California ISO

Final Flexible Capacity Needs Assessment for 2021

May 14, 2020

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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 maintain 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 2021.

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 2021 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 2021:

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) System-wide flexible capacity needs for 2021 are greatest in the non-summer months and range from 15,725 MW in July to 19,832 MW in March 2021.

2) The calculated flexible capacity needed from the "base flexibility" category is 49 percent of the total amount of installed or available flexible capacity in the summer months (May – September) and 38 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 2021 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 2021.

4) The ISO published advisory requirements for the two years (2022 and 2023) following the upcoming Resource Adequacy (RA) year at the ISO system total levels as shown in Figure 3.

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 2021 RA compliance year, the ISO will continue to set 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 forecast 2021-2023 minute-by-minute net load 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 (2019) data to formulate a shaped and smoothed minute-by-minute 2021-2023 load forecast.

2) Calculate the monthly system-level forecasted three-hour upward net load ramp plus the contingency reserves. 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 upward net load ramp in each month. For the definition of each of the three category and the relevant percentage, please go to section 6 below.

3) Apply 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) Analyze the distributions of both the largest three-hour net load ramps for the primary and secondary net load ramps to determine appropriate seasonal demarcations[5].

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

6) Determine 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

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[3] For the 2021 flex assessment, the ISO assumes that 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 also includes monthly incremental renewable resources that's dynamically scheduled into the ISO.
[5] 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.

load. To produce this forecast, the ISO collected the requisite information regarding the existing build-out in 2019 and the expected build-out through 2023 of the grid-connected fleet of variable energy 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 2021 through 2023.

4.1 Building the Forecasted Variable Energy Resource Portfolio

To collect the necessary data, the ISO sent a data request in December, 2019 to the scheduling coordinators for all LSEs representing load in the ISO balancing area[6]. The deadline for submitting the data was January 15, 2020. At the time of the draft report, 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 as well as expected hybrid resources. The submittals showed about 90 MW of expected hybrid in the 2021 timeframe, however this was not factored in the flexible needs assessment because it's not clear at this time how hybrid resources should be treated. 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 is or would be dynamically scheduled into the ISO. The ISO only included incremental external resources in the flexible capacity requirements assessment if they were 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[7] output for 2021, 2022 and 2023 using actual minute-by-minute load, wind and solar for 2019. A breakdown of the LSEs submittal is shown in Table 1.

[6] A reminder notice was also sent out in early January, 2020

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

Table 1: Total ISO System Variable Energy Resource Capacity (Net Dependable Capacity-MW)[8]

Resource Type	*Existing VERs 2019 (MW)*	*Expected 2020 (MW)*	*Expected 2021 (MW)*
ISO Solar PV	10,151	11,244	11,690
ISO Solar Thermal	1,018	938	858
ISO Wind	4,513	4,730	4,712
Total Variable Energy Resource Capacity in the 2021 Flexible Capacity Needs Assessment	***15,682***	***16,911***	***17,260***
Non ISO Solar Resources that's Dynamically Scheduled into the ISO	347	500	500
Non ISO Wind Resources that's Dynamically Scheduled into the ISO	755	950	950
Total Internal and dynamically scheduled VERs in 2021 Flexible Capacity Needs Assessment	***16,785***	***18,362***	***18,710***
Incremental New Additions Each Year		1,577	348
Incremental behind-the-meter Solar PV Capacity submitted by LSEs*		1,235	1,317

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

Table 1 aggregates the variable energy resources system wide. Additionally, for existing solar and wind resources, the ISO used the most recent full year of actual solar output data available, which was 2019. 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 2021, the ISO used the following formula:

$$2021W_{Mth\_Sim\_1min} = 2019W_{Act\_1min} * \frac{2021W_{Mth\ Capacity}}{2019W_{Mth\ Capacity}}$$

To develop one-minute transmission connected solar profiles for 2021, the ISO used the actual one-minute profiles for 2019 using the following formula:

[8] 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.[9]
https://ww2.energy.ca.gov/2019_energypolicy/documents/Demand_2020-2030_revised_forecast_hourly.php

$$2021S_{Mth\_Sim\_1min} = 2019S_{Act\_1min} * \frac{2021S_{Mth\ Capacity}}{2019S_{Mth\ Capacity}}$$

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 2019 Integrated Energy Policy Report (IEPR) 1-in-2 hourly managed net load forecast (CED 2019 Hourly Results – CAISO – MID-MID) to develop minute-by-minute load forecasts for each month[9]. The ISO scaled the actual load for each minute of each hour of 2019 using an expected CEC's load growth factor for the corresponding hour.

$$2021L_{Mth,Day,Hour\_Sim\_1min} = 2019L_{Mth,Day,Hour\_Act\_1min} * \frac{2021L_{Mth,Day,Hour\_Forecast}}{2019L_{Mth,Day,Hour\_Actual}}$$

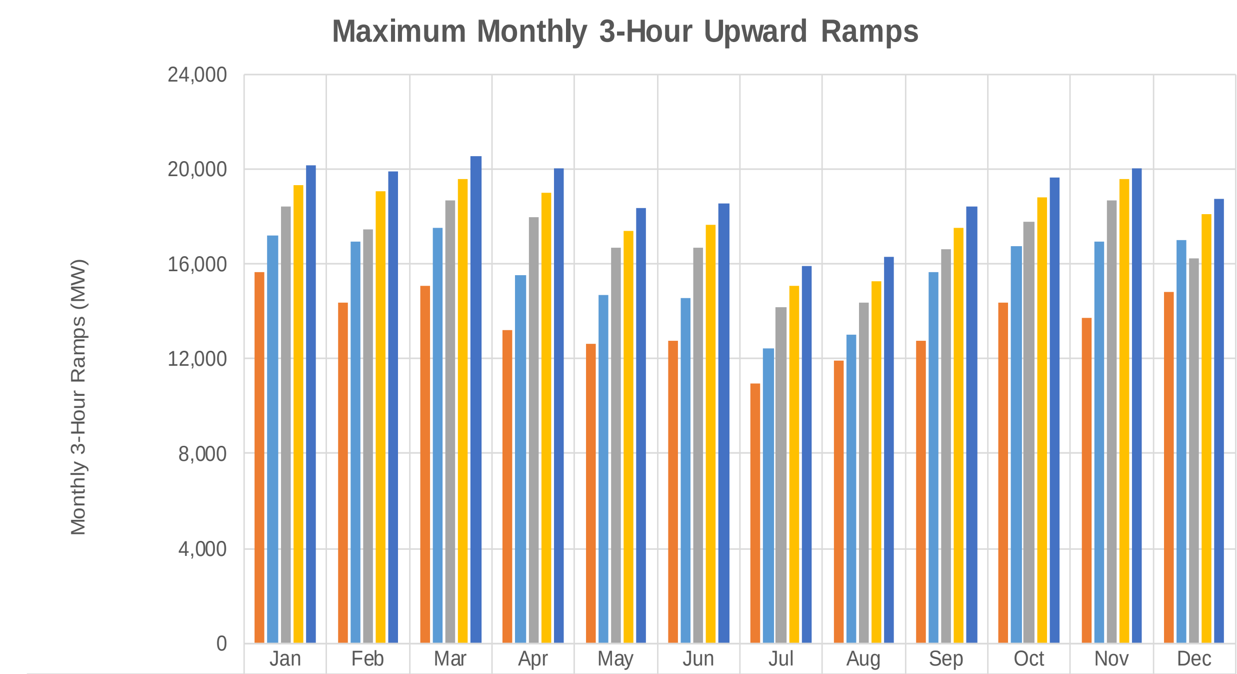
Using this load forecast and the expected wind and solar profiles developed in Section 4.1, the ISO developed the minute-by-minute net load profiles for subsequent years by aligning weekdays and weekends within each month.

