Resource Adequacy Enhancements: Supplemental Report – Preliminary Portfolio Assessment

Supplement to the Fifth Revised Straw Proposal

November 6, 2020

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1. Executive Summary

One of the core elements of the CAISO's RA Enhancements stakeholder initiative is the development and use of a production simulation tool that can assess how likely the shown monthly RA fleet supports grid reliability. The CAISO will conduct a monthly portfolio deficiency test of the shown RA fleet to determine if the RA portfolio is adequate to serve load under various load and net load conditions during all hours of the day. The portfolio deficiency test will use only the shown RA fleet in a production simulation to determine if the CAISO can serve forecasted gross and net-load peaks, and maintain adequate reserves and load following capability in that relevant RA compliance month.

This paper provides the RA portfolio assessment results using July 2020 RA showings. This paper's objective is to provide insight and transparency into the CAISO's assessment model, methods, and initial findings that inform the portfolio assessment. The results presented here are instructive, though not conclusive. The CAISO will conduct further modeling using other months' RA showings to complete the picture about how likely the RA fleet meets grid reliability needs across all months. The CAISO expects that additional monthly assessments will provide more robust results and definitive findings about the level of reliability the existing RA fleet supports. Even though the CAISO is not making a final recommendation for a reliability metric or framework now, the study results and recent reliability events confirm the need to take interim measures that focus on ensuring sufficient RA resources are available during the net-load peak and the hours immediately following, not just during the gross load peak. This could be accomplished by setting an additional planning reserve margin that must be met with RA resources across these critical evening hours. Lastly, the CAISO provides thoughts on an initial framework for determining the desired level of reliability RA procurement will provide. The framework focuses on the questions that must be asked and answered to inform this question, as well as some examples of how these questions could be answered.

For the current study process, the CAISO used the stochastic production simulation tool used for the Summer Loads and Resources Assessment (Summer Assessment) study on the July 2020 RA showings. In addition to testing the July 2020 RA fleet, the CAISO also tested a "Thermal Scenario." The Thermal Scenario was designed to approximate a baseline level of reliability for the original RA design by recreating a fleet similar to a 2005 RA fleet.

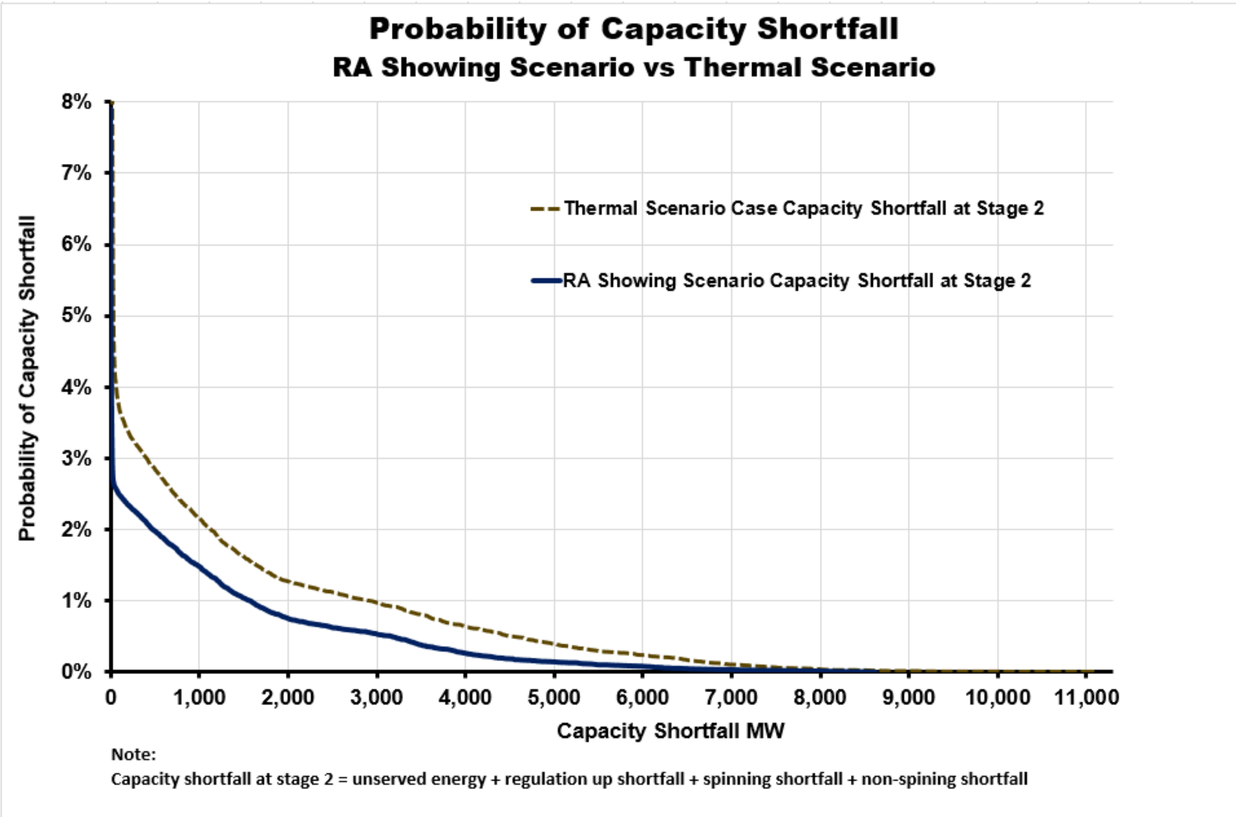
A stochastic monthly assessment of the RA fleet poses unique challenges that do not exist under the simple accounting tools currently used to ensure RA compliance. Two core challenges must be addressed:

(1) Establishing a defined reliability criteria or loss-of-load expectation that determines procurement targets and backstop procurement triggers; and
(2) Determining the quantity and attributes of capacity needed to address a portfolio deficiency.

At this time, the CAISO does not explicitly answer these two questions. Instead, using actual RA showings from July 2020, the CAISO provides a framework to consider how to derive answers to these questions so that these two issues can be further vetted with stakeholders.

Figure ES 1, below, shows the probability of a daily deficiency of a given size. As noted above, the RA Showing Scenario had lower overall probability of a shortfall than the Thermal Scenario, 7.9 percent compared to 15.5 percent. However, as shown in Figure ES 1, many of these shortfalls are very small. For example, the probability of shortfall of greater than 50 MW is 2.6 percent and 4.1 percent for the RA Showing and Thermal Scenarios respectively.

Figure ES 1: Probability of capacity deficiency



As a final measure, the CAISO reviewed a collection of frequency distributions with respect to the duration, frequency and timing of deficiencies. Each of these are critical to ensuring the correct capacity is procured to resolve the deficiency. These distributions can be informative when trying to assess potential additional risks that may be present and provide guidance on the type of resource needed to deal with the deficiencies.

To establish resource procurement obligations, it is necessary to determine an acceptable level of service reliability given the probability of a capacity shortfall and potential for involuntary load shedding. In this context, service level reliability refers to the targeted level of reliability to firm load, taking into account some marginal level of accepted probability of interruption due to supply shortage. For example, is a level of service reliability based on a three percent probability of a capacity shortfall acceptable, or should it be higher or lower? The answer is determined at the intersection of service reliability and the cost to protect against a possible capacity shortfall.[1]

Three decisions help inform this issue:

1) <u>The granularity of the RA program: Annual, Seasonal, or Monthly?</u>

[1] The use of three percent in this instance already assumes that it is possible to make up for deficiencies smaller than 50 MW.

Should the existing monthly RA program be maintained or transitioned to an annual or seasonal construct. It must also examine the benefits of multi-year procurement obligations. This will determine, in part, how reliability provided by the RA program is measured because it will determine how an annual reliability metric is allocated over the year.

