Interface Pricing Issue – PJM Position Paper

DRAFT - February 17, 2015

Introduction

Interface prices are the mechanism by which organized markets charge exports of energy from and credit imports of energy into their respective balancing authorities. Exports of energy from a balancing authority area represent a withdrawal from the market, and therefore are subject to a charge. Imports of energy into a balancing authority represent supply to the market, and therefore receive a credit. The interface prices established by the organized markets are those prices at which these charges and credits are established.

Interface prices are determined similarly by all the organized markets that utilize locational pricing. In general, a set of pricing nodes is selected such that the nodal prices at each of those locations is aggregated together to constitute the final interface price. A complete description of the methodology by which PJM establishes interface prices can be found on the PJM web site[1].

Establishment of interface prices by the organized markets has been impacted by the creation of "market-to-market" redispatch agreements. Under such agreements, two RTOs mutually determine a set of transmission facilities on which the dispatch of both RTOs has an impact. The two RTOs then jointly operate for those constraints, meaning those constraints simultaneously "bind" and impact both the dispatch and the nodal prices of both RTOs. PJM, MISO, and our respective IMMs, Monitoring Analytics and Potomac Economics, have been actively discussing the merits of various interface pricing methodologies with the goal of identifying an approach that most accurately reflects the impact of transactions on transmission constraints for which both RTOs are operating. Interface prices must also simultaneously provide the correct price incentives that reflect the full impact of transactions on transmission constraints that are entirely within only one of the RTOs and not subject to market-to-market coordination.

The primary issue the MISO IMM raised with the interface price calculation methods in use by the RTOs was that the "overlap" in the way the two interface prices were determined resulted in an overstatement of the congestion impacts of interchange transactions. That is, interchange transactions were being charged either too much or too little congestion because both RTOs included too much of the congestion impact of a given transaction in their respective interface prices. Two solutions to this identified issue have been proposed, one by PJM and one by the MISO IMM. Both PJM and MISO IMM's solutions have the potential to meet the above core objectives. However, as discussed in detail in this paper, PJM is concerned that MISO IMM's solution may generate unintended consequences. PJM

[1] Following is the web link to the PJM Interface Price Definition Methodology: http://www.pjm.com/~/media/markets-ops/energy/lmp-model-info/20060929-interface-definition-methodology1.ashx

therefore believes that its proposal for PJM and MISO to establish a common interface price definition at the border between the RTOs and further incorporate an adjustment to the Market Flow calculations utilized in the market-to-market settlement process is a preferable solution. On June 1, 2014, PJM changed its definition for its interface pricing point for MISO consistent with this proposal. PJM stands ready to work with MISO to implement the Commercial Market Flow approach to adjusting the Market Flow calculations in order to complete the implementation of its proposed solution.

The MISO IMM proposal has two essential components: 1) move the interface definitions each RTO uses to price transactions to/from the other RTO to the center of the other RTO's load; and 2) eliminate the congestion component from market-to-market constraints for which the other RTO (known as the non-monitoring RTO) has monitoring responsibility in the interface price. This paper explains PJM's concerns with each of the components of the MISO IMM proposal, specifically that 1) an interface definition electrically far removed from the border between the two RTOs will unacceptably attenuate the effectiveness (and in some cases reverse the impact) of the interface model on internal, non-market-to-market constraints; and 2) elimination of the congestion component from market-to-market constraints for which the other RTO has monitoring capability will not result in more efficient congestion management, but rather would result in higher PJM, Day-ahead Market congestion costs, and also result in the collection of less PJM balancing market congestion.

