

PJM MISO Joint Common Market Initiative Meeting

Modeling Interface between PJM and MISO

May 27, 2015

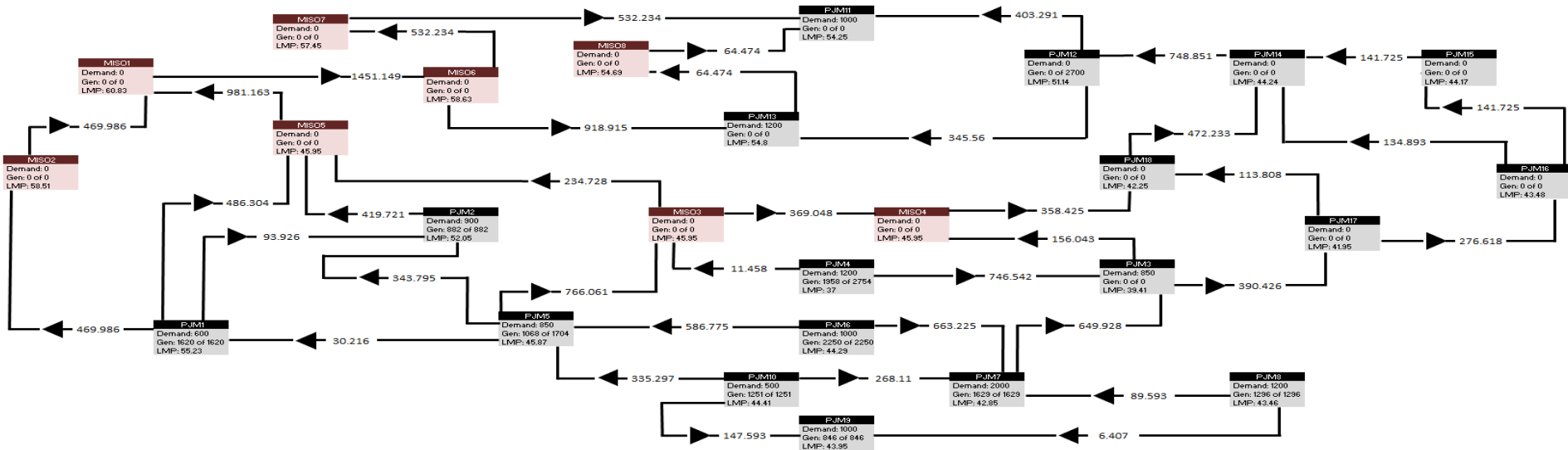


Monitoring Analytics

Model

- **Two RTO network model**
- **PJM's network comprises 18 buses and MISO's network comprises 8 buses**
- **Overlapping regions: flow on the tie lines are affected by both PJM's and MISO's actions**
- **Allows for applying shadow price convergence logic**

Model



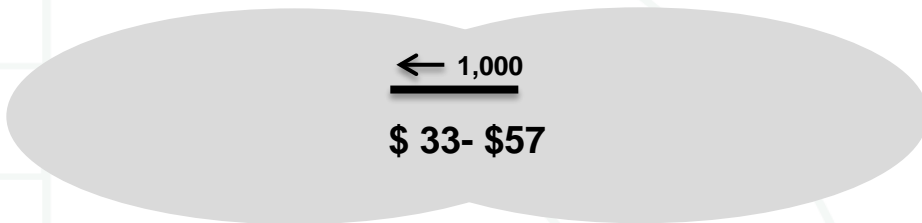
Model

- **Step 1 (MISO)**
 - **MISO is the monitoring RTO**
 - **Solve the dispatch model**
 - **Compare State Estimator (SE) flow against Model flow**
- **Step 2 (MISO)**
 - **If SE flow exceeds the Model flow, MISO redispatches its generators to reduce the flow**
 - **Compute shadow price**
 - **Pass the shadow price and flow limit to PJM**
- **Step 3 (PJM)**
 - **Solve the dispatch model using MISO's shadow price and flow limit**

