

California ISO

Potential market inefficiencies from convergence bidding at interties with insufficient liquidity of fifteen-minute bids

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Department of Market Monitoring

Summary

When structural differences exist between the day-ahead and real-time markets, convergence (or virtual) bids can decrease the efficiency of day-ahead market schedules even while converging prices between the markets.¹ External impediments to the participation of price-sensitive intertie resources that can respond to fifteen-minute schedule changes create this type of structural difference between the ISO's day-ahead and fifteen-minute market on intertie constraints. These structural differences create systematic differences between the ISO's day-ahead and fifteen-minute market intertie congestion prices which would be profitable for virtual bidders. However, this paper provides analysis showing how the reintroduction of virtual bids at ISO interties that lack sufficient liquidity of fifteen-minute market economic bids is likely to decrease the efficiency of ISO intertie schedules.

If there is intertie constraint congestion in the day-ahead market, but there are no economic bids in the fifteen-minute market, the ISO's fifteen-minute market software generally does not currently produce shadow costs reflecting any congestion. In this situation, intertie convergence bids would first settle on the day-ahead market price that includes intertie congestion and would then be liquidated at a fifteen-minute market price which does not include intertie congestion. Convergence bidders would therefore have the incentives to profit from the structural differences between congestion prices in the day-ahead market and the fifteen-minute market. In order to profit from these congestion price differences, convergence bids would create counterflow that would increase the extent to which physical schedules exceeded intertie scheduling limits.

At interties that lack sufficient liquidity of fifteen-minute market economic bids, congestion in the real-time market would likely be managed by hour-ahead curtailments made on a *pro rata* basis rather than on the underlying costs of the intertie resources. Therefore, the reintroduction of convergence bidding under these conditions is likely to decrease economic efficiency by increasing the need to manage real-time congestion through *pro rata* schedule cuts, instead of based on economic merit order of physical bids. While intertie convergence bidding would be profitable for the convergence bidder and may decrease differences in congestion prices by lowering day-ahead congestion, the overall impact of convergence bidding would be to decrease economic efficiency. Moreover, profits received from these virtual bids would ultimately be borne by other participants.

Careful consideration should be given to understanding the structural barriers outside of ISO markets preventing such fifteen-minute market bidding before fully implementing convergence bidding on the interties.

¹ See John E. Parsons, et al, "Financial Arbitrage and Efficient Dispatch in Wholesale Electricity Markets," CEEPR WP 2015-002, February 2015.

Introduction

Background

In May 2014, the ISO implemented a major re-design of its real-time energy market in response to FERC Order No. 764. FERC Order No. 764 required the ISO to establish fifteen-minute intra-hour schedule changes along interties to facilitate the integration of large amounts of renewable variable energy resources. The ISO's new market design went beyond the requirements of FERC Order 764, and established a real-time market based on bidding and settlement of intertie transactions in a fifteen-minute energy market.

The new real-time market design allows participants a variety of options for scheduling intertie transactions:

- **Fifteen-minute economic bid:** Market participants have the option to submit economic bids that the ISO can schedule in fifteen-minute intervals based on price. These transactions are settled at the fifteen-minute market price.
- **Fixed hourly self-schedules:** Market participants can submit fixed self-schedules for the hour. These transactions are settled at the average fifteen-minute market price over the operating hour.
- **Fixed hourly economic bid:** Market participants can submit economic bids for intertie transactions that are a fixed quantity for the hour and that the ISO schedules in the hour-ahead scheduling process based on price. These transactions are settled at the average fifteen-minute market price over the operating hour.
- **Fixed hourly economic bid with single intra-hour schedule change:** Similar to the fixed hourly economic bid option above, market participants can submit economic bids for intertie transactions that are a fixed quantity for the hour and that the ISO schedules based on price. However, this option allows for the schedule to be changed once per hour during the fifteen-minute market. These transactions are settled against fifteen-minute market prices.
- **Dynamic transfer:** Market participants continue to be able to establish dynamic transfer arrangements that enable 5-minute dispatch and settlement of intertie transactions. These are settled similar to internal generation.

The real-time market continues to include an hour-ahead scheduling process. However, it is only used to schedule intertie transactions that must be fixed for the hour. These fixed hourly schedules are no longer guaranteed the price projected by the hour-ahead scheduling process. Rather, they are paid the price in each of the fifteen-minute market settlement intervals during the hour they are scheduled. This settlement feature of the new market design was intended to encourage a transition from hourly bidding on interties to more flexible fifteen-minute bidding of interties resources.

Under this new market design, convergence (or virtual) bids on interties are settled based on the difference between the day-ahead market price and the fifteen-minute market prices. These fifteen-minute prices are used to settle the bulk of physical imports/exports and resources within the ISO system. The settlement of convergence bids based on the same fifteen-minute prices used to settle most other real-time transactions was intended to avoid revenue imbalances that were created under

the prior market design by settling intertie virtual bids on hourly prices while settling internal virtual bids on 5-minute prices.²

However, due to the uncertainties associated with this new market structure and prior problems caused by convergence bidding at interties, this market design called for convergence bidding on interties to be phased in after at least the first 12 month of this new market design. Intertie convergence bidding position limits were set to zero for the first year after implementation, to be followed by a gradual increase afterwards. On May 1, 2015, convergence bidding on interties is scheduled to be re-introduced by raising the position limit for each entity registered to participate in convergence bidding to 5 percent of the total capacity on each intertie.

