MISO-PJM Coordinated Transaction Scheduling Workshop

June 10, 2014

Opportunity Identification

- Both IMMs expect cost savings from more efficient real-time interchange and better convergence of the prices between MISO and PJM
  - PJM IMM[1]: “The direction of flow was consistent with price differentials in 45.0 percent of hours in 2013
  - MISO IMM[2]: “The share of hours in which PJM transactions were scheduled in the profitable direction rose to 51 percent in 2012”
- The ability of Market Participants to arbitrage MISO/PJM price differentials is limited
  - Advance transaction scheduling requirements and price uncertainty leads to inefficient response
  - No capability to provide price preferences

1. PJM 2013 State-of-the-Market Report Section 9 page 380
2. MISO 2012 State-of-the-Market Report Appendix page 151

Opportunity Identification

- Stakeholders have expressed broad support for market enhancements which improve seams management

- Both MISO and PJM have identified opportunities for improved generation commitment and dispatch processes, and market outcomes through more efficient and predictable real-time NSI (Net Scheduled Interchange)

Objectives of Real-Time Interchange Optimization

- Enhance scheduling flexibility across the interface
  - Allow participants' ability to further utilize the available transfer capability across the interface for scheduling interchange transactions
  - Reduce or provide more certainty of uplift charges associated with deviation between DA and RT markets
- Increase economic efficiency of real-time energy interchange across the interface
  - Lower overall operating costs across the two markets
  - Improve price signals
  - Improve convergence of average real-time prices at the seam
- Improve manageability of operational issues associated reliability coordination
  - Reduce volatility and unpredictability of Net Scheduled Interchange (NSI) to improve confidence in resource commitment and dispatch for meeting reliability goals

AGENDA ITEM – 1
BENEFITS ANALYSIS

JCM Interface Pricing Topic

- Potomac Economics, MISO's Market Monitor, identified an issue with the magnitude of congestion that was captured in the Interface price when M2M constraints are binding in both MISO and PJM and transactions settle with both RTOs
  - In this scenario, the congestion calculated by the Monitoring RTO is sufficient to fully compensate the transaction so there is no need for the Non-Monitoring RTO to also compensate the transaction
- PJM and MISO have communicated at the JCM that they intend to change their interface definitions in response to this issue

Revised Benefit Analysis

- PJM repeated the cost benefit analysis that was previously done for 2013 to gauge the impact of different interface definitions
  - PJM updated its MISO interface definition to be closer to the border on June 1, 2014
  - MISO has stated that it plans to remove external congestion from its PJMC interface definition in the near future
- Cost benefit analysis was performed using a supply curve based approach to approximate the amount of MWs that need to be moved in each ISO to simulate various price alignment scenarios
- An iterative approach was used to determine the movement each RTO would make along their supply curve to decrease price separations between the areas
  - 500 MW, 1000 MW, and 1500 MW restrictions were imposed from the original starting point

Benefits Analysis Comparison

Original Results			
	$5 Scenario	***$10 Scenario***	***$15 Scenario***
500 MW Total	$26,717,084	$21,392,222	$17,579,495
1000 MW Total	$51,459,683	$41,144,530	$33,692,663
1500 MW Total	$74,243,308	$59,230,704	$48,276,857

Results with Updated Interface Definitions			
	$5 Scenario	***$10 Scenario***	***$15 Scenario***
500 MW Total	$26,012,234	$20,840,192	$16,961,002
1000 MW Total	$50,033,200	$40,036,276	$32,408,275
1500 MW Total	$72,038,511	$57,519,176	$46,273,721

AGENDA ITEM – 2
CTS CLEARING PROCESS

MISO/PJM CTS Overview

- CTS would be a new transmission and scheduling product available for:
  - Real Time Market only
  - Transaction between PJM and MISO only

- MISO and PJM (RTOs) will develop a portal through which E-tags with CTS offers can be submitted to both RTOs simultaneously

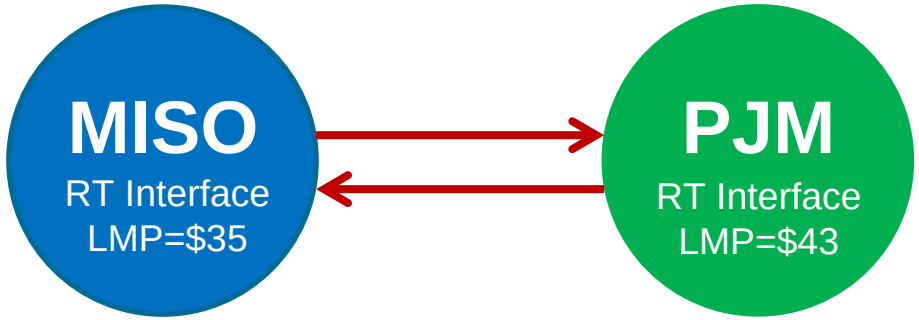
- RTOs would develop and exchange projected prices and feed these along with the CTS offers into the look-ahead dispatch engine

MISO/PJM CTS Overview (contd.)