Example (Step 1)

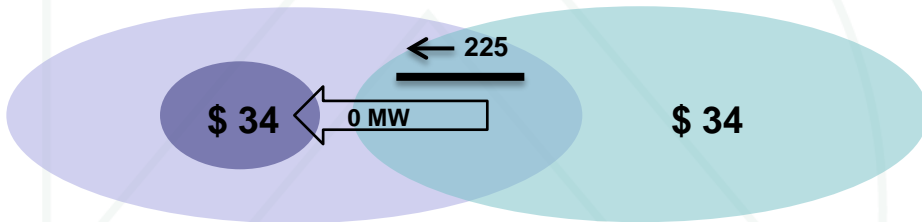
Joint Optimization

Load (MW)	18,050
Gen (MW)	18,050
Interchange (MW)	N/A
Total system cost	\$471,392
Marginal Generators	MISO2 & PJM8



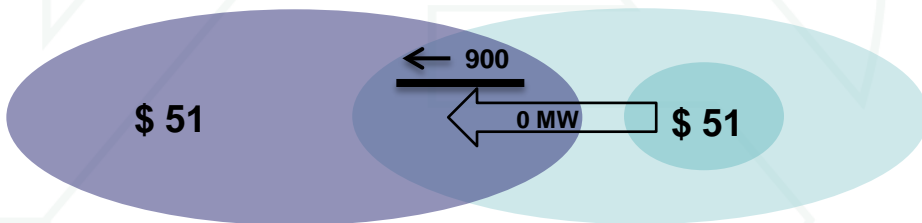
PJM's World

Load (MW)	12,500
Gen (MW)	12,500
Interchange (MW)	0
Marginal Generator	PJM4



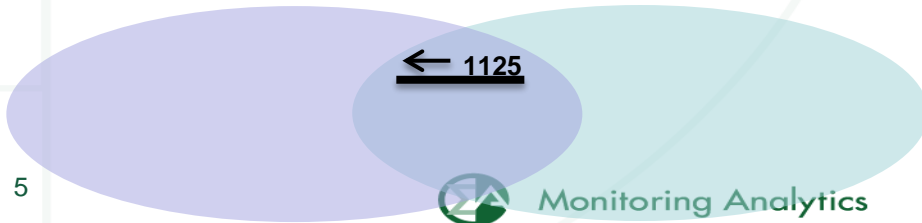
MISO's World

Load (MW)	5,550
Gen (MW)	5,550
Interchange (MW)	0
Marginal Generator	MISO3



Reality

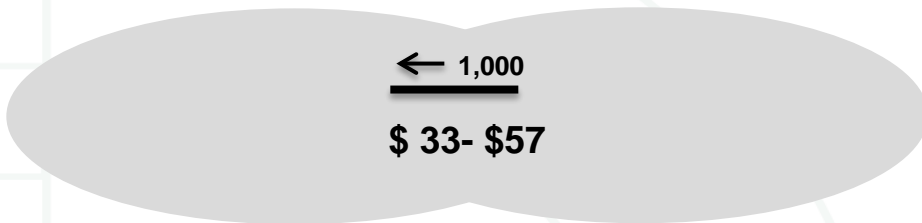
Load (MW)	18,050
Gen (MW)	18,050
Interchange (MW)	N/A
Marginal Generator	N/A



Example (Step 2)

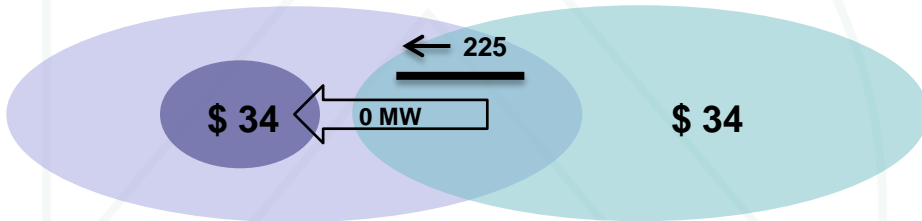
Joint Optimization

Load (MW)	18,050
Gen (MW)	18,050
Interchange (MW)	N/A
Total system cost	\$471,392
Marginal Generators	MISO2 & PJM8