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 2021 through 2023 using the CEC's hourly load forecast. Figure 1 shows the ISO system-wide largest three-hour net load ramp for each month of 2021 compared with each month of the actual three-hour net load ramp for 2019.

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

Figure 1: ISO System Maximum Monthly Three-Hour Net Load Ramps



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019 (Actual)	15,639	14,360	15,070	13,177	12,611	12,744	10,981	11,914	12,757	14,333	13,704	14,782
2020 Max 3-Hr Ramp	17,181	16,945	17,545	15,541	14,716	14,563	12,440	13,038	15,674	16,746	16,941	16,991
2021 Max 3-Hr_Ramp	18,446	17,424	18,682	17,936	16,695	16,652	14,156	14,335	16,589	17,779	18,666	16,207
2022Max 3-Hr Ramp	19,318	19,081	19,598	19,019	17,364	17,615	15,058	15,276	17,512	18,785	19,565	18,106
2023 Max 3-Hr Ramp	20,167	19,890	20,530	20,054	18,336	18,560	15,910	16,281	18,415	19,613	20,052	18,736

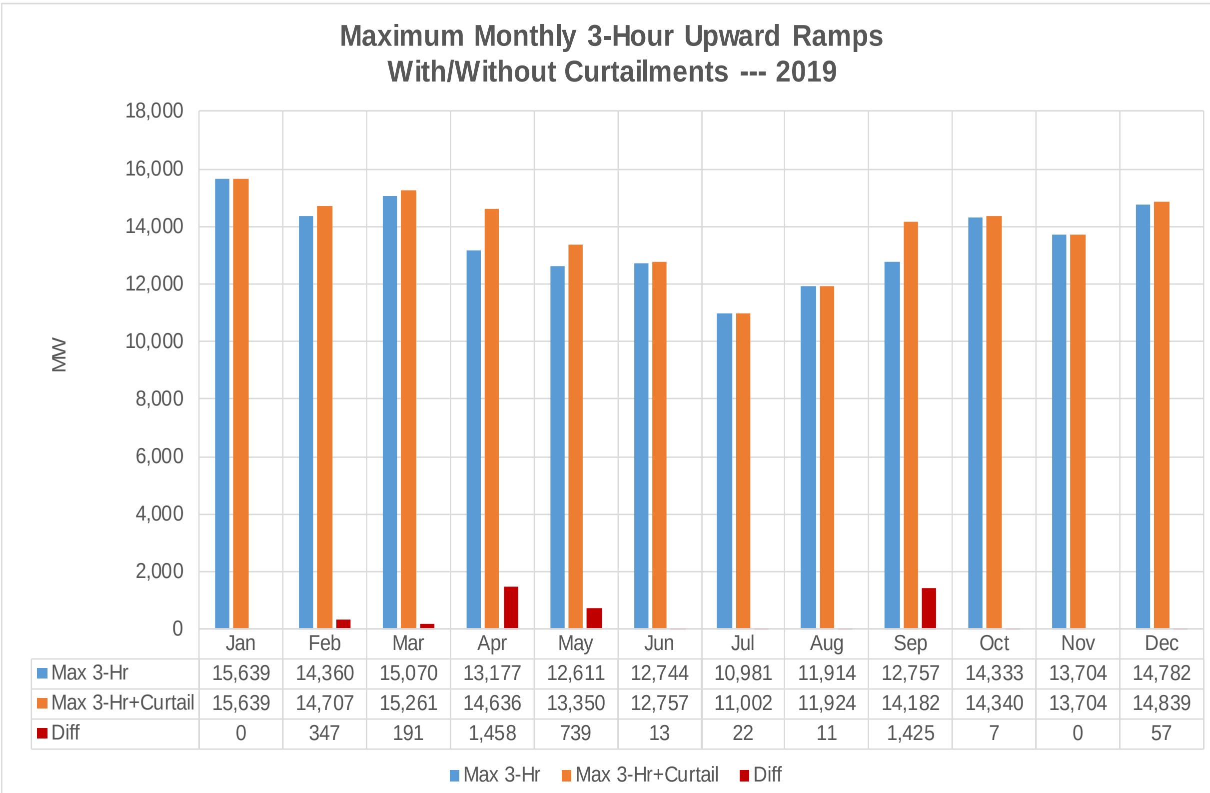
2019 (Actual) 2020 Max 3-Hr Ramp 2021 Max 3-Hr_Ramp 2022Max 3-Hr Ramp 2023 Max 3-Hr Ramp

As shown in Figure 1 the maximum upward three-hour monthly ramps for the non-summer months of 2021 are higher than those predicted for the summer months, which is consistent with historical trends. A shown, in 2021 the three-hour ramp for November is about 2,400 MW greater than December. From the needs analysis, the maximum three-hour ramp in November is expected to occur on November 2, while the maximum three-hour ramp in December is expected to occur on December 20. A closer look at these two days shows that the average 4-hour loss of solar and wind production between 15:00 and 19:00 was about 3,700 MW higher on November 2 than on December 20. Overall, the net load change on November 2 was about 4,500 MW higher than December 20 between hours 15:00 and 19:00. Thus, a maximum three-hour ramp between hours 15:00 to 19:00 of about 2,400 MW seems logical. A detailed breakdown of the above analysis would be presented in the presentation slides.