- RTOs would utilize forward-looking dispatch functionality to determine the cleared set of transactions and the net interchange for a target interval
  - CTS offers are cleared as long as the predicted price differential is better than offer irrespective of eventual real time prices
  - Functionally one clearing message for each interval
- Resulting net interchange would be used in checkout process and as input into the real-time market clearing engine
- Cleared transactions would be settled by Market Participants with individual RTOs using RT prices

Simple Example – MISO/PJM CTS Illustration

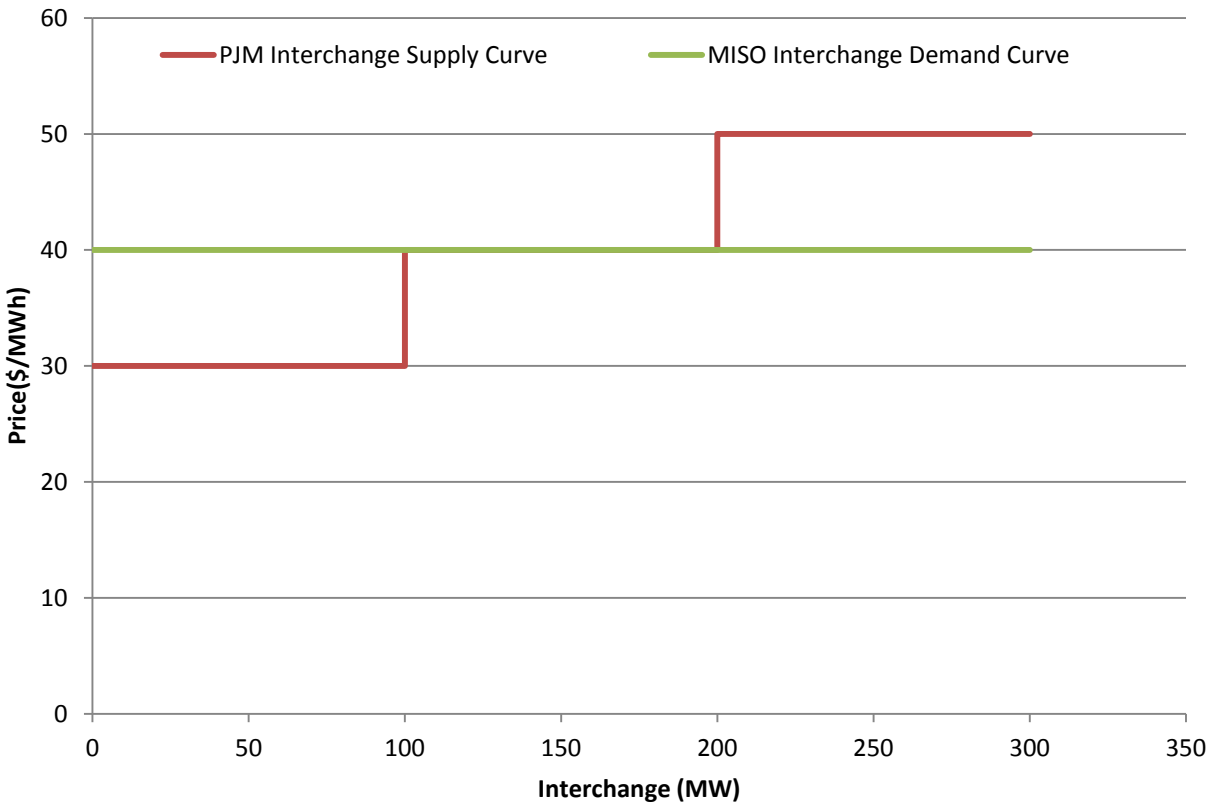
- Assumptions:
  - Fixed Transactions: 100 MW
  - Projected prices equal to settlement prices
  - Interface price spread: +/- $8
  - CTS transaction A: 100 MW @ $4
  - CTS transaction B: 100 MW @ $10
  - CTS transaction C: 100 MW @ $8



