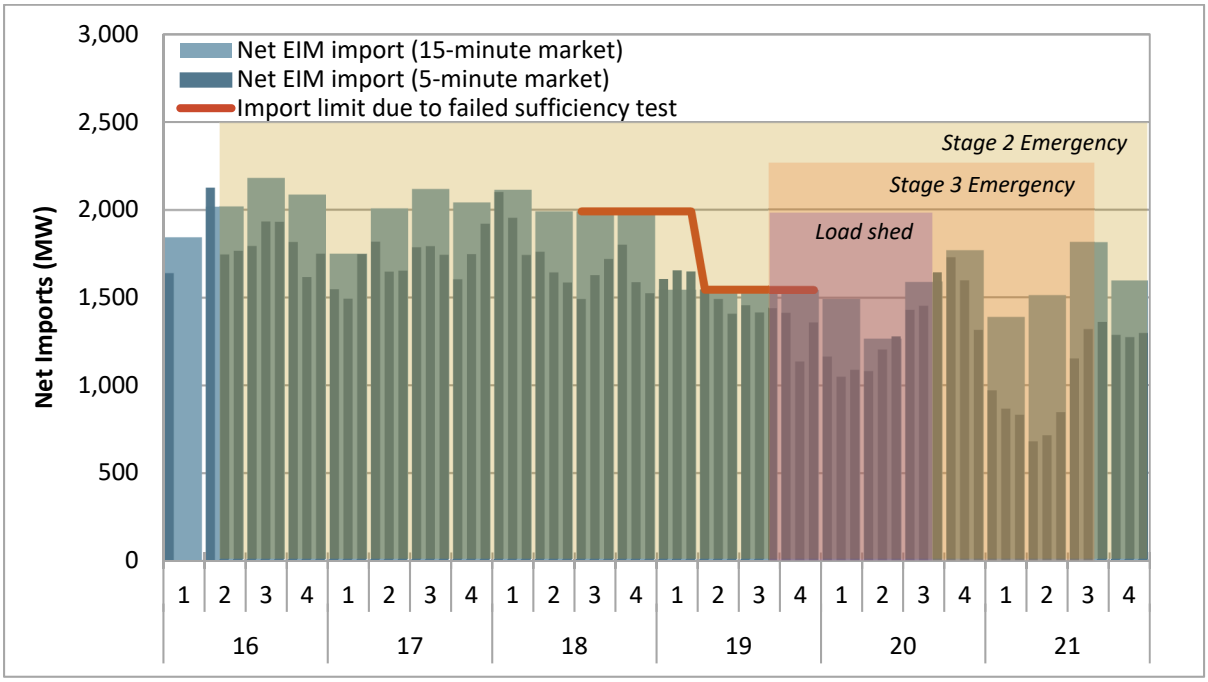


**Figure 3.2 Limits on EIM imports into CAISO due to resource sufficiency test failure (August 15, 2020)**

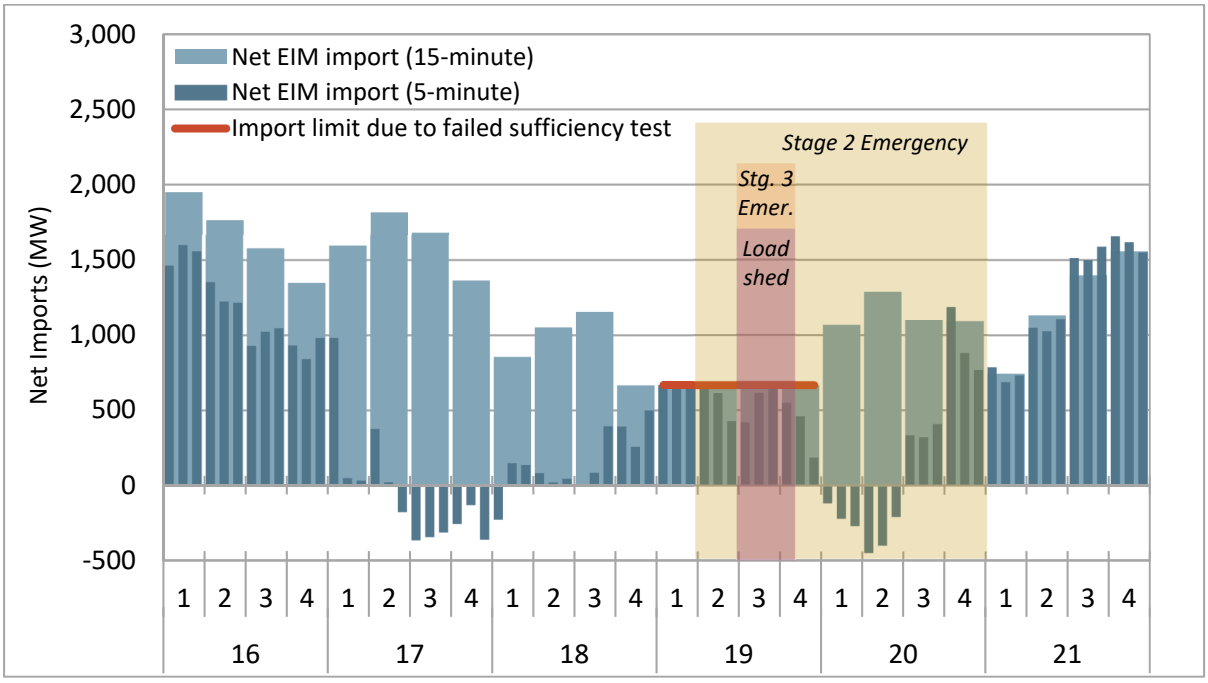



Figure 3.3 summarizes the bid range capacity test for the ISO on August 14, 2020. The yellow line shows the original capacity test requirement including the mirror resource issue which impacted net scheduled interchange. The dotted black line shows the recalculated requirement, which correctly accounts for mirror resources, and the dotted gray line adds uncertainty, net of the diversity benefit. Figure 3.4 shows the same information for August 15.

The bars show the bid range capacity that was used to meet capacity test requirements. The blue and yellow bars are for 15-minute dispatchable incremental imports and decremental exports. The red bars reflect generation capacity which was unavailable after accounting for outages and derates. Therefore, comparing the bars net of derates and outages against the recalculated requirement plus uncertainty illustrates the ISO's capacity test evaluation, had the changes proposed by the ISO been effective.

The dark green bars reflect capacity that was considered available for the bid range capacity test but unavailable for the flexible ramping sufficiency test because of all other resource constraints. These constraints include exceptional dispatches, start-up times, transition times, ramp rates, and other intertemporal constraints.

The bid range capacity test should measure capacity that could be feasible without energy imbalance market transfers. In some cases, this constrained capacity may be offline or unrampable in the immediate interval because of energy imbalance market imports and associated commitment decisions in a current *or previous* interval. In that case, this capacity should be considered in the capacity test as it could have been available had the balancing area been required to meet its load on its own.

However, in other cases, this constrained capacity would not have been available regardless of energy imbalance market participation. Examples of this include a maximum or fixed exceptional dispatch

issued by grid operators, a long start time beyond the horizon of the real-time market, or ramp-constrained capacity immediately following an outage. In the case of the ISO in hour-ending 19 and 20 on August 14, most of the constrained resource capacity would have been unavailable regardless of energy imbalance market transfers.

Figure 3.4 shows the same information for August 15. Based on the ISO's proposed changes and comparing the upward capacity accounting for derates against the recalculated requirement including uncertainty, the ISO would have still passed the capacity test for hour-ending 19 interval 3, the period in which the ISO curtailed load. However, the ISO did fail the flexible ramping sufficiency test for the entire hour, which resulted in the same effective outcome.

DMM recommends that the ISO consider eliminating constrained capacity that would be unavailable regardless of energy imbalance market transfers from the bid range capacity test.

**Figure 3.3 CAISO upward bid range capacity test requirement and capacity (August 14, 2020)**

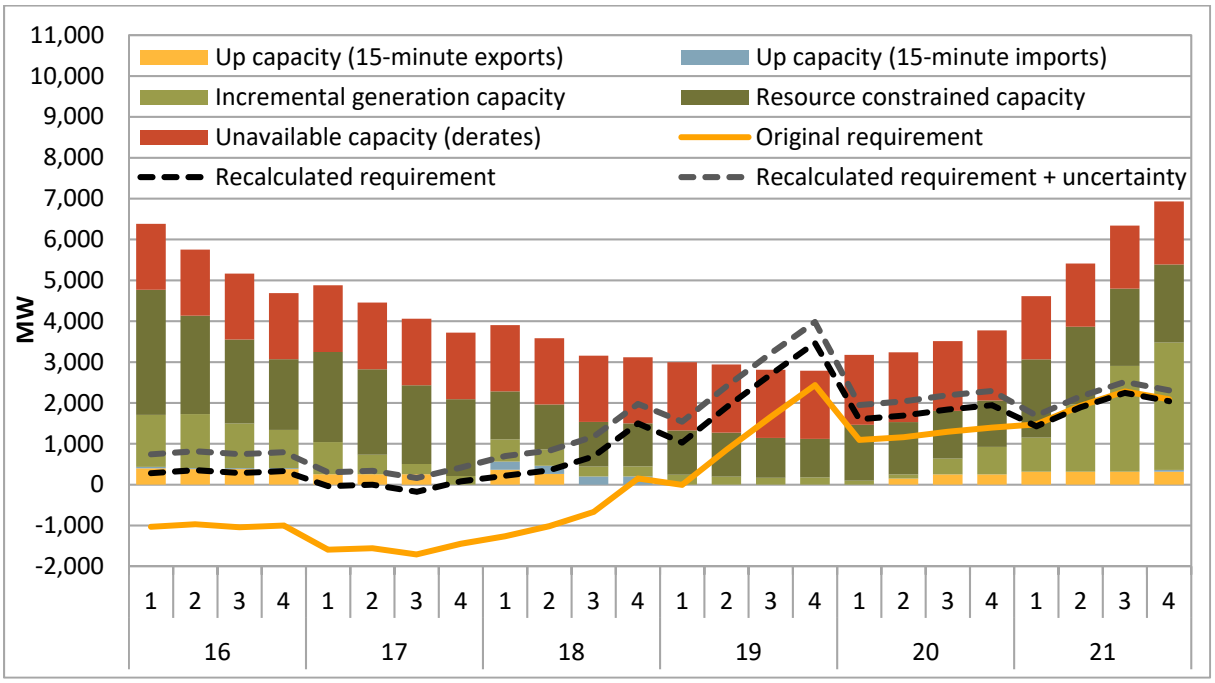
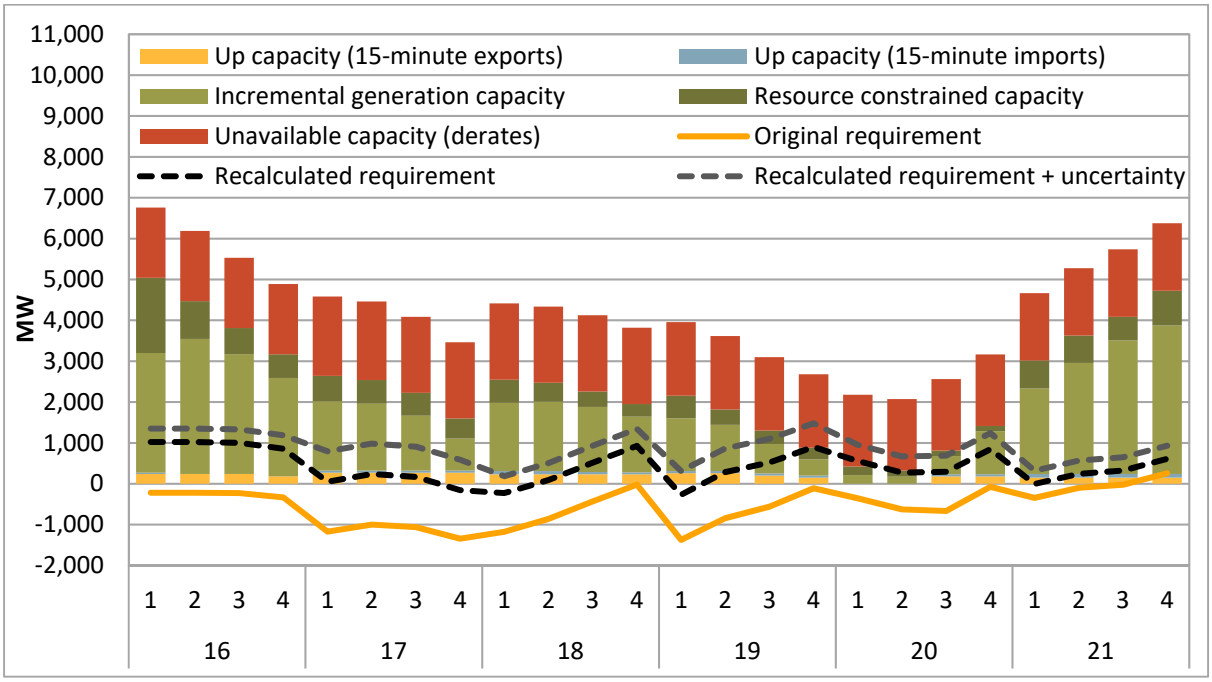