Impacts of the Current PJM Interface Definition vs. the MISO IMM Proposal

The MISO IMM has asserted that the current PJM interface definition for MISO results in incorrect shift factors on the market-to-market constraints for which the RTOs jointly operate. The MISO IMM has further asserted that these incorrect shift factors are causing tens of millions of dollars of incorrect congestion credits to transactions from PJM to MISO. The MISO IMM therefore proposes that each RTO move its interface definition for the other RTO to the center of the other RTO's load. PJM does not believe that the shift factors resulting from this interface definition are incorrect. In fact, they are the result of the choice of the interface definition used to represent the power flows induced by interchange transactions on the transmission system. PJM has defined the interface pricing point for MISO according to a power flow analysis of the facilities on which the vast majority of the flow (around 80%) resulting from an interchange transaction between PJM and MISO occurs. PJM recognizes that the distribution of these flows is not constant over time, and could implement mechanisms by which the interface definition would dynamically adjust as power flows change[2]. However, Dr. Patton's analysis and proposed interface pricing point definition relies on an assumption that the source and sink of energy transacted between the two RTOs is at the load weighted center of each RTO. This assumption also is not consistently correct since the load center changes constantly as load changes and economic dispatch occurs. Further, as PJM demonstrates below, this assumption has the detrimental impact of significantly reducing the calculated flow impact of transfers across the RTO border on transmission facilities. The PJM methodology is intended to ensure that the impact of interchange transactions on binding

[2] Implementing the Dynamic Weighting Calculation described in the posted PJM Interface Price Definition Methodology would be one such method for adjusting for flow patterns.

transmission constraints is completely reflected. This is the highest priority for PJM as far as the purpose of the interface pricing point definitions and therefore the congestion impact resulting from this definition is expected and appropriate.

As shown in the figures below, PJM has performed analysis on how the distribution factor impact on major, internal, non-market-to-market PJM constraints would change if the MISO IMM's proposal was adopted. Figure 1 graphically shows the result of moving the interface definition from the current location at the border of the PJM and MISO systems to the center of MISO load. As the text boxes indicate, with the current PJM interface price definition for MISO, the distribution factor impact of a MISO to PJM transaction on internal PJM constraints is determined from the border location to the center of PJM load ("PJM Centroid") as illustrated by the blue arrow. Under the MISO IMM proposal, the impact of a MISO to PJM transaction would be determined from the center of MISO load ("MISO Centroid") to the center of PJM load, as illustrated by the orange arrow, significantly reducing the calculated impact of such a transaction on PJM transmission facilities.