Simple Example – MISO/PJM CTS Illustration

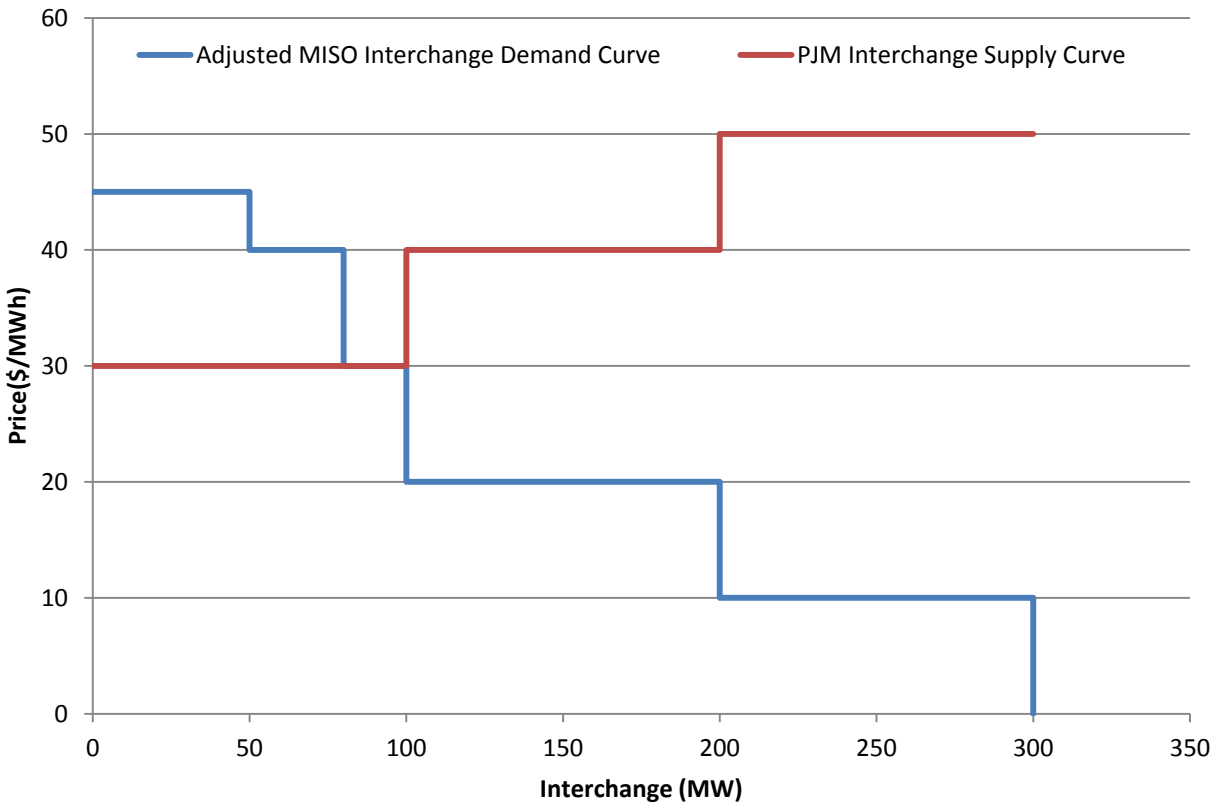
	DIRECTION	CLEARING	RESULT
Fixed Transaction	MISO to PJM	Charge $3500 and Credit $4300	Credit $800
	PJM to MISO	Charge $4300 and Credit $3500	Charge $800
CTS Transaction A	MISO to PJM	Approved with Bid $4<Price spread $8	Credit $800
	PJM to MISO	Denied with Bid $4 >Price spread -$8	0
CTS Transaction B	MISO to PJM	Denied with Bid $10>Price spread $8	0
	PJM to MISO	Denied with Bid $10>Price spread -$8	0
CTS Transaction C	MISO to PJM	Approved with Bid $8=Price spread $8	Credit $800
	PJM to MISO	Denied with Bid $8>Price spread -$8	0

