Summary of 2018 MISO State of the Market Report

Presented to:

MISO Board Markets Committee

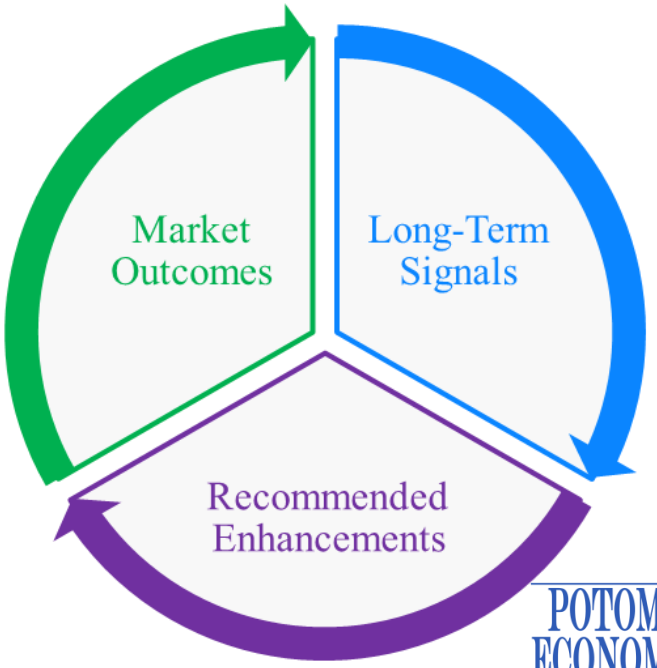
David B. Patton, Ph.D.
MISO Independent Market Monitor

June 26, 2019

POTOMAC ECONOMICS

Introduction

- As the Independent Market Monitor (IMM) for the Midcontinent ISO (MISO), we:
  - ✓ Evaluate the competitive performance and operation of the MISO markets; and
  - ✓ Identify and recommend changes to existing and proposed market rules and operating procedures.
- This presentation summarizes:
  - ✓ Market highlights from 2018;
  - ✓ The competitive performance and operational efficiency of the markets;
  - ✓ Long-term economic signals; and
  - ✓ Recommendations.



2018 Market Summary

- The MISO markets performed competitively.
  - ✓ The "price-cost mark-up" was close to zero – offers were highly competitive.
  - ✓ The "output gap" measure of potential economic withholding remained low at 0.1 percent of load, and market power mitigation was rare.
- Energy prices increased by 8 percent over 2017, primarily due to higher fuel prices and higher average load.
- Despite higher fuel and energy prices, congestion fell 7 percent to $1.4 billion due to transmission investments and improvements in market-to-market coordination.
- Design issues caused the capacity prices to remain inefficiently low.
  - ✓ Clearing prices in the Planning Resource Auction (PRA) remained close to zero market-wide in the 2018/2019 and 2019/2020 planning years.
  - ✓ This will become a greater concern as capacity margins fall.

Key Market Developments in 2018

- MISO implemented several market design changes that improved efficiency and competitiveness in 2018:
  - ✓ On January 4, FERC granted MISO the authority to define Dynamic Narrowly Constrained Areas (DNCAs) consistent with our 2012-9 Recommendation.
  - ✓ On July 1, MISO implemented five-minute real-time settlements consistent with our Recommendation 2012-2.
  - ✓ On August 23, FERC granted RSG mitigation authority for resources committed in the South for the Regional Directional Transfer (RDT) constraint and granted MISO authority to apply the Reserve Procurement Enhancement (RPE) on the RDT.
  - ✓ In October, MISO filed to reform Uninstructed Deviation and Price Volatility Make-Whole Payments, which FERC approved in January 2019 and MISO implemented on May 1, 2019.
  - ✓ In December, MISO filed LMR-related Tariff changes as part of the Resource Availability and Need (RAN). FERC approved these changes in 2019.