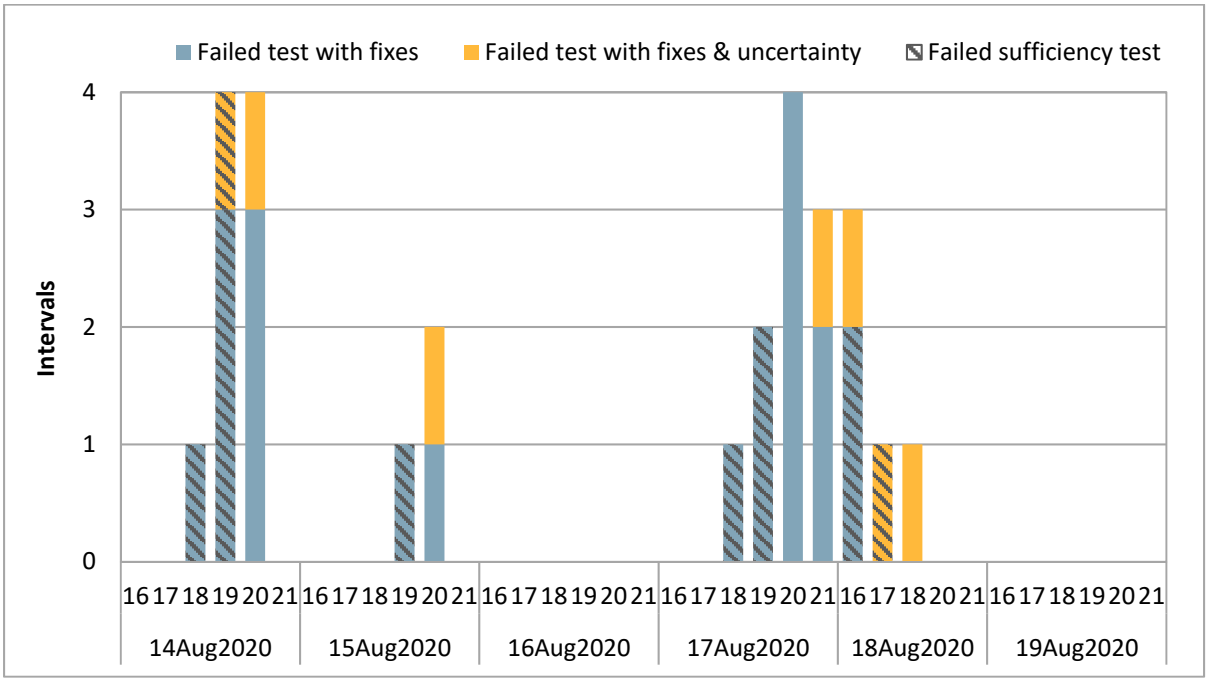
**Figure 3.4 CAISO upward bid range capacity test requirement and capacity (August 15, 2020)**




The ISO passed the bid range capacity test in all intervals during the August heat wave in part because of the two errors the ISO identified related to resource derates and mirror resources. Figure 3.5 summarizes intervals that would have failed the capacity test with the ISO identified issues corrected as well as intervals that would have failed with uncertainty added on top of that. The dashed bars reflect capacity tests in which the ISO failed the upward flexible ramping sufficiency test, resulting in the same outcome regardless of whether or not the capacity test would have failed.

Results of this analysis show that with the errors corrected and uncertainty added to the requirement, the ISO would have failed the capacity test during 27 intervals across this August heatwave period. If constrained capacity, which is unavailable regardless of energy imbalance market operation, were accounted for, the number of failed capacity test intervals would have been higher.

**Figure 3.5 CAISO upward bid range capacity test failures with proposed enhancements (August 14 – August 19, 2020)**




## Flexible ramping sufficiency tests

The ISO passed the flexible ramping sufficiency test (sufficiency test) during all of hour-ending 20 on August 14, during a period when the ISO shed load. The ISO passed the flexible ramping sufficiency test despite emergency conditions because this test only measures the *change* associated with load and ramping capacity. If the area is starting from a state of deficiency, but is able to meet the changing conditions in the next hour, then the area will pass the test and can simultaneously have emergency or scarcity conditions.

For example, assume that the load-forecast increases significantly in the current hour such that the area fails the flexible ramping sufficiency test during all intervals in the hour and experiences high levels of scarcity in the real-time market. If in the next hour, the load forecast declines slightly, the flexible ramping sufficiency test requirement could be negative reflecting the change in load despite very high loads and a continuation of scarcity conditions.

On August 14, this scenario describes the ISO balancing area between hour-ending 19 and hour-ending 20, except with a significant decline in solar rather than an increase in load. Figure 3.6 and Figure 3.7 show the requirement and calculated supply for the ISO system's upward flexible ramping sufficiency test during the peak hours on this day.

Starting with the requirement components in Figure 3.6, the upward requirement for the flexible ramping sufficiency test is calculated as the forecasted change in load plus uncertainty minus two discounts, diversity benefit and flexible ramping credits. The diversity benefit reflects that system-level

flexible ramping needs are typically smaller than the sum of the individual balancing area flexible ramping needs because of reduced uncertainty across a larger footprint.

Upward credits are net EIM exports prior to the hour, reflecting the ability to reduce exports to increase upward ramping capability. For this peak period on August 14, the ISO was importing on net in every interval so no credits were applied to the upward sufficiency test.

Last, the reduction in the upward sufficiency test requirement because of any diversity benefit or flexible ramping credit is capped by the area's net import capability. For hour-ending 19 and 20, the load forecast is declining resulting in a negative upward sufficiency test requirement for most of this period. Changes in wind and solar forecasts are instead accounted for on the opposite side of the equation as positive or negative ramping capacity.

Figure 3.7 shows ramping capacity used to meet the sufficiency test requirement by resource type. The dotted line shows the sufficiency test requirement from the previous chart. Ramping capacity accounts for both economic energy bids (constrained by unit limitations such as ramp rates) as well as fixed changes in schedules or renewable forecasts from the previous hour to the next. So, an increase in imports (or decrease in exports) will contribute to positive ramping capacity.

In hour-ending 19, the ISO failed the sufficiency test in large part because of a significant decline in solar and limited remaining ramping capacity. However, starting from a point of deficiency, the ISO was able to meet the mild decline in solar paired with a decline in load in the next hour. This occurred even though the ISO was short in the real-time market during this hour.

Instead, resource sufficiency needed to meet total load is captured by the capacity test. However, as discussed in the previous section, additional capacity test enhancements are needed to account for constrained resource capacity that is unavailable independent of energy imbalance market transfers.