Also, the maximum three-hour ramp shown for 2020 is a recalculation using the most recent CEC's load forecast, the LSEs submittals, and is simply illustrative. The 2020 values shown in Figure 1 do not supersedes the binding 2020 monthly three-hour ramps reflected in the 2019 Flexible Capacity Needs Assessment.

It is important to note that the actual three-hour net load ramps may have curtailments[10] present in the actual data used. In relation to Figure 2 below, depending on the time of day the curtailments occur, it can have an effect on reducing the three-hour ramp by raising the “belly of the duck.”

Figure 2: The ISO 2019 Maximum Monthly Three-Hour Ramp With and Without Curtailments

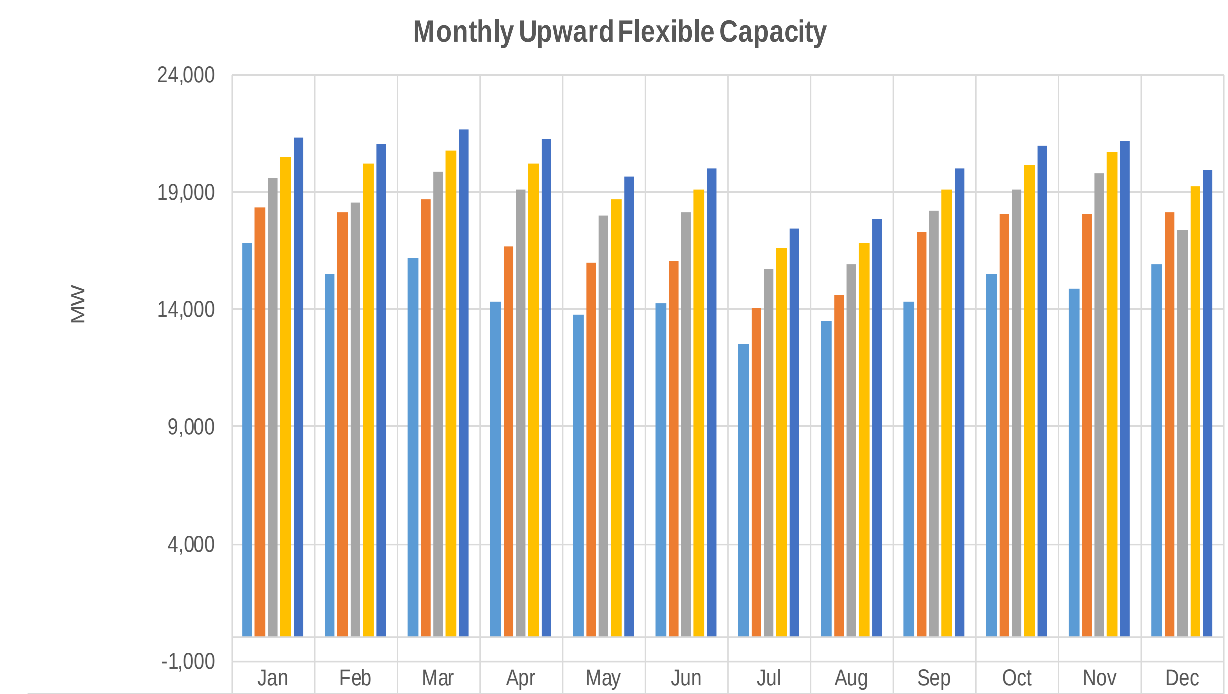


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max 3-Hr	15,639	14,360	15,070	13,177	12,611	12,744	10,981	11,914	12,757	14,333	13,704	14,782
Max 3-Hr+Curtail	15,639	14,707	15,261	14,636	13,350	12,757	11,002	11,924	14,182	14,340	13,704	14,839
Diff	0	347	191	1,458	739	13	22	11	1,425	7	0	57

Finally, 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 2021 and advisory needs for 2022 and 2023. The monthly flexible capacity needs for 2021 together with the actual monthly flexible capacity needed for 2019 is shown in Figure 3 below.

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

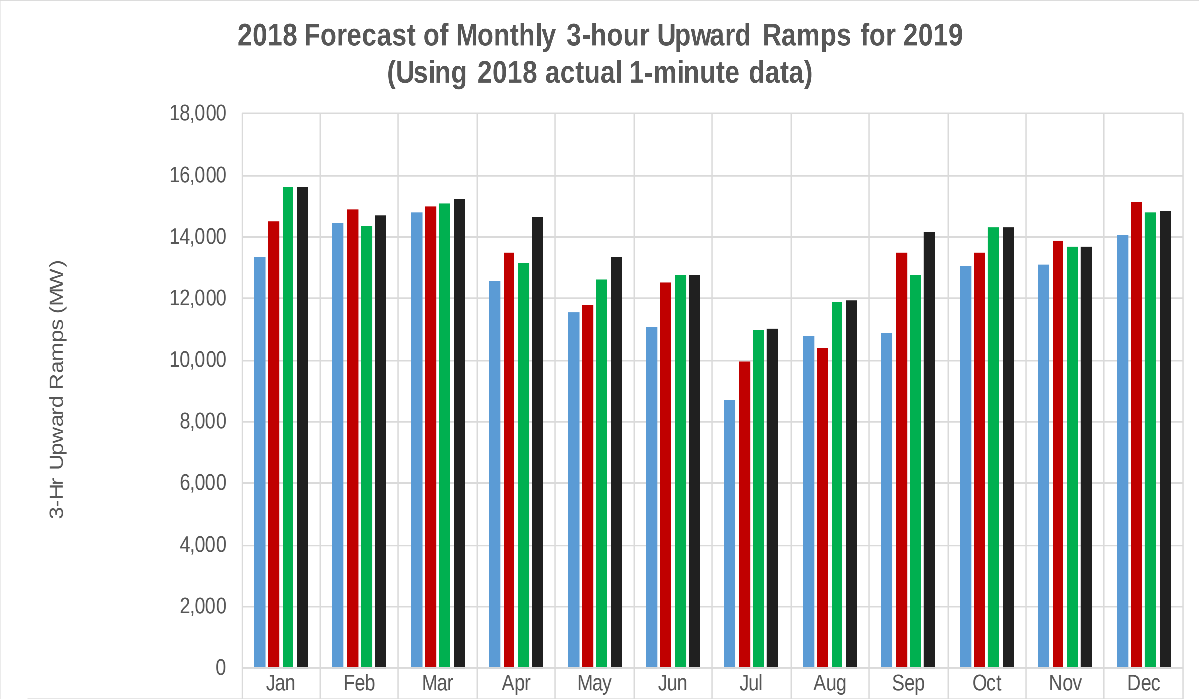
Figure 3: The ISO Monthly Maximum Three-Hour Flexible Capacity Requirements



