California ISO

Flexible Resource Adequacy Criteria and Must Offer Obligation – Phase 2

Supplemental Issue Paper:

Expanding the Scope of the Initiative

November 8, 2016

Contents

1. Executive Summary

This Supplemental Issue Paper in the Flexible Resource Adequacy Criteria and Must-Offer Obligation – Phase 2 (FRACMOO2) stakeholder process focuses on an assessment of the flexible capacity showings to date, a review of the forecasted flexible capacity needs, and efforts to enhance the current flexible capacity product so it can meet the ISO's needs into the future. Based on the results of this assessment, the ISO outlines an initial set of issues that require further review. Once this review is completed, the ISO will propose any appropriate enhancements to the current flexible capacity product.

Although not explicitly discussed in this document, the enhancements to the flexible resource adequacy capacity product covered in the straw proposal[1] remain within the scope of this initiative. Specifically, the ISO will address in this initiative (1) imports and exports providing flexible capacity, (2) pumped hydro resources, and (3) allocation of negative flexible capacity obligations.[2]

This paper focuses on issues with the existing flexible capacity product that the ISO identified in its initial assessment of flexible RA capacity showings and forecasted ISO flexible capacity needs. The flexible capacity showings to date indicate that the flexible capacity product, as currently designed, is not sending the correct signal to ensure sufficient flexible capacity will be maintained long-term. The ISO is considering enhancements to the flexible capacity product that increase the overall availability and ramp rate of the flexible capacity fleet, while reducing the minimum operating level of flexible capacity resources. The ISO is also considering how it can review the flexible capacity resource adequacy (RA) showings to determine if the flexible capacity fleet will be able to meet the ISO's expected ramping needs. Specifically, the ISO has identified the following issues and potential enhancements that warrant further assessment:

a. Requiring that resources have a minimum weighted average ramp rate to be eligible to provide flexible capacity
b. Resource daily start requirements to qualify for category one flexible capacity (*i.e*. Base Flexible Capacity) will be based on a resource's full cycle time and additional limitations as identified through the data provided in the Commitment Cost Enhancement – Phase 3 initiative
c. Resources with a Pmin/Pmax ratio of greater than a predetermined level must have at least two starts per day to provide flex RA

[1] Available at http://www.caiso.com/Documents/StrawProposal-FlexibleResourceAdequacyCriteria-MustOfferObligationPhase2.pdf.
[2] The FRACMOO2 Straw Proposal also discussed treatment of small LSEs. However, these items were rescoped into the RSI2 initiative, which received ISO Board approval on October 27, 2016. Therefore, the ISO does not plan to revisit those issues in FRACMOO2.

d. Category three (*i.e*. Super-Peak Flexible Capacity) should be available seven days a week because many of the ISO's peak three-hour ramps occur on weekends
e. The ISO is considering the need to cap the quantity of long-start resources that can be shown as flexible capacity
f. The ISO is considering developing an assessment of the Flexible RA showings to assess how likely it will be that the flexible fleet is able to meet its ramping needs

This paper discusses the aforementioned elements and the empirical basis for each.

2. Stakeholder Comments and Changes to Proposal

The ISO received comments on the FRACMOO2 stakeholder process. Although the ISO does not discuss these comments in this issue paper, the ISO will address them and any comments in response to this supplemental issue paper in a revised straw proposal).

3. Plan for Stakeholder Engagement

The current schedule for this initiative is shown below.

Milestone	Date
Supplemental issue paper	November 9, 2016
Stakeholder meeting on supplemental issue paper	November 30, 2016
Comments due on supplemental issue paper	December 14, 2016
Revised straw proposal posted	February 2017
Draft final proposal posted	TBD
Board of Governors Meeting	TBD

A complete schedule of the entire process will be offered in a subsequent iteration and will attempt to facilitate collaboration with local regulatory authority processes.

4. Background

The ISO issued a straw proposal in this initiative in December 2015. The straw proposal focused on outstanding issues remaining from the initial FRACMOO stakeholder process, including (1) allowing intertie resources to provide flexible

capacity, (2) assessing the flexible capacity capability of storage resources such as pumped-storage hydro resources that do not align with the ISO's NGR market design, and (3) the allocation of negative flexible capacity contributions.

Based on stakeholder comments to the straw proposal, the availability of sufficient flexible RA showing data, and the need to enhance the overall flexible capacity product, the ISO expanded the original scope of this initiative to include potential enhancements to the current flexible capacity product. Specifically, in addition to the list of issues identified in the in the straw proposal, the ISO will consider potential enhancements to the existing flexible capacity product.

As such, below is a list of topics the ISO proposes to cover in the FRACMOO2 initiative:

1) Enhancements to the existing flexible capacity product
2) Imports and exports providing flexible capacity, including any modifications to the EFC calculation to incorporate flexible capacity
3) Flexible capacity from storage resources not using the NGR model
4) Allocating the negative contributions of flexible capacity requirements

Issues pertaining to items 2-4 have already been outlined in the ISO's initial issue straw proposal. As such, this paper will focus on enhancements to the existing flexible capacity product.

