BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Oversee the Resource Adequacy Program, Consider Program Refinements, and Establish Annual Local and Flexible Procurement Obligations for the 2019 and 2020 Compliance Years	Rulemaking 17-09-020 (Filed September 28, 2017)

CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION 2019 ANNUAL RESOURCE ADEQUACY RELATED ANALYSES

The California Independent System Operator Corporation (CAISO) hereby provides its Final Flexible Capacity Needs Assessment for the 2019 resource adequacy year. The Final Flexible Capacity Needs Assessment is included as Attachment A to this filing and can be downloaded at the CAISO's website.

Respectfully submitted,

By: *<u>/s/ Jordan Pinjuv</u>*
Roger E. Collanton
General Counsel
Anthony Ivancovich
Deputy General Counsel
Jordan Pinjuv
Senior Counsel
California Independent System
Operator Corporation
250 Outcropping Way
Folsom, CA 95630
Tel: (916) 351-4429
Fax: (916) 608-7222
jpinjuv@caiso.com

Attorneys for the California Independent
System Operator Corporation

Dated: May 21, 2018

Attachment A

California Independent System Operator Corporation

Final Flexible Capacity Needs Assessment

California ISO

Final Flexible Capacity Needs Assessment for 2019

May 21, 2018

Table of Contents

1. Introduction

The ISO conducts an annual flexible capacity technical study to determine the flexible capacity needed to help ensure the ISO maintain system reliability as specified in the ISO Tariff section 40.10.1. The ISO developed 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 2019.

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 attributable to individual local regulatory authorities (LRAs) other than the CPUC.

The ISO will use the results from the final study to allocate shares of the system flexible capacity[1] need 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 need.

2. Summary

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 developed in the FRAC-MOO stakeholder initiative and 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 2019 are based on the following dataset provide by the California Energy Commission for 2019:

1. Monthly "1 in 2" peak load weather pattern mid load profiles and mid AAEE,
2. Hourly mid solar PV production

1) System-wide flexible capacity needs for 2019 are greatest in the non-summer months and range from 11,517 MW in July to 16,323 MW in December.

2) The minimum amount of flexible capacity needed from the "base flexibility" category is 62 percent of the total amount of installed or available flexible capacity in the summer months (May – September) and 46 percent of the total amount of flexible capacity for the non-summer months (October – April).

3) The ISO established 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 HE 14 through HE 19 for January through April and October through December; HE 15 through HE 20 for May through September. These hours are the same from those in Final Flexible Capacity Needs Assessment for 2018.

4) The ISO published advisory requirements for the two years following the upcoming Resource Adequacy (RA) year at the ISO system total levels as shown in Figure 2.

3. Defining 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
MSSC = Most Severe Single Contingency

ε = Annually adjustable error term to account for load forecast errors and variability methodology

For the 2019 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:

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

1) Forecast minute-by-minute net load using all expected and existing wind and solar resources and the most recent year of actual load, as adjusted for load growth;

2) Calculate the monthly system-level 3-hour net load ramp needs using forecast minute-to-minute net load forecast;

3) Calculate the percentages needed in each category in each month and add the contingency requirements into the categories proportionally to the percentages established calculated in step 2;

4) Analyze the distributions of both largest three-hour net load ramps for the primary and secondary net load ramps to determine appropriate seasonal demarcations;

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.

This methodology allows the ISO to make enhancements and assumptions based on its experience and any updated or new information that becomes available.

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 expected build-out of the fleet of variable energy resources. After obtaining this data from all LSEs, the ISO constructed the forecast minute-by-minute load, wind, grid connected solar and behind-the-meter rooftop solar PV profiles before calculating the net load curves for 2018 through 2021.

4.1 Building the Forecasted Variable Energy Resource Portfolio

To collect the necessary data, the ISO sent a data request in December, 2017 to the scheduling coordinators for all LSEs representing load in the ISO balancing area.[3] The deadline for submitting the data was January 15, 2018. At the time of the draft report, the ISO had received data from all LSEs. The data request asked for information on each wind, solar, and distributed wind and solar resource that the LSE owns, in whole or in part, or is under contractual commitment to the LSE for all or a portion of its capacity. As part of the data request, the ISO asked for information on resources internal and external to the ISO. For resources that are external to the ISO, the ISO requested additional information as to whether the resource is or will be dynamically scheduled into the ISO. The ISO only included external

[3] A reminder notice was also sent out in early January, 2018.

resources in the flexible capacity requirements assessment if they were dynamically scheduled to the ISO. Based on the ISO review of the responses to the data request, it appears that the information submitted represents all wind, solar, and distributed wind and solar resources that the LSE owns, in whole or in part, or is contractually committed to the LSE for all or a portion of its capacity within the ISO balancing area.

Using the LSEs' data, the ISO simulated the variable energy resources' output to produce forecast minute-by-minute net load curves[4] for 2019. The forecasted aggregated variable energy resource fleet capacity is provided in Table 1.

Table 1: Total ISO System Variable Energy Resource Capacity (Net Dependable Capacity-MW)[5]

Resource Type	Existing MW (2017)	2018 MW	2019 MW
ISO Solar PV	8,262	9,018	10,095
ISO Solar Thermal	1,433	1,178	1,108
ISO Wind	4,611	4,932	4,761
Incremental behind-the-meter Solar PV		1,100	1,194
Total Variable Energy Resource Capacity in the 2017 Flexible Capacity Needs Assessment[6]	14,306	16,228	17,158
Non ISO Resources All external VERS not-firmed by external BAA	1,271	1,197	1,201
Total internal and non-firmed external VERs	15,577	17,425	18,359
Incremental New Additions in Each Year		1,848	934

Table 1 aggregates the variable energy resources system wide, while the behind-the-meter solar PV were modeled as five separate aggregation dispersed throughout the ISO's balancing area. This ensured that the assessment captured the geographic diversity benefits. Additionally, for existing solar and wind resources, the ISO used the most recent full year of actual solar output data available, which was 2017. For future wind resources, the ISO scaled overall wind production for each minute of the most recent year by the expected future capacity divided by the installed wind capacity of the most recent year. Specifically, to develop the wind profiles for wind resources, the ISO used the following formula:

$$2019\,W_{Mth\_Sim\_1\text{-}min} = 2017W_{Act\_1\text{-}min} * 2019W_{Mth\ Capacity} / 2017W_{Mth\ Capacity}$$

4 Net-load load is defined as load minus wind production minus solar production minus behind-the-meter solar PV production.

