Congestion Revenue Rights Settlement Rule

Department of Market Monitoring

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I. Background

Under nodal convergence bidding, the California Independent System Operator (ISO) Department of Market Monitoring (DMM) recommended that the ISO adopt a settlement rule similar to that implemented by PJM Interconnection (PJM) and the ISO New England (ISO-NE) to help deter the potential use of virtual bidding to increase congestion revenue rights (CRR) payments. The specific language in the PJM tariff limiting a participant's CRR payments (referred to as Financial Transmission Rights or FTRs in PJM) in cases where the participant's virtual bids may have otherwise increased CRR payments reads as follows:

> **5.2 Transmission Congestion Credit Calculation.**
>
> (b) If a holder of a Financial Transmission Right between specified delivery and receipt busses acquired the Financial Transmission Right in a Financial Transmission Rights Auction (the procedures for which are set forth in Part 7 of this Schedule 1) and (i) had an Increment Bid and/or Decrement Bid that was accepted by the Office of the Interconnection for an applicable hour in the Day-ahead Energy Market for delivery or receipt at or near delivery or receipt busses of the Financial Transmission Right; and (ii) the result of the acceptance of such Increment Bid or Decrement Bid is that the difference in locational marginal prices in the Day-ahead Energy Market between such delivery and receipt busses is greater than the difference in locational marginal prices between such delivery and receipt busses in the Real Time Energy Market, then the Market Participant shall not receive any Transmission Congestion Credit, associated with such Financial Transmission Right in such hour, in excess of one divided by the number of hours in the applicable month multiplied by the amount that the Market Participant paid for the Financial Transmission Right in the Financial Transmission Rights Auction.

PJM extends the CRR settlement rule described above to buses "nearby" the delivery or receipt buses specified by the CRR. The tariff defines busses that are "at or near" each CRR delivery or receipt Location as follows:

> [a] Location shall be considered at or near the FTR delivery or receipt Location if seventy-five % or more of the energy injected or withdrawn at that Location and which is withdrawn or injected at another Location is reflected in the constrained path between the subject FTR delivery and receipt Locations that were acquired in the FTR Auction.

The ISO-NE tariff incorporates virtually the same language. DMM staff has worked with PJM's market monitor to clarify the details of how this language is actually applied. Section II of this paper describes how the above tariff language is implemented by PJM in specific detail and provides a number of hypothetical examples to illustrate key details of the methodology. Section

III then outlines a modified approach that we believe may provide a more targeted way of limiting CRR payments in cases when the CRR holders' virtual bids may otherwise increase their CRR payments.

II. PJM Approach

Step 1. Compare Day Ahead and Real Time Price Differences

First, all CRR source/sink combinations are reviewed to determine if the difference between the congestion component locational marginal prices (or CLMPs) for the CRR source/sink nodes in the day ahead market is greater than the difference in the CLMPs sourcing the real time market. Specifically, convergence bidding by holders of a CRR are further reviewed and potential CRR payments limited only if:

$$(CLMP_{DA,\ Sink} - CLMP_{DA,\ Source}) - (CLMP_{RT,Sink} - CLMP_{RT,Source}) > 0$$

This step reflects the assumption that if the price difference between the CRR source and sink in the real-time market is greater than the price difference in the day-ahead market, then convergence bidding did not inappropriately exacerbate the price difference between the CRR source and sink in the day-ahead market.

Step 2. Identify Constraints Making Significant Contribution to Congestion

For each CRR identified in Step 1, the next step is to determine the set of constraints that are determined to have made a significant contribution to the difference in day-ahead CLMPs at the CRR source and sink (i.e., the revenues paid to the holders of the CRR). For this step, PJM assumes that a constraint makes a significant contribution to the difference in day-ahead CLMPs at the CRR source and sink if the following two conditions are met:[1]

a) The shift factor for the CRR source node relative to the constraint is positive, and the shift factor for the CRR sink node is negative; and

b) If the absolute value of the difference between the shift factors for the CRR sink and source is greater than .10.