Intertie participation and pricing in new fifteen-minute market

With this new real-time market design, under most scenarios in which there are no economic bids at an intertie in the 15-minute market, the current ISO optimization will not generate a shadow value for the intertie constraint. This is because if the only real-time participation is by hourly block bids or self-schedules, any congestion is resolved in the hour-ahead scheduling process. The quantity of fixed hourly schedules will equal the intertie constraint limit if there was congestion from these hourly blocks. These fixed hourly schedules are then transferred to each fifteen-minute market with penalty prices to protect them from being changed in a fifteen-minute market run. In the absence of any fifteen-minute market economic bids, the bid stack at the intertie will end with the protected hourly block schedules at the intertie limit. There will not be any economic bids above or below the intertie limit that can be used to set a congestion price for the intertie constraint.³

Figure 1 shows the average bidding over interties in the FMM for March 2015. Each color represents a distinct market participant.⁴ Most ISO interties have little or no economic bids in the fifteen-minute market.

Stakeholders have indicated that there may be structural reasons that imports and exports cannot be bid into the fifteen-minute Market.⁵ Therefore, there appears to be structural barriers outside of the ISO's markets currently preventing the fifteen-minute market from accurately reflecting the cost of congestion of most intertie constraints. Table 1 describes the differences in intertie congestion between the DAM and FMM over the most recent month. As shown in Table 1, congestion has occurred in a relatively high portion of hours on three interties in March. Significant congestion has occurred in the FMM on only one of these interties (MALIN500), but not on the other two interties frequently congested in the DAM (NOB_ITC and IPPUTAH_ITC). Figure 2 illustrates how the congestion at MALIN500 is being reflected in both the day-ahead and fifteen-minute markets. This reflects how economic bids in the FMM from EIM internal Participating Resources and other dynamic resources allow the underlying real-time cost of congestion at MALIN500 to be reflected in the FMM.

² See Department of Market Monitoring, "Real-time Revenue Imbalance in CAISO Markets," April 2013, available at: http://www.caiso.com/Documents/DiscussionPaper-Real-timeRevenueImbalance_CaliforniaISO_Markets.pdf

³ The ISO has indicated it will provide more information on this in a forthcoming Market Quality and Validation report.

⁴ The economic bids include dynamic schedules, with the exception of the economic bids over MALIN500 from all Participating Resources in the PacifiCorp EIM BAAs. These were excluded because their large quantity would distort the scale of the graph, reducing visibility into the details of the other interties. See DMM's reports to FERC on the EIM transitional period for information on the quantity of capacity bid by Participating Resources in PacifiCorp EIM BAAs.

⁵ See stakeholder comments on the FO 764 market initiative.

Figure 1. Average fifteen-minute market intertie bids (March 1 – 30, 2015)