**Figure 3.6 CAISO flexible ramping sufficiency test requirement by component (August 14, 2020)**

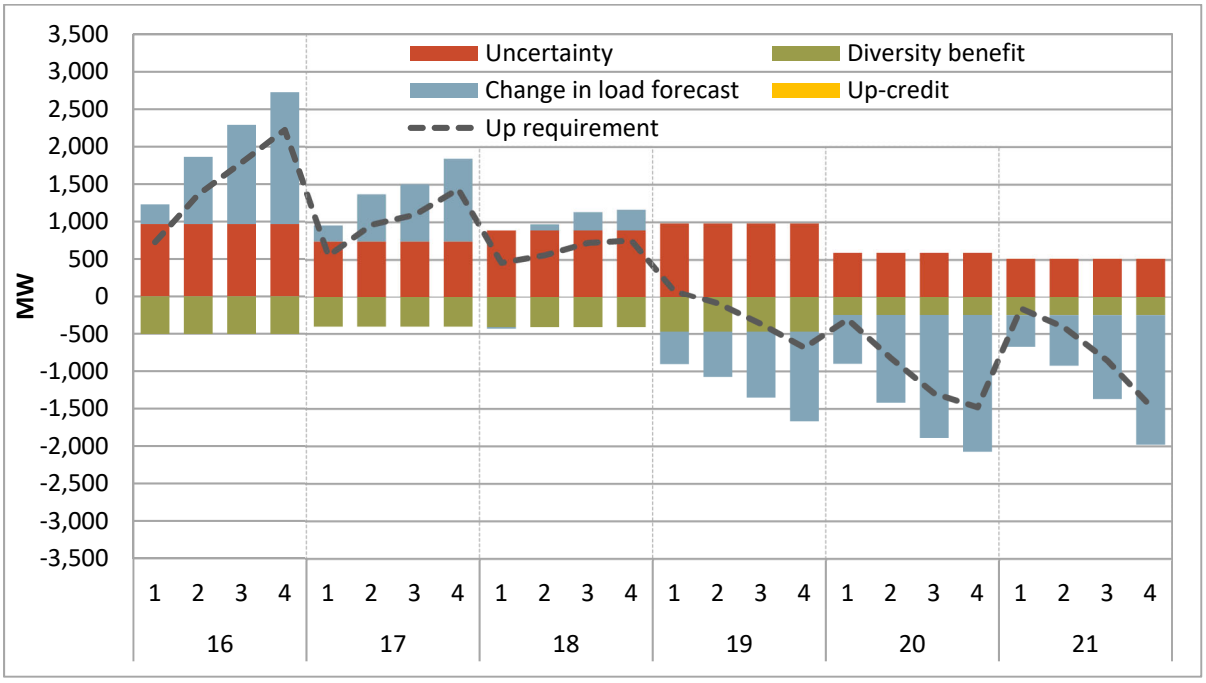
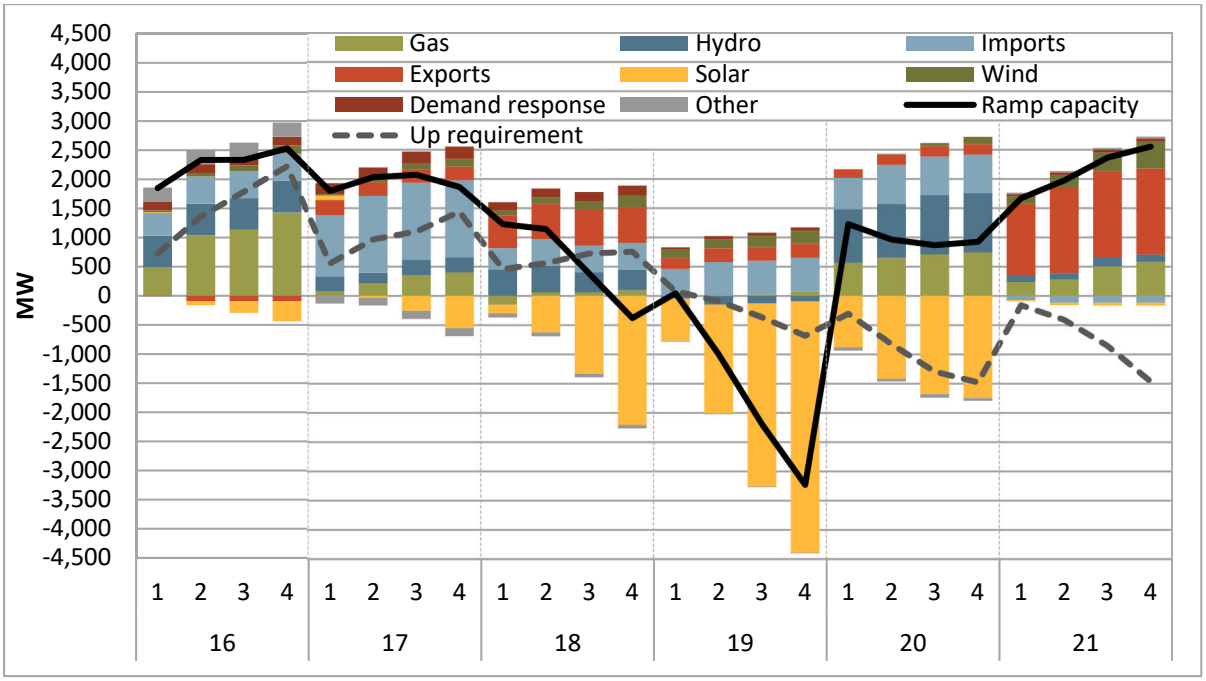



**Figure 3.7 CAISO flexible ramping sufficiency test ramping capacity by type (August 14, 2020)**



# 4 EIM balancing area errors and uncertainty impact examples

This section provides examples for each balancing area of the energy imbalance market. These examples cover both the impact of the two errors as well as the proposed addition of uncertainty on the bid range capacity test. Two examples are provided for each area: (1) peak hours on August 14 as a consistent point of comparison and (2) a specific period that particularly highlights the impact of the errors and addition of uncertainty on that area.

Similar to the figures in the previous section, the yellow line for each of the examples below show the original capacity test requirement. Since the implementation error with mirror resources only impacted the ISO, the dotted black line which shows the recalculated requirement is the same as the original capacity test requirement for each of the EIM areas. The dotted gray line in these figures show uncertainty net of the diversity benefit added on top of the capacity test requirement.

The bars shows the bid range capacity that was used originally to meet capacity test requirements. The inclusion of derated or outage capacity in the capacity test overestimated available capacity across the EIM, allowing many passed capacity tests which should have been failures. The red bars reflect generation capacity which was unavailable after accounting for outages and derates. Therefore, comparing the bars net of derates and outages against the original requirement illustrates the impact of the implementation errors while comparing against the requirement with uncertainty illustrates the impact of the changes proposed by the ISO.

The dark green bars reflect capacity that was considered available for the bid range capacity test but unavailable for the flexible ramping sufficiency test because of all other resource constraints. These constraints include exceptional dispatches, start-up times, transition times, ramp rates, and other intertemporal constraints. DMM recommends that a subset of this category be omitted in the bid range capacity test to the extent that it is independent of any displacement from EIM transfers. For more information, see section 1.3.

## Arizona Public Service

**Figure 4.1 Arizona Public Service upward bid range capacity test requirement and capacity (August 14, 2020)**

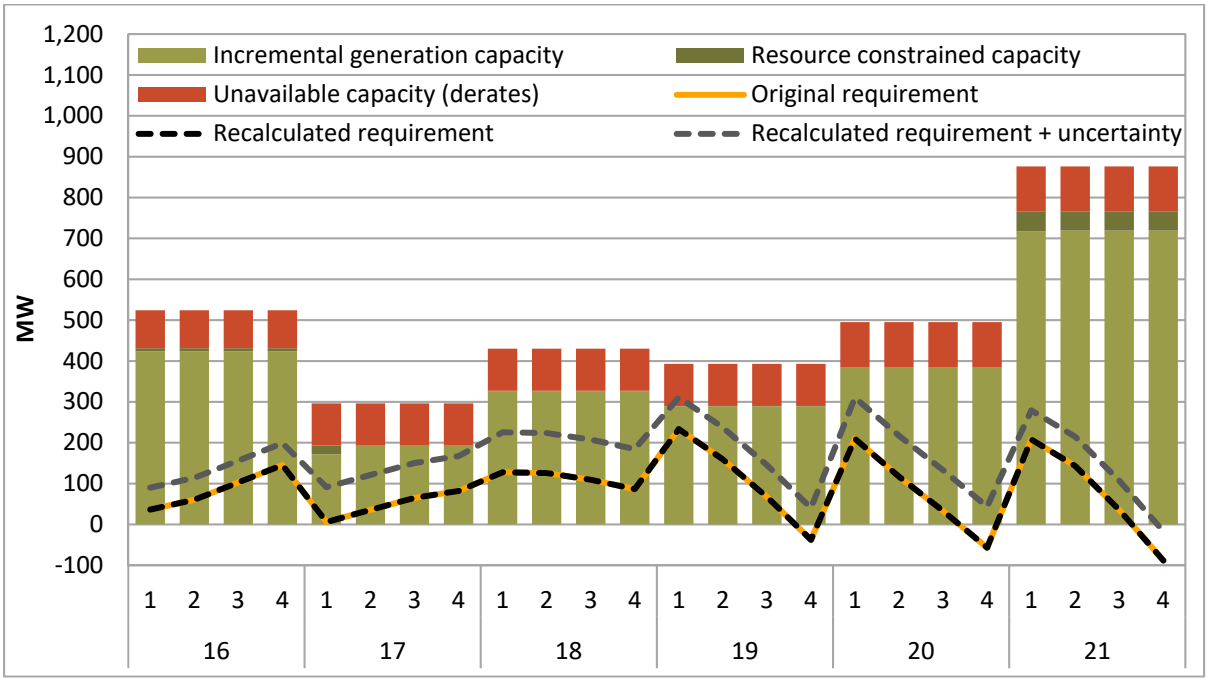
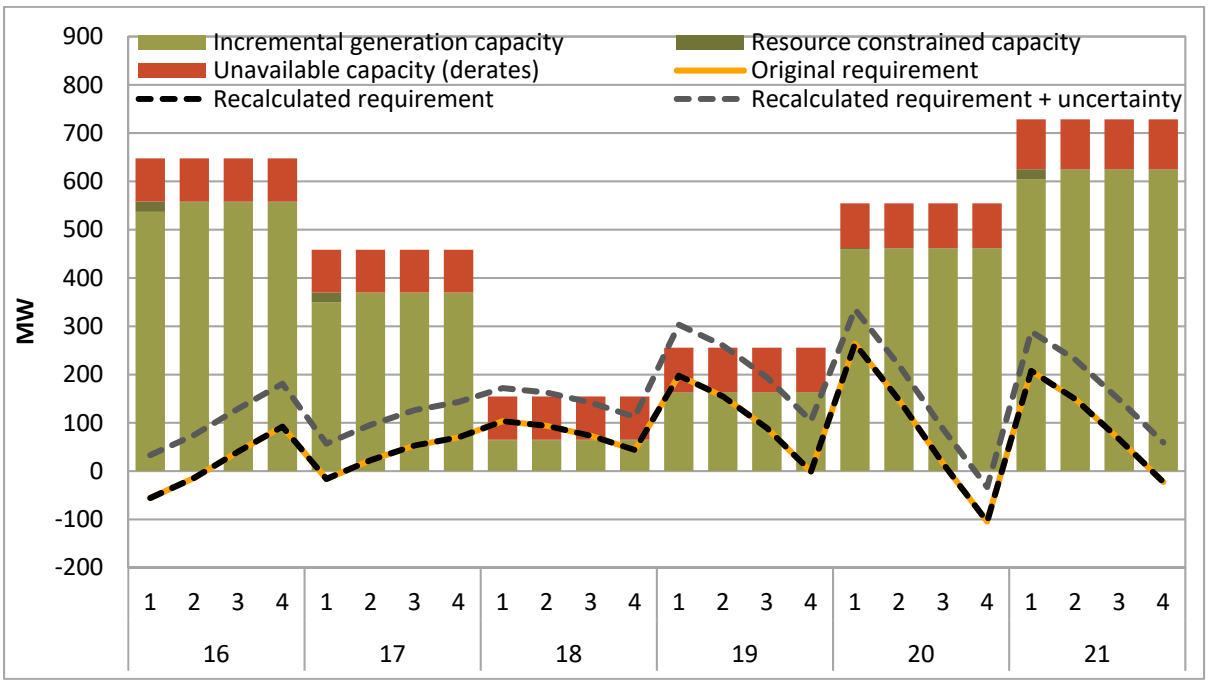



