CRR Auction Analysis Report

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California Independent System Operator

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1 Executive Summary

The report is organized in four main areas, including CRR auctions, market performance, modelling of transmission outages and detailed analysis of auctions for a representative set of months. The following bullets provide a summary of the main findings.

- The number of participants in the CAISO CRR auctions have steadily increased over the years, going from 33 participants in 2014 to 49 participant in 2017 in the annual auction, and from 41 participants in 2014 to 63 participants in 2017 in the monthly auctions. Participation from financial entities has increased more than any other type of participant throughout the timeframe analyzed.

- The number of CRR bids has increased from 10,000 in 2014 to more than 20,000 in 2017 in the annual auctions, while the monthly auctions have observed an increase from 16,000 in 2014 to about 33,000 bids in 2017. The number of CRR source-to-sink definitions cleared in the annual and monthly auctions have increased by about 44 and 51 percent, respectively, between 2014 and 2017.

- The bid-in volume of CRRs submitted in the annual and monthly auctions has been as high as 230,000 MW and 320,000 MW, respectively. The volume of cleared CRR awards, has consistently been in the range of 20 percent (about 30,000 to 50,000 MW).

- About 45 percent of the total volume of CRR awards in both the annual and monthly auctions has been for unique CRRs source-to-sink definitions with one single award.

- Between 20 and 44 percent of CRR awards in the CRR auctions have been cleared at negative prices in the annual auction, while 50 to 60 percent of CRR awards in the monthly auction have been cleared at negative prices. Since the transmission capacity made available for the auctions is the leftover capacity after the allocation, a fair portion of this volume reflect counter-flow positions among CRRs.

- Over 60 percent of CRR prices are consistently cleared in the annual auction in the low and tight price band between -$0.25/MWh and +$0.25/MWh. In the monthly auction this is even more pronounced with about 90 percent of CRRs valued in this price range. Furthermore, there is a small but persistent volume of CRRs cleared at $0/MWh in both the annual and monthly auctions.

- In the annual auctions, over 90 percent of the CRR volume was awarded at prices between $0/MWh and $1/MWh, while for monthly auctions over 90 percent of the total volume of CRRs awarded in the monthly auctions between at prices

between -0.25/MWh and +$0.25/MWh, which is a relative low price range. The volume of CRRs awarded at zero price in the monthly auctions used to be about 25 percent until May 2015; starting with June 2015, the volume of CRRs at zero prices has dropped to about 7 percent. This steep reduction is a by-product of starting to enforce nodal group constraints in the CRR auctions; these constraints impose limitation on the amount of CRR that can be awarded at the location level.

- About 100 to 200 constraints consistently appear binding in the annual and monthly auctions, respectively. With the introduction of the nodal group constraints in the CRR auctions in 2015, the number of additional types of constraints binding reduced. Nodal group constraints have been binding persistently since being introduced, reaching up to 1,000 constraints in the monthly auction. Since many nodal group constraints appear binding, this type of constraint becomes in many instances the limiting factor for CRR awards and prevents other types of constraints from binding.

- About 80 percent of the CRRs have internal locations (either individual or aggregated locations) used as the CRR source in both annual and monthly auctions, with a declining trend in 2016 and 2017. Interties are the second most frequently type of location where CRRs are sourced. This is not surprising given the fair volume of energy coming through the interties. Aggregated locations such as default load aggregation points (DLAPs) or Trading Hubs (THs) do not appear as frequently.

- About 56 percent of all net CRR payments accrued on CRRs awarded (in both annual and monthly auctions and both times of use had a source-to-sink definition) from generation location to generation location, while over 85 percent of all net CRR payment accrued on CRRs from supply to supply locations.

- Total monthly auction revenues have seen a declining trend, going from as high as $11.9 million in September 2014 to about $6.7 million in March 2017. Auction revenues are distributed across annual versus monthly auctions, and between on-peak and off-peak time of use. Overall, auction revenues were the highest in the in summer months and lowest in the winter months.

- The proportion of negative auction revenues (where a counter-party pays the CRR holders to acquire the CRR) to positive auction revenues amounted to about 40 percent and 50 percent of the annual and monthly auctions, respectively. The higher percentage in monthly auctions is expected given that the monthly auctions have CRRs with a shorter life term (a month versus a quarter of the annual auction) and are run closer to day-ahead market conditions (a couple of weeks in advance of the settlement months, compared to up to 10 months in advance of the annual auction).

- Congestion rents comprise the total surplus collected by the CAISO when congestion arises and account for the amount used to fund the CRR payments. Of the years analyzed, 2014 saw a spike in congestion rents reaching $430 million, and then stabilized in subsequent years, reducing to approximately $213 million in 2015, $235 million in 2016 and finally reaching $108 million in 2017 (January to May).

- CRR revenue adequacy measures the overall alignment between the CRR market and the day-ahead market by quantifying the balance between the money collected from the day-ahead market and the CRR payment made to CRR holders. For the period of analysis, there has always been a CRR revenue deficiency or shortfall, meaning the CAISO has had to payout more to CRR holders than it has collected from the day-ahead market. The largest shortfall was observed in July 2014 with over $40 million, while 2015 through 2017 have observed revenue deficiencies of up to $22 million in a given month.

- As part of the CRR markets design, auction revenues, which are the proceeds from selling CRRs in the auction, go into the balancing account and can be used as a buffer to offset revenue shortfalls. When these auction revenues are used, about 45 percent of the monthly shortfalls were fully offset.

- Based on the period under analysis, there does not seem to be any direct impact on revenue shortfalls driven by market system changes, such as the additions of new market functionalities or regular network model updates. Furthermore, in analyzing the hours when the day-ahead market had direct current (DC) solutions, there was no strong evidence that those DC solutions in the day-ahead market lead to a better or worse performance of revenue shortfall.

- For most of the time, when auction revenues were collected from CRRs released in the CRR auctions, the net amount was lower than the money paid to auction CRRs. Throughout this report, the difference between these two quantities is referenced as the net CRR payment. In 2014, the money paid to auction CRRs was as high as five times the auction revenues collected on these CRRs. In 2017, that ratio oscillated between 1.5 to 2.2 times.

- Net CRR payments have been rising from both annual and monthly auctions, as well as from both time of use definitions. A large share of these net CRR payments are associated with CRRs that have a source or sink from individual internal locations in the CAISO balancing authority area. The amount (in dollars settled) where participants received less from CRR payments than what they paid for in the auction represents about 32 percent of the amount settled, compared to when CRR holders received more CRR payments than what they paid for in the auction. Although a modest proportion, this shows that there are CRR holders in

every auction which end up in a position where the money collected through CRR payments was less than the money they paid to acquire CRRs.

- When comparing auction revenues versus CRR payments, about 47.6 percent of CRR awards account for when CRR holders paid for auction CRRs and received CRR payments. 13.9 percent of CRR awards are associated with when CRR holders paid for auction CRRs and were charged CRR payments. About 28 percent of CRR awards represent when CRR holders were paid in the CRR auction and were charged when settling CRRs. Finally, about 10.5 percent of the CRR awards signify when the CRR holders were paid in the CRR auction and also received CRR payments.

- Overall, about 17 percent of CRRs acquired in the auction had a net negative money inflow (net CRR payments) from holding CRRs. Although a modest percentage, this shows that holding CRRs from the auctions do not always present a winning proposition. Holding CRRs pose a certain level of risk since congestion patterns may change in the day-ahead market with respect to projected conditions when participating in the CRR auctions.

- CRRs with zero auction revenues exist when the CRR holder did not have to pay for or be charged for acquiring CRRs, have predominantly seen a CRR payment when settled in the day-ahead market at non-zero prices. However, there are cases when these CRRs have actually become a liability and their holders have been charged. The settlement value of these CRRs have diminished over time.

- For the period under analysis, the top and bottom CRR source-to-sink pairs based on their associated net CRR payment, do not show a systemic pattern over time. These particular CRRs have been mostly driven by the occurrence of a specific event that influenced their payments.

- The current requirement for planned outages that last at least 24 hours in duration must be submitted to the CAISO at least 30 days in advance of the start of the month in which the outage will take place. Consideration of outages in the CRR auctions is critical to ensure the CRR auctions will reflect the conditions expected for the day-ahead market. About 80 percent of planned outages, regardless of their duration, were not reported within this timeframe. The majority of these outages had a duration of less than 24 hours, for which there is no timing requirement to submit to the ISO.

- For outages subject to the 30-day submission requirement, about 57 percent of these outages were not submitted to the ISO in time. PG&E, SCE and SDG&E outages subject to the 30-day submission window were not received in time in about 50 percent, 65 percent and 70 percent of the time, respectively.

- About 15 percent of the planned outages that were compliant with the submission requirements were modelled as out-of-service, meaning that they had a duration of at least 10 days. Outages with a duration of less than 10 days are modelled with a pro-rata derate for the period of the auction the outages exists within. Outages with a duration of less than 24 hours are not modelled in the CRR auctions. These outages represented the largest portion of outages in the system for the time period analyzed.

- The analysis in this report shows that there is a persistent and strong correlation between CRR revenue inadequacy (congestion rents not being sufficient to cover all CRR payouts) and net CRR payments (difference between auction CRR payments and auction revenues). This does not indicate that one is the cause of the other; instead, it reflects that both items are being driven by a common cause. This common factor happens to be the misalignment of transmission modelling between the CRR auctions and the day-ahead market.

- The last part of the analysis focuses on the auction performance at the individual transmission constraint level. Through this detailed analysis, one common finding arose that leads to late or missed outages and constraints in the CRR auctions being the primary driver for revenue shortfalls and large net CRR payments to auction CRRs. In some cases, like January 2017, one single constraint missed being modelled in the annual and monthly auctions and as a result drove over 80 percent of the revenue shortfall and accounted for a significant portion of the large payout to auction CRR holders.

- There are different levels of complexity in this dynamic; there are cases where the outages are not known by the time the CRR auctions are run; in other cases, outages may be known but they have a short duration (less than 24 hours) and pose a dilemma of how to incorporate them into the CRR auctions. There are two available options once this dilemma arises; do nothing (current approach), or model the outage as a derate or as a full outage which implies having modelled for the full period of the auction. Modelling as a full outage may be seen as an extreme approach for outages that may last a few hours, but in these few hours there may be large revenue shortfalls and CRR payments. Then there is another set of instances where specific constraints are not captured or not known by the time the auctions are run and then these are only enforced in the day-ahead market. Typically these instances involve nomograms that may or may not be associated with specific outages. Regardless of the origin, the end result is that the CRR auctions do not reflect these changing conditions in transmission system and thus, these conditions are not priced accordingly in the auction. Once they are in the day-ahead market and congestion arises, a persistent divergence between markets is created.

From these findings, there are several items that need consideration for further improvements, including:

- Enforcement of constraints. Misalignment of transmission constraints between CRR auctions and the day-ahead market is a systemic issue impacting the overall efficiency of the CRR auctions. If a constraint is not enforced in the CRR auction but is enforced in the day-ahead market, this can lead to a lack of pricing the transmission properly in the CRR auction, and can also result in releasing more transmission capacity on that element in the CRR auctions.

- Consideration of outages. There is a large set of outages that last less than 24 hours in duration, that even when known in advance are not considered in the CRR auctions. These outages can drive steep and concentrated revenue deficiencies and large net CRR payments due to a misalignment of transmission configuration between markets. Furthermore, even when outages are known on time and have a duration longer than 24 hours, there is a modelling challenge of how to consider these outages in the CRR auction. Currently, if these outages last less than 10 days, they are modelled as pro-rata derate. This aims at balancing the potential large impact of the days on outage with the lower limit applied to the rest of the period. Then the most systemic issue is for outages not submitted on time and are not considered in the CRR auctions at all; these outages have a straight negative impact on the CRR auction performance, as illustrated in the monthly analysis.

- Zero priced CRRs. There is a set of CRRs in every auction that clear at $0 prices. Usually these CRRs have sources and sinks located close one to another, electrically speaking. These represent CRRs that are acquired by CRR holders at zero cost. Although these CRRs may turn to a liability for CRR holders in some conditions, it is not clear what value these CRR add to the overall efficiency of the market.

Lastly, based on the analysis of auction CRRs, the vast majority of CRR payments are for auction CRR definitions between individual supply points, mostly from generation point to generation point and from intertie point to intertie point. A large volume of CRRs released in the auction are for CRR definitions with very few awards. Indeed, about half of the CRR volume released in the auctions are based on CRR definitions with one single award. This opens the question on how much liquidity or hedging the auctions may be generally providing with such large volume of single definition awards.

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2 Acronyms

AC	Alternating current
CAISO	California Independent System Operator
CRR	Congestion revenue right
CLAP	Custom load aggregation point
DAM	Day ahead market
DC	Direct current
FNM	Full network model
IFM	Integrated forward market
ISO	Independent System Operator
LMP	Locational marginal pricing
MCC	Marginal congestion component
MSS	Metered Subsystem
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
VEA	Valley Electric Association

3 Introduction

The nodal market implemented by the California ISO (CAISO) on April 1, 2009 consists of the standard elements of a market design ubiquitous for ISO's in the United States; this standard design consists of a real-time market complemented with a day-ahead market, which in turn is complemented with a market for congestion revenue rights (*aka* financial transmission rights in other ISO's). The CAISO's design is based on a tiered approach. First, there is an allocation process in which CRRs are directly allocated to load serving entities. Once the allocation is complete, the CRR auctions are open to any entity qualified to participate in the CRR market, regardless if they have an obligation to serve load or any other type of participation in the ISO markets.

The CAISO's CRR market includes both an allocation and auction process for the annual and monthly timeframes. The annual auction runs in the last quarter of the year preceding the binding year and is organized in calendar seasons. The monthly auctions are run a couple of weeks in advance of the binding month. CRRs are defined for two times of use (TOU): on-peak and off-peak. The CAISO's design also provides for full funding; *i.e*., when the money paid to CRR holders is greater than the money collected to fund the CRR payouts, the CRRs are still fully paid their face value and any shortfall from this balance is allocated to the measured demand. Only congestion rents from the day-ahead market are utilized to fund CRRs; congestion from the real-time markets are settled separately. Any surplus, is allocated to the measured demand. Under this design, proceeds from auction revenues as well as clawback proceeds are used to fund CRR revenue adequacy.

Over the years, the CAISO has been monitoring the performance of the CRR markets and has or is in the process of implementing several market and or process changes to improve its performance, including:

- Implementation of a break-even analysis for interties to ensure the amount of transmission capacity released in CRR auctions reflects the historical availability;
- Systematic enforcement of nodal group constraints to align the CRR auctions with the day-ahead market;
- Internal process improvements to better handle outages in the CRR auctions;
- CRR clawback rule modifications to better consider convergence bids; and
- Contingency modelling enhancements.

In early 2017, the CAISO opened up an initiative to address a concern with the CRR auction efficiency. This concern was on the large CRR payments made to holders of auction CRRs in comparison to the auction revenues collected when releasing the CRRs through the auctions.

This initiative is composed of two main stages:

1. Analysis stage. In this part of the initiative the CAISO committed to carry out a comprehensive analysis of the CRR auction performance. This stage was separated in three different phases depending on the type of analysis carried out. The CAISO held a workshop with market participants in April 2017 to layout the plan for the scope of the analysis. The CAISO reported its progress on the analysis track during the July 2017 market planning and performance forum meeting and committed to complete this stage of the initiative in the last quarter of 2017.

2. Policy stage. Once the analysis stage is complete the CAISO will formally start up the policy discussion. The results of the analysis stage will serve to guide the policy discussion.

In terms of the analysis carried out in the first part of this initiative, the CAISO focused on the performance that can be analyzed within the scope of the CAISO market data. Although it can be recognized that there may be other benefits provided through CRRs and the auction processes, this analysis only illustrates those benefits that are tangible to the CAISO.

Finally, the CAISO will host a technical workshop on December 19, 2017 to discuss the analysis presented in this report.

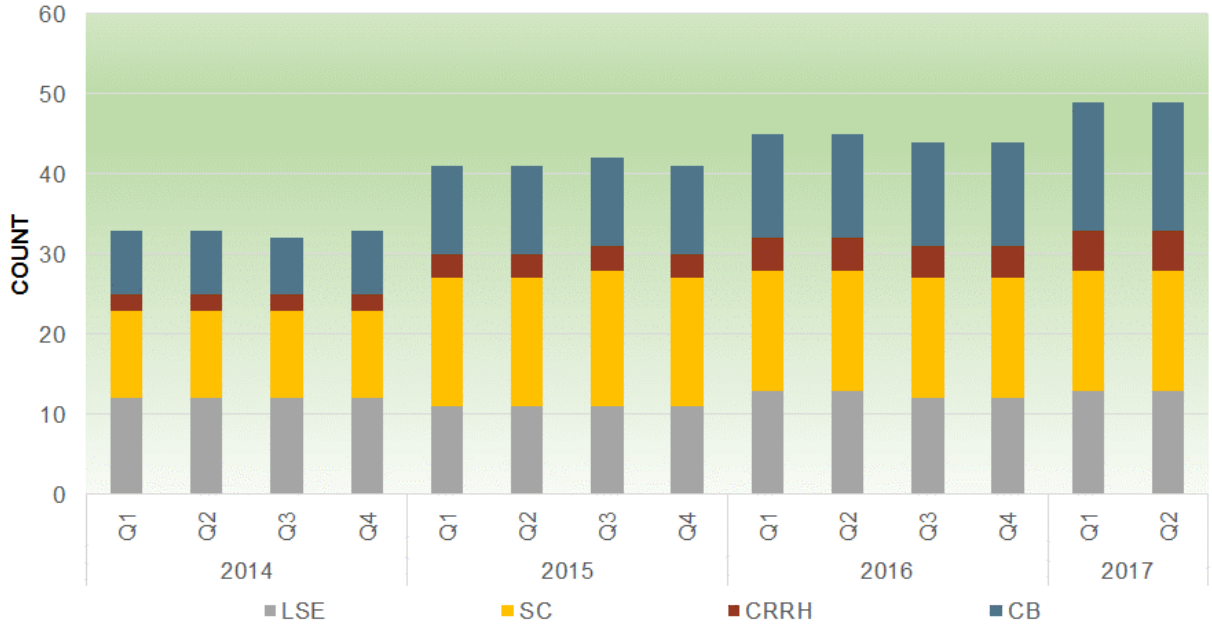
4 Congestion Revenue Right Auctions

CRR auctions are available both in annual and monthly processes. Each auction is treated individually as a different market. Additionally, two time of use (TOU) are defined for CRRs: On-peak and Off-peak.

Participation

Figure 1 shows the number of participants in annual auctions by type of participant[1] (Load serving entity, scheduling coordinator, CRR holder and convergence bidding participant only). The count of participants is by season for Off-peak. The number of participants in the annual CRR auction has steadily increased year after year, going from 33 participants in 2014 to 49 participants in 2017.

Figure 1: Number of participants in annual CRR auctions by CRR type for off peak

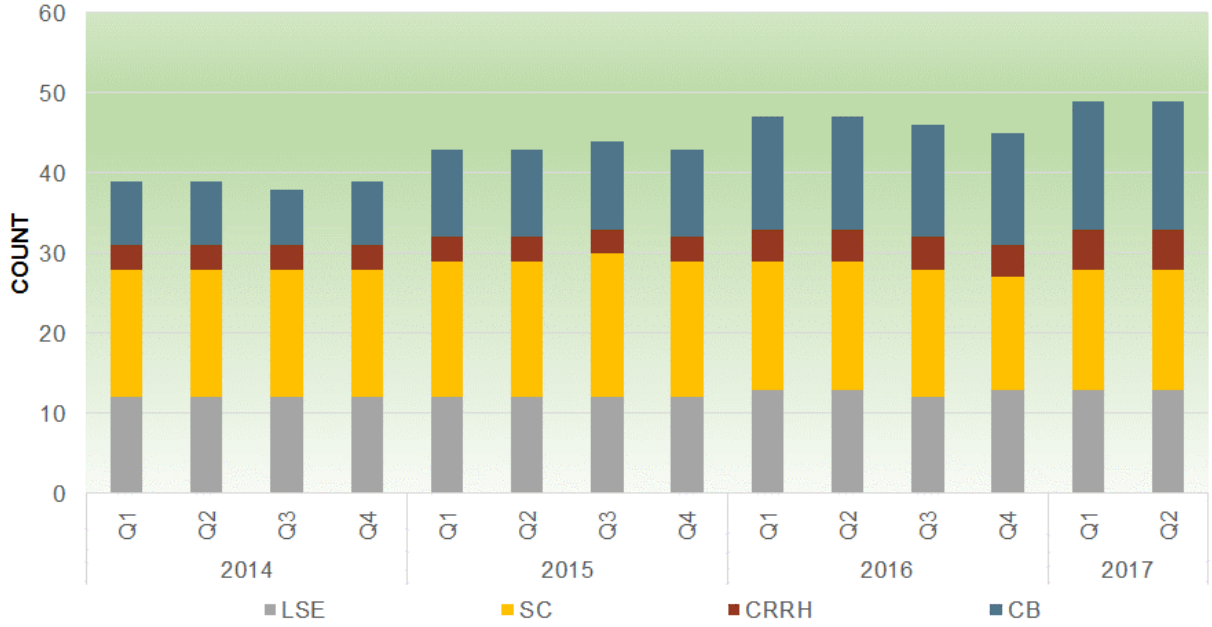


Similarly Figure 2 shows the number of participants in annual auctions by CRR type. The count of participants is by season for On-peak and similar to the Off-peak there is a steady increase in the count of participants from year to year. Since there is a separate annual auction

[1] This classification is based on the definition used by the ISO in the participant registration. CRRH stands for entities participating only in the CRR auctions; CB stand for entities participating in both the CRR auction and with convergence bids in the day-ahead market; LSE is for entities that have participated in the allocation process and as such have an obligation as load serving entities. Any other participant is classified as a scheduling coordinator. This classification is available at http://www.caiso.com/Documents/ListofSchedulingCoordinatorsCRRHoldersandConvergenceBiddingEntities.pdf

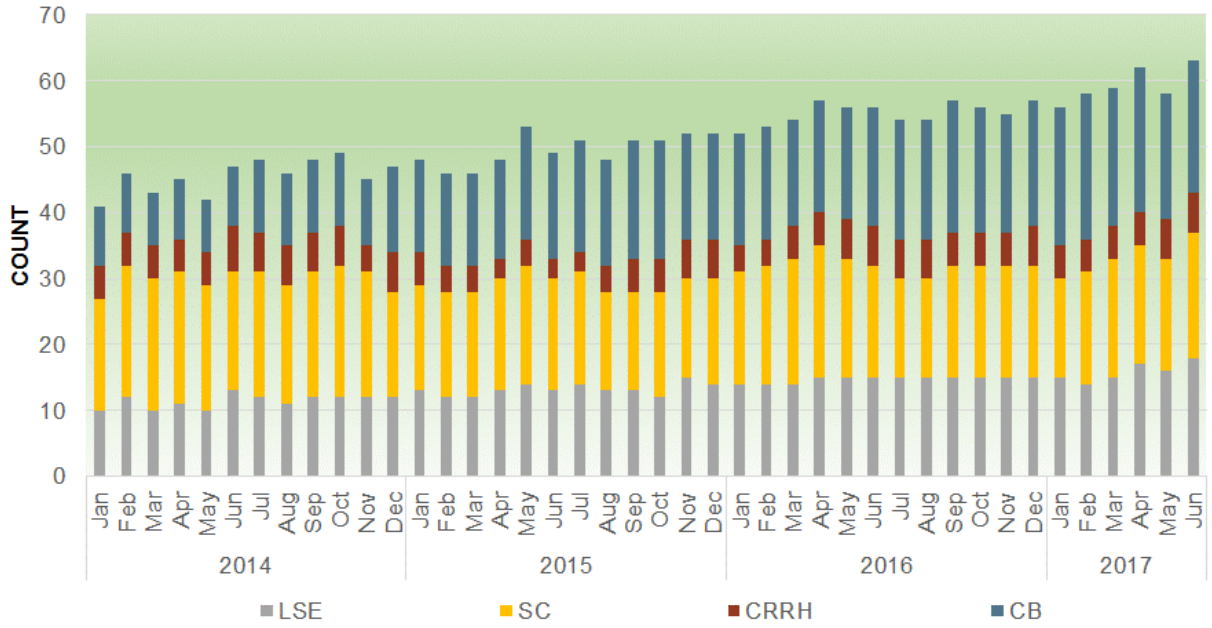
for each time of use, participants have the flexibility to participate in both or any of the two auctions; this is the reason the number of participants is different for each time of use.

Figure 2: Number of participants in annual CRR auctions by CRR type for on peak



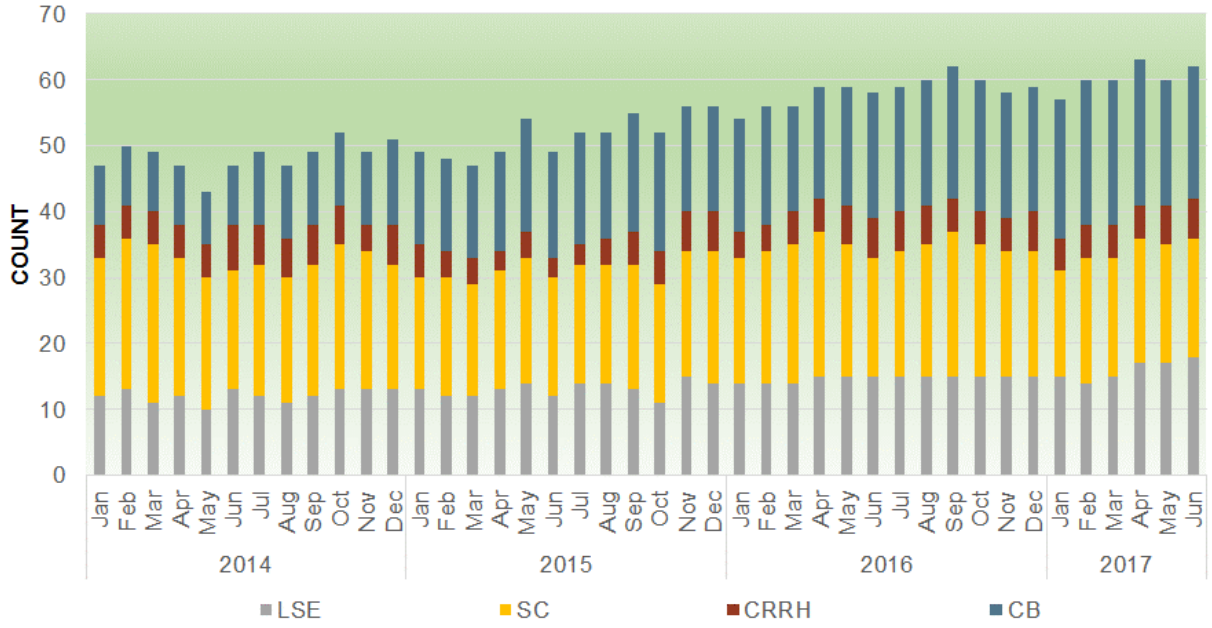
Correspondingly, Figure 3 shows the number of entities participating in the monthly CRR auctions by type of participant for Off-peak. The number of participants has also steadily increased from 41 entities in 2014 to 63 entities in May 2017.

Figure 3: Number of participants in monthly CRR auctions by CRR type for off peak



Similarly, Figure 4 shows the number of entities participating in the monthly CRR auctions by CRR type for the On-peak market. There was higher participation in the On-peak market during 2014 than the Off-peak market. Entities participating in both the CRR auctions and convergence bids saw the most increased participation from 2014 to June 2017, going from 9 to 20 participants; this type of financial participants in the market have no load serving obligations or scheduling coordinator responsibilities, thus they have a profit seeking objective. The fact that this type of participation has steadily increased may reflect that participants may find attractive to participate in this financial market. This participation also increases the activity in the CRR auction and may drive for more liquidity in the market.

Figure 4: Number of participants in monthly CRR auctions by CRR type for on peak



Market bids

Figure 5 shows the number of bids submitted in the annual auctions by season, TOU and year. The number of bids in the annual auctions have observed an increased over the years, going from about 10,000 in 2014 to more than 20,000 in 2017.

Figure 5: Number of bids in annual CRR auctions by TOU

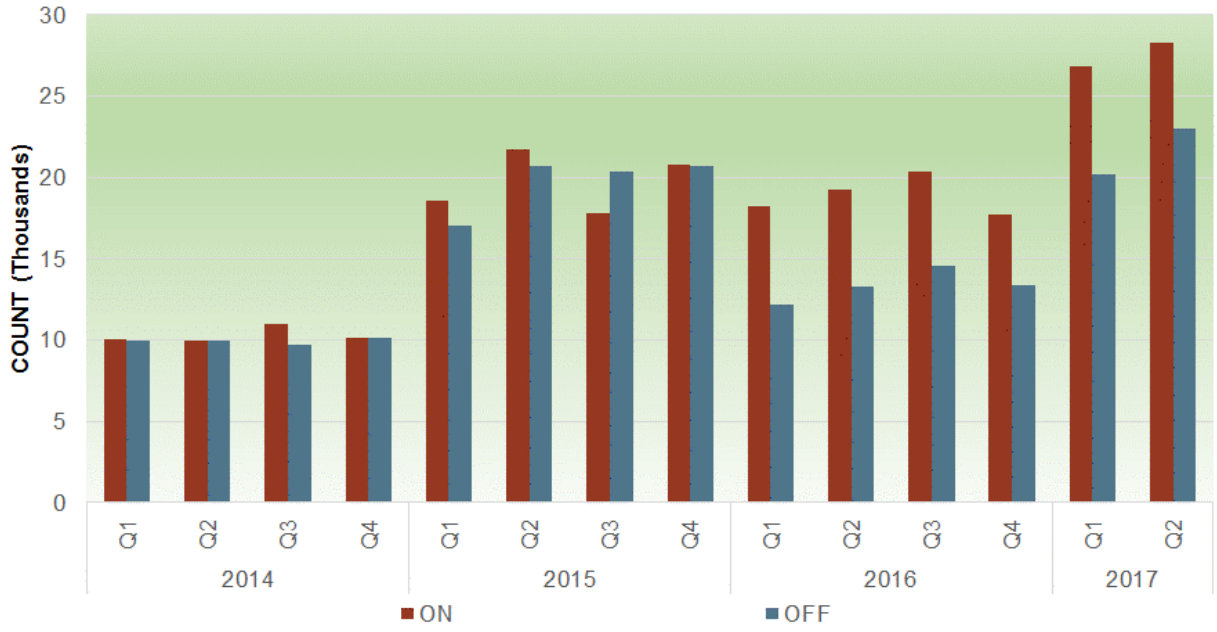
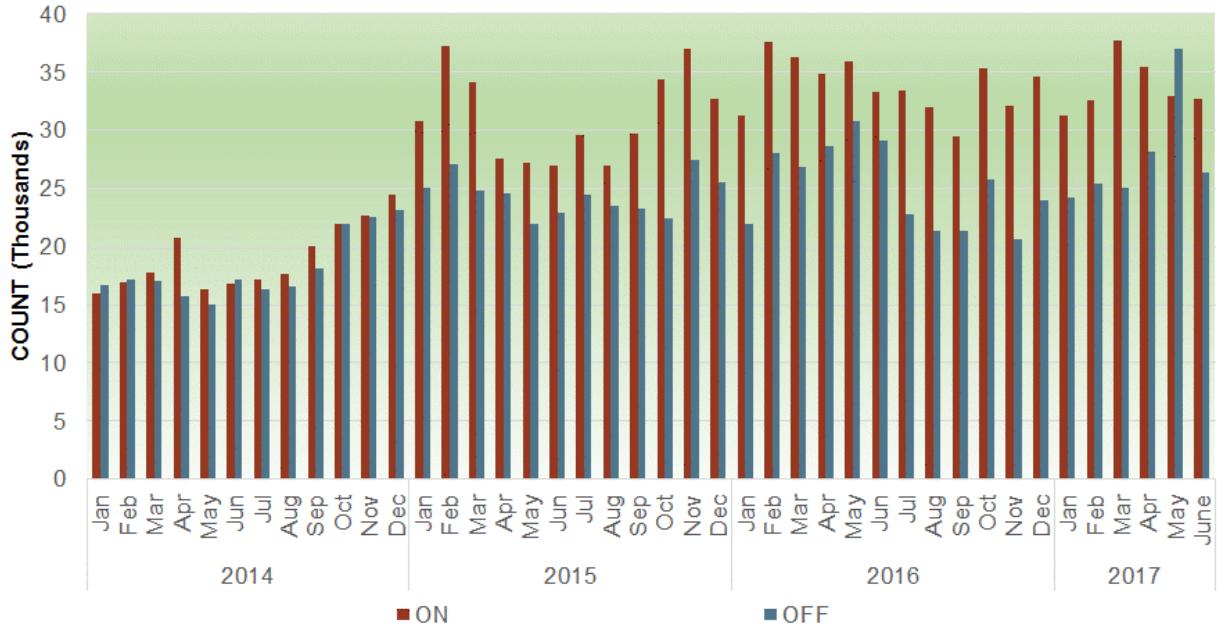


Figure 6 shows the number of the bids in the monthly CRR auctions by month, TOU and year. The number of bids have increased over time, going from about 16,000 bids in early 2014 to as high as almost 33,000 bids in 2017. It is important to note that the number of bids is not a direct metric of CRR awards, but it is a reflection of the activity and liquidity in the auction and the willingness to acquire CRRs.

Figure 6: Number of bids in monthly auctions by TOU



CRR source-to-sink definitions

Figure 7 and Figure 8 show the number of different CRR definitions awarded in the annual and monthly auctions, respectively, by TOU and year. The number of different CRR definitions cleared in the annual auction have shown an increase of about 44 percent from 2014 to the first two quarters of 2017. Correspondingly, the number of CRR definitions cleared in the monthly auctions has increased by about 51 percent between 2014 and 2017.

Figure 7: Number of different CRR definitions in annual auctions

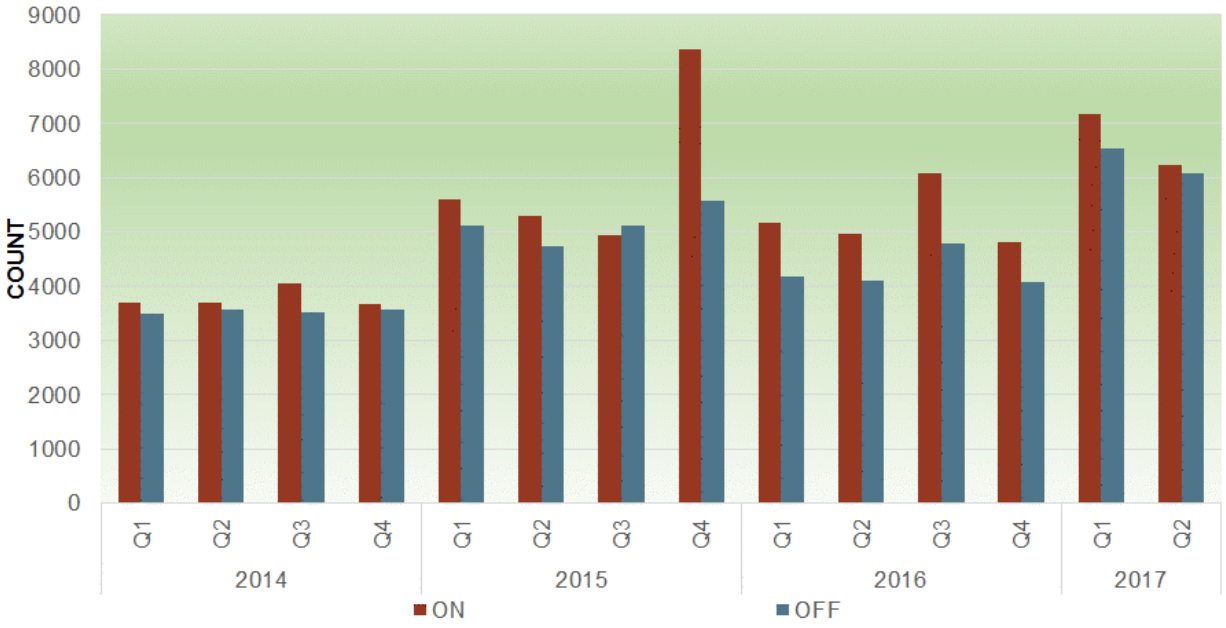


Figure 8: Number of different CRR definitions in monthly auctions

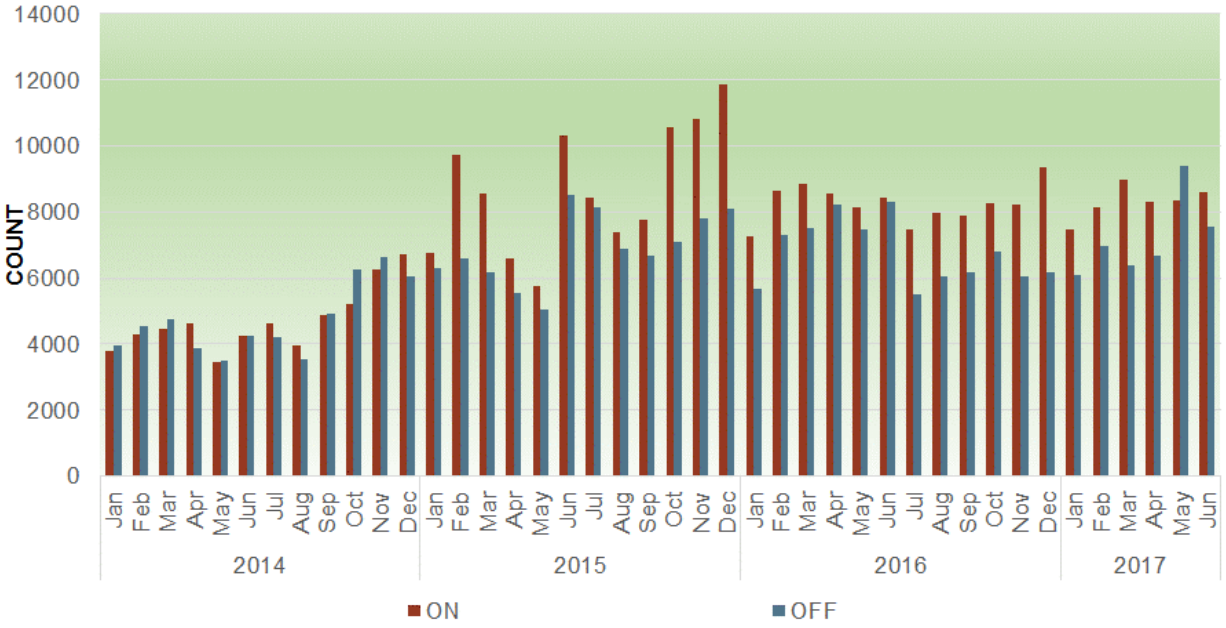


Figure 9 through Figure 12 show the volume of CRRs awards cleared in the annual and monthly auctions by time of use. These volumes are grouped into sets of numbers of awards for each CRR definition. For instance, the bin associated with the label "1" is the estimate of CRR volume with awards for definitions that are unique; i.e. there is only one single award for a specific and different source-to-sink definition. In both the annual and monthly auctions, about 45 percent of the overall CRR award volume was for CRRs source-to-sink definitions that had one single award.

Figure 9: Volume of annual CRR organized by number of awards per definition –On peak

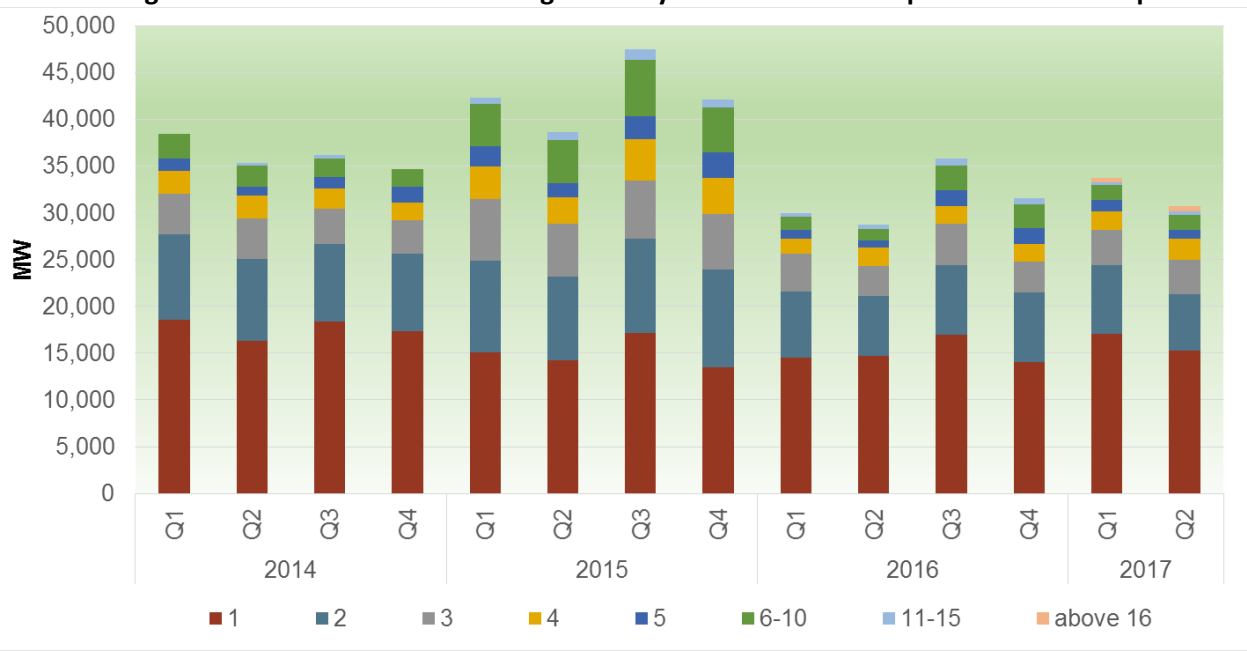


Figure 10: Volume of annual CRR organized by number of awards per definition –Off peak

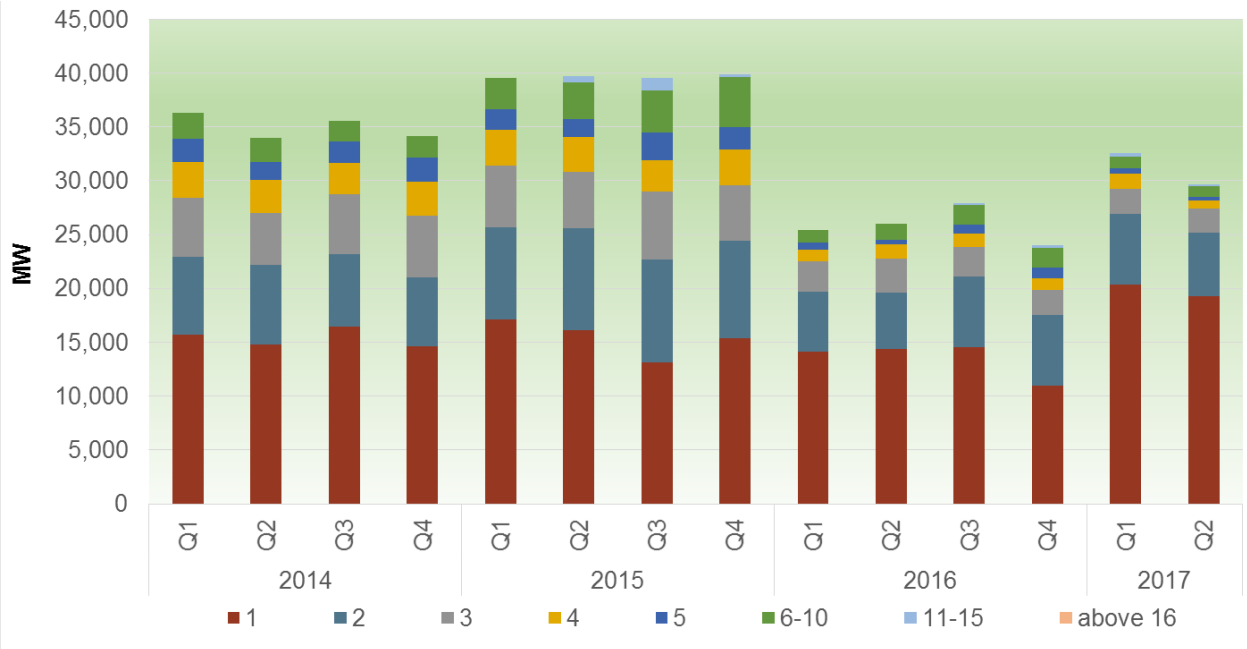


Figure 11: Volume of monthly CRR organized by number of awards per definition –On peak

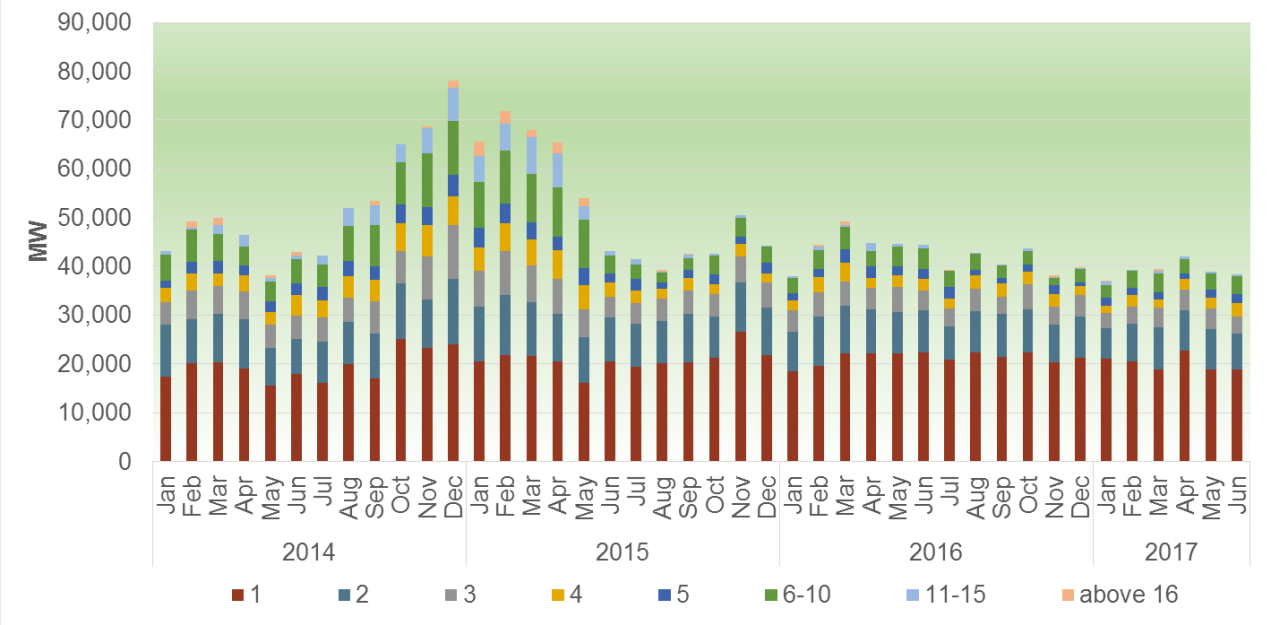
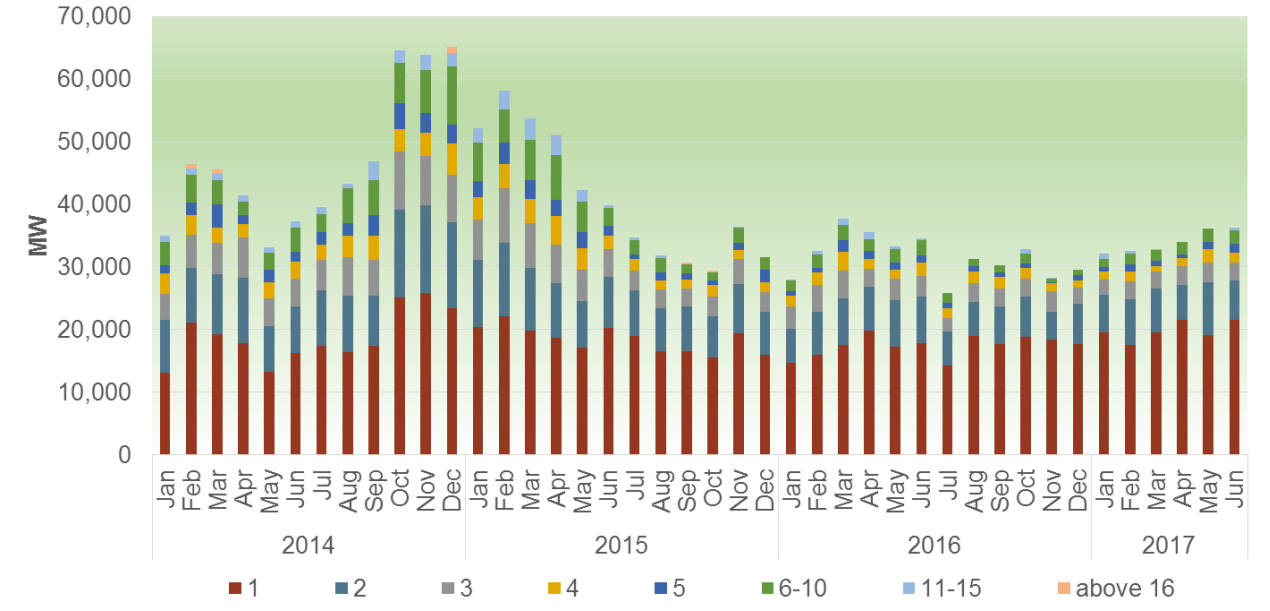


Figure 12: Volume of annual CRR organized by number of awards per definition –On peak



Bid-in volumes and awards

Figure 13 and Figure 14 show the trend of bid-in and award volumes in annual auctions organized by TOU and year. Although the number of bids submitted in the auctions have shown a steady increase, the bid-in MW volume has been relatively stable; this may indicate that the increase of bids in the auction could be driven by an increase of bids with a relatively small MW offer, which usually are bids used to discover prices. The percentage of bid volume cleared in the annual auctions has been declining, going from 26 percent in early 2014 to about 20 to 18 percent in 2017.

Figure 13: Volume of bids and awards in annual auctions for off peak

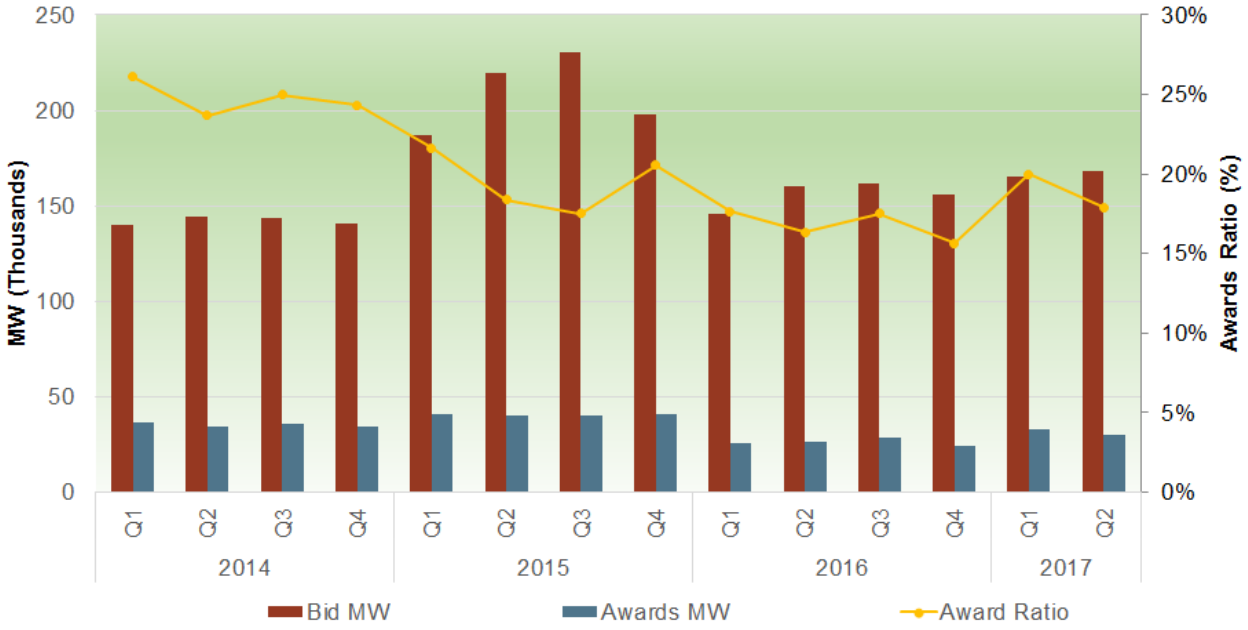


Figure 14: Volume of bids and awards in annual auctions for on peak

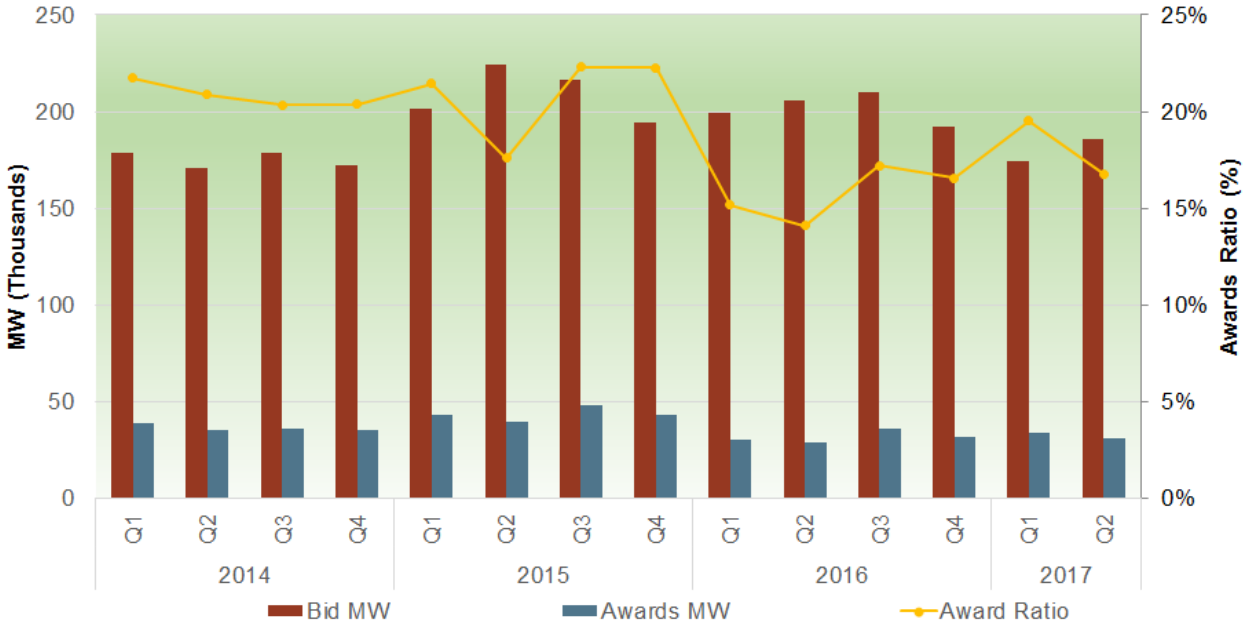


Figure 15 shows the trend of bid-in and award volumes in monthly auctions for the Off-peak period, organized by month and year. The awards for the Off-peak period, have been steady and clearing at about 31,000 to 36,000 MW in the last two years.

Figure 15: Volume of bids and awards in monthly auctions for off peak

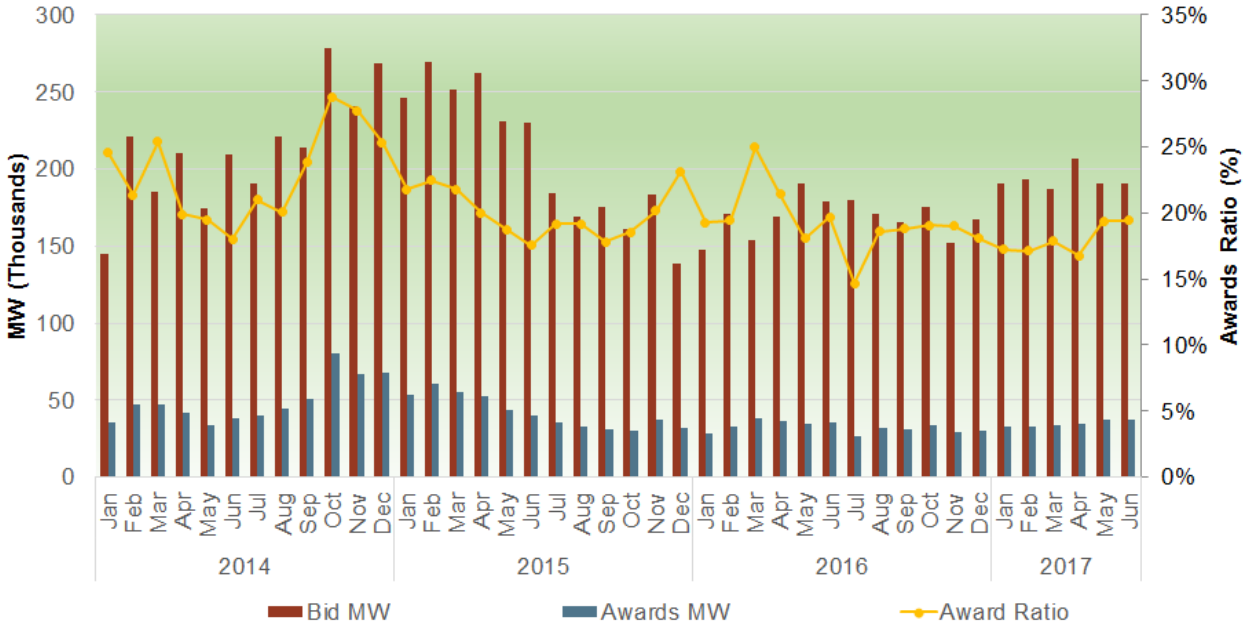
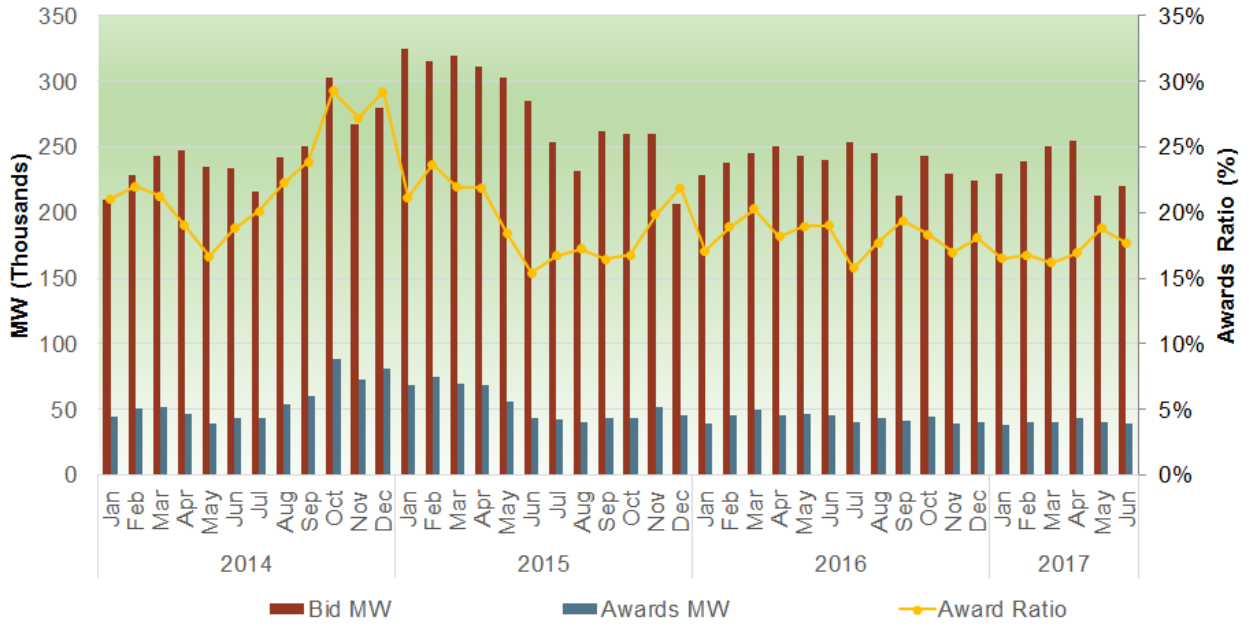


Figure 16 shows the trend of the bid-in volume compared to the volume of awards for monthly auctions for on-peak and shows that bid-in volume has been steady with a slight increase in 2015, ranging from about 220,000 to 320,000 MW. However the award ratio for on-peak period is about 15 to 20 percent in the last two years.

Figure 16: Volume of bids and awards in monthly auctions for on peak



A key point in CRR auctions is that participants can bid negatively for CRRs. This will usually be associated with counter-flow CRRs. The expectation is that an awarded CRR will have an associated negative price, and this implies that the bidder will be paid to take on the CRRs. Once

the CRR award materializes in the energy market, the CRR holder of these negatively valued CRRs expects to be charged, i.e., the CRR becomes a liability.

Figure 17 classifies CRR awards by the type of payment they are associated with in the annual auctions. A volume labeled as positive quantifies the volume of CRRs sold to participants through the auction; i.e., participants paid the CAISO to acquire CRRs. On the other hand, volumes labeled as negative, quantify the CRR volume for which participants were paid by the CAISO to acquire CRRs. Similarly, Figure 18 classifies CRR awards by the type of payment they are associated with in the monthly auctions.

Figure 17: Volume of awards in annual auctions by TOU

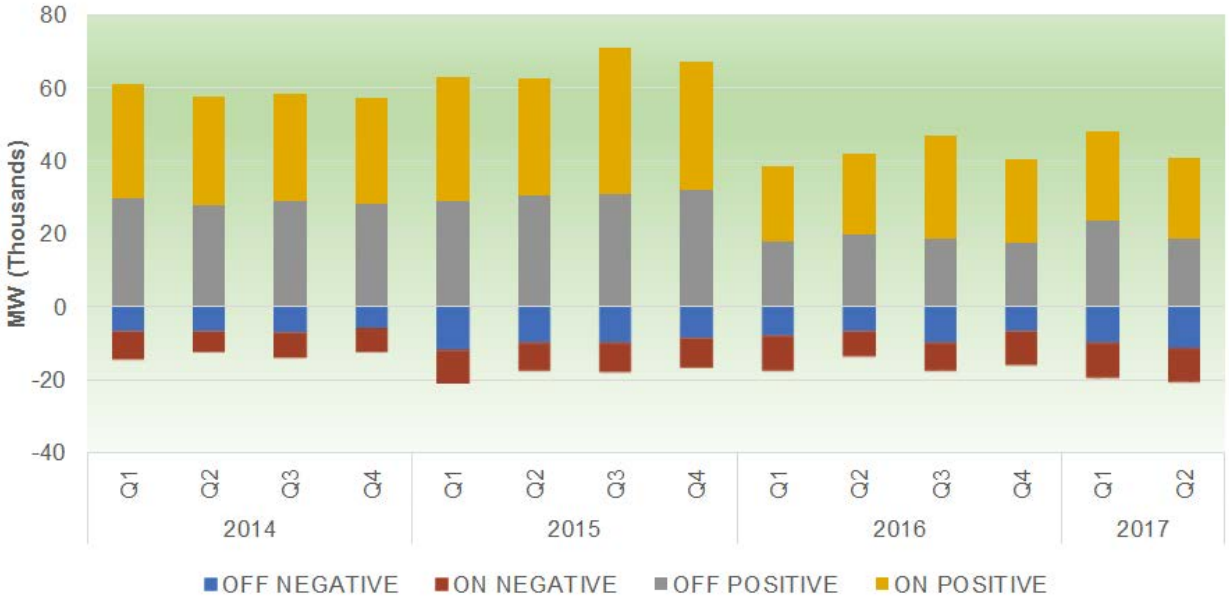
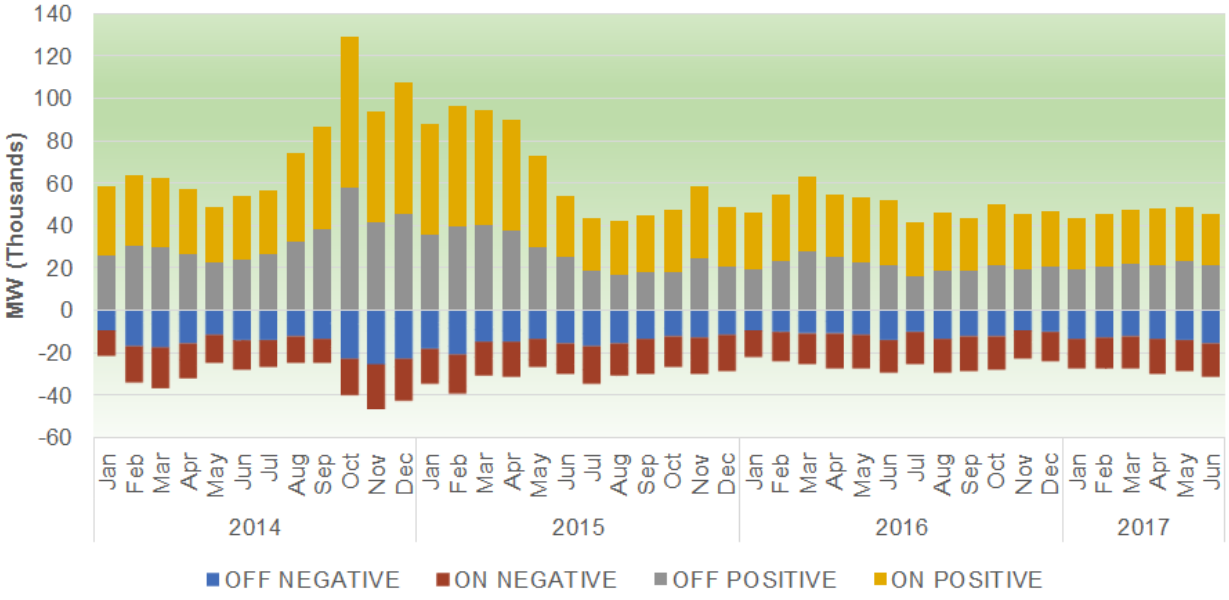


Figure 18: Volume of awards in monthly auctions by TOU



Generally, the volume of negatively priced CRRs in the annual and monthly auctions have been about 22.5 and 44 percent of the positively priced CRRs for the annual auction and 50 and 61 percent of the positively priced CRRs for the monthly auction.

Auction prices

The trend of prices from annual auctions is presented in Figure 19 and Figure 20. The vertical axis shows the count of prices only for CRRs that have an award greater than zero.

Figure 19: Hourly prices from annual auctions - Off peak

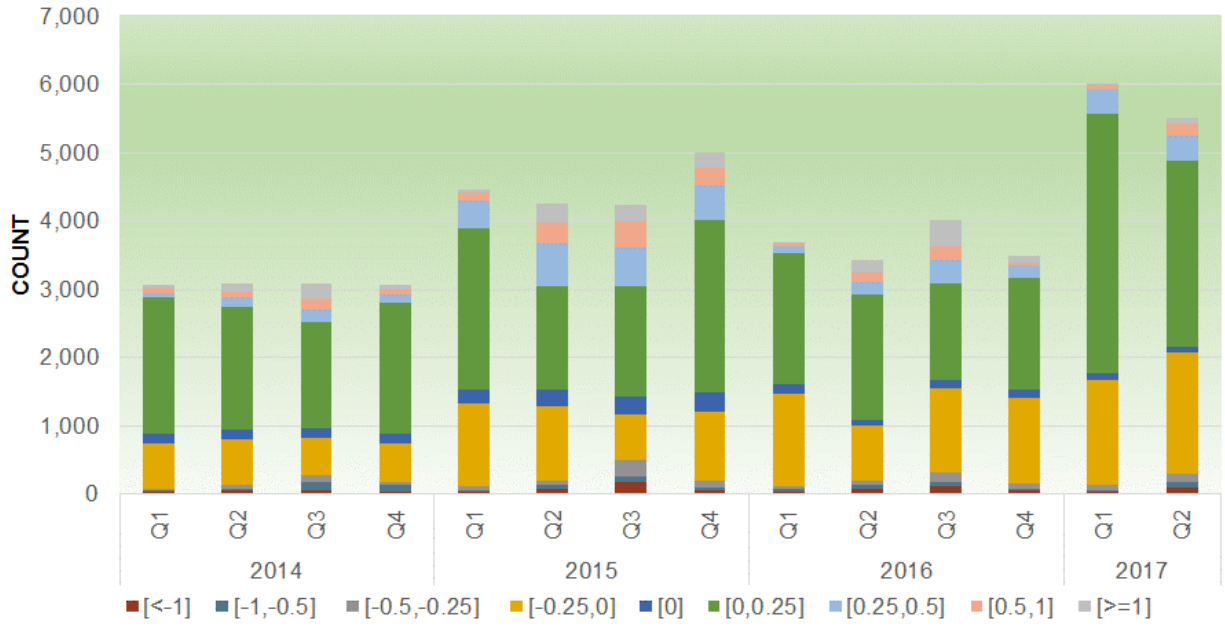
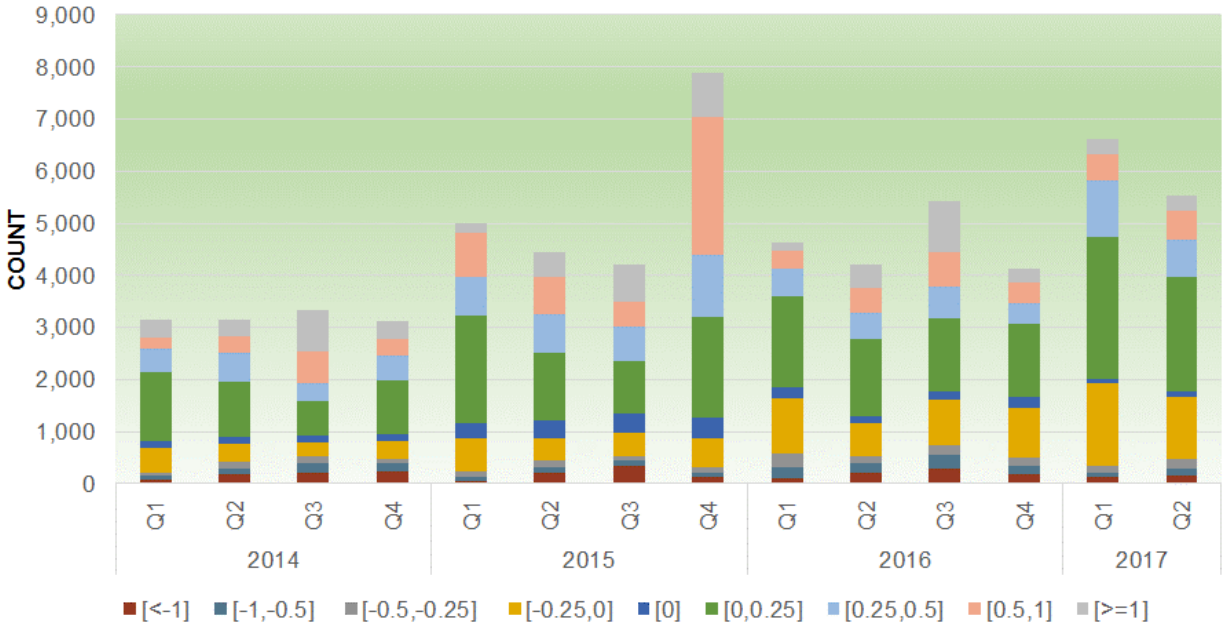


Figure 20: Hourly prices from annual auctions - On peak



Prices are computed as the auction prices divided by the number of hours for the corresponding TOU of each season. Therefore, prices are on an hourly basis of $/MWh. About 61 percent of the CRR awards are valued in the low price range of -$0.25/MWh and +$0.25/MWh.

Similar grouping of prices is used to estimate the volume (in MW) of CRR awarded in the annual auction; Figure 21 and Figure 22 and shows this distribution for the annual Off-peak CRRs. Over 90 percent of the CRR volume was awarded between $0/MWh and $1/MWh.

Figure 21: Volume of annual auction CRRs organized by prices from annual auctions - Off peak

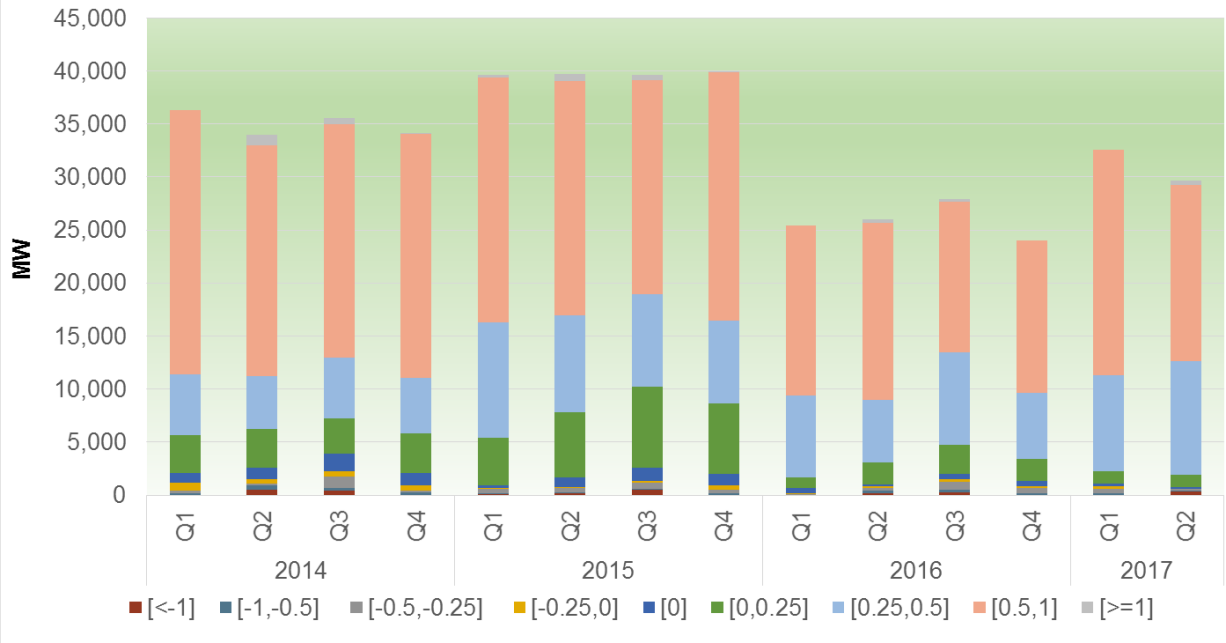


Figure 22: Volume of annual auction CRRs organized by prices from annual auctions - On peak

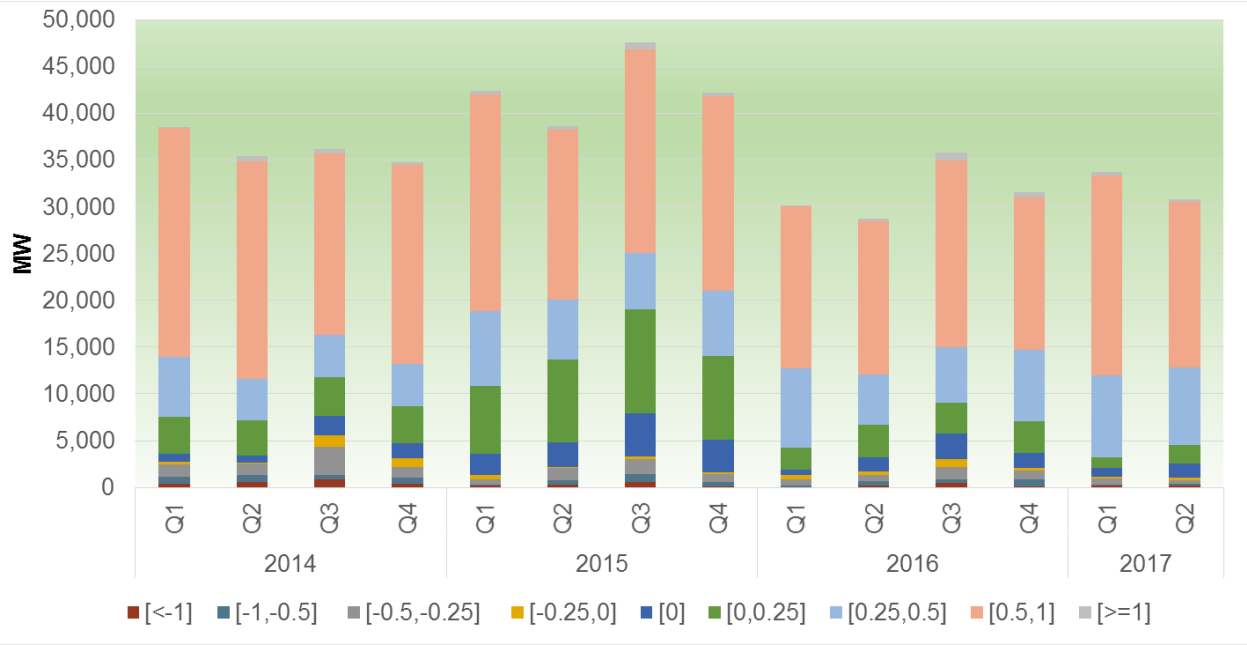


Figure 23 and Figure 24 shows the monthly auction prices organized by price ranges and TOU. Over time, most of the paths cleared in the monthly auctions fell in the price range of -0.25 and 0.25 $/MWh. This trend is indeed more vivid in the Off-peak periods, in which about 92 percent of the paths were cleared in the price range of -0.25$/MWh and 0.25 $/MWh as compared to 76 percent of the paths cleared for the same price range in the On-peak period.

Figure 23: Hourly prices from monthly auctions - Off peak

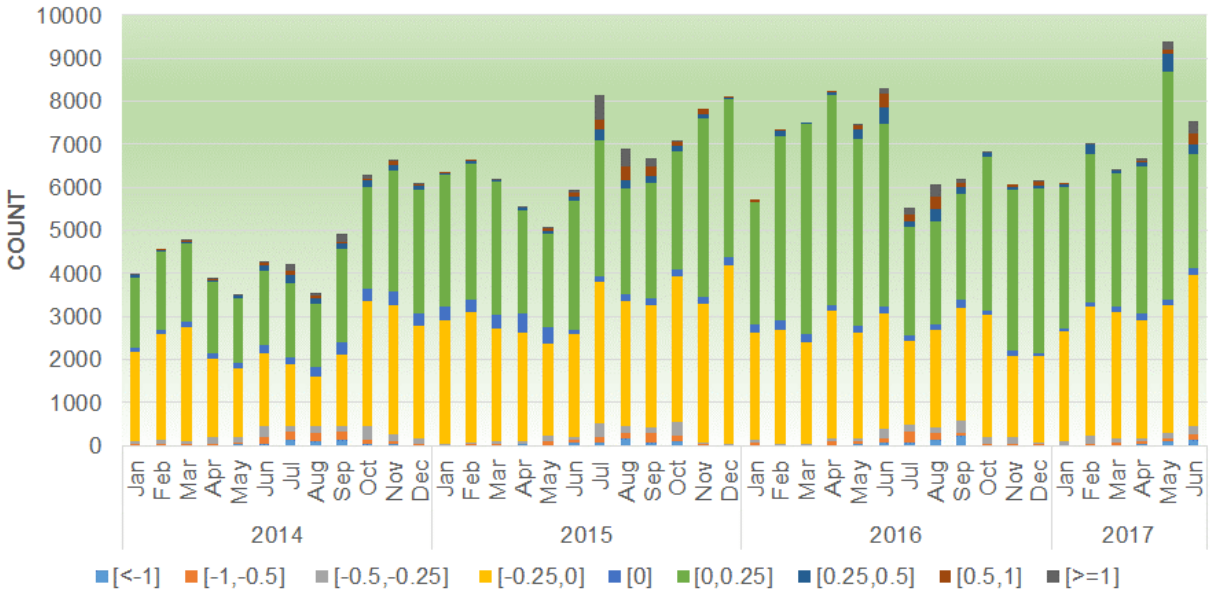
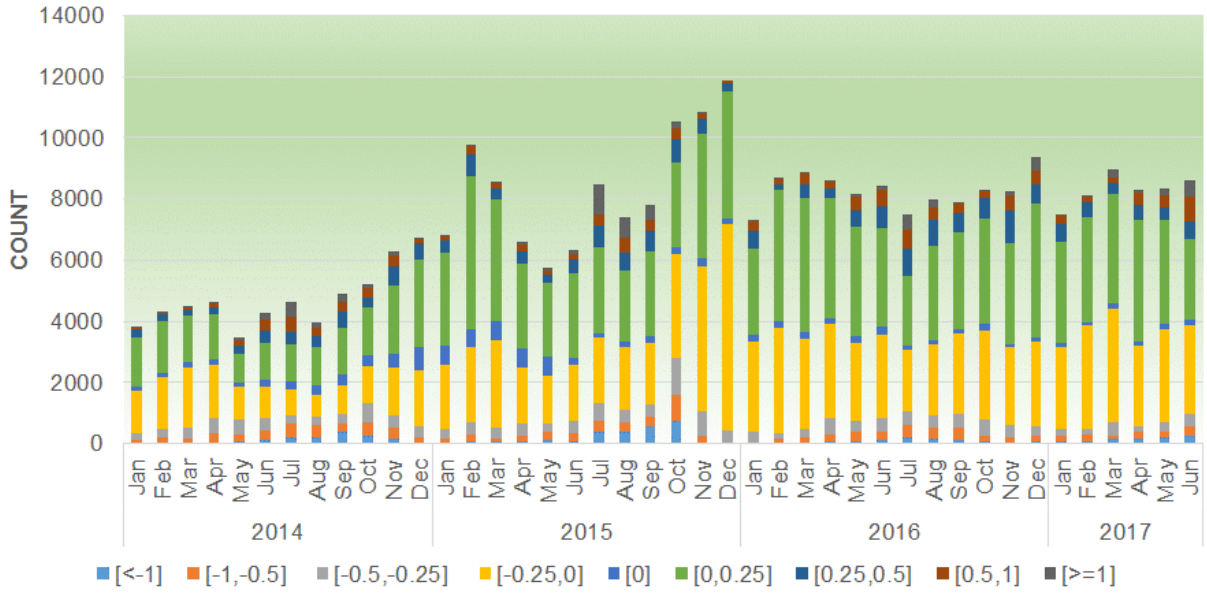


Figure 24: Hourly prices from monthly auctions - On peak



Furthermore, there is a set of CRRs awards cleared at $0/MWh. This set is persistently cleared in every CRR auction for the period under analysis. Those CRRs that are acquired at zero cost in the CRR market were found, based on further analysis, most of the time to have not

accrued any CRR payments in the day-ahead market. However, there are several instances where these CRRs actually have a non-zero CRR payout.

Figure 25 and Figure 26 show the volume of monthly CRRs in MW awarded in the monthly auctions by time of use. Similar to the pattern observed on the count of CRRs, over 90 percent of the total volume of CRRs awarded in the monthly auctions between at prices between -0.25/MWh and +$0.25/MWh, which is a relative low price range. The volume of CRRs awarded at zero price in the monthly auctions used to be about 25 percent until May 2015; starting with June 2015, the volume of CRRs at zero prices has dropped to about 7 percent. This steep reduction is a by-product of starting to enforce nodal group constraints in the CRR auctions; these constraints impose limitation on the amount of CRR that can be awarded at the location level.

