

California ISO

Shortcomings in the congestion revenue right auction design

November 28, 2016

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TABLE OF CONTENTS

1 The CRR auction facilitates trading of financial forward contracts4

2 CRRs auctioned for less than half their day-ahead payments8

3 CRRs are inconsistently defined products..... 11

4 Ratepayers face significant limitations to bidding in auctions 13

5 Buyers may not bid auctioned CRRs up to their expected value 14

6 Alternatives to the CRR auction 15

Appendix A The CRR auction and economic property rights..... 17

Summary

In an LMP market binding transmission constraints cause locational prices to differ. These price differences cause energy buyers to pay more than suppliers are paid. This creates congestion rent. Transmission ratepayers own most of the congestion rent because they pay for most of the transmission system through the transmission access charge (TAC). The TAC pays for the capital costs and rate of return for transmission assets. Any revenues above the rate of return, including congestion rent, belongs to the TAC ratepayers.

Allocated CRRs are part of a system that distributes congestion rent to load serving entities on behalf of retail ratepayers and to other TAC ratepayers. This paper does not concern the congestion rent allocation or propose any changes to the current CRR allocation process.

Auctioned CRRs, on the other hand, are purely financial instruments that obligate the ISO's transmission ratepayers to pay entities purchasing these CRRs the difference in day-ahead market prices between two locations. An auctioned CRR is a forward price swap. Payments in the auction are exchanged for payments at the day-ahead market prices.

California ISO transmission ratepayers lost \$520 million in the congestion revenue right (CRR) auction from 2012 through 2015. For every dollar ratepayers paid to entities purchasing CRRs in the auction, ratepayers received only 46 cents in auction revenues. This consistent underpricing of CRRs calls into question a fundamental assumption of the CRR auction design that competition will drive auction prices to equal the CRR's expected value.

As described in this paper, the CRR auction differs from a competitive market—and other forward financial markets—in several ways. These differences create opportunities for purely financial entities to purchase CRRs at prices systematically lower than the payments ratepayers are obligated to pay the auction participants. The ISO and stakeholders should consider whether the ISO should continue auctioning CRRs under the current design or whether CRRs or similar price swaps should instead only be traded between willing buyers and sellers through a market based only on bids and offers.

Auctioned CRRs are not needed for transmission access or to ship power between nodes. An LMP market is a centrally cleared market. Power is sold or bought through the central market at the market price. Market participants do not ship power from one location to another. The locational marginal price at each location is the appropriate market price for that location. A CRR is not needed to ship power between locations because power is not shipped between locations.

A CRR is not a day-ahead market transmission right. All day-ahead market bidders have access to the transmission system regardless of whether or not they hold a CRR. Instead, an auctioned CRR is simply a forward contract. This forward contract allows auction participants to hedge financial exposure to—or speculate on—uncertain day-ahead price differences between two locations.

The demand for a financial hedge against day-ahead market locational price differences primarily comes from forward contracting on power prices. This forward contracting takes place outside the ISO markets. A supplier may sell a forward power contract at a location different than its generator's location. When this occurs, the day-ahead price on which the forward contract settles will be different than the day-ahead price the generator receives for selling power into the day-ahead market. Different settlement locations cause the supplier to face an uncertain day-ahead price difference that will not be hedged by the forward power contract. In order to hedge this uncertainty, a supplier may be willing to buy a forward contract for the difference between the day-ahead prices at the two locations.

Financial forward contracts on locational price differences can be purchased in the CRR auction. Unlike most other forward contract markets, the CRR auction allows participants to take positions without a counterparty offering to take the opposite position. Market participants can buy forward contracts in the CRR auction without trading with a willing seller. This is because the auction makes CRR forward contracts available at zero offer prices. By default, the ISO's transmission ratepayers are the counterparty to contracts bought from the CRR auction without being an explicit willing seller.

To avoid being a counterparty to the forward contracts offered under the current CRR auction design, ratepayers would need to participate in the auction to buy contracts from themselves. This is the opposite of most other forward markets where sellers must willingly offer to enter a forward contract.

While ratepayers may want to buy CRRs to avoid forward contract obligations, they cannot readily buy them. Technical, economic and regulatory hurdles restrict ratepayer participation in the auction. Ratepayers cannot easily avoid being a counterparty to the forward contracts they did not offer to enter. An auction participant can therefore buy a CRR from ratepayers for a price at which ratepayers would not willingly sell.

The CRR auction also differs from other forward markets, and competitive markets generally, in another significant way. Competitive markets trade a well-defined product or property right. For example, a forward contract for a bushel of wheat is defined as a bushel of wheat in both the forward and spot markets. A natural gas forward basis contract between Henry Hub and Chicago is defined as the price difference between Henry Hub and Chicago in both the forward and spot markets. A CRR is not consistently defined between the auction and day-ahead market.

CRRs are auctioned as a bundle of forward contracts on specific transmission constraints. They are not settled as the same bundle of forward contracts at day-ahead market prices. Instead, the CRRs are settled at the day-ahead market locational price differences between two locations. A CRR will only be consistently defined if the bundle in the auction is the same as the implied bundle from the day-ahead market price differences. When the transmission models are different in the auction and day-ahead market, the bundles will not be the same. The CRR will be a different product when bought than when settled at day-ahead market prices.

CRRs are unlikely to be consistently defined because the CRR auction relies on a single estimated network model to estimate the hourly day-ahead network models over the entire settlement month or quarter. This settlement is like allowing auction participants to purchase premium gasoline at regular prices with ratepayers making up the difference. Profit maximizing auction participants would bid to obtain CRRs that the auction models as regular but which they anticipate to be premium.

The peculiarities and complexities of the CRR auction can create opportunities for participants to extract payments from ratepayers. The majority of payments from ratepayers appear to go to purely financial entities seeking to profit from participation in the auction, rather than suppliers that may be seeking to hedge risks related to day-ahead market schedules.

There is no clear rationale for the ISO to offer forward price swaps. Market participants can freely contract and trade forward price swaps outside the ISO. If the ISO continues to facilitate the trading of forward price swaps, the auction design should be changed so that only willing counterparties will enter forward contract obligations.

1 The CRR auction facilitates trading of financial forward contracts

Ratepayers pay for and own most congestion rent

The transmission system both facilitates and limits the ability to reliably trade energy. Nodal markets are designed to promote efficient use of the scarce transmission system. The limited transmission available in the day-ahead market constrains the choice of optimal energy schedules. This creates locational price differences which in turn creates congestion rent.¹

Ratepayers own the day-ahead congestion rent.² Ratepayers pay for the capital costs and rate of return on transmission assets through the transmission access charge (TAC) that is imposed on all load schedules. Any revenues that these transmission assets earn in excess of the rate of return included in the TAC belongs to the ratepayers. Ratepayers therefore own the rights to the day-ahead market congestion rents generated by their transmission assets.