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019 (Act. Flex Cap.)	16,789	15,510	16,220	14,327	13,761	14,238	12,492	13,464	14,302	15,505	14,854	15,932
2020 Flex Req.	18,331	18,095	18,695	16,691	16,007	16,032	14,035	14,629	17,281	18,066	18,091	18,142
2021 Flex. Cap.	19,596	18,574	19,832	19,088	17,987	18,106	15,725	15,909	18,183	19,102	19,816	17,361
2022 Flex Cap.	20,468	20,231	20,748	20,178	18,657	19,068	16,616	16,840	19,103	20,115	20,715	19,266
2023 Flex. Cap.	21,317	21,040	21,680	21,226	19,635	20,019	17,467	17,847	20,011	20,955	21,202	19,907

Figure 4 below shows the ISO's forecast of the net load three hour ramps that was done for the last full year of actual data. The maximum 2018 forecast of the monthly net load three hour ramps for 2019 were calculated using the 2017 1-minute actual load, wind and solar data, which is similar to the ISO's methodology of its forecast for 2021 and the advisory years 2022 and 2023. As shown, the ISO's monthly forecast of the three hour ramps are typically, slightly less than the actual three-hour ramps experienced.

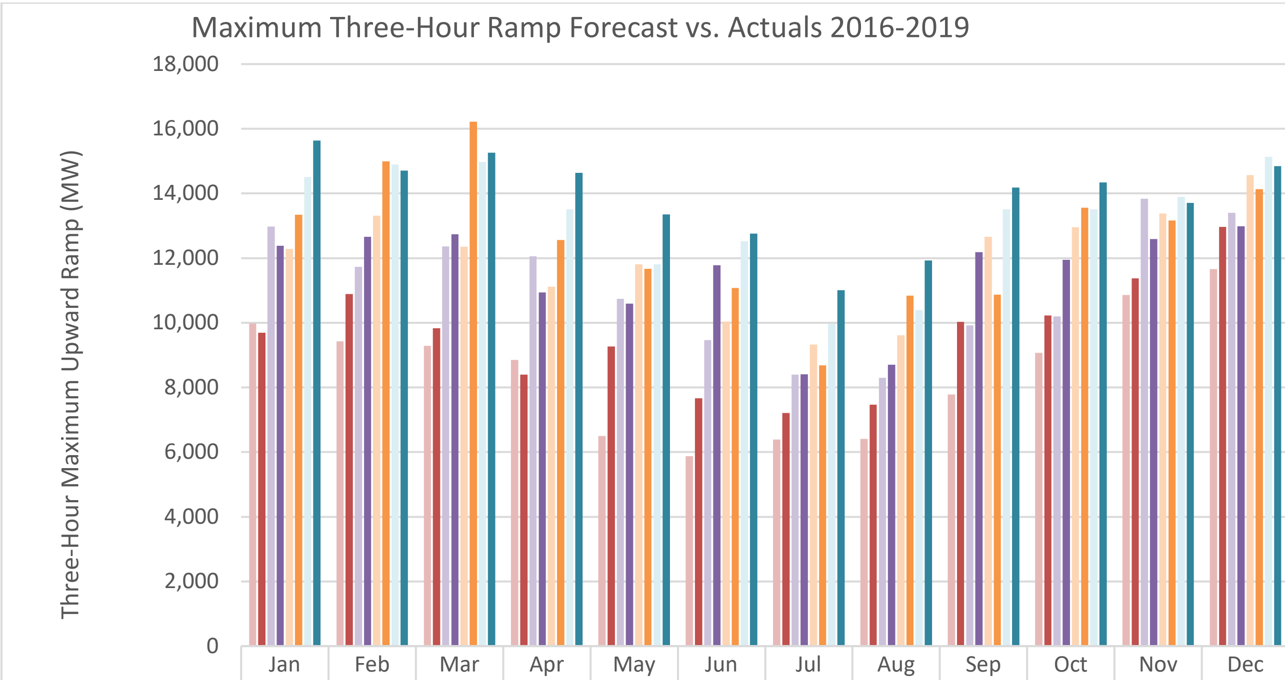
Figure 4: Comparison of Three-Hour Net Load Ramp Forecast vs. Actual Three-Hour Net Load Ramps



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018 (Actual)	13,326	14,440	14,777	12,553	11,571	11,057	8,679	10,805	10,866	13,082	13,087	14,059
2018 Forecast for 2019	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 (Actual)	15,639	14,360	15,070	13,177	12,611	12,744	10,981	11,914	12,757	14,333	13,704	14,782
2019 (Act+Curt)	15,639	14,707	15,261	14,636	13,350	12,757	11,002	11,924	14,182	14,340	13,704	14,839

An expanded accuracy analysis of the three-hour ramp forecast for years 2016-2019 is shown in Figure 5. It is noteworthy here that the actuals for years 2016 and 2017 do not include curtailments while for 2018 and 2019 they do, as indicated by the labels. In Figure 2 above, a comparison between the three-hour ramp actual with and without curtailments is made for 2019, 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 2017 forecast bar was the forecast created in 2016 using 2015's 1-minute load, wind and solar data. As shown, the monthly three-hour ramp is often under-forecast compared to the actuals.