Table 1 illustrates this step for four different constraints under a hypothetical set of conditions. As shown in Table 1:

- Constraint 1 would be included in the next step of this process since both conditions above are met.
- Constraint 2 would *not* be included in the next step of this process since condition (a) is not met (shift factor for the CRR source is *negative).*
- Constraint 3 would *not* be included in the next step of this process since condition (a) is not met (shift factor for the CRR sink is *positive*).

[1] This description reflects how PJM's CRR settlement rule would apply given the ISO's convention of representing shadow prices as *positive* values, so that nodes with *positive* shift factors (PTDFs) relative to a constraint represent nodes where additional supply would exacerbate congestion and additional demand would relieve congestion. Conversely, nodes with *negative* shift factors are nodes where additional supply would relieve congestion and additional demand would increase congestion.

- Constraint 4 would *not* be included in the next step of this process since condition (b) is not met (absolute value of difference in shift factor is < .10).

Table 1 Determining Critical Constraints under PJM Approach

	Shadow Price	Shift Factors			Subject to CRR Rule?	CLMP		
		Source	Sink	Difference		Source	Sink	Difference
		A	B	abs(B - A)		A	B	B – A
Constraint 1	$100	**.3**	**-.3**	**.6**	**Yes**	-$30	$30	$60
Constraint 2	$200	**.9**	**.5**	.4	**No**	-$180	-$100	$80
Constraint 3	$100	**-.5**	**-.9**	.4	**No**	$50	$90	$40
Constraint 4	$100	.02	-.06	**.08**	**No**	-$2	$6	$8
					Totals	-$162	$26	$188

The last three columns of Table 1 also illustrate how the shift factors for the source and sink nodes can be multiplied by the negative of the shadow prices for each constraint to determine the contribution of each constraint to the source and sink CLMP. This hypothetical example has been constructed to illustrate that in some cases virtual bidding that exacerbates congestion on constraints that make a very significant contribution to the CRR payments may not be subject to any settlement limitations under the PJM approach. For instance, while Constraint 2 in this hypothetical example accounts for over 40 percent of the CRR payments in this example ($80 out of $188), none of the virtual bids by CRR holders that could affect this constraint would be subject to the further screening described below.

Step 3. Identify Convergence Bids at Nodes "Nearby" Key Constraints

For each key constraint identified in Step 2, the set of "nearby" nodes at which each CRR holder had accepted convergence bids that could have significantly exacerbated congestion are then identified. PJM's procedure for doing this is as follows:

a) All nodes with *positive* shift factors where the CRR holder had virtual *supply* bids accepted are identified, and the *maximum* value of these shift factors is calculated. This maximum value represents the shift factor for the accepted virtual *supply* bid that had the highest impact (per MW of virtual bid accepted) on congestion on the constraint. If the participant does not have a virtual supply bid accepted, this value is 0.

b) All nodes with *negative* shift factors where the CRR holder had virtual *demand* bids accepted are identified and the *minimum* value of these shift factors is calculated. This minimum value represents the shift factor for the accepted virtual *demand* bid that had the highest impact (per MW of virtual bid accepted) on congestion on the constraint. If the participant does not have a virtual demand bid accepted, this value is 0.

c) Finally, the difference between the highest (positive) shift factor identified in step (a) and the lowest (negative) shift factor identified in step (b) is calculated. If this difference is greater than .75, then the participant's CRR revenues for the CRR being examined are subject to a cap, as described in the last step of this process.

Table 2 provides an illustrative example of how this approach would be applied. This illustrative example builds upon the example in Table 1, in which Constraint 1 was identified as being subject to further review.

- As described under Step 3(a) above, the first stage of this process would be to identify all of the participant's accepted virtual supply bids with positive shift factors (relative to Constraint 1), and to take the maximum of these values. As shown in Table 2, this would be .7, corresponding to the shift factor for Node J, where the participant has a 1 MW virtual supply bid accepted.
- As described under Step 3(b) above, the second stage of this process would be to identify all of the participant's accepted virtual demand bids with negative shift factors (relative to Constraint 1), and to take the minimum of these values. As shown in Table 2, this would be -.1, corresponding to the shift factor for Node X, where the participant has a 1 MW virtual demand bid accepted.
- As described under Step 3(c) above, the final stage involves taking the difference between the maximum positive shift factor from Step 3(a) and subtracting the minimum negative shift factor identified in Step 3(b) (i.e., .7 – (-.1) = .8).