2) The application of an annualized planning standard
   If a monthly RA program is maintained, an annual planning standard must be allocated over twelve individual months. There are at least two ways to apply an annual standard over a full year: Uniformly of shaped.
3) The desired service level reliability target
   The desired service level reliability target is defined by determining an acceptable loss of load probability when setting RA procurement targets. That is not to say that the CAISO would shed firm load during each instance of an RA shortage, but it does mean the CAISO would likely lean more heavily on backstop procurement.[2]

2. Background of the CAISO's Proposed Portfolio Assessment

One of the core elements of the CAISO's RA Enhancements stakeholder initiative is the development and use of a production simulation tool that can assess how likely the shown monthly RA fleet supports grid reliability. The CAISO will conduct a monthly portfolio deficiency test of the shown RA fleet to determine if the RA portfolio is adequate to serve load under various load and net load conditions during all hours of the day. The portfolio deficiency test will use only the shown RA fleet in a production simulation to determine if the CAISO can serve forecasted gross and net-load peaks, and maintain adequate reserves and load following capability in that relevant RA compliance month. This test will be done for system level needs. Local capacity needs will continue to be assessed under the existing methods. The need for this assessment is similar in concept to the collective deficiency test CAISO conducts for local RA. The CAISO will only conduct this assessment for monthly RA showings because they are the only showings where LSEs must meet 100 percent of the system, local, and flexible RA capacity requirements. The increased number of energy and availability-limited resources on the system and the reliance on these resources to meet RA needs means that some resource mixes provided to meet RA requirements may not ensure reliable operation of the grid during all hours of the day across the entire RA compliance month. However, the CAISO must assess how the shown RA fleet works collectively to meet system needs over all hours and under a broad range of load conditions.

This paper provides the RA portfolio assessment results using July 2020 RA showings. This paper's objective is to provide insight and transparency into the CAISO's assessment model, methods, and initial findings that inform the portfolio assessment. The results presented here are instructive, though not conclusive. The CAISO will conduct further modeling using other months' RA showings to complete the picture about how likely the RA fleet meets grid reliability needs across all months. The CAISO expects that additional monthly assessments will provide

[2] The CAISO has various tools to help maintain system reliability. For instance, if non-resource adequacy capacity remained available, the CAISO would exercise its backstop procurement authority before turning to involuntary firm load shedding.

more robust results and definitive findings about the level of reliability the existing RA fleet supports. Even though the CAISO is not making a final recommendation for a reliability metric or framework now, the study results and recent reliability events confirm the need to take interim measures that focus on ensuring sufficient RA resources are available during the net-load peak and the hours immediately following, not just during the gross load peak. This could be accomplished by setting an additional planning reserve margin that must be met with RA resources across these critical evening hours. Lastly, the CAISO provides thoughts on an initial framework for determining the desired level of reliability RA procurement will provide. The framework focuses on the questions that must be asked and answered to inform this question, as well as some examples of how these questions could be answered. The CAISO considered a variety of deterministic, stochastic, and hybrid modelling approaches for this portfolio analysis. Based on stakeholder feedback and additional CAISO assessments, the CAISO determined that a stochastic approach offers the greatest opportunity to assess the widest array of load, wind, and solar profiles as well as historic outage profiles for fully dispatchable resources.

A stochastic monthly assessment of the RA fleet poses unique challenges that do not exist under the simple accounting tools currently used to ensure RA compliance. Two core challenges must be addressed:

(1) Establishing a defined reliability criteria or loss-of-load expectation that determines procurement targets and backstop procurement triggers; and
(2) Determining the quantity and attributes of capacity needed to address a portfolio deficiency.

At this time, the CAISO does not explicitly answer these two questions. Instead, using actual RA showings from July 2020, the CAISO provides a framework to consider how to derive answers to these questions so that these two issues can be further vetted with stakeholders.

In addition to testing the July 2020 RA fleet, the CAISO also tested a “Thermal Scenario.” The Thermal Scenario was designed to approximate a baseline level of reliability for the original RA design by recreating a fleet similar to a 2005 RA fleet. This provides information about the probabilities of shortfalls the RA program generated at the outset. Specifically, the CAISO replaces all wind and solar capacity with thermal resources to reach a 115 percent planning reserve margin. This allows the CAISO to compare the relative needs created by the RA fleet in 2005, when the fleet relied on a significant share of thermal generation, and the resources used for the July 2020 RA month. Specifically, the CAISO can compare probabilities, time of day, duration, and magnitudes of deficiency. It is important to note that the Thermal Scenario in no way represents the actual levels of reliability offered since 2005. The excess levels of capacity in the CAISO and across the west allowed the CAISO to utilize economic energy from non-RA resources and provide a higher level of reliability. However, over the last 15 years this excess capacity has steadily dried up. These tightening supply conditions have lead the CAISO to conduct this assessment to measure the expected level of reliability if that economic energy was not there. In other words, the goal of this assessment is to measure the expected level of reliability if the CAISO was to rely solely on the shown RA fleet to meet gross and net-load peaks, and maintain adequate reserves and load following capability.

The CAISO sought to leverage its existing production simulation expertise and modeling by relying on existing tools and methods. This provides at least two benefits. First, using an existing production simulation model will help the CAISO expedite testing and implementation.

Second, the CAISO can utilize an accepted and vetted model that has been relied on for other CAISO published studies. For the current study process, the CAISO used the production simulation tool used for the Summer Loads and Resources Assessment (Summer Assessment) study.[3] The CAISO has used this production simulation tool to conduct this study since 2016, updating the model annually to create a robust tool for CAISO to convey potential risks for the upcoming summer needs. More specifically:

> The 2020 Summer Loads and Resources Assessment ("2020 Assessment") provides an assessment of the upcoming summer supply and demand outlook for the California Independent System Operator (CAISO) balancing authority area. In developing the supply and demand forecasts and identify potential issues concerning upcoming operating conditions for the summer 2020, the CAISO uses internal sources of information, third party modeling tools, and public information from various state agencies, generation and transmission owners, load serving entities, and other balancing authorities (BAs). The 2020 Assessment considers the supply and demand conditions across the entire CAISO balancing authority area, and to a more limited extent, the entire Western Electricity Coordinating Council (WECC).[4]

Although the Summer Assessment was developed for a slightly different purpose, the core modelling functions are identical to what the CAISO needs for an RA portfolio analysis. For example, the model is a detailed representation of load and resource characteristics across the CAISO. It can also model resources across the WECC, allowing for energy imports into the CAISO based on availability. The model commits resources based on load, unit minimum and maximum capacities, start times, ramp rates, minimum down times and unit specific forced outage rates to meet CAISO needs, including operating reserves, regulation, and load following. One exception to this rule is that the model does not currently model use-limitations that extend beyond a single day (i.e. monthly or annual use-limitations). Load following requirements are necessary because the analysis is run on hourly blocks. The model can run both stochastically and deterministically, allowing the CAISO to develop robust statistical results while still testing specific sensitivities.

The Summer Assessment assumes that all resources are available to the CAISO to meet peak summer loads. However, the portfolio assessment only models the shown RA resources to assess the probability and magnitude of capacity shortfalls. The only exception to this rule is that the CAISO modeled all wind and solar capacity. Although wind and solar capacity above the RA showing does not have an explicit must offer obligation to the CAISO, known RPS goals provide the CAISO with similar confidence that this capacity will be available comparably to RA capacity. Energy provided in the CAISO's day-ahead or real-time markets from non-RA resources, including non-RA resources internal to the CAISO and non-RA economic energy imports, represents non-firm economic energy substitutes, which will not be considered in the portfolio assessment. These resources can improve the outcome of day-ahead and real-time markets, but they do not have the same availability obligation as the modeled RA resources and

[3] The annual study process is typically completed in May of each year. The most current study is the 2019 assessment, available at http://www.caiso.com/Documents/Briefing-2019-SummerLoads-Resources-Assessment-Report-May2019.pdf

[4] http://www.caiso.com/Documents/2020SummerLoadsandResourcesAssessment.pdf at p. 1.

cannot be relied upon to determine if adequate forward procurement has occurred such that the CAISO is able to reliably operate the grid.