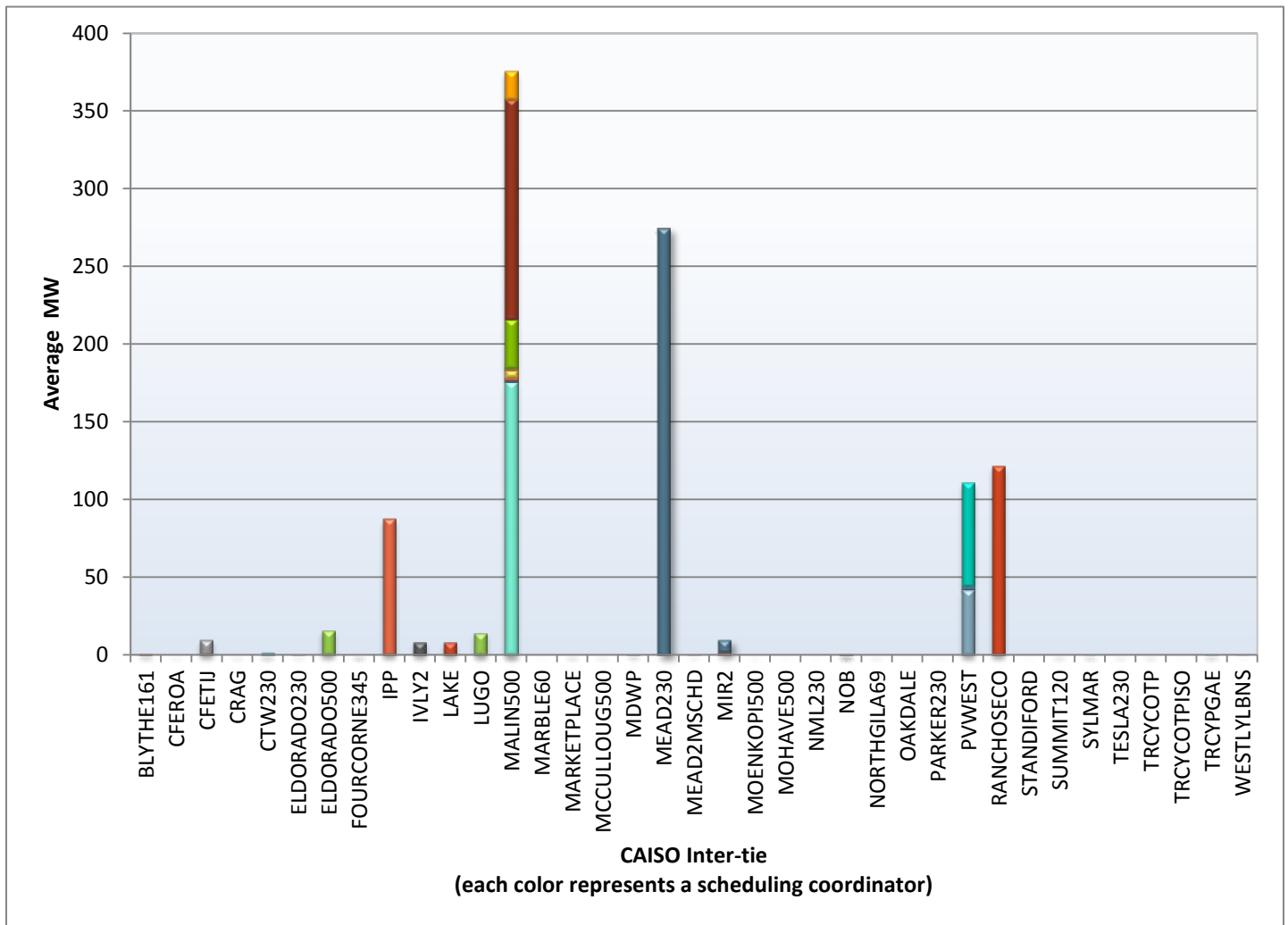
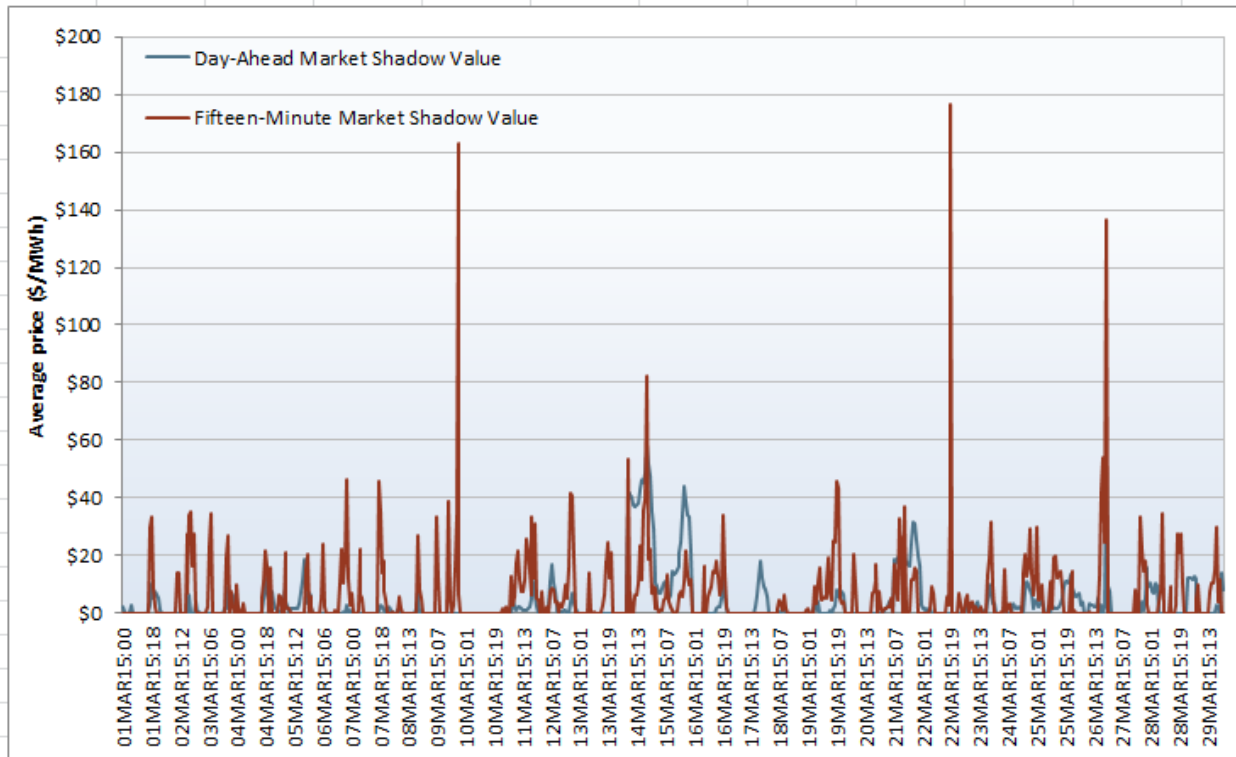


Table 1. Differences in DAM and FMM congestion on intertie constraints (March 1 – 30, 2015)

Intertie Name	DAM Hours	DAM Average	FMM Hours	FMM Average
	Binding	Shadow Price	Binding	Shadow Price
NOB_ITC	442	\$4.60	11	\$2.17
MALIN500	304	\$3.62	335	\$6.05
IPPUTAH_ITC	210	\$1.26	1	\$0.06
PALOVNDE_ITC	14	\$0.87	7	\$0.16
IPPCADLN_ITC	7	\$0.05	0	\$0.00
CASCADE_ITC	10	\$0.05	0	\$0.00
SUMMIT_ITC	6	\$0.02	0	\$0.00

Figure 2. MALIN500 - Average hourly DAM and FMM shadow prices (March 2015)



However, the congestion at NOB_ITC and IPPUTAH_ITC is markedly different, as shown in Figure 3 and Figure 4.⁶ Given the absence of economic bids in FMM over those intertie constraints during most hours, the real-time congestion cannot be accurately reflected in the FMM shadow prices. As a result, convergence bids at interties such as this would have the opportunity to profit from the expected structural discrepancy between the DAM and FMM shadow prices.