**Figure 4.2 Arizona Public Service upward bid range capacity test requirement and capacity (October 1, 2020)**



## Balancing Authority of Northern California

**Figure 4.3 BANC upward bid range capacity test requirement and capacity (August 14, 2020)**

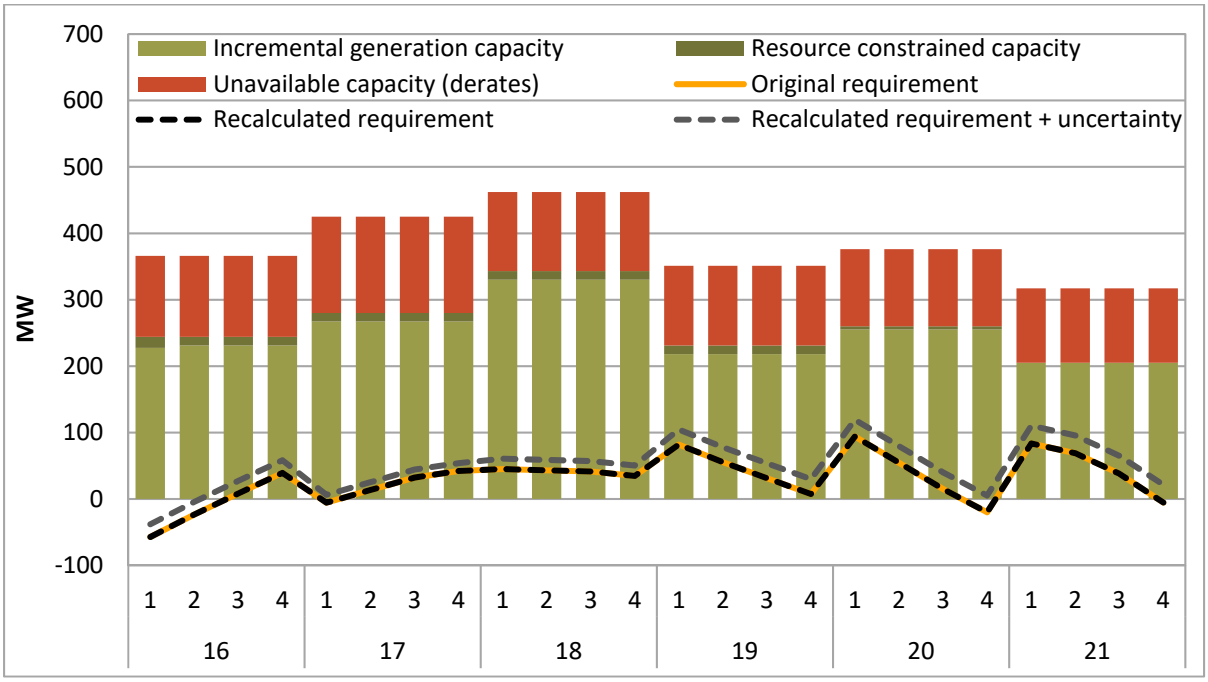
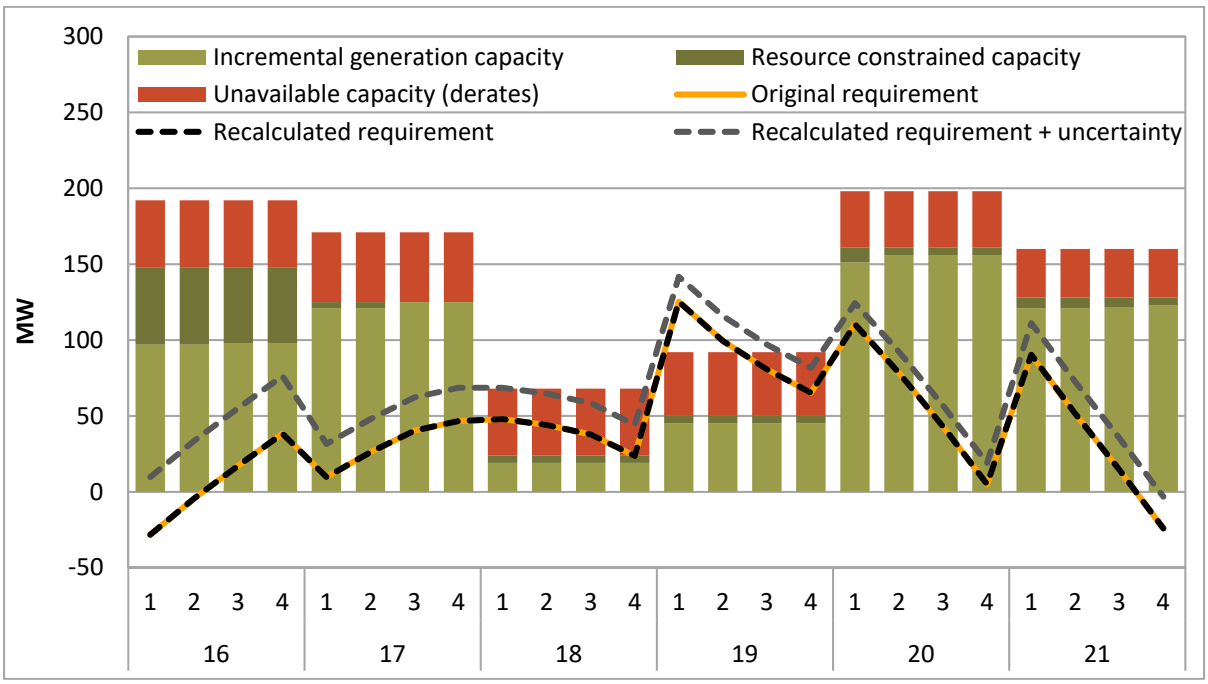



**Figure 4.4 BANC upward bid range capacity test requirement and capacity (October 5, 2020)**



## Idaho Power

**Figure 4.5 Idaho Power upward bid range capacity test requirement and capacity (August 14, 2020)**

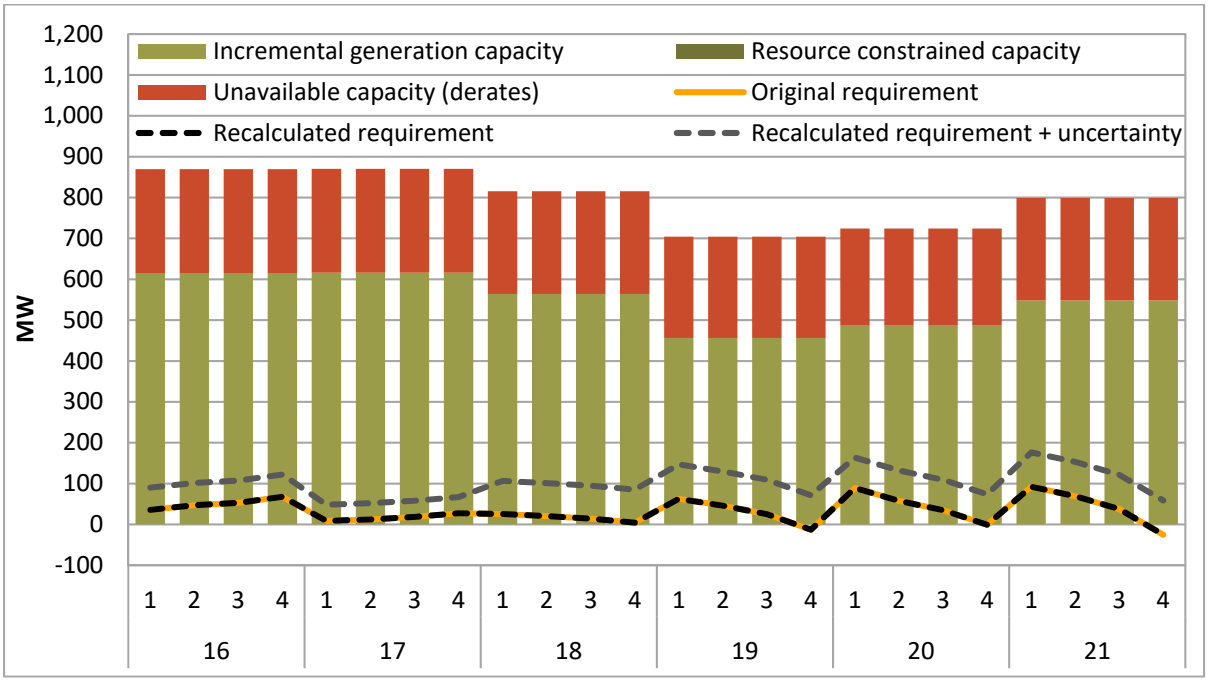
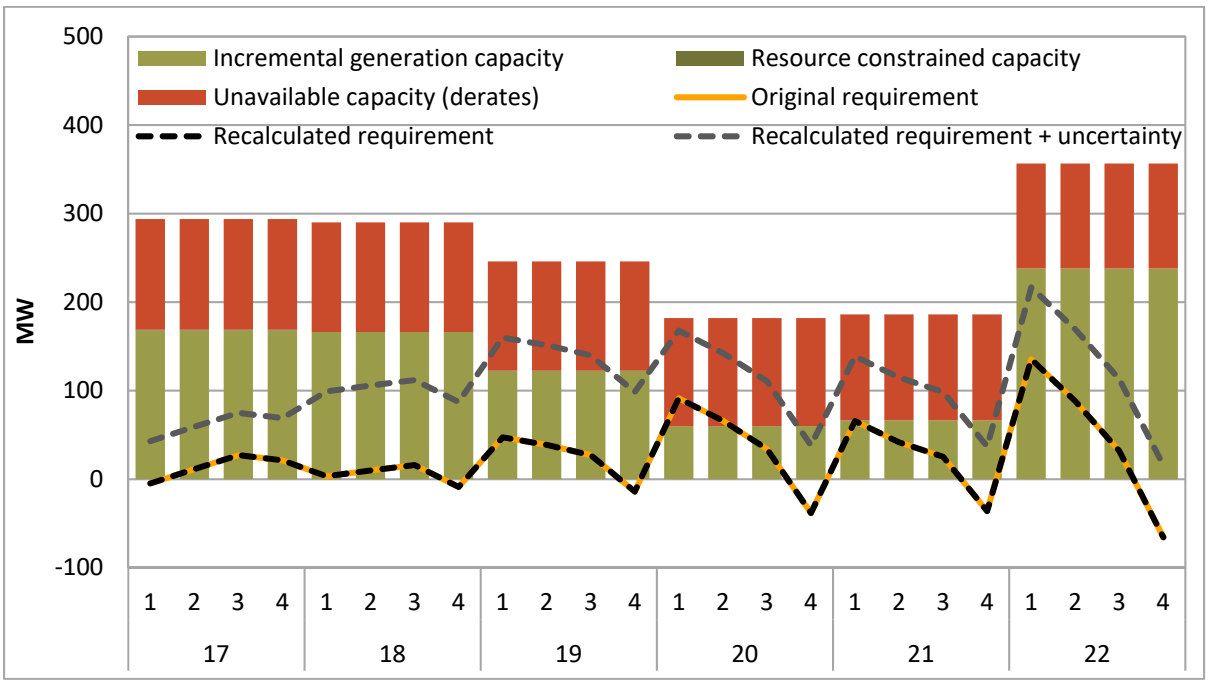



