California ISO

Draft Flexible Capacity Needs Assessment for 2022

April 22, 2021

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1. Introduction

Each year, the ISO conducts an annual flexible capacity technical study to determine the flexible capacity needs of the system for up to three years into the future. This helps to ensure the ISO maintains system reliability as specified in the ISO Tariff section 40.10.1. The ISO developed and evolved the study process in the ISO's Flexible Resource Adequacy Criteria and Must-Offer Obligation ("FRAC-MOO") stakeholder initiative and in conjunction with the CPUC annual Resource Adequacy proceeding (R.11-10-023). This report presents the ISO's flexible capacity needs assessment specifying the ISO's forecast monthly flexible capacity needs in year 2022.

The ISO calculates the overall flexible capacity need of the ISO system and the relative contributions to this need attributable to the load serving entities (LSEs) under each local regulatory authority (LRA). This report details the system-level flexible capacity needs and the aggregate flexible capacity need attributable to CPUC jurisdictional load serving entities (LSEs). This report does not break-out the flexible capacity need by LSE attributable to individual local regulatory authorities (LRAs) other than the CPUC.

The ISO will use the results from the study to allocate shares of the system flexible capacity needs to each LRA with LSEs responsible for load in the ISO Balancing Authority area consistent with the allocation methodology set forth in the ISO's Tariff section 40.10.2. Based on that allocation, the ISO will advise each LRA of its MW share of the ISO's flexible capacity needs.

2. Summary of Overall Process

The ISO determines the quantity of flexible capacity needed each month to reliably address its flexibility and ramping needs for the upcoming resource adequacy year and publishes its findings in this flexible capacity needs assessment. The ISO calculates flexible capacity needs using the calculation method codified in the ISO Tariff. This methodology includes calculating the seasonal amounts of three flexible capacity categories and determining seasonal must-offer obligations for two of these flexible capacity categories.

The key results of the ISO's flexible capacity needs assessment for 2022 are based on the CEC's 1-in-2 hourly IEPR forecast Managed Total Energy for Load[1], which looks at the following components provided by the California Energy Commission for 2022:

a. Baseline Consumption Load
b. Behind the meter photo voltaic (PV)
c. Behind the meter storage residential (RES)

[1] https://ww2.energy.ca.gov/2019_energypolicy/documents/Demand_2020-2030_revised_forecast_hourly.php

d. Behind the meter storage non-residential (NONRES)
e. Additional achievable energy efficiency (AAEE)

2.1 Summary of Overall Results

1) Expected system-wide flexible capacity needs for 2022 are greatest in the non-summer months and range from 16,648 MW in July to 20,180 MW in May 2022.

2) The calculated flexible capacity needed from the "base flexibility" category is 50 percent of the total amount of installed or available flexible capacity in the summer months (May – September) and 40 percent of the total amount of flexible capacity for the non-summer months (October – April). See Section 6 for detailed description of the method used.

3) The ISO established in this year's assessment for 2022 the time period of the must-offer obligation for resources counted in the "Peak" and "Super-Peak" flexible capacity categories as the five-hour periods of hour ending HE15 to HE19 for November through February and HE17 to HE21 for March through August, the shoulder months September and October will use HE16-HE20. Section 8 is devoted for the discussion of the monthly pattern of the must-offer obligation hours in 2022.

4) The ISO also published advisory requirements for two additional years (2023 and 2024) following the upcoming Resource Adequacy (RA) year at the ISO system total levels as shown in Figure 5.

3. Calculation of the ISO System-Wide Flexible Capacity Need

Based on the methodology described in the ISO's Tariff and the business practice manual[2], the ISO calculated the ISO system-wide flexible capacity needs as follows:

$$Flexibility\ Need_{MTH_y} = Max\left[\left(3RR_{HR_x}\right)_{MTH_y}\right] + Max\left(MSSC, 3.5\% * E\left(PL_{MTH_y}\right)\right) + \varepsilon$$

Where:

$Max[(3RR_{HRx})_{MTHy}]$ = Largest three hour contiguous ramp starting in hour x for month y
E(PL) = Expected peak load
MTHy = Month y

[2] Reliability Requirements business practice manual Section 10. Available at http://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Reliability%20Requirements

MSSC = Most Severe Single Contingency[3]
ε = Annually adjustable error term to account for load forecast errors and variability methodology

For the 2022 RA compliance year, the ISO will continue to set epsilon (ε) equal to zero.

In order to determine the flexible capacity needs, including the quantities needed in each of the defined flexible capacity categories, the ISO conducted a six-step assessment process:

1) Generated 1-minute net load forecast for years 2022 through 2024 using all expected[4] and existing grid connected wind and solar resources and the CEC (CAISO 1-in-2 MID-MID) Hourly IEPR load forecast. The ISO used the most recent year of minute-by-minute actual load (2020) data to formulate a shaped and smoothed minute-by-minute 2022-2024 load forecast. [5]

2) Calculated the forecast monthly system-level three-hour upward net load ramp plus the contingency reserves requirement of the system. Further, classify the monthly three-hour upward net load ramp into three categories and then calculate the percentages of each category relative to the three-hour upward net load ramp in each month. For the definition of each of the three categories and the relevant percentage, please refer to Section 6 below.

3) Applied the calculated percentages in Step 2 to the contingency reserve requirements for each month, so that each category has the appropriate amount of contingency reserve as well the three-hour net load ramp component. For each category, the ISO uses the sum of these two quantities as the monthly flexible capacity need.

4) Analyzed the distributions of both the largest three-hour net load ramps for the primary and secondary net load ramps to determine the appropriate seasonal demarcations[6].

5) Calculated a simple average of the percent of base flexibility needs for all months within a season; and

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[3] For the 2022 flex assessment, the ISO assumed its MSSC is the loss of one Diablo Unit, which is consistent with what was done in past assessments. Also, for this analysis the ISO continues to use 3.5% of its peak monthly load forecast to estimate the spinning reserve requirement of its contingency reserve obligation.
[4] Expected wind and solar resources also included monthly incremental renewable resources that are dynamically scheduled into the ISO.
[5] See the Draft 2022 Flexible Capacity Needs Assessment at https://stakeholdercenter.caiso.com/RecurringStakeholderProcesses/Flexible-capacity-needs-assessment-2022 for more information on the shifting and smoothing methodology
[6] The three-hour primary ramp in each day is the largest three-hour ramp in that day, while the secondary three-hour ramp is the largest three-hour ramp outside the range of the primary three-hour ramp.

6) Determined each LRA's contribution to the flexible capacity need.

4. Forecasting Minute-by-Minute Net load

The first step in developing the flexible capacity needs assessment was to forecast the net load. To produce this forecast, the ISO collected the requisite information regarding the existing build-out in 2020 and the expected build-out in 2022 through 2024 of the grid-connected wind and solar resources. After obtaining this data from all LSEs, the ISO constructed the forecast minute-by-minute load, wind, and grid connected solar before calculating the net load curves for 2022 through 2024.

4.1 Building the Forecasted Variable Energy Resource Portfolio

To collect the necessary data, the ISO sent a data request in December, 2020 to the scheduling coordinators for all LSEs representing load in the ISO balancing area[7]. The deadline for submitting the data was January 15, 2021. At the time of the stakeholder call in January, the ISO had received data from all LSEs. The data request asked for information on each grid connected wind and solar resource that is connected within the ISO's footprint, in whole or in part, in addition to external wind/solar resources that's under contractual commitment to the LSE for all or a portion of its capacity. Since the CEC's load forecast accounted for the expected behind-the-meter production, there was no need for the ISO to include the behind-the-meter production in the net load calculation.

