Price Inconsistency Caused by Intertie Constraints

Draft Final Proposal

May 18, 2011

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1 Introduction

The California ISO (ISO) implemented convergence bidding on February 1, 2011, which includes the ability to submit virtual bids on the intertie scheduling points in the ISO market. Under the current design, the ISO enforces two constraints at scheduling points: (1) net physical schedules across each scheduling point, ignoring the accepted virtual schedules to ensure that the physical schedules are within the established scheduling limit for that scheduling point and (2) physical and virtual imports net of physical and virtual exports must also be within established scheduling limits for that scheduling point. Since convergence bidding was implemented, the ISO has seen cases where physical export bids are clearing the market at LMPs that are inconsistent (higher) than the submitted bid for the scheduled resource. Market participants have raised concerns regarding the negative impact this pricing inconsistency[1] may have on their settlement outcome.

To address this pricing inconsistency, the ISO proposes incorporating the shadow price of the two constraints in to the settlement Locational Marginal Price (LMP) for physical bids and virtual bids on the interties. This will result in different settlement LMPs for virtual and physical imports/exports when the physical intertie scheduling limit is binding and will eliminate the discrepancy in between market clearing and bid prices.

In the Straw Proposal, the ISO included two options that would result in consistent pricing: (A) different settlement LMPs for physical awards and virtual awards and (B) economic curtailment. However, since the stakeholder call and through discussion with the Department of Market Monitoring (DMM) the ISO has identified a potential adverse market outcome concern with Option B. Although most stakeholders favored Option B because it would result in the same price for virtual and physical awards, given this new information the ISO has eliminated it as a viable option. Therefore the ISO proposes to seek Board approval in June for Option A.

2 Plan for Stakeholder Engagement

Item	Date
Post Draft Final Proposal	May 18, 2011
Stakeholder Conference Call	May 25, 2011
Stakeholder Comments Due	June 1, 2011
Board Meeting	June 29-30, 2011

3 Background

The ISO implemented convergence bidding on February 1, 2011. Convergence or “virtual” bids are financial bids submitted only in the day-ahead market. There is no requirement for such bids to be backed by physical assets, nor does the market recognize any linkage between the virtual bids and any physical supply or demand bids submitted by the same entity. If cleared in

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1 Some other price and award inconsistency have also been observed at the interties that are unrelated to the convergence bidding implementation of the two intertie constraints. Rather these observations are related to uneconomic solution in the scheduling run and the resultant differences in the pricing run. Therefore, possible solutions for these observed pricing and scheduling run inconsistency would be different then the solutions discussed in this paper. The ISO will consider addressing this additional issue in parallel with this effort.

the Integrated Forward Market (IFM), these virtual supply and virtual demand bids settle first at day-ahead prices and then automatically liquidate with the opposite sell/buy position at the applicable HASP or real-time prices.

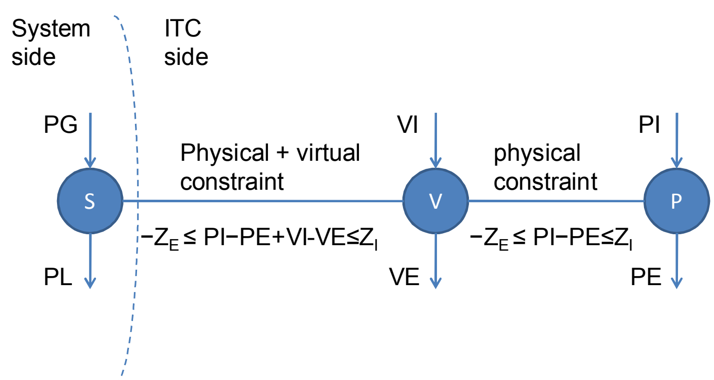
The ISO conducted an extensive stakeholder process that began in summer of 2006 and concluded in October 2009 to develop the design for convergence bidding. One design element was whether to allow convergence bidding on the intertie scheduling points in the ISO market. The stakeholder process yielded consensus that it should be based on two underlying principles:

1. Net physical schedules at the interties must be within established scheduling limits.
2. Virtual and physical schedules on the interties must be co-determined based on their economic bid prices and have a shared congestion price.