**Figure 4.6 Idaho Power upward bid range capacity test requirement and capacity (July 6, 2020)**



## NV Energy

**Figure 4.7 NV Energy upward bid range capacity test requirement and capacity (August 14, 2020)**

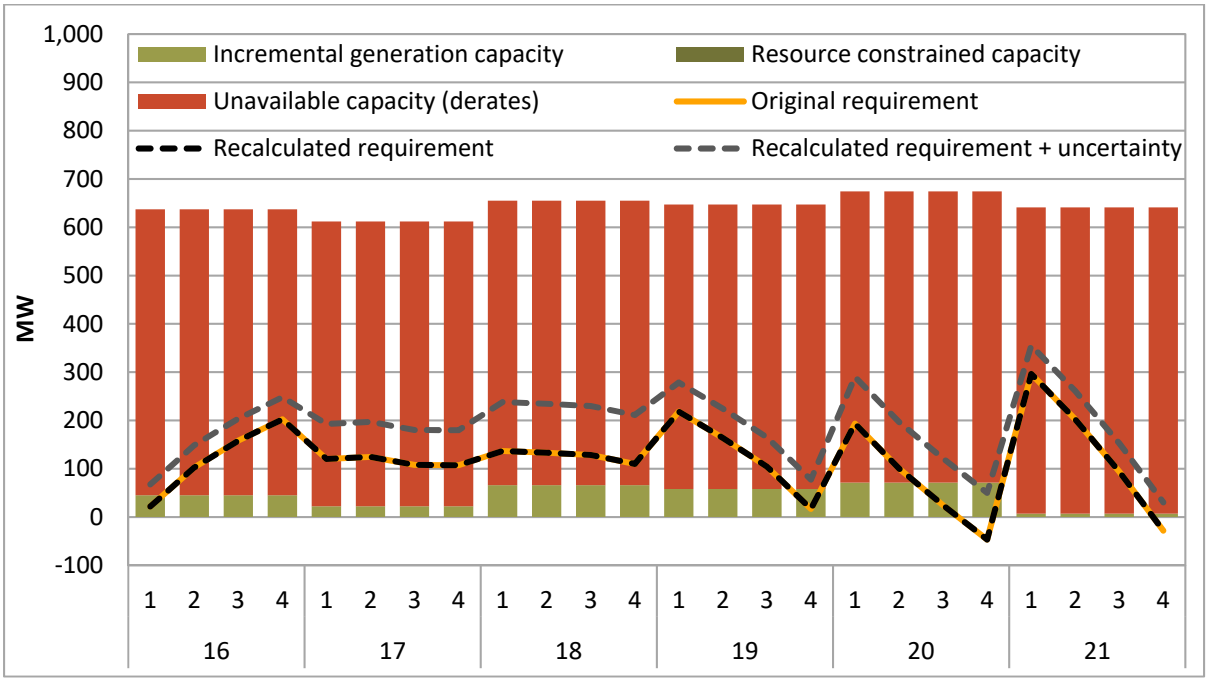
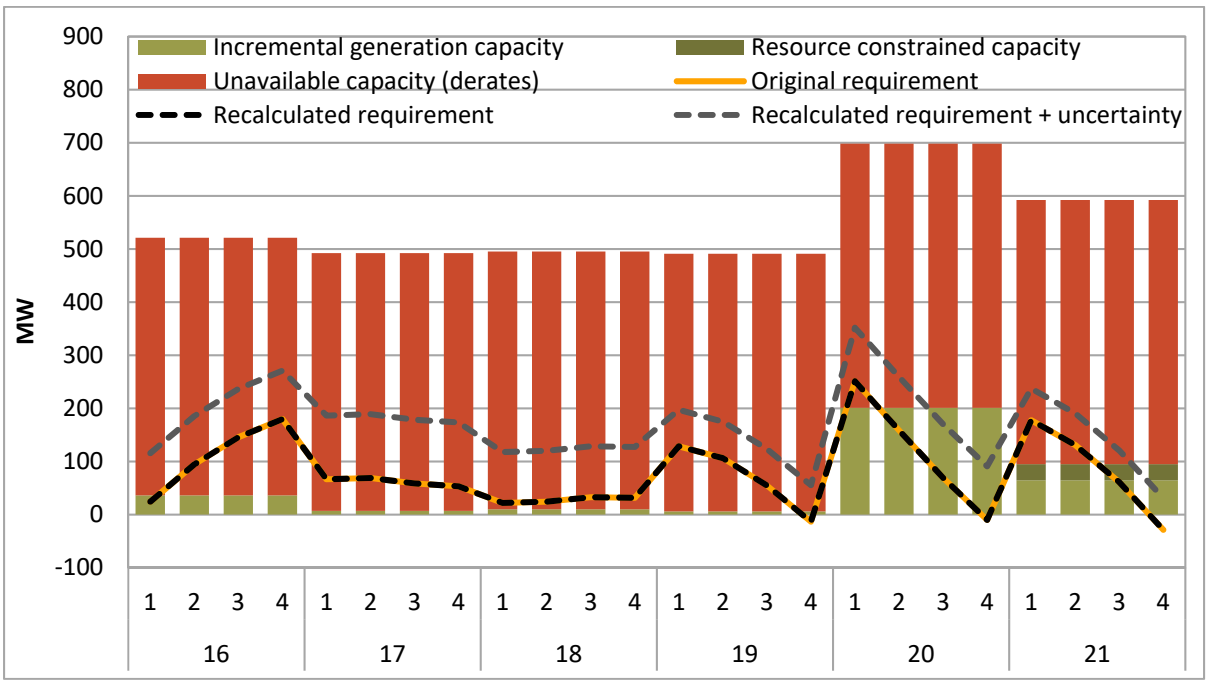



**Figure 4.8 NV Energy upward bid range capacity test requirement and capacity (July 21, 2020)**



## PacifiCorp East

**Figure 4.9 PacifiCorp East upward bid range capacity test requirement and capacity (August 14, 2020)**

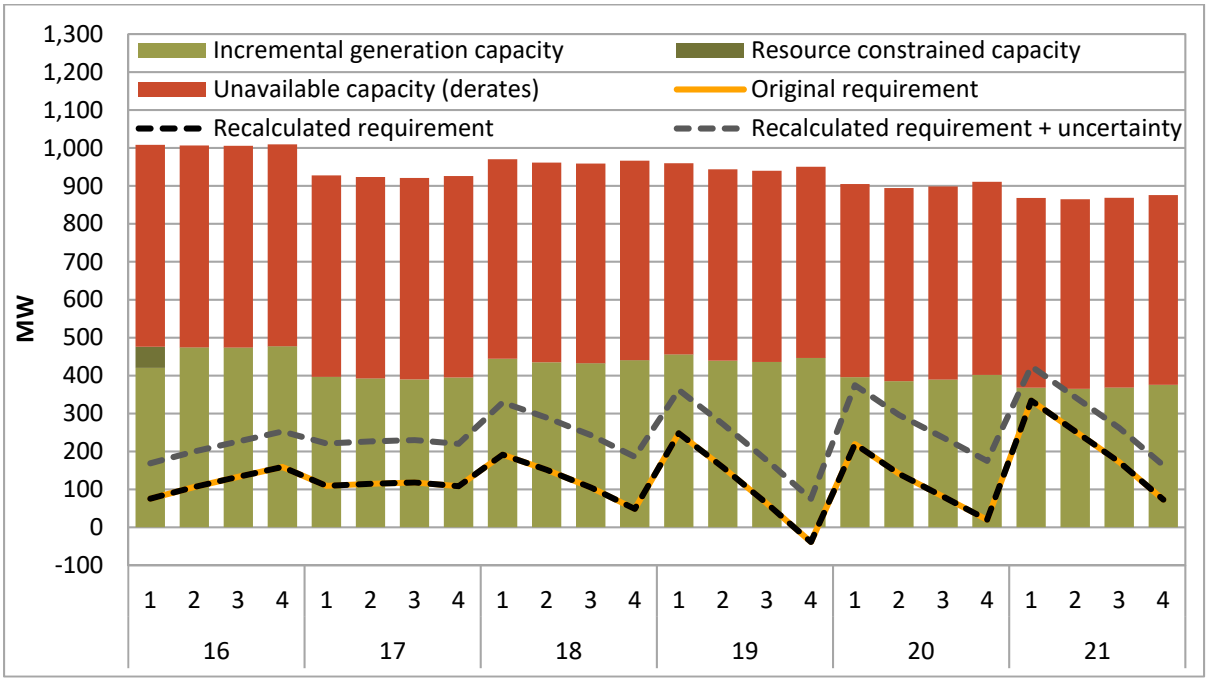
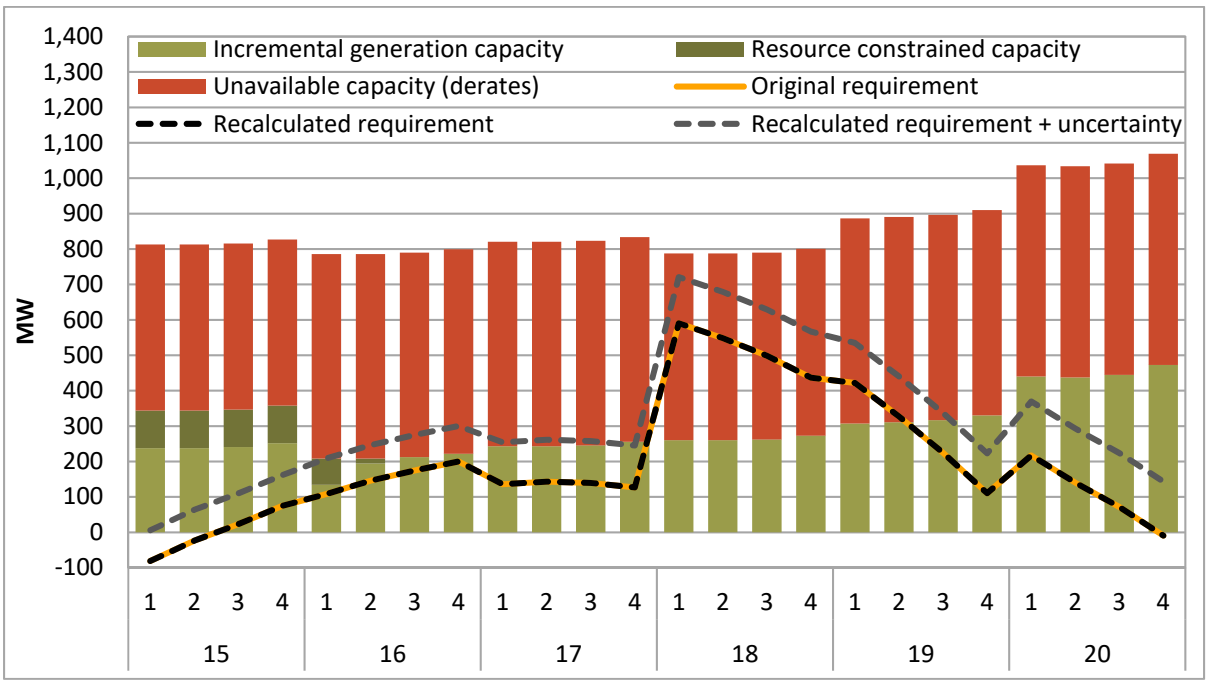