5 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.

6 Includes all internal variable energy resources

To develop 1-minute solar profiles for 2019, the ISO used the actual 1-minute profiles for 2017 using the following formula:

$$2019S_{Mth\_Sim\_1\text{-}min} = 2017S_{Act\_1\text{-}min} * 2019S_{Mth\ Capacity} / 2017S_{Mth\ Capacity}$$

Given the amount of incremental wind and solar resources coming on line, this approach allows the ISO to maintain the load/wind/solar correlation for the forecasted wind and solar capacity outputs.

The ISO's assumptions for solar resources' production portfolios for future years were primarily based on the overall capacity of the new resources.

The ISO obtained hourly incremental behind-the-meter solar PV production data from the CEC, which was used to generate 1-minute of behind-the-meter solar profiles. If this hourly solar PV production data is not factored into the model, it would lead to an undercounting of the net load ramps for future years. Therefore, the ISO has created an additional element to account for the incremental behind the meter solar PV resources in the calculation of the monthly three hour net load ramps. Including this incremental capacity allows the ISO to more accurately capture the forecasted monthly three hour net load ramps. Because behind-the-meter resources are solar PV, the ISO included the contribution of the incremental behind-the-meter solar PV as a subset of the Δ Solar PV, but provides a breakout of the contribution for purposes of determining an LRA's allocable share of the flexible capacity needs.

4.2 Building Minute-by-Minute Net Load Curves

The ISO used the CEC 2017 Integrated Energy Policy Report (IEPR) 1-in-2 monthly peak load forecast (Mid Demand Scenario, with mid-additional achievable energy efficiency) to develop minute-by-minute load forecasts for each month.[7] The ISO scaled the actual load for each minute of each hour of 2017 using an expected load growth factor of the average for the peak hour forecast for each month of 2019 provided by the CEC divided by the 2017 average for the peak hour of each month's actual production.

Using this forecasted load and expected wind and solar expansions, the ISO developed the minute-by-minute load, wind, and solar profiles. The ISO aligned these profiles and subtracted the output of the wind, solar and behind-the-meter production from the load to generate the

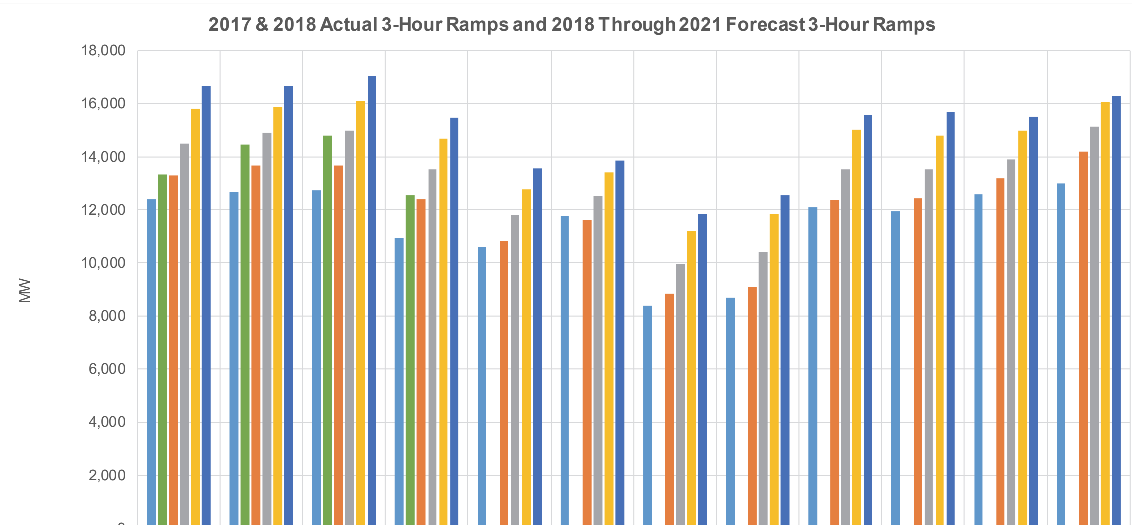
[7] http://www.energy.ca.gov/2014publications/CEC-200-2014-009/CEC-200-2014-009-SD.pdf
http://www.energy.ca.gov/2017_energypolicy/documents/2018-02-21_business_meeting/2018-02-21_hourly_forecasts.php

minute-by-minute net load curves, which is necessary to conduct the flexible capacity needs assessment.

5. Calculating the Monthly Maximum Three-Hour Net load Ramps Plus 3.5 Percent Expected Peak-Load

The ISO, using the net load forecast developed in Section 4, calculated the maximum three-hour net load ramp for each month of 2019. Figure 1 shows the ISO system-wide largest three-hour net load ramp for each month of 2019 compared with each month of the actual three-hour net load ramp for 2017 and the first four months of 2018.