Clearing Logic with Single Projected Price



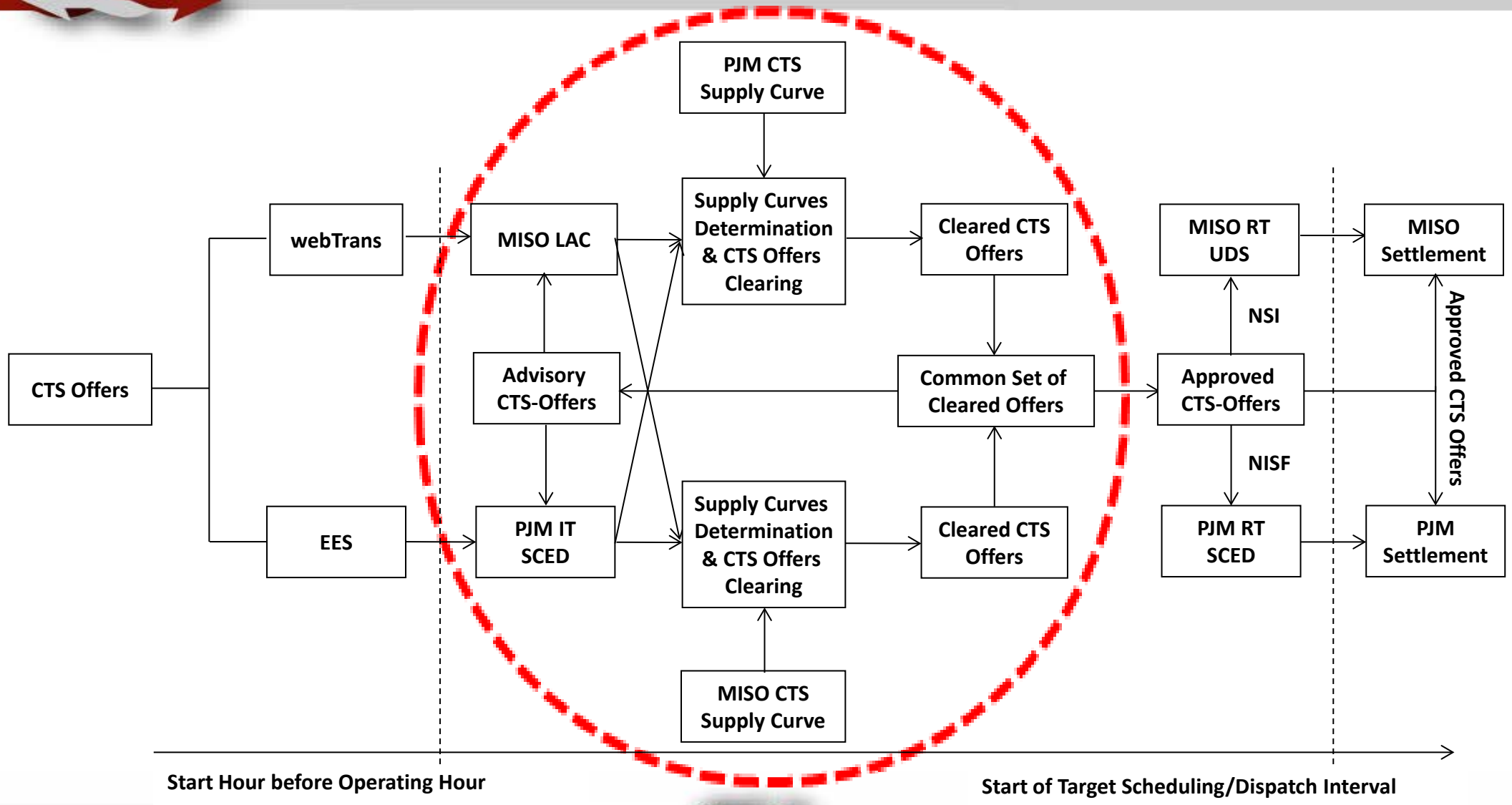
- CTS offers will be scheduled based on the projected price difference between two involving RTOs at the interface
- Both RTOs provide look ahead prices, evaluate their own look ahead MWs and exchange those data
- The most limiting cleared MWs between the involving two RTOs will be communicated to the E-tag
- Approved schedules for target time frame and advisory schedules for future intervals

Clearing Logic with Supply Curve



- CTS offers are stacked based on the flow direction and in the order of price from low to high to make up the transaction price-interchange supply curve
- The transaction interchange supply-price curve will be subtracted from the importing RTO's price-interchange demand curve to generate the new adjusted price-interchange demand curve
- The intersection of the adjusted price-interchange demand and the price-interchange supply curve will set the optimal interchange and determine clearing of DIT offers