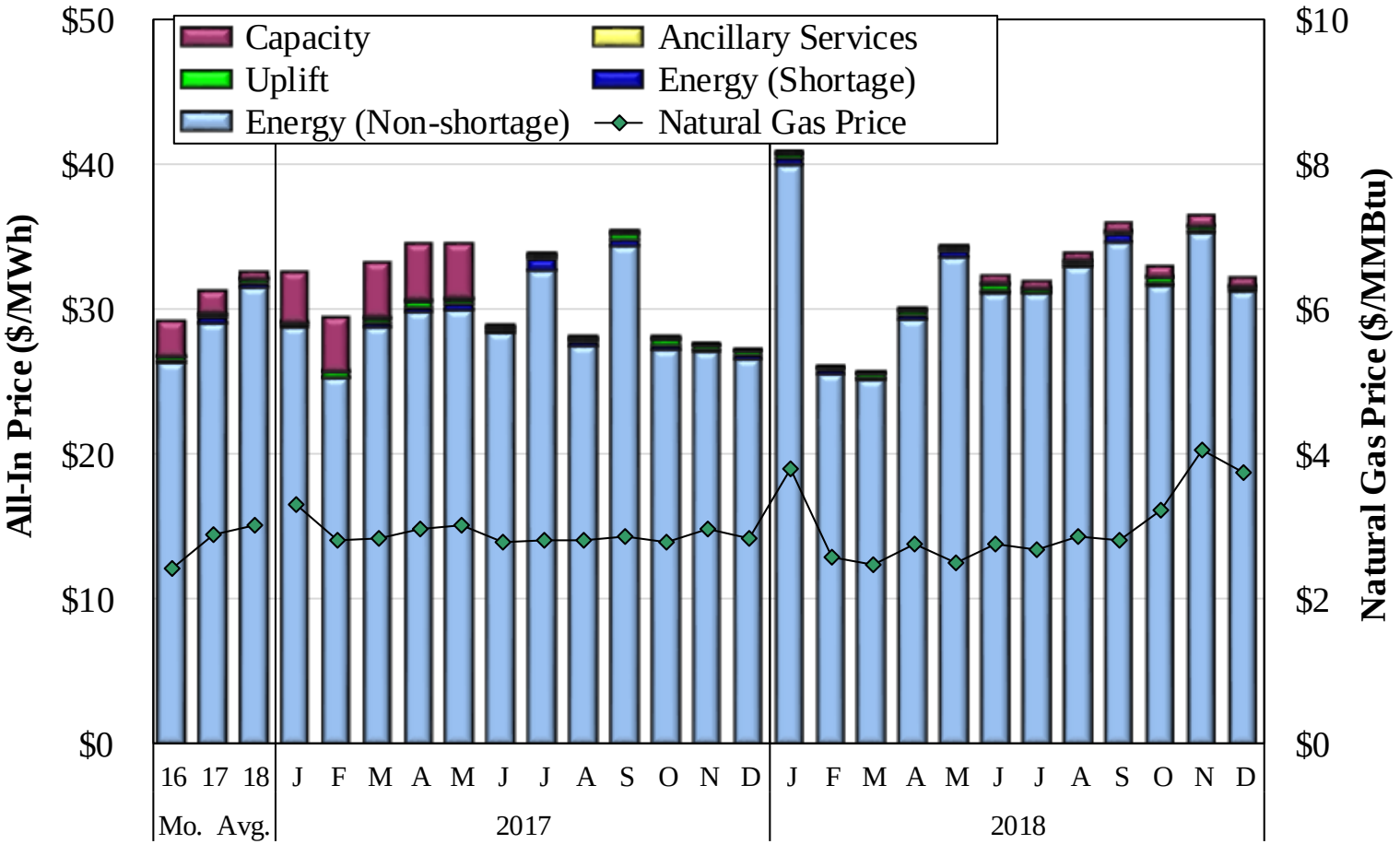
Highlights of Market Outcomes in 2018

POTOMAC ECONOMICS

Market Highlights: Load and Prices

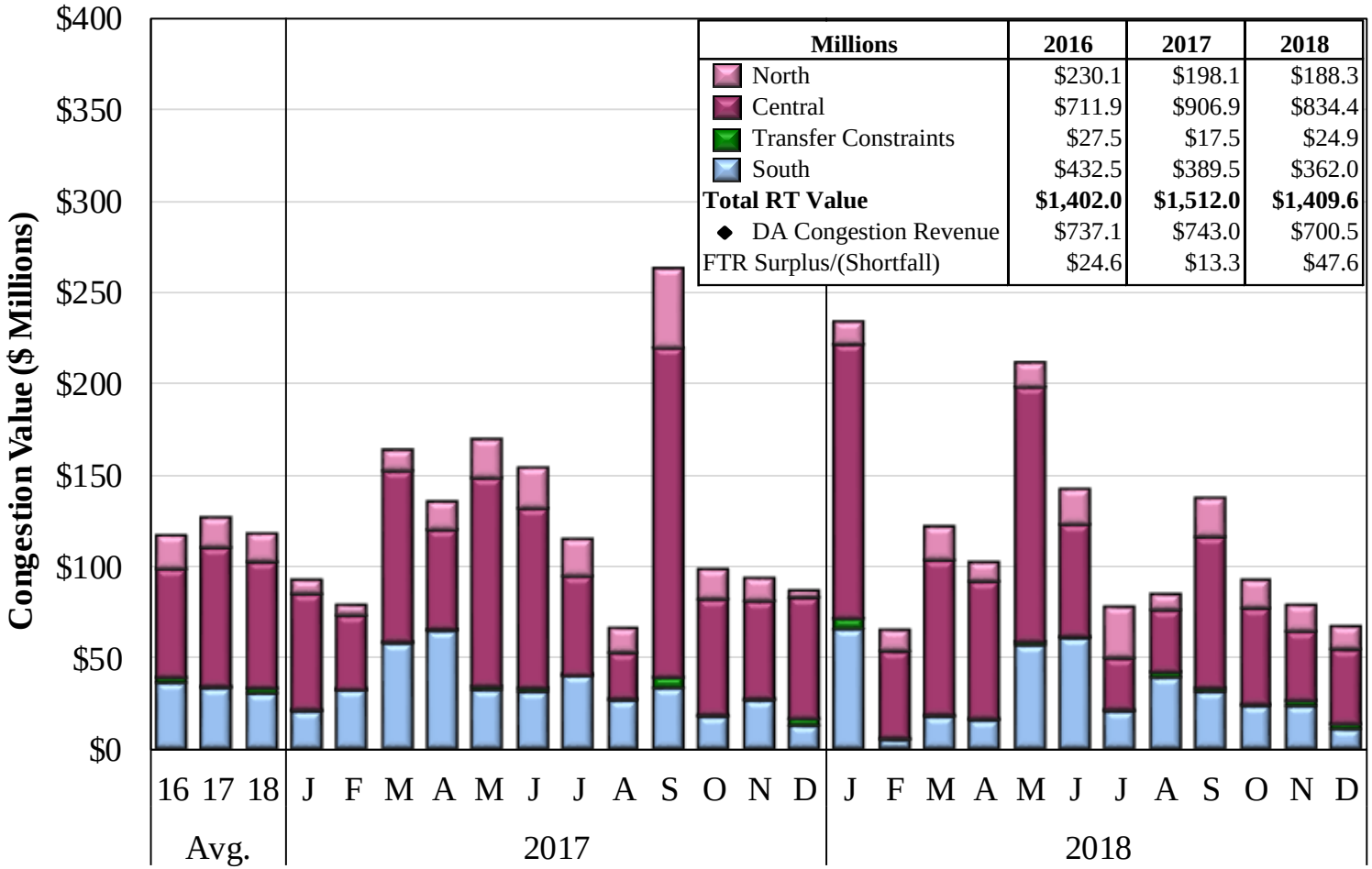
- The all-in price increased by 4 percent to average $32.57 per MWh.
  - ✓ Higher energy prices, driven by higher average load and increases in fuel prices were contributing factors.
- We exclude the effects of fuel price changes by calculating a fuel-adjusted system marginal price (SMP), which increased by just three percent.
  - ✓ We expect the fuel-adjusted SMP to be relatively flat since most price changes in a competitive electricity market are driven by fuel cost changes.
- Average degree days increased by 21 percent overall in 2018, as temperature and weather patterns returned from the mild conditions of 2017 and exceeded historical seasonal trends.
  - ✓ MISO's annual peak load of 121.6 GW occurred on June 29, almost a month earlier than peak load in prior years and below the forecast peak of 124.7 GW.
- Higher fuel prices and a new reliability requirement established in the Summer in MISO South led to higher real-time RSG costs in 2018.
  - ✓ When adjusted for fuel price changes, real-time RSG increased by just 10 percent.