During the design process the ISO evaluated a number of different alternatives in order to meet both of these principles. All of the different options were problematic and created advantages and/or disadvantages either for virtual bids or physical bids. Ultimately, the proposal, which is in operation today, was to enforce two constraints at scheduling points: (1) net physical schedules across each scheduling point, ignoring the accepted virtual schedules must be within the established scheduling limit for that scheduling point and (2) physical and virtual imports net of physical and virtual exports must also be must also be within established scheduling limits for the scheduling point. For purposes of establishing IFM prices, only the shadow price of the second constraint determines the congestion components of intertie prices. This rule was adopted in order to adhere to principal #2 described above and to settle on a single LMP for both virtual bids and physical bids at the same scheduling point. The ISO recognized that this design proposal could result in some potential disadvantageous as well as advantageous outcomes for physical intertie schedules. However, it was estimated that these outcomes should occur infrequently and also that the market would likely self-correct in such instances.

Since convergence bidding was implemented, the ISO has seen more frequent cases where physical export bids are clearing the market at LMPs that are inconsistent with their bid prices resulting in them clearing at a price higher than they offered to pay. In addition, physical import bids are clearing at LMPs that are also inconsistent with their bids resulting in higher payments than they would have otherwise received. The impact to the market on the export side has been approximately $250,000 per month.

Figure 1 - Modeling Physical and virtual bids on inter ties



The ISO enforces two constraints on interties to ensure both the physical plus virtual flow and the physical flow are not exceeding the intertie import limit and export limit. As illustrated in

Figure 1, a simplified version (excluding ancillary service schedules) of the two types of constraints can be written as follows:

Import direction:

Equation 1 import physical plus virtual constraint: $PI – PE + VI – VE <= ZI$

Equation 2 import physical constraint: $PI – PE <= ZI$

Export direction:

Equation 3 export physical plus virtual constraint: $– (PI – PE + VI – VE) <= ZE$

Equation 4 export physical constraint: $– (PI – PE) <= ZE$

Where:

PI is the sum of physical imports,

PE is the sum of physical exports,

VI is the sum of virtual imports,

VE is the sum of virtual exports,

ZI is the intertie import limit,

ZE is the intertie export limit.

The shadow prices for import physical plus virtual constraint, import physical constraint, export physical plus virtual constraint, and export physical constraint are denoted respectively by xPVI, xPI, xPVE, xPE. As a convention, assume all these shadow prices are non-negative.

At the optimal solution (denoted by superscript *), the following inequalities hold:

Equation 5: $x^*SYS – x^*PVI – x^*PI + x^*PVE + x^*PE >= bidPI$

Equation 6: $x^*SYS – x^*PVI – x^*PI + x^*PVE + x^*PE <= bidPE$

Equation 7: $x^*SYS – x^*PVI \quad + x^*PVE \quad >= bidVI$

Equation 8: $x^*SYS – x^*PVI \quad + x^*PVE \quad <= bidVE$

In the current ISO convergence bidding implementation, physical and virtual imports and exports will be settled at:

Equation 9: $LMP^*V = x^*SYS – x^*PVI + x^*PVE$

As shown in Equation 7 and Equation 8, LMP*V is consistent with virtual import and virtual export bid. The meaning of the consistency is that, for the cleared award, a virtual import will have a settlement LMP greater or equal to its bid, and a virtual export will have a settlement LMP less than or equal to its bid.

However, if the import physical constraint or the export physical constraint is binding with positive shadow price, the physical export or physical import may have a settlement LMP inconsistent with their bids as summarized in Table 1. If the import physical constraint is binding, the LMP is consistent with the physical import bid because of $x^*PI>0$ and $x^*PE=0$ in Equation 5. However, the settlement LMP may be inconsistent with the physical export bid because of $x^*PI>0$ and $x^*PE=0$ in Equation 6. Due to similar reasons, the physical import bid may be inconsistent with the settlement LMP if the export physical constraint is binding.

Table 1 - Settlement LMP = x*SYS – x*PVI + x*PVE and Bid Price Consistency

Binding Constraint	PI	PE	VI	VE
Import physical	Consistent	Possibly inconsistent	Consistent	Consistent
Export physical	Possibly inconsistent	Consistent	Consistent	Consistent

The ISO seeks to address these inconsistent outcomes with the goal of upholding the following principles:

1. Both the physical and virtual cleared awards receive settlement LMPs consistent with their bids
2. Net physical schedules at the interties must be within established scheduling limits