PJM's World

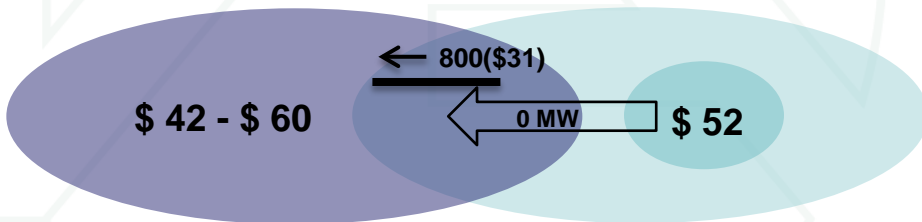
Load (MW)	12,500
Gen (MW)	12,500
Interchange (MW)	0
Marginal Generator	PJM4



MISO's World

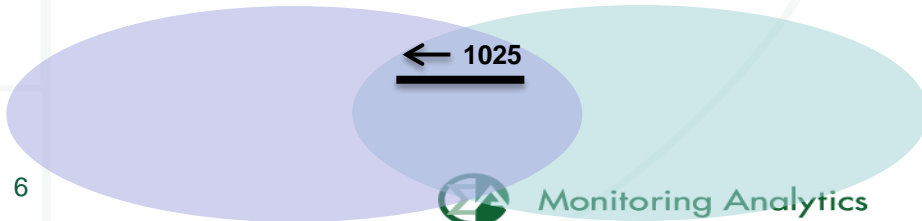
MISO passes shadow price and flow limit to PJM

Load (MW)	5,550
Gen (MW)	5,550
Interchange (MW)	0
Total system cost	\$187,230
Marginal Generator	MISO3 & MISO5



Reality

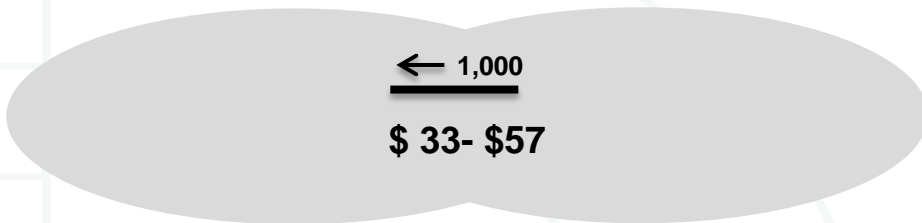
Load (MW)	18,050
Gen (MW)	18,050
Interchange (MW)	N/A
Marginal Generator	N/A



Example (Step 3)

Joint Optimization

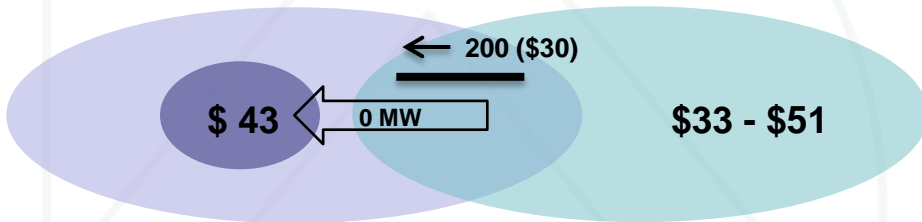
Load (MW)	18,050
Gen (MW)	18,050
Interchange (MW)	N/A
Total system cost	\$471,392
Marginal Generators	MISO2 & PJM8