The ISO currently distributes congestion rent to the TAC ratepayers through an allocation process that includes the CRR allocation process. This paper does not concern the congestion rent allocation. Instead the focus of this paper is on the CRR auction.

Network models define the transmission right products

As described in the following subsections, auctioned CRRs are not rights to physical transmission, nor are auctioned CRRs even the rights to day-ahead market congestion rents. A CRR is a forward contract that settles on the day-ahead market price difference between two locations. Although a CRR settles on the day-ahead market congestion price differences, the ISO auctions CRRs as bundles of forward contracts to specific transmission constraints. Using the term “rights” to refer to CRRs is inaccurate and misleading. Therefore, for the rest of this paper, we refer to CRRs as “forward contracts.”

The CRR auction clears by maximizing total bid value constrained by the transmission network model. The transmission constraints and network model, represented by shift factors, define the forward contracts sold in the auction. A shift factor describes how many forward contracts on a constraint are bought or sold from a one megawatt injection at a location. A CRR bids as an injection at a source location balanced by a withdrawal at a sink location. The forward contracts a CRR buys or sells on a particular constraint is the source shift factor minus the sink shift factor multiplied by the cleared CRR megawatts. The auction price for each increment of forward contract for that one constraint is the CRR auction’s shadow price on the constraint.

If a CRR’s net shift factor (source shift factor minus sink shift factor) is positive, the CRR purchases forward contracts for the constraint’s price. If a CRR’s net shift factor is negative, the CRR sells forward contracts. The total forward contracts purchased by participants bidding in the auction do not need to equal the forward contracts sold by participants bidding into the auction. Instead, the forward contracts bought minus the forward contracts sold must be less than the forward contracts made available in the

¹ A good analogy is that transmission use is an externality of scheduling power and the transmission price is an externality tax, as explained on pg. 26 of Oren, Shmuel S., Pablo T. Spiller, Pravin Varaiya, and Felix Wu. 1995. "Nodal Prices and Transmission Rights: A Critical Appraisal." *Electricity Journal*, p. 32: <http://www.ieor.berkeley.edu/~oren/pubs/nodal.pdf>.

² Exceptions to this are rights owned by merchant transmission and long-term rights holders. However, these are very minor in the CAISO system.

auction through each constraint's transmission limit. Equation 1 shows a CRR auction transmission constraint called k. Individual CRRs are indexed by i.

Equation 1. CRR market constraints define forward contracts auctioned

$$\sum_i MW_i^{CRR} (\text{ShiftFactor}_{i,source}^k - \text{ShiftFactor}_{i,sink}^k) \leq \text{Limit}^k$$

Contracts Bought – Contracts Sold ≤ Contracts offered by auction

Auction participants can buy more forward contracts than are sold by other participants bidding in the CRR auction. More forward contracts can be bought than sold because the ISO makes forward contracts available through its auction's transmission model. The ISO sells these forward contracts on behalf of transmission ratepayers. The CRR buyers pay ratepayers the auction revenues. The ratepayers then pay the buyers the day-ahead prices for these forward contracts. The ISO offers forward contracts on the ratepayers' behalf (through the limits on transmission elements in the CRR auction) with zero offer prices.

CRRs are considered *revenue adequate* when revenues from congestion rents are greater than or equal to the payments to CRRs. CRRs will be revenue adequate if the transmission limits and network models (shift factors) are the same³ in both the auction and day-ahead market.⁴ When the auction limits or network models are different, the CRRs may not be revenue adequate.

Revenue adequacy is not a concern in forward markets for other commodities.⁵ In forward markets for other commodities buyers and sellers are matched and revenue adequacy is assured. Revenue adequacy does not matter for CRRs either. Revenue adequacy does not matter because the CRR auction actually does match buyers and sellers. Ratepayers will always be the counterparties to contracts not matched between the buyers and willing sellers who bid into the auction.

As discussed in detail in the next three sub-sections, CRRs can be better understood by interpreting CRRs from the perspective of the transactions between the buyers and sellers of CRRs, rather than from the perspective of revenue adequacy. The underlying transactions are the exchange of a fixed payment in the auction for floating payments at the uncertain day-ahead market prices. The transactions that matter to ratepayers are the auction revenues they receive compared to the payments they are obligated to make to CRR holders.

Ratepayer gains or losses are the auction revenues they receive less their payments to CRR holders

The CRR balancing account is a settlement mechanism. This settlement mechanism ensures that the final *net* payments and charges to the day-ahead market and to CRR auction participants are correct. The CRR balancing account processes two underlying transaction types. To understand the actual day-

³ More precisely, the difference between shift factors has to be the same between all locations.

⁴ Hogan, William W. 1992. "Contract Networks for Electric Power Transmission." *Journal of Regulatory Economics*. See the version at: <http://www.hks.harvard.edu/fs/whogan/acnetref.pdf>.

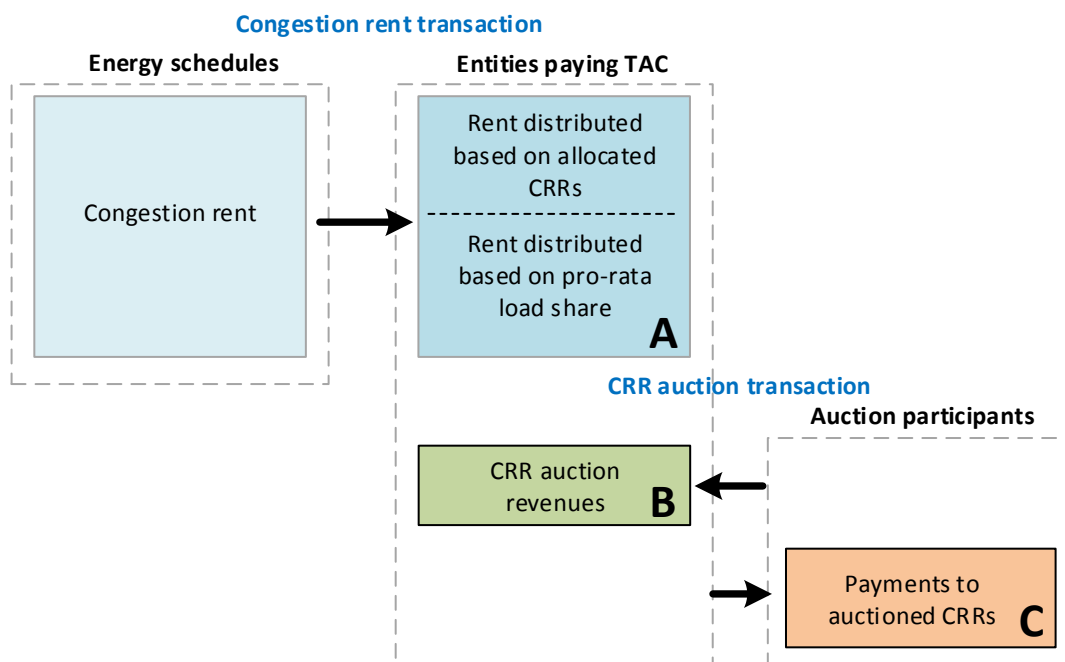
⁵ This assumes away default risk, which is different than the revenue adequacy referred to here.

ahead market and CRR auction trades, we should consider the underlying transactions and not the CRR balancing account.