Figure 1: ISO System Maximum 3-hour Net load Ramps



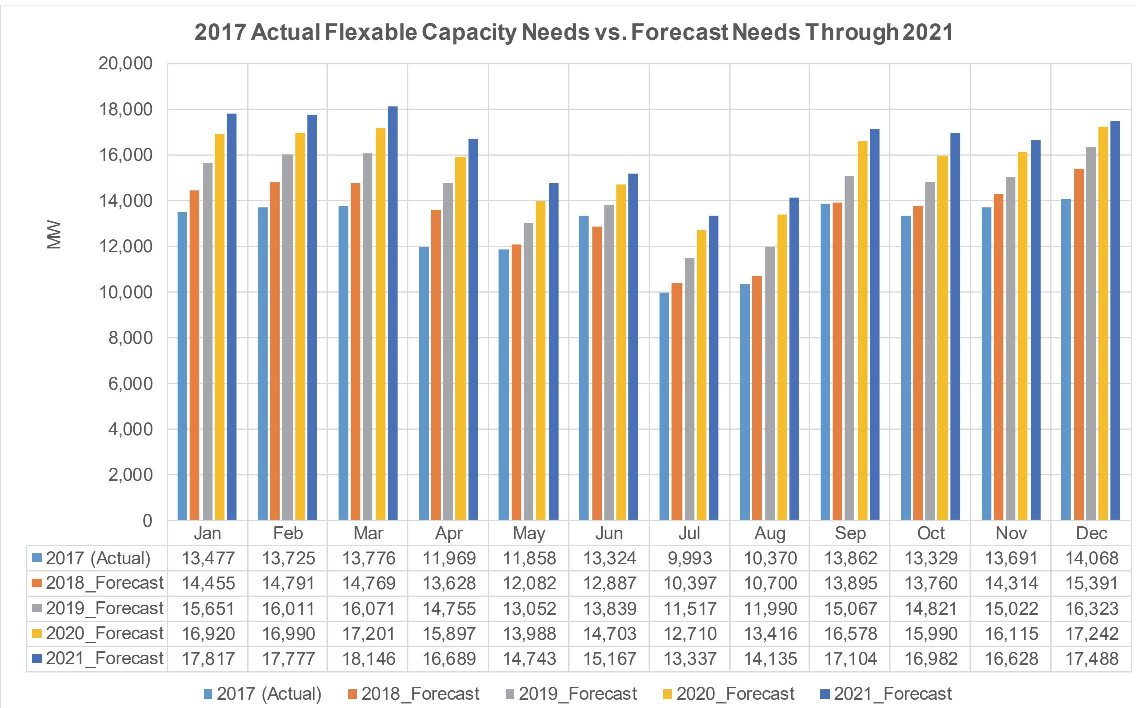
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017 (Actual)	12,378	12,659	12,733	10,939	10,591	11,774	8,403	8,706	12,108	11,949	12,591	12,981
2018 (Actual)	13326	14440	14777	12553								
2018_Forecast	13,310	13,668	13,669	12,380	10,832	11,618	8,836	9,093	12,355	12,437	13,184	14,197
2019_Forecast	14,506	14,889	14,971	13,509	11,808	12,524	9,967	10,393	13,511	13,510	13,898	15,129
2020_Forecast	15,784	15,877	16,110	14,664	12,762	13,404	11,187	11,823	15,024	14,791	14,993	16,057
2021_Forecast	16,674	16,677	17,048	15,450	13,546	13,864	11,817	12,536	15,575	15,679	15,507	16,296

2017 (Actual) 2018 (Actual) 2018_Forecast 2019_Forecast 2020_Forecast 2021_Forecast

The results for the non-summer months of 2019 are higher than those predicted in the summer months. This is consistent with historical trends.

As part of the 2019 Flexible Capacity Needs Assessment, the ISO assessed the weather patterns to identify anomalous results. As shown in Figure 1, flexible capacity needs follow a predictable pattern, whereby the flexible capacity needs for all summer months remain low relative to the flexible capacity needs for non-summer months. Finally, the ISO summed the monthly largest three-hour contiguous ramps and 3.5 percent of the forecast peak-load for each month.[8] This sum yields the ISO system-wide flexible capacity needs for 2019. The monthly flexible capacity needs for 2019 together with the actual monthly flexible capacity needed for 2017 are shown in Figure 2 below.

Figure 2: The ISO System Maximum 3-Hour Net load Ramps Plus 3.5 Percent of Forecast Peak Load



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017 (Actual)	13,477	13,725	13,776	11,969	11,858	13,324	9,993	10,370	13,862	13,329	13,691	14,068
2018_Forecast	14,455	14,791	14,769	13,628	12,082	12,887	10,397	10,700	13,895	13,760	14,314	15,391
2019_Forecast	15,651	16,011	16,071	14,755	13,052	13,839	11,517	11,990	15,067	14,821	15,022	16,323
2020_Forecast	16,920	16,990	17,201	15,897	13,988	14,703	12,710	13,416	16,578	15,990	16,115	17,242
2021_Forecast	17,817	17,777	18,146	16,689	14,743	15,167	13,337	14,135	17,104	16,982	16,628	17,488

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

8 The most severe single contingency was consistently less than 3.5 expected peak-load.

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:

<u>Base Flexibility</u>: Operational needs determined by the magnitude of the largest 3-hour secondary net load[9] ramp

<u>Peak Flexibility</u>: Operational need determined by the difference between 95 percent of the maximum 3-hour net load ramp and the largest 3-hour secondary net load ramp

<u>Super-Peak Flexibility</u>: Operational need determined by five percent of the maximum 3-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.