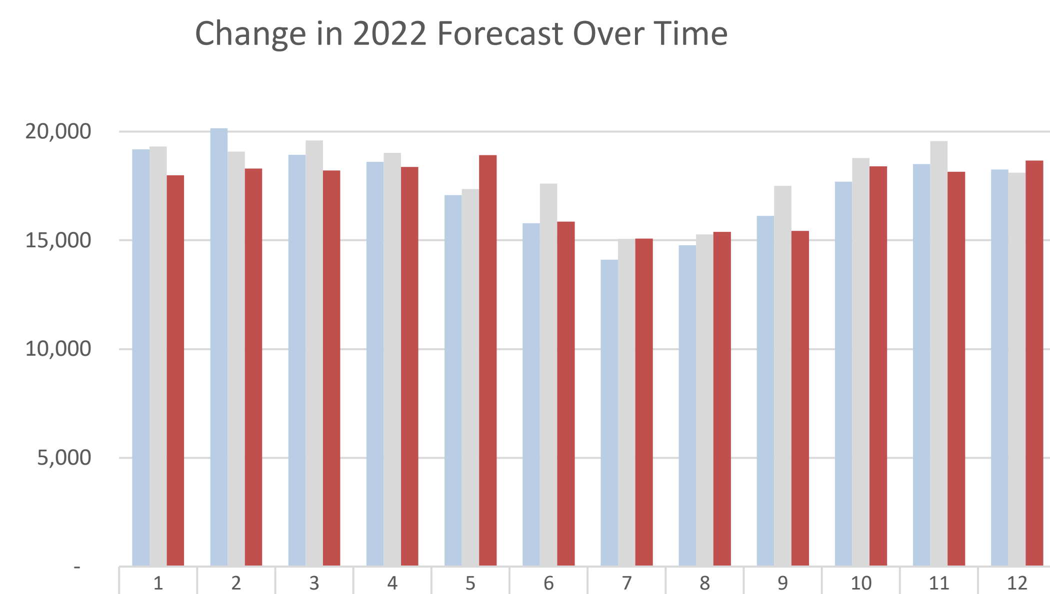
This year, the ISO also requested LSEs to provide data on existing and expected hybrid and co-located resources. The submittals showed an average of about 1,140 MW of expected co-located renewable resources in the 2022 timeframe, which were factored into the flexible needs assessment. The new Co-Located resource type went live in December 2020 as part of Phase 1 of the Hybrid resources initiative[8], and when phase 2 goes live in Fall 2021, we expect there to be a large increase in this new type of resource on the system. For these reasons, as well as their ability to produce as capable and their treatment in the market being nearly identical to those of a traditional VER, co-located resources in the official 2022 three-hour ramp forecast and flexible capacity.

Because there is expected to be over 1,000 MW of co-located resources (see Table 1 below) by year-end 2022, the CAISO feels it is important to include these co-located resources in the 2022 Flexible RA study. The submittals of hybrid resources showed an average of about 930 MW of renewable hybrid components in the 2022 timeframe, however these were not factored in the flexible needs assessment because it is anticipated per policy hybrid resource will follow

[7] A reminder notice was also sent out in early January, 2021
[8] https://stakeholdercenter.caiso.com/StakeholderInitiatives/Hybrid-resources

their dispatch optimization targets. The ISO will continue to monitor the operations of hybrid resources and see if they need to be incorporated in the Flex RA study in future years.

Figure 1: Comparing the Change in the 2022 3-hour Ramp Forecast From 2019-2021



	1	2	3	4	5	6	7	8	9	10	11	12
2019 Forecast for 2022	19,176	20,145	18,927	18,603	17,080	15,784	14,106	14,773	16,126	17,695	18,498	18,258
2020 Forecast for 2022	19,318	19,081	19,598	19,019	17,364	17,615	15,058	15,276	17,512	18,785	19,565	18,106
2021 Forecast for 2022	17,990	18,294	18,212	18,377	18,911	15,863	15,085	15,382	15,429	18,400	18,150	18,669

As part of the data request, the ISO also asked for behind-the-meter existing and expected capacity within each LSEs portfolio. For resources that are external to the ISO, the ISO requested additional information as to whether the resource would be either fixed or dynamically scheduled into the ISO. The ISO only included incremental external resources in the flexible capacity requirements assessment if they were identified to be dynamically scheduled to the ISO.

Using the LSEs' submitted renewable resources data and the CEC's hourly load forecast, the ISO simulated the variable energy resources' net load[9] output for 2022, 2023 and 2024 using actual minute-by-minute load, wind and solar data for 2020. A breakdown of the LSEs submittal is shown in Table 1.

[9] Net load is defined as load minus wind production minus solar production.

Table 1: Total ISO System Variable Energy Resource Capacity for Year End Based on LSE Survey Data (Net Dependable Capacity-MW)[10]

Resource Type	*Existing VERs 2020 (MW)*	*Expected 2021 (MW)*	*Expected 2022 (MW)*
ISO Solar PV	11,050	10,985	11,535
ISO Solar Thermal	938	858	858
ISO Wind	4,294	4,513	4,515
Total Variable Energy Resource Capacity in the 2022 Flexible Capacity Needs Assessment	***16,282***	***16,356***	***16,908***
Non ISO Solar Resources that's Dynamically Scheduled into the ISO	503	501	501
Non ISO Wind Resources that's Dynamically Scheduled into the ISO	1,055	1,160	1,385
Co-Located Resources		1,090	1,255
Total Internal and dynamically scheduled VERs in 2021 Flexible Capacity Needs Assessment	***17,840***	***19,107***	***20,049***
Incremental New Additions Each Year		1,267	942
Incremental behind-the-meter Solar PV Capacity submitted by LSEs*		1,336	1,215

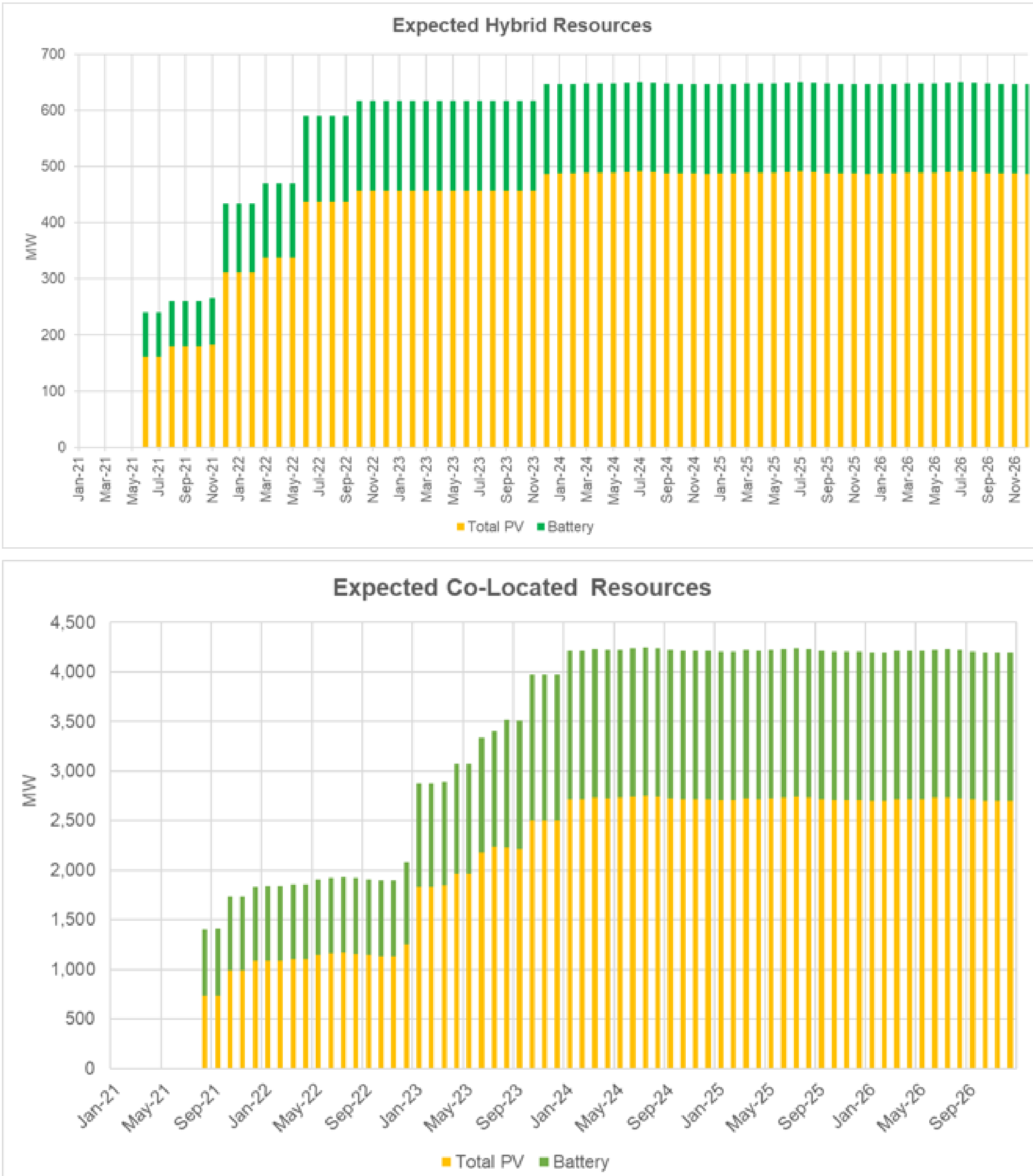
*Note: The incremental behind-the-meter Solar PV production was imbedded in the CEC's hourly load forecast and therefore the LSE survey data was not explicitly factored into the flexible needs assessment.

Table 1 aggregates the variable energy resources system wide by year. Additionally, for existing solar and wind resources, the ISO used the most recent full year of actual solar output data available, which was 2020.

