CRR Market Analysis Report

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Content

1 Executive Summary

This report summarizes the California ISO's analysis of the performance of its Congestion Revenue Rights (CRRs) processes in light of three sets of market rule changes adopted on January 1, 2019. The rule changes were adopted to address concerns identified in the CAISO's earlier analysis of its CRR processes and include the:

1. elimination of non-delivery paths for bidding in CRR auctions;
2. reduction of transmission capacity released in the annual process from 75 percent to 65 percent; and
3. pro-rata adjustments of CRR's settlement based on their contribution to revenue deficiency.

The CAISO also enhanced its CRR auction software so that participants could directly sell their CRRs because they no longer could purchase counter-flow CRRs to dispose of previously acquired CRRs. The analysis assessed all of these changes as a whole because their impacts cannot be evaluated individually, as they took effect concurrently.

This report shows that the policy changes had reduced the differences between auction revenues and payments to CRRs procured in the CRR auction, increasing the auction efficiency to 87 percent. Load serving entities (LSEs) are increasingly relying on the CRR auctions to balance their CRR portfolios, but have undervalued their CRRs in the auction as compared to their day-ahead market congestion revenues. Furthermore, the pro-rata funding has effectively eliminated the CRR deficits but the overall CRR value has reduced by 29 percent.

This assessment is part of the CAISO's commitment to evaluate the effectiveness of the policy changes implemented in 2019 once a year worth of data is available. This assessment helps inform the CAISO and stakeholders regarding areas for potential additional improvements to further enhance the performance of the CRR processes. It also provides valuable information about other drivers impacting the efficiency of the CRR processes not related to the auction design.

CRR Auction results show a change in patterns

CRR auction participation measured by bid-in volumes decreased by up to 50 percent in most of the auctions. Consequently, CRRs cleared in the auctions reduced by up to 57 percent when compared to previous years, with about 78 percent of that reduction occurring in the low-priced CRR group. The volume of zero-priced CRRs have also decreased significantly from an average of 2,600 MW to 100 MW.

Net auction revenues decreased to $63 million in 2019 from an average of $83 million in 2018 and 2017. This modest reduction in net auction revenues is in contrast to the large reduction of cleared bids in the auction. Approximately 62 percent of the overall auction revenues were collected in monthly auctions.

In contrast, auction revenues from the sale of allocated CRRs increased significantly from an average of $31 million in 2017 and 2018, to $51 million in 2019. Approximately 63 percent of these negative auction revenues were payments to load serving entities (LSEs) selling their allocated CRRs. Negative auction revenues from the sale of auctioned CRRs decreased from an average of $11.9 million 2017 and 2018, to $7.8 million in 2019.

For 2017 and 2018, an average of about 2,500 MW of allocated CRRs were sold into auctions. In 2019, that amount increased by about 40 percent (or 1,000 MW) to approximately 3,500 MW, and out of all the allocated CRRs sold in auctions in 2019 and 2020, about 70 percent were sold in the monthly auctions.

The increasing volume of sales of allocated CRRs into the auctions by LSEs over the three-year study period indicates an increased reliance on the auction by LSEs to rebalance their CRR portfolio. This reflects the value LSEs place on the CRR auctions as a tool to manage their congestion exposure and risk. Over 90 percent of the allocated CRRs being sold in CRR auctions are from non investor-owned utilities.

CRR auction efficiency improved with the policy changes implemented in 2019

The overall auction efficiency, as measured by the difference between the revenue collected for a CRR in the auction, versus what that CRR was paid through congestion revenue collected in the day-ahead market, improved from an average of 47 percent in 2017 and 2018, to an average of 87 percent in 2019 and 80 percent in Q1 2020. In absolute terms, the CRR auction shortfall was $14.2 million and $6.7 million in 2019 and Q1 2020, respectively. This is noticeably smaller than the auction shortfalls of $114 million and $139 million in 2017 and 2018, respectively. This shows moderate improvement in the auction efficiency after the implementation of the policy changes.

The policy changes required a modification to the *CRR auction shortfall* metric (used interchangeably as auction efficiency in this report) developed during the policy development process preceding the market rule changes implemented on January 1, 2019. The original *CRR auction shortfall* compared the net CRR auction revenues to payments for those CRRs later yielded from revenues from the day-ahead market for CRRs released through auctions. That metric accounted for the efficiency related to the purchase of CRRs, the undervaluation or sales at a discount of selling allocated CRRs and arbitrage between auctions (which is when a CRR is purchased in the annual auction and sold or liquidated in the monthly auction). The sale feature eliminates the need to take counter-flow positions to sell CRRs in the auction and such CRRs are no longer settled as separate CRRs. The pro-rata reduction of CRR funding impacts the notional value of all CRRs, including the sold CRRs, based on their contribution to deficits. These two factors no longer allow to estimate the auction efficiency with the previous metric. Thus, the revised auction efficiency metric is limited to consider (1) the purchase of CRRs; and (2) the arbitrage between auctions.

For 2017 and 2018, LSEs undervalued or sold CRRs at a discount in the auction by about $13.8 and $17 million, respectively. This represents a loss for LSEs, because if they had retained those CRRs they would have obtained day-ahead market congestion payments for more than they sold the CRRs for in the auction. This is not caused by an auction inefficiency, but rather it is driven by the LSE's price offered to sell CRRs in the auction. Such undervaluation or sales at a discount would have still existed and possibly would have been greater if participants had sold previously acquired CRRs in bilateral markets in the absence of a CAISO auction.

The volume of arbitrage between CRRs in the annual auction sold in the monthly auctions decreased by 56 percent, from an average of 4,000 MW to an average of 1,735 MW. This may be related to the elimination of non-delivery paths that are no longer biddable, reducing arbitrage opportunities between auctions. In 2017 and 2018, arbitrage between the annual auction and monthly auctions was on average 29 percent. This means CRR holders paid on average 29 cents to buy CRRs in the annual auction and subsequently were paid $1 when selling these CRRs in the monthly auction. This amounted to

approximately $17.1 million in sales related to arbitrage. This same metric was about 27 percent for 2019 and the first quarter of 2020, with an arbitrage of about $7.8 million.

CRR Revenue Adequacy has eliminated the deficits allocated to measured demand

The implementation of the CRR pro-rata adjustment rules shifts the consequences of revenue inadequacies (deficiencies in day-ahead congestion revenues to fund-awarded CRRs) from load serving entities to the CRR holders. For the period of 2019 and Q1 2020, the CRR face value (notional value based on awarded amounts) was adjusted down by about $146.1 million. Although the primary objective of pro-rata funding was revenue adequacy, the CRR deficit allocation has also improved the CRR auction efficiency. The pro-rata funding alone reduced the payments to auctioned CRRs by about $44.2 million and $26 million in 2019 and Q1 2020, respectively.

The source of congestion revenue inadequacies or the pro-rata adjustment were investigated. The pro-rata adjustment policy also highlights the impact on revenue adequacy of the use of a shift factor threshold to evaluate the effectiveness of energy bids to manage congestion in the clearing of the day-ahead market. The CRR processes do not use the same shift factor threshold. The CRR deficits are driven in part by the differences in practice regarding the use of threshold between the two markets. The use of shift factor threshold in clearing the day-ahead market may also result on a settlement reversal on certain constraints or CRR portfolios. Also, the use of shift factor threshold can result in less congestion rents collected in the day-ahead market. The CAISO is considering enhancement on how to apply the shift factor effectiveness threshold in the energy market.

Overall, during the first 15 months of operation, the pro-rata funding has reduced the CRR notional value by 29 percent. With the pro-rata funding, CRR deficits are allocated to each CRR based on their net portfolio effect on a given constraint. This has resulted in the same CRR having a wide range of different valuations. This may further complicate the LSEs' ability to accurately value the CRRs they need to trade and highlights the importance of studies such as this to understand the dynamics now at play.

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4 Acronyms

AC	Alternating current
CAISO	California Independent System Operator
CRR	Congestion revenue right
CLAP	Custom load aggregation point
DAM	Day ahead market
DLAP	Default load aggregated point
DC	Direct current
FNM	Full network model
IFM	Integrated forward market
IOU	Investor-owned utility
ISO	Independent System Operator
LMP	Locational marginal pricing
LSE	Load serving entity
MCC	Marginal congestion component
OMS	Outage management system
PGAE	Pacific Gas and Electric
PTO	Participating transmission owner
RTM	Real-time market
SDGE	San Diego Gas and Electric
SCE	Southern California Edison
TH	Trading hub
TOU	Time of use

5 Introduction

The design of the CAISO nodal market includes a market for congestion revenue rights (CRRs). This market is composed of both allocation and auction processes as vehicles to release CRRs. Only load serving entities (LSEs) can nominate and have CRRs allocated in the allocation processes, while the auctions are open to any participant that has met the credit requirements.

In 2017, the CAISO launched a stakeholder process to address concerns regarding the overall CRR auction efficiency. This effort started with an analysis phase to identify the areas for improvement; this was followed by a formal policy initiative that culminated in three main market design changes[1]. These changes took effect on January 1, 2019.

The first policy change was targeted at improving the CRR auction efficiency and consisted of the elimination of non-delivery paths. Prior to this change, any combination between sources and sinks was allowed for bidding in the auction. With this change, only a subset of these source-to-sink combinations are allowed. The allowable paths follow the natural direction for delivery of power, meaning it goes from a supply source to a load sink.

The second policy change was targeted at improving CRR revenue adequacy. Prior to this change, the CAISO market guarantee full funding for CRRs. This resulted in paying CRRs its full (notional) value based on the day-ahead congestion prices, regardless if the CAISO collected sufficient rents form the day-ahead market. When the CAISO collected less or more rents in the day-ahead than the money required to pay all CRRs, a condition referred as *CRR revenue inadequacy*, the imbalance was allocated to measured demand (*i.e.*, metered demand and exports). This was changed to have a mechanism for partial funding, which pays CRRs their value only up to the amount of congestion rents collected in the day-ahead market. The affected CRRs are pro-rate based on the contributions the CRRs has on the deficits on a constraint=by-constraint basis.

The third change was to reduce the amount of transmission capacity released in the annual process from 75 percent to 65 percent. The intent was to minimize the risk of releasing too much capacity too far in advance that becomes unavailable in the day-ahead market when outages or configurations changes happen.

This report summarizes the CAISO's analysis of the first 15 months of performance with these policy changes implemented.

[1] The Policy initiative material can be found at http://www.caiso.com/StakeholderProcesses/Congestion-revenue-rights-auction-efficiency.

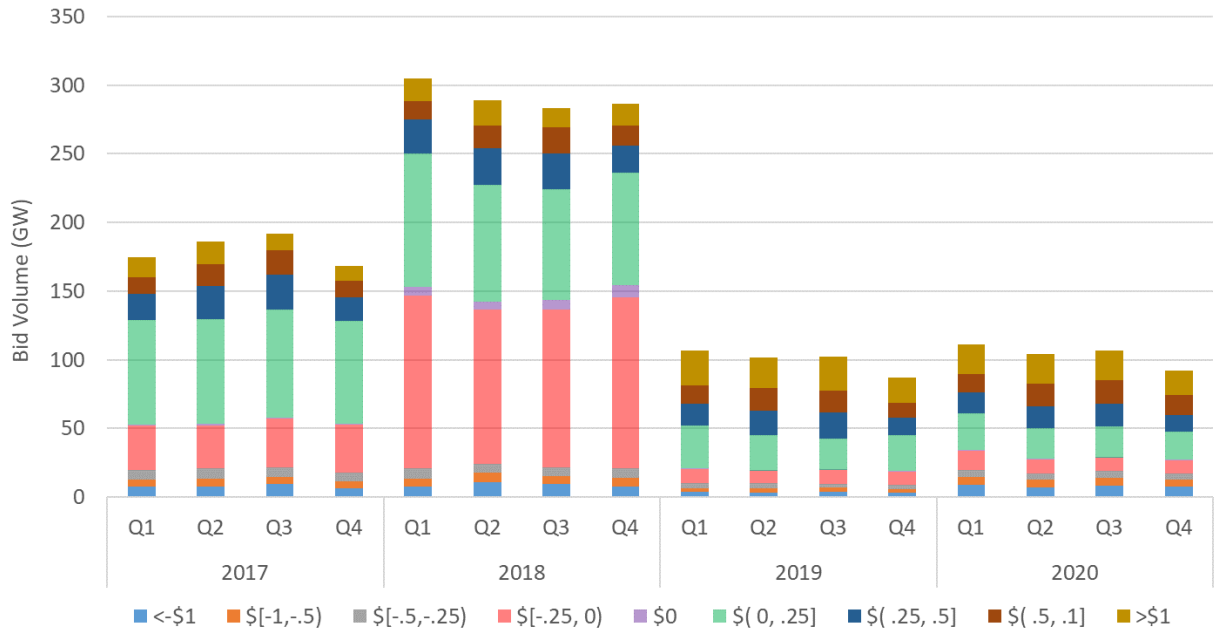
6 CRR Auctions

All three policy changes will impact the CRR auction in different ways and to different degrees. It is not possible to isolate the effect of each of the changes. Generally, the elimination of non-delivery points is going to impact the auction participation since now less path definitions are available. This consequently will lead to different auction outcomes. The pro-rata funding can also influence the auction participation since it may introduce more risk of funding the CRRs procured in the auction and thus the CRR valuation as reflected through CRR bids can be impacted. The reduction of transmission capacity in the annual process may also influence the level of participation between the annual and monthly auctions. The following subsections highlight the performance trends of different areas of the auction performance.

6.1 Auction bids

With respect to 2018 and 2017, volume of CRRs bids submitted in the auctions has reduced by about 40 percent and 50 percent in the annual and monthly auctions, respectively. This is a natural consequence of having less paths available for bidding in the auctions, and the potential additional risk of introducing the pro-rata funding[2]. The annual and monthly trends by bid price level are shown in Figure 1 and Figure 2. They only show the On-peak as a representative sample.

Figure 1: Volume of CRRs bids in annual auctions for On Peak hours

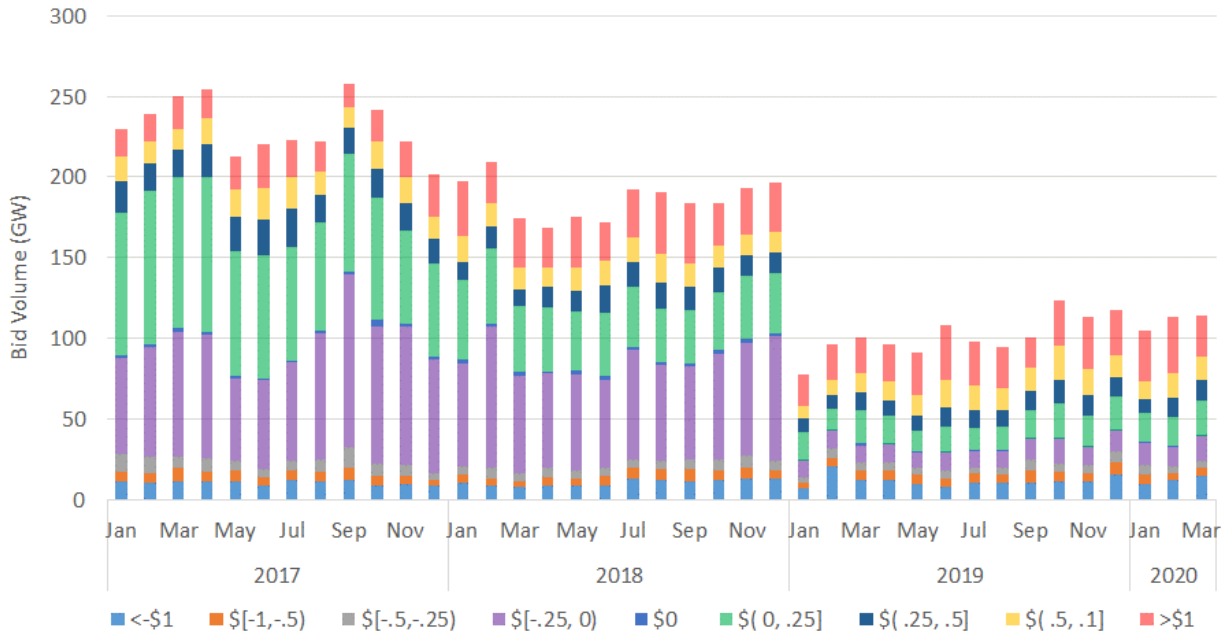


The higher volume of bids submitted in the annual auction for 2018 calendar year was atypical and may have been driven by the uncertainty at that time due to potential CRR policy changes that could eliminate

[2] In the 2017 CRR performance analysis, it was found that the majority of the bids submitted and cleared in the auctions belonged to non-delivery paths. Thus, once these paths are no longer available, it is expected the volume of bids in the auctions will reduce.

the CRR auction. For both trends, the most significant reduction of bids occurred in the low-price range between -$0.25/MWh and +0.25/MWh.

Figure 2: Volume of CRRs bids in monthly auctions for On Peak hours

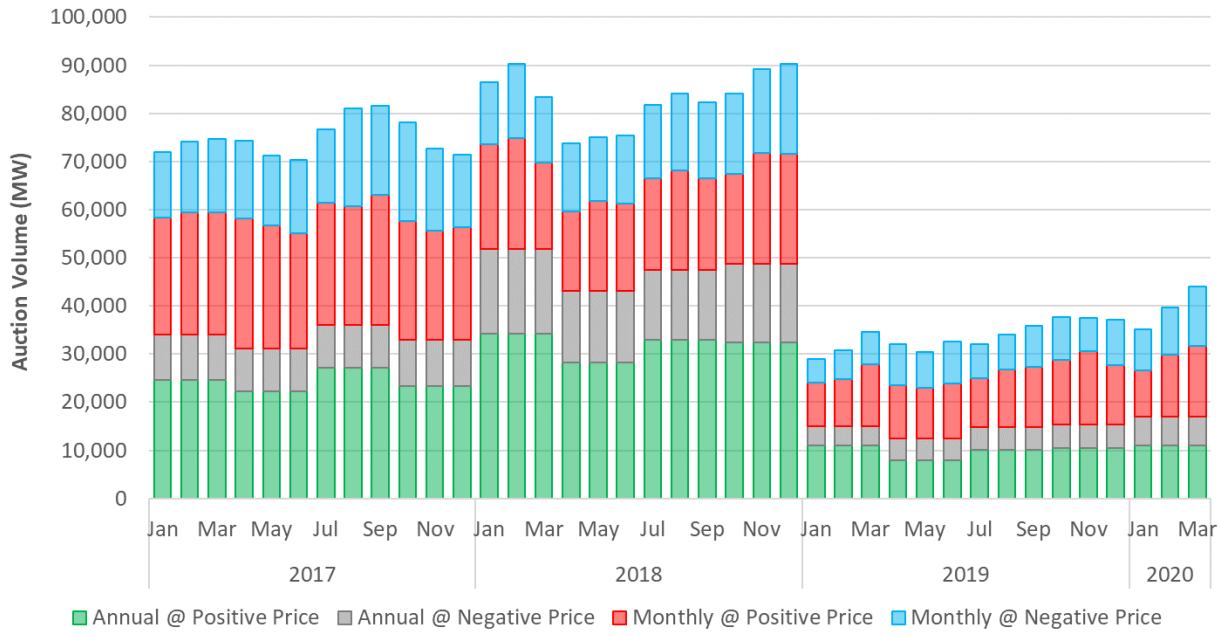


6.2 Volume of bids cleared in auctions

Cleared volumes in 2019 auctions have shown a fair reduction of about 57 percent as compared to the volumes cleared in 2017 and 2018. This volume trend is shown in Figure 3. This was pronounced in the annual auction with about 64 percent reduction of volume in 2019 and 58 percent in 2020. The reduction in volume is expected since many non-delivery paths are no longer available to bid. The volume cleared under the new policies account for both CRR bids for delivery paths and CRRs being sold explicitly in the auctions.

Prior to the implementation of the new policies, counter-flow CRRs could result from bidding based on two different purposes. The first purpose was for CRR holders to sell existing CRRs given that the CAISO did not have an explicit sell-type feature in the CAISO auctions at the time. Therefore, the only way to achieve this sale was to buy a counter-flow to the existing CRR. With the policies implemented in 2019, participants now can sell their CRRs through an actual sell feature in the CRR auctions. The second purpose is for CRR participants that actually want to take on counter-flow positions, which could be done by bidding for CRRs for non-delivery paths (i.e., a CRR from sink to source). These non-delivery paths are no longer available for bidding in the CRR auctions with the implementation of the policy change that took effect for the settlement of CRRs as of January 1, 2019.

Figure 3: Volume of CRRs released in auctions organized by price direction



By eliminating non-delivery paths, the CAISO expected to confine bidding to delivery paths, creating more competition, and thus bringing prices closer to the expected day-ahead congestion which in turn could improve auction efficiency.

Figure 4: Volume of seasonal CRR auctioned by price (in $/MWh) for On-Peak

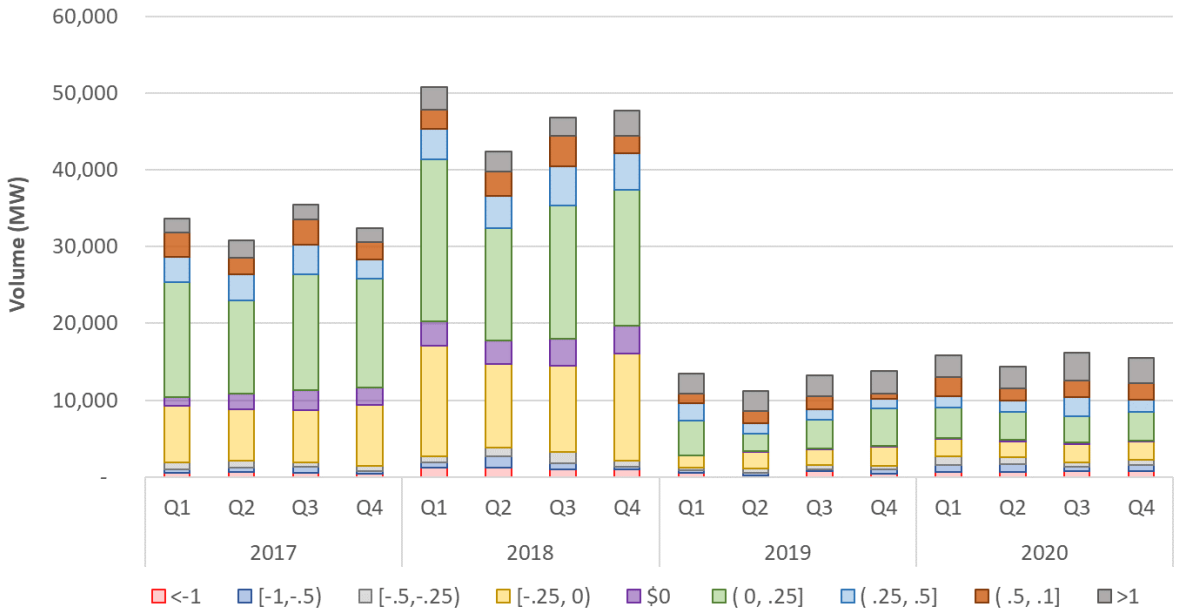
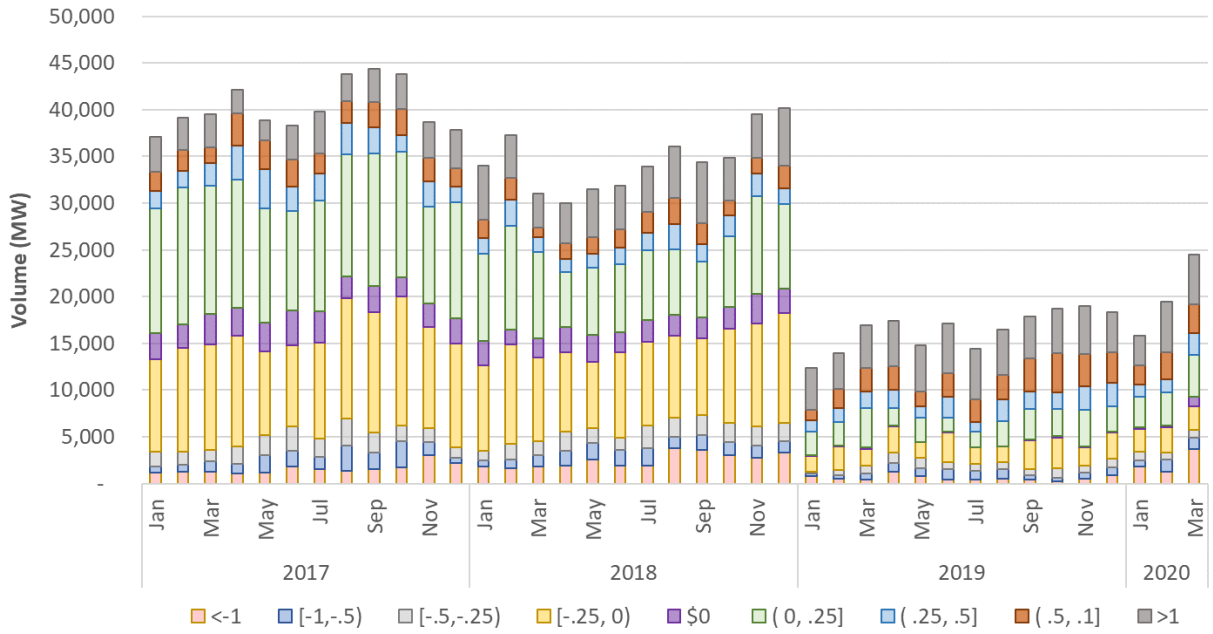


Figure 4 and Figure 7 below show the volume cleared in the annual and monthly CAISO's auctions, organized by CRR clearing price.[3]

The figures illustrate the cases for on-peak time of use. Using the annual auction as a reference, a significant portion of the reduction in CRR volume was attributed the low-price CRRs. The volume of CRRs with prices between -$0.25/MWh and +$0.25/MWh reduced by about 78 percent with the elimination of the non-delivery paths. Also, with the elimination of non-delivery paths, the share of low-priced CRRs with respect to the overall volume reduced from 70 percent in 2017 and 2018 to about 43 percent in 2019 and 2020. CRRs cleared at $0/MWh in the auctions reduced from an average of 2,600 MW to about 100 MW.

Figure 5: Volume of monthly CRR auctioned by price (in $/MWh) for On-Peak



6.3 Auction revenues

The elimination of non-delivery paths can impact two variables of the auction: cleared CRR volume will tend to reduce and CRR clearing prices will tend to increase. Analyzing the MW volume reduction or clearing prices in isolation may not provide a conclusive reference about the overall scope of the impact. The change in auction revenues can better measure the overall dynamic between volume and clearing prices.[4]

[3] The clearing prices are converted first to a $/MWh basis by dividing the CRR clearing price from the auctions by the number of hours in the time-of-use definition of each CRR.