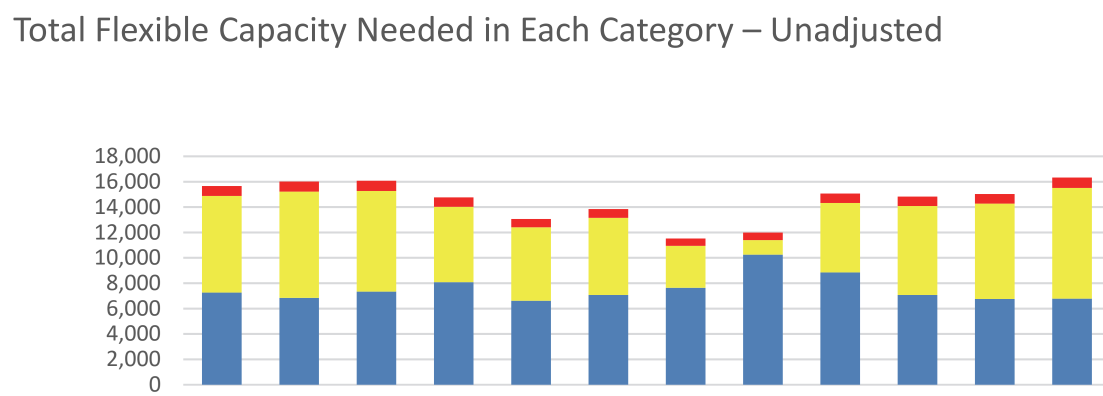
6.1 Calculating the Forecast Percentages Needed in Each Category in Each Month

Based on the categories defined above, the ISO calculated the system level needs for 2019 based only on the maximum monthly 3-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 3-hour net load ramp. The ISO distributed contingency reserve based on the proportions of the corresponding categories.

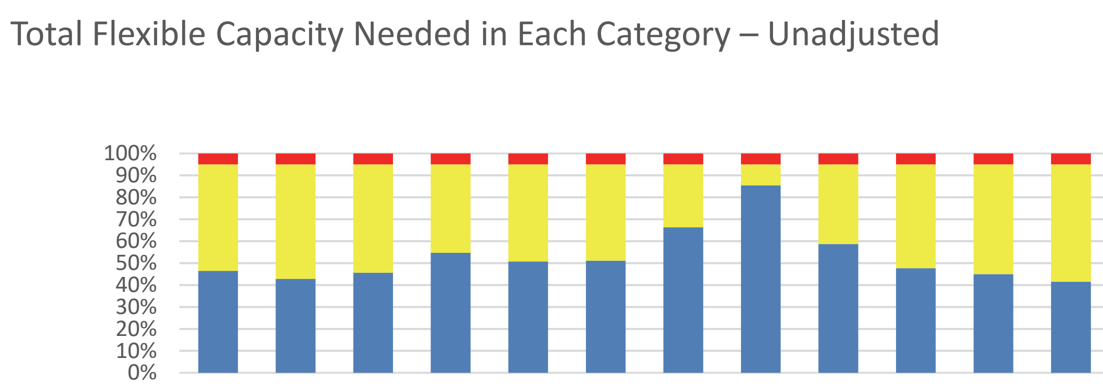
The calculation of flexible capacity needs for each category for 2019 is shown in Figure 3.

[9] The largest daily secondary 3-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 3-hour net-load ramp occurs between 5:00 p.m. and 8:00 p.m., then the largest secondary ramp would be determined by the largest morning 3-hour net-load ramp.

Figure 3: ISO System-Wide Flexible Capacity Monthly Calculation by Category for 2019



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	783	801	804	738	653	692	576	600	753	741	751	816
Peak Flexibility	7,609	8,367	7,940	5,947	5,780	6,076	3,308	1,148	5,470	7,013	7,521	8,727
Base Flexibility	7,259	6,843	7,327	8,070	6,619	7,071	7,634	10,243	8,844	7,067	6,749	6,781



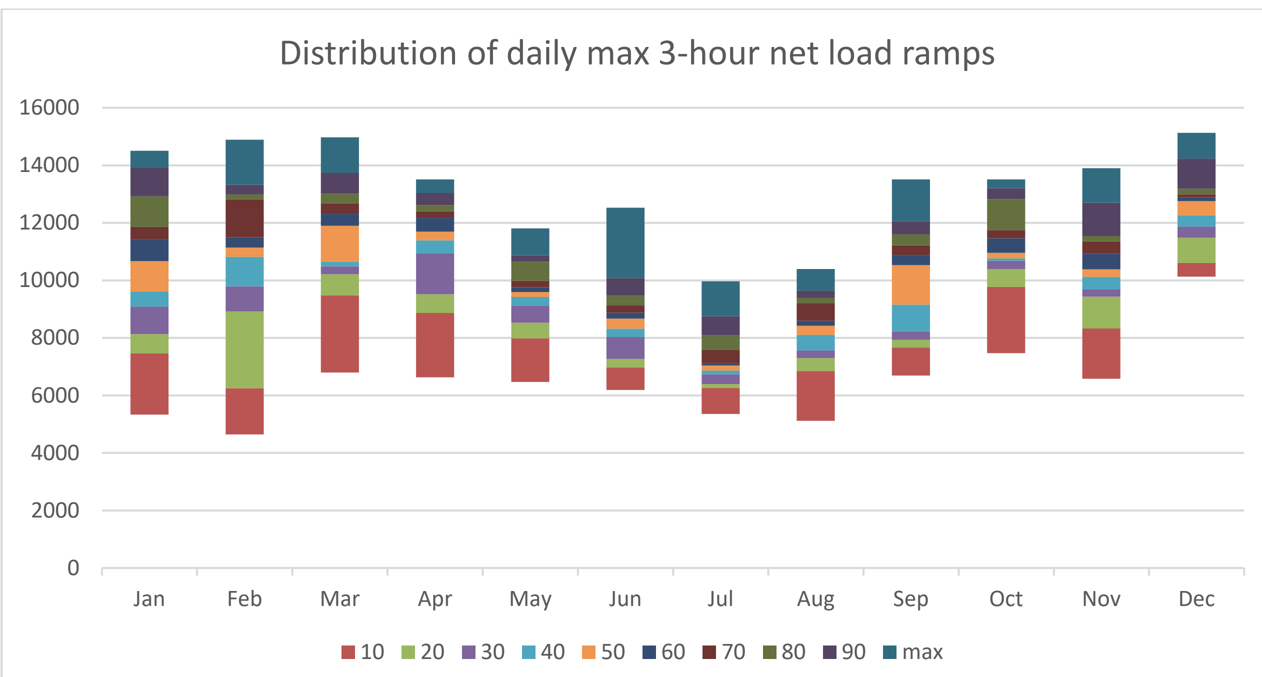
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	783	801	804	738	653	692	576	600	753	741	751	816
Peak Flexibility	7,609	8,367	7,940	5,947	5,780	6,076	3,308	1,148	5,470	7,013	7,521	8,727
Base Flexibility	7,259	6,843	7,327	8,070	6,619	7,071	7,634	10,243	8,844	7,067	6,749	6,781