The remainder of this supplement report provides:

1) The CAISO's definition of a deficiency
2) Details regarding:
    a. Model outputs
    b. Modelling iterations
    c. Inputs and assumptions, including System configurations, loads, and resources
3) The results of this model for both the RA and Thermal Scenarios
4) Framework for determining capacity needs

3. Stakeholder Engagement Plan

Date	Milestone
November 6	**Supplement to the Fifth revised straw proposal**
November 12	Stakeholder working group meeting on supplement to the fifth revised straw proposal and other RA Enhancements elements
November 13	Market Surveillance Committee meeting
November 25	Stakeholder comments on supplement to the fifth revised straw proposal and working group meetings due
December 14	**Draft final proposal**
January 5-7	Stakeholder meeting on draft final proposal
January 21	Stakeholder comments on draft final proposal
August – Q1 2021	Draft BRS and Tariff
Q1 2021	**Final proposal**
Q1 2021	**Present proposal to CAISO Board**

4. Overview of the CAISO's Production Simulation Model

As noted in 2, to conduct the portfolio assessment, the CAISO will use the same base model used in its Summer Assessment, but modified to account for only RA resources. This section provides details regarding all of the relevant inputs into the CAISO's model.

4.1. Defining "deficiency"

For the portfolio assessment, the CAISO believes that maintaining operational reserve requirements should be used to set the reliability standard. Currently, the CPUC and LRAs are responsible for defining service level reliability by establishing the RA requirements the LSEs under their jurisdiction must meet. Based on these requirements and subsequent RA showings, the CAISO must determine if the portfolio of resources it is provided under the RA program are sufficient to meet its real time operational requirements, including NERC and WECC reliability standards. At a Stage Two Emergency the CAISO begins using spinning reserves to serve load and sets up firm load to be shed as contingency reserve in its place. This process complies with NERC and WECC operating standards. Therefore, the CAISO defines a deficiency as follows:

> Any hour in which the production simulation shows the CAISO would have to call a Stage Two Emergency. This means the model shows the CAISO would have inadequate capacity to meet the aggregate of non-spin, spin, regulation, and load.[5]

4.2. Iterations and output

The CAISO's model is run using 2,000 month-long iterations. Each iteration pulls from data sets containing various load, wind, solar, and resource outage profiles. Once all iterations are complete, the CAISO can compute the probability of a portfolio deficiency. The model output can be expressed in terms of the probabilities of occurrence for the range of deficiency magnitudes observed. The CAISO expresses the results in different levels of granularity, including hourly, daily, and monthly. Hourly level data is primarily used to assess the hours during which the CAISO is most likely in need of additional capacity and the duration of deficiencies. The daily level results reflect the probability that any day within the production simulation is deficient. The magnitude of the deficiency for that day is the largest observed deficiency for the day. There are 62,000 daily observations in a 31 day study month. Similarly, the CAISO provides data on an iteration level. This data shows the instances where the RA fleet provided was not able to achieve a reliable outcome for a given iteration based on the defined parameters for reliable grid operation for the month.

4.3. Model details

This section provides the specific details of the model structure,[6] load, and resource inputs into the portfolio assessment.

4.3.1. CAISO system

The model simulates 35 WECC zones and 91 WECC interchange paths between zones, with the CAISO represented by three of those zones. The zonal interchange path limits were set based on the WECC Path Rating Catalog and net imports into the CAISO are limited to the amount of RA imports shown each month during on peak periods (hour-ending 16-21). Net imports during off peak hours (hour-ending 1-15, 22-24) are allowed to historical off peak levels, currently 11,666 MW. Transmission limits within the zones were not modeled and the model cannot provide results related to local capacity requirements.

4.3.2. Load inputs

The CAISO used the exact same load inputs in both the RA Showing and Thermal Scenarios. The CAISO load inputs into the model are based on the CAISO's load forecast process used for

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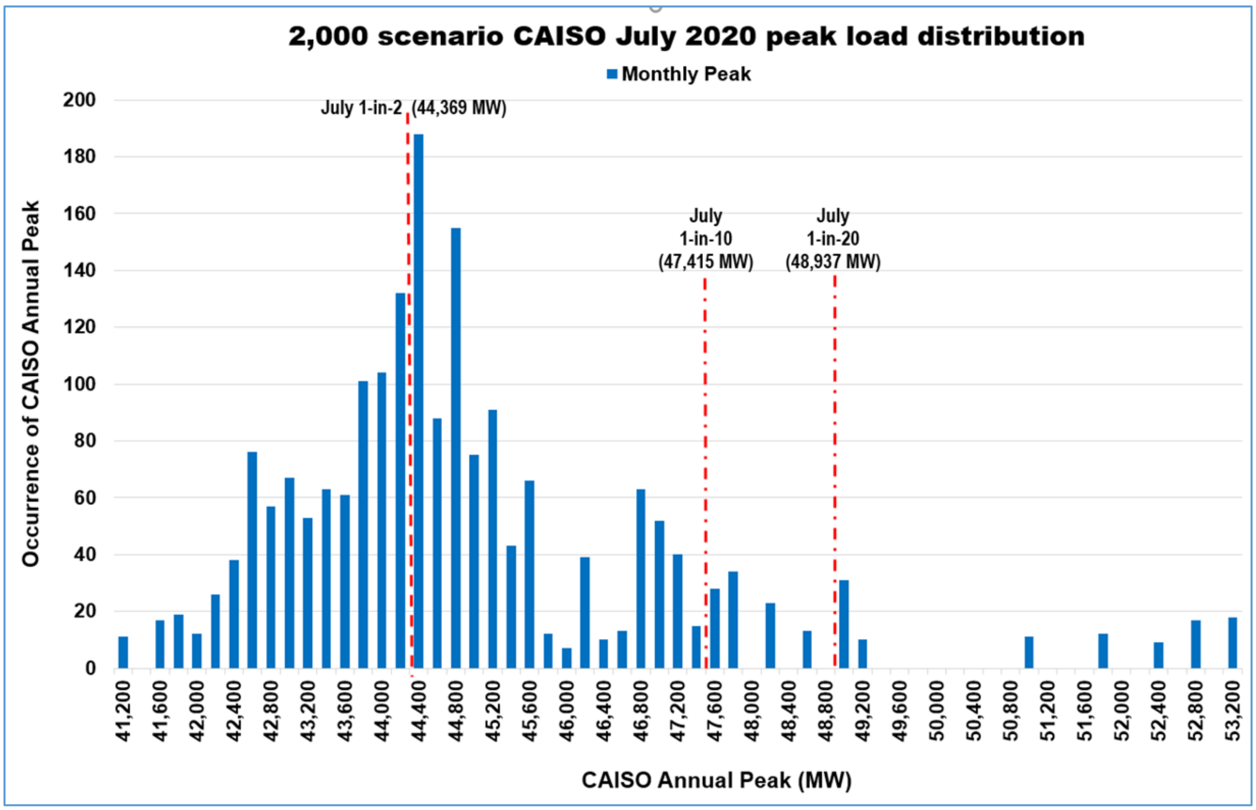
[5] Though included in the model, shortfalls in load following alone are not flagged as deficiencies.
[6] Additional details regarding the model are available in the CAISO's Loads and Resources Study, at http://www.caiso.com/Documents/2020SummerLoadsandResourcesAssessment.pdf

the CAISO summer assessment.[7] For comparison, the CAISO's 1-in-2 peak load forecast for July 2020 is 44,369 MW compared to the CEC IEPR forecast of 44,217 MW for July. The CAISO uses 25 years of historical weather data from 1995 through 2019 and produces seven different weather scenarios for each historical year to simulate calendar effects across the weekdays. This process generates 175 weather scenarios used as inputs to the forecast model to produce 175 hourly load profiles. The process produces a distribution of load profiles that include monthly peaks ranging from the mildest to the most extreme weather events as represented in each month's historical weather data. Forecasts for specific load events such as 1-in-2, 1-in-5, 1-in-10 and 1-in-20 can be determined from the range of forecasts produced[8]. In the CAISO's assessment of the probability of entering into problematic operating conditions, overall, the probability these events follows the declining probability of the weather event as the event becomes more extreme. As an example, Figure 1 shows the distribution of the daily peak loads used in all 2,000 iterations for the month of July.