Figure 5: A comparison of the forecast three-hour ramp to the actual three hour ramp for years 2016-2019



	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

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 define 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 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[11] 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:

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

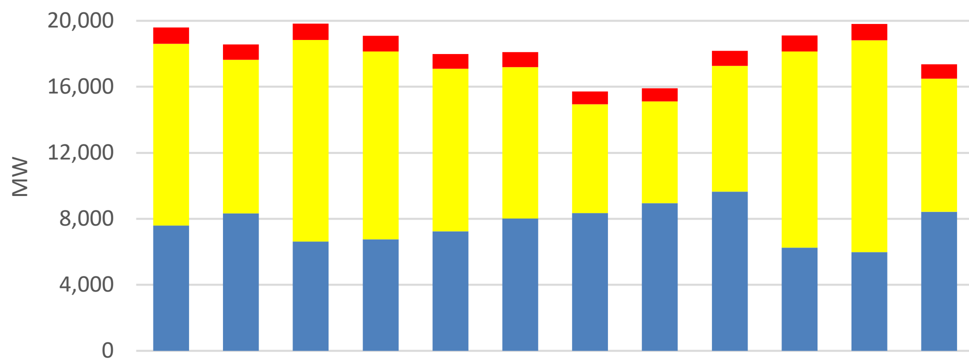
6.1 Calculating the Forecast Percentages Needed in Each Category in Each Month

Based on the categories defined above, the ISO calculated the system level needs for 2021 based only on the maximum monthly three-hour net load calculation. Then the ISO calculated the quantity needed in each category in each month based on the above descriptions. The ISO calculated the secondary net load ramps to eliminate the possibility of over-lapping time intervals between the primary and secondary net load ramps. The ISO then added the contingency requirements into the categories proportionally to the percentages established by the maximum three-hour net load ramp. The ISO distributed contingency reserve based on the proportions of the corresponding categories.

The calculation of flexible capacity needs for each category for 2021 is shown in Figure 6. In the 2021 results, we continue to see the general trend that the base category as a percentage of total flexibility is declining, which is related to the changes of the net load shape primarily due to solar and load.

[11] 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 6: ISO System-Wide Flexible Capacity Monthly Calculation by Category for 2021



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	980	929	992	954	899	905	786	795	909	955	991	868
Peak Flexibility	11,025	9,310	12,216	11,369	9,845	9,188	6,589	6,163	7,635	11,893	12,838	8,071
Base Flexibility	7,592	8,336	6,624	6,765	7,243	8,012	8,350	8,950	9,640	6,254	5,987	8,421

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 7 and Figure 8, respectively.

Figure 7: Distribution of Daily Primary Three-hour Net Load Ramps for 2021

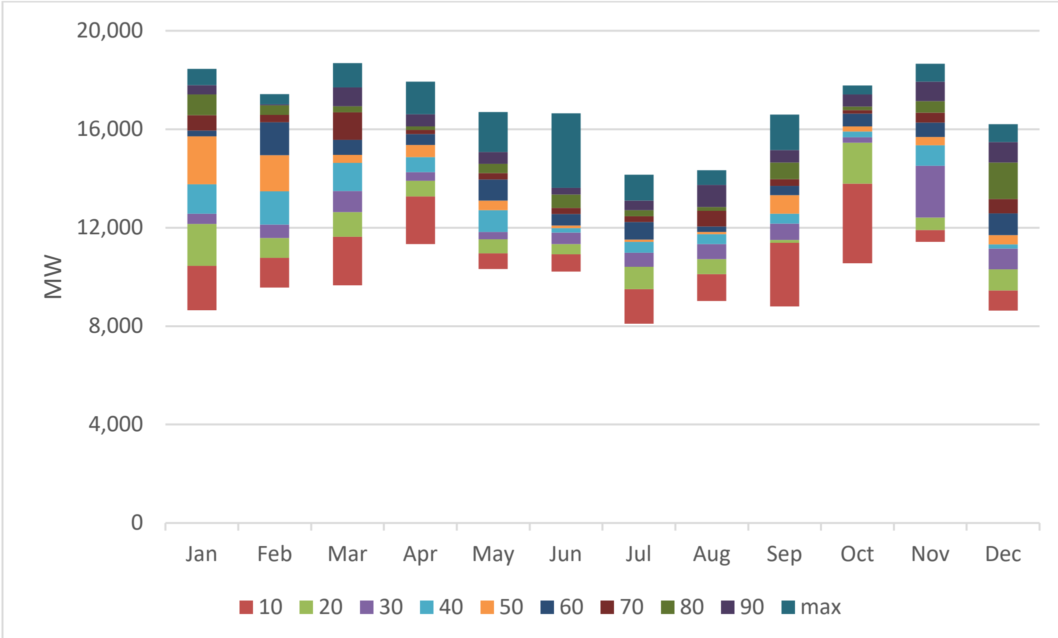
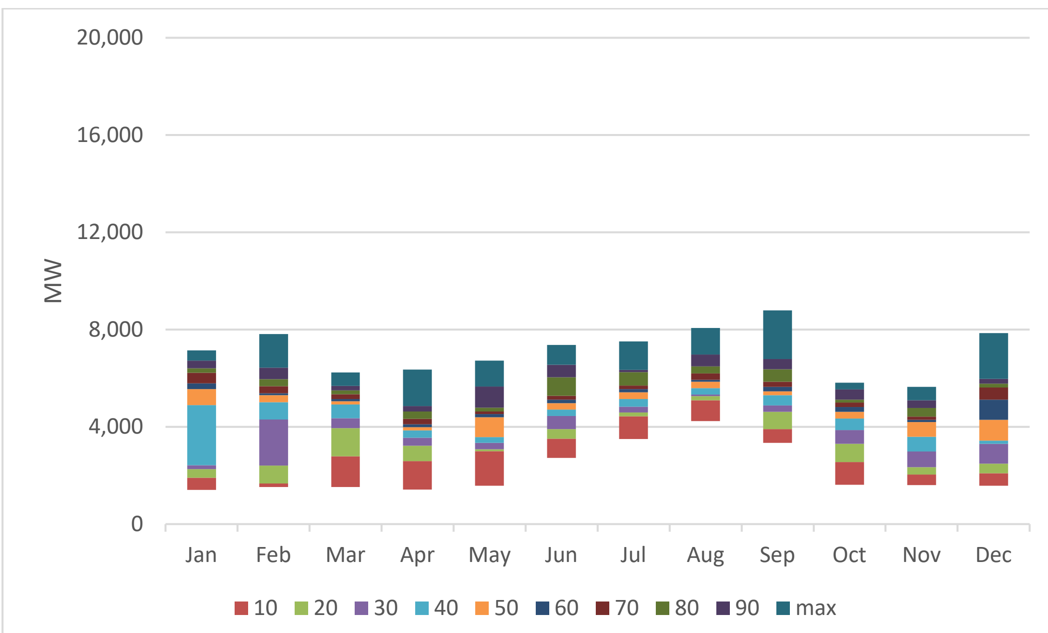