[4] Auction revenues for a given CRR is calculated as *(cleared MW)*(auction clearing price).*

Figure 6: Monthly CRR auction revenues

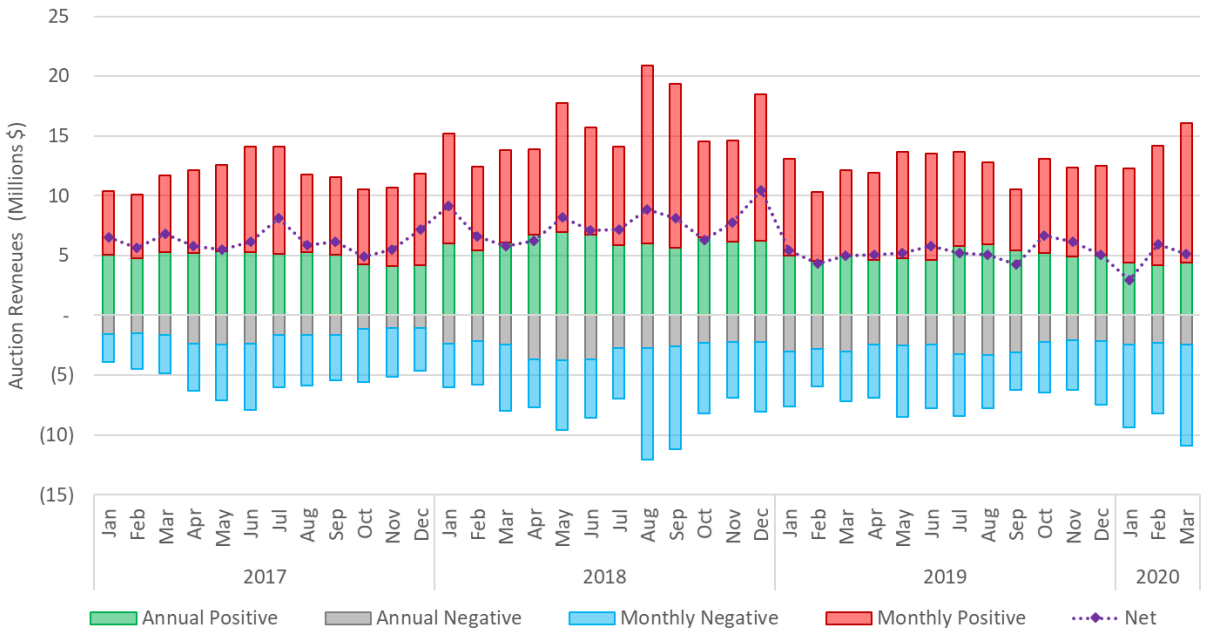
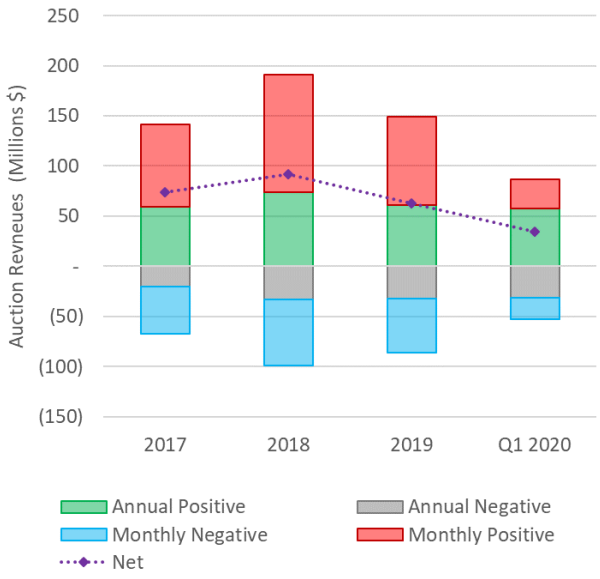


Figure 6 above shows the monthly trend of auction revenues organized by annual and monthly auctions, and by the direction of the revenues.[5] Each bar color represents a specific process and direction of revenue, while the dotted purple line reflects the net auction revenues the CAISO collects from running the auctions. Overall, with the implementation of the new CRR policies in 2019, there is no marked pattern change regarding auction revenues, which indicates that the large reduction in CRR awards is offset to a great extent by having CRRs cleared at a higher auction clearing prices. The annual trend is shown in Figure 7 below, in which the auction revenue dropped to $63 million in 2019 from an average of $83 million in 2018 and 2017. Notice that auction revenues for 2020 reflect only the first quarter and thus cannot be compared on an annual basis to previous years.

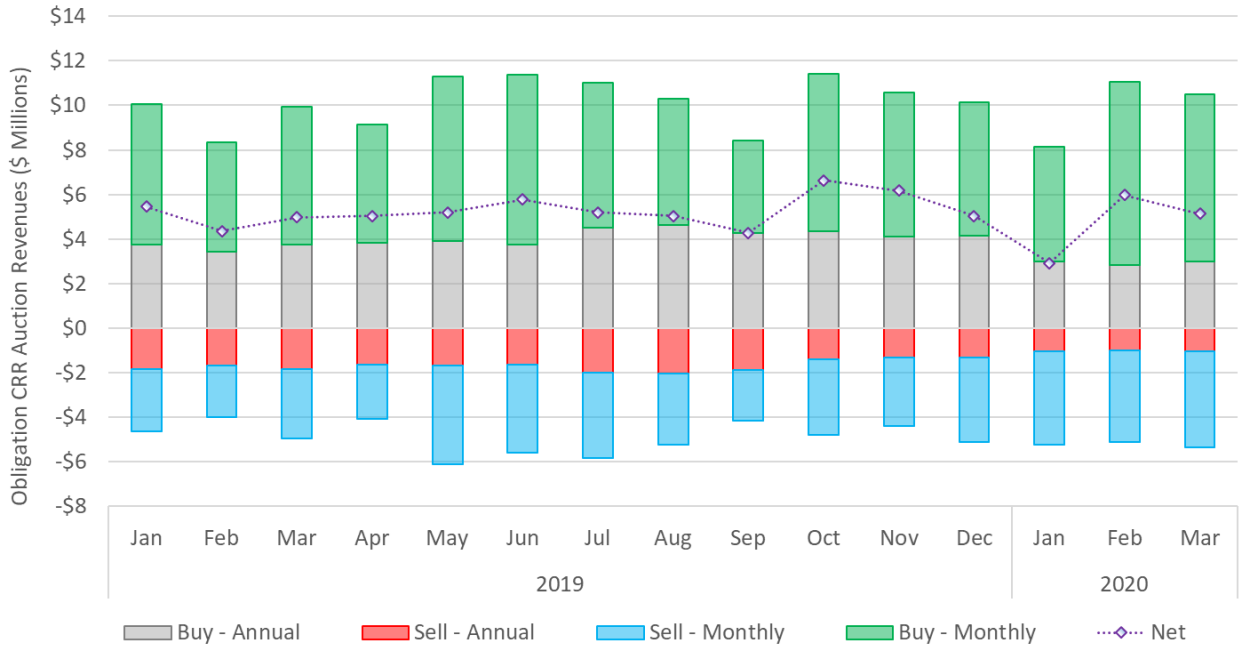
[5] Positive auction revenues represent a money inflow to the CRR balancing account since CRR holders are paying the CAISO to acquire CRRs. Negative auction revenues represent a money outflow for the CRR balancing account since the CAISO is paying CRR holders who sell their CRRs in the auction. In some cases, some buy-type CRRs may be clearing at negative prices, which may reflect a counter-flow position where the CAISO is paying to these CRR holders to acquire these negatively valued CRRs.

Figure 7: Annual CRR auction revenues by direction



The positive auction revenues in 2017 and 2018 were on average about $166 million, which reduced to about $149 million 2019. The negative auction revenues in 2019 were about $86 million, with a moderate increase from the average $83 million is observed in 2018 and 2017. CRRs associated with negative auction revenues after the policy changes are mainly attributed to sell-type CRRs.

Figure 8: Monthly CRR auction revenues by type of CRR



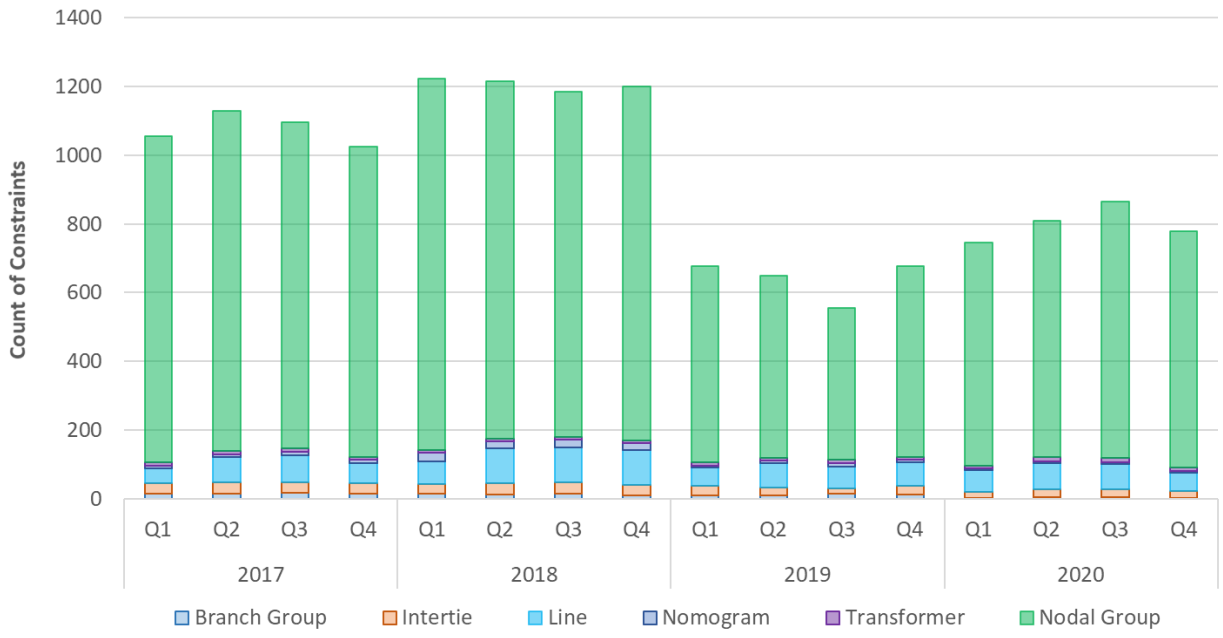
CRRs that, prior to the implementation of the policy changes, were traded as counter-flow CRRs, continue to be sold by CRR holders in auctions explicitly as sell-type CRRs. Existing CRRs from either the allocation, load migration, or auction processes continue to be sold in subsequent auctions. Figure 8 shows the

auction revenues associated with the type of CRR transaction. For instance, CRRs acquired by LSEs through the annual processes can be sold in either the annual or monthly auctions, while CRRs acquired in the monthly allocations can be sold by LSEs in the monthly auctions. CRRs acquired in the annual auction can be sold in the corresponding monthly auctions.

6.4 Transmission constraint in CRR auctions

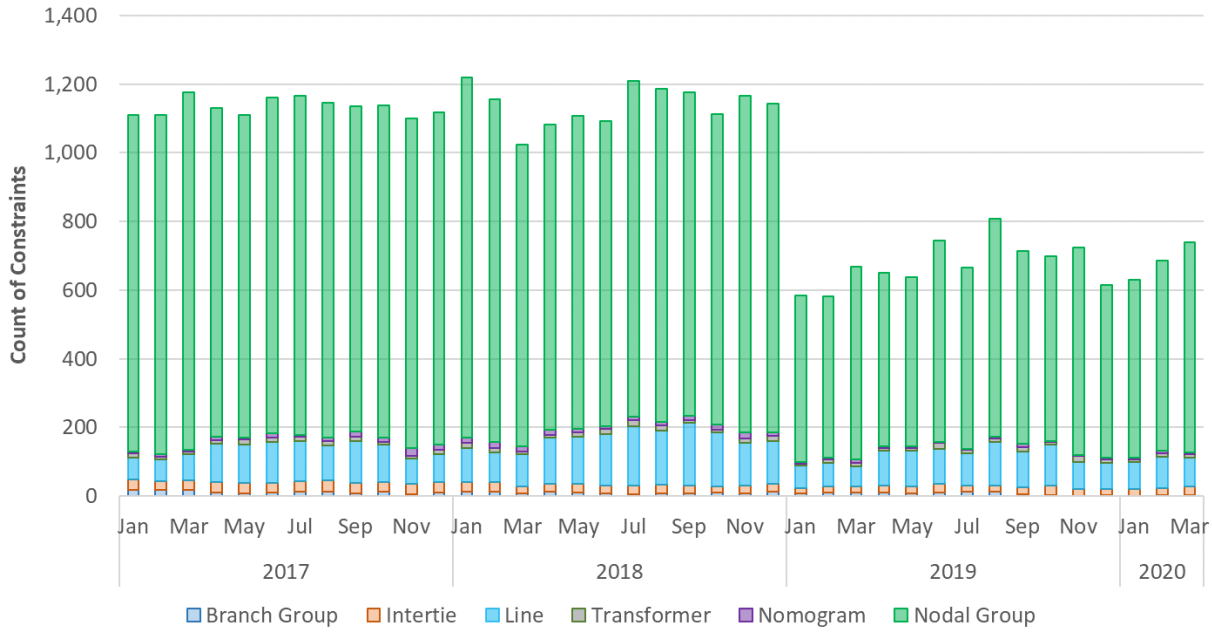
The CRR process -allocations or auctions- use a transmission network model that resembles the full network model used in the day-ahead market as close as possible. CRR prices cleared in the auctions, therefore, reflect the cost of binding transmission constraints. Only binding constraints are used to construct the CRR prices. The CRR valuation in the auction is no more than the valuation of binding transmission constraints. Historically, over 80 percent of the constraints that bind are nodal group constraints. This trend continues with the market rule changes implemented in 2019. The nodal group constraint enforced in the CRR allocations and auctions are local constraints formed around a small subset of locations that historically have been created in the day-ahead market to help converge the power flow solution. These constraints limit the amount of net injection from both physical and virtual injections in these dynamically created local areas. Once they trigger in the day-ahead market, they will be created as close as possible in the subsequent CRR processes and enforced all the time.

Figure 9: Frequency of constraints binding in annual auctions



The annual and monthly trends are shown in Figure 9 and Figure 10. With the changes implemented in 2019, the number of transmission constraints binding in the auctions has reduced by about 37 and 40 percent in the annual and monthly auctions, respectively. About 80 percent of that reduction has been in nodal group constraints.

Figure 10: Frequency of constraints binding in monthly auctions



With the local nature of these constraints, when the non-delivery path CRRs were biddable in the market these constraints could be binding more frequently. Once these CRRs are no longer in place, the delivery path CRRs will more closely resemble the natural flows in the physical system and these local constraint will bind less.

7 CRR Auction Efficiency

During the policy development process preceding the changes implemented on January 1, 2019, the CAISO developed a metric to evaluate CRR auction efficiency. This metric considered the overall set of CRRs participating in the auction without differentiating whether they were counter-flow positions or implicit sales of existing allocated CRRs. This metric was referred as *CRR auction shortfall* and compared the net auction revenues to the CRR payments for auctioned CRRs. Auction efficiency was measured by the difference between what a CRR holder pays to acquire the CRR versus what the CRR holder is paid in the CRR settlements process. By considering the auction revenues and CRR payments related to the sale of allocated CRRs, this metric included the under-valuation caused by selling allocated CRRs. One of the enhancements made in January of 2019, was the addition of a new sale feature so that participants could offer to sell unwanted CRRs directly.

Based on the performance assessment of the new CRR policy that was implemented in 2019, there are some salient conditions that are being reconsidered in the measurement of auction efficiency. This section provides a background on the original auction efficiency metric and the treatment of sell CRRs before and after the policy changes. Then it analyses auction arbitrage and undervaluation of CRRs and how they impact the assessment of auction efficiency. The last subsection introduces a revised metric for auction efficiency to assess the improvements in performance with the implementation of the policy changes.

7.1 Types of CRRs traded in auctions

Figure 11 presents the types of CRRs traded in the auction before and after the policy changes implemented in 2019. It illustrates five groups and the subgroups within each group are identified by different colors and enumerated accordingly.

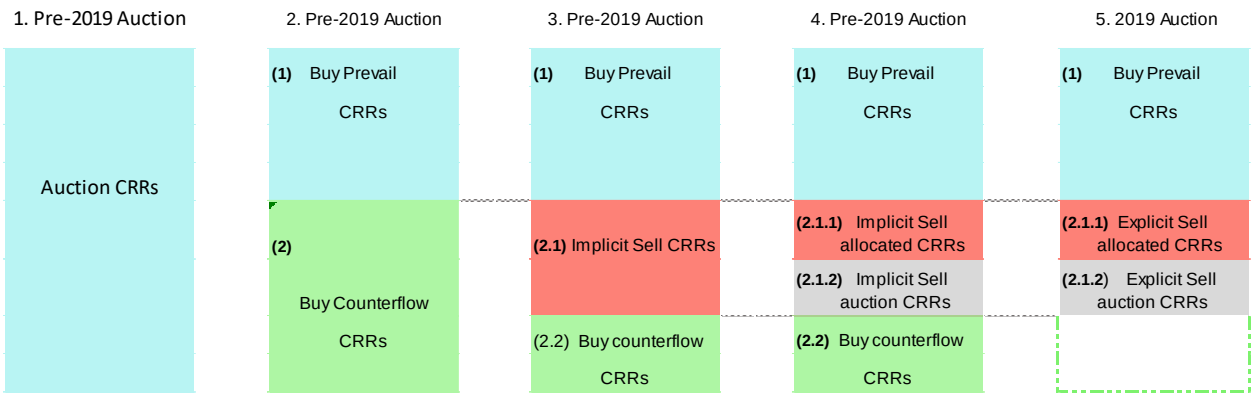
Prior to the policy changes of 2019, participants could only buy CRRs (group 1 in Figure 11). These buy-type CRRs could generally be grouped into prevailing CRRs (typically defined for a path going from supply to demand locations or positively priced CRRs), and counter-flow CRRs (group 2 in Figure 11 going from demand to supply locations or negatively priced CRRs). Previously, the lack of a sell feature to facilitate sale of existing CRRs acquired through any of the CRR processes (auctions, allocations or load migration) required that CRR holder purchase a counter-flow CRR (sink to source – labelled in Figure 11 as Buy Counter-flow CRRs) for the corresponding CRR (source to sink) they wish to sell, which would in effect offset the pre-existing CRR. This purchase of a counter-flow CRR was equivalent to the action of explicitly selling that CRR.

Group 3 in Figure 11 illustrates that the Buy Counter-flow CRRs can be organized in two subgroups: one for those participants that wanted to sell CRRs and the only vehicle to do so was to buy a counter-flow CRR (Implicit Sell CRRs), and the other for participants with an explicit position to buy Counter-flow CRRs (Explicit Buy-Counterflow CRRs).

Group 4 in Figure 11 shows that buying an offsetting counter-flow CRR to sell an existing CRR (the Implicit Sell CRRs group) could be for CRRs originated from either one of the allocation processes, such as an LSE selling a previously allocated CRR, or from an auction, such as a financial trader buying a CRR in the annual auction to then sell it in the monthly auction.

This layout demonstrates that with the changes implemented in 2019, only the Buy Counter-flow CRRs for a market position (portion in green) were eliminated with source-sink limitations because the sell feature enables the CRR holders to still sell off the CRRs without having to purchase the counter-flow CRR (i.e., Implicit Sell CRRs) (see group 5 in Figure 11).[6]

Figure 11: Type of CRRs traded in the CRR auctions



[6] The elimination of non-delivery paths generally no longer allow to buy an explicit counter-flow position for certain combinations of sources and sinks that do not align with the direction of delivering power. However, there may be still the possibility of buying CRRs that may end up being a counter-flow.

The metric developed during the prior policy development process to evaluate CRR auction efficiency was based on the overall set of CRRs participating in the auction without consideration of why the CRR holders took the positions as they did as illustrated by the various groups defined in Figure 11. This metric narrowly considers the monetary influx from the net auction revenues compared to the CRR payments for all the CRRs cleared in the auction.

In this section, an enhanced metric for auction efficiency is derived by considering the different dynamics associated with the various groups of auction CRRs. The first group of CRRs is prevailing CRRs (in blue in Figure 11): CRRs that are purchased in the auction, typically at a positive price, and have a path from source to sink. When these CRRs are settled based on congestion revenues in the day-ahead market, their holders will generally be paid. Auction efficiency is measured by the difference between what a CRR holder pays to acquire the CRR versus what is paid in the CRR settlements process. For example, if a CRR holder pays $0.80 in the auction to acquire the CRR, and then the nominal value of that CRR when settled in the day-ahead market is $1, the auction efficiency is measured as 80 percent. This metric effectively measures how efficient the auction is at pricing and clearing CRRs. The closer this ratio is to 100%, the closer the CRR auction is converging to the day-ahead market.

The second group, the counter-flow CRRs noted in green [subgroup (2.2) in Figure 11] are considered similarly in terms of their purchase price and settlement (counter-flow CRRs are those that have a non-delivery path and that are priced negatively). These were the CRRs that existed prior to 2019 that were eliminated with the policy changes. Auction efficiency in that case could also be measured by comparing what the participant is paid to acquire the CRR in the auction versus what is charged when settling in the day-ahead market.

The third group in grey [subgroup (2.1.2)] represents CRRs that are acquired in one auction, then sold in a subsequent auction. Arbitrage between auctions can only happen when a holder buys a CRR in the annual auction, then sell it in the monthly auction. Prior to the policy changes of 2019, the following scenarios could occur:

i) A CRR for quantity A was bought in the annual auction; then in the monthly auction, that holder bought a CRR for quantity B in the counter-flow position, which is less than quantity A. This could occur because the holder either explicitly bid to sell only a portion of their annual CRR, or bid to sell the entire amount of the annual CRR, but is cleared only for a portion of it. In this case, the arbitrage is only partial for quantity B. The CRR holder still has the ownership of CRR for the portion (A-B).

ii) A CRR for quantity A was bought in the annual auction; then in the monthly auction, that holder bought a CRR for quantity B in the counter-flow position, which is equal to quantity A. In this case, the holder bought back its position and arbitraged for the full quantity between auctions. This specific scenario represents cases in which the CRR holder has no exposure to the congestion risk of the day-ahead market since there is no CRR position to settle in the day-ahead timeframe.

iii) A CRR for quantity A was bought in the annual auction; then in the monthly auction, that holder bought a CRR for quantity B in the counter-flow position that is greater than quantity

A. In this case, the holder not only bought back its annual CRR in full, but also bought a CRR in excess such that it now holds a relative counter-flow position for the portion of (B-A).[7]

With the implementation of the explicit sell feature in 2019, only the first two scenarios can occur because a holder can now only sell a CRR up to the amount it currently holds. Given any of the three scenarios, the CRR arbitraged between auctions is set by the minimum of two quantities: the MW quantity of the purchased CRR in the annual auction and the CRR sold in the monthly auction. The implementation of both the reduction of non-delivery points (CRR1A) and the pro-rata funding (CRR1B) may have an impact on the arbitrage since they will influence CRR valuation. However, the pro-rata funding will not impact directly the arbitrage between auctions since these CRRs will not be exposed to the day-ahead settlements process. Indeed, the pro-rata funding might incentivize more arbitrage opportunities between auctions to avoid exposure to the pro-rata funding in the CRR settlements.

The portion of the CRRs being sold is an arbitrage between auctions. Such arbitrage can also be considered part of the auction efficiency. This type of transaction also involves a CRR valuation since it has to assess if the arbitrage between auctions is financially more beneficial than holding that CRR and waiting for payment in the day-ahead market. For instance, if a CRR was purchased for $60 in the annual auction (assume the cost is $20 for each of the three months of the season) then was sold for $25 in the monthly auction, its holder will have a $5 arbitrage between the two auctions. If this CRR had an associated CRR payment in the day-ahead market greater than $25, the arbitrage was less beneficial than holding the CRR. The valuation of the day-ahead notional value of auctioned CRRs compared to their value in the CRR auction has not been assessed in this performance evaluation effort.

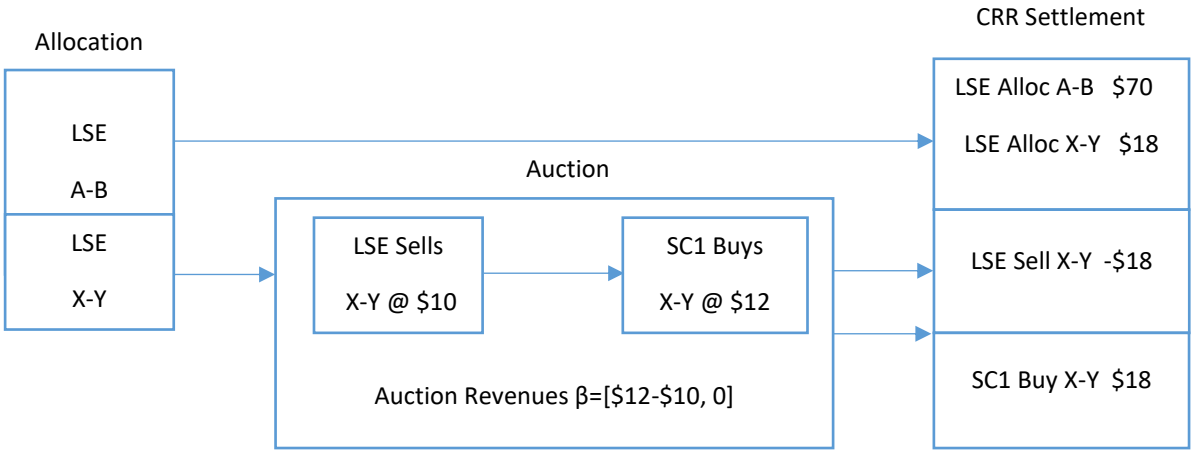
The fourth group of CRRs in red [subgroup (2.1.1)] represents those CRRs originally allocated to LSEs – through any of the allocation processes –that subsequently the LSE put up for sale in an auction. For instance, a seasonal CRR allocated to an LSE in the annual process can then be sold into either the annual auction for the whole season or in any of the monthly auctions of that season. Similarly, a CRR allocated in the monthly process can then be sold into the corresponding monthly auction.

Prior to the 2019 policy changes, when an LSE wanted to sell an existing CRR, it had to buy a counter-flow CRR in the auction that effectively netted out their allocated CRR. When an LSE sells an allocated CRR, either with a counter-flow CRR (pre-2019) or with a sell CRR (in 2019 and beyond), the LSE willingly let go of the opportunity to collect the CRR payout in the day-ahead market. How this outcome will play out for the LSE is unknown by the time the sale is made. If the LSE sells the CRR for less than what it would actually settle in the day-ahead market, the LSE is undervaluing the CRR and is effectively letting other market participants into the auction to monetize the potential additional value of the CRR. This is not an auction efficiency problem, but rather an issue with the LSE's valuation of the CRR. This undervaluation may very well be an explicit decision by the LSE to dispose of such CRRs at a discount price based on their risk aversion level. Eliminating the CRR auction or replacing it with any other mechanism will not resolve the issue of CRR's valuation.