Since the result of this calculation (.8) exceeds the .75 threshold, the participant's CRR payment is subject to the limit described in Step 4 below. However, as illustrated in this example, if the participant did not have the 1 MW virtual demand bid accepted at Node X, the CRR payment limit would not apply.

Table 2 Virtual bids at "Nearby Nodes"

Bid Type	Node	Cleared Quantity (MW)	Shift Factor
Virtual Supply	J	1	.7
Virtual Supply	K	100	.6
Virtual Supply	L	100	.5
		$A_{Maximum}$ =	.7

Bid Type	Node	Cleared Quantity (MW)	Shift Factor
Virtual Demand	X	1	- .1
Virtual Demand	Y	100	- .04
Virtual Demand	Z	100	- .03
		$B_{Minimum}$ =	-.1
		$A_{Maximum} - B_{Minimum}$ =	.8

Step 4. CRR Payment Limit

In the event that Step 3 indicates a participant had virtual bids accepted at a "nearby" node, the participant's CRR payment price for that hour (per MW of CRR) is limited so that it does not exceed the average auction price of the CRR (per MW/hour). For purposes of this calculation, the average price paid for the CRR is derived by taking the market clearing price for the monthly CRR divided by the number of hours in the month.[2] Thus, the CRR payment when this limitation is in effect is as follows:

$$CRR = Q_{CRR} \times \text{Min}\ [\ \text{Avg}\ (P_{CRR}),\ (CLMP_{DA,\ Sink} - CLMP_{DA,Source})\ ]$$

where Q_{CRR} is the quantity in MW of CRRs owned from the Source Node to the Sink Node, and Avg (P_{CRR}) equals the average CRR price (P_{CRR}), the price the participant paid for the monthly CRR, divided by the number of hours in the month. In practice, since PJM applies this limit as a separate adjustment after CRR payments have been made, the following adjustment is made as part of the settlement process:

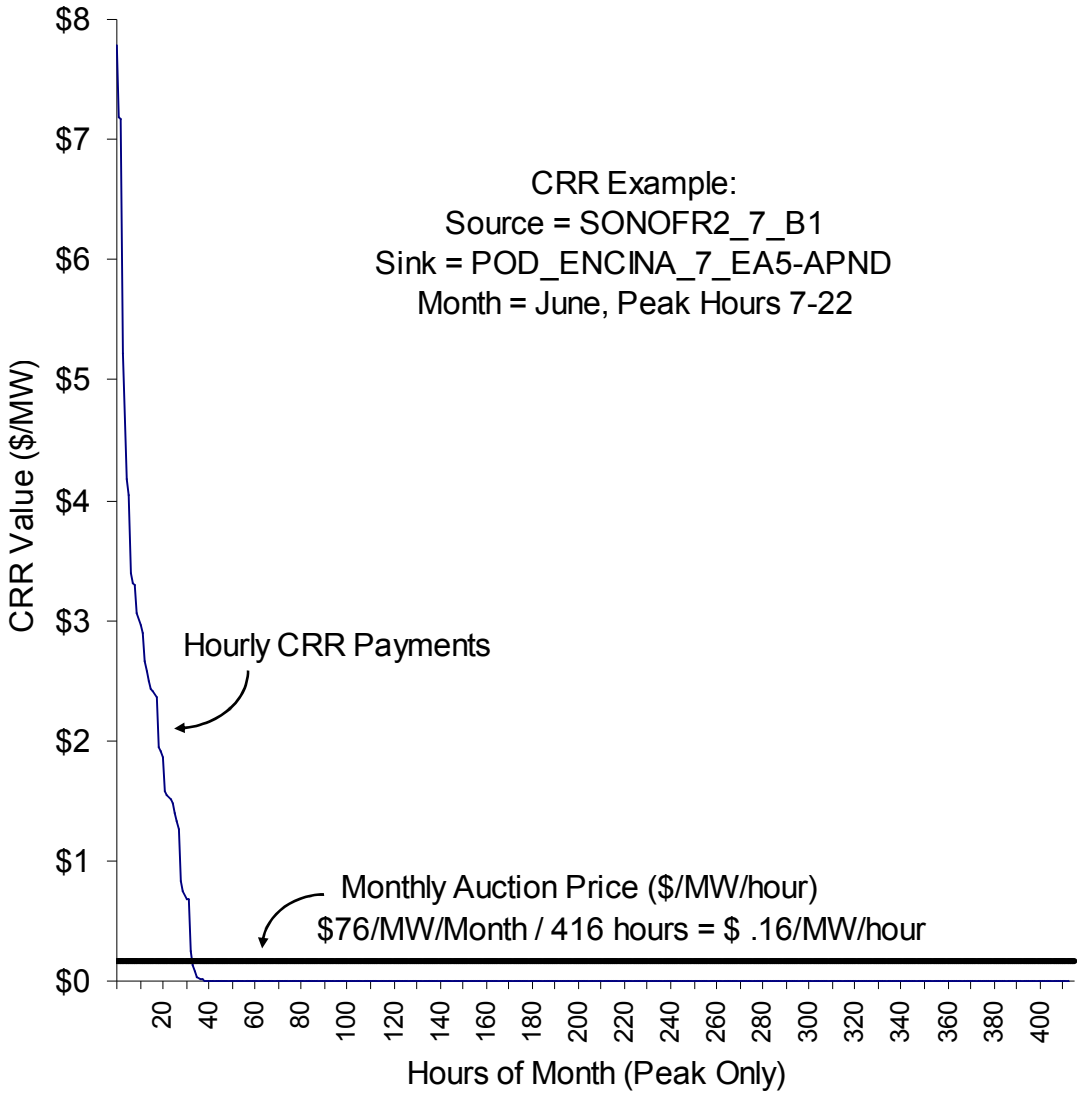
$$\text{If } (CLMP_{DA,\ Sink} - CLMP_{DA,\ Source}) > \text{Avg}\ (P_{CRR}), \text{ then}$$
$$\text{CRR Adjustment} = Q_{CRR} \times [(CLMP_{DA,\ Sink} - CLMP_{DA,\ Source}) - \text{Avg}\ (P_{CRR})].$$