Figure 1 shows the two transaction types from the ratepayer’s perspective. In the first transaction, day-ahead energy schedules pay congestion rents in the day-ahead market. As discussed in the first subsection of section 1 above, transmission ratepayers own these congestion rents. Therefore, the ISO distributes congestion rents to transmission ratepayers by allocated CRR or, for any congestion rents remaining after the allocation process, by pro-rata load share. Load serving entities, who are the largest transmission ratepayers, then pass the congestion rents to ratepayers.

In the second transaction, CRR auction participants and ratepayers (who do not participate in the auction) trade financial forward contracts through auctioned CRRs. Auction participants pay the forward price (the auction price) to ratepayers. In exchange, ratepayers take on the obligation to pay the spot price (the difference between the source and sink day-ahead market prices) to auction participants. The exchange of forward CRR auction revenues for spot market payments to auctioned CRRs at day-ahead market prices is the ratepayers’ overall net forward contract trade.

Figure 1. Day-Ahead transmission and CRR transactions from ratepayer perspective



Congestion revenue rights are not actually rights to congestion rents

When the CRR auction transmission model and day-ahead market transmission model are the same, we can view a CRR as a forward contract, a point-to-point transmission right, or a right to a share of congestion rent.⁶ All three views are financially equivalent.

⁶ Harvey, Scott M, William W Hogan, and Susan L Pope. 1997. *Transmission Capacity Reservations and Transmission Congestion Contracts*. Cambridge, MA: Harvard University, p. 62 of the version at: <http://www.hks.harvard.edu/fs/whogan/tccopr3.pdf>.

However, the CRR auction and day-ahead market transmission models are inevitably different. When the models are different, paying CRRs the day-ahead market settlement price is not the same as paying a share of the congestion rent. If the day-ahead market sells 100 megawatts of transmission to day-ahead market schedules, the ISO cannot pay CRRs for rights to 115 megawatts worth of congestion rent. The CRRs clearly do not represent the rights to the congestion rents. Instead, ratepayers receive the congestion rents for the 100 megawatts of transmission sold to day-ahead market schedules (Transaction 1 in Figure 1). Separately, ratepayers must pay day-ahead market locational price differences to settle the 115 megawatts of CRR forward contracts that the ISO auctioned off on the ratepayers' behalf (Transaction 2 in Figure 1).

Even if the transmission models are the same, the CRR contracts sold for a constraint can be greater than the transmission limit because auction participants can sell additional forward contracts. If the constraint limit is 10 MWs and some participants sell an additional 50MWs of forward contracts through CRR bids, a total of 60 MWs of forward contracts can be purchased by other CRR auction participants. 60 MWs of rights to congestion rent do not exist. Do we arbitrarily decide that a particular 10 MWs of CRRs is rights to congestion while the other 50 are something else? All 60 MWs are forward contract purchases with 50 MWs sold by parties bidding into the auction and 10 MWs sold on behalf of transmission ratepayers.

CRR profitability is the relevant measure of CRR auction performance

Revenue inadequacy has traditionally received a lot of attention. Concerns over whether there will be sufficient congestion rent to pay the CRRs are rooted in the prevalent and incorrect view that CRRs are rights to the day-ahead market congestion rent. But once we recognize that CRRs are simply forward contracts, and not rights to congestion rent, it becomes clearer that revenue inadequacy is not a cost to ratepayers. Focusing on revenue adequacy incorrectly frames the problem as a need for the ISO to make the "correct" amount of forward contracts available in the auction on behalf of ratepayers.

The relevant question for ratepayers is *not* how total payments to CRRs compare to total day-ahead congestion rent (i.e. it is not a question of revenue adequacy). The relevant question for ratepayers is how the payments ratepayers are obligated to make to auctioned CRR holders compare to the CRR auction revenues ratepayers receive. If ratepayers pay auctioned CRR holders more than the auction revenues ratepayers receive, then ratepayers will lose money on their CRR forward contracts.

The auction revenues ratepayers receive depends on how well the CRR auction prices CRRs. A well-functioning competitive auction would price CRRs near their expected value. The CRR auction revenues ratepayers receive would roughly equal the ratepayers' expected payments to non-LSE CRR holders. The CRRs purchased from ratepayers by non-LSE auction participants would not be highly profitable. If the CRR auction is not a well-functioning competitive market, non-LSE auction participants can consistently profit from ratepayers' losses without driving up CRR auction prices.

2 CRRs auctioned for less than half their day-ahead payments

Ratepayers lost \$520 million in the CRR auction from 2012 through 2015. Ratepayers paid \$970 million to non-LSE CRR holders but received only \$450 million in auction revenues. For every dollar paid to non-LSE CRR holders, ratepayers received just 46 cents. Figure 2 and Figure 3 show CRRs have been consistently profitable over time and across the majority of non-TAC ratepayer (non-LSE) CRR auction participants.

Auction participants may be risk adverse. Risk aversion may cause the CRR auction prices to not equal the expected day-ahead payments. Auction participants may be increasing or decreasing their risk by procuring a CRR. Participants increasing their risk would be willing to pay less than the expected value. Participants decreasing their risk would be willing to pay more than the expected value as an “insurance premium.” Therefore we cannot presume that risk aversion will decrease or increase auction prices relative to the expected value.

We do not discount the auction revenue and CRR payment flows for the time value of money. Only the payments to annual CRRs in late November and December occur more than a year after the CRRs are purchased. Most of the monthly CRR payments occur less than a month after purchase. Given the short time periods, discounting the cash flows would not appreciably affect the values. The effects of risk aversion and the time value of money are not going to account for pricing an expected dollar at 46 cents.