[7] This is labeled as a relative counter-flow position because it is only relative to its original position of the annual CRR. Analysis has shown that there were instances in which the annual CRR held was a counter-flow CRR and then in the monthly auction, the participant ended with a net prevailing position.

To further illustrate the concept of undervaluation, consider the following example in Figure 12. In the allocation process, the LSE is allocated two CRRs, one from source A to sink B and the other from source X to sink Y. The LSE offers to sell CRR X-Y for $10 in the auction. Assume participant SC1 is willing to buy that CRR for $12. The auction will clear both the sell and the buy and the utility function of the CRR auction will be $2.[8] In the illustration and discussion below, the net auction revenue is defined as β. This auction revenue is allocated to measured demand. Assume in this case the bulk of measured demand is accounted for by the LSE that was originally allocated the CRR. In the day-ahead settlements, assume that the allocated CRR A-B is paid $70. CRR X-Y originally allocated to LSE is settled at $18. LSE is paid $18 for the original allocated CRR and also charged -$18 for the sell CRR, its net settlement is effectively $0. SC1 is paid $18 for the purchased CRR. For simplicity also assume revenue neutrality in which all the congestion rents equals the CRR payouts, which is $88 ($70+$18).

Figure 12: Illustration of undervaluation of an allocated CRR



In this case, the LSE's overall position is $80+ β ($70 from allocation CRR+ $10 from selling X-Y in the auction+$ β auction revenues allocated to measured demand). If we assume for illustration purposes that the clearing price is at the upper bound of $12, then the auction revenues will be β =$2. Then comparing this overall position of $82 versus the overall congestion in the day-ahead market of $88, it seems the LSE has a loss of $6.

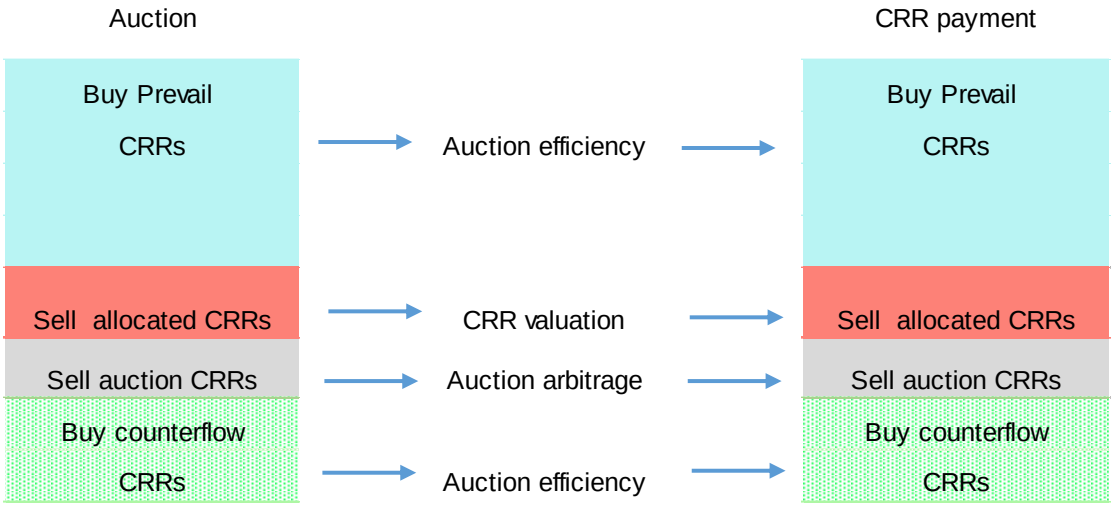
SC1's overall position is $6 ($18 from CRR payout - $12 for buying the CRR in the auction). Thus SC1's net profit is $6, which happens to be equal to the LSE's loss.

This LSE's loss or SC1's profit is not all because of an auction inefficiency; this is the issue that LSE undervalued its allocated CRR in the auction to be $10 when the CRR value is actually $18. If the LSE had valued its CRR for sale at $18, SC1 could not buy it and profit for it. LSE willingly underbid the CRR for $10.

[8] If the cleared price is more than $10, then there is also a contribution to net auction revenues, calculated as the difference between what the purchaser of CRR pays and what is paid to the seller. This net auction revenue can take a value anywhere between $0 and $2, and for generality is referred as value β.
A simpler example but less obvious is to illustrate this with one CRR X-Y sold for $10 and another CRR W-Z bought for 12 dollars. CRR X-Y enables the purchased of CRR W-Z by releasing the transmission capacity needed for W-Z to be feasible.

The type of (in)efficiency related to each of the four types of CRRs groups is summarized in Figure 13 below.

Figure 13: Efficiency related to the various types of auction CRRs



7.2 Illustrative example

Before introducing the revised metric for auction efficiency, the following example is used to illustrate the nuances with the measurements of auction efficiency. This example compares the calculation of the auction efficiency metric used in the previous analysis of the CRR performance (pre-2019 settlement section) against the current logic implemented via the policy initiative in 2019 (2019 settlement section).[9] Table 1 below highlights the nuances in the settlement of counter-flow CRRs that were purchased to buy back existing positions.

Table 1: Settlements comparison before and after 2019 policy changes

		Pre-2019 settlement				2019 settlement			
Process	Participant	Transaction	CRR	Auction Revenue	CRR payment	Transaction	CRR	Auction Revenue	CRR payment
Annual Allocation	LSE	Allocated CRR	A-B	-	$185+$15	Allocated CRR	A-B	-	$200-$15=$185
Monthly Auction	LSE	Buy counterflow	B-A	-$8	-$15	Sell portion of allocated CRR	A-B	-$8	-
Monthly Auction	SC1	Buy CRR	C-D	$60	$110	Buy CRR	C-D	$60	$110
Annual Auction	TRADER	Buy CRR	E-F	$10	-	Buy CRR	E-F	$10	-
Monthly Auction	TRADER	Buy counterflow	F-E	-$14	-	Sell seasonal CRR	E-F	-$14	-
Total				$60+($10-$14)-$8= $60-$4-$8=$48	$110-$15= $95			$60+($10-$14)= $60-$4=$56	$110
CRR auction profit				CRR payment-Auction Revenue	$95-$48=$47			CRR payment-Auction Revenue	$110-$56=$54
CRR auction efficiency				Auction Revenue/CRR payment	$48/$95=50.5%			Auction Revenue/CRR payment	$56/$110=50.9%

[9] This metrics is described and analyzed in the CRR performance report available at http://www.caiso.com/InitiativeDocuments/CRRAuctionAnalysisReport.pdf

7.2.1 Pre-2019 calculation

Prior to 2019, every CRR originated in an auction process was explicitly settled regardless of whether they were purchased for prevailing or counter-flow positions. Consider the scenarios of three participants:

i) An LSE has a CRR allocated in the annual process from source A to sink B. This CRR has no auction revenues since it is directly allocated. When this CRR is settled at the day-ahead price, its payout is, say, $200. For example, consider this CRR A-B is split in two uneven portions, one that is worth $185 and the other that is worth $15. In a subsequent monthly auction, this LSE sells the portion of the CRR associated with the $15 payout.
Prior to 2019, there was no explicit sell feature and thus the LSE had to buy a counter-flow CRR B-A. This CRR was treated like an auction CRR and was tracked separately from the original allocated CRR B-A. This means the LSE had a portfolio with two separate CRRs. Assume the counter-flow B-A CRR is bought into the auction and the LSE receives a payment (negative auction revenue) of $8. Although this CRR purchased with the original intention of selling a portion of the allocated CRR held by the LSE, the counter-flow CRR B-A is settled as a separate CRR in the day-ahead market and its payout is -$15, meaning the LSE is charged $15 in the day-ahead market for that CRR purchased in the auction.
The full allocation CRR settles at $200 ($185+$15) and the counter-flow CRR bought in the auction is settled at -$15. The final CRR payment for the LSE is $200 - $15 = $185. Although the settlements of the two CRRs were record-wise separate and explicit, the final CRR payout is the result of netting the two separate payouts, resulting in the lower final payout for the LSE of $185.

ii) A Scheduling Coordinator (SC1) buys a prevailing CRR C-D in the monthly auction for $60. This CRR payout in the day-ahead market is worth $110. SC1 makes a profit of $50 ($110 - $60). The auction revenue shortfall (auction efficiency) of this CRR transaction is 54.5% ($60/$110).

iii) A trader buys a CRR E-F in the annual auction for $10; this is money paid to the CAISO and represents a positive auction revenue. Then, this trader buys a counter-flow CRR F-E in the monthly auction for -$14; this is a payment from the CAISO to the trader and represents a negative auction revenue. Effectively, the trader is buying back its annual CRRs. This is a condition where the trader arbitrages between auctions. It paid $10 to buy the CRR and is paid $14 to sell it, making a profit of $4 ($14-$10). When the day-ahead settlement is finalized, this trader has a net portfolio of zero from the netting of its two CRRs. This means the trader has no exposure to any day-ahead congestion risk.

7.2.2 2019 calculation

With the policy changes implemented on January 1, 2019, counter-flow CRRs are generally no longer available for purchase. However, when a CRR holder wants to buy back a CRR position, the holder can now explicitly sell the CRR in an auction process. Consider the same scenario as described in the section above but now settled through the rules applicable in 2019.

i) An LSE has a CRR allocated in the annual process from source A to sink B. This CRR has no auction revenues since it is directly allocated. When this CRR is settled at the day-ahead prices

its payout is $200. For example, consider this CRR A-B is split in two uneven portions: one that is worth $185 and the other that is worth $15. In a subsequent monthly auction, the LSE sells the portion of the CRR explicitly associated with the $15 payout. In 2019, the LSE now can only explicitly sell its CRR A-B. This sell CRR is no longer tracked separately in the settlements process as an auction CRR. Instead, the LSE's position is netted first (allocation CRR reduced by the sell portion of the CRR) and then the CRR payout is calculated based on the net CRR. Now the LSE portfolio will reflect a net portfolio of only one allocation CRR worth $185 ($200 - $15). This is the main difference between the new settlement and the pre-2019 logic, in which there were two CRRs that comprised the LSE portfolio (one allocation and one auction CRR) and the CRR payout was calculated separately. The pre-2019 logic enabled the CAISO to explicitly track the LSE's counter-flow position through the CRR settlements since the position was not netted a priori of the settlements and it was instead netted after the calculation of each the CRR payout.

ii) A Scheduling Coordinator (SC1) buys a prevailing CRR C-D in the monthly auction for $60. This CRRs payout in the day-ahead market is worth $110. This means SC1 profits by $50 ($110 - $60). The auction efficiency of this CRR is 54.5% ($60/$110). There is no difference in the pre – and post 2019 logic in this calculation.

iii) A trader buys a CRR E-F in the annual auction for $10; this is money paid to the CRR balancing account and represents a positive auction revenue. Then this traders buys a counter-flow CRR F-E in the monthly auction for -$14; this is a payment to the trader based on funds collected in the auction sand represents a negative auction revenue to acquire the CRR. Effectively, the trader is buying back its annual CRRs. This is a condition where the trader arbitrages between auctions. It paid $10 to buy the CRR and is paid $14 to sell it, making a profit of $4 ($14-$10). When the day-ahead settlement is finalized, this trader has a portfolio with a zero position. This means the trader has no exposure to any day-ahead congestion risk. This is no different than how the calculation would be performed between the pre- and post-2019 logic.

7.2.3 CRR holders' position

The main difference between the pre and post- 2019 (current) logic is the treatment of CRRs associated with selling an allocated CRR.[10] Under the pre-2019 logic, this was achieved through buying an explicit counter-flow CRR in the auction, while under the current logic, it can be sold explicitly.

i) LSE's position

The pre-2019 logic enabled the tracking of the CRR payout for the selling position. For instance, the purchase of CRR B-A allows the CAISO to track that the LSE sold the CRR A-B for $8 when in reality the actual value of the CRR A-B is $15 in the day-ahead market. This means that the LSE undervalued the CRR by $7 ($15-$8). The overall CRR position for the LSE is:

[10] This only impacts the sales of allocated CRRs because of the netting taking place prior to the settlements since the original allocation was kept separately from the buy counter flow CRRs. With the policy changes, the ales of auctioned CRRs is not impacted because the netting of the buy and sale of an auctioned CRR is netted prior to settlements before and after.

+$200 (CRR payment for allocation)
-$15 (CRR payment for buying counter-flow)
+$8 (buy counter-flow CRR in the auction)

This nets out to $193 for the LSE's overall CRR position, or $200 - ($15 - $8).

The 2019 logic does not change the overall LSE's position; only the tracking of the components is affected. The overall position is determined as:

+$185 (CRR payment of net allocated CRR)
+$8 (sold CRR in the auction)

This nets out to $193, or $185 + $8.

ii) The overall positions for the SC1 and the TRADER remain exactly the same under both pre- and post-2019 scenarios.

7.3 Revised metric for auction efficiency

The auction efficiency metric historically reported in previous CRR performance reports and used during the policy discussions was calculated as:

$$CRR\ auction\ shortfall = Auctioned\ CRR\ payments - Net\ Auction\ revenues$$

Which can also be expressed as a coefficient:

$$CRR\ auction\ shortfall\ ratio = \frac{Net\ Auction\ revenues}{Auctioned\ CRR\ payments}$$

The metric to estimate the auction efficiency needs to be adjusted to consider the treatment and availability of data for sell CRRs and to remain consistent in the calculation for CRRs before and after the change.

i) Pre-2019 metric

The net auction revenues account for all CRRs traded in the auction, regardless if participants were to buy prevailing flow CRRs, counter-flow CRRs, or counter-flows CRRs as a strategy to buy back existing allocated CRRs (which was an indirect way to sell an allocation CRR). Using the description of the different subgroups in Figure 11, the term *AR(i)* represents auction revenues and the term *CRRP(i)* represents CRR payments belonging to the *i-th* subgroup, and the absolute and relative auction revenue shortfall are denoted by *AAS* and *RAS*, respectively. With this notation the original auction revenue shortfall metric is defined as follows:

$$AAS = CRRP(1) + CRRP(2.1.1) + CRRP(2.1.2) + CRRP(2.2)$$
$$-AR(1) - AR(2.1.1) - AR(2.1.2) - AR(2.2)$$

and the relative auction efficiency is

$$RAS = \frac{AR(1) + AR(2.1.1) + AR(2.1.2) + AR(2.2)}{CRRP(1) + CRRP(2.1.1) + CRRP(2.1.2) + CRRP(2.2)}$$

This is shown in detail in the Pre-2019 settlements section in Table 1 above. The net auction revenues are simply the summation of auction revenues from all CRRs bought in the auction, which is $48 ($56-$8). This includes the negative auction revenues of $8 for the counter-flow CRR bought by the LSE.

CRR payments are also calculated as the summation of all CRR payments bought in the auction. In the previous example, this also includes the $15 CRR charge for the CRR bought by the LSE. The total CRR payment in this example would be $95, or $110-$15.

The two terms related to the sell CRRs (auction revenue and CRR payments) are consistently included in both the auction revenues and the CRR payments. The valuation of this CRR is consistent with the calculation of the CRR auction shortfall. In Table 1 above, these CRR figures are shown in red in the pre-2019 scenario.

This results in an auction shortfall of $47 ($95-$48), with a ratio of $48/$95 = 50.5%. By including the counter-flow CRR bought by the LSE, this metric explicitly factors in the $7 ($15-$8) LSE's undervaluation of CRR B-A.

ii) Post 2019 (current) metric

With the explicit sell feature and the netting which takes place between allocation CRRs and sell CRRs prior to settlement, the CRR payment for the sell CRR is no longer settled explicitly. Also, with the elimination of the non-delivery paths, as discussed above there will no longer be counter-flow CRRs purchased in the auction to dispose of previously obtained CRRs. The above formulas are therefore adjusted as follows:

$$AAS = CRRP(1) + CRRP(2.1.2) - AR(1) - R(2.1.2)$$

and the relative auction efficiency is

$$RAS = \frac{AR(1) + AR(2.1.2)}{CRRP(1) + CRRP(2.1.2)}$$

The payment for the sale of CRRs is part of the CRR payment of the net allocation CRR. Therefore, the CRR payment for auction CRRs can no longer be tracked. In this case, CRR payments for the set of auction CRRs are composed of only the explicit buy CRRs, amounting to $110.

Correspondingly, the sold CRRs should not be considered in the auction revenues component in order to maintain consistency in treatment. Therefore, the auction revenues are calculated as the sum of the revenues from all auctioned CRRs, with the exception of the sell CRRs associated with the allocation CRR. The sell CRR E-F, which is the sale of a CRR originated from an auction, is still considered as part of the auction revenue. This CRR is still considered as it was prior to the 2019 policy changes because the original buy CRRs and the sell CRRs are still considered as auction CRRs. The auction revenue in this case is calculated as $54, or $60 + ($10-$14); the $60 is the CRR payment for the buy CRR and the -$4 ($10-$14) is the arbitrage between the annual and monthly auction by the trader. The -$8 of auction revenues associated with the sell CRR A-B is disregarded.

With these components, the CRR auction shortfall is $54 ($110-$56), which results in a ratio of $56/$110 = 50.9%. This metric is slightly higher than the metric calculated under the pre-2019 logic because it does not factor in the loss due to the LSE's undervaluation of its CRR.

The pre-2019 auction shortfall with the consideration of the allocated CRR being sold was $47, while the 2019 (current) auction shortfall which disregards the sell CRR is $54; a difference of $7 ($47-$54) is the undervaluation of the sell CRR, which is determined as the difference between the $15 CRR value in the day ahead market and the $8 paid to the LSE when selling the CRR.

In order to be able to compare the performance of the CRR auction efficiency, the pre-2019 needs to be adjusted to not account for the contribution to auctions revenues from the sale of allocated CRRs. The contribution of the sale of allocated CRRs is naturally not included in the CRR payments. With this, the pre-2019 metric is revised as follows

$$AAS = CRRP(1) + CRRP(2.1.2) + CRRP(2.2) - AR(1) - AR(2.1.2) - AR(2.2)$$

And the relative auction efficiency is

$$RAS = \frac{AR(1) + AR(2.1.2) + AR(2.2)}{CRRP(1) + CRRP(2.1.2) + CRRP(2.2)}$$

7.4 CRR auction revenues

Following the breakdown introduced in Figure 11, Figure 14 organizes auction revenues into three groups: buy CRRs, sell allocated CRRs, and sell auctioned CRRs. These groups can also be disaggregated into annual and monthly auction groups, as shown in Figure 14.[11] This breakdown allows for a meaningful comparison of the different components before and after the policy changes implemented in 2019. For instance, the pre-2019 sales of allocation CRRs are actually buy counter-flow CRRs by LSEs, while in 2019 they are explicit sell CRRs.

In 2019 and Q1 2020, about 62 percent of all auction revenues were collected in the monthly auctions. This trend is also reflected in the sell CRRs, with about 63 percent of the revenues disbursed were to allocation CRRs sold in the monthly auctions. When comparing the magnitude of revenues disbursed between allocation and auctioned CRRs, 15 percent of revenues were disbursed to auctioned CRRs (bars in green) and 85 percent of auction revenues were paid to allocated CRRs being sold (bars in red).

[11] The profile of each of the revenues component may be different to the ones shown in Figure 6 in earlier section due to the netting that may happen among CRRs that are buy CRRs but cleared at negative prices or sell CRRs cleared at positive prices; however, the net revenues remain the same.

Figure 14: Auction revenues organized by process and type of auctioned CRRs

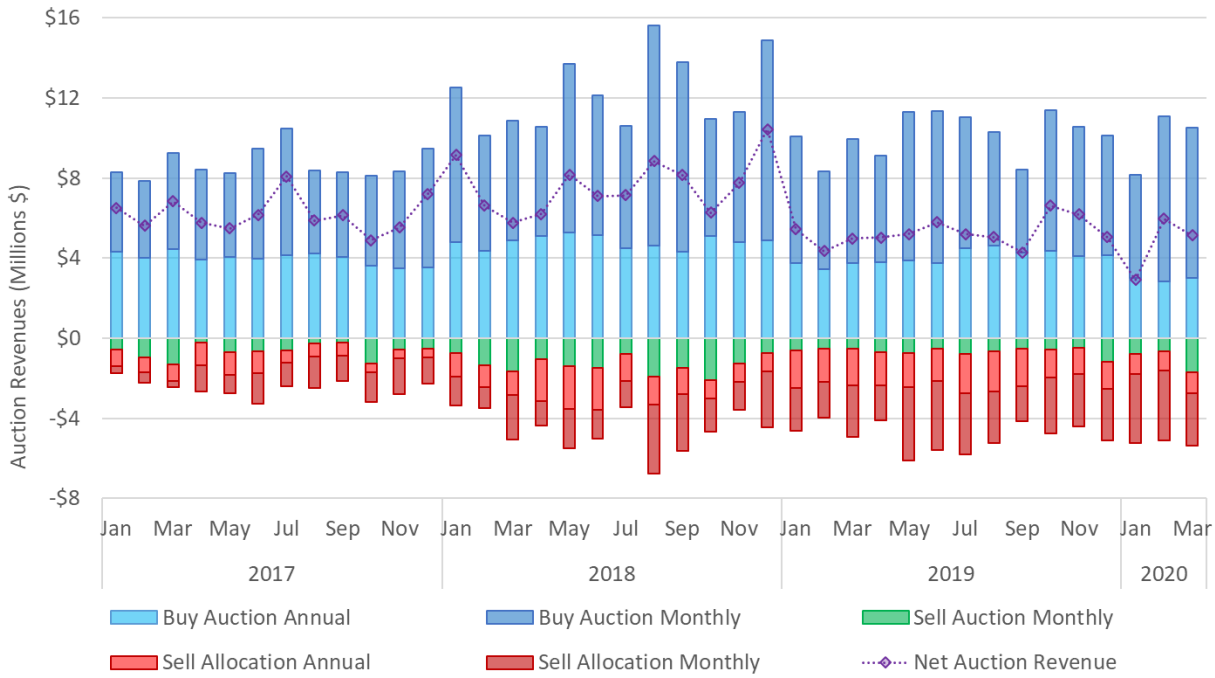
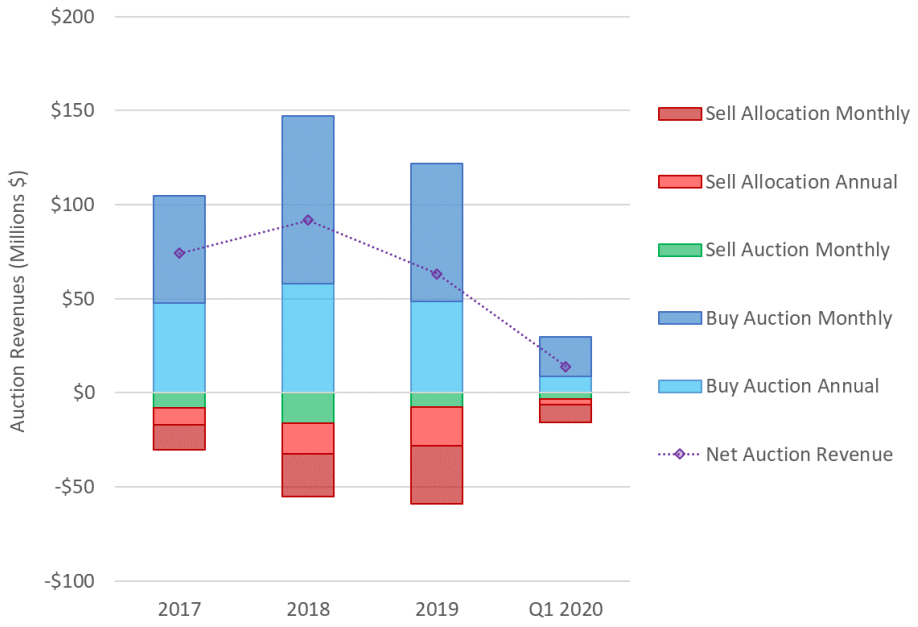


Figure 15 shows the auction revenues aggregated in an annual basis. The negative auction revenues for the sale of allocated CRRs has increased from an average of $31 million in 2017 and 2018 to $51 million in 2019. In contrast, the negative auction revenues for the sale of auctioned CRRs has reduced from an average of $12 million 2017 and 2018 to $7.8 million in 2019. This can be also a reflection of the new condition of having only delivery points in the auction.

Figure 15: Annual auction revenues organized by process and type of auctioned CRRs



The sell CRRs originated from auctions can only appear in the monthly auction because they are purchased in the annual auction and the only opportunity to later sell them is in the subsequent monthly auction for the monthly portion of that CRR. The auction revenues for 2020 cannot be compared on the same basis since it reflects only the first quarter of the year.

7.5 Auctions arbitrage

As explained in previous sections, arbitrage between CRR auctions is considered to be part of the auction efficiency. This section further analyzes this type of auction activity. Figure 16 shows the CRR volume (in MW) of arbitrage from the annual auction to the monthly auctions, organized by time of use. With the implementation of the policy changes in 2019, the volume of arbitrage reduced by 56 percent from an average of 4,000 MW to an average of 1,735 MW. This may be related to the elimination of non-delivery paths, making fewer options available to arbitrage between auctions. Although the sudden drop is observed after implementing the policy changes, since then a gradual but increasing trend can be seen with March volume reaching levels similar to those observed prior to the changes.