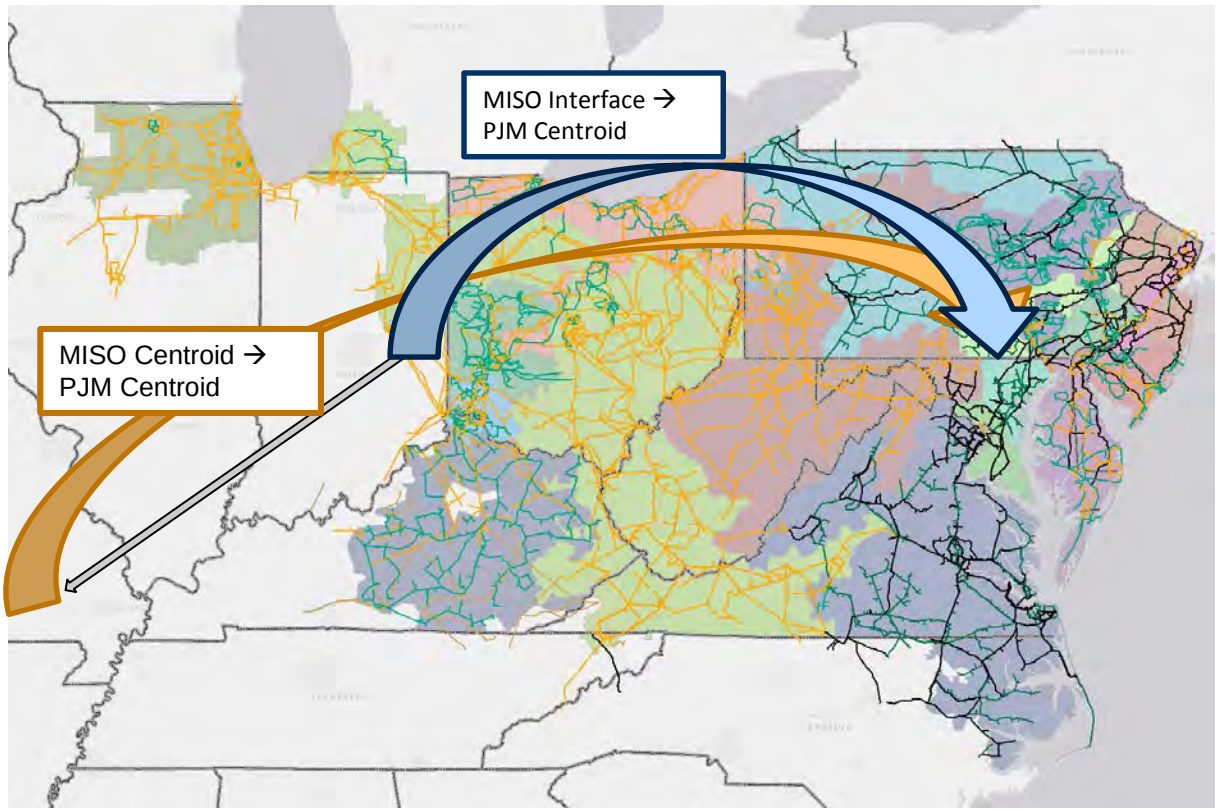
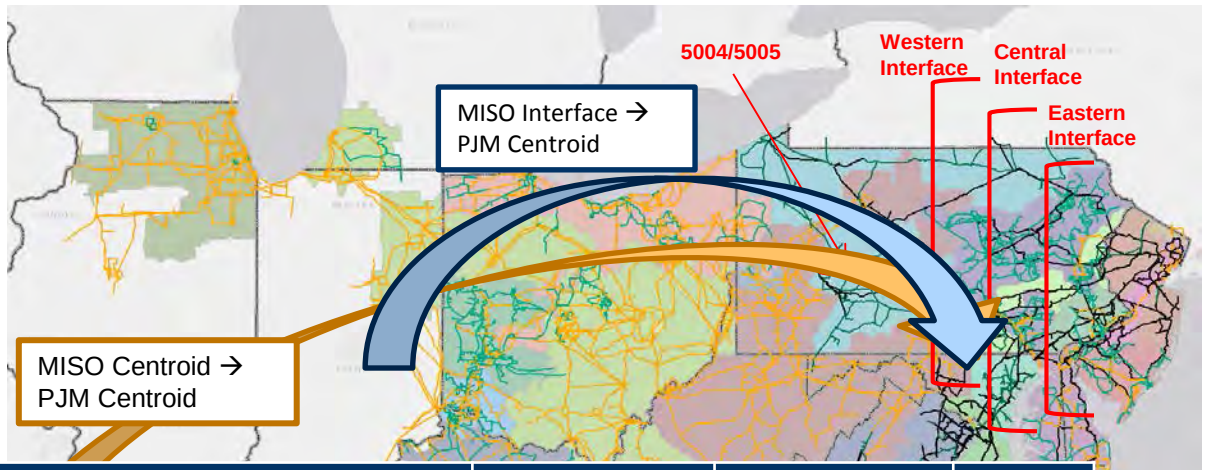


Figure 1: conceptual difference between current PJM interface for MISO and MISO IMM proposal

Figure 2 shows the differences PJM determined between the current PJM interface definition and the MISO IMM proposed interface definition with respect to the calculated impact of a MISO to PJM

transaction on major, PJM internal transmission interfaces[3]. As can be seen from the figure, the calculated impact of such transactions is significantly reduced under the MISO IMM proposal. This reduced impact is a significant concern for PJM because the impacts stemming from the interface definition are utilized together in the dispatch algorithms that determine the dispatch solutions anticipating the impact of interchange schedule changes on transmission constraints, and also on the prices at which interchange transactions are settled. This means that when the PJM dispatch algorithms determine the dispatch solutions for an upcoming interval, the impact of interchange transactions that are not yet flowing but will be implemented before the interval being studied are included. Significantly underestimating the impact of upcoming interchange transaction schedules on transmission constraints in the dispatch algorithm would lead to large changes in the dispatch solutions that are subsequently calculated once the interchange transaction schedules are implemented and the flows on the transmission constraints are actually observed. PJM currently avoids the volatility this understating of transaction impacts would cause by ensuring that the full impact of scheduled transactions is included in the forward-looking dispatch solution. The impacts of these differences in the interface distribution factors would extend to the pricing of interchange transactions. The alternative factors resulting from the MISO IMM proposal would result in significantly different price impacts with respect to the charges or credits an interchange transaction would receive. It is important that these prices are calculated consistently with the physical impact of interchange transactions so that those charges and credits are reflective of the physical impact of the transactions. This linkage is critical to ensuring that market participants scheduling physical transactions do so in a manner that supports reliable operation of the transmission system. The significant reduction in distribution factors stemming from the MISO IMM proposal would unacceptably attenuate this linkage.