Figure 8: Distribution of Secondary Three-hour Net load Ramps for 2021



As Figure 7 and Figure 8 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

	Unadjusted			Adjusted		
Month	Base Flexibility	Peak Flexibility	Super-Peak Flexibility	Base Flexibility	Peak Flexibility	Super-Peak Flexibility
January	39%	56%	5%	38%	57%	5%
February	45%	50%	5%	38%	57%	5%
March	33%	62%	5%	38%	57%	5%
April	35%	60%	5%	38%	57%	5%
May	40%	55%	5%	49%	46%	5%
June	44%	51%	5%	49%	46%	5%
July	53%	42%	5%	49%	46%	5%
August	56%	39%	5%	49%	46%	5%
September	53%	42%	5%	49%	46%	5%
October	33%	62%	5%	38%	57%	5%
November	30%	65%	5%	38%	57%	5%
December	49%	46%	5%	38%	57%	5%

As Figure 7 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.

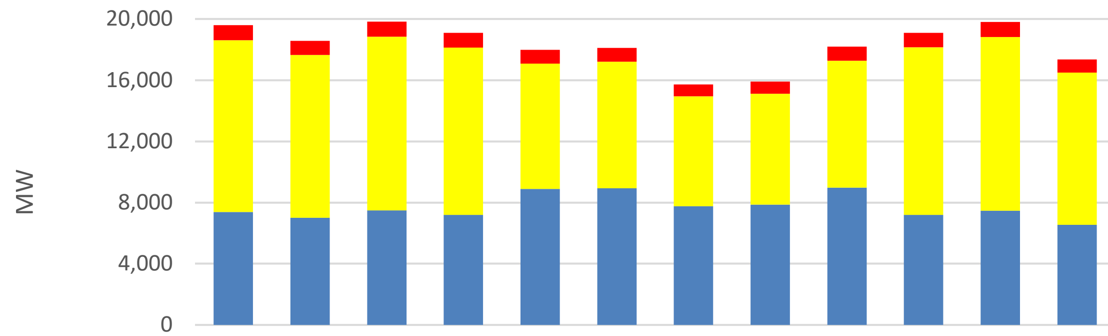
First, it mitigates the impact that variations in the net load ramp in any given month can have on determining the amounts for the various flexible capacity categories for a given season. For example, a month may have either very high or low secondary ramps that are simply the result of the weather in 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 38 percent of the ISO system flexible capacity need for the non-summer months and 49 percent for the summer months. Peak flexible capacity resources could be used to fulfill up to 57 percent of non-summer flexibility needs and 46 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 9.

Figure 9: 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	980	929	992	954	899	905	786	795	909	955	991	868
Peak Flexibility	11,228	10,642	11,363	10,937	8,206	8,260	7,174	7,258	8,296	10,945	11,354	9,947
Base Flexibility	7,388	7,003	7,477	7,197	8,881	8,940	7,764	7,855	8,979	7,202	7,471	6,545

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

$$\textit{Flex Requirement} = \Delta NL_{2021} + R_{2021}$$

$$= \Delta L_{2021} - \Delta W_{2021} - \Delta S_{2021} + R_{2021}$$

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_{2021} Net Load Ramp Req in 2021, $\Delta NL_{sc,2021}$ Net Load Ramp Allocation for LSC in 2021,

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

In 2021, the ISO has forecasts from CEC L_{2021} , survey results from $W_{2021} = \Sigma W_{lsc,\,2021}$, $S_{2021} = \Sigma S_{lsc,\,2021}$, hence all the ramps ΔL_{2021}, ΔW_{2021}, ΔS_{2021}, plus R_{2021}. 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

$$\textit{Flex Need} = \Delta NL_{2021} + \Sigma pl\_r_{lsc} * R_{2021}$$

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

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 $y = 2019$, the allocation of ΔL_{2021} 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

$$\Delta L_{lsc,y+2} = L^E_{lsc,y}\left(\frac{L^E_{y+2}}{L^E_y}\right) - L^S_{lsc,y}\left(\frac{L^S_{y+2}}{L^S_y}\right),$$

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,

$$\Delta L_{2021} = \Delta L_{2019} + (\Delta L_{2021} - \Delta L_{2019})$$

$$= \Sigma \Delta L_{lsc,\,2019} + \frac{\Sigma L^M_{lsc,\,2019}}{L^M_{2019}} * \left(\Delta L_{2021} - \Delta L_{2019}\right),$$

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^M_{2019} is the average load at beginning and the end of points during those top 5 ramps. In 2021, each LSC will receive:

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

Therefore each LSC's contribution $\Delta L_{lsc,\,2019}$ will be explicitly projected into future year 2021, and any additional increase of $(\Delta L_{2021} - \Delta L_{2019})$ 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 available all non-confidential working papers and data that the ISO relied on for the Final Flexible Capacity Needs Assessment for 2021. 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 "2021 Flexible Capacity Needs Assessment – 2021 Net Load Data" at:

http://www.caiso.com/informed/Pages/StakeholderProcesses/FlexibleCapacityNeedsAssessmentProcess.aspx

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	Average of Load contribution 2021	Average of Wind contribution 2021	Average of Solar contribution 2021	Total percent 2021
January	46.61%	0.52%	-53.91%	100%
February	44.99%	2.68%	-57.69%	100%
March	40.13%	-0.82%	-59.05%	100%
April	36.79%	-0.22%	-62.99%	100%
May	34.47%	-3.02%	-62.50%	100%
June	32.10%	-2.98%	-64.92%	100%
July	21.34%	-2.73%	-75.93%	100%
August	23.98%	-1.10%	-74.92%	100%
September	29.98%	-1.07%	-68.96%	100%
October	34.01%	-1.49%	-64.50%	100%
November	38.40%	-8.90%	-52.71%	100%
December	41.13%	-3.18%	-55.68%	100%