Figure 25: Volume of monthly auction CRRs by hourly prices from monthly auctions - Off peak

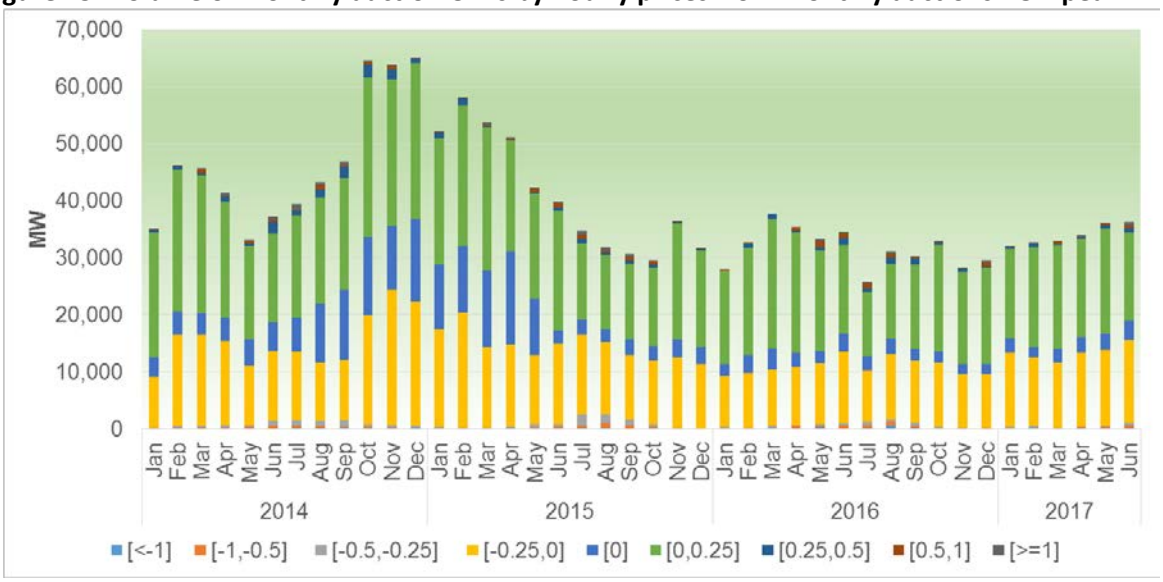
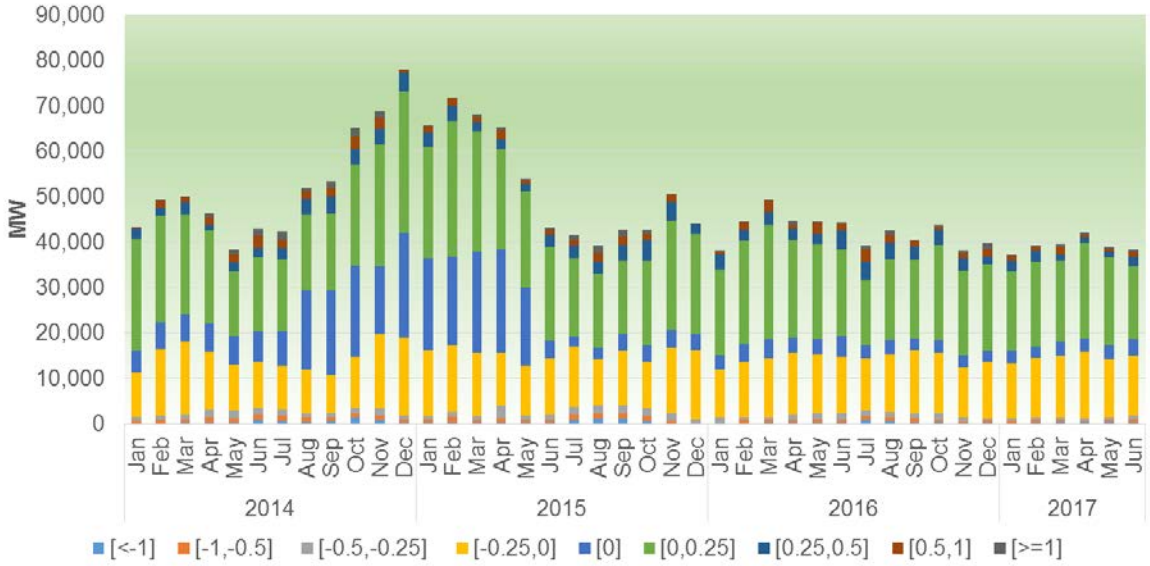


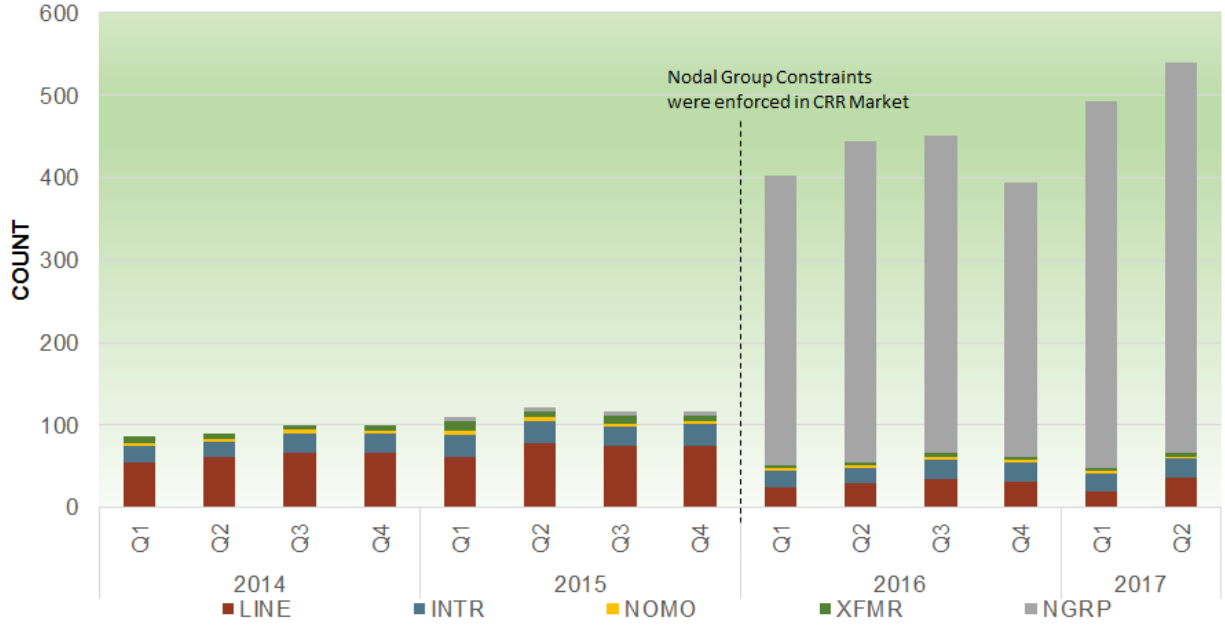
Figure 26: Volume of monthly auction CRRs by hourly prices from monthly auctions - On peak



CRR Binding constraints

Figure 27 and Figure 28 show the trends of binding constraints in the CRR annual auctions. These figures show that there was significant increase in binding constraints in annual auctions for Off- and On-peak due to the introduction of nodal group constraints. Prior to 2016, very few nodal constraints were modelled in the CRR auctions.

Figure 27: Number of binding constraints in annual auctions by type - Off peak



Starting with the annual auction of 2016, nodal group constraints were more comprehensively modelled and enforced in the 2016. An interesting by-product effect observed

with the enforcement of nodal constraints is that the frequency of binding constraints for the other type of constraints has sharply decreased by 40 percent. One possibility for this effect is that with the nodal constraints enforced and binding, they have become more limiting at locational level. By limiting the injections at the nodal level, excessive flows to bind the typical transmission constraints like flowgates or nomograms are prevented.

Figure 28: Number of binding constraints in annual auctions by type - On peak

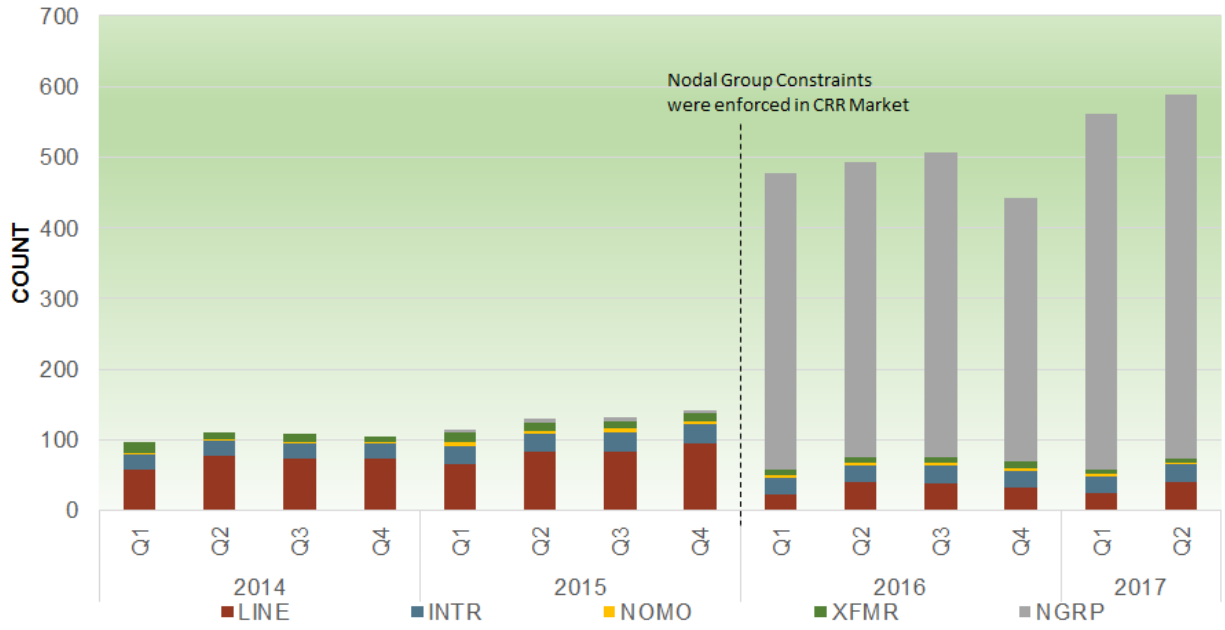


Figure 29 and Figure 30 show the trends of binding constraints in CRR monthly auctions. Similarly, these figures show that in the monthly auctions there was a significant increase in binding constraints for both Off- and On-peak periods due to the introduction of nodal group constraints. Nodal group constraints started to be modeled and enforced in the June 2015 monthly auction market.

Figure 29: Number of binding constraints in monthly auctions by type -Off peak

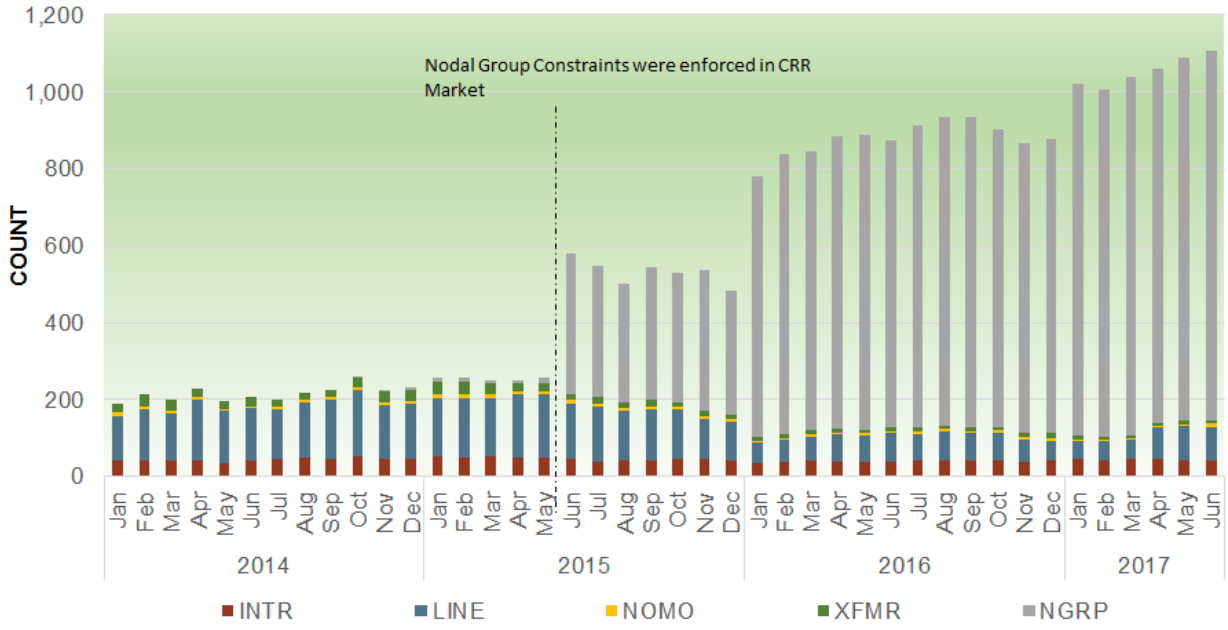
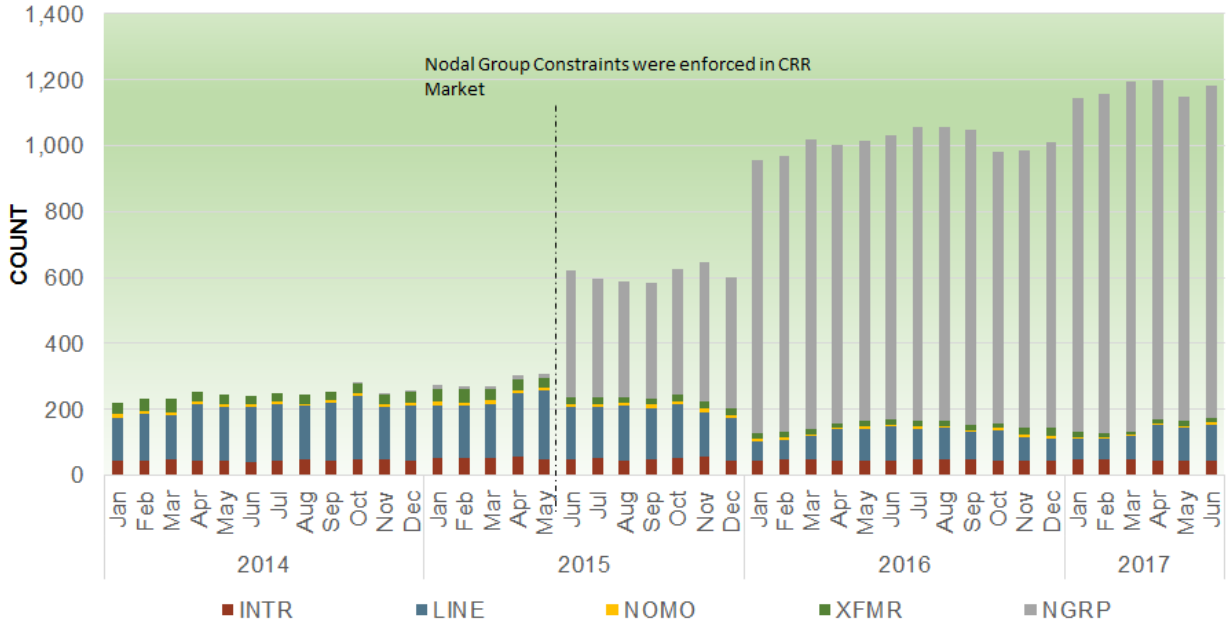


Figure 30: Number of binding constraints in monthly auctions by type -On peak



CRR awards

Figure 31 and Figure 32 show the volume of CRR awards in the annual auctions for off and on-peak periods, respectively, by the type of location used as a CRR source. The CRR award sources were categorized as default load aggregated point (DLAP), Trading Hub, Interties and all of the rest are others. About 84 percent of the CRRs have internal locations (either individual or aggregated locations) used as the CRR source, with a declining trend in 2016 and 2017; interties then become the second predominant type of location where CRRs are

sourced. This is not surprising given the fair volume of energy coming through the interties. It is not conclusive if the enforcement of the nodal constraints resulted in the lower volume of CRRs with sources at internal locations or if it is simply due to other dynamics.

Figure 31: Volume of awards in annual auctions by source type - Off peak

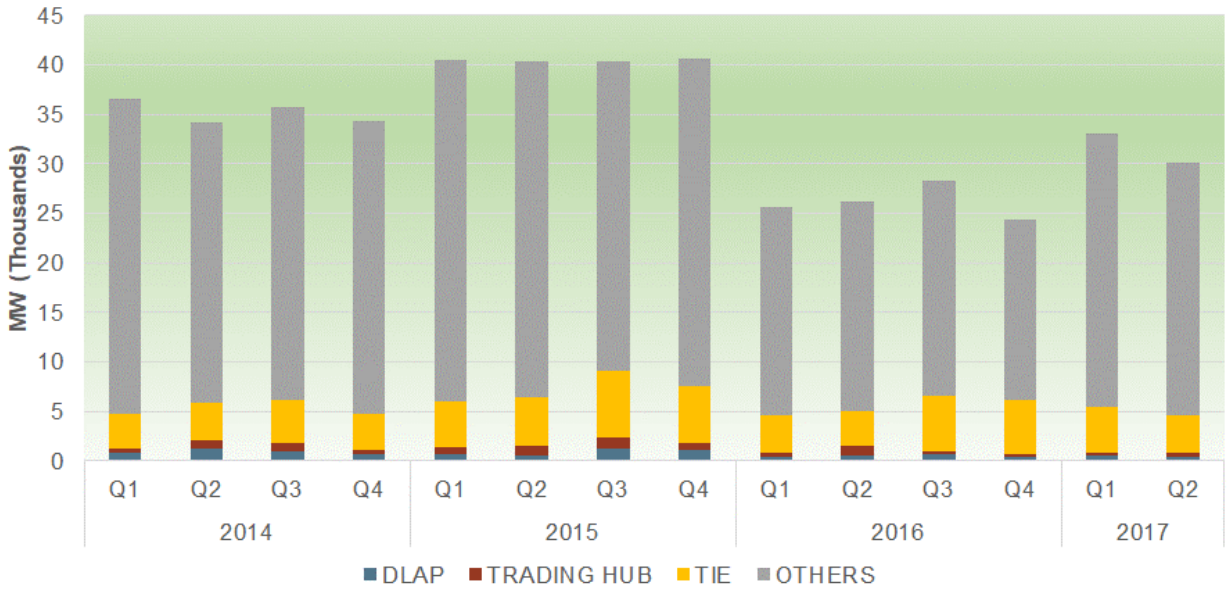
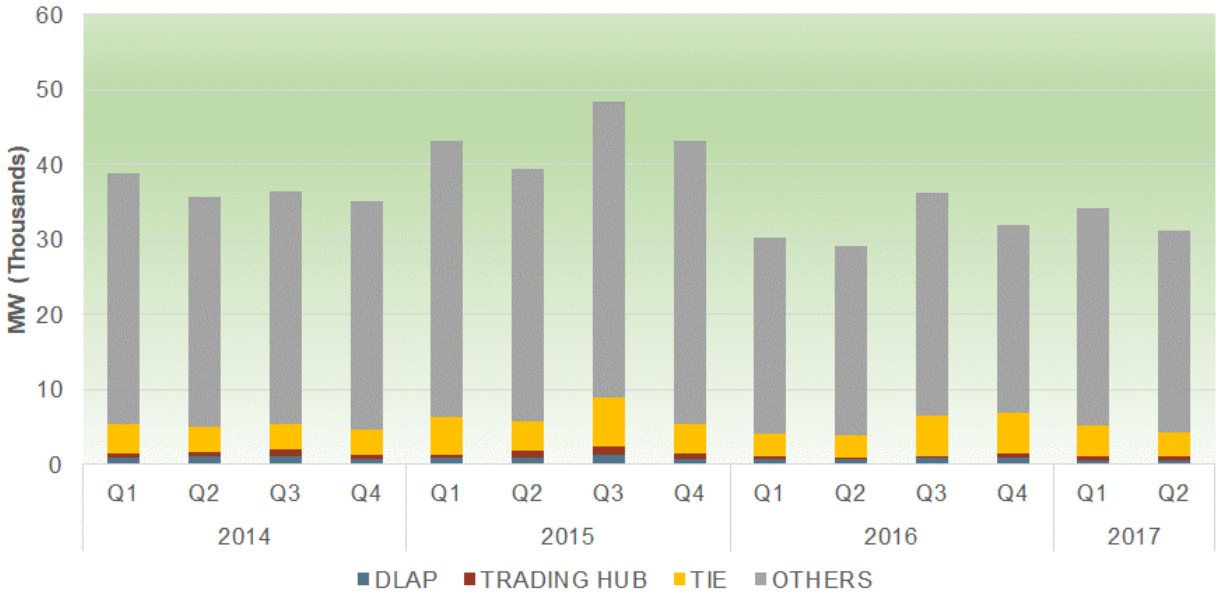


Figure 32: Volume of awards in annual auctions by source type - On peak



Similarly, Figure 33 and Figure 34 show the volume of CRR awards from the monthly auctions for Off- and On-peak periods, respectively, by the type of locations used as a CRR source.

Figure 33: Volume of awards in monthly auctions by source type - Off peak

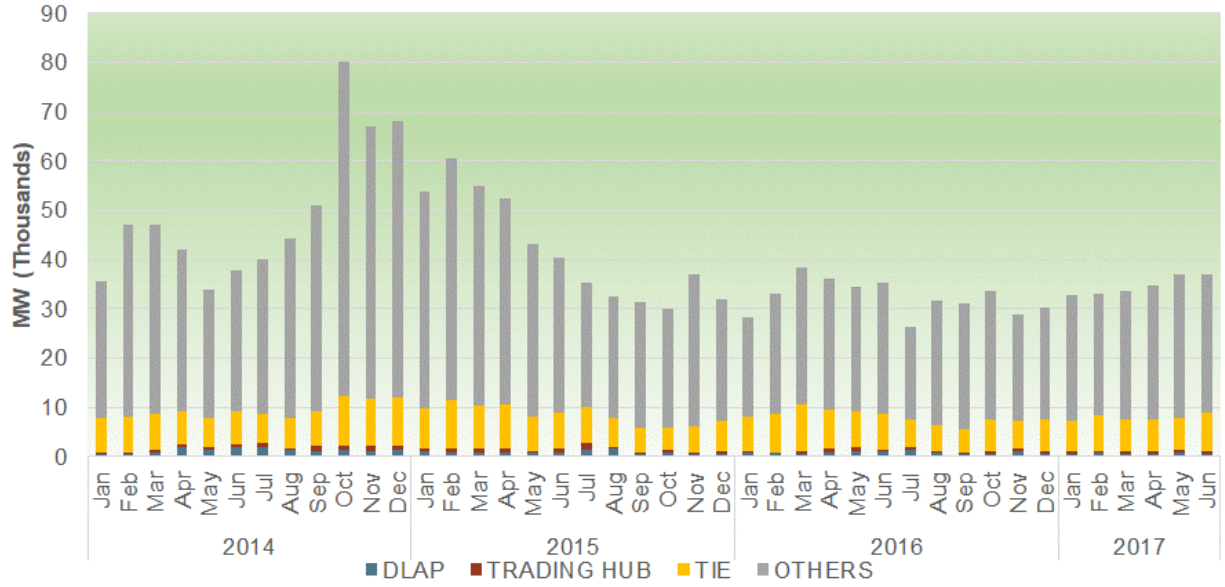
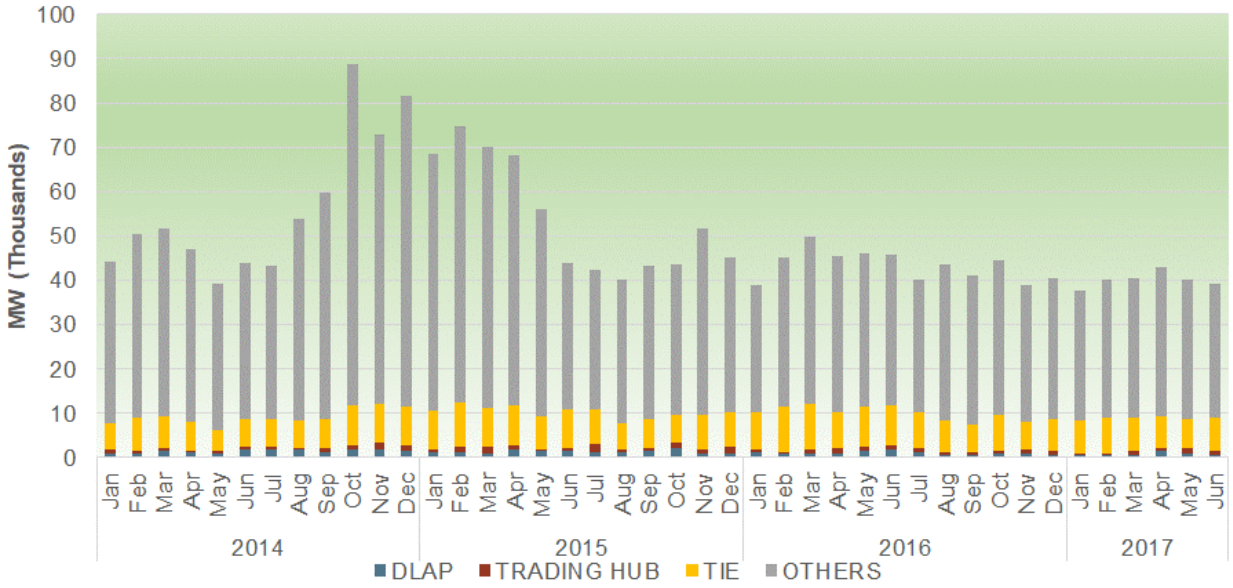


Figure 34: Volume of awards in monthly auctions by source type - On peak



Auction revenues

Participants in CRR auctions may get charged or paid to acquire CRRs. Participants receiving CRRs at positive prices pay the CRR awards at their clearing price. The expectation for participants looking to acquire CRRs for profit seeking opportunities, is that the revenue stream from the IFM congestion component prices will at least offset this cost plus some risk premium and any other costs associated with their participation in the CRR market. For participants looking to acquire CRRs for hedging needs, this may not be ultimate goal but

rather they seek to hedge their position in the energy market. Conversely, participants acquiring CRRs at negative prices are paid the CRR award at the clearing price. Negative auction revenues are funded with positive revenues. The net balance is the CRR auction revenues collected by the ISO. Figure 35 shows the total auction revenues collected in each month through the annual and monthly CRR auction process. The annual CRR auction revenues are attributed to each month through a pro-rata share of seasonal revenues based on the number of hours for each month.

Figure 35: Auction revenues by month

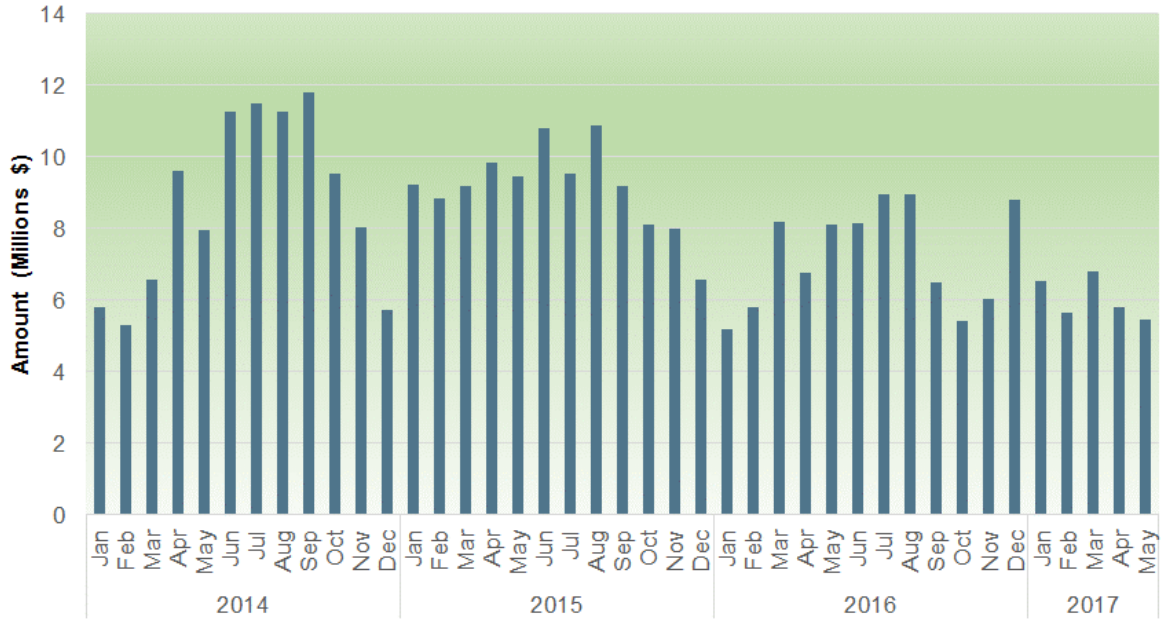
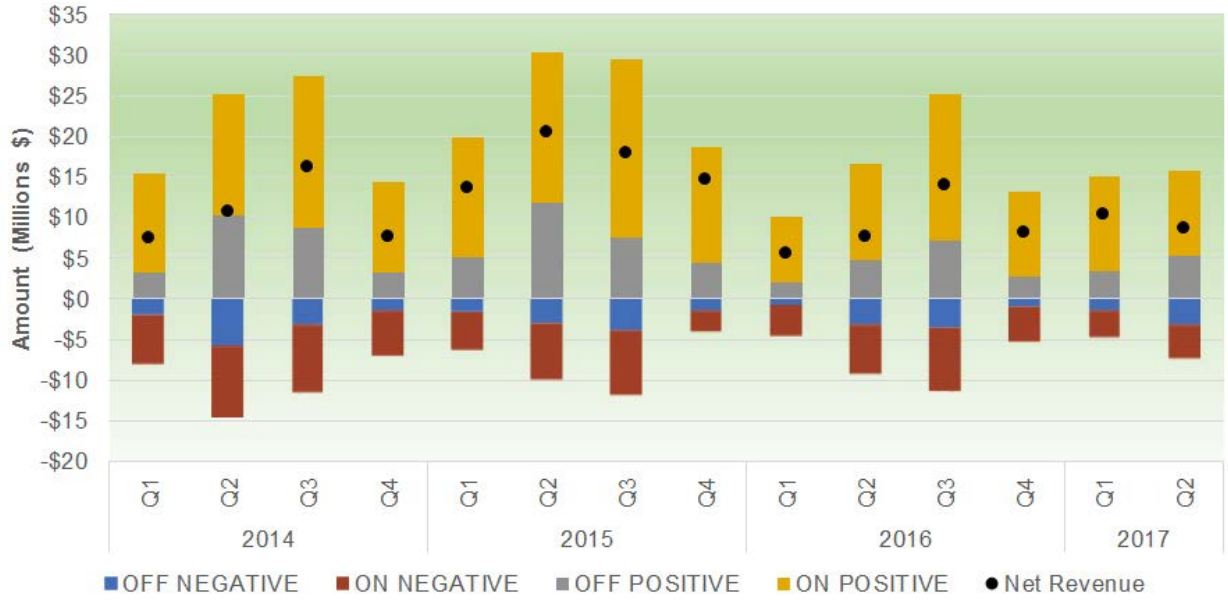


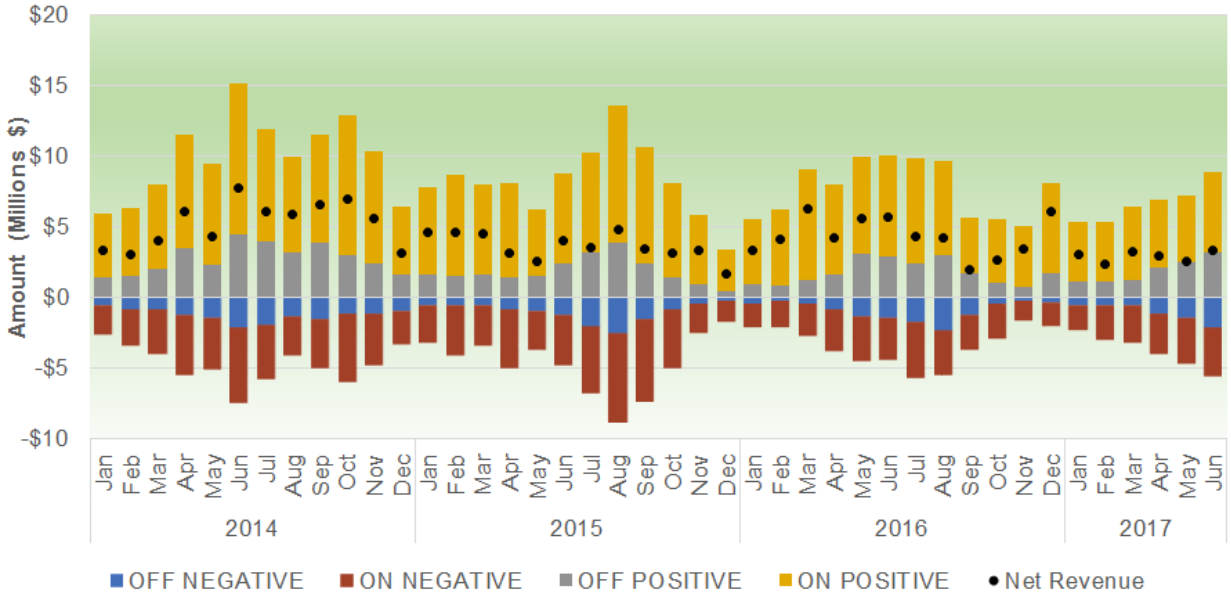
Figure 36 and Figure 37 show the auction revenues organized by positive and negative revenues in each TOU from annual and monthly auctions. These figures also show the net auction revenues collected by the ISO by TOU with a black dot on the chart. This net revenue illustration shows a trend with higher auction revenues collected in summer months.

Figure 36: Revenues collected from annual auctions by TOU



The monthly auctions observe more negative auction revenues offsetting the positive auction revenues, indicating the dynamic where more counter-flow positions may be bidding and clearing in the shorter-term auction. In the annual and monthly auctions, negative auction revenues amount to about 40 percent and 50 percent, respectively, of those of positive auction revenues. This would be expected given that the more frequent (monthly auction) can have CRRs with a shorter life term (a month versus a quarter of the annual) and this auction is run closer to day-ahead conditions (a couple of weeks in advance of the settlement months in contrast to up to 10 months in advance of the annual auction).

Figure 37: Revenues collected from monthly auctions by TOU



5 Market Performance

DA congestion rents

Congestion rent is a by-product of using locational pricing to trade energy and stands for the market surplus collected by the CAISO when congestion arises. This surplus is obtained from the basic principle of having demand paying higher prices than what is paid to supply due to using scarce transmission. From a settlements perspective, congestion rents are defined as the difference between congestion charges from demand (physical and virtual) and exports, minus congestion payments to generation (physical and virtual) and imports[2]. With the current nodal market design, ancillary services can also be awarded over interties and they have to compete for transmission capacity over those ties. If ancillary services (AS) are awarded over a congested inter-tie, then that AS award also has to pay for congestion, contributing to congestion rents. For each hour of the IFM, demand and exports are charged the scheduled MW amount times the marginal congestion component (MCC), and supply and imports are paid the scheduled MW amount times the MCC. The MCC is at the applicable individual pricing locations (Pnodes), aggregated pricing locations (APnodes) or scheduling points (SP). The monthly congestion rents shown in Figure 38 are computed as the sum of hourly congestion rents across all hours of the day, for all days in a month.

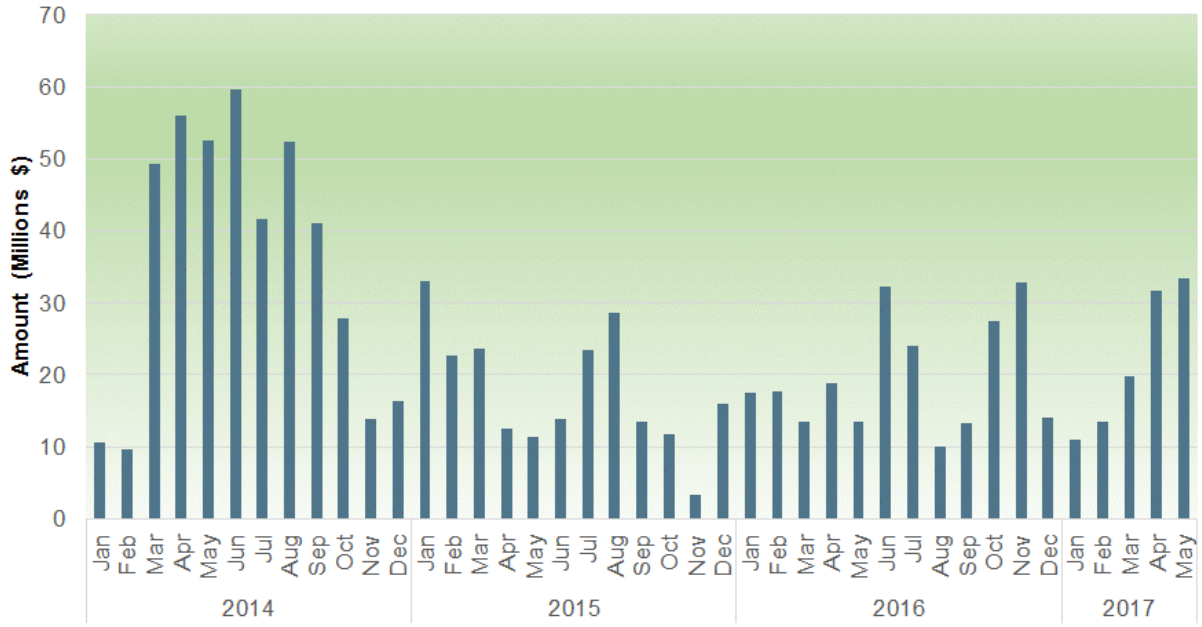
In addition, the revenue stream available from the IFM to fund the CRR payments are reduced by the amount to be paid back to holders of existing rights (TOR, ETC and CVR), as they are fully exempt from congestion charges. This requirement is contractual and is a tariff requirement[3]. The CAISO explicitly tracks the costs of the existing right exemptions so that the costs of honoring the contracts associated with the existing rights holders can be clearly broken out for analysis. Figure 38 shows the summation of IFM congestion rents reduced by the cost of existing rights exemption that would be used to fund the CRR payments.

Over the recent years under analysis, 2014 saw about $430 million in 2014, and then stabilized in subsequent years, reducing to about $213 million in 2015 and about $235 million in 2016 and about $108 million in 2017 (January to May).

[2] Throughout this document, congestion rents have been estimated in two different ways. At the system wide level, congestion rents can be estimated based on the settlements data, which reflects payments and charges to participants based on the congestion component of the LMP. However, when the analysis needs to be carried out by each transmission constraint, two variations can be used. One variation relies on reconstructing the implied congestion rents on each element by using the shift factors, resource awards and the MCCs. A simpler calculation relies on the shadow prices and nominal power flow on each transmission constraint. The difference between these two estimates is that the latter does not reflect the effect of the 2 percent shift factor threshold and, therefore, it becomes an upper bound on the estimate for congestion rents. Generally the difference is expected to be small, even though there may be some cases where a specific constraint may be impacted more significantly due to the shift factor threshold. Throughout this document, when the analysis is carried out by transmission constraint, the latter approach is used for simplicity; again, this will always provide an upper bound on the congestion rents estimate, which generally can be estimated more optimistically than it actually was in settlements.

[3] CAISO tariff section 11.2.1.5.

Figure 38: Monthly IFM congestion rents including costs of existing rights exemptions



CRR revenue adequacy

The requirement to maintain revenue adequacy is the main factor that limits the number of CRRs released through allocations and auctions. Simply, it means that there should be sufficient congestion rents emanating from the IFM energy market to pay all of the CRR entitlements. Conceptually, and under certain assumptions, such as the use of the same transmission configuration in both the CRR and energy markets, revenue adequacy may be guaranteed when limiting the release of CRRs with a simultaneous feasibility test. The CAISO's market for CRRs uses a simultaneous feasibility test in each of the release processes (allocations and auctions) to ensure, to the extent possible, the appropriate number of CRRs are released. In real-world markets, and based on the inherently changing nature of the transmission system configuration, the theoretical assumptions to guarantee revenue adequacy at every single hour may not be possible to fulfill without overly restricting the number of CRRs released. The CRR market is a forward-looking market, and at the time that the CRRs are released some outages and constraints are not known and, therefore, cannot be modeled in the network used in the simultaneous feasibility test. Hence, shift factors, transmission limits and constraint enforcements used in the CRR market may be different to the ones actually used in the energy market, which may lead to revenue deficiencies. For instance, the annual processes release CRRs as far 10 months in advance and, consequently, even planned outages may not be known by the time CRRs are released. Although the CAISO's energy market is based on an AC-based model, the CRR market is a DC-based model. This simplified model is obtained by following the well-known linearization of the power flow expressions.

For annual processes, all transmission facilities are considered in service, and outages of any significant elements known before the start of the processes may be modeled in the

network for the season in which the outage occurs[4]. Furthermore, for monthly processes the CAISO has in place a process for transmission owners to submit requests to the CAISO to schedule significant outages at least 30 days prior to the start of the month in which the outage will take place. This 30-day rule provides a critical mechanism for the CAISO to account for significant transmission outages when determining the network capacity available for each monthly CRR release process. The monthly processes are the last occasion wherein the CAISO may make adjustments to the release of CRRs with the intention of protecting revenue adequacy based on feedback from the prior months' performance. At the same time, the CAISO is trying to ensure revenue adequacy without adversely affecting the quantity of CRRs released. There are three adjustments the CAISO uses for this purpose:

a) Modeling of outages in monthly CRR release processes. As transmission outages play an important role in revenue adequacy, a critical element of the ISO's monthly CRR release process is to account for the impact of expected transmission outages in the monthly CRR releases. The CAISO tariff requires that Participating Transmission Owners (PTO) submit requests to the CAISO to schedule significant outages at least 30 days prior to the start of the month in which the outage will occur[5]. The transmission outages spanning less than 10 days were modeled with pro-rata derates to reflect the portion of the month they were planned to be out of service.
b) Global Derate Factor. Outages that cannot be captured by the 30-day rule, such as unscheduled outages, cannot be explicitly reflected in the CRR release process. To account for the likelihood of unscheduled outages, the monthly CRR process employs a global derate factor which reduces the system-wide transmission capacity available in the release process and thereby limits the number of CRRs released. The global derate factor has been 17.5 percent since January 2014.
c) Local Derate Factor. For known outages that can impact interface or branch group limits the CRR process makes pro-rata adjustments to reflect and reduce interface limits. For unscheduled outages the CRR process can apply a Local Derate Factor to any individual interface or branch group in a manner similar to the Global Derate Factor. The Local Derate Factor is not applied across all interfaces and branch groups but only on specific locations.

Figure 39 illustrates the monthly congestion revenue adequacy ratio and CRR entitlements. The ratio was below 1 for all the months indicating that CAISO was revenue deficient, when congestion rents collected in the day-ahead market were not sufficient to fund the CRR payments.

[4] CAISO tariff section 36.4.
[5] Tariff sections 9.3.6.3.2 and 36.4.3. See also BPM for CRRs section 10.3.1 and Operating Procedure 3210 appendices B,C and D.

Figure 39: Monthly comparison of congestion rents with CRR entitlements

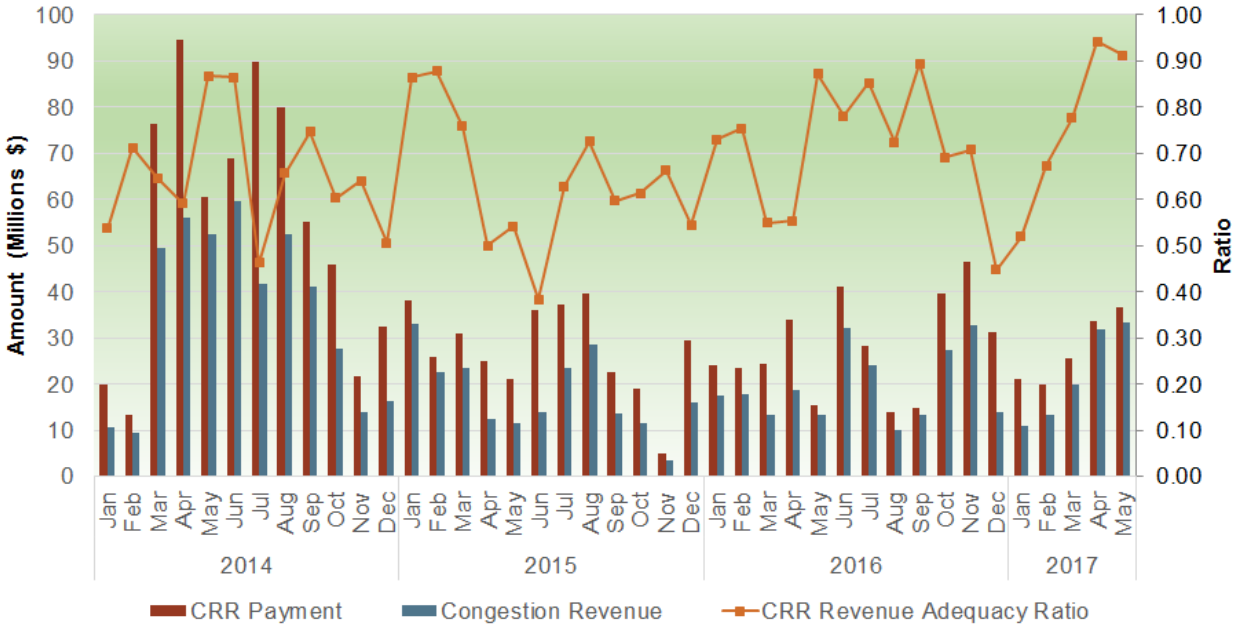


Figure 40 illustrates the monthly congestion revenue adequacy before including the auction revenues. Although auction revenues can be used to offset any CRR revenue deficiency that results from the IFM, the intention of the CAISO's CRR release process is that proceeds from the IFM will be sufficient to cover all CRR payments over the course of each month. The annual and monthly processes to release CRRs through allocations and auctions are built upon this concept. In addition, transmission capacity is set aside in the release processes in order to account for the perfect hedge congestion payment reversal for existing transmission rights.

Figure 40: Monthly CRR revenue adequacy before auction revenues

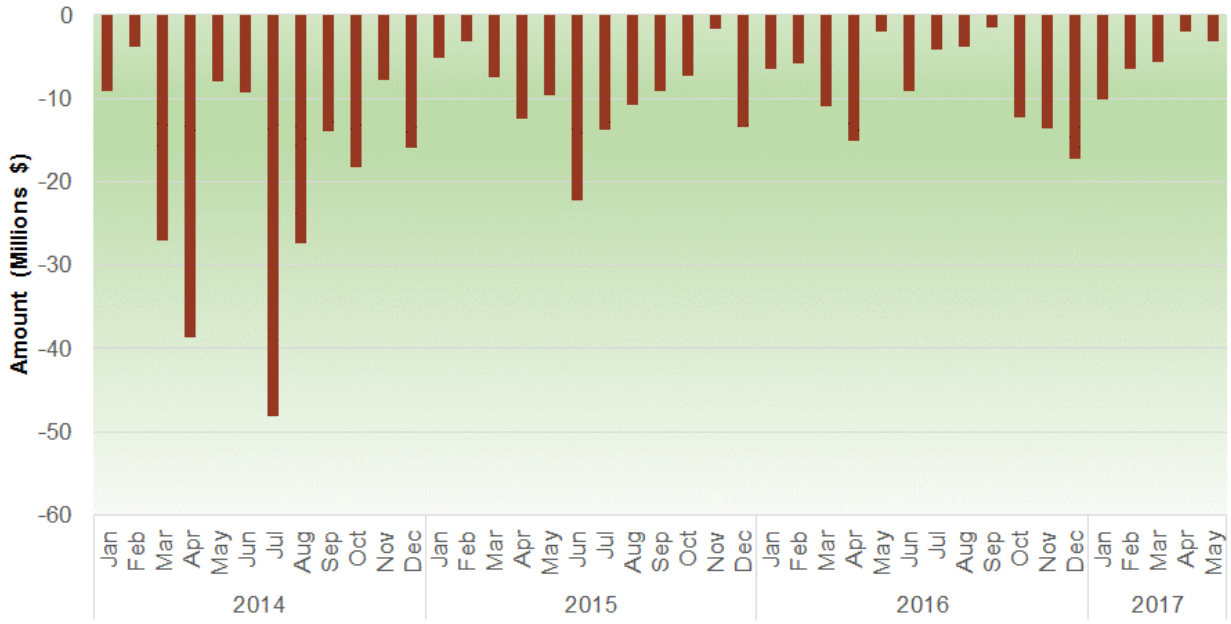


Figure 41: Monthly comparison of congestion rents incl. auction revenue with CRR entitlements

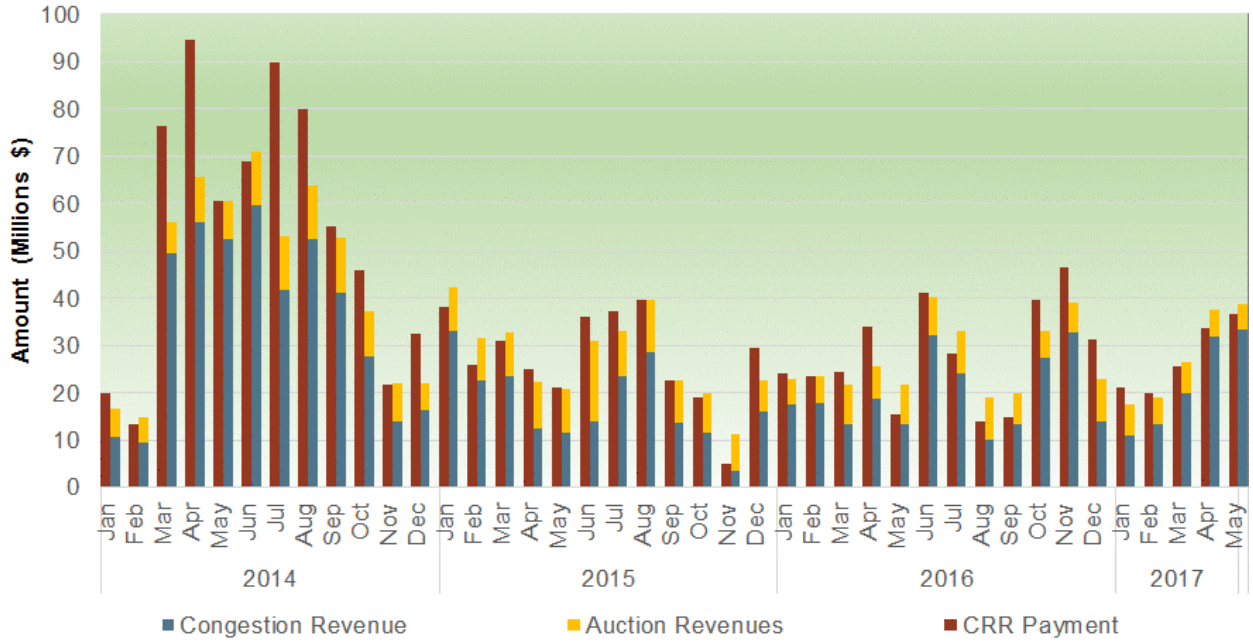


Figure 41 shows the comparison of congestion rents from IFM with CRR payments; this also includes the auction revenues from the monthly and annual CRR auctions. Similarly, Figure 42 shows the difference between congestion rent from IFM and CRR payments including the auction revenue to check if the proceeds from the IFM will be sufficient to cover net CRR payments over the course of each month. This figure represents the money available in the CRR balancing account which is allocated to the measured demand. This balancing account money (whether representing a surplus or shortfall) is allocated to the measured demand. Once the auction revenues are used as a buffer, multiple months regained sufficiency; still, there are many other months in which there is a revenue deficiency even with the auction revenues being fully used.

Figure 43 shows daily revenue adequacy on the system level. Along with the daily revenue adequacy, it also shows the comparison of updates in the Full Network Model (FNM) with the revenue adequacy. Each FNM promotion has been marked in the chart starting from 2014 along with high revenue deficient days and the top transmission constraints that impacted the revenue deficiency. From this trend, there is no clear correlation over this period of time in which a system change may have driven the pattern of revenue deficiency in one way or another. Indeed the level of congestion and revenue deficiency seem to have diluted after the full network implementation in October 2014.

Figure 42: Balancing account allocated to measured demand

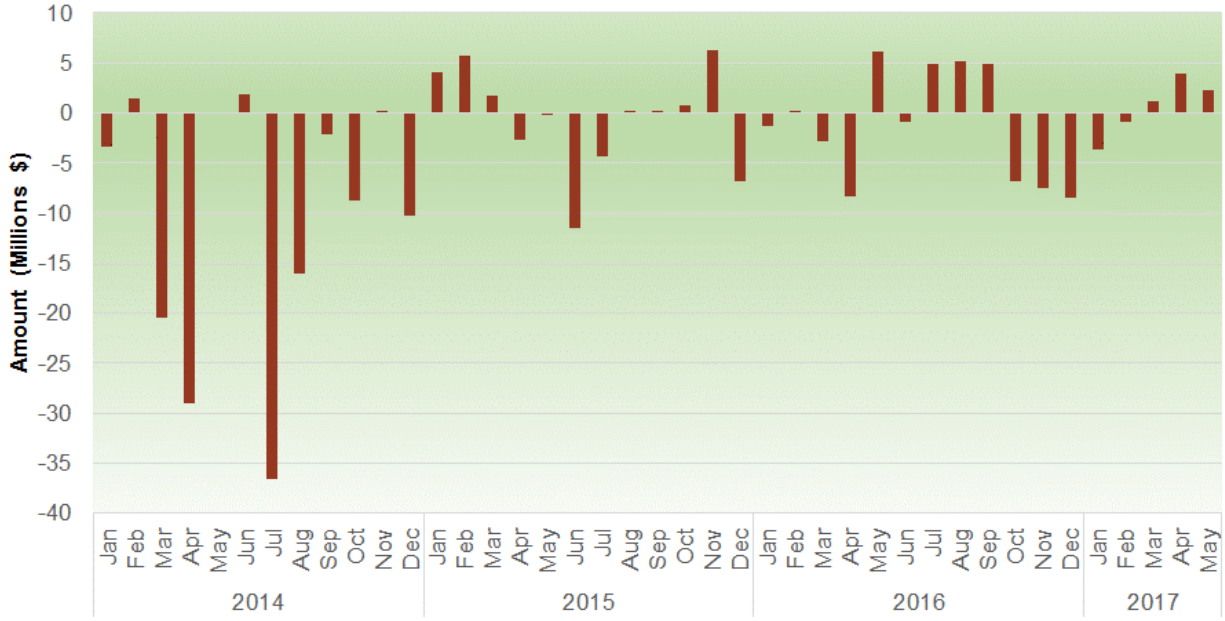
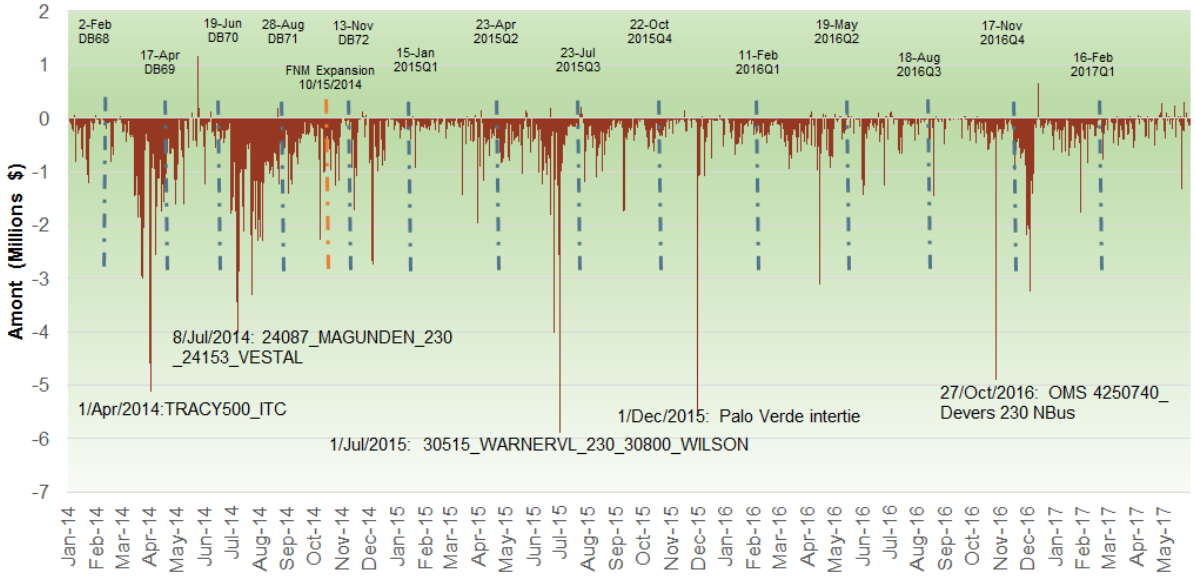


Figure 43: Daily CRR revenue adequacy

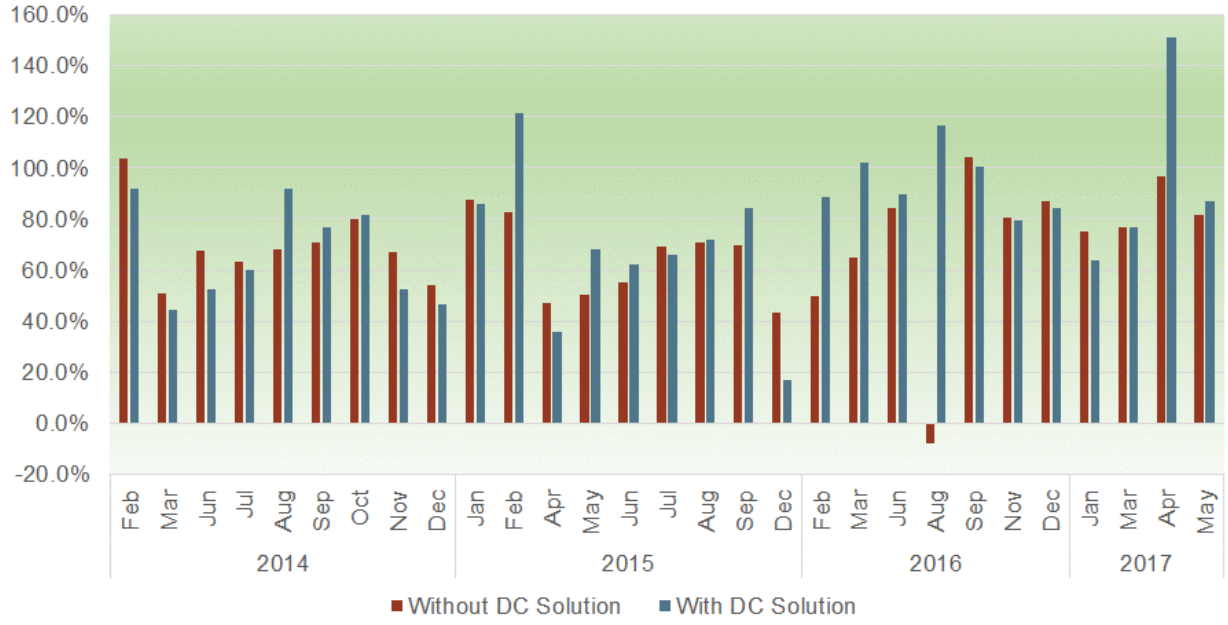


DC solutions and CRR revenue shortfalls

The CAISO markets are based on the use of a linearized AC power solution; when the AC power flow does not converge, the market application defaults to use a DC power flow solution. There has been some concern that with the CRR auctions using a DC model while the day-ahead market uses linearized AC power flows, systemic high payout or revenue shortfalls could be attained. An approach aiming to quantify this model difference was set-up by using instances of the day-ahead market when an AC solution could not be attained and the DAM

defaulted to a DC solution. Since the day-ahead market cannot be rerun with the all DC solution, an alternative approach to gauge the impact on revenue adequacy for having DC solutions is to identify the hours when there was a DC solution and then compare the level of revenue adequacy with AC and DC solutions for only the set of days in which there was at least one hour with DC solutions. Figure 44 shows the monthly comparison of CRR revenue adequacy ratio when the IFM market solved with a DC solution. The trade dates with any hour with a DC solution were identified and then a comparison was made of revenue adequacy ratios for hours with a DC solution and hours without a DC solution for the same trade dates. In general the results are mixed, even though there are more instances in which the hours with DC solutions have a better revenue adequacy (higher revenue adequacy ratios).

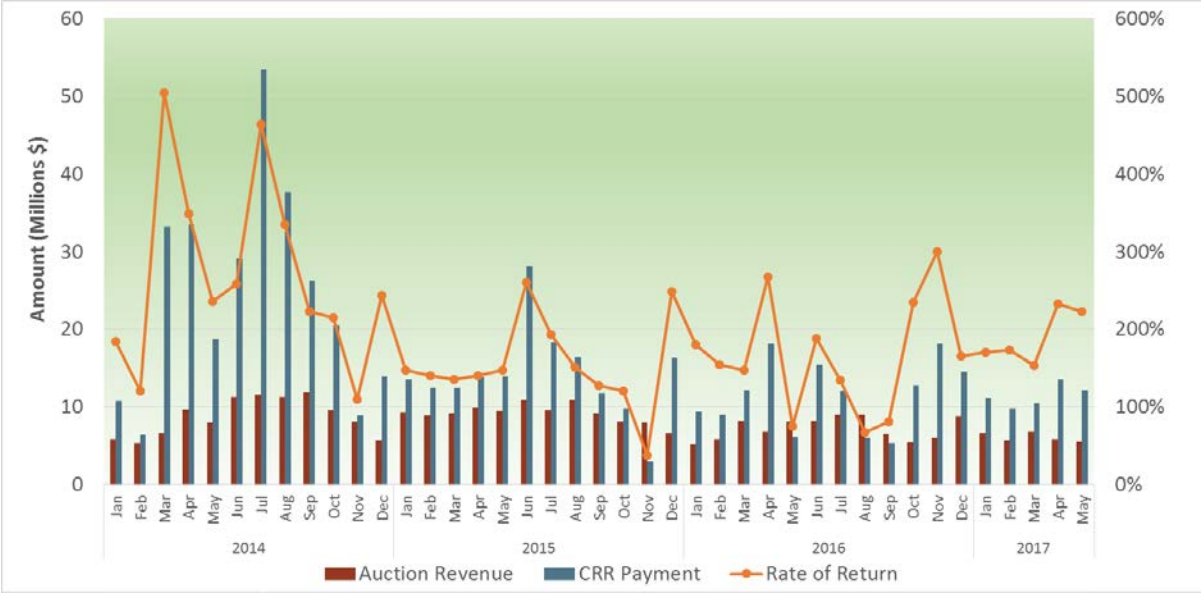
Figure 44: CRR revenue adequacy ratio - for trade dates with DC solution in IFM



Auction revenues *vs.* payments to auction CRRs

Figure 45 shows the comparison between auction revenues (monthly and annual) with the payments to auction CRRs by month. The auction revenues collected from the annual auctions for each season are distributed pro-rata to each month of the season based on the number of hours in each TOU. It shows that the amount collected from the auction market was less than the payments to holders of auction CRRs. The payments to auction CRRs were significantly high in 2014 at approximately $292 million. The auction revenues for the same year were about $104 million. This resulted in a net CRR payment of $187 million. The CRR payments to auction CRRs reduced significantly in 2015 to about $169 million and further reducing in 2016 to about $138 million. The delta between the CRR payments to auction CRRs and auction revenues reduced in 2015 to about -$60 million, further reducing in 2016 to about -$51 million. In 2017 (January to May) the total delta was at about -$21 million. The negative sign indicates that the payments made to the CRR holders for auction CRRs were higher than the total amount collected through auction revenues.

Figure 45: Comparison of auction revenues and CRR entitlements from auction CRRs



This graph also shows the proportion of CRR payments to auction revenues with the line in orange. A value of 100 percent indicates the CRR payment equals the auction revenues. A value higher than 100 percent indicates the CRR holder is collecting a CRR payment above the money paid to acquire the CRR in the CRR auctions.

Although this metric is useful to see the system-wide pattern, it does not show how and why this is happening. In order to further understand this dynamic, this metric was analyzed from different perspectives, breaking it down by TOU, annual and monthly auctions and source and sink locations. Figure 46 shows the difference between CRR payments to auction CRRs and the auction revenues; this difference is what is referred to as net CRR payments and is estimated from the CAISO's point of view, with a negative value meaning the CAISO has an overall payment to the holder of auction CRRs (CRR payments are greater than the auction revenues collected in the auction). Broken out by TOU to see if this pattern is common to both time of use or not, this trend shows that the negative net CRR payment is significantly more concentrated in the on-peak period. The net CRR payment for on-peak in 2014 was about -$132 million, reducing to about -$62 million in 2015 and -$41 million in 2016. The delta was about -$15 million in 2017 (January to May) for the on-peak period.

For the off-peak period, the net CRR payments were about -$55 million in 2014, and reduced to about $2 million in 2015. In 2016 and 2017 (January to May), the net CRR payment was about -$10 million and -$11 million respectively.

Figure 46: Net CRR payments to CRRs released in auctions organized by TOU

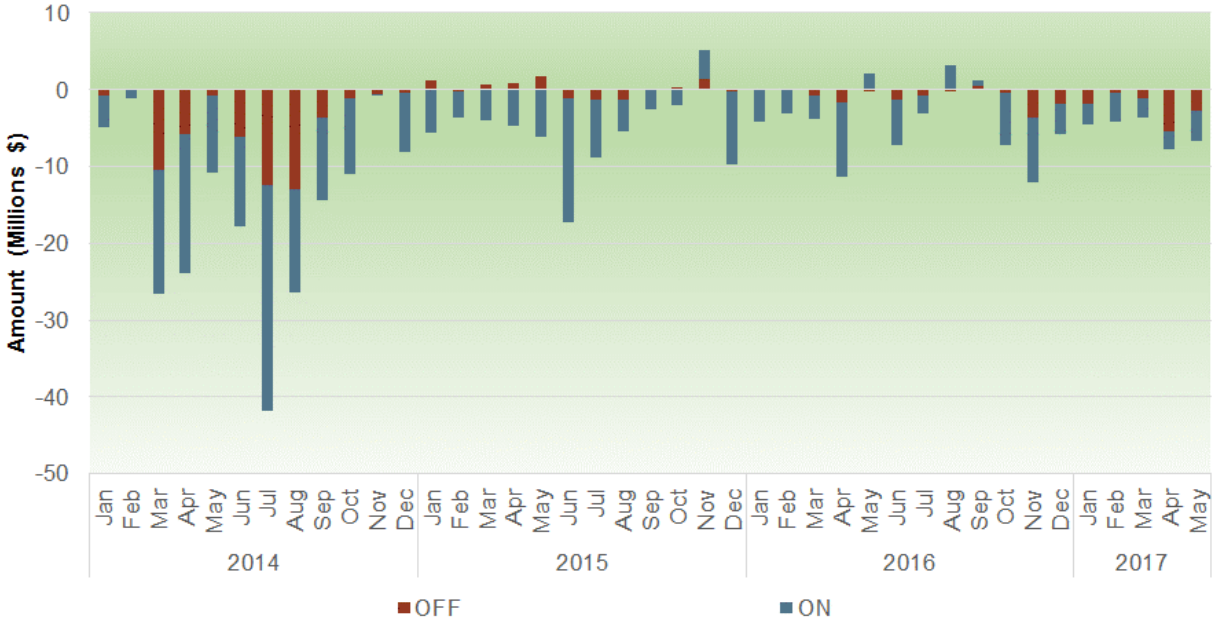
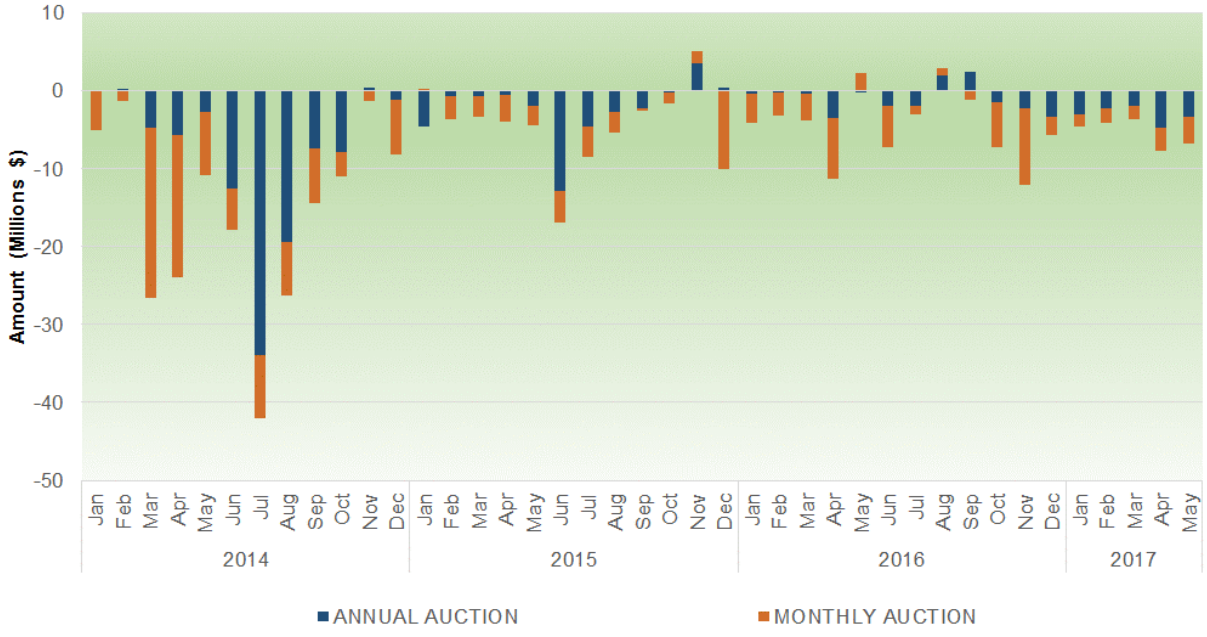


Figure 47 shows the net CRR payments for CRRs organized by annual and monthly auctions. The trend shows that the difference between the payments from the auction CRRs and auction revenues are evenly distributed between the monthly auction market and the annual auction market. The net CRR payments to the monthly auction CRRs was about -$93 million for 2014, reducing it to about -$32 million in 2015 and -$40 million in 2016. The delta was about -$11 million in 2017 (January to May).

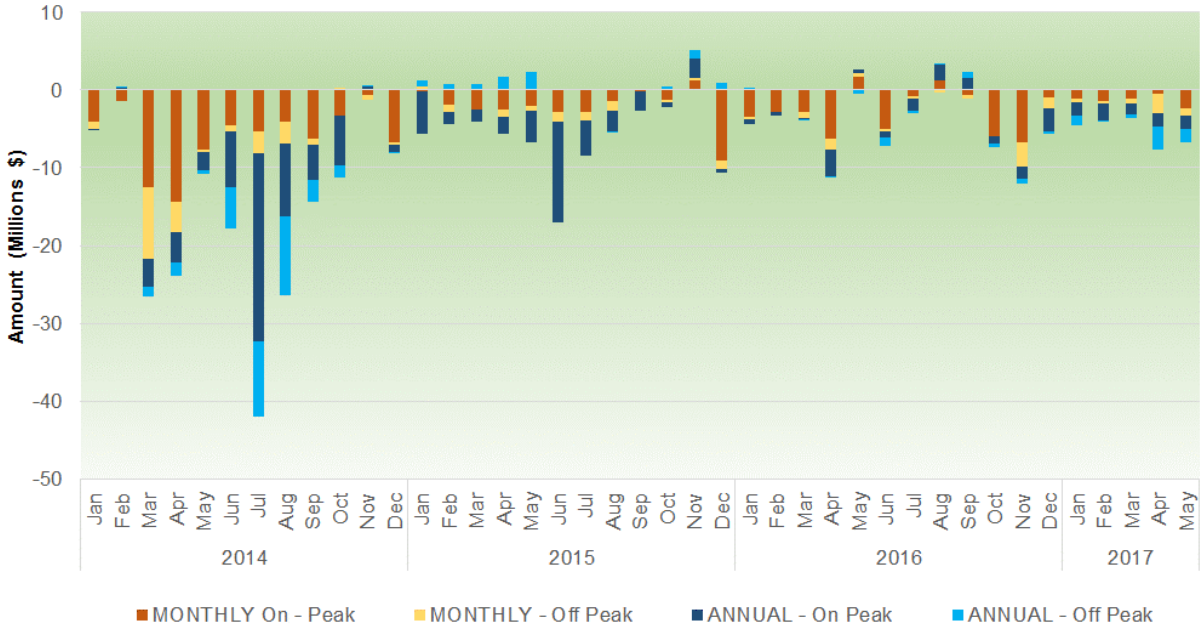
Figure 47: Net CRR payments to CRRs released in the monthly auctions



For the annual auction market, the net CRR payment was about -$94 million in 2014, reducing to about -$26 million in 2015, and further reducing it to -$11 million in 2016. In 2017 (January to May), the delta was about -$15 million.

Figure 48 shows another variation of the metric with the annual and monthly market by TOU. It shows that out of -$94 million delta from the annual auction market in 2014, about -$61 million came from the on-peak period. Similarly, about -$35 million and -$8 million came from the annual auction market for the on-peak period in 2015 and 2016.

Figure 48: Net CRR payments organized by auction and TOU



For the monthly auction market, out of -$93 million delta in 2014, about -$71 million came from the on-peak period. It shows that the on-peak period delta was higher than the off-peak for both the annual and monthly auction markets.

Figure 49 shows another variation of the metric by source type. The source types are categorized by DLAPs, Trading Hubs, Interties and the rest are *Others*. If a CRR is sourced from the DLAP then it falls under the DLAP type. This figure shows that net CRR payments have been mainly collected in CRRs with source or sinks locations at internal CAISO locations, such as individual pricing locations, group in the bin of *Others*. This may seem to be related more to counter-flow CRRs since the source and sink location happens at targeted internal pricing locations rather than DLAPs or trading hubs which reflect aggregated load and generation locations. The second largest source location is from interties, which is expected given the fair volume of energy coming from interties.

Figure 49: Net CRR payments broken out by type of source location

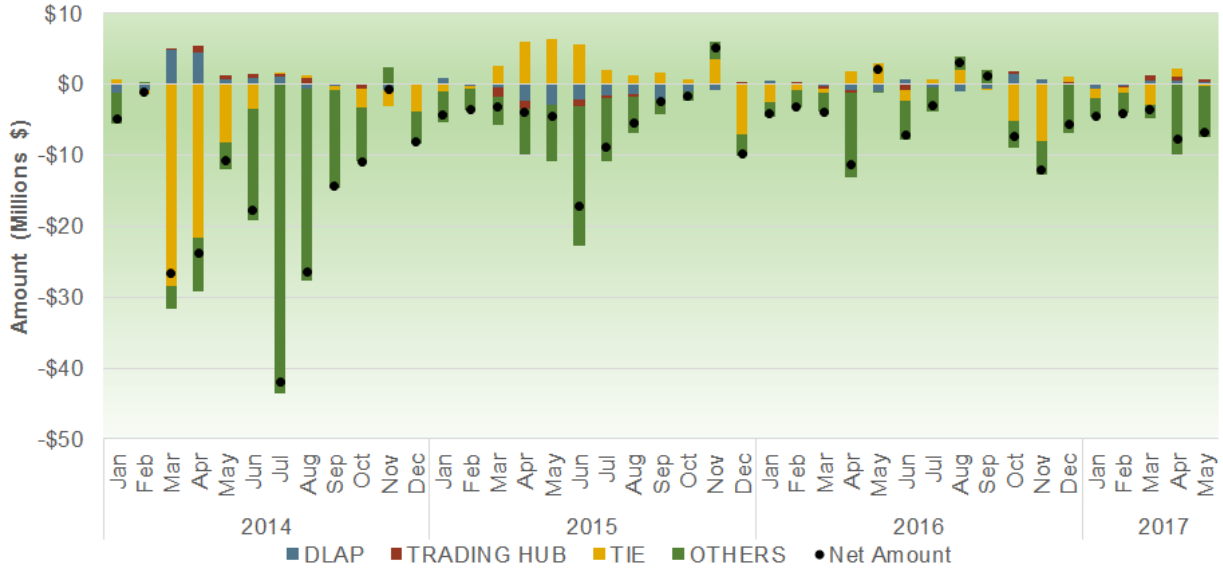
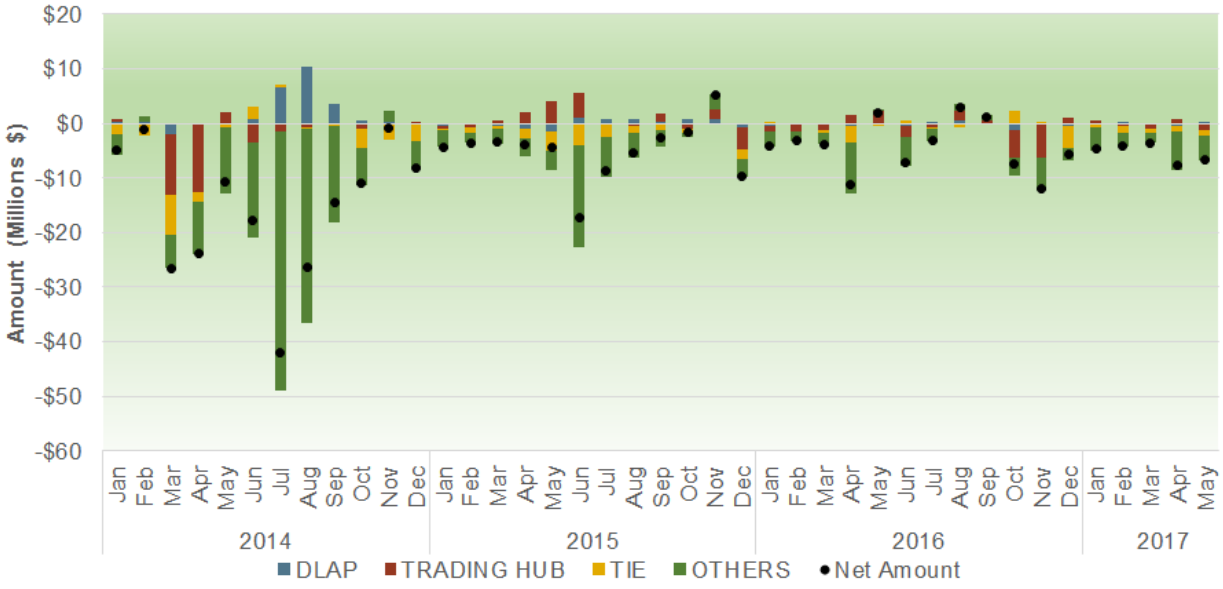


Figure 50 shows a similar metric by grouping the net CRR payments by type of sink location. This trend shows that overtime a particular sink type, namely the *Others*, has been the most lucrative sink for the auction CRR holders.

Figure 50: Net CRR payments broken out by type of sink location



In the auction process there is a set of pricing locations that are eligible for sources and sinks. Such locations can be Intertie scheduling points, DLAPs, Trading Hubs, Custom and Sub LAPs, Metered Sub=systems (MSS), and locations where a generating resource is located. Unlike the allocation process where CRRs are defined with source from supply-type locations and sinks

with load-type locations. There is no limitation what type of location can be used for sources and locations. Auction CRRs typically result in counter-flows to allocation CRRs and also to each other auction CRRs. Figure 51 shows the net CRR payments organized by the various source-to-sink definitions that were awarded the auction CRRs; both time of use and both the annual and monthly auctions are all together. About 56 percent of the net CRR payments were accrued on CRR awarded from a generation location to another generation location, followed by 7 percent and 6 percent for CRRs defined from intertie location to TH, and from intertie to intertie, respectively. Although some intertie locations may be seen some times in the energy market with export schedules, the dominant flow on interties is generally as imports, meaning that the intertie points can be seen as supply type of locations; with this reference, over 85 percent of awarded CRRs were with supply locations for both sources and sinks.

Figure 51: Net CRR payments broken out by type of sink location

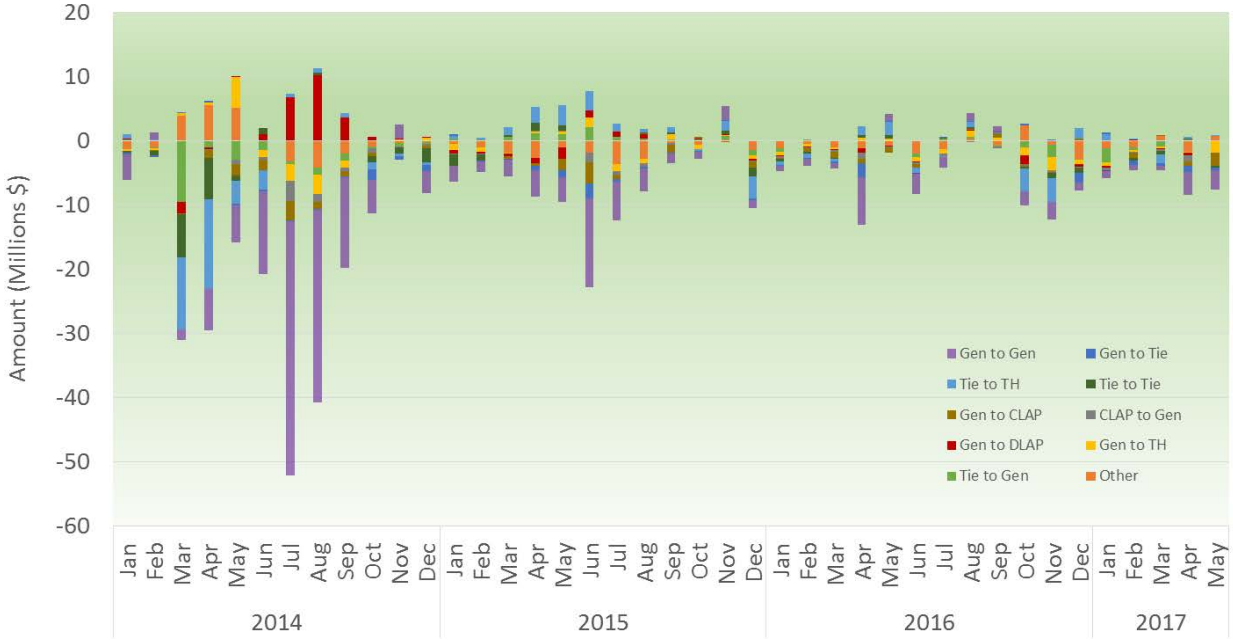


Table 1 summarizes the net CRR payments accrued on all potential combinations of location type to be used as source and sinks in auction CRRs. The summary is broken out by year. The columns list the different types of sinks while the rows shows the different types of sources; the diagonal entries will show the CRR definitions that have both the sources and sinks to be of the same type. This breakdown still shows that the largest share of net CRR payments accrued on CRRs bid in for generation points to be used for both source and sinks, even though over the years it shows a declining trend.

Table 1: Net CRR payments by type of source and sink

2014		Sink					
		CLAP	DLAP	GEN	PNODE	TIE	TH
Source	CLAP	1.5	0.1	7.5	0.1	0.5	0.0
	DLAP	0.1	0.3	1.1	0.0	-9.8	0.2
	GEN	10.6	-20.9	119.5	6.1	4.6	1.8
	PNODE	0.2	0.0	-1.3	0.0	0.3	0.0
	TIE	0.1	0.4	18.5	1.1	17.6	30.9
	TH	-0.1	0.1	1.2	0.0	0.3	-5.0

2015		Sink					
		CLAP	DLAP	GEN	PNODE	TIE	TH
Source	CLAP	1.2	-0.1	2.9	0.1	1.5	0.1
	DLAP	0.1	-0.2	2.2	0.0	11.7	0.2
	GEN	8.5	1.2	39.5	0.8	5.1	1.7
	PNODE	0.0	0.0	0.9	0.0	-0.3	0.0
	TIE	-1.1	-1.9	-7.1	-1.4	1.0	-10.6
	TH	0.1	1.1	1.1	0.0	0.6	0.7

2016		Sink					
		CLAP	DLAP	GEN	PNODE	TIE	TH
Source	CLAP	0.8	0.1	3.6	0.1	-0.2	0.0
	DLAP	0.0	0.0	0.4	0.0	0.2	0.0
	GEN	3.0	2.9	17.8	-0.8	3.5	4.5
	PNODE	0.2	0.1	3.5	0.5	1.5	0.1
	TIE	0.5	0.3	3.0	-0.1	1.1	4.0
	TH	0.0	-0.3	0.3	0.0	-0.3	1.4

2017		Sink					
		CLAP	DLAP	GEN	PNODE	TIE	TH
Source	CLAP	0.5	0.0	1.8	0.2	0.6	0.1
	DLAP	0.0	0.0	0.1	0.0	1.5	0.1
	GEN	3.2	0.4	5.1	0.4	2.3	2.6
	PNODE	0.0	0.0	1.5	0.9	-0.1	0.1
	TIE	-0.1	-0.2	2.6	0.0	0.8	-2.2
	TH	0.0	0.0	0.0	0.0	0.1	-1.9

Figure 52 shows the breakdown of CRR payments by its direction, a negative CRR payment indicates that the CRR payment to the CRR holder was greater than the auction revenue collected in the CRR auction. The yellow dot shows the net result of the two directions. This trend illustrates that auction CRR holders see profit by holding auction CRRs. The amount (in dollars settled) where participants were short in the CRR payments (losses) is about 32 percent of the amount

when CRR holders received a net money inflow by holding auction CRRs. Although a modest proportion, it still shows that there are CRR holders in every auction which end up with a position where the money collected through CRR payments was less than the money they paid to acquire CRRs.

Figure 52: Net CRR Payment by direction

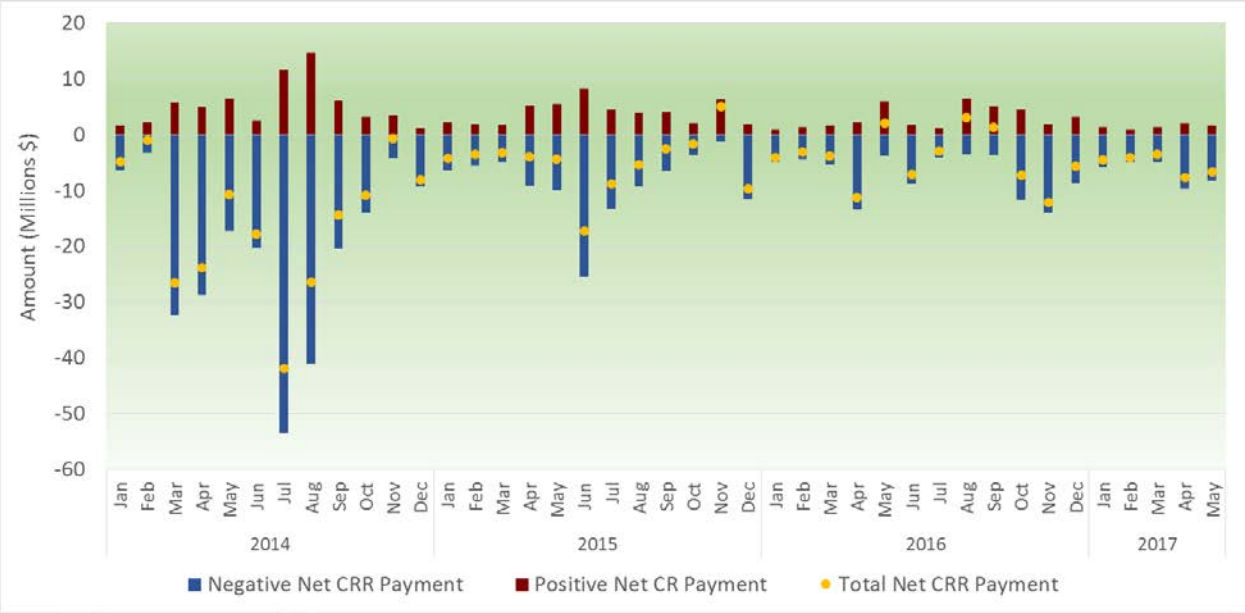


Figure 53 shows the frequency of auction CRRs that have payments less than the money collected through auction revenues. For some cases, a CRR holder might take a counter flow position and it might be a payment to the CRR holders in auction revenues. It shows that about 25 percent of CRRs have less payments than auction revenues.