[3] PJM utilized the Interchange Distribution Calculator (IDC), a standard industry tool used to determine the impact of interchange transactions on transmission facilities, to perform this analysis.



Interface	MISO Interface	MISO Centroid	Delta
5004/5005 l/o Conemaugh-Keystone	5.47%	2.82%	2.65%
Western Interface	11.15%	5.73%	5.42%
Central Interface	14.30%	3.66%	10.64%
Eastern Interface	10.34%	2.65%	7.69%

Figure 2: difference between the calculated impact of a MISO to PJM transaction on major PJM internal Interconnection Reliability Operating Limit (IROL) transmission interfaces with the current PJM interface definition for MISO and the MISO IMM proposal

Figure 3 shows the most significant, negative impact of the MISO IMM proposal in this regard. As indicated in Figure 3, the result of changing the PJM interface definition as the MISO IMM proposes would *reverse* the impact determined on the PJM AEP-DOM IROL Interface. This means that while the current PJM interface definition indicates that transactions from MISO *increase* the flow on this constraint, consistent with what PJM actually observes in real time operations, the interface definition proposed by the MISO IMM would indicate that transactions from MISO *reduce* the flow on the constraint. From a pricing perspective, this means that market participants would receive increased credits for transacting in the MISO to PJM direction and thereby increasing the flow on this 500kV transfer constraint. Clearly PJM cannot implement an interface price definition that would have this negative impact.