PJM's World

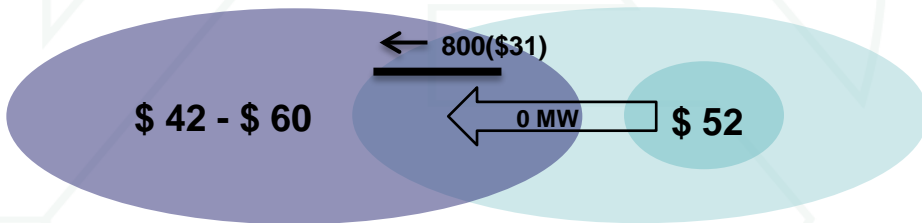
Load (MW)	12,500
Gen (MW)	12,500
Interchange (MW)	0
Total system cost	287,410
Marginal Generator	PJM5 & PJM12

PJM uses MISO's shadow price and flow limit



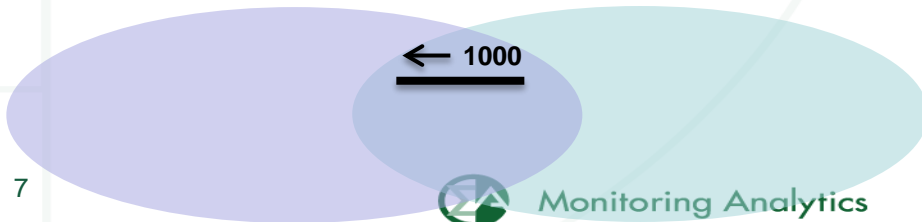
MISO's World

Load (MW)	5,550
Gen (MW)	5,550
Interchange (MW)	0
Total system cost	\$187,230
Marginal Generator	MISO3 & MISO5