***Figure 1**: Distribution of peak loads used for July production simulation*



4.3.3. Resource Inputs

In running the two scenarios, the CAISO tried to maintain consistent resource inputs to the greatest extent possible. The resource mix used by the CAISO in the RA showing scenario

[7] In future studies, the CAISO will coordinate with the CPUC and CEC to develop a common set of hourly load profiles so that the CAISO and the CPUC are using consistent distribution of load profiles for their respective modeling purposes. Pending the completion of the CEC hourly load set, the CAISO will utilize its own load forecast set.

[8] As the load level increases from 1-in-2 to 1-in-20 and higher, the probability of the load occurring continually decreases.

includes all generating resources provided on LSE RA showings. A side-by-side comparison of the resource inputs is provided in Table 1. The remainder of this section provides details about how resources have been modeled in the production simulation.

***Table 1**: Aggregate NQC values of resources used in the RA Showing and Thermal Scenarios*

Fuel Type	RA Showing Scenario	Thermal Scenario
Battery	106	106
Biomass	535	535
Coal	11	11
Demand Response*	1289	1289
Distribution	165	165
Gas*	27,512	27,512
Geothermal	994	994
Hydro	4,316	4,316
Nuclear	2150	2150
Pump Hydro	1391	1391
Interchange*	6335	6335
Solar (RA)	4,233	--
Wind (RA)	1,222	--
HRCV	29	29
Other	45	45
Pumping Load	131	131
Generic CCGT	--	3932
Generic SCGT	--	2621
Total RA	50,466	50,466
Solar (non-RA)	333	--
Wind (RA)	0	--
Total	50,799	51,593
*** Includes both RA showings and credits**		

For wind and solar resources, the CAISO relies on the same wind and solar profiles generated for its Summer Assessment, which includes the actual generation profiles from all participating wind and solar resources. This is a more reasonable approach to modeling wind and solar resources than trying to model simply the shown NQC capacity. The NQC somewhat accounts for these types of production profiles when calculating the resources' ELCC used in the NQC calculation. This makes modeling wind and solar based on actual historical operating profiles fairly consistent with wind and solar resources' RA capacity values. Furthermore, non-RA wind and solar resources have RPS production obligations and will have availability similar to their RA counterparts. The CAISO assessed the average of the coincident peak output of all solar resource profiles to be 11,708 MW. Applying the CPUC's July ELCC adjustment of 0.39 to this peak output results in approximately 4566 MW of solar capacity. Averaging the maximum solar output across all profiles results in the equivalent 333 MW of additional capacity above the RA showings.

The CAISO has also reviewed all RA "credits" allowed by LRAs to ensure all capacity used to meet RA obligations are reflected. These credits are discussed in greater detail below. CPM/RMR resources are not specifically included in an RA showing, but are included in the model. Finally, the CAISO includes all capacity used for RA obligations, with the production simulation using CAISO confidential Masterfile parameters for each resource. As a result, the production simulation honors individual resource constraints such as minimum run time, minimum down and ramp rates, but is currently not configured to model individual resource use-limitations such as maximum starts or run hours per month. The CAISO recognizes that this will result in a more optimistic result than if all use-limitations were modelled.

For the Thermal Scenario, the CAISO used all of the same resources as were included in the RA Showing scenario except for the wind and solar resources. In this scenario, the CAISO removed all of the wind and solar resources, replacing them with sufficient generic thermal resources to meet a 115 percent planning reserve margin. To reach this threshold, the CAISO added 6,553 MW of capacity using a 60-40 split of combined cycle and simple cycle gas turbine resources.

To determine the resource availability in both scenarios, the simulation model generates a unique forced outage profile for each of the 2,000 simulation scenarios based on historical forced outage rates for each dispatchable resource from the CAISO's Outage Management System (OMS). The generic resources used in the Thermal Scenario use the average forced outage rate for their respective technology type. Outage profiles for non-dispatchable resources[9] are modeled using fixed hourly generation profiles based on aggregated historical hourly generation profiles, which has forced outage rates embedded within these profiles. These outage rates and profiles serve as the basis for resource availability in the production simulation monthly runs. The model respects Masterfile limitations regarding minimum run and down times.

Hydro resources are modelled using actual hydro MWh generation from similar hydro years based on comparison of the current year's and historical snow water content and other water year conditions. Maximum production levels for dispatchable hydro units are capped at the shown NQC. While the resource may be capable of producing more than NQC, the CAISO's objective was to test the shown RA values. Additionally, based on the CAISO's preliminary review of hydro resource availability, NQC seems to provide a reasonable cap on its overall maximum availability.

Imports are modelled up to the shown RA value. The production simulation respects all specific intertie line limits, but will not limit imports to MIC designated ties. For example, if an intertie has a 1,000 MW capacity and sum total of used MIC on the line equal to 500 MW, then the production simulation would allow for that line to flow 1,000 MW. Imports are based on the intertie limits and the model's least cost dispatch using the cost of surplus resources in other BAAs, capped at the level of imports shown for the month.

Shown demand response resources are modelled as supply side resources that have triggering conditions in the simulation model. Whenever the model depletes all available resources before meeting the load and ancillary service requirements the model will utilize demand response programs. It is important to note that the model assumes these demand response resources

[9] Non-dispatchable resources are technologies that are dependent on a variable fuel source and are modeled as energy production profiles based on historical generation patterns. Non-dispatchable technologies include biofuels, geothermal, wind, solar, run-of-river hydro, and non-dispatchable natural gas.

are available regardless of time or day of the week. Although not explicitly considered in this study, additional research may be needed to assesses the frequency with which DR is used and during which hours.[10] This will provide important insight regarding how useful existing DR resources are at mitigating the probability of deficiencies or how future DR programs should be designed.

The CAISO receives RA “credits” from various LSEs. These credits refer to capacity that an LSE uses to meet its RA obligation, but may not represent as specific capacity resource (i.e. a generating resource with a specific resource ID shown on an RA showing) for the LSE. These credits include Cost Allocation Mechanism (CAM), Demand Response, Liquidated Damage (LD) Contracts, and CPM/RMR. The CAISO has reviewed all of these credits to ensure there is no exclusions or double counting. Based on the CAISO’s review, CAM credits have been removed since that resource backing those credits must appear on another LSE’s RA showing. Demand response credits have been included in the model and adjusted their available capacity based on CAISO operational experience, currently 75%. LD contract credits are included and modeled by adding to the shown import resources, increasing the import limit. CPM/RMR credits are excluded to avoid double counting because all CPM/RMR resources are already modelled as specific resources. Included in the capacity shown in Table 2, above, are the following “credited” capacity:

- RMR: 289 MW,
- DR: 1,025 MW, and
- LD: 471 MW
- Total: 1,785 MW

5. Results

Stochastic monthly assessments pose unique challenges that do not exist under the simple accounting tools currently used for RA showings or even a simple deterministic production simulation. In those two approaches, there are clear yes-no answers regarding the adequacy of the portfolio of resources. However, a stochastic production simulation provides a distribution of potential outcomes. The results are expressed in terms of probabilities, not yes-no. In this results section, the CAISO attempts to provide a clear, transparent overview of the results both for the Thermal and RA Showing scenarios. At this time, the goal of this results section is not to derive a specific solution regarding the adequacy of the portfolios modeled. Instead, the goal is to establish the data needed to build the framework to determine (1) the adequacy of a given portfolio and (b) how much additional capacity may be needed if the fleet is determined to be inadequate.