Figure 16: Volume of CRR auctions arbitrage

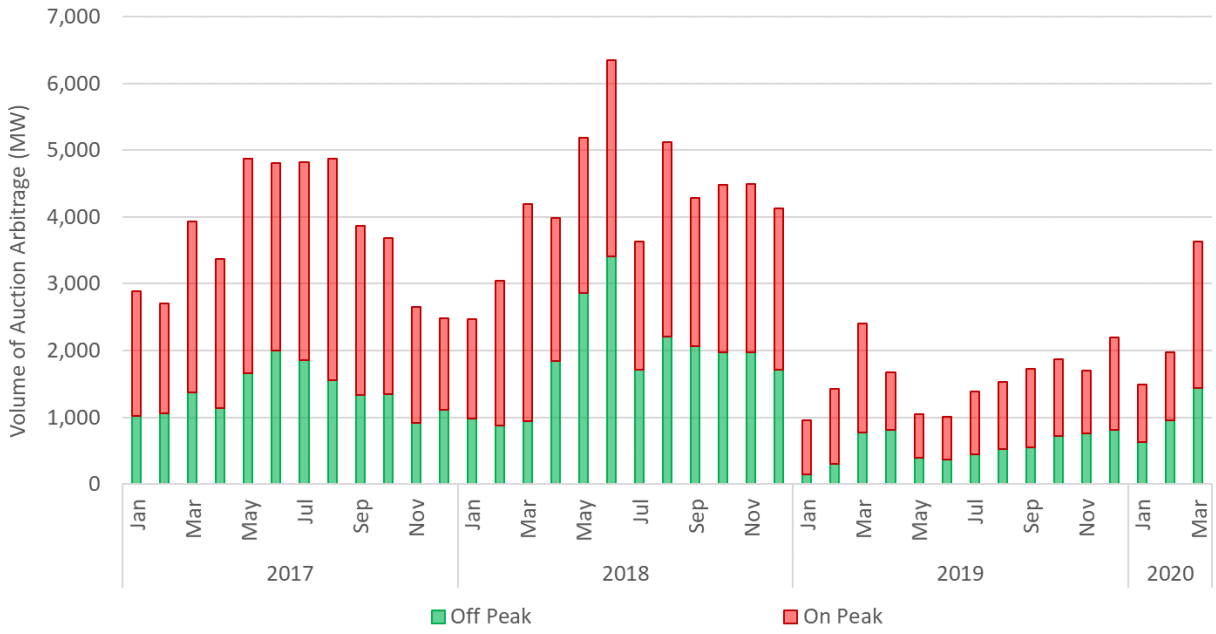
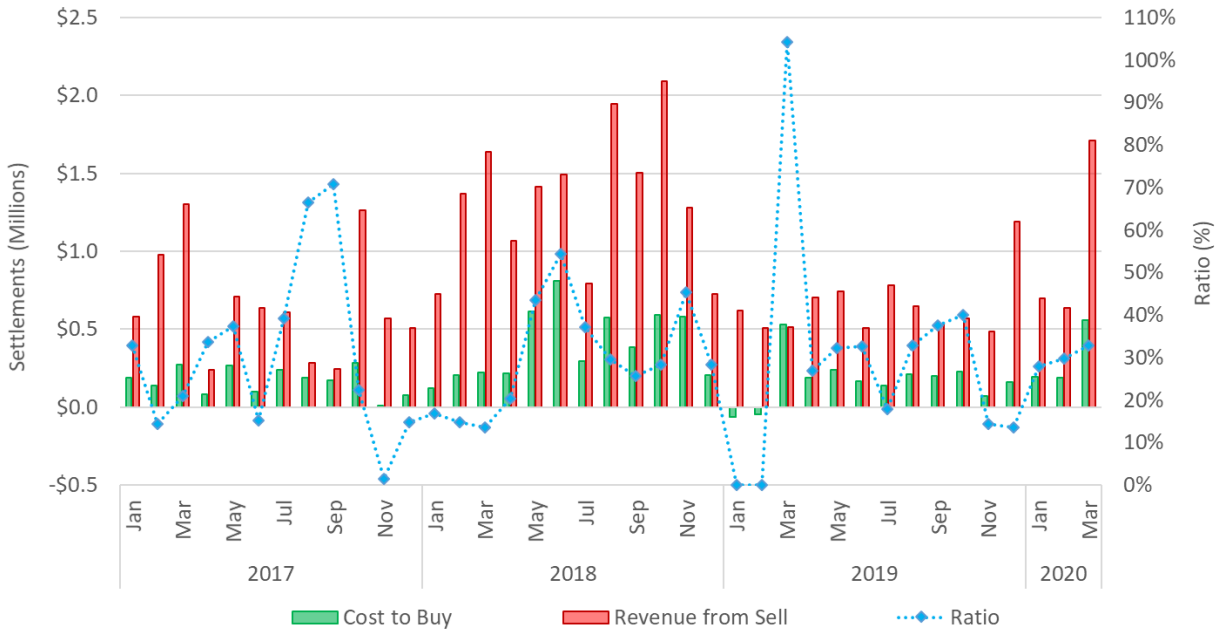


Figure 17 shows the monthly trend of arbitrage between the annual and monthly auctions. The amount paid by CRR holders to buy CRRs in the annual auction is shown in red bars, while the payments to holders for selling the same CRRs in the monthly auction are shown with bars in green.

Figure 17: Monthly auction arbitrage between CRR auctions



This metric is based only on revenues associated with CRRs up to the amount that is fully arbitraged between auctions. This is defined for CRRs with the same source and sink that are purchased in the annual auction and sold in the monthly auction as the minimum. These two metrics allow the CAISO to derive a metric that is analogous to the auction efficiency but focusing only on auction arbitrage. The ratio shown in blue stands for the proportion of funds paid to buy the CRR to the funds received to sell the CRR. This arbitrage opportunity is present before and after the policy changes implemented in 2019. The ratio varies largely from month to month but, generally is low in the reported period.

Figure 18: Annual auction arbitrage between CRR auctions

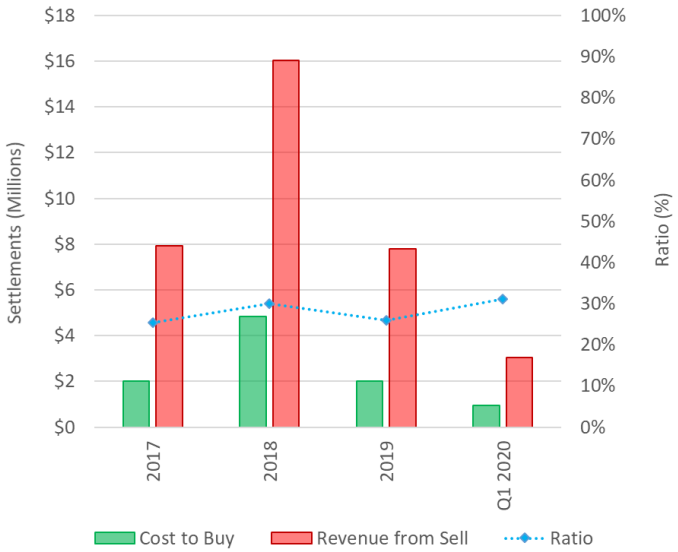


Figure 18 provides the same information on an annual basis for a simpler comparison. On average, auction arbitrage in 2017 and 2018 was approximately 29 percent, meaning CRR holders paid 29 cents to buy CRRs in the annual auction and subsequently were paid one dollar when selling these same CRRs in monthly auctions.

In these two years, arbitrage between auctions amounted to about $17.1 million. This same metric was about 27 percent for 2019 and the first quarter of 2020, with an arbitrage of about $7.8 million. The only month during which this auction arbitrage was not profitable was March 2019, when congestion had an unexpected pattern change.

Table 2 provides a breakdown of the auction arbitrage before and after the policy changes. The source and sink definitions used in the matrix reflect the path of the original CRR being purchased in the annual auctions. The largest arbitrage opportunity accrued in generation-to-generation CRRs prior to 2019. After the policy change, the largest arbitrage opportunity accrued in sell CRRs that were originally purchased for paths from generation locations to CLAPs and SLAP locations.

Table 2: Auction arbitrage in $ millions organized by CRR paths

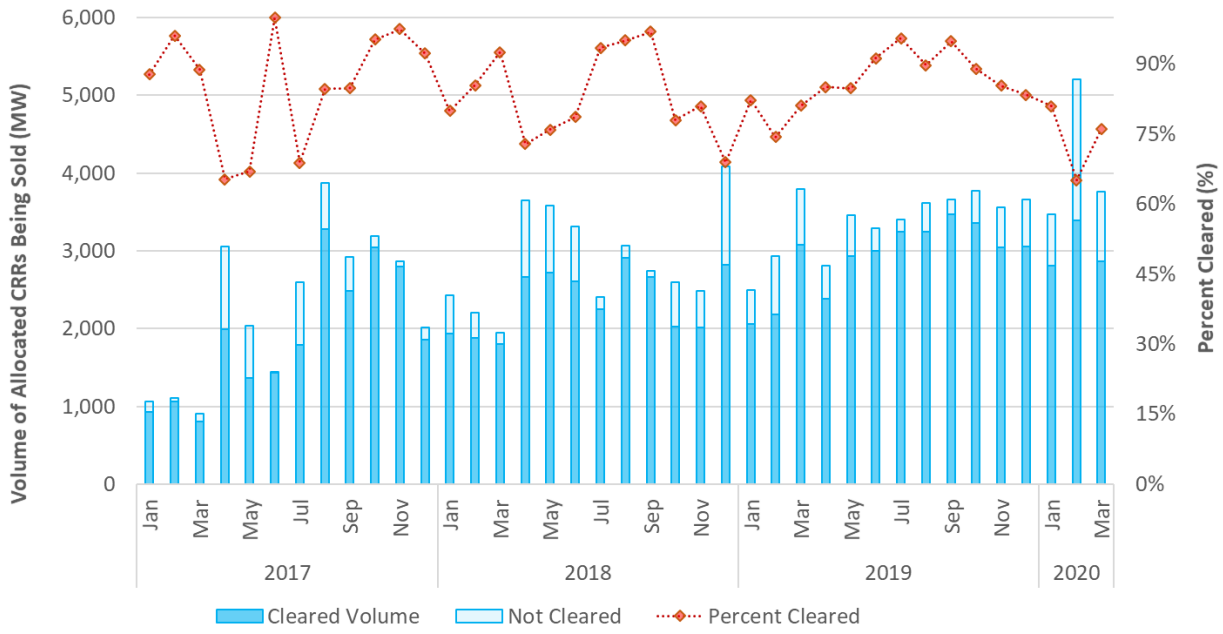
2017-2018	Sink						
Source	CLAP	DLAP	G	PNODE	SLAP	SP	THUB
CLAP	0.06	0.05	0.46	0.06	0.07	-0.02	0.00
DLAP		0.00	0.03		0.00	0.01	-0.01
G	0.39	0.32	8.53	0.05	1.20	0.19	-0.25
PNODE	0.02	0.01	1.01	0.12	0.09	0.05	0.10
SLAP	0.02	0.04	0.13		0.05	0.00	0.00
SP	0.33	0.11	2.63	0.03	0.24	0.86	0.30
THUB	0.00	0.06	0.05	0.00	0.01	-0.01	-0.23

2019-2019	Sink						
Source	CLAP	DLAP	G	PNODE	SLAP	SP	THUB
CLAP							
DLAP							
G	2.67	0.79			2.51	1.17	-0.18
PNODE							
SLAP							
SP	0.52	0.06			0.36		-0.08
THUB	0.02	0.01			0.02	0.01	

7.6 LSE's valuation of allocated CRRs

Another area explicitly analyzed in this effort is regarding the undervaluation of allocated CRRs when sold in auctions. Figure 19 shows the volume of cleared and not cleared CRRs for on-peak time of use for allocation CRRs sold into the annual and monthly auctions. The red markers stand for the percentage of bid-in volume that is ultimately cleared in the auctions.

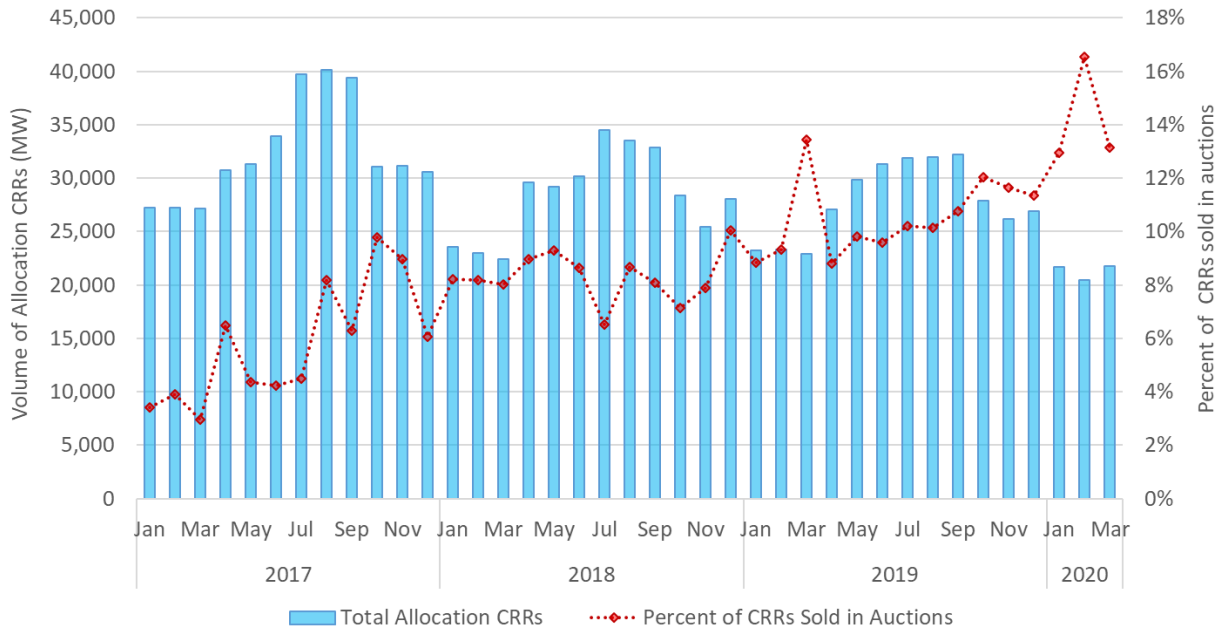
Figure 19: Volume of Sell On-peak CRRs originated from allocations



For 2017 and 2018, an average of approximately 2,500 MW of allocated CRRs were sold into auctions. This volume was increasing steadily even before the policy changes and reached on average 3,500 MW sold in 2019 and first quarter of 2020. The percentage of the bid-in volume cleared in the auctions remained constant through the years at about 83 percent. The increasing volume of selling allocated CRRs into the auction may indicate an increasing reliance of LSEs to rebalance their CRR portfolio and risk profile through the auctions.

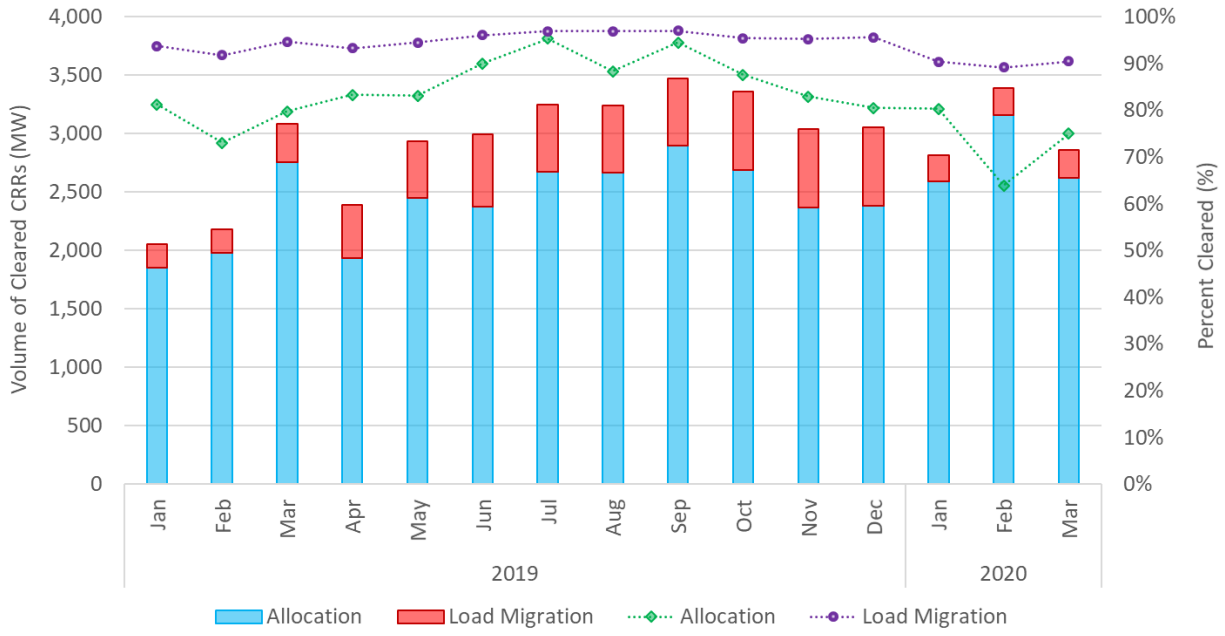
Figure 20 shows the volume of CRRs allocated to LSEs from the allocation processes as well as from the load migration processes. The red markets stand for the percentage of the allocated CRRs that were sold by LSEs in the CRR auctions. In early 2017 only about 4 percent of all allocated CRRs to LSEs was sold in auctions and that increased to about 17 percent of all allocated CRRs in February 2020. The group of LSEs is composed of all entities that are allocated CRRs and is broader than just the main investor-owned utilities (IOUs). Over 90 percent of allocated CRRs being sold in auctions are from non-IOU entities.

Figure 20: Volume of CRRs allocated to LSEs



The increasing volume may also reflect the value of CRR auctions to LSEs. There is also a notable similar trend for allocated CRRs being sold in the auctions for off-peak time of use. The volume of CRRs sold into auctions has a direct impact on the auction results because the sale of these allocated CRRs releases prevailing-flow capacity into the auction that further enables the trading and buying of CRRs.

Figure 21: Cleared volume of On-Peak CRRs organized by type of allocation



There are two general groups of allocated CRRs being sold into auctions: those directly allocated in the allocation processes due to an explicit nomination from the LSEs, and those that are directly assigned to

LSEs due to load migration between different LSEs. Figure 23 shows the relative comparison of these two types of allocated CRRs sold into the auctions. The volume of allocated CRRs is much higher than that of the load migration CRRs, but, in relative terms, the volume of load migration CRRs is fairly significant and represents about 15 percent of all allocation CRRs sold in the auctions. The load migration CRRs put on sale by LSEs are clearing at higher ratios than those from standard allocation CRRs, averaging about 95 percent of cleared CRRs compared to 82 percent of allocation CRRs cleared.

Load migration CRRs are not originally nominated and requested by LSEs. Instead they are assigned to LSEs when load migrates and the receiving LSEs has no option to select which CRRs get allocated. Thus, the auction represents a unique opportunity for LSEs to rebalance their CRR portfolio and get rid of these migrated CRRs if they do not fit into the risk profile. Since load migration CRRs also represent prevailing flows like the standard CRRs, the higher percentage of successful sales in the auction may indicate a willingness to sell those CRRs for less than the allocation CRRs.

Figure 22 shows the selling activity, organized by the origin of the allocated CRs being sold. A CRR allocated in the annual process can be subsequently sold in either the annual or monthly auction, while CRRs allocated in the monthly process can only be subsequently sold in the monthly auction. This metric represents the percentage of allocated CRRs sold. On average, out of all the allocated CRRs put for sale, approximately 70 percent were sold in the monthly auctions.

Figure 22: Cleared volume of On-Peak CRRs organized by process

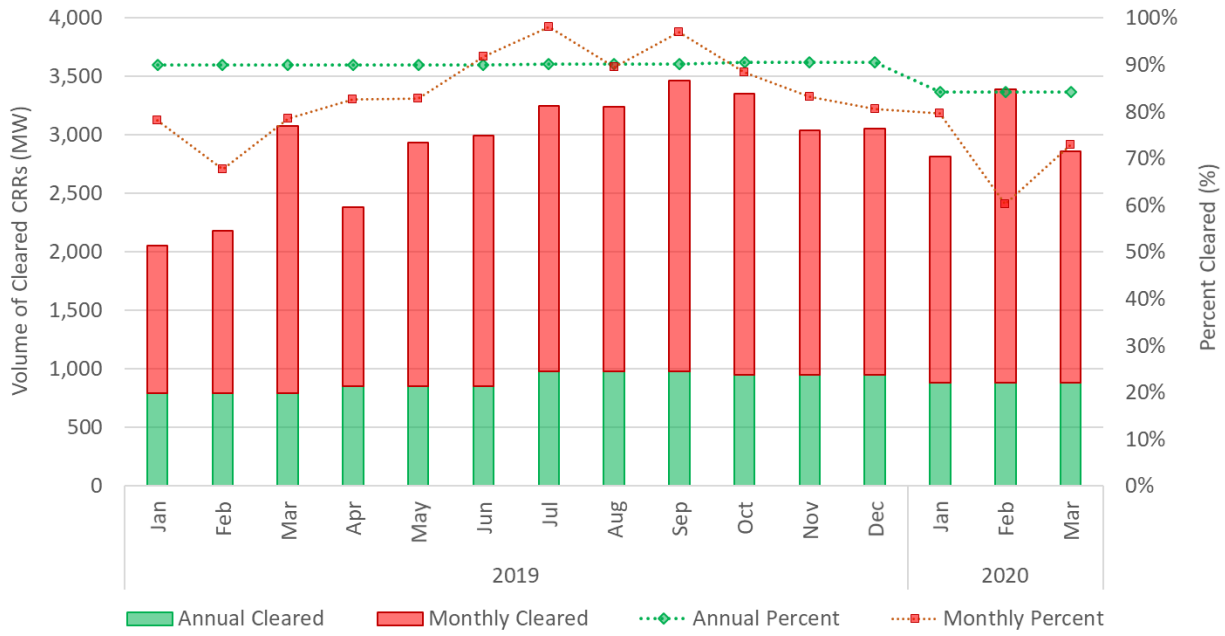
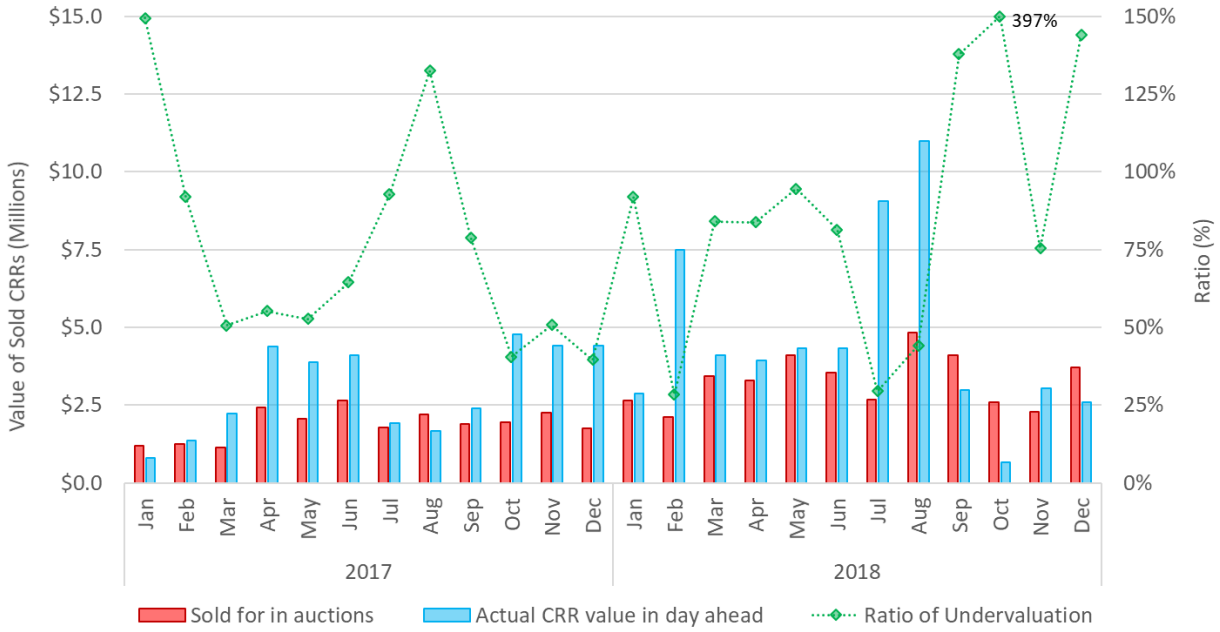


Figure 23 compares the money flow associated with allocated CRRs sold in the CRR auctions. The bar in red represents the auction revenues paid to LSEs for selling their CRRs. The bars in blue represent the face value of these CRRs when settled at the day-ahead congestion prices; *i.e.*, the CRR payments the LSE would had received if they had kept these CRRs instead of selling them. When these two bars track relatively closely one to another, the LSEs valued these allocated CRRs based on what turned out to be their actual value in the day-ahead market. When the bars in blue are higher than the bars in red, LSEs are undervaluing the CRRs. For instance, consider the month of August 2018, LSEs were paid about $4.8

million in the auctions for selling allocated CRRs, while the actual value of those CRRs in the day-ahead market was about $10.9 million. Overall, LSEs undervalued CRRs by about $13.8 and $17 million in 2017 and 2018, respectively.

Figure 23: Undervaluation of allocated CRRs sold in auctions



LSEs, like any other CRR auction participant, actively submit bids expressing their willingness to sell CRRs; they can fully control the price at which to sell CRRs. The LSE may be properly valuing their CRR based on their risk tolerance given the day-ahead congestion is not certain. Regardless, when looking at the day-ahead settlements after-the-fact, the undervaluation represents a loss for LSEs because they may have been able to sell those CRRs at a higher price.

This loss is not a question of auction efficiency, but it represents a loss born by LSEs due to the undervaluation of the sold CRRs or the sale of CRRs at a discount which may also reflect their aversion to day-ahead congestion risk. This undervaluation may also be a result of the complexity in properly hedging congestion risk. Further, this undervaluation problem is not rooted in the fact that the CAISO makes the auction available to LSEs to dispose of their unwanted CRRs. Even if the CAISO lacked an auction, this LSE loss would still materialize through the bilateral market and may even be more significant because LSEs would be engaging in bilateral transactions that are more restrictive in terms of collecting buyers and sellers. The benefit with the auction is that the CAISO can track this loss and LSEs can tailor their offers more accurately based on the historical sales.