Systematic differences in congestion between the DAM and FMM on interties such as these would make it profitable for participants to place virtual demand bids at these interties (representing virtual exports). Counterflow on these interties from these convergence bids may tend to converge the shadow prices by reducing the day-ahead market congestion. However, such virtual counterflow would exacerbate the divergence between the physical schedules in the day-ahead and fifteen-minute markets.

Convergence bids at these interties would create a divergence in the physical schedules by allowing the physical imports that clear in the day-ahead market to exceed the limit on the physical schedules that can actually flow in real-time. In the following section, we use a series of examples to illustrate the inefficiencies that can arise from allowing convergence bidding over interties at which there is insufficient liquidity of fifteen-minute market bids.

⁶ The IPPUTAH_ITC is the MDWP intertie in Figure 1.

Figure 3. NOB_ITC - Average hourly DAM and FMM shadow prices (March 2015)

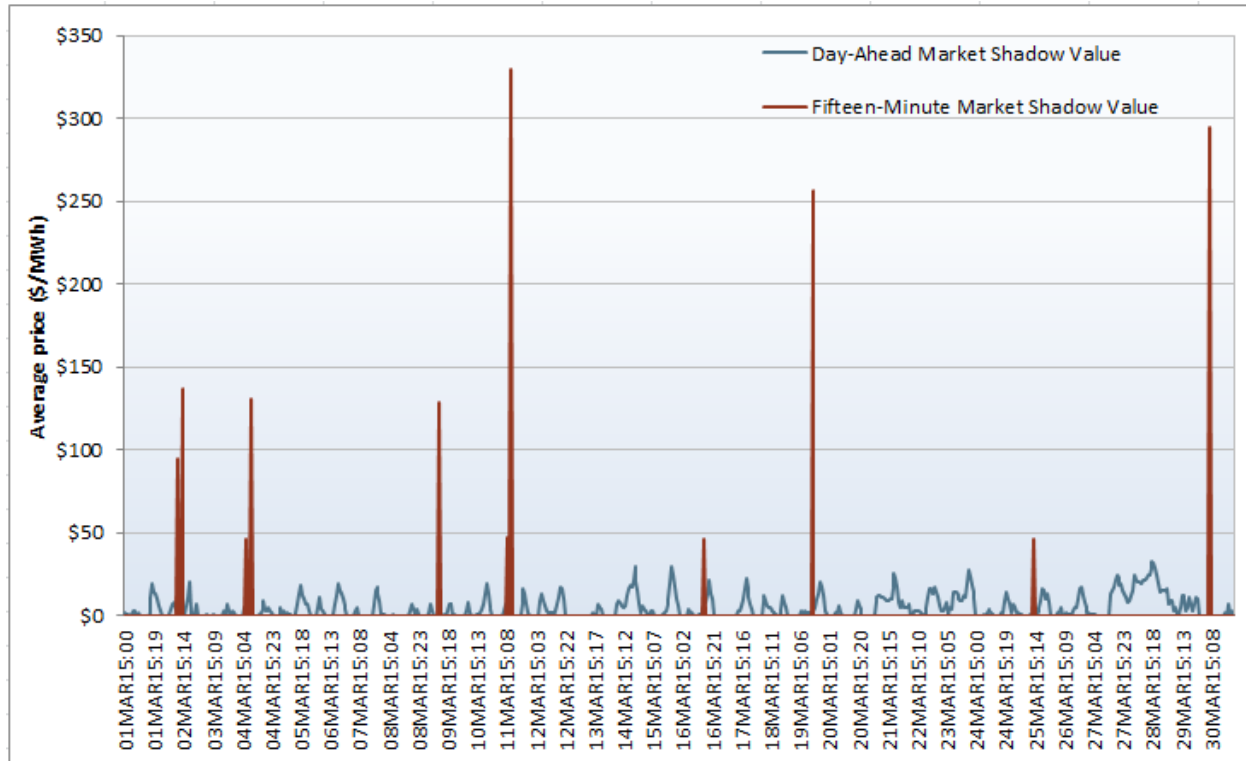
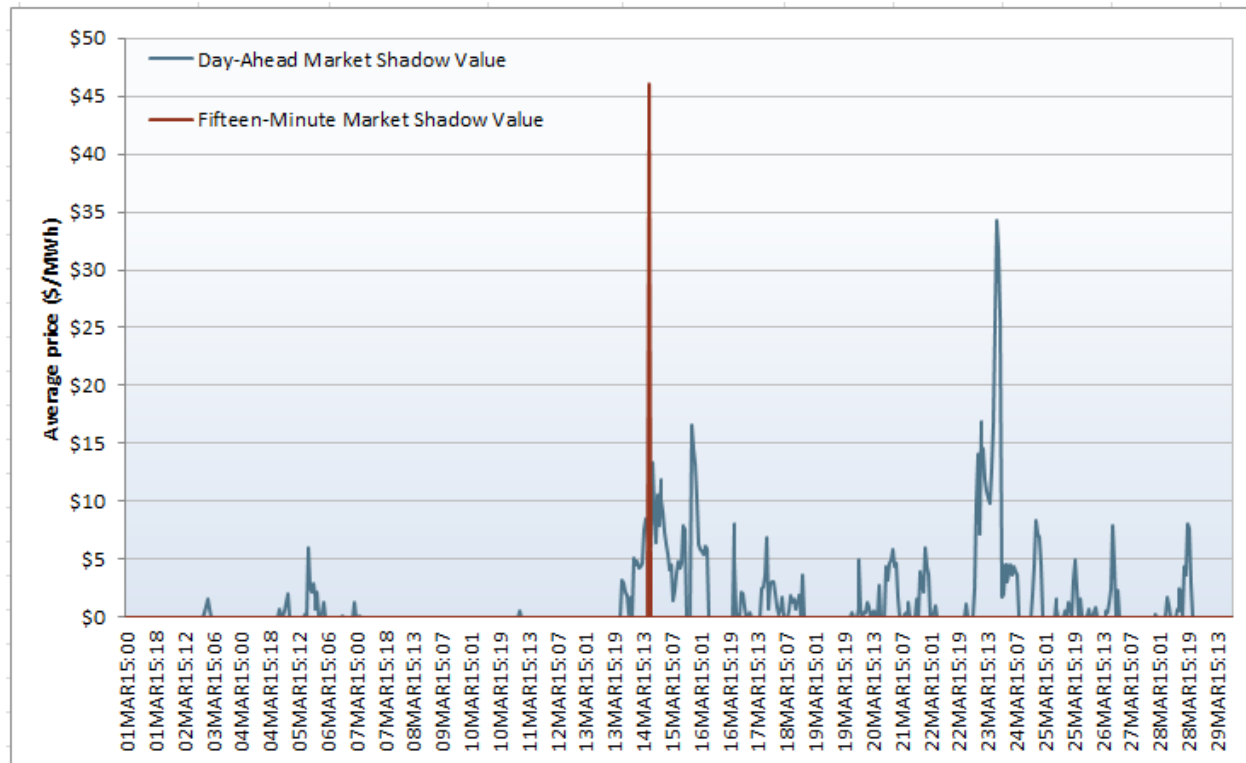