**Figure 4.10 PacifiCorp East upward bid range capacity test requirement and capacity (August 18, 2020)**



## PacifiCorp West

**Figure 4.11 PacifiCorp West upward bid range capacity test requirement and capacity (August 14, 2020)**

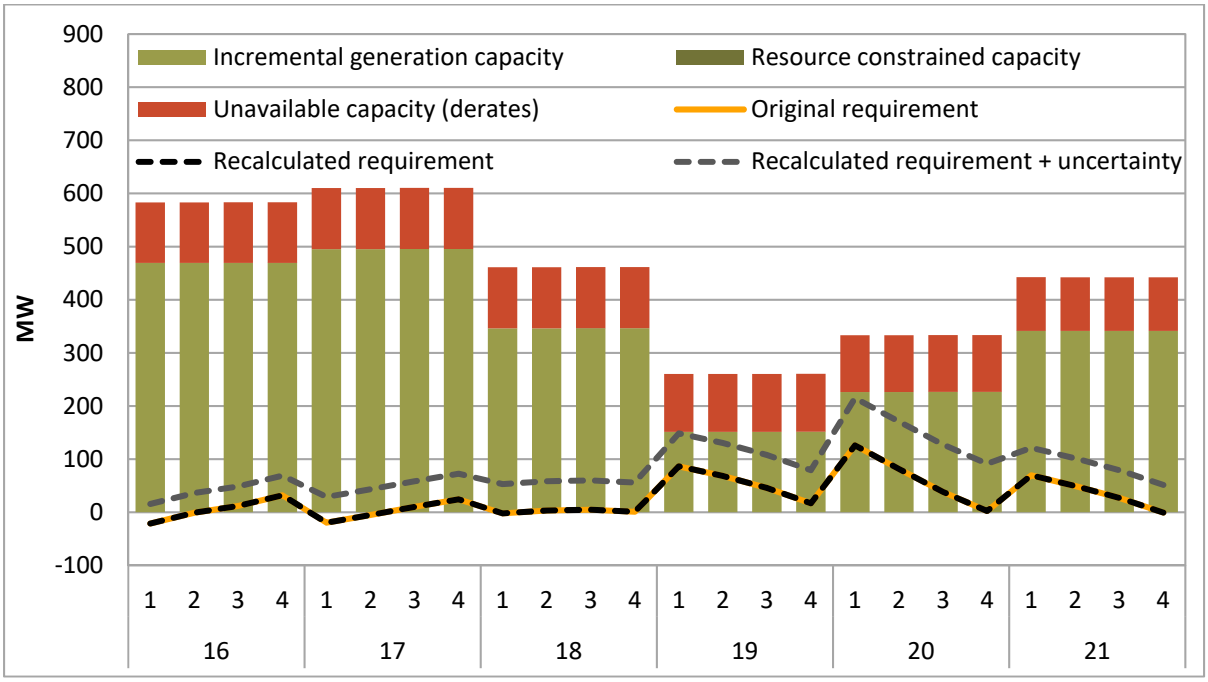
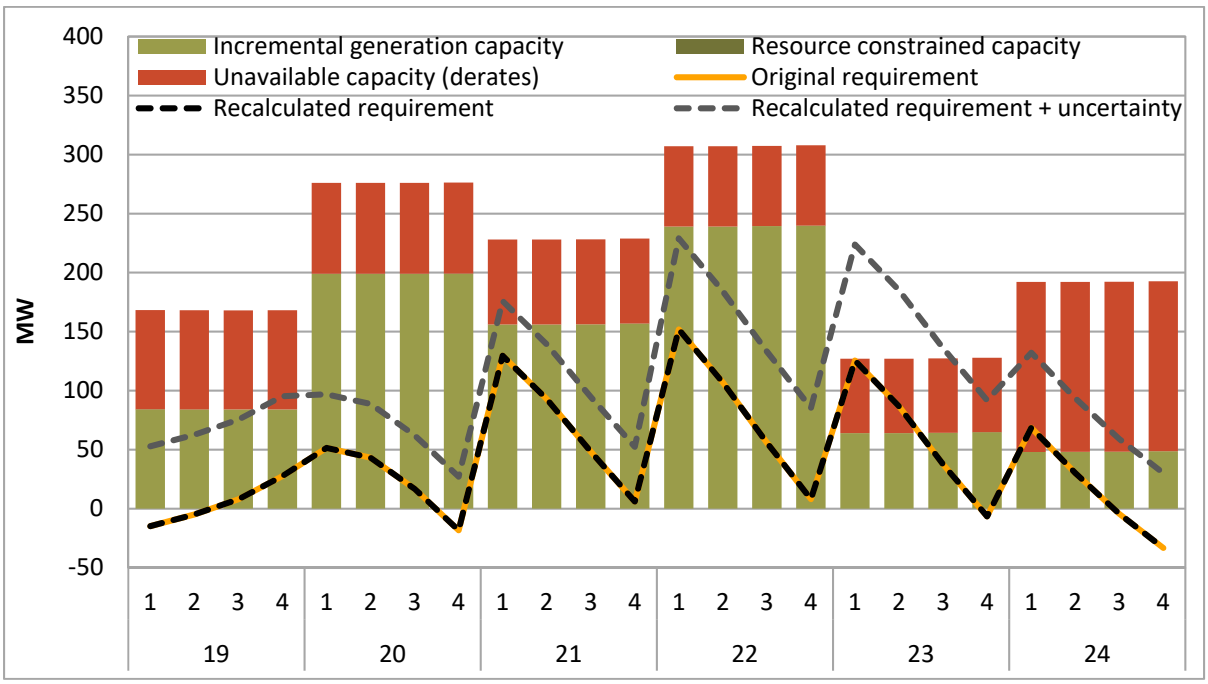



**Figure 4.12 PacifiCorp West upward bid range capacity test requirement and capacity (October 5, 2020)**



## Portland General Electric

**Figure 4.13 Portland General Electric upward bid range capacity test requirement and capacity (August 14, 2020)**

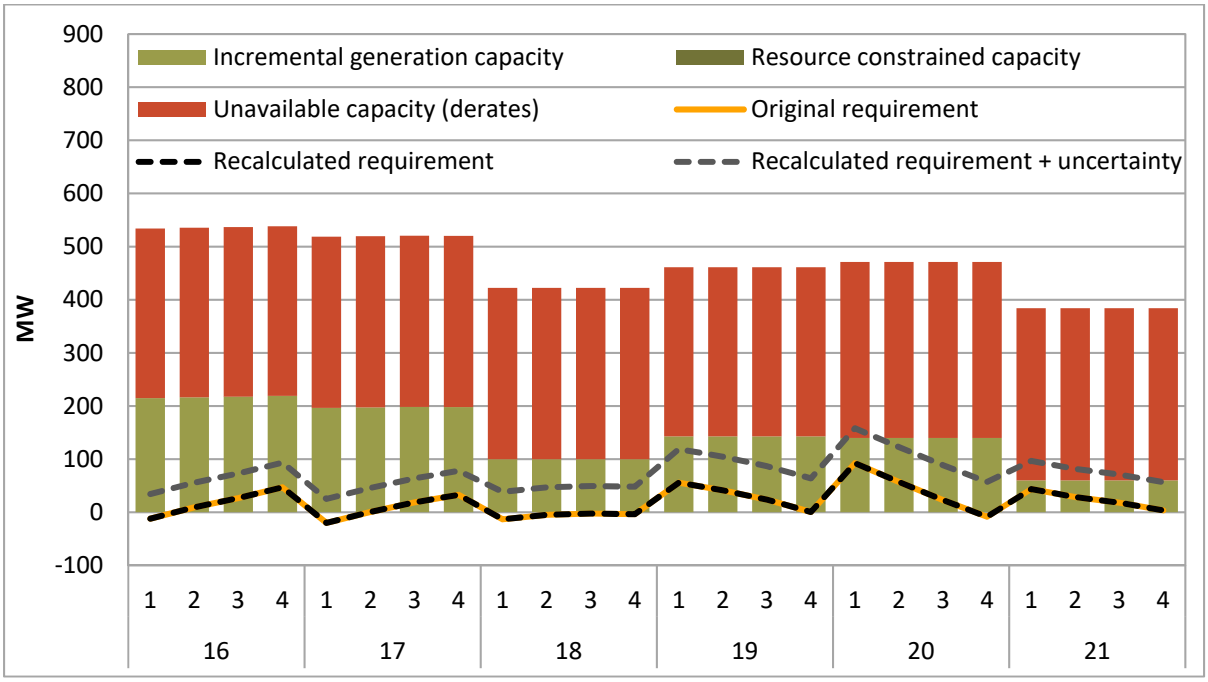
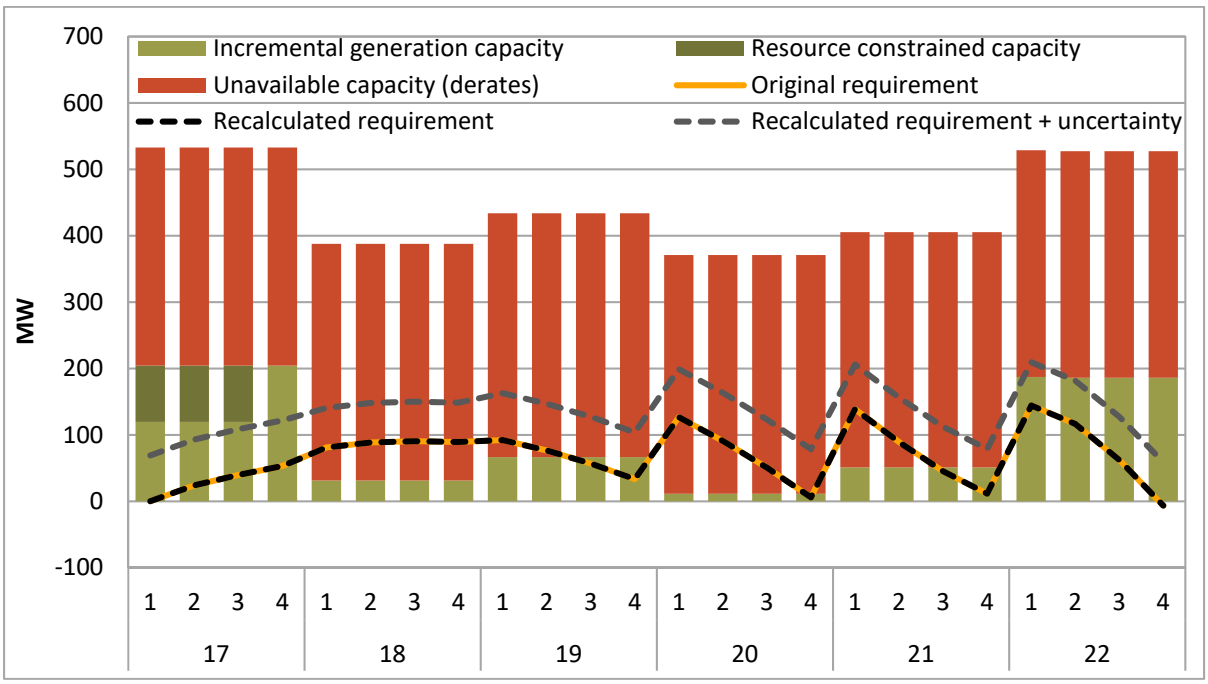