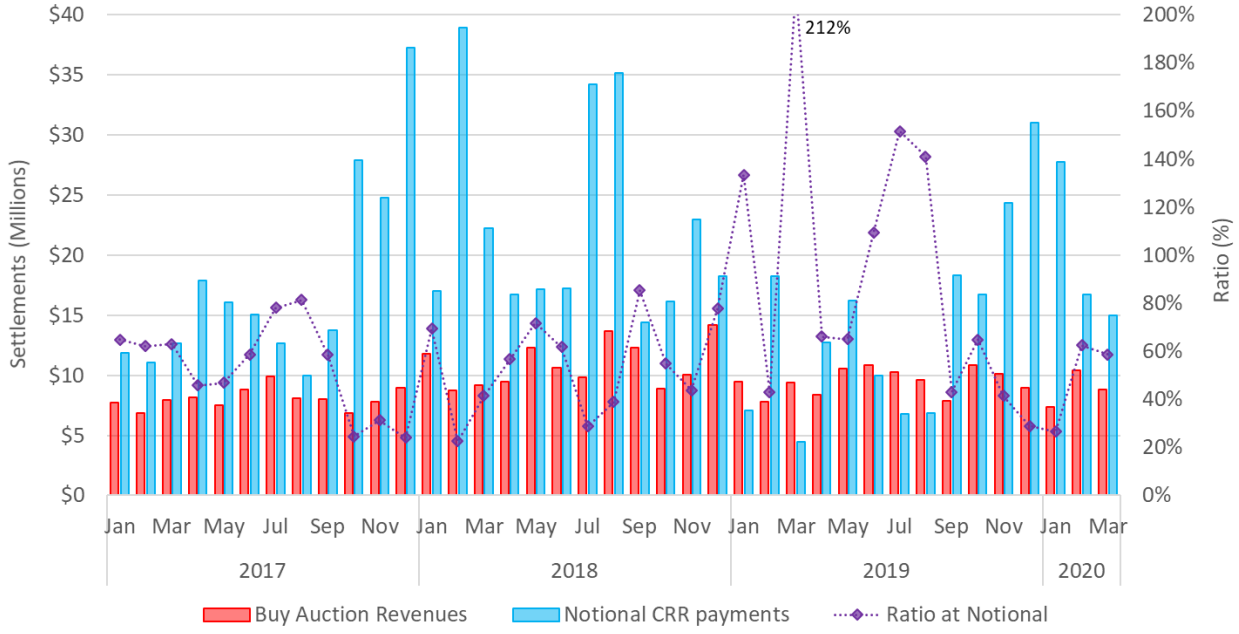
The assessment of undervalued allocated CRRs sold in auctions could be done precisely prior to 2019 because CRR payments then were explicitly tracked as buy counter-flow CRRs and because CRRs were guaranteed full-funding of the awarded MWs. Full funding effectively values CRRs at the payment they obtain in the day-ahead market, regardless of which LSE's portfolio they belong. This assessment cannot be done the same way after the implementation of the pro-rata funding. The valuation of a CRR is simply the auction revenues paid to the holder by selling allocated CRRs versus the CRR payment that otherwise would have been collected in the day-ahead market. After pro-rata funding was implemented, the CRR

payments are not fixed values for the full MWs awarded. Instead, the CRR payments are now pro-rated based on the particular CRR's impact on the deficits across the different constraints as a part of the overall portfolio of its holder. Therefore, a CRR with the very same definition (source, sink, TOU) will have a different payout and therefore a different value depending on who owns the CRRs. Even if one assumes that CRR is held by the same LSE that is selling the CRR, the issue is that by the mere fact of the CRR being held by the LSE the pro-rata allocation of the deficits on that portfolio will now be different because the ownership of that additional CRR will change the proportionality of the deficit being allocated to the LSE. In order to properly assess the loss from undervaluation, the CAISO would need to recalculate the entire pro-rata CRR settlements under the assumption that LSEs still hold their CRRs. This is a complex and intensive calculation that cannot be pursued.[12]

7.7 Assessment of auction efficiency

The CAISO has no feasible way to assess the impact of each policy of the policy changes that took effect on 2019 separately because all three policy changes impact the valuation by market participants of the CRRs they choose to sell as reflected in their CRR bids. The elimination on non-delivery paths redirects CRR participants to bid for the allowed paths, while the potential impact of the pro-rata is also factored into participants' CRR bids.

Figure 24: Monthly CRR auction revenue shortfall with full CRR notional value



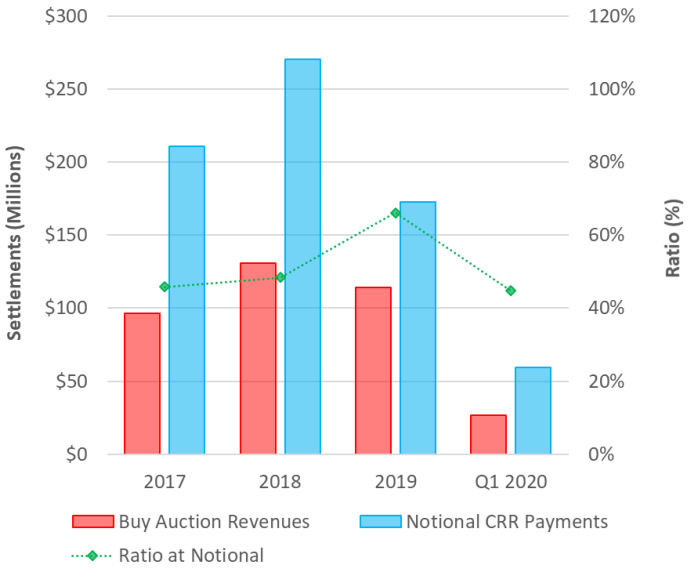
[12] Although it is not feasible to calculate the CRR undervaluation for each allocated CRRs being sold in auctions, there may be an indirect way to assess the overall undervaluation of all CRRs sold if the overall congestion rents are compared to the overall position of LSEs and the total auction efficiency analyzed in this report. Effectively the difference between the overall LSEs position and the auction efficiency could measure the undervaluation. This may be a metric developed in subsequent efforts.

Based on the additional considerations explained in the previous section, Figure 24 shows this metric for the last three years. For the years 2017 and 2018, this reflects the revised metric explained earlier which does not include the LSE's undervaluation for selling their allocated CRRs.

This adjustment allows the CAISO to compare the 2017 and 2018 outcomes to the 2019 outcomes on the same basis. Figure 24 reflects only the auctioned CRRs with the full notional CRR payment. Auction revenues account for the revenues from both the annual and monthly auctions and reflect the net auction revenues where negative revenues from selling auction CRRs (or negatively priced CRRs) offset the gross and positive auction revenues from the buy CRRs. This figure does not include the revenues for selling allocated CRRs. The dotted line in purple shows the ratio of auction revenues to CRR payments. This auction efficiency measurement improves marginally as compared to 2018 and 2017. In fact, there are some months, including February, July and August 2019, where the auction efficiency is greater than 100 percent, which indicates months in which the auction revenues were higher than the CRR payments for auction CRRs.

Figure 25 shows this marginal improvement in 2019 on a more consolidated and annual basis. It also shows the first quarter of 2020. Auction efficiency performance in Q1 2020 appears to be about the same performance as in 2017 and 2018, but it is only preliminary and inconclusive as to its performance over the rest of the year. This metric does not show the final settlements nor the explicit effect of the pro-rata funding. It reflects only the efficiency when using the CRR notional value prior to the application of the pro-rata funding.

Figure 25: Annual CRR auction revenue shortfall based on full CRR notional value



The second main policy pertaining to the pro-rata CRR funding was primarily developed to address concerns of revenue inadequacy. The impact on revenue adequacy is discussed in the next section of this report. The implementation of the pro-rata funding logic indirectly impacts the auction efficiency because it reduces the CRR payments to auctioned CRRs and, thus, will only improve the CRR auction revenue shortfall ratio. Figure 26 compares the CRR payments at full notional value versus at the pro-rata value only for CRRs released in the auctions. The application of the pro-rata funding results in lower CRR

payments. As reflected by the difference in the blue and red bars, the reductions in CRR payments were fairly significant in the Q4 2019 and Q1 2020, respectively. This difference reflects the impact of the pro-rata funding implemented in January 2019. Prior to 2019, the notional value and the adjusted value are equal since full funding was in place.

Figure 26: Monthly CRR value at full notional vs. pro-rata basis

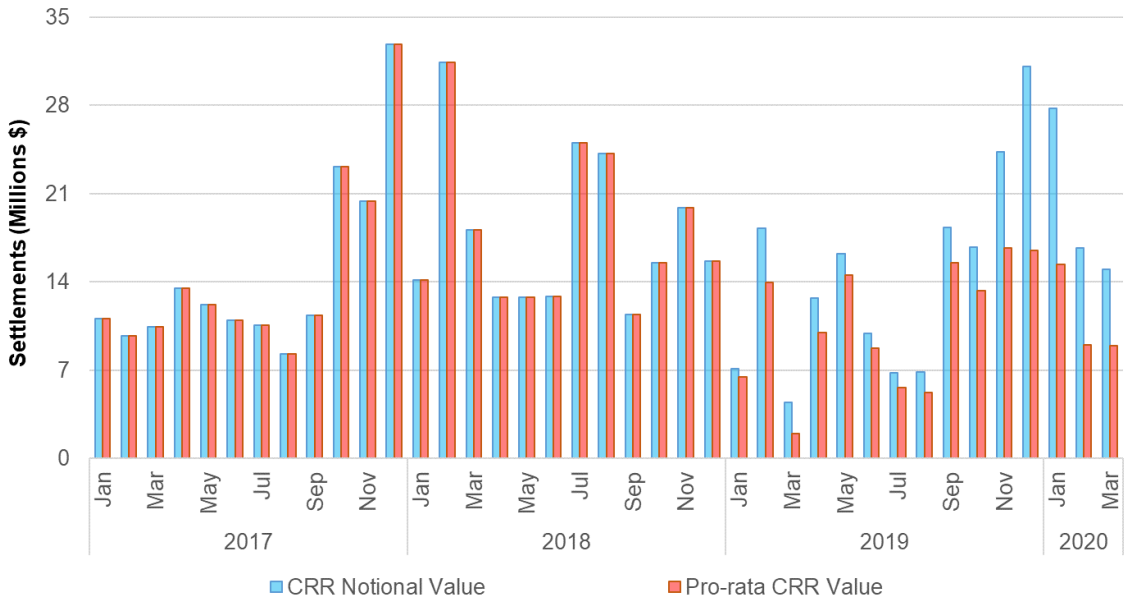
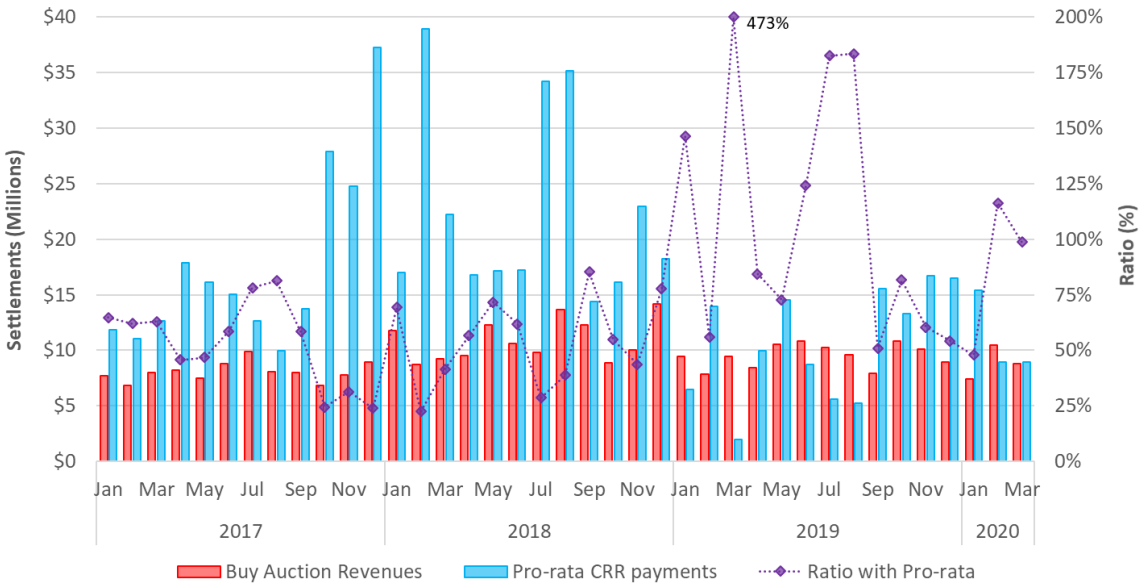


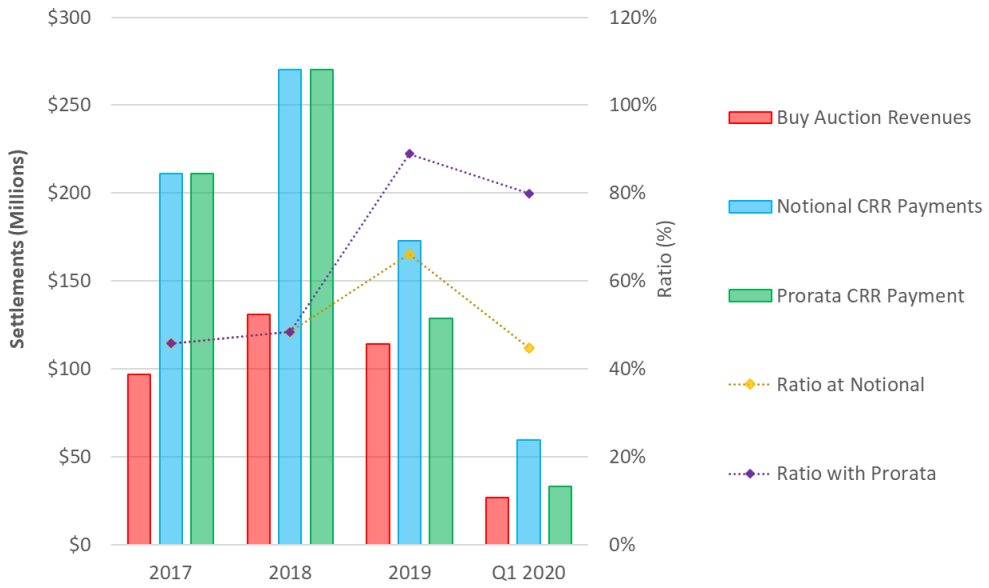
Figure 27 shows the CRR auction revenue shortfall using the final pro-rata CRR payments. As expected, the pro-rata funding reduces the CRR payments to auctioned CRRs, while the auction revenues remain the same, which in turn improves the CRR auction revenue shortfall ratio.

Figure 27: Monthly CRR auction revenue shortfall based on CRR pro-rata value



The improvement is shown concisely in Figure 28. This figure shows that the pro-rata funding alone reduced the payments to auctioned CRRs by about $44.2 million and $26 million in 2019 and Q1 2020, respectively. The pro-rata funding in turn improved the CRR auction revenue shortfall ratio from 66 percent to 87 percent in 2019 and from 45 percent to 80 percent in Q1 2020.

Figure 28: Annual impact of pro-rata funding on auction revenue shortfall



In comparison to the performance prior to the policy changes, the auction efficiency improved from 47 percent in 2017 and 2018 to 61 percent in 2019 and Q1 2010 with no pro-rata adjustment. Once the pro-rata adjustment is applied, the improvement in 2019 increases to 87 percent. In absolute terms, the CRR auction shortfall was $14.2 million and $6.7 million in 2019 and Q1 2020, respectively. This is noticeably smaller than the auction shortfalls of $114 million and $139 million in 2017 and 2018, respectively.

Although it is not possible to assess the individual impact of each policy, the figures above show the policy changes implemented in 2019 improved the performance of the CRR processes. As explained earlier, this metric cannot assess the inefficiency introduced by LSEs undervaluing their sold CRRs, but this is not an inefficiency of the auction. However, the CRR auction shortfall does track the efficiency of the auction by targeting the efficiency of participants to profitably arbitrage i) from the annual auction to the monthly auction, and ii) from the CRR auctions to the day-ahead market.

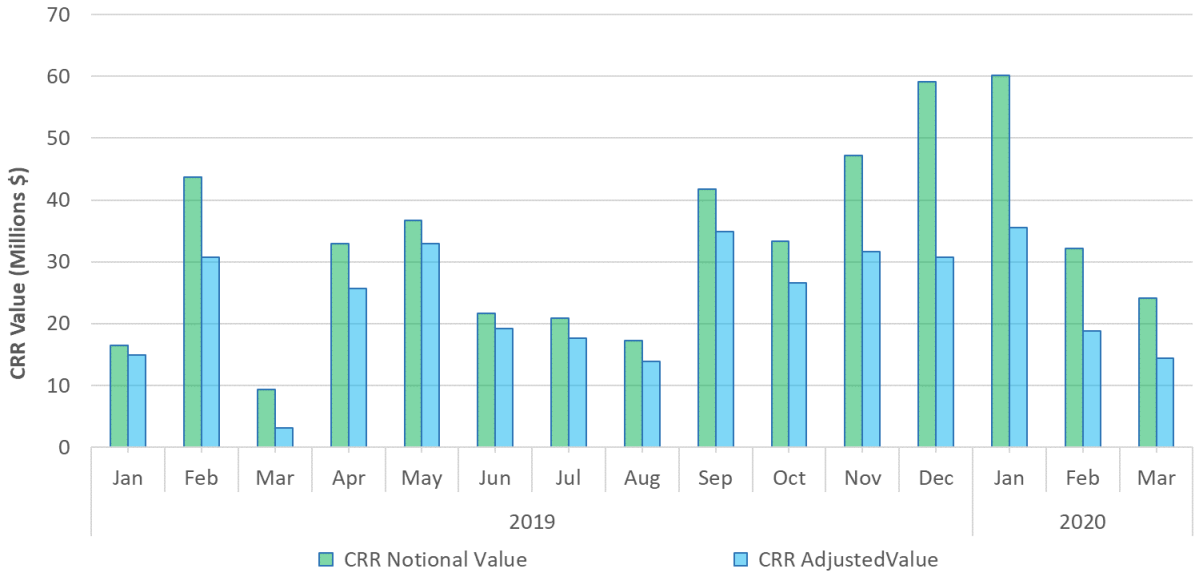
8 Revenue Adequacy and Pro-Rata Funding

Revenue adequacy is a term used to refer to the sufficiency of the funds collected in the day-ahead market to pay the notional value of released CRRs. In the purest definition of revenue adequacy, the congestion rents collected in the day-ahead market should be sufficient to fund all the CRR payments. Under the original CAISO construct, the auction revenues were also used to fund CRRs together with the congestion funds collected in the day-ahead market. If the CAISO did not collect sufficient funds to cover the released CRRs, the CAISO would cover such deficiencies by allocating the costs to metered demand and exports, regardless of the nature of CRRs – allocations, auctions or load migration. These actions were performed through the CRR *balancing account*. Any surpluses in the CRR balancing account were also allocated to measured demand. Since the inception of the CRR market, CRRs have generally observed a deficit in the congestion revenue collected in the day-ahead market which has necessitated the need to use the auction revenues to fund the released CRRs and, in some instances, resulted in an uplift to measured demand. The drivers of revenue inadequacies were extensively discussed in previous CRR performance efforts and arise mainly from model differences between the CRR auctions and the day-ahead market.

The partial funding policy adopted as of January 2019, requires that the CAISO adjust CRR payments down based on entities CRR's contributions on deficits on a constraint-by-constraint basis. Because different constraints may lead to surpluses or deficits, surpluses from a constraint are not netted against deficits from another constraint.

Figure 29 shows the monthly trend of CRR payments under the new pro rata funding approach. The full funding approach is reflected by the *notional value*, and the partial funding approach is reflected by the *CRR adjusted value.*

Figure 29: Adjustment to all CRR notional value with pro-rata funding



The difference between these two values reflects the level of deficit that has been allocated on a pro-rata basis to all CRRs based on their specific contribution on the deficit. For the period under analysis, the CRR

notational value was adjusted down by about $146.1 million, which is approximately 29 percent of the full notional value of $496 million; this is effectively the amount of the CRR deficit that was allocated pro-rata. In addition to allocating CRR deficits, the new settlements rule implemented as part of CRR1B collects any CRR surplus into the balancing account. In any given settled hour, the settlements system may observe both surplus and deficit accrued on CRRs. These surpluses and deficits do not offset each other when they are associated with different constraints. The only offsetting between surplus and deficits is within the same calendar month for the same constraint. The system surplus and deficit collected on a monthly basis are shown in Figure 30. The system-wide surplus was about $80 million and deficit was about $145.2 million. These estimates are summarized on an annual basis in Figure 31.

Figure 30: Directional offset applied to CRR settlements

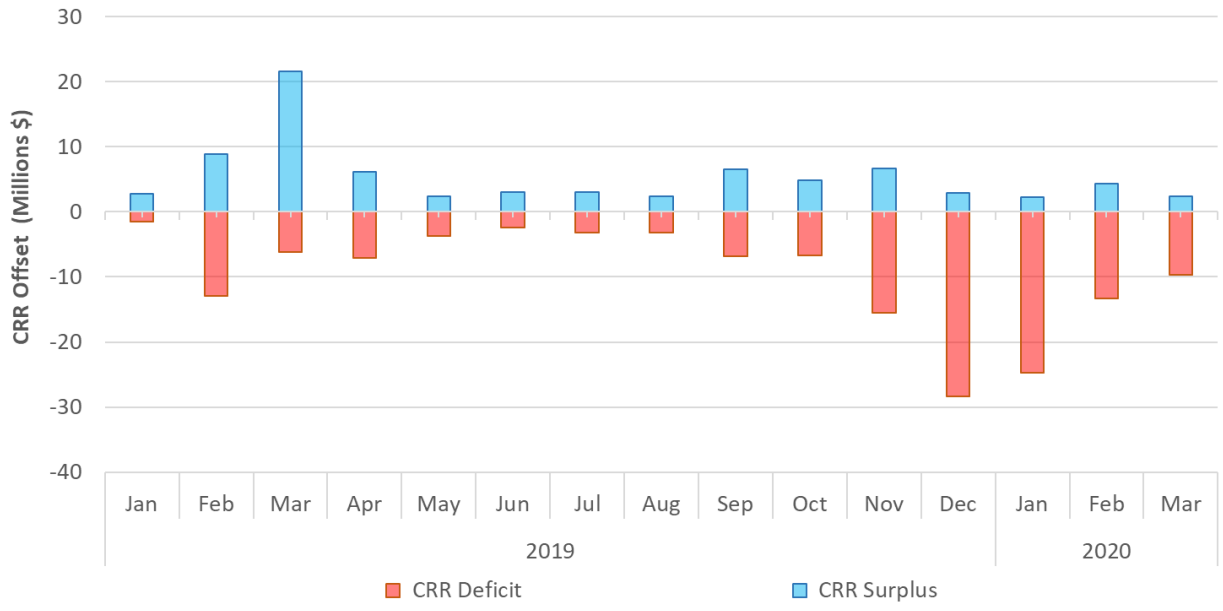
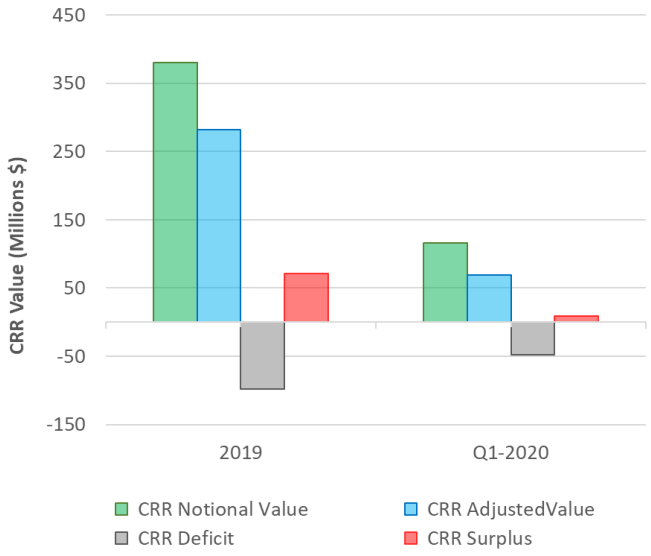


Figure 31: Annual CRR settlements with pro-rata funding



The pro-rata funding effectively achieves revenue neutrality which in turns eliminates the uplift allocated to measure demand. Under the current rules, measured demands is still allocated any surplus of the balancing account. Figure 32 compares the outcome of the current partial funding to the scenario if full funding were still in place. This comparison allows to size the impact of the pro-rata funding on measured demand, which was about $146.6 million for 2019 and Q1 2020.

Figure 32: Impact of pro-rata funding to the balancing account allocated to measured demand

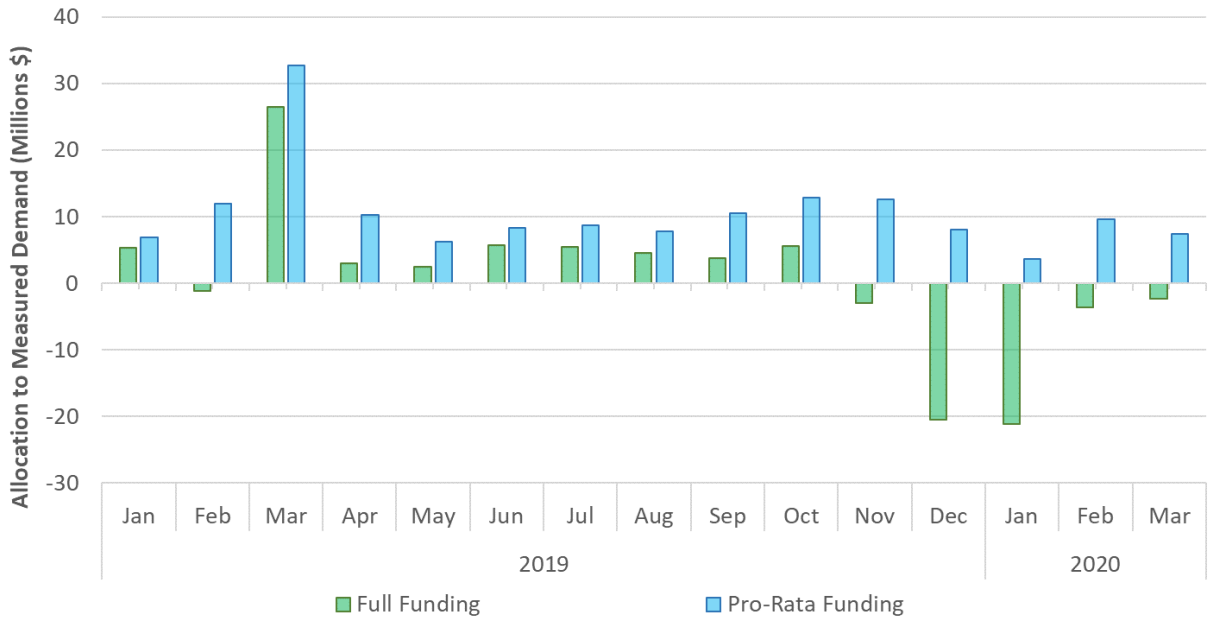
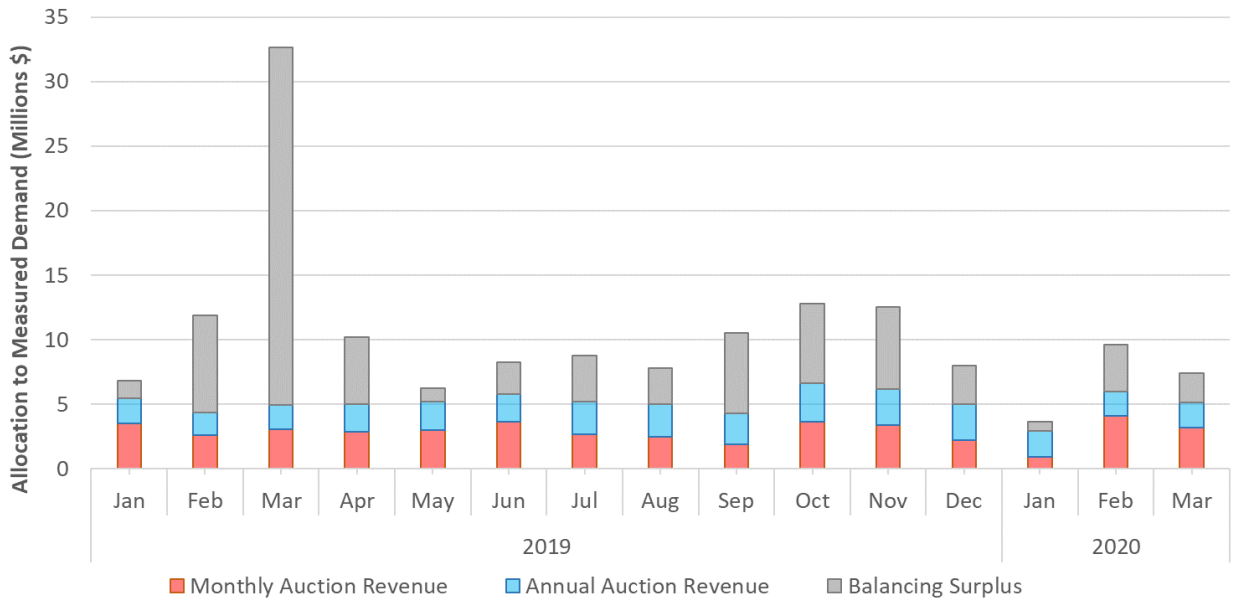


Figure 33 shows the breakdown of the balancing allocated to measured demand and the relative contribution of the auction revenues and to the surplus.