Figure 4. IPPUTAH_ITC average hourly DAM and FMM shadow prices (March 2015)



1 Scenario 1: Interties without convergence bidding and without economic bids in the fifteen-minute market

Scenario description

Table 2 shows an example where suppliers with 1,200 MW of hourly physical imports bid their marginal cost into the DAM. The intertie limit constrains imports to 1,000 MW. The System Marginal Energy cost in the DAM is \$35.⁷ There are no convergence bids in this example.

The DAM clears 1,000 MWs of total imports. The LMP at the intertie is the cost of the marginal import, \$12. The shadow value on the constraint is \$23. This reflects the difference between the cost of energy in the ISO (\$35) and the cost of importing at the intertie (\$12).

In this scenario, suppliers have no ability for fifteen-minute scheduling to this intertie. In order to minimize the probability of having to buy back day-ahead schedules at FMM prices above their marginal cost, suppliers clearing the DAM self-schedule their DAM awards into the HASP as fixed hourly blocks.⁸ Supplier 5 and Supplier 6 rebid energy that did not clear the day-ahead market as fixed hourly blocks into the HASP at prices of \$12 and \$14, respectively.

In the HASP, the same 1,000 MW of imports clearing the day-ahead market clears. As in the day-ahead market, the LMP at the intertie is the cost of the marginal import (\$12/MW). The shadow value on the constraint is \$23, reflecting the difference between the cost of energy in the ISO (\$35) and the cost of importing at the intertie (\$12).

However, the HASP LMP is not used in the settlement of any transactions. In the FMM there will be no shadow values generated for the intertie because there are no economic bids. The intertie LMPs in the FMM will be \$35. The \$35 LMP in FMM is higher than the \$12 LMP generated in HASP because the FMM LMP does not reflect congestion from the intertie constraint.

⁷ To simplify the example, we assume there are no losses or congestion on other constraints.

⁸ If the resources economically bid their marginal costs into the HASP it would not change the underlying point of this example.

Table 2. Schedules and prices without convergence bids

Day-Ahead Market				Hour-Ahead Scheduling Process				Fifteen-Minute Market			
Intertie Limit = 1,000 MW				Intertie Limit = 1,000 MW				Intertie Limit = 1,000 MW			
System Marginal Energy Cost = \$35				System Marginal Energy Cost = \$35				System Marginal Energy Cost = \$35			
Bids	MW	\$/MW	Award	Bids	MW	\$/MW	Award	Bids	MW	Award	
Import 1	300	\$2	300	Import 1	300	Self Sch.	300	Import 1	300	Hourly	300
Import 2	200	\$4	200	Import 2	200	Self Sch.	200	Import 2	200	Hourly	200
Import 3	200	\$8	200	Import 3	200	Self Sch.	200	Import 3	200	Hourly	200
Import 4	200	\$10	200	Import 4	200	Self Sch.	200	Import 4	200	Hourly	200
Import 5	200	\$12	100	Import 5	100	Self Sch.	100	Import 5	100	Hourly	100
				Import 5	100	\$12	0				
Import 6	100	\$14	0	Import 6	100	\$14	0				
Total	1,200		1,000	Total	1,200		1,000	Total	1,000		1,000
Net Cleared MW on Intertie			1,000	Net Cleared MW on Intertie			1,000	Net Cleared MW on Intertie			1,000
Shadow Value on Intertie			-\$23	Shadow Value on Intertie			-\$23	Shadow Value on Intertie			--
LMP at Intertie			\$12	LMP at Intertie			\$12	LMP at Intertie			\$35