Both scenarios result in observations with inadequate capacity. This result is typical for stochastic production simulations. These deficiencies provide the CAISO with a robust data set to determine when the portfolios are unable to provide the necessary level of reliability. Perhaps the most surprising result of the assessment is that, in many instances, the RA Showing Scenario performed slightly better than the Thermal Scenario. The CAISO attributes this to two factors. First, as noted above, the CAISO included, on average, 333 MW of

[10] This is particularly important since most DR programs have monthly or annual limitations, which are also not modeled

additional solar capacity in the RA Showing Scenario. Although this will not impact deficiencies that occur in the non-solar production hours, it can resolve some deficiencies during solar production hours. Overall, this will lower the probability of shortfall in some hours. Additionally, as discussed in greater detail below, the window over which deficiencies are observed are more compact for the RA Showings Scenario than it is for the Thermal Scenario. Specifically, the Thermal Scenario showed shortfalls over a much wider range of hours than the RA Showing Scenario. This is consistent with a flat gross load curve and a more “peaky” net-load curve. Finally, the relative quantity of load at the time of deficiency is lower in the RA Showing Scenario than in the Thermal Scenario, occurring after the net-load peak as compared to overall peak. The availability of DR resources hours 19-21 in the model may also result in under-estimating the probability of shortfalls in the RA Showing Scenario. It is reasonable to assume that DR is available in the middle of the day for the Thermal Scenario, however, it likely a generous estimate is DR’s incremental load drop capabilities in the mid- to late-evening hours.

While the model assesses all hours of each month, the CAISO primarily focuses on the probability of a deficiency at a daily granularity. This means that the CAISO calculates the probability of a deficiency looking at the whole day. The CAISO also considered using both iteration (monthly) and hourly level granularity. However, the CAISO selected daily granularity for several reasons. First and foremost, solving for the maximum shortfall in a given day will typically also solve any smaller deficiencies on that same day. The CAISO applied this same logic to using a full monthly iteration as the reporting metric. However, there is sufficient variability over any given monthly profile to make the connection more difficult. Additionally, by using monthly granularity, the CAISO would be sacrificing the robust data created by looking at 62,000 different days as opposed 2,000 months. As an extreme case, if the CAISO used monthly granularity, it would treat an iteration with one hour of shortfall the same as it would an iteration that was short for all hours or all days of the month. Finally, using daily granularity is consistent with the unit of measure applied to the CPUC’s Integrated Resource Planning Process.

A single daily observation will yield a 0.0016 percent increase in the loss of load expectation (LOLE). A single 31 day iteration can have no more than a 0.05 percent cumulative increase on the loss of load expectation. In other words, if all 31 days of a given iteration are deficient, the daily LOLE would increase by 0.05 percent. As discussed in greater detail below, most iterations are deficient less than five days.

Figure 2, below, shows the probability of a daily deficiency of a given size. As noted above, the RA Showing Scenario had lower overall probability of a shortfall than the Thermal Scenario, 7.9 percent compared to 15.5 percent. However, as shown in Figure 2, many of these shortfalls are very small. For example, the probability of shortfall of greater than 50 MW is 2.6 percent and 4.1 percent for the RA Showing and Thermal Scenarios respectively. Table 2, below provides a break out of the probabilities and MW deficiencies.

***Figure 2**: Probability of capacity deficiency*

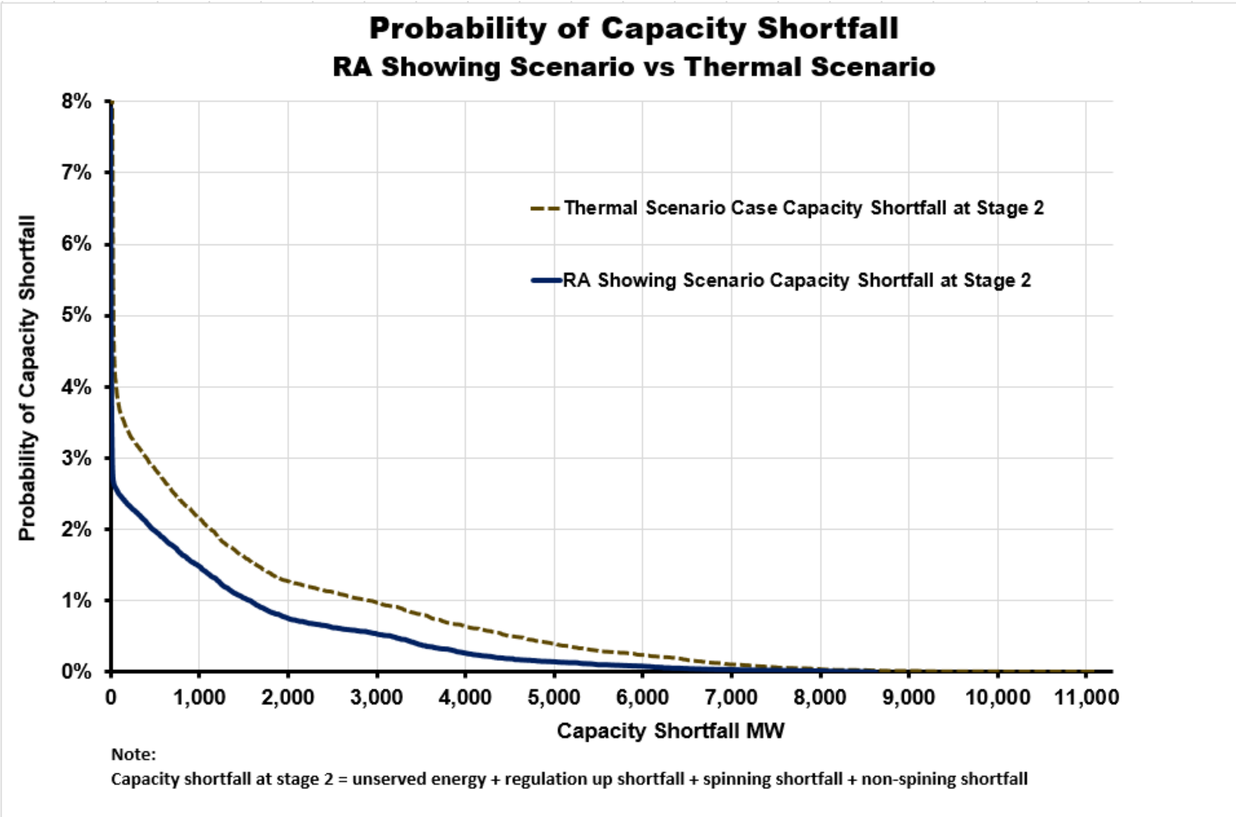


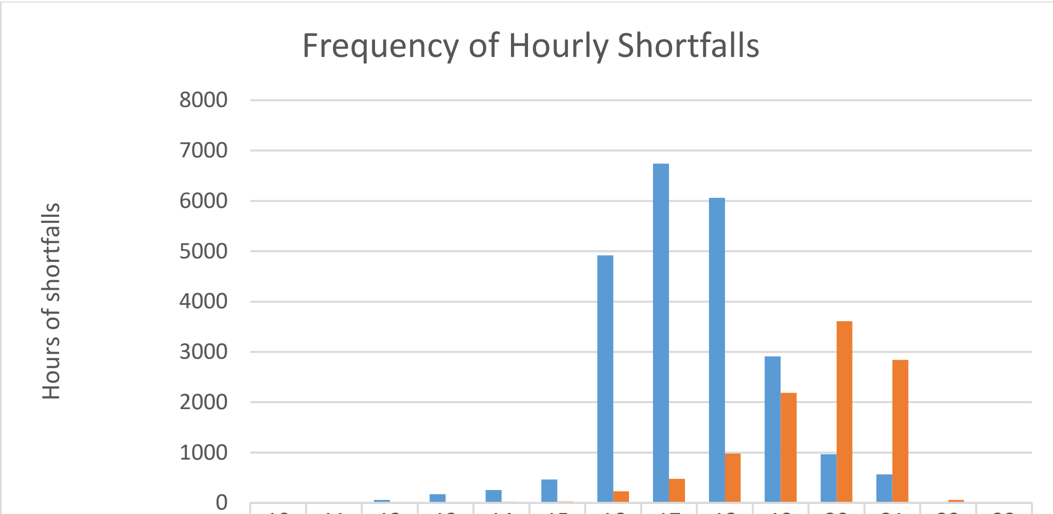
Table 2: Break out of probabilities of MW shortfalls and shortfalls at various probabilities