MISO/PJM CTS Implementation

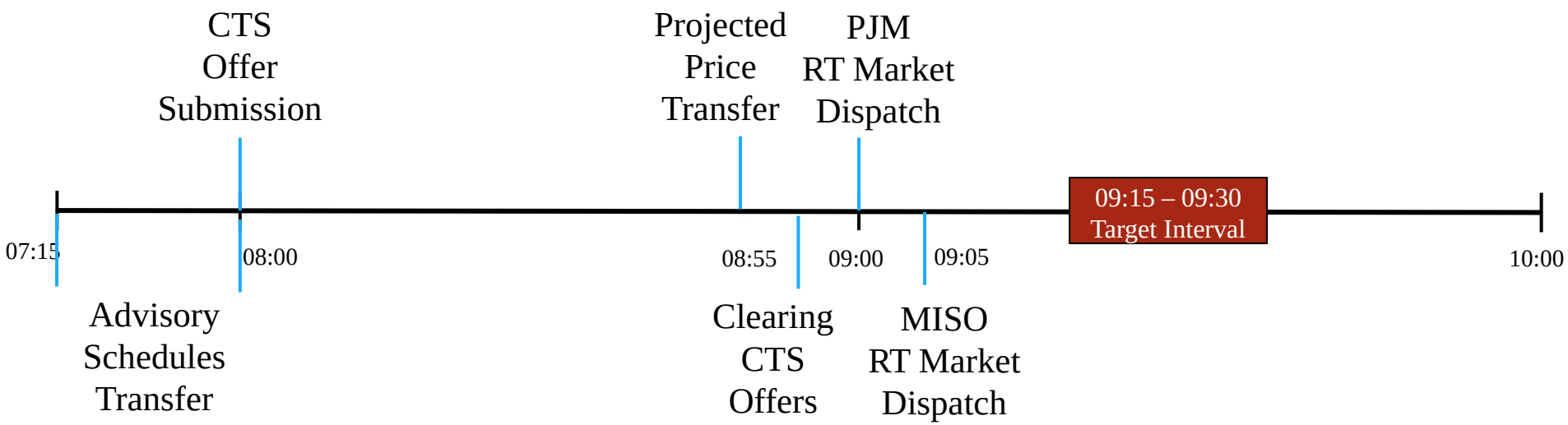


MISO/PJM CTS Potential Timeline

- Assume
  - T: start of the target 15-min transaction scheduling interval
  - OH: Operating hour

TIME	PROPOSED ACTIONS FOR CTS NEXT HOUR MARKET SEGMENT
-	Participants submit/adjust CTS offers
OH – 60	CTS offers submission deadline
T – 25	Cost curve transfer
T – 20	Clearing of CTS Offers
T – 15	PJM RT market dispatch
T – 10	MISO RT Market dispatch
T	CTS schedules start
ATF	PJM/MISO post after-the-fact OASIS transactions
-	Settlement/bill

MISO/PJM CTS Potential Timeline



AGENDA ITEM – 3
TRANSMISSION SERVICE RESERVATION REQUIREMENTS

Transmission Service Requirements

Overview

Both PJM and MISO will require Transmission Service for CTS transactions.

- PJM will require a Confirmed TSR.
- MISO plans to allow the use of pre-reserved Confirmed TSRs.
- MISO is investigating the use of the MISO Spot Market product
- MISO will also allow the post-assignment of TSRs based on the MWs cleared in the CTS process.

Transmission Service Requirements

Tag Examples

Physical Path							
CA	TP	PSE	POR	POD	ched Entitie	Contract	Misc
PJM		PJM	Source: PJMSYSGEN				
	PJM	PJM	PJM	CIN			No
	MISO	MISO	PJM	MISO	MISO		Yes
MISO		MISO	Sink: MISO				No

Current Energy and Transmission Profiles
MW (out of)

	Energy	Transmission
Start Time	05/29/2014 12:00	05/29/2014 12:00
Stop Time	05/29/2014 16:00	05/29/2014 16:00

Date	Start	Stop	Gen	PJM			MISO			Ramp Dur.	
			MW	Trans	276629	MW	Trans	CTS	MW	Start	Stop
5/29	12:00	16:00	300	300	300	300	300	300	300		
Display MWH Total:			1200	1200	1200	1200	1200	1200	1200		

Transmission Allocation

TP	Owner	Product	OASIS
PJM	PJM	7-F	276629
MISO	MISO	2-NH	CTS

Attributes of the PJM transmission will follow normal PJM business practices.

Transmission Service Requirements

MISO TSR

Transmission Allocation			
TP	**Owner**	**Product**	**OASIS**
PJM	PJM	7-F	276629
MISO	MISO	2-NH	CTS

MISO customers may, instead of a reference number from MISO's OASIS, enter a common code that will communicate the transmission profile to the MISO OASIS for TSR creation.

The example "CTS" is used here.

Transmission Service Requirements

MISO TSR

Transmission Allocation			
TP	**Owner**	**Product**	**OASIS**
PJM	PJM	7-F	276629
MISO	MISO	2-NH	CTS

The Owner listed on the MISO TP line where “CTS” is the OASIS reference will be the Customer designated on the post-created MISO TSR.

The Entity listed in this field will be settled for *Transmission* charges for an hourly non-firm Import or Export.