Discussion of results

In this example there are no market impacts from the lack of liquidity in the FMM because there are no schedule changes settling at the FMM price. However, this creates an incentive for convergence bids to arbitrage the difference in congestion prices created by the absence of economic bidding on the intertie in the FMM. In the next example we explore the impacts of convergence bids on interties without economic bids in the FMM.

2 Scenario 2: Interties with convergence bidding and no economic bids in the fifteen-minute market

Scenario description

Table 3 shows this same scenario, but assumes there are now 400 MW of virtual demand bid at \$15 in the DAM. This allows all 1,200 MW of physical imports to clear, setting the intertie LMP at \$15. The virtual demand is automatically liquidated at the FMM price and does not enter the optimization in either the HASP or FMM.

The imports again self-schedule their DAM awards in the HASP. However, it is not feasible to clear all 1,200 MW in real-time. Therefore, *pro rata* schedule cuts are necessary and a penalty price sets the HASP intertie LMP at -\$150.

Again, no schedules settle at the HASP price. And since there are no economic bids in the FMM, no shadow value is generated and the LMP on which the schedule changes settle is \$35.

The settlement impacts under this scenario are shown in Table 4.

Table 3. Schedules and prices with convergence bids and no economic bids in FMM

Day-Ahead Market				Hour-Ahead Scheduling Process				Fifteen-Minute Market			
Intertie Limit = 1,000 MW				Intertie Limit = 1,000 MW				Intertie Limit = 1,000 MW			
System Marginal Energy Cost = \$35				System Marginal Energy Cost = \$35				System Marginal Energy Cost = \$35			
Bids	MW	\$/MW	Award	Bids	MW	\$/MW	Award	Bids	MW	\$/MW	Award
Import 1	300	\$2	300	Import 1	300	Self Sch.	250	Import 1	250	Hourly	250
Import 2	200	\$4	200	Import 2	200	Self Sch.	167	Import 2	167	Hourly	167
Import 3	200	\$8	200	Import 3	200	Self Sch.	167	Import 3	167	Hourly	167
Import 4	200	\$10	200	Import 4	200	Self Sch.	167	Import 4	167	Hourly	167
Import 5	200	\$12	200	Import 5	200	Self Sch.	167	Import 5	167	Hourly	167
Import 6	100	\$14	100	Import 6	100	Self Sch.	83	Import 6	83	Hourly	83
Total	1,200		1,200	Total	1,200		1,000	Total	1,000		1,000
Virtual Bids	MW	\$/MW	Award	Virtual Bids	MW	\$/MW	Award	Virtual Bids	MW	\$/MW	Award
Demand	-400	\$15	-200	None	0	--	0	None	0	--	0
Net Cleared MW on Intertie			1,000	Net Cleared MW on Intertie			1,000	Net Cleared MW on Intertie			1,000
Shadow Value on Intertie			-\$20	Shadow Value on Intertie			-\$185	Shadow Value on Intertie			--
LMP at Intertie			\$15	LMP at Intertie			-\$150	LMP at Intertie			\$35

Table 4. Settlement of imports and virtual demand

Schedule	Day-Ahead Market			Fifteen-Minute Market			Total Revenue
	Award	LMP	Revenue	Award	LMP	Revenue	
Import 1	300	\$15	\$4,500	-50	\$35	(\$1,750)	\$2,750
Import 2	200	\$15	\$3,000	-33	\$35	(\$1,167)	\$1,833
Import 3	200	\$15	\$3,000	-33	\$35	(\$1,167)	\$1,833
Import 4	200	\$15	\$3,000	-33	\$35	(\$1,167)	\$1,833
Import 5	200	\$15	\$3,000	-33	\$35	(\$1,167)	\$1,833
Import 6	100	\$15	\$1,500	-17	\$35	(\$583)	\$917
Virtual Demand	-200	\$15	(\$3,000)	200	\$35	\$7,000	\$4,000

Discussion of results

Compared to Scenario 1, the introduction of virtual demand has increased the day-ahead market price from \$12 to \$15, thereby contributing to converging the day-ahead and fifteen-minute market prices. The virtual demand profits from buying at a lower day-ahead market price than the FMM price at which it sells. However, the virtual demand profits come from the physical imports that are reduced in the real-time market.

The physical imports that are cut in real-time sell at a lower day-ahead market price than the FMM price at which they must buy back their schedule cuts. The FMM price at which the physical importers must buy back their schedule cuts is inflated due to the FMM price not reflecting the underlying intertie constraint congestion cost.

Structural impediment to economic bids at an intertie in the fifteen-minute market creates incentives for convergence bids to provide counterflow to the intertie constraint.

A lack of economic bids at an intertie in the FMM results in no congestion over the intertie constraint in the FMM. When there is congestion over the constraint in the day-ahead market, virtual bids can profit by clearing counterflow over the constraint. However, by clearing counterflow over a constraint congested in the import direction in the day-ahead market, convergence bids allow the quantity of physical imports clearing the day-ahead market to exceed the constraint's limit.