Probability of a shortfall greater than X MW			MW shortfall at X probability		
MW shortfall	RA Showing	Thermal	Probability	RA Showing	Thermal
500	1.98	2.82	4	12	56
1000	1.49	2.14	3.5	15	147
2000	0.75	1.27	3	21	397
3000	0.54	0.97	2.5	94	709
4000	0.26	0.63	2	483	1124
5000	0.15	0.39	1.5	983	1636
6000	0.09	0.23	1	1585	2905
7000	0.04	0.1	0.5	3183	4487
8000	0.02	0.03	0.01	5706	7035

As a final measure, the CAISO reviewed a collection of frequency distributions. These distributions can be informative when trying to assess potential additional risks that may be present and provide guidance on the type of resource needed to deal with the deficiencies.

The CAISO assessed the frequency distribution for when shortfalls occurred in each scenario. As expected, the results show the hours in which a deficiency was most likely to occur shifted from the mid-day gross-peak hours in the Thermal Scenario to the evening net-load peak hours in the RA Showing Scenario. Figure 3 shows the distribution of all observed deficiencies by hour.

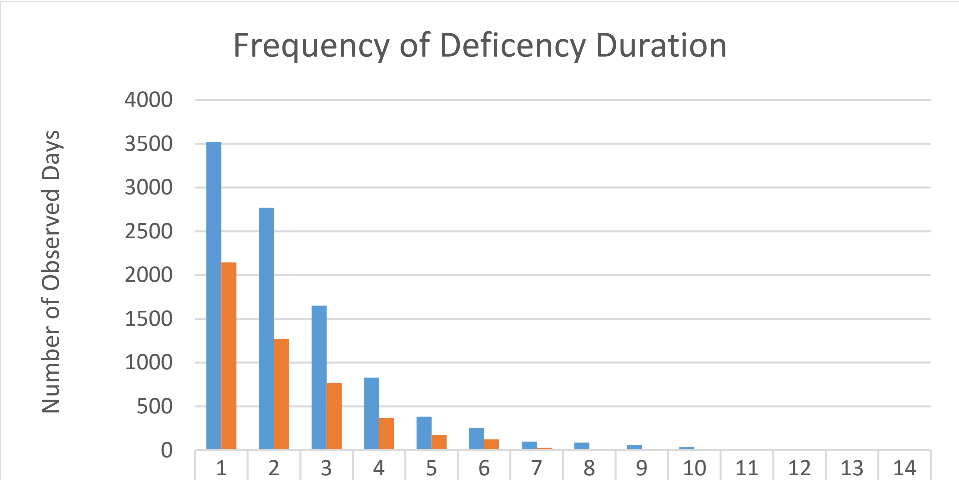
Figure 3*: Frequency of observed deficiencies by hour*



	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Thermal Scenario	1	9	61	172	255	467	4915	6742	6062	2914	967	568	3	1
RA Showing	0	0	1	9	18	26	228	479	977	2187	3611	2844	57	0

In addition to assessing the timing of the deficiencies, the duration of the deficiencies is important to determining the both nature of the deficiency and potential solutions. For example, if the expected duration of the deficiencies exceeds four hours, then procuring additional four-hour battery storage may not resolve the deficiency. As shown in Figure 4, in both scenarios over 90 percent of the days with deficiencies had deficiencies of less than four hours in duration.

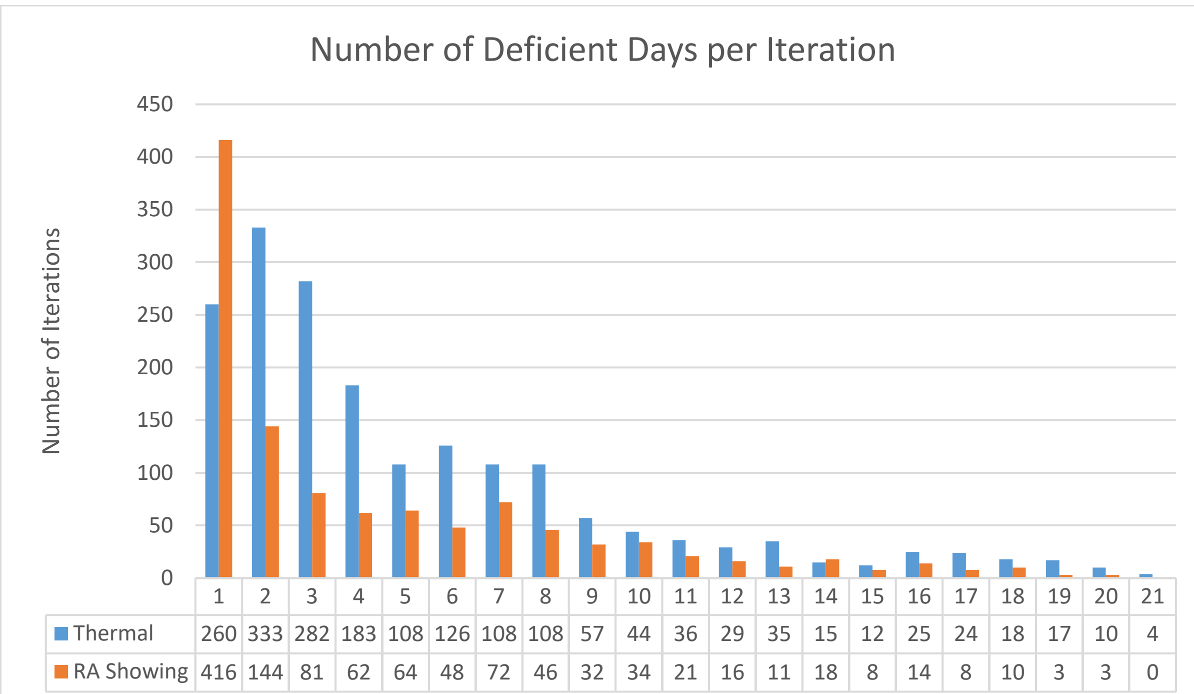
Figure 4*: Frequency of Deficiency Duration*



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Thermal	3523	2771	1651	831	383	257	97	86	60	35	5	1	0	1
RA Showing	2145	1271	771	366	174	123	28	11	9	0	0	0	0	0