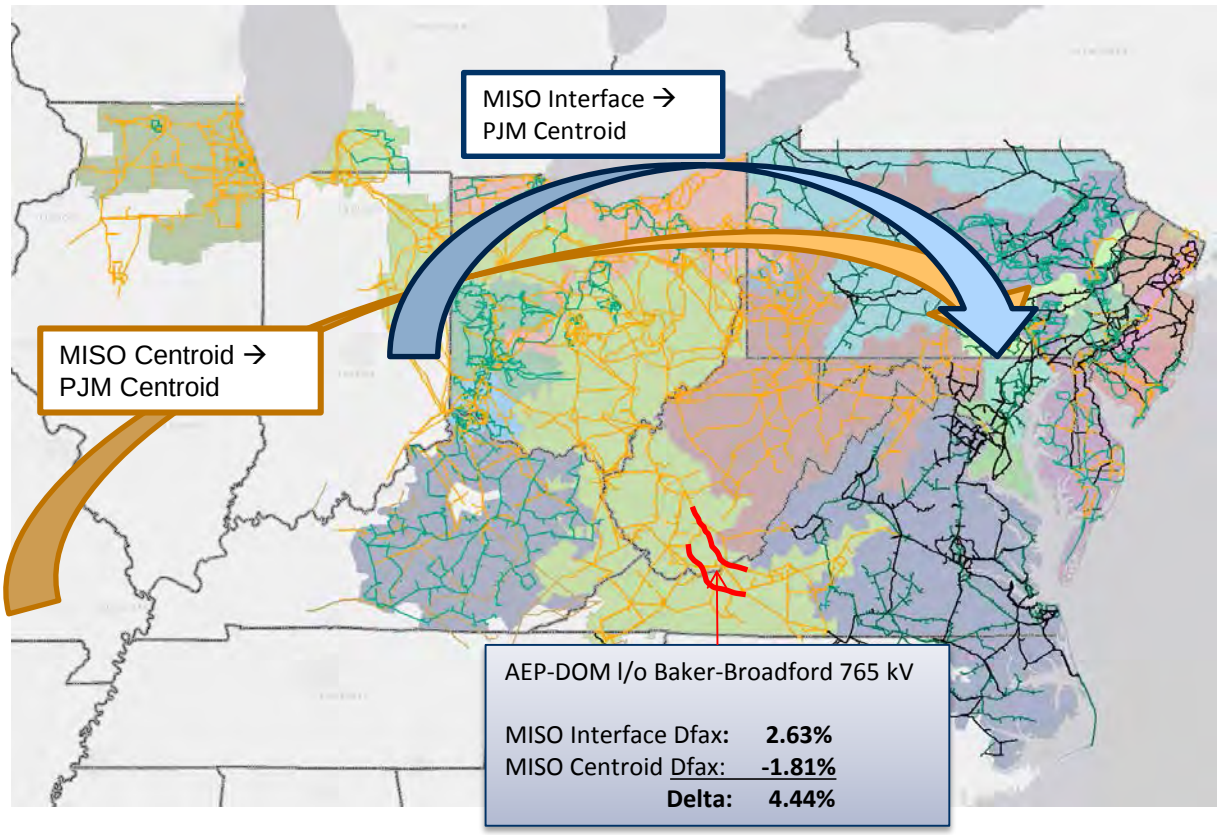


Figure 3: difference between the calculated impact of a MISO to PJM transaction on the AEP-DOM 500kV IROL interface with the current PJM interface definition for MISO and the MISO IMM proposal

PJM's Interface Price Definition Change on June 1, 2014

The second component of the MISO IMM's proposal is to eliminate the congestion component in the interface price from market-to-market constraints for which the other RTO has monitoring responsibility. The MISO IMM indicates that doing so will eliminate the over-charging of congestion to interchange transactions. The change PJM implemented to its interface pricing point definition for MISO on June 1, 2014 has already eliminated the concern raised by the MISO IMM regarding overcharging and crediting congestion to interchange transactions on the PJM side of the seam. Sometimes referred to as the "double-counting" concern, this effect was caused by the fact that the PJM interface definition for MISO was located inside the MISO system instead of right at the border between the RTOs. The MISO interface definition for PJM currently consists of buses that are located well inside the PJM system. The combination of these two interface definitions that were inside the others' system resulted in an "overlap" of the PJM interface with the MISO interface, in turn resulting in the overstatement of congestion charges and credits to interchange transactions. This overlapping is illustrated in Figure 4.

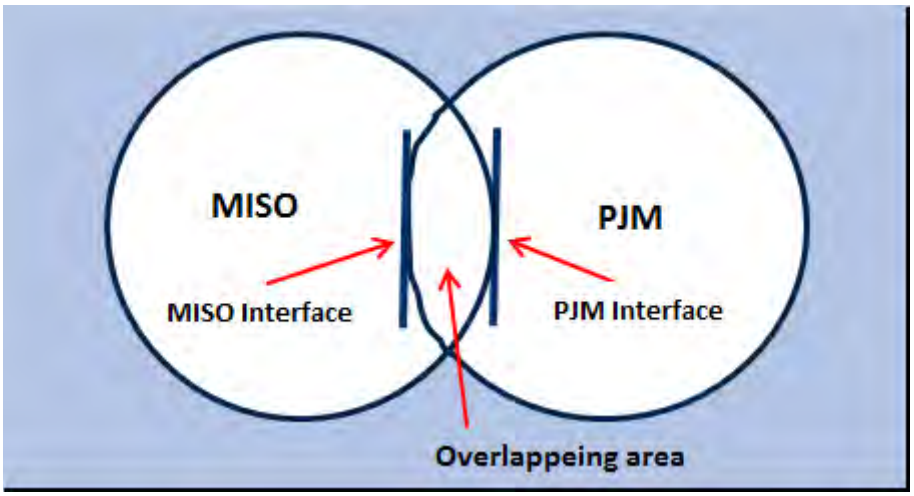


Figure 4: Illustration of the overlapping of PJM and MISO Interfaces that results in overstatement of congestion charges and credits.

PJM's June 1, 2014 change that moved the interface definition to the RTO border eliminated the overlap caused by the PJM interface price definition. If MISO were to implement an interface pricing point for PJM consistent with PJM's definition of the MISO interface pricing point, then the double-counting concern would be entirely eliminated. Figure 5 illustrates the removal of the overlap with the use of a common interface definition.