The addition of new Hybrid and Co-Located resource types are likely the reason that the CAISO sees a reduction in the expected solar buildout between 2020 and 2021, which is likely accounted for in the 1,000+ MW of co-located resources expected in 2021 and 2022. Figure 2 below shows the expected buildout by month and year for hybrid and co-located resources with renewable components, broken down by fuel type. For this study only the renewable components of co-located resources were considered.

[10] Data shown is for December of the corresponding year. The ISO aggregated variable energy resources across the ISO system to avoid concerns regarding the release of confidential information.

Figure 2: Expected buildout of Hybrid and Co-Located Resources for 2021 through 2026



For future wind resources, the ISO scaled the overall one-minute wind production for each month of the most recent year by the expected future capacity divided by the installed wind capacity for the same month of the most recent year. Specifically, to develop the 1-minute wind profiles for 2022, the ISO used the following formula:

$$2022W_{Mth\_Sim\_1min} = 2020W_{Act\_1min} * \frac{2022W_{Mth\ Capacity}}{2020W_{Mth\ Capacity}}$$

Similarly, to develop one-minute transmission connected solar profiles for 2022, the ISO used the actual one-minute profiles for 2020 using the following formula:

$$2022S_{Mth\_Sim\_1min} = 2020S_{Act\_1min} * \frac{2022S_{Mth\ Capacity}}{2020S_{Mth\ Capacity}}$$

Given the amount of incremental wind and solar resources expected to come on line, this approach maintains the load/wind/solar correlation for subsequent years.

4.2 Building Minute-by-Minute Net Load Profiles

The ISO used the CEC 2020 Integrated Energy Policy Report (IEPR) 1-in-2 hourly managed net load forecast (CED 2020 Hourly Results – CAISO – MID-MID) to develop minute-by-minute load forecasts for each month[11]. The ISO first scaled the actual load for each minute of each hour of 2020 using an expected CEC's load growth factor for the corresponding hour.

$$2022L_{Mth,Day,Hour\_Sim\_1min} = 2020L_{Mth,Day,Hour\_Act\_1min} * \frac{2022L_{Mth,Day,Hour\_Forecast}}{2020L_{Mth,Day,Hour\_Actual}}$$

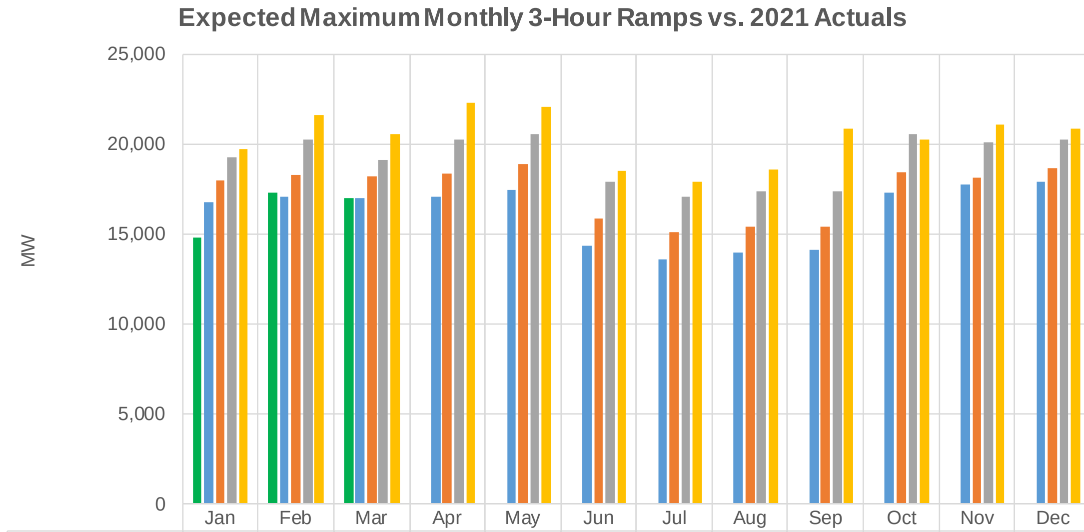
Using this load forecast and the expected wind and solar profiles developed in Section 4.1, the ISO then developed the minute-by-minute net load profiles for subsequent years by aligning weekdays and weekends within each month.

5. Calculating the Monthly Maximum Three-Hour Net load Ramps plus Reserve

The ISO, using the net load forecast developed in Section 4, calculated the maximum three-hour net load ramp for each month of 2022 through 2024. Figure 1 shows the ISO system-wide largest three-hour net load ramp for each month of 2022 through 2024 compared with each month of the actual three-hour net load ramp for 2020.

[11] https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2020-integrated-energy-policy-report-update-0

Figure 3: Expected ISO System Maximum Monthly Three-Hour Net Load Ramps



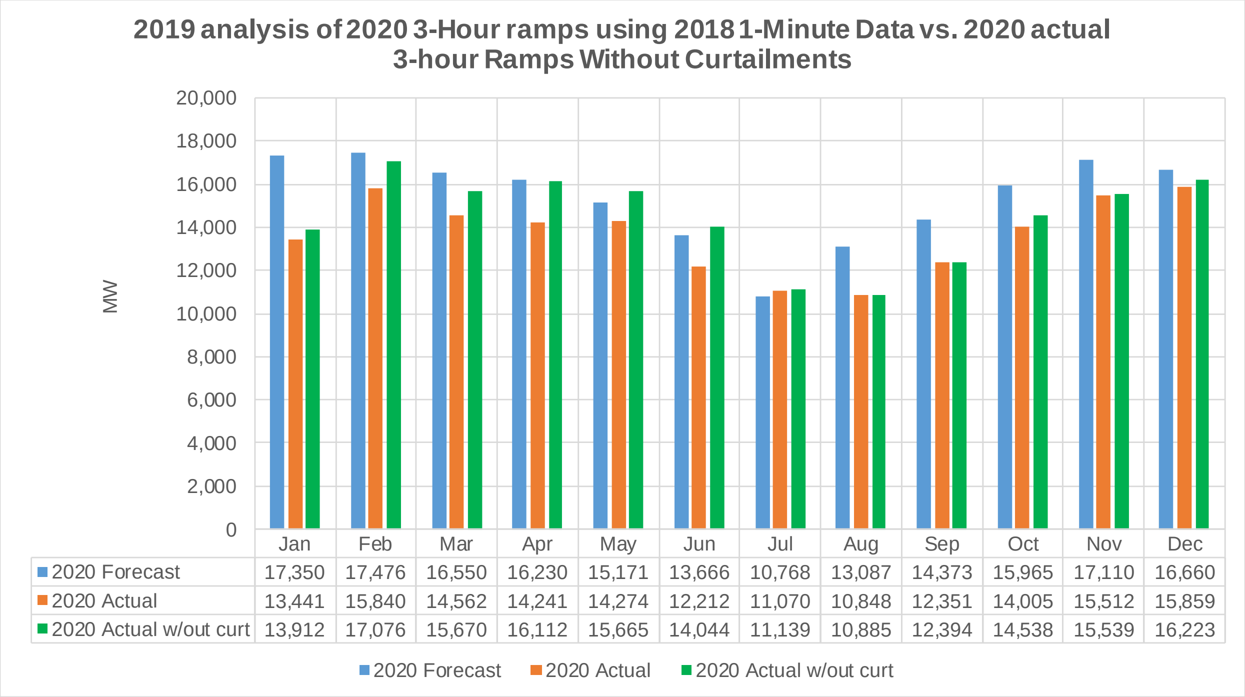
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021 Actual	14,795	17,259	17,012									
2021_3_Hr Ramp	16,760	17,061	16,959	17,071	17,464	14,345	13,572	13,973	14,133	17,311	17,709	17,911
2022_3_Hr Ramp	17,990	18,294	18,212	18,377	18,911	15,863	15,085	15,382	15,429	18,400	18,150	18,669
2023_3_Hr Ramp	19,283	20,241	19,110	20,228	20,519	17,877	17,033	17,363	17,358	20,568	20,087	20,205
2024_3_Hr Ramp	19,687	21,573	20,511	22,309	22,029	18,536	17,882	18,565	20,815	20,206	21,092	20,808

As shown in Figure 3, based on the LSEs submittal and the CEC's load forecast, the maximum upward three-hour monthly ramps for the non-summer months of 2022 are higher than those predicted for the summer months, which is consistent with historical trends. For 2022, the maximum 3-hour upward ramp of approximately 18,911 MW is expected to occur in May and the minimum 3-hour upward ramp of approximately 15,085 MW is expected to occur in July.