Again, the larger quantity of existing and incremental grid connected and behind-the-meter solar PV results in a greater difference between the primary and secondary net load ramps, particularly in the non-summer months. This results in a lower percent requirement for base flexible capacity resources compared to last year's study.

6.2 Analyzing Ramp Distributions to Determine Appropriate Seasonal Demarcations

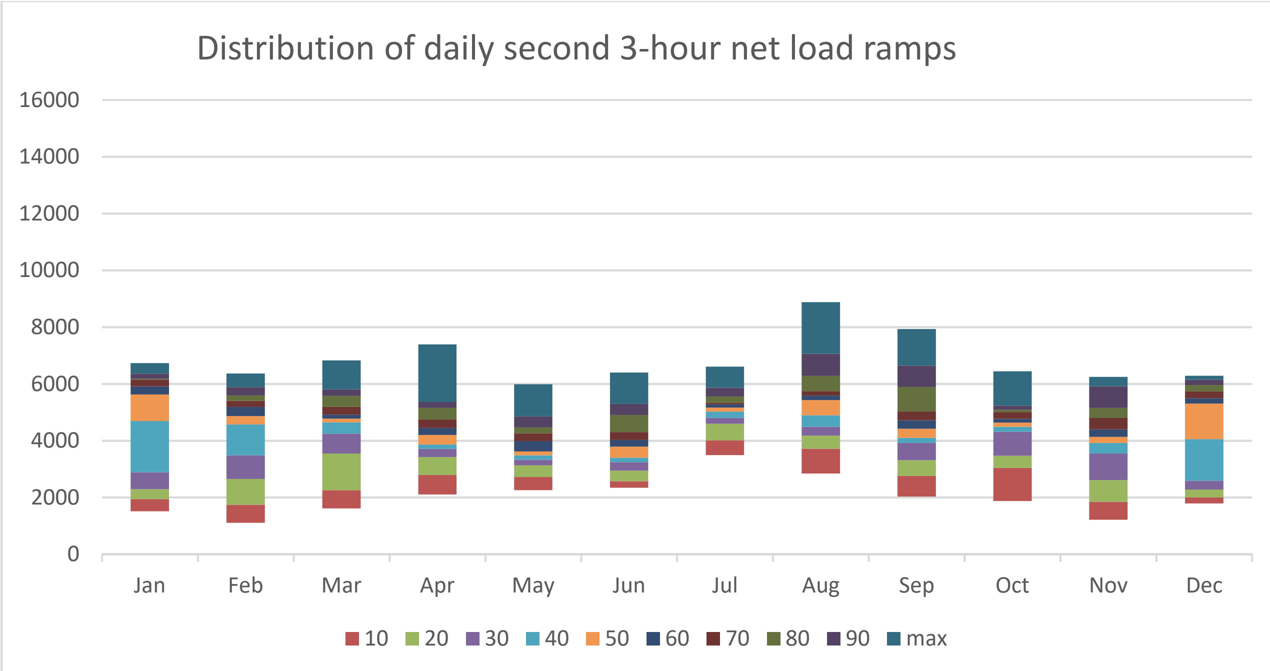
To determine the seasonal percentages for each flexible capacity category, the ISO analyzed the distributions of the largest three-hour net load ramps for the primary and secondary net load ramps to determine appropriate seasonal demarcations for the base flexibility category. The secondary net load 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 that is needed. Although this year's assessment focused on the data produced in this study process, the ISO also referred back to last year's[10] assessment to confirm that the patterns persist. The primary and secondary net load ramp distributions are shown for each month in Figures 4 and 5 respectively.

Figure 4: Distribution of Daily Primary 3-hour Net Load Ramps for 2019



[10] Last year's assessment refers to the 2018 Flexible Capacity Needs Assessment. The ISO has changed the naming convention to refer to the RA year, and not the year in which the study was conducted.

Figure 5: Distribution of Secondary 3-hour Net load Ramps for 2019



As Figure 4 shows, the distribution (*i.e*. the height of the distribution for each month) of the daily maximum three-hour net load ramps is slightly smaller during the summer months. The maximum three-hour net load ramps for May and September are slightly higher than seen in previous years. This is due in large part to these months being transitional months where some days are similar to summer days, while other days are similar to non-summer days. In other words, these months can exhibit a wide range of daily net-load profiles. Transitional months like May and September differ slightly from their seasonal counterparts, but not sufficiently to warrant changes to any seasonal treatment for those months. Further, the daily secondary three-hour net load ramps are also similar, except for May and September.[11] These distributions indicate two traits. First, given the magnitude of this distribution, it is unlikely that all base flexible capacity resources will be used for two ramps every day. The base flexibility resources were designed to address days with two separate significant 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. Second, because there are still numerous bimodal ramping days in the distribution, many of the base flexibility resources will still be needed to address bimodal ramping needs. Accordingly, the ISO must ensure there is sufficient base ramping for all days of

---

[11] The secondary net load ramp for May 20 was deleted due to the fact that it was clear outlier, at 9,279 MW.

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.

Figures 3-5 show that the seasonal divide established in last year's assessment remains reasonable. 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.