Similarly, Figure 54 shows the percentage of CRR awards that have a payment less than the auction revenues. About 55 percent of CRR awards have CRR payments to be less than the auction revenues, meaning that the CRR holder had a negative net money inflow for holding a CRR.

Figure 53: Number of CRRs with CRR payments less than auction revenues

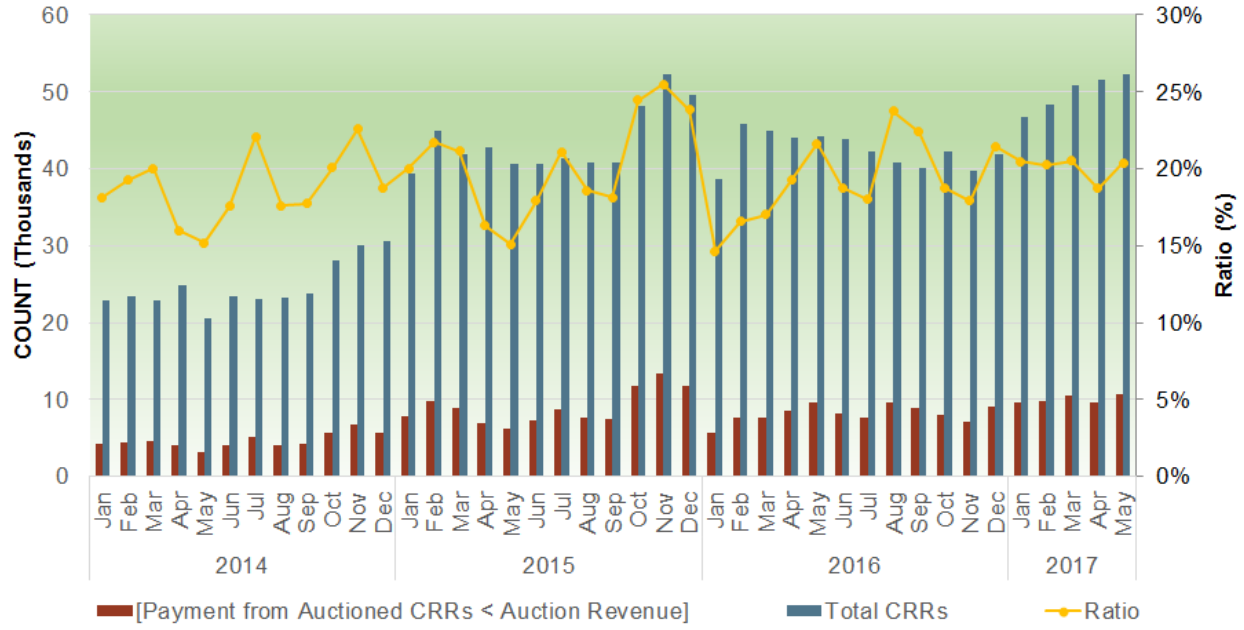
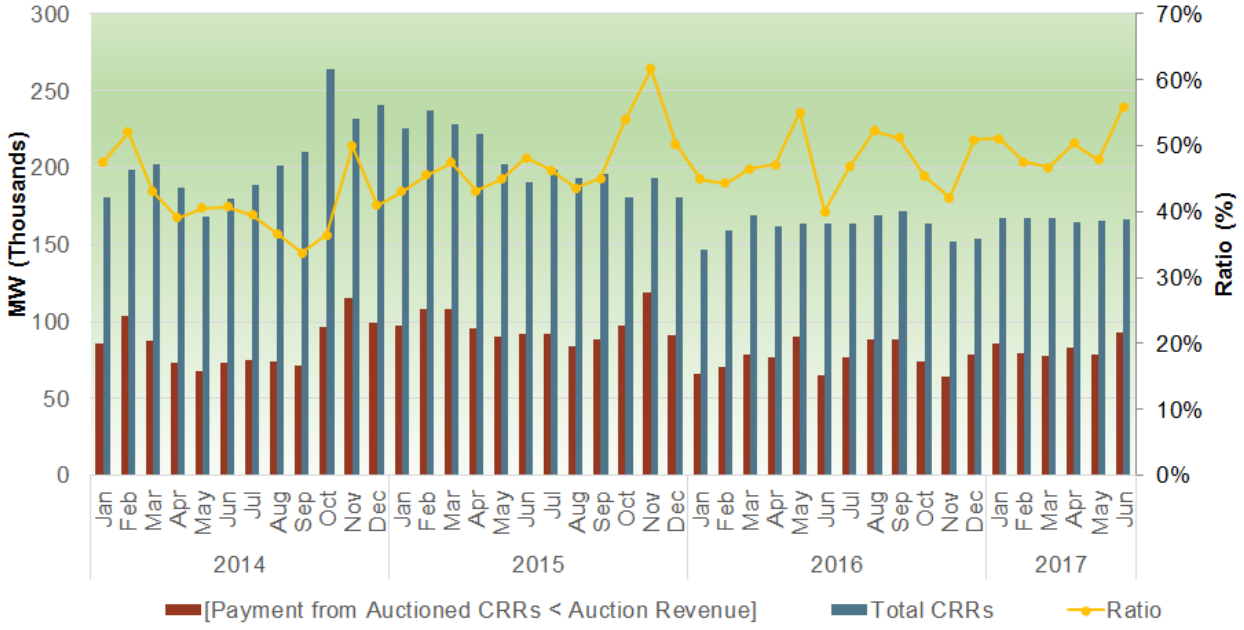


Figure 54: CRR awards with CRR payments less than auction revenues



Looking further into the spread of net CRR payments, Figure 55 shows a scatter plot of each CRR payment and its auction revenue. The scatter plot is illustrated with two sections divided by a 45 degree line. The line indicates when the auction revenues are exactly equal to the CRR payments for the auction CRRs. The blue section is when the CRR holders have a net CRR payment that results in a money inflow (negative net CRR payment from the CAISO's perspective) on their positions on a particular CRR source-sink award in the CRR market. The

pink section stands for when CRR holders makes less from the CRR payments than what they had paid in auction revenues.

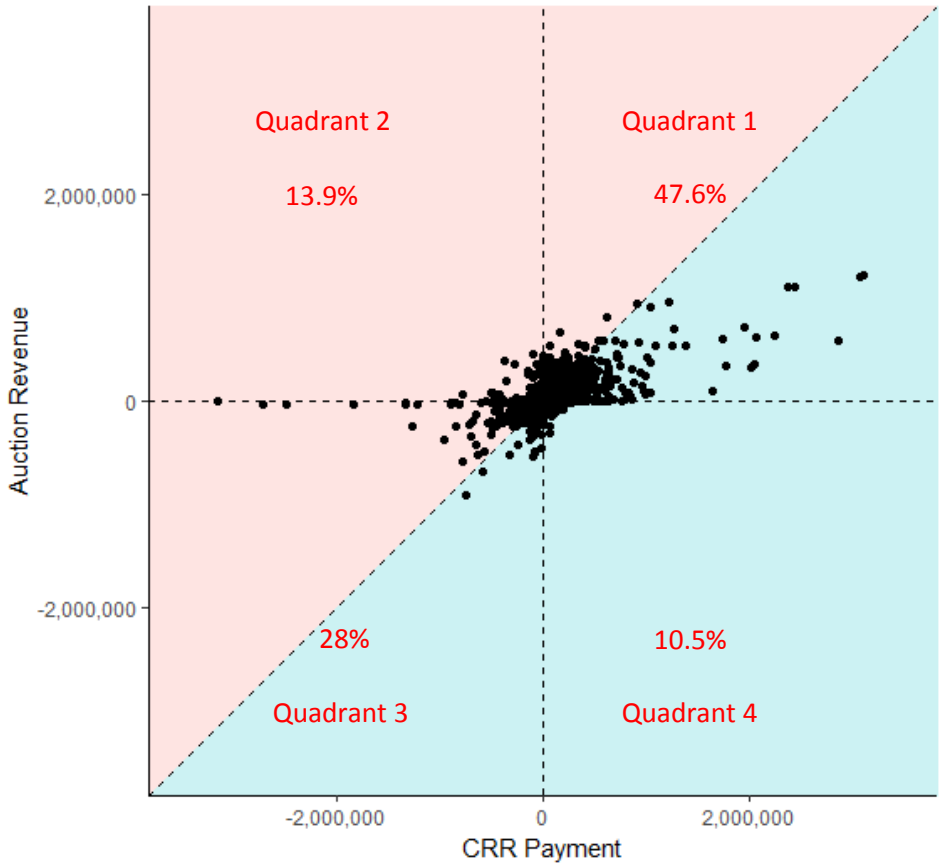
The scatter plot is divided into four quadrants with the following characterizations:

Quadrant 1) CRR holders pay for in the auction and receive CRR payments,
Quadrant 2) CRR holders pay for in the auction and are charged CRR payments,
Quadrant 3) CRR holders get paid in auction and are charged CRR payments and
Quadrant 4) CRR holders get paid in auction and receive CRR payments.

About 47.6 percent of CRR awards account for when CRR holders paid for in the auction and received CRR payments for the auction CRRs.

Similarly, about 13.9 percent of CRR awards, represent when CRR holders paid for in the auction and were charged through the CRR payments. This means that the CRR holder had to pay for the CRR position in the auction market and the direction got reversed when the CRR payments were made; thus, the CRR holders also had to pay through CRR payments.

Figure 55: Spread of auction revenues vs CRR payments for auction CRRs



In about 28 percent of the CRR awards, the CRR holders got paid in the auction revenues and were charged when settling CRRs. This means that the CRR holder had a counter flow

position in the CRR auction market and hence got paid for that position in the auction market. In the CRR payment process, the CRR holder had to pay because of the counter flow position. If the CRR award falls in the blue section, then the holder would have made a net positive money inflow from that counter flow position.

About 10.5 percent of the CRR awards resulted in the CRR holder getting paid in the CRR auction and also getting paid through the CRR payments. This indicates that CRR holder had a counter flow position in the auction market, and was paid in the auction market. However, the directions got reversed and the holder was paid in the CRR settlements as well. All of the CRR awards that fall in this quadrant make a net positive money inflow (negative net CRR payment from CAISO's perspective). The chart shows all the CRR awards from January 2014 to May 2017. Overall, about 17 percent of CRRs had a net and negative money inflow from holding CRRs (dots in the pink region). This shows that holding CRRs from auctions is not always a winning proposition or a one-sided equation. Holding CRRs poses a certain level of risk since congestion patterns may change in the day-ahead market with respect to projected conditions.

Figure 56 through Figure 59Figure 59 show the same plot but organized by each year under analysis. These figures show that most of the CRR awards that accrued significant profits or losses happened in 2014. For 2015 and 2016 the points are more concentrated towards the center axis indicating that the CRR holders did not make a significant profit or loss from a particular CRR position in any auction market.

Figure 56: Spread of auction revenues vs CRR entitlements for auction CRRs – 2014

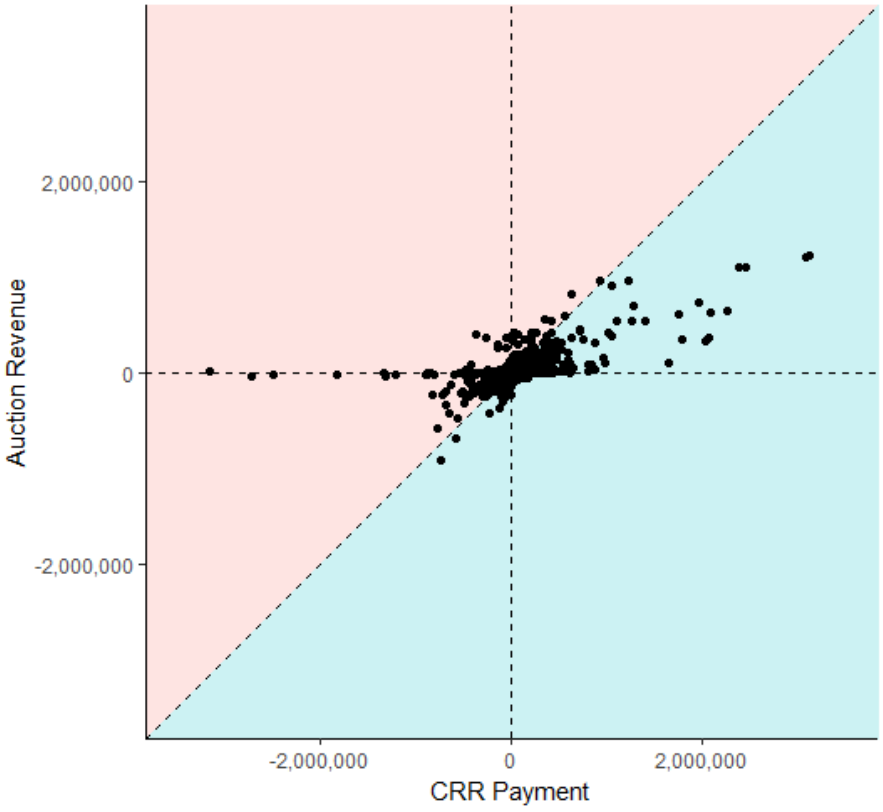


Figure 57: Spread of auction revenues vs CRR entitlements for auction CRRs – 2015

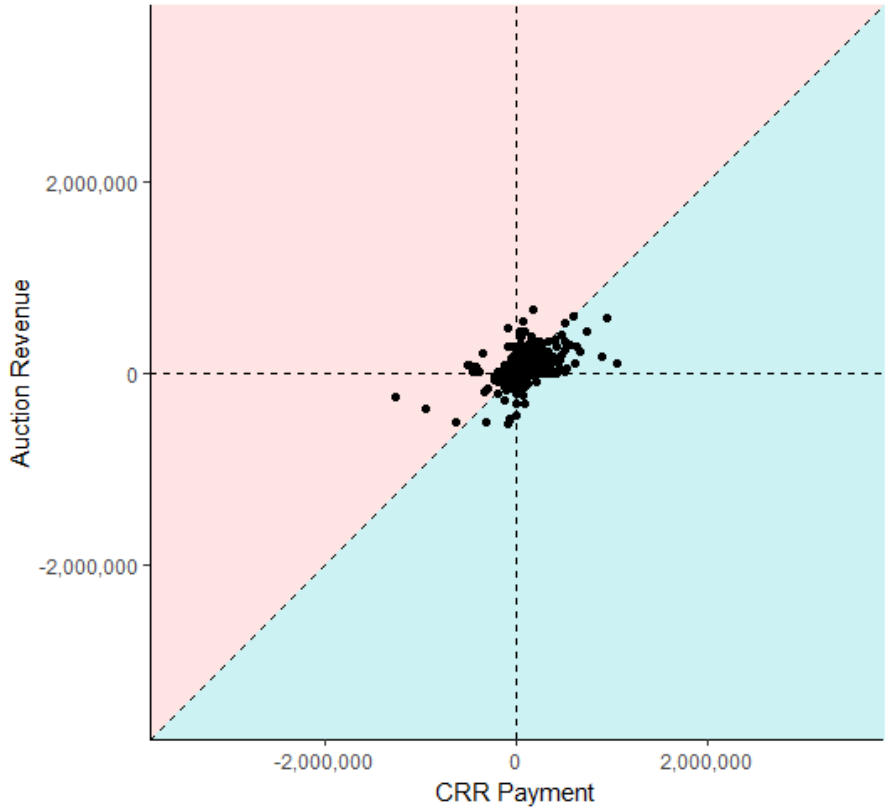


Figure 58: Spread of auction revenues vs CRR entitlements for auction CRRs - 2016

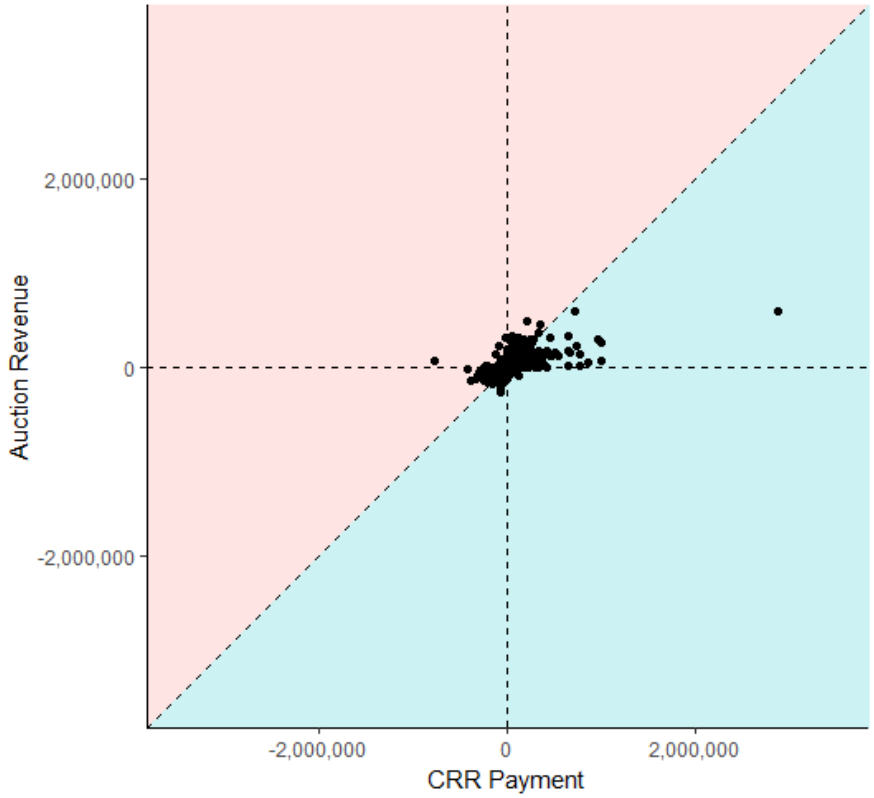


Figure 59: Spread of auction revenues vs CRR entitlements for auction CRRs – 2017

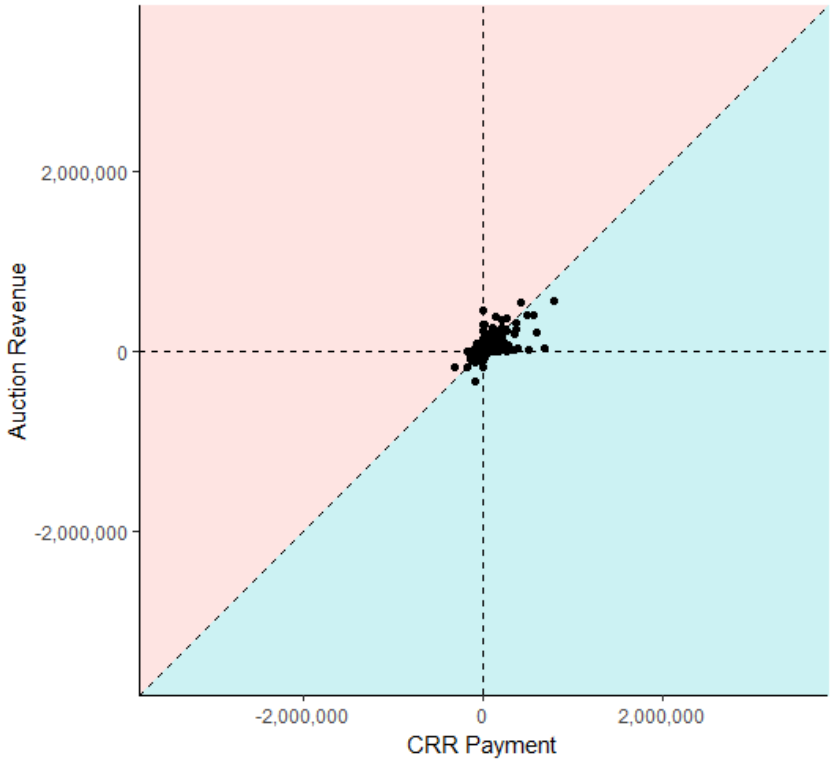


Figure 60 shows the scatter plot comparing the auction revenues and CRR payments organized by CRR holder instead of CRR award. For this metric, all of the auction revenues and payments are summed up for each CRR holder (for all their CRR positions). It shows that there are a few CRR holders that were paid significantly higher than their auction revenues.

Figure 61 to Figure 64 show a similar metric comparing the auction revenues and payments made to the CRR holders for auction CRRs by CRR holders by year. This illustrates that the payments to CRR holders and revenues collected through auctions by CRR holders have reduced over time from 2014 to 2017.

Figure 60: Spread of auction revenues vs CRR payments by CRR holder

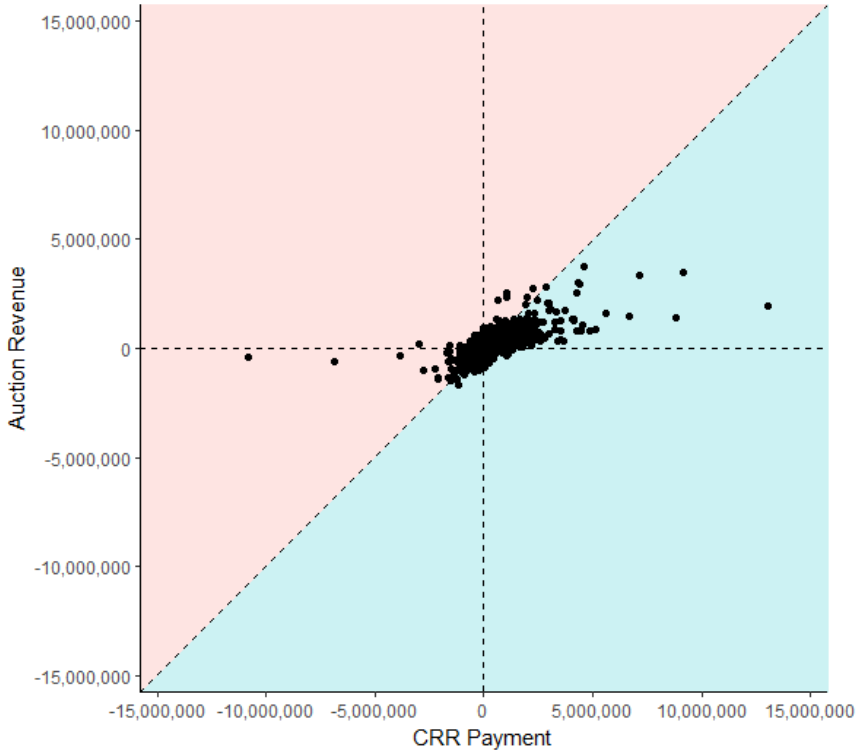


Figure 61: Spread of auction revenues vs CRR payments by CRR holder – 2014

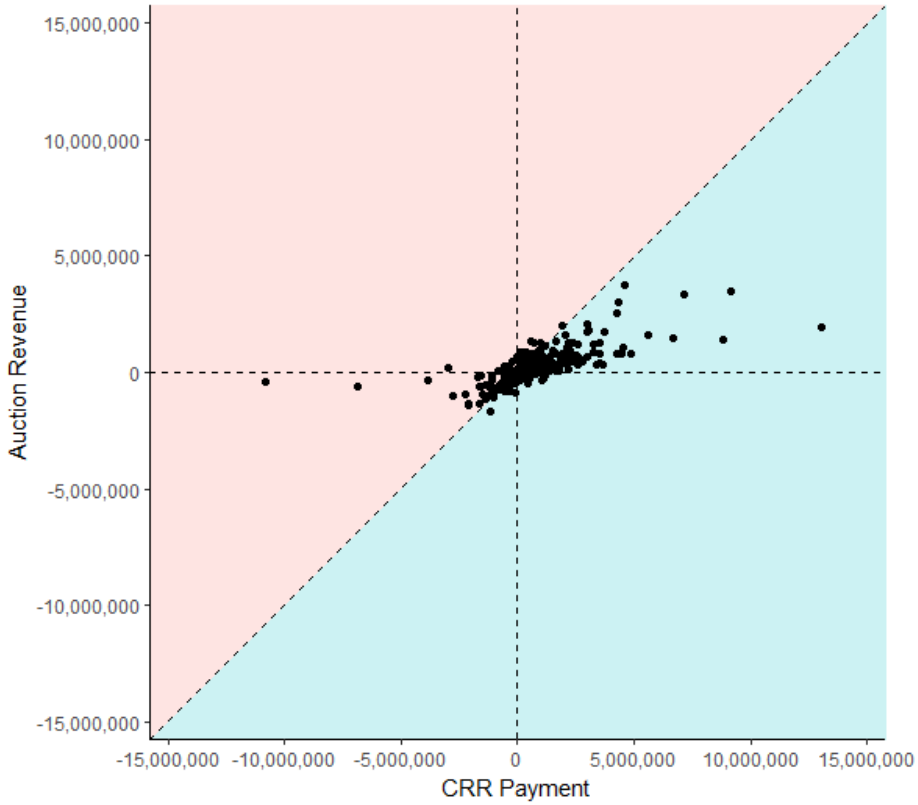


Figure 62: Spread of auction revenues vs CRR payments by CRR holder – 2015

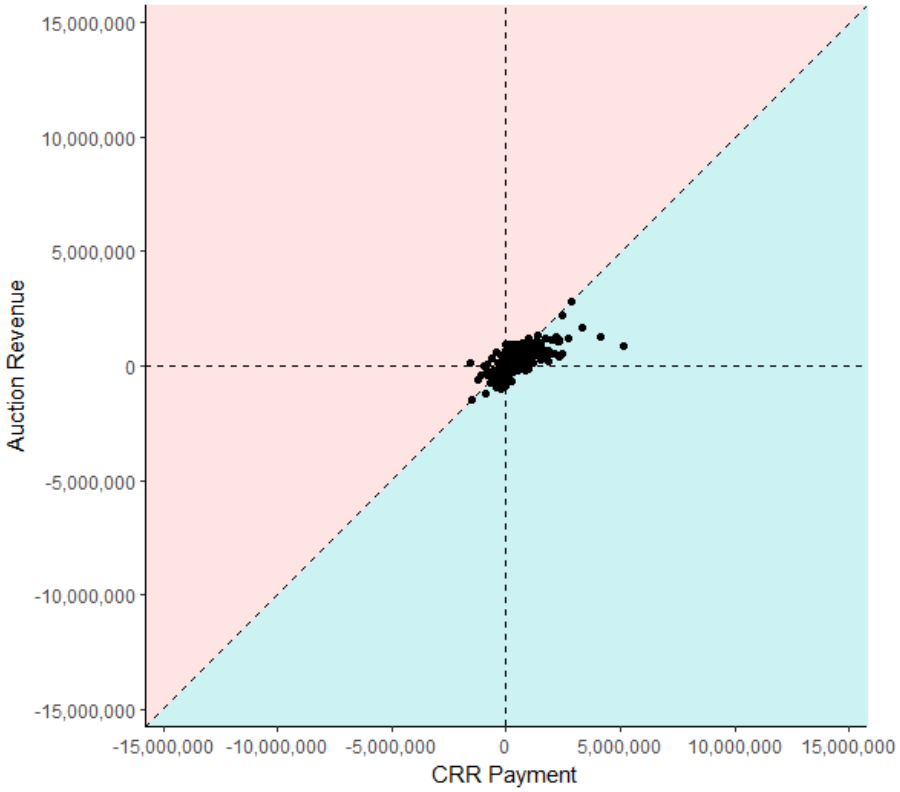


Figure 63: Spread of auction revenues vs CRR payments by CRR holder – 2016

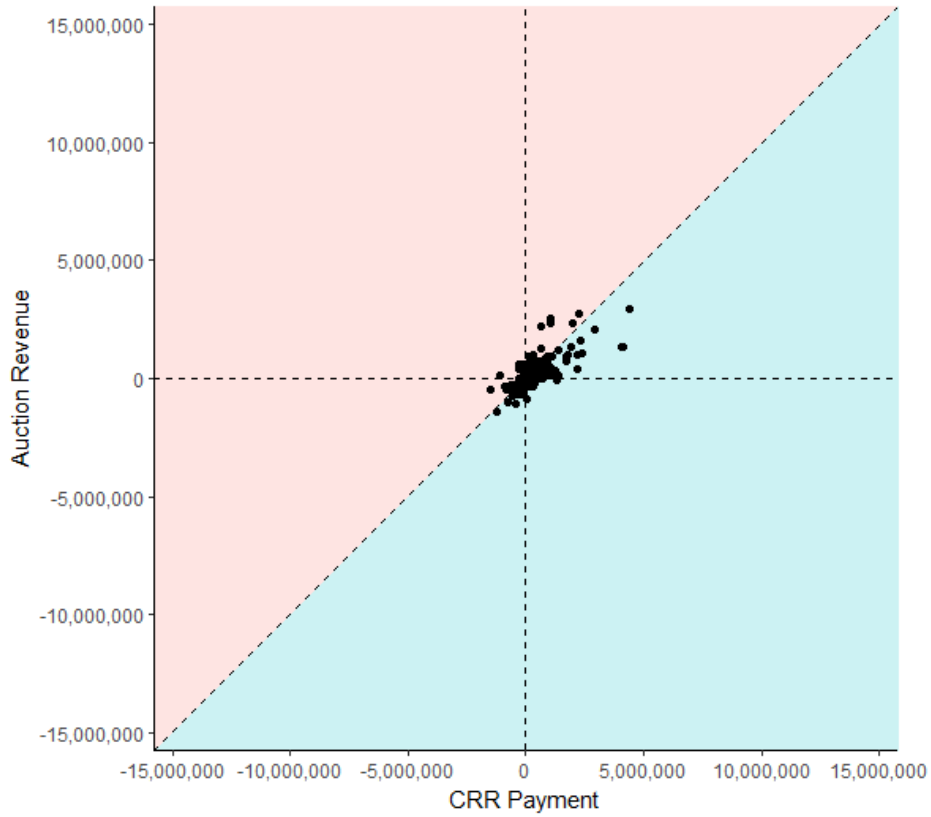
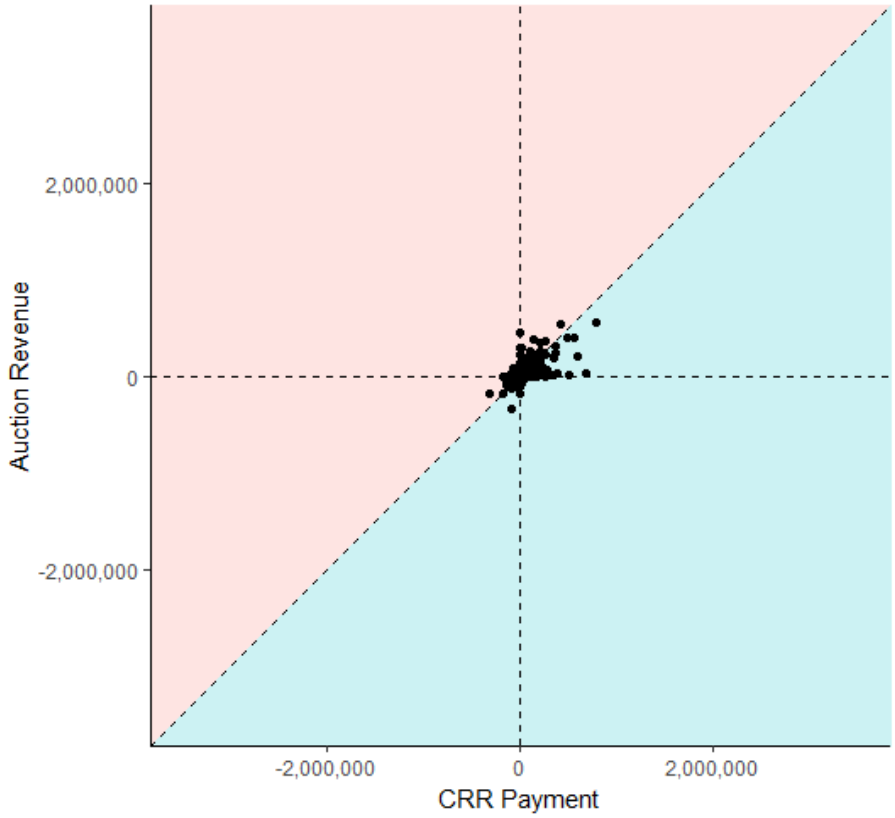


Figure 64: Spread of auction revenues vs CRR payments by CRR holder – 2017



As observed in a section above, there is a set of CRRs acquired in the auctions that cleared at zero prices. A point of interest is to see how these CRR have performed. Figure 65 shows the scatter plot comparing the payments made to the CRR holders for auction CRRs which had no auction revenues. This means, CRR holders were either paid or charged through the CRR payment process and did not have to pay anything in the CRR auctions revenues to acquire these CRRs. It clearly indicates that even if the CRR positions are free for the CRR holders, it does not necessarily translate into a profit for the CRR holder for that CRR position.

Figure 66 to Figure 69 show a similar metric comparing the zero auction revenues and payments made to the CRR holders for the auction CRRs by year.

Figure 71 to Figure 74 shows a variation of the similar metric comparing the zero auction revenues and CRR payments made to the CRR holders for auction CRRs by CRR holder. It shows that CRR payments made to the CRR holders have reduced over time from 2014 to 2017.

Figure 65: Spread of auction revenues vs. CRR payments for CRRs with zero auction revenue

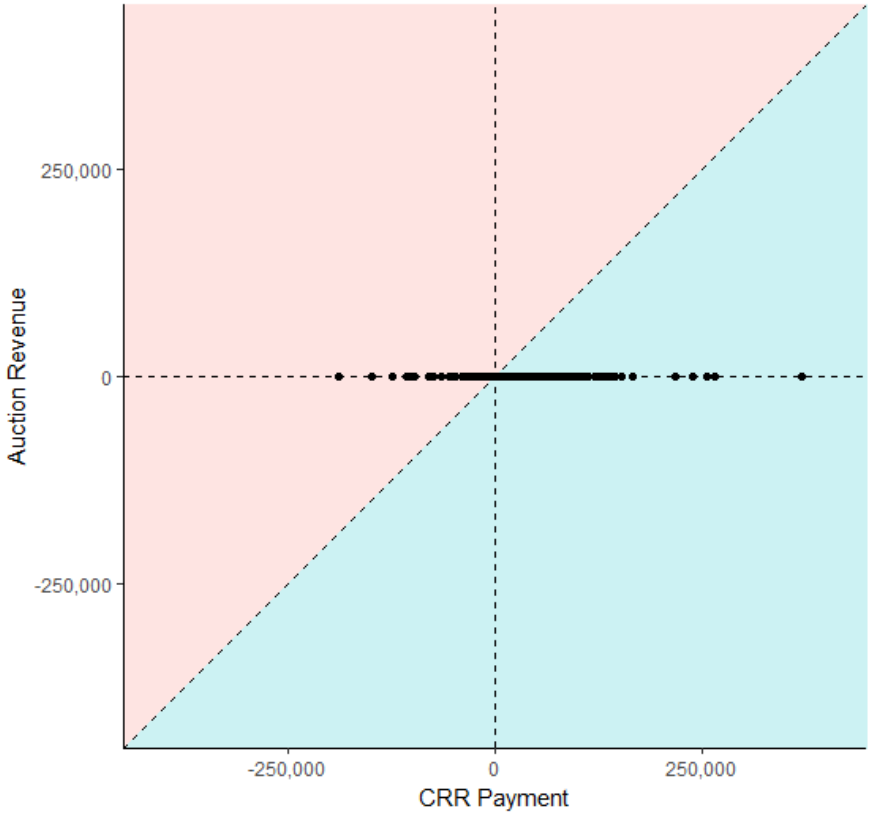


Figure 66: Spread of auction revenues vs. CRR payments for CRRs with zero auction revenue - 2014

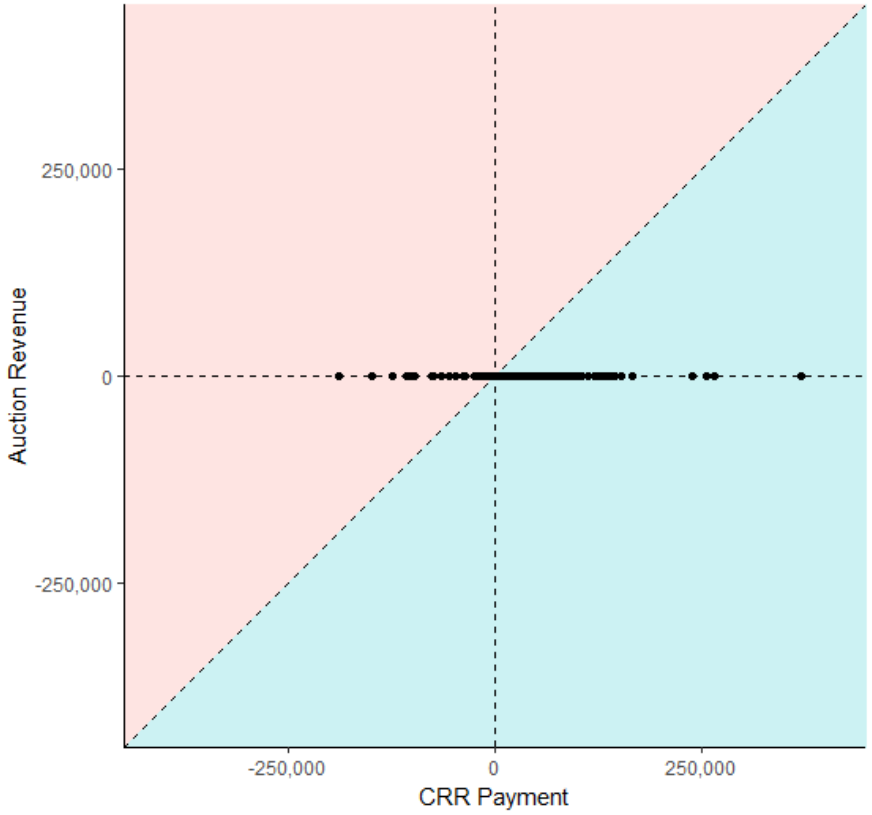


Figure 67: Spread of auction revenues vs. CRR payments for CRRs with zero auction revenue - 2015

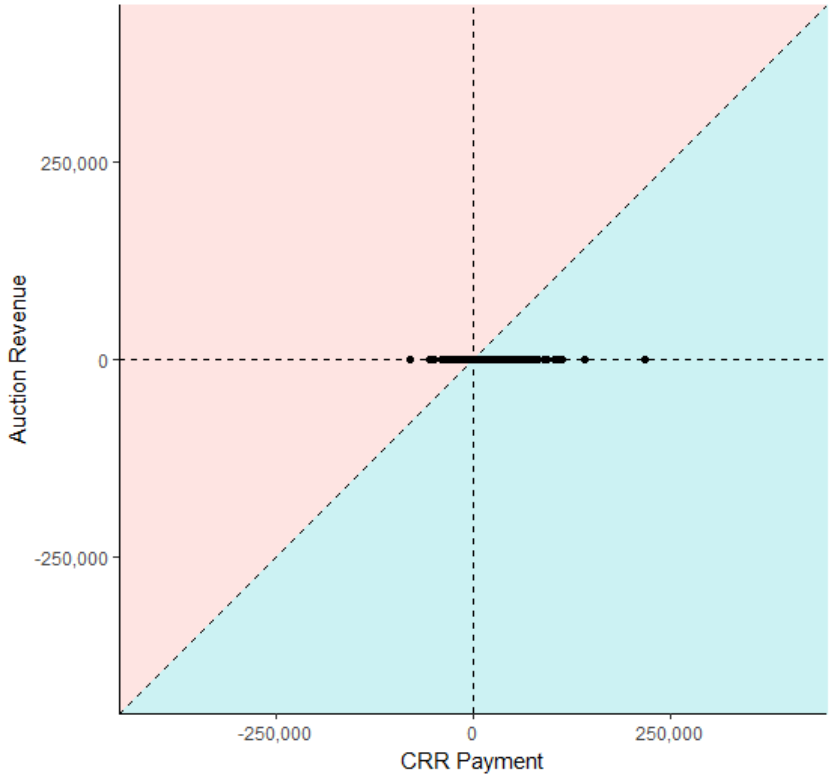


Figure 68: Spread of auction revenues vs. CRR payments for CRRs with zero auction revenue - 2016

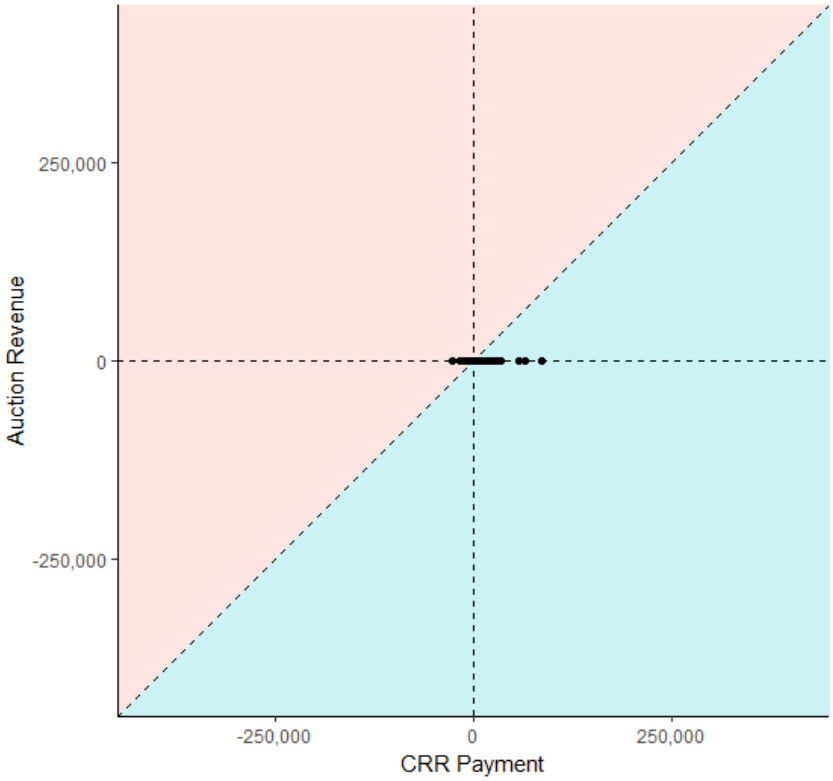


Figure 69: Spread of auction revenues vs. CRR payments for CRRs with zero auction revenue - 2017

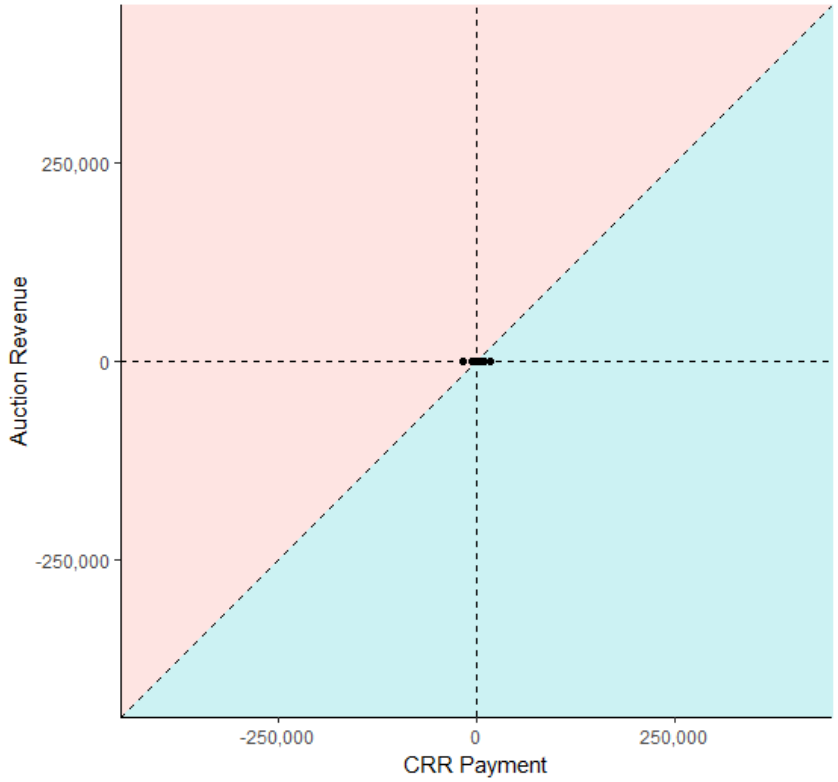


Figure 70: Spread of CRR payments for auction CRRs with zero auction revenue by CRR holder

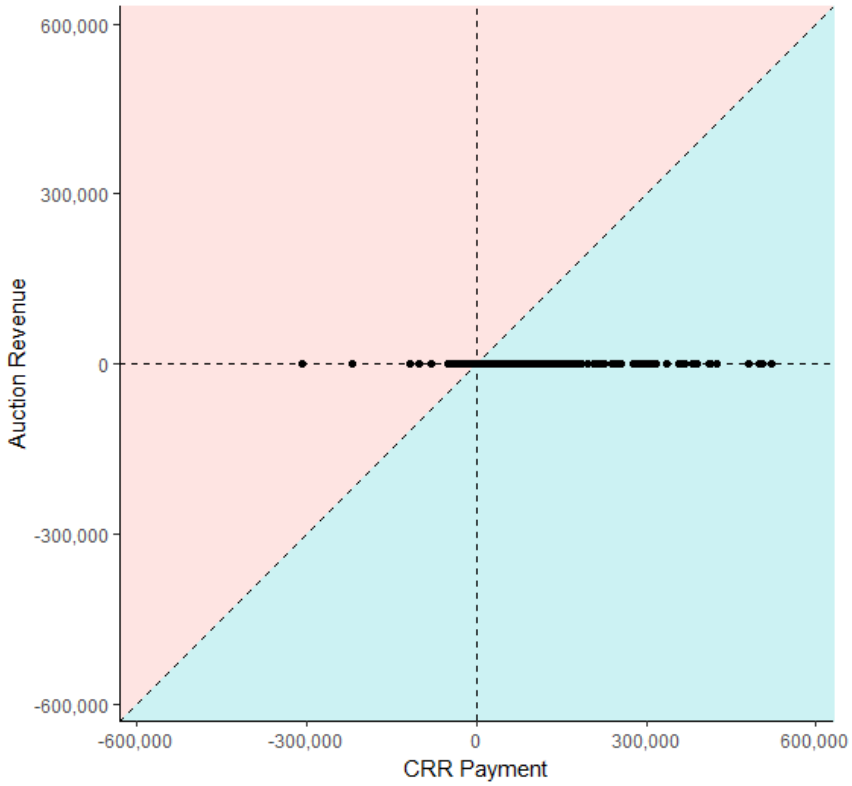


Figure 71: Spread of CRR payments for auction CRRs with zero auction revenue by CRR holder - 2014

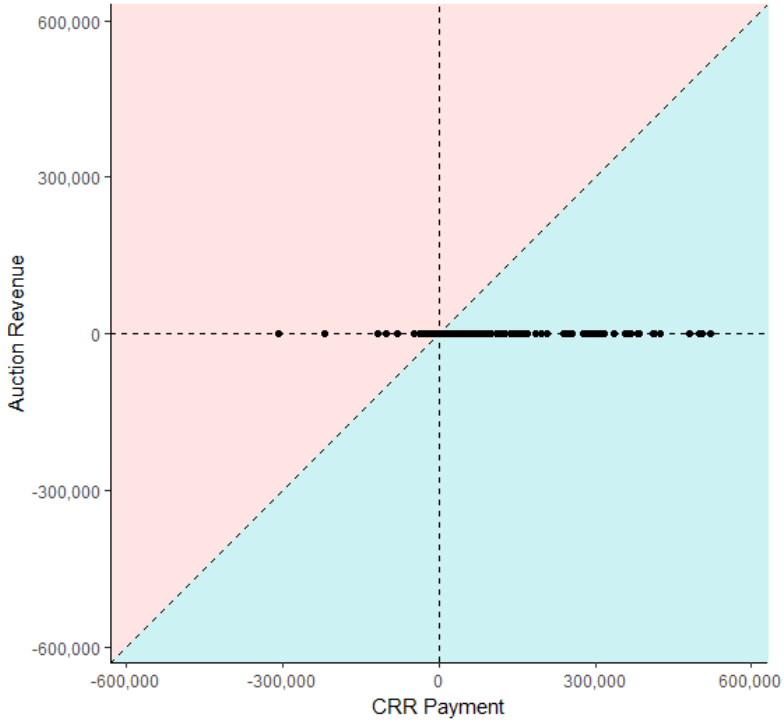


Figure 72: Spread of CRR payments for auction CRRs with zero auction revenue by CRR holder - 2015

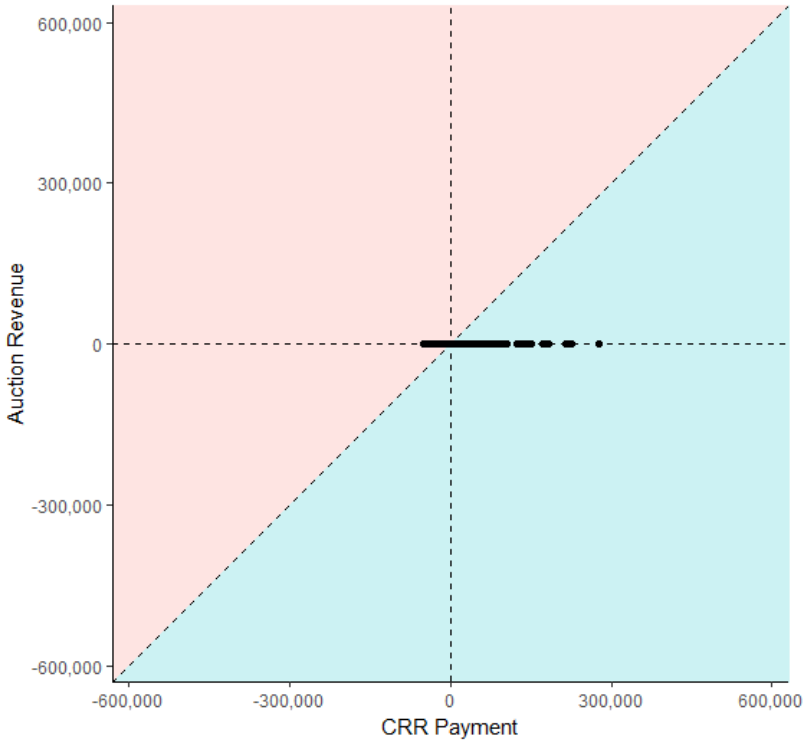


Figure 73: Spread of CRR payments for auction CRRs with zero auction revenue by CRR holder - 2016

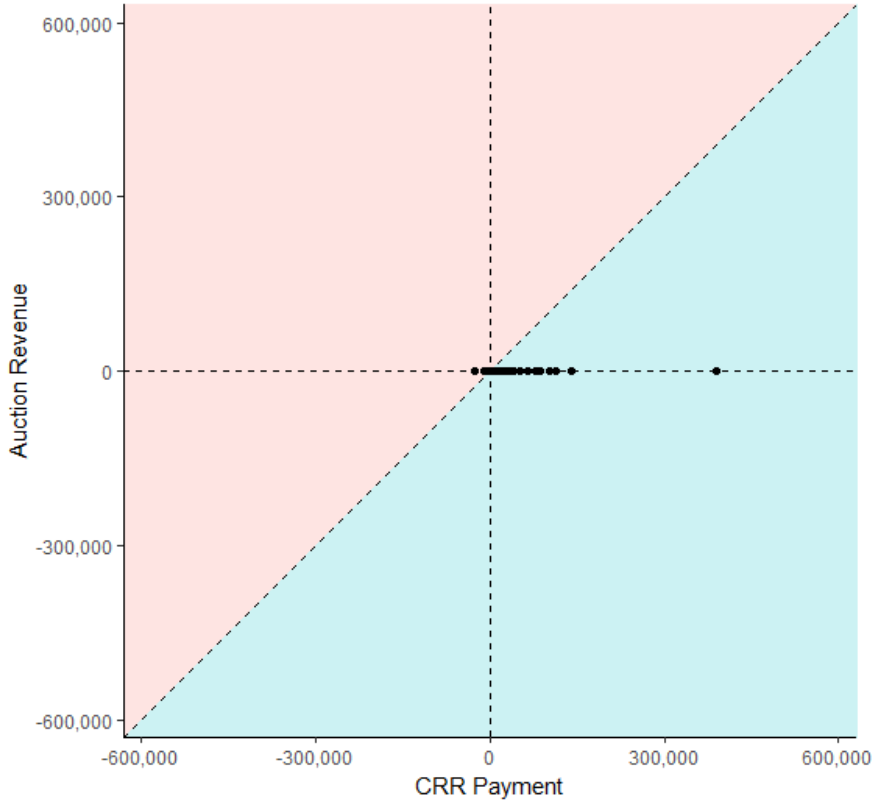
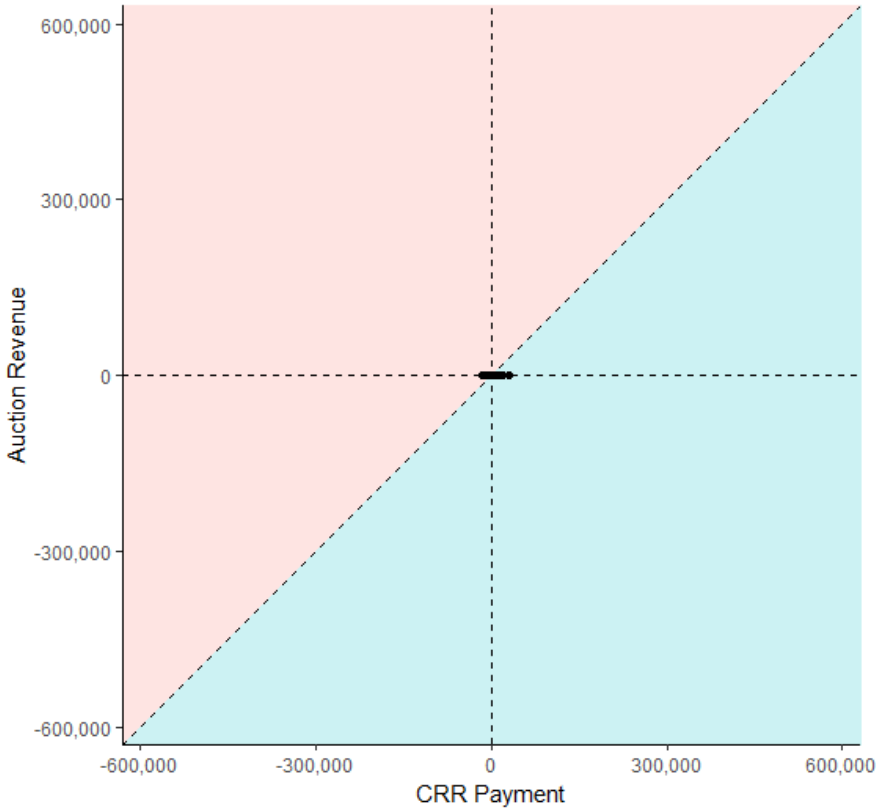


Figure 74: Spread of CRR payments for auction CRRs with zero auction revenue by CRR holder - 2017



Most valuable CRRs

Table 2 and Table 3 shows the top 10 and bottom 10 source – sink pairs in terms of payments made to the CRR holders for auction CRRs and money collected through auction revenue. This is based on the analysis period of January 2014 through May 2017. Top 10 would mean that the net CRR payments (CRR payment less auction revenues) were the highest to the CRR holders (largest negative CRR payments from the ISO perspective). Similarly, bottom 10 CRR would mean that these CRR positions had the lowest net CRR payment for auction CRRs.

Table 2: Top 10 - CRR source/sink pair

CRR_SOURCE	CRR_SINK
MALIN_5_N101	TH_NP15_GEN-APND
SYLMARDC_2_N501	TH_NP15_GEN-APND
PALOVRDE_ASR-APND	TH_SP15_GEN-APND
PALOVRDE_ASR-APND	C643TM1_7_N001
POD_GATES_6_PL1X2-APND	POD_HELMPG_7_UNIT 2-APND
POD_LAROA2_2_UNITA1-APND	TH_SP15_GEN-APND
MALIN_5_N101	TH_SP15_GEN-APND
DLAP_SCE-APND	FOURCORN_5_N501
AGUCALG1_7_B1	NGILA1_5_N001
POD_LAROA1_2_UNITA1-APND	TH_SP15_GEN-APND

Table 3: Bottom 10 CRR source/sink pair

CRR_SOURCE	CRR_SINK
POD_HELMPG_7_UNIT 2-APND	DLAP_PGAE-APND
POD_HELMPG_7_UNIT 1-APND	DLAP_PGAE-APND
TH_NP15_GEN-APND	TH_SP15_GEN-APND
POD_HELMPG_7_UNIT 3-APND	DLAP_PGAE-APND
POD_BIGCRK_2_EXESWD-APND	DLAP_SCE-APND
POD_LMEC_1_PL1X3-APND	TH_NP15_GEN-APND
DLAP_PGAE-APND	SYLMARDC_2_N501
POD_EXCHEC_7_UNIT 1-APND	DLAP_PGAE-APND
DLAP_PGAE-APND	MALIN_5_N101
VESTAL_6_N002	DLAP_SCE-APND

Figure 75 to Figure 77 show the trend of the Top 3 source-sink pairs from January 2014 to May 2017. These trends show that generally, these top CRRs were so because of performance was concentrated in a specific period instead of a systematic performance, most of that arising from 2014.

Figure 75: Comparison of CRR payments (auction CRRs) vs auction revenue for - MALIN_5_N101 to TH_NP15_GEN_APND

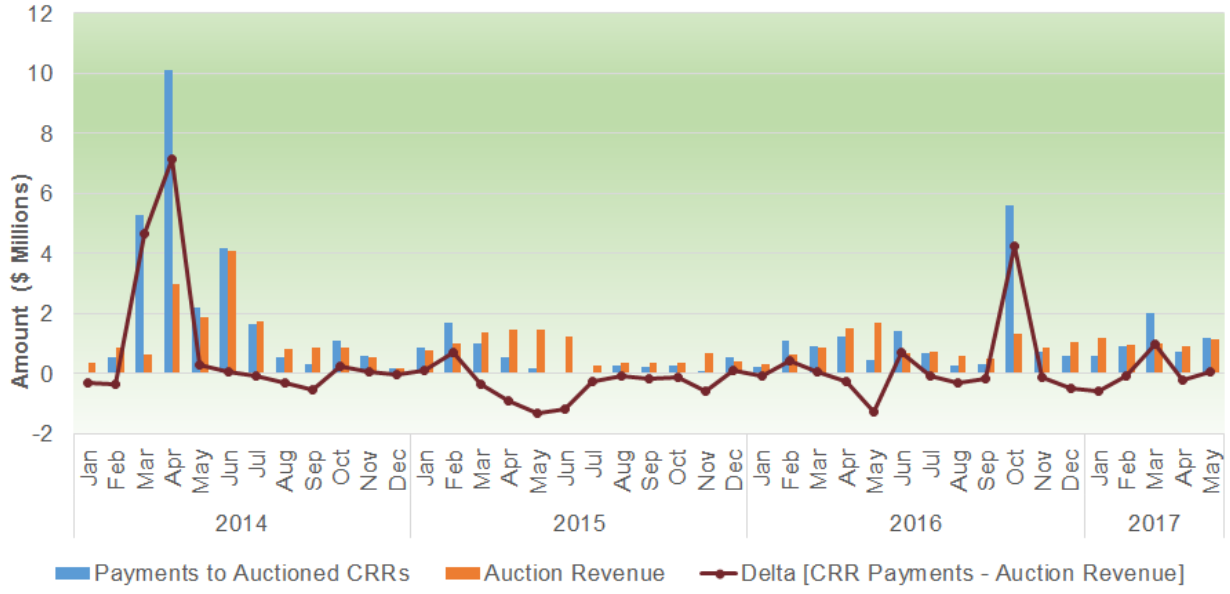


Figure 76: Comparison of CRR payments (auction CRRs) vs auction revenue for - SYLMARDC_2_N501 to TH_NP15_GEN_APND

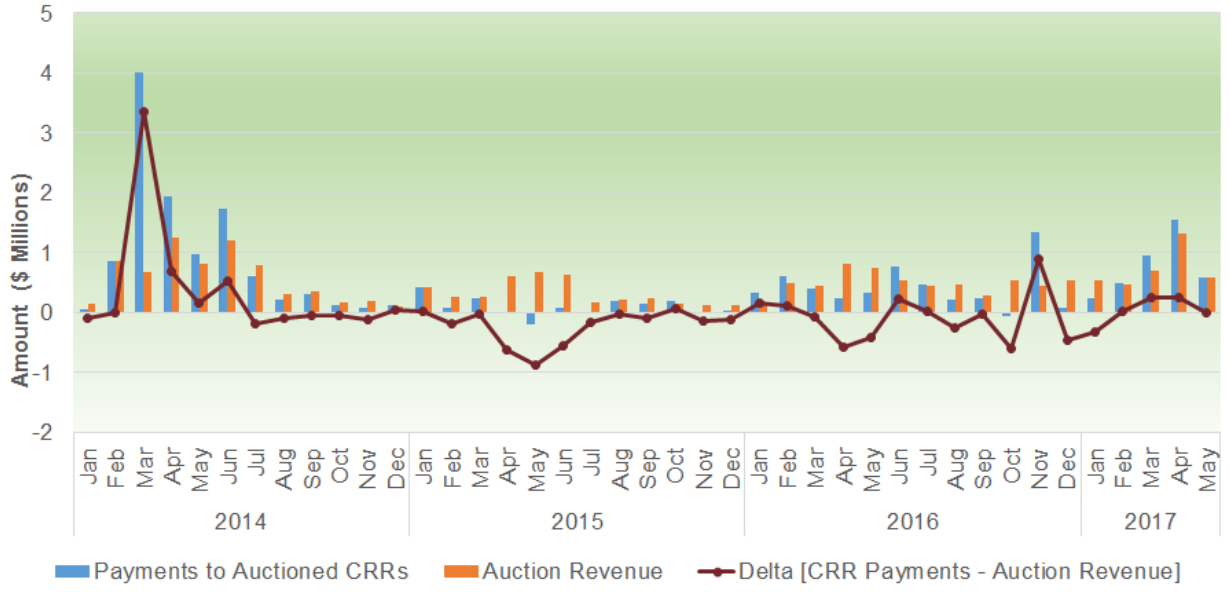


Figure 77: Comparison of CRR payments (auction CRRs) vs auction revenue for - PALOVRDE_ASR_APND to TH_SP15_GEN_APND

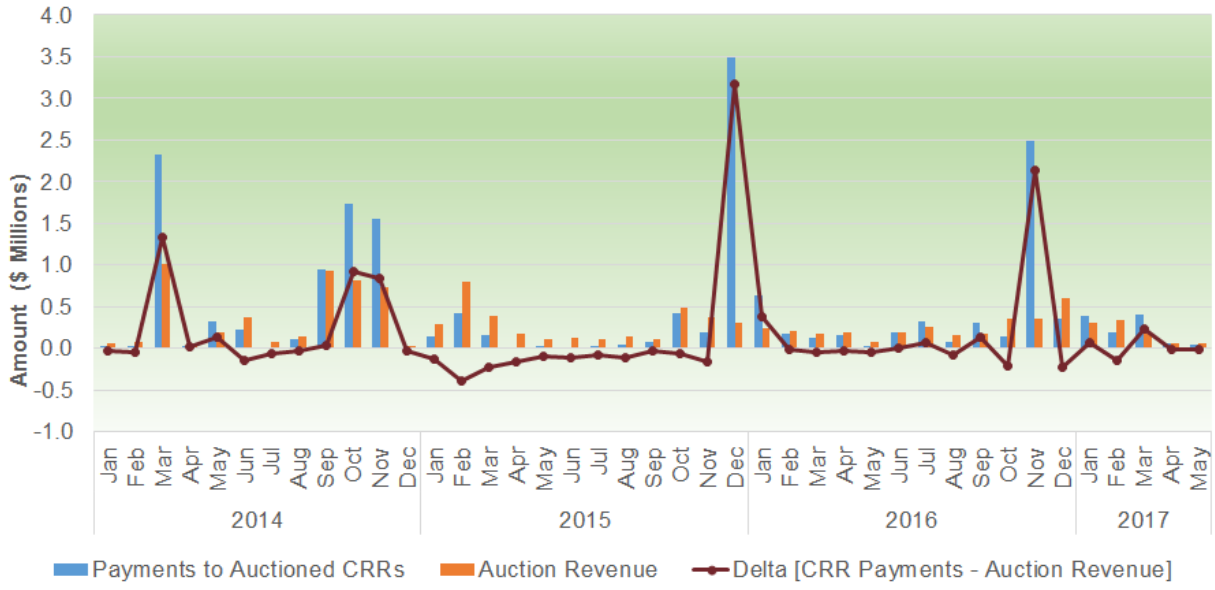


Figure 78 to Figure 80 show the trend of the bottom 3 source-sink pairs from January 2014 to May 2017.

Figure 78: Comparison of CRR payments (auction CRRs) vs auction revenue for - POD_HELMPG_7_UNIT 2-APND to DLAP_PGAE-APND

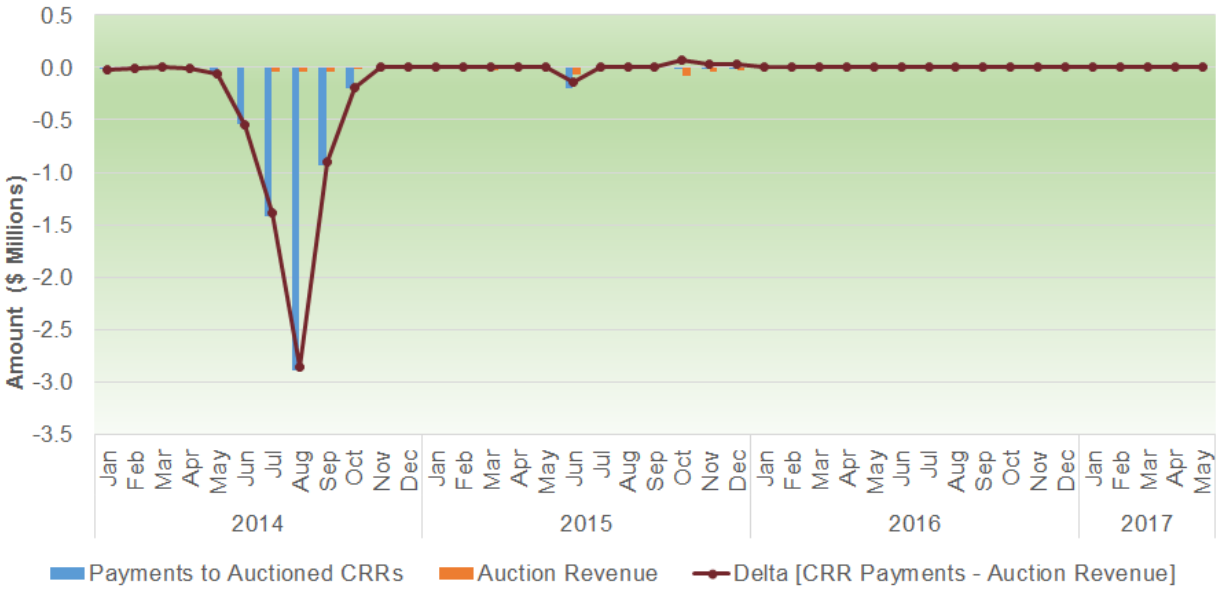


Figure 79: Comparison of CRR payments (auction CRRs) vs auction revenue for - POD_HELMPG_7_UNIT 1-APND to DLAP_PGAE-APND

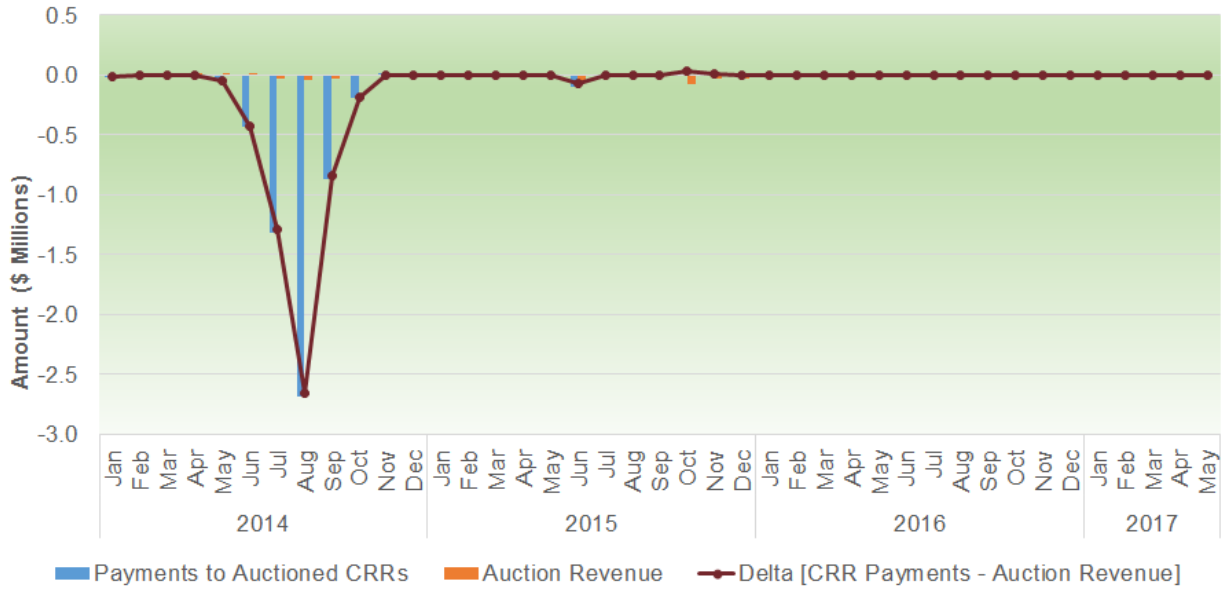
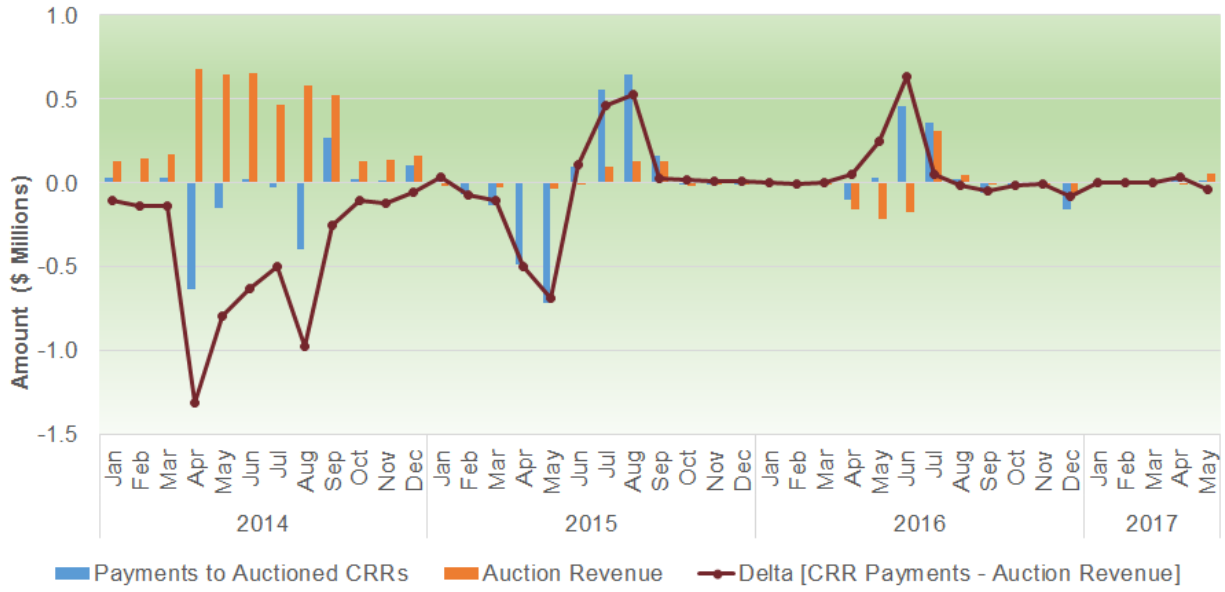


Figure 80: Comparison of CRR payments (auction CRRs) vs auction revenue for - TH_NP15_GEN-APND to TH_SP15_GEN-APND



Previous metrics show that the top and bottom CRRs in terms of profitability do not show a persistent performance; rather there are specific short periods where large net CRR payments accrued. Although interesting to see the pattern on the top and bottom CRRs, there is still a need to see the extent to which CRRs show a persistent pattern. Figure 81 and Figure 82 show the top 200 CRRs based on the amount of net CRR payments; i.e., the CRRs where the difference between the payments to CRR holders in the day-ahead market and the auction revenues holders had to

pay in the auction were the largest. This top 200 CRRs represent about a half of the net CRR payments accrued for the period under analysis. These CRRs are shown in two parts for a better graphical representation. The horizontal axis stands for every month of the period under analysis, the vertical axis stands for the enumeration of the top CRRs, with label 1 being for the top CRR, a 100 for the top 100 CRR, etc.[6]. The bubbles in blue and red are for the net CRR payment to represent a money inflow or outflow for the holders of these auction CRRs.

For the plot with the first 100 top CRRs, the largest bubble in blue reflect a net CRR payment of about $7 million; for the second set of top CRRs it is scaled to show the relative value of these CRRs and the largest bubble reflects a net CRR payment of about $0.7 million. The first pattern to note in these plots is that even for the top CRRs, there is no persistent positions over time, some top CRR see large inflows followed by large outflow. For many other top CRRs, they are more scattered over time, meaning that there is no persistent system conditions where they can be profiting from over time. To a great extent this is expected given the constantly changing dynamics of congestion in the system. For multiple CRRs, the CRR payment are clustered in short period of few consecutive months.

Figure 83

Figure 83 shows a different organization of top CRRs; this plot shows the top CRR based on the frequency of CRRs having a money inflow from net CRR payments. This is to portray the top CRR which are persistently over time resulting in a net CRR payment to their holders. This metric only takes into account the absolute frequency of the months in which CRRs represent a money inflow to their holders. In relative terms the top 100 CRRs shown with the most consistent performance amount to just 2 percent of the overall net CRR payment for the period under analysis. This means that the top 100 CRRs that have consistently profit from the day-ahead market represent a very small sample of all the set auction CRRs.

For the top 100 most consistent CRRs shown in Figure 83, the corresponding number of awards are now shown in Figure 84. This reflects the number of awards (arising from different bids) for these CRRs. The largest bubble stand for 35 different awards. For instance, for some CRRs, including the top CRR, it shows that the number of awards has grown from six different awards in early 2014 to 35 different awards in summer 2015. This could be expected that for consistently profitable CRRs, more fierce competition could happen when such opportunities are found such that more participants could get a share of that CRR. There are other cases in which the number of awards for a given CRR definition is relatively constant over time, which may indicate less competition to acquire that CRR in the auctions.

[6] Due to space the actual source-to-sink definition cannot fit into the plot.

Figure 81: Top 200 CRRs based on net CRR payments

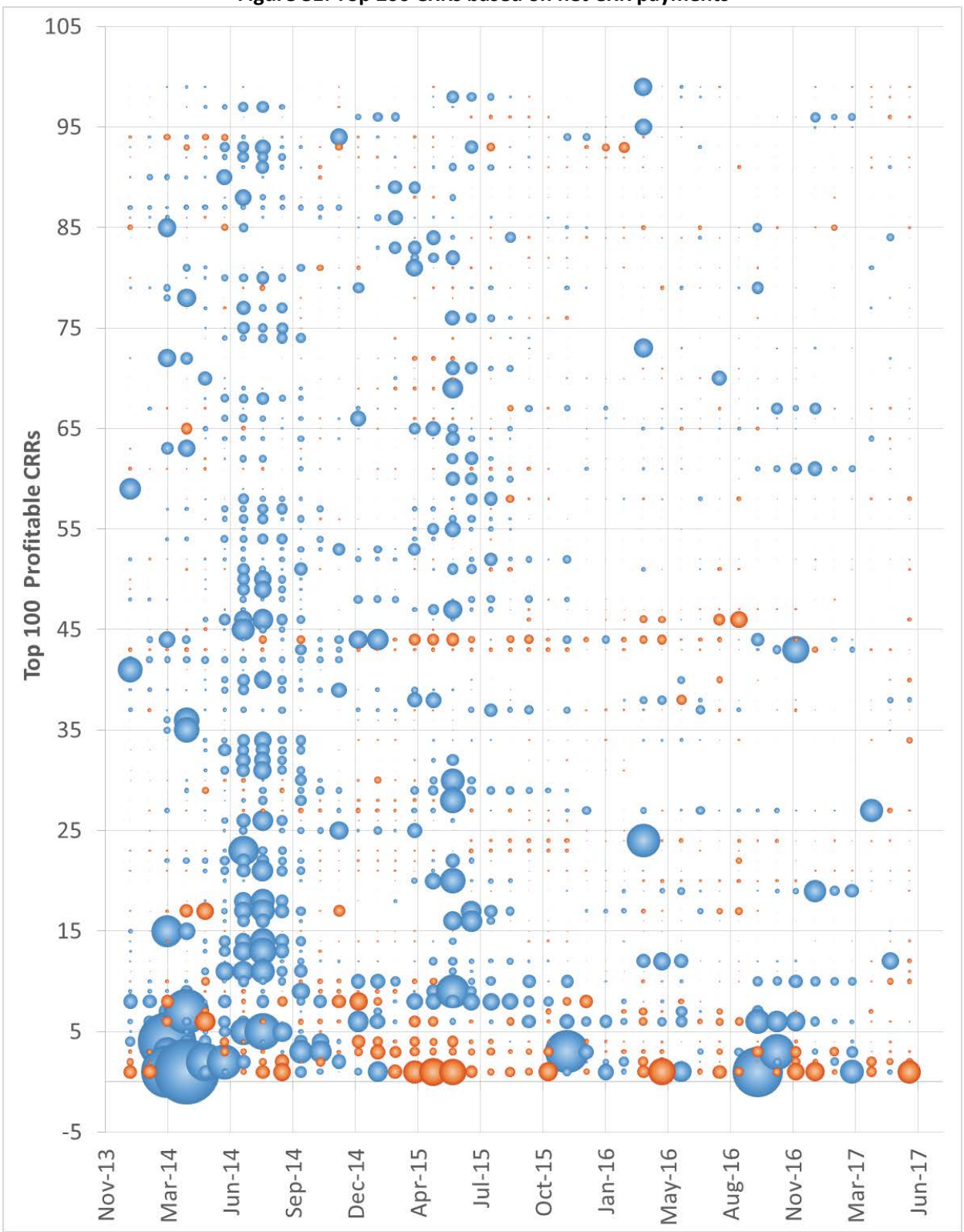


Figure 82: Top 200 CRRs based on net CRR payments

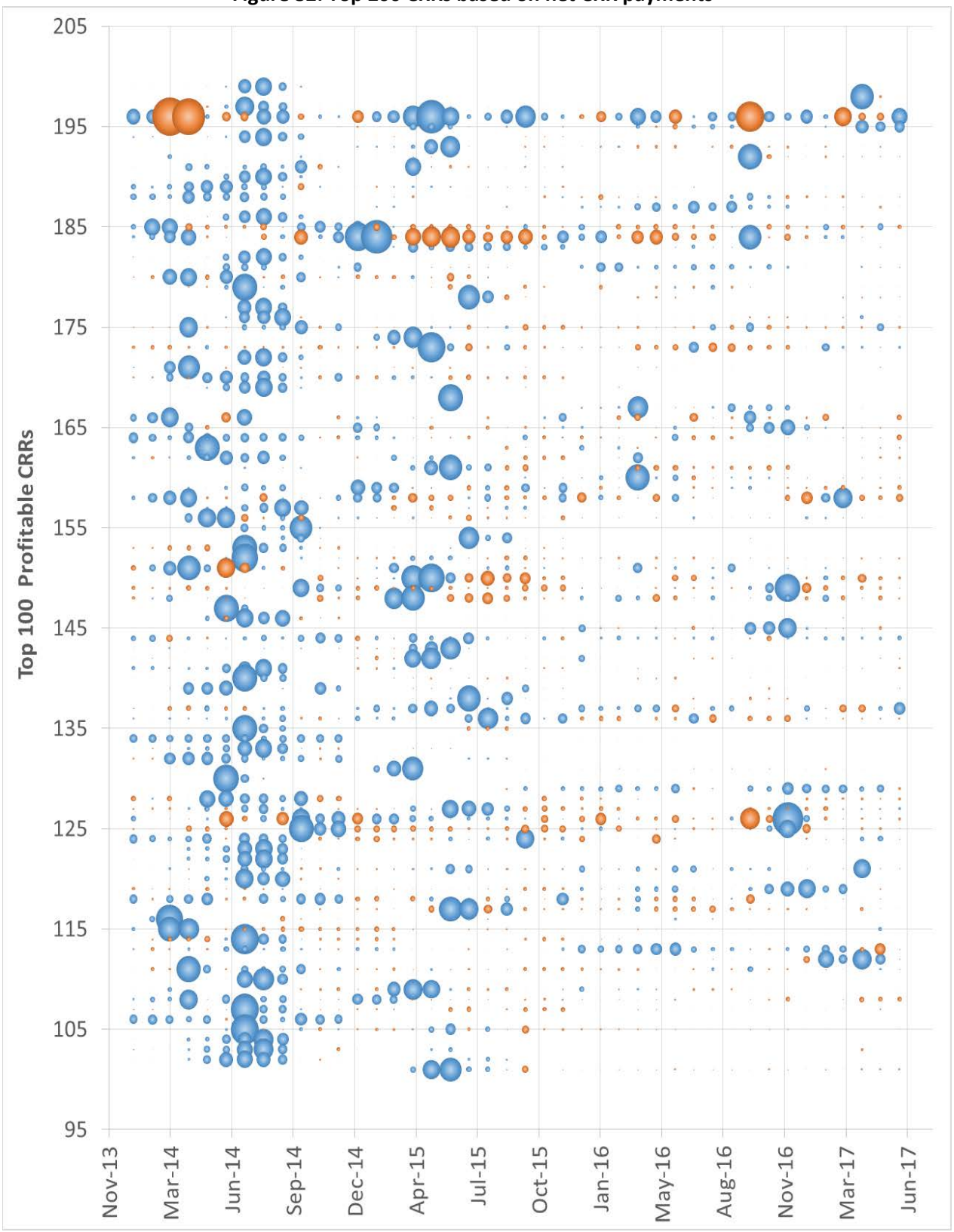


Figure 83: Top 200 CRRs based on consistency of monthly net CRR payments

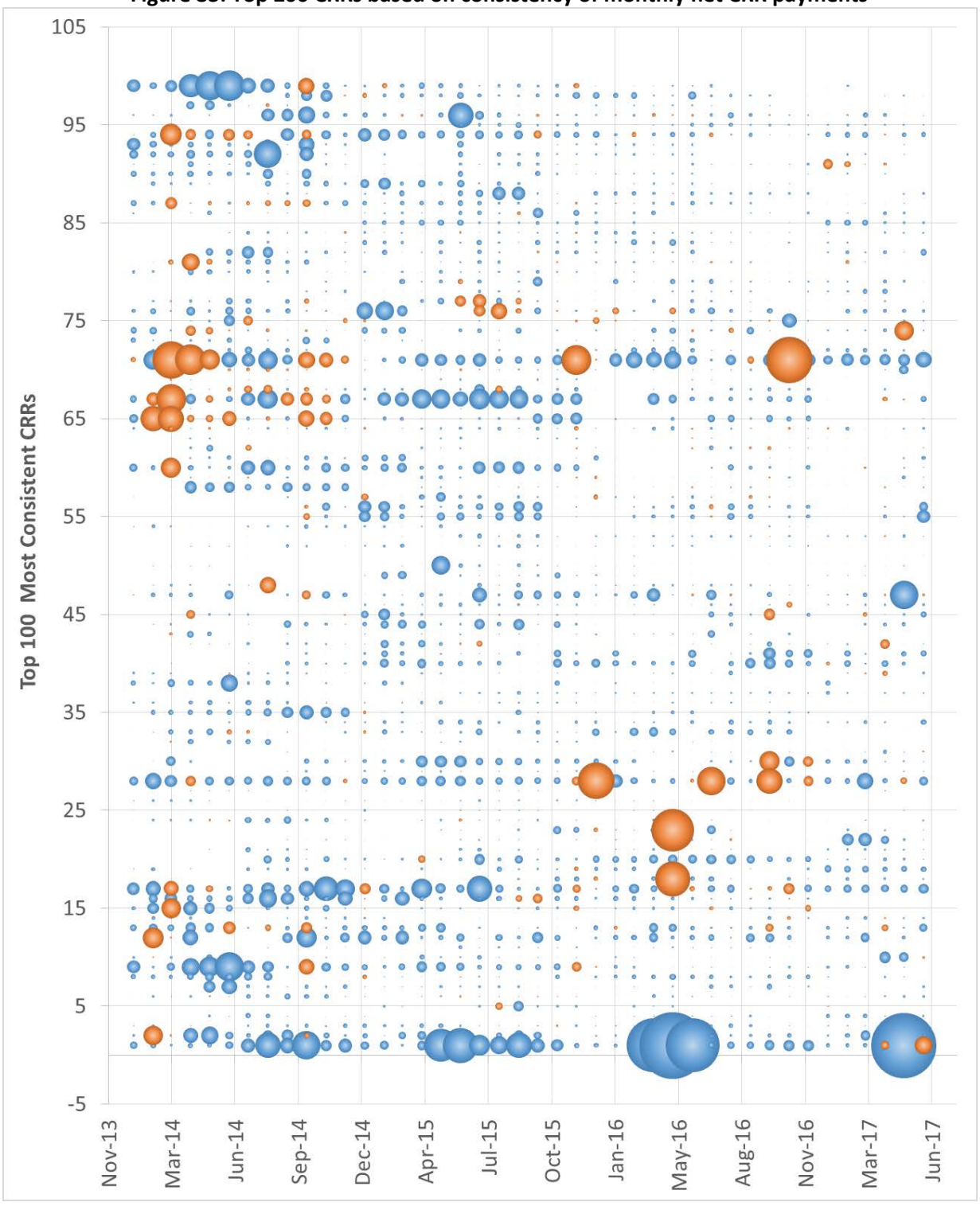
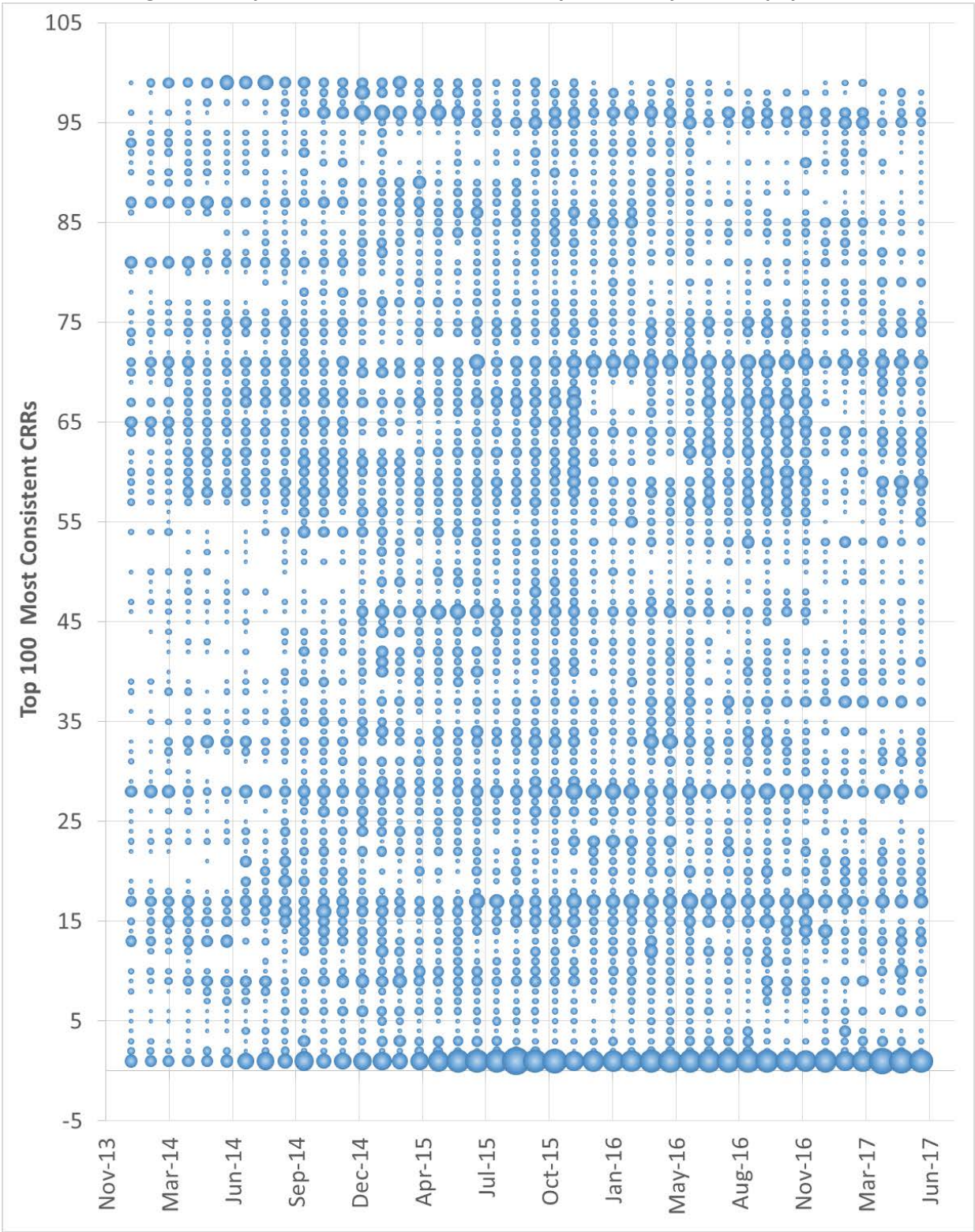


Figure 84: Top 200 CRRs based on consistency of monthly net CRR payments

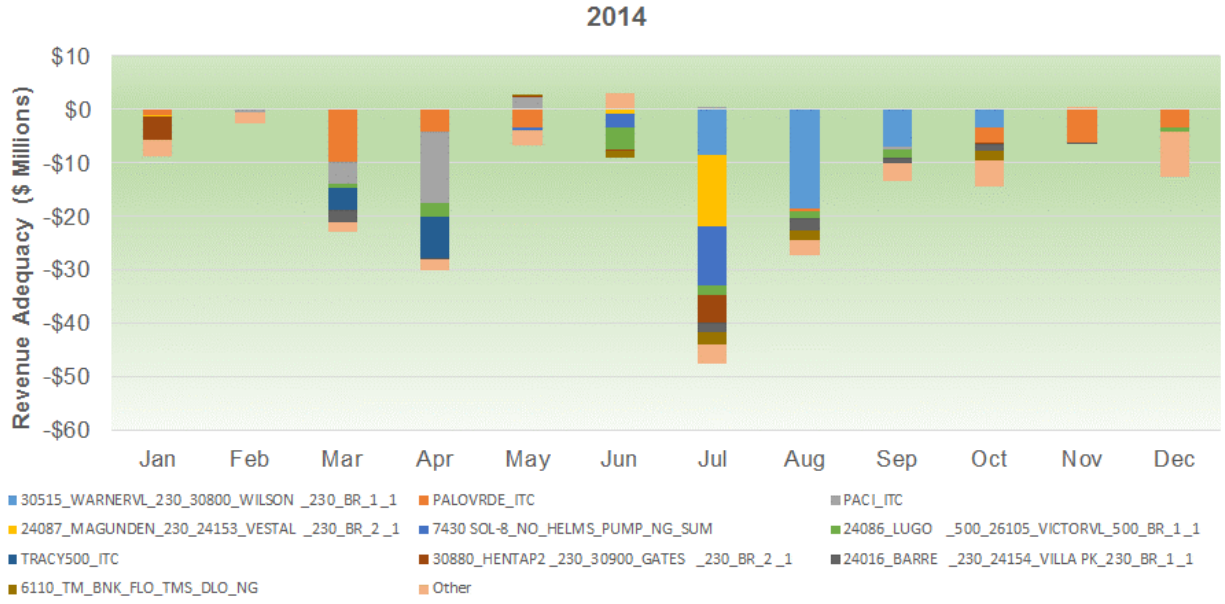


CRR revenue adequacy by transmission element

Revenue adequacy for CRRs reflects the extent to which the net congestion revenues available from the integrated forward market are sufficient to cover the net payments to CRR holders. On one side, when congestion arises in the integrated forward market, congestion rents are collected. These congestion rents are the market surplus resulting from pricing scarce transmission at locational marginal prices. On the other side, the congestion revenue rights released through the CRR markets are funded with such congestion rents. Since congestion rents are only collected on transmission elements experiencing congestion, it is possible to determine equivalently how many CRRs were paid on these same transmission elements, and then determine the level of revenue adequacy by each transmission element that experienced congestion.