**Figure 4.14 Portland General Electric upward bid range capacity test requirement and capacity (July 20, 2020)**



## Powerex

**Figure 4.15 Powerex upward bid range capacity test requirement and capacity (August 14, 2020)**

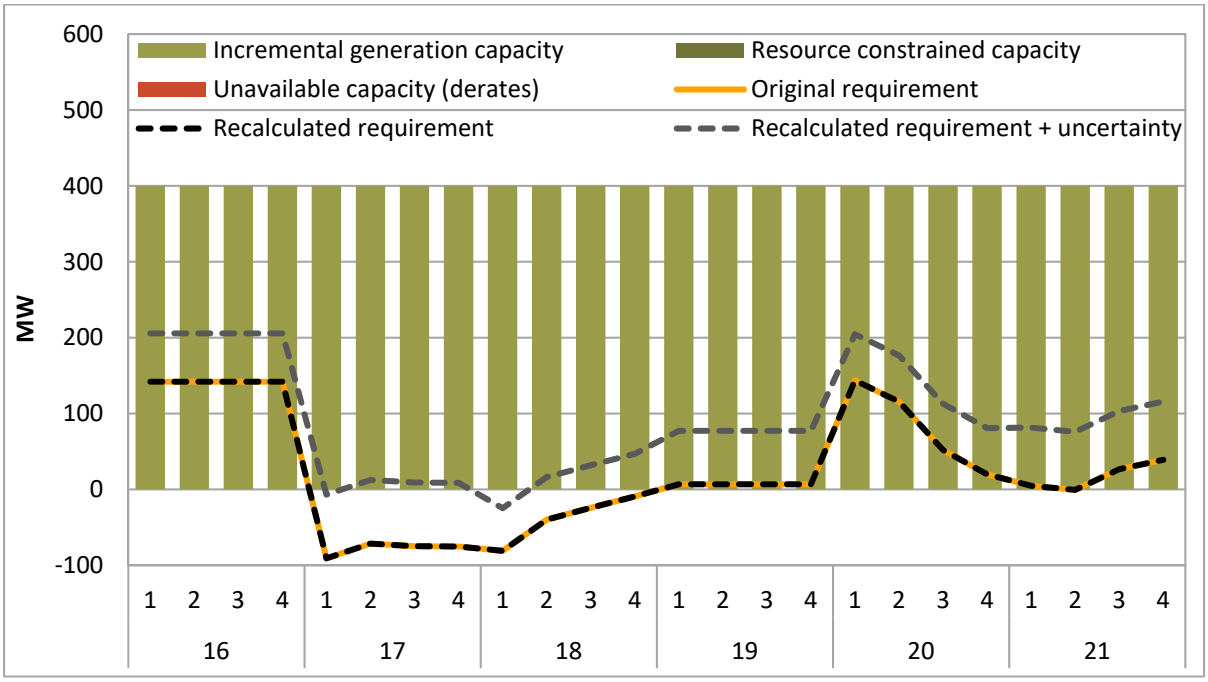
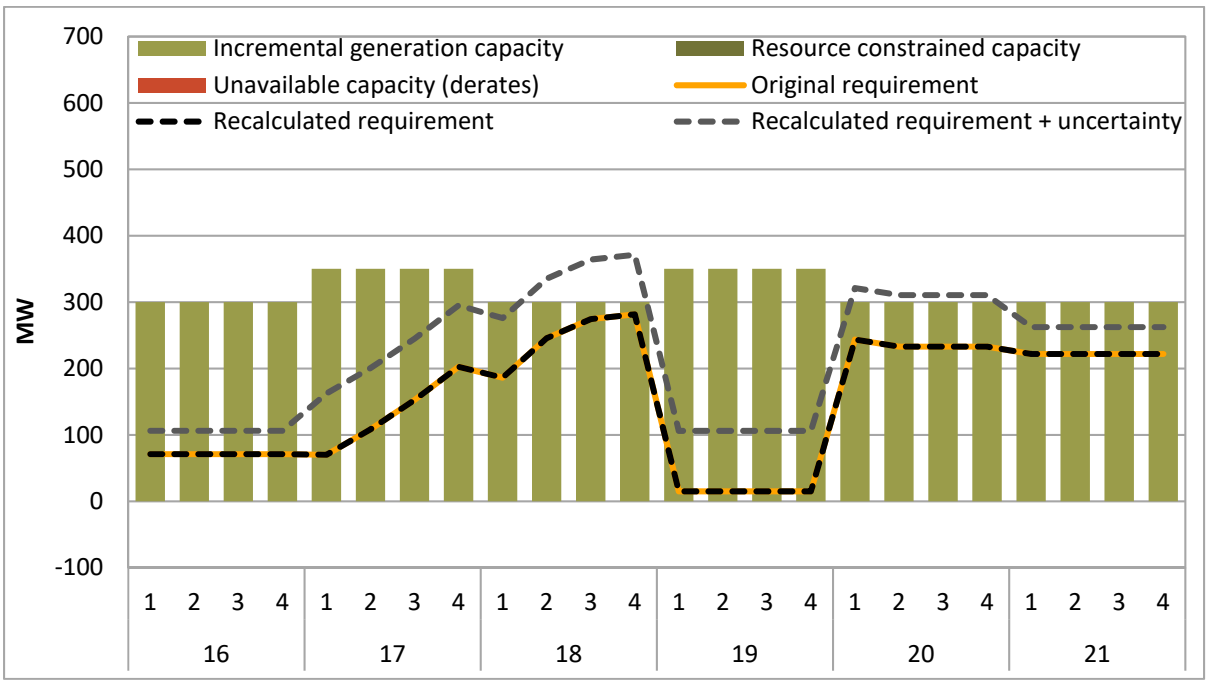



**Figure 4.16 Powerex upward bid range capacity test requirement and capacity (May 17, 2020)**



## Puget Sound Energy

**Figure 4.17 Puget Sound Energy upward bid range capacity test requirement and capacity (August 14, 2020)**

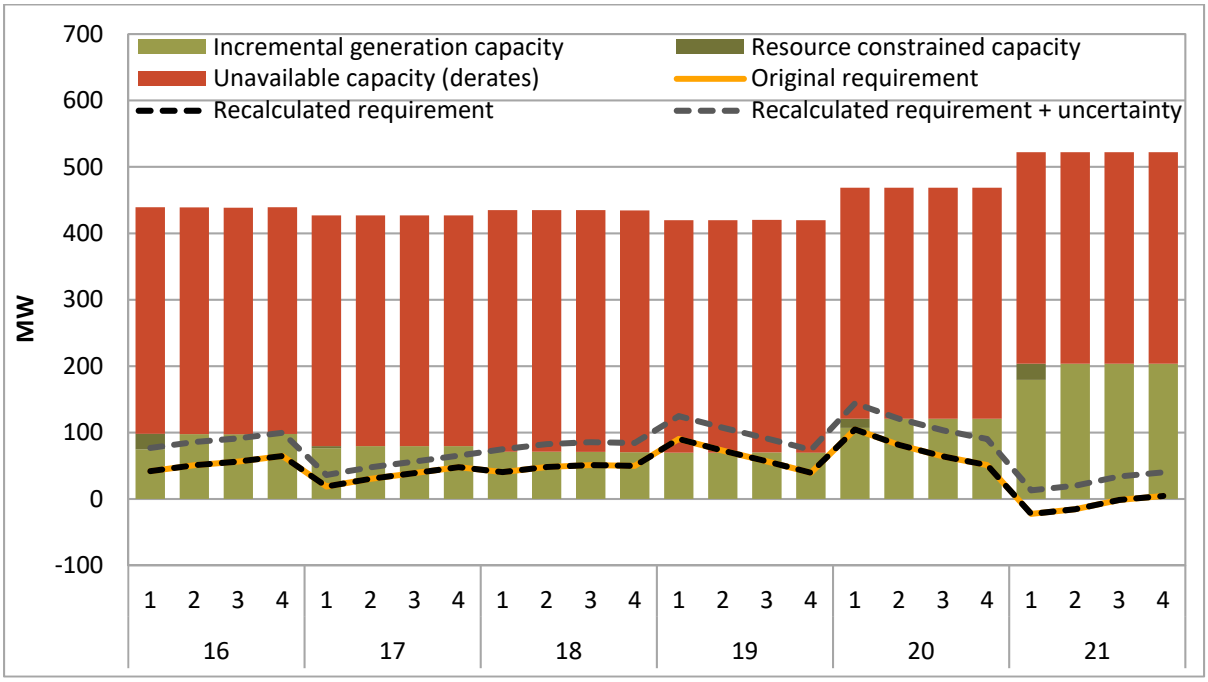
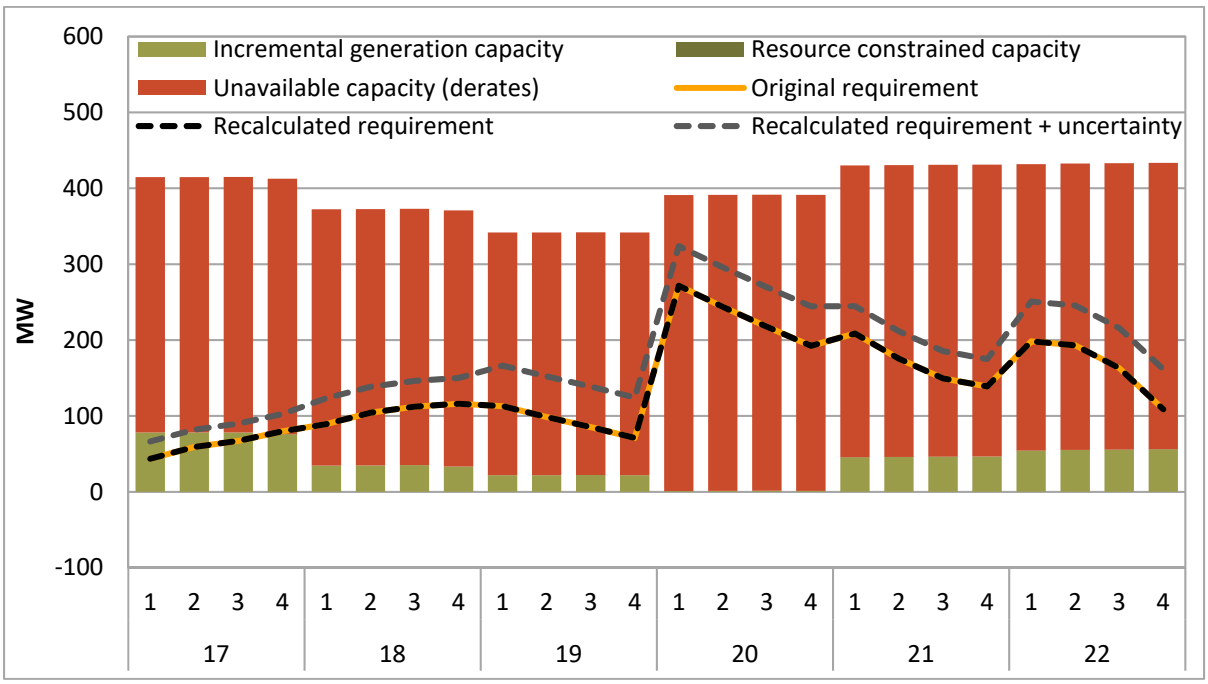