All-In Price



POTOMAC ECONOMICS

Real-Time Value of Congestion in MISO

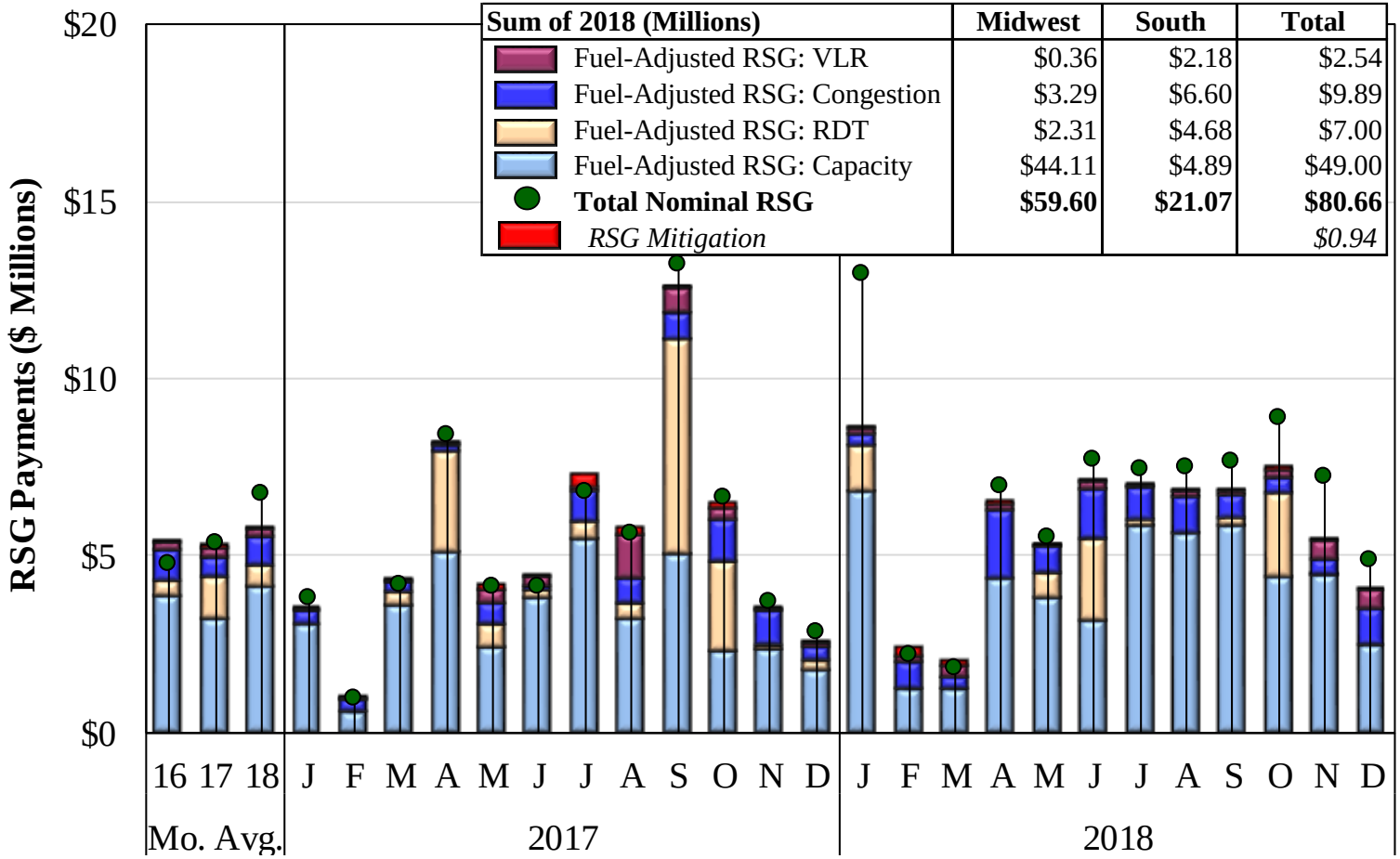


Millions	2016	2017	2018
North	$230.1	$198.1	$188.3
Central	$711.9	$906.9	$834.4
Transfer Constraints	$27.5	$17.5	$24.9
South	$432.5	$389.5	$362.0
Total RT Value	**$1,402.0**	**$1,512.0**	**$1,409.6**
◆ DA Congestion Revenue	$737.1	$743.0	$700.5
FTR Surplus/(Shortfall)	$24.6	$13.3	$47.6

POTOMAC ECONOMICS

Real-Time RSG Payments 2017-2018

Sum of 2018 (Millions)	Midwest	South	Total
Fuel-Adjusted RSG: VLR	$0.36	$2.18	$2.54
Fuel-Adjusted RSG: Congestion	$3.29	$6.60	$9.89
Fuel-Adjusted RSG: RDT	$2.31	$4.68	$7.00
Fuel-Adjusted RSG: Capacity	$44.11	$4.89	$49.00
Total Nominal RSG	**$59.60**	**$21.07**	**$80.66**
RSG Mitigation			*$0.94*