Figure 85 illustrates the revenue adequacy (congestion rents less exemptions of existing transmission rights less CRR entitlements) for CRRs in the corresponding month for the various transmission elements that experienced congestion during the month for 2014. A positive value indicates that there is a surplus and a negative value indicates there is a shortfall. For illustration purposes, the CRR revenue adequacy amounts are computed hourly and then aggregated across all hours of each day and month. The chart illustrates only the top 10 most revenue deficient transmission elements across the year and indicates their revenue adequacy trends across the months to check if they have been revenue deficient in one month or distributed across the months for the particular year.

Figure 85: Top 10 CRR revenue inadequate transmission elements



Similarly, Figure 86 through Figure 88 illustrates the revenue adequacy (congestion rents less exemptions of existing transmission rights less CRR entitlements) for CRRs in the corresponding month for the top 10 transmission elements that experienced congestion during the month from 2015 to 2017 respectively.

Figure 86: Top 10 CRR revenue inadequate transmission elements

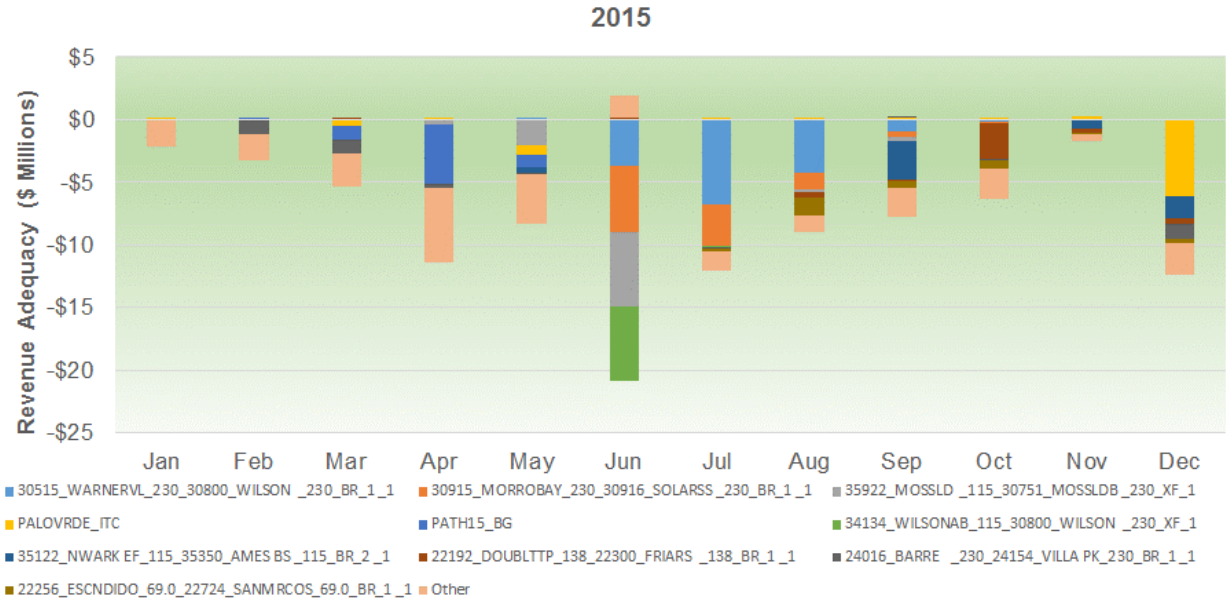


Figure 87: Top 10 CRR revenue inadequate transmission elements

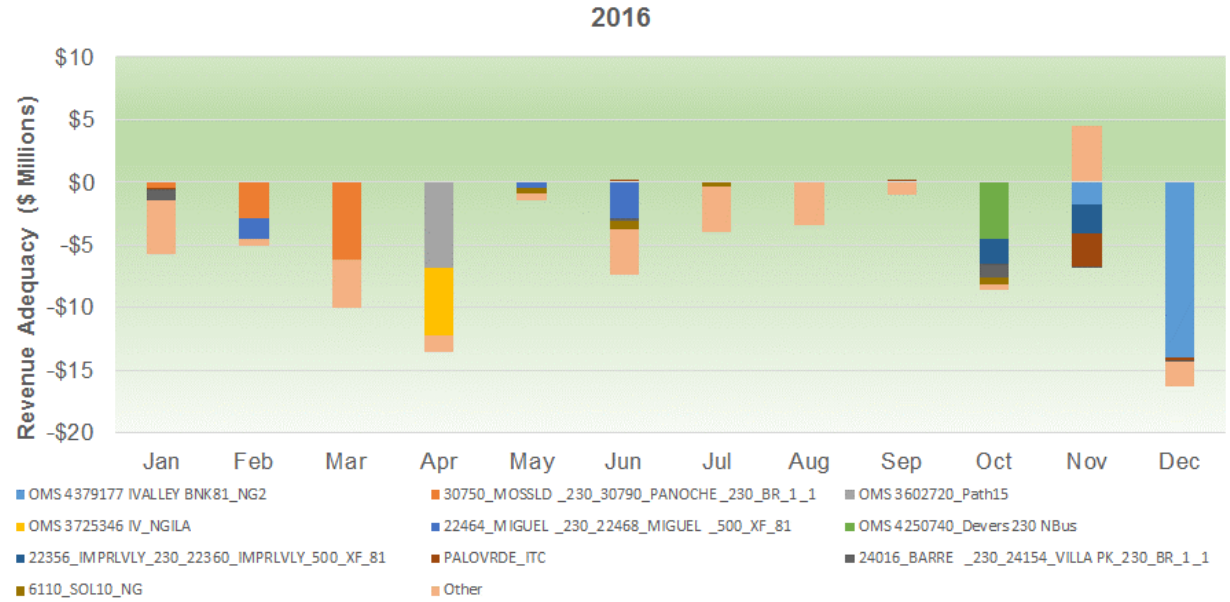
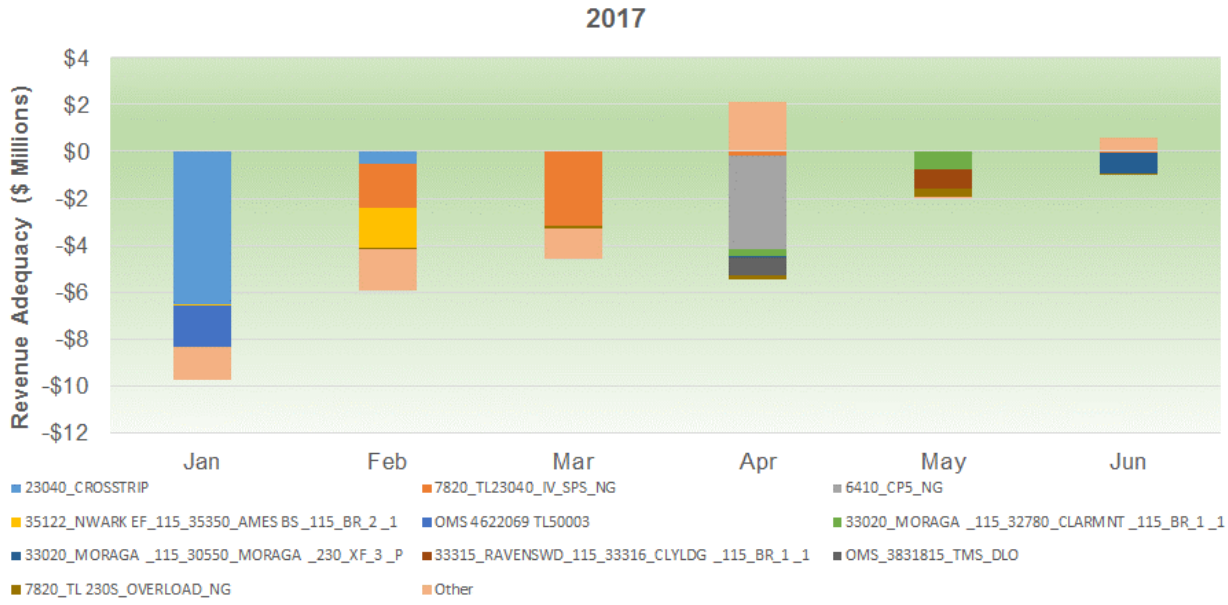


Figure 88: Top 10 CRR revenue inadequate transmission elements



6 Transmission Outages

Outages of transmission facilities rated above 200 kV are considered to have a significant effect upon CRR revenue adequacy. These outages that are more than 24 hours in duration must be submitted for CAISO approval at least 30 days in advance of the first day of the month the outage is scheduled.[7] The CAISO analyzed the planned transmission outages with transmission facilities rated above 200 kV in four sub control areas (VEA, SDGE, SCE, PGAE), whose start dates are between March 2015 and June 2017[8].

Figure 89 shows the total number of planned transmission outages, regardless of their duration. For the period under analysis, about 80 percent of the outages were not scheduled in time to be modelled in the CRR monthly auctions.

Figure 89: Total number of planned transmission outages timely submissions

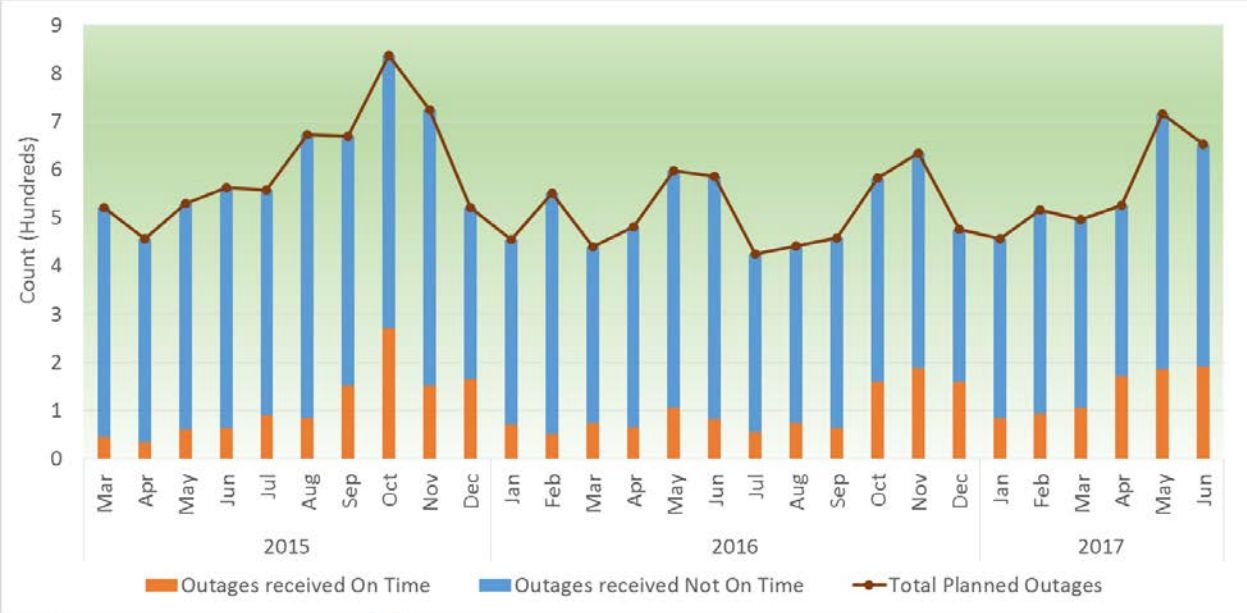


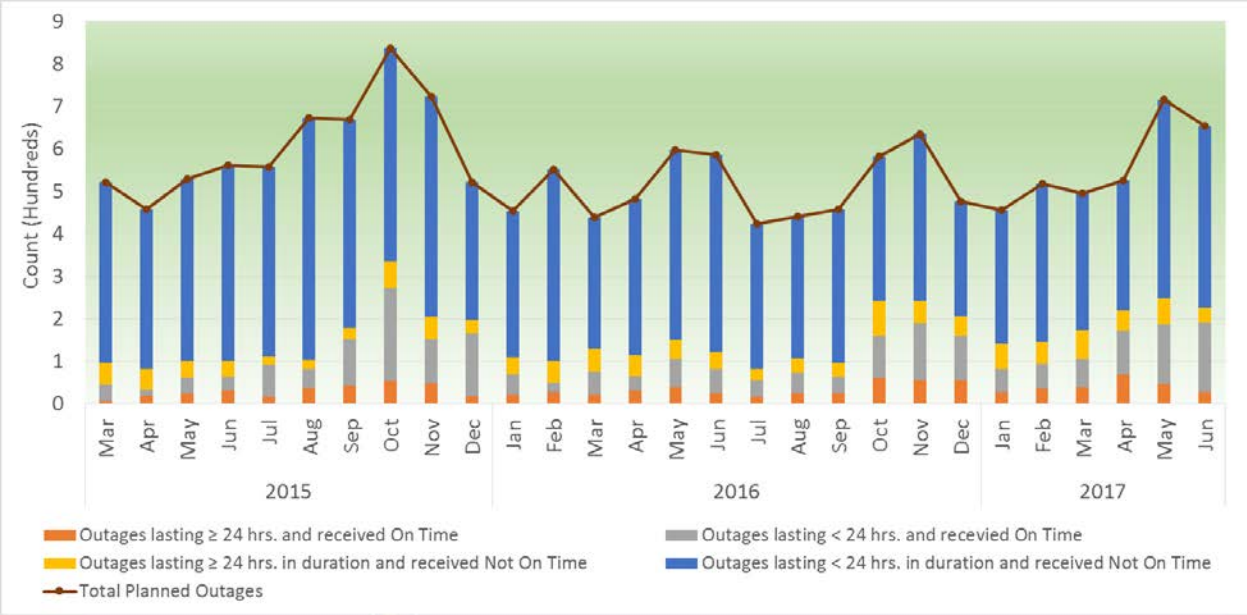
Figure 90 shows the total number of planned transmission outages associated with the number of outages broken out in two main groups; one group to identify if the outages have a duration of at least 24 hours, and the second grouping to identify the portion of outages submitted on time. The majority of outages that were not submitted on time had a duration of less than 24 hours; such outages are not subject to the 30-day submission window. For practical purposes in the CRR markets, these outages, even when submitted on time, are not considered

[7] This deadline and limitation on duration for planned transmission outages are set by the ISO Tariff Section 36.4.3 *Outages That May Affect CRR Revenue; Scheduling Requirements*.

[8] The time period for this metric is shorter than the general time period of analysis of this report because this is the period in which the outage information became available in a new application named Outage Management System (OMS); prior to that the legacy system of SLIC was used to record the outages.

explicitly in the modelling of the CRR market[9]. Out of the 2,200 outages for the period under analysis and that are subject to the 30-day window for submission, about 57 percent of them were not submitted in time.

Figure 90: Total number of planned transmission outages organized by duration



Furthermore, even when an outage with a duration of less than 24 hours is submitted well in advanced for being considered in the CRR auctions, there is an inherent limiting factor on how to model it. With such a short duration, generally the element under outage is not fully modelled on outage but rather it is derated based on some logic taking a pro-rata value based on the number of hours out of service. This derate over the period of the CRR market may not fully capture the nature of the short-term outage and what may be observed is that the small derate applied over the month (or season) may not bring enough congestion rents to offset the potential impact of the outage for the short duration. Needless to say, this can lead to instances of such short duration outages causing large revenue deficiency accrued in the few hours of its duration.

Currently, the CAISO models outages equal to or greater than 10 days as out-of-service in the CRR auction. Figure 91 shows the total number of planned transmission outages with a duration of 24 hours or longer. This metric is then broken out further by outages with a duration of less than 10 days and outages with a duration of at least 10 days. The grouping is also done by whether the outages were received on time or not. The significance of the 10 day threshold is based on the CAISO's practice to model the element with outage with just a pro-rata derate in the CRR auction if the duration is less than 10 days; otherwise, the outage is modelled fully in the CRR market. On average, about 15 percent of outages submitted in time were modelled as full outages.

[9] Outages lasting less than 24 hours are not modelled by any means (derate or full outage in the CRR market model); the exception is only for outages that accrue multiple partial days; in this case if the total number of hours of the outages span 24 hours or more then they are modelled in the CRR market. This is the case of daily outages that are scheduled for multiple days for only certain hours of each day.

Figure 91: Total number of planned transmission outages based on duration and timely submissions

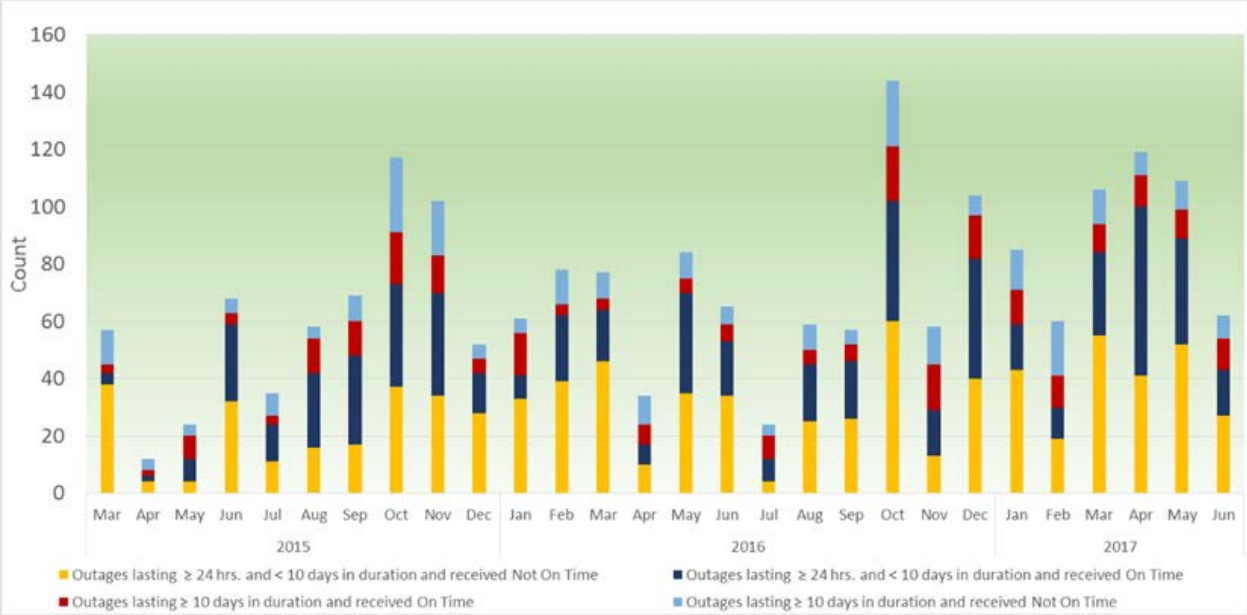
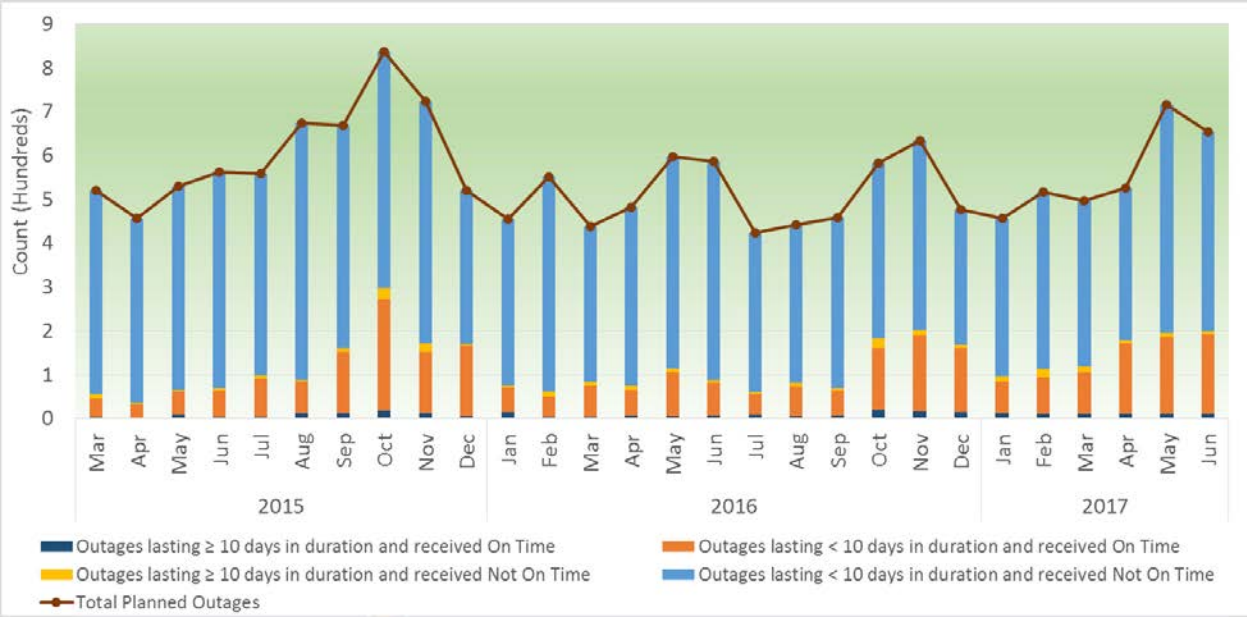


Figure 92: Total number of planned transmission outages organized by 10-day duration



In previous metrics, the outage information was provided at the CAISO system level; subsequent figures show the same information organized by PTO. Figure 93 and Figure 94 show the total number of planned transmission outages that the CAISO analyzed in the sub control area of PGAE. This figure is outlined by the timeliness of when the CAISO received the outages. On average, about 50 percent of PGAE's system outages that were subject to the 30-day submission window were not received in time.

Figure 93: Total number of planned transmission outages timely submissions for PGAE

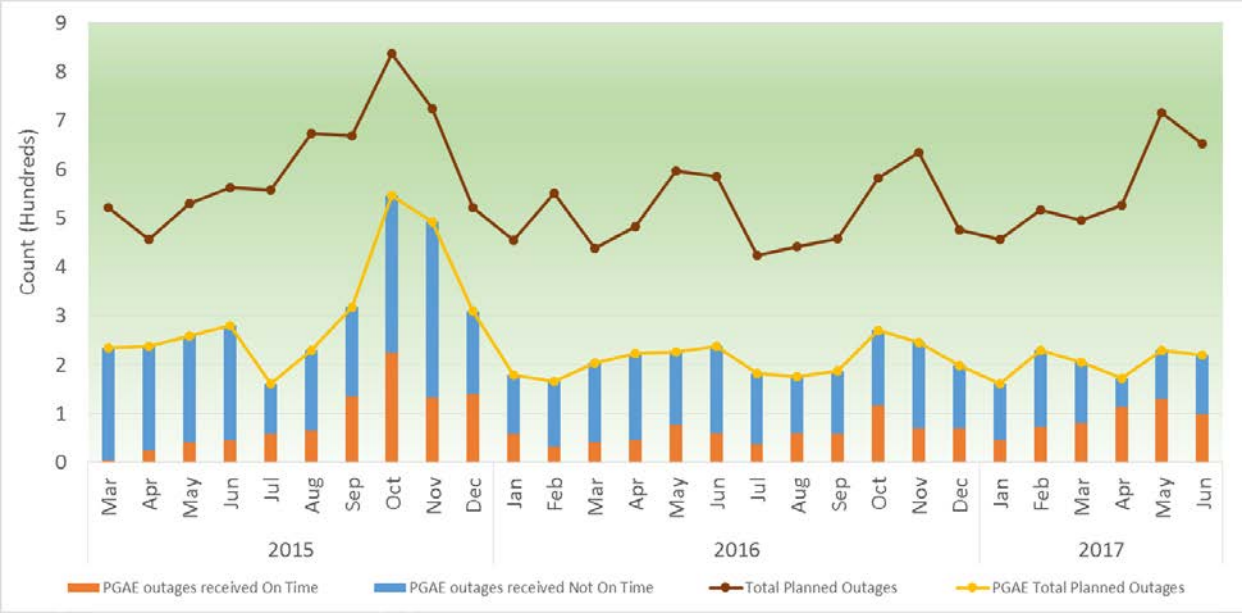


Figure 94: Total number of planned transmission outages subject to submission window for PGAE

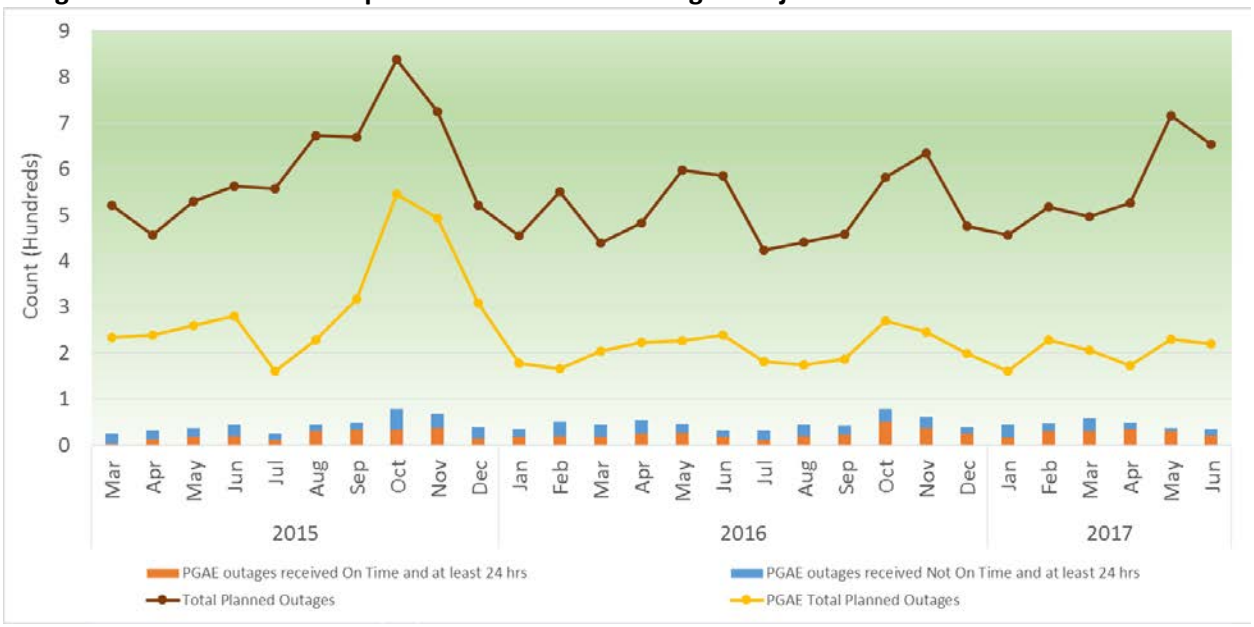


Figure 95 and Figure 96 shows the total number of planned transmission outages that the CAISO analyzed in the sub control area of SCE. This figure is outlined by the timeliness of when the CAISO received the outages. On average, about 65 percent of SCE's system outages subject to the 30-day submission requirement were not received in time.

Figure 95: Total number of planned transmission outages timely submissions for SCE

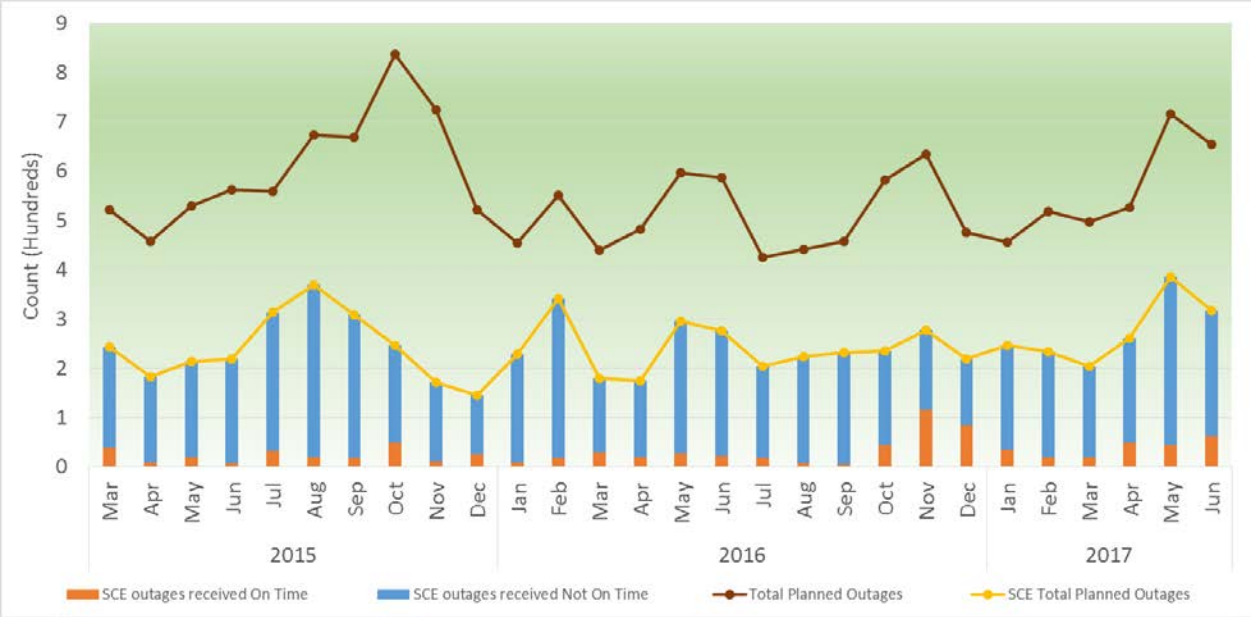


Figure 96: Total number of planned transmission outages subject to submission window for SCE

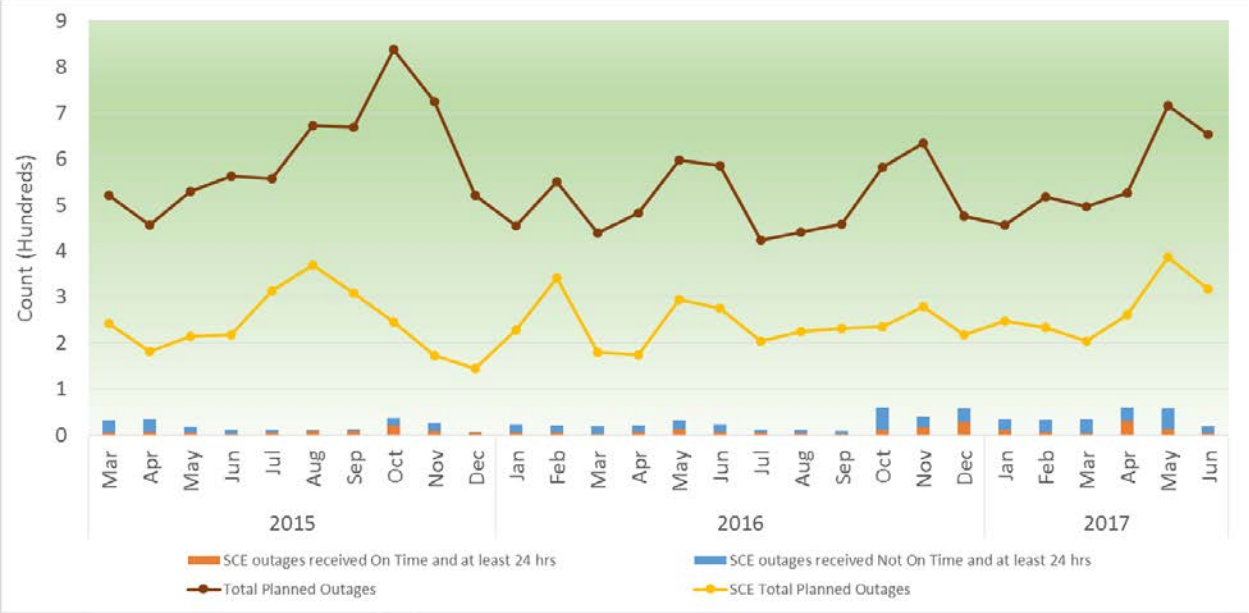


Figure 97 and Figure 98 shows the total number of planned transmission outages that the CAISO analyzed in the sub control area of SDGE. This figure is outlined by the timeliness of when the CAISO received the outages. On average, about 70 percent of SDGE's system outages subject to the 30-day submission requirement were not received in time. For the VEA system, there were no applicable outages.

Figure 97: Total number of planned transmission outages timely submissions for SDGE

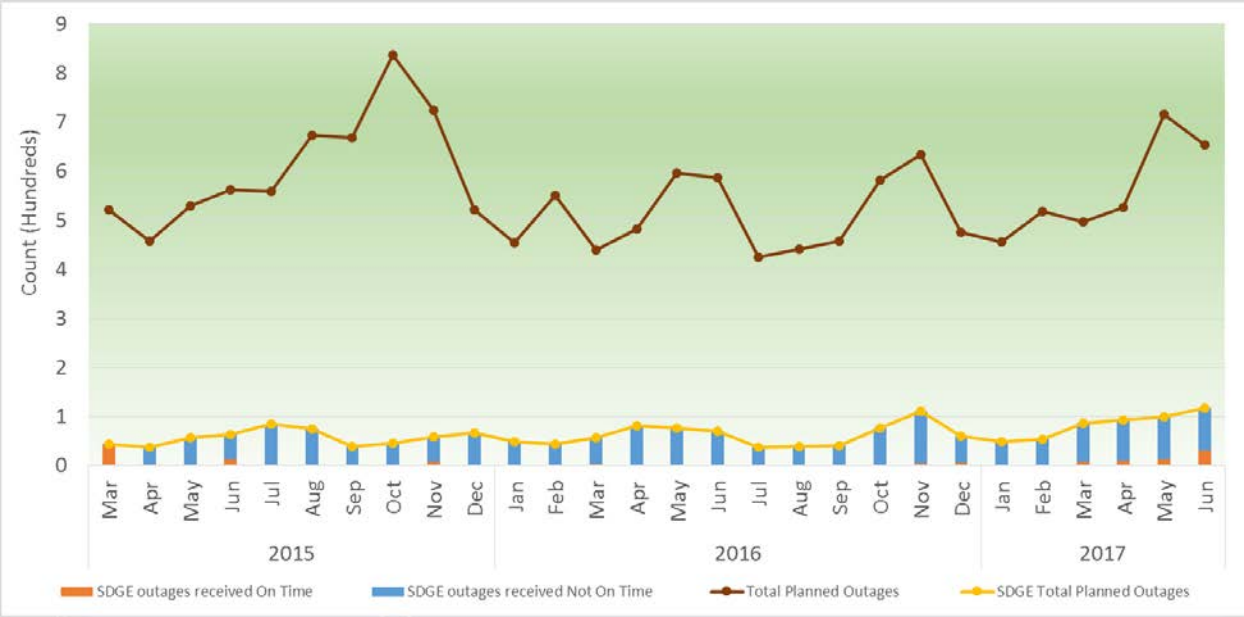
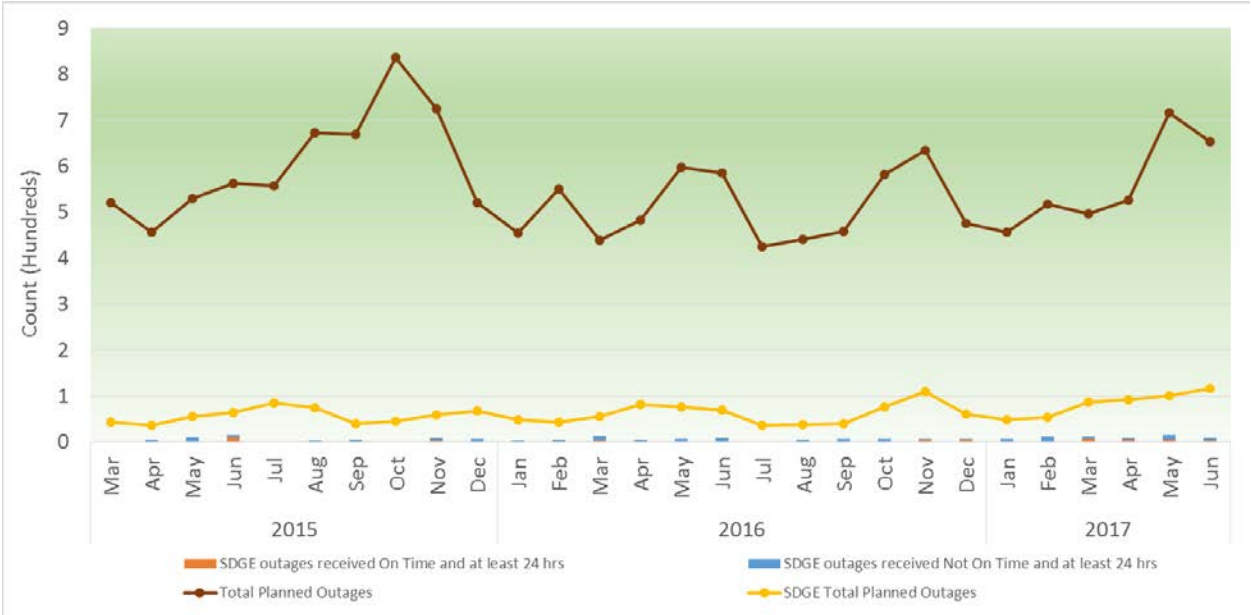


Figure 98: Total number of planned transmission outages subject to submission window for SDGE



7 CRR Auction Performance

The previous sections of this report covered different items for the CRR auction performance; these trends can provide insights on developing patterns and help guide more focused analysis. However, in order to specifically understand the performance of the CRR auction, a more focused and deeper analysis of the basics of CRR auctions is needed. Both CRR awards and prices cleared in the auction process define the auction revenues collected; the clearing prices are not only a reflection of the willingness to buy CRRs from market participants but also reflect the given value of transmission released in the auction. The conceptual construct of auction CRRs is that over time they converge towards the day-ahead congestion prices. If day-ahead congestion prices are simply the reality of the market, they are naturally the point of reference of what transmission is valued at; therefore, from that perspective, it is expected that the CRR auction prices converge towards the day-ahead prices, not the other way around. If there is a persistent divergence, naturally the reference for analysis is the CRR auction rather than the day-ahead market.

The CRR auction prices are primarily driven by the bids reflecting the willingness of participants to pay for CRRs and the available transmission capacity released in the auctions. The prices defined for each CRR source-to-sink combination are not, however, the most fundamental basis of the auction; these are by-product prices and are a reflection of the value of scarce transmission measured by the shadow prices of the underlying transmission constraints binding in the auction.[10] Thus, to understand the fundamental drivers of auction revenues, whether they are too low or too high, implying the transmission is valued too low or too high, it is necessary to analyze the underlying elements: transmission capacity released in the CRR auctions.

The concept of auction revenues is defined as the money collected by the CAISO by releasing CRRs at the auction clearing prices. In settlements, these revenues are simply calculated as the product of quantity and price for each CRR. This gives the actual value of auction revenues; however, this metric has no information to decipher what has defined such clearing prices and thus the level of auction revenues. Similar to the analysis done for CRR revenue adequacy, auction revenues and net CRR payments can be derived on a more basic level by de-constructing these auction revenues and payments on an individual transmission constraint contribution. This is applicable to both annual and monthly CRR auctions. This section provides such analysis for the most recent months.

[10] This construct is ubiquitous in the technical literature, in which the marginal congestion component of a given location is defined as the linear combination of the different shadow prices for transmission constraints binding in the market where the factors of the linear combination are no more than the shift factors.

August 2016

Table 4 summarizes the main settlements metrics for CRR performance in the month of August 2016. The sign convention is based from the CAISO's perspective; a positive value indicates the CAISO collects or has a surplus of money; a negative value indicates the CAISO pays or has a shortfall. Day-ahead congestion rents will be positive, CRR payments will be negative and auction revenues will be positive.

Table 4: Summary of CRR performance for August 2016

Metric	Amount
DA Congestion Rents	$10,432,605
Perfect Hedge	-$562,954
CRR Clawback	$130,037
CRR Payments [Auction + Allocation]	-$13,816,558
CRR Payments to Auction CRRs	-$5,983,425
CRR Payments to Monthly Auction CRRs	-$3,227,669
CRR Payments to Annual Auction CRRs	-$2,755,756
CRR Payments to Allocation CRRs	-$7,833,133
CRR Auction Revenue Monthly	$4,189,193
CRR Auction Revenue Annual	$4,758,563
Revenue Adequacy	-$3,816,871
Revenue Adequacy with Auction Revenues	$5,130,885
Net payment to auction CRR	$2,964,331

In August, there was a revenue deficiency of $3.81 million, which is the difference between all of the proceeds from day-ahead congestion rents, CRR clawback and the payments made to CRR holders. About 43 percent of the CRR payments were to CRRs originating from the annual and monthly auctions. The auction revenues represent the proceeds from selling CRRs through the auction. The revenues arising from the annual auction for each season are estimated pro-rata to each month of the calendar quarter based on the number of hours in each time of use. The net payment to auction CRRs stands for the difference between the money paid to CRR holders and the money charged to CRR holders to acquire that portfolio of CRRs through the corresponding auction. This does not take into account any expenses the CRR holders incur associated with their participation in the CRR market and use of money. This is only a net accounting from the point of view of the cash inflow and outflow in the CAISO system in the CRR settlements. August was one of the few months in which the auction revenues collected by selling CRRs in the auction were higher than the CRR payments to auction CRRs, in the amount of $2.96 million.

In order to further understand this performance, there is a need to estimate over time and by constraint the CRR settlements. Figure 99 shows the daily congestion rents accrued on each transmission constraint that was binding in the day-ahead market in the month of August. August 2nd, 19th, and 31st account for about 32% of the total congestion rents for the entire month. Correspondingly, Figure 100 shows the daily CRR revenue adequacy also illustrated by transmission constraint. On

August 19th, about $1.4 million of revenue deficiency was accrued which accounts for about 37 percent of the total deficiency.

Figure 99: Daily congestion rents - August 2016

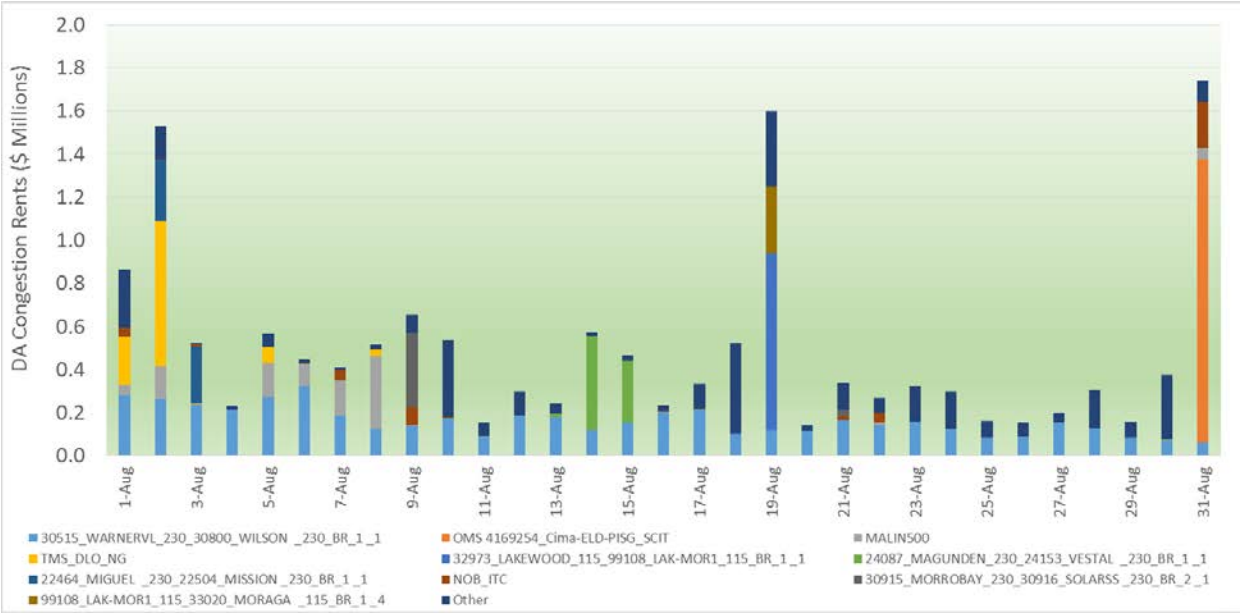


Figure 100: Daily CRR revenue adequacy - August 2016

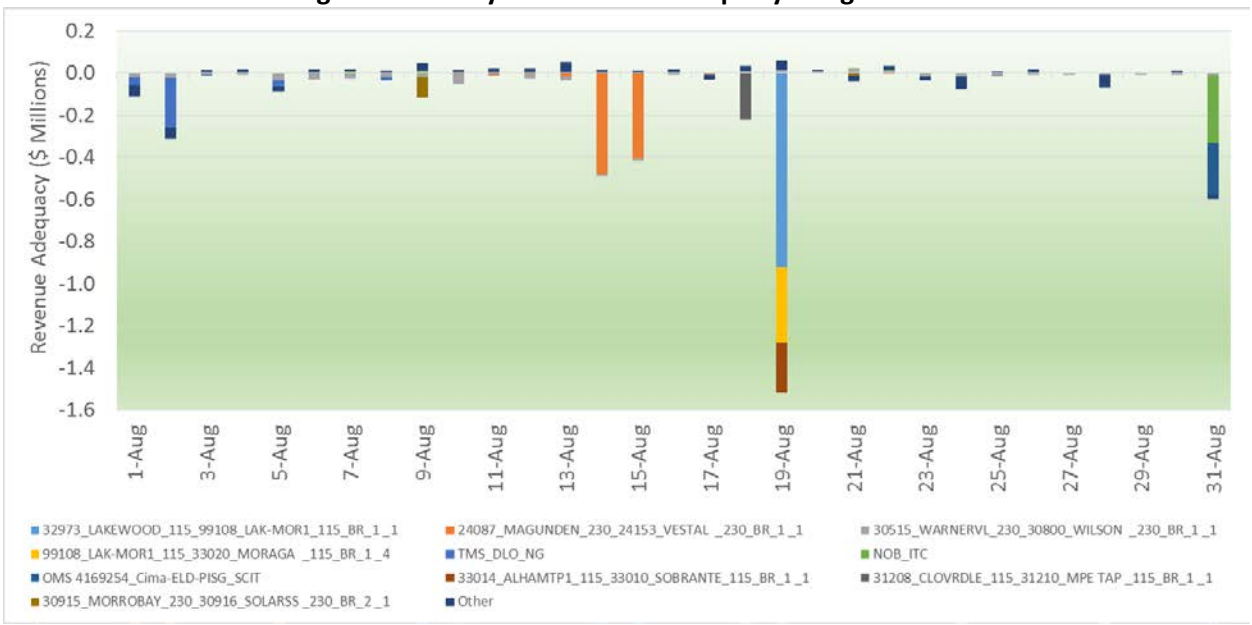


Figure 101 shows the net CRR payment per day. This net payment is the difference between the CRR payments to CRR holders and the auction revenues collected by the CAISO through the CRR auction process; such revenues become a lump revenue for the auction. For this metric, the annual auction revenues are allocated on a pro-rata estimation to each day of the month based on the number of hours in each time of use. The CRR payments are estimated as the total sum of CRR payments over the hours of the day only for CRRs that were released

through both the annual and monthly CRR auctions; that is, no CRR payments to allocated CRRs are included. The purpose of this estimate for net CRR payments is to calculate the net balance for CRRs that were released only in the auctions. For August, there was a persistent positive net CRR payment, indicating that overall the money paid to CRR holders was less than the money the CAISO collected when releasing such CRRs in the annual and monthly auctions.

Figure 101: Daily net CRR payment to auction CRRs - August 2016

Figure 102 compares the level of CRR revenue deficiency and the level of net CRR payments paid to holders for CRRs released in the auction processes. This plot shows that both metrics move together to some extent; in this month in particular, the correlation was weaker than observed in other months. A negative value for CRR revenue adequacy represents a shortfall for the CAISO, while a negative value for net CRR payment represents a payment to holders of auction CRRs from the CAISO. This indicates that the CAISO paid more to auction CRRs than it charged to release CRRs in the auction process.

Figure 102: Comparison of daily net CRR payment with CRR revenue adequacy – August 2016

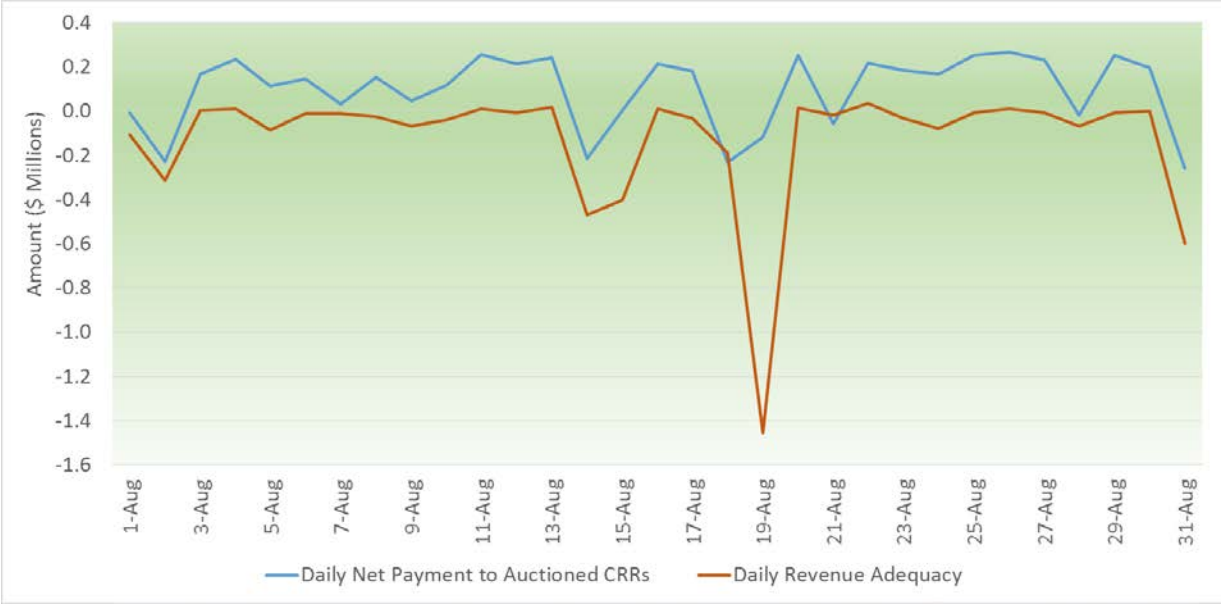
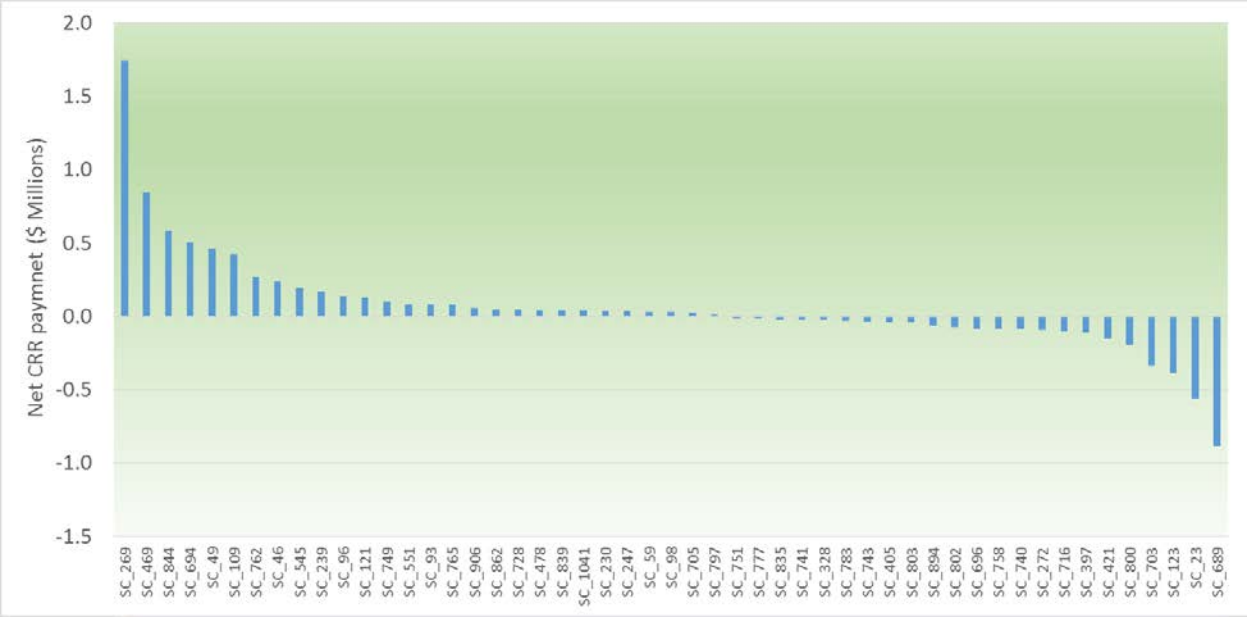


Figure 103 shows the net CRR payments to CRR participants, regardless of the type of participant. This only reflects the payments for CRRs released in both the annual and monthly CRR auctions applicable for the month of August 2016. Since this is from the CAISO's perspective, a negative value means the CAISO disbursed a net CRR payment to the CRR holder (or a net money inflow to the CRR holder). The names of the CRR holders are masked, but the identifier shown in the plot is unique across all the months provided in this analysis. A positive value represents a net inflow for the CAISO since it paid less to CRR holders in the day-ahead market than what it charged to release CRRs in the auction. For August, a large share of holders of auction CRRs saw a net loss from having these positions[11].

[11] CRR holders with net CRR payments between -$10,000 and +$10,000 were dropped from this plot for simplicity in the presentation.

Figure 103: Net CRR payment to auction CRR – August 2016

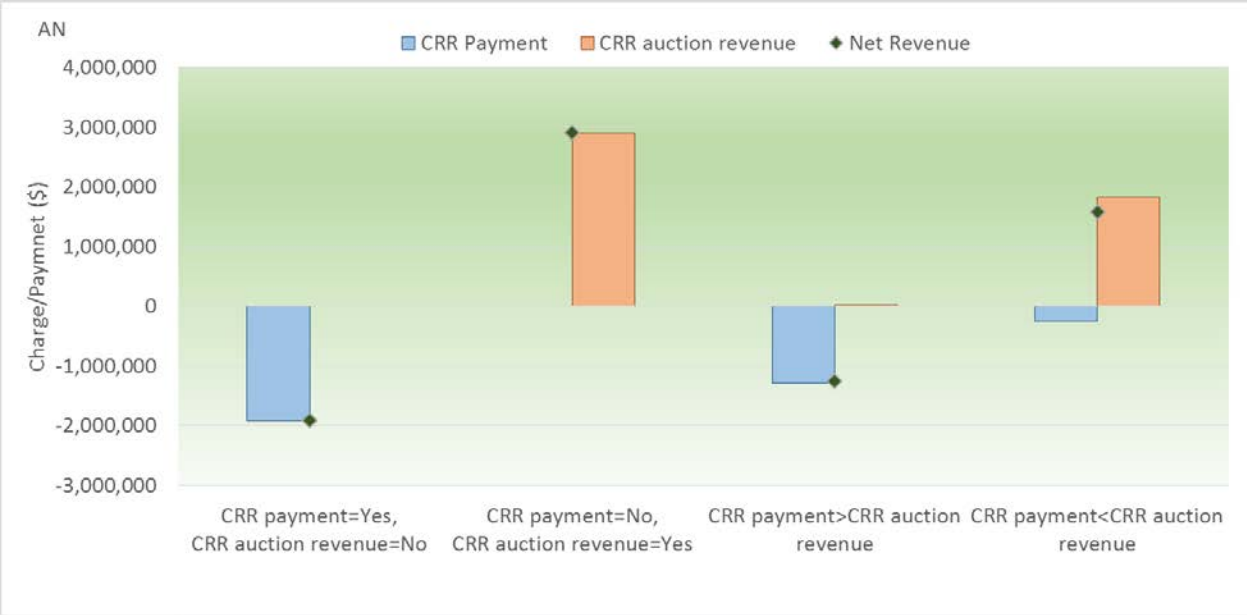


To better understand the dynamics leading to such an outcome, the CAISO shifted the analysis to the fundamentals of the CRR auction construct by analyzing the CRR auction results at the constraint level. CRRs are released and priced based on the CRR clearing prices; such prices are derived as the relative difference between locational prices between the source and the sink locations. These locational prices originate from the cleared prices when any transmission constraint becomes binding with nonzero pries in the CRR auction, commonly referred as *shadow prices*. The CAISO turned out to analyze what constraints have been binding in the CRR auction process and compared that with the set of constraints that were binding in the day-ahead market. To some extent, one expects that there is certain level of alignment between the markets. Figure 104Figure 104 and Figure 105 show a comparison of net CRR payments. The CRR payments reflect the CRR settlements for CRRs with the day-ahead congestion rents, while the CRR auction revenues are the money the CAISO collected from releasing CRRs through the auctions. That is, it reflects the net money participants were charged to acquire CRRs and the money they were paid; in a loose sense, it could be interpreted as profits for holding.

There are four possible permutations to analyze. The first case represents when a CRR payment to CRR holders was made in the day-ahead market settlement, but the CAISO did not collect any revenues from releasing these CRRs from the auctions because the constraint was not binding in the CRR auction. This is shown for both the pro-rata portion of the annual auction for August and for the monthly CRR auction. A negative value indicates that the CAISO had a net CRR payment to CRR holders. The second case is the opposite in which there was no CRR payments when settling CRRs in the day-ahead market but the CAISO collected revenue when releasing these CRRs in the auction process. The third and fourth cases are for CRRs that had a CRR payment in the day-ahead market and the CAISO also charged them in the CRR auctions to release these CRRs. The third case is when the net CRR payment is negative, while the fourth case

is when the net CRR payment is positive[12]. This metric reveals any potential misalignment of constrains enforced and binding between the day-ahead market and CRR auctions.

Figure 104: CRR payment versus CRR auction revenues for annual CRR - August 2016



[12] This type of breakdown of net CRR payments can be easily done using straight CRR settlements data since it simply classifies CRRs by the potential positions they had in both the CRR auctions and the day-ahead market settlements. However, with the need to further understand how this was originated, the CAISO based this estimate on a constraint by constraint analysis. That is, the CAISO first estimated the day-ahead congestion rents by constraint and also the CRR auction revenue by constraint. This type of analysis provides an estimate of the net CRR payment by each constraint. With this approach, the estimates provided in this analysis may observe a small discrepancy when comparing against the actual settlements data. The reason for this potential discrepancy relies on the fact that when dissecting the CRR payment by each constraint, the CAISO uses the underlying shift factors and CRR MW values and constraints shadow prices to derive the corresponding payments and revenues. With the CAISO day-ahead market using a shift factor threshold of 2 percent, the estimates for congestion rents by constraint may be slightly different than simply estimating the congestion rents as the product of shadow price of a constraint times its transmission limit.

Figure 105: CRR payment versus CRR auction revenues for monthly CRR - August 2016

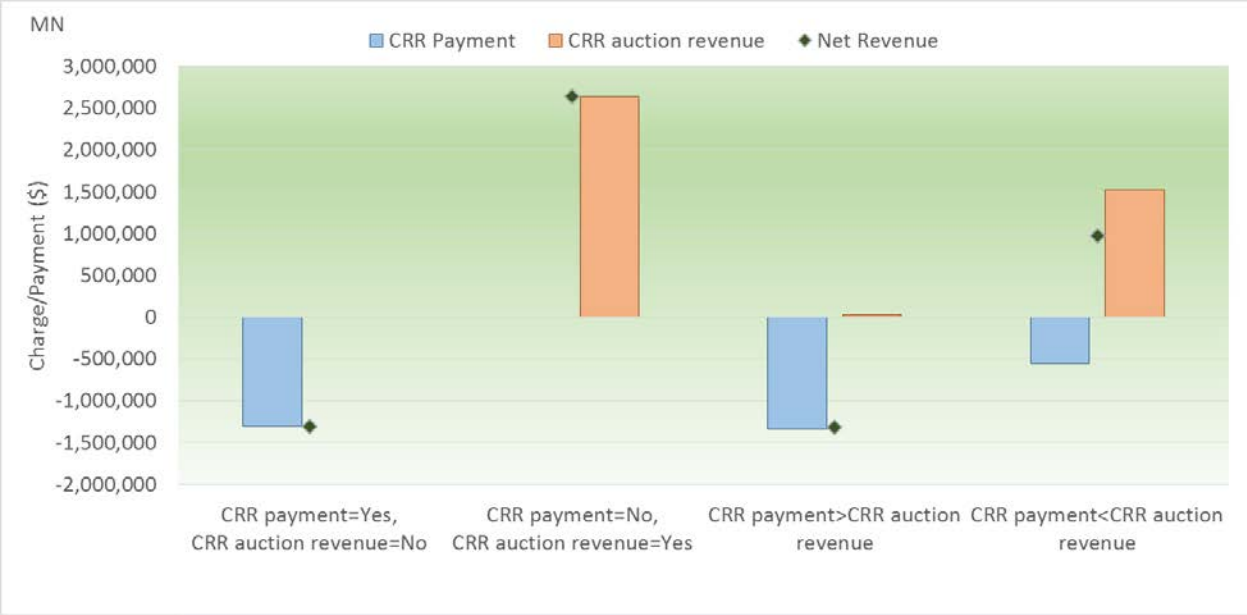


Table 5 provides one level deeper of understanding of such misalignments between markets. This tables show the top and bottom constraints when sorted by net CRR payments. In the first column it shows the estimated CRR payment to CRR holders accrued by each constraint; the second column shows the auction revenues collected by the CAISO on that same constraint; the last column shows the net CRR payment, which is the balance between this money outflow (CRR payment) and money inflow (CRR auction revenues). Table 6 shows the same information for CRRs released in the monthly auction for August 2016. The top constraints reflect cases where large CRR payments to auction CRRs accrued when the CRR market collected little or no auction revenues when releasing these CRRs. The bottom constraints reflect cases where the net CRR payment is actually positive meaning cases where the CAISO collected more auction revenues than it had to pay to auction CRRs, mostly because the constraints were not binding in the CRR auction.

Table 5: Net CRR payment by constraint – August 2016, annual process

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	-$1,110,625.9	$24.5	-$1,110,601.3
31208_CLOVRDLE_115_31210_MPE TAP _115_BR_1 _1	-$559,476.2	$0.0	-$559,476.2
24087_MAGUNDEN_230_24153_VESTAL _230_BR_1 _1	-$315,218.1	$0.0	-$315,218.1
32973_LAKEWOOD_115_99108_LAK-MOR1_115_BR_1 _1	-$263,724.2	$0.0	-$263,724.2
OMS 4169254_Cima-ELD-PISG_SCIT	-$252,780.6	$0.0	-$252,780.6
TMS_DLO_NG	-$161,976.3	$0.0	-$161,976.3
99108_LAK-MOR1_115_33020_MORAGA _115_BR_1 _4	-$99,606.0	$0.0	-$99,606.0
33014_ALHAMTP1_115_33010_SOBRANTE_115_BR_1 _1	-$87,256.0	$0.0	-$87,256.0
30915_MORROBAY_230_30916_SOLARSS _230_BR_2 _1	-$86,960.3	$0.0	-$86,960.3
31566_KESWICK _60.0_31582_STLLWATR_60.0_BR_1 _1	-$96,426.7	$23,982.0	-$72,444.7
34752_KERN PWR_115_34797_KERNWTP2_115_BR_1 _1	-$53,909.0	$3,840.5	-$50,068.5
22604_OTAY _69.0_22616_OTAYLKTP_69.0_BR_1 _1	-$33,760.0	$0.0	-$33,760.0
OMS 4216681 TL50001OUT_NG	-$24,032.8	$0.0	-$24,032.8
22464_MIGUEL _230_22504_MISSION _230_BR_1 _1	-$22,485.5	$0.0	-$22,485.5
31378_FULTON _60.0_31382_FTCHMTNP_60.0_BR_1 _1	-$18,982.2	$0.0	-$18,982.2
22256_ESCNDIDO_69.0_22724_SANMRCOS_69.0_BR_1 _1	-$17,484.4	$0.0	-$17,484.4
34112_EXCHEQUR_115_34116_LE GRAND_115_BR_1 _1	-$16,656.6	$0.0	-$16,656.6
OMS 4059507 Path15_S_N	-$13,254.3	$0.0	-$13,254.3
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	-$14,594.2	$2,336.1	-$12,258.1
OMS 3969865 Path15_S_N	-$11,019.4	$0.0	-$11,019.4
34104_ATWATER _115_34114_JRWD GEN_115_BR_1 _1	$0.0	$56,980.8	$56,980.8
31581_OREGNTRL_60.0_31578_LOMS JCT_60.0_BR_1 _1	$66,235.5	$0.0	$66,235.5
31218_ER_FTNJT_115_31220_EGLE RCK_115_BR_1 _1	$0.0	$70,457.4	$70,457.4
6110_SOL10_NG	-$16,927.8	$89,489.2	$72,561.4
35922_MOSSLD _115_30751_MOSSLDB _230_XF_1	$0.0	$73,925.4	$73,925.4
33542_LEPRINO _115_33546_TRACY JC_115_BR_1 _1	$0.0	$78,108.1	$78,108.1
34116_LE GRAND_115_34134_WILSONAB_115_BR_1 _1	-$26,554.7	$105,940.0	$79,385.3
WARNRVIL_STNDIFRD_TOR	$0.0	$84,494.3	$84,494.3
OAKDL_MOCASN_TOR	$0.0	$87,494.1	$87,494.1
NdGrp_POD_INTKEP_2_UNITS-APND	$0.0	$89,160.9	$89,160.9
24087_MAGUNDEN_230_24153_VESTAL _230_BR_2 _1	$0.0	$114,943.6	$114,943.6
PALOVRDE_ITC	-$59,156.1	$175,099.0	$115,943.0
NdGrp_COGNTNL_7_B1	$0.0	$128,659.9	$128,659.9
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	-$25,930.7	$176,170.1	$150,239.4
MALIN500	-$94,906.9	$245,268.4	$150,361.5
33310_SANMATEO_115_30700_SANMATEO_230_XF_7 _S	$0.0	$175,828.2	$175,828.2
32782_STATIN D_115_32788_STATIN L_115_BR_1 _1	$0.0	$182,642.5	$182,642.5
PATH15_BG	$0.0	$193,766.4	$193,766.4
6110_TM_BNK_FLO_TMS_DLO_NG	$0.0	$246,778.1	$246,778.1
30915_MORROBAY_230_30916_SOLARSS _230_BR_1 _1	-$39,970.4	$769,923.4	$729,953.0

Table 6: Net CRR payment by constraint – August 2016, monthly process.

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	-$924,512.8	$90.4	-$924,422.4
24087_MAGUNDEN_230_24153_VESTAL _230_BR_1 _1	-$392,790.4	$17,373.0	-$375,417.4
TMS_DLO_NG	-$285,054.8	$0.0	-$285,054.8
OMS 4169254_Cima-ELD-PISG_SCIT	-$216,901.1	$0.0	-$216,901.1
32973_LAKEWOOD_115_99108_LAK-MOR1_115_BR_1 _1	-$177,275.9	$0.0	-$177,275.9
34112_EXCHEQUR_115_34116_LE GRAND_115_BR_1 _1	-$107,682.2	$0.0	-$107,682.2
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	-$79,025.1	$0.0	-$79,025.1
31208_CLOVRDLE_115_31210_MPE TAP _115_BR_1 _1	-$75,407.4	$0.0	-$75,407.4
99108_LAK-MOR1_115_33020_MORAGA _115_BR_1 _4	-$66,983.0	$0.0	-$66,983.0
30915_MORROBAY_230_30916_SOLARSS _230_BR_1 _1	-$62,860.1	$0.0	-$62,860.1
OMS 4059507 Path15_S_N	-$59,109.5	$0.0	-$59,109.5
6110_SOL10_NG	-$51,299.2	$0.0	-$51,299.2
OMS 4216681 TL50001OUT_NG	-$45,563.7	$0.0	-$45,563.7
OMS 3969865 Path15_S_N	-$38,682.8	$0.0	-$38,682.8
PATH15_S-N	-$31,685.4	$0.0	-$31,685.4
31566_KESWICK _60.0_31582_STLLWATR_60.0_BR_1 _1	-$21,425.0	$0.0	-$21,425.0
22476_MIGUELTP_69.0_22456_MIGUEL _69.0_BR_1 _1	-$17,762.1	$0.0	-$17,762.1
33014_ALHAMTP1_115_33010_SOBRANTE_115_BR_1 _1	-$15,679.0	$0.0	-$15,679.0
22464_MIGUEL _230_22468_MIGUEL _500_XF_81	-$13,884.1	$0.0	-$13,884.1
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$10,965.2	$0.0	-$10,965.2
NdGrp_AGUCALG1_7_B1	$0.0	$40,512.1	$40,512.1
NdGrp_ELNIDBIO_6_N001	$0.0	$43,328.4	$43,328.4
30523_CC SUB _230_30525_C.COSTA _230_BR_1 _1	$0.0	$44,043.6	$44,043.6
32782_STATIN D_115_32788_STATIN L_115_BR_1 _1	$0.0	$45,928.8	$45,928.8
30750_MOSSLD _230_30760_COBURN _230_BR_1 _1	$0.0	$62,285.9	$62,285.9
33308_SFIA-MA _115_33303_EST GRND_115_BR_2 _1	$0.0	$63,127.2	$63,127.2
WARNRVIL_STNDIFRD_TOR	$0.0	$64,912.3	$64,912.3
30915_MORROBAY_230_30916_SOLARSS _230_BR_2 _1	-$130,625.5	$203,155.5	$72,530.0
22831_SYCAMORE_138_22124_CHCARITA_138_BR_1 _1	-$10,323.0	$89,538.2	$79,215.3
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	-$30,518.7	$117,868.0	$87,349.2
24901_VSTA _230_24804_DEVERS _230_BR_1 _1	$0.0	$122,877.3	$122,877.3
30900_GATES _230_30970_MIDWAY _230_BR_1 _1	$0.0	$148,475.3	$148,475.3
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	-$31,511.5	$197,937.4	$166,425.9
22464_MIGUEL _230_22504_MISSION _230_BR_1 _1	-$95,424.5	$265,126.5	$169,701.9
30040_TESLA _500_30042_METCALF _500_BR_1 _1	$0.0	$170,564.8	$170,564.8
MALIN500	-$139,701.6	$311,645.4	$171,943.8
PATH26_BG	$0.0	$210,046.9	$210,046.9
22468_MIGUEL _500_22472_MIGUELMP_1.0_XF_80	$0.0	$217,545.6	$217,545.6
40687_MALIN _500_30010_INDSPRNG_500_BR_2 _3	$0.0	$283,385.6	$283,385.6
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	$0.0	$351,058.0	$351,058.0

These two tables illustrate instances of constraint misalignment between the CRR auctions and the day-ahead market. To understand this mismatch one level deeper, Table 7 lists the subset of constraints that are not binding or not enforced in the CRR monthly auction or that have a significant CRR payment. The portion that were paid only to CRRs from the annual and monthly auctions is also provided. Then it compares the average transmission limit used in the day-ahead market and the limits actually used in both the annual and monthly auctions. These are the constraints that will mostly drive the divergence between the day-ahead and CRR markets. One of the cornerstones of the CRR market efficiency is for the CRR market to closely reflect the transmission capacity of the day-ahead market. When the transmission capacity released in the CRR market is less than that of the day-ahead market, there may be an exposure of revenue deficiency. This may also have a fair impact on the level of CRR net payments and how transmission capacity is valued in the CRR auction. This occurs because when CRRs are released in the auction process they are priced on the value of the capacity made available, or on the lack of it. A systemic issue identified during the evaluation of the CRR auction efficiency is that multiple transmission constraints are not modelled or enforced in the CRR auctions.

In cases where the constraint was enforced in the day-ahead market but not modelled or enforced in the CRR auctions, the amount of transmission capacity by means of CRRs that may be released on that constraints is effectively unbounded, which indicates that more transmission capacity may be released in the CRR auction than in the day-ahead market. This is a major problem to the efficiency of the CRR market. For the case of August 2016 and relative to other months analyzed, there were relatively few instances of constraints not enforced in the CRR auctions. In such cases the level of congestion rents and CRR payments were relatively modest, such that even with the misalignment, the financial impact was low. In further investigating why these constraints were not modelled/enforced in the CRR auctions, the common factors are related to how outages were considered and when transmission constraints were enforced in the CRR auction.

1. Constraint OMS 4169254_Cima-ELD-PISG_SCIT. This constraint was associated with an outage (4169254) submitted after the monthly CRR cutoff date and lasted less than 24 hours in duration.
2. Constraint OMS 4216681 TL50001OUT_NG. This constraint was associated with an outage (4216681) submitted after the monthly CRR cutoff date and lasted less than 24 hours in duration.
3. Constraint 22476_MIGUELTP_69.0_22456_MIGUEL _69.0_BR_1 _1. This element is not part of the normally enforced list of transmission elements. There was no known outage at the time of the running of the CRR process that activated this flowgate.
4. Constraint OMS 3969865 Path15_S_N. This outage (3969865) was picked up in the CRR model but was reflected as a derate to the PATH15_S-N constraint. The new NG was added just after the monthly CRR outage cutoff and the outage also lasted less than 24 hours in duration.
5. Constraint 22604_OTAY_69.0_22616_OTAYLKTP_69.0_BR_1 _1. This element is not part of the normally enforced list of transmission elements. There is no known outage at the time of the running of the CRR process that required the activation of this flowgate.

There are several other constraints that accrued congestion in the day-ahead market and, even though they were enforced in the market, they were not binding in the CRR auctions. These cases are labelled as auction economics since it is based on the auction clearing prices whether these constraint were binding or not.

Furthermore, there are some constraints that were enforced and binding in the CRR auctions but still caused a large difference between the day-ahead and CRR auctions. In cases like 30515_WARNERVL_230_30800_WILSON _230_BR_1 _1 constraint, the limit binding in the day-ahead market was lower in multiple hours than the limits used in the CRR auctions.

Table 7: Top constraints binding in the day-ahead market not binding in CRR market - August 2016

Constraint	Constraint Type	TOU	Payment to annual CRR	Payment to monthly CRR	DAM Limit	Annual CRR Limit	Monthly CRR Limit	Annual CRR Status	Monthly CRR Status	Reason
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	FLOWGATE	OFF	-$838,267.7	-$633,190.5	227.7	255.6	210.9	Binding	Binding	Higher Limit
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	FLOWGATE	ON	-$272,358.1	-$291,322.3	201.5	255.6	210.9	Binding	Binding	Higher Limit
32973_LAKEWOOD_115_99108_LAK-MOR1_115_BR_1 _1	FLOWGATE	ON	-$263,724.2	-$177,275.9	154.8	123.1	101.6	Not Binding	Not Binding	Auction Economics
OMS 4169254_Cima-ELD-PISG_SCIT	NOMOGRAM	ON	-$252,780.6	-$216,901.1	15266.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
TMS_DLO_NG	NOMOGRAM	ON	-$159,917.8	-$281,680.5	472.0	462.6	462.6	Not Binding	Not Binding	Auction Economics
24087_MAGUNDEN_230_24153_VESTAL _230_BR_1 _1	FLOWGATE	OFF	-$173,816.6	-$178,952.5	308.4	335.1	276.4	Not Binding	Not Binding	Auction Economics
MALIN500	INTER_TIE	ON	-$71,667.2	-$139,780.6	3165.0	1825.4	2800.0	Binding	Binding	Auction Economics
24087_MAGUNDEN_230_24153_VESTAL _230_BR_1 _1	FLOWGATE	ON	-$141,401.5	-$213,837.9	312.4	335.1	276.4	Not Binding	Binding	Auction Economics
99108_LAK-MOR1_115_33020_MORAGA _115_BR_1 _4	FLOWGATE	ON	-$99,606.0	-$66,983.0	155.2	123.1	Unbounded	Not Binding	Not Enforced	Higher Limit
31208_CLOVRDLE_115_31210_MPE TAP _115_BR_1 _1	FLOWGATE	ON	-$403,959.9	-$57,142.1	147.6	119.5	98.6	Not Binding	Not Binding	Auction Economics
33014_ALHAMTP1_115_33010_SOBRANTE_115_BR_1 _1	FLOWGATE	ON	-$87,256.0	-$15,679.0	100.2	78.8	65.0	Not Binding	Not Binding	Auction Economics
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	FLOWGATE	ON	-$14,594.2	-$79,025.1	1254.3	1136.1	937.3	Not Binding	Not Binding	Auction Economics
6110_SOL10_NG	NOMOGRAM	ON	-$16,927.8	-$51,299.2	276.0	285.2	395.9	Binding	Not Binding	Higher Limit
30915_MORROBAY_230_30916_SOLARSS _230_BR_1 _1	FLOWGATE	ON	-$22,154.8	-$55,556.7	386.9	312.4	257.7	Binding	Not Binding	Auction Economics
OMS 4216681 TL50001OUT_NG	NOMOGRAM	OFF	-$24,032.8	-$45,563.7	789.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
31208_CLOVRDLE_115_31210_MPE TAP _115_BR_1 _1	FLOWGATE	OFF	-$155,516.3	-$18,265.3	147.7	119.5	98.6	Not Binding	Not Binding	Auction Economics
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	FLOWGATE	ON	-$12,965.3	-$15,259.4	2527.7	2469.7	2037.5	Binding	Not Binding	Higher Limit
22464_MIGUEL _230_22468_MIGUEL _500_XF_81	FLOWGATE	ON	-$1,407.4	-$13,884.1	1104.3	1064.7	624.3	Not Binding	Not Binding	Auction Economics
22476_MIGUELTP_69.0_22456_MIGUEL _69.0_BR_1 _1	FLOWGATE	ON	$6,518.7	-$17,762.1	129.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
34112_EXCHEQUR_115_34116_LE GRAND_115_BR_1 _1	FLOWGATE	OFF	-$6,105.5	-$63,144.9	78.5	64.9	53.6	Not Binding	Not Binding	Auction Economics
OMS 3969865 Path15_S_N	NOMOGRAM	OFF	-$11,019.4	-$38,682.8	2250.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
30055_GATES1 _500_30900_GATES _230_XF_11_P	FLOWGATE	OFF	$126.1	-$2,268.7	1098.1	1066.6	879.9	Not Binding	Not Binding	Auction Economics
34112_EXCHEQUR_115_34116_LE GRAND_115_BR_1 _1	FLOWGATE	ON	-$10,551.1	-$44,537.3	78.9	64.9	53.6	Not Binding	Not Binding	Auction Economics
22604_OTAY _69.0_22616_OTAYLKTP_69.0_BR_1 _1	FLOWGATE	ON	-$33,760.0	$8,588.8	56.8	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
30915_MORROBAY_230_30916_SOLARSS _230_BR_1 _1	FLOWGATE	OFF	-$17,815.6	-$7,303.3	386.9	312.4	257.7	Binding	Not Binding	Auction Economics

September 2016

Table 8 summarizes the main settlements metrics for CRR performance in the month of September 2016. The sign convention is based from the CAISO's perspective; a positive value indicates the CAISO collects or has a surplus of money; a negative value indicates the CAISO pays or has a shortfall. Day-ahead congestion rents will be positive, CRR payments will be negative and auction revenues will be positive.