Figure 33: Breakdown of surplus allocated to measured demand



About a half of the balancing account is sourced from the surplus collected in the CRR settlements while the other half is from auction revenues. The extreme surplus collected in March 2019 arose when congestion in the norther part of the system observed an atypical pattern, resulting in reversal of direction for many CRRs.

8.1 Impact of pro-rata funding on CRRs

The pro-rata funding applied to achieve revenue is based on the relative contribution of each CRR to the calculated CRR deficit by constraint. Different CRRs have different impact on the constraint deficit and will be allocated different contributions of the CRR deficit. This relative contribution is independent of the origin of the CRR (allocation, auction or load migration). Figure 34 shows the breakdown of the obligation CRR deficit allocated to CRRs by the type of process where these CRRs originated. Overall, there is an even distribution of CRR deficits across all type of CRRs, with about 56 percent of the deficit allocated to obligation CRRs coming from the auctions.

Figure 34: Allocation of CRR Deficit to different types of CRRs

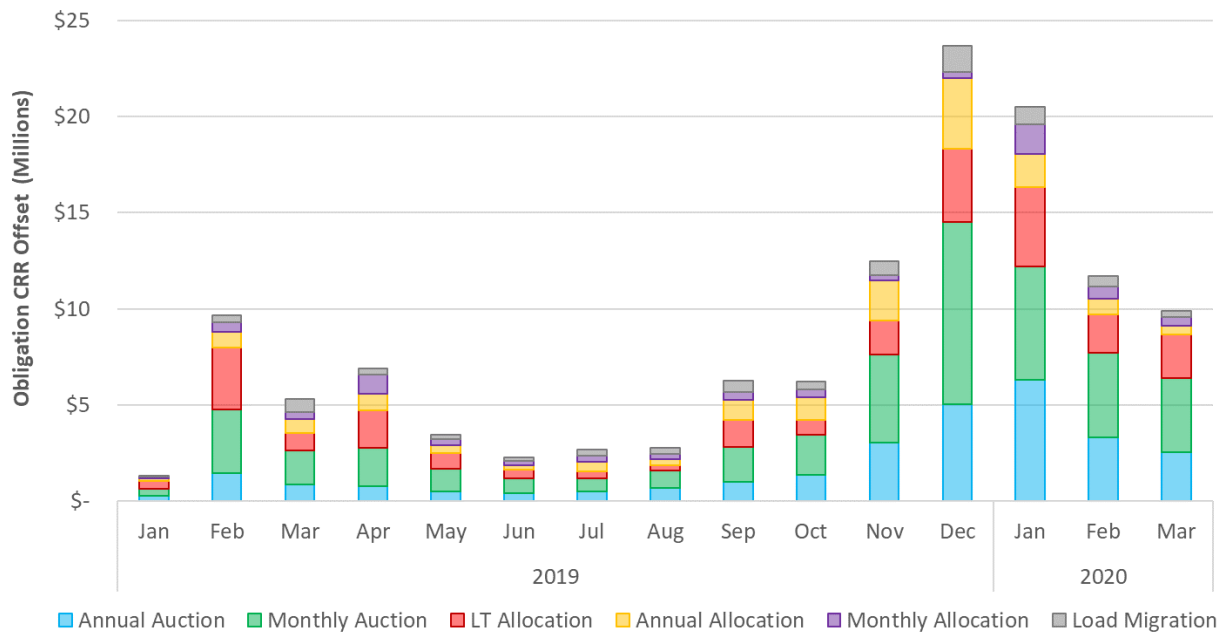


Figure 35 shows the relative distribution of CRR adjusted values after the deficit has been allocated. About a half of the adjusted value is associated with obligation CRRs originated from the auctions.

Figure 35: Adjusted CRR value by different types of CRRs

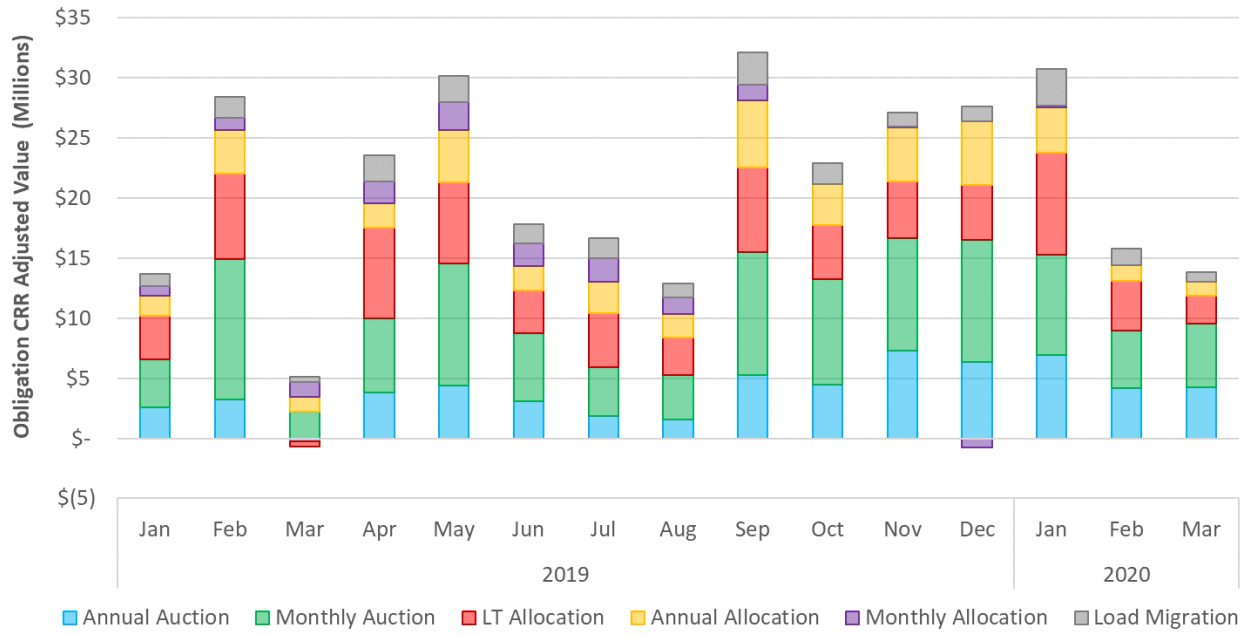
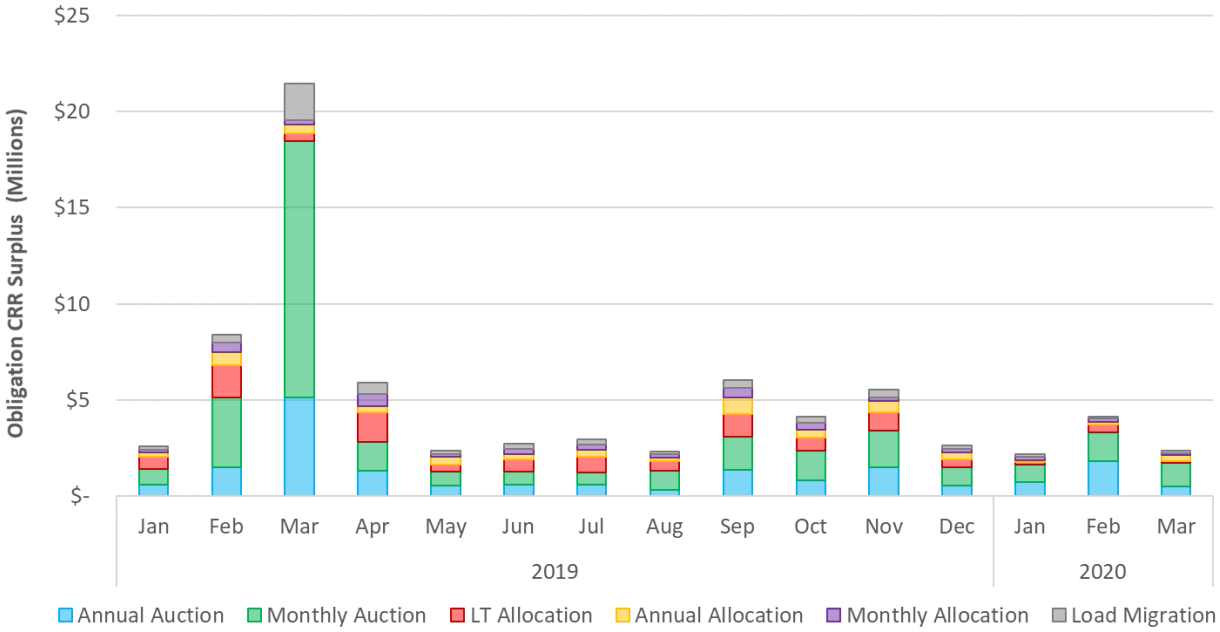


Figure 36 shows the distribution of the CRR surplus relative the different types of obligation CRRs. About 66 percent of the surplus is associated with obligation CRRs originated form auctions; the rest is distributed among the various types of obligation CRRs released in the allocation processes.

Figure 36: CRR surplus allocated to different types of CRRs



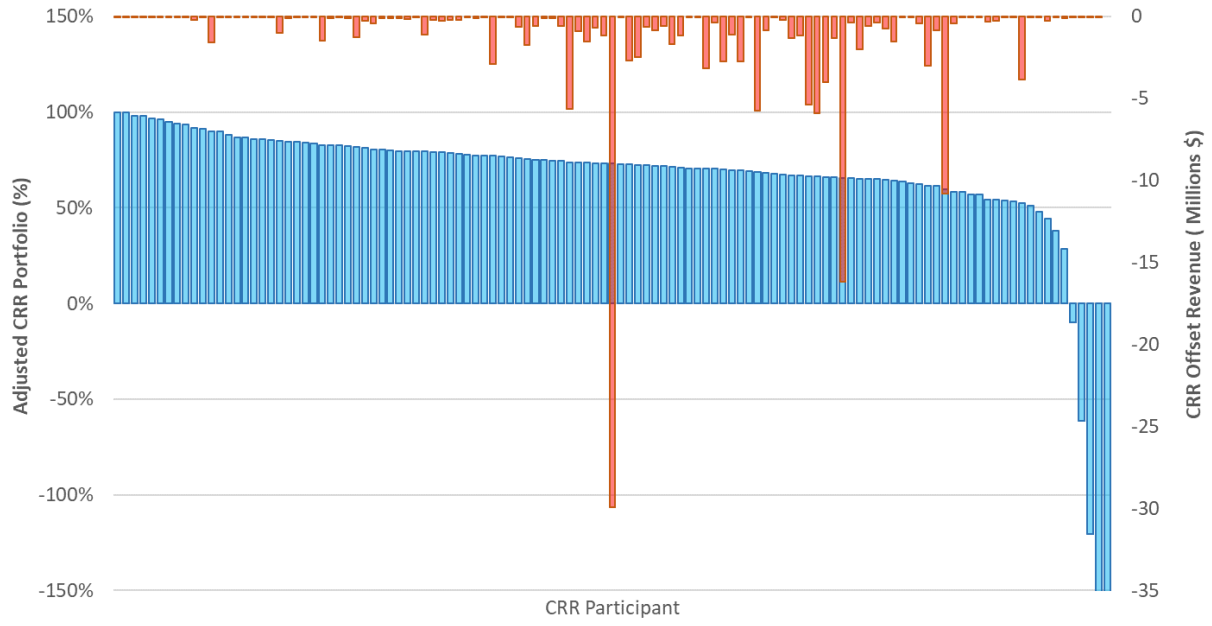
8.2 CRR settlements reversal due to pro-rata funding

The pro-rata allocations of deficits are on a constraint-by-constraint basis. The notional and adjusted CRR portfolio value can be calculated by summing up all the constraint contributions.

Figure 37 shows all CRR portfolios ranked by the adjustments performed. The left side of the plot shows portfolios with no adjustment (*i.e.*, no deficit allocation). CRR portfolios that have been adjusted to near zero are shown towards the left side of the figure. On the far right, there are a few portfolios that have actually reversed position. An 80 percent value indicates that the portfolio is now worth only 80 percent of the face (nominal) value, *i.e.*, the CRR portfolio was reduced by 20 percent. This 20 percent is the aggregated reduction since some constraints may have larger or smaller reductions. The bars in red represent the deficit in dollars allocated to the particular CRR portfolio to provide a reference of magnitude of the adjustment. For instance, the portfolios on the far right of the plot show steep reductions but, when complemented with the magnitude of deficit allocation, these reductions were made to relatively small portfolios. The level of adjustment applied to each CRR portfolio depends on the composition and is relative to the constraints congested in the settlements period.

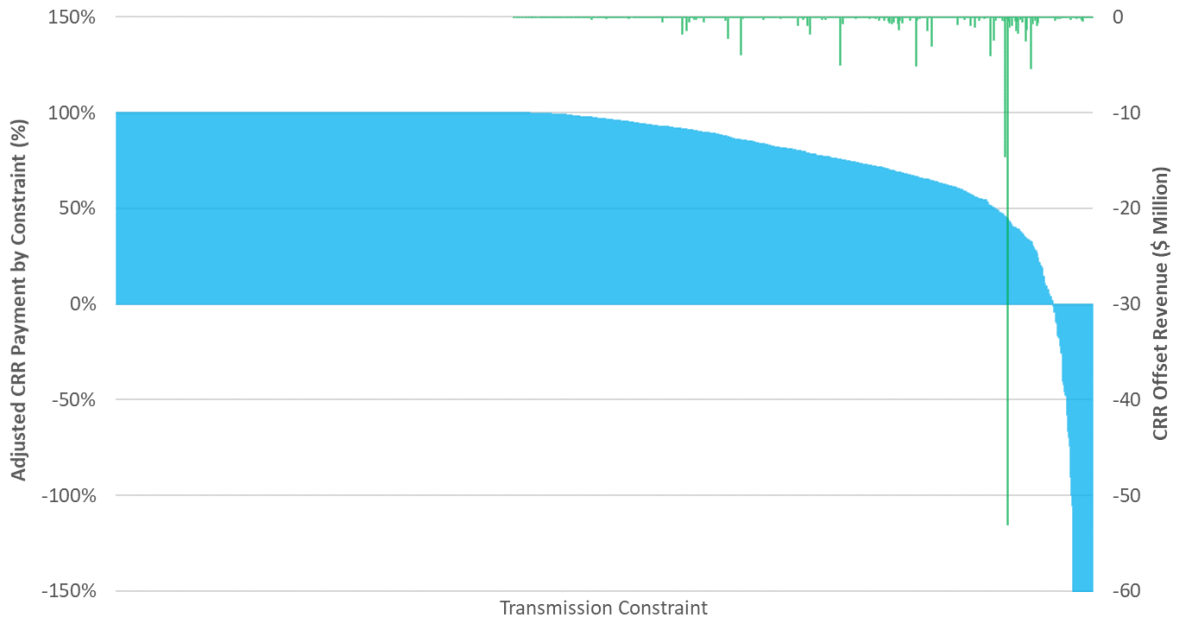
After the implementation of the pro-rata funding, there have been instances in which a CRR portfolio value reverses its position. In other words, the notional value of the CRR portfolio was positive (a payment to the CRR holder) but, after the pro-rata allocation of the deficit, the adjusted CRR portfolio value turns out negative, meaning the CRR holder faces a charge. This is not an issue or a flaw in the implementation of the pro-rata logic. Generally, this may happen when CRR portfolios are composed of both positive and negative contributions. Then deficit allocations reduce only the positive contribution to a level such that it becomes less than the negative contribution, resulting in a net negative position.

Figure 37: Portfolio adjustments due to pro-rata funding



Another driver of this reversal for CRR portfolios has its root in specific constraints reversing themselves. In such cases, a constraint may have a positive notional value and the allocated deficit is such that the resulting adjusted value turns out to be negative. Figure 38 shows a similar illustration as Figure 37 but for individual constraints; each blue bar represents a specific transmission constraint. About 44 percent of all constraints had no adjustment and about 4 of constraints see a reversal. The bars in green also show the magnitude of the deficit allocation in dollars, providing a reference of relative proportion.

Figure 38: Constraint adjustments due to pro-rata funding



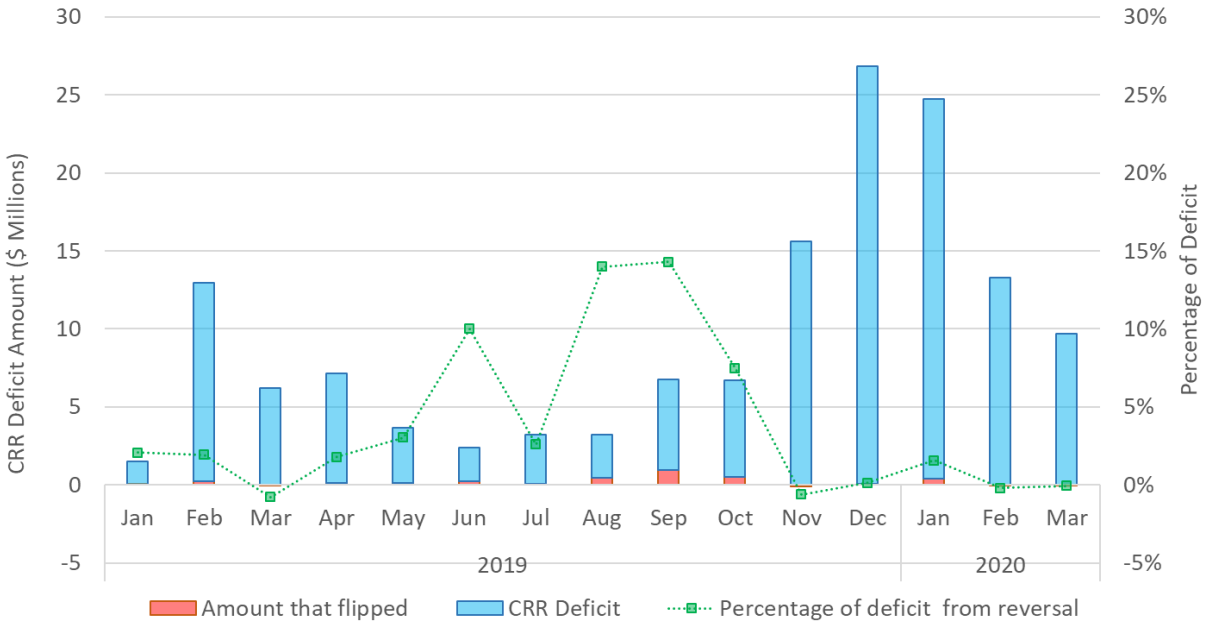
This outcome does originate in the CAISO's congestion management protocol used in the day-ahead market and typically materialize for relatively small constraints that are associated with small load pockets when these constraints happen to bind.

In the CAISO energy markets, congestion management is carried out by using linearized constraints around a given operating point using AC power flows. In order to handle computational burden and minimize the potential for ineffective movement of generation located far away from transmission constraints, the CAISO uses a shift factor threshold of 2 percent for congestion management. This means that any resource - either demand or supply, physical or virtual - that has a shift factor below 2 percent will not be used in the management of congestion to clear the energy market. As a result, the locations with shift factors below 2 percent are not used in the CRR pro-rata funding calculation. This becomes relevant when dealing with aggregated locations such as default load aggregation points (DLAPs) or Trading Hubs, which are significantly larger than any typical individual resource. For instance, in the summer with loads near 50,000 MW of peak load, the DLAPs can easily be in the range of 15,000 MW. When the shift factor of 2 percent is applied, it means that an injection of 15,000 MW with an effectiveness of, say, 1.5 percent will not be considered for congestion management, even though this means a flow contribution of 225 MW (15,000 MW * 1.5%) on a given constraint. The key factor is that the day-ahead market linearizes the power flows around a given operating point, even when this implies a flow contribution over 200 MW on a given constraint it is part of the fixed flow contribution instead of

the incremental contribution defined with shift factors. If this constraint is small, say, about 100 MW, the effect of the shift factor alone can easily lead the constraint to reverse direction in the CRR pro-rata funding. In relative terms, this issue is small when compared to the overall CRR settlements, but it does represent about $3 million of settlements reversal in the first 15 months of the implementation of the new policy.

Figure 39 shows this comparison. The bars in blue represent the CRR settlements that did not reverse direction, while the bars in orange is the CRR settlements that reversed direction once the deficit is allocated. The CAISO is currently exploring an enhancement to not apply the shift factor threshold to Trading Hubs and DLAPs in the energy markets, which may address the root cause of this flow reversal.

Figure 39: Settlement impact of constraint reversal in pro-rata funding



8.3 Drivers of CRR deficits

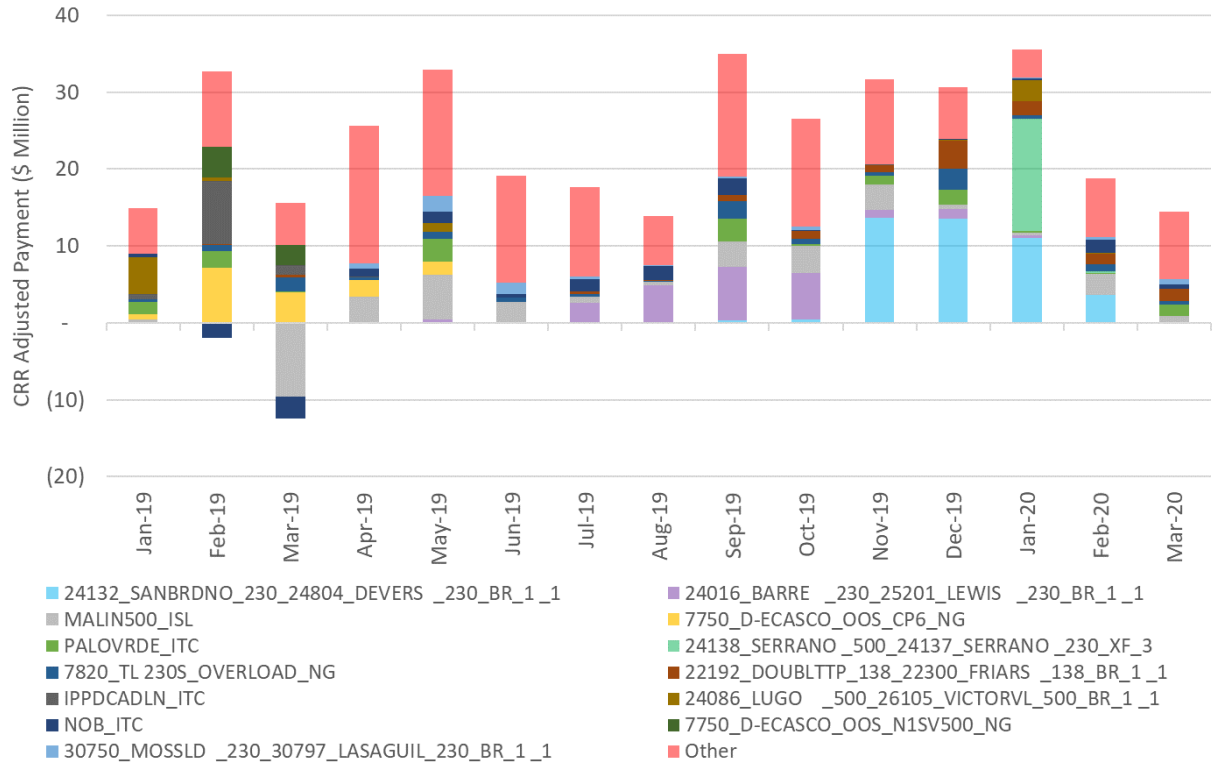
Since the implementation of the CRR markets, the CAISO has tracked the drivers of revenue adequacy. The implementation of the pro-rata funding has largely neutralized revenue inadequacies, as they are allocated to the constraints and CRRs that drive the deficiencies. The calculation of the pro-rata funding makes it possible for the CAISO to more easily identify the constraints driving either CRR surplus or deficits.

Revenue adequacy is rooted in transmission capacity differences between the CRR market and the day-ahead market. This was extensively discussed in the previous effort of the CRR auction performance. Effectively, any transmission modelling differences between these two markets can drive revenue deficits. Some of these differences are inherent to the nature of these two markets, including i) model granularity when the CRR model uses one single transmission limit per constraint while the day-ahead can vary hourly, ii) timing differences when the CRR market may not account for outages run versus outages being modeled in the day-ahead market timeframe as well as more dynamic changes happening in the day-ahead market. There are also other factors rooted in the fact that the CRR system models the transmission

system in a DC-based market versus the day-ahead market using a linearized AC. In previous sections of this report and also in previous discussions about CRR performance, it has been explained that loop flows modeled in the day-ahead market have been a contributor to revenue deficiencies when these loop flows use capacity that no longer collect congestion rents while the CRR market may fully release transmission capacity as CRRs. The CAISO has also provided analysis that the shift factor threshold has implications on CRR deficits. These drivers are explained in more detailed below.

Figure 40 shows the CRR adjusted payments broken out by the top transmission constraints. The "Other" category represents the many other transmission constraints that are too small to be represented individually. Having individually small constraints is generally a good thing because it means that no pervasive constraint leads to systemic congestion in the transmission system. In the last quarter of 2019, this was not the case when a single constraint collected the largest deficiency. This was the constraint of San Bernardino–Devers, which is a contingency–based constraint for a transmission element located in the southern part of the CAISO system. The CAISO analyzes this constraint in more detail in the subsequent subsection.

Figure 40: CRR adjusted value organized by constraint



These adjusted values reflect the deficit allocation, which can also be explicitly identified by constraint as shown in Figure 41. This shows that the majority of the deficit was allocated to the San Bernardino–Devers constraint. Concurrent with the CRR deficit, the pro-rata logic also tracks separately the CRR surplus by constraint as shown in Figure 42. The Malin intertie has the largest surplus accrued in March when congestion changed the typical flow pattern in the northern part of the system (at some point Malin intertie was actually binding in the export direction).