5. Discussion

5.1. Assessment of flexible capacity showings to date

The Initial FRACMOO tariff became effective starting with the 2015 RA showings. The ISO now has 24 months of flexible capacity showings from LSEs. In all months, the total flexible capacity provided in RA showings have met or exceeded the ISO's predetermined flexible capacity requirements. The ISO noted in the initial FRACMOO stakeholder initiative process that the flexible capacity product designed therein likely would not be sufficient to address all of the ISO's forecasted flexible capacity needs. Specifically, the ISO stated

> As more renewable resources come on line, not only will the net load curve look substantially different than it does today but so will the need for regulation and load following. Due to the intermittency of renewable resources the potential for inter-hour variations requiring load following and regulation will also increase. Addressing these needs will require more precise and forward looking capacity procurement that includes specific requirements for load following and regulation, in addition to the current need based on each day's maximum overall net-load ramp. For these reason, the ISO believes this must be an interim solution to

address the system's need for flexible capacity while a permanent and more holistic solution is designed.[3]

The ISO's forecasted net load ramps have increased at a pace greater than initially contemplated. This is attributable to the expansion of both grid and distribution connected variable energy resources. Further, the ISO has experienced more than expected intra-hour net load variability and predicts that this variability will continue to grow. The flexible capacity showings to date indicate that the flexible capacity product, as currently designed, is not sending the correct signal to ensure flexible capacity will be maintained long-term. The ISO has identified the following potential areas that require additional exploration in considering design enhancements to the existing flexible capacity product:

1) Insufficient ramping speed
2) Cycle time for determining daily start requirements for base flexible capacity requires additional clarity
3) High minimum operating levels from both RA and flexible RA
4) Most significant net load ramps occur on weekends or holiday weekdays
5) Significant quantities of long start resources may limit the ISO's ability to address real-time flexibility needs
6) There is currently no means in place for the ISO to assess the likelihood that the flexible RA showings will adequately meet all ramping needs

The ISO recognizes that several of these issues overlap, and the solution for one issue may alleviate or even eliminate another. However, at this time the ISO is simply identifying the issues with the current flexible capacity product. The remainder of this section provides an overview of these elements and the need for flexible capacity product enhancements to address them.