Table 8: Summary of CRR performance for September 2016

Metric	Amount
DA Congestion Rents	$14,025,706
Perfect Hedge	-$708,604
CRR Clawback	$29,246
CRR Payments [Auction + Allocation]	-$14,914,141
CRR Payments to Auction CRRs	-$5,254,466
CRR Payments to Monthly Auction CRRs	-$3,061,390
CRR Payments to Annual Auction CRRs	-$2,193,076
CRR Payments to Allocation CRRs	-$9,659,675
CRR Auction Revenue Monthly	$1,931,820
CRR Auction Revenue Annual	$4,568,346
Revenue Adequacy	-$1,567,793
Revenue Adequacy with Auction Revenues	$4,932,372
Net payment to auction CRRs	$1,245,699

In September, there was a revenue deficiency of over $1.5 million, which is the difference between all of the proceeds from day-ahead congestion rents, CRR clawback and the payments made to CRR holders. About 35 percent of the CRR payments were to CRRs originating from the annual and monthly auctions, which is relatively low percentage. The auction revenues represent the proceeds from selling CRRs through the auction. The revenues arising from the annual auction for each season are estimated pro-rata to each month of the calendar quarter based on the number of hours in each time of use. The net payment to auction CRRs stands for the difference between the money paid to CRR holders and the money charged to CRR holders to acquire that portfolio of CRRs in the auction. This does not take into account any expenses the CRR holders incur associated with their participation in the CRR market and use of money. This is only a net accounting balance from the point of view of the cash inflow and outflow in the CAISO system.

For the month of September, the net CRR payment for auction CRRs was actually positive, meaning the CAISO collected more auction revenues when releasing CRRs in the auction than it paid to holders of auction CRRs; overall this net CRR payment represent in excess of $1.24 million. This net payment was the product of having an over-collection of $2.37 million in the annual auction, and under-collection of $1.13 million in the monthly auction.

In order to further understand the origin of this outcome, there is a need to estimate over time and by constraint the CRR settlements. Figure 106 shows the daily congestion rents accrued on each transmission constraint that was binding in the day-ahead market in the month of

September. Correspondingly, Figure 107 shows the daily CRR revenue adequacy also broken out by transmission constraint. Approximately, $950,000 of the revenue deficiency was accrued in the last 5 days of September. This accounts for about 60 percent of the total revenue deficiency for September.

Figure 106: Daily congestion rents – September 2016

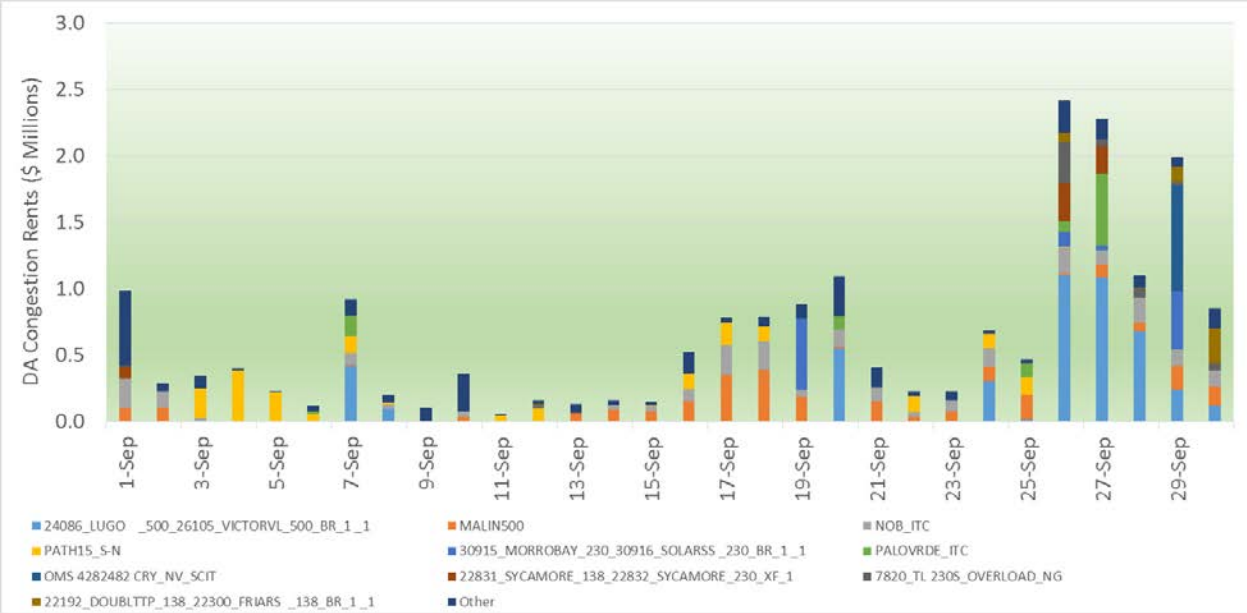


Figure 107: Daily CRR revenue adequacy - September 2016

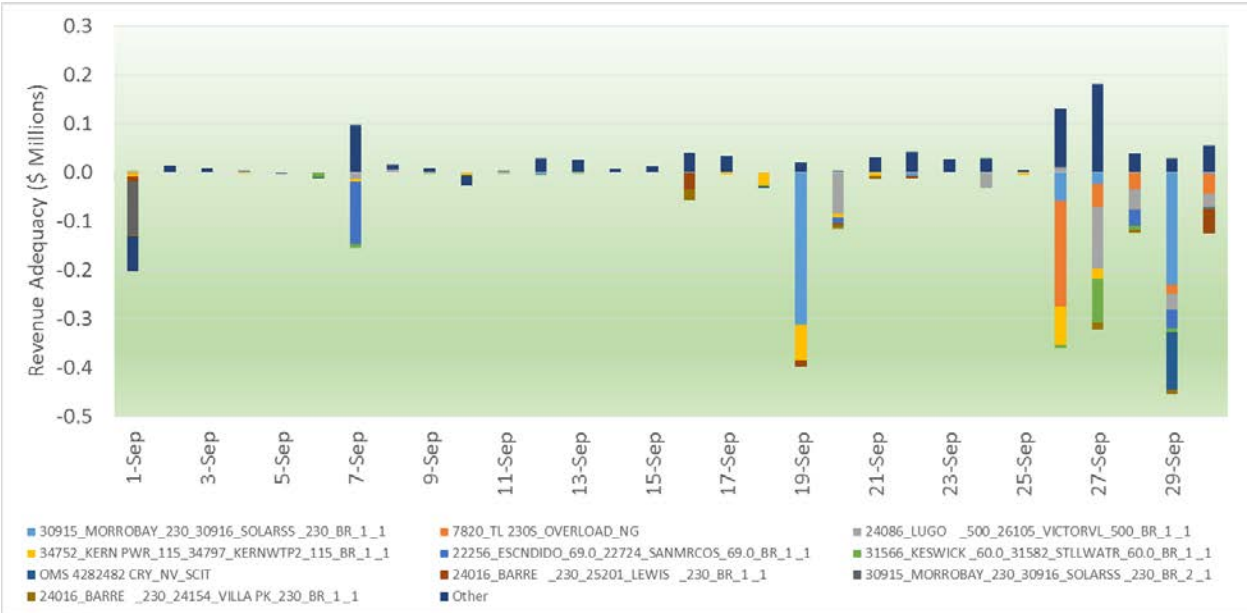


Figure 108 shows the net CRR payment per day. This net payment is the difference between the CRR payments to CRR holders and the auction revenues collected by the CAISO through the CRR auction process; such revenues become a lump revenue for the auction. For this

metric, the annual auction revenues are allocated on a pro-rata estimation to each day of the month based on the number of hours in each time of use. The CRR payments are estimated as the total sum of CRR payments over the hours of the day only for CRRs that were released through both the annual and monthly CRR auction; that is, no CRR payments to allocated CRRs are included. The purpose of this estimate for net CRR payments is to calculate the net balance for CRRs that were released only in the auctions. For September, there was a persistent positive net CRR payment, indicating that overall the money paid to CRR holders was less than the money the CAISO collected when releasing such CRRs in the annual and monthly auctions.

Figure 108: Daily net CRR payment to auction CRRs – September 2016

Figure 109 compares the level of CRR revenue deficiency and the level of net CRR payments paid to holders for CRRs released in the auction processes. This plot shows that both metrics move together to some extent; in this month in particular, the correlation was weaker than observed in other months. A negative value for CRR revenue adequacy represents a shortfall for the CAISO, while a negative value for net CRR payment represents a payment to holders of auction CRRs from the CAISO. This indicates the CAISO paid more to auction CRRs than it charged to release CRRs in the auction process.

Figure 109: Comparison of daily net CRR payment with CRR revenue adequacy – September 2016

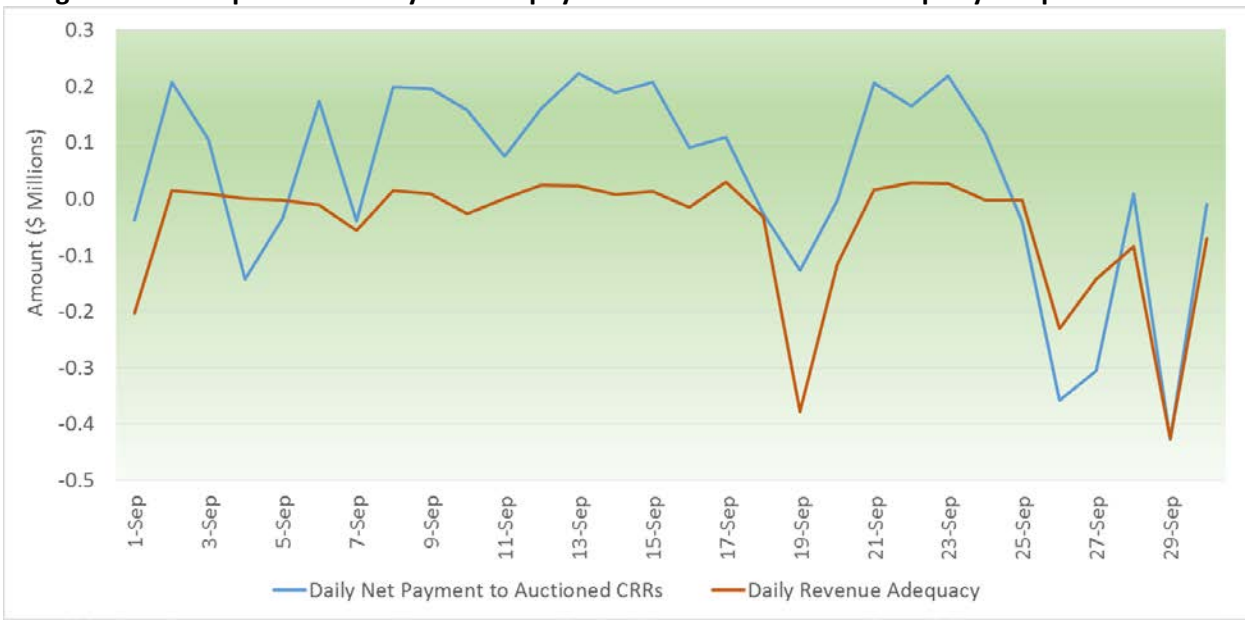
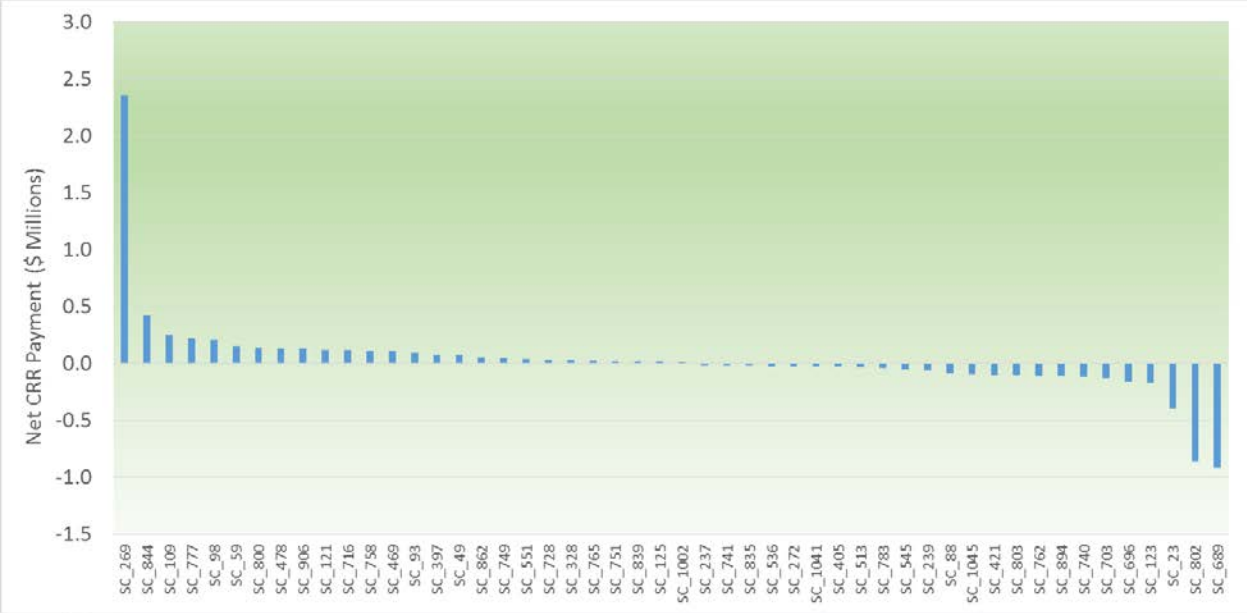


Figure 110 shows the net CRR payments to CRR participants, regardless of the type of participant. This only reflects the payments for CRRs released in both the annual and monthly CRR auctions applicable for the month of September 2016.

Figure 110: Net CRR payment to auction CRR – September 2016



Since this is from the CAISO's perspective, a negative value means the CAISO disbursed a net CRR payment to the CRR holder (or a net money inflow to the CRR holder). The names of the CRR holders are masked, but the identifier shown in the plot is unique across all the months provided in this analysis. A positive value represents a net inflow for the CAISO since it paid less

to CRR holders in the day-ahead market than what it charged to release CRRs in the auction. For September, the positive CRR payment fairly offset the negative CRR payments.

To better understand the dynamics leading to such an outcome, the CAISO shifted the analysis to the fundamentals of the CRR auction construct by analyzing the CRR auction results at the constraint level. CRRs are released and priced based on the CRR clearing prices; such prices are derived as the relative difference between locational prices between the source and the sink locations. These locational prices originate from the cleared prices when any transmission constraint becomes binding with nonzero pries in the CRR auction, commonly referred as *shadow prices*. The CAISO turned out to analyze what constraints have been binding in the CRR auction process and compared that with the set of constraints that were binding in the day-ahead market. To some extent, one expects that there is a certain level of alignment between the markets.

Figure 111 and Figure 112 show a comparison of net CRR payments. The CRR payments reflect the CRR settlements for CRRs with day-ahead congestion rents, while the CRR auction revenues is the money the CAISO collected from releasing CRRs through the auctions. That is, it reflects the net money participants were charged to acquire CRRs and the money they were paid; in a loose sense, it could be interpreted as profits for holding.

There are four possible permutations to analyze. The first case represents when a CRR payment to CRR holders was made in the day-ahead market settlement, but the CAISO did not collect any revenues from releasing these CRRs from the auctions because the constraint was not binding in the CRR auction. This is shown for both the pro-rata portion of the annual auction for September and for the monthly CRR auction. A negative value indicates that the CAISO had a net CRR payment to CRR holders. The second case is the opposite in which there was no CRR payments when settling CRRs in the day-ahead market but the CAISO collected revenue when releasing these CRRs in the auction process. The third and fourth cases are for CRRs that had a CRR payment in the day-ahead market and the CAISO also charged them in the CRR auctions to release these CRRs. The third case is when the net CRR payment is negative, while the fourth case is when the net CRR payment is positive. This metric reveals any potential misalignment of constrains enforced and binding between the day-ahead market and CRR auctions.

Figure 111: CRR payment versus CRR auction revenues for annual CRR – September 2016

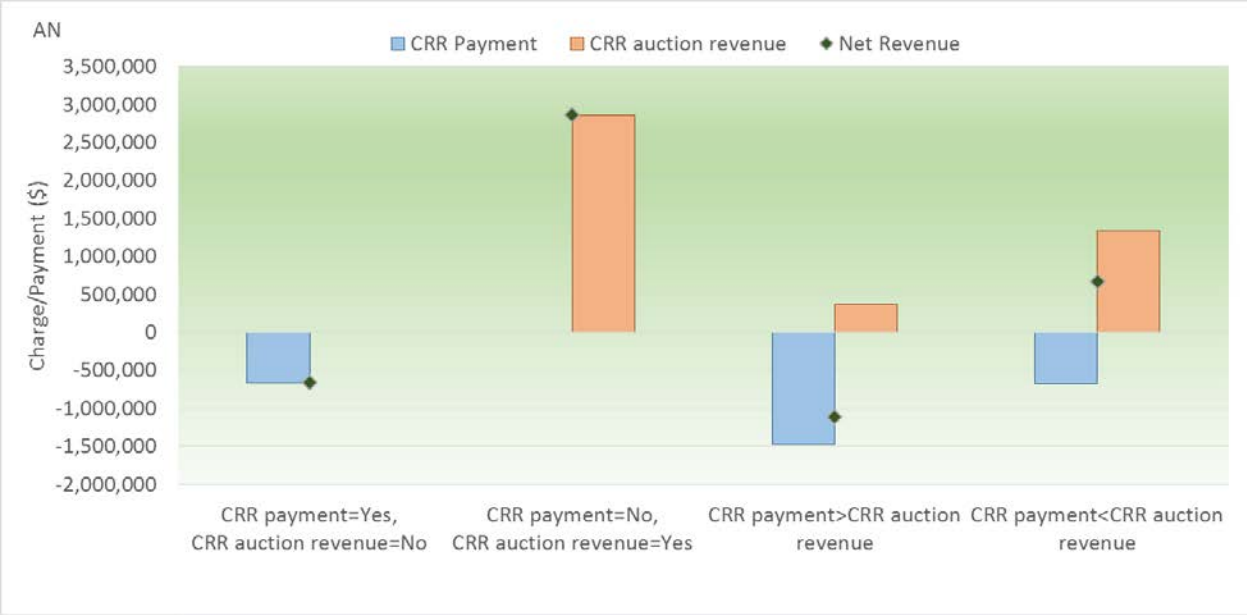


Figure 112: CRR payment versus CRR auction revenues for monthly CRR - September 2016

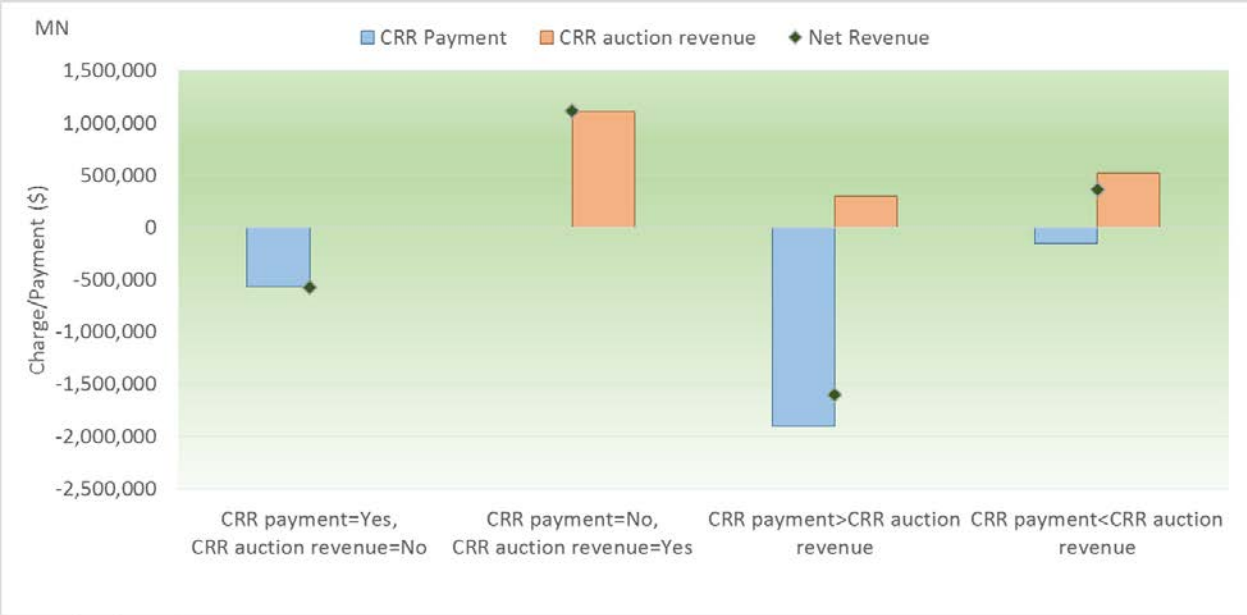


Table 9 provides one level deeper of understanding of such misalignments between markets. This tables show the top and bottom constraints when sorted by net CRR payments. In the first column it shows the estimated CRR payment to CRR holders accrued by each constraint; the second column shows the auction revenues collected by the CAISO on that same constraint; the last column shows the net CRR payment, which is the balance between this money outflow (CRR payment) and money inflow (CRR auction revenues). Table 5Table 10 shows the same information for CRRs released in the monthly auction for September 2016. The top constraints reflect cases where large CRR payments to auction CRRs accrued when the CRR market collected

little or no auction revenues when releasing these CRRs. The bottom constraints reflect cases where the net CRR payment is actually positive meaning cases where the CAISO collected more auction revenues than it had to pay to auction CRRs, mostly because the constraints were not binding in the CRR auction.

Table 9: Net CRR payment by constraint – September 2016, annual auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	-$976,360.3	$168,897.4	-$807,462.9
OMS 4282482 CRY_NV_SCIT	-$167,417.0	$0.0	-$167,417.0
22256_ESCNDIDO_69.0_22724_SANMRCOS_69.0_BR_1 _1	-$152,266.8	$0.0	-$152,266.8
PATH15_S-N	-$127,428.9	$0.0	-$127,428.9
30915_MORROBAY_230_30916_SOLARSS _230_BR_2 _1	-$117,114.3	$0.0	-$117,114.3
34752_KERN PWR_115_34797_KERNWTP2_115_BR_1 _1	-$99,924.7	$3,646.0	-$96,278.7
PALOVRDE_ITC	-$260,869.9	$168,754.5	-$92,115.4
7820_TL 230S_OVERLOAD_NG	-$62,705.0	$0.0	-$62,705.0
31566_KESWICK _60.0_31582_STLLWATR_60.0_BR_1 _1	-$79,626.5	$23,140.2	-$56,486.3
22831_SYCAMORE_138_22832_SYCAMORE_230_XF_1	-$42,916.9	$0.0	-$42,916.9
24086_LUGO _500_24092_MIRALOMA_500_BR_3 _1	-$22,792.9	$0.0	-$22,792.9
7430_SOL-6_NG_SUM	-$22,499.7	$0.0	-$22,499.7
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	-$20,358.3	$61.3	-$20,297.0
31556_TRINITY _60.0_31555_MSS TAP2_60.0_BR_1 _1	-$17,774.3	$0.0	-$17,774.3
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	-$17,313.9	$24.3	-$17,289.6
32218_DRUM _115_32222_DTCH2TAP_115_BR_1 _1	-$12,123.3	$1,578.7	-$10,544.6
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	-$11,691.7	$2,316.8	-$9,374.9
22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1	-$7,741.9	$0.0	-$7,741.9
34112_EXCHEQUR_115_34116_LE GRAND_115_BR_1 _1	-$6,470.2	$0.0	-$6,470.2
22773_BAY BLVD_69.0_22604_OTAY _69.0_BR_1 _1	-$6,314.3	$0.0	-$6,314.3
NdGrp_GRIZZLY_7_N101	$0.0	$39,631.6	$39,631.6
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	$0.0	$44,626.8	$44,626.8
30505_WEBER _230_30624_TESLA E _230_BR_1 _1	$0.0	$51,101.3	$51,101.3
34104_ATWATER _115_34114_JRWD GEN_115_BR_1 _1	$0.0	$55,027.1	$55,027.1
31218_ER_FTNJT_115_31220_EGLE RCK_115_BR_1 _1	$0.0	$67,254.0	$67,254.0
35922_MOSSLD _115_30751_MOSSLDB _230_XF_1	$0.0	$70,510.1	$70,510.1
33542_LEPRINO _115_33546_TRACY JC_115_BR_1 _1	$0.0	$74,372.3	$74,372.3
WARNRVIL_STNDIFRD_TOR	$0.0	$80,216.4	$80,216.4
MALIN500	-$156,503.9	$239,072.5	$82,568.6
6110_SOL10_NG	-$2,462.5	$86,007.9	$83,545.5
NdGrp_POD_INTKEP_2_UNITS-APND	$0.0	$86,504.7	$86,504.7
OAKDL_MOCASN_TOR	$0.0	$86,528.4	$86,528.4
34116_LE GRAND_115_34134_WILSONAB_115_BR_1 _1	-$4,142.2	$103,018.2	$98,876.0
24087_MAGUNDEN_230_24153_VESTAL _230_BR_2 _1	$0.0	$110,035.6	$110,035.6
NdGrp_COGNTNL_7_B1	$0.0	$122,747.6	$122,747.6
33310_SANMATEO_115_30700_SANMATEO_230_XF_7 _S	$0.0	$166,925.5	$166,925.5
32782_STATIN D_115_32788_STATIN L_115_BR_1 _1	$0.0	$174,387.3	$174,387.3
PATH15_BG	$0.0	$188,741.6	$188,741.6
6110_TM_BNK_FLO_TMS_DLO_NG	$0.0	$235,318.3	$235,318.3
30915_MORROBAY_230_30916_SOLARSS _230_BR_1 _1	-$482,428.4	$735,391.2	$252,962.8

Table 10: Net CRR payment by constraint – September 2016, monthly auction.

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
PATH15_S-N	-$848,294.1	$15,170.4	-$833,123.6
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	-$443,651.9	$36,238.3	-$407,413.6
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$190,014.7	$0.0	-$190,014.7
7820_TL 230S_OVERLOAD_NG	-$142,287.3	$20,321.8	-$121,965.5
OMS 4282482 CRY_NV_SCIT	-$102,734.2	$0.0	-$102,734.2
30915_MORROBAY_230_30916_SOLARSS _230_BR_1 _1	-$81,594.2	$0.0	-$81,594.2
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	-$65,400.3	$0.0	-$65,400.3
34752_KERN PWR_115_34797_KERNWTP2_115_BR_1 _1	-$62,338.8	$13,234.8	-$49,104.0
OMS 4235148 TL50001_NG	-$47,979.2	$0.0	-$47,979.2
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	-$129,956.6	$82,489.0	-$47,467.6
31581_OREGNTRL_60.0_31578_LOMS JCT_60.0_BR_1 _1	-$46,485.3	$0.0	-$46,485.3
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	-$38,745.7	$48.6	-$38,697.1
MALIN500	-$108,991.4	$84,377.7	-$24,613.7
34112_EXCHEQUR_115_34116_LE GRAND_115_BR_1 _1	-$62,024.6	$40,904.6	-$21,120.0
OMS 3994241 TVYVLY CB42	-$19,335.8	$0.0	-$19,335.8
22831_SYCAMORE_138_22832_SYCAMORE_230_XF_1	-$17,215.4	$0.0	-$17,215.4
NOB_ITC	-$16,315.6	$0.3	-$16,315.3
32218_DRUM _115_32222_DTCH2TAP_115_BR_1 _1	-$15,511.1	$443.1	-$15,068.0
IPPUTAH_ITC	-$17,281.4	$6,213.7	-$11,067.8
24086_LUGO _500_24092_MIRALOMA_500_BR_3 _1	-$10,520.4	$0.0	-$10,520.4
24723_CONTROL _115_24791_TAP710 _115_BR_2 _1	$18,275.9	$0.0	$18,275.9
30735_METCALF _230_30042_METCALF _500_XF_12	$0.0	$18,912.2	$18,912.2
22456_MIGUEL _69.0_22464_MIGUEL _230_XF_2	$0.0	$18,915.6	$18,915.6
OMS 3938352 LBN_S-N	$19,869.2	$0.0	$19,869.2
33020_MORAGA _115_32790_STATIN X_115_BR_1 _1	-$336.4	$20,614.1	$20,277.6
22828_SYCAMORE_69.0_22756_SCRIPPS _69.0_BR_1 _1	$29.1	$21,925.7	$21,954.8
WARNRVIL_STNDIFRD_TOR	$0.0	$21,968.4	$21,968.4
22831_SYCAMORE_138_22124_CHCARITA_138_BR_1 _1	-$56,983.9	$79,066.1	$22,082.2
NdGrp_AGUCALG1_7_B1	$0.0	$22,121.7	$22,121.7
IID-SCE_BG	$0.0	$24,339.2	$24,339.2
SILVERPK_BG	$29,707.5	$0.0	$29,707.5
PATH26_BG	$0.0	$30,305.6	$30,305.6
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	$0.0	$30,546.5	$30,546.5
30105_COTTNWD _230_30245_ROUND MT_230_BR_2 _1	$0.0	$41,885.3	$41,885.3
PALOVRDE_ITC	-$100,146.4	$160,433.0	$60,286.6
30900_GATES _230_30970_MIDWAY _230_BR_1 _1	$0.0	$72,083.4	$72,083.4
30915_MORROBAY_230_30916_SOLARSS _230_BR_2 _1	-$19,004.0	$104,152.4	$85,148.4
24087_MAGUNDEN_230_24153_VESTAL _230_BR_1 _1	-$2,764.9	$109,525.3	$106,760.4
32950_PITSBURG_115_30527_PITSBRG _230_XF_13	$0.0	$117,935.6	$117,935.6
22468_MIGUEL _500_22472_MIGUELMP_1.0_XF_80	$0.0	$301,855.4	$301,855.4

These two tables illustrate instances of constraint misalignment between the CRR auctions and the day-ahead market. To understand this mismatch one level deeper, Table 11 lists the subset of constraints that are not binding or not enforced in the CRR monthly auction or that have a significant CRR payment. The portion that were paid only to CRRs from the annual and monthly auctions is also provided. Then it compares the average transmission limit used in the day-ahead market and the limits actually used in both the annual and monthly auctions. These are the constraints that will mostly drive the divergence between the day-ahead and CRR markets. One of the cornerstones of the CRR market efficiency is for the CRR market to closely reflect the transmission capacity of the day-ahead market. When the transmission capacity released in the CRR market is less than that of the day-ahead market, there may be an exposure of revenue deficiency. This may also have a fair impact on the level of CRR net payments and how transmission capacity is valued in the CRR auction. This occurs because when CRRs are released in the auction process they are priced on the value of the capacity made available, or on the lack of it. A systemic issue identified during the evaluation of the CRR auction efficiency is that multiple transmission constraints are not modelled or enforced in the CRR auctions.

In cases where the constraint was enforced in the day-ahead market but not modelled or enforced in the CRR auctions, the amount of transmission capacity by means of CRRs that may be released on that constraints is effectively unbounded, which indicates that more transmission capacity may be released in the CRR auction than in the day-ahead market. This is a major problem to the efficiency of the CRR market. For the case of September 2016 and relative to other months analyzed, there were relatively few instances of constraints not enforced in the CRR auctions. In such cases the level of congestion rents and CRR payments were relatively modest, such that even with the misalignment, the financial impact was low. In further investigating why these constraints were not modelled/enforced in the CRR auctions, the common factors are related to how outages were considered and when transmission constraints were enforced in the CRR auction.

1. OMS 4282482 CRY_NV_SCIT. This constraint was associated with an outage (4282482) that lasted less than 24 hours and, therefore, was not modelled in the CRR auctions.
2. OMS 4235148 TL50001_NG. This constraint was associated with an outage (4235148) that lasted less than 24 hours and, therefore, was not modelled in the CRR auctions.
3. 31581_OREGNTRL_60.0_31578_LOMS JCT_60.0_BR_1 _1. This element is not part of the normally enforced list of transmission elements. There was no known outage at the time of the running of the CRR process that activated this flowgate.
4. 22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1. This element is not part of the normally enforced list of transmission elements. There was no known outage at the time of the running of the CRR process that activated this flowgate.
5. Constraint 7430_SOL-6_NG_SUM. This constraint was enforced in the CRR model for September 2016 but was with a slightly different format to the name: 7430_SOL6_NG_SUM.

There are several other constraints that accrued congestion in the day-ahead market and, even though they were enforced in the market, they were not binding in the CRR auctions. These

cases are labelled as auction economics since it is based on the auction clearing process whether these constraints were binding or not based on the economics driven by the CRR bids.

Furthermore, there are some constraints that were enforced and binding in the CRR auctions but still there was a large difference between the day-ahead and CRR auctions. In several cases, the limit binding in the day-ahead market was lower in multiple hours than the limits used in the CRR auctions. Even though the average limit shown for the day-ahead market may show a value higher than the CRR limit, there may be hours when the limit was actually lower than the average and represented more restrictive conditions in the day-ahead market.

Table 11: Top constraints binding in the day-ahead market not binding in CRR market - September 2016

Constraint	Constraint Type	TOU	Payment to annual CRR	Payment to monthly CRR	DAM Limit	Annual CRR Limit	Monthly CRR Limit	Annual CRR Status	Monthly CRR Status	Reason
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	FLOWGATE	ON	-$481,417.8	-$220,728.7	2531.7	2469.7	2037.5	Binding	Not Binding	Auction Economics
30915_MORROBAY_230_30916_SOLARSS _230_BR_1 _1	FLOWGATE	ON	-$482,428.4	-$81,594.2	343.1	312.4	257.7	Binding	Not Binding	Higher Limit
OMS 4282482 CRY_NV_SCIT	NOMOGRAM	ON	-$167,417.0	-$102,734.2	15183.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	FLOWGATE	ON	$15,358.3	-$190,014.7	162.1	143.4	118.3	Not Binding	Not Binding	Higher Limit
22831_SYCAMORE_138_22832_SYCAMORE_230_XF_1	FLOWGATE	ON	-$42,916.9	-$17,215.4	332.4	372.6	307.4	Not Binding	Not Binding	Auction Economics
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	FLOWGATE	ON	-$11,691.7	-$65,400.3	1256.9	1136.1	937.3	Not Binding	Not Binding	Auction Economics
PATH15_S-N	NOMOGRAM	ON	-$66,957.5	-$355,733.5	2994.1	Unbounded	2940.0	Not Enforced	Not Binding	Auction Economics
OMS 4235148 TL50001_NG	NOMOGRAM	ON	$5,522.9	-$47,979.2	789.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
24086_LUGO _500_24092_MIRALOMA_500_BR_3 _1	FLOWGATE	ON	-$22,792.9	-$10,520.4	3256.8	3251.7	2682.7	Not Binding	Not Binding	Auction Economics
31990_DAVIS _115_31962_WDLND_BM_115_BR_1 _1	FLOWGATE	ON	$25,919.1	$6,226.6	114.9	113.6	Unbounded	Not Binding	Not Enforced	Higher Limit
31581_OREGNTRL_60.0_31578_LOMS JCT_60.0_BR_1 _1	FLOWGATE	ON	$35,342.4	-$43,490.1	31.9	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
6110_SOL10_NG	NOMOGRAM	ON	-$2,462.5	-$5,290.8	276.0	285.2	285.2	Binding	Not Binding	Higher Limit
22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1	FLOWGATE	ON	-$7,741.9	$1,735.5	70.2	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
30105_COTTNWD _230_30245_ROUND MT_230_BR_3 _1	FLOWGATE	ON	-$5,184.8	-$3,479.3	291.3	240.9	198.7	Not Binding	Not Binding	Auction Economics
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	FLOWGATE	OFF	-$1,078.2	-$5,839.7	1401.3	1136.1	937.3	Not Binding	Not Binding	Auction Economics
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	FLOWGATE	OFF	-$6,762.3	-$1,097.2	2543.7	2469.7	2037.5	Binding	Not Binding	Auction Economics
MEAD_ITC	INTER_TIE	ON	$654.3	-$2,372.3	1619.0	947.7	1586.6	Binding	Not Binding	Auction Economics
7430_SOL-6_NG_SUM	NOMOGRAM	ON	-$22,499.7	$11,773.3	286.5	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
TMS_DLO_NG	NOMOGRAM	ON	-$2,344.6	-$5,352.9	472.0	462.6	462.6	Not Binding	Not Binding	Auction Economics
33310_SANMATEO_115_33312_BELMONT _115_BR_1 _1	FLOWGATE	ON	-$5,709.4	$2,190.0	99.6	93.7	77.3	Not Binding	Not Binding	Auction Economics
30261_BELDENTP_230_30300_TABLMTN _230_BR_1 _1	FLOWGATE	ON	-$746.0	-$2,052.4	295.6	281.0	231.8	Not Binding	Not Binding	Auction Economics

October 2016

Table 12 summarizes the main settlements metrics for CRR performance in the month of October 2016. The sign convention is based from the CAISO's perspective; a positive value indicates the CAISO collects or has a surplus of money; a negative value indicates the CAISO pays or has a shortfall. Day-ahead congestion rents will be positive, CRR payments will be negative and auction revenues will be positive.

Table 12: Summary of CRR performance for October 2016

Metric	Amount
DA Congestion Rents	$31,233,392
Perfect Hedge	-$3,784,388
CRR Clawback	$58,463
CRR Payments [Auction + Allocation]	-$39,750,837
CRR Payments to Auction CRRs	-$12,716,717
CRR Payments to Monthly Auction CRRs	-$8,515,006
CRR Payments to Annual Auction CRRs	-$4,201,711
CRR Payments to Allocation CRRs	-$27,034,120
CRR Auction Revenue Monthly	$2,625,251
CRR Auction Revenue Annual	$2,789,547
Revenue Adequacy	-$12,243,371
Revenue Adequacy with Auction Revenues	-$6,828,572
Net payment to auction CRRs	-$7,301,919

In October, the overall CRR performance was poor since there was a revenue deficiency of $12.2 million, which is the difference between all of the proceeds from day-ahead congestion rents, CRR clawback and the payments made to CRR holders. About 32 percent of the CRR payments were to CRRs originating from the annual and monthly auctions. The auction revenues represent the proceeds from selling CRRs through the auction. The revenues arising from the annual auction for each season are estimated pro-rata to each month of the calendar quarter based on the number of hours in each time of use. The net payment to auction CRRs stands for the difference between the money paid to CRR holders less the money charge to CRR holders to acquire that portfolio of CRRs in the auction. This does not take into account any expenses the CRR holders incur associated with their participation in the CRR market and use of money. This is only a net accounting balance from the point of view of the cash inflow and outflow in the CAISO system. Net the CRR payments was -$7.3 million (a net payment to auction CRR holders), from which $5.89 million was originated from monthly auction CRRs; this amounts to 80 percent of the total CRR payments.

In order to further understand the origin of this poor performance, there is a need to estimate over time and by constraint the CRR settlements. Figure 113 shows the daily congestion rents accrued on each transmission constraint that was binding in the day-ahead market in the month of October. For entire month the constraint *MALIN500* was binding and contributing to the daily congestion rent amount. Correspondingly, Figure 114 shows the daily CRR revenue adequacy also broken out by transmission constraint. On October 27th, about $4.9 million of

revenue deficiency was accrued which accounts for about 40 percent of the total deficiency. The constraint *OMS 4250740_Devers 230 NBus* accounts for about 94 percent of the total revenue deficiency for this day and about 38 percent of the total revenue deficiency for the entire month.

Figure 113: Daily congestion rents – October 2016

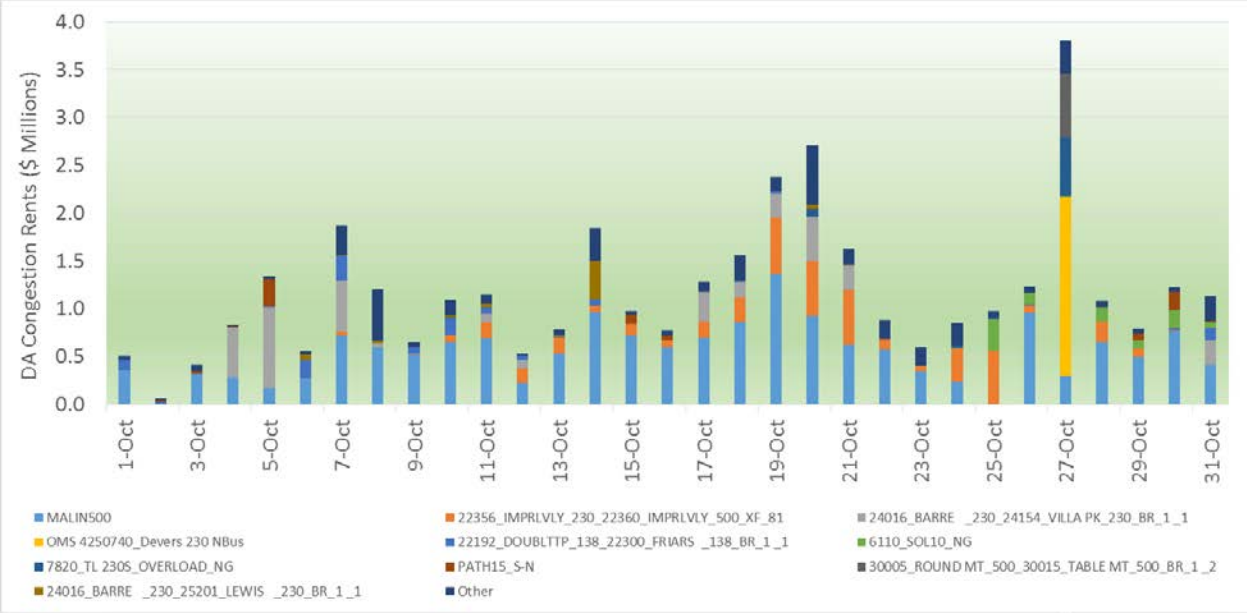


Figure 114: Daily CRR revenue adequacy - October 2016

Figure 115 shows the net CRR payment per day. This net revenue is the difference between the CRR payments to CRR holders and the auction revenues collected by the CAISO through the CRR auction process; such revenues become a lump revenue for the auction. For this metric, the annual auction revenues are allocated on a pro-rata estimation to each day of the

month based on the number of hours in each time of use. The CRR payments are estimated as the total sum of CRR payments over the hours of the day only for CRRs that were released through both the annual and monthly CRR auction; that is, no CRR payments to allocated CRRs are included. The purpose of this estimate for net CRR payments is to calculate the net balance for CRRs that were released only in the auctions. For October, there was a persistent negative net CRR payment, indicating that overall the money paid to CRR holders was higher than the money the CAISO collected when releasing such CRRs in the annual and monthly auctions.

Figure 115: Daily net CRR payment to auction CRRs – October 2016

As shown in Figure 116, there is a strong correlation between the level of CRR revenue deficiency and the level of net CRR payments paid to holders of CRRs released in the auction processes. This is not surprising since both metrics reflect to some extent the effect of CRRs released (and priced) in the CRR auction and the capacity released (and priced) in the day-ahead market. A negative value for CRR revenue adequacy represents a shortfall for the CAISO, while a negative value for net CRR payment represents a payment to holders of auction CRRs from the CAISO. This indicates that the CAISO paid more to auction CRRs than it charged to release CRRs in the auction process.

Figure 116: Comparison of daily net CRR payment with CRR revenue adequacy – October 2016

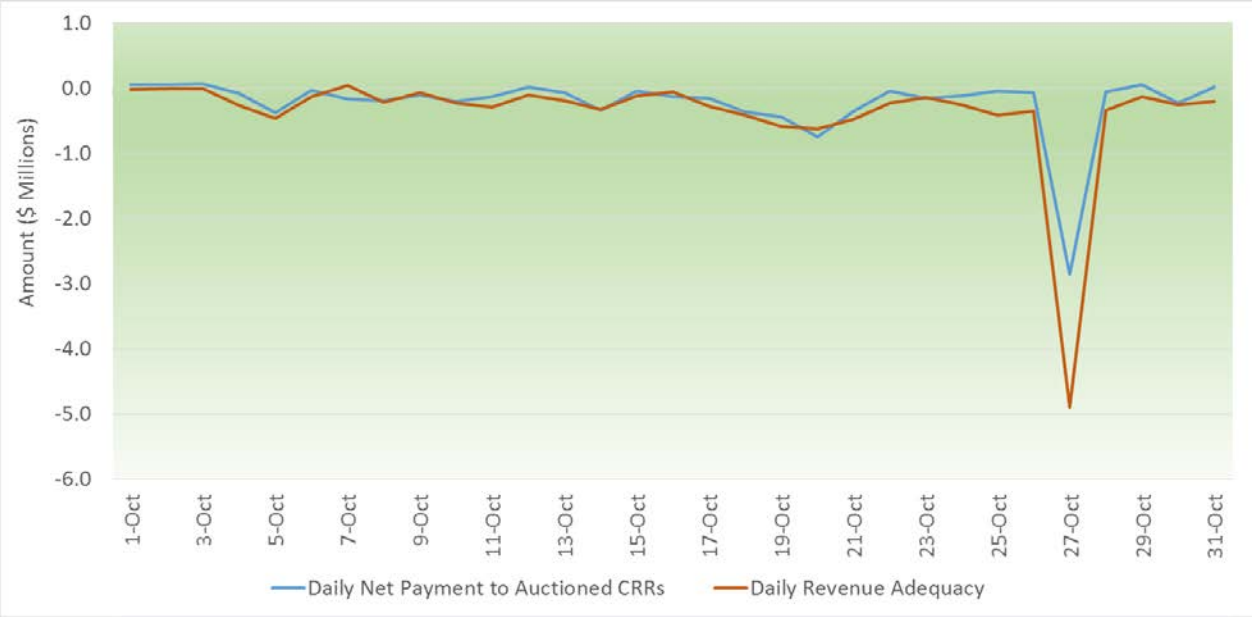


Figure 117 shows the net CRR payments to CRR participants, regardless of the type of participant. This only reflects the payments for CRRs released in both the annual and monthly CRR auctions applicable for the month of October 2016. Since this is from the CAISO's perspective, a negative value means the CAISO disbursed a net CRR payment to the CRR holder (or a net money inflow to the CRR holder).

Figure 117: Net CRR payment to auction CRR – October 2016

The names of the CRR holders are masked, but the identifier shown in the plot is unique across all the months provided in this analysis. A positive value represents a net inflow for the CAISO since it settled less to CRR holders in the day-ahead market than what it charged to release CRRs in the auction. For October, the majority of holders of auction CRRs saw a net gain from having these positions.

To better understand the dynamics leading to such an outcome, the CAISO shifted the analysis to the fundamentals of the CRR auction construct by analyzing the CRR auction results at the constraint level. CRRs are released and priced based on the CRR clearing prices; such prices are derived as the relative difference between locational prices between the source and the sink locations. These locational prices originate from the cleared prices when any transmission constraint becomes binding with nonzero pries in the CRR auction, commonly referred as *shadow prices*. The CAISO turned out to analyze what constraints have been binding in the CRR auction process and compared that with the set of constraints that were binding in the day-ahead market. To some extent, one expects that there is certain level of alignment between the markets. Figure 118 and Figure 119 show a comparison of net CRR payments. The CRR payments reflect the CRR settlements for CRRs with the day-ahead congestion rents, while the CRR auction revenues are the money the CAISO collected from releasing CRRs through the auctions. That is, it reflects the net money participants were charged to acquire CRRs and the money they were paid; in a loose sense, it could be interpreted as profits for holding.

There are four possible permutations to analyze. The first case represents when a CRR payment to CRR holders was made in the day-ahead market settlement, but the CAISO did not collect any revenues from releasing these CRRs from the auctions because the constraint was not binding in the CRR auction. This is shown for both the pro-rata portion of the annual auction for October and for the monthly CRR auction. A negative value indicates that the CAISO had a net CRR payment to CRR holders. The second case is the opposite in which there was no CRR payments when settling CRRs in the day-ahead market but the CAISO collected revenue when releasing these CRRs in the auction process. The third and fourth cases are for CRRs that had a CRR payment in the day-ahead market and the CAISO also charged them in the CRR auctions to release these CRRs. The third case is when the net CRR payment is negative, while the fourth case is when the net CRR payment is positive. This metric reveals any potential misalignment of constrains enforced and binding between the day-ahead market and CRR auctions.

Figure 118: CRR payment versus CRR auction revenues for annual CRR – October 2016

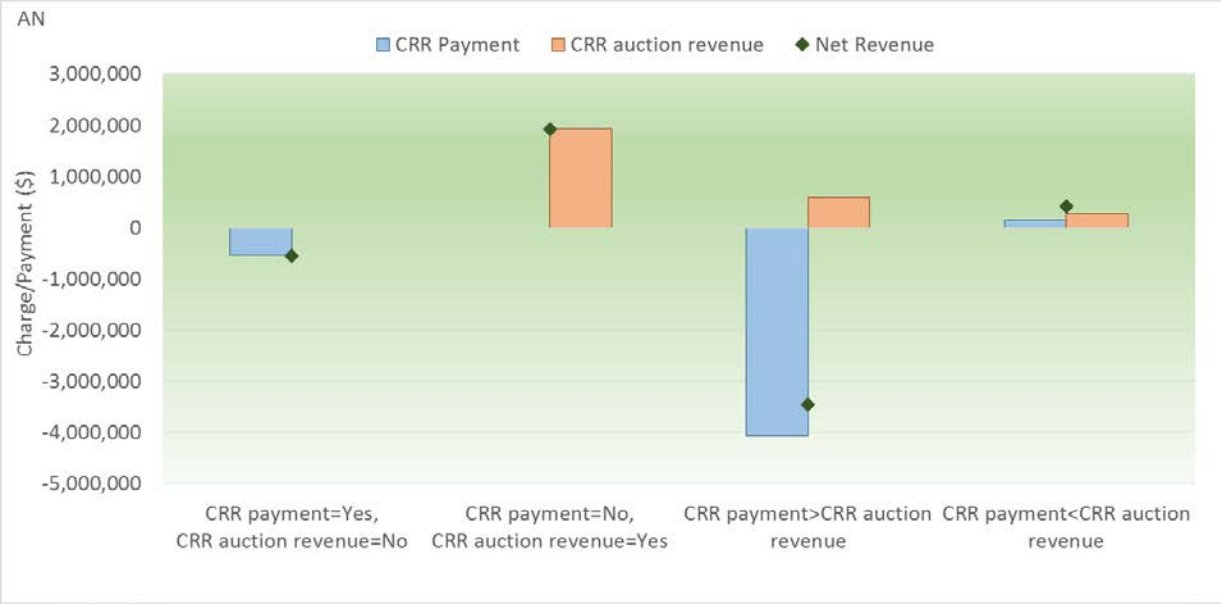


Figure 119: CRR payment versus CRR auction revenues for monthly CRR - October 2016

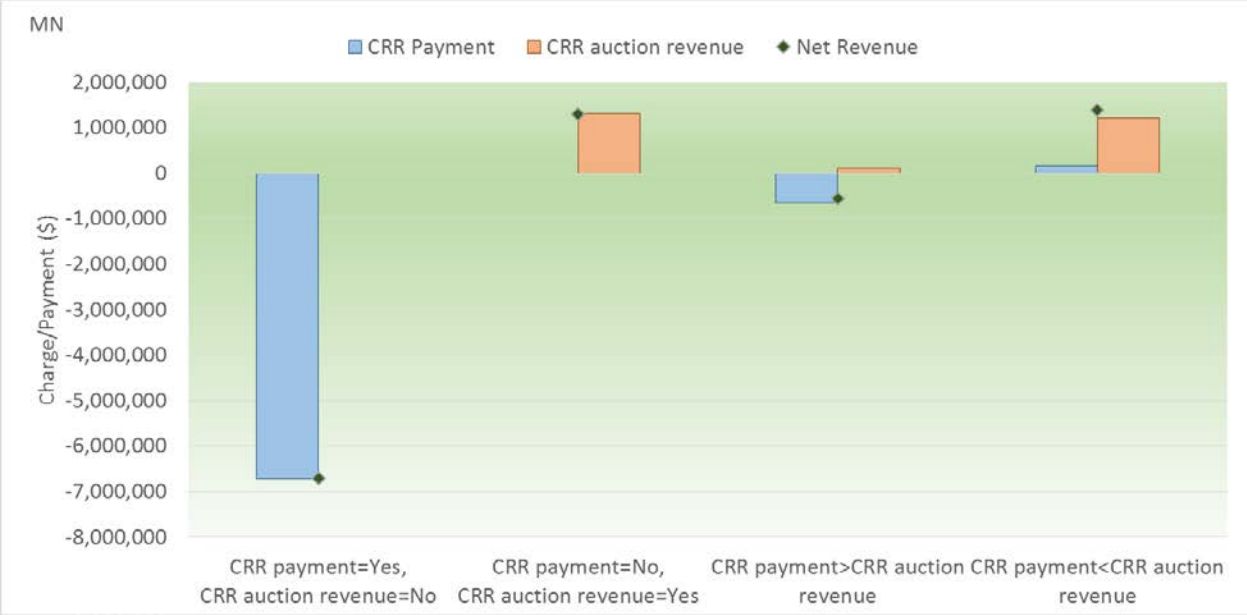


Table 13 provides one level deeper of understanding of such misalignments between markets. This tables shows the top and bottom constraints when sorted by net CRR payments. In the first column it shows the estimated CRR payment to CRR holders accrued in each constraint; the second column shows the revenues collected by the CAISO on that same constraint; the last column shows the net CRR payment, which is the balance between this money outflow (CRR payment) and money inflow (CRR auction revenues) from the CAISO's perspective. Table 14 shows the same information for CRRs released in the monthly auction for October 2016. The top constraints reflect cases where large CRR payments to auction CRRs accrued when the CRR market did not collect any auction revenues when releasing these CRRs.

Table 13: Net CRR payment by constraint – October 2016, annual process

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
MALIN500	-$3,557,161.4	$509,232.0	-$3,047,929.4
31334_CLER LKE_60.0_31338_KONOCTI6_60.0_BR_1 _1	-$379,256.0	$0.0	-$379,256.0
30005_ROUND MT_500_30015_TABLE MT_500_BR_1 _2	-$271,600.9	$0.0	-$271,600.9
CASCADE_ITC	-$159,587.2	$12,966.0	-$146,621.2
6110_SOL10_NG	-$199,772.1	$65,749.6	-$134,022.5
32380_WEMR SWS_60.0_32382_FORST HL_60.0_BR_1 _1	-$110,186.8	$0.0	-$110,186.8
32218_DRUM _115_32222_DTCH2TAP_115_BR_1 _1	-$81,049.7	$895.2	-$80,154.4
PATH15_S-N	-$79,535.6	$0.0	-$79,535.6
PATH26_BG	-$78,093.3	$0.0	-$78,093.3
22256_ESCNDIDO_69.0_22724_SANMRCOS_69.0_BR_1 _1	-$55,068.0	$0.0	-$55,068.0
22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1	-$46,165.9	$0.0	-$46,165.9
22604_OTAY _69.0_22616_OTAYLKTP_69.0_BR_1 _1	-$45,048.4	$0.0	-$45,048.4
OMS 4008893 Path15_SN	-$44,034.3	$0.0	-$44,034.3
31336_HPLND JT_60.0_31370_CLVRDLJT_60.0_BR_1 _1	-$40,291.8	$0.0	-$40,291.8
31556_TRINITY _60.0_31555_MSS TAP2_60.0_BR_1 _1	-$34,633.2	$0.0	-$34,633.2
22596_OLD TOWN_230_22504_MISSION _230_BR_1 _1	-$26,732.2	$0.0	-$26,732.2
31566_KESWICK _60.0_31582_STLLWATR_60.0_BR_1 _1	-$30,288.4	$3,969.0	-$26,319.3
31576_WNTU PMS_60.0_31570_BENTON _60.0_BR_1 _1	-$24,968.7	$0.0	-$24,968.7
NdGrp: 22999_LAROA1 _230_B1	-$20,614.5	$0.0	-$20,614.5
6110 SOL7_NG	-$17,110.5	$0.0	-$17,110.5
33020_MORAGA _115_30550_MORAGA _230_XF_1 _P	$0.0	$33,649.5	$33,649.5
WARNRVIL_STNDIFRD_TOR	$0.0	$34,439.6	$34,439.6
NdGrp_POD_PALOMR_2_PL1X3-APND	$0.0	$39,158.3	$39,158.3
7820_TL 230S_OVERLOAD_NG	$49,094.6	$0.0	$49,094.6
22468_MIGUEL _500_22472_MIGUELMP_ 1.0_XF_80	$0.0	$53,223.6	$53,223.6
SILVERPK_BG	$53,396.9	$1,191.8	$54,588.8
35922_MOSSLD _115_30751_MOSSLDB _230_XF_1	$0.0	$54,969.9	$54,969.9
33310_SANMATEO_115_30700_SANMATEO_230_XF_7 _S	$0.0	$73,868.1	$73,868.1
34116_LE GRAND_115_34134_WILSONAB_115_BR_1 _1	$0.0	$74,142.8	$74,142.8
6110_TM_BNK_FLO_TMS_DLO_NG	$0.0	$97,727.6	$97,727.6
30915_MORROBAY_230_30916_SOLARSS _230_BR_1 _1	-$9,769.4	$124,695.9	$114,926.5
OMS 4250740_Devers 230 NBus	$117,348.1	$0.0	$117,348.1
34651_DERIKTP _70.0_34572_TORNADO _70.0_BR_1 _1	$126,820.9	$0.0	$126,820.9
29408_WIRLWIND_230_29402_WIRLWIND_500_XF_1 _P	$132,855.9	$0.0	$132,855.9
COTPISO_ITC	$134,671.8	$278.7	$134,950.5
PATH15_BG	$0.0	$137,967.7	$137,967.7
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$149,594.0	$149,594.0
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	$0.0	$175,671.8	$175,671.8
NOB_ITC	$0.0	$237,523.1	$237,523.1
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	$330,886.6	$0.0	$330,886.6

Table 14: Net CRR payment by constraint – October 2016, monthly process.

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
OMS 4250740_Devers 230 NBus	-$2,005,769.8	$0.0	-$2,005,769.8
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	-$1,954,930.4	$0.0	-$1,954,930.4
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	-$1,132,190.6	$0.0	-$1,132,190.6
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$612,578.9	$0.0	-$612,578.9
22596_OLD TOWN_230_22504_MISSION _230_BR_1 _1	-$209,097.5	$0.0	-$209,097.5
7820_TL 230S_OVERLOAD_NG	-$211,875.2	$4,910.3	-$206,964.9
30005_ROUND MT_500_30015_TABLE MT_500_BR_1 _2	-$194,105.4	$0.0	-$194,105.4
31334_CLER LKE_60.0_31338_KONOCTI6_60.0_BR_1 _1	-$175,622.7	$0.0	-$175,622.7
MEAD_ITC	-$151,949.1	$0.0	-$151,949.1
6110_SOL10_NG	-$175,818.8	$41,556.1	-$134,262.8
OMS 4008893 Path15_SN	-$106,808.8	$0.0	-$106,808.8
32218_DRUM _115_32222_DTCH2TAP_115_BR_1 _1	-$73,759.4	$4,126.6	-$69,632.7
32380_WEMR SWS_60.0_32382_FORST HL_60.0_BR_1 _1	-$60,831.9	$0.0	-$60,831.9
OMS 4008879 Path15_SN	-$56,158.4	$0.0	-$56,158.4
SILVERPK_BG	-$54,321.7	$0.0	-$54,321.6
31556_TRINITY _60.0_31555_MSS TAP2_60.0_BR_1 _1	-$47,278.3	$0.0	-$47,278.3
31566_KESWICK _60.0_31582_STLLWATR_60.0_BR_1 _1	-$37,627.2	$1,811.8	-$35,815.3
32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	-$34,587.0	$0.0	-$34,587.0
PATH26_BG	-$31,342.0	$0.0	-$31,342.0
OMS 3959238 Path15_SN	-$28,746.4	$0.0	-$28,746.4
24086_LUGO _500_24092_MIRALOMA_500_BR_3 _1	$0.0	$26,162.8	$26,162.8
30900_GATES _230_30970_MIDWAY _230_BR_1 _1	$0.0	$27,395.2	$27,395.2
30879_HENTAP1 _230_30885_MUSTANGS_230_BR_1 _1	$0.0	$31,330.1	$31,330.1
CFETIJ_ITC	$0.0	$37,066.2	$37,066.2
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	-$151,819.8	$192,512.1	$40,692.3
CASCADE_ITC	$37,110.9	$10,199.3	$47,310.2
29408_WIRLWIND_230_29402_WIRLWIND_500_XF_1 _P	$50,218.5	$0.0	$50,218.5
COTPISO_ITC	$52,924.6	$48.8	$52,973.4
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$59,193.5	$59,193.5
PATH15_S-N	-$368,558.4	$437,437.6	$68,879.2
34774_MIDWAY _115_34225_BELRDG J_115_BR_1 _1	$78,424.0	$0.0	$78,424.0
34651_DERIKTP _70.0_34572_TORNADO _70.0_BR_1 _1	$86,992.4	$0.0	$86,992.4
33541_AEC_TP1 _115_33540_TESLA _115_BR_1 _1	$94,223.5	$310.0	$94,533.4
30040_TESLA _500_30042_METCALF _500_BR_1 _1	$0.0	$116,744.7	$116,744.7
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	$0.0	$146,427.1	$146,427.1
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	$0.0	$186,880.5	$186,880.5
22468_MIGUEL _500_22472_MIGUELMP_ 1.0_XF_80	$0.0	$194,353.0	$194,353.0
PALOVRDE_ITC	-$59,661.9	$267,858.1	$208,196.2
22831_SYCAMORE_138_22124_CHCARITA_138_BR_1 _1	-$7,927.5	$218,890.5	$210,963.0
MALIN500	$565,643.1	$67,653.8	$633,296.9

These two tables illustrate instances of constraint misalignment between the CRR auctions and the day-ahead market. To understand this mismatch one level deeper, Table 15 lists the subset of constraints that are not binding or not enforced in the CRR monthly auction or that have a significant CRR payment. The portion that were paid only to CRRs from the annual and monthly auctions is also provided. Then it compares the average transmission limit used in the day-ahead market and the limits actually used in both the annual and monthly auctions. These are the constraints that will mostly drive the divergence between the day-ahead and CRR markets. One of the cornerstones of the CRR market efficiency is for the CRR market to closely reflect the transmission capacity of the day-ahead market. When the transmission capacity released in the CRR market is less than that of the day-ahead market, there may be an exposure of revenue deficiency. This may also have a fair impact on the level of CRR net payments and how transmission capacity is valued in the CRR auction. This occurs because when CRRs are released in the auction process they are priced on the value of the capacity made available, or on the lack of it. A systemic issue identified during the evaluation of the CRR auction efficiency is that multiple transmission constraints are not modelled or enforced in the CRR auctions.

In cases where the constraint was enforced in the day-ahead market but not modelled or enforced in the CRR auctions, the amount of transmission capacity by means of CRRs that may be released on that constraints is effectively unbounded, which indicates that more transmission capacity may be released in the CRR auction than in the day-ahead market. This is a major problem to the efficiency of the CRR market. For the case of October 2016 and relative to other months analyzed, there were relatively few instances of constraints not enforced in the CRR auctions. In such cases the level of congestion rents and CRR payments were relatively modest, such that even with the misalignment, the financial impact was low. In further investigating why these constraints were not modelled/enforced in the CRR auctions, the common factors are related to how outages were considered and when transmission constraints were enforced in the CRR auction.

1. Constraint OMS 4250740_Devers 230 NBus. The requirement for having a Nomogram was found out later in the short-term outage study and after the CRR auction. The associated outage lasted las than 24 hours.
2. Constraint OMS 4008893 Path15_SN. The path derate was needed due to later submitted overlapping outages and more detail study in the short-term outage study. This outage was received on time and lasted more than 24 hours but less than 10 days; in this case the outage should have been modeled with a derate. With IRO-017 requirement came in effect this year, this kind of scenario will be less frequent.
3. Constraint 32380_WEMR SWS_60.0_32382_FORST HL_60.0_BR_1 _1. This element is not part of the normally enforced list of transmission elements. No known outage at the time of the running of the CRR process that activated this flowgate.
4. Constraint 22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1. This element is not part of the normally enforced list of transmission elements. No known outage at the time of the running of the CRR process that activated this flowgate.
5. Constraint 22476_MIGUELTP_69.0_22456_MIGUEL _69.0_BR_1 _1. This element is not part of the normally enforced list of transmission elements. No known outage at the time of the running of the CRR process that activated this flowgate.

6. Constraint 22604_OTAY _69.0_22616_OTAYLKTP_69.0_BR_1 _1. This element is not part of the normally enforced list of transmission elements. No known outage at the time of the running of the CRR process that activated this flowgate.
7. Constraint OMS 3959238 Path15_SN. The path derate was needed due to later submitted overlapping outages and more detailed study in short-term outage study. This outage was received well in advance but it lasted last than 24 hours. With IRO-017 requirement came in effect this year, this kind of scenario will be less frequent.
8. Constraint OMS 4008879 Path15_SN. It seems like the path Derate was needed due to later submitted overlapping outages and more detail study in short-term outage study. With IRO-017 requirement came in effect this year, this kind of will be less frequent.

There are several other constraints that accrued congestion in the day-ahead market and, even though they were enforced in the market, they were not binding in the CRR auctions. These cases are labelled as auction economics since it is based on the auction clearing process whether these constraint were binding or not based on the economics driven by the CRR bids.

Furthermore, there are some constraints that were enforced and binding in the CRR auctions but still there was a large difference between the day-ahead and CRR auctions. In several cases, the limit binding in the day-ahead market was lower in multiple hours than the limits used in the CRR auctions. Even when the average limit shown for the day-ahead market may show a value higher than the CRR limit, there may be hours when the limit was actually lower than the average and represented more restrictive conditions in the day-ahead market, some instances are

1. Malin500. The Malin intertie observed steep derates during October, due to multiple outages.
2. Imperial Valley transformer. The limit used in the CRR auction was higher than the limit used in the DAM market, resulting in more transmission capacity released on this constraint that what was made available in the day-ahead market. The limit used in the day-ahead market was as low as 620MW.

Table 15: Top constraints binding in the day-ahead market not binding in CRR market - October 2016

Constraint	Constraint Type	TOU	Payment to annual CRR	Payment to monthly CRR	DAM Limit	Annual CRR Limit	Monthly CRR Limit	Annual CRR Status	Monthly CRR Status	Reason
MALIN500	INTER_TIE	ON	-$2,702,755.7	$618,929.9	2095.1	1747.2	2088.3	Binding	Binding	Auction Economics
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	FLOWGATE	ON	$369,069.7	-$3,706,277.1	710.3	1064.7	878.4	Not Binding	Not Binding	Higher Limit
OMS 4250740_Devers 230 NBus	NOMOGRAM	ON	$117,348.1	-$4,011,539.7	249.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
MALIN500	INTER_TIE	OFF	-$854,405.7	-$53,286.8	2134.0	1789.1	2088.3	Binding	Binding	Auction Economics
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	FLOWGATE	ON	$14,715.4	-$2,264,381.2	1237.1	1136.1	937.3	Not Binding	Not Binding	Auction Economics
30005_ROUND MT_500_30015_TABLE MT_500_BR_1 _2	FLOWGATE	ON	-$271,600.9	-$388,210.8	1838.7	1811.1	1494.1	Not Binding	Not Binding	Auction Economics
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	FLOWGATE	ON	$36,425.9	-$1,139,914.0	164.4	143.4	118.3	Not Binding	Not Binding	Auction Economics
31334_CLER LKE_60.0_31338_KONOCTI6_60.0_BR_1 _1	FLOWGATE	ON	-$338,569.7	-$322,850.9	37.7	Unbounded	26.9	Not Enforced	Not Binding	Auction Economics
22596_OLD TOWN_230_22504_MISSION _230_BR_1 _1	FLOWGATE	ON	-$26,732.2	-$418,194.9	499.2	433.6	357.7	Not Binding	Not Binding	Auction Economics
MEAD_ITC	INTER_TIE	ON	$93.1	-$303,898.2	1619.0	991.1	1586.6	Binding	Not Binding	Auction Economics
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	FLOWGATE	OFF	-$38,183.1	-$203,583.7	694.0	1064.7	878.4	Not Binding	Not Binding	Higher Limit
PATH26_BG	FLOWGATE	ON	-$78,093.3	-$62,684.0	4000.1	3920.0	3920.0	Not Binding	Not Binding	Auction Economics
OMS 4008893 Path15_SN	NOMOGRAM	ON	-$44,034.3	-$213,617.6	2450.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
32380_WEMR SWS_60.0_32382_FORST HL_60.0_BR_1 _1	FLOWGATE	ON	-$97,174.3	-$111,996.0	11.7	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1	FLOWGATE	ON	-$46,165.9	-$6,240.3	69.9	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
22476_MIGUELTP_69.0_22456_MIGUEL _69.0_BR_1 _1	FLOWGATE	ON	$2,332.4	-$47,504.0	121.5	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	FLOWGATE	OFF	-$18,614.1	-$85,243.7	164.4	143.4	118.3	Binding	Not Binding	Auction Economics
31556_TRINITY _60.0_31555_MSS TAP2_60.0_BR_1 _1	FLOWGATE	ON	-$33,919.9	-$89,279.8	33.6	29.9	24.7	Not Binding	Not Binding	Auction Economics
22604_OTAY _69.0_22616_OTAYLKTP_69.0_BR_1 _1	FLOWGATE	ON	-$45,048.4	-$11,249.4	61.2	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
31334_CLER LKE_60.0_31338_KONOCTI6_60.0_BR_1 _1	FLOWGATE	OFF	-$40,686.3	-$28,394.6	37.4	Unbounded	26.9	Not Enforced	Not Binding	Auction Economics
OMS 3959238 Path15_SN	NOMOGRAM	ON	-$12,168.8	-$57,492.8	2250.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
OMS 4008879 Path15_SN	NOMOGRAM	OFF	$5,271.1	-$73,811.2	2300.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
31092_MPLE CRK_60.0_31093_HYMPOMJT_60.0_BR_1 _1	FLOWGATE	ON	-$12,994.9	-$36,277.8	27.8	29.9	24.7	Not Binding	Not Binding	Auction Economics

November 2016

Table 16 summarizes the main settlements metrics for CRR performance in the month of November 2016. The sign convention is based from the CAISO's perspective; a positive value indicates the CAISO collects or has a surplus of money; a negative value indicates the CAISO pays or has a shortfall. Day-ahead congestion rents will be positive, CRR payments will be negative and auction revenues will be positive.

Table 16: Summary of CRR performance for November 2016

Metric	Amount
DA Congestion Rents	$35,317,671
Perfect Hedge	-$2,461,714
CRR Clawback	$36,311
CRR Payments [Auction + Allocation]	-$46,465,351
CRR Payments to Auction CRRs	-$18,117,875
CRR Payments to Monthly Auction CRRs	-$13,119,561
CRR Payments to Annual Auction CRRs	-$4,998,314
CRR Payments to Allocation CRRs	-$28,347,476
CRR Auction Revenue Monthly	$3,407,136
CRR Auction Revenue Annual	$2,623,909
Revenue Adequacy	-$13,573,083
Revenue Adequacy with Auction Revenues	-$7,542,039
Net payment to auction CRRs	-$12,086,830

In November, the overall CRR performance was poor since there was a revenue deficiency of $13.5 million, which is the difference between all the proceeds from day-ahead congestion rents, CRR clawback and the payments made to CRR holders. About 39 percent of the CRR payments were to CRRs originating from the annual and monthly auctions. The auction revenues represent the proceeds from selling CRRs through the auction. The revenues arising from the annual auction for each season are estimated pro-rata to each month of the calendar quarter based on the number of hours in each time of use. The net payment to auction CRRs stands for the difference between the money paid to CRR holders less the money charge to CRR holders to acquire that portfolio of CRRs in the auction. This does not take into account any expenses the CRR holders incur associated with their participation in the CRR market and use of money. This is only a net accounting balance from the point of view of the cash inflow and outflow in the CAISO system. Overall, the net CRR payments to auction CRRs were $12.08 million, with $9.7 million originating from monthly auction CRRs (80 percent of the overall CRR payments).

In order to further understand the origin of this poor performance, there is a need to estimate over time and by constraint the CRR settlements.

Figure 120 shows the daily congestion rents accrued on each transmission constraint that was binding in the day-ahead market in the month of November. Correspondingly, Figure 121 shows the daily CRR revenue adequacy also broken out by transmission constraint. On November 29th and November 30th, about $3.5 million of revenue deficiency was accrued which accounts for about 26 percent of the total deficiency. The constraint *OMS 4379177 IVALLEY BNK81_NG2*

accrued about $2 million of revenue deficiency during these two days which accounts for 15 percent of the total deficiency.

Figure 120: Daily congestion rents – November 2016

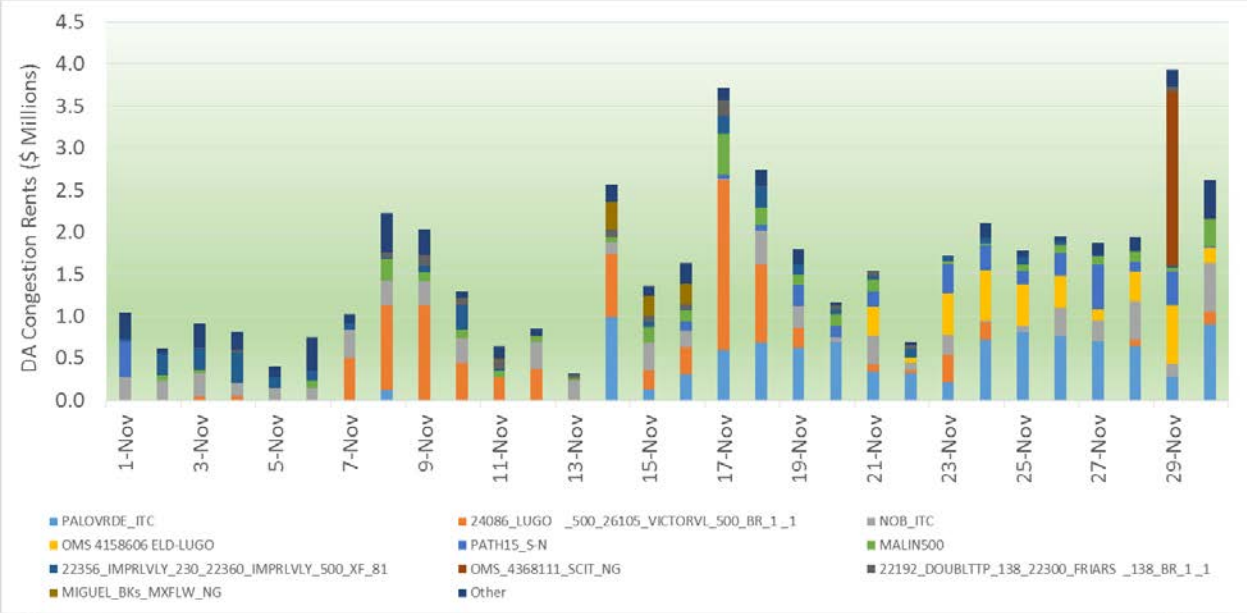


Figure 121: Daily CRR revenue adequacy - November 2016

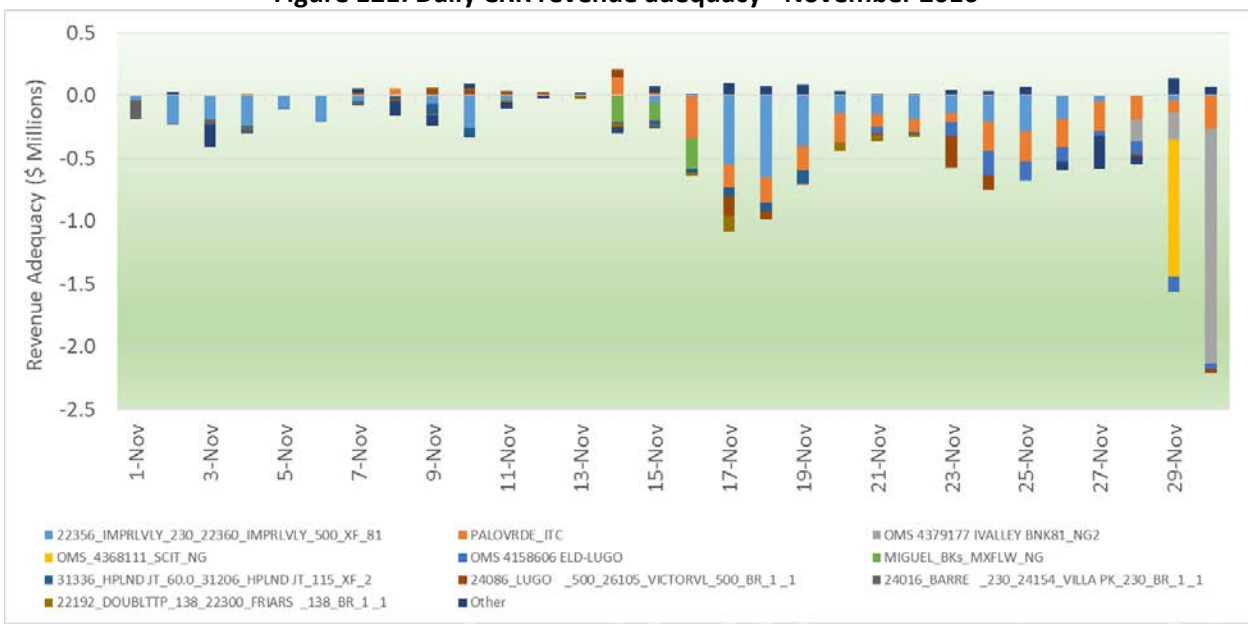
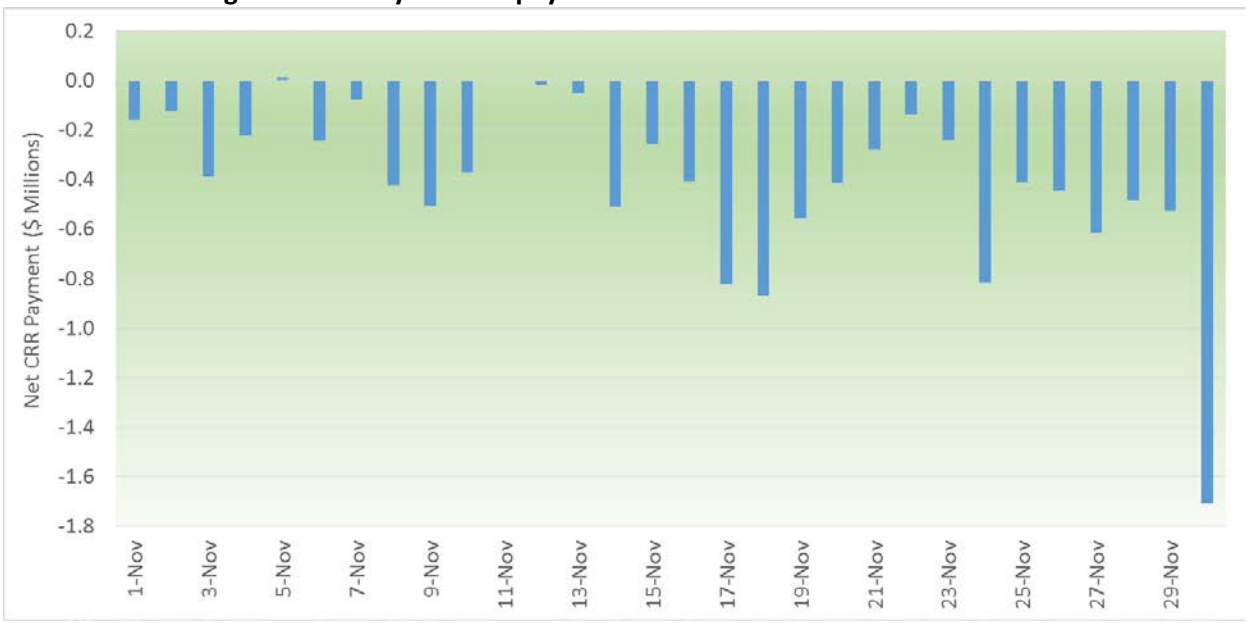


Figure 122 shows the net CRR payment per day. This net revenue is the difference between the CRR payments to CRR holders and the auction revenues collected by the CAISO through the CRR auction process; such revenues become a lump revenue for the auction. For this metric, the annual auction revenues are allocated on a pro-rata estimation to each day of the month based on the number of hours in each time of use. The CRR payments are estimated as

the total sum of CRR payments over the hours of the day only for CRRs that were released through both the annual and monthly CRR auction; that is, no CRR payments to allocated CRRs are included. The purpose of this estimate for net CRR payments is to calculate the net balance for CRR that were auction. For November, there was a persistent negative net CRR payment, indicating that overall the money paid to CRR holders was higher than the money the CAISO collected when releasing such CRRs in the annual and monthly auctions.

Figure 122: Daily net CRR payment to auction CRRs – November 2016



As shown in Figure 123 , there is a strong correlation between the level of CRR revenue deficiency and the level of net CRR payments paid to holders of CRRs released in the auction processes. This is not surprising since both metrics reflect to some extent the effect of CRRs released (and priced) in the CRR auction and the capacity released (and priced) in the day-ahead market. A negative value for CRR revenue adequacy represents a shortfall for the CAISO, while a negative value for net CRR payment represents a payment to holders of auction CRRs from the CAISO, meaning the CAISO paid more to auction CRRs than it charged to release CRRs in the auction process.

Figure 123: Comparison of daily net CRR payment with CRR revenue adequacy – November 2016

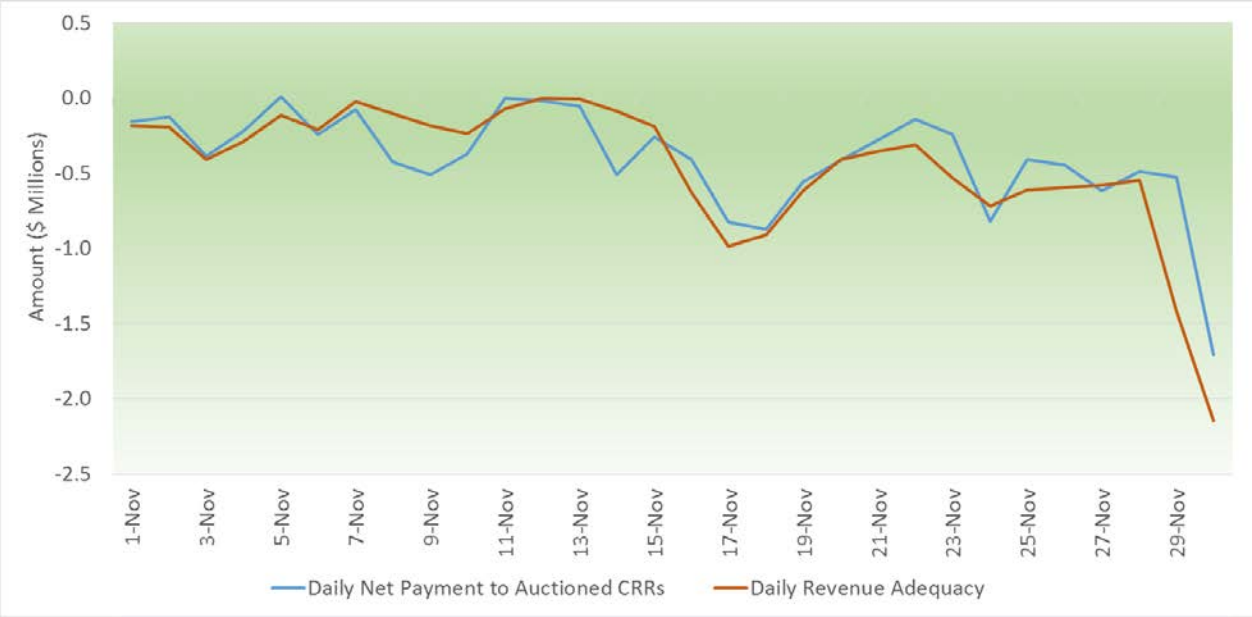


Figure 124 shows the net CRR payments to CRR participants, regardless of the type of participant. This only reflects the payments for CRRs released in both the annual and monthly CRR auctions applicable for the month of November 2016.

Figure 124: Net CRR payment to auction CRR – November 2016

Since this is from the CAISO's perspective, a negative value means the CAISO disbursed a net CRR payment to the CRR holder (or a net money inflow to the CRR holder). The names of the

CRR holders are masked, but the identifier shown in the plot is unique across all the months provided in this analysis. A positive value represents a net inflow for the CAISO since it settled less to CRR holders in the day-ahead market than what it charged to release CRRs in the auction. For November, the majority of holders of auction CRRs saw a net gain from having these positions.

To better understand the dynamics leading to such an outcome, the CAISO shifted the analysis to the fundamentals of the CRR auction construct by analyzing the CRR auction results at the constraint level. CRRs are released and priced based on the CRR clearing prices; such prices are derived as the relative difference between locational prices between the source and the sink locations. These locational prices originate from the cleared prices when any transmission constraint becomes binding with nonzero pries in the CRR auction, commonly referred as *shadow prices*. The CAISO turned out to analyze what constraints have been binding in the CRR auction process and compared that with the set of constraints that were binding in the day-ahead market. To some extent, one expects that there is a certain level of alignment between the markets.