Figure 41: CRR Deficit organized by constraint

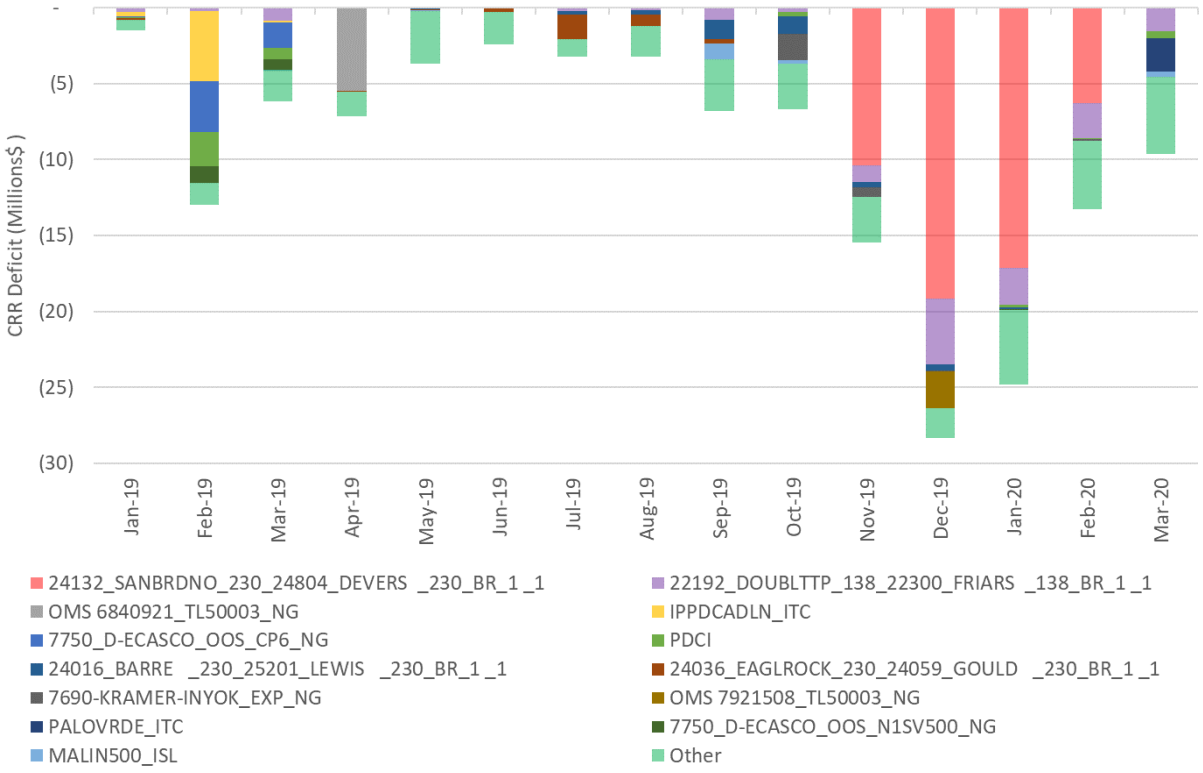
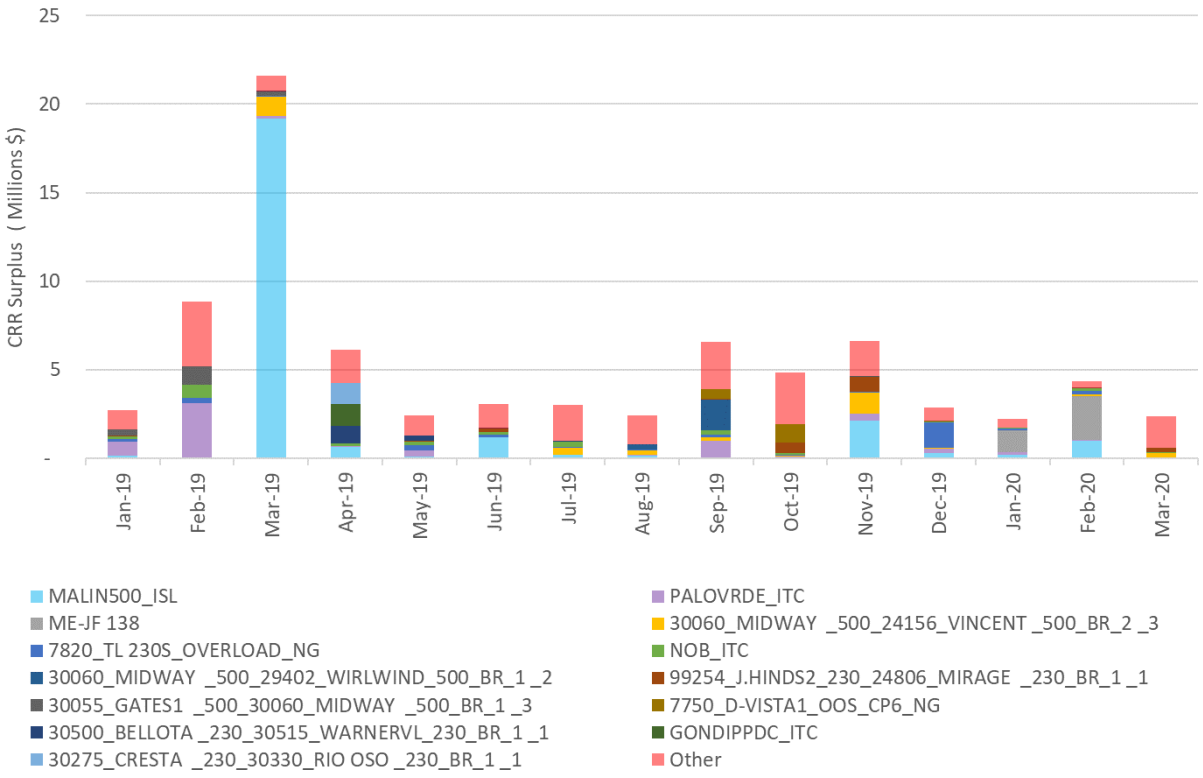


Figure 42: CRR Surplus organized by constraint



8.3.1 Impact of loop flows

The CAISO markets are affected by inadvertent loop flows that may circulate in different transmission elements of the CAISO system and may also affect the CRR markets. These loop flows are dynamically calculated as part of the market solution when the estimated demand and generation from adjacent balancing authority areas are included in the full network model. The contributions of these loop flow estimates are considered as fixed flows in the system constraints. Although these flows are not optimized as part of the market solution, they can reduce or add more transmission capacity to constraints when they are in the prevailing or counter-flow direction, respectively. When the loop flows reduce capacity available for optimization in the day-ahead market, less congestion rents are collected in the market. If that capacity is less than the capacity released in the CRR markets, a revenue deficiency will arise. This will consequently require CRRs on that constraint to be pro-rata funded to achieve neutrality. As described in earlier sections, the use of a 2 percent threshold for shift factors also impacts the capacity on which congestion rents are collected.[13]

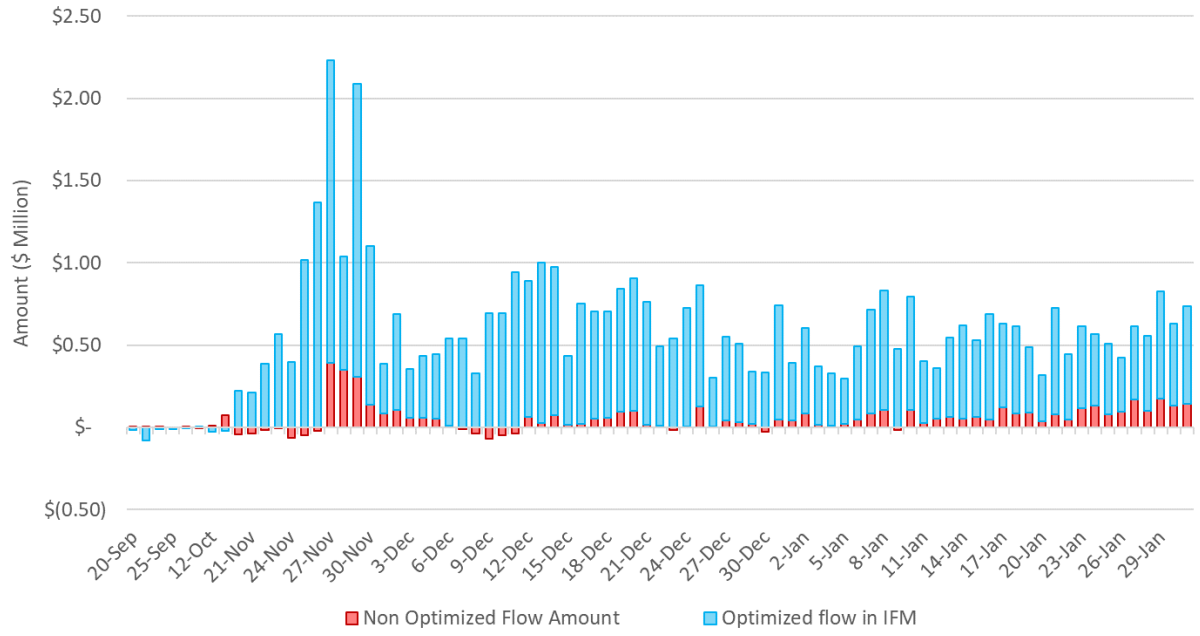
Loop flows are explicitly modelled in the day-ahead market. However, doing so is more complex in the CRR processes. Loop flows are dynamically estimated as part of the day-ahead market solution when the expanded full network model is utilized. These estimates take into account the supply, demand, and interchanges in external balancing areas. This allows the CAISO to estimate loop flows on an hourly basis for the day-ahead market. Estimated loop flows can vary significantly from hour to hour. In some cases it can reverse direction. Because these flows are dynamic, it is more challenging to factor in these dynamic estimates into the CRR processes that rely on one single snapshot of the transmission system for a whole month or season. The current approach has been to consider that the capacity potentially not optimized due to loop flows can be captured in the CRR model with the global derate applied in each CRR auction.

Some market participants have expressed concerns that loop flows may be the main driver for revenue deficits observed in the CRR market. Early in 2019, the CAISO reported that two of the constraints analyzed accrued revenue deficits due to the loop flow effect.[14] As the CAISO analyzed these factors further, the CAISO targeted the top constraint with CRR deficits to understand their drivers, which in in the last quarter of 2019 was mainly the San Bernardino –Devers constraint. Figure 43 shows the CRR deficit on this specific constraint broken out by two components: the bars in red represent the CRR deficit associated with the capacity not optimized in the day ahead market that may be due to either loop flows or the settled flow falling off of calculation due to the shift factor threshold. The bars in blue show the CRR deficit for any other model differences in the transmission system in either the CRR or day-ahead markets. Overall, the loop flows have an impact on some days of the analyzed period but as shown in Figure 40 are not the main driver of the CRR deficit accrued on that constraint. Overall, the non-optimized flows on this constraint, which includes the effect of the loop flows, was about 10 percent of the overall CRR deficit.

[13] When analyzing the market solution, an approximation of the impact of these two factors, loop flows and shift factor threshold, can be estimated as a whole; this estimation is done by exclusion when comparing the binding limit in the day-ahead market versus the IFM estimated flow. The share of each component cannot be identified explicitly without market reruns, which is not feasible for more than a sample of days.

[14] MPP presentation available at
http://www.caiso.com/Documents/Presentation-MarketPerformanceandPlanningForum-Feb202019.pdf

Figure 43: Break down of CRR deficit for the San Bernardino-Devers constraint

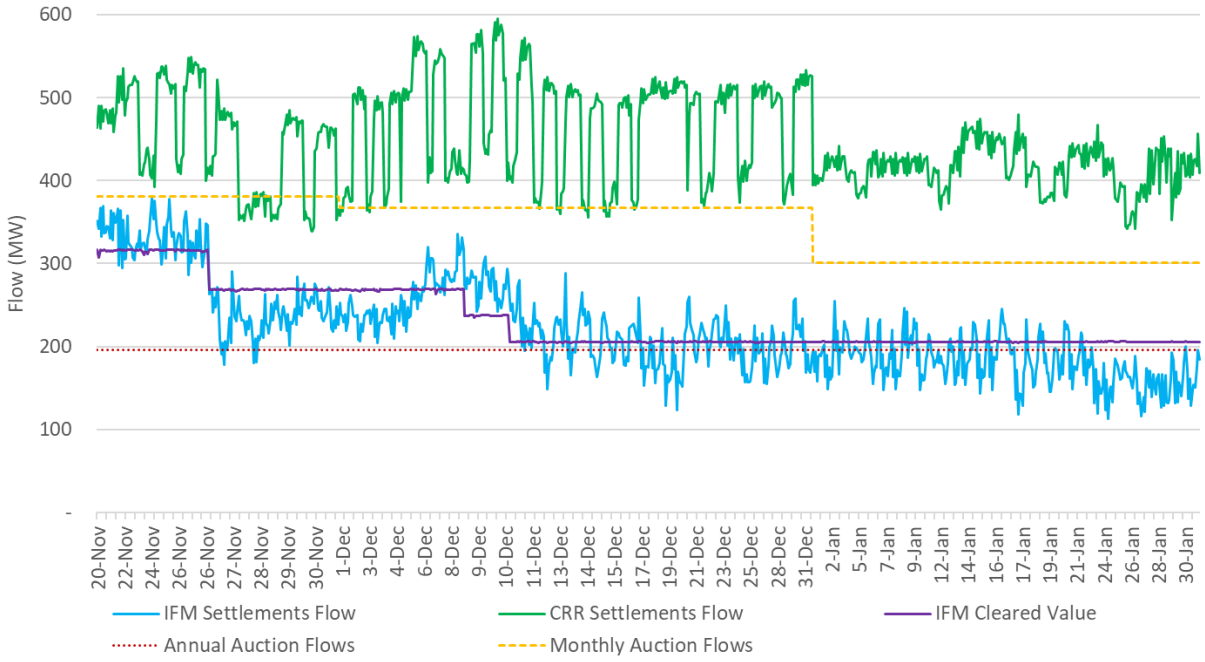


8.3.2 Impact of shift factor threshold

The use of a shift factor threshold in the day-ahead market may have different effects that manifest in various outcomes. As explained in previous sections, the use of a shift factor threshold may result in flow contributions not accounted for in the day-ahead flow settlements by means of not collecting congestion rents, and that can also lead to flow reversals in the CRR settlements. Although, the CRR deficit allocated to the San Bernardino-Devers constraint is quite large, the shift factor threshold and loop flows impacting the day-ahead solution are main driver of CRR deficits.

In order to dissect the different drivers, consider Figure 44 to compare the various power flows on this constraint. The dotted yellow and red lines represent the flows used in the annual and monthly auctions, respectively, and they effectively represent the power flow in the CRR auctions and measure the amount of CRRs released on that constraint. These are constant values over the analysis period since the auction generates a value for the season or month. The line in purple represents the constraint limit enforced in the day-ahead market. The decreasing value over time reflects the downward conformance applied to this constraint to align it better with the reliability margin used dynamically in the real-time market. The line in blue is the day-ahead flow estimated in the CRR settlements based on the day-ahead shift factors and the day-ahead injections from supply and demand; this measures how much capacity is priced in the day-ahead market and, thus, determines the congestion rents collected. The line in green is the estimated CRR flows based on the day-ahead shift factors and the locational injections represented with the CRR source and sinks as calculated in the CRR settlements. This represents the CRR payments.

Figure 44: Flows comparison for the San Bernardino-Devers constraint



The mapping of these flows provide insights on the deficits.

i) The difference between the red and yellow lines against the purple line represents CRR deficits or surplus generated by releasing more or less transmission capacity in the day-ahead market in comparison to the CRR market. When the purple line is below the monthly line, it means the day-ahead market was more conservative and released less transmission capacity in its congestion management than what was release as CRRs, and this delta represents a CRR deficit. This was a factor for CRR deficits on this constraint since the day-ahead market ran with a more conservative limit.

ii) The delta between the purple line and the blue line represents a CRR deficit or surplus due to the loop flows and shift factor threshold effect on the day-ahead flows, which impacts how much congestion rents are collected. Any time the blue line is different than the purple line, congestion rents will be collected less or more in the day-ahead market than it should be, which in turn will lead to a CRR deficit (if shortfall of congestion rents are collected) or a surplus (if excess congestion rents are collected). This was a factor for the CRR deficits for this constraint since there has been a difference of flows due to the loop flows and shift factors.

So far these two factors are well identified to lead to CRR deficits by impacting the blue line. However, they do not fully account for the large deficit observed on this constraint. The main deficit accrued by having the CRR settlements flow being too high in comparison to any of the other flows.

iii) The overall CRR deficit observed on this constraint is the difference between the green line and the blue line once the other drivers are factored in. The green line represents the notional value of CRRs based on the day-ahead market solution using the day-ahead shift factors. Multiplying this CRR flow with the corresponding shadow price of the constraint in the day-

ahead market provides effectively the CRR payments. Multiplying the day-ahead flow in blue with the corresponding shadow price of the constraint provides effectively the congestion rents collected in the day-ahead market. Thus, the difference quantifies the CRR deficit, and in turn the deficit is relative to whether the blue line is too low or actually the green line is too high. The transmission limit in the day-ahead market can provide such a reference. This obviously means the CRR payments are too high.
In the CRR auction if the limit is binding it effectively means the CRR flow in the CRR auction is the same as the yellow line since it is a DC-based power flow, assuming the CRR auction does not have an infeasible limit that has to be relaxed. Therefore, differences between the green line and the yellow line provide important information. The green line is day-ahead shift factors times CRR injections while the yellow line is CRR auction shift factors times CRR injections. The difference between lines is due to the collective difference of shift factors because the CRR injections are the same for both.

The shift factors from the CRR auction can be different than the day-ahead shift factors due to a variety of reasons but related to transmission configuration and model differences. For instance, an outage model in the day-ahead market but not modelled in the CRR auction may potentially lead to different shift factors. Although differences of outages existed between the CRR auctions and the day-ahead market that can explain to some extent a difference, the largest contributors to the CRR deficit is the use of the shift factor threshold in the day-ahead market. This, however, is a different type of interplay to what has already been explained for the impact on blue line. This other interplay impacts the estimated CRR flow for CRR settlements as represented with the line in green.

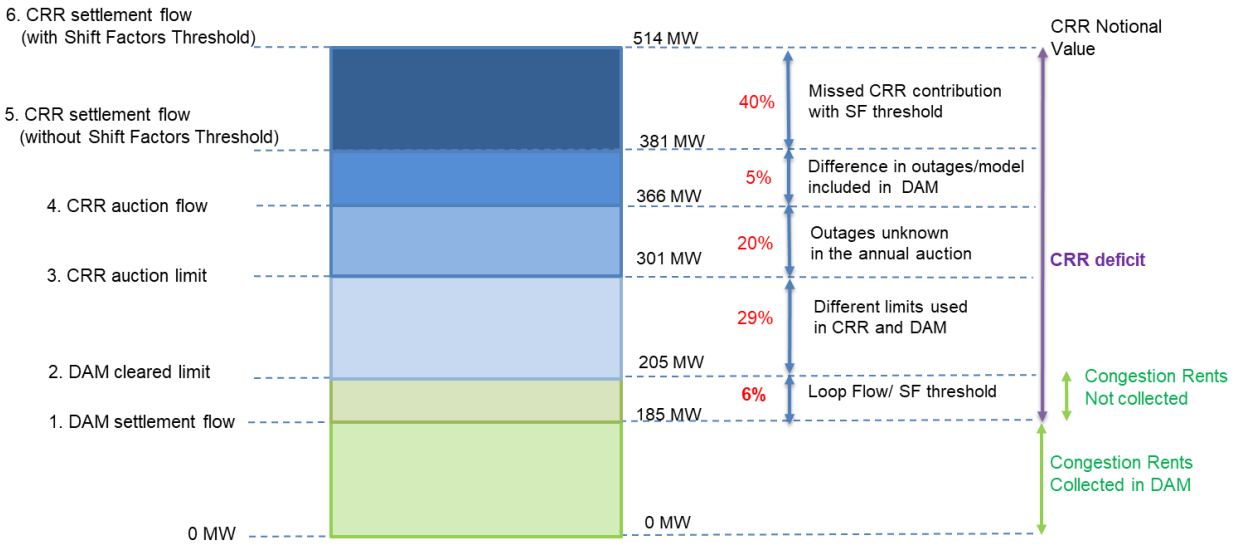
The CRR auctions use DC-based shift factors with no threshold in place. When the CRR auction clears for CRRs it takes into account any shift factor contribution even if they are smaller than 2 percent. The flow estimated in the CRR auction will considered every single contribution of all CRRs as shown by the yellow line. When all these CRR injections are applied to the day-ahead shift factors to calculate CRR payments, only CRRs with injections related to shift factors greater than 2 percent will contribute to the CRR estimated flow. These flow contributions on the CRR flows can be in either direction –prevailing or counter-flow- and can result in a higher or lower CRR flow than was released in the CRR processes. The lack of accounting for the contributions for locations with shift factors below the threshold results in a settlements CRR flow higher than what the CRR flow was in the CRR process. Once these contributions are actually factored in, the flows between the day-ahead market and the CRRs processes converge fairly close.

The partial funding logic pro-rates the payments to CRRs, which brings the green line to the level of the blue line. The pro-rata finding logic applied on a constraint by constraint basis cures the deficit even though some cross socialization of the allocation can happen among CRRs due to the lack of effect for locations with shift factors below the threshold.

Let’s consider the breakdown illustrated in Figure 45 to summarize the various causes of CRR deficits on the San Bernardino-Devers constraint. This is based on a small set of market outcomes for December 2019

and does not reflect the relative contribution of these drivers for the entire period when the constraint was binding. The illustration uses different lines enumerated from 1 to 6 for an easy reference across the various flows used in the markets.

Figure 45: Causes of CRR deficits



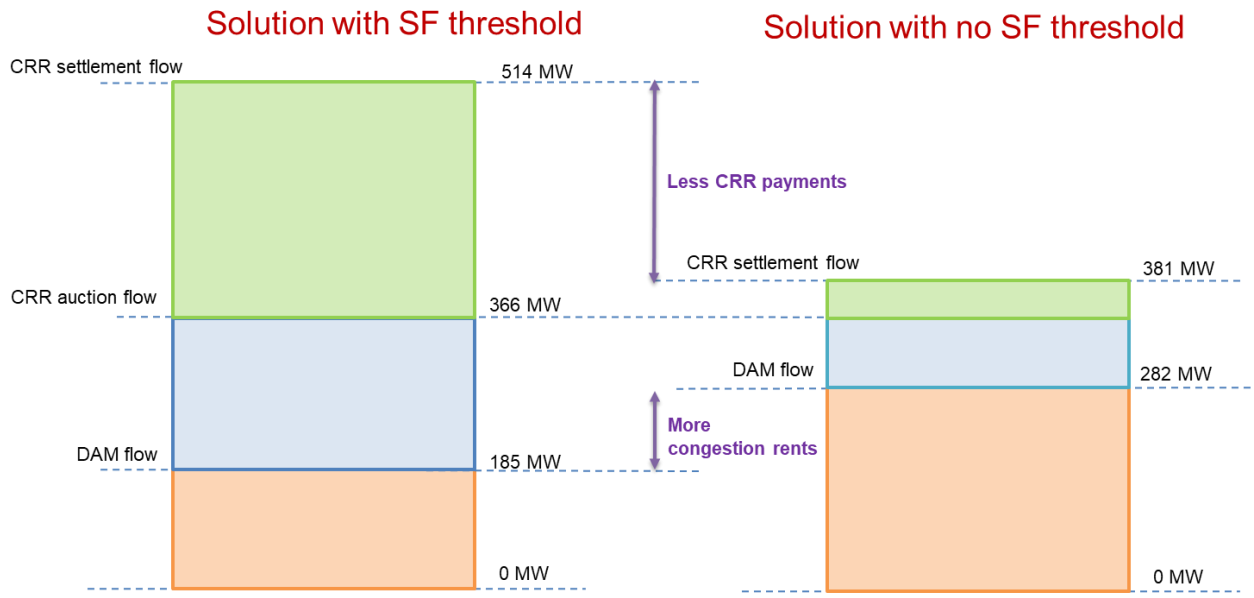
1. Loop Flows and shift factor threshold. These two factors contributed to collect less congestion rents in the day-ahead market since less transmission capacity was optimized due to the loop flows and some flow contribution was not considered in the IFM settlements flow. From the overall CRR deficit, this contributed to about 6 percent and is defined by the capacity between lines 1 and 2.
2. Different limits used between CRR monthly auction and the IFM. The IFM used a more restrictive limit and, thus, released less transmission capacity than that of the CRR auction. This contributed to about 29 percent of the deficit. This is defined by the capacity between lines 2 and 3.
3. Infeasibility in CRR auction. The monthly auction used a limit of 301 MW but the actual flow was 366 due to the need to relax the constraint in the monthly CRR auction. This relaxation is required to start with a feasible solution after taking as fixed the awards already released up to prior running the monthly process. This effectively means that the awards from the annual process were already infeasible or above the transmission limit. The difference arises by having now different transmission models between the annual and monthly processes. Therefore, this difference measures the deficit generated by the model difference between the annual and monthly auctions. The monthly auction inherently reflects more up to date transmission conditions. This created about 20 percent of the CRR deficit. This is defined by the capacity between lines 3 and 4.
4. Different flows in CRR auction and CRR settlements. The difference in flows between the CRR auction and the CRR settlements flow (based on IFM shift factors) measures the model differences between the IFM and CRR monthly auction. This is defined between lines 4 and 6 and contributed to about 45 percent. This reference, however, is based on the current IFM solution that uses a shift factor threshold of 2 percent. If the CRR settlements flow were calculated with the IFM solution and no shift factor threshold, the new CRR settlements flow would be defined by line 5

and would be quite close to the CRR auction flow. The difference between line 4 and 5 measures effectively any model differences between the CRR auction and the IFM market, which is about 5 percent of the CRR deficit.

The remaining difference between the CRR settlements flow with and without the shift factor threshold accounts for approximately 40 percent of the CRR deficit. This is caused by the use of the shift factor threshold in IFM.

The shift factor threshold has a double effect, it may result in collecting less congestion rents while increasing the CRR payments. Figure 46 illustrates these two drivers of the CRR deficit under the current use of a shift factor threshold and compares it with a scenario where there is no shift factor threshold. The CAISO is currently exploring an enhancement to not apply the shift factor threshold to trading hubs and DLAPs, which will largely address this marked delta of flow contributions in CRR payments. For the specific constraint studied in this case, the elimination of the shift factor threshold would reduce the overall CRR deficit by approximately 69 percent. A CRR deficit will still exist because of the model differences between the annual and monthly auctions, and between the monthly and IFM market as well as because of the different transmission limits between the monthly CRR auction and the IFM markets.