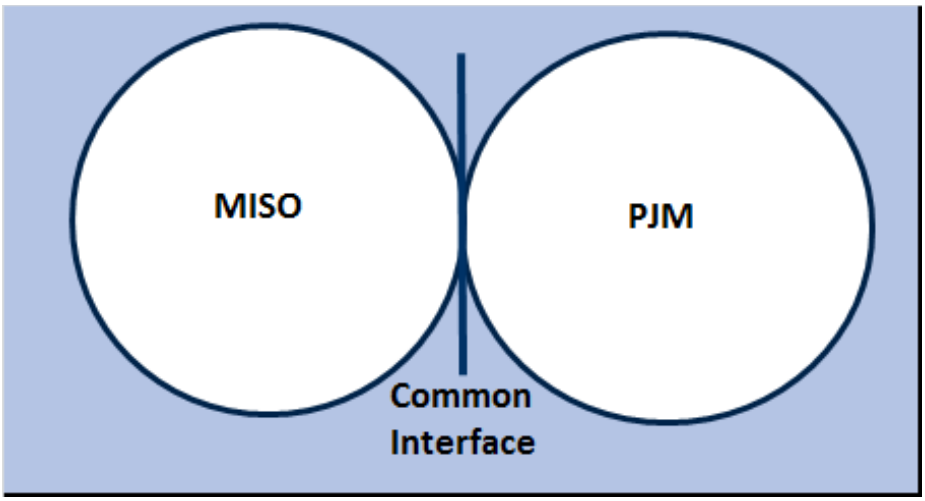


Figure 5: Illustration of removal of the overlapping with use of a common interface.

The MISO IMM has indicated that the settlement impact of the current PJM interface price definition is well into the tens of millions of dollars per year. That is, the MISO IMM contends that even with the PJM interface definition defined at the border between the RTOs, the distribution factors resulting from this definition overstate the impact of transactions on transmission constraints such that PJM congestion charges and credits to interchange transactions are too high. Because prevailing net interchange is in the PJM to MISO direction, and because the congestion price at the PJM interface for

MISO is typically negative, the MISO IMM contends that PJM is collecting too little congestion from transactions between PJM and MISO.

PJM has conducted analysis on what the impacts would be of adopting the interface pricing mechanism the MISO IMM proposes, and this analysis is summarized below in Table 1. In conducting this analysis, PJM has calculated the settlement impact of removing the congestion component of market-to-market constraints for which MISO is the monitoring RTO. PJM has conducted this analysis for the Day-ahead Market, the balancing market (deviations between day-ahead and real time quantities times the real time price), and for real time transactions separately. The balancing market impacts represent the actual, real time settlement impacts stemming from this analysis. Since the actual, real time settlement is based upon deviations between day-ahead and real time quantities and not just the real time quantities themselves, the calculations showing real time transactions separately do not represent actual settlement quantities and are therefore only included as a reference point since the initial, MISO IMM analysis utilized only real time transaction quantities.

The Day-ahead Market calculations show the difference in settlements that would result solely from changing the PJM interface price such that the congestion component of the interface LMP caused by market-to-market constraints for which MISO is the monitoring RTO is removed. The analysis includes all Day-ahead Market activity at the MISO interface, including day-ahead interchange transactions, increment offers, decrement bids, and up-to congestion transactions. However, as explained below and very important for the purposes of this analysis, the calculations do not represent the impact of removing the flow impacts of the market activity at the interface point in the Day-ahead Market. Because the combination of all such activity on average results in a net withdrawal at the MISO interface, and also because the congestion component of the market-to-market constraints for which MISO is the monitoring RTO is typically negative, PJM charges less congestion to these net withdrawals due to the typically negative congestion component of the LMP. It would appear from these calculations as if removing this congestion component would have resulted in PJM collecting almost $80 million in additional congestion charges in the Day-ahead Market in 2014[4]. However, this is NOT the result that would have actually occurred. The reason why PJM charged these net withdrawals a lower congestion price is because these withdrawals served to reduce the flow on the MISO transmission constraints in the PJM day-ahead model. If PJM were to remove the congestion component of the LMP caused by these constraints in the interface LMP in the Day-ahead Market, PJM would also need to remove the flow impact of all of the net withdrawals at the MISO interface point on the MISO constraints. Importantly though, PJM would then need to replace the beneficial flow impact provided by those withdrawals on the MISO constraints through redispatch of its internal generation resources or by clearing other virtual activity. By definition, because the net withdrawals cleared in the Day-ahead Market were the most cost-effective way for the market clearing software to achieve the necessary relief on the MISO constraints, replacing the flow impact from those withdrawals would necessarily be

[4] It is important to note, as PJM does further on in this paper, that 83% of this impact occurred in the months of January through May, before PJM changed its interface definition for MISO on June 1. Applying the average, monthly impact from June through December to the entire, 12-month period would yield a total impact of about $24 million.

at a higher congestion cost. Therefore, there are actually NO savings to be achieved in the Day-ahead Market through the adoption of the MISO IMM proposal. In fact, PJM would still be required to limit its Day-ahead Market flows to its Firm Flow Entitlement values on MISO constraints, but without the benefit of including the flow impact of market activity at the interface, which would result in an even higher congestion cost than is experienced today.