In the event that the difference between the LMPs is less than the average hourly price of the CRRs, no adjustment would be made.

The portion of hours over a month when this settlement rule can be applicable may vary, depending on the percentage of hours when congestion prices are above or below the calculated average cost of the CRR. Figure 1 below provides an illustrative example of hourly CRR payments over the peak hours of a month compared to the average cost of a CRR in the monthly auction. This highlights another potential limitation of this methodology. For instance, during most of the hours of the month, the CRR payment could typically be increased by virtual bidding without reaching the cap. In other hours, when CRR payments are very high, even a small amount of virtual bids making a relatively small contribution to congestion can result in significant payment reductions.

[2] In the event that the CRR was allocated to the participant rather than purchased, the last auction price would be used as a proxy in this calculation. This is because the auction price is the closest measure of the market value available for the CRR.

Figure 1 Illustrative Comparison of Hourly CRR Revenues vs. Average Hourly Cost



III. Potential Alternative Approach

Key Issues

In reviewing PJM's approach for developing a settlement rule for deterring potential use of virtual bidding to increase CRR revenues, we have identified several aspects of PJM's approach that might be further refined to provide for more targeted application of the settlement rule limiting CRR payments for CRR holders engaged in convergence bidding. For example:

- *Congestion on multiple constraints:* In practice, congestion contributing to the price difference from CRR source to CRR sink can occur on multiple constraints. In this situation, the contribution of congestion on different constraints to the overall price difference from CRR source to CRR sink can be quantified separately for each constraint. However, some of these key constraints may not be captured under the PJM approach described in Section 2, Step 2.

- *Multiple convergence bids:* In practice, participants (including affiliates) holding CRRs may also have multiple convergence bids that could significantly affect the revenue of the CRR congestion contributing to the price difference from CRR source to CRR sink. In PJM, the CRR settlement rule is applied based only on the individual virtual supply and demand bids with the most "extreme" shift factors (i.e. the maximum positive shift factor and the minimum negative shift factor). However, other approaches could be developed that look at the combined effect of all virtual bids by a participant. This approach could be particularly appropriate under an approach that assesses the impact of virtual bids on multiple congested constraints that contribute to the overall price difference from CRR source to CRR sink.