In relation to Figure 4 below, depending on the time of day the curtailments occur, they can have an effect on reducing the three-hour ramp by raising the "belly of the duck." It is important to note that the actual three-hour net load ramps may have curtailments[12] present in the actual data used. In January 2020, heavy cloud cover impacts across the state lead to higher mid-day loads due to the reduction in behind-the-meter solar generation. This resulted in lower observed three-hour ramps, and is likely the reason why the January actuals are significantly lower than the forecast. March through June saw major impacts from COVID-19, leading to lower midday loads and increased three-hour ramps due. Widespread extreme heat in August, September and October also kept midday loads elevated and likely resulted in lower three-hour ramps than what was forecast for those months.

[12] Curtailments would be reflected in the actual three-hour ramps if the ISO curtailed renewables in real time.

Figure 4: The ISO 2020 Expected Maximum Monthly 3-Hour Ramp vs 2020 Actuals With and Without Curtailments



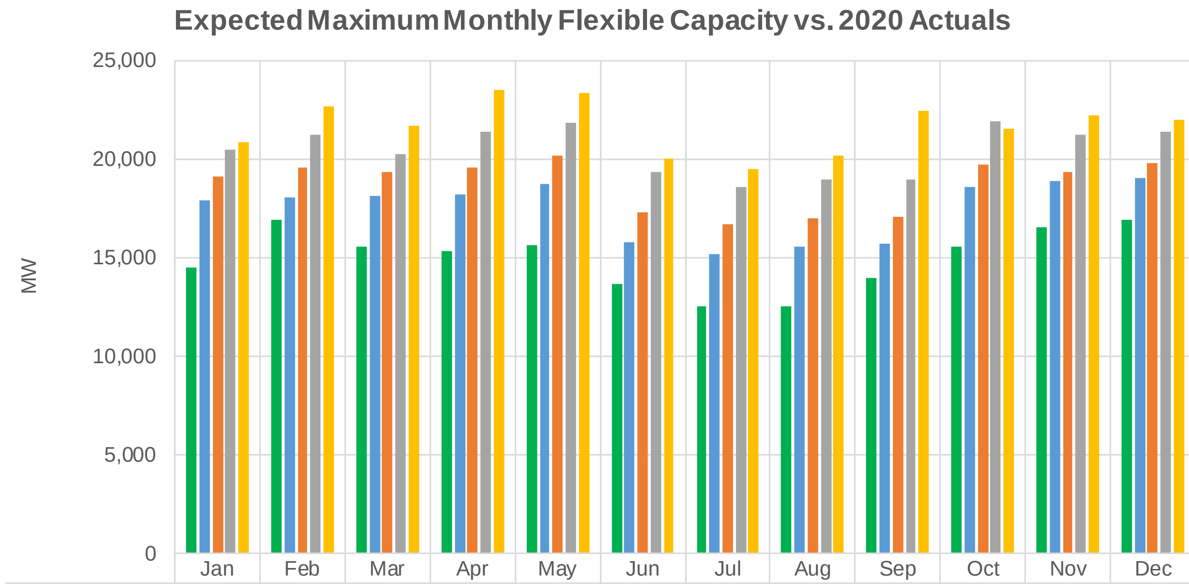
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020 Forecast	17,350	17,476	16,550	16,230	15,171	13,666	10,768	13,087	14,373	15,965	17,110	16,660
2020 Actual	13,441	15,840	14,562	14,241	14,274	12,212	11,070	10,848	12,351	14,005	15,512	15,859
2020 Actual w/out curt	13,912	17,076	15,670	16,112	15,665	14,044	11,139	10,885	12,394	14,538	15,539	16,223

Another noteworthy comment on Figure 4 is that the actual 1-minute wind and solar data used to create the three-hour ramp forecast and flexibility capacity needs does include impacts from curtailments. It is shown above that curtailments can act to reduce the observed three-hour ramp. This can then have an impact on future years' three-hour ramp forecasts by having lower solar and wind generation data used to form future requirements, which could lead to lower forecasts.

Finally, to determine the monthly flexible capacity needs for 2022, the ISO summed the monthly largest three-hour contiguous ramps and the maximum of the most severe contingency or 3.5 percent of the forecast peak-load for each month. This sum yields the ISO system-wide flexible capacity needs for 2022 and advisory needs for 2023 and 2024. The monthly flexible capacity needs for 2022 together with the actual monthly flexible capacity needed for 2020 is shown in Figure 5 below.

As shown in Figure 5, the forecast flexible capacity for all months for years 2021-2024 are higherthan the actual flexible capacity needs in 2020.

Figure 5: The ISO Monthly Maximum Three-Hour Flexible Capacity Requirements

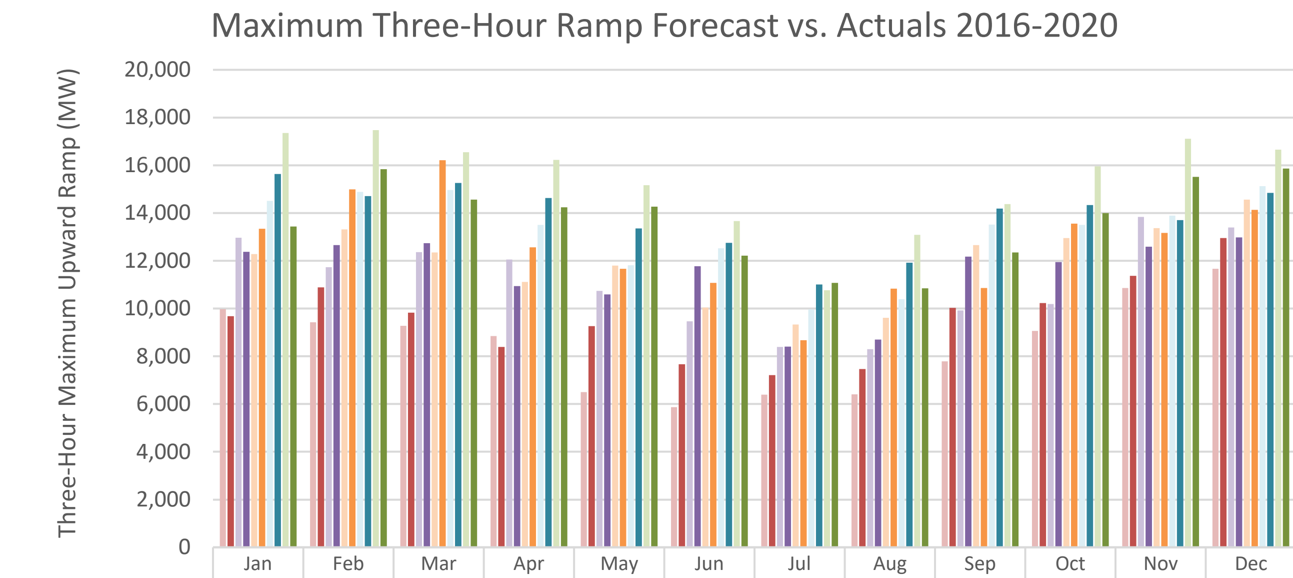


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020 Actuals	14,470	16,879	15,556	15,316	15,604	13,617	12,531	12,497	13,992	15,524	16,555	16,897
2021_Flex Cap	17,910	18,008	18,109	18,221	18,727	15,786	15,137	15,547	15,728	18,604	18,859	19,061
2022_Flex Cap	19,140	19,584	19,362	19,527	20,180	17,318	16,648	16,956	17,030	19,707	19,300	19,819
2023_Flex Cap	20,433	21,260	20,260	21,381	21,804	19,342	18,598	18,943	18,967	21,895	21,237	21,367
2024_Flex Cap	20,837	22,674	21,661	23,478	23,329	20,007	19,458	20,156	22,446	21,554	22,242	21,984

2020 Actuals 2021_Flex Cap 2022_Flex Cap 2023_Flex Cap 2024_Flex Cap

An expanded accuracy analysis of the three-hour ramp forecast for years 2016-2020 is shown in Figure 6. It is noteworthy here that the actuals for years 2016 and 2017 do not include curtailments while for 2018-2020 they do, as indicated by the labels. In Figure 4 above, a comparison between the three-hour ramp actual with and without curtailments is made for 2020, and for most months there is a 0-10% impact on the three-hour ramp actuals when curtailments are included. Each year's forecast was created from the previous year's 1-minute actual load, wind, and solar data. For example, the 2019 forecast bar was the forecast created in 2018 using actual 2017's 1-minute load, wind and solar data. As shown, the monthly three-hour ramp is often under-forecast compared to the actuals, with the exception of July where the 2020 actuals with curtailments were higher than the 2020 forecasted ramp.