Intertie convergence bids result in inefficient cutting and scheduling of ISO imports.

With virtual counterflow allowing DAM physical imports to exceed the intertie scheduling limit, DAM import schedules must be cut in real-time. However, in the absence of economic bids and pricing of the intertie's congestion in the FMM, hourly block schedules have the incentive to bid as low possible. When the DAM schedules are reduced in HASP to make net import schedules conform to the intertie limit, the HASP optimization does not know which import schedules are the most expensive and should be cut first. Instead, with hourly block schedules self-scheduling, HASP makes *pro rata* cuts to all of the import schedules, including the most efficient, least cost imports.

This results in a loss of economic efficiency, as shown in Table 5.

- Under Scenario 1, without intertie convergence bids, the final FMM awards correspond to the least cost scheduling of imports. The total cost is \$6,200 for 1,000 MW of imports.
- Under Scenario 2, with the introduction of convergence bids at the intertie, a total of 1,200 MW of imports are awarded in the DAM. HASP reduces these 1,200 MW of DAM imports down to the 1,000 MW limit through *pro rata* cuts in HASP. This results in a total cost of \$7,333 for the 1,000 MW of imports that are actually scheduled in real-time. Thus, the introduction of intertie convergence bids results in an efficiency loss of \$1,133 in this example. The lowest cost resources (Imports 1-4) are sub-optimally dispatched down in order to make room on the intertie for the more expensive resources (Imports 5 and 6) that cleared the DAM due to virtual counterflow.

Table 5. Production cost comparison of scenarios 1 and 2

	Scenario 1			Scenario 2		
	No Convergence Bids			With Convergence Bids		
	Award	Bid Cost	Costs	Award	Bid Cost	Costs
Import 1	300	\$2	\$600	250	\$2	\$500
Import 2	200	\$4	\$800	167	\$4	\$667
Import 3	200	\$8	\$1,600	167	\$8	\$1,333
Import 4	200	\$10	\$2,000	167	\$10	\$1,667
Import 5	100	\$12	\$1,200	167	\$12	\$2,000
Import 6	0	\$14	\$0	83	\$14	\$1,167
Total Production Costs			\$6,200			\$7,333

Increase in Production Costs = \$1,133

By allowing physical imports to exceed the DAM intertie limit, convergence bids exacerbate incentives for hourly block imports to bid below marginal cost and to self-schedule.

Day-Ahead Market import schedules that are reduced in real-time pay the FMM price. Hourly block schedules are set in the HASP. As a result, changes to DAM import schedules face risk that conditions may change between HASP and FMM, resulting in hourly block import schedules buying back imports at prices higher than their bid price. When convergence bids allow the quantity of cleared physical imports at an intertie in the DAM to exceed the intertie's limits, these schedules will compete in HASP. They will compete to avoid being cut and having buybacks exposed to FMM prices that are not lowered by the intertie constraint congestion. Therefore, DAM imports that clear over a congested intertie constraint that does not have economic FMM bids have the incentive to self-schedule as hourly blocks in real-time.

Inefficiency remains regardless of whether or not intertie convergence bids contribute to converging prices between day-ahead and fifteen-minute market.

Virtual counterflow would tend to reduce day-ahead market congestion and increase the DAM price to be closer on average to the FMM price at which imports would have to buy back their schedules. However, a greater quantity of counterflow from convergence bids would allow even more physical imports to clear the day-ahead market. This would increase the quantity of DAM import schedules that

would have to be cut in HASP in order to keep the net import schedules below the scheduling limit. Despite more convergence between DAM and FMM prices at the intertie, imports would still face strong incentives to self-schedule their DAM awards in HASP. Therefore, despite any increased convergence of prices from intertie convergence bids, these virtual exports would create more of the inefficient cutting and scheduling of ISO imports described above. Moreover, profits received from these virtual bids would ultimately be borne by other participants.

Other physical scheduling inefficiencies caused by convergence bids at interties without economic bids in fifteen-minute market.

Intertie convergence bids can create other inefficiencies. Intertie convergence bids at ties with no economic bids in the FMM increase the likelihood that DAM import schedules will be cut in HASP and have to buy back their schedules at FMM prices inflated by the structural lack of intertie congestion. This may result in many suppliers seeking to inefficiently change the intertie over which they schedule imports. It could even result in some suppliers offering fewer imports in the ISO markets.

Counterflow from internal virtual bids does not cause the inefficient physical schedules caused by intertie virtual bids at interties with insufficient liquidity of economic bids in the fifteen-minute market.

Internal virtual bids have incentives to create counterflow on internal constraints over which the virtual bidding entities expect more DAM congestion than FMM congestion. This virtual counterflow can result in physical schedules in the IFM exceeding the physical limit of the constraint. However, internal constraint virtual counterflow does not result in the inefficient dispatch of physical resources described above.

This is because internal physical resources will not face the same incentives that intertie resources do to self-schedule in real-time under these conditions. If internal resources bid their marginal cost in real-time, they will generally only have their schedules reduced if the FMM price on which they settle is below their marginal cost. Internal resources can therefore expect to maximize their profits by rebidding their marginal cost in real-time.