Transmission Service Requirements

MISO TSR

Seller	Asset Owner	Source / Sink	POR / POD	Request Type	Start	Stop	MW Req	MW Grant
MISO		PJM MISO	PJM MISO	ORIGINAL	2014-05-29 12:00 ES	2014-05-29 16:00 ES	300	300

Path: A/MISO/MPDCW-MPDCE//

Service Code	Increment	Class	Type	Period	Window	Subclass
HOURLY NON-FIRM PTP	HOURLY	NON-FIRM	POINT_TO_POINT	FULL_PERIOD	FIXED	

Preconfirmed: No **Competing:** N **Negotiated:** **Nerc Priority:** 2 **Affiliate:** No

Customer: **MISO**

The Entity listed in this field will be settled for *Transmission* charges for an hourly non-firm Import or Export.

Transmission Service Requirements

MISO Asset Owner

Physical Path							
CA	TP	PSE	POR	POD	ched Entitie	Contract	Misc
PJM		PJM	Source: PJMSYSGEN				
	PJM	PJM	PJM	CIN			No
	MISO	MISO	PJM	MISO	MISO		Yes
MISO		MISO	Sink: MISO				No

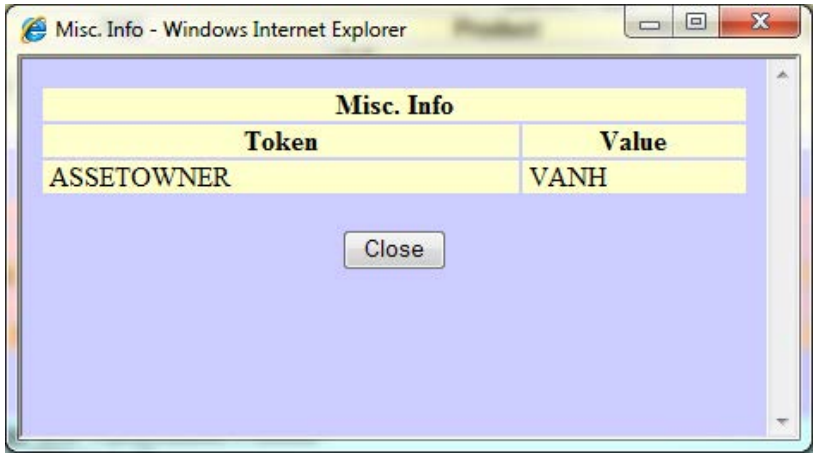
Seller	Asset Owner	Source Sink
MISO		PJM MISO
Path: A/MISO/MPDCW-MPDCE//		
Service Code	Increment	Class
HOURLY NON-FIRM PTP	HOURLY	NON-FIRM
Preconfirmed: No	Competing: N	Negotiat

Under normal circumstances, the Asset Owner settled for MISO Energy charges is taken from the TSR associated with the Energy transaction. With CTS, there will be no TSR to choose that AO.

Transmission Service Requirements

MISO Asset Owner

			Physical Path				
CA	TP	PSE	POR	POD	ched Entitie	Contract	Misc
PJM		PJM	Source: PJMSYSGEN				
	PJM	PJM	PJM	CIN			No
	MISO	MISO	PJM	MISO	MISO		Yes
MISO		MISO	Sink: MISO				No



With CTS, customers will have to enter a Token/Value pairing in order to communicate an Entity with whom to settle the MISO *Energy*.

AGENDA ITEM – 4
SETTLEMENT RULES

PJM Settlement Rules and Credit Requirements

- At a high level, MISO-PJM CTS transactions would be settled in PJM just like any other import/export transactions between PJM and MISO; **normal import/export charges would apply**
  - Consistent with how all other transactions, including the PJM-NYISO CTS transactions, are settled in PJM
  - CTS Transactions will continue to be settled on an hourly basis consistent with the current PJM Energy Market settlements
  - Subject to Balancing Operating charges
  - Not eligible for make-whole payments
  - CTS Credit requirement will be the greater of the 97th percentile historical hourly price for the node or the projected price for the node

MISO Settlement Rules

- At a high level, MISO-PJM CTS transactions would be settled in MISO just like any other import/export transactions between PJM and MISO; **normal import/export charges would apply**
  - MISO Order 764 compliance changed interchange scheduling rules (effective June 30, 2015)
  - Transactions will be settled using five-minute prices, aligned with the 15-minute volumes
  - Assessment of deviation charges for Revenue Sufficiency Guarantee uplift will be further determined
    - Market recommendation of helping deviations after notification deadline is pending and will influence this area
    - Cost causation principals will be applied
  - Not eligible for make-whole payments