POTOMAC ECONOMICS

Generation by Fuel Type

- Total unforced capacity (installed capacity adjusted for forced outages) fell roughly 2 GW in 2018 as coal resources continued to retire, offset only partially be continued entry of wind resources.
- Energy output shares reflected relative costs:
  - ✓ The lowest marginal cost resources (coal and nuclear) operated at the highest capacity factors and coal continued to produce the greatest share of energy.
  - ✓ Natural gas units' share of output grew in 2018 to 27 percent, but remained well below its share of capacity (43 percent) because a large portion of the gas-fired resources are peaking units that rarely run.
- Flexible resources set prices in the largest share of hours:
  - ✓ Coal resources set system-wide prices in 46 percent of hours, down from 55 percent in 2017.
  - ✓ Although gas units produce a modest share of the energy, they set the system-wide price in more than half of all intervals, including in almost all peak hours.
  - ✓ In addition, congestion caused flexible gas-fired units to set prices in local areas in 87 percent of intervals.
  - ✓ Wind units that load constraints set local prices in almost one third of intervals.

Generation by Fuel Type

	Unforced Capacity				Energy Output		Price Setting			
	Total (MW)		Share (%)		Share (%)		SMP (%)		LMP (%)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Nuclear	12,420	12,225	10%	10%	16%	16%	0%	0%	0%	0%
Coal	50,843	48,775	39%	38%	47%	46%	55%	46%	84%	78%
Natural Gas	55,794	55,240	43%	43%	23%	27%	44%	53%	85%	87%
Oil	1,904	1,691	1%	1%	0%	0%	0%	0%	0%	0%
Hydro	3,929	3,966	3%	3%	1%	1%	0%	1%	1%	1%
Wind	2,610	3,005	2%	2%	8%	8%	0%	0%	30%	31%
Other	2,273	2,678	2%	2%	4%	2%	0%	0%	4%	2%
Total	**129,773**	**127,580**								

POTOMAC ECONOMICS

Emergency Events in MISO

- MISO has experienced a sharp increase in the frequency of generation emergencies partly due to changes in reserve margins and resource mix.
- MISO declared three emergencies in regions or local areas throughout the footprint in 2018, and two emergencies on consecutive days in early 2019.
  - January 17–18, 2018: emergency conditions in MISO South in the morning due to cold temperatures and forced outages.
  - September 8, 2018: MISO did not declare an emergency in the South despite being short of capacity to withstand the largest contingency.
  - September 15, 2018: Similar condition to the prior week and MISO did declare an emergency in MISO South.
  - January 30 – 31, 2019 emergency conditions in the Central and North Regions due to extremely cold temperatures and high uncertainty.
- These reginal emergencies are relatively new, having not occurred before 2016.
- We find that MISO's emergency declarations and actions were inconsistent from event to event, and recommend MISO clarify its procedures and improve its logging related to regional emergency declarations and actions.