Figure 125 and Figure 126 show a comparison of net CRR payments. The CRR payments reflect the CRR settlements for CRRs with day-ahead congestion rents, while the CRR auction revenues is the money the CAISO collected from releasing CRRs through the auctions. That is, it reflects the net money participants were charged to acquire CRRs and the money they were paid; in a loose sense, it could be interpreted as profits for holding.

There are four possible permutations to analyze. The first case represents when a CRR payment to CRR holders was made in the day-ahead market settlement, but the CAISO did not collect any revenues from releasing these CRRs from the auctions because the constraint was not binding in the CRR auction. This is shown for both the pro-rata portion of the annual auction for November and for the monthly CRR auction. A negative value indicates that the CAISO had a net CRR payment to CRR holders. The second case is the opposite in which there was no CRR payments when settling CRRs in the day-ahead market but the CAISO collected revenue when releasing these CRRs in the auction process. The third and fourth cases are for CRRs that had a CRR payment in the day-ahead market and the CAISO also charged them in the CRR auctions to release these CRRs. The third case is when the net CRR payment is negative, while the fourth case is when the net CRR payment is positive. This metric reveals any potential misalignment of constrains enforced and binding between the day-ahead market and CRR auctions.

Figure 125: CRR payment versus CRR auction revenues for annual CRR – November 2016

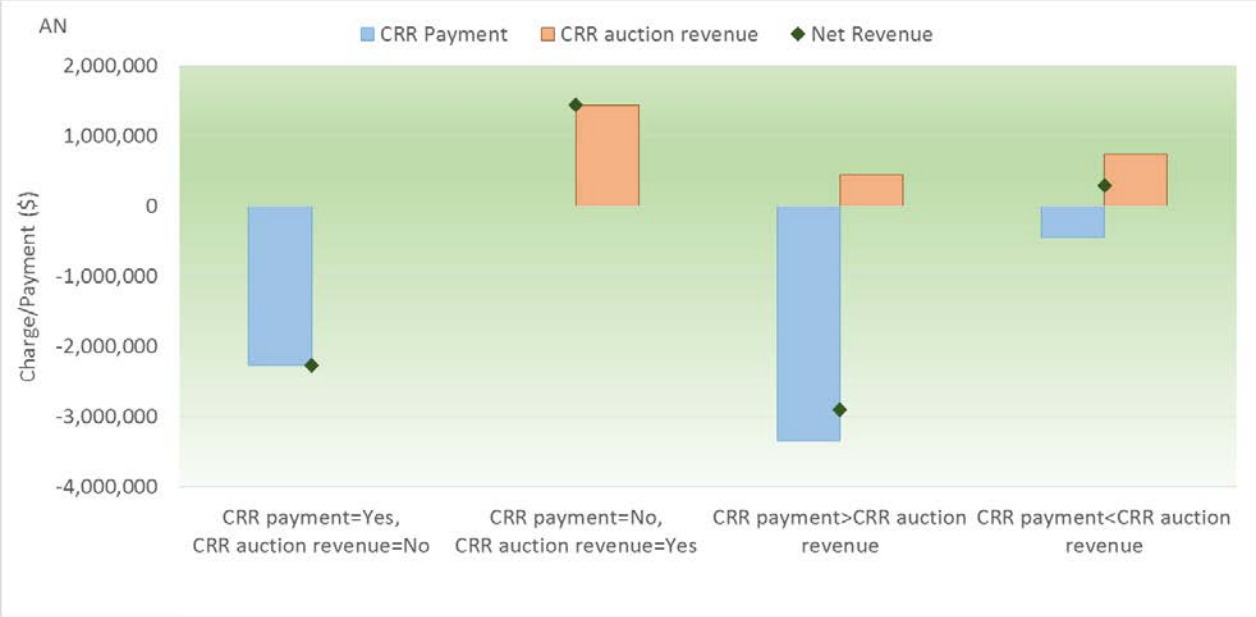


Figure 126: CRR payment versus CRR auction revenues for monthly CRR -November 2016

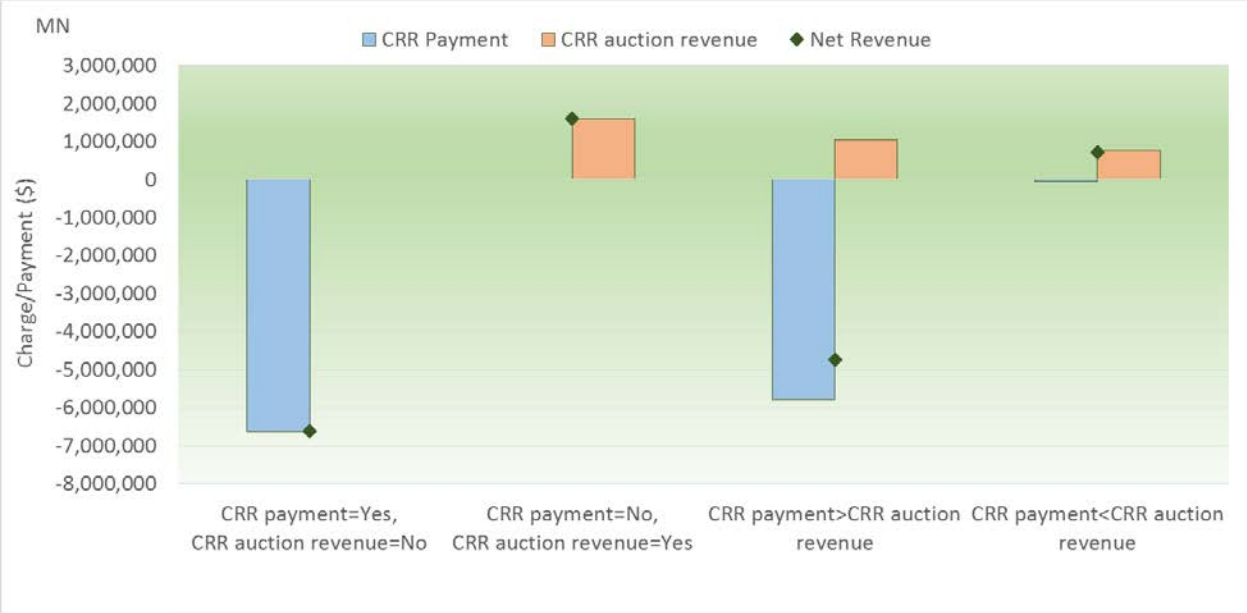


Table 17 provides one level deeper of understanding of such misalignments between markets. This tables shows the top and bottom constraints when sorted by net CRR payments. In the first column it shows the estimated CRR payment to CRR holders accrued in each constraint; the second column shows the revenues collected by the CAISO on that same constraint; the last column shows the net CRR payment, which is the balance between this money outflow (CRR payment) and money inflow (CRR auction revenues) from the CAISO's perspective. Table 18 shows the same information for CRRs released in the monthly auction for November 2016. The

top constraints reflect cases where large CRR payments to auction CRRs accrued when the CRR market did not collect any auction revenues when releasing these CRRs.

Table 17: Net CRR payment by constraint – November 2016, annual auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	-$1,520,118.0	$162,242.3	-$1,357,875.7
NOB_ITC	-$860,027.3	$229,727.4	-$630,299.9
OMS 4158606 ELD-LUGO	-$510,030.2	$0.0	-$510,030.2
OMS 4379177 IVALLEY BNK81_NG2	-$469,832.5	$0.0	-$469,832.5
WSTWGMEAD_ITC	-$486,968.4	$30,113.9	-$456,854.5
PATH15_S-N	-$448,683.0	$0.0	-$448,683.0
PALOVRDE_ITC	-$279,076.1	$0.0	-$279,076.1
OMS_4368111_SCIT_NG	-$198,240.3	$0.0	-$198,240.3
31336_HPLND JT_60.0_31206_HPLND JT_115_XF_2	-$159,901.4	$14,940.3	-$144,961.1
30750_MOSSLD _230_30760_COBURN _230_BR_1 _1	-$121,398.0	$0.0	-$121,398.0
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	-$99,465.1	$0.0	-$99,465.1
MIGUEL_BKs_MXFLW_NG	-$95,642.9	$0.0	-$95,642.9
22256_ESCNDIDO_69.0_22724_SANMRCOS_69.0_BR_1 _1	-$68,492.2	$0.0	-$68,492.2
PATH26_BG	-$57,719.4	$0.0	-$57,719.4
OMS 4186537 FL1	-$38,580.4	$0.0	-$38,580.4
ADLANTO-SP_ITC	-$35,292.0	$0.0	-$35,292.0
30900_GATES _230_30970_MIDWAY _230_BR_1 _1	-$25,240.7	$0.0	-$25,240.7
OMS 4379177 IVALLEY BNK81_NG1	-$23,548.6	$0.0	-$23,548.6
SYLMAR-AC_ITC	-$23,061.2	$6,189.6	-$16,871.7
HUMBOLDT_IMP_NG	-$15,209.1	$3.2	-$15,206.0
22430_SILVERGT_230_22596_OLD TOWN_230_BR_1 _1	$0.0	$17,070.2	$17,070.2
MSOLAR_XFMR_BG	$0.0	$25,252.3	$25,252.3
MKTPCADLN_ITC	$0.0	$26,174.8	$26,174.8
24087_MAGUNDEN_230_24153_VESTAL _230_BR_2 _1	$0.0	$27,210.8	$27,210.8
32782_STATIN D_115_32788_STATIN L_115_BR_1 _1	$0.0	$27,485.4	$27,485.4
33020_MORAGA _115_30550_MORAGA _230_XF_1 _P	$0.0	$31,400.7	$31,400.7
WARNRVIL_STNDIFRD_TOR	$0.0	$31,427.2	$31,427.2
NdGrp_POD_PALOMR_2_PL1X3-APND	$0.0	$35,732.0	$35,732.0
MALIN500	-$442,880.8	$491,197.7	$48,316.9
22468_MIGUEL _500_22472_MIGUELMP_ 1.0_XF_80	$0.0	$48,566.6	$48,566.6
35922_MOSSLD _115_30751_MOSSLDB _230_XF_1	$0.0	$50,174.3	$50,174.3
IPPUTAH_ITC	-$22,996.2	$74,504.6	$51,508.4
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	$43,636.8	$9,675.1	$53,311.9
6110_SOL10_NG	$0.0	$62,167.1	$62,167.1
33310_SANMATEO_115_30700_SANMATEO_230_XF_7 _S	$0.0	$67,404.7	$67,404.7
34116_LE GRAND_115_34134_WILSONAB_115_BR_1 _1	$0.0	$70,261.5	$70,261.5
6110_TM_BNK_FLO_TMS_DLO_NG	$0.0	$91,293.8	$91,293.8
30915_MORROBAY_230_30916_SOLARSS _230_BR_1 _1	-$16,647.2	$114,616.8	$97,969.6
PATH15_BG	$0.0	$127,576.4	$127,576.4
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$136,514.3	$136,514.3

Table 18: Net CRR payment by constraint – November 2016, monthly auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	-$3,172,578.4	$0.0	-$3,172,578.4
PALOVRDE_ITC	-$2,532,835.8	$422,309.3	-$2,110,526.4
NOB_ITC	-$1,703,470.0	$99,070.3	-$1,604,399.7
OMS 4379177 IVALLEY BNK81_NG2	-$980,124.4	$0.0	-$980,124.4
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$623,069.7	$0.0	-$623,069.7
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	-$708,240.0	$90,847.2	-$617,392.8
OMS_4368111_SCIT_NG	-$261,117.1	$0.0	-$261,117.1
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	-$252,486.7	$0.0	-$252,486.7
OMS 4158606 ELD-LUGO	-$251,611.0	$0.0	-$251,611.0
PATH15_S-N	-$612,164.5	$362,641.7	-$249,522.8
MIGUEL_BKs_MXFLW_NG	-$188,347.0	$0.0	-$188,347.0
OMS 4186537 Path15_S-N	-$161,067.3	$0.0	-$161,067.3
OMS 4379177 IVALLEY BNK81_NG1	-$124,590.4	$0.0	-$124,590.4
31336_HPLND JT_60.0_31206_HPLND JT_115_XF_2	-$129,780.4	$5,439.8	-$124,340.6
30750_MOSSLD _230_30760_COBURN _230_BR_1 _1	-$101,329.8	$0.0	-$101,329.8
OMS 4392033 TL50003_NG	-$91,702.8	$0.0	-$91,702.8
OMS 4391827 TL50003_NG	-$91,411.0	$0.0	-$91,411.0
22596_OLD TOWN_230_22504_MISSION _230_BR_1 _1	-$82,137.4	$0.0	-$82,137.4
OMS 4402394 TL50003_NG	-$69,349.0	$0.0	-$69,349.0
PATH26_BG	-$47,041.8	$0.0	-$47,041.8
30750_MOSSLD _230_30045_MOSSLAND_500_XF_9	$0.0	$13,806.1	$13,806.1
22828_SYCAMORE_69.0_22756_SCRIPPS _69.0_BR_1 _1	$0.0	$15,744.9	$15,744.9
NdGrp_NEORBLF_7_B1	$0.0	$18,830.1	$18,830.1
32218_DRUM _115_32222_DTCH2TAP_115_BR_1 _1	-$893.4	$20,255.2	$19,361.8
CASCADE_ITC	$0.0	$22,187.4	$22,187.4
NdGrp_POD_MDFKRL_2_PROJCT-APND	$0.0	$22,966.9	$22,966.9
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$24,487.5	$24,487.5
NdGrp_AGUCALG1_7_B1	$0.0	$27,168.7	$27,168.7
6110_SOL7_NG	$0.0	$28,795.8	$28,795.8
33310_SANMATEO_115_30700_SANMATEO_230_XF_7 _S	$0.0	$35,014.7	$35,014.7
SDGE_CFEIMP_BG	$0.0	$39,684.8	$39,684.8
NdGrp_CHCARITA_1_N012	$0.0	$43,519.7	$43,519.7
IID-SDGE_ITC	$0.0	$69,902.1	$69,902.1
22831_SYCAMORE_138_22832_SYCAMORE_230_XF_1	$0.0	$70,782.0	$70,782.0
IID-SCE_BG	-$1,972.3	$81,291.0	$79,318.7
SYLMAR-AC_BG	$0.0	$190,136.6	$190,136.6
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	$0.0	$214,939.0	$214,939.0
22355_I VALLY2_230_22360_IMPRLVLY_500_XF_80	$0.0	$286,037.5	$286,037.5
22831_SYCAMORE_138_22124_CHCARITA_138_BR_1 _1	-$20,486.7	$313,934.6	$293,447.9
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	-$3,126.7	$319,045.8	$315,919.1

These two tables illustrate instances of constraint misalignment between the CRR auctions and the day-ahead market. To understand this mismatch one level deeper, Table 19 lists the subset of constraints that are not binding or not enforced in the CRR monthly auction or that have a significant CRR payment. The portion that were paid only to CRRs from the annual and monthly auctions is also provided. Then it compares the average transmission limit used in the day-ahead market and the limits actually used in both the annual and monthly auctions. These are the constraints that will mostly drive the divergence between the day-ahead and CRR markets. One of the cornerstones of the CRR market efficiency is for the CRR market to closely reflect the transmission capacity of the day-ahead market. When the transmission capacity released in the CRR market is less than that of the day-ahead market, there may be an exposure of revenue deficiency. This may also have a fair impact on the level of CRR net payments and how transmission capacity is valued in the CRR auction. This occurs because when CRRs are released in the auction process they are priced on the value of the capacity made available, or on the lack of it. A systemic issue identified during the evaluation of the CRR auction efficiency is that multiple transmission constraints are not modelled or enforced in the CRR auctions.

In cases where the constraint was enforced in the day-ahead market but not modelled or enforced in the CRR auctions, the amount of transmission capacity by means of CRRs that may be released on that constraints is effectively unbounded, which indicates that more transmission capacity may be released in the CRR auction than in the day-ahead market. This is a major problem to the efficiency of the CRR market. For the case of November 2016 and relative to other months analyzed, there were relatively few instances of constraints not enforced in the CRR auctions. In such cases the level of congestion rents and CRR payments were relatively modest, such that even with the misalignment, the financial impact was low. In further investigating why these constraints were not modelled/enforced in the CRR auctions, the common factors are related to how outages were considered and when transmission constraints were enforced in the CRR auction.

1. Constraint OMS_4368111_SCIT_NG. This constraint was associated with an outage (4368111) that was submitted after the CRR cutoff date.
2. Constraint OMS 4158606 ELD-LUGO. This constraint was associated with an outage (4158606) that was submitted after the CRR cutoff date.
3. Constraint OMS 4379177 IVALLEY BNK81_NG2. This constraint was associated with an outage (4379177) that was submitted after the CRR cutoff date.
4. Constraint OMS 4392033 TL50003_NG. This constraint was associated with an outage (4392033) that was submitted after the CRR cutoff date.
5. Constraint OMS 4391827 TL50003_NG. This constraint was associated with an outage (4391827) that was submitted after the CRR cutoff date.
6. Constraint OMS 4379177 IVALLEY BNK81_NG1. This constraint was associated with an outage (4379177) that was submitted after the CRR cutoff date.
7. Constraint OMS 4402394 TL50003_NG. This constraint was associated with an outage (4402394) that was submitted after CRR cutoff date.
8. Constraint OMS 4186537 FL1. It seems like the requirement for Nomogram was found out later in short-term outage study. With IRO-017 requirement came in effect this year, this

kind of scenario should go down. This outage lasted more than 24 but less than 10 days and was submitted on time.

There are several other constraints that accrued congestion in the day-ahead market and, even though they were enforced in the market, they were not binding in the CRR auctions. These cases are labelled as auction economics since it is based on the auction clearing prices whether these constraint were binding or not.

Furthermore, there are some constraints that were enforced and binding in the CRR auctions but still there was a large difference between the day-ahead and CRR auction limits. In several, the limit binding in the day-ahead market was lower in multiple hours than the limits used in the CRR auctions. Even when the average limit shown for the day-ahead market may show a value higher than the CRR limit, there may be hours when the limit was actually lower than the average and represented more restrictive conditions in the day-ahead market. Constraints include:

1. Paloverde intertie. This constraint was heavily derated during the month of November due to outages in the area. The monthly auction considered these derates for the majority; however, the annual auction run with nominal limit.
2. NOB intertie. This constraint did not bind in the CRR auctions but bind heavily in the day-ahead market. This was caused by using more restrictive limits in the day ahead market than the ones used in the CRR auctions.

Table 19: Top constraints binding in the day-ahead market not binding in CRR market - November 2016

Constraint	Constraint Type	TOU	Payment to annual CRR	Payment to monthly CRR	DAM Limit	Annual CRR Limit	Monthly CRR Limit	Annual CRR Status	Monthly CRR Status	Reason
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	FLOWGATE	ON	-$684,955.7	-$349,158.0	2402.9	2469.7	2037.5	Binding	Binding	Auction Economics
PALOVRDE_ITC	INTER_TIE	OFF	-$192,089.9	-$1,462,296.1	2367.9	1114.1	1565.8	Binding	Binding	Auction Economics
PALOVRDE_ITC	INTER_TIE	ON	-$86,986.2	-$1,070,539.7	2158.0	1160.9	1565.8	Binding	Binding	Auction Economics
NOB_ITC	INTER_TIE	ON	-$506,221.8	-$1,379,203.1	1564.0	1016.7	1450.0	Binding	Binding	Auction Economics
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	FLOWGATE	ON	-$15,415.3	-$2,827,120.9	591.4	1064.7	878.4	Not Binding	Not Binding	Higher Limit
OMS_4368111_SCIT_NG	NOMOGRAM	ON	-$198,240.3	-$261,117.1	7674.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
OMS 4158606 ELD-LUGO	NOMOGRAM	ON	-$261,087.4	-$214,228.6	2301.3	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
OMS 4379177 IVALLEY BNK81_NG2	NOMOGRAM	ON	-$454,412.1	-$946,164.5	335.1	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
NOB_ITC	INTER_TIE	OFF	-$353,805.5	-$324,266.9	1564.0	950.7	1450.0	Binding	Binding	Auction Economics
MIGUEL_BKs_MXFLW_NG	NOMOGRAM	ON	-$95,642.9	-$188,347.0	1084.2	Unbounded	1313.2	Not Enforced	Not Binding	Higher Limit
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	FLOWGATE	ON	$64,629.2	-$569,445.4	164.2	143.4	118.3	Not Binding	Not Binding	Auction Economics
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	FLOWGATE	ON	$1,048.9	-$252,486.7	1257.4	1136.1	937.3	Not Binding	Not Binding	Auction Economics
OMS 4158606 ELD-LUGO	NOMOGRAM	OFF	-$248,942.8	-$37,382.4	2297.4	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	FLOWGATE	OFF	-$84,049.8	-$345,457.5	600.8	1064.7	878.4	Not Binding	Not Binding	Higher Limit
30750_MOSSLD _230_30760_COBURN _230_BR_1 _1	FLOWGATE	ON	-$121,398.0	-$101,329.8	300.5	281.0	249.9	Not Binding	Not Binding	Auction Economics
OMS 4392033 TL50003_NG	NOMOGRAM	ON	-$8,300.1	-$91,702.8	789.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
OMS 4391827 TL50003_NG	NOMOGRAM	ON	-$7,907.2	-$91,411.0	789.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
OMS 4379177 IVALLEY BNK81_NG1	NOMOGRAM	ON	-$21,160.6	-$118,638.5	404.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
OMS 4186537 Path15_S-N	NOMOGRAM	OFF	$32,505.9	-$136,928.0	2950.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
22596_OLD TOWN_230_22504_MISSION _230_BR_1 _1	FLOWGATE	ON	$1,826.4	-$82,137.4	502.8	433.6	357.7	Not Binding	Not Binding	Auction Economics
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	FLOWGATE	OFF	-$75,103.3	-$4,962.0	2407.2	2469.7	2037.5	Binding	Binding	Auction Economics
OMS 4402394 TL50003_NG	NOMOGRAM	ON	-$5,271.0	-$69,349.0	789.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
PATH26_BG	FLOWGATE	ON	-$57,719.4	-$47,041.8	2700.1	3920.0	3622.8	Not Binding	Not Binding	Higher Limit
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	FLOWGATE	OFF	-$20,992.4	-$53,624.2	164.1	143.4	118.3	Binding	Not Binding	Auction Economics
OMS 4186537 FL1	NOMOGRAM	ON	-$38,580.4	-$18,940.8	470.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage
ADLANTO-SP_ITC	INTER_TIE	ON	-$35,292.0	$3,049.4	1340.4	1029.7	1340.6	Not Binding	Not Binding	Higher Limit
OMS 4379177 IVALLEY BNK81_NG2	NOMOGRAM	OFF	-$15,420.5	-$33,959.9	267.1	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missing Outage

December 2016

Table 20 summarizes the main settlements metrics for CRR performance in the month of December 2016. The sign convention is based from the CAISO's perspective; a positive value indicates the CAISO collects or has a surplus of money; a negative value indicates the CAISO pays or has a shortfall. Day-ahead congestion rents will be positive, CRR payments will be negative and auction revenues will be positive.

Table 20: Summary of CRR performance for December 2016

Metric	Amount
DA Congestion Rents	$15,066,599
Perfect Hedge	-$1,100,593
CRR Clawback	$84,822
CRR Payments [Auction + Allocation]	-$31,400,209
CRR Payments to Auction CRRs	-$14,511,510
CRR Payments to Monthly Auction CRRs	- $8,459,523
CRR Payments to Annual Auction CRRs	-$6,051,987
CRR Payments to Allocation CRRs	-$16,888,698
CRR Auction Revenue Monthly	$6,048,734
CRR Auction Revenue Annual	$2,754,467
Revenue Adequacy	-$17,349,381
Revenue Adequacy with Auction Revenues	-$8,546,180
Net payment to auction CRRs	-$5,708,310

In December, the overall CRR performance was poor since there was a revenue deficiency of over $17 million, which is the difference between all of the proceeds from day-ahead congestion rents, CRR clawback, and the payments made to CRR holders. About 46 percent of the CRR payments were to CRRs originating from the annual and monthly auctions. The auction revenues represent the proceeds from selling CRRs through the auction. The revenues arising from the annual auction for each season are estimated pro-rata to each month of the calendar quarter based on the number of hours in each time of use. The net payment to auction CRRs stands for the difference between the money paid to CRR holders less the money charge to CRR holders to acquire that portfolio of CRRs in the auction. This does not take into account any expenses the CRR holders incur associated with their participation in the CRR market and use of money. This is only a net accounting balance from the point of view of the cash inflow and outflow in the CAISO system. In this month there was a net CRR payment to auction CRR of $5.7 million, with $3.29 million and $2.4 million paid to CRRs from the monthly and annual auctions.

In order to further understand the origin of this poor performance, there is a need to estimate over time and by constraint the CRR settlements.

Figure 127 shows the daily congestion rents accrued on each transmission constraint that was binding in the day-ahead market in the month of December. Correspondingly, Figure 128 shows the daily CRR revenue adequacy also broken out by transmission constraint. In December, about $14.5 million of revenue deficiency was accrued on the constraint *OMS 4379177 IVALLEY BNK81_NG2* which accounts for over 84 percent of the total revenue deficiency.

Figure 127: Daily congestion rents – December 2016

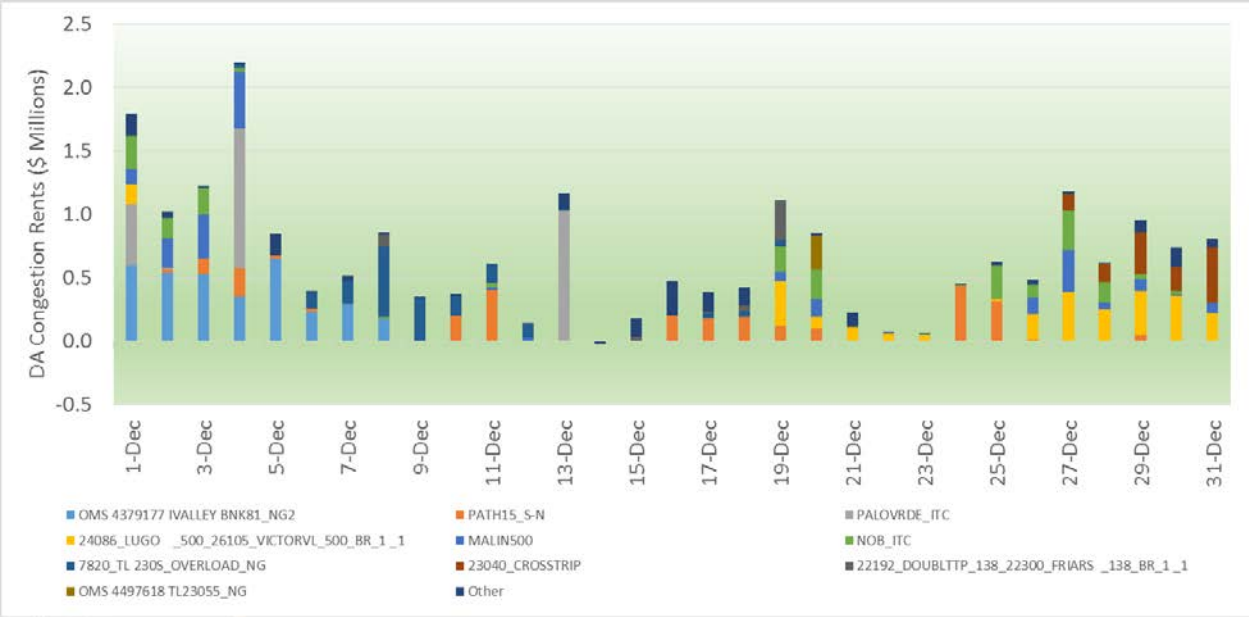
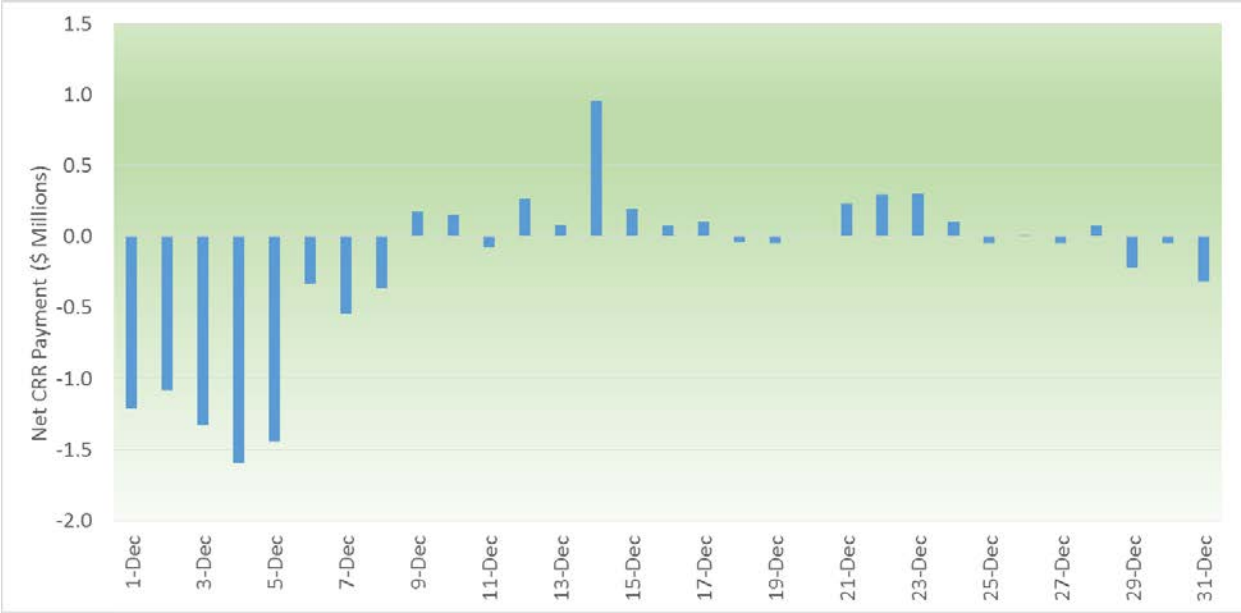


Figure 128: Daily CRR revenue adequacy - December 2016

Figure 129 shows the net CRR payment per day. This net revenue is the difference between the CRR payments to CRR holders and the auction revenues collected by the CAISO through the CRR auction process; such revenues become a lump revenue for the auction. For this metric, the annual auction revenues are allocated on a pro-rata estimation to each day of the month based on the number of hours in each time of use. The CRR payments are estimated as the total sum of CRR payments over the hours of the day only for CRRs that were released through both the annual and monthly CRR auction; that is, no CRR payments to allocated CRRs are included. The

purpose of this estimate for net CRR payments is to calculate the net balance for CRRs that were released only in the auctions. For December, there was a persistent negative net CRR payment during the beginning quarter of the month, indicating that overall the money paid to CRR holders was higher than the money the CAISO collected when releasing such CRRs in the annual and monthly auctions. During the last three quarters of the month there was a persistent positive net CRR payment, indicating that overall the money paid to CRR holders was less than the money the CAISO collected when releasing such CRRs in the annual and monthly auctions.

Figure 129: Daily net CRR payment to auction CRRs – December 2016



As shown in Figure 130, there is a strong correlation between the level of CRR revenue deficiency and the level of net CRR payments paid to holders of CRRs released in the auction processes. This is not surprising since both metrics reflect to some extent the effect of CRRs released (and priced) in the CRR auction and the capacity released (and priced) in the day-ahead market. A negative value for CRR revenue adequacy represents a shortfall for the CAISO, while a negative value for net CRR payment represents a payment to holders of auction CRRs from the CAISO. This indicates that the CAISO paid more to auction CRRs than it charged to release CRRs in the auction process.

Figure 130: Comparison of daily net CRR payment with CRR revenue adequacy – December 2016

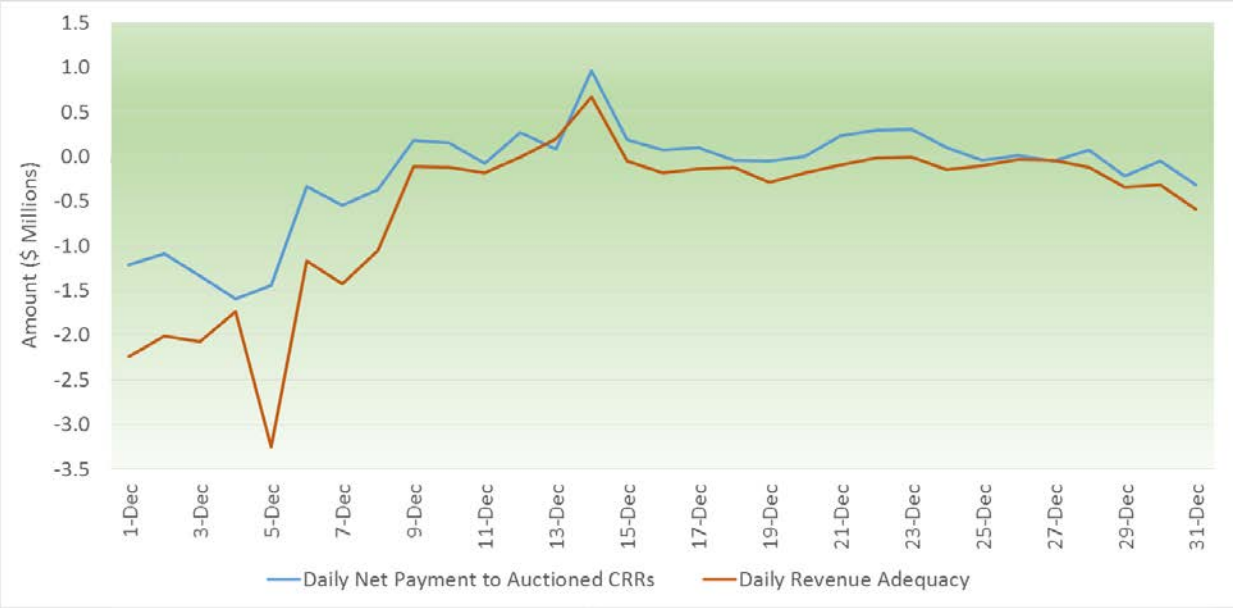
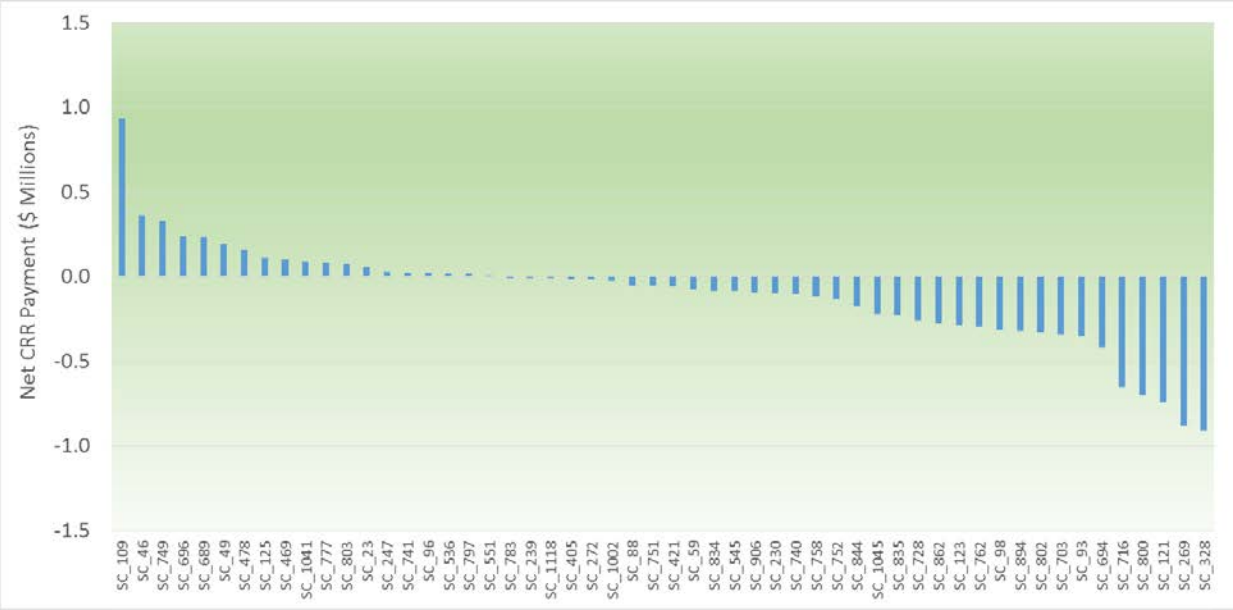


Figure 131 shows the net CRR payments to CRR participants, regardless of the type of participant. This only reflects the payments for CRRs released in both the annual and monthly CRR auctions applicable for the month of December 2016. Since this is from the CAISO's perspective, a negative value means the CAISO disbursed a net CRR payment to the CRR holder (or a net money inflow to the CRR holder). The names of the CRR holders are masked, but the identifier shown in the plot is unique across all the months provided in this analysis. A positive value represents a net inflow for the CAISO since it settled less to CRR holders in the day-ahead market than what it charged to release CRRs in the auction. For December, the majority of holders of auction CRRs saw a net gain from having these positions.

Figure 131: Net CRR payment to auction CRR –December 2016



To better understand the dynamics leading to such an outcome, the CAISO shifted the analysis to the fundamentals of the CRR auction construct by analyzing the CRR auction results at the constraint level. CRRs are released and priced based on the CRR clearing prices; such prices are derived as the relative difference between locational prices between the source and the sink locations. These locational prices originate from the cleared prices when any transmission constraint becomes binding with nonzero pries in the CRR auction, commonly referred as *shadow prices*. The CAISO turned out to analyze what constraints have been binding in the CRR auction process and compared that with the set of constraints that were binding in the day-ahead market. To some extent, one expects that there is a certain level of alignment between the markets.

Figure 132 and Figure 133 show a comparison of net CRR payments. The CRR payments reflect the CRR settlements for CRRs with day-ahead congestion rents, while the CRR auction revenues is the money the CAISO collected from releasing CRRs through the auctions. That is, it reflects the net money participants were charged to acquire CRRs and the money they were paid; in a loose sense, it could be interpreted as profits for holding.

There are four possible permutations to analyze. The first case represents when a CRR payment to CRR holders was made in the day-ahead market settlement, but the CAISO did not collect any revenues from releasing these CRRs from the auctions because the constraint was not binding in the CRR auction. This is shown for both the pro-rata portion of the annual auction for December and for the monthly CRR auction. A negative value indicates that the CAISO had a net CRR payment to CRR holders. The second case is the opposite in which there was no CRR payments when settling CRRs in the day-ahead market but the CAISO collected revenue when releasing these CRRs in the auction process. The third and fourth cases are for CRRs that had a CRR payment in the day-ahead market and the CAISO also charged them in the CRR auctions to release these CRRs. The third case is when the net CRR payment is negative, while the fourth case is when the net CRR payment is positive. This metric reveals any potential misalignment of constrains enforced and binding between the day-ahead market and CRR auctions.

Figure 132: CRR payment versus CRR auction revenues for annual CRR – December 2016

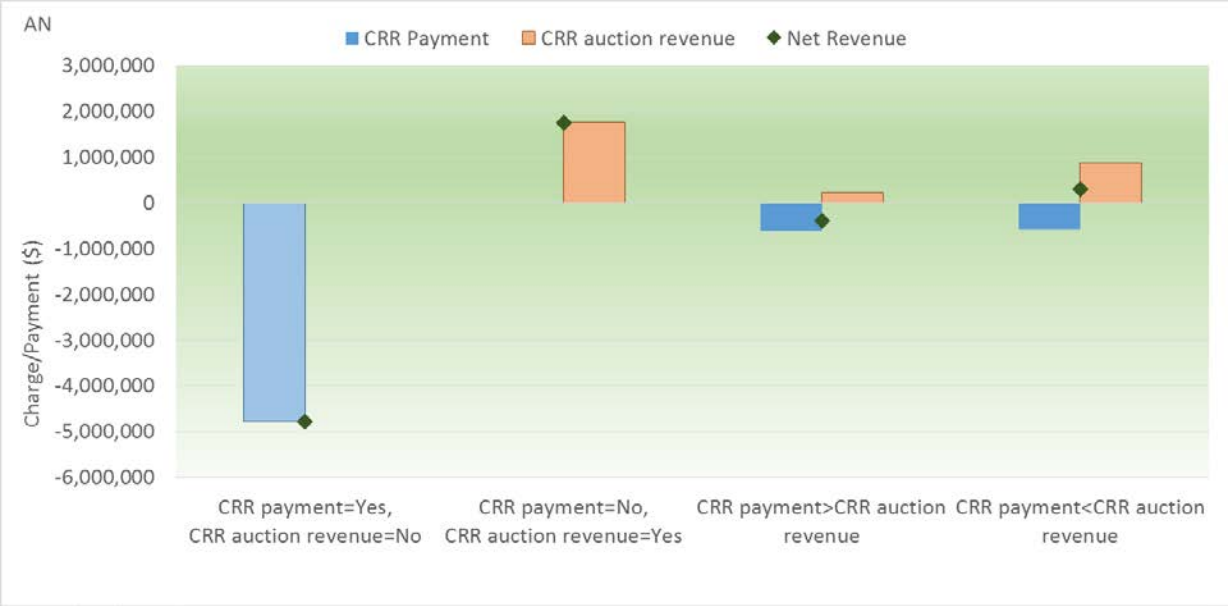


Figure 133: CRR payment versus CRR auction revenues for monthly CRR - December 2016

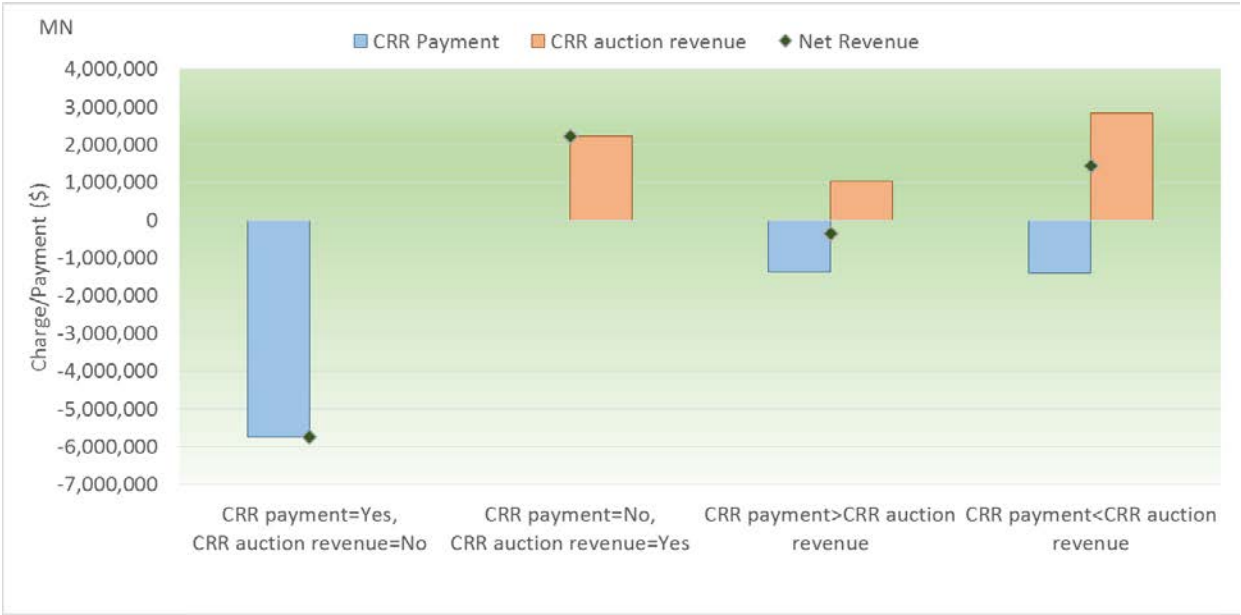


Table 21 provides one level deeper of understanding of such misalignments between markets. This tables shows the top and bottom constraints when sorted by net CRR payments. In the first column it shows the estimated CRR payment to CRR holders accrued in each constraint; the second column shows the revenues collected by the CAISO on that same constraint; the last column shows the net CRR payment, which is the balance between this money outflow (CRR payment) and money inflow (CRR auction revenues) from the CAISO's perspective. Table 22 shows the same information for CRRs released in the monthly auction for December 2016. The top constraints reflect cases where large CRR payments to auction CRRs accrued when the CRR market did not collect any auction revenues when releasing these CRRs.

Table 21: Net CRR payment by constraint – December 2016, annual auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
OMS 4379177 IVALLEY BNK81_NG2	-$4,333,492.6	$0.0	-$4,333,492.6
PATH15_S-N	-$285,606.3	$0.0	-$285,606.3
23040_CROSSTRIP	-$217,429.9	$0.0	-$217,429.9
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	-$204,028.2	$0.0	-$204,028.2
PALOVRDE_ITC	-$60,922.3	$0.0	-$60,922.3
NORTHGILA500_ITC	-$58,506.0	$12,686.8	-$45,819.3
OMS_3849098_LBN_SN	-$29,887.3	$0.0	-$29,887.3
31334_CLER LKE_60.0_31338_KONOCTI6_60.0_BR_1 _1	-$28,371.8	$0.0	-$28,371.8
OMS3877502 DV_SB	-$28,160.2	$0.0	-$28,160.2
34874_WHEELER _70.0_34756_WHEELER _115_XF_2	-$27,996.0	$0.0	-$27,996.0
HUMBOLDT_IMP_NG	-$23,516.9	$3.2	-$23,513.7
22604_OTAY _69.0_22616_OTAYLKTP_69.0_BR_1 _1	-$23,022.3	$0.0	-$23,022.3
OMS 4489686 TL23055_NG	-$17,456.0	$0.0	-$17,456.0
35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	-$16,202.7	$0.0	-$16,202.7
WSTWGMEAD_ITC	-$47,443.1	$31,506.8	-$15,936.4
OMS 4497618 TL23055_NG	-$15,101.3	$0.0	-$15,101.3
22256_ESCNDIDO_69.0_22724_SANMRCOS_69.0_BR_1 _1	-$13,849.6	$0.0	-$13,849.6
30750_MOSSLD _230_30790_PANOCHE _230_BR_1 _1	-$10,685.2	$0.0	-$10,685.2
OMS4489577_PATH15_S-N	-$9,610.1	$0.0	-$9,610.1
OMS3877502 DV_VST2	-$9,520.1	$0.0	-$9,520.1
MSOLAR_XFMR_BG	$0.0	$26,790.0	$26,790.0
24087_MAGUNDEN_230_24153_VESTAL _230_BR_2 _1	$0.0	$28,682.5	$28,682.5
32782_STATIN D_115_32788_STATIN L_115_BR_1 _1	$0.0	$28,999.8	$28,999.8
33020_MORAGA _115_30550_MORAGA _230_XF_1 _P	$0.0	$33,115.6	$33,115.6
WARNRVIL_STNDIFRD_TOR	$0.0	$33,579.0	$33,579.0
NdGrp_POD_PALOMR_2_PL1X3-APND	$0.0	$38,179.3	$38,179.3
COTPISO_ITC	$41,521.4	$288.0	$41,809.5
22468_MIGUEL _500_22472_MIGUELMP_ 1.0_XF_80	$0.0	$51,893.1	$51,893.1
35922_MOSSLD _115_30751_MOSSLDB _230_XF_1	$0.0	$53,601.9	$53,601.9
IPPUTAH_ITC	-$21,992.0	$77,214.8	$55,222.7
6110_SOL10_NG	$0.0	$65,064.8	$65,064.8
33310_SANMATEO_115_30700_SANMATEO_230_XF_7 _S	$0.0	$72,021.4	$72,021.4
34116_LE GRAND_115_34134_WILSONAB_115_BR_1 _1	$0.0	$73,440.6	$73,440.6
6110_TM_BNK_FLO_TMS_DLO_NG	$0.0	$96,219.8	$96,219.8
30915_MORROBAY_230_30916_SOLARSS _230_BR_1 _1	$0.0	$121,946.0	$121,946.0
PATH15_BG	$0.0	$135,261.1	$135,261.1
OMS 4282107_TVYVLY	$136,188.4	$0.0	$136,188.4
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$145,858.4	$145,858.4
MALIN500	-$342,656.4	$508,219.4	$165,563.0
7820_TL 230S_OVERLOAD_NG	$191,250.4	$0.0	$191,250.4

Table 22: Net CRR payment by constraint – December 2016, monthly auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
OMS 4379177 IVALLEY BNK81_NG2	-$3,759,187.7	$0.0	-$3,759,187.7
23040_CROSSTRIP	-$1,126,775.5	$0.0	-$1,126,775.5
7820_TL 230S_OVERLOAD_NG	-$805,214.8	$0.0	-$805,214.8
PATH15_S-N	-$705,885.0	$594,446.1	-$111,439.0
OMS 4497618 TL23055_NG	-$100,330.6	$0.0	-$100,330.6
OMS 4489686 TL23055_NG	-$95,799.7	$0.0	-$95,799.7
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	-$88,475.1	$0.0	-$88,475.1
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	-$88,424.8	$0.0	-$88,424.8
34874_WHEELER _70.0_34756_WHEELER _115_XF_2	-$57,273.4	$0.0	-$57,273.4
OMS_3849098_LBN_SN	-$41,973.4	$0.0	-$41,973.4
OMS 4497673 TL23055_NG	-$36,308.6	$0.0	-$36,308.6
OMS3877502 DV_SB	-$30,636.5	$0.0	-$30,636.5
30750_MOSSLD _230_30790_PANOCHE _230_BR_1 _1	-$18,582.2	$0.0	-$18,582.2
IPPUTAH_ITC	-$16,880.6	$1,184.8	-$15,695.8
OMS4489577_PATH15_S-N	-$15,254.5	$0.0	-$15,254.5
MEAD_ITC	-$29,688.7	$14,578.6	-$15,110.1
OMS3877502 DV_VST2	-$12,626.7	$0.0	-$12,626.7
OMS4489569_PATH15_S-N	-$9,403.2	$0.0	-$9,403.2
31334_CLER LKE_60.0_31338_KONOCTI6_60.0_BR_1 _1	-$6,392.4	$0.0	-$6,392.4
35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	-$6,092.1	$0.0	-$6,092.1
22356_IMPRLVLY_230_21025_ELCENTRO_230_BR_1 _1	$0.0	$24,820.9	$24,820.9
IID-SCE_BG	-$21,252.7	$47,190.7	$25,938.0
NdGrp_AGUCALG1_7_B1	$0.0	$27,620.0	$27,620.0
WSTWGMEAD_ITC	-$52,996.9	$82,158.1	$29,161.1
CASCADE_BG	$0.0	$29,274.8	$29,274.8
NdGrp_POD_ENERSJ_2_WIND-APND	$0.0	$29,608.9	$29,608.9
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$32,799.7	$32,799.7
NOB_ITC	-$248,740.7	$283,851.0	$35,110.3
22831_SYCAMORE_138_22832_SYCAMORE_230_XF_1	$0.0	$37,328.5	$37,328.5
COTPISO_ITC	$52,459.8	$2.0	$52,461.8
30900_GATES _230_30970_MIDWAY _230_BR_1 _1	$0.0	$77,179.1	$77,179.1
RM_TM12_NG	$0.0	$86,238.2	$86,238.2
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	-$312,245.3	$405,299.0	$93,053.7
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$159,893.1	$344,154.4	$184,261.3
24138_SERRANO _500_24137_SERRANO _230_XF_3	$0.0	$222,442.4	$222,442.4
MALIN500	-$212,588.9	$438,388.7	$225,799.8
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	$0.0	$339,476.3	$339,476.3
OMS 4282107_TVYVLY	$554,536.8	$0.0	$554,536.8
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	$0.0	$627,915.8	$627,915.8
PALOVRDE_ITC	-$757,130.8	$1,617,624.5	$860,493.7

These two tables illustrate instances of constraint misalignment between the CRR auctions and the day-ahead market. To understand this mismatch one level deeper, Table 23 lists the subset of constraints that are not binding or not enforced in the CRR monthly auction or that have a significant CRR payment. The portion that were paid only to CRRs from the annual and monthly auctions is also provided. Then it compares the average transmission limit used in the day-ahead market and the limits actually used in both the annual and monthly auctions. These are the constraints that will mostly drive the divergence between the day-ahead and CRR markets. One of the cornerstones of the CRR market efficiency is for the CRR market to closely reflect the transmission capacity of the day-ahead market. When the transmission capacity released in the CRR market is less than that of the day-ahead market, there may be an exposure of revenue deficiency. This may also have a fair impact on the level of CRR net payments and how transmission capacity is valued in the CRR auction. This occurs because when CRRs are released in the auction process they are priced on the value of the capacity made available, or on the lack of it. A systemic issue identified during the evaluation of the CRR auction efficiency is that multiple transmission constraints are not modelled or enforced in the CRR auctions.

In cases where the constraint was enforced in the day-ahead market but not modelled or enforced in the CRR auctions, the amount of transmission capacity by means of CRRs that may be released on that constraints is effectively unbounded, which indicates that more transmission capacity may be released in the CRR auction than in the day-ahead market. This is a major problem to the efficiency of the CRR market. For the case of December 2016 and relative to other months analyzed, there were relatively few instances of constraints not enforced in the CRR auctions. In such cases the level of congestion rents and CRR payments were relatively modest, such that even with the misalignment, the financial impact was low. In further investigating why these constraints were not modelled/enforced in the CRR auctions, the common factors are related to how outages were considered and when transmission constraints were enforced in the CRR auction.

1. Constraint OMS 4379177 IVALLEY BNK81_NG2. This constraint was associated with an outage (4379177) that was picked up in the CRR process but the need to include a nomogram was not known at the time of the CRR cutoff.
2. Constraint 23040_CROSSTRIP. This constraint was not known at the time the CRR auction was run, and was later on added into the February 2017 monthly model.
3. Constraint OMS 4497618 TL23055_NG. This constraint was associated with an outage (4497618) that was for less than 24 hours and was received after CRR cutoff.
4. Constraint OMS 4489686 TL23055_NG. This constraint was associated with an outage (4489686) that was for less than 24 hours and was received after CRR cutoff.
5. Constraint OMS 4497673 TL23055_NG. This constraint was associated with an outage (4497673) that was for less than 24 hours and was received after CRR cutoff.
6. Constraint 34874_WHEELER _70.0_34756_WHEELER _115_XF_2. This element is not part of the normally enforced list of transmission elements. There was no known outage at the time of the running of the CRR process that activated this flowgate.
7. Constraint OMS3877502 DV_SB. The nomogram associated with this outage was not added until after the CRR cutoff. This outage lasted more than 24 hours but less than 10 days and was submitted in time.

8. Constraint 31334_CLER LKE_60.0_31338_KONOCTI6_60.0_BR_1 _1. This element is not part of the normally enforced list of transmission elements. There was no known outage at the time of the running of the CRR process that activated this flowgate.
9. Constraint 22604_OTAY _69.0_22616_OTAYLKTP_69.0_BR_1 _1. This element is not part of the normally enforced list of transmission elements. There was no known outage at the time of the running of the CRR process that activated this flowgate.
10. Constraint OMS3877502 DV_VST2. The nomogram associated with this outage was not added until after the CRR cutoff. This outage lasted more than 24 hours but less than 10 days and was submitted in time.
11. Constraint OMS4489577_PATH15_S-N. This constraint was associated with an outage (4489577) that was for less than 24 hours and was received after CRR cutoff.

Table 23: Top constraints binding in the day-ahead market not binding in CRR market - December 2016

Constraint	Constraint Type	TOU	Payment to annual CRR	Payment to monthly CRR	DAM Limit	Annual CRR Limit	Monthly CRR Limit	Annual CRR Status	Monthly CRR Status	Reason
OMS 4379177 IVALLEY BNK81_NG2	NOMOGRAM	ON	-$3,508,302.8	-$2,648,257.1	170.1	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
OMS 4379177 IVALLEY BNK81_NG2	NOMOGRAM	OFF	-$825,189.8	-$1,110,930.6	172.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
23040_CROSSTRIP	NOMOGRAM	ON	-$175,832.7	-$960,157.0	458.8	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
7820_TL 230S_OVERLOAD_NG	NOMOGRAM	ON	$189,169.9	-$607,412.0	304.5	Unbounded	392.0	Not Enforced	Not Binding	Auction Economics
OMS 4497618 TL23055_NG	NOMOGRAM	ON	-$15,101.3	-$100,330.6	997.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
OMS 4489686 TL23055_NG	NOMOGRAM	ON	-$17,456.0	-$95,799.7	998.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
7820_TL 230S_OVERLOAD_NG	NOMOGRAM	OFF	$2,080.5	-$197,802.9	303.4	Unbounded	392.0	Not Enforced	Not Binding	Higher Limit
23040_CROSSTRIP	NOMOGRAM	OFF	-$41,597.2	-$166,618.6	449.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
24016_BARRE _230_24154_VILLA PK_230_BR_1 _1	FLOWGATE	ON	$844.2	-$88,424.8	1327.4	1136.1	937.3	Not Binding	Not Binding	Auction Economics
OMS 4497673 TL23055_NG	NOMOGRAM	ON	-$5,496.7	-$36,308.6	997.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	FLOWGATE	ON	-$8,787.0	-$88,399.4	316.5	301.1	248.4	Binding	Not Binding	Auction Economics
34874_WHEELER _70.0_34756_WHEELER _115_XF_2	FLOWGATE	ON	-$26,054.9	-$51,055.3	69.8	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
OMS3877502 DV_SB	NOMOGRAM	OFF	-$28,160.2	-$30,636.5	310.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
31334_CLER LKE_60.0_31338_KONOCTI6_60.0_BR_1 _1	FLOWGATE	ON	-$28,371.8	-$6,392.4	58.9	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
22604_OTAY _69.0_22616_OTAYLKTP_69.0_BR_1 _1	FLOWGATE	ON	-$23,022.3	-$5,154.0	61.2	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	FLOWGATE	ON	-$16,202.7	-$6,092.1	118.7	78.6	87.4	Not Binding	Not Binding	Auction Economics
30750_MOSSLD _230_30790_PANOCHE _230_BR_1 _1	FLOWGATE	ON	-$10,685.2	-$18,582.2	318.7	281.0	249.9	Not Binding	Not Binding	Auction Economics
31566_KESWICK _60.0_31582_STLLWATR_60.0_BR_1 _1	FLOWGATE	ON	-$6,916.0	-$2,821.6	37.7	24.1	29.2	Binding	Not Binding	Auction Economics
OMS3877502 DV_VST2	NOMOGRAM	OFF	-$9,262.1	-$11,339.5	483.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
OMS4489577_PATH15_S-N	NOMOGRAM	ON	-$9,610.1	-$15,254.5	3100.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage

January 2017

Table 24 summarizes the main settlements metrics for CRR performance in the month of January 2017. The sign convention is based from the CAISO's perspective; a positive value indicates the CAISO collects or has a surplus of money; a negative value indicates the CAISO pays or has a shortfall. Day-ahead congestion rents will be positive, CRR payments will be negative and auction revenues will be positive.

Table 24: Summary of CRR performance for January 2017

Metric	Amount
DA Congestion Rents	$11,265,612
Perfect Hedge	-$295,793
CRR Clawback	$14,555
CRR Payments [Auction + Allocation]	-$21,139,516
CRR Payments to Auction CRRs	-$11,093,405
CRR Payments to Monthly Auction CRRs	-$4,599,038
CRR Payments to Annual Auction CRRs	-$6,494,367
CRR Payments to Allocation CRRs	-$10,046,111
CRR Auction Revenue Monthly	$3,014,927
CRR Auction Revenue Annual	$3,524,436
Revenue Adequacy	-$10,155,142
Revenue Adequacy with Auction Revenues	-$3,615,779
Net payment to auction CRR	-$4,554,041

In January, the overall CRR performance was poor since there was a revenue deficiency of $10.1 million, which is the difference between all of the proceeds from day-ahead congestion rents, CRR clawback and the payments made to CRR holders. About 52 percent of the CRR payments were to CRRs originated from the annual and monthly auctions. The auction revenues represent the proceeds from selling CRRs through the auction. The revenues arising from the annual auction for each season are estimated pro-rata to each month of the calendar quarter based on the number of hours in each time of use. The net payment to auction CRRs stands for the difference between the money paid to CRR holders less the money charge to CRR holders to acquire that portfolio of CRRs in the auction. This does not take into account any expenses the CRR holders incur associated with their participation in the CRR market and use of money. This is only a net accounting balance from the point of view of the cash inflow and outflow in the CAISO system.

In order to further understand the origin of this poor performance, there is a need to estimate over time and by constraint the CRR settlements. Figure 134 shows the daily congestion rents accrued on each transmission constraint that was binding in the day-ahead market in the month of January. Correspondingly, Figure 135Figure 135 shows the daily CRR revenue adequacy also broken out by transmission constraint. In January, about $6.4 million of revenue deficiency was accrued on the Crosstrip transmission constraint alone, which accounts for over 60 percent of the total deficiency. Furthermore, an additional $1.8 million of deficiency accrued on the constraint *OMS 4622069 TL50003*. This constraint was indeed a constraint also associated to the Crosstrip constraint for

outage ID 4622069. When this constraint was enforced on January 29, the Crosstrip constraint was unenforced. Overall, the Crosstrip constraint drove about 80 percent of the revenue deficiency in January.

Figure 134: Daily congestion rents - January 2017

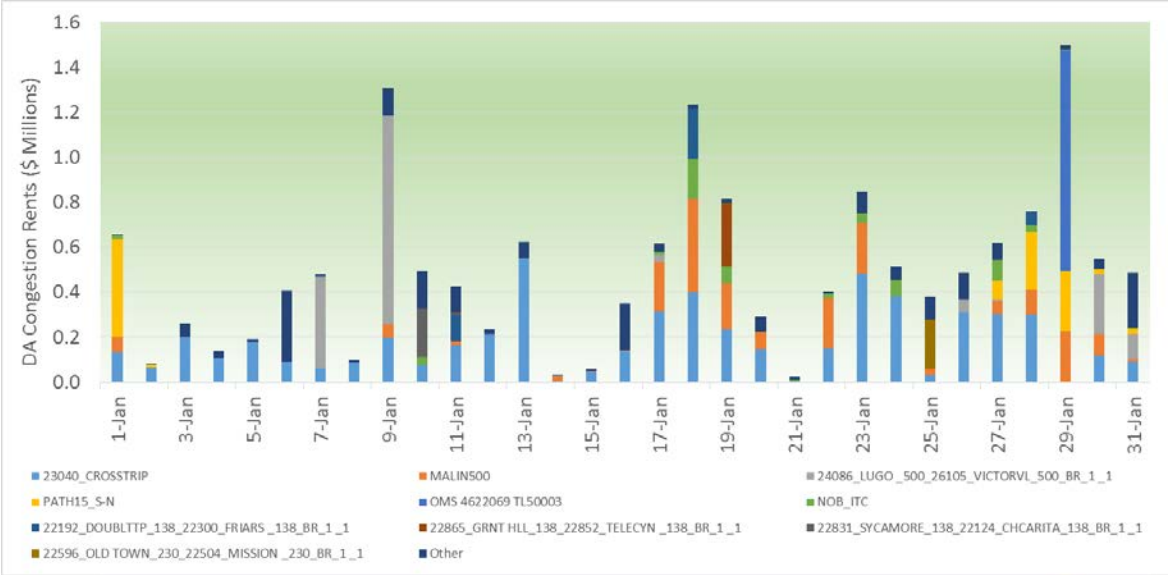


Figure 135: Daily CRR revenue adequacy - January 2017

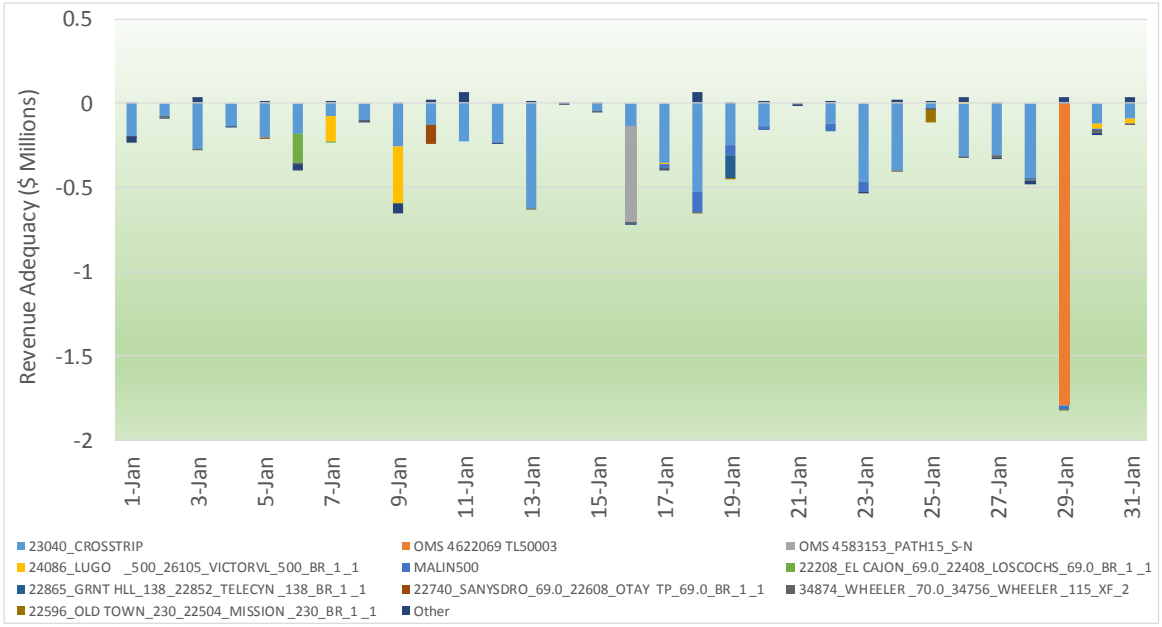
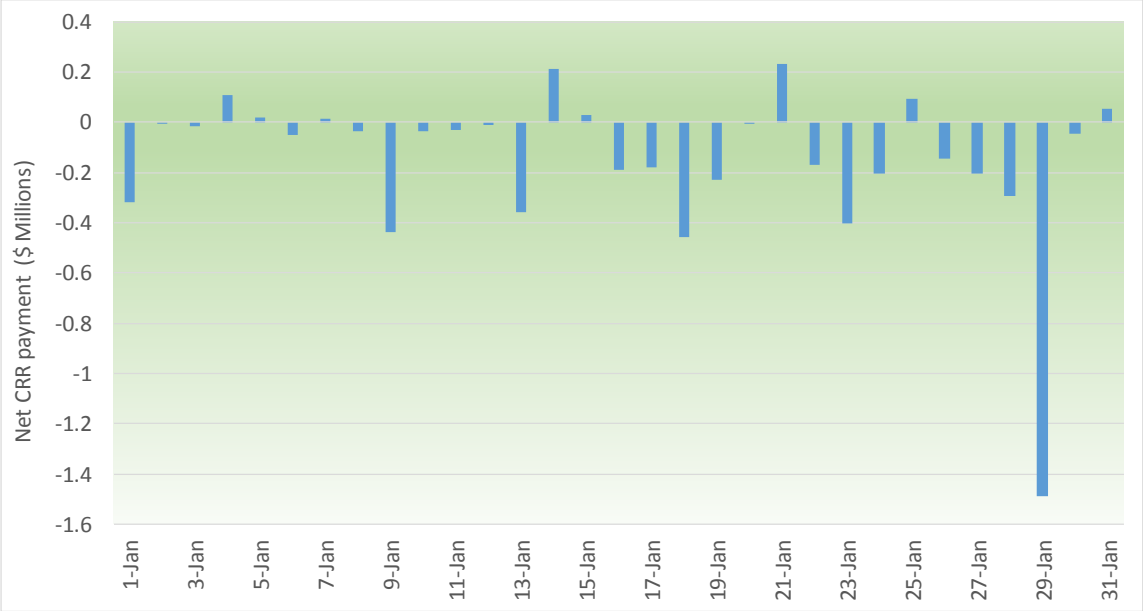


Figure 136 shows the net CRR payment per day. This net revenue is the difference between the CRR payments to CRR holders and the auction revenues collected by the CAISO through the CRR auction process; such revenues become a lump revenue for the auction. For this metric, the annual auction revenues are allocated on a pro-rata estimation to each day of the month based on the number of hours in each time of use. The CRR payments are estimated as the total sum of CRR payments over the hours of the

day only for CRRs that were released through both the annual and monthly CRR auction; that is, no CRR payments to allocated CRRs are included. The purpose of this estimate for net CRR payments is to calculate the net balance for CRR that were auction. For January, there was a persistent negative net CRR payment, indicating that overall the money paid to CRR holders was higher than the money the CAISO collected when releasing such CRRs in the annual and monthly auctions.

Figure 136: Daily net CRR payment to auction CRRs – January 2017

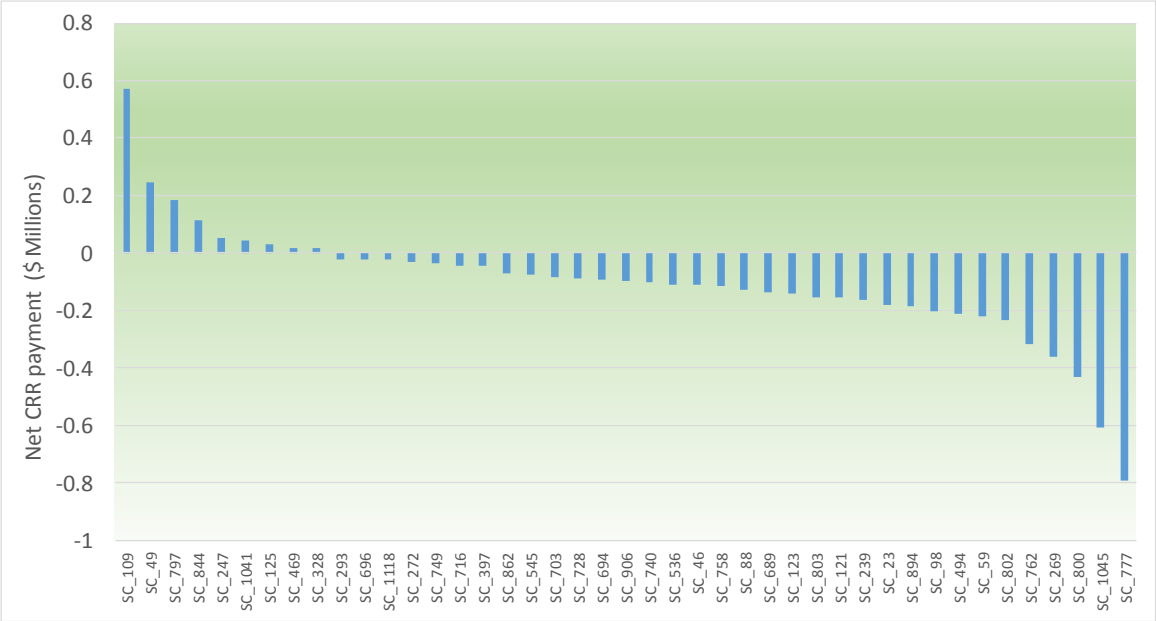


As shown in Figure 137, there is a strong correlation between the level of CRR revenue deficiency and the level of net CRR payments paid to holders of CRRs released in the auction processes. This is not surprising since both metrics reflect to some extent the effect of CRRs released (and priced) in the CRR auction and the capacity released (and priced) in the day-ahead market. A negative value for CRR revenue adequacy represents a shortfall for the CAISO, while a negative value for net CRR payment represents a payment to holders of auction CRRs from the CAISO, meaning the CAISO paid more to auction CRRs than it charged to release CRRs in the auction process.

Figure 137: Comparison of daily net CRR payment with CRR revenue adequacy – January 2017

Figure 138 shows the net CRR payments to CRR participants, regardless of the type of participant. This only reflects the payments for CRRs released in both the annual and monthly CRR auctions applicable for the month of January 2017. Since this is from the CAISO's perspective, a negative value means the CAISO disbursed a net CRR payment to the CRR holder (or a net money inflow to the CRR holder). The names of the CRR holders are masked, but the identifier shown in the plot is unique across all the months provided in this analysis. A positive value represents a net inflow for the CAISO since it settled less to CRR holders in the day-ahead market than what it charged to release CRRs in the auction. For January, the majority of holders of auction CRRs saw a net gain from having these positions.

Figure 138: Net CRR payment to auction CRR – January 2017



To better understand the dynamics leading to such an outcome, the CAISO shifted the analysis to the fundamentals of the CRR auction construct by analyzing the CRR auction results at the constraint level. CRRs are released and priced based on the CRR clearing prices; such prices are derived as the relative difference between locational prices between the source and the sink locations. These locational prices originate from the cleared prices when any transmission constraint becomes binding with nonzero pries in the CRR auction, commonly referred as *shadow prices*. The CAISO turned out to analyze what constraints have been binding in the CRR auction process and compared that with the set of constraints that were binding in the day-ahead market. To some extent, one expects that there is a certain level of alignment between the markets.

Figure 139 and Figure 140 show a comparison of net CRR payments. The CRR payments reflect the CRR settlements for CRRs with day-ahead congestion rents, while the CRR auction revenues is the money the CAISO collected from releasing CRRs through the auctions. That is, it reflects the net money participants were charged to acquire CRRs and the money they were paid; in a loose sense, it could be interpreted as profits for holding.

There are four possible permutations to analyze. The first case represents when a CRR payment to CRR holders was made in the day-ahead market settlement, but the CAISO did not collect any revenues from releasing these CRRs from the auctions because the constraint was not binding in the CRR auction. This is shown for both the pro-rata portion of the annual auction for January and for the monthly CRR auction. A negative value indicates that the CAISO had a net CRR payment to CRR holders. The second case is the opposite in which there was no CRR payments when settling CRRs in the day-ahead market but the CAISO collected revenue when releasing these CRRs in the auction process. The third and fourth cases are for CRRs that had a CRR payment in the day-ahead market and the CAISO also charged them in the CRR auctions to release these CRRs. The third case is when the net CRR payment is negative, while the fourth case is when the net CRR payment is positive. This metric reveals any potential misalignment of constrains enforced and binding between the day-ahead market and CRR auctions.

Figure 139: CRR payment versus CRR auction revenues for annual CRR - January 2017

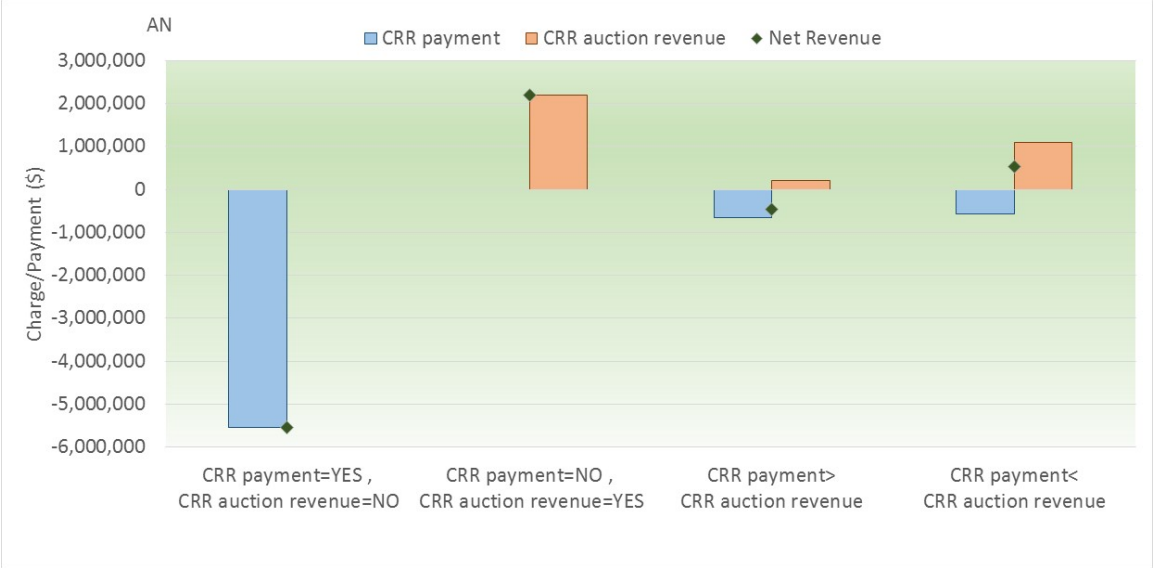


Figure 140: CRR payment versus CRR auction revenues for monthly CRR - January 2017

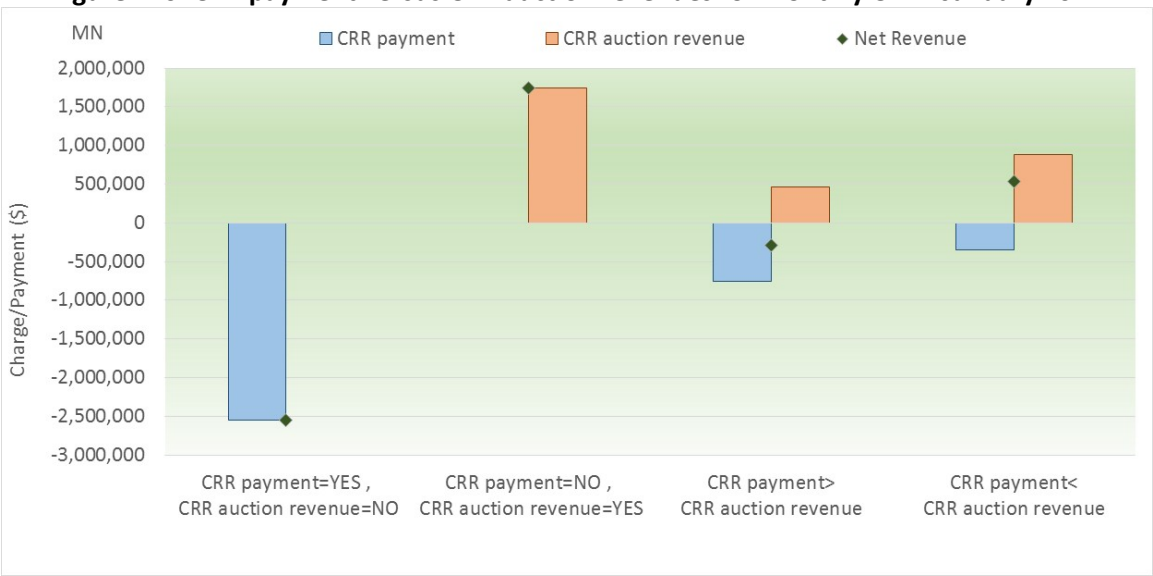


Table 25 provides one level deeper of understanding of such misalignments between markets. This tables shows the top and bottom constraints when sorted by net CRR payments. In the first column it shows the estimated CRR payment to CRR holders accrued in each constraint; the second column shows the revenues collected by the CAISO on that same constraint; the last column shows the net CRR payment, which is the balance between this money outflow (CRR payment) and money inflow (CRR auction revenues) from the CAISO's perspective. Table 26 shows the same information for CRRs released in the monthly auction for January 2017. The top constraints reflect cases where large CRR payments to auction CRRs accrued when the CRR market did not collect any auction revenues when releasing these CRRs.

Table 25: Net CRR payment by constraint - January 2017, annual auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
23040_CROSSTRIP	-$3,963,393.0	$0.0	-$3,963,393.0
OMS 4622069 TL50003	-$932,224.1	$0.0	-$932,224.1
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	-$383,394.1	$142,491.5	-$240,902.6
OMS 4583153_PATH15_S-N	-$155,226.2	$0.0	-$155,226.2
NOB_ITC	-$88,365.6	$0.0	-$88,365.6
35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	-$70,969.9	$0.0	-$70,969.9
22865_GRNT HLL_138_22852_TELECYN _138_BR_1 _1	-$59,520.8	$0.0	-$59,520.8
OMS_4444156_Path15_S_N	-$54,856.3	$0.0	-$54,856.3
22596_OLD TOWN_230_22504_MISSION _230_BR_1 _1	-$53,174.7	$0.0	-$53,174.7
32314_SMRTSVLE_60.0_32316_YUBAGOLD_60.0_BR_1 _1	-$51,468.6	$0.0	-$51,468.6
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$47,812.0	$0.0	-$47,812.0
22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1	-$37,506.3	$0.0	-$37,506.3
22740_SANYSDRO_69.0_22608_OTAY TP_69.0_BR_1 _1	-$35,980.2	$0.0	-$35,980.2
HUMBOLDT_IMP_NG	-$47,107.2	$13,797.3	-$33,309.9
22256_ESCNDIDO_69.0_22724_SANMRCOS_69.0_BR_1 _1	-$39,189.7	$7,471.1	-$31,718.6
24085_LUGO _230_24086_LUGO _500_XF_1 _P	-$20,553.8	$0.0	-$20,553.8
30056_GATES2 _500_30060_MIDWAY _500_BR_2 _3	-$18,655.4	$0.0	-$18,655.4
31566_KESWICK _60.0_31582_STLLWATR_60.0_BR_1 _1	-$17,085.7	$0.0	-$17,085.7
Devers NORTH BUS OUTAGE NG	-$11,611.0	$0.0	-$11,611.0
31461_JESSTAP _115_31464_COTWDPGE_115_BR_1 _1	-$10,224.9	$0.0	-$10,224.9
PATH26_BG	$0.0	$29,150.5	$29,150.5
WSTWGMEAD_ITC	$0.0	$30,645.6	$30,645.6
PATH15_S-N	-$251,216.9	$286,182.7	$34,965.8
SYLMAR-AC_ITC	-$96.9	$35,162.0	$35,065.1
IID-SDGE_ITC	$0.0	$35,597.7	$35,597.7
BLYTHE_BG	$0.0	$37,852.9	$37,852.9
MSOLAR_XFMR_BG	$0.0	$39,200.3	$39,200.3
30005_ROUND MT_500_30245_ROUND MT_230_XF_1 _P	$0.0	$41,535.1	$41,535.1
PALOVRDE_ITC	$0.0	$46,109.2	$46,109.2
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$50,635.0	$50,635.0
30523_CC SUB _230_30525_C.COSTA _230_BR_1 _1	$0.0	$55,450.2	$55,450.2
22831_SYCAMORE_138_22832_SYCAMORE_230_XF_1	$0.0	$56,823.2	$56,823.2
22456_MIGUEL _69.0_22464_MIGUEL _230_XF_2	$0.0	$73,875.7	$73,875.7
22831_SYCAMORE_138_22124_CHCARITA_138_BR_1 _1	-$30,111.3	$129,564.6	$99,453.3
SDGE_CFEIMP_BG	$0.0	$112,447.0	$112,447.0
22828_SYCAMORE_69.0_22756_SCRIPPS _69.0_BR_1 _1	$0.0	$116,143.0	$116,143.0
22464_MIGUEL _230_22504_MISSION _230_BR_1 _1	$0.0	$127,891.3	$127,891.3
30750_MOSSLD _230_30790_PANOCHE _230_BR_1 _1	$0.0	$264,875.9	$264,875.9
MALIN500	-$382,095.7	$703,411.6	$321,315.8
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	$0.0	$409,044.8	$409,044.8

Table 26: Net CRR payment by constraint - January 2017, monthly auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
23040_CROSSTRIP	-$1,769,340.9	$0.0	-$1,769,340.9
OMS 4622069 TL50003	-$312,298.1	$0.0	-$312,298.1
OMS 4583153_PATH15_S-N	-$121,071.5	$0.0	-$121,071.5
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	-$310,756.4	$197,327.1	-$113,429.3
22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1	-$62,323.8	$0.0	-$62,323.8
22865_GRNT HLL_138_22852_TELECYN _138_BR_1 _1	-$58,999.5	$0.0	-$58,999.5
22740_SANYSDRO_69.0_22608_OTAY TP_69.0_BR_1 _1	-$55,496.6	$0.0	-$55,496.6
OMS_4444156_Path15_S_N	-$48,200.7	$0.0	-$48,200.7
34874_WHEELER _70.0_34756_WHEELER _115_XF_2	-$47,149.8	$0.0	-$47,149.8
32214_RIO OSO _115_30330_RIO OSO _230_XF_2	-$34,813.3	$0.0	-$34,813.3
22596_OLD TOWN_230_22504_MISSION _230_BR_1 _1	-$31,150.3	$1,837.2	-$29,313.2
22831_SYCAMORE_138_22124_CHCARITA_138_BR_1 _1	-$20,177.5	$0.0	-$20,177.5
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$17,717.8	$0.1	-$17,717.7
35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	-$16,335.7	$0.0	-$16,335.7
30056_GATES2 _500_30060_MIDWAY _500_BR_2 _3	-$15,953.5	$0.0	-$15,953.5
MALIN500	-$316,461.7	$302,864.1	-$13,597.6
22256_ESCNDIDO_69.0_22724_SANMRCOS_69.0_BR_1 _1	-$9,586.9	$204.3	-$9,382.7
Devers NORTH BUS OUTAGE NG	-$3,608.5	$0.0	-$3,608.5
32214_RIO OSO _115_30330_RIO OSO _230_XF_1	-$3,497.7	$0.0	-$3,497.7
24085_LUGO _230_24086_LUGO _500_XF_1 _P	-$1,867.6	$0.0	-$1,867.6
32314_SMRTSVLE_60.0_32316_YUBAGOLD_60.0_BR_1 _1	$17,398.7	$0.0	$17,398.7
22773_BAY BLVD_69.0_22604_OTAY _69.0_BR_2 _1	$0.0	$23,154.4	$23,154.4
MEAD_ITC	$0.0	$28,994.8	$28,994.8
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$29,547.3	$29,547.3
PATH26_BG	$0.0	$30,534.0	$30,534.0
MEADMKTPC_ITC	$0.0	$32,932.2	$32,932.2
MKTPCADLN_ITC	$0.0	$47,489.6	$47,489.6
22468_MIGUEL _500_22472_MIGUELMP_ 1.0_XF_80	$0.0	$47,860.2	$47,860.2
IID-SCE_BG	-$18,489.9	$68,353.6	$49,863.6
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	$0.0	$57,802.4	$57,802.4
NdGrp_AGUCALG1_7_B1	$0.0	$86,411.8	$86,411.8
30040_TESLA _500_30042_METCALF _500_BR_1 _1	$0.0	$92,295.7	$92,295.7
22355_I VALLY2_230_22360_IMPRLVLY_500_XF_80	$0.0	$95,580.0	$95,580.0
PALOVRDE_ITC	$0.0	$95,930.4	$95,930.4
NdGrp_MISSION_2_N035	$0.0	$97,409.7	$97,409.7
22831_SYCAMORE_138_22832_SYCAMORE_230_XF_1	$0.0	$139,965.1	$139,965.1
NORTHGILA500_BG	$0.0	$145,443.3	$145,443.3
NOB_ITC	-$64,306.1	$239,213.1	$174,907.0
SDGE_CFEIMP_BG	$0.0	$185,696.2	$185,696.2
PATH15_S-N	-$342,401.2	$541,518.5	$199,117.2

These two tables illustrate instances of constraint misalignment between the CRR auctions and the day-ahead market. To understand this mismatch one level deeper, Table 27 lists the subset of constraints that are not binding or not enforced in the CRR monthly auction or that have a significant CRR payment. The portion that were paid only to CRRs from the annual and monthly auctions is also provided. Then it compares the average transmission limit used in the day-ahead market and the limits actually used in both the annual and monthly auctions. These are the constraints that will mostly drive the

divergence between the day-ahead and CRR markets. One of the cornerstones of the CRR market efficiency is for the CRR market to closely reflect the transmission capacity of the day-ahead market. When the transmission capacity released in the CRR market is less than that of the day-ahead market, there may be an exposure of revenue deficiency. This may also have a fair impact on the level of CRR net payments and how transmission capacity is valued in the CRR auction. This occurs because when CRRs are released in the auction process they are priced on the value of the capacity made available, or on the lack of it. A systemic issue identified during the evaluation of the CRR auction efficiency is that multiple transmission constraints are not modelled or enforced in the CRR auctions.