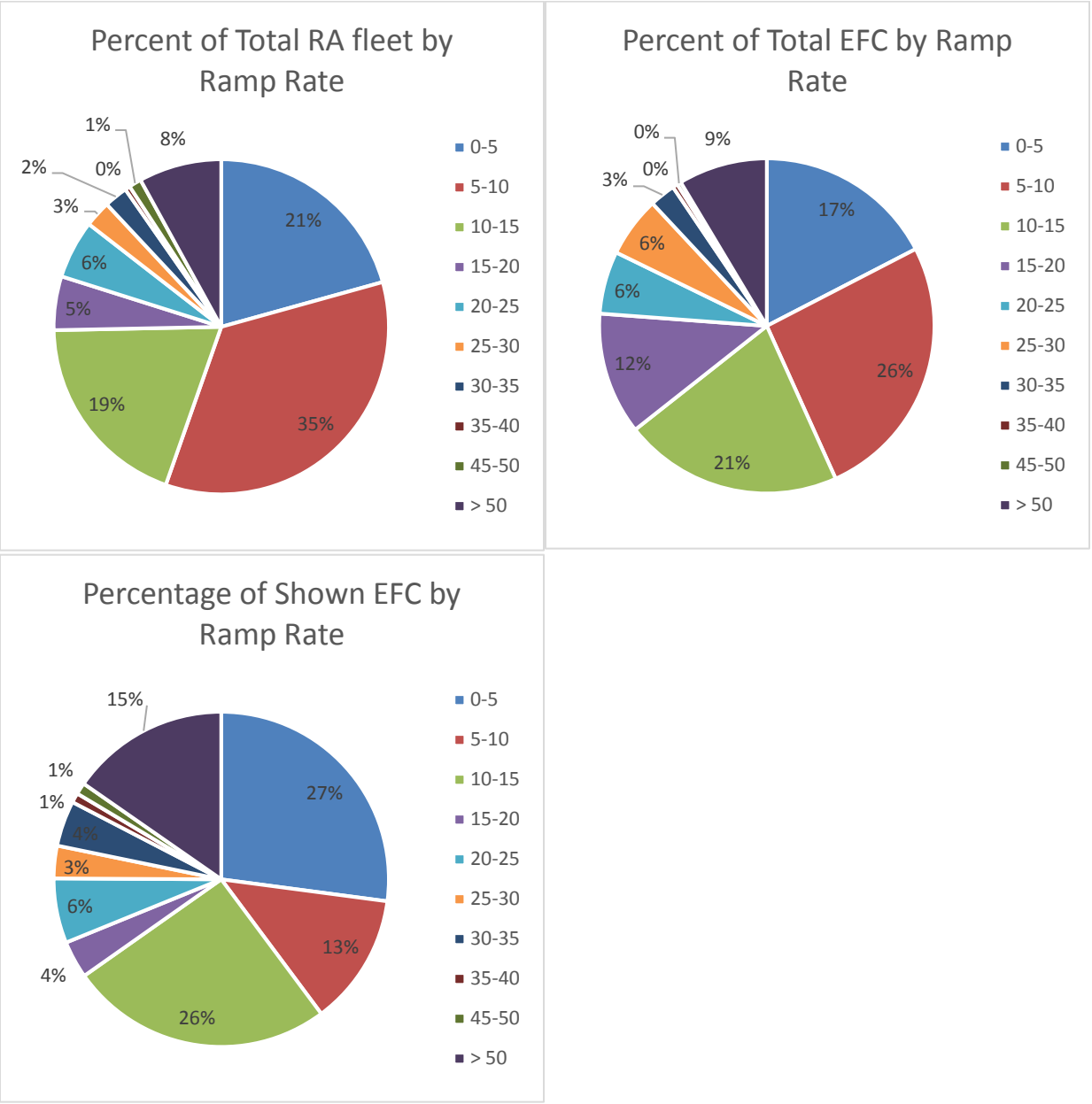
5.1.1. Insufficient ramping speed

To date, ramping capability for flexible capacity has been defined as the potential range a resource can ramp over three hours. Based on the ISO's analysis of flexible capacity showings, there is a growing need to ensure that faster ramping resources are procured and made available to the ISO. The EFC list for the 2016 RA year contained resources with weighted average ramp rates that range from 0.33 MW/minute to 150 MW/minute. Figure 1 provides a breakout of the flexible capacity fleet ramps relative to the overall EFC list and the RA fleet for March of 2016. As a percentage of the product shown, the flexible fleet is not very different the overall RA fleet in terms of the proportion of resources shown with a weighted average ramp rate of 10MW/minute or

[3] http://www.caiso.com/Documents/RevisedDraftFinalProposal-FlexibleRACriteriaMustOfferObligation-Clean.pdf

less than. Further, the ISO has identified that between 25 and 33 percent of total flexible RA showings come from once through cooling resources.

Figure 1: Weighted Average Ramp Rates of the RA, EFC, and Shown Flexible capacity resources



Although the existing flexible capacity product focuses on three hour net load ramps, one of the stated goals of the product was to address multiple flexible capacity needs, including hourly and sub-hourly ramping needs. Given the flexible RA showings to date, the ISO believes that additional limitations on weighted average ramp rate may be

needed for EFC eligibility to ensure sufficient ramping capacity moving forward. The ISO believes it is necessary to consider minimum ramp rate limitations to address:

- Large single hour net load ramps
- The transition from low net loads to steep ramps
- Intra-hour variability