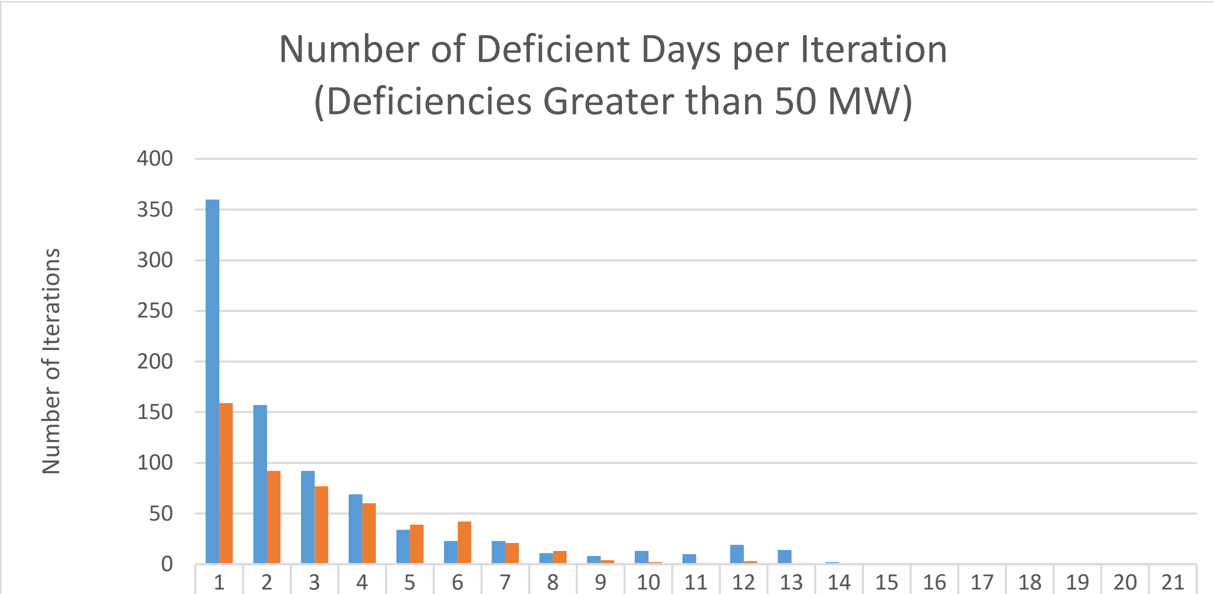
Finally, with respect to frequency, it is also important to assess the distribution of the number of days within an iteration that have a deficiency. As noted above, and shown in Figure 5, most iterations have 5 or fewer deficient days. There was a 17 percent probability and 33 percent probability that an iteration had more than 5 days deficient in the RA Showing and Thermal Scenarios, respectively. These drop to 4 and 11 percent probabilities that an iteration had more than 10 days. These probabilities do not consider the magnitude of any of the deficiencies. This becomes more pronounced when looking only at deficiencies greater than 50 MW, as shown in Figure 6. This data is useful to determine how use-limitations should be considered when resolving deficiencies.

***Figure 5**: Number of deficient Days per Iteration - All*



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Thermal	260	333	282	183	108	126	108	108	57	44	36	29	35	15	12	25	24	18	17	10	4
RA Showing	416	144	81	62	64	48	72	46	32	34	21	16	11	18	8	14	8	10	3	3	0

Figure 6*:* *Number of deficient Days per Iteration – Deficiencies greater the 50 MW*



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Thermal	360	157	92	69	34	23	23	11	8	13	10	19	14	2	0	0	0	0	0	0	0
RA Showing	159	92	77	60	39	42	21	13	4	2	1	3	0	0	0	0	0	0	0	0	0

6. Interim Needs

The results of this study further emphasize that a sole resource adequacy procurement target focused on the gross peak load misses the growing and more urgent reliability needs that occur during the net-load peak and the hours immediately following. Therefore, the CAISO believes that in addition to the current gross peak requirements, a secondary resource adequacy reliability requirement must be promptly instituted to ensure sufficient RA capacity is available across the net-load peak hours. In the CPUC's RA proceeding, SCE has proposed to transition to only a net-load peak requirement. The CAISO agrees that a net-load peak RA requirement is essential, but believes it is premature to remove the gross load peak requirement. For this interim period, these additional net load RA requirements could be set on deterministic modeling with a planning reserve margin. Therefore, the CAISO will work LRAs and market participants to develop a net-load RA procurement requirement for the 2022 RA year. The two requirements would stay in place until there is additional information and vetting of these portfolio assessment results to inform and develop a more comprehensive measure for resource adequacy. The data produced in these CAISO studies should provide more and better insight into the specifics for setting that reliability metric.

7. Framework

As the grid operator, the CAISO carries the ultimate obligation for maintaining the reliability of the bulk power system. The RA program is the first line of defense in this effort. The last line of defense is controlled involuntary firm load shedding. Therefore, RA procurement is really a means to provide for a certain probability of service level reliability with a chance that some amount of load shed of different quantities might occur. In this context, service level reliability refers to the targeted level of reliability to firm load, taking into account some marginal level of accepted probability of interruption due to supply shortage. Service level reliability differs from system level or grid reliability in that it is possible to maintain system level reliability (i.e. avoid uncontrolled load shed across the BAA) by using controlled load shedding, which reduces service level reliability but maintain system or grid reliability. As shown in Figure 2, above, the RA program has provided enough capacity in July 2020 to ensure service level reliability at approximately a 96-97 percent probability. If the RA program was to guarantee a service level reliability level of near 100 percent, based on modeling results, it would need an additional 8,637 MW of capacity.[11]

To establish procurement obligations it is necessary determine if some level of load shedding is acceptable. For example, is the three percent shown above, or some other probability, acceptable? As an alternative, procurement requirements could be set at a level to procure sufficient capacity ensure a near zero probability of load shedding. A key consideration for determining the desired service level reliability is willingness to incur the costs needed to insure a given probability.[12]

The CAISO has provided data to establish a foundational framework to answer the primary questions provided above in Section 2. The two core challenges that must be addressed are:

(1) Establishing a defined reliability criteria or loss-of-load expectation that determines procurement targets and backstop procurement trigger,
(2) Determining the quantity and attributes of capacity needed to address a portfolio deficiency.

To answer the first question, three decisions must be made:

1) The correct granularity of the RA program: Annual, Seasonal, or Monthly?
2) The application of an annualized planning standard
3) The desired service level reliability target

Regardless of the desired level of reliability ultimately selected, the standards must be made uniformly across all entities within the CAISO footprint. It is neither possible nor desirable for different LRA's to plan to different standards. When the CAISO system is stressed and load shed is imminent, grid operators are attempting to use all means to maintain system reliability. They rely on the entire pool of resources within its footprint and across the WECC for help. LRAs planning to lower standards means they are leaning on other LRAs and members of the pool since the CAISO manages the reliability of the grid uniformly.

Granularity of RA Program

Currently, the CPUC employs a monthly RA program. The structure must be reevaluated to determine the efficiency and efficacy in meeting the desired reliability standard. Alternatives to the monthly program transitioning to an annual or seasonal construct. This will determine, in part, how reliability provided by the RA program is measured because it will determine how an annual reliability metric is allocated over the year. It must also examine the benefits of multi-

[11] Though it does not technically ensure a zero percent probability of a shortfall, 8,637 MW was the largest observed deficiency in the RA Showing Scenario.
[12] The use of three percent in this instance already assumes that it is possible to make up for deficiencies smaller than 50 MW.

year procurement obligations.[13] Historically, planning standards have been done on a yearly basis with the goal of a one day in ten years (1-in-10) loss of load expectation.[14] This standard, ensures that there is enough capacity available to serve firm load except during extremely rare events. California is unique in the sense that the RA program is administered monthly. All other organized markets with RA programs are run annually. This means that applying an annual standard is measured over all twelve months at the same time. However, because the CPUC – which has jurisdiction over LSEs serving just over 90 percent of the CAISO's load – runs a monthly program, it is not possible to apply the same test. Instead, it must predetermine twelve monthly probabilities. However, the application of annual standard is necessary to ensure that all 12 months are bound together by a single guiding reliability standard. Maintaining a monthly standard adds complexity to setting procurement targets to meet an annual reliability goal.