The Balancing Impact column of the PJM analysis shows the impact of removing the congestion component of the interface LMP caused by market-to-market constraints for which MISO is the monitoring RTO on the PJM balancing settlement. This impact is calculated by multiplying the MW deviations from day-ahead to real time market activity at the MISO interface times the real time LMP at the MISO interface, with and without the congestion components from the MISO market-to-market constraints. This calculation shows that if the congestion component caused by the MISO market-to-market constraints was removed from the interface price, the balancing settlement impact would be negative. This means that PJM would have collected less in balancing congestion if the congestion component from MISO market-to-market constraints were removed from the PJM interface price for MISO. Further, since June, when PJM changed its interface definition for MISO, the balancing impact would also have been relatively small. Negative balancing congestion occurs when less flow can be accommodated in real time than was allowed to flow in the Day-ahead Market. Because the impact of adopting the proposed change to the PJM interface methodology would have resulted in collection of less balancing congestion, this means that the current interface methodology results in more flow being allowed in real time than results from the Day-ahead Market. The conclusion PJM draws from this result is that PJM is actually receiving, on average, slightly more flow relief on the MISO market-to-market constraints in real time than is caused by the market activity at the interface in the Day-ahead Market. Because the difference was small, roughly $50,000 per month, this means that on average the current PJM interface is a fairly good approximation of the impact of market activity at the interface on MISO market-to-market constraints. While this conclusion may not hold for every constraint, the calculations show that this is the result when all constraints for which PJM operated in 2014 are taken together. From this analysis then, it does not appear as if the MISO IMM's contention that the interface definition currently used by PJM overstates the distribution factor impact of activity at the interface on transmission constraints is correct.

The final conclusion that PJM draws from the analysis summarized in the table is that the estimates of the impact of the current interface definition are significantly overstated given the interface definition change PJM made on June 1, 2014. It is clear from the monthly calculation results summarized in the table that the impact of any change was drastically reduced beginning in June. Since June, 2014, the real time impact of the proposed change would have been less than $250,000 per month, or less than $4 million per year, nowhere near the tens of millions of dollars per year that the MISO IMM has estimated.

Month	Day-ahead Impact	Balancing Impact	Net Impact	RT Impact
1	$ 11,191,620.43	$ (6,783,841.95)	$ 4,407,778.48	$ (2,599,711.99)
2	$ 10,557,335.81	$ (2,819,256.00)	$ 7,738,079.80	$ 7,103,174.23
3	$ 24,389,932.56	$ (1,887,143.58)	$ 22,502,788.98	$ 12,735,179.89
4	$ 10,254,412.16	$ (1,814,264.46)	$ 8,440,147.70	$ 3,015,092.58
5	$ 9,150,099.78	$ (5,398,184.00)	$ 3,751,915.78	$ (235,712.08)
6	$ 5,366,831.12	$ (375,596.48)	$ 4,991,234.64	$ 243,562.35
7	$ 2,095,469.49	$ (176,552.46)	$ 1,918,917.03	$ 126,039.56
8	$ 287,457.55	$ 374,647.41	$ 662,104.96	$ 6,285.79
9	$ 1,929,674.24	$ (232,097.77)	$ 1,697,576.48	$ 618,812.89
10	$ 1,643,582.26	$ 85,616.01	$ 1,729,198.27	$ 460,973.72
11	$ 1,599,142.76	$ (62,173.66)	$ 1,536,969.09	$ 134,721.15
12	$ 650,652.95	$ 2,241.58	$ 652,894.53	$ 63,322.06
Total	***$ 79,116,211.09***	***$ (19,086,605.35)***	***$ 60,029,605.74***	***$ 21,671,740.15***
Average before June	***$ 13,108,680.14***	***$ (3,740,538.00)***	***$ 9,368,142.15***	***$ 4,003,604.53***
Average after June	***$ 1,938,972.91***	***$ (54,845.05)***	***$ 1,884,127.86***	***$ 236,245.36***

Table 1: PJM analysis of the impacts of adopting the MISO IMM proposal for interface pricing