4 Proposal to Address Pricing Inconsistency

The ISO outlines below the two options that were considered for resolving the pricing inconsistency resulting from enforcement of the intertie scheduling limit constraints from the straw proposal. For this draft final proposal, the ISO has selected Option A which allows for different settlement LMPs for physical and virtual awards. If the import or export physical scheduling limit constraint is binding, virtual awards will not receive the same LMP as physical awards. The current implementation only prices the combined net physical and virtual schedules scheduling limit constraint. However, the two shadow prices of both constraints do affect the dispatches in the market optimization. Thus currently physical resources and virtual resources are economically dispatched according to different LMPs that result from the shadow prices; however, the settlement LMP is only based upon the physical scheduling limit when binding. The ISO agrees with the overall principle that the market clearing LMP should be consistent with the dispatch solution. Option A honors the physical limitations that only apply to interties and allows virtual resources to transact with other resources if the physical scheduling limit is binding. As a result, Option A is the most transparent and mathematically correct approach to maintain price consistency. In addition, Option A does allow market participant to hedge physical positions albeit not a perfect hedge because when the physical constraint is binding the virtual supply/demand will clear at a higher price than physical import/exports.

Option B, if implemented, presents adverse market outcome concerns which are outlined below in section 4.2.2. Although Option B received broad support from stakeholder because virtual and physical awards would clear at the same price, due to the adverse market outcome concerns the ISO has selected Option A as the preferred approach.

4.1 Different Settlement LMPs for Physical Awards & Virtual Awards (Option A)

Currently, only the net virtual + physical constraint is used in pricing. In order to resolve the current price inconsistency problem the ISO proposes to allow the shadow prices of both constraints that are currently implemented to be factored into the settlement LMPs. This will produce two different settlement LMPs for cleared physical and virtual bids. The virtual award will still be settled at LMP*V in Equation 9, while the physical award will be settled at:

Equation 10: LMP*P = x*SYS – x*PVI – x*PI + x*PVE + x*PE

The two different settlement LMPs for the physical and virtual awards are consistent with their bids as illustrated in Equations 5, 6, 7 and 8.

One outcome of this option is that the virtual awards do not receive the same settlement LMP as the physical awards if the import or export physical constraint is binding. However, this poses no adverse outcome because even today where only one constraint is being priced, the two shadow prices of both constraints already affect the dispatches in the market optimization. In other words, even today physical and virtual bids are economically cleared according to different LMPs, but priced at the same settlement LMP. Option A, therefore, produces a better outcome where the physical and virtual bids are priced in a way that is consistent with how they are cleared, which makes this option the most transparent and mathematically correct approach to maintain price consistency.

This option does not require changes to the current market optimization. However, it does require some settlement changes, OASIS reporting changes, and business practice changes. Today, there is only one pricing node at the ITC priced at LMP*V. In order to accommodate the two different settlement prices, the ISO needs to create an additional pricing node for the physical resources at LMP*P at the ITC. For physical bids, the pricing node priced at LMP*P must be specified, and for virtual bids, the pricing node at LMP*V must be specified. Both LMP*V and LMP*P will be published in OASIS. The ISO will complete a full impact assessment prior to the June board meeting and will provide more implementation details after the assessment has been completed.

Parties raised a concern that Option A may drive market participants to change their behavior and implement a bidding strategy of submitting physical bids rather than virtual bids with the intent to liquidate their positions in HASP assuming a more advantageous LMP for physical awards. For example, if the physical constraint is binding in the import direction, physical export will receive a lower price than a virtual export, so the virtual export may opt to be physical and liquidate in the real-time market. While this strategy would not be prohibited, it cannot generate sustainable revenue, because the increased physical exports can relieve the physical constraint congestion, rendering this strategy less profitable. It is also possible that the strategy could create congestion in the export direction resulting in an adverse affect. In addition, the ISO implemented the HASP reversal settlement rule concurrently with convergence bidding. This rule was put in place to eliminate any potential incentive for market participants to submit implicit virtual bids by reversing any monies paid due the difference between the day-ahead price and the HASP price for any MW quantity that is not e-tagged. Therefore, this rule to some extent alleviates the concern of using physical bids to conduct implicit virtual bidding because they are settled at different prices.

Many stakeholders commented that the potential for different prices for physical imports/exports and virtual supply/demand at the interties would limit the ability for market participants to hedge day ahead positions. Table 2 illustrates the hedge of a physical import. Since the virtual export price is greater than the physical import, the physical import limit is binding in this example. As long as the day-ahead price at which the virtual export clears is lower than the HASP price the market participant is able to hedge a portion of the outage that is bought back in HASP.