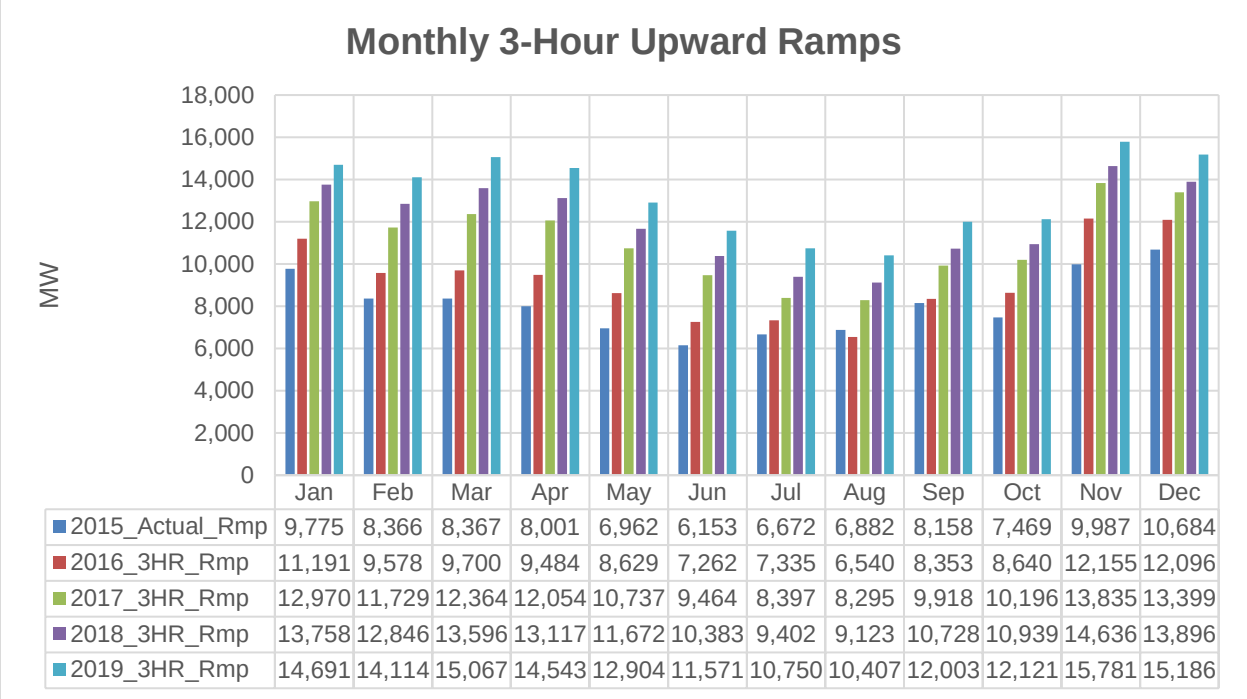
Large single hour ramps

The largest three hour net load ramp in 2015 was 10,684 MW. This was slightly larger than the forecasted largest 2015 net load ramp of 9,940 MW in the initial flexible capacity needs assessment.[4] As shown in Figure 2, by 2019 the largest three hour net load is currently forecasted to reach as much as 15,781 MW.[5] The largest single hour net load ramp for 2017 is estimated to be 5,937 MW. By 2019, this single hour net load ramp is estimated to increase to as much as 7,000 MW, with hourly ramps of greater than 6,000 MW in most non-summer months.

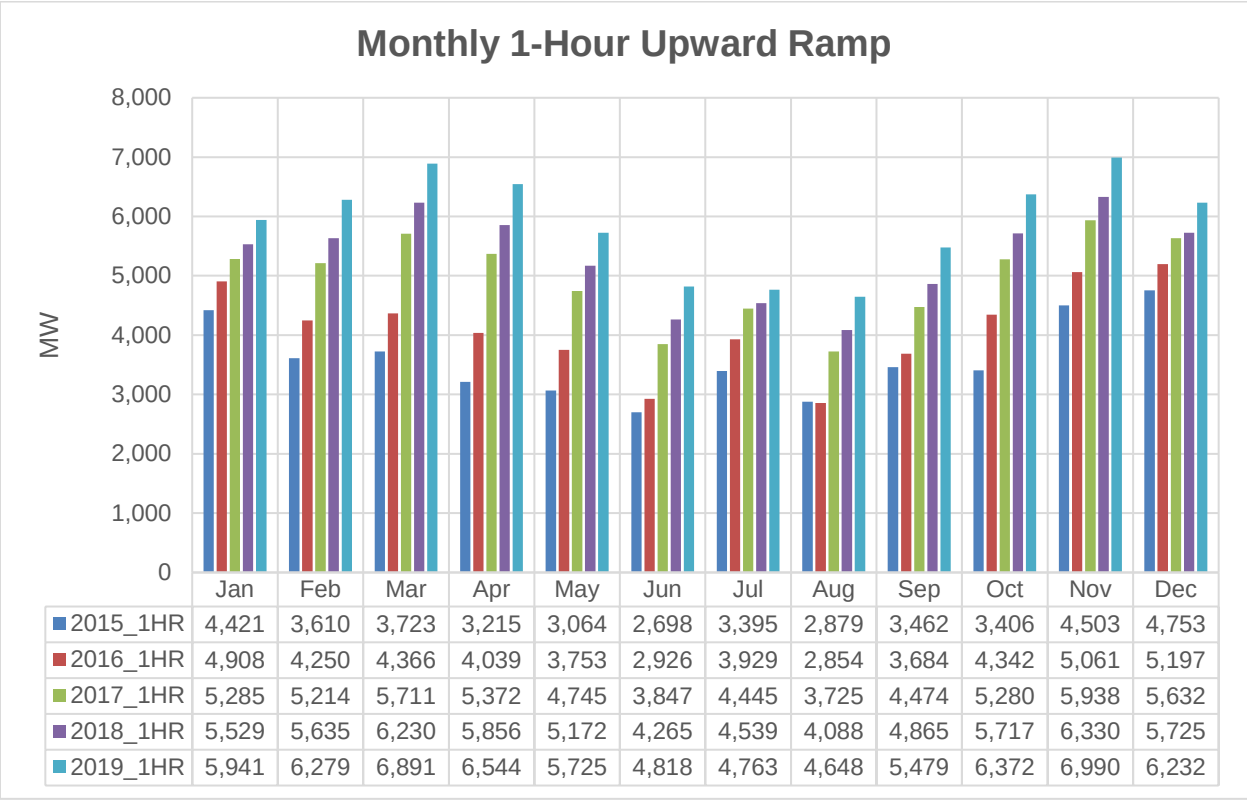
Although in theory combining more slow ramping resources would allow the ISO to ramp to meet these ramp needs, the ISO believes the operational and environmental implications must be considered before simply pursuing this status quo view of flexible capacity. To address hourly and multi-hourly ramps of the magnitudes identified above, the ISO would need to commit slow ramping resources well in advance of the net load ramps. These dispatches will result in either over-supply or frequent and voluminous wind and solar curtailment. The reliability aspect is further complicated by continued increase of non-dispatchable behind the meter resources. The best way to mitigate reliability risks and wide-spread renewable curtailment is to ensure the ISO can utilize resources that can ramp quickly.