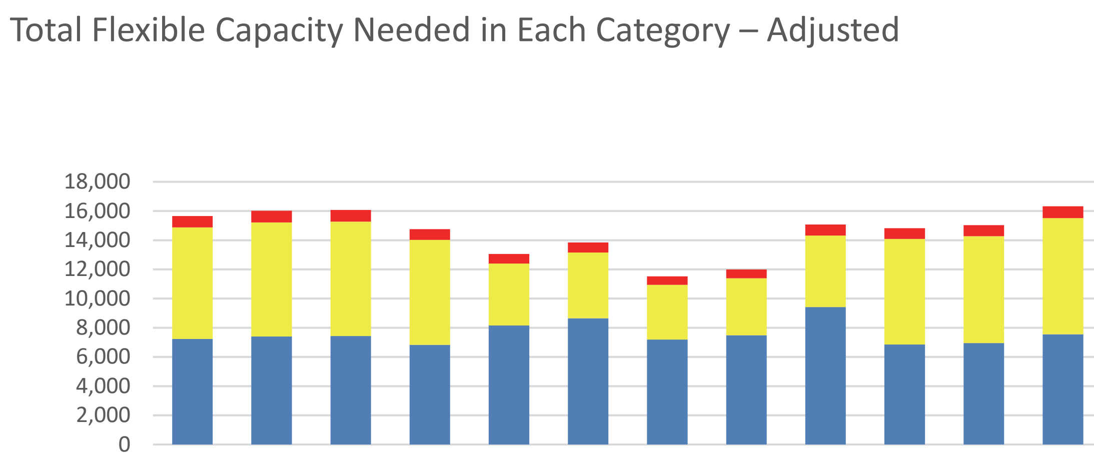
Second, adding flexible capacity procurement to the RA program will increase the process and information requirements. Maintaining a seasonal demarcation that is consistent with the current RA program will reduce the potential for errors in resource adequacy showings.

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 46 percent of the ISO system flexible capacity need for the non-summer months and 62 percent for the summer months. Peak flexible capacity resources could be used to fulfill up to 46 percent of non-summer flexibility needs and 62 percent of summer flexible capacity needs. The super-peak flexibility category is fixed at a maximum five percent across the year. These percentages are significantly different than those in the 2018 Flexible Capacity Needs Assessment. 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. The increase in grid connected solar and incremental behind-the-meter solar will reduce the secondary net load ramp in the non-summer months, but will increase the primary net load ramp, which reduces the percentage of base-ramping capacity in the non-summer months.

However, it would have the opposite effect in the summer months. The ISO's proposed system-wide flexible capacity categories are provided in Figure 6.

Figure 6: System-wide Flexible Capacity Need in Each Category for 2019



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	783	801	804	738	653	692	576	600	753	741	751	816
Peak Flexibility	7,634	7,809	7,839	7,197	4,249	4,505	3,750	3,904	4,905	7,229	7,327	7,962
Base Flexibility	7,234	7,401	7,428	6,820	8,150	8,641	7,192	7,487	9,408	6,851	6,943	7,545

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 3-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 3-hour net load changes x ISO total change in wind output during the largest 3-hour net load change

4) Δ Solar PV – LRA's average percent contribution to changes in solar PV output during the five greatest forecasted 3-hour net load changes x total change in solar PV output during the largest 3-hour net load change

5) Δ BTM Solar – LRA's average percent contribution to changes in BTM solar PV output during the five greatest forecasted 3-hour net load changes x total change in BTM solar output during the largest 3-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 – Δ BTM Solar + (3.5% * Expected Peak * Peak Load Ratio Share)

The ISO calculates the average contribution of Δ Load using the change of the proportion of load at the end of the ramp minus the proportion of load at the start of the ramp. The resulting calculations provided stable results.

$$\Delta L_{sc,2019} = L^{E}_{sc,2017}\left(\frac{L^{E}_{2019}}{L^{E}_{2017}}\right) - L^{S}_{sc,2017}\left(\frac{L^{S}_{2019}}{L^{S}_{2017}}\right),$$

where $L = Load$,

2017 has metered load, 2019 has forecasted load

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

Subscript sc is for each RALSE scheduling coordinator.

Therefore, when sum (Σ) it over all sc, we have

$$\Sigma\Delta L_{sc,2019} = \Delta L_{2019}$$

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.[12] 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 is examining ways to address this issue as part of the Flexible Resource Adequacy Criteria and Must Offer Obligation – Phase 2 stakeholder initiative.

The ISO has made available all non-confidential working papers and data that the ISO relied on for the Final Flexible Capacity Needs Assessment for 2019.[13] Specifically, the ISO has posted 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 name "2019 Flexible Capacity Needs Assessment – 2019 Net Load Data" at: http://www.caiso.com/informed/Pages/StakeholderProcesses/FlexibleCapacityNeedsAssessmentProcess.aspx

Table 2 shows the final calculations of the individual contributions of each of the inputs to the calculation of the maximum 3-hour continuous net load ramp at a system level.

Table 2: Contribution to Maximum 3-hour Continuous Net load Ramp for 2019

Month	Average of Load contribution 2019	Average of Solar contribution 2019	Average of BTM Inc contribution 2019	Average of Wind contribution 2019	Total percent 2019
January	32.67%	-59.39%	-6.08%	-1.86%	100%
February	42.28%	-48.61%	-6.58%	-2.53%	100%
March	35.82%	-60.34%	-5.37%	1.53%	100%
April	38.04%	-70.43%	-4.41%	12.88%	100%
May	23.41%	-66.81%	-5.97%	-3.82%	100%
June	20.34%	-59.89%	-2.83%	-16.94%	100%
July	18.57%	-75.70%	-8.43%	2.70%	100%
August	7.97%	-80.65%	-10.34%	-1.04%	100%
September	22.25%	-71.27%	-6.17%	-0.31%	100%
October	20.58%	-67.65%	-7.48%	-4.28%	100%
November	36.76%	-54.90%	-3.30%	-5.04%	100%
December	36.30%	-53.61%	-3.77%	-6.32%	100%

[12] Some small LRAs had negative contributions to the flexible capacity needs. The ISO is proposing to change this limitation as part of the Flexible Resource Adequacy Criteria and Offer Obligation – Phase 2 stakeholder initiative. However, this initiative is not yet complete, and thus the ISO cannot modify this rule.