Table 2 – Hedge of Physical Import with Virtual Export

	MW	DA	HASP	Revenue
Physical Import	100	$ 50.00		$ 5,000.00
Virtual Export	20	$ (55.00)	$ 60.00	$ 100.00
HASP Outage	20		$ (60.00)	$ (1,200.00)
Actual with Hedge	80		$ 48.75	$ 3,900.00
Actual w/o Hedge	80		$ 47.50	$ 3,800.00

	MW	DA	HASP	Revenue
Physical Import	100	$ 50.00		$ 5,000.00
Virtual Export	20	$ (65.00)	$ 60.00	$ (100.00)
HASP Outage	20		$ (60.00)	$ (1,200.00)
Actual with Hedge	80		$ 46.25	$ 3,700.00
Actual w/o Hedge	80		$ 47.50	$ 3,800.00

Some market participants advocate that the ISO provide bid cost recovery to exports to remedy the inconsistencies that result from the existing approach for settling the two constraints. Bid cost recovery has the indirect effect of settling virtual and physical bids at different net prices; therefore, the ISO finds that it is preferable to settle at the two LMPs that could result from the two different constraints, but renders the pricing consistent with the resources bid.

4.2 Economic Curtailment (Option B) not Viable

The ISO has identified a potential adverse market outcome concern with the option to curtail price inconsistent awards. The adverse market outcome concern is outlined in section 4.2.2. As a result, the ISO has eliminated Option B as a potential solution.

4.2.1 Option B design from Straw Proposal

As is the case in the current implementation, both the physical and physical plus virtual constraints will be enforced. The change from the current implementation is to use LMP*P as the settlement LMP instead of LMP*V. In the real-time market, the node V in Figure 1 does not exist, thus LMP*V cannot be calculated to properly settle virtual awards in the real-time market. In contrast, LMP*P is calculated for the real-time market, and cleared virtual awards could be settled at the price difference of LMP*P between IFM and RTM.

As shown in Equation 10, LMP*P factors in the shadow prices of the physical constraints (x*PI and x*PE) as well as the shadow prices of the physical plus virtual constraints (x*PVI and x*PVE). By Equation 5 and Equation 6, LMP*P ensures the physical bids are consistent LMP*P, but the virtual bids may have inconsistency issue as summarized in Table 3.

Table 3 - Settlement LMP*P = x*SYS – x*PVI – x*PI + x*PVE + x*PE and bid price consistency

Binding Constraint	PI	PE	VI	VE
Import physical	Consistent	Consistent	Possibly inconsistent	Consistent
Export physical	Consistent	Consistent	Consistent	Possibly inconsistent

Scenario 1: the import physical constraint is binding with x*PI>0

In this case, x*PE=0, because the physical import constraint and physical export constraint cannot be binding simultaneously. By Equation 8, cleared virtual export awards always have consistent bid and LMP:

$$LMP{*}P = x{*}SYS - x{*}PVI - x{*}PI + x{*}PVE + x{*}PE \le x{*}SYS - x{*}PVI + x{*}PVE \le bidVE.$$

However, the cleared virtual import award may have inconsistent bid and LMP:

Equation 11: LMP*P = x*SYS – x*PVI – x*PI + x*PVE + x*PE < bidVI.

In this case, the inconsistent virtual import awards as in Equation 11 need to be curtailed. Denote by VIC the sum of cleared virtual import schedules that have bids consistent with the settlement LMP LMP*P:

LMP*P = x*SYS – x*PVI – x*PI + x*PVE + x*PE >= bidVI.

For example, assume Resource A is bidding a virtual import for 10 MW at $10 and 20 MW at $20 and is awarded 30 MW. Resource B is bidding a virtual import for 40 MW at $12 is awarded 40 MW. If LMP*P=$15, then VIC = 50 MW consists of 10 MW (at $10) from Resource A and 40 MW (at $12) from Resource B.

A virtual intertie constraint is enforced such that VI <= VIC to economically curtail the virtual imports that have inconsistent bids and LMPs. Next, an additional economic dispatch is run with the virtual intertie constraint, as well as all other constraints, to curtail the virtual imports respecting all other constraints including system wide energy balance. This economic dispatch is referred to as the consistency run. From implementation perspective, the consistency run is an additional pricing run with the virtual intertie constraint being added into the optimization. The schedules from the consistency run still respect the scheduling priorities of self schedules. The schedules and the prices from the consistency run will be used for settlement purpose.

Scenario 2: the export physical constraint is binding with x*PE>0

In this case, x*PI=0. By Equation 7, cleared virtual import award always have consistent bid and LMP:

LMP*P = x*SYS – x*PVI – x*PI + x*PVE + x*PE >= x*SYS – x*PVI + x*PVE >= bidVI.

However, the cleared virtual export award may have inconsistent bid and LMP:

Equation 12: LMP*P = x*SYS – x*PVI – x*PI + x*PVE + x*PE > bidVE.