In cases where the constraint was enforced in the day-ahead market but not modelled or enforced in the CRR auctions, the amount of transmission capacity by means of CRRs that may be released on that constraints is effectively unbounded, which indicates that more transmission capacity may be released in the CRR auction than in the day-ahead market. This is a major problem to the efficiency of the CRR market. For the case of January 2017 and relative to other months analyzed, there were relatively few instances of constraints not enforced in the CRR auctions. In such cases the level of congestion rents and CRR payments were relatively modest, such that even with the misalignment, the financial impact was low. In further investigating why these constraints were not modelled/enforced in the CRR auctions, the common factors are related to how outages were considered and when transmission constraints were enforced in the CRR auction.

1. Constraint 23040_CROSSTRIP. It started to be enforced on December 27, 2016 due to an upgrade of procedure 7820, which required more generation to be re-dispatched in the market. By the time it was enforced in the day-ahead market, both the annual and monthly CRR auctions for January 2017 had already been run. This outage lasted less than 24 hours.
2. Constraint OMS 4622069 TL50003. The outage (4622069) that required the enforcement of this nomogram was submitted on January 27, 2017 to be effective on January 2017. By this time, the monthly CRR auction (and annual auction as well) has already run. The enforcement of this constraint required the un-enforcement of constraint 23040_CROSSTRIP.
3. Constraint OMS 4583153_PATH15_S-N. The outage (4583153) that required this nomogram to be created and enforced was submitted on 1/12/17 for start date of 1/16/17; this was to late submission to be considered in the annual and monthly auctions.
4. Constraint 22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1. The outage 4365195 was picked up in the CRR outage review but the enforcement of flowgate 22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1 was added after the CRR model cutoff. This outage lasted more than 24 hours but less than 10 days and was submitted in time.
5. Constraint 34874_WHEELER _70.0_34756_WHEELER _115_XF_2. Outage 4452779 was picked up in the CRR outage review and was set for enforcement in the January CRR model. During the process of putting it into the CRR model this

transformer was inadvertently excluded. The process picked it up correctly, but the manual data entry was missed.

6. Constraint 22740_SANYSDRO_69.0_22608_OTAY TP_69.0_BR_1 _1. Outage 4529499 submitted on 12/20 and 4563688 submitted on 1/5, both were too late to be included in CRR model. These outages lasted less than 24 hours.
7. Constraint OMS_4444156_Path15_S_N. This outage was picked up in the CRR outage review but at the time of the CRR review the market impacts were not known. Nomograms added after CRR model cutoff.
8. Constraint Devers NORTH BUS OUTAGE NG. Outage 4347088 was picked up in the CRR outage review but at the time of the CRR review the market impacts were not known. Nomogram was added after the CRR model cutoff. This outage lasted less than 24 hours and was submitted in time.

Table 27: Top constraints binding in the day-ahead market not binding in CRR market - January 2017

Constraint	Constraint Type	TOU	Payment to Annual CRR	Payments to monthly CRR	DAM limit	Annual CRR Limit	Monthly CRR Limit	Annual CRR Status	Monthly CRR Status	Reason
23040_CROSSTRIP	NOMOGRAM	ON	-$3,297,367.0	-$1,594,164.9	433.8	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
OMS 4622069 TL50003	NOMOGRAM	OFF	-$932,224.1	-$312,298.1	450.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
23040_CROSSTRIP	NOMOGRAM	OFF	-$666,026.0	-$175,176.0	435.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
OMS 4583153_PATH15_S-N	NOMOGRAM	ON	-$155,226.2	-$121,071.5	1250.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
22865_GRNT HLL_138_22852_TELECYN _138_BR_1 _1	FLOWGATE	ON	-$59,520.8	-$58,999.5	420.2	303.8	250.6	Not Binding	Not Binding	Auction economics
22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1	FLOWGATE	ON	-$37,506.3	-$62,323.8	69.6	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
34874_WHEELER _70.0_34756_WHEELER _115_XF_2	FLOWGATE	ON	-$1,214.1	-$33,285.1	70.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Missed Enforcement
35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	FLOWGATE	ON	-$70,969.9	-$16,335.7	111.4	106.0	87.4	Not Binding	Not Binding	Auction economics
32214_RIO OSO _115_30330_RIO OSO _230_XF_2	FLOWGATE	ON	$7,692.1	-$34,813.3	146.4	127.4	105.1	Not Binding	Not Binding	Auction economics
22831_SYCAMORE_138_22124_CHCARITA_138_BR_1 _1	FLOWGATE	ON	-$30,111.3	-$20,177.5	206.8	194.0	160.1	Binding	Not Binding	Auction economics
OMS_4444156_Path15_S_N	NOMOGRAM	ON	-$54,856.3	-$48,200.7	2950.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
22740_SANYSDRO_69.0_22608_OTAY TP_69.0_BR_1 _1	FLOWGATE	ON	-$35,980.2	-$55,496.6	53.6	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
24085_LUGO _230_24086_LUGO _500_XF_1 _P	FLOWGATE	ON	-$20,553.8	-$1,867.6	1326.3	1064.7	878.4	Not Binding	Not Binding	Auction economics
30056_GATES2 _500_30060_MIDWAY _500_BR_2 _3	FLOWGATE	ON	-$18,655.4	-$15,953.5	1897.3	2469.7	1514.4	Not Binding	Not Binding	Auction economics
32314_SMRTSVLE_60.0_32316_YUBAGOLD_60.0_BR_1 _1	FLOWGATE	OFF	-$30,171.4	$12,576.6	33.2	35.4	29.2	Not Binding	Not Binding	Auction economics
30300_TABLMTN _230_30066_TB MT 1M_ 1.0_XF_1	FLOWGATE	OFF	$0.0	$0.0	1118.1	1066.6	879.9	Not Binding	Not Binding	Auction economics
34874_WHEELER _70.0_34756_WHEELER _115_XF_2	FLOWGATE	OFF	-$7,047.8	-$13,864.7	70.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Missed Enforcement
31566_KESWICK _60.0_31582_STLLWATR_60.0_BR_1 _1	FLOWGATE	ON	-$17,085.7	-$1,561.6	33.5	35.4	29.2	Not Binding	Not Binding	Auction economics
32314_SMRTSVLE_60.0_32316_YUBAGOLD_60.0_BR_1 _1	FLOWGATE	ON	-$21,297.2	$4,822.1	32.4	35.4	29.2	Not Binding	Not Binding	Auction economics
31461_JESSTAP _115_31464_COTWDPGE_115_BR_1 _1	FLOWGATE	ON	-$10,224.9	-$1,509.1	76.2	75.8	62.5	Not Binding	Not Binding	Auction economics
Devers NORTH BUS OUTAGE NG	NOMOGRAM	ON	-$11,611.0	-$3,608.5	351.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage

February 2017

Table 28 summarizes the main settlements metrics for CRR performance in the month of February 2017. The sign convention is based from the CAISO's perspective; a positive value indicates the CAISO collects or has a surplus of money; a negative value indicates the CAISO pays or has a shortfall. Day-ahead congestion rents will be positive, CRR payments will be negative and auction revenues will be positive.

Table 28: Summary of CRR performance for February 2017

Metric	Amount
DA Congestion Rents	$13,909,669
Perfect Hedge	-$560,580
CRR Clawback	$64,684
CRR Payments [Auction + Allocation]	-$19,907,010
CRR Payments to Auction CRRs	-$9,749,790
CRR Payments to Monthly Auction CRRs	-$4,101,152
CRR Payments to Annual Auction CRRs	-$5,648,638
CRR Payments to Allocation CRRs	-$10,157,220
CRR Auction Revenue Monthly	$2,348,850
CRR Auction Revenue Annual	$3,286,084
Revenue Adequacy	-$6,493,237
Revenue Adequacy with Auction Revenues	-$858,303
Net payment to auction CRR	-$4,114,856

In February, the overall CRR performance was poor since there was a revenue deficiency of $6.4 million, which is the difference between all of the proceeds from day-ahead congestion rents, CRR clawback and the payments made to CRR holders. About 49 percent of the CRR payments were to CRRs originated from the annual and monthly auctions. The auction revenues represent the proceeds from selling CRRs through the auction. The revenues arising from the annual auction for each season are estimated pro-rata to each month of the calendar quarter based on the number of hours in each time of use. The net payment to auction CRRs stands for the difference between the money paid to CRR holders less the money charge to CRR holders to acquire that portfolio of CRRs in the auction. This does not take into account any expenses the CRR holders incur associated with their participation in the CRR market and use of money. This is only a net accounting balance from the point of view of the cash inflow and outflow in the CAISO system.

In order to further understand the origin of this poor performance, there is a need to estimate over time and by constraint the CRR settlements. Figure 141 shows the daily congestion rents accrued on each transmission constraint that was binding in the day-ahead market in the month of February. Correspondingly, Figure 142 shows the daily CRR revenue adequacy also broken out by transmission constraint. In February, about $2 million of revenue deficiency was accrued on the constraint *7820_TL23040_IV_SPS_NG*. This constraint was added to the CRR model in February but was called

23040_CROSSTRIP_NG when it was first set up and was later changed to *7820_TL23040_IV_SPS_NG.* The Crosstrip constraint alone accrued about $0.5 million of revenue deficiency in February.

Figure 141: Daily Congestion rents - February 2017

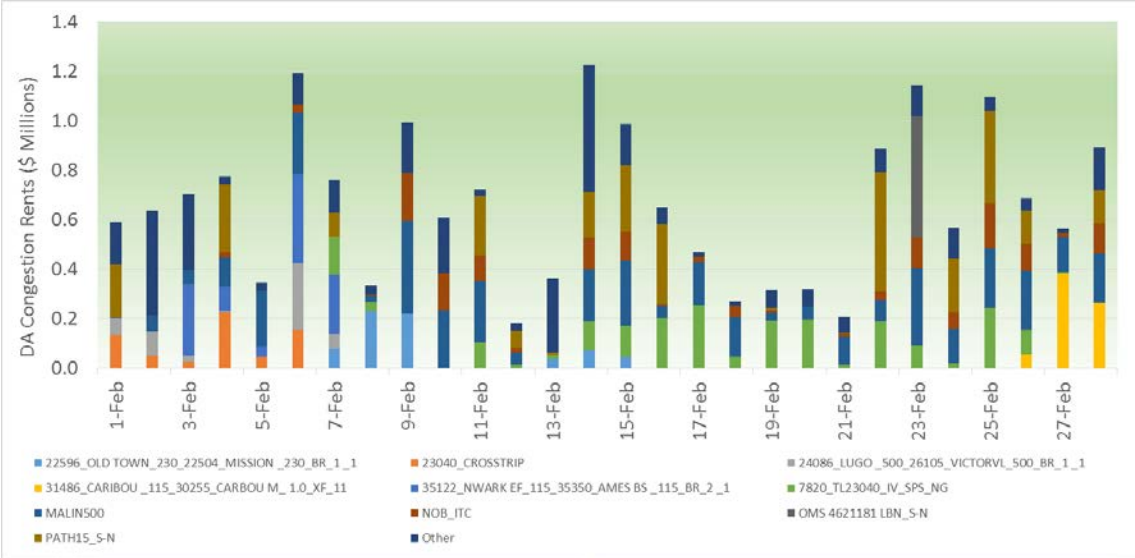


Figure 142: Daily CRR revenue adequacy - February 2017

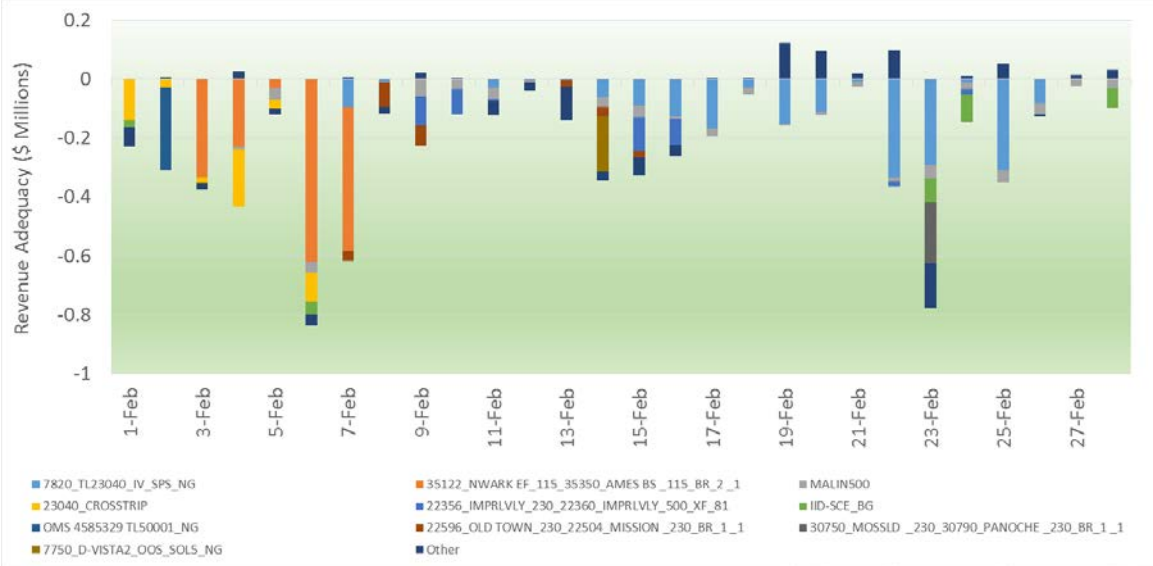


Figure 143 shows the net CRR payment per day. This net revenue is the difference between the CRR payments to CRR holders and the auction revenues collected by the CAISO through the CRR auction process; such revenues become a lump revenue for the auction. For this metric, the annual auction revenues are allocated on a pro-rata estimation to each day of the month based on the number of hours in each time of use. The CRR payments are estimated as the total sum of CRR payments over the hours of the day only for CRRs that were released through both the annual and monthly CRR auction; that is, no CRR payments to allocated CRRs are included. The purpose of this estimate for

net CRR payments is to calculate the net balance for CRR that were auction. For February, there was a persistent negative net CRR payment, indicating that overall the money paid to CRR holders was higher than the money the CAISO collected when releasing such CRRs in the annual and monthly auctions.

Figure 143: Daily net CRR payment to auction CRRs – February 2017

As shown in Figure 144 , there is a strong correlation between the level of CRR revenue deficiency and the level of net CRR payments paid to holders of CRRs released in the auction processes. This is not surprising since both metrics reflect to some extent the effect of CRRs released (and priced) in the CRR auction and the capacity released (and priced) in the day-ahead market. A negative value for CRR revenue adequacy represents a shortfall for the CAISO, while a negative value for net CRR payment represents a payment to holders of auction CRRs from the CAISO, meaning the CAISO paid more to auction CRRs than it charged to release CRRs in the auction process.

Figure 144: Comparison of daily net CRR payment with CRR revenue adequacy – February 2017

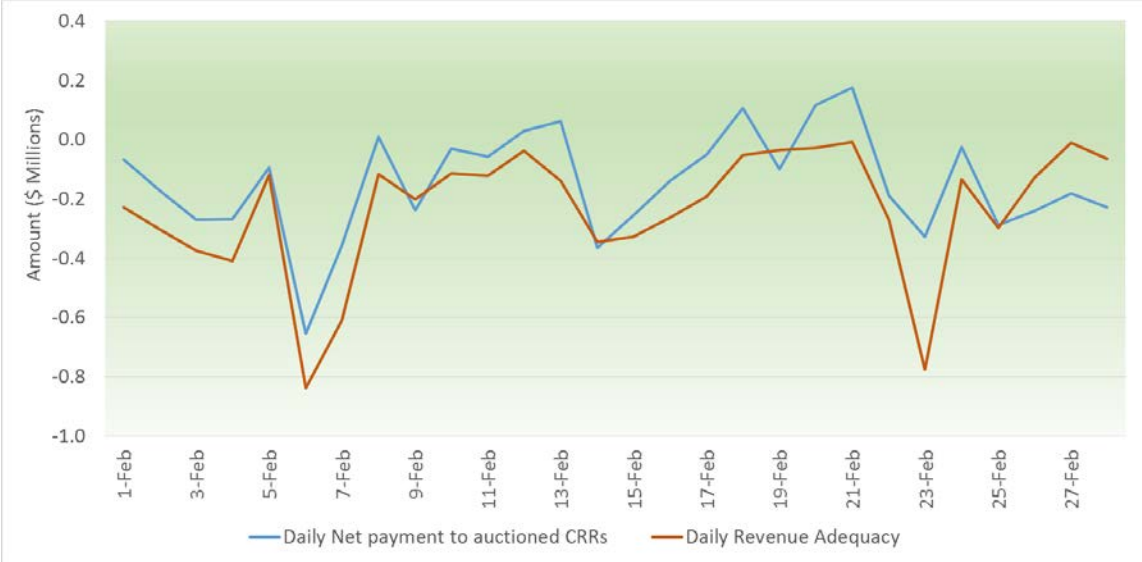
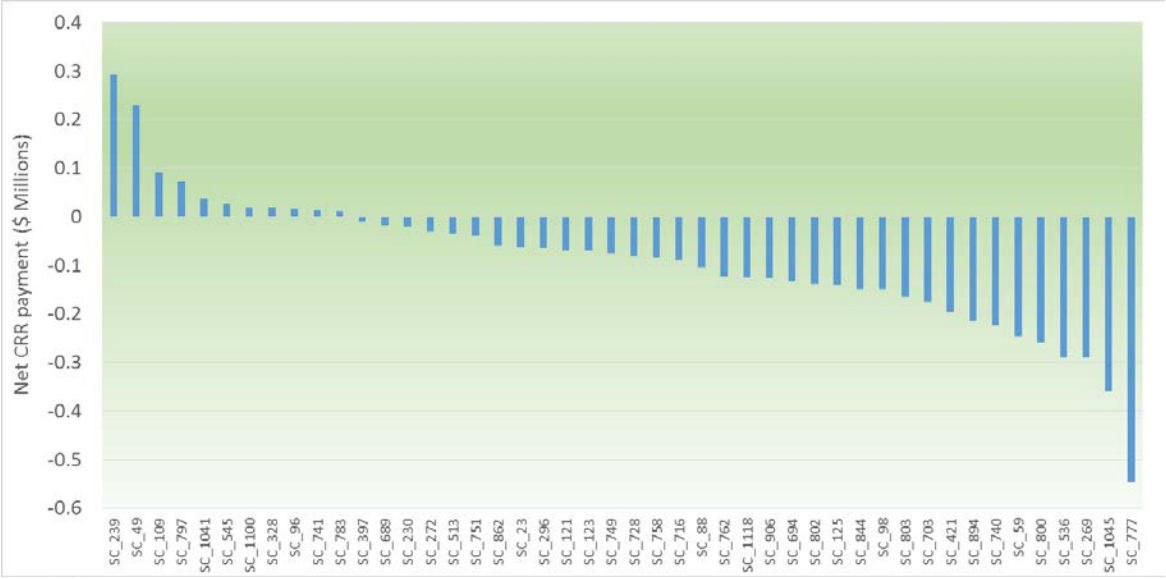


Figure 145 shows the net CRR payments to CRR participants, regardless of the type of participant. This only reflects the payments for CRRs released in both the annual and monthly CRR auctions applicable for the month of February 2017. Since this is from the CAISO's perspective, a negative value means the CAISO disbursed a net CRR payment to the CRR holder (or a net money inflow to the CRR holder). The names of the CRR holders are masked, but the identifier shown in the plot is unique across all the months provided in this analysis. A positive value represents a net inflow for the CAISO since it settled less to CRR holders in the day-ahead market than what it charged to release CRRs in the auction. For February, the majority of holders of auction CRRs saw a net gain from having these positions.

Figure 145: Net CRR payment to auction CRR – February 2017



To better understand the dynamics leading to such an outcome, the CAISO shifted the analysis to the fundamentals of the CRR auction construct by analyzing the CRR auction results at the constraint level. CRRs are released and priced based on the CRR clearing prices; such prices are derived as the relative difference between locational prices between the source and the sink locations. These locational prices originate from the cleared prices when any transmission constraint becomes binding with nonzero pries in the CRR auction, commonly referred as *shadow prices*. The CAISO turned out to analyze what constraints have been binding in the CRR auction process and compared that with the set of constraints that were binding in the day-ahead market. To some extent, one expects that there is a certain level of alignment between the markets.

Figure 146 and Figure 147 show a comparison of net CRR payments. The CRR payments reflect the CRR settlements for CRRs with day-ahead congestion rents, while the CRR auction revenues is the money the CAISO collected from releasing CRRs through the auctions. That is, it reflects the net money participants were charged to acquire CRRs and the money they were paid; in a loose sense, it could be interpreted as profits for holding.

There are four possible permutations to analyze. The first case represents when a CRR payment to CRR holders was made in the day-ahead market settlement, but the CAISO did not collect any revenues from releasing these CRRs from the auctions because the constraint was not binding in the CRR auction. This is shown for both the pro-rata portion of the annual auction for January and for the monthly CRR auction. A negative value indicates that the CAISO had a net CRR payment to CRR holders. The second case is the opposite in which there was no CRR payments when settling CRRs in the day-ahead market but the CAISO collected revenue when releasing these CRRs in the auction process. The third and fourth cases are for CRRs that had a CRR payment in the day-ahead market and the CAISO also charged them in the CRR auctions to release these CRRs. The third case is when the net CRR payment is negative, while the fourth case is when the net CRR payment is positive. This metric reveals any potential misalignment of constrains enforced and binding between the day-ahead market and CRR auctions.

Figure 146: CRR payment versus CRR auction revenues for annual CRR - February 2017

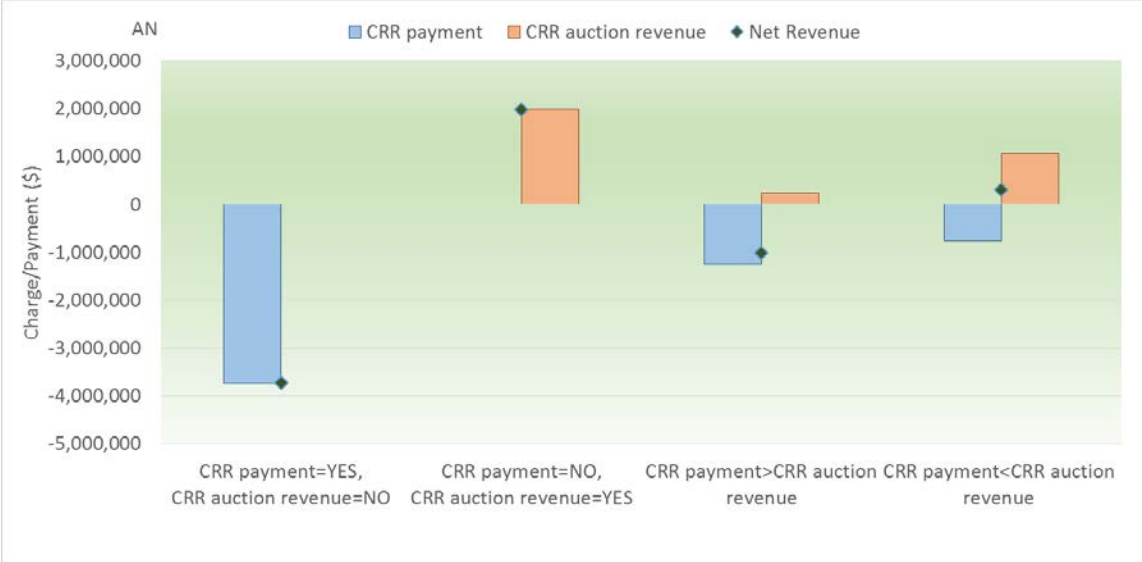


Figure 147: CRR payment versus CRR auction revenues for monthly CRR - February 2017

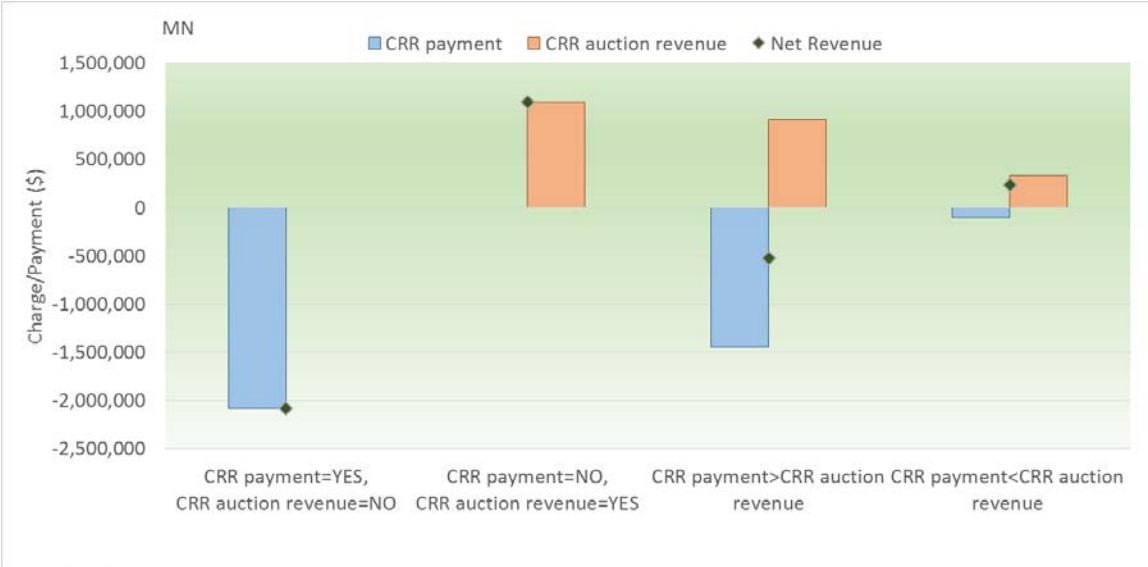


Table 29 provides one level deeper of understanding of such misalignments between markets. This tables shows the top and bottom constraints when sorted by net CRR payments. In the first column it shows the estimated CRR payment to CRR holders accrued in each constraint; the second column shows the revenues collected by the CAISO on that same constraint; the last column shows the net CRR payment, which is the balance between this money outflow (CRR payment) and money inflow (CRR auction revenues) from the CAISO's perspective. Table 30 shows the same information for CRRs released in the monthly auction February 2017. The top constraints reflect cases where large CRR payments to auction CRRs accrued when the CRR market did not collect any auction revenues when releasing these CRRs.

Table 29: Net CRR payment by constraint - February 2017, annual auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
7820_TL23040_IV_SPS_NG	-$1,156,252.8	$0.0	-$1,156,252.8
35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	-$898,747.4	$0.0	-$898,747.4
PATH15_S-N	-$876,463.7	$265,109.3	-$611,354.4
23040_CROSSTRIP	-$326,493.5	$0.0	-$326,493.5
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	-$317,575.7	$0.0	-$317,575.7
NOB_ITC	-$265,244.1	$0.0	-$265,244.1
7750_D-VISTA2_OOS_SOL5_NG	-$196,651.4	$0.0	-$196,651.4
22596_OLD TOWN_230_22504_MISSION _230_BR_1 _1	-$174,714.8	$0.0	-$174,714.8
OMS 4621181 LBN_S-N	-$159,164.8	$0.0	-$159,164.8
OMS 4585329 TL50001_NG	-$121,341.9	$0.0	-$121,341.9
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$106,403.1	$0.0	-$106,403.1
31486_CARIBOU _115_30255_CARBOU M_ 1.0_XF_11	-$52,520.8	$0.0	-$52,520.8
31658_BANGOR _60.0_32308_COLGATE _60.0_BR_1 _1	-$48,110.5	$0.0	-$48,110.5
HUMBOLDT_IMP_NG	-$57,821.8	$13,120.9	-$44,700.8
IPPUTAH_ITC	-$70,328.2	$30,755.5	-$39,572.6
7750_D-VISTA2_OOS_SOL6_NG	-$39,131.2	$0.0	-$39,131.2
OMS 4608811 MG_BK80_NG	-$35,039.7	$0.0	-$35,039.7
7820_TL 230S_OVERLOAD_NG	-$31,001.2	$0.0	-$31,001.2
OMS 4436916_PATH15_S-N	-$29,036.7	$0.0	-$29,036.7
31580_CASCADE _60.0_31581_OREGNTRL_60.0_BR_1 _1	-$20,627.2	$0.0	-$20,627.2
PATH26_BG	$0.0	$27,721.5	$27,721.5
WSTWGMEAD_ITC	$0.0	$27,953.9	$27,953.9
SYLMAR-AC_ITC	$0.0	$33,006.3	$33,006.3
IID-SDGE_ITC	$0.0	$33,234.5	$33,234.5
BLYTHE_BG	$0.0	$35,997.3	$35,997.3
MSOLAR_XFMR_BG	$0.0	$37,278.7	$37,278.7
30005_ROUND MT_500_30245_ROUND MT_230_XF_1 _P	$0.0	$38,503.9	$38,503.9
PALOVRDE_ITC	$0.0	$40,811.1	$40,811.1
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$43,702.8	$43,702.8
30523_CC SUB _230_30525_C.COSTA _230_BR_1 _1	$0.0	$51,965.9	$51,965.9
22831_SYCAMORE_138_22832_SYCAMORE_230_XF_1	$0.0	$54,037.8	$54,037.8
22456_MIGUEL _69.0_22464_MIGUEL _230_XF_2	$0.0	$67,898.1	$67,898.1
24087_MAGUNDEN_230_24153_VESTAL _230_BR_1 _1	$79,576.7	$0.0	$79,576.7
MALIN500	-$553,511.9	$645,766.4	$92,254.4
SDGE_CFEIMP_BG	$0.0	$106,370.7	$106,370.7
22828_SYCAMORE_69.0_22756_SCRIPPS _69.0_BR_1 _1	$0.0	$109,361.5	$109,361.5
22464_MIGUEL _230_22504_MISSION _230_BR_1 _1	$0.0	$121,622.2	$121,622.2
22831_SYCAMORE_138_22124_CHCARITA_138_BR_1 _1	$0.0	$122,527.7	$122,527.7
30750_MOSSLD _230_30790_PANOCHE _230_BR_1 _1	-$67,220.9	$249,365.8	$182,145.0
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	$0.0	$387,946.0	$387,946.0

Table 30: Net CRR payment by constraint - February 2017, monthly auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
31486_CARIBOU _115_30255_CARBOU M_ 1.0_XF_11	-$536,743.4	$0.0	-$536,743.4
7820_TL23040_IV_SPS_NG	-$480,755.6	$0.0	-$480,755.6
35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	-$349,222.1	$0.0	-$349,222.1
MALIN500	-$829,944.0	$547,067.4	-$282,876.6
22596_OLD TOWN_230_22504_MISSION _230_BR_1 _1	-$168,688.1	$0.0	-$168,688.1
23040_CROSSTRIP	-$148,788.7	$0.1	-$148,788.6
IID-SCE_BG	-$146,036.6	$25,198.4	-$120,838.2
7750_D-VISTA2_OOS_SOL5_NG	-$120,429.3	$0.0	-$120,429.3
OMS 4585329 TL50001_NG	-$76,276.8	$0.0	-$76,276.8
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	-$47,001.7	$0.0	-$47,001.7
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$54,083.9	$14,072.3	-$40,011.6
OMS 4621181 LBN_S-N	-$37,503.6	$0.0	-$37,503.6
OMS 4608811 MG_BK80_NG	-$24,718.7	$0.0	-$24,718.7
31658_BANGOR _60.0_32308_COLGATE _60.0_BR_1 _1	-$23,925.3	$0.0	-$23,925.3
22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1	-$20,079.0	$0.0	-$20,079.0
22865_GRNT HLL_138_22852_TELECYN _138_BR_1 _1	-$17,222.8	$0.0	-$17,222.8
31580_CASCADE _60.0_31581_OREGNTRL_60.0_BR_1 _1	-$16,126.2	$156.8	-$15,969.4
32214_RIO OSO _115_32244_BRNSWKT2_115_BR_2 _1	-$15,502.1	$0.0	-$15,502.1
7820_TL 230S_OVERLOAD_NG	-$15,500.4	$0.0	-$15,500.4
22597_OLDTWNTP_230_22504_MISSION _230_BR_1 _1	-$12,588.6	$0.0	-$12,588.6
PATH15_S-N	-$227,204.3	$245,115.3	$17,911.0
HUMBOLDT_IMP_NG	$20,035.0	$3.2	$20,038.2
NdGrp_POD_IVWEST_2_SOLAR1-APND	$0.0	$20,543.6	$20,543.6
PARKER_ITC	$0.0	$21,123.0	$21,123.0
PATH26_BG	$0.0	$23,861.5	$23,861.5
NdGrp_AGUCALG1_7_B1	$0.0	$24,623.5	$24,623.5
PALOVRDE_ITC	$0.0	$25,446.9	$25,446.9
PARKER_BG	$0.0	$25,786.2	$25,786.2
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$26,420.7	$26,420.7
WSTWGMEAD_ITC	$0.0	$27,700.1	$27,700.1
NdGrp_POD_CNTNLA_2_SOLAR1-APND	$0.0	$31,146.8	$31,146.8
22773_BAY BLVD_69.0_22604_OTAY _69.0_BR_2 _1	$0.0	$32,035.6	$32,035.6
NdGrp_POD_CPVERD_2_SOLAR-APND	$0.0	$35,317.6	$35,317.6
24087_MAGUNDEN_230_24153_VESTAL _230_BR_1 _1	$36,964.8	$1,656.5	$38,621.4
NdGrp_POD_IVSLRP_2_SOLAR1-APND	$0.0	$46,845.1	$46,845.1
IPPDCADLN_ITC	$59,194.2	$0.0	$59,194.2
30040_TESLA _500_30042_METCALF _500_BR_1 _1	$0.0	$70,485.8	$70,485.8
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	$0.0	$99,078.3	$99,078.3
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	-$89,195.7	$203,431.8	$114,236.1
NORTHGILA500_BG	$0.0	$197,695.9	$197,695.9

These two tables illustrate instances of constraint misalignment between the CRR auctions and the day-ahead market. To understand this mismatch one level deeper, Table 31 lists the subset of constraints that are not binding or not enforced in the CRR monthly auction or that have a significant CRR payment. The portion that were paid only to CRRs from the annual and monthly auctions is also provided. Then it compares the average transmission limit used in the day-ahead market and the limits actually used in

both the annual and monthly auctions. These are the constraints that will mostly drive the divergence between the day-ahead and CRR markets. One of the cornerstones of the CRR market efficiency is for the CRR market to closely reflect the transmission capacity of the day-ahead market. When the transmission capacity released in the CRR market is less than that of the day-ahead market, there may be an exposure of revenue deficiency. This may also have a fair impact on the level of CRR net payments and how transmission capacity is valued in the CRR auction. This occurs because when CRRs are released in the auction process they are priced on the value of the capacity made available, or on the lack of it. A systemic issue identified during the evaluation of the CRR auction efficiency is that multiple transmission constraints are not modelled or enforced in the CRR auctions.

In cases where the constraint was enforced in the day-ahead market but not modelled or enforced in the CRR auctions, the amount of transmission capacity by means of CRRs that may be released on that constraints is effectively unbounded, which indicates that more transmission capacity may be released in the CRR auction than in the day-ahead market. This is a major problem to the efficiency of the CRR market. For the case of February 2017 and relative to other months analyzed, there were relatively few instances of constraints not enforced in the CRR auctions. In such cases the level of congestion rents and CRR payments were relatively modest, such that even with the misalignment, the financial impact was low. In further investigating why these constraints were not modelled/enforced in the CRR auctions, the common factors are related to how outages were considered and when transmission constraints were enforced in the CRR auction.

1. Constraint 7820_TL23040_IV_SPS_NG. This constraint was added to the CRR model in February but it was called "23040_CROSSTRIP_NG" when it was first set up. It was later changed to "7820_TL23040_IV_SPS_NG" in the April CRR model.
2. Constraint OMS 4585329 TL50001_NG. Outage 4585329 received by the CAISO after CRR model cutoff date. This outage lasted less than 24 hours.
3. Constraint 31486_CARIBOU _115_30255_CARBOU M_ 1.0_XF_11. No outage associated with this line was included in the list of CRR outages. This constraint is not part of the normally enforced list from 3610B version that was used for the February 2017 CRR model.
4. Constraint 7750_D-VISTA2_OOS_SOL5_NG. For outage 4358200 the market impacts of adding this nomogram were not included in the outage card until after the CRR model cutoff date. Outage 4649742 received after CRR model cutoff date. The first outage lasted more than 24 hours but less than 10 days and was submitted in time, while the second lasted less than 24 hours.
5. Constraint OMS 4621181 LBN_S-N. Outage 4621181 received by the CAISO after CRR model cutoff date.
6. Constraint OMS 4608811 MG_BK80_NG. Outage 4608811 received by CAISO after CRR model cutoff date.
7. Constraint 22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1. All outages listed that were associated with this device (4602629, 4609444, 4614650, 4652453) were received by the CAISO after the CRR model cutoff date. This element is not part of the normally enforced list from 3610B version that was

used for the February 2017 CRR model. All outages but one lasted less than 24 hours.

8. Constraint OMS 4436916_PATH15_S-N. For outage 4436916 the market impacts of adding this nomogram were not included in the outage card until after the CRR model cutoff date. This outage lasted more than 24 hours but less than 10 days and was submitted in time.

Table 31: Top constraints binding in the day-ahead market not binding in CRR market - February 2017

Constraint	Constraint Type	TOU	Payment to Annual CRR	Payment to Monthly CRR	DAM Limit	Annual CRR Limit	Monthly CRR Limit	Annual CRR Status	Monthly CRR Status	Reason
7820_TL23040_IV_SPS_NG	NOMOGRAM	ON	$880,577.2	$376,883.3	453.4	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	FLOWGATE	ON	$854,331.6	$343,169.6	87.2	106.0	87.4	Not Binding	Not Binding	Higher Limit
22596_OLD TOWN_230_22504_MISSION _230_BR_1 _1	FLOWGATE	ON	$174,714.8	$168,688.1	510.8	433.6	357.7	Not Binding	Not Binding	Auction Economics
22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_81	FLOWGATE	ON	$317,575.7	$47,001.7	690.3	1064.7	878.4	Not Binding	Not Binding	Higher Limit
7820_TL23040_IV_SPS_NG	NOMOGRAM	OFF	$275,675.6	$103,872.3	453.1	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
OMS 4585329 TL50001_NG	NOMOGRAM	ON	$121,341.9	$76,276.8	600.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
31486_CARIBOU _115_30255_CARBOU M_ 1.0_XF_11	FLOWGATE	ON	$10,671.4	$347,211.7	95.8	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
7750_D-VISTA2_OOS_SOL5_NG	NOMOGRAM	ON	$196,651.4	$120,429.3	310.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
31486_CARIBOU _115_30255_CARBOU M_ 1.0_XF_11	FLOWGATE	OFF	$41,849.5	$189,531.8	95.5	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
OMS 4621181 LBN_S-N	NOMOGRAM	ON	$159,164.8	$37,503.6	1650.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
OMS 4608811 MG_BK80_NG	NOMOGRAM	ON	$35,039.7	$24,718.7	1333.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
34874_WHEELER _70.0_34756_WHEELER _115_XF_2	FLOWGATE	ON	-$693.3	$4,900.5	66.9	Unbounded	47.1	Not Enforced	Not Binding	Auction Economics
35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	FLOWGATE	OFF	$44,415.8	$6,052.5	84.8	106.0	87.4	Not Binding	Not Binding	Higher Limit
22865_GRNT HLL_138_22852_TELECYN _138_BR_1 _1	FLOWGATE	ON	$16,906.9	$17,222.8	419.4	303.8	250.6	Not Binding	Not Binding	Auction Economics
22208_EL CAJON_69.0_22408_LOSCOCHS_69.0_BR_1 _1	FLOWGATE	ON	$12,735.4	$20,079.0	69.6	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
7820_TL 230S_OVERLOAD_NG	NOMOGRAM	OFF	$21,089.4	$9,301.8	332.4	368.5	392.0	Not Binding	Not Binding	Higher Limit
22597_OLDTWNTP_230_22504_MISSION _230_BR_1 _1	FLOWGATE	ON	$8,804.0	$9,451.6	478.7	433.6	357.7	Not Binding	Not Binding	Auction Economics
OMS 4436916_PATH15_S-N	NOMOGRAM	ON	$29,036.7	$8,236.8	2770.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
32214_RIO OSO _115_32244_BRNSWKT2_115_BR_2 _1	FLOWGATE	ON	$2,998.5	$12,403.1	68.3	75.8	62.5	Not Binding	Not Binding	Auction Economics
22500_MISSION _138_22865_GRNT HLL_138_BR_1 _1	FLOWGATE	ON	$8,227.1	$8,633.5	401.6	295.4	243.7	Not Binding	Not Binding	Auction Economics
IPPDCADLN_ITC	INTER_TIE	ON	-$26,161.6	-$57,215.3	673.4	300.4	634.1	Not Binding	Not Binding	Auction Economics

March 2017

Table 32 summarizes the main settlements metrics for CRR performance in the month of March 2017. The sign convention is based from the CAISO's perspective; a positive value indicates the CAISO collects or has a surplus of money; a negative value indicates the CAISO pays or has a shortfall. Day-ahead congestion rents will be positive, CRR payments will be negative and auction revenues will be positive.

Table 32: Summary of CRR performance for March 2017

Metric	Amount
DA Congestion Rents	$20,755,457
Perfect Hedge	-$1,019,574
CRR Clawback	$42,736
CRR Payments [Auction + Allocation]	-$25,466,860
CRR Payments to Auction CRRs	-$10,427,145
CRR Payments to Monthly Auction CRRs	- $4,959,178
CRR Payments to Annual Auction CRRs	-$5,468,664
CRR Payments to Allocation CRRs	-$15,039,715
CRR Auction Revenue Monthly	$3,202,807
CRR Auction Revenue Annual	$3,595,627
Revenue Adequacy	-$5,688,241
Revenue Adequacy with Auction Revenues	$1,110,193
Net payment to auction CRR	-$3,628,710

In March, the overall CRR performance was poor since there was a revenue deficiency of over $5.5 million, which is the difference between all of the proceeds from day-ahead congestion rents, CRR clawback and the payments made to CRR holders. About 41 percent of the CRR payments were to CRRs originated from the annual and monthly auctions. The auction revenues represent the proceeds from selling CRRs through the auction. The revenues arising from the annual auction for each season are estimated pro-rata to each month of the calendar quarter based on the number of hours in each time of use. The net payment to auction CRRs stands for the difference between the money paid to CRR holders less the money charge to CRR holders to acquire that portfolio of CRRs in the auction. This does not take into account any expenses the CRR holders incur associated with their participation in the CRR market and use of money. This is only a net accounting balance from the point of view of the cash inflow and outflow in the CAISO system.

In order to further understand the origin of this poor performance, there is a need to estimate over time and by constraint the CRR settlements. Figure 148 shows the daily congestion rents accrued on each transmission constraint that was binding in the day-ahead market in the month of March. Correspondingly, Figure 149 shows the daily CRR revenue adequacy also broken out by transmission constraint. In March, about $3.2 million of revenue deficiency was accrued on the constraint *7820_TL23040_IV_SPS_NG*. This constraint was added to the CRR model but was called *23040_CROSSTRIP_NG* when it was first set up and was later changed to *7820_TL23040_IV_SPS_NG.* Furthermore,

about $2 million of revenue deficiency was accrued on the constraint *MALIN500*. When combined, the constraints *7820_TL23040_IV_SPS_NG* and *MALIN500*, account for approximately 90 percent of the total deficiency.

Figure 148: Daily congestion rents - March 2017

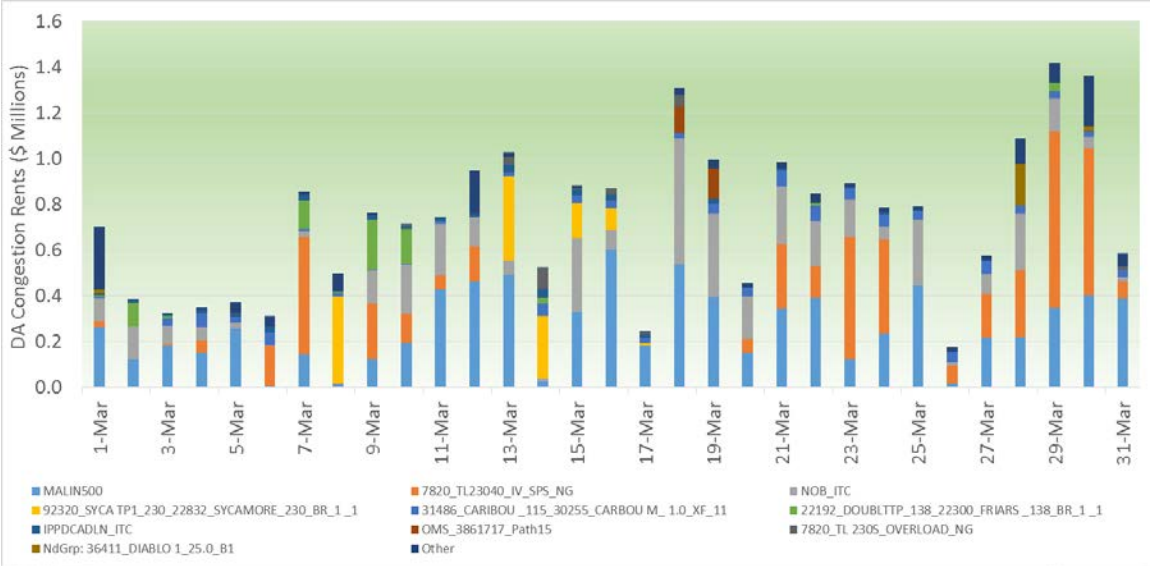


Figure 149: Daily CRR revenue adequacy - March 2017

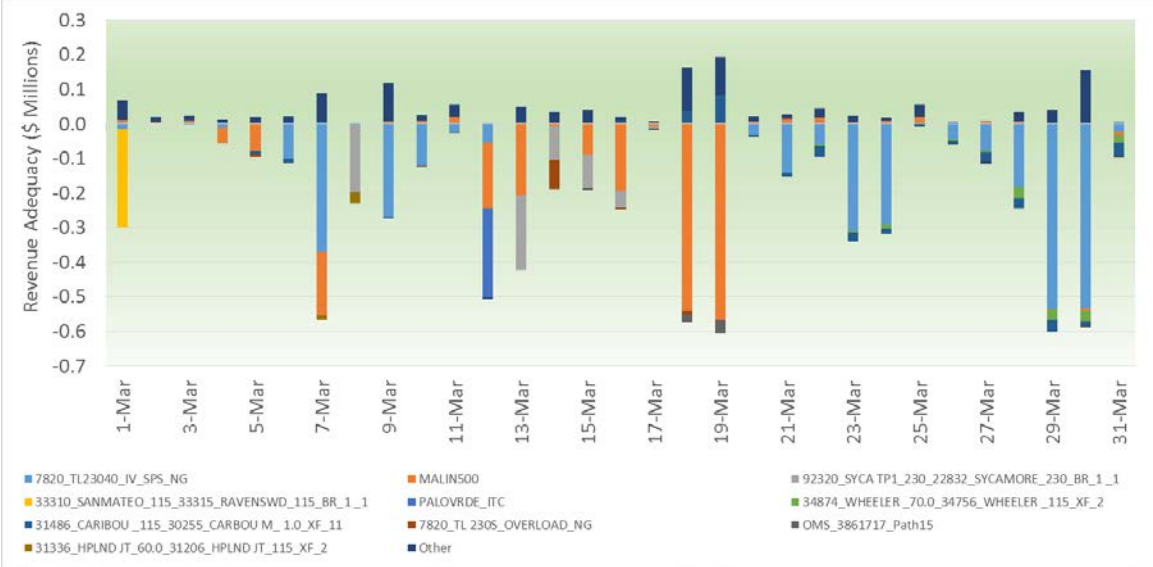
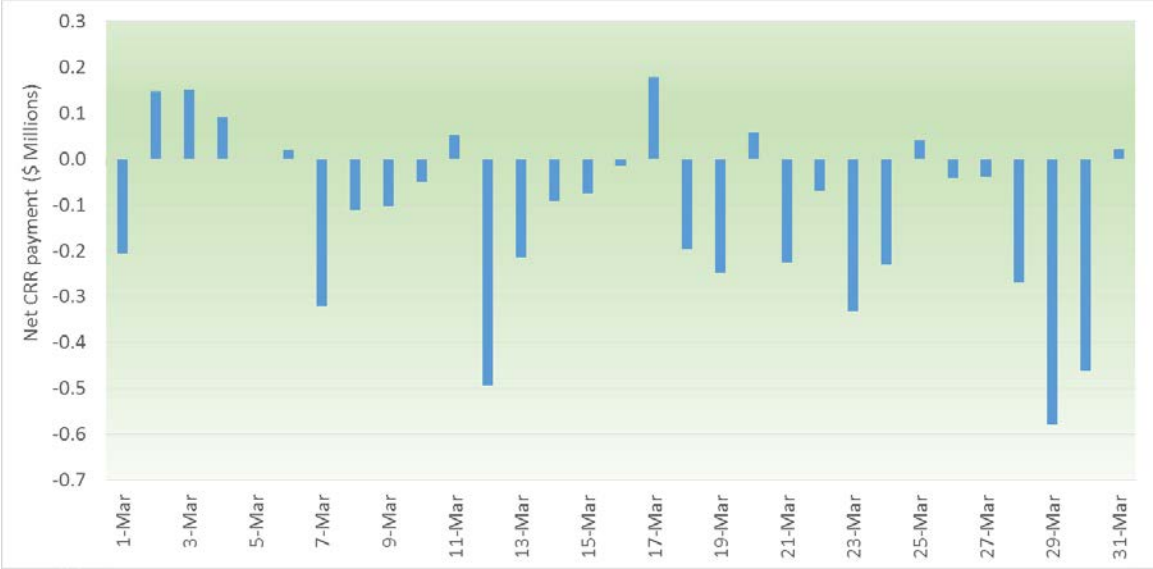


Figure 150 shows the net CRR payment per day. This net revenue is the difference between the CRR payments to CRR holders and the auction revenues collected by the CAISO through the CRR auction process; such revenues become a lump revenue for the auction. For this metric, the annual auction revenues are allocated on a pro-rata estimation to each day of the month based on the number of hours in each time of use. The CRR payments are estimated as the total sum of CRR payments over the hours of the day only for CRRs that were released through both the annual and monthly CRR auction; that is, no CRR payments to allocated CRRs are included. The purpose of this estimate for

net CRR payments is to calculate the net balance for CRR that were auction. For March, there was a persistent negative net CRR payment, indicating that overall the money paid to CRR holders was higher than the money the CAISO collected when releasing such CRRs in the annual and monthly auctions.

Figure 150: Daily net CRR payment to auction CRRs – March 2017



As shown in Figure 151, there is a strong correlation between the level of CRR revenue deficiency and the level of net CRR payments paid to holders of CRRs released in the auction processes. This is not surprising since both metrics reflect to some extent the effect of CRRs released (and priced) in the CRR auction and the capacity released (and priced) in the day-ahead market. A negative value for CRR revenue adequacy represents a shortfall for the CAISO, while a negative value for net CRR payment represents a payment to holders of auction CRRs from the CAISO, meaning the CAISO paid more to auction CRRs than it charged to release CRRs in the auction process.

Figure 151: Comparison of daily net CRR payment with CRR revenue adequacy –March 2017

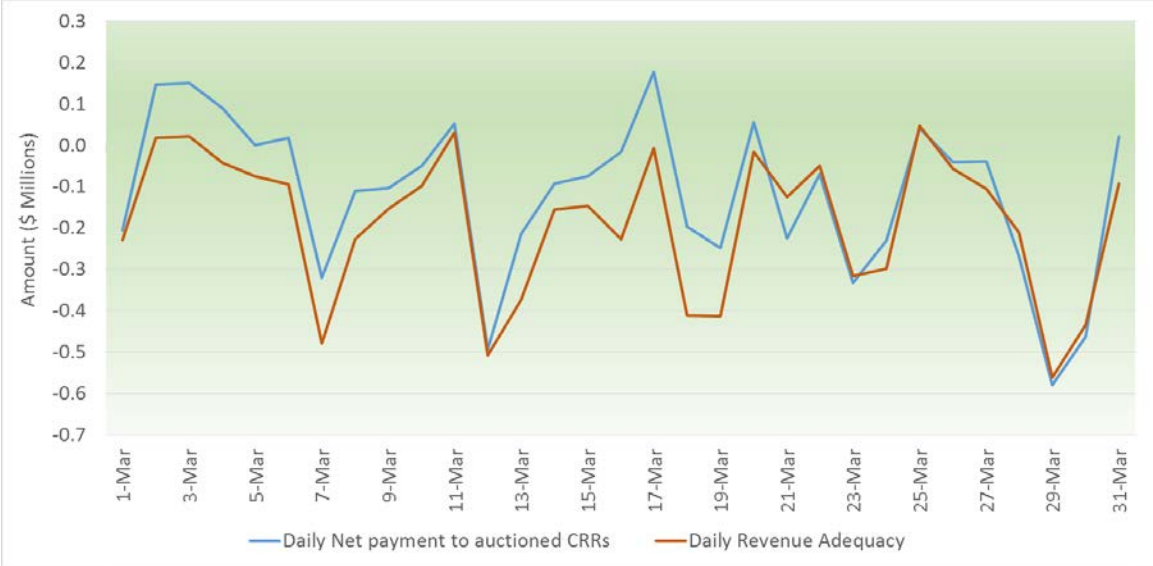
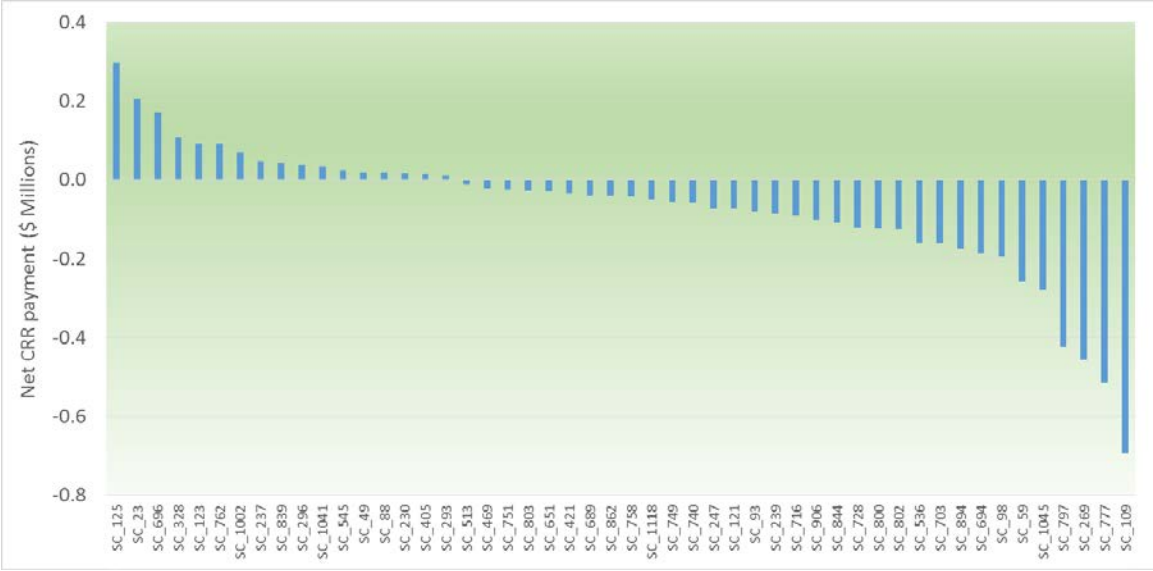


Figure 152 shows the net CRR payments to CRR participants, regardless of the type of participant. This only reflects the payments for CRRs released in both the annual and monthly CRR auctions applicable for the month of March 2017. Since this is from the CAISO's perspective, a negative value means the CAISO disbursed a net CRR payment to the CRR holder (or a net money inflow to the CRR holder). The names of the CRR holders are masked, but the identifier shown in the plot is unique across all the months provided in this analysis. A positive value represents a net inflow for the CAISO since it settled less to CRR holders in the day-ahead market than what it charged to release CRRs in the auction. For March, the majority of holders of auction CRRs saw a net gain from having these positions.

Figure 152: Net CRR payment to auction CRR –March 2017



To better understand the dynamics leading to such an outcome, the CAISO shifted the analysis to the fundamentals of the CRR auction construct by analyzing the CRR auction results at the constraint level. CRRs are released and priced based on the CRR clearing prices; such prices are derived as the relative difference between locational prices between the source and the sink locations. These locational prices originate from the cleared prices when any transmission constraint becomes binding with nonzero pries in the CRR auction, commonly referred as *shadow prices*. The CAISO turned out to analyze what constraints have been binding in the CRR auction process and compared that with the set of constraints that were binding in the day-ahead market. To some extent, one expects that there is a certain level of alignment between the markets.

Figure 153 and Figure 154 show a comparison of net CRR payments. The CRR payments reflect the CRR settlements for CRRs with day-ahead congestion rents, while the CRR auction revenues is the money the CAISO collected from releasing CRRs through the auctions. That is, it reflects the net money participants were charged to acquire CRRs and the money they were paid; in a loose sense, it could be interpreted as profits for holding.

There are four possible permutations to analyze. The first case represents when a CRR payment to CRR holders was made in the day-ahead market settlement, but the CAISO did not collect any revenues from releasing these CRRs from the auctions because the constraint was not binding in the CRR auction. This is shown for both the pro-rata portion of the annual auction for March and for the monthly CRR auction. A negative value indicates that the CAISO had a net CRR payment to CRR holders. The second case is the opposite in which there was no CRR payments when settling CRRs in the day-ahead market but the CAISO collected revenue when releasing these CRRs in the auction process. The third and fourth cases are for CRRs that had a CRR payment in the day-ahead market and the CAISO also charged them in the CRR auctions to release these CRRs. The third case is when the net CRR payment is negative, while the fourth case is when the net CRR payment is positive. This metric reveals any potential misalignment of constrains enforced and binding between the day-ahead market and CRR auctions.

Figure 153: CRR payment versus CRR auction revenues for annual CRR -March 2017

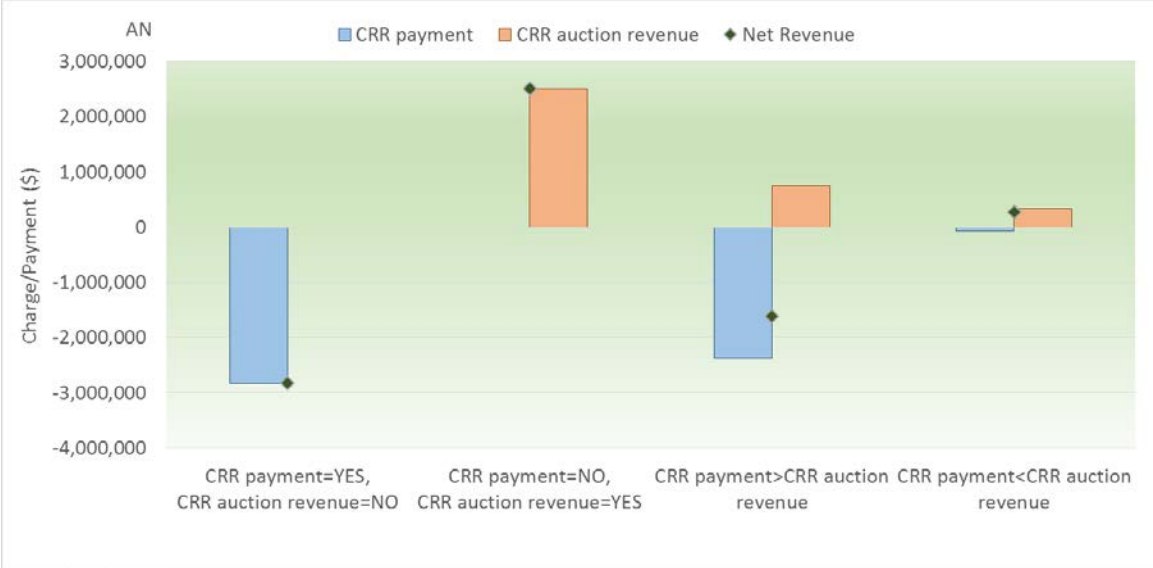


Figure 154: CRR payment versus CRR auction revenues for monthly CRR -March 2017

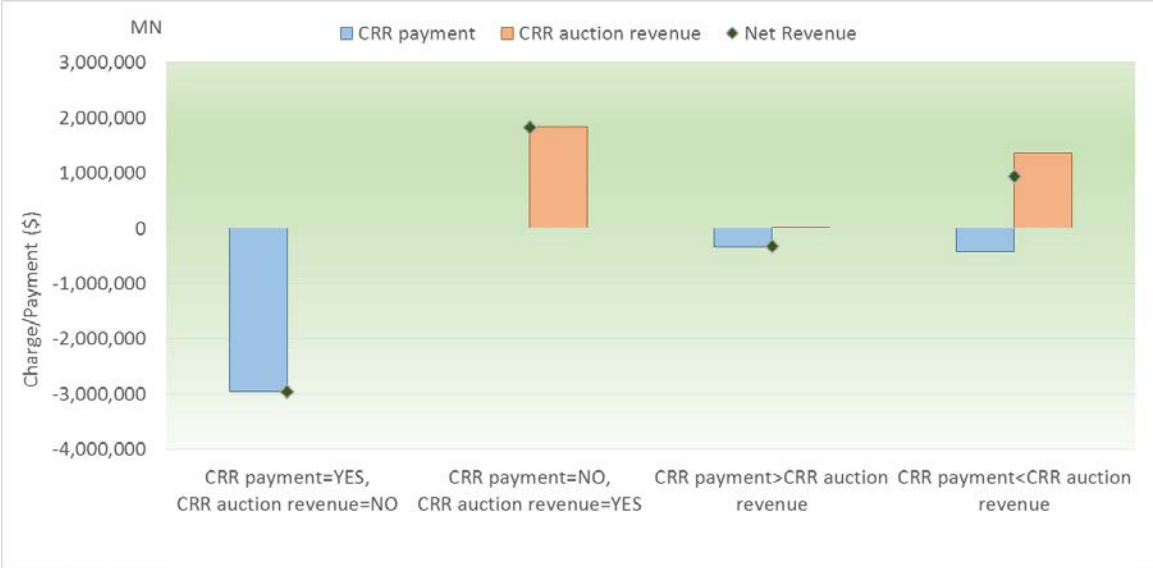


Table 33 provides one level deeper of understanding of such misalignments between markets. This tables shows the top and bottom constraints when sorted by net CRR payments. In the first column it shows the estimated CRR payment to CRR holders accrued in each constraint; the second column shows the revenues collected by the CAISO on that same constraint; the last column shows the net CRR payment, which is the balance between this money outflow (CRR payment) and money inflow (CRR auction revenues) from the CAISO's perspective. Table 34 shows the same information for CRRs released in the monthly auction for March 2017. The top constraints reflect cases where large CRR payments to auction CRRs accrued when the CRR market did not collect any auction revenues when releasing these CRRs.

Table 33: Net CRR payment by constraint - March 2017, Annual auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
7820_TL23040_IV_SPS_NG	-$2,136,802.4	$0.0	-$2,136,802.4
MALIN500	-$1,513,619.8	$707,324.5	-$806,295.3
NOB_ITC	-$728,073.6	$0.0	-$728,073.6
92320_SYCA TP1_230_22832_SYCAMORE_230_BR_1 _1	-$259,171.0	$0.0	-$259,171.0
7820_TL 230S_OVERLOAD_NG	-$98,678.7	$0.0	-$98,678.7
33310_SANMATEO_115_33315_RAVENSWD_115_BR_1 _1	-$90,212.3	$0.0	-$90,212.3
31486_CARIBOU _115_30255_CARBOU M_ 1.0_XF_11	-$65,211.2	$0.0	-$65,211.2
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$59,937.7	$0.0	-$59,937.7
31224_INDIN VL_115_31215_LUCERNJ1_115_BR_1 _1	-$57,071.5	$0.0	-$57,071.5
31336_HPLND JT_60.0_31206_HPLND JT_115_XF_2	-$48,656.6	$15,602.2	-$33,054.3
34874_WHEELER _70.0_34756_WHEELER _115_XF_2	-$29,981.5	$0.0	-$29,981.5
PALOVRDE_ITC	-$71,911.9	$44,813.0	-$27,098.9
OMS_4654659_LBN_S_N	-$17,278.6	$0.0	-$17,278.6
32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	-$11,827.1	$0.0	-$11,827.1
CASCADE_ITC	-$9,704.7	$0.0	-$9,704.7
31566_KESWICK _60.0_31582_STLLWATR_60.0_BR_1 _1	-$5,793.9	$0.0	-$5,793.9
22820_SWEETWTR_69.0_22476_MIGUELTP_69.0_BR_1 _1	-$5,257.8	$0.0	-$5,257.8
32314_SMRTSVLE_60.0_32316_YUBAGOLD_60.0_BR_1 _1	-$4,225.7	$0.0	-$4,225.7
31461_JESSTAP _115_31464_COTWDPGE_115_BR_1 _1	-$3,736.0	$0.0	-$3,736.0
31512_BIG BEN2_115_31516_WYANDJT2_115_BR_1 _2	-$2,080.4	$0.0	-$2,080.4
32950_PITSBURG_115_30527_PITSBRG _230_XF_13	$0.0	$24,766.9	$24,766.9
PATH26_BG	$0.0	$30,293.7	$30,293.7
WSTWGMEAD_ITC	$0.0	$30,631.8	$30,631.8
SYLMAR-AC_ITC	$0.0	$36,099.3	$36,099.3
IID-SDGE_ITC	$0.0	$36,361.9	$36,361.9
BLYTHE_BG	$0.0	$39,337.3	$39,337.3
MSOLAR_XFMR_BG	$0.0	$40,737.5	$40,737.5
30005_ROUND MT_500_30245_ROUND MT_230_XF_1 _P	$0.0	$42,147.0	$42,147.0
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$48,073.1	$48,073.1
30523_CC SUB _230_30525_C.COSTA _230_BR_1 _1	$0.0	$56,841.8	$56,841.8
22831_SYCAMORE_138_22832_SYCAMORE_230_XF_1	$0.0	$59,051.6	$59,051.6
22456_MIGUEL _69.0_22464_MIGUEL _230_XF_2	$0.0	$74,365.0	$74,365.0
SDGE_CFEIMP_BG	$0.0	$116,280.1	$116,280.1
22828_SYCAMORE_69.0_22756_SCRIPPS _69.0_BR_1 _1	$0.0	$119,585.5	$119,585.5
22464_MIGUEL _230_22504_MISSION _230_BR_1 _1	$0.0	$132,906.7	$132,906.7
22831_SYCAMORE_138_22124_CHCARITA_138_BR_1 _1	$0.0	$133,944.9	$133,944.9
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	$0.0	$147,060.1	$147,060.1
PATH15_S-N	-$64,603.5	$290,206.3	$225,602.8
30750_MOSSLD _230_30790_PANOCHE _230_BR_1 _1	$0.0	$272,681.9	$272,681.9
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	$0.0	$424,015.3	$424,015.3

Table 34: Net CRR payment by constraint - March 2017, Monthly auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
7820_TL23040_IV_SPS_NG	-$1,309,536.2	$0.0	-$1,309,536.2
31486_CARIBOU _115_30255_CARBOU M_ 1.0_XF_11	-$770,142.0	$0.0	-$770,142.0
92320_SYCA TP1_230_22832_SYCAMORE_230_BR_1 _1	-$555,159.4	$0.0	-$555,159.4
7820_TL 230S_OVERLOAD_NG	-$89,600.1	$0.0	-$89,600.1
34112_EXCHEQUR_115_34116_LE GRAND_115_BR_1 _1	-$83,690.5	$2,048.4	-$81,642.1
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$72,559.8	$46.1	-$72,513.7
33310_SANMATEO_115_33315_RAVENSWD_115_BR_1 _1	-$71,928.3	$0.0	-$71,928.3
IPPDCADLN_ITC	-$27,179.8	$0.0	-$27,179.8
31512_BIG BEN2_115_31516_WYANDJT2_115_BR_1 _2	-$24,957.9	$0.0	-$24,957.9
32228_PLACER _115_32238_BELL PGE_115_BR_1 _1	-$19,269.3	$0.0	-$19,269.3
32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	-$15,337.7	$0.0	-$15,337.7
32314_SMRTSVLE_60.0_32316_YUBAGOLD_60.0_BR_1 _1	-$17,835.4	$2,758.9	-$15,076.4
IPPUTAH_ITC	-$9,694.6	$0.1	-$9,694.4
22820_SWEETWTR_69.0_22476_MIGUELTP_69.0_BR_1 _1	-$9,230.6	$0.0	-$9,230.6
33541_AEC_TP1 _115_33540_TESLA _115_BR_1 _1	-$8,550.3	$0.0	-$8,550.3
OMS_4654659_LBN_S_N	-$8,383.7	$0.0	-$8,383.7
31580_CASCADE _60.0_31581_OREGNTRL_60.0_BR_1 _1	-$6,442.8	$0.0	-$6,442.8
31224_INDIN VL_115_31215_LUCERNJ1_115_BR_1 _1	-$6,208.4	$0.0	-$6,208.4
34548_KETTLEMN_70.0_34552_GATES _70.0_BR_1 _1	-$1,970.4	$0.0	-$1,970.4
CASCADE_ITC	-$1,489.7	$0.0	-$1,489.7
NdGrp_POD_CNTNLA_2_SOLAR1-APND	$0.0	$25,738.5	$25,738.5
WSTWGMEAD_ITC	$0.0	$28,925.6	$28,925.6
COTPISO_ITC	$29,260.2	$1,062.1	$30,322.3
NdGrp_POD_CPVERD_2_SOLAR-APND	$0.0	$34,309.7	$34,309.7
NdGrp_POD_DOUBLC_1_UNITS-APND	$0.0	$38,922.6	$38,922.6
CASCADE_BG	$0.0	$39,778.6	$39,778.6
22828_SYCAMORE_69.0_22756_SCRIPPS _69.0_BR_1 _1	$0.0	$42,036.8	$42,036.8
NdGrp_AGUCALG1_7_B1	$0.0	$42,188.3	$42,188.3
22596_OLD TOWN_230_22504_MISSION _230_BR_1 _1	$0.0	$44,918.7	$44,918.7
NdGrp_POD_IVSLRP_2_SOLAR1-APND	$0.0	$48,263.1	$48,263.1
30750_MOSSLD _230_30790_PANOCHE _230_BR_1 _1	$0.0	$49,640.0	$49,640.0
IID-SCE_BG	$0.0	$53,969.9	$53,969.9
NdGrp_POD_IVWEST_2_SOLAR1-APND	$0.0	$63,447.8	$63,447.8
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	$0.0	$71,753.1	$71,753.1
30040_TESLA _500_30042_METCALF _500_BR_1 _1	$0.0	$84,381.2	$84,381.2
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	$0.0	$89,673.7	$89,673.7
NORTHGILA500_BG	$0.0	$127,911.0	$127,911.0
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	$0.0	$217,604.1	$217,604.1
NOB_ITC	-$486,329.4	$844,821.9	$358,492.5
PATH15_S-N	$3,272.0	$511,517.2	$514,789.2

These two tables illustrate instances of constraint misalignment between the CRR auctions and the day-ahead market. To understand this mismatch one level deeper, Table 35 lists the subset of constraints that are not binding or not enforced in the CRR monthly auction or that have a significant CRR payment. The portion that were paid only to CRRs from the annual and monthly auctions is also provided. Then it compares the average transmission limit used in the day-ahead market and the limits actually used in both the annual and monthly auctions. These are the constraints that will mostly drive the divergence between the day-ahead and CRR markets. One of the cornerstones of the CRR

market efficiency is for the CRR market to closely reflect the transmission capacity of the day-ahead market. When the transmission capacity released in the CRR market is less than that of the day-ahead market, there may be an exposure of revenue deficiency. This may also have a fair impact on the level of CRR net payments and how transmission capacity is valued in the CRR auction. This occurs because when CRRs are released in the auction process they are priced on the value of the capacity made available, or on the lack of it. A systemic issue identified during the evaluation of the CRR auction efficiency is that multiple transmission constraints are not modelled or enforced in the CRR auctions.

In cases where the constraint was enforced in the day-ahead market but not modelled or enforced in the CRR auctions, the amount of transmission capacity by means of CRRs that may be released on that constraints is effectively unbounded, which indicates that more transmission capacity may be released in the CRR auction than in the day-ahead market. This is a major problem to the efficiency of the CRR market. For the case of March 2017 and relative to other months analyzed, there were relatively few instances of constraints not enforced in the CRR auctions. In such cases the level of congestion rents and CRR payments were relatively modest, such that even with the misalignment, the financial impact was low. In further investigating why these constraints were not modelled/enforced in the CRR auctions, the common factors are related to how outages were considered and when transmission constraints were enforced in the CRR auction.

1. Constraint 7820_TL23040_IV_SPS_NG. This constraint was added to the CRR model but it was called "23040_CROSSTRIP_NG" when it was first set up. It was later changed to "7820_TL23040_IV_SPS_NG" in the April CRR model. There were several outages related to this that lasted less than 24 hours.
2. Constraint 31486_CARIBOU _115_30255_CARBOU M_ 1.0_XF_11. This constraint is normally not enforced in the market and as such it was not enforced in the CRR auctions.
3. Constraint OMS_3861717_Path15. Outage submitted before CRR cutoff date. However, OEs didn't have Path 15 limitation in initial study until PG&E submitted the outage 4710104 for related impact on PG&E RAS on 3/2/17. This outage lasted more than 24 hours but less than 10 days and was submitted in time.

Table 35: Top constraints binding in the day-ahead market not binding in CRR market - March 2017

Constraint	Constraint Type	TOU	Payments to Annual CRR	Payments to Monthly CRR	DAM Limit	Annual CRR Limit	Monthly CRR Limit	Annual CRR Status	Monthly CRR Status	Reason
7820_TL23040_IV_SPS_NG	NOMOGRAM	ON	-$1,927,414.3	-$1,219,119.6	487.2	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
92320_SYCA TP1_230_22832_SYCAMORE_230_BR_1 _1	FLOWGATE	ON	-$259,171.0	-$555,159.4	1126.5	866.9	715.2	Not Binding	Not Binding	Auction Economics
31486_CARIBOU _115_30255_CARBOU M_ 1.0_XF_11	FLOWGATE	ON	-$66,125.8	-$475,444.2	93.5	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
31486_CARIBOU _115_30255_CARBOU M_ 1.0_XF_11	FLOWGATE	OFF	$914.6	-$294,697.8	93.5	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
7820_TL23040_IV_SPS_NG	NOMOGRAM	OFF	-$209,388.1	-$90,416.6	486.8	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
7820_TL 230S_OVERLOAD_NG	NOMOGRAM	ON	-$93,986.8	-$85,974.9	350.0	370.7	392.0	Not Binding	Not Binding	Higher Limit
IPPDCADLN_ITC	INTER_TIE	ON	$29,878.8	-$32,741.1	404.0	300.4	526.6	Not Binding	Not Binding	Higher Limit
33310_SANMATEO_115_33315_RAVENSWD_115_BR_1 _1	FLOWGATE	ON	-$90,212.3	-$71,928.3	109.3	Unbounded	97.3	Not Enforced	Not Binding	Auction Economics
34874_WHEELER _70.0_34756_WHEELER _115_XF_2	FLOWGATE	ON	-$26,335.9	$15,101.7	71.9	Unbounded	47.1	Not Enforced	Not Binding	Auction Economics
OMS_3861717_Path15	NOMOGRAM	OFF	$0.0	$0.0	3300.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
OMS_3861717_Path15	NOMOGRAM	ON	$0.0	$0.0	3300.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
31512_BIG BEN2_115_31516_WYANDJT2_115_BR_1 _2	FLOWGATE	ON	-$2,080.4	-$24,957.9	75.5	75.8	62.5	Not Binding	Not Binding	Auction Economics
IPPDCADLN_ITC	INTER_TIE	OFF	-$8,934.3	$5,561.3	404.0	433.7	526.6	Not Binding	Not Binding	Higher Limit
33541_AEC_TP1 _115_33540_TESLA _115_BR_1 _1	FLOWGATE	OFF	$316.4	$399.3	180.0	184.0	151.8	Not Binding	Not Binding	Auction Economics
31224_INDIN VL_115_31215_LUCERNJ1_115_BR_1 _1	FLOWGATE	ON	-$57,071.5	-$6,208.4	98.6	113.6	93.7	Not Binding	Not Binding	Auction Economics
34112_EXCHEQUR_115_34116_LE GRAND_115_BR_1 _1	FLOWGATE	ON	$2,100.5	-$38,337.8	107.5	97.3	80.3	Not Binding	Not Binding	Auction Economics
32228_PLACER _115_32238_BELL PGE_115_BR_1 _1	FLOWGATE	ON	$5,962.9	-$13,507.6	111.3	113.6	93.7	Not Binding	Not Binding	Auction Economics
22820_SWEETWTR_69.0_22476_MIGUELTP_69.0_BR_1 _1	FLOWGATE	ON	-$5,257.8	-$9,230.6	106.3	Unbounded	76.5	Not Enforced	Not Binding	Auction Economics
32228_PLACER _115_32238_BELL PGE_115_BR_1 _1	FLOWGATE	OFF	$351.2	-$5,761.7	111.6	113.6	93.7	Not Binding	Not Binding	Auction Economics
34874_WHEELER _70.0_34756_WHEELER _115_XF_2	FLOWGATE	OFF	-$3,645.6	-$1,594.5	71.9	Unbounded	47.1	Not Enforced	Not Binding	Auction Economics
33541_AEC_TP1 _115_33540_TESLA _115_BR_1 _1	FLOWGATE	ON	$19,035.6	-$8,949.6	179.9	184.0	151.8	Binding	Not Binding	Auction Economics
MALIN500	INTER_TIE	OFF	-$794,507.0	$28,284.5	2033.1	1926.4	2151.4	Binding	Binding	Higher Limit
NOB_ITC	INTER_TIE	OFF	-$465,649.0	-$51,435.9	1564.0	809.3	1400.0	Binding	Binding	Auction Economics
MALIN500	INTER_TIE	ON	-$719,112.8	-$20,460.8	1919.4	1899.8	2124.8	Binding	Binding	Higher Limit
NOB_ITC	INTER_TIE	ON	-$262,424.6	-$434,893.5	1562.1	743.5	1400.0	Binding	Binding	Auction Economics

April 2017

Table 36 summarizes the main settlements metrics for CRR performance in the month of April 2017. The sign convention is based from the CAISO's perspective; a positive value indicates the CAISO collects or has a surplus of money; a negative value indicates the CAISO pays or has a shortfall. Day-ahead congestion rents will be positive, CRR payments will be negative and auction revenues will be positive.

Table 36: Summary of CRR performance for April 2017

Metric	Amount
DA Congestion Rents	$30,341,196
Perfect Hedge	-$1,347,886
CRR Clawback	$291,971
CRR Payments [Auction + Allocation]	-$33,653,859
CRR Payments to Auction CRRs	-$13,506,767
CRR Payments to Monthly Auction CRRs	- $5,865,739
CRR Payments to Annual Auction CRRs	-$7,641,384
CRR Payments to Allocation CRRs	-$20,147,092
CRR Auction Revenue Monthly	$2,939,837
CRR Auction Revenue Annual	$2,866,818
Revenue Adequacy	-$4,368,578
Revenue Adequacy with Auction Revenues	$1,438,077
Net payment to auction CRR	-$7,700,112

In April, the overall CRR performance was poor since there was a revenue deficiency of over $4 million, which is the difference between all of the proceeds from day-ahead congestion rents, CRR clawback and the payments made to CRR holders. About 40 percent of the CRR payments were to CRRs originated from the annual and monthly auctions. The auction revenues represent the proceeds from selling CRRs through the auction. The revenues arising from the annual auction for each season are estimated pro-rata to each month of the calendar quarter based on the number of hours in each time of use. The net payment to auction CRRs stands for the difference between the money paid to CRR holders less the money charge to CRR holders to acquire that portfolio of CRRs in the auction. This does not take into account any expenses the CRR holders incur associated with their participation in the CRR market and use of money. This is only a net accounting balance from the point of view of the cash inflow and outflow in the CAISO system.

In order to further understand the origin of this poor performance, there is a need to estimate over time and by constraint the CRR settlements. Figure 155 shows the daily congestion rents accrued on each transmission constraint that was binding in the day-ahead market in the month of April. Correspondingly, Figure 156 shows the daily CRR revenue adequacy also broken out by transmission constraint. In April, about $4.3 million of revenue deficiency was accrued on the constraint *6410_CP5_NG*. This constraint alone accounts for over 95 percent of the total deficiency.