The California ISO’s CRR auction is not the only CRR forward contract auction with high profits. The PJM Independent Market Monitor reports consistently high returns for financial transmission rights (FTRs), the PJM version of CRRs. From 2012 to 2015, non-LSE FTR profits were over \$1 billion. Auction costs were roughly 45 cents per dollar of FTR payments.⁷ Academic studies have noted periods of large profits from auctioned FTRs in the PJM Interconnection, Midcontinent ISO, and New York ISO.⁸ The PJM Independent Market Monitor noted “[t]he fact that FTRs are consistently profitable regardless of [revenue adequacy] raises questions about the design of the process.”⁹

⁷ Calculated from data provided by Monitoring Analytics LLC. Similar data can be seen in the *2015 State of the Market Report for PJM*, p.503: http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2015.shtml.

⁸ Zhang, Ning. 2008. “Market performance and bidders’ bidding behavior in the New York Transmission Congestion Contract market.” *Energy Economics*.

Molzahn, Daniel, and Corey Singletary. 2011. “An Empirical Investigation of Speculation in the MISO Financial Transmission Rights Auction Market.” *The Electricity Journal*.

Myers, James. 2012. “Risk and Abnormal Returns in Markets for Financial Transmission Rights.” Master’s thesis in Economics Gettysburg College.

Toole, Cameron J. 2014 “An empirical analysis of the New York Independent System Operator’s Transmission Congestion Contract market: Speculator and hedger transaction characteristics, competition, and profit.” Master’s thesis in Energy and Mineral Engineering, The Pennsylvania State University.

⁹ *2015 State of the Market Report for PJM*, p.503: http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2015.shtml.