MISO Credit Requirements

- MISO will be discussing the credit requirements for MISO-PJM CTS transactions at its next Credit Practices Working Group (CPWG) meeting on July 15, 2014
  - Invoiced and Measured Credit Exposure for transactions will likely be just like any other import/export transactions between PJM and MISO
  - Initial possibilities for Estimated Credit Exposure include:
    - The use of a rolling average based on prior settlements (similar to DA and RT transactions currently)
    - The use a proxy price similar to Virtual Transactions Estimated Exposure
    - Evaluating bids/offers at the point of submission
    - Other suggestions from Stakeholders

AGENDA ITEM – 5
MISO EXTENDED LOCATIONAL MARGINAL PRICE

Reasons for Developing Extended LMP

Issues:

Improve Price Signals

- Better approximation of market clearing prices was needed.
- Market clearing prices are generally prices that consumers are willing to pay and producers are willing to be paid.
- Startup cost and no-load costs were not reflected in LMP

Prices Should Not Reflect Transitory Shortages

- Ancillary services clearing might be inadequate or transmission constraint might be violated briefly in dispatch engine.
- Not necessarily representative of true operational scarcity.
- In either of these cases, prices would likely be set with a very demand curve price.

Reasons for Developing Extended LMP

Solution:

Extended LMP Logic

- Allows Online Fast-start units to be dispatched below their minimum limits and the set price in all intervals.
- Allows Offline Fast-start units to be dispatched in intervals with reserve or transmission scarcity.
- This Fast-start unit dispatch is *only used in the ELMP engine* – not the dispatch engine.
- Reflects startup and noload cost of Fast Start units in price
- Reflects Emergency Demand Response cost in price

Expected ELMP Results

Prices reflect costs appropriate to the situation

- On-line Fast start units operating at a limit
- Off-line fast-start resources that help during transient shortages or transmission constraints
- When such actions are not needed, LMP and ELMP are very close.

Status	Comparison of ELMP and LMP
When online fast-start resource is committed to meet requirements	Can be different and expect ELMP > LMP
When in transitory scarcity or Transmission Constraint Violation	Can be different and expect ELMP < LMP
Most Conditions	ELMP and LMP very close

Observations from Parallel Operations

Real-time LMP and ELMP 5-min MEC data comparison for 05/01/2014 – 05/10/2014

Status	Comparison of ELMP and LMP	Total # of Intervals	2880	% of Intervals	Average ELMP MEC Increase
When CT is Committed to Meet Requirements	Can be different and expect ELMP > LMP	# of Intervals ELMP > LMP	139	4.8%	$1.36
When in Transitory Scarcity or Transmission Constraint Violation	Can be different and expect ELMP < LMP	# of Intervals ELMP < LMP	26	0.9%	-$122.30
Most Conditions	ELMP and LMP very close	# of Intervals ELMP = LMP	2715	94.3%	$0.00

Observations from Parallel Operations

Price impacts of fast-start units were consistent with design during 5/1-5/10

- ✓ 1391 market units, and about 60 units qualified as fast start units.
- ✓ No energy/reserve scarcity or constraint violation: Consideration of online fast-start units raised ELMP.
- ✓ Energy/reserve scarcity: Consideration of both Online and Offline fast-start units generally mitigated the price spike and lowered ELMP.
- ✓ Transmission constraint violation: Consideration of both Online and Offline fast-start units reduced use of constraint demand curve, lowering ELMP.

MEC: marginal energy component

Associated Unit Dispatch Case Solution	# of RT 5 min ELMP Cases	ELMP MEC Increase ($/MW)			Cleared Energy MW			
					Online Fast-start		Offline Fast-start	
		Average	Maximum	Minimum	Average	Maximum	Average	Maximum
w/o scarcity or Violation	1359	$0.09	$6.60	-$0.14	77.4	254.7	0.0	0.0
Energy/Reserve scarcity	6	-$397.61	-$31.40	-$1,035.57	156.8	292.5	274.6	482.5
Transmission Constraint Violation Only	1515	-$0.27	$6.70	-$166.65	18.0	826.6	1.2	315.6

Improvement of Price Signal

- ✓ DA/RT price convergence has been improved. DA/RT average absolute MEC deviation decreased from $11.09/MWh to $9.97/MWh.
- ✓ The price volatility has been reduced. The standard deviation of MEC decreased from $34.72/MWh to $25.58/MWh.
- ✓ The average MEC of ELMP is approximately $1.00/MWh lower than that of LMP.
  - o ELMP helped to alleviate reserve scarcity price with off-line resources eligible to set price

RT/DA pricing comparison for 05/01/2014 – 05/10/2014

Unit: $/MWh	Operation Period			05/01/2014 ----05/10/2014	
Pricing Type	Average MEC			Average Absolute MEC Deviation between DA and RT	Standard Deviation of MEC in All Intervals
	All Intervals	On-Peak Intervals	Off-Peak Intervals		
RT-ELMP	$36.65	$43.74	$30.45	$9.97	$25.58
RT-LMP	$37.67	$45.87	$30.50	$11.09	$34.72
ELMP Increase	-$1.02	-$2.13	-$0.05	-$1.12	-$9.14