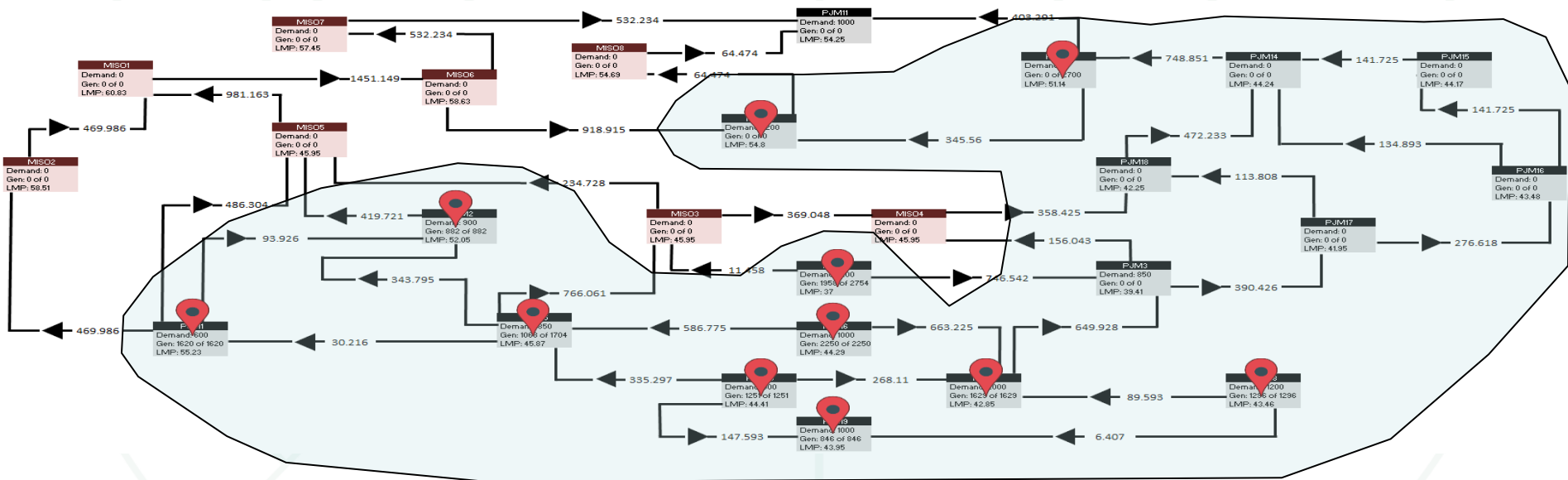
Reality

Load (MW)	18,050
Gen (MW)	18,050
Interchange (MW)	N/A
Marginal Generator	N/A



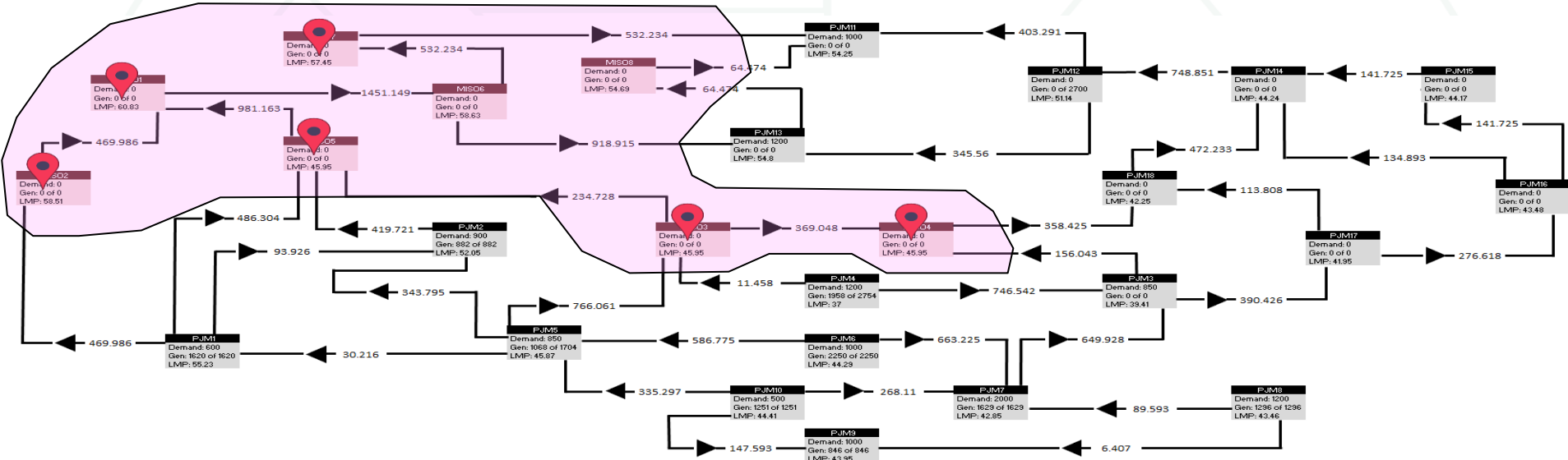
MISO/Patton Proposed Interface Definition