[4] See http://www.caiso.com/Documents/Final_2014_FlexCapacityNeedsAssessment.pdf at p. 7
[5] The original duck chart forecasted a 13,000 MW net load ramp over three hours by 2020

Figure 2: Forecasted Maximum Three Hour and One Hour Net Load Ramps



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015_Actual_Rmp	9,775	8,366	8,367	8,001	6,962	6,153	6,672	6,882	8,158	7,469	9,987	10,684
2016_3HR_Rmp	11,191	9,578	9,700	9,484	8,629	7,262	7,335	6,540	8,353	8,640	12,155	12,096
2017_3HR_Rmp	12,970	11,729	12,364	12,054	10,737	9,464	8,397	8,295	9,918	10,196	13,835	13,399
2018_3HR_Rmp	13,758	12,846	13,596	13,117	11,672	10,383	9,402	9,123	10,728	10,939	14,636	13,896
2019_3HR_Rmp	14,691	14,114	15,067	14,543	12,904	11,571	10,750	10,407	12,003	12,121	15,781	15,186

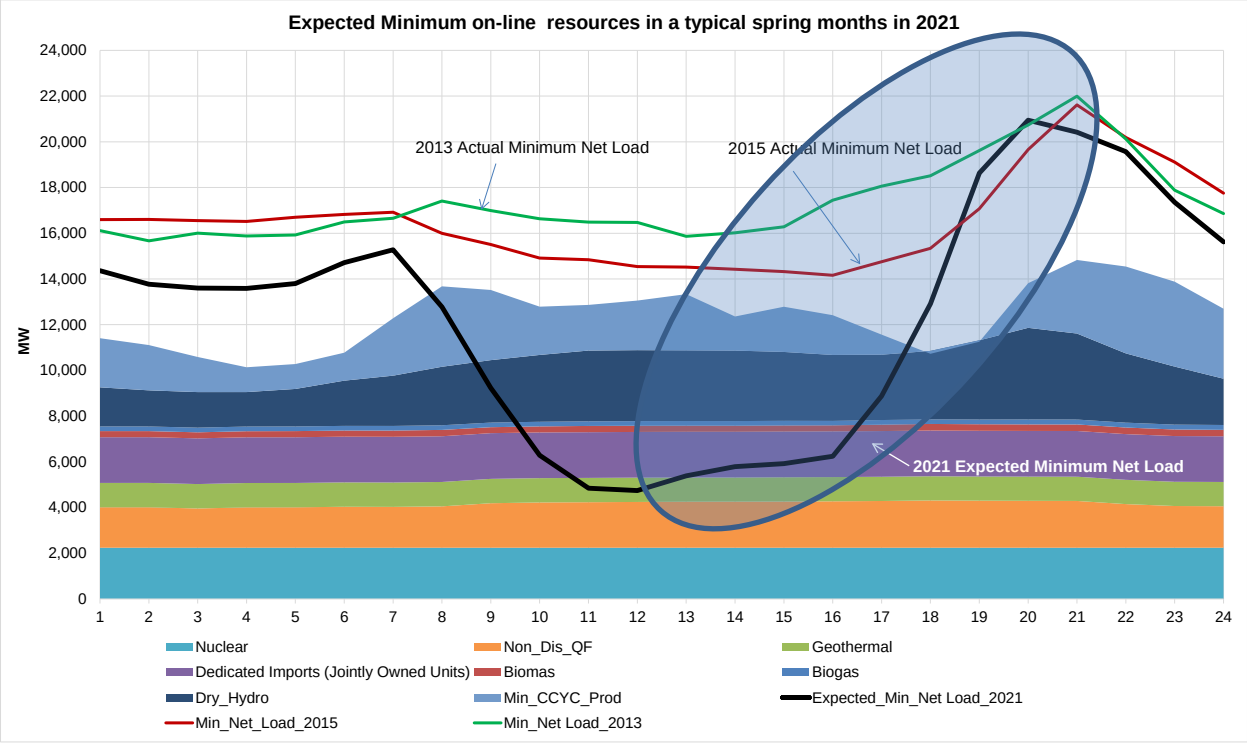


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015_1HR	4,421	3,610	3,723	3,215	3,064	2,698	3,395	2,879	3,462	3,406	4,503	4,753
2016_1HR	4,908	4,250	4,366	4,039	3,753	2,926	3,929	2,854	3,684	4,342	5,061	5,197
2017_1HR	5,285	5,214	5,711	5,372	4,745	3,847	4,445	3,725	4,474	5,280	5,938	5,632
2018_1HR	5,529	5,635	6,230	5,856	5,172	4,265	4,539	4,088	4,865	5,717	6,330	5,725
2019_1HR	5,941	6,279	6,891	6,544	5,725	4,818	4,763	4,648	5,479	6,372	6,990	6,232