- *Magnitude of effect on congestion.* The basic settlement rule adopted by PJM is triggered by any accepted virtual bid at a node that is "nearby" to the node that comprises the source/sink of the participant's CRR (i.e., a shift factor > .75). Thus, the settlement rule could be triggered by even a 1 MW virtual bid that increases flow on a congested path by as little as .75 MW (1 MW x .75 shift factor). Meanwhile, the settlement rule would not be triggered by a 1,000 MW virtual bid that increases flows on the same path by as much as 744 MW (1,000 MW x .74 shift factor). Thus, one potential refinement of this approach would be to trigger a settlement rule based on the magnitude of the impact of a participant's virtual bids on flows on a congested constraint, rather than on the shift factor for the node at which a virtual bid occurs. This approach could be particularly appropriate in cases where a participant has virtual bids at multiple nodes that affect congestion on multiple constraints that all contribute to the price difference between the source and sink of the participant's CRR.

- *Price impact of congestion.* Finally, in some cases it may be that a participant's virtual bids do have a significant impact on congestion on a particular constraint, but that the actual price impact of this congestion on the difference in CLMPs at the CRR source and sink is relatively low. Thus, another potential option is to more explicitly tie the degree to which a CRR payment may be limited to the degree to which a constraint affected by the participant's virtual bidding actually contributes to their CRR payments.

Description of Potential Alternative Approach

The following steps outline a potential alternative approach (and related options or variations) that could be used to address the issues identified above.

Step 1. Compare Day Ahead and Real Time Price Differences

As with the PJM approach, the first step would be to determine if the difference between the day ahead CLMPs for the CRR source/sink nodes is greater than the difference in the real time CLMPs for the CRR source/sink nodes. Specifically, convergence bidding by holders of a CRR would be subject to further review and potential CRR payment limits only if:

$$(CLMP_{DA,\,Sink} - CLMP_{DA,\,Source}) - (CLMP_{RT,Sink} - CLMP_{RT,Source}) > 0$$

Step 2. Identify Constraints Contributing to Participant's Potential CRR Payments

As with the PJM approach, this step would begin by identifying all congested constraints contributing to the difference in the congestion components of day-ahead LMPs for each CRR passing Step 1. However, unlike the PJM approach, no constraints making a positive contribution to the CRR payment would be dropped from further examination at this point (except perhaps only constraints making a *de minimus* impact). For example, in the hypothetical example in Table 1, none of the four constraints would be excluded at this stage of the analysis.

Step 3. Calculate Combined Impact of CRR Holder's Portfolio of Virtual Bids on Flows

Next, the combined impact of the participant's portfolio of accepted virtual supply and demand bids on the flows of all constraints identified in Step 2 is calculated. For a given CRR from *A* to *B*, the total MW flow contribution from all the accepted virtual bids of the CRR holder to the total MW flow on each constraint *k* is calculated as follows.

$$F_{k,i} = \sum_{j \in i} S_{k,j} VB_j$$

Where $S_{k,j}$ is the shift factor of constraint *k* with respect to accepted virtual bids at node *j* and (VB_j) is the volume (MW) of accepted virtual bids by the CRR holder at node *j*. The convergence bids of each CRR holder *i* include virtual bids by any entities to which the CRR holder is affiliated. Accepted virtual supply bids are represented as *positive* values of VB_j while virtual demand bids are represented as *negative* values of VB_j. All the shift factors would be based on the default slack, e.g., load distributed slack.

A variation of this approach could be to exclude virtual bids which have a very indirect impact on flows on a constraint (e.g., virtual supply bids with a shift factor < .10 or virtual demand bids with a shift factor > - .10). Under this approach, the analysis would exclude virtual bids at nodes at which a CRR holder would need to have a very large volume of virtual bids accepted in order to impact flows on a constraint. The rationale for setting this type of threshold would be that a CRR holder seeking to manipulate CRR prices would seek to place convergence bids at nodes having a more direct impact on constraints that could drive up their CRR payments.