PJM's analysis demonstrates that the revised PJM interface definition for MISO results in a good approximation of the impact of activity at the interface on MISO market-to-market constraints. PJM therefore recommends that its proposal be adopted by both RTOs, and that the RTOs further implement the commercial flow approach to modeling transactions in the Market Flow calculations. Adjusting the Market Flow calculations according to the flow calculations utilized by the RTOs in their actual settlement processes will ensure that market-to-market settlements are consistent with the settlements otherwise resulting from the LMP markets[5]. The interface pricing change that PJM has already made is simple and can be implemented immediately (or coincident with the start of the next planning period if necessary for FTR purposes, as PJM did on June 1). PJM and MISO staffs have been discussing the commercial flow approach for over a year and can mutually agree on a reasonable timeframe by which the Commercial Flow approach can be adopted as well.

The MISO IMM has also indicated that they believe the impact of the PJM interface definition choice should be greater in the Day-ahead Market because PJM day-ahead constraint shadow prices on MISO market-to-market constraints are greater than real time shadow prices. As can be seen from Table 2 below, this is not the case. The chart below depicts the PJM average day-ahead and real time constraint shadow prices for the most impactful MISO market-to-market constraints. Only one of these constraints has a higher average PJM shadow price in day-ahead than it does in real time.

[5] A detailed document describing the PJM Commercial Market Flow approach can be found at the following link: http://www.miso-pjm.com/~/media/committees-groups/stakeholder-meetings/pjm-miso-joint-common/20141110/20141110-item-03-pjm-m2m-commercial-market-flow-proposal-october-2014.ashx

CONSTRAINT	DA Average Shadow Price	RT Average Shadow Price
Benton Harbor-Palisades 345 kV l/o Cook-Palisades 345 kV	$ (30.46)	$ (135.06)
Oakgrove-Galesburg 161kv l/o Nelson-Electric Junction	$ (57.25)	$ (187.64)
Cook-Palisades 345 kV l/o Benton Harbor-Palisades 345 kV	$ (20.33)	$ (57.39)
Breed-Wheatland 345 l/o Jefferson-Rockport 765 kV	$ (24.81)	$ (66.23)
Rising 45TR1	$ (110.83)	$ (13.19)
Cook-Palisades 345 kV l/o Twin Branch-Argenta 345 kV	$ (98.75)	$ (131.43)
Rantoul-Rantoul Jct 138 KV l/o Rising-N Champaign-Mahomet 138 kV	$ (76.42)	$ (188.53)
Bunsonville-Eugene 345 kV l/o Casey-Breed 345 kV	$ (10.19)	$ (25.54)
Monticello-East Winamac 138 kV l/o Schahfer-Burr Oak 345 kV	$ (232.41)	$ (502.25)
Kewanee-Edwards 138kv l/o Nelson-electric Jct	$ (38.10)	$ (156.76)
Benton Harbor-Palisades 345 kV l/o Twin Branch-Argenta	$ (38.38)	$ (73.25)

Table 2: comparison of PJM average day-ahead and real time shadow prices on MISO constraints

The MISO IMM's Concerns with the PJM Proposal

The MISO IMM has expressed concern with adopting the PJM proposal to resolve the interface pricing issue due to the differences in constraint shadow prices in the two RTOs' dispatches. PJM believes that the shadow price differences Dr. Patton has highlighted appear to be caused by the volatility of the MISO shadow prices. From the examples PJM has reviewed, the PJM and MISO shadow prices are consistent but for intermittent, 5-minute intervals where the MISO shadow prices "spike" to levels much higher than PJM's. PJM's shadow prices, on the other hand, are much more stable and do not reflect the "spikes" observed in the MISO shadow prices. PJM believes this is the case because PJM has intentionally implemented algorithms that result in the stability of its shadow prices in order to ensure that dispatch instructions received by generators are ones that can actually be followed. No generator can react to a dispatch signal that is extremely volatile and caused by equally volatile constraint shadow prices. Similarly, market participants cannot adjust interchange transaction schedules quickly enough to react to interface price changes that are volatile and result from volatile constraint shadow prices. Regardless, differences in constraint shadow prices is an issue that deserves further study in order to determine whether changes in the mechanism by which market-to-market congestion management is accomplished might be beneficial in achieving greater convergence.