[13] There were no revisions to the data posted for the draft report.

When looking at the contribution to the maximum 3-hour continuous net load ramp shown in Table 2, the above total percentage is calculated as Load – Solar – BTM Inc – Wind. When looking at August you get to 100% by following the below example.

Total Contribution is equal to: 7.97% – (-80.65%) – (-10.34%) – (-1.04%) = 100%

As Table 2 shows, Δ Load is not the largest contributor to the net load ramp during the summer months because the incremental solar PV mitigates morning net load ramps. This changed the timing of the largest net load ramps and changed the Δ Load impact on the net load ramps. However, the percentage contribution of load to the net load ramp is down in all months compared to last year's study. Again, this is attributable to the inclusion of the incremental behind-the-meter solar resources. The behind-the-meter 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, when the contribution of delta load is negative. This implies that load is less at the end of the net load ramp than it was at the beginning. This is caused by the timing of the largest three net load ramp in July and August. It typically occurs midday and when both load and solar are decreasing. Further, 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.

Consistent with the ISO's flexible capacity needs allocation methodology, the ISO used 2017 actual load data to determine each local regulatory authority's contribution to the Δ Load component. The ISO calculated minute-by-minute net load curves for 2017. Then, using the same methodology it used for determining the maximum 3-hour continuous net load ramp described above, the ISO calculated the maximum three-hour net load ramps for 2017 and applied the Δ load calculation methodology described above. The ISO used 5 minute granularity settlements data to determine the LRA's contribution the Δ load component.

Based on this methodology, the ISO determined the flexible capacity need attributable to the CPUC jurisdictional LSEs.[14 & 15] Next, the ISO multiplied the flexible capacity needs from Figure 2 and the contribution to each factor to determine the relative contribution of each component at a system level. The ISO then multiplied the resultant numbers by the Local Regulatory Authority's calculated contribution to each individual component. Finally, the ISO added the 3.5 percent expected peak load times the LRA's peak load ratio share. The resulting CPUC allocations are shown in Table 4 and Figure 7. The contributions are calculated by LRA

[14] Because the Energy Division proposal states that the CPUC will allocate flexible capacity requirements to its jurisdictional LSEs based on peak load ratio share, the ISO has not calculated the individual contribution of each LSE.

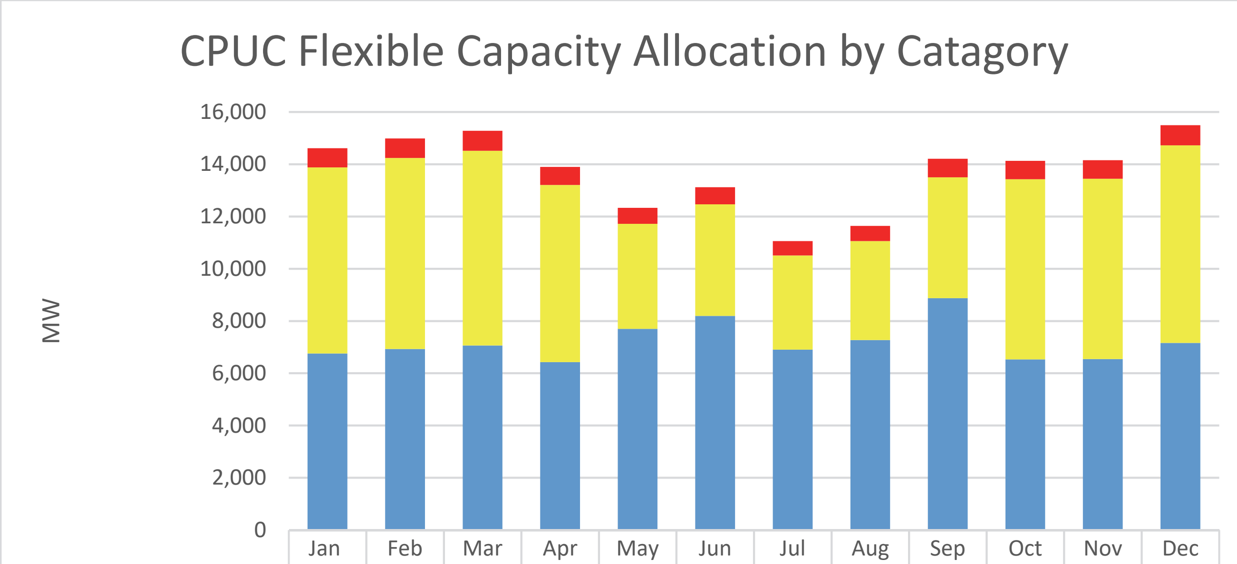
and LRA will only be provided the contribution of its jurisdictional LRA as per section 40.10.2.1 of the ISO tariff.

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

	Δ Load MW	Δ PV Fixed MW	Δ BTM Inc Solar MW	Δ Wind MW	3.5% expected peak load* Peak load ration share 2018	Total Allocation
Jan	4266	-8175	-873	-260	1034	14608
Feb	5765	-6875	-970	-364	1014	14987
Mar	5132	-8579	-795	221	994	15279
Apr	4827	-9036	-590	1680	1126	13898
May	2581	-7492	-697	-436	1124	12331
Jun	2406	-7125	-351	-2049	1188	13118
Jul	1916	-7167	-832	260	1401	11056
Aug	1065	-7962	-1063	-104	1443	11637
Sep	2791	-9147	-824	-41	1406	14209
Oct	2705	-8682	-1000	-559	1184	14131
Nov	4759	-7247	-454	-677	1015	14152
Dec	5206	-7720	-565	-923	1079	15493

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 7.