Figure 6: A comparison of the forecast three-hour ramp to the actual three hour ramp for years 2016-2020



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016 Forecast	9,974	9,421	9,284	8,850	6,498	5,876	6,392	6,412	7,784	9,066	10,858	11,662
2016 Actual	9,687	10,891	9,828	8,397	9,263	7,669	7,214	7,463	10,030	10,228	11,375	12,960
2017 Forecast	12,970	11,729	12,364	12,054	10,737	9,464	8,397	8,295	9,918	10,196	13,835	13,399
2017 Actual	12,378	12,659	12,733	10,939	10,591	11,774	8,403	8,706	12,180	11,949	12,591	12,981
2018 Forecast	12,282	13,313	12,352	11,111	11,803	10,039	9,326	9,617	12,660	12,954	13,376	14,567
2018 Act + Curtail	13,342	14,988	16,217	12,559	11,672	11,077	8,681	10,835	10,867	13,554	13,165	14,134
2019 Forecast	14,506	14,889	14,971	13,509	11,808	12,524	9,967	10,393	13,511	13,510	13,898	15,129
2019 Act + Curtail	15,639	14,707	15,261	14,636	13,350	12,757	11,002	11,924	14,182	14,340	13,704	14,839
2020 Forecast	17,350	17,476	16,550	16,230	15,171	13,666	10,768	13,087	14,373	15,965	17,110	16,660
2020 Act + Curtail	13,441	15,840	14,562	14,241	14,274	12,212	11,070	10,848	12,351	14,005	15,512	15,859

6. Calculating the Seasonal Percentages Needed in Each Category

As described in the ISO Tariff sections 40.10.3.2 and 40.10.3.3, the ISO divided its flexible capacity needs into various categories based on the system's operational needs. These categories are based on the characteristics of the system's net load ramps and the mix of resources that can be used to meet the system's flexible capacity needs. Certain use-limited resources may not qualify to be counted towards the flexible capacity needs under the base flexibility category and may only be counted under the peak flexibility or super-peak flexibility categories, depending on their characteristics. Although there is no limit to the amount of flexible capacity that can come from resources meeting the base flexibility criteria, there is a maximum amount of flexible capacity that can come from resources that only meet the criteria to be counted under the peak flexibility or super-peak flexibility categories.

The ISO structured the flexible capacity categories to meet the following needs:

Base Flexibility: Operational needs determined by the magnitude of the largest three-hour secondary net load[13] ramp

Peak Flexibility: Operational need determined by the difference between 95 percent of the maximum three-hour net load ramp and the largest three-hour secondary net load ramp

Super-Peak Flexibility: Operational need determined by five percent of the maximum three-hour net load ramp of the month

These categories include different minimum flexible capacity operating characteristics and different limits on the total quantity of flexible capacity within each category. In order to calculate the quantities needed in each flexible capacity category, the ISO conducted a three-step assessment process as follows:

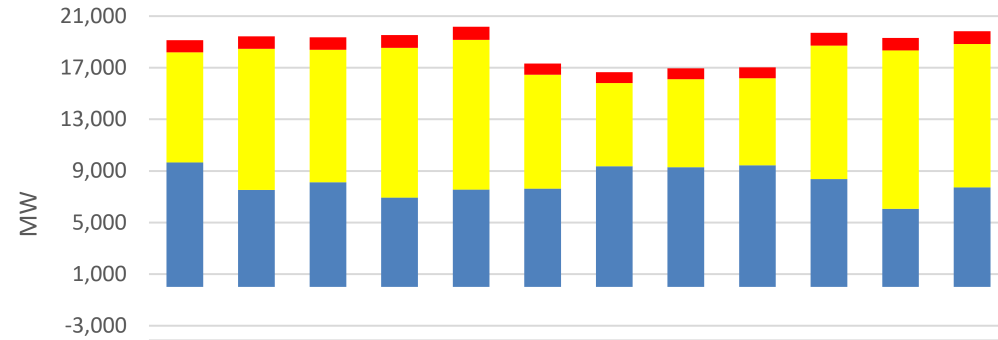
1) Calculated the forecast percentages needed in each category in each month;
2) Analyzed the distributions of both the largest three-hour net load ramps for the primary and secondary net load ramps to determine appropriate seasonal demarcations; and
3) Calculated a simple average of the percent of base flexibility needs from all months within a season.

6.1 Calculating the Forecast Percentages Needed in Each Category in Each Month

Based on the categories defined above, the system level needs for 2022 were calculated based only on the maximum monthly three-hour net load calculation. Then the quantity needed in each category in each month was calculated based on the above descriptions. The secondary net load ramps were then calculated to eliminate the possibility of over-lapping time intervals between the primary and secondary net load ramps. Finally, the contingency reserve requirements were added to the different categories proportional to the percentages established by the maximum three-hour net load ramp. The calculation of flexible capacity needs for each category for 2022 is shown in Figure 7.

[13] The largest daily secondary three-hour net load ramp is calculated as the largest net load ramp that does not correspond with the daily maximum net load ramp. For example, if the daily maximum three-hour net load ramp occurs between 5:00 p.m. and 8:00 p.m., then the largest secondary ramp would not overlap with the 5:00 p.m. - 8:00 p.m. period

Figure 7: ISO System-Wide Flexible Capacity Monthly Calculation by Category for 2022



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	957	972	968	976	1,009	866	832	848	852	985	965	991
Peak Flexibility	8,515	10,95	10,27	11,60	11,61	8,825	6,444	6,816	6,735	10,34	12,27	11,10
Base Flexibility	9,668	7,522	8,121	6,942	7,559	7,627	9,372	9,292	9,443	8,376	6,058	7,724

6.2 Analyzing Ramp Distributions to Determine Appropriate Seasonal Demarcations

To determine the seasonal percentages for each flexible capacity category, the ISO analyzed the distributions of the largest three-hour net load ramps for the primary and secondary net load ramps to determine appropriate seasonal demarcations for the base flexibility category. The secondary net load ramps provide the ISO with the frequency and magnitude of secondary net load ramps. Assessing these distributions helps the ISO identify seasonal differences that are needed for the final determination of percent of each category of flexible capacity. The primary and secondary net load ramp distributions are shown for each month in Figure 8 and Figure 9, respectively.

Figure 8: Distribution of Daily Primary Three-hour Net Load Ramps for 2022

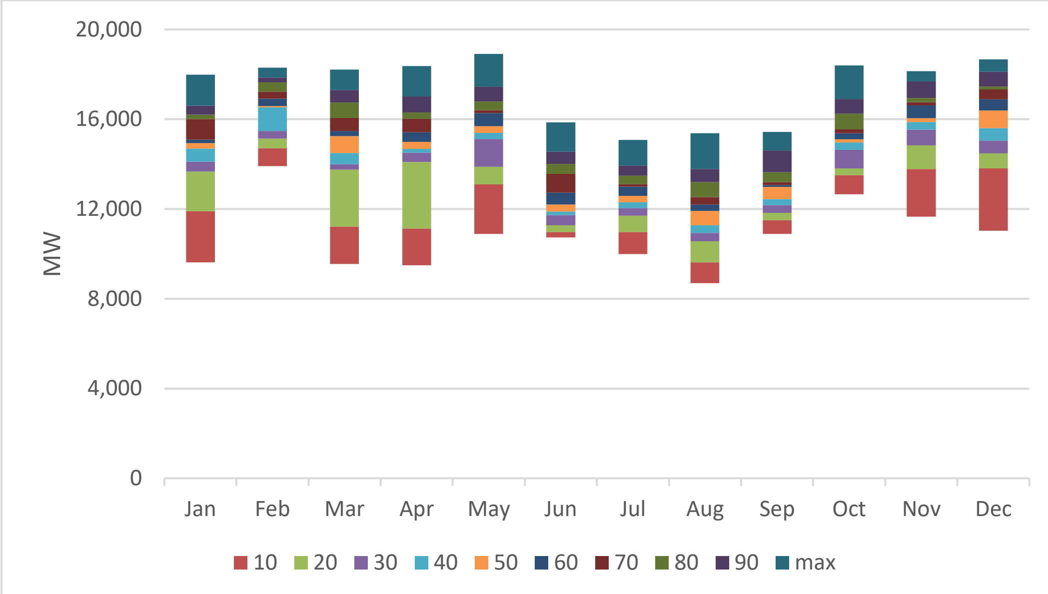
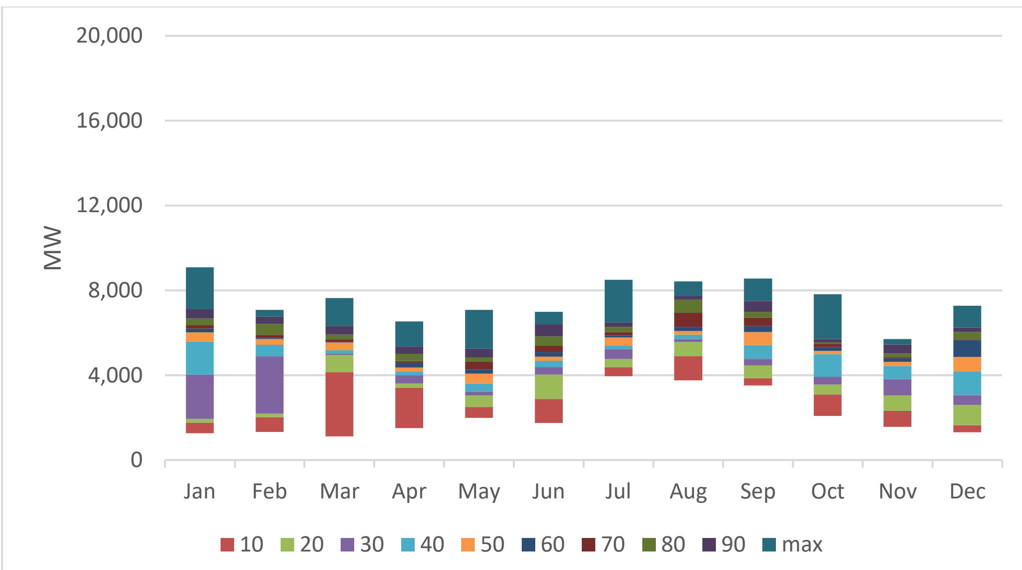