Figure 2. Auction revenues and auctioned CRR payments excluding LSEs

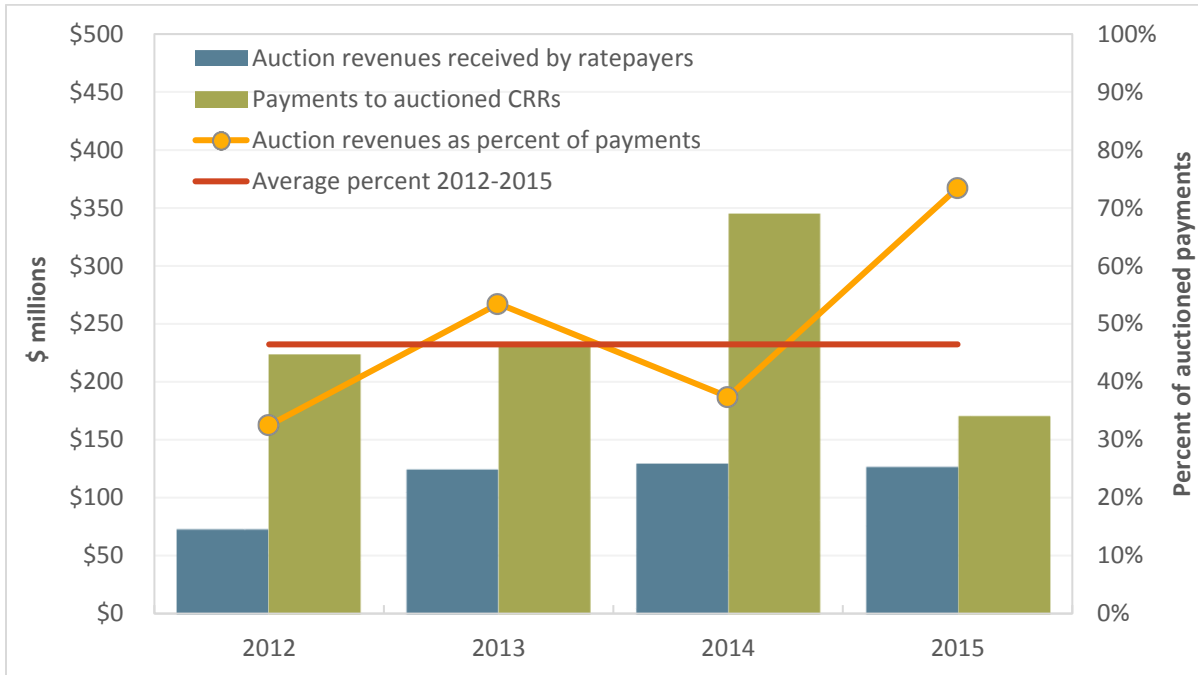


Figure 3. Annual profits on auctioned CRRs by entity (excluding LSEs) 2012-2015

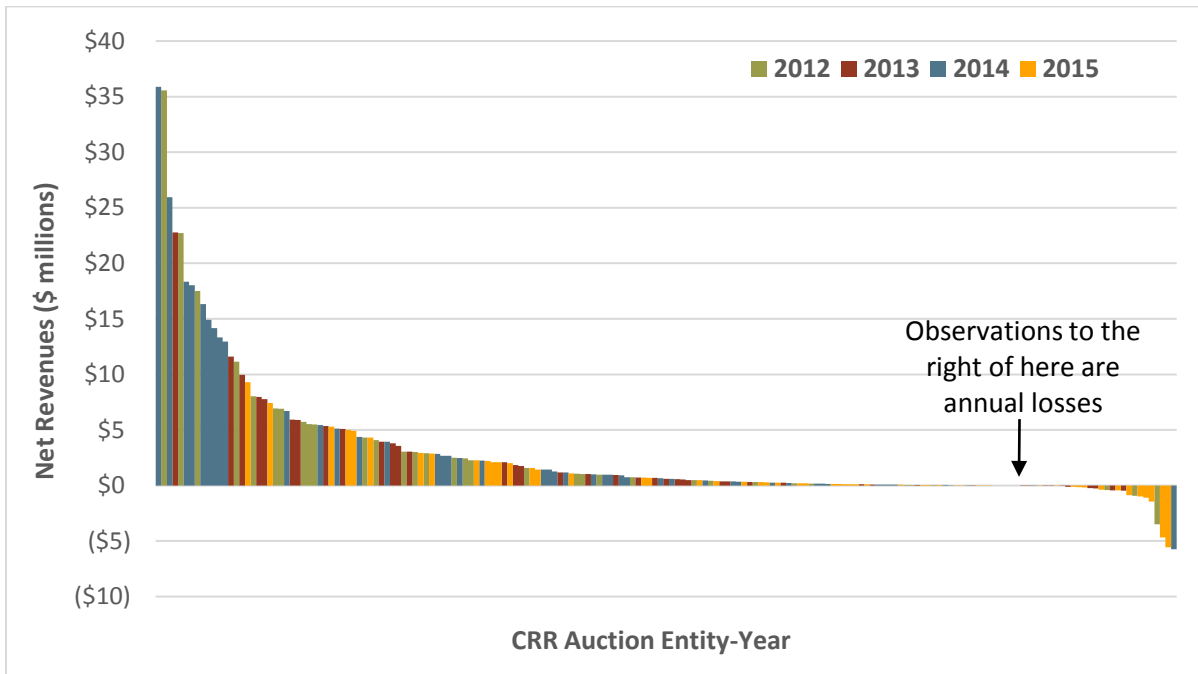


Table 1. Auction revenues and payments to auctioned CRR by entity type

Entity Type	Year	Auction Revenues	CRR Payments	Profits
Financial	2012	\$4	\$34	\$31
Financial	2013	\$21	\$62	\$40
Financial	2014	\$25	\$120	\$95
Financial	2015	\$48	\$94	\$47
Marketer	2012	\$60	\$165	\$105
Marketer	2013	\$88	\$139	\$51
Marketer	2014	\$90	\$177	\$87
Marketer	2015	\$61	\$53	-\$8
Physical generation	2012	\$9	\$25	\$16
Physical generation	2013	\$14	\$31	\$16
Physical generation	2014	\$14	\$48	\$34
Physical generation	2015	\$17	\$24	\$7
Load Serving	2012	-\$12	-\$22	-\$9
Load Serving	2013	-\$19	-\$22	-\$3
Load Serving	2014	-\$24	-\$53	-\$29
Load Serving	2015	-\$16	-\$2	\$14
All Entities	2012-15	\$380	\$873	\$493
Non-LSE Entities	2012-15	\$451	\$972	\$520

3 CRRs are inconsistently defined products

This section explains a cause of CRR auctions not being competitive. CRRs are not consistently defined products in both the auction and day-ahead market.

CRR auction and day-ahead market shift factors are going to be different

In the monthly CRR auction, the ISO uses a transmission model developed at least several weeks, and as much as a month, prior to the relevant day-ahead market hour. The ISO holds the seasonal CRR auctions at the end of the year prior to the settlement year. Many outages “...cannot be known until real-time operations...” and these outages can “...change the system configuration and result in different shift factors...” than used in the auction.¹⁰ Different limits and network configurations are possible and likely. “Therefore, it might be that the assignment [of CRRs] is not, in all circumstances and under all conditions, actually feasible.”¹¹

Different shift factors mean CRRs are different bundles in auction and day-ahead market

Different network models in the CRR auction and day-ahead market creates a more basic issue than revenue inadequacy. Different models mean the CRR product is defined differently in the CRR auction than in the day-ahead market. A CRR holder buys a specific bundle of forward contracts in the auction. But the CRR holder can be paid the day-ahead prices for a different bundle of forward contracts. The product purchased in the CRR auction is not the same product settled in the day-ahead market. Because the day-ahead market network model is not and cannot be known when the auction is run, it is uncertain what transmission constraint prices the CRR will settle on in the day-ahead market.

Consider a case where the ISO introduces a completely new constraint named River-Woods into the day-ahead market. When the River-Woods constraint is binding in the day-ahead market, it increases payments to a CRR. When the ISO pays the CRR holder for the entire difference in day-ahead market congestion prices between the source and sink nodes, the ISO pays the CRR holder for a forward contract to the constraint River-Woods which was not even modeled in the auction. The CRR holder is paid for this forward contract even though a forward contract to River-Woods was not purchased, or even offered, in the auction. Though the ISO does not explicitly offer a forward contract for River-Woods in the auction, a River-Woods forward contract is actually available. The CRR will be settled on the entire day-ahead market source-sink price difference, which includes the River-Woods day-ahead market transmission price. This CRR is a different bundle of forward contracts in the auction than it is in the day-ahead market. At the time the CRR auction is held, it is not clear what constraints will be enforced in the day-ahead market. Therefore, it is not clear what forward transmission right contracts are actually available in the CRR auction.

Similar problems occur when the ISO models a constraint differently between the CRR auction and day-ahead market. Consider a 100 megawatt CRR whose source and sink locations both have 0.10 shift factors to the transmission constraint Hill-Valley. The holder of this CRR would purchase zero net megawatts of forward contracts to the Hill-Valley constraint. If in the day-ahead market model the source shift factor to Hill-Valley changes to 0.05, while the sink shift factor remains 0.10, the CRR holder

¹⁰ Bautista Alderete, Guillermo. “FTRs and Revenue Adequacy” in *Financial Transmission Rights: Analysis, Experience and Prospects*. Springer 2013. Edited by Juan Rosellón and Tarjei Kristiansen, p. 253.

¹¹ Harvey, Scott M, William W Hogan, and Susan L Pope. 1997. *Transmission Capacity Reservations and Transmission Congestion Contracts*. Cambridge, MA: Harvard University, p. 62 of the version at: <http://www.hks.harvard.edu/fs/whogan/tccopr3.pdf>.

would be paid for 5 megawatts of forward contracts to the Hill-Valley constraint at the day-ahead market price. Again the CRR holder never purchased a Hill-Valley forward contract. Different transmission models, as defined by different shift factors in the CRR model and day-ahead market model, can create the same or similar problems as non-modeled constraints.

CRR auction participants can profit from better information on actual shift factors

Paying CRRs at the full day-ahead market congestion price differences between the source and sink nodes is like allowing buyers to purchase regular gasoline now to sell at premium prices later. The network model in the auction is public information to the CRR auction participants. Auction participants can compare the public CRR auction model to their private estimates of the multiple network models over the month or season in which the auctioned CRRs will settle. An auction participant may find CRRs modeled in the auction as lower value, “regular,” that the participant models as higher value, “premium.” Profit maximizing participants would bid to obtain CRRs modeled in the auction as regular but which they anticipate to be premium. Similar use of superior private information to bid into auctions has been studied in construction contract, government procurement, timber, and online advertisement auctions.¹² These studies show that the use of superior private information in auctions with inconsistently defined products can result in decreased auction revenues relative to the value of the product actually being auctioned.¹³

A simple example CRR auction illustrates how a CRR auction participant can profit from having better estimates of the actual day-ahead market shift factors. The example auction has one constraint called Elk-Wapiti with a 10 MW limit. Table 4 shows the auction bids, auction shift factors, actual day-ahead shift factors and actual day-ahead Elk-Wapiti shadow value. Both the auction participants, Bob and Sue, expect a \$30/MW Elk Wapiti shadow value which equals the actual day-ahead market shadow price.

Table 2. Example of CRR auction with shift factors different than day-ahead market

Bidder	CRR Name	CRR Bid		Cleared CRR MW	Net Shift Factor		Bid Price Per MW		DA Mkt S.V.
		Price	MW		Auction	DA Mkt	Auction	Actual	
Bob	A-C	\$3.00	150	0	0.10	0.10	\$30.00	\$30.00	\$30.00
Sue	B-C	\$3.10	150	100	0.10	0.15	\$31.00	\$20.67	\$30.00

Bob does not have better estimates of the day-ahead shift factors than the auction. Bob wants a CRR between locations A and C. He bids the expected price difference between A and C of \$3.00/MW which equals \$30/MW of Elk-Wapiti forward contracts.