Figure 46: Impact of sift factor threshold on CRR deficits

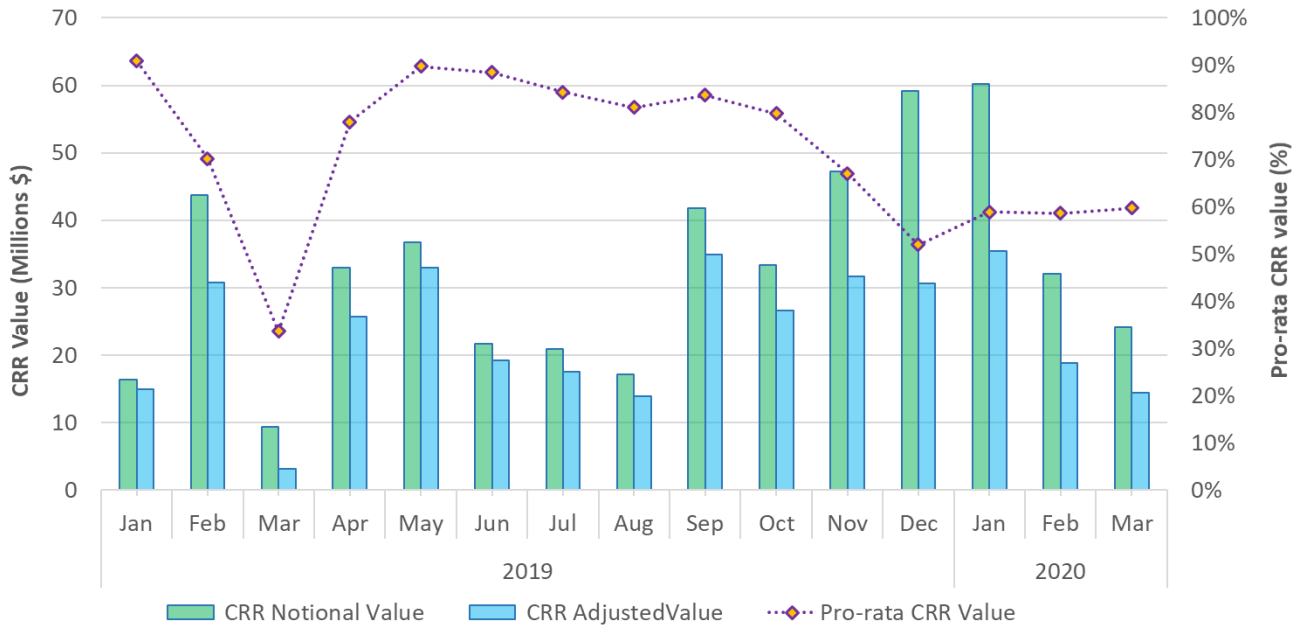


8.4 CRR valuation after pro-rata adjustments

With the implementation of partial funding, CRRs value are naturally adjusted down from their face (notional) value. Based on this pro-rata funding, the impact on each CRR differs according to their contribution to the constraints that accrue deficits.

Figure 47 shows the total adjusted CRR values once pro-rata funding has been applied.

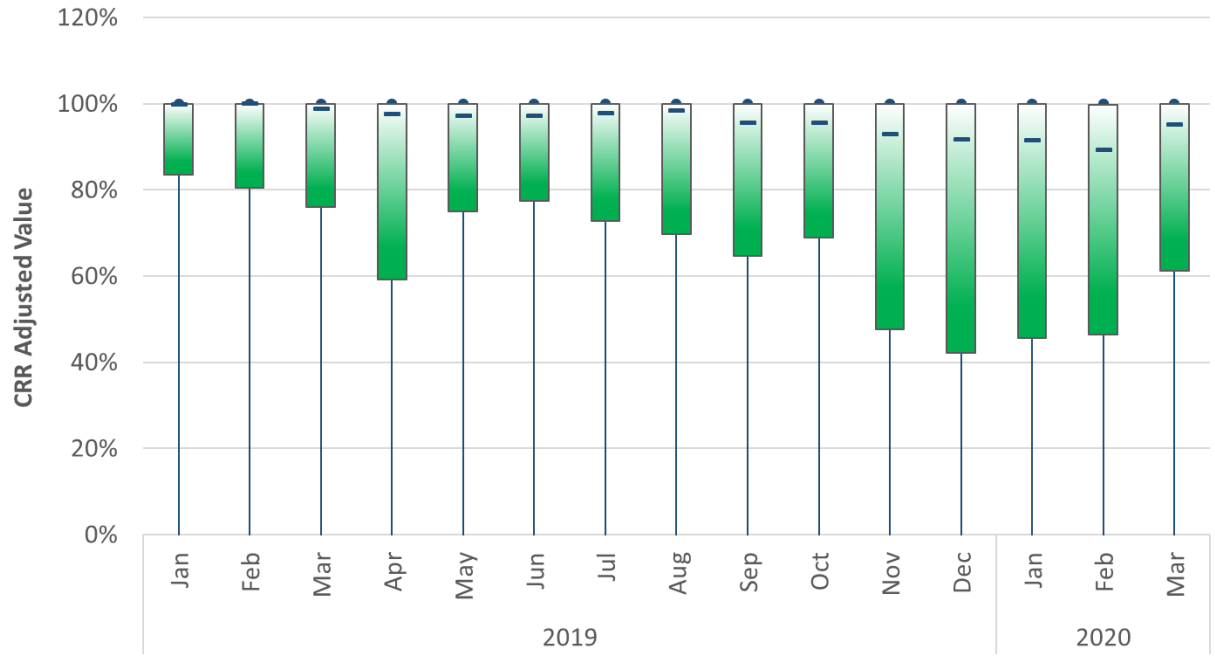
Figure 47: CRR adjusted value with pro-rata funding



The bars in blue reflect the CRR remaining value, while the markers in yellow estimate the overall percentage of the CRR remaining value. Overall, the implementation of the pro-rata funding in the first 15 months of implementation of the CRR policy enhancements represent a 29 percent reduction of the CRR value. The adjusted CRR value was as low as 33.6 percent and 52 percent in March and December 2019, respectively, while the highest CRR adjusted value was observed in January 2019 at about 90.8 percent.

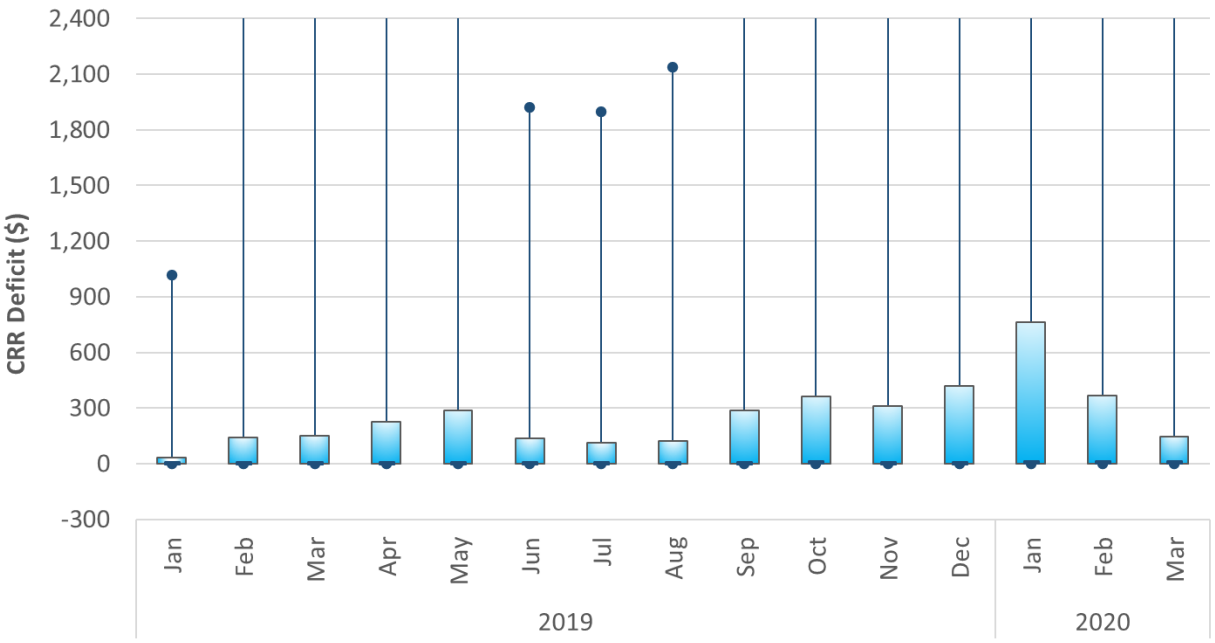
Figure 48 shows a box-whisker plot for the CRR value adjustments due to partial funding. This shows the distribution of adjustment for each and all CRRs per month. The box represents the 10th and 90th percentile, while the whiskers represent the maximum and minimum adjustment. The blue markers show the median value. The maximum value can be as high as 100 percent, which represents the instances of no adjustments made to CRRs. This plot only shows the distribution between 0 and +100 percent because that is the range where most of the adjustments fall, despite minimum values falling outside this range. The lower edge of the green box indicates that about 90 percent of all CRR adjusted values fall between 100 percent (*i.e.*, no adjustment) to approximately 40 percent (as happened in December 2019). The latter case represents months in which the adjustments have decreased the CRR value by as much as 60 percent.

Figure 48: Monthly frequency of adjustments to CRR values



Examining the percent of the adjustments, rather than the absolute value of the adjustments, allows the CAISO to compare CRRs of significantly different sizes against each other. Figure 49 provides a reference in absolute terms by showing the distribution of deficits allocated to each CRR.

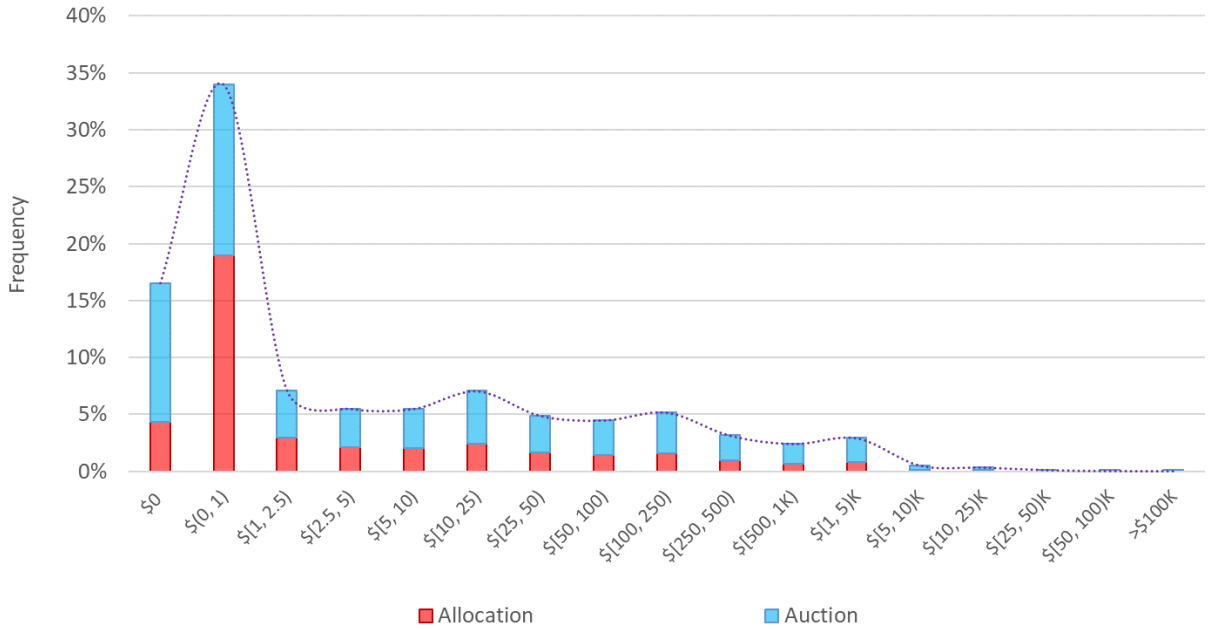
Figure 49: Monthly frequency of CRR deficits



The majority of adjustments are less than $500, with the largest deficits applied in the last months of the period under analysis.

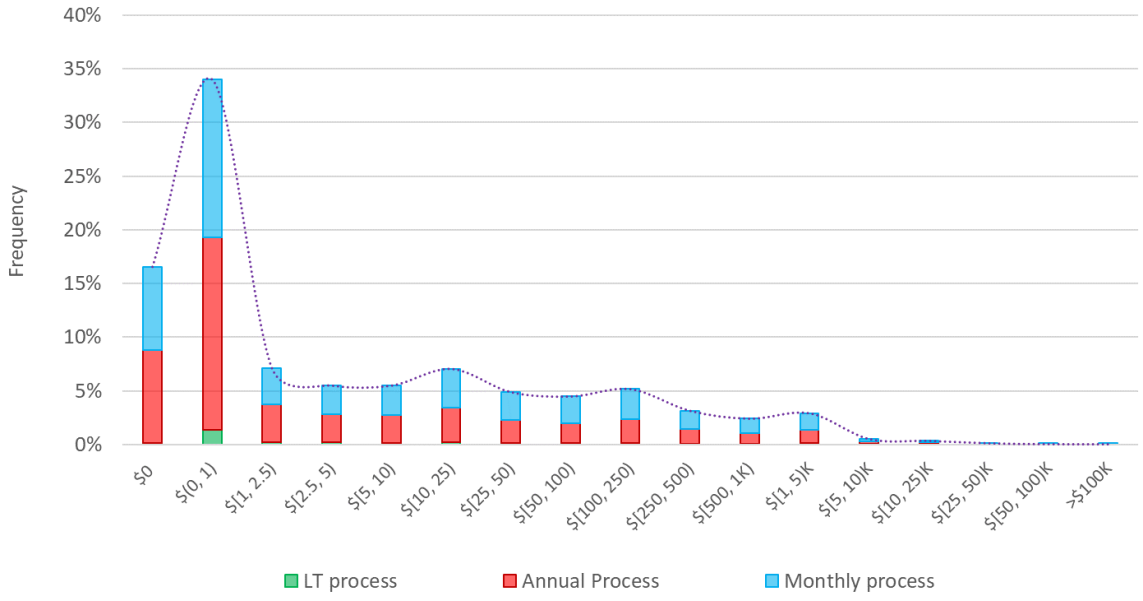
Figure 50 shows all deficits allocated to CRRs in the reported period broken out for deficits allocated to either allocation or auction CRRs.

Figure 50: Frequency of CRR deficits in dollars by CRR type



The X-axis represents the deficit in dollars by range of the distribution, while the Y-axis represents the frequency of deficits by size. The first bar demonstrates that about 17 percent of all CRRs did not have any deficit allocated, while the second bar shows that about 34 percent of all CRRs had an allocated deficit of less than $1. While the majority of allocated deficits are small, Figure 51 also shows that there are some CRRs with an allocated deficit of greater than $10,000.

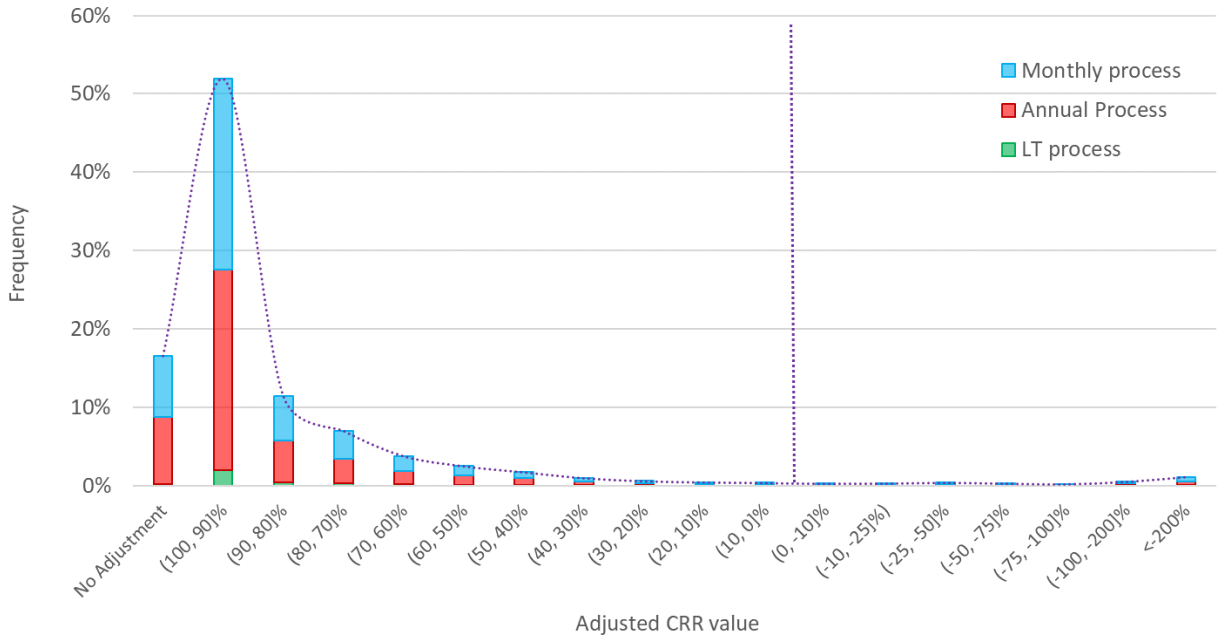
Figure 51: Frequency of CRR deficits (in $) by CRR process



This same distribution can be organized by the impacted CRRs by their origin, *i.e.*, whether they originated from the long-term process, the annual, or the monthly process. The deficits are evenly distributed between the annual and monthly process at about 48 percent.

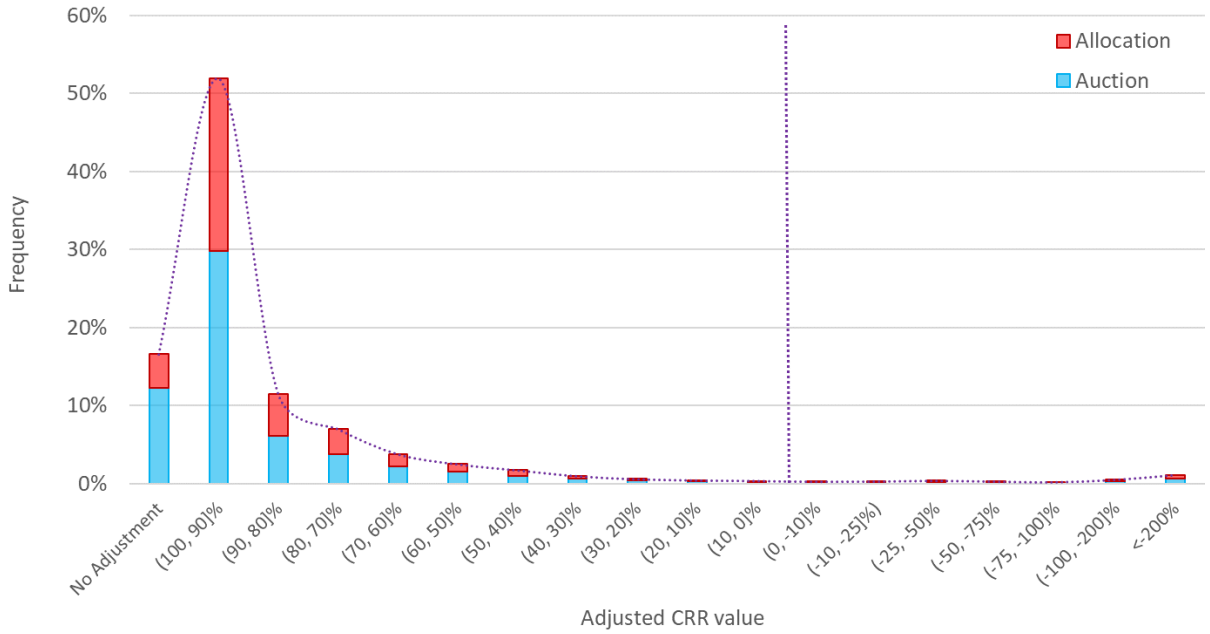
Figure 52 illustrates a deficit distribution in relative terms of the percent of the CRR adjusted value. Most values have little to no adjustments. The first bar shows that 17 percent are not adjusted while the second bar shows that 51 percent of all CRRs have an adjusted value between none and 90 percent.

Figure 52: Frequency of CRR deficits by CRR process organized by adjustment range



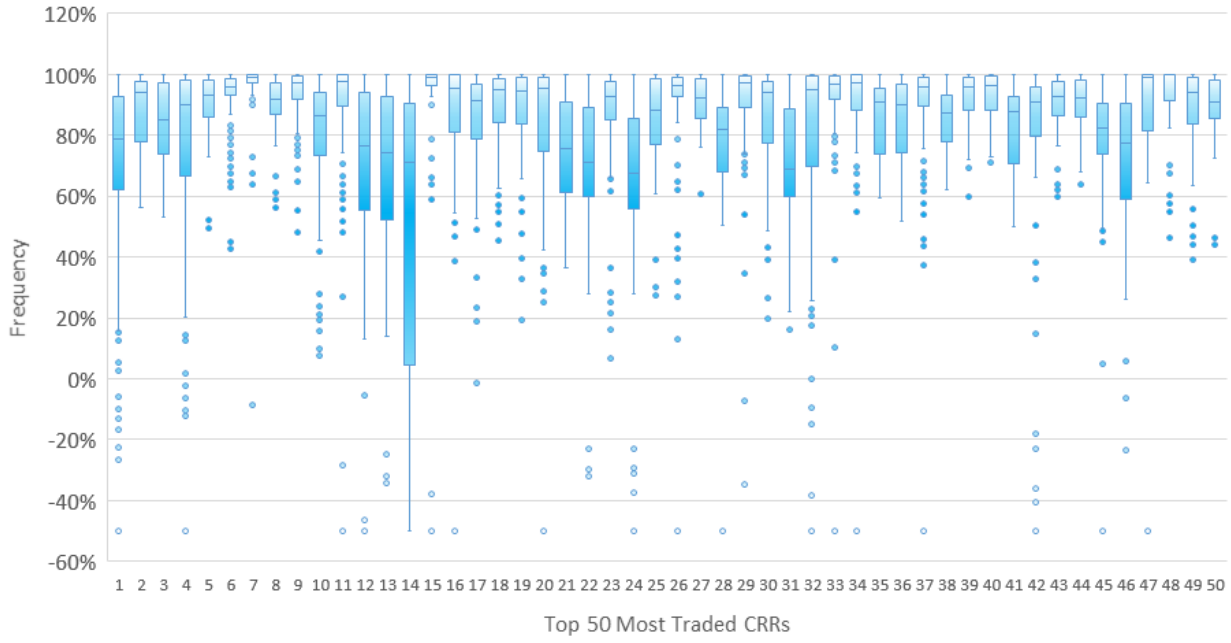
This distribution is also broken out between allocation and auction CRRs in Figure 53. About 60 percent of the CRR deficits are allocated to the auction CRRs.

Figure 53: Frequency of CRR deficits by CRR type organized by adjustment range



With the netting logic applied to the portfolio level, the allocation of deficit to each CRR will depend not only on the effectiveness of that CRR on a given constraint, but also on what CRR portfolio that CRR belongs to. This will effectively lead to different valuations of the same CRR depending on the portfolio. Figure 54 illustrates the distribution of different valuations for the same CRR definition.

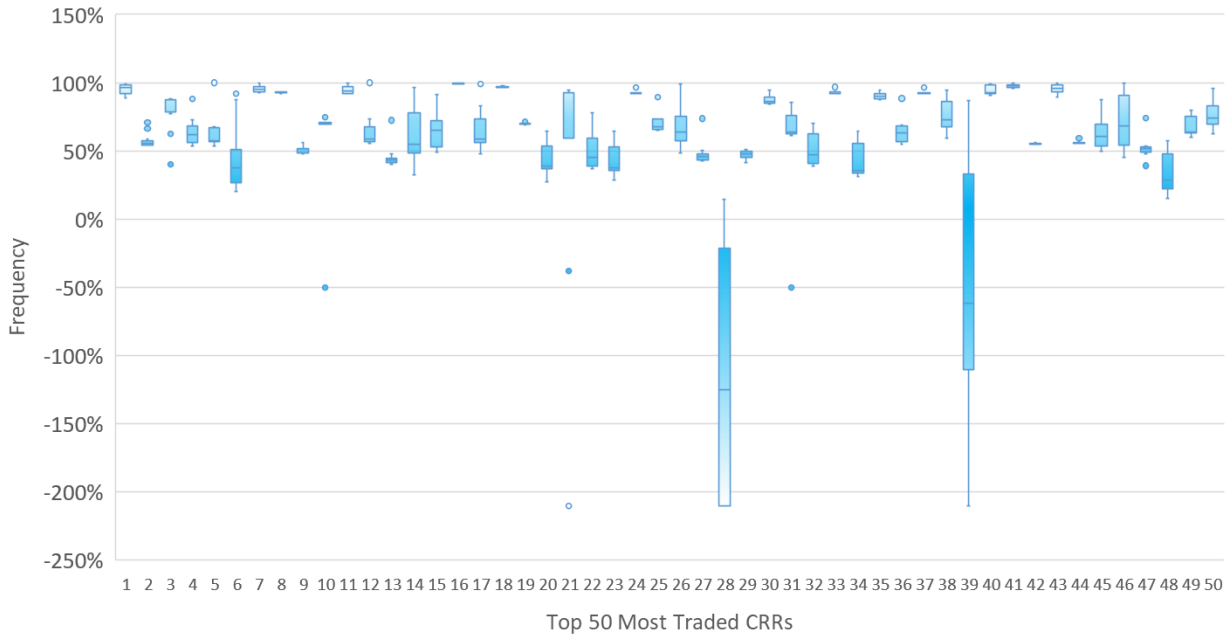
Figure 54: Frequency of CRR deficits (in percent) for the top 50 most traded CRRs



This shows the distribution for the top 50 most traded CRRs for the reported period. The distribution is based on the relative CRR adjustment in percentage terms so that CRRs from different months are

comparable on the same basis. Figure 54 illustrates the large range of adjustments that the same CRR can have, depending on the portfolio the CRR belongs to.

Figure 55: Frequency of CRR deficits (in percent) for the top 50 most traded CRRs in January 2020



The same distribution is provided in Figure 55 for just the month of January 2020. This targeted distribution allows for fair comparison of CRR values within the same month by removing the variations across months or time of use.

Figure 56 shows the same CRRs but provides both the relative CRR adjusted value and the magnitude of the CRR deficit allocated to that CRR. The relative size of the bubble reflects the value in dollars of the deficit. The variation of the adjusted value and the corresponding deficit in absolute dollars illustrates the wide range of variation that can exist with the current pro-rata funding logic.

Figure 56: Frequency and magnitude of CRR deficits for the top 50 most traded CRRs in January 2020