Figure 7: CPUC Flexible Capacity Need in Each Category for 2018



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	730	749	764	695	617	656	553	582	710	707	708	775
Peak Flexibility	7,125	7,310	7,453	6,779	4,015	4,271	3,599	3,789	4,626	6,893	6,903	7,557
Base Flexiblity	6,752	6,928	7,063	6,424	7,700	8,192	6,904	7,267	8,873	6,532	6,542	7,162

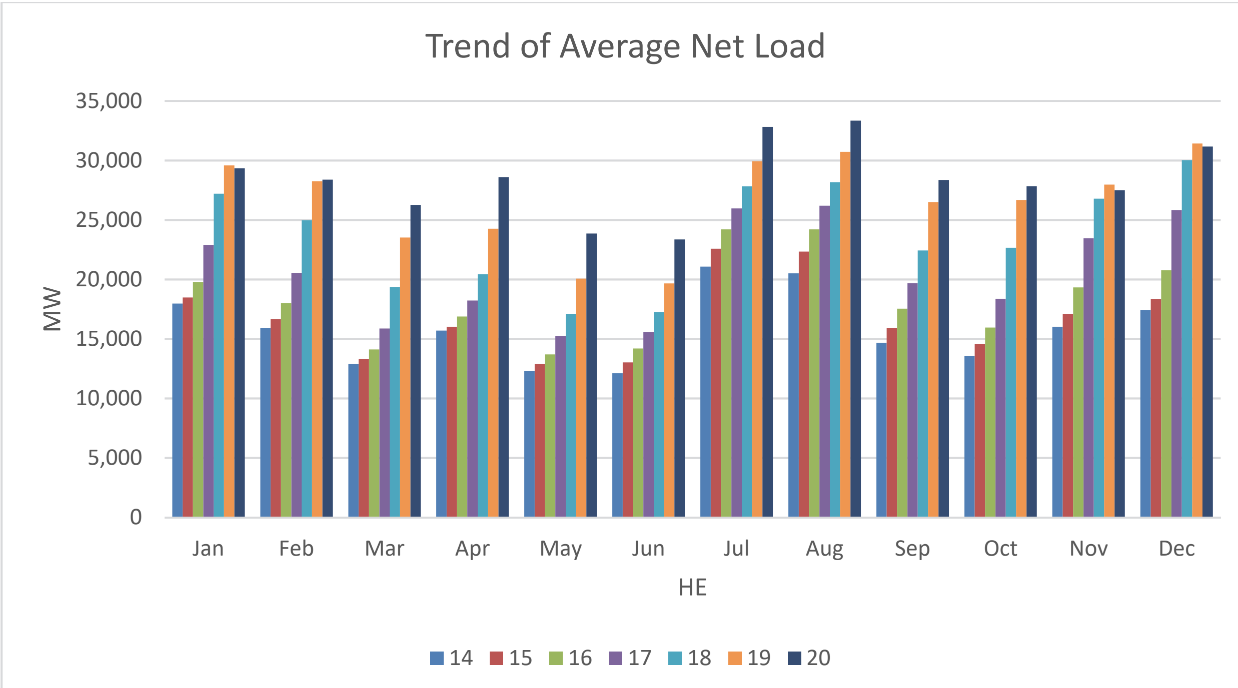
8. Determining the Seasonal Must-Offer Obligation Period

Under ISO tariff sections 40.10.3.3 and 40.10.3.4, the ISO establishes, by season, 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 be greatest benefit to the stability of ISO. The ISO analyzes the morning and afternoon ramps to ensure the must-offer obligation lines up with the calculated maximum three-hour net load movement. The selection of the five-hour period by season (Summer May-Sep; Winter Nov-Dec, Jan-Apr) has two major inputs: it should cover the hours with maximum three hour ramp and it occurs during the continuous net load ramp, which is typically correlated to the solar ramp down during sunset. These two major inputs can be seen graphically looking at Table 6 and Figure 8. Table 5 shows the hours in which the maximum monthly average net load ramp began, where Figure 8 shows the trend of average net load between HE 14-HE 20.

Table 5: 2019Forecasted Hour in Which Monthly Maximum 3-Hour Net load Ramp Began

	Frequency of All Three Hour Net Load Ramp Start Hour (Hour Beginning)							
Month	4:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
January				1	29	1		
February	2				19	7		
March					3	12	16	
April						8	22	
May						8	21	2
June						5	24	1
July			1	2		18	10	
August		1	5	1		22	2	
September			2	2	5	20	1	
October					23	8		
November				4	22	4		
December					31			

Figure 8: Trend of Average Net Load in 2019



In Figure 8, for the summer season of May through September, the net load continues to ramp up to HE 20, 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 20. For winter season, the net load flattens or slightly decreases starting HE 20 during the majority of the Winter Season months. The ISO continues to watch the behavior of the shoulder seasons (March through April, and September) as you can see some characteristics look similar to the current summer season patterns. For the winter season; the ISO believes overall that the appropriate flexible capacity must-offer obligation period for peak and super-peak flexible capacity categories is HE 14 through HE 19 for January through April and October through December. These hours are the same from those in Final Flexible Capacity Needs Assessment for 2018.

Table 9: Summary of MOO hours proposed by ISO for 2019

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HE14-HE19	v	v	v	v						v	v	v
HE15-HE20					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 14 through HE 19 for January through April and October through December; HE 15 through HE 20 for May through September. These hours are the same from those in Final Flexible Capacity Needs Assessment for 2018.

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 2020 in early 2019. 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.