Application of a planning standard

If a monthly RA program is maintained, then an annual planning standard must be allocated over twelve individual months. There are at least two different ways it could apply an annual standard over a full year: Uniformly of shaped. For example, an annual standard could be applied uniformly over all twelve months. If applying a 1-in-10 LOLE standard, or a 0.1 day over the year, then each month could have 0.008 days in any given month. Alternatively, the standard could be shaped over the year to balance procurement costs and reliability. This approach would allow for higher probabilities of loss of load in the peak months by setting procurement targets closer to forecasted peak because capacity is scarce and more costly to procure. This, in turn, requires lower probabilities of loss-of-load in the off-peak months and higher levels of procurement relative to the forecasted monthly peak. A similar approach could be applied in a seasonal construct. For example, if all of the LOLE was focused on the summer months, then procurement in the non-summer months should be set to achieve a zero probability LOLE. Although this seems like an extreme example when applied to a monthly program, the results of this example would largely mirror those of an annual assessment.

Desired service level reliability standard

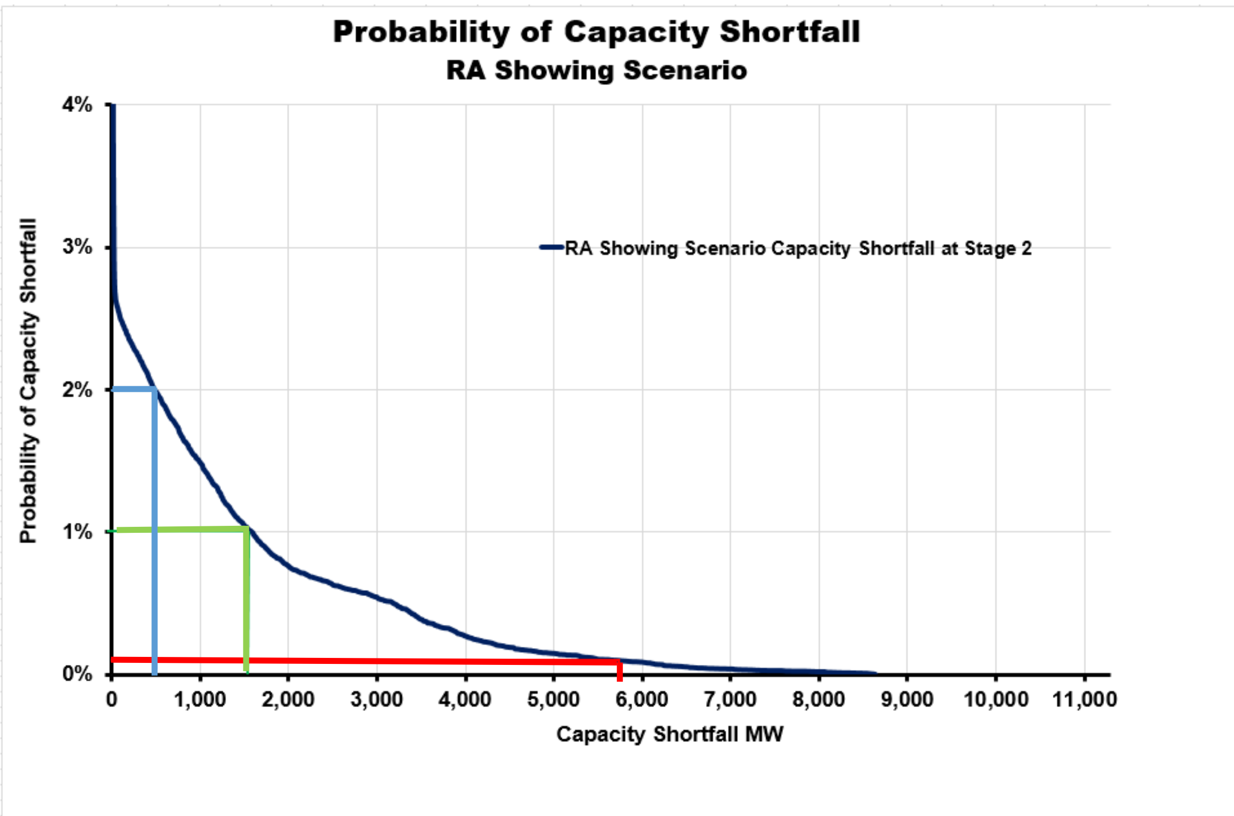
The desired service level reliability standard is defined by determining an acceptable loss of load probability when setting its RA procurement targets. As noted above the CAISO's Thermal Scenario was designed to provide a baseline for the level of reliability the RA program offered at its onset. Figure 7 provides a closer view of the probabilities of a deficiency in the RA Showing Scenario. Where that probability intersects the curve will define the amount of capacity needed to achieve the desired service level reliability through forward procurement. In this instance, the standard is applied monthly, but could be established seasonally or annually. The CAISO reiterates, that any monthly standard must be connected to an over-arching annual standard. However, based on the results from the CAISO's study, the July 2020 RA showing would provide for approximately a three percent LOLE. This probability translates to a 0.93 days expected loss of load in July. If July is representative of all 12 months, then there would be a three percent LOLE for RA showings for all twelve months. This would result in an equivalent 10.95 days LOLE for the year. That is not to say that the CAISO would shed firm load during each instance when it is short of RA, but it does mean the CAISO would lean more heavily on

[13] Currently, the CPUC only requires multi-year procurement for local RA obligations.
[14] The use of 1-in-10 LOLE should not be confused with 1-in-10 load levels.

backstop procurement.[15] For example, the CAISO is unlikely to shed load in March, but it may issue CPM designations to non-RA resources.

Figure 7, shows one estimation of how much additional capacity would be needed to meet a higher service level reliability. For example, approximately 500 MW and 1,500 MW of additional capacity are needed to go from a three percent to a two percent and one percent, loss-of-load expectation respectively. Finally, to reach a 0.008 days per month (i.e., the monthly equivalent of an annual 0.1 loss-of-load expectation) monthly equivalent,[16] approximately 5,800 MW of capacity would be needed.

Figure 7*: Estimating capacity needs to achieve service level reliability standards*



Once the appropriate framework is vetted and set, the second primary question must be answered – what actions are necessary in the event that the amount of capacity shown is insufficient to achieve the desired service level reliability. Specifically, the CAISO must determine which resources can cure the deficiency given the desired reliability standard, how much capacity to backstop to meet that standard and the time of day and duration of the capacity shortfall.

As noted above with Figure 7, the quantity of capacity needed to cure the deficiency can be estimated by assessing how much capacity is needed to have the curve of the probability of a deficiency intersect the horizontal axis at the desired level of expected loss-of-load. However,

[15] The CAISO has many tools for maintaining system reliability. The CAISO will use backstop procurement is before it turns to firm load shed.
[16] This monthly equivalent was find using a uniform distribution across all months.

this is only an estimate. The CAISO's ability to take adequate supplemental action will be directly impacted by the choice regarding the granularity of the RA program. For example, if a monthly RA program is maintained, then study and notification timelines will be very condensed. The CAISO will have limited opportunity to notify LSE of deficiencies and allow LSE to cure deficiencies. It will also not have an opportunity to rerun the study process. Alternatively, an annual or seasonal process with enough lead time could allow for a more robust assessment of the study results and supplemental procurement by LSEs.

As shown in Figure 3 through Figure 5, the duration, frequency and timing of the need are critical to ensuring the capacity will resolve the deficiency. For example, a four-hour DR resource that can drop 100 MW through the midday for 6 days a month may not provide the capacity needed to resolve an identified deficiency. The CAISO will provide these details from the study process to LSEs to facilitate any supplemental procurement. However, the CAISO will need sufficient discretion in its backstop procurement authority to ensure it can address these factors.

8. Next Steps

The CAISO will discuss this report with stakeholders during a stakeholder meeting on November 12. Stakeholders are asked to submit written comments by November 25, 2020 through the CAISO's commenting tool.