**Figure 4.18 Puget Sound Energy upward bid range capacity test requirement and capacity (July 20, 2020)**



## Salt River Project

**Figure 4.19 Salt River Project upward bid range capacity test requirement and capacity (August 14, 2020)**

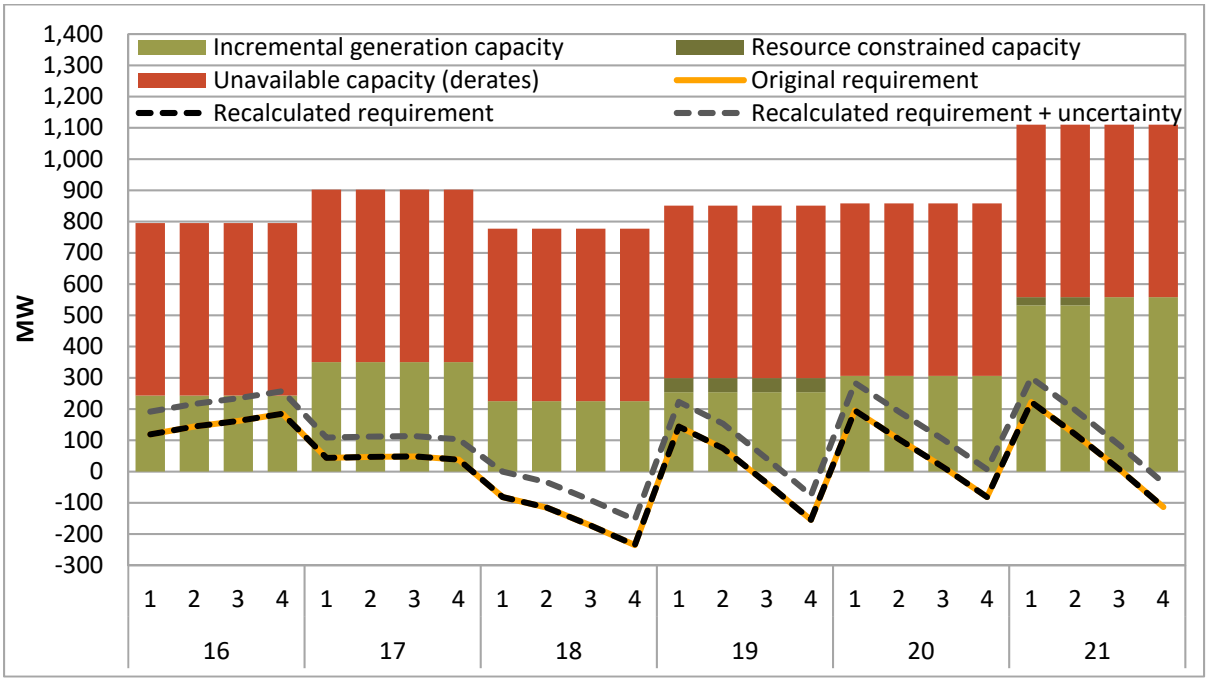
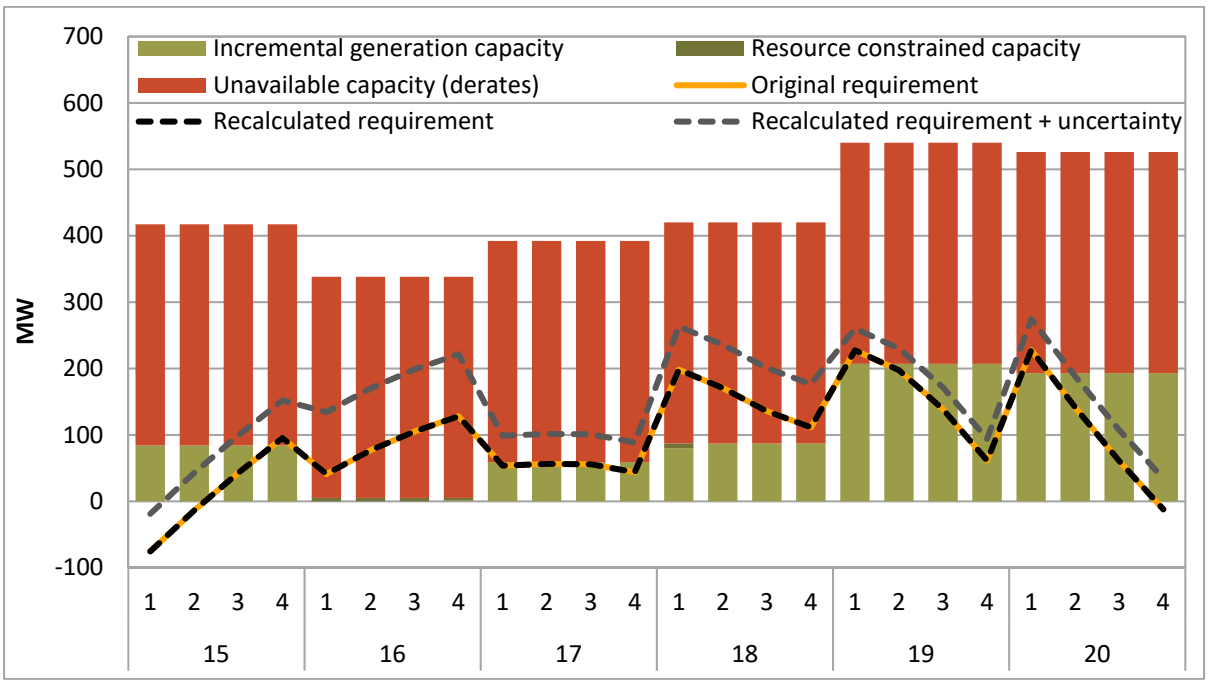



**Figure 4.20 Salt River Project upward bid range capacity test requirement and capacity (October 18, 2020)**



## Seattle City Light

**Figure 4.21 Seattle City Light upward bid range capacity test requirement and capacity (August 14, 2020)**

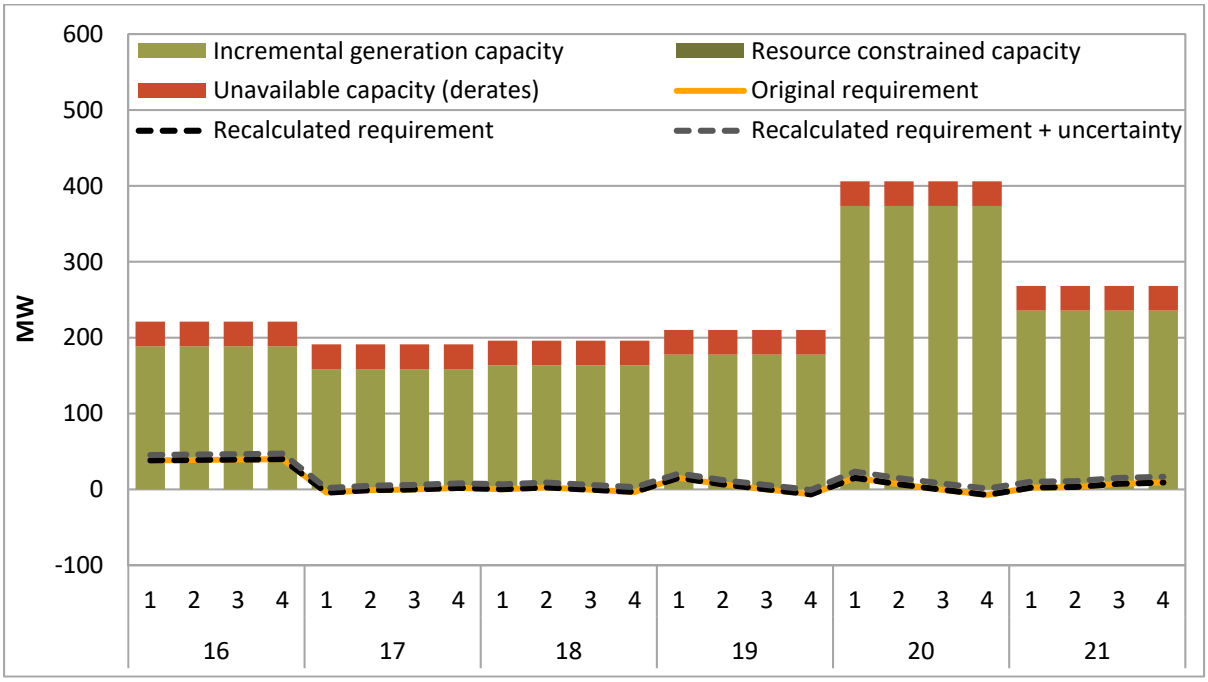



**Figure 4.22 Seattle City Light upward bid range capacity test requirement and capacity (August 20, 2020)**