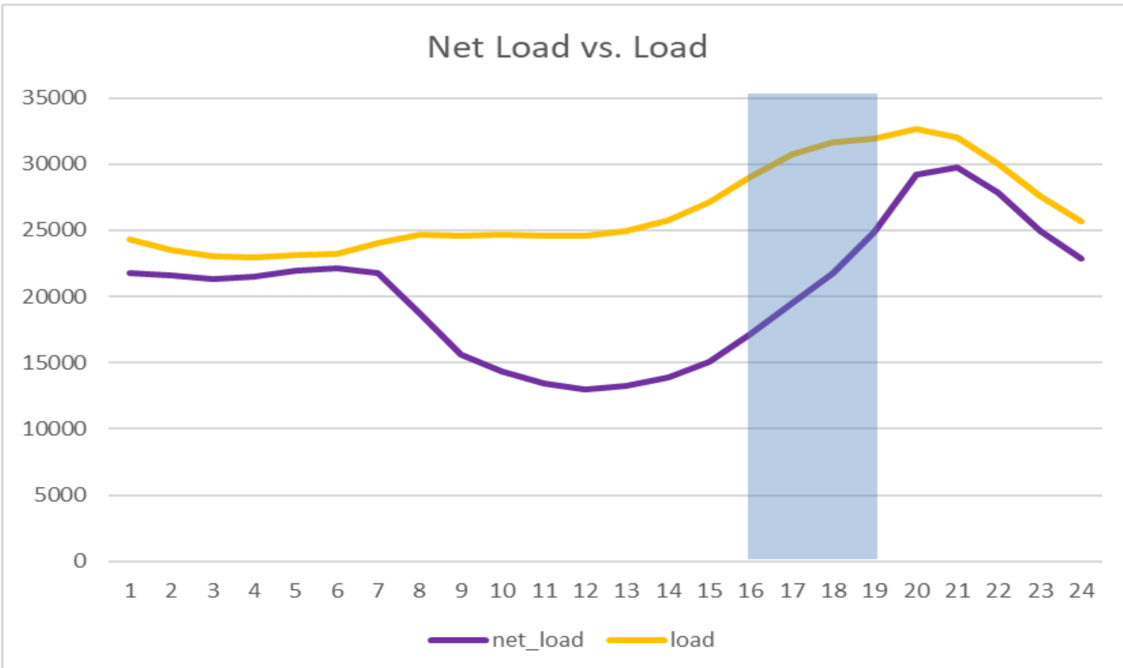
When looking at the contribution to the maximum three-hour continuous net load ramp shown in Table 3, the above total percentage is calculated as Load – Wind – Solar For example, when looking at August you get to 100 percent by:

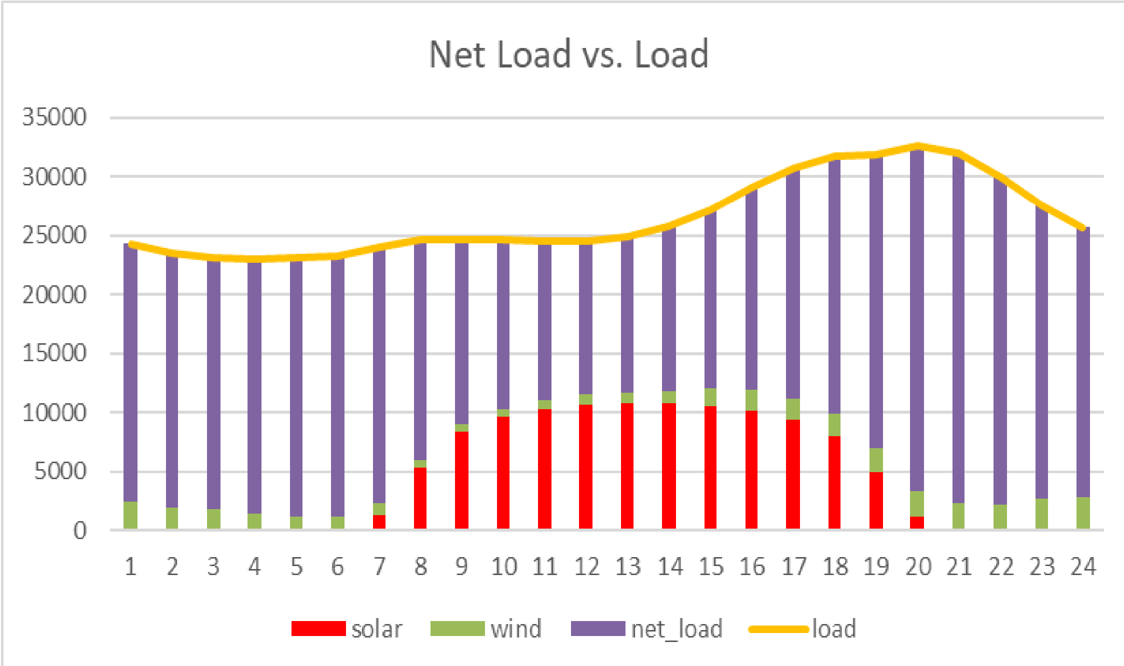
Total Contribution = 23.98%– (-1.10%) – (-74.92%) = 100%

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 happens when the sun is setting. 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 **10** 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 10: Examples of Load Contribution to Net Load Ramp





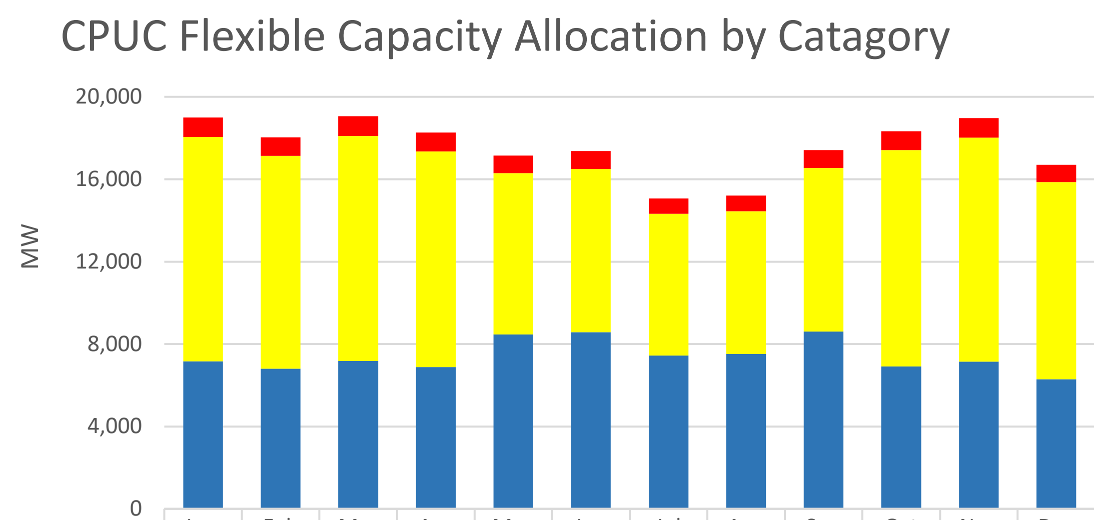
The CPUC allocations are shown in Table 4 and Figure 11. The contributions calculated for other LRAs will only be provided the contribution of its jurisdictional LRA as per section 40.10.2.1 of the ISO tariff.