Figure 9: Distribution of Secondary Three-hour Net load Ramps for 2022



As Figure 8 and Figure 9 show, there are certain variations for the primary and the secondary ramps over the months. These variations may have some impact on the ratios of maximum secondary ramp over maximum of primary ramp in each month. To reduce the potential impact of these ratios, which defines the values of base category in the flexible requirement, the ISO substitutes the seasonal averages of the ratios into the ratio in each months. Here, summer is May through September, and winter is October to February. Table 2 shows the unadjusted and adjusted percentages used in calculating the base category over the months.

Table 2: Unadjusted Monthly Ratio and Adjusted Seasonal Ratio

	Actual Contributions			Seasonal Contribution		
	Unadjusted			Adjusted		
Month	Base Flexibility	Peak Flexibility	Super-Peak Flexibility	Base Flexibility	Peak Flexibility	Super-Peak Flexibility
January	51%	44%	5%	40%	55%	5%
February	39%	56%	5%	40%	55%	5%
March	42%	53%	5%	40%	55%	5%
April	36%	59%	5%	40%	55%	5%
May	37%	58%	5%	50%	45%	5%
June	44%	51%	5%	50%	45%	5%
July	56%	39%	5%	50%	45%	5%
August	55%	40%	5%	50%	45%	5%
September	55%	40%	5%	50%	45%	5%
October	43%	52%	5%	40%	55%	5%
November	31%	64%	5%	40%	55%	5%
December	39%	56%	5%	40%	55%	5%

As Figure 8 shows, the distribution (i.e. the height of the distribution for each month) of the daily maximum three-hour net load ramps are smaller during the summer months. The base flexibility resources were designed to address days with two separate net load ramps. The distributions of these secondary net load ramps indicates that the ISO does not need to set seasonal percentages in the base flexibility category at the percentage of the higher month within that season. Accordingly, the ISO must ensure there is sufficient base ramping for all days of the month. Further, particularly for summer months, the ISO did not identify two distinct ramps each day. Instead, the secondary net load ramp may be a part of single long net load ramp.

The distributions of the primary and secondary ramps provide additional support for the summer/non-summer split. Accordingly, the ISO proposes to maintain two flexible capacity needs seasons that mirror the existing summer season (May through September) and non-summer season (January through April and October through December) used for resource adequacy. This approach has two benefits.

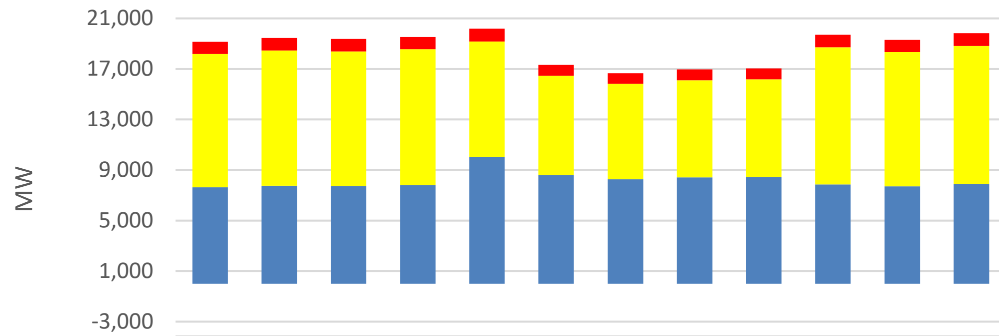
First, it mitigates the impact that variations in the net load ramp in any given month can have on determining the amounts for the various flexible capacity categories for a given season. For example, a month may have either very high or low secondary ramps that are simply the result of the weather in the year. However, because differences in the characteristics of net load ramps are largely due to variations in the output of variable energy resources, and these variations are predominantly due to weather and seasonal conditions, it is reasonable to break out the flexibility categories by season. Because the main differences in weather in the ISO system are between summer and non-summer months, the ISO proposes to use this as the basis for the seasonal breakout of the needs for the flexible capacity categories.

Second, adding flexible capacity procurement to the RA program will increase the process and information requirements. Maintaining a seasonal demarcation that is consistent with the current RA program will reduce the potential for errors in resource adequacy showings.

6.3 Calculate a Simple Average of the Percent of Base Flexibility Needs

The ISO calculated the percentage of base flexibility needed using a simple average of the percent of base flexibility needs from all months within a season. Based on that calculation, the ISO proposes that flexible capacity meeting the base-flexibility category criteria comprise 40 percent of the ISO system flexible capacity need for the non-summer months and 50 percent for the summer months. Peak flexible capacity resources could be used to fulfill up to 55 percent of non-summer flexibility needs and 45 percent of summer flexible capacity needs. The super-peak flexibility category is fixed at a maximum five percent across the year. We have observed over the years that the base flexibility category percentages continue to lower where the peak flexible capacity percentages continue to rise. As with the increase in the flexible capacity need, the change is largely attributable to the continued growth of both grid connected and behind-the-meter solar. As the gird connected solar and the incremental behind-the-meter solar continue to grow we are seeing an increase in the down-ramp associated with sunrise, especially during the shoulder months where there is minimal heating or cooling load. The ISO's proposed system-wide flexible capacity categories are provided in Figure 10.

Figure 10: System-wide Flexible Capacity Need in Each Category for 2021 -Adjusted



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	957	972	968	976	1,009	866	832	848	852	985	965	991
Peak Flexibility	10,53	10,70	10,66	10,75	9,160	7,861	7,557	7,696	7,730	10,85	10,62	10,91
Base Flexibility	7,644	7,765	7,733	7,798	10,01	8,591	8,259	8,412	8,449	7,870	7,708	7,915

7. Allocating the Flexible Capacity Needs to Local Regulatory Authorities

The ISO's allocation methodology is based on the contribution of a local regulatory authority's LSEs to the maximum three-hour net load ramp.

Specifically, the ISO calculated the LSEs under each local regulatory authority's contribution to the flexible capacity needs using the following inputs:

1) The maximum of the most severe single contingency or 3.5 percent of forecasted peak load for each LRA based on its jurisdictional LSEs' peak load ratio share

2) Δ Load – LRA's average contribution to load change during top five daily maximum three-hour net load ramps within a given month from the previous year x total change in ISO load

3) Δ Wind Output – LRA's average percent contribution to changes in wind output during the five greatest forecasted three-hour net load changes x ISO total change in wind output during the largest three-hour net load change

4) Δ Solar PV – LRA's average percent contribution to changes in solar PV output during the five greatest forecasted three-hour net load changes x total change in solar PV output during the largest three-hour net load change

These amounts are combined using the equation below to determine the contribution of each LRA, including the CPUC and its jurisdictional load serving entities, to the flexible capacity need.

Flexible Capacity Need = Δ Load – Δ Wind Output – Δ Solar PV +

*Max(MSSC, 3.5% * Expected Peak * Peak Load Ratio Share)*

The above equation can be simply expressed as

$$\textit{Flex Requirement} = \Delta NL_{2022} + R_{2022}$$
$$= \Delta L_{2022} - \Delta W_{2022} - \Delta S_{2022} + R_{2022}$$

The ISO uses the following symbols to illustrate the evolution of allocation formula:

*L (load), W (wind), S (solar), and NL(net load), R (reserve) = max(MSCC, 3.5*peak_load),*

Δ Ramp, NL = L – W – S, ΔNL = ΔL – ΔW – ΔS,

ΔNL_{2022} Net Load Ramp Req in 2022, $\Delta NL_{sc,2022}$ Net Load Ramp Allocation for LSC in 2022,

pl_r_{lsc} CEC peak load ratio, and finally, Σ summation of all LSC.