Figure 155: Daily Congestion rents -April 2017

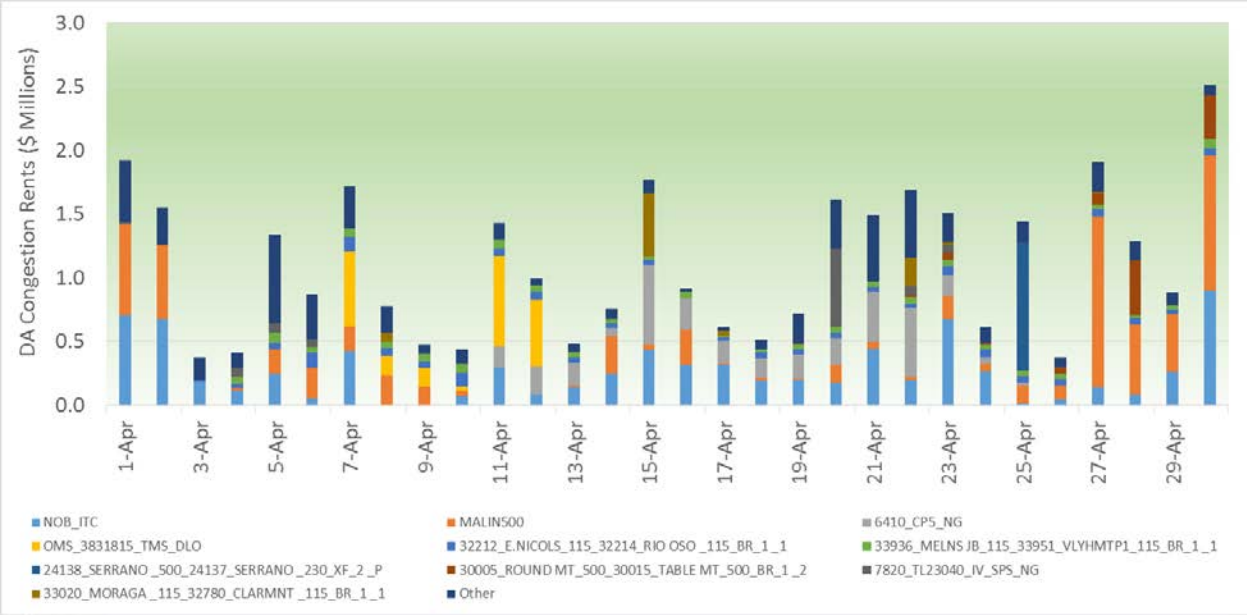


Figure 156: Daily CRR revenue adequacy -April 2017

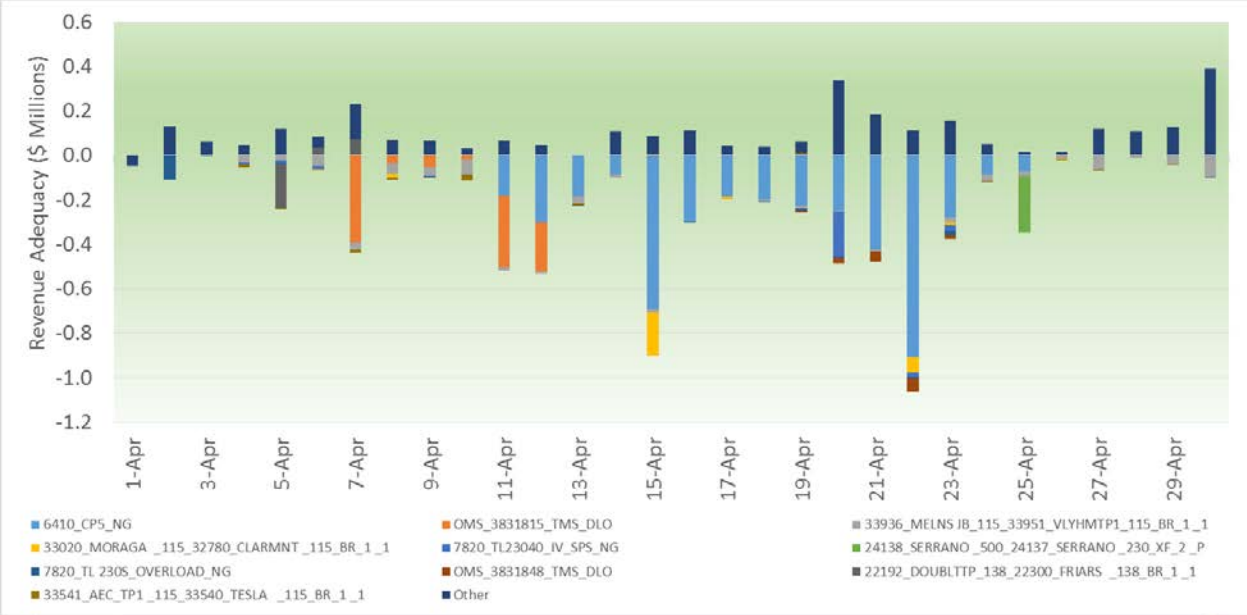
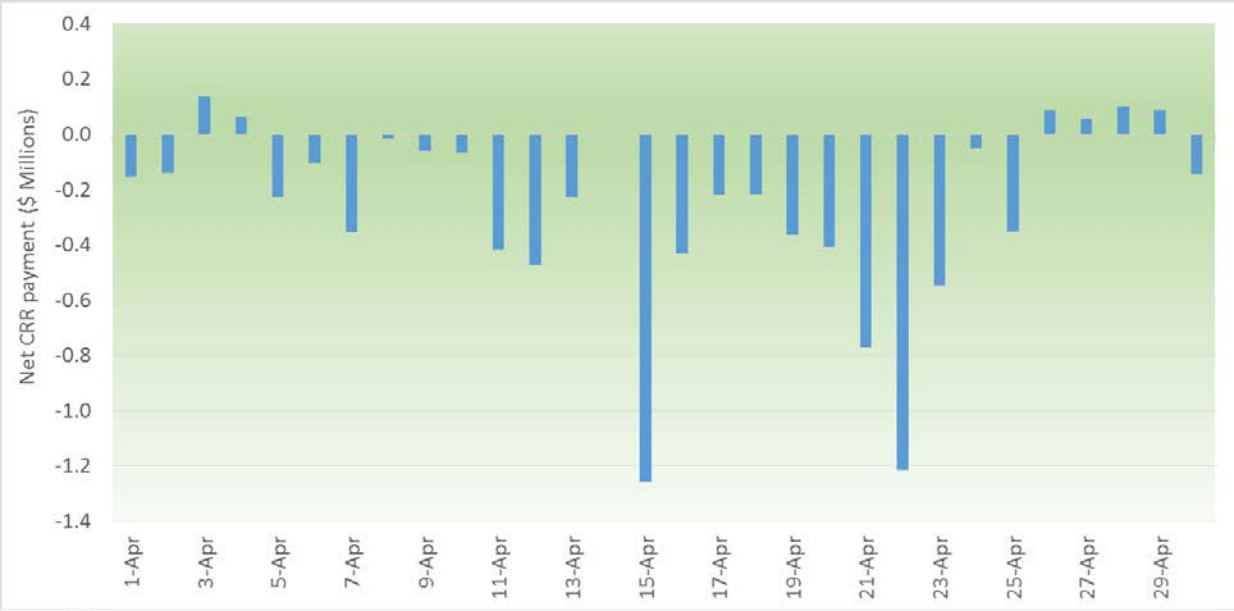


Figure 157 shows the net CRR payment per day. This net revenue is the difference between the CRR payments to CRR holders and the auction revenues collected by the CAISO through the CRR auction process; such revenues become a lump revenue for the auction. For this metric, the annual auction revenues are allocated on a pro-rata estimation to each day of the month based on the number of hours in each time of use. The CRR payments are estimated as the total sum of CRR payments over the hours of the day only for CRRs that were released through both the annual and monthly CRR auction; that is, no CRR payments to allocated CRRs are included. The purpose of this estimate for net CRR payments is to calculate the net balance for CRR that were

auction. For April, there was a persistent negative net CRR payment, indicating that overall the money paid to CRR holders was higher than the money the CAISO collected when releasing such CRRs in the annual and monthly auctions.

Figure 157: Daily net CRR payment to auction CRRs –April 2017



As shown in Figure 158, there is a strong correlation between the level of CRR revenue deficiency and the level of net CRR payments paid to holders of CRRs released in the auction processes. This is not surprising since both metrics reflect to some extent the effect of CRRs released (and priced) in the CRR auction and the capacity released (and priced) in the day-ahead market. A negative value for CRR revenue adequacy represents a shortfall for the CAISO, while a negative value for net CRR payment represents a payment to holders of auction CRRs from the CAISO, meaning the CAISO paid more to auction CRRs than it charged to release CRRs in the auction process.

Figure 158: Comparison of daily net CRR payment with CRR revenue adequacy –April 2017

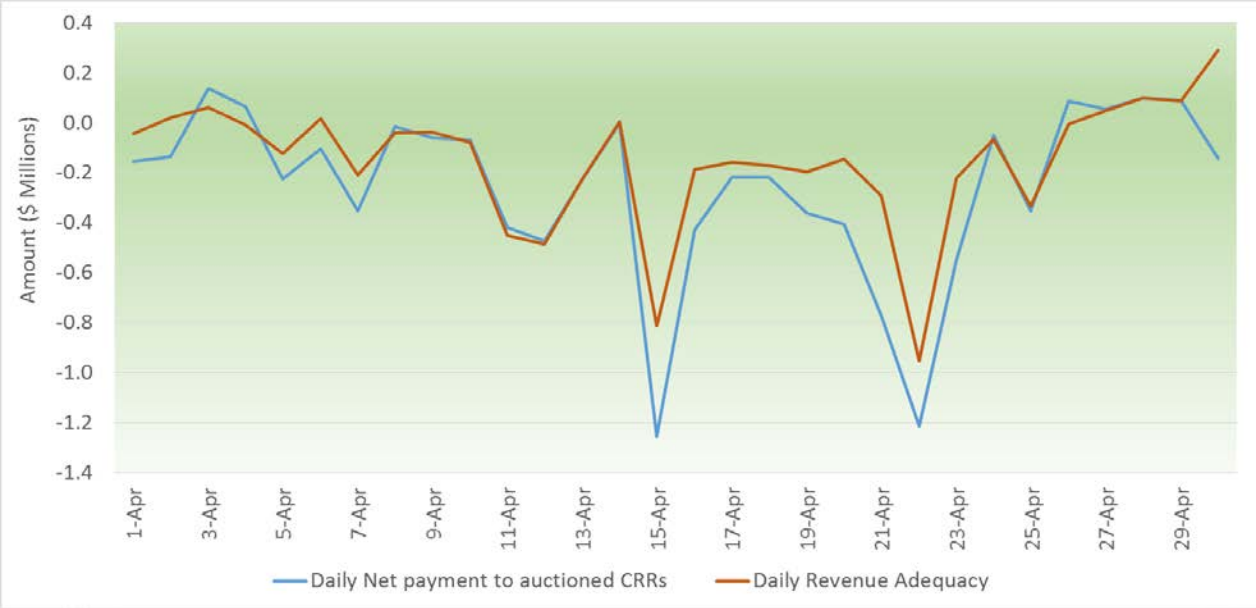
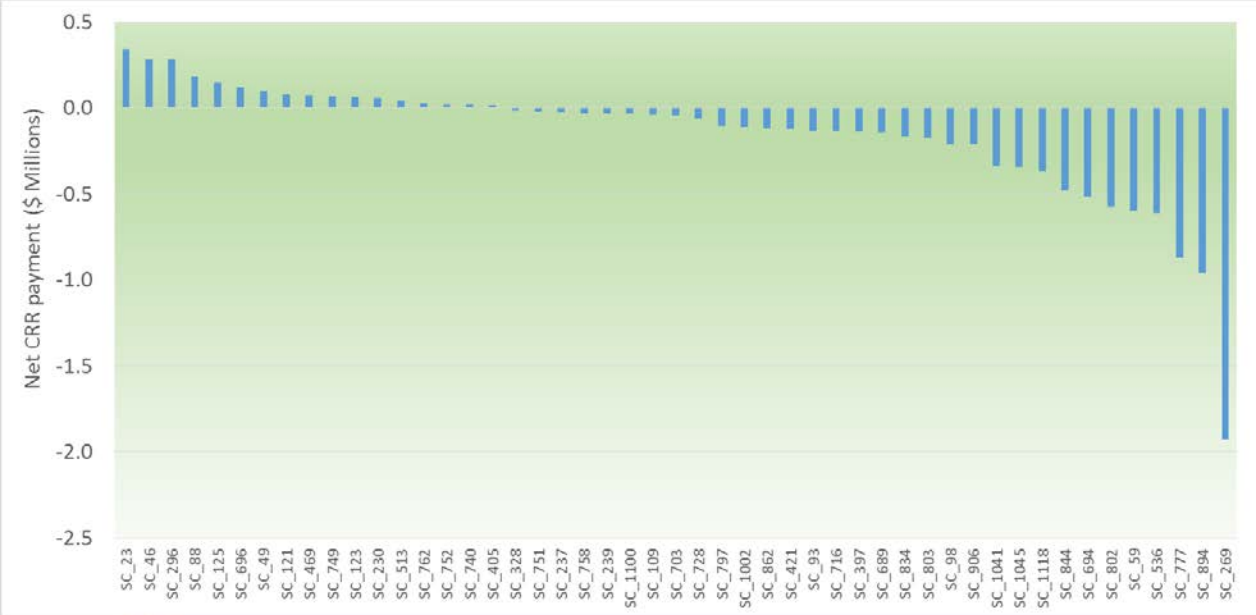


Table 159 shows the net CRR payments to CRR participants, regardless of the type of participant. This only reflects the payments for CRRs released in both the annual and monthly CRR auctions applicable for the month of April 2017. Since this is from the CAISO's perspective, a negative value means the CAISO disbursed a net CRR payment to the CRR holder (or a net money inflow to the CRR holder). The names of the CRR holders are masked, but the identifier shown in the plot is unique across all the months provided in this analysis. A positive value represents a net inflow for the CAISO since it settled less to CRR holders in the day-ahead market than what it charged to release CRRs in the auction. For April, the majority of holders of auction CRRs saw a net gain from having these positions

Figure 159: Net CRR payment to auction CRR –April 2017



To better understand the dynamics leading to such an outcome, the CAISO shifted the analysis to the fundamentals of the CRR auction construct by analyzing the CRR auction results at the constraint level. CRRs are released and priced based on the CRR clearing prices; such prices are derived as the relative difference between locational prices between the source and the sink locations. These locational prices originate from the cleared prices when any transmission constraint becomes binding with nonzero pries in the CRR auction, commonly referred as *shadow prices*. The CAISO turned out to analyze what constraints have been binding in the CRR auction process and compared that with the set of constraints that were binding in the day-ahead market. To some extent, one expects that there is a certain level of alignment between the markets.

Figure 160 and Figure 161 show a comparison of net CRR payments. The CRR payments reflect the CRR settlements for CRRs with day-ahead congestion rents, while the CRR auction revenues is the money the CAISO collected from releasing CRRs through the auctions. That is, it reflects the net money participants were charged to acquire CRRs and the money they were paid; in a loose sense, it could be interpreted as profits for holding.

There are four possible permutations to analyze. The first case represents when a CRR payment to CRR holders was made in the day-ahead market settlement, but the CAISO did not collect any revenues from releasing these CRRs from the auctions because the constraint was not binding in the CRR auction. This is shown for both the pro-rata portion of the annual auction for April and for the monthly CRR auction. A negative value indicates that the CAISO had a net CRR payment to CRR holders. The second case is the opposite in which there was no CRR payments when settling CRRs in the day-ahead market but the CAISO collected revenue when releasing these CRRs in the auction process. The third and fourth cases are for CRRs that had a CRR payment in the day-ahead market and the CAISO also charged them in the CRR auctions to release these CRRs. The third case is when the net CRR payment is negative, while the fourth case is when the net CRR payment is positive. This metric reveals any potential misalignment of constrains enforced and binding between the day-ahead market and CRR auctions.

Figure 160: CRR payment versus CRR auction revenues for annual CRR -April 2017

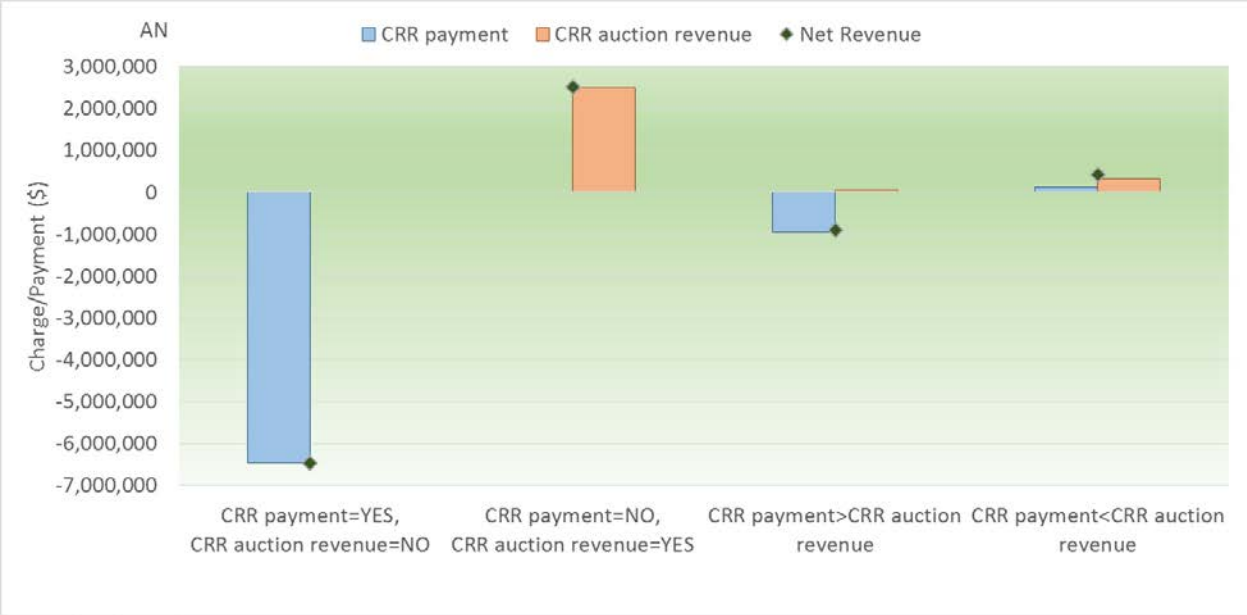


Figure 161: CRR payment versus CRR auction revenues for monthly CRR -April 2017

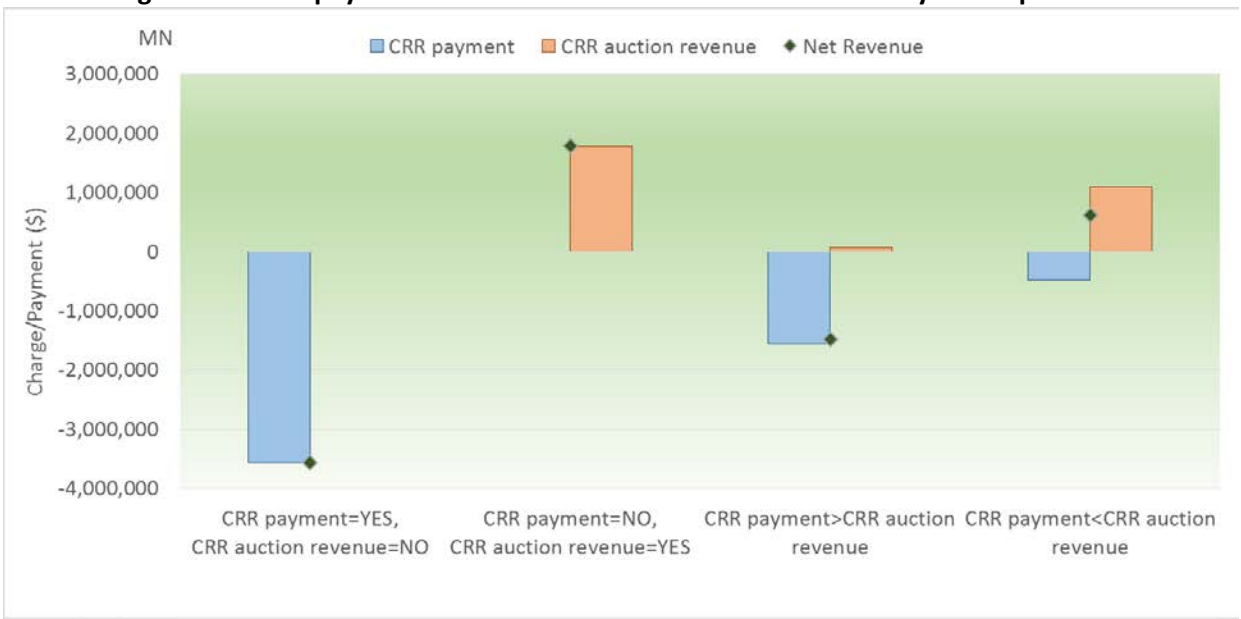


Table 37 provides one level deeper of understanding of such misalignments between markets. This tables shows the top and bottom constraints when sorted by net CRR payments. In the first column it shows the estimated CRR payment to CRR holders accrued in each constraint; the second column shows the revenues collected by the CAISO on that same constraint; the last column shows the net CRR payment, which is the balance between this money outflow (CRR payment) and money inflow (CRR auction revenues) from the CAISO's perspective. Table 38 shows the same information for CRRs released in the monthly auction for April 2017. The top

constraints reflect cases where large CRR payments to auction CRRs accrued when the CRR market did not collect any auction revenues when releasing these CRRs.

Table 37: Net CRR payment by constraint - April 2017, Annual auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
6410_CP5_NG	-$4,292,300.6	$0.0	-$4,292,300.6
32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	-$1,153,925.1	$0.0	-$1,153,925.1
34112_EXCHEQUR_115_34116_LE GRAND_115_BR_1 _1	-$397,891.1	$19,659.1	-$378,232.1
33020_MORAGA _115_32780_CLARMNT _115_BR_1 _1	-$283,926.8	$0.0	-$283,926.8
OMS_3831815_TMS_DLO	-$275,130.6	$0.0	-$275,130.6
33936_MELNS JB_115_33951_VLYHMTP1_115_BR_1 _1	-$217,608.1	$1,019.0	-$216,589.1
NOB_ITC	-$159,380.7	$0.0	-$159,380.7
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$155,303.9	$0.0	-$155,303.9
24138_SERRANO _500_24137_SERRANO _230_XF_2 _P	-$131,885.3	$0.0	-$131,885.3
7820_TL23040_IV_SPS_NG	-$129,933.7	$0.0	-$129,933.7
OMS_3831848_TMS_DLO	-$111,547.8	$0.0	-$111,547.8
32228_PLACER _115_32238_BELL PGE_115_BR_1 _1	-$104,570.6	$0.0	-$104,570.6
30005_ROUND MT_500_30015_TABLE MT_500_BR_1 _2	-$52,039.4	$0.0	-$52,039.4
7820_TL 230S_OVERLOAD_NG	-$50,379.2	$6,257.2	-$44,122.0
32218_DRUM _115_32220_DTCH FL1_115_BR_1 _1	-$39,072.5	$0.0	-$39,072.5
OMS 4673799 Devers_SBus	-$21,786.7	$0.0	-$21,786.7
33020_MORAGA _115_30550_MORAGA _230_XF_3 _P	-$21,449.3	$0.0	-$21,449.3
31336_HPLND JT_60.0_31370_CLVRDLJT_60.0_BR_1 _1	-$19,891.8	$0.1	-$19,891.8
31224_INDIN VL_115_31215_LUCERNJ1_115_BR_1 _1	-$19,780.5	$0.0	-$19,780.5
33932_MELONES _115_33936_MELNS JB_115_BR_1 _1	-$19,518.1	$0.0	-$19,518.1
34116_LE GRAND_115_34134_WILSONAB_115_BR_1 _1	$33,380.2	$909.8	$34,290.0
NdGrp_POD_CHWCHL_1_UNIT-APND	$0.0	$42,955.3	$42,955.3
30106_CARBERRY_230_30245_ROUND MT_230_BR_1 _1	$0.0	$43,871.7	$43,871.7
IPPDCADLN_ITC	$44,005.7	$0.0	$44,005.7
24156_VINCENT _500_24155_VINCENT _230_XF_4 _P	$0.0	$48,013.5	$48,013.5
24086_LUGO _500_24092_MIRALOMA_500_BR_3 _1	$0.0	$48,474.9	$48,474.9
32950_PITSBURG_115_30527_PITSBRG _230_XF_13	$0.0	$50,515.0	$50,515.0
NdGrp_AGUCALG1_7_B1	$0.0	$51,202.4	$51,202.4
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	$0.0	$68,658.5	$68,658.5
33541_AEC_TP1 _115_33540_TESLA _115_BR_1 _1	$75,049.6	$0.0	$75,049.6
22456_MIGUEL _69.0_22464_MIGUEL _230_XF_2	$0.0	$75,165.3	$75,165.3
MALIN500	$66,297.0	$9,917.1	$76,214.2
30523_CC SUB _230_30525_C.COSTA _230_BR_1 _1	$0.0	$86,832.2	$86,832.2
NdGrp_POD_INTKEP_2_UNITS-APND	$0.0	$88,398.7	$88,398.7
22831_SYCAMORE_138_22124_CHCARITA_138_BR_1 _1	$0.0	$90,990.9	$90,990.9
22828_SYCAMORE_69.0_22756_SCRIPPS _69.0_BR_1 _1	$0.0	$102,647.6	$102,647.6
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	-$7,618.1	$153,779.5	$146,161.4
22464_MIGUEL _230_22504_MISSION _230_BR_1 _1	$0.0	$197,517.6	$197,517.6
34548_KETTLEMN_70.0_34552_GATES _70.0_BR_1 _1	$224,140.9	$0.0	$224,140.9
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	$0.0	$381,657.1	$381,657.1

Table 38: Net CRR payment by constraint - April 2017, Monthly auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
6410_CP5_NG	-$2,473,332.1	$0.0	-$2,473,332.1
32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	-$491,203.7	$20,432.5	-$470,771.1
OMS_3831815_TMS_DLO	-$410,080.2	$0.0	-$410,080.2
34548_KETTLEMN_70.0_34552_GATES _70.0_BR_1 _1	-$384,199.3	$4,312.0	-$379,887.3
33541_AEC_TP1 _115_33540_TESLA _115_BR_1 _1	-$286,384.4	$24,746.5	-$261,637.9
24138_SERRANO _500_24137_SERRANO _230_XF_2 _P	-$219,725.8	$0.0	-$219,725.8
7820_TL 230S_OVERLOAD_NG	-$187,499.0	$0.0	-$187,499.0
34112_EXCHEQUR_115_34116_LE GRAND_115_BR_1 _1	-$136,619.5	$7,984.4	-$128,635.1
OMS_3831848_TMS_DLO	-$127,473.2	$0.0	-$127,473.2
32228_PLACER _115_32238_BELL PGE_115_BR_1 _1	-$103,779.3	$0.0	-$103,779.3
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$92,840.9	$7,832.6	-$85,008.3
MALIN500	-$77,025.3	$0.0	-$77,025.3
30335_ATLANTC _230_30337_GOLDHILL_230_BR_1 _1	-$56,531.6	$0.0	-$56,531.6
30005_ROUND MT_500_30015_TABLE MT_500_BR_1 _2	-$41,172.6	$0.0	-$41,172.6
31990_DAVIS _115_31962_WDLND_BM_115_BR_1 _1	-$27,974.7	$0.0	-$27,974.7
6310_CP6_NG	-$12,222.7	$0.0	-$12,222.7
NdGrp: 34546_AVENAL _70.0_B1	-$11,805.6	$0.0	-$11,805.6
NdGrp: 33506_STANISLS_115_B1	-$10,738.0	$0.0	-$10,738.0
32218_DRUM _115_32220_DTCH FL1_115_BR_1 _1	-$10,679.4	$0.0	-$10,679.4
31224_INDIN VL_115_31215_LUCERNJ1_115_BR_1 _1	-$10,672.7	$0.0	-$10,672.7
NdGrp_POD_CPVERD_2_SOLAR-APND	$0.0	$30,644.3	$30,644.3
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	-$18,724.3	$52,521.9	$33,797.5
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	$0.0	$34,160.2	$34,160.2
33936_MELNS JB_115_33951_VLYHMTP1_115_BR_1 _1	$34,499.7	$0.0	$34,499.7
NdGrp_POD_CNTNLA_2_SOLAR1-APND	$0.0	$35,245.3	$35,245.3
7820_TL23040_IV_SPS_NG	$35,779.6	$0.4	$35,780.0
NdGrp_POD_IVWEST_2_SOLAR1-APND	$0.0	$37,123.8	$37,123.8
34418_KINGSBRG_115_34405_FRWT TAP_115_BR_1 _1	$37,268.1	$0.0	$37,268.1
34410_MANCHSTR_115_34357_AIRWAYJ1_115_BR_1 _1	$40,530.5	$0.0	$40,530.5
NdGrp_POD_IVSLRP_2_SOLAR1-APND	$0.0	$41,442.8	$41,442.8
22592_OLD TOWN_69.0_22596_OLD TOWN_230_XF_2	$0.0	$46,844.3	$46,844.3
IID-SDGE_ITC	$0.0	$47,569.6	$47,569.6
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	$0.0	$54,326.3	$54,326.3
33020_MORAGA _115_32780_CLARMNT _115_BR_1 _1	$63,454.2	$795.4	$64,249.5
NdGrp_AGUCALG1_7_B1	$0.0	$82,086.3	$82,086.3
CFE_ITC	$0.0	$97,579.6	$97,579.6
NORTHGILA500_BG	$0.0	$121,315.1	$121,315.1
NOB_ITC	-$585,362.1	$752,681.4	$167,319.3
31486_CARIBOU _115_30255_CARBOU M_ 1.0_XF_11	-$19,018.0	$210,076.3	$191,058.4
PATH15_S-N	$0.0	$465,745.5	$465,745.5

These two tables illustrate instances of constraint misalignment between the CRR auctions and the day-ahead market. To understand this mismatch one level deeper, Table 39 lists the subset of constraints that are not binding or not enforced in the CRR monthly auction or that have a significant CRR payment. The portion that were paid only to CRRs from the annual and monthly auctions is also provided. Then it compares the average transmission limit used in the day-ahead market and the limits actually used in both the annual and monthly auctions. These are the constraints that will mostly drive the divergence between the day-ahead and CRR markets. One of the cornerstones of the CRR market efficiency is for the CRR market to closely reflect the transmission capacity of the day-ahead market. When the transmission capacity released in the CRR market is less than that of the day-ahead market, there may be an exposure of revenue deficiency. This may also have a fair impact on the level of CRR net payments and how transmission capacity is valued in the CRR auction. This occurs because when CRRs are released in the auction process they are priced on the value of the capacity made available, or on the lack of it. A systemic issue identified during the evaluation of the CRR auction efficiency is that multiple transmission constraints are not modelled or enforced in the CRR auctions.

In cases where the constraint was enforced in the day-ahead market but not modelled or enforced in the CRR auctions, the amount of transmission capacity by means of CRRs that may be released on that constraints is effectively unbounded, which indicates that more transmission capacity may be released in the CRR auction than in the day-ahead market. This is a major problem to the efficiency of the CRR market. For the case of April 2017 and relative to other months analyzed, there were relatively few instances of constraints not enforced in the CRR auctions. In such cases the level of congestion rents and CRR payments were relatively modest, such that even with the misalignment, the financial impact was low. In further investigating why these constraints were not modelled/enforced in the CRR auctions, the common factors are related to how outages were considered and when transmission constraints were enforced in the CRR auction.

1. Constraint 6410_CP5_NG. For April and May the CRR team was still using the 6310 SOL nomograms and PATH15_S-N and PATH26_BG constraints. The constraint 6410_CP5_NG has the same definition as PATH26_BG but has a lower limit. For April the CRR model enforced the PATH26_BG constraint instead since the nomogram definitions were not defined yet. There were two outages related to this constraint which lasted more than 10 days and were submitted in time.
2. Constraint OMS_3831815_TMS_DLO. This constraint was associated with an outage that was submitted on 03/08/16 for 3 months. It was rescheduled for multiple times with multiple overlapping outages. There were over 58 outage revisions related to this outage and constraint. This outage was modeled in the CRR model for April 2017 with the associated derate's on PACI and COTP_ISO but this specific nomogram was not added to the outage card until after the CRR model was finalized. The CRR model did enforce the normal TMS_DLO_NG constraint. This outage lasted more than 24 hours but less than 10 days.
3. Constraint OMS_3831848_TMS_DLO. This constraint was associated with an outage that was submitted on 03/08/16 for 3 months. It was rescheduled for multiple times with multiple overlapping outages. There are 58 outage revisions changing the COI limits and

Nomograms. This outage was modeled in the CRR model for April 2017 with the associated derate's on PACI and COTP_ISO but this specific nomogram was not added to the outage card until after the CRR model was finalized. The CRR model did enforce the normal TMS_DLO_NG constraint. This outage lasted more than 10 days but was not submitted in time.

4. Constraint OMS 4673799 Devers_SBus. The outage (4673794) was reviewed and added Contingency/Flowgate enforcement in the initial assessment for CRR. Once the outage got closer to scheduled date with more detail study the contingency and flowgate was replaced with the nomogram in the day-ahead market. This outage lasted less than 24 hours.

Table 39: Top constraints binding in the day-ahead market not binding in CRR market - April 2017

Constraint	Constraint Type	TOU	Payments to Annual CRR	Payments to Monthly CRR	DAM Limit	Annual CRR Limit	Monthly CRR Limit	Annual CRR Status	Monthly CRR Status	Reason
6410_CP5_NG	NOMOGRAM	OFF	-$2,597,954.2	-$1,694,229.9	1534.3	Unbounded	Unbounded	Not Enforced	Not Enforced	Missed Enforcement
6410_CP5_NG	NOMOGRAM	ON	-$1,694,346.4	-$779,102.2	1535.9	Unbounded	Unbounded	Not Enforced	Not Enforced	Missed Enforcement
OMS_3831815_TMS_DLO	NOMOGRAM	ON	-$51,112.5	-$210,730.7	291.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
OMS_3831815_TMS_DLO	NOMOGRAM	OFF	-$224,018.0	-$199,349.5	291.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
24138_SERRANO _500_24137_SERRANO _230_XF_2 _P	FLOWGATE	ON	-$131,885.3	-$219,725.8	1334.8	1064.7	878.4	Not Binding	Not Binding	Auction Economics
OMS_3831848_TMS_DLO	NOMOGRAM	OFF	-$96,273.1	-$77,159.3	298.8	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
OMS_3831848_TMS_DLO	NOMOGRAM	ON	-$15,274.6	-$50,313.9	306.4	Unbounded	Unbounded	Not Enforced	Not Enforced	Late/Missed Outage
32228_PLACER _115_32238_BELL PGE_115_BR_1 _1	FLOWGATE	ON	-$69,653.2	-$32,023.2	115.8	113.6	93.7	Not Binding	Not Binding	Auction Economics
32228_PLACER _115_32238_BELL PGE_115_BR_1 _1	FLOWGATE	OFF	-$34,917.5	-$71,756.1	115.8	113.6	93.7	Not Binding	Not Binding	Auction Economics
7820_TL 230S_OVERLOAD_NG	NOMOGRAM	ON	-$9,132.9	-$120,472.1	358.2	354.0	392.0	Not Binding	Not Binding	Higher Limit
7820_TL 230S_OVERLOAD_NG	NOMOGRAM	OFF	-$41,246.3	-$67,026.8	361.3	337.6	392.0	Binding	Not Binding	Higher Limit
30335_ATLANTC _230_30337_GOLDHILL_230_BR_1 _1	FLOWGATE	OFF	-$1,196.4	-$35,402.8	357.2	312.4	257.7	Not Binding	Not Binding	Auction Economics
33020_MORAGA _115_30550_MORAGA _230_XF_3 _P	FLOWGATE	ON	-$21,449.3	-$2,651.6	396.5	378.3	312.1	Not Binding	Not Binding	Auction Economics
30335_ATLANTC _230_30337_GOLDHILL_230_BR_1 _1	FLOWGATE	ON	-$4,628.4	-$21,128.8	370.7	312.4	257.7	Not Binding	Not Binding	Auction Economics
31990_DAVIS _115_31962_WDLND_BM_115_BR_1 _1	FLOWGATE	OFF	$6,960.7	-$25,017.0	113.5	Unbounded	93.7	Not Enforced	Not Binding	Auction Economics
OMS 4673799 Devers_SBus	NOMOGRAM	ON	-$21,786.7	-$4,130.5	351.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Missed Enforcement
22886_SUNCREST_230_92860_SUNC TP1_230_BR_1 _1	FLOWGATE	ON	-$2,473.4	-$7,160.2	1175.4	866.9	715.2	Not Binding	Not Binding	Auction Economics
31224_INDIN VL_115_31215_LUCERNJ1_115_BR_1 _1	FLOWGATE	ON	-$19,780.5	-$10,672.7	98.6	111.3	91.8	Not Binding	Not Binding	Auction Economics
31566_KESWICK _60.0_31582_STLLWATR_60.0_BR_1 _1	FLOWGATE	ON	-$9,909.5	-$809.5	26.5	24.1	19.8	Binding	Not Binding	Auction Economics
33932_MELONES _115_33936_MELNS JB_115_BR_1 _1	FLOWGATE	ON	-$16,671.9	$18,714.1	61.9	53.2	43.9	Not Binding	Not Binding	Auction Economics
31336_HPLND JT_60.0_31206_HPLND JT_115_XF_2	FLOWGATE	ON	-$8,841.7	-$3,176.3	45.0	38.0	31.4	Binding	Not Binding	Auction Economics
32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	FLOWGATE	OFF	-$508,578.4	-$186,440.0	47.5	61.5	50.7	Not Binding	Binding	Higher Limit
32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	FLOWGATE	ON	-$645,346.7	-$304,763.7	48.9	61.5	50.7	Not Binding	Binding	Higher Limit

May 2017

Table 40 summarizes the main settlements metrics for CRR performance in the month of May 2017. The sign convention is based from the CAISO's perspective; a positive value indicates the CAISO collects or has a surplus of money; a negative value indicates the CAISO pays or has a shortfall. Day-ahead congestion rents will be positive, CRR payments will be negative and auction revenues will be positive.

Table 40: Summary of CRR performance for May 2017

Metric	Amount
DA Congestion Rents	$36,479,978
Perfect Hedge	-$1,932,172
Clawback	$675,007
CRR Payments [Auction + Allocation]	-$38,362,619
CRR Payments to Auction CRRs	-$12,159,951
CRR Payments to Monthly Auction CRRs	-$5,895,609
CRR Payments to Annual Auction CRRs	-$6,264,342
CRR Payments to Allocation CRRs	-$26,202,667
CRR Auction Revenue Monthly	$2,547,111
CRR Auction Revenue Annual	$2,907,716
Revenue Adequacy	-$3,139,805
Revenue Adequacy with Auction Revenues	$2,315,022
Net payment to auction CRR	-$6,705,125

In May, the overall CRR performance was poor since there was a revenue deficiency of over $3 million, which is the difference between all of the proceeds from day-ahead congestion rents, CRR clawback and the payments made to CRR holders. About 32 percent of the CRR payments were to CRRs originating from the annual and monthly auctions. The auction revenues represent the proceeds from selling CRRs through the auction. The revenues arising from the annual auction for each season are estimated pro-rata to each month of the calendar quarter based on the number of hours in each time of use. The net payment to auction CRRs stands for the difference between the money paid to CRR holders less the money charge to CRR holders to acquire that portfolio of CRRs in the auction. This does not take into account any expenses the CRR holders incur associated with their participation in the CRR market and use of money. This is only a net accounting balance from the point of view of the cash inflow and outflow in the ISO system.

In order to further understand the origin of this poor performance, there is a need to estimate over time and by constraint the CRR settlements.

Figure 162 shows the daily congestion rents accrued on each transmission constraint that was binding in the day-ahead market in the month of May. Correspondingly, Figure 163 shows the daily CRR revenue adequacy also broken out by transmission constraint. On May 22nd, the total revenue deficiency accounted for about 41% of the entire revenue deficiency for the month.

Figure 162: Daily Congestion rents -May 2017

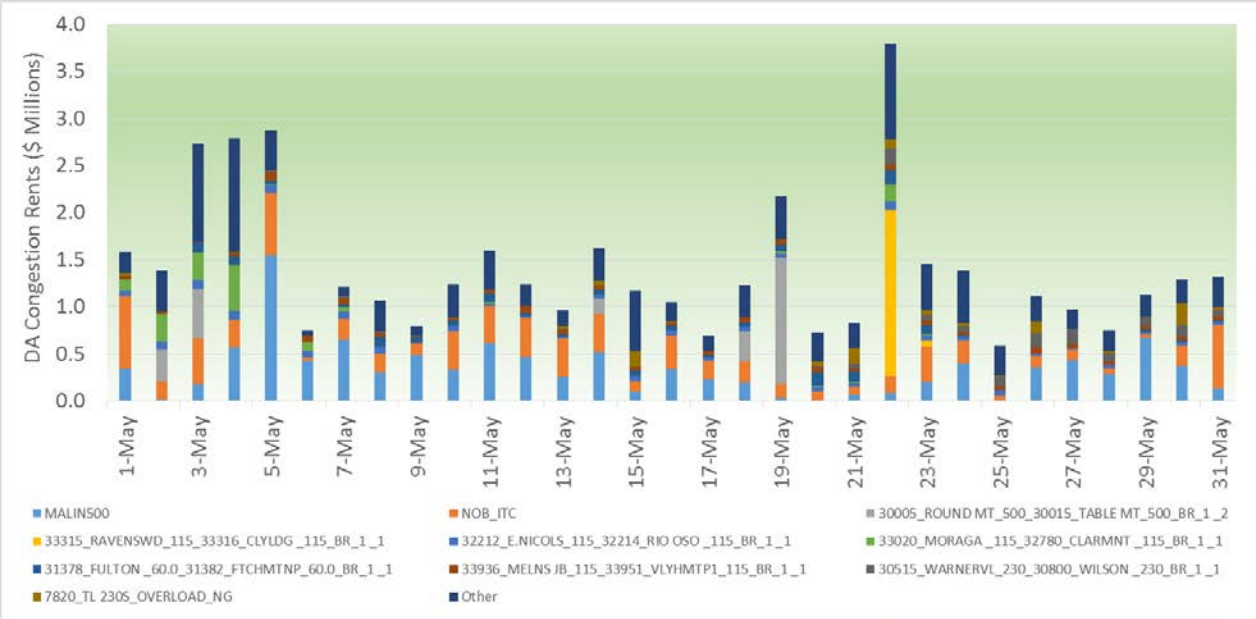


Figure 163: Daily CRR revenue adequacy -May 2017

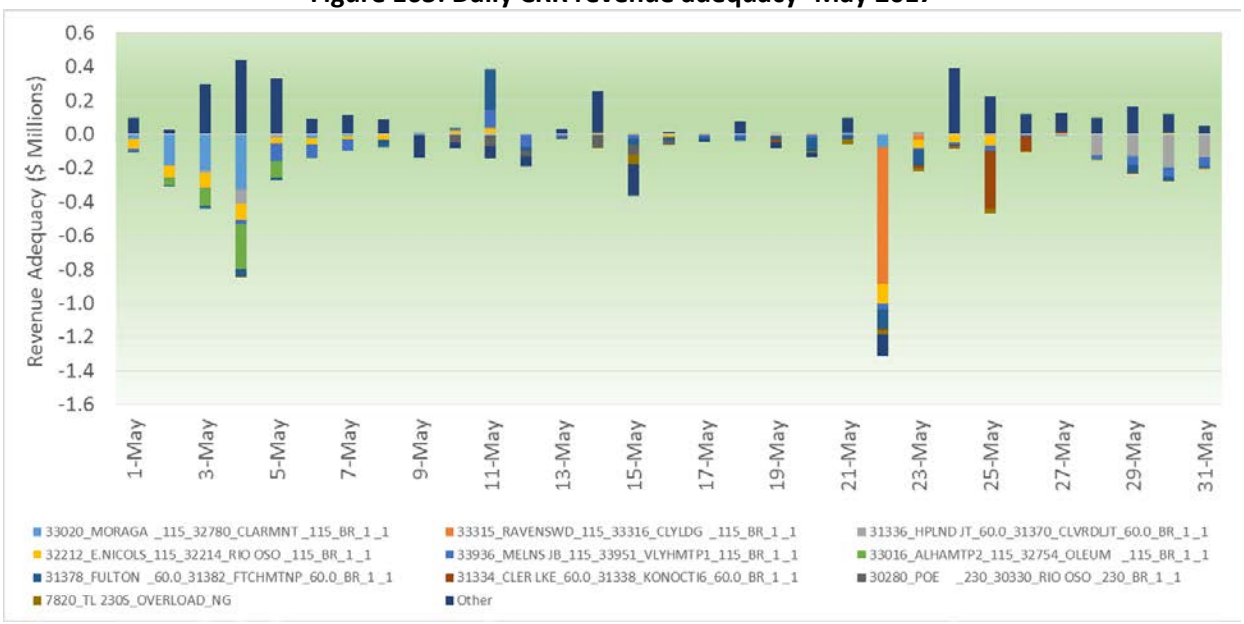
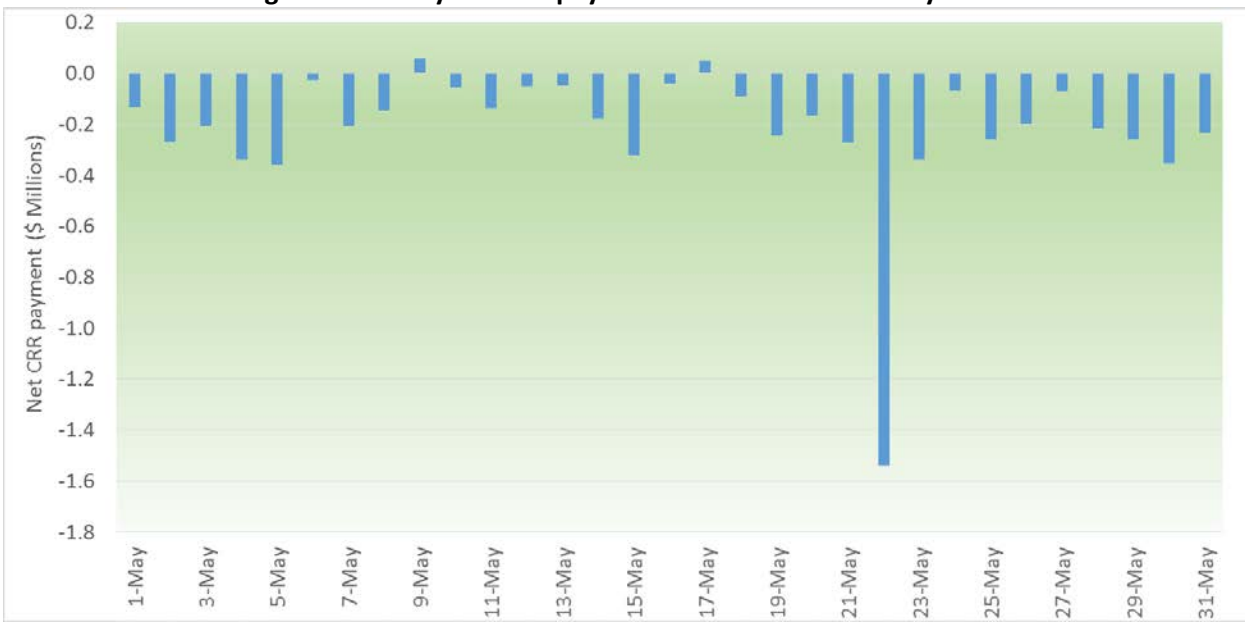


Figure 164 shows the net CRR payment per day. This net revenue is the difference between the CRR payments to CRR holders and the auction revenues collected by the CAISO through the CRR auction process; such revenues become a lump revenue for the auction. For this metric, the annual auction revenues are allocated on a pro-rata estimation to each day of the month based on the number of hours in each time of use. The CRR payments are estimated as the total sum of CRR payments over the hours of the day only for CRRs that were released through both the annual and monthly CRR auction; that is, no CRR payments to allocated CRRs are included. The

purpose of this estimate for net CRR payments is to calculate the net balance for CRR that were auction. For May, there was a persistent negative net CRR payment, indicating that overall the money paid to CRR holders was higher than the money the CAISO collected when releasing such CRRs in the annual and monthly auctions.

Figure 164: Daily net CRR payment to auction CRRs –May 2017



As shown in Figure 165 , there is a strong correlation between the level of CRR revenue deficiency and the level of net CRR payments paid to holders of CRRs released in the auction processes. This is not surprising since both metrics reflect to some extent the effect of CRRs released (and priced) in the CRR auction and the capacity released (and priced) in the day-ahead market. A negative value for CRR revenue adequacy represents a shortfall for the CAISO, while a negative value for net CRR payment represents a payment to holders of auction CRRs from the CAISO, meaning the CAISO paid more to auction CRRs than it charged to release CRRs in the auction process.

Figure 165: Comparison of daily net CRR payment with CRR revenue adequacy –May 2017

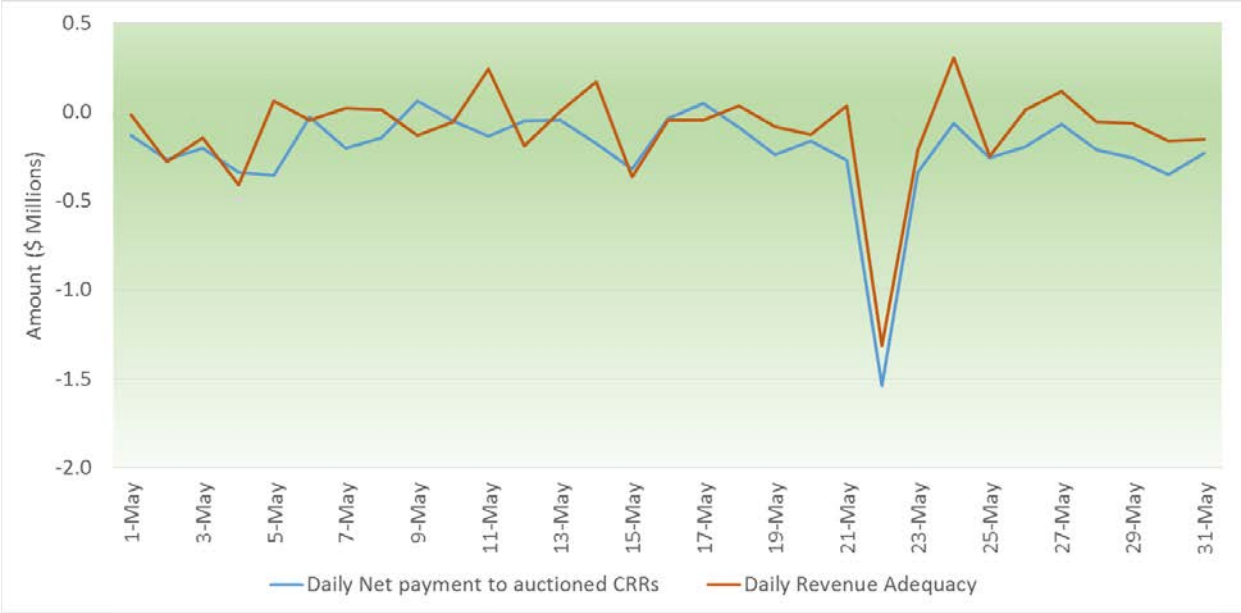
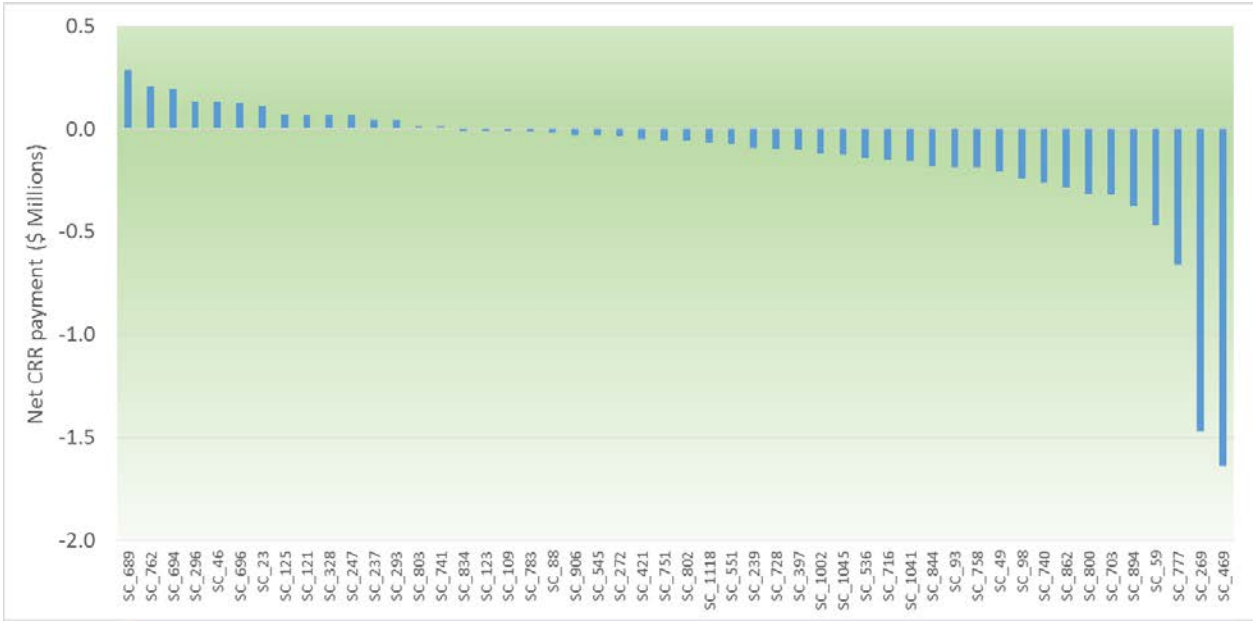


Figure 166 shows the net CRR payments to CRR participants, regardless of the type of participant. This only reflects the payments for CRRs released in both the annual and monthly CRR auctions applicable for the month of May 2017. Since this is from the CAISO's perspective, a negative value means the CAISO disbursed a net CRR payment to the CRR holder (or a net money inflow to the CRR holder). The names of the CRR holders are masked, but the identifier shown in the plot is unique across all the months provided in this analysis. A positive value represents a net inflow for the CAISO since it settled less to CRR holders in the day-ahead market than what it charged to release CRRs in the auction. For May, the majority of holders of auction CRRs saw a net gain from having these positions.

Figure 166: Net CRR payment to auction CRR –May 2017



To better understand the dynamics leading to such an outcome, the CAISO shifted the analysis to the fundamentals of the CRR auction construct by analyzing the CRR auction results at the constraint level. CRRs are released and priced based on the CRR clearing prices; such prices are derived as the relative difference between locational prices between the source and the sink locations. These locational prices originate from the cleared prices when any transmission constraint becomes binding with nonzero pries in the CRR auction, commonly referred as *shadow prices*. The CAISO turned out to analyze what constraints have been binding in the CRR auction process and compared that with the set of constraints that were binding in the day-ahead market. To some extent, one expects that there is a certain level of alignment between the markets.

Figure 167 and Figure 168 show a comparison of net CRR payments. The CRR payments reflect the CRR settlements for CRRs with day-ahead congestion rents, while the CRR auction revenues is the money the CAISO collected from releasing CRRs through the auctions. That is, it reflects the net money participants were charged to acquire CRRs and the money they were paid; in a loose sense, it could be interpreted as profits for holding.

There are four possible permutations to analyze. The first case represents when a CRR payment to CRR holders was made in the day-ahead market settlement, but the CAISO did not collect any revenues from releasing these CRRs from the auctions because the constraint was not binding in the CRR auction. This is shown for both the pro-rata portion of the annual auction for May and for the monthly CRR auction. A negative value indicates that the CAISO had a net CRR payment to CRR holders. The second case is the opposite in which there was no CRR payments when settling CRRs in the day-ahead market but the CAISO collected revenue when releasing these CRRs in the auction process. The third and fourth cases are for CRRs that had a CRR payment in the day-ahead market and the CAISO also charged them in the CRR auctions to release these CRRs. The third case is when the net CRR payment is negative, while the fourth case is when the net CRR payment is positive. This metric reveals any potential misalignment of constrains enforced and binding between the day-ahead market and CRR auctions.

Figure 167: CRR payment versus CRR auction revenues for annual CRR -May 2017

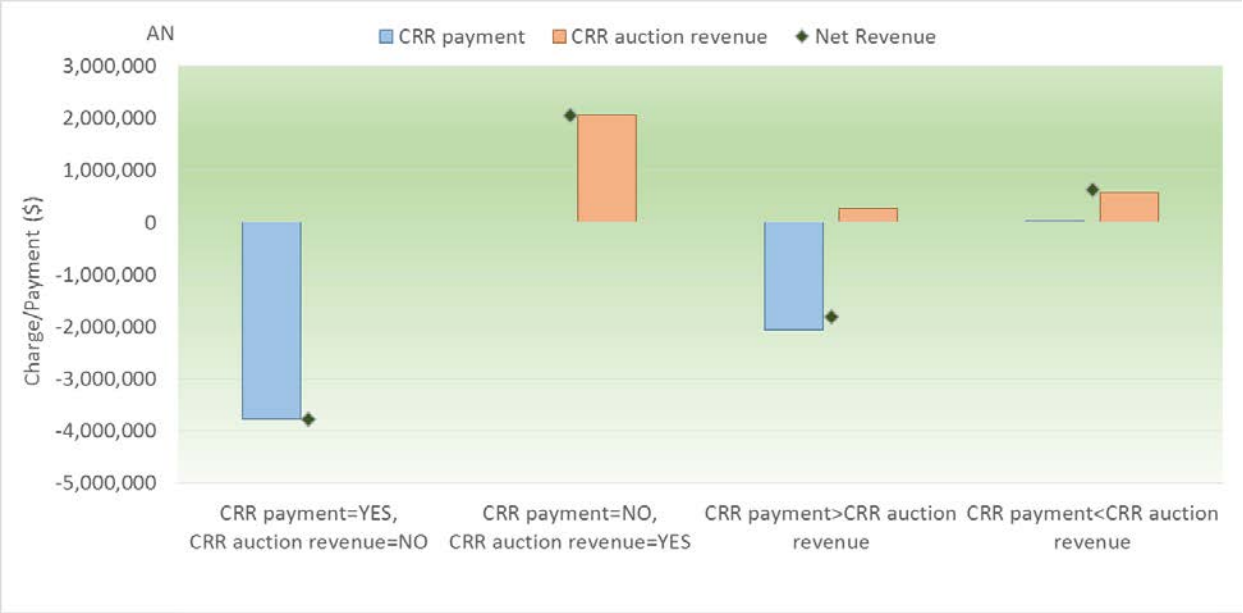


Figure 168: CRR payment versus CRR auction revenues for monthly CRR -May 2017

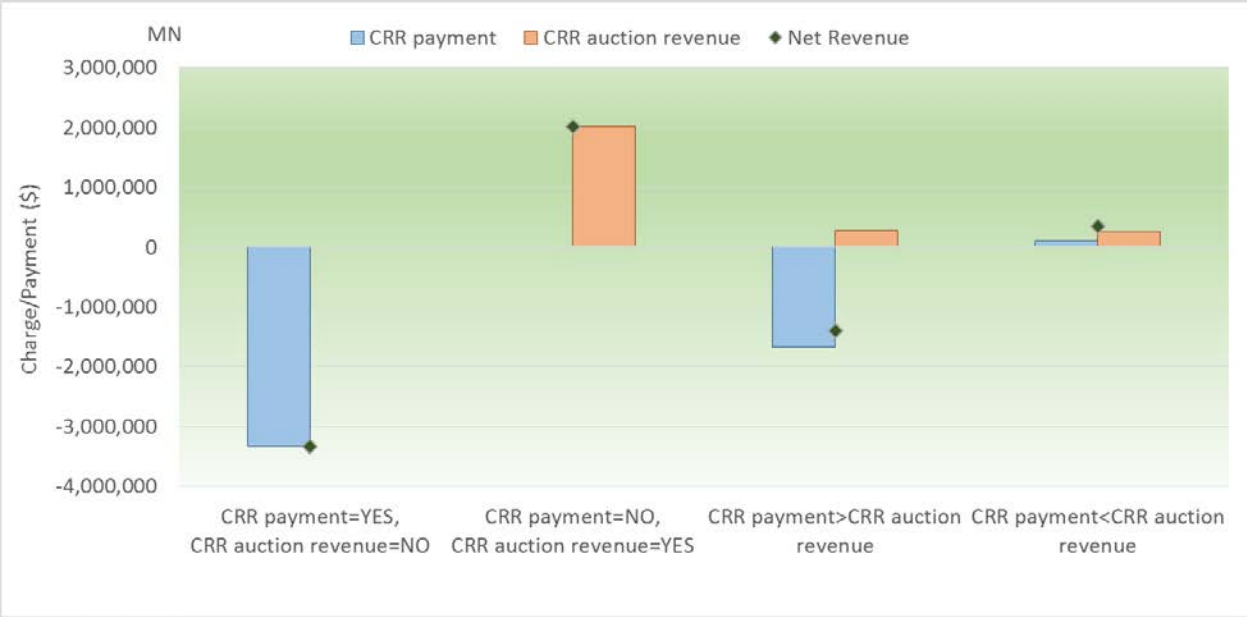


Table 41 provides one level deeper of understanding of such misalignments between markets. This tables shows the top and bottom constraints when sorted by net CRR payments. In the first column it shows the estimated CRR payment to CRR holders accrued in each constraint; the second column shows the revenues collected by the CAISO on that same constraint; the last column shows the net CRR payment, which is the balance between this money outflow (CRR payment) and money inflow (CRR auction revenues) from the CAISO's perspective. Table 42 shows the same information for CRRs released in the monthly auction for May 2017. The top constraints

reflect cases where large CRR payments to auction CRRs accrued when the CRR market did not collect any auction revenues when releasing these CRRs.

Table 41: Net CRR payment by constraint - May 2017, Annual auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	-$1,576,367.7	$0.0	-$1,576,367.7
31378_FULTON _60.0_31382_FTCHMTNP_60.0_BR_1 _1	-$656,966.8	$0.0	-$656,966.8
33315_RAVENSWD_115_33316_CLYLDG _115_BR_1 _1	-$625,600.1	$0.0	-$625,600.1
31336_HPLND JT_60.0_31370_CLVRDLJT_60.0_BR_1 _1	-$546,542.5	$0.1	-$546,542.4
7820_TL 230S_OVERLOAD_NG	-$405,704.9	$6,826.0	-$398,878.9
33020_MORAGA _115_32780_CLARMNT _115_BR_1 _1	-$344,048.7	$0.0	-$344,048.7
34112_EXCHEQUR_115_34116_LE GRAND_115_BR_1 _1	-$318,876.6	$20,046.8	-$298,829.8
6310_CP3_NG	-$260,039.3	$0.0	-$260,039.3
33016_ALHAMTP2_115_32754_OLEUM _115_BR_1 _1	-$250,914.0	$0.0	-$250,914.0
31334_CLER LKE_60.0_31338_KONOCTI6_60.0_BR_1 _1	-$233,407.7	$0.0	-$233,407.7
33936_MELNS JB_115_33951_VLYHMTP1_115_BR_1 _1	-$151,253.9	$1,101.9	-$150,152.0
30005_ROUND MT_500_30015_TABLE MT_500_BR_1 _2	-$131,464.1	$0.0	-$131,464.1
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	-$498,910.3	$390,055.3	-$108,855.0
31220_EGLE RCK_115_31228_HOMSTKTP_115_BR_1 _1	-$97,305.5	$0.0	-$97,305.5
22480_MIRAMAR _69.0_22756_SCRIPPS _69.0_BR_1 _1	-$97,263.5	$0.0	-$97,263.5
IPPUTAH_ITC	-$108,183.2	$24,909.7	-$83,273.6
MALIN500	-$86,881.0	$10,818.7	-$76,062.3
34427_ATWELL _115_34701_SMYRNA 1_115_BR_1 _1	-$83,941.3	$14,024.2	-$69,917.1
30500_BELLOTA _230_30515_WARNERVL_230_BR_1 _1	-$49,989.3	$0.0	-$49,989.3
22820_SWEETWTR_69.0_22476_MIGUELTP_69.0_BR_1 _1	-$46,454.0	$0.0	-$46,454.0
NdGrp_POD_CHWCHL_1_UNIT-APND	$0.0	$45,427.0	$45,427.0
24086_LUGO _500_24092_MIRALOMA_500_BR_3 _1	$0.0	$48,004.3	$48,004.3
24156_VINCENT _500_24155_VINCENT _230_XF_4 _P	$0.0	$48,818.0	$48,818.0
32950_PITSBURG_115_30527_PITSBRG _230_XF_13	$0.0	$50,252.5	$50,252.5
NdGrp_AGUCALG1_7_B1	$0.0	$50,705.3	$50,705.3
30035_TRACY _500_99006_TAP737 1_500_BR_1 _1	$64,848.3	$0.0	$64,848.3
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	$0.0	$67,991.9	$67,991.9
32766_EL CRRTO_115_33010_SOBRANTE_115_BR_2 _1	$69,581.0	$0.0	$69,581.0
NdGrp: 24702_KRAMER _115_B2	$73,749.2	$0.0	$73,749.2
22456_MIGUEL _69.0_22464_MIGUEL _230_XF_2	$0.0	$75,733.7	$75,733.7
34548_KETTLEMN_70.0_34552_GATES _70.0_BR_1 _1	$88,702.3	$0.0	$88,702.3
22831_SYCAMORE_138_22124_CHCARITA_138_BR_1 _1	$0.0	$90,412.8	$90,412.8
NdGrp_POD_INTKEP_2_UNITS-APND	$0.0	$92,236.3	$92,236.3
22828_SYCAMORE_69.0_22756_SCRIPPS _69.0_BR_1 _1	$0.0	$102,423.2	$102,423.2
NOB_ITC	$113,898.5	$0.0	$113,898.5
OMS 4821903 Tivy Valley CB 42	$120,826.1	$0.0	$120,826.1
30440_TULUCAY _230_30460_VACA-DIX_230_BR_1 _1	$129,884.6	$0.0	$129,884.6
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	-$1,082.9	$154,084.4	$153,001.4
30435_LAKEVILE_230_30460_VACA-DIX_230_BR_1 _1	$190,967.9	$0.0	$190,967.9
22464_MIGUEL _230_22504_MISSION _230_BR_1 _1	$0.0	$196,156.3	$196,156.3

Table 42: Net CRR payment by constraint - May 2017, Monthly auction

Constraints	Total CRR Payment	Total CRR Auction Revenue	Net CRR Payment
32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	-$1,048,283.5	$0.0	-$1,048,283.5
7820_TL 230S_OVERLOAD_NG	-$537,721.9	$0.0	-$537,721.9
31378_FULTON _60.0_31382_FTCHMTNP_60.0_BR_1 _1	-$513,981.8	$0.0	-$513,981.8
33315_RAVENSWD_115_33316_CLYLDG _115_BR_1 _1	-$374,589.4	$0.0	-$374,589.4
30515_WARNERVL_230_30800_WILSON _230_BR_1 _1	-$301,074.1	$21,500.3	-$279,573.8
30280_POE _230_30330_RIO OSO _230_BR_1 _1	-$267,932.0	$3,775.6	-$264,156.5
31336_HPLND JT_60.0_31370_CLVRDLJT_60.0_BR_1 _1	-$247,277.1	$0.0	-$247,277.1
34418_KINGSBRG_115_34405_FRWT TAP_115_BR_1 _1	-$208,035.9	$0.0	-$208,035.9
34158_PANOCHE _115_34350_KAMM _115_BR_1 _1	-$184,407.1	$0.0	-$184,407.1
33936_MELNS JB_115_33951_VLYHMTP1_115_BR_1 _1	-$168,357.1	$0.1	-$168,357.0
33016_ALHAMTP2_115_32754_OLEUM _115_BR_1 _1	-$162,838.6	$0.0	-$162,838.6
33541_AEC_TP1 _115_33540_TESLA _115_BR_1 _1	-$181,270.3	$22,369.1	-$158,901.3
6310_CP3_NG	-$141,713.6	$0.0	-$141,713.6
22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	-$135,827.5	$0.0	-$135,827.5
32766_EL CRRTO_115_33010_SOBRANTE_115_BR_2 _1	-$129,854.9	$0.0	-$129,854.9
NOB_ITC	-$113,891.0	$0.0	-$113,891.0
OMS 4821903 Tivy Valley CB 42	-$83,755.3	$0.0	-$83,755.3
34427_ATWELL _115_34701_SMYRNA 1_115_BR_1 _1	-$75,838.3	$0.0	-$75,838.3
33020_MORAGA _115_32780_CLARMNT _115_BR_1 _1	-$92,962.0	$21,541.2	-$71,420.9
MEAD_ITC	-$47,660.1	$0.0	-$47,660.1
30805_BORDEN _230_30810_GREGG _230_BR_1 _1	$29,878.2	$0.0	$29,878.2
NdGrp_POD_INTKEP_2_UNITS-APND	$0.0	$31,096.5	$31,096.5
IID-SCE_BG	$0.0	$32,184.4	$32,184.4
NdGrp_POD_NAROW2_2_UNIT-APND	$0.0	$35,955.0	$35,955.0
30750_MOSSLD _230_30045_MOSSLAND_500_XF_9	$0.0	$38,825.5	$38,825.5
24132_SANBRDNO_230_24804_DEVERS _230_BR_1 _1	$0.0	$45,164.6	$45,164.6
NdGrp_AGUCALG1_7_B1	$0.0	$45,967.5	$45,967.5
MERCHANT_ITC	$46,704.8	$0.0	$46,704.8
24016_BARRE _230_25201_LEWIS _230_BR_1 _1	-$2,561.1	$50,560.6	$47,999.5
33950_RVRBK TP_115_33934_TULLOCH _115_BR_1 _1	$0.0	$50,797.8	$50,797.8
32200_PEASE _115_32288_E.MRY J1_115_BR_1 _1	-$17,020.3	$75,274.4	$58,254.1
30440_TULUCAY _230_30460_VACA-DIX_230_BR_1 _1	$61,422.0	$0.0	$61,422.0
30035_TRACY _500_99006_TAP737 1_500_BR_1 _1	$66,163.7	$0.0	$66,163.7
MALIN500	$69,167.8	$0.0	$69,167.8
30435_LAKEVILE_230_30460_VACA-DIX_230_BR_1 _1	$81,694.0	$0.0	$81,694.0
24086_LUGO _500_26105_VICTORVL_500_BR_1 _1	$0.0	$94,044.8	$94,044.8
22356_IMPRLVLY_230_21025_ELCENTRO_230_BR_1 _1	$0.0	$96,375.7	$96,375.7
30105_COTTNWD _230_30245_ROUND MT_230_BR_3 _1	-$563.9	$262,112.9	$261,549.0
PATH26_BG	$0.0	$383,814.5	$383,814.5
NdGrp: 24702_KRAMER _115_B2	$421,301.2	$0.0	$421,301.2

These two tables illustrate instances of constraint misalignment between the CRR auctions and the day-ahead market. To understand this mismatch one level deeper, Table 43 lists the subset of constraints that are not binding or not enforced in the CRR monthly auction or that have a significant CRR payment. The portion that were paid only to CRRs from the annual and monthly auctions is also provided. Then it compares the average transmission limit used in the day-ahead market and the limits actually used in both the annual and monthly auctions. These are the constraints that will mostly drive the divergence between the day-ahead and CRR markets. One of the cornerstones of the CRR market efficiency is for the CRR market to closely reflect the transmission capacity of the day-ahead market. When the transmission capacity released in the CRR market is less than that of the day-ahead market, there may be an exposure of revenue deficiency. This may also have a fair impact on the level of CRR net payments and how transmission capacity is valued in the CRR auction. This occurs because when CRRs are released in the auction process they are priced on the value of the capacity made available, or on the lack of it. A systemic issue identified during the evaluation of the CRR auction efficiency is that multiple transmission constraints are not modelled or enforced in the CRR auctions.

In cases where the constraint was enforced in the day-ahead market but not modelled or enforced in the CRR auctions, the amount of transmission capacity by means of CRRs that may be released on that constraints is effectively unbounded, which indicates that more transmission capacity may be released in the CRR auction than in the day-ahead market. This is a major problem to the efficiency of the CRR market. For the case of May 2017 and relative to other months analyzed, there were relatively few instances of constraints not enforced in the CRR auctions. In such cases the level of congestion rents and CRR payments were relatively modest, such that even with the misalignment, the financial impact was low. In further investigating why these constraints were not modelled/enforced in the CRR auctions, the common factors are related to how outages were considered and when transmission constraints were enforced in the CRR auction.

1. Constraint 6310_CP3_NG. This constraint's name was changed from 6310_SOL NG to CP3 NG. SOL NG was modeled in the May CRR auctions. For April and May the CRR auction was still using the 6310 SOL nomograms and PATH15_S-N and PATH26_BG constraints. Specifically the CRR model did enforce 6310_SOL3_NG_SUM for the May CRR model with a limit of 307MW. By the time the modelled was created the nomogram definition did not exist yet.

Table 43: Top constraints binding in the day-ahead market not binding in CRR market - May 2017

Constraint	Constraint Type	TOU	Payments to Annual CRR	Payments to Monthly CRR	DAM Limit	Annual CRR Limit	Monthly CRR Limit	Annual CRR Status	Monthly CRR Status	Reason
33315_RAVENSWD_115_33316_CLYLDG _115_BR_1 _1	FLOWGATE	ON	-$625,600.1	-$374,589.4	137.7	147.7	121.9	Not Binding	Not Binding	Auction Economics
31378_FULTON _60.0_31382_FTCHMTNP_60.0_BR_1 _1	FLOWGATE	ON	-$377,640.5	-$462,051.3	25.6	29.4	24.2	Not Binding	Not Binding	Higher Limit
32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	FLOWGATE	ON	-$916,117.3	-$650,949.2	65.8	61.5	50.7	Not Binding	Not Binding	Auction Economics
7820_TL 230S_OVERLOAD_NG	NOMOGRAM	ON	-$241,146.4	-$374,361.6	368.0	354.0	392.0	Not Binding	Not Binding	Higher Limit
33016_ALHAMTP2_115_32754_OLEUM _115_BR_1 _1	FLOWGATE	ON	-$237,215.7	-$168,759.4	92.7	78.8	65.0	Not Binding	Not Binding	Auction Economics
6310_CP3_NG	NOMOGRAM	OFF	-$260,039.3	-$141,713.6	292.0	Unbounded	Unbounded	Not Enforced	Not Enforced	Late Enforcement
32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	FLOWGATE	OFF	-$660,250.4	-$397,334.3	64.9	61.5	50.7	Not Binding	Not Binding	Auction Economics
31336_HPLND JT_60.0_31370_CLVRDLJT_60.0_BR_1 _1	FLOWGATE	ON	-$226,143.2	-$218,496.1	32.9	29.4	24.2	Binding	Not Binding	Auction Economics
31378_FULTON _60.0_31382_FTCHMTNP_60.0_BR_1 _1	FLOWGATE	OFF	-$279,326.3	-$51,930.5	25.1	29.4	24.2	Not Binding	Not Binding	Higher Limit
31336_HPLND JT_60.0_31370_CLVRDLJT_60.0_BR_1 _1	FLOWGATE	OFF	-$320,399.3	-$28,781.0	32.8	29.4	24.2	Binding	Not Binding	Auction Economics
7820_TL 230S_OVERLOAD_NG	NOMOGRAM	OFF	-$164,558.6	-$163,360.3	368.0	337.6	392.0	Binding	Not Binding	Higher Limit
31334_CLER LKE_60.0_31338_KONOCTI6_60.0_BR_1 _1	FLOWGATE	ON	-$194,384.1	-$34,828.0	35.3	Unbounded	26.9	Not Enforced	Not Binding	Auction Economics
32766_EL CRRTO_115_33010_SOBRANTE_115_BR_2 _1	FLOWGATE	ON	$72,416.0	-$129,526.6	154.8	133.1	109.8	Not Binding	Not Binding	Auction Economics
34418_KINGSBRG_115_34405_FRWT TAP_115_BR_1 _1	FLOWGATE	ON	-$41,145.5	-$176,984.1	77.8	64.9	53.6	Not Binding	Not Binding	Auction Economics
31336_HPLND JT_60.0_31206_HPLND JT_115_XF_2	FLOWGATE	ON	-$54,027.6	-$19,838.1	45.7	38.0	31.4	Binding	Not Binding	Auction Economics
MEAD_ITC	INTER_TIE	ON	$640.6	-$47,660.1	1619.0	977.5	1586.6	Binding	Not Binding	Higher Limit
33932_MELONES _115_33936_MELNS JB_115_BR_1 _1	FLOWGATE	OFF	-$7,706.2	-$41,752.5	57.8	53.2	43.9	Not Binding	Not Binding	Auction Economics
30500_BELLOTA _230_30515_WARNERVL_230_BR_1 _1	FLOWGATE	ON	-$49,989.3	-$37,643.1	312.6	255.6	210.9	Not Binding	Not Binding	Auction Economics
22820_SWEETWTR_69.0_22476_MIGUELTP_69.0_BR_1 _1	FLOWGATE	ON	-$46,454.0	-$14,708.3	100.7	Unbounded	76.5	Not Enforced	Not Binding	Auction Economics
IPPDCADLN_ITC	INTER_TIE	ON	$302.1	-$16,681.5	726.4	299.5	780.0	Not Binding	Not Binding	Higher Limit
31220_EGLE RCK_115_31228_HOMSTKTP_115_BR_1 _1	FLOWGATE	ON	-$38,174.9	-$24,327.4	139.9	119.5	98.6	Not Binding	Not Binding	Auction Economics

Net CRR payments on nodal group constraints

With the detailed analysis performed in this section for a subset of monthly auctions, a trend of auction revenues was created. The nodal group constraints have been consistently binding in the CRR auctions since the introduction of this type of constraint in June 2015, as seen in Figure 169. Since the majority of the time these constraints do not arise in the day-ahead market, the nodal constraints have been a steady money inflow (auction revenues collected in the CRR auctions are greater than the CRR payment to holders of auction CRRs) for the CAISO settlements for net CRR payments. Unlike the CRR auctions, where these constraints are now enforced in every auction, these constraints are generated in the day-ahead market only when there is a difficulty to converge to AC power flows.

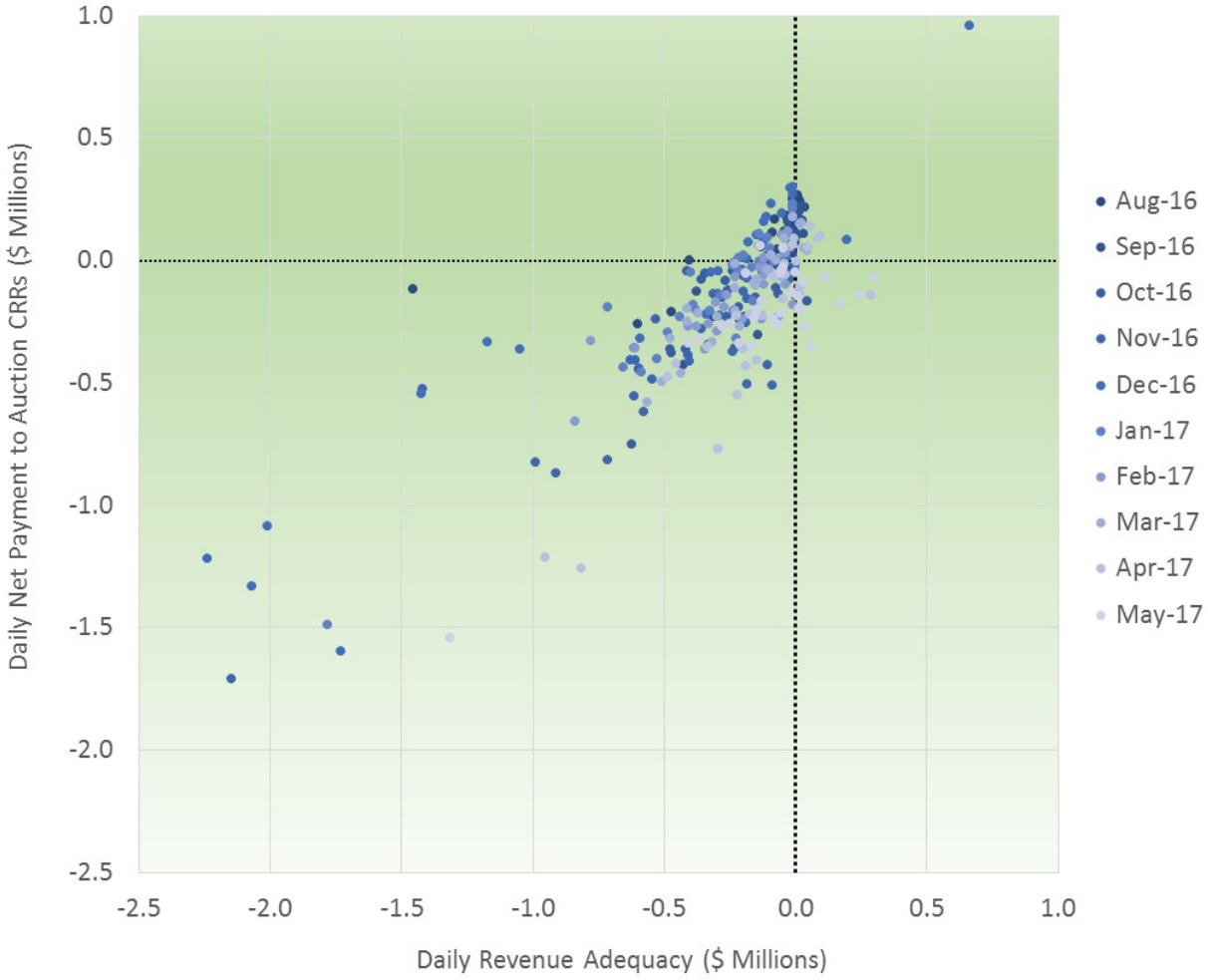
Figure 169: Net CRR payments accrued on nodal group constraints

Net CRR payments and CRR revenue adequacy

As provided in the analysis of each of the months in this section, there is a strong correlation between the net CRR payments and the CRR revenue adequacy.

Figure 170 shows that correlation for the 10 months analyzed. This correlation does not mean that one is the driver of the other; instead, both metrics are impacted largely by some common drivers such as late or missed outages and late enforcement of constraints. For any dot in which both quantities are negative, it means there was a CRR revenue deficiency and holders of auction CRRs were paid more than what they were charged in the auction to acquire these CRRs. Each dot stands for one day of the 10-month period analyzed earlier in this section.

Figure 170: Net CRR payment vs. CRR revenue adequacy



8 Final Remarks

Congestion revenue rights are a key and natural complement to electricity markets based on locational marginal pricing. The purpose of CRRs is to provide a hedging mechanism to entities directly exposed to congestion in the day-ahead market or to those managing risk associated capacity or energy based contracts that could be exposed to congestion. Inherently, CRRs are risk-based instruments and when evaluating the merit or value of the instrument the risk component and its secondary effects cannot be ignored. This risk component is indeed built into the CRR prices and reflected eventually in the auction revenues. There are market design variations among ISO's in regards to how they are released (allocations versus auctions), how often they are released (annual, monthly, sequential), how they are funded (full funding versus partial funding). In the CAISO market, CRRs are allocated in both allocation and auction processes, in annual and monthly cycles and are currently fully funded. Two of the main concerns typically observed about the overall performance of CRRs is regarding revenue sufficiency and net CRR payments. The former is to ensure there are sufficient funds from day-ahead congestion rent to cover all CRR payouts, while the latter is to see how well the CRR auction is discovering the day-ahead market. Convergence between the CRR auction and the day-ahead market will be reflected by means of the relative difference between the money collected as auction revenues when releasing CRRs versus the money paid to the auction CRR holders, namely in this report as net CRR payments.

In this report, the CAISO undertook the analysis of the CRR auctions performance, given the concerns that historically the level of CRR payment to holders of auction CRRs may be too large in comparison to what they paid to acquire these CRRs in the auctions. Different angles of the CRR performance were analyzed and estimated, going from how the participation has evolved over time, the number and volume of CRRs released in the auctions, the prices discovered and formed in the CRR auctions, the level of auction revenues collected, the patterns of the delta between CRR payments and auction revenues to acquire CRRs to isolate if this has its origin in one specific area. There was also some analysis on the type of bids awarded in the CRR markets where the study found that most of the payments for CRRs were defined between supply locations, like from generation location to generation location, as opposed to from a supply to load location. All these metrics are useful to see dynamics and observe bidding patterns; some working hypothesis on the bidding behavior can be constructed; however, to understand how the CRRs were performing the way they were, there was a need to analyze deeper the underlying fundamentals of the market.

While the first part of report focuses on analysis of the auction process including bid-in price/quantity patterns, what is ultimately of interest is the underlying cleared price and quantity which are what make up the auction revenues and become a function of the transmission capacity available in the auction. Similarly, the cleared price and quantity of transmission used in day-ahead market that determines the relationship of the congestion revenue collected which is a function of the transmission available in the day-head market. These prices and quantities, however, are by-product variables of more fundamental variables. The locational marginal prices are by-products of congestion prices on transmission constraints. Thus, to understand the drivers

of the difference between the amount of CRR payments and the money collected as auction revenues, one must understand the drivers causing the differences in the transmission pricing for constraints modeled between CRR auction and the day-ahead market. Therefore, the analysis ultimately focuses on understanding the cause for the differences of transmission available in the CRR market versus the day-ahead market and their pricing.

From that perspective, the CAISO first analyzed the outage information since one critical component in a transmission-based market is to ensure the transmission capacity is properly modelled. The chapter on transmission outages provides some useful information on how frequently outages are submitted on time to be accounted for in the CRR auction processes. Furthermore, this information is then leveraged in the subsequent chapter where the most recent 10 months of CRR auction performance is analyzed. By doing this detailed analysis of auction by auction and constraint by constraint, instead of generic patterns, the CAISO was able to identify critical elements driving the differences between the CRR auctions and the day-ahead market, which can be succinctly summarized as:

i) There have been outages not submitted in time to the CAISO that resulted in missing to include these outages in the CRR auctions.
ii) There were multiple outages that have a short duration that impact the day-ahead congestion prices but even if submitted with plenty of time for their consideration in the CRR auctions, there is no easy and clear way to account for them in the model of the CRR auction.
iii) There were some outages submitted in time but there was a gap in the CAISO process to properly reflect the outages in the CRR auction model.
iv) There were also process gaps in the CAISO processes to enforce and manage transmission constraints between the CRR auction and the day-ahead market that eventually were binding in the day-ahead market even in the absence of any outage.

While through the detailed analysis the significant drivers to the differences were identified, the analysis was not able quantify the relative frequency of each of the four drivers identified. Indeed the dominate drivers often changed from month to month and was situational based rather than creating a pattern where one or some of the drivers are dominate over time.

One of the premises for having a robust CRR market is that there is a high degree of constancy between transmission capacity released in the CRR process with the transmission capacity used in the day-ahead market. All these issues related to transmission constraints and outages not considered or enforced in the CRR auction diminish that fundamental premise.

Furthermore, CRR auctions can be seen as a dynamic interaction of participants who observe results from both CRR auctions and energy markets to define the bidding strategies for the subsequent auctions. The noise introduced when there is a transmission misalignment between markets impacts not only the applicable CRR auction but may also distort the incentives and pricing for subsequent auctions. Once one given auction has been impacted by a model issue, the overall economics of that auction may be distorted since enforcing or not enforcing one specific constraint may ultimately impact the pricing of other transmission constraints since the auction result is based on a simultaneous feasibility test.

Through the analysis, it is shown that there is a strong correlation between CRR revenue adequacy and net CRR payments. This points to the fact that both market performance metrics reflect a common underlying driver, which is the various issues leading to a discrepancy of transmission capacity modelling between the CRR auction and the day-ahead market. The approach implemented by the CAISO is based on full funding; this means that when the congestion rents collected from the day-ahead market are not sufficient to cover all the CRR payments, all CRR payments are still fully paid and the difference (shortfall or surplus) is absorbed by measured demand. In this case, the full funding may actually exacerbate the level of net CRR payments.

Finally, there is an inherent complication to align the CRR auctions with the day-ahead market. Granted, even when knowing all the information about outages and transmission configuration changes in time for the monthly auction, the limiting factor is how to accurately incorporate these into the monthly auctions. For instance, if there is an outage lasting for less than a day, in the monthly auction it is for one single market where the element needs to be on outage or not, or it can be derated. Having the element fully on outage for the monthly auction may be excessively restrictive, but not modelling it at all may fall on the other side of the spectrum. Where to strike the balance when modelling this kind of more granular information than the monthly auction can naturally reflect as an open question. Then the second complication is in the annual auction; this auction runs in the last quarter of the year prior to the binding year of the action, this means that outages or transmission configuration changes impacting the last quarter of the annual auction may be effectively modeled a year apart; by that time there is very limited information of what outages may be really scheduled to happen that far in advance.