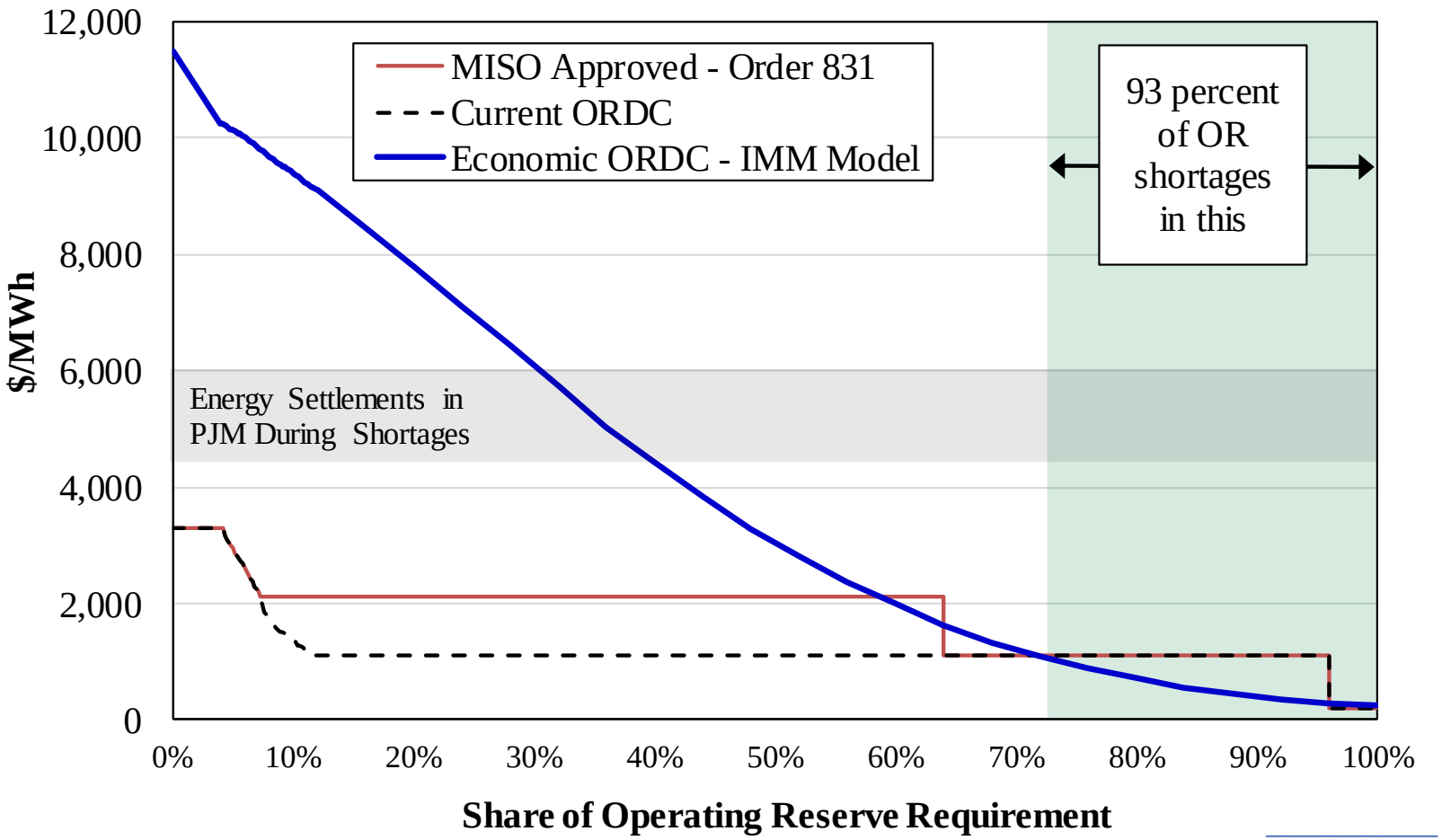
Real-Time Pricing Evaluations

POTOMAC ECONOMICS

Improving Real-Time Price Formation in MISO: Shortage Pricing

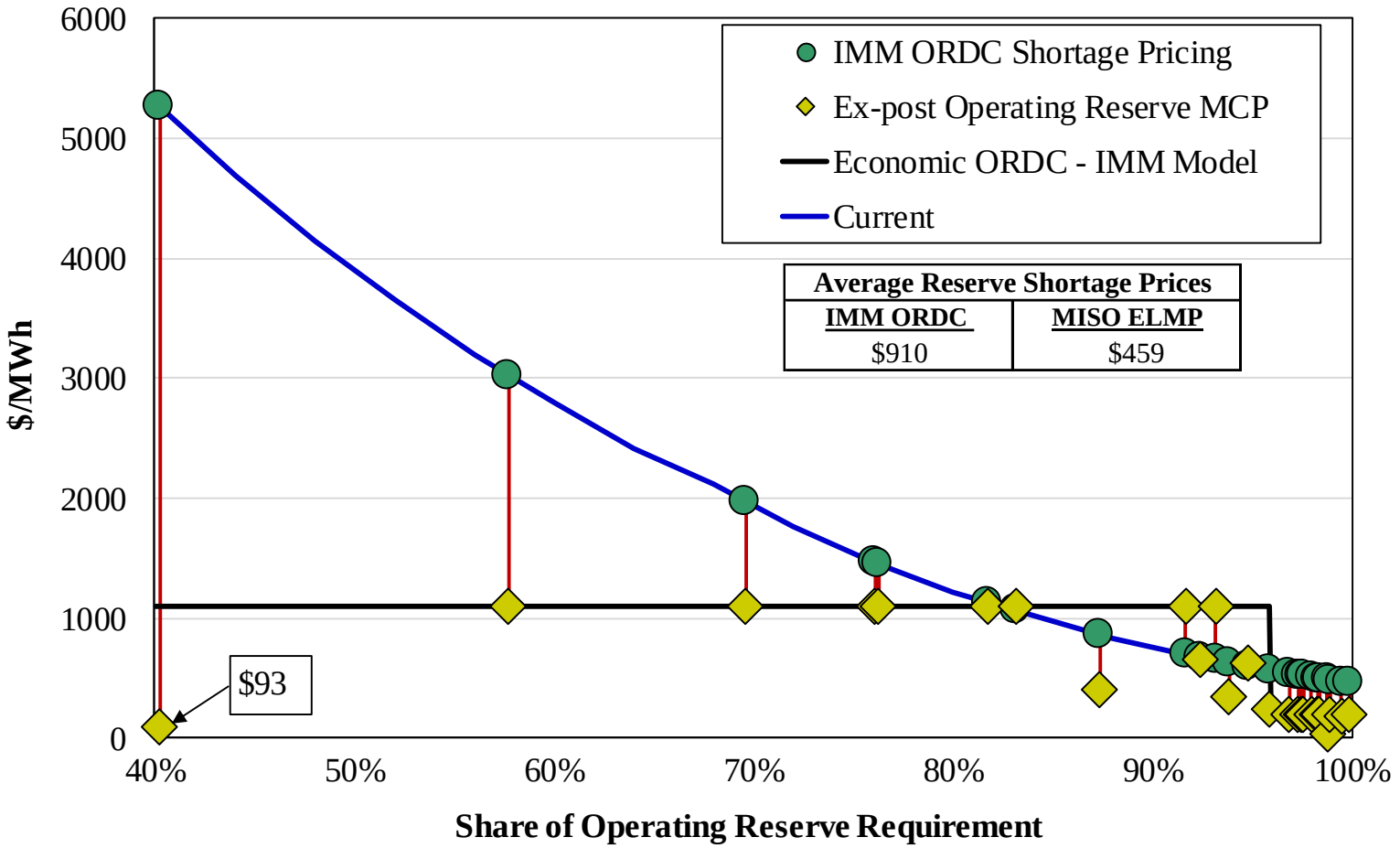
- Shortage pricing provides critical economic signals to suppliers to be available and flexible, to perform well, and accommodate long-term changes:
  - ✓ Expansion of renewable resources,
  - ✓ Greater reliance on demand response, and
  - ✓ Lower capacity margins.
- Efficient shortage pricing is produced by Operating Reserve Demand Curves (ORDC) that are based on the value of electricity to customers: the expected value of lost load (VOLL).
  - ✓ ORDCs should set prices when MISO is short of reserves.
  - ✓ The current ORDC is not optimal, so we recommend that MISO develop ORDCs based on the probability of losing load at different reserve levels.
  - ✓ We have also recommended that MISO disable offline pricing in ELMP that causes it not to price real shortages of reserves and transmission.