On the other hand, imports at interties with no economic FMM bids who bid their marginal cost in real-time could have their DAM schedules reduced by a HASP price that is below their marginal cost because of congestion on the intertie constraint in HASP. However, the imports would be exposed to buying back their DAM schedules at a price greater than their marginal cost in the FMM because the intertie constraint congestion would not be reflected in the FMM price.

3 Scenario 3: Interties with convergence bidding and with economic bids in the fifteen-minute market

Scenario description

The ability to economically bid into the FMM can change the pricing and settlements at the intertie significantly. Consider what would happen if Import 6 from the prior scenarios could economically bid into the FMM. Table 6 shows the results of Import 6 submitting economic bids at -\$150 in the FMM. In this example, the FMM will set the intertie LMP at -\$150. Table 7 shows the settlements under these prices.

Table 6. Effect of economic bidding on intertie in the fifteen-minute market

Day-Ahead Market				Hour-Ahead Scheduling Process				Fifteen-Minute Market			
Intertie Limit = 1,000 MW				Intertie Limit = 1,000 MW				Intertie Limit = 1,000 MW			
System Marginal Energy Cost = \$35				System Marginal Energy Cost = \$35				System Marginal Energy Cost = \$35			
Bids	MW	\$/MW	Award	Bids	MW	\$/MW	Award	Bids	MW	\$/MW	Award
Import 1	300	\$2	300	Import 1	300	Self Sch.	273	Import 1	273	Hourly	273
Import 2	200	\$4	200	Import 2	200	Self Sch.	182	Import 2	182	Hourly	182
Import 3	200	\$8	200	Import 3	200	Self Sch.	182	Import 3	182	Hourly	182
Import 4	200	\$10	200	Import 4	200	Self Sch.	182	Import 4	182	Hourly	182
Import 5	200	\$12	200	Import 5	200	Self Sch.	182	Import 5	182	Hourly	182
Import 6	100	\$14	100	Import 6	100	-\$150	0	Import 6	100	-\$150	0
Total	1,200		1,200	Total	1,200		1,000	Total	1,100		1,000
Virtual Bids	MW	\$/MW	Award	Virtual Bids	MW	\$/MW	Award	Virtual Bids	MW	\$/MW	Award
Demand	-400	\$15	-200	None	0	--	0	None	0	--	0
Net Cleared MW on Intertie			1,000	Net Cleared MW on Intertie			1,000	Net Cleared MW on Intertie			1,000
Shadow Value on Intertie			-\$20	Shadow Value on Intertie			-\$185	Shadow Value on Intertie			-\$185
LMP at Intertie			\$15	LMP at Intertie			-\$150	LMP at Intertie			-\$150

Table 7. Settlement of imports and virtual demand

Schedule	Day-Ahead Market			Fifteen-Minute Market			Total Revenue
	Award	LMP	Revenue	Award	LMP	Revenue	
Import 1	300	\$15	\$4,500	-27	-\$150	\$4,091	\$8,591
Import 2	200	\$15	\$3,000	-18	-\$150	\$2,727	\$5,727
Import 3	200	\$15	\$3,000	-18	-\$150	\$2,727	\$5,727
Import 4	200	\$15	\$3,000	-18	-\$150	\$2,727	\$5,727
Import 5	200	\$15	\$3,000	-18	-\$150	\$2,727	\$5,727
Import 6	100	\$15	\$1,500	-100	-\$150	\$15,000	\$16,500
Virtual Demand	-200	\$15	(\$3,000)	200	-\$150	(\$30,000)	(\$33,000)

Discussion of results

As illustrated by this scenario, submitting convergence bids to attempt to arbitrage the congestion discrepancy could be very risky when a physical importer can place economic bids and schedule on a fifteen-minute basis.

The importer with the ability to schedule on a fifteen-minute basis would have an incentive to bid as low as possible, while still being decremented in the fifteen-minute market, so as to increase revenues from the import buy back. In this case, the lowest the importer could bid would be the -\$150 bid floor. The virtual demand loses substantially from having to sell at a very low FMM price. As the number of importers who can bid economically in the FMM increases, the incentive to bid as low as possible while still maximizing the amount of buy-back profits will likely push bids towards marginal costs and make the dynamics at the intertie more stable.

Convergence bids at interties with low, but non-zero, liquidity for economic bids in the FMM can still create inefficiencies.

This third scenario illustrates that the existence of one physical importer that can economically bid and schedule in the fifteen-minute market on an intertie could create a substantial deterrent to other entities bidding virtual counterflow in the day-ahead market. However, in the absence of multiple physical importers that can participate in the FMM at an intertie, convergence bids at the intertie could create the inefficiencies previously described in Scenario 2. This is because if only one physical importer can participate in the FMM at an intertie with multiple day-ahead and HASP market participants, that one FMM importer may find it more profitable to play the role of the virtual demand from Scenario 2.

4 Conclusions

Interties where there is little or no economic bidding in the fifteen-minute market can create incentives for convergence bidding strategies that create inefficient market scheduling. This is particularly important for interties on which there are structural barriers to economic bidding in the fifteen-minute market. Moreover, profits received from these virtual bids would ultimately be borne by other participants. As shown above, there is a lack of bidding on the interties in the fifteen-minute market. Careful consideration should be given to understanding the structural barriers outside of ISO markets preventing such fifteen-minute market bidding before fully implementing convergence bidding on the interties.