Step 4. Determine Constraints Significantly Impacted by CRR Holder's Portfolio of Virtual Bids

For this step, the net impact of the participant's portfolio of accepted virtual supply and demand bids ($F_{k,i}$) would be compared to the total flow of each constraint (e.g., as a percent of the total flow on the constraint). A threshold would then be used to determine if congestion on each constraint may have been significantly impacted by the CRR holder's accepted virtual bids. Two options for this threshold include:

1) A static threshold (e.g., 5 or 10 percent of the total flow on the constraint); or
2) A sliding scale under which the threshold would decrease as the impact of the congestion on the CRR payment increased.

This second approach would be designed to reflect the fact that the impact of a given volume of increased flow due to virtual bids may be significantly higher under more extreme congestion. Table 3 illustrating this approach is provided below.

Table 3 Illustrative Example of Sliding Scale Used to Determine if Virtual Bidding Significantly Impacted Congestion on a Constraint

Impact of Congestion on CRR payment ($/MW)	Impact of Virtual Bids as Percent of Flow
< $2	20%
$2 to $5	10%
$5-$10	5%
>$10	2%

Note: Specific values used to illustrate concept of this approach only.

In practice, we note that under both these approaches, it may be necessary to periodically refine and adjust the specific thresholds used in this step to determine if a CRR holder's virtual bidding significantly impacted congestion on a constraint. Such adjustments would be done based on actual operating experience and off-line studies of the potential price impacts resulting from different levels of virtual bids (as a percentage of the flows on a constraint). With this approach, the specific thresholds used in this step would be incorporated as a parameter in a Business Process Manual (BPM) rather than the ISO tariff, and could therefore be modified through the BPM change management process rather than a tariff filing.

Step 5. Apply CRR Payment Adjustment

There are at least two options for adjusting the CRR payments to the CRR holder based on the results of the previous steps described above.

- **Approach A (PJM)**. Under the first option – which would most closely mirror PJM's approach – if the CRR holder's accepted virtual bids were determined to have impacted flows on any constraint contributing to the value of the CRR during any hour (as described

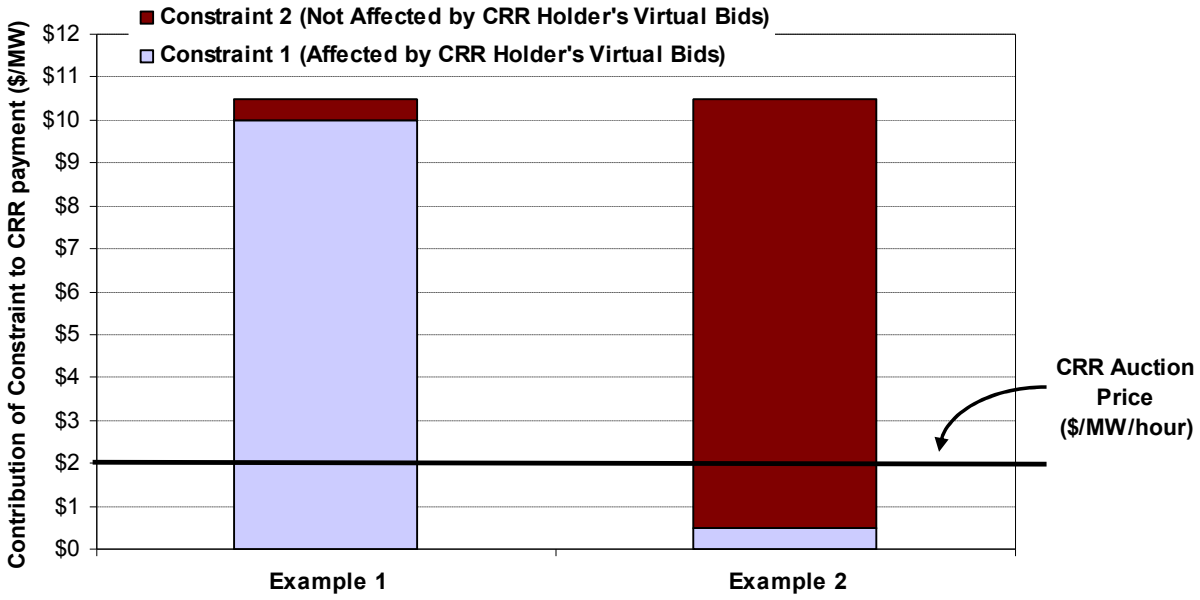
in Step 4 above), then the CRR holder payment for that CRR during that hour would be capped at the average price for that CRR in the monthly auction (see Section II, PJM Approach, Step 4).