The transition from low net loads to steep ramps

The ISO also requires fast ramping resources when it starts the net load ramp out of the belly of the duck. As shown in Figure 3, as the belly of the duck flattens and begins to turn upward, the ISO should expect to ramp quickly, even if it predicts the ramp perfectly (*i.e.* predicts both the time and ramp rate). The challenge of meeting this ramp is complicated by two factors: the need to commit resources; and forecast error. When the ISO is operating at low net loads, there may be limited amounts of dispatchable capacity available and online. Further, the resources that are online may not be fast ramping resources. Therefore, in addition to dispatching the online resources to meet the net load ramp, the ISO also must be able to commit fast starting and ramping resources. Additionally, if the forecast of when the ramp starts or the rate at which it increases is off, the ISO may have to ramp much quicker than originally expected as it "chases load" up the neck of the duck. As ISO tries to catch up with this ramp, it may use its regulation up or drop below acceptable CPS1 levels *(i.e.* lean on other BAAs for help maintaining system frequency).

Figure 3: Transitioning out of the Belly of the Duck



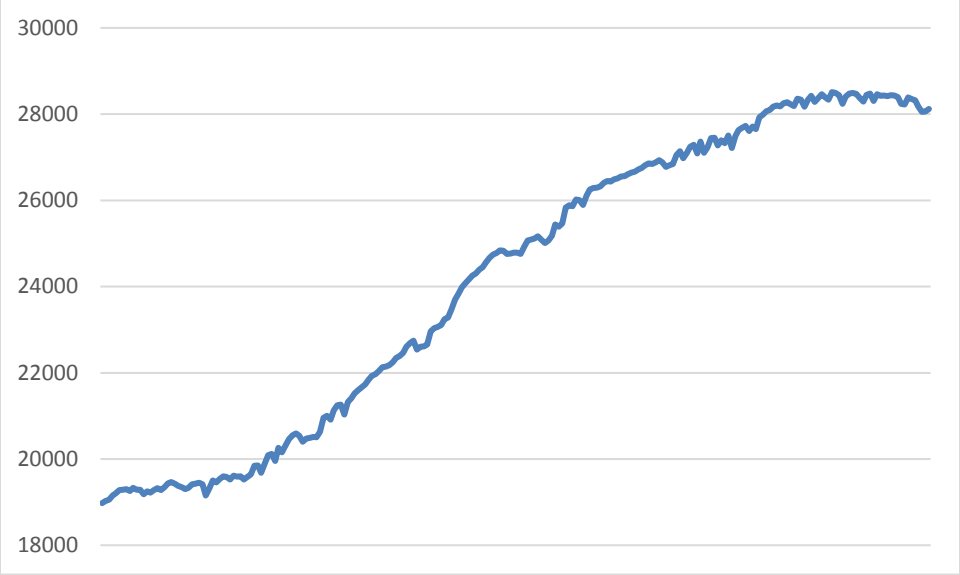
If the ISO is not able to commit resources quickly and ramp the resources sufficiently to follow load, then the system frequency will drop, the ISO will lean on adjacent BAAs,

and the CPS01 violations may result. The ISO seeks to ensure a portfolio of resources is available to mitigate the frequency and magnitude of instances of such violations.

Intra-hour variability

Just as the ISO has always contemplated the need to address steep hourly ramps with the existing flexible capacity product, it has also assumed that the existing product could meet short, intra-hour flexibility needs for some period of time. The ISO continues to review the forecasted intra-hour flexibility need. The ISO reviewed the minute-by-minute data produced in the 2017 Flexible Capacity Technical Needs Assessment to determine how much total variability, both upward and downward movement, occurs over three hour stretches. In all months, the maximum total variability exceeded 12,000 MW. The largest total variability over three hours occurred on a March afternoon and exceed 17,500 MW. This ramp and variability is shown in Figure 4.

Figure 4: Total Forecasted Variability Over a Three Hour Period



Further, the largest total variability did not always correspond to the same days and hours as the single largest three hour net load ramp. The ramp with the greatest variability was only 8,660 MW; however, on a separate day the ISO forecasted a March three hour net load ramp of greater than 12,300 MW. The fact that these dates do not overlap demonstrates that the ISO relied on the same flexible capacity to meet two very different ramps. Flexible capacity must be able to provide the up and down ramping capability to address frequent and rapid increases and decreases in net load.