Table 4: CPUC Jurisdictional LSEs' Contribution to Flexible

Month	Load	Wind	Solar	reserve	Total Allocation
January	8,488	93	-9,562	1,039	18,996
February	7,777	450	-9,665	1,039	18,031
March	7,273	-148	-10,596	1,039	19,056
April	6,350	-38	-10,840	1,041	18,269
May	5,520	-486	-9,972	1,167	17,146
June	5,245	-478	-10,328	1,314	17,364
July	3,027	-372	-10,259	1,418	15,076
August	3,385	-152	-10,254	1,422	15,213
September	4,884	-170	-10,921	1,441	17,416
October	5,920	-255	-10,956	1,196	18,327
November	6,913	-1,596	-9,416	1,039	18,965
December	6,530	-496	-8,633	1,043	16,702

Finally, the ISO applied the seasonal percentage established in Section 6 to the contribution of CPUC jurisdictional load serving entities to determine the quantity of flexible capacity needed in each flexible capacity category. These results are detailed in Figure 11.

Figure 11: CPUC Flexible Capacity Need in Each Category for 2021



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	950	902	953	913	857	868	754	761	871	916	948	835
Peak Flexibility	10,884	10,331	10,919	10,468	7,822	7,922	6,878	6,941	7,946	10,501	10866	9569
Base Flexiblity	7,162	6,798	7,185	6,888	8,466	8,574	7,444	7,512	8,599	6,910	7150	6297

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 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 2021.

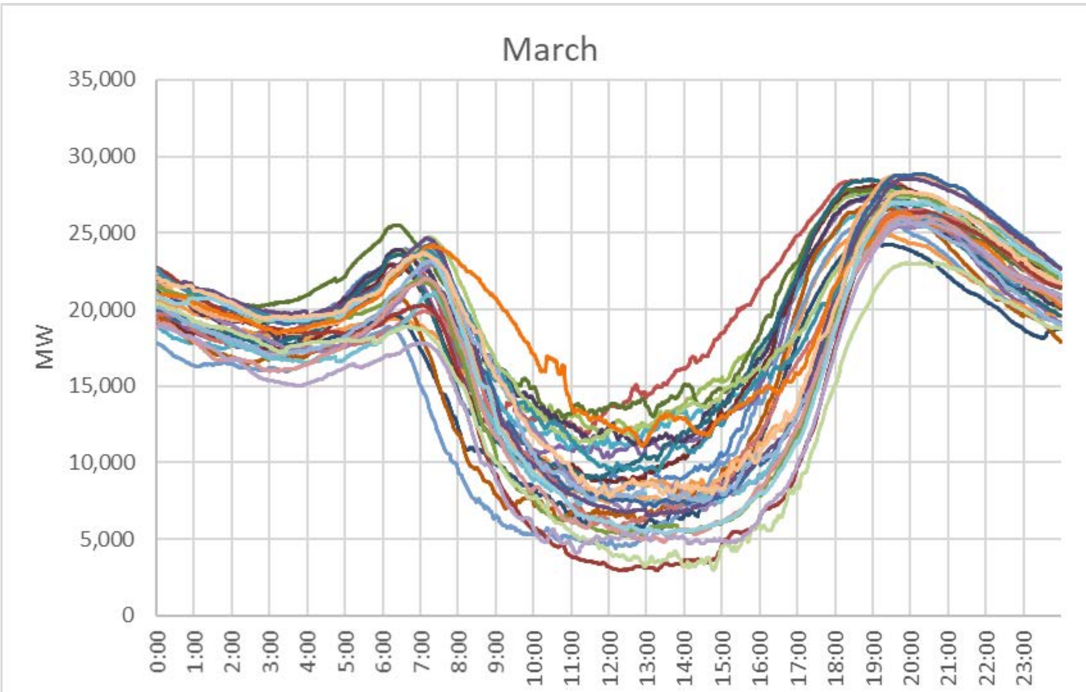
Table 5: Forecasted Starting Hour of the Maximum Three-Hour Net Load Ramp by Month for 2021

	Three-Hour Net Load Ramp Start Hour (Hour Ending)					
Month	**13:00**	**14:00**	**15:00**	**16:00**	**17:00**	**18:00**
January		1	30			
February		1	16	11		
March			1	14	16	
April				4	25	1
May				6	24	1
June				3	25	2
July				6	25	
August				7	24	
September	1		4	20	5	
October			4	27		
November		3	21	6		
December		1	30			

Table 5 shows an early (HE 15), start of the three-hour ramp pattern for November through February. For the months of April 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. The spring shoulder month of March shows a near-even split between the three-hour net load ramp beginning HE 16 and HE 17.

To assist in determining why this split for March was observed, the forecast daily net load values for March 2021 were plotted. These are shown in Figure 12 which displays a split in March between HE 16 and HE 17 for the start of the three-hour ramp.

Figure 12: Daily Net Load Forecast for March 2021



It is suspected that daylight savings time occurring mid-March, as well as the high variability in March temperatures and cloud cover year-to-year are the primary drivers between creating this split. It is observed that the days with a net load ramp start of HE 17 have a larger net load MW ramp, as well as a higher net load peak. Based on this, the MOO hours of HE 17 to HE 21 for March will result in more stability for the ISO grid operation. The recommended MOO hours for all months of 2021 are summarized in Table 6.

Table 6: Summary of MOO Hours Proposed by the ISO for 2021

	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 2022 in early 2021. 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 CAISO did not receive any stakeholder comments in relation to the Flexible Capacity Needs Assessment for 2021.