Sue has better estimates of the day-ahead market shift factors. She expects the actual day-ahead market net shift factor difference between locations B and C will be 0.15 and not the 0.10 modeled in the auction. Sue bids \$3.10/MW for CRRs between B and C. Sue’s bid appears to be \$31/MW of Elk-

¹² As examples see:

Athey, Susan, and Jonathan Levin. 2001. “Information and competition in US Forest Service timber auctions.” *Journal of Political Economy*: <http://web.stanford.edu/~jdlevin/Papers/Skewing.pdf>.

Agarwal, Nikhil, Susan Athay, and David Yang. 2009. “Skewed Bidding in Pay Per Action Auctions for Online Advertising” *The American Economic Review*: <http://economics.mit.edu/files/10630>.

¹³ For procurement auctions it can result in increased payments to the auction participant relative to the value of the product or service procured.

Wapiti forward contracts in the auction. Because \$31/MW is greater than \$30/MW Sue wins all 10 MW of Elk-Wapiti forward contracts (100 CRR MWs multiplied by the 0.10 shift factor). Sue pays ratepayers \$310 in auction revenues (10 MWs multiplied by \$31/MW).

But Sue did not actually buy 10 MW of Elk-Wapiti forward contracts. Because the actual net shift factor is 0.15, she really bought 15 MW of Elk-Wapiti forward contracts. Sue's CRR is not a "regular" CRR with a 10 MW forward contract. Her CRR is a "premium" CRR with a 15 MW forward contract. Ratepayers pay Sue \$450 in the day-ahead market (15 MW multiplied by the \$30/MW day-ahead Elk-Wapiti shadow value). Sue's profits are \$140 (\$450 minus \$310). Ratepayers lose \$140 because they received \$310 in auction revenues but paid Sue \$450 when settling the forward contract.

Sue actually bids only \$20.67/MW of Elk-Wapiti forward contracts (\$310 divided by 15 MW). Sue's bid appears to be \$31/MW because the auction used the wrong shift factors and it appeared she was only buying 10 MW. Bob is actually the highest bidder. His \$30/MW bid is higher than Sue's \$20.67/MW bid. If the correct net shift factor for A to C had been used, Bob would have won all the Elk-Wapiti forward contracts in the auction. Because the CRR auction uses different shift factors than the day-ahead market, the actual highest bidder does not win the forward transmission right contracts in this example CRR auction.

4 Ratepayers face significant limitations to bidding in auctions

Through the CRR auction transmission limits, the ISO determines the initial set of CRR forward contracts that ratepayers must offer at a \$0 reservation price. If ratepayers wanted to auction off less CRR forward contracts than the quantity implied by the auction's transmission limits, ratepayers would have to bid into the CRR auction to buy the forward contracts. Ratepayers could in theory set reserve prices for the CRR forward contracts. They could set reserve prices by submitting price sensitive demand bids to buy CRRs. However, ratepayers face significant limitations to transacting in the CRR auction.

The costs for individual ratepayers to enter the auction obviously outweigh the benefits. Load serving entities therefore participate in ISO markets on the ratepayers' behalf. But load serving entities do not have a direct monetary incentive to manage the ratepayers' CRR forward contracts in the auction. One reason for this is that load serving entities directly pass through to ratepayers any profits or losses from these CRRs that are passively auctioned off by the ISO on the ratepayers' behalf.

Load serving entities also face regulatory hurdles from managing these CRR forward contracts. For example, see the procurement plan passage below:

As the Commission determined in Resolutions E-4135 and E-4122, [The LSE] uses CRRs and LT-CRRs to hedge against congestion costs (expected and anticipated). [The LSE] does not use CRRs and LT-CRRs for financial speculation.¹⁴

The above passage reflects the prevalent misunderstanding of the current CRR auction design. Under the current CRR auction design, if load serving entities do not participate in the auction at all, ratepayers will be engaging in risky financial speculation. This is because running a CRR auction with non-zero

¹⁴ *Pacific Gas and Electric Company Conformed Long Term Procurement Plan, Attachment A, Clean Public Version, 2012, p.158:* <https://pgereregulation.blob.core.windows.net/pge-com-regulation-docs/BundledProcurementPlan-Public.pdf>.

transmission limits forces ratepayers to offer to sell risky CRR forward contracts at a \$0 reservation price.

Regulations such as those cited in the passage above result in load serving entities not being able to purchase CRR forward contracts at auction. As a result, load serving entities cannot use explicit CRR purchases to help ratepayers avoid being forced to sell risky CRR forward contracts. Load serving entities can only bid for CRR forward contracts if they expect to use these CRR contracts to offset specific expected congestion costs as approved by the utility commission. Load serving entity procurement plans contain similar passages for all three investor owned load serving entities in the ISO.¹⁵

In order to purchase or set reserve prices on the CRR forward contracts offered by the ISO at \$0 reservation prices, load serving entities would also need to determine what CRR forward contracts are actually being offered. As described in Section 4 above, because CRRs are inconsistently defined products between the auction and day-ahead markets, LSEs cannot easily determine the set of CRR forward contracts being offered in the CRR auction. Load serving entities would likely find it difficult to purchase or set reserve prices on the CRR forward contracts if they do not know what forward contracts are actually available.

5 Buyers may not bid auctioned CRRs up to their expected value

Ratepayers face significant economic, regulatory and technical hurdles restricting them from effectively bidding in the CRR auction. Therefore, ratepayers cannot effectively raise the reservation prices of CRR forward contracts auctioned by the ISO from zero up to ratepayers' willingness to sell.

However, CRR buyers competing for profitable CRRs might bid up the CRR prices. Because ratepayers are paid the auction revenue, they would receive the value of higher priced CRRs. If these CRR buyers compete by non-price methods, or transaction costs lower the buyers' willingness to pay, the auction prices they pay to ratepayers for the CRR forward contracts may not rise to expected CRR values.

Non-price competition for CRRs is any action to obtain profitable CRRs other than raising the prices paid for CRRs. For example, by creating better transmission modeling and forecasting tools CRR buyers can find CRRs that are undervalued or modeled differently in the CRR auction than in the day-ahead market.