MISO's PJM Price



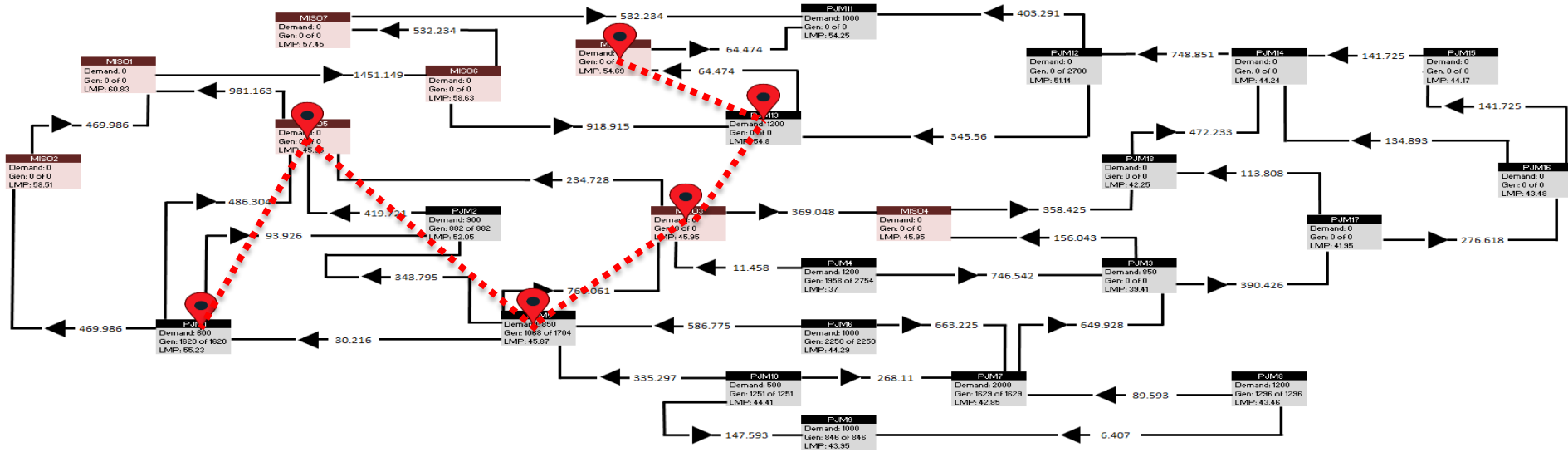
MISO/Patton Proposed Interface Definition

PJM's MISO Price



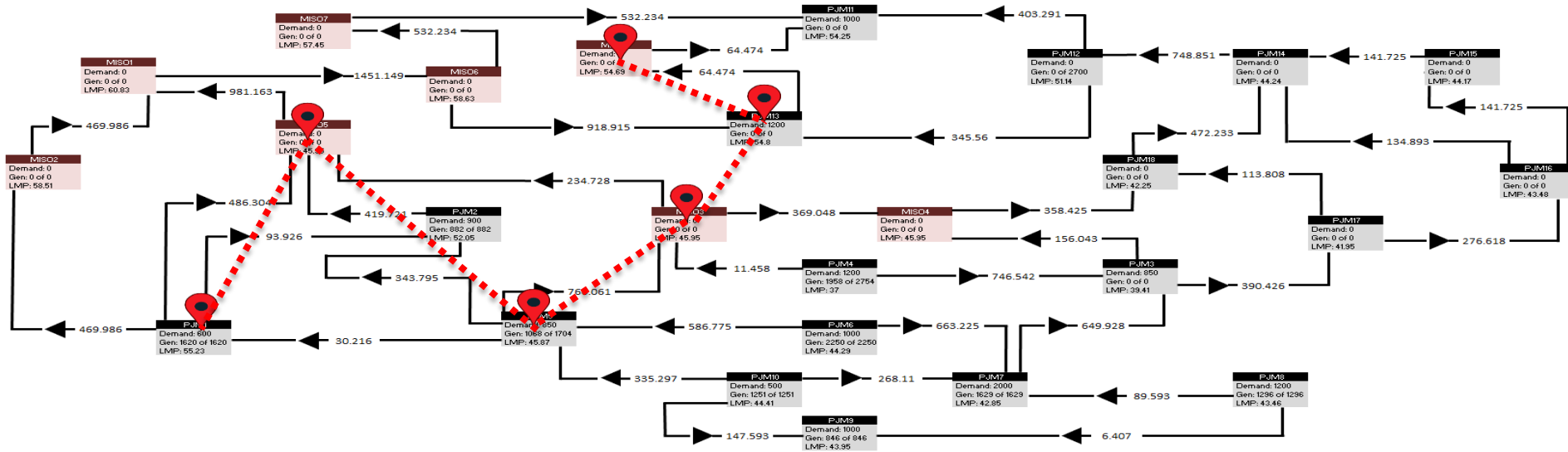
PJM Proposed Interface Definition

PJM's MISO Price



PJM Proposed Interface Definition

MISO's PJM Price



Results

Joint Optimization	Binding at 1000 MW
LMP	\$33 - \$57
Shadow Price	\$41.69
Load (MW)	18,050
Gen (MW)	18,050
Transaction (MW)	N/A
Cost of Generation	\$471,392
Marginal Generator(s)	MISO2 & PJM8
Flow on MISO5-MISO3	1000