CTS Bid Clearing and Pricing

ELMP Engine – 10 minute horizon

- Used for *CTS Bid Pricing*
- Solution reflects commitment/re-dispatch of fast-start units
  - Re-dispatch of online fast-start below ecomin in all hours
  - Commitment/dispatch of offline fast-start in hours with reserve scarcity or transmission constraint violation
  - Cleared CTS bids would be modeled just like other fixed physical schedule in UDS and ELMP
  - ELMP is very close to Dispatch Engine prices, but slightly less volatile

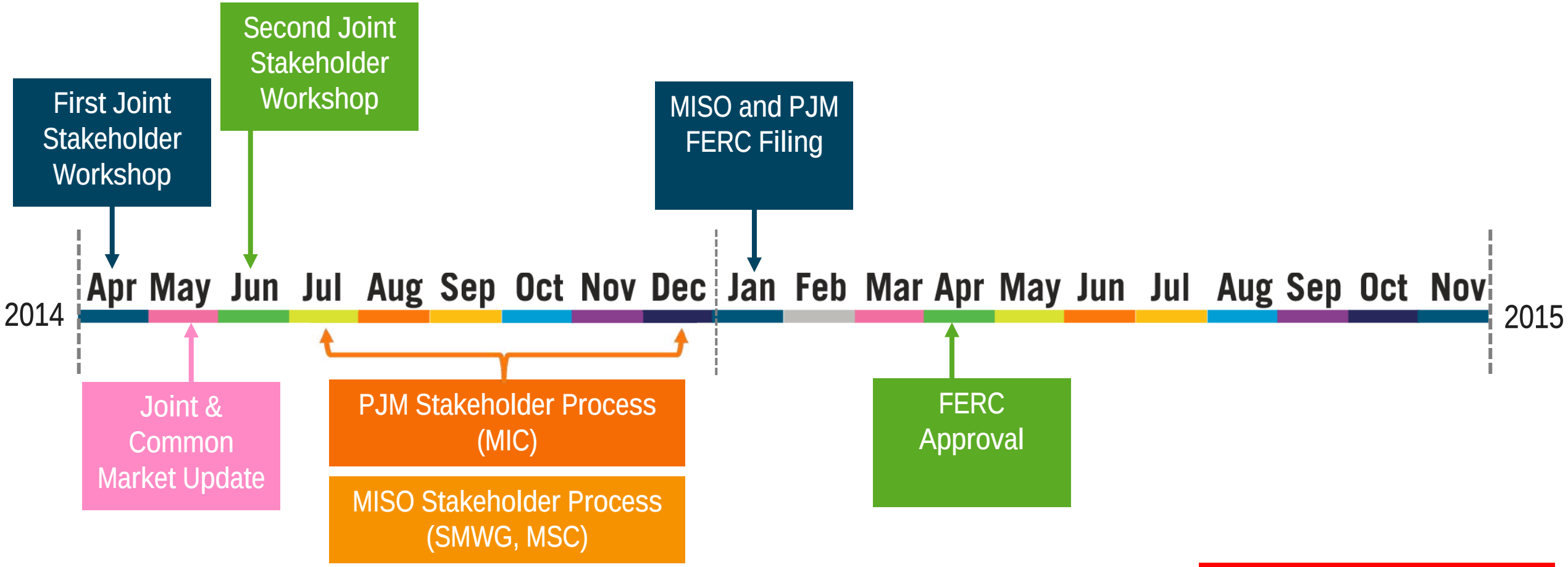
CTS Bid Clearing and Pricing

LAC Engine – 30 minute horizon for binding CTS bid

- LAC solution LMP used for *CTS Bid Clearing*
- Solution reflects *advisory* unit commitment
  - Final unit commitment decision made by operator, not LAC
- Assumes units follow dispatch signals perfectly

AGENDA ITEM – 6
TIMELINE AND NEXT STEPS

Timeline


First Joint Stakeholder Workshop
Second Joint Stakeholder Workshop
MISO and PJM FERC Filing
2014
Apr May Jun Jul Aug Sep Oct Nov Dec
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov
2015
Joint & Common Market Update
PJM Stakeholder Process (MIC)
MISO Stakeholder Process (SMWG, MSC)
FERC Approval
2016 Implementation

Questions

JCM - Interchange Optimization
PJM: Rebecca Carroll (rebecca.carroll@pjm.com)
MISO: Dhiman Chatterjee (dchatterjee@misoenergy.org)