In 2021, the ISO has forecasts from CEC L_{2022} , survey results from $W_{2022} = \Sigma W_{lsc,\,2022}$, $S_{2022} = \Sigma S_{lsc,\,2022}$, hence all the ramps ΔL_{2022}, ΔW_{2022}, ΔS_{2022}, plus R_{2022}. Moreover, the ISO has the peak load ratio list from CEC, $\Sigma pl\_r_{lsc} = 1$.

Based the above information, the allocation for wind, solar, and reserve portion of flexible need is straight forward as follows

$$\textit{Flex Need} = \Delta NL_{2022} + \Sigma pl\_r_{lsc} * R_{2022}$$
$$= \Delta L_{2022} - \frac{\Sigma W_{lsc,\,2022}}{W_{2022}} * \Delta W_{2021} - \frac{\Sigma S_{lsc,2022}}{S_{2022}} * \Delta S_{2022} + \Sigma pl\_r_{lsc} * R_{2022}$$

Since the ISO has no pre-knowledge of, $\Delta L_{lsc,y+2}$, the load ramp at LSC level in future year $y + 2$ at the current year $y = 2020$, the allocation of ΔL_{2022} to SC has been more challenging. Over the years, the ISO has used different approaches to meet the challenge.

In year 2014-2016, the ISO used an intuitive formula as

$$\frac{\Delta L_{lsc,\,y}}{\Delta L_y} \Delta L_{y+2},$$

where $\Delta L_y = \Sigma \Delta L_{lsc,\,y}$ is the summation of metered load ramp available at LSC level in year y. Later, the ISO realized this approach had a risk to unstable allocation, since the divider, ΔL_y , the system load ramp can be zero or negative.

In year 2017-2018, the ISO employed the following formula

$$\Delta L_{lsc,y+2} = L_{lsc,y}^{E}\left(\frac{L_{y+2}^{E}}{L_{y}^{E}}\right) - L_{lsc,y}^{S}\left(\frac{L_{y+2}^{S}}{L_{y}^{S}}\right),$$

where $S =$ ramping start time, $E =$ramping end time.

The above seemingly a bit more complicated formula carefully avoided the potential zero divider ΔL_y, but later the ISO found out that it had a nontrivial drawback. Unlike the original formula used in 2014-2016, the revised formula carried little scalability for each SC, that is, the historical load ramp $\Delta L_{lsc,\,y}$ has no explicit impact on future $y+2$ allocation $\Delta L_{lsc,\,y+2}$.

Starting from year 2019, the ISO proposes a new formula which best utilizes $\Delta L_{sc,\,y}$ while the system ΔL_y is not in the denominator,

$$\Delta L_{2022} = \Delta L_{2020} + (\Delta L_{2022} - \Delta L_{2020})$$

$$= \Sigma\Delta L_{lsc,\,2020} + \frac{\Sigma L_{lsc,\,2020}^{M}}{L_{2020}^{M}} * \left(\Delta L_{2022} - \Delta L_{2020}\right),$$

where ΔL_{2019} is the average load portion of top 5 maximum 2019 three-hour ramps while matching 2021 maximum 3h ramp on month and time, and L_{2019}^{M} is the average load at beginning and the end of points during those top 5 ramps. In 2021, each LSC will receive:

$$\Delta L_{lsc,\,2020} + \frac{L_{lsc,\,2020}^{M}}{L_{2020}^{M}} * (\Delta L_{2021} - \Delta L_{2019})$$

Therefore each LSC's contribution $\Delta L_{lsc,\,2020}$ will be explicitly projected into future year 2022, and any additional increase of $(\Delta L_{2022} - \Delta L_{2020})$ will be allocated by a load ratio share. The new calculation provides stable allocation for the load proportion.

Any LRA with a negative contribution to the flexible capacity need is limited to a zero megawatt allocation, not a negative contribution. As such, the total allocable share of all LRAs may sum to a number that is slightly larger than the flexible capacity need. The ISO does not currently have a process by which a negative contribution could be reallocated or used as a credit for another LRA or LSE.

The ISO will make all non-confidential working papers available and data that the ISO relied on for the Final Flexible Capacity Needs Assessment for 2022. Specifically, the ISO will post materials and data used to determine the monthly flexible capacity needs, the contribution of CPUC jurisdictional load serving entities to the change in load, and seasonal needs for each flexible capacity category. This data is available for download as a large Excel file named "2022 Flexible Capacity Needs Assessment – 2022 Net Load Data" at:

https://stakeholdercenter.caiso.com/RecurringStakeholderProcesses/Flexible-capacity-needs-assessment-2022

Table 3 shows the final calculations of the individual contributions, of each of the inputs to the calculation of the maximum three-hour continuous net load ramp at a system level.

Table 3: Individual Contributions of each Input into the Net Load

Month	Load contribution 2022	Wind contribution 2022	Solar contribution 2022	Total percent 2022
January	35.46%	-13.04%	-51.50%	100%
February	39.51%	-5.25%	-55.24%	100%
March	37.17%	0.42%	-63.25%	100%
April	38.20%	-9.68%	-52.12%	100%
May	34.65%	-6.82%	-58.53%	100%
June	28.06%	-3.37%	-68.57%	100%
July	25.65%	-1.03%	-73.32%	100%
August	32.04%	0.44%	-68.40%	100%
September	38.86%	8.06%	-69.20%	100%
October	37.10%	-3.18%	-59.72%	100%
November	41.69%	1.53%	-59.84%	100%
December	43.96%	-0.77%	-55.27%	100%

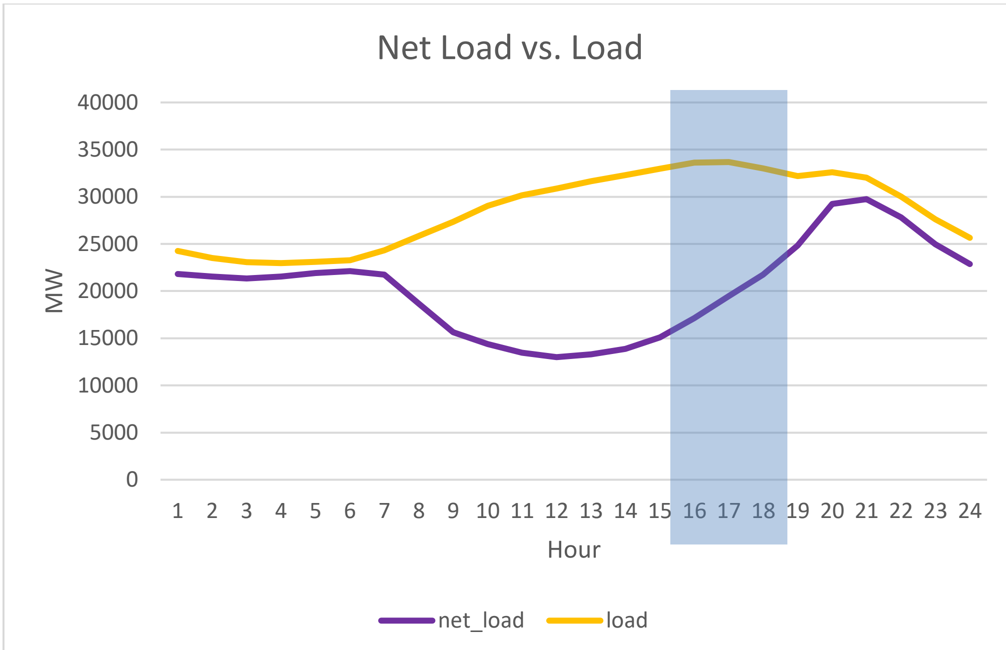
When looking at the contribution to the maximum three-hour continuous net load ramp shown in Table 3, the above total percentage is calculated as Load – Wind – Solar. For example, when looking at July 100 percent contribution is determined by:

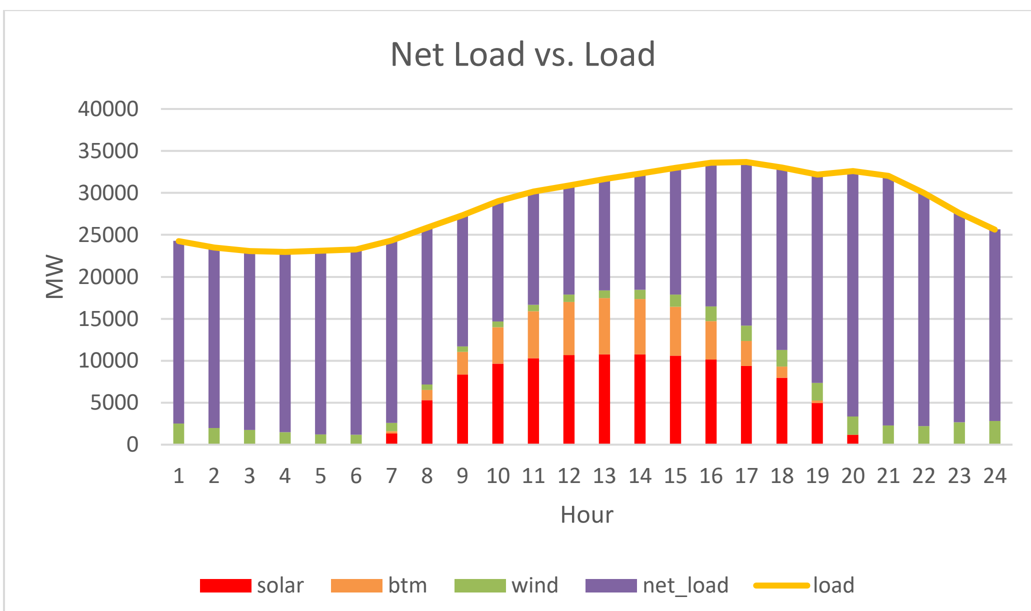
$$\text{Total Contribution} = 25.65\% - (-1.03\%) - (-73.32\%) = 100\%$$

As Table 3 shows, Δ Load is not the largest contributor to the net load ramp because the incremental solar PV mitigates morning net load ramps. The solar resources are leading to maximum three-hour net load ramps during summer months that occur in the afternoon. This is particularly evident during July and August. This implies that the maximum three-hour net load ramp typically occurs during sunset. The contribution of solar PV resources has increased relative to last year's study and remains a significant driver of the three-hour net load ramps. Since the CEC has behind meter solar imbedded in its 2021 hourly load forecast, the interplay between load and solar contributions will depend on the scales of future expansion of utility base solar PV and future installation of behind meter solar panels. The ISO anticipates more solar dominance in the ISO flexible needs in the coming years.

Figure 11 illustrates the behavior of load, wind, and solar when the net load reaches its maximum. In this example, the load ramp has only about 25 percent contribution to the net load ramp.

Figure 11: Examples of Load Contribution to Net Load Ramp





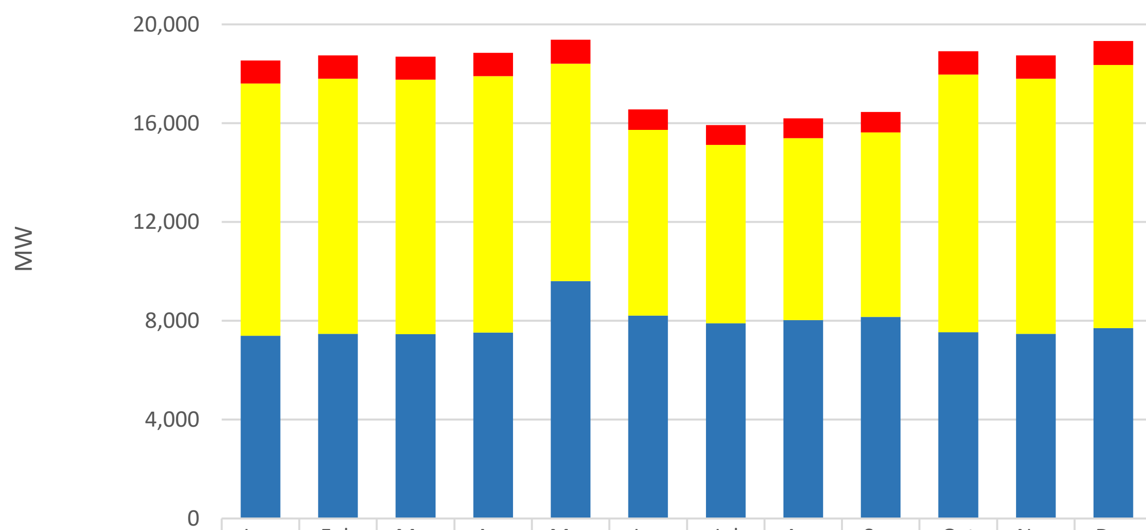
The CPUC allocations are shown in Table 4 and Figure 12. The contributions calculated for other LRAs will only be provided to show the contribution of its jurisdictional LRA as per section 40.10.2.1 of the ISO tariff.

Table 4: CPUC Jurisdictional LSEs' Contribution to Flexible Capacity Needs

Month	Load	Wind	Solar	reserve	Total Allocation
January	6,332	-2,259	-8,907	1,034	18,531
February	7,066	-924	-9,719	1,034	18,743
March	6,673	74	-11,060	1,034	18,693
April	6,914	-1,713	-9,191	1,034	18,852
May	6,412	-1,243	-10,582	1,141	19,378
June	4,334	-515	-10,396	1,307	16,552
July	3,791	-150	-10,578	1,405	15,924
August	4,783	65	-10,066	1,415	16,198
September	5,989	1,193	-10,217	1,439	16,452
October	6,651	-561	-10,523	1,176	18,911
November	7,563	266	-10,410	1,034	18,740
December	8,245	-138	-9,904	1,034	19,320

Finally, the ISO applied the seasonal percentage established in Section 6 to the contribution of CPUC jurisdictional load serving entities to determine the expected flexible capacity needed in each flexible capacity category. These results are detailed in Figure 12.

Figure 12: CPUC Flexible Capacity Need in Each Category for 2022



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	927	937	935	943	969	828	796	810	823	946	937	966
Peak Flexibility	10,212	10,328	10,301	10,389	8,796	7,513	7,228	7,352	7,468	10,421	10327	10647
Base Flexiblity	7,393	7,477	7,458	7,521	9,613	8,211	7,900	8,036	8,162	7,545	7476	7708

8. Determining the Seasonal Must-Offer Obligation Period

Under ISO Tariff Sections 40.10.3.3 and 40.10.3.4, the ISO establishes the specific five-hour period during which flexible capacity counted in the peak and super-peak categories will be required to submit economic energy bids into the ISO's market (*i.e.*, have an economic bid must-offer obligation). The average net load curves for each month provide the most reliable assessment of whether a flexible capacity resource would provide the greatest benefit to the stability of ISO. The ISO analyzes the starting time of the calculated daily net load ramp to ensure the must-offer obligation hours line up with daily maximum three hour net load ramp and support the continuous net load need thereafter, which is typically correlated to the solar ramp down during sunset. Table 5 shows the hours in which the maximum monthly average net load ramp are forecast to begin in 2022.

Table 5: Forecasted Starting Hour of the Maximum Three-Hour Net Load Ramp by Month for 2022

	Three Hour Net Load Ramp Start Hour (Hour Ending)					
Month	12:00	14:00	15:00	16:00	17:00	18:00
January			31			
February			20	8		
March			5	8	18	
April				2	27	1
May				1	24	6
June				4	24	2
July					30	1
August	1	1		10	19	
September			7	19	4	
October			5	26		
November		2	23	5		
December			31			

Table 5 shows an early (HE 15), start of the three-hour ramp pattern for November through February. For the months of March through August, the majority of days have a HE 17 starting time of the three hour net load ramp. The fall shoulder months, September and October, have the starting time concentrated on HE 16.

Table 6: Summary of MOO Hours Proposed by the ISO for 2022

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HE15-HE19	v	v									v	v
HE16-HE20									v	v		
HE17-HE21			v	v	v	v	v	v				

In summary, based on the data for all daily maximum three hour net load ramps, the ISO believes that the appropriate flexible capacity must-offer obligation period for peak and super-peak flexible capacity categories is HE 15 through HE 19 for January and February, and November through December; HE 16 to HE 20 for September and October, HE 17 through HE 21 for March through August.

The ISO reviewed the timing of the top five net load ramps to confirm that the intervals captured the largest net load ramps. As shown above, the proposed intervals do, in fact, capture the intervals of the largest ramps. Both of these changes are consistent with continued solar growth and reflect the fact that the initial solar drop-off is a primary driver of the three-hour net load ramp. This is further supported by the contributing factors shown in Table 2, above.

9. Next Steps

The ISO will commence the flexible capacity needs assessment to establish the ISO system flexible capacity needs for 2023 in early 2022. The ISO will continue to assess the modeling approach used for distributed solar resources, further review methods to address year-to-year volatility, and account for potential controllability of some variable energy resources.

10. Stakeholder Comments

The ISO supports continued improvement on the load forecast coming from the CEC, but encourages enough time for agencies to work through the technical assumptions going in to ensure the appropriate benefit is obtained within the ISO’s Annual Flex Capacity Needs Assessment. Stakeholder comments are due on April 30, 2021.