Further, CRR auction participation is a complex undertaking:

“...a typical FTR [a.k.a. CRR] desk has to deal not only with standard roles of trading financial products, but also the technical ones of power analytics. Building and operating a successful FTR business is a complex enterprise, with multiple factors to consider. Additionally, the still exotic nature of the product makes standard solutions from the trading industry difficult to use.”¹⁶

¹⁵ *Southern California Edison 2015 General Rate Case Generation Volume 4 – Power Procurement* p.2: [http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/6A7265B21497F49F88257C210080D7A9/\\$FILE/SCE-02+Vol.+04.pdf](http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/6A7265B21497F49F88257C210080D7A9/$FILE/SCE-02+Vol.+04.pdf)
San Diego Gas and Electric Company's 2006 Long Term Procurement Plan, p.17: <https://www.sdge.com/sites/default/files/regulatory/2006LTPP-Redacted.pdf>.

¹⁶ Arce, Jose. “Trading FTRs: Real Life Challenges” in *Financial Transmission Rights: Analysis, Experience and Prospects*. Springer 2013. Edited by Juan Rosellón and Tarjei Kristiansen, p.271.

To trade in the complex CRR auction many CRR buyers employ PhDs in electrical engineering. The complexity of CRR trading indicates that transaction costs are high. Transaction costs are the costs, other than actual CRR prices, of transacting in the CRR auction. Transaction costs are not only faced by the actual buyers in the auction but also potential buyers who did not enter the auction. Potential transaction costs for CRR auction participation may include:

- Obtaining technical knowledge of power flow analysis, finance, and CRR markets
- Obtaining knowledge specific to the ISO transmission system, outages, and operations
- Collateral requirements limiting total trades¹⁷
- Company risk management policies, particularly for companies whose main business is not CRRs
- Time and effort spent searching for modeling differences
- Opportunity cost of participating in other markets

CRR auction prices will likely fall as non-price competition and transaction costs increase. CRR buyers can also take advantage of having better and more flexible models of the day-ahead market models than the single model used in the CRR auction. With better models and better information, buyers can bid for CRRs they believe to be high value but which are modeled in the auction as low value. This is described in Section 4 above.

Any one of these or other factors may be preventing buyers from bidding CRR auction prices up to their expected value. The non-ratepayer CRR profits from CRRs are clearly large and consistent. Returns over 115 percent are not consistent with a competitive auction without transaction costs.

6 Alternatives to the CRR auction

The ISO's day-ahead market is a centrally cleared market. In a centrally cleared market power is not traded directly between market participants. It is sold *to the market* at the market price. Similarly power is bought *from the market* at the market price. The market price at any location is the locational marginal price. It follows that power is not shipped from one location to another. A CRR is not needed as a right to ship power between locations or for transmission access.

The demand for a hedge against locational price difference primarily comes from forward contracting on power prices. Suppliers, loads, and others trade these forward power contracts outside the ISO markets. A supplier may sell a forward power contract at a location different than its generator's location. When this happens, the day-ahead settlement prices for the forward power contract and the generator's energy schedule will be different. The supplier will face an uncertain day-ahead price difference not hedged by the forward power contract. A supplier may be willing to buy a forward contract for the day-ahead price difference to hedge this uncertainty.

One alternative to auctioned CRRs would simply be a bilateral or exchange market for forward contracts for price differences between pairs of nodes. Forward contracts for price differences already exist in many markets today. They are called locational basis price swaps. A swap contract is relatively straight forward. The swap buyer pays the seller a price in the forward market. In return the swap seller pays

¹⁷ Market participants must hold collateral for each megawatt of CRRs held as shown in *Business Practice Manual for Congestion Revenue Rights Appendix H. Credit Requirement* at:
<https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Congestion%20Revenue%20Rights>

the buyer the spot price difference between two locations. Oren, Spiller, Varaiya and Wu¹⁸ detailed how forward contract pairs, one contract at the “source” location and one at the “sink” location, could be bought and sold to create a hedge on locational price differences with the same effect as a locational basis price swap.

Price swaps could be traded between willing counterparties either through an exchange or bi-laterally. Generators with forward power contracts at locations different than their generator location would naturally benefit from decreased price differences between their power contract location and their generator location. The generators would be natural buyers of a locational basis price swaps. Load with forward power contracts, and who own the day-ahead congestion rents, would benefit from increased price differences between the power contract location and the generator location. The load would be a natural seller of a locational basis price swap. The same parties that benefit from trading forward power contracts could also benefit from trading forward contracts for price differences.

Unlike a CRR forward contract, a price swap would be consistently defined in the forward market and day-ahead market. The buyer of the price swap purchases the right to be paid the day-ahead price difference between two locations by the seller. In the day-ahead market, the price swap seller pays the buyer this price difference. This is in contrast to a CRR which can be an inconsistently defined product because it can be a different bundle of forward contracts in the CRR auction than in the day-ahead market.

There is no clear rationale for the ISO to offer forward price swaps. However, policy makers may determine that there are benefits to having the ISO provide a market for price swaps. Options for how the ISO could create a market for financial swaps between willing counterparties can be discussed in future papers.

Financial swap exchange markets external to the ISO or facilitated by the ISO would result in *markets* connecting willing buyers and sellers. Alternative markets should produce prices reflecting participants' willingness to trade. This is in contrast to the current CRR auction that allows participants to buy forward contracts from ratepayers not bidding into the auction. A market based only on trades between willing participants would also greatly reduce the potential for large wealth transfers from ratepayers to other participants. With these alternative markets any generator, marketer, financial entity, or load-serving entity could buy or sell forward contracts to hedge or speculate on locational price differences.

Appendix A The CRR auction and economic property rights

A main point in the above paper is that CRRs are *not* rights to congestion rent or rights to transmission access. CRRs are bundles of cash settled forward contracts. To understand the CRR auction we must change from viewing the CRR auction as selling rights to congestion rent to viewing the underlying forward contract trades.

Economic property rights, described below, are what are ultimately traded in a market. We must understand what economic property rights the CRR auction defines to understand what is being traded. To understand the trade of economic property rights we must also seek to understand how *transaction costs*, also described below, affect participants. As shown in the above paper and described in this appendix, many of the CRR auction's shortcomings derive from a design that poorly defines economic property rights and does not account for transaction costs.

Economic property rights are “rights to use, control, and obtain the benefits from a good or resource.”¹⁹ Well-defined economic property rights, secure from appropriation, are a central requirement for a competitive market.²⁰ To trade a good or product through a market, it helps if buyers and sellers know what the product they are trading is. Clearly defined economic property rights facilitate market exchange.

A textbook (Walrasian) competitive market model assumes all buyers and sellers know exactly each attribute of the product being traded. To decide how much of a product to buy or sell, a market participant only needs to see the market price. Market participants do not need to make other efforts or incur costs to ascertain the value of the product or to protect their property rights during or after the transaction.