Similar to scenario 1, run a consistency run with virtual inter tie constraint for virtual export VE <= VIE, where VIE is the sum of cleared virtual export schedules that have bids consistent with the settlement LMP LMP*P:

LMP*P = x*SYS – x*PVI – x*PI + x*PVE + x*PE <= bidVE.

Again, the schedules and prices from the consistency run will be used for settlement purpose.

This proposed approach ensures that physical exports and imports are always settled with an LMP that is consistent with their bids. It also ensures that virtual bids are settled consistently with their bids. Also this approach will be transparent to other systems/process and hence market participants can continue to use existing application/process. However, this approach requires an additional economic dispatch and the consistency run in order to maintain power balance in the market.

4.2.2 Adverse Market Outcome under Option B

The economic curtailment outlined above creates the opportunity for entities to engage in bidding behavior which would not provide any economic value and would negatively impact day-ahead revenue adequacy. Option B would enable parties to bid in their physical imports to create large shadow prices on the physical import constraint. Virtual exports up to the export limit would clear at the low intertie scheduling point price created by the physical imports. A marginal amount of physical exports in HASP could then alleviate the congestion in HASP. The virtual exports would earn the difference between the HASP system marginal energy price and the low day-ahead intertie LMP. To the extent the entity holds sufficient quantities of

Congestion Revenue Rights (CRR) sourced at the affected intertie, the entity would be indifferent to import congestion resulting from this bidding strategy.

If the physical import constraint is binding, price-taking virtual exports will clear at the system marginal energy price less the shadow price of the physical import constraint (up to the point of the physical and virtual export constraint binding). However, when the physical import constraint is binding, these virtual exports cannot relieve the physical import constraint. The virtual exports can only clear against generation at other nodes. Therefore, whenever the physical import constraint is binding, virtual exports would clear at a lower price than the generation or virtual supply it cleared against. This creates day-ahead revenue inadequacy because it results in the collection of lesser congestion revenue than paid out.

Consider the following example. An intertie has an import and export limit of 1,000 MW. The system marginal energy price is $21. Over 1,000 MW of physical imports bid $1 at the intertie. 1,000 MW of physical imports will clear and set a physical import shadow price of $20. Assume no other constraints in the system are binding. The physical imports settle at the intertie LMP of $1. Assuming 1,000 MWs of net CRRs have been sold that have sources at the intertie scheduling point, the ISO is revenue neutral in the day-ahead market in the above situation. The market collects $20 more from each of the 1,000 MW of internal demand than paid to each of the 1,000 MW of physical intertie imports that supply that internal demand. The excess revenue is distributed to CRR holders.

Now, consider 900 MW of virtual exports bidding at $999 at the same intertie. The virtual exports cannot relieve the physical import constraint. The virtual exports must clear against 900 MW of physical internal generation. Assume there is in fact another 900 MW of physical internal generation bidding below $999. For simplicity, assume the new marginal internal physical generator is still bidding $21. The system marginal energy price will be $21. However, the 900 MW of virtual exports will clear at the intertie LMP set at $1 by the physical imports. The virtual exports only pay $1, while internal generation (or internal virtual supply) is paid $21 for each of the 900 that supplies the virtual exports. Therefore, each MW of virtual export that clears at an intertie that has a binding physical import limit will contribute the shadow price of the physical import constraint to day-ahead revenue inadequacy.

As such, market participants can employ bidding strategies that would exacerbate day-ahead revenue inadequacy. In the above example, assume no change in system conditions in the hour-ahead or real-time markets. The market participant with the 900 MW of virtual exports can submit a small amount of price taking physical exports in the HASP which would alleviate congestion on the intertie constraint. The 900 MW of virtual exports would settle at the HASP marginal energy price of $21. The bidding strategy will earn the day-ahead physical import constraint shadow price on each of its 900 MW of virtual exports or $20.

Furthermore, the profit that virtual exports can earn from the day-ahead physical import shadow price creates incentives for entities to create the physical import congestion in the day-ahead market. In particular, if an entity holds CRRs that have a source at the intertie, the entity would be indifferent to bidding up to its CRR quantity with price-taking virtual imports. The entity could thereby cause the day-ahead congestion from which a large quantity of virtual exports (up to the export limit) could directly profit.

5 Next Steps

The ISO is proposing Option A and plans to seek Board approval in June.

The ISO will discuss the Draft Final Proposal with stakeholders during a teleconference to be held on May 25, 2011. The ISO is seeking comments on the proposed enhancements. Stakeholders should submit written comments by June 1, 2011 to constraints@caiso.com.