- **Approach B (Alternative)**. Another option would be to limit (or eliminate) the CRR holder's payments only for the components of the CRR payment associated with congestion on constraints that was determined to be exacerbated by the CRR holder's accepted virtual bids. For instance, in the example shown in Table 1, if only Constraint 3 and Constraint 4 were determined to have been significantly impacted by the participant's virtual bids, the total potential impact of these virtual bids on CRR payments would be $48/MW (i.e., Constraint 3 ($40) + Constraint 4 ($8) = $48). Variations of this general approach are discussed in more detail below.

Figure 2 illustrates the differences in the two basic approaches described above using two different examples. Both these examples assume an average CRR price of $2/MW/hour, based on the CRR auction price divided by the number of hours covered by the CRR during that month. However, the two examples in Figure 2 differ as follows:

- Example 1 in Figure 2 assumes that congestion on Constraint 1 – which contributed $10/MW to the CRR value during this hour – was found to have been affected by the CRR holder's virtual bids that hour. Meanwhile, this first example assumes that Constraint 2 was found *not* to have been affected by the CRR holder's virtual bids that hour, but contributed only $.50/MW to the overall value of the CRR that hour ($10.50).
- Example 2 in Figure 2 assumes that congestion on Constraint 1 contributed only $.50/MW to the CRR value during this hour (and was again found to have been affected by the CRR holder's virtual bids that hour), while Constraint 2 contributed $10 to the CRR value that hour and was again *not* found to have been affected by the CRR holder's virtual bids that hour.

Figure 2 CRR Payment Adjustment Examples



Approach A. Under the first approach for limiting CRR payments – which would most closely mirror PJM's approach – the CRR holder's payments this hour would be capped at $2/MW under each of these examples. Under Example 1, this approach would still allow the CRR holder to earn an extra $1.50/MW from the congestion on Constraint 1, which was exacerbated by the CRR holder's virtual bids.[3] However, under Example 2, this approach would allow the CRR holder to earn only $2/MW, even though congestion on Constraint 2 (which was unaffected by the CRR holder's virtual bids) accounted for $10/MW of the total $10.50 value of the CRR payments that hour.

Approach B. Under this option, the CRR holder's payments would be reduced based only on the components of the CRR payment specifically associated with congestion on constraints that was determined to be exacerbated by the CRR holder's accepted virtual bids. Under Example 1, this approach would either limit or eliminate payment of the $10/MW portion of the CRR value that was attributable to congestion on Constraint 1, which was exacerbated by the CRR holder's virtual bids. With this approach, if the entire contribution from Constraint 1 was eliminated (Option B1), the CRR holder's payment would be $.50 If the payment under this scenario was capped at the CRR auction price (Option B2), the CRR holder's payment would be $2.00. Meanwhile, in Example 2, the total potential CRR payment ($10.50) would be reduced by only $.50/MW, which represents the components of the CRR payment specifically attributable to congestion on Constraint 1 that was exacerbated by the CRR holder's virtual bids.

IV. Next Steps

We are seeking input on this whitepaper from stakeholders and the ISO Market Surveillance Committee (MSC). Provided below is an initial schedule for further consideration of this issue as part of the CAISO's process for finalizing its proposal for convergence bidding.

- August 27 - Discuss whitepaper with stakeholders on Convergence Bidding Stakeholder Call.
- September 2 - Initial written comments from stakeholders on whitepaper.
- September 11 –Draft DMM proposal.
- September 18 - MSC/Stakeholder meeting.
- October 2 – Written comments from stakeholders on DMM proposal.

[3] $2/MW minus $.50/MW from congestion on Constraint 2 (which was not affected by the CRR holder's virtual bids) = $1.50.