One M2M Constraint (MRTO: MISO) Shadow Price Converges	Solution with Binding M2M Constraint with Shadow-Price Convergence - No transactions		Solution with Binding M2M Constraint with Shadow-Price Non Convergence - 300 MW PJM-MISO transaction		
	Patton's Design (all generator buses)	PJM Design (buses at the seams)	Patton's Design (zero out dfax) (all generator buses)	Patton's Design (zero out CLMP) (all generator buses)	PJM Design (buses at the seams)
Price difference prior to scheduling transaction	\$9.45	\$9.11			
Transaction Settlement					
Difference in Prices Post Transaction			\$5.72	\$5.03	\$3.54
Gross Profit to Market			\$1,716.00	\$1,509.00	\$1,062.00
PJM+MISO Generation Costs	\$474,640		\$472,399	\$472,887	\$471,761
Total Cost	\$474,640		\$474,115	\$474,396	\$472,823

Appendix

One M2M Constraint (MRTO: MISO) Shadow Price Converges	Solution with Binding M2M Constraint with Shadow-Price Convergence - No transactions		Solution with Binding M2M Constraint with Shadow-Price Non Convergence - 300 MW PJM-MISO transaction		
	Patton's Design (all generator buses)	PJM Design (buses at the seams)	Patton's Design (zero out dfax) (all generator buses)	Patton's Design (zero out CLMP) (all generator buses)	PJM Design (buses at the seams)
MISO Model	Binding at 800 MW		Binding at 800 MW		
LMP	\$42 - \$60		\$37 - \$61		\$37 - \$59
Shadow Price (Passed to PJM)	\$31.28		\$41.77		\$37.58
Load (MW)	5,550		5,550		
Gen (MW)	5,550		5,250		
Transaction (MW)	0		300		
Cost of Generation	\$187,230		\$172,899		\$171,846
Marginal Generator(s)	MISO1 & MISO3		MISO1 & MISO3		
Flow on MISO5-MISO3	800		800		
MISO's PJM Price	\$48.97	\$51.88	\$46.27		\$48.85
Energy Component	\$54.92	\$54.92	\$54.23		\$52.51
Congestion Component	(\$5.96)	(\$3.04)	(\$7.95)		(\$3.66)
PJM Model	Violation penalty beyond 200 MW		Violation penalty beyond 200 MW		
LMP	\$34 - \$47	\$33 - \$51	\$37 - \$45	\$33 - \$56	\$34 - \$55
Shadow Price	\$30.57		\$19.49	\$41.77	\$37.58
Load (MW)	12,500		12,500		
Gen (MW)	12,500		12,800		
Transaction (MW)	0		300		
Cost of Generation	\$287,410		\$299,500	\$299,988	\$299,915
Marginal Generator(s)	PJM5 & PJM12		PJM4 & PJM12	PJM12	PJM8
Flow on MISO5-MISO3	200		200	214.62	211
PJM's MISO Price	\$39.52	\$42.77	\$40.55	\$41.24	\$45.31
Energy Component	\$39.52		\$40.55	\$41.24	\$41.32
Congestion Component	\$0.00	\$3.25	\$0.00	\$5.16	\$3.99



Monitoring Analytics, LLC
2621 Van Buren Avenue
Suite 160
Eagleville, PA
19403
(610) 271-8050
MA@monitoringanalytics.com
www.MonitoringAnalytics.com