5.1.2. Cycle time and other factors for determining daily start requirements for base flexible capacity requires additional clarity

Resource eligibility to provide different types of flexible capacity is the number of starts per month. Resources providing Category One Flexible Capacity must be able to start either once or twice per day based on the resource's operational attributes. The number of start required per month currently is a function of the number of times a resource can start in a given day. The number of starts required per day is based on the operational parameters of the resource. For example, the ISO currently requires resources with a minimum downtime of greater than 12 hours to have one start per day to provide base flexible capacity. This translates into requiring 30 starts per month to provide base flexible capacity.

Based on feedback from stakeholders, other policy enhancements, and a review of current practices, the ISO believes that additional clarity, more precise rules, and revisions to the existing calculations are needed regarding flexible capacity category eligibility. Since the inception of the flexible capacity product, two things have led the ISO to reexamine the calculations it currently uses to determine flexible capacity category eligibility. First, the ISO continues to receive questions about what this means and how the ISO makes this determination. Second, the ISO Board approved Commitment Cost Enhancements – Phase 3 proposal, which, if approved by FERC, will allow the ISO to calculate opportunity costs for resources based on monthly starts, run-hours, energy, or other limitations. The same information that the ISO uses to determine the opportunity costs for resources might also be utilized to determine resource eligibility for flexible capacity categories. Therefore, the ISO will review the applicability of using the full cycle time for resources (*i.e.* minimum down time, start time, and shut-down time) as a more appropriate measurement for this daily start requirements. Additionally, the ISO will assess if it could use resources' submitted monthly limitations for flexible capacity category eligibility. As such, the ISO will look to clarify the rules for determining daily start requirements and flexible capacity category eligibility.

5.1.3. High minimum operating levels from both RA and flexible RA

The ISO is attempting to integrate larger amounts of wind and solar resources, as well as non-dispatchable behind the meter resources. In order to meet ramps, the ISO must be able to commit sufficient resources and access needed flexible capacity. Relying on resources with high minimum operating levels or PMins can cause the ISO to dispatch large quantities of inflexible capacity to meet upcoming ramping needs. At times of low net load, as shown in Figure 3, above, this can result in over-supply and significant

quantities decremental dispatches to wind or solar resources. As such, it may be prudent to consider the PMin to PMax ratios of resources, in addition to the other operational attributes, in determining if a resource is eligible to provide flexible capacity. For example, some flexible capacity require the ISO to commit hundreds of MW to access less than a hundred MW of flexible capacity. The Flexible RA showings for March of 2016 had a cumulative PMin burden of over 3,200 MW. The overall RA fleet had a PMin burden of 9,600 MW. The flexible capacity fleet with the lowest PMin burden that would have met the flexible capacity requirements could have been as low as 1,325 MW depending on use-limitations and category qualifications.

In isolation, a high PMin to PMax ratio may not be problematic. For example, many peaking resources have a high PMin to PMax Ratio, but they also can start and stop frequently and ramp quickly. This means that the ISO can commit and decommit the resource as needed and need not commit significant amounts inflexible capacity to access the flexible capacity range. Therefore, as noted above, any assessment of the PMin to PMax ratio would also have to include considerations for daily starts and minimum run times.

5.1.4. Most significant net load ramps occur on weekends and holiday weekdays

Category Three flexible capacity is currently required to be available during all non-holiday weekdays for at least five starts per month. However, several of the ISO's largest net load ramps occurred on either holidays or weekends. For example, the largest ramp (10,675 MW) in December 2015 occurred on Saturday December 26. Further, as noted the Department of Market Monitoring's 2015 Annual report "[i]n eight months of the year, the maximum net load ramp occurred on a holiday or weekend when Category 3 capacity does not have a must-offer obligation."[6]

Net load ramps are greatest on weekends because evening peaks during non-summer months tend to be fairly stable regardless of day of the week because they are driven by residential load. However, typically mid-day loads are higher during the week because of commercial and industrial load. This means that the same wind and solar output will drive net load lower on weekend than it will on weekdays. Because mid-day net load is lower on weekends, but evening peaks are similar, the net load ramps are likely greater on weekends.

Because Category Three Flexible Capacity was not required to be available during many of the ISO largest ramps, the ISO is considering removing the provision that allows Category Three Flexible Capacity to only be available during all non-holiday