For example, the market for wheat is generally considered competitive. Farmers and millers all know what a bushel of wheat is. The miller only needs to know the market price to decide how much wheat to buy.²¹

The market for a used car is further from a textbook competitive market. The buyer does not know the full condition of the car. The buyer needs to know more than the car's price or risk getting a lemon. The buyer needs to take non-price actions such as inspecting the car, reviewing service records, obtaining a warranty, and negotiating trade terms.

As an extreme example, imagine Sue offers to sell you a mystery box for only \$5,000. You do not know what is in the box, it could be anything. Would you buy the box? How would you know whether Sue is offering you a good deal or trying to take advantage of you? It is hard to imagine a robust competitive market in mystery boxes.

Most markets do not fit the textbook competitive market. Market participants must often undertake efforts and incur costs in addition to the market price. That is, market participants must often incur

¹⁹ Gwartney, James D., Richard L. Stroup, Russel S. Sobel, and David A. MacPherson. Microeconomics: Public and Private Choice 14th Ed. South-Western 2013, p.485.

²⁰ Gwartney et al 2013, p.66.

²¹ This is more of a textbook example. The actual wheat market is more complex.

transaction costs. *Transaction costs* are the “the costs associated with the transfer, capture, or protection of [economic property] rights.”²²

Of course imperfectly defined property rights and transaction costs do not mean that markets will not work. To the contrary, an amazing aspect of markets is the many ways people respond to imperfectly defined property rights and transaction costs to maximize the value of market participation. Inspecting goods and obtaining warranties are just a few simple examples of non-price actions in response to imperfectly defined property rights and transaction costs.

CRRs are meant to provide clear economic property rights. Clear property rights would facilitate competitive market trading.²³ The mechanism that clears the CRR auction is a textbook (Walrasian) competitive market model. The auction design depends on the assumptions of the textbook competitive market model, including well-defined economic property rights and no transaction costs.

As explained in the above paper, the ISO makes a set of forward contracts available at zero offer prices. Electric ratepayers must pay the buyers of these forward contracts that were offered with no reservation price. Because the ISO initially allocates ratepayers’ property rights (the rights to payments from ratepayers) as available in the auction, property right definitions and transaction costs should be carefully considered. If property rights are not well-defined or transactions costs restrict auction participation, the initial allocation of CRR forward contracts as offered at \$0 reservation price will significantly affect the final allocation of the ratepayers’ economic property rights.²⁴

As shown in the paper, the CRRs bought in the auction can be, and often are, different products when settled in the day-ahead market. Looking at the auction model alone, it is not even possible to know what CRR forward contracts are actually available in the auction. The CRRs sold in the auction do not have well-defined property rights.

Ratepayers face multiple and significant transaction costs to auction participation. These transaction costs limit the ratepayers’ ability to avoid entering CRR forward contracts. Contrary to what economic theory would suggest,²⁵ the burden of acting, and costs of not acting, are placed on those with the most transaction costs and least ability to act.

Ratepayer property rights are not secure as a direct result of the CRR auction design. The property rights made insecure are simply the rights to payments from ratepayers. Auction participants can obtain CRR obligations from ratepayers to capture these ratepayer property rights. Transaction costs limit ratepayer’s ability to protect these rights in the auction. Auction participants can capture these property rights to extract payments from ratepayers.

In most markets people attempt to act around poorly defined property rights and seek ways to reduce transaction costs. If poorly defined property rights and transaction costs cannot be overcome, people may also choose not to enter the market or exchange products. Many construction contract and government procurement auctions have rules that reject particular bids or allow for renegotiating prices

²² Barzel, Yoram. *Economic Analysis of Property Rights* 2nd Ed. Cambridge University Press 1997, 1st Ed. 1989, p.4.

²³ Hogan, William W. 1992. "Contract Networks for Electric Power Transmission." *Journal of Regulatory Economics*, p.25: <http://www.hks.harvard.edu/fs/whogan/acnetref.pdf>.

²⁴ Coase, Ronald H. 1960. "The Problem of Social Cost." *Journal of Law and Economics*.

²⁵ See for example Barzel, Yoram. *Economic Analysis of Property Rights* 2nd Ed. Cambridge University Press 1997, 1st Ed. 1989 Chapter 1.

if “realized quantities differ from initial estimates by more than some fixed amount.”²⁶ These construction and procurement auction rules protect against bidders extracting value because the bidders have better private estimates of the property rights offered than the auction’s public estimates. The auction rules protect against issues created by poorly defined economic property rights similar to the poorly defined rights in the CRR auction. But in the CRR auction ratepayers cannot contract around poorly defined property rights or even avoid exchanging products.

The ISO’s CRR auction is part of a broader market design governed by a FERC approved tariff. Auction participants, particularly ratepayers, cannot contract around the tariff or the CRR auction’s poorly defined property rights. The contract rules are already set in the ISO tariff. Unlike other private trading platforms, the ISO can force ratepayers to “offer” to sell CRR forward contracts. Limited by transaction costs, ratepayers cannot choose to avoid exchanging these forward contracts. Ratepayers cannot take actions to contract around, minimize, or avoid the potential for CRR auction participants to extract ratepayer payments. To get around the poorly defined property rights, and close the opportunities to capture ratepayer payments, the ISO would need to change the CRR auction design.

Many of the CRR auction’s shortcomings derive from the ISO using an estimated network model in the auction. The ISO uses an estimated network model in the CRR auction to “bridge the electrical engineering and economic market formulations.”²⁷ But the day-ahead market congestion prices are already a bridge between the electrical engineering and economic models. A product that pays the difference between locational prices could simply be defined as the difference between locational prices. Using an estimated network model in the forward auction introduces complications, estimation errors and poorly defined property rights.²⁸ It is unlikely that rules similar to the CRR auction design would emerge in many competitive markets that are not designed by a regulatory process.

²⁶ Athey, Susan, and Jonathan Levin. 2001. “Information and competition in US Forest Service timber auctions.” *Journal of Political Economy*, p.377: <http://web.stanford.edu/~jdlevin/Papers/Skewing.pdf>.

²⁷ Hogan, William W. “Financial Transmission Rights: Point-to-Point Formulations” in *Financial Transmission Rights: Analysis, Experience and Prospects*. Springer 2013. Edited by Juan Rosellón and Tarjei Kristiansen, p.2.

²⁸ Focusing on the electrical engineering models also leads to a focus on revenue adequacy which Hogan 2013 p.2 calls “...a financial counterpart of physical “available transmission capacity.”” Revenue adequacy would be an odd thing to worry about if the Walrasian competitive market assumptions underlying the CRR auction were true. If the assumptions were true, and CRRs were rights to congestion rents, the initial allocation of rights as offered in the CRR auction would still be irrelevant per Coase 1960.