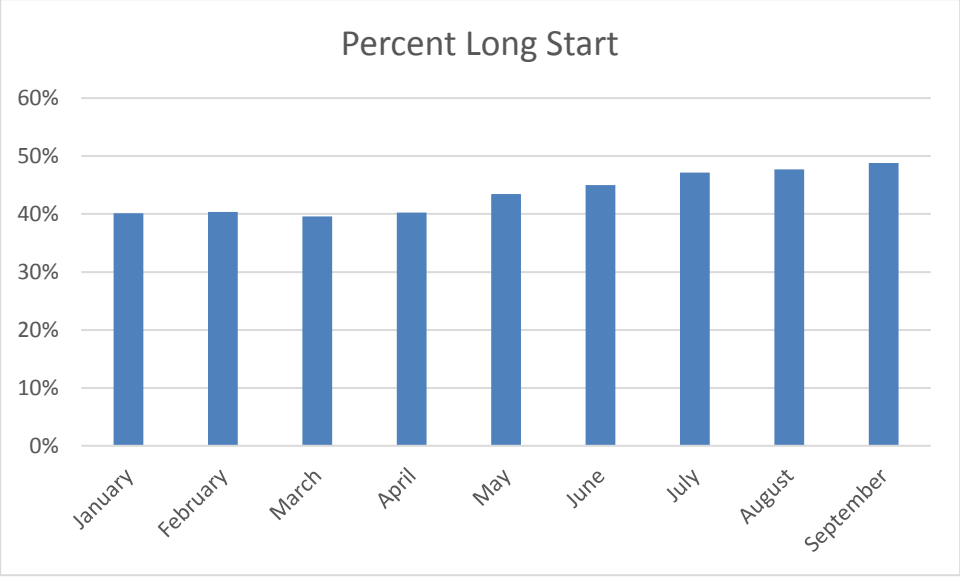
[6] http://www.caiso.com/Documents/May12_2016_2015AnnualReport_MarketIssues_Performance_ZZ16-4.pdf at p. 213.

weekdays. Instead, the ISO will consider changing Category Three Flexible Capacity to seven days a week, similar to Categories One and Two Flexible Capacity. However, the ISO believes the five starts per month for Category Three Flexible Capacity remains adequate.

5.1.5. Significant quantities of long start resources that may limit the ISO's ability to address real-time flexibility needs

The flexible capacity product was originally designed to address both somewhat predictable ramps and uncertainty, particularly in the real-time market. As shown in Figure 5, typically 40 percent or more of the fleet shown on flexible RA showings are long start resources. Upon looking closer at these resources, the ISO determined that approximately 30 percent of flexible RA MWs come from once through cooling resources.

Figure 5: Percent of Flexible Capacity Showings that are Long Start Resources



Long start resources are only available to meet real-time flexible capacity needs if they receive day-ahead commitments. If long-start resources do not receive a day ahead commitment, then they are deemed to have met their must-offer obligation and are not required to re-bid into the real-time market. The ISO reviewed the frequency with which long start flexible capacity resources received day-ahead commitments in March 2016. The ISO's results show that there were 31 long-start resources shown as flexible capacity, accounting for 5,100 MW of flexible capacity. These 31 resources received a combined 244 day-ahead commitments. This is a commitment rate of 25

percent.[7] However, 17 of these resources, totaling 3,444 MW of flexible capacity, accounted for only 29 combined day-ahead commitments. This is a commitment rate of 5.5 percent. In short, the ISO assessment shows that roughly 40 percent of the flexible capacity resources are unlikely to be available to address real-time flexibility needs because they did not receive a day-ahead commitment.

Based on this review, the ISO is concerned that excessive long-start resources on flexible RA showings may limit the effectiveness of the flexible RA fleet's ability to address the ISO's real-time flexible capacity needs. It is prudent to determine if there is a need to limit the quantity of long-start resources that can be provided in flexible RA showing.

5.1.6. There is no means for the ISO to assess the likelihood that the flexible RA showings will adequately be able to meet all ramping needs

Currently, there is no means for the ISO to assess the effectiveness of the shown flexible RA fleet at meeting the identified flexible capacity. The ISO assesses the adequacy of flexible RA showings by assessing the quantity of EFC MWs shown on flexible RA showings and compares it to the Flexible RA Requirement. If the quantity shown exceeds the quantity required, then the ISO determines that the flexible RA requirement has been met and proceeds to the operational month. However, based on all of the issues identified above, the ISO is exploring tools that it can use to assess the effectiveness of the flexible capacity showings.

This concept is not new to the flexible RA discussion. For example, SCE has put forth a conceptual plan for assessing whether the shown flexible RA resources can address various ramping needs.[8] Further, the ISO has similar authority to test the effectiveness of local RA showings. This authority grants the ISO broad authority and discretion to conduct a variety tests to determine how effective the local RA showings are at ensuring the ISO is able maintain local reliability. Therefore, the ISO will explore the potential costs and benefits of a variety of means to assess the adequacy of flexible capacity showings.

[7] The commitment rate found by dividing the total commitments by the total possible number of commitments. In this case, the total number of possible commitments is 961 (31 resources times 31days)
[8] http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442451586 .

6. Next Steps

The ISO will discuss this straw proposal with stakeholders during a call on November 30, 2016. The ISO requests that stakeholders submit written comments on the straw proposal by December 14, 2016 to initiativecomments@caiso.com. The ISO will provide a comments template by December 2, 2016.