MISO's Operating Reserve Demand Curve



POTOMAC ECONOMICS

Shortage Pricing in 2018



POTOMAC ECONOMICS

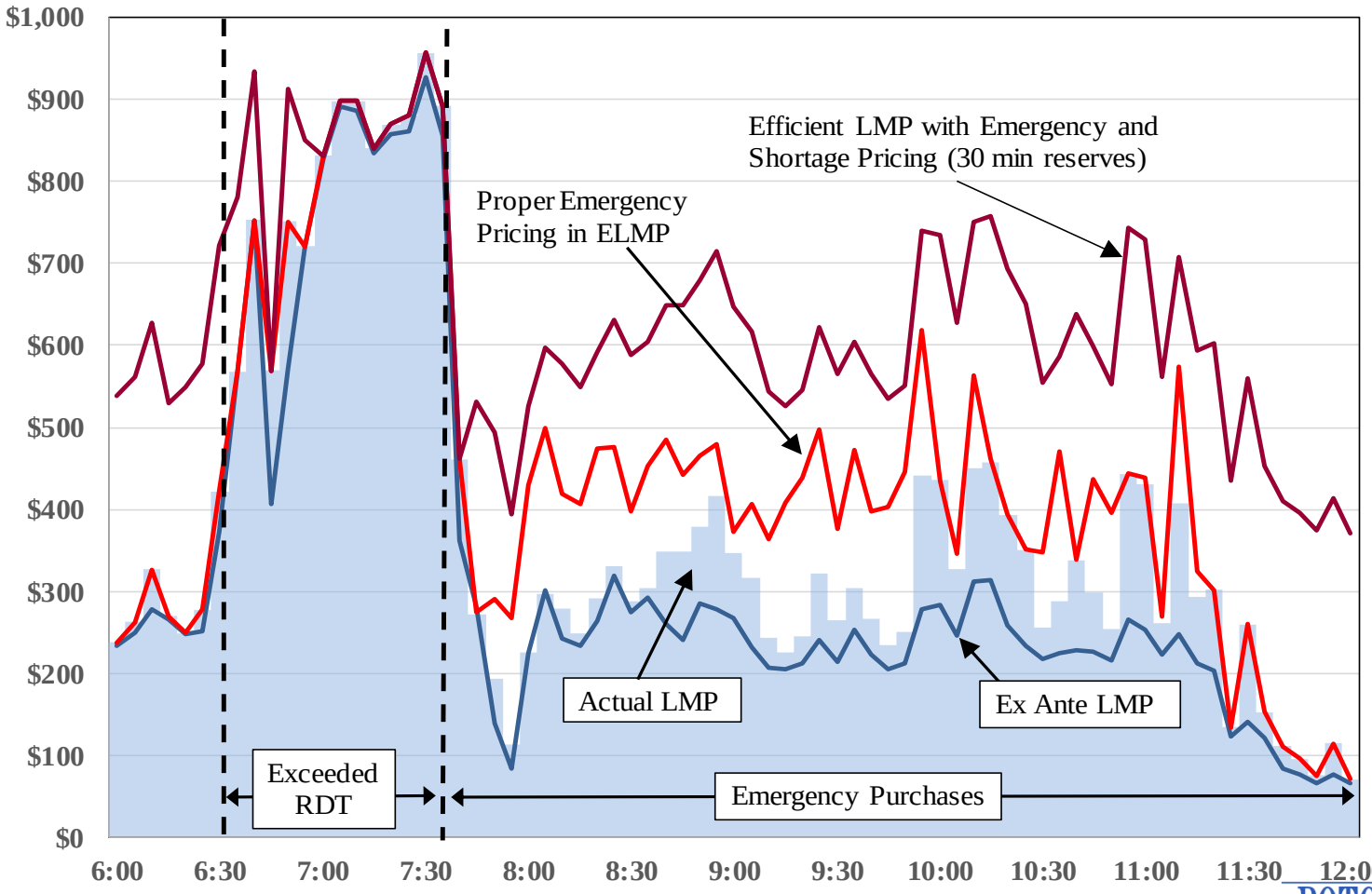
Efficient Emergency Offer Price Floor

- During emergency events, emergency offer floors are applied to emergency MWs in the ELMP pricing engine to allow them to set prices.
- An efficient Emergency Offer Floor Price should:
  - ✓ Reflect the cost of reliability requirements or constraints that would not be satisfied without the emergency MWs;
  - ✓ Be stable and should not be subject to manipulation by any single entity.
- Our analysis of the hourly offer floors in 2018 indicate that they are highly variability and unpredictable because they depend on suppliers' offers.

Region	Extreme Values		Largest Inter-hour Change
	Minimum	Maximum	
MIDWEST	$335	$1,081	$593
SOUTH	$109	$525	$198

- During actual emergencies, the floors have generally been inefficiently low – we recommend MISO establish efficient floors in the Tariff that do not depend on suppliers' offers.

Emergency Pricing: January 17



POTOMAC ECONOMICS

Improving Real-Time Price Formation in MISO: ELMP

- Allowing fast-start peaking resources and emergency actions to set prices is essential for establishing efficient real-time prices, which:
  - ✓ Sends key price signals to schedule imports and exports, and to commit resources efficiently in the day-ahead market.
- Based on our evaluation of the performance of the ELMP model in allowing online resources to set prices, we find:
  - ✓ The price effects are small and fail to capture the costs of some fast-start resources that should be setting prices.
  - ✓ Allowing all online fast-start resources to participate and changing one ramp assumption could increase its effectiveness by 300 to 400 percent.
- Our evaluation of offline pricing in ELMP continued to show that it is generally muting legitimate shortage pricing and should be disabled.
  - ✓ Shortages are often caused by uncertainty: continencies, load uncertainty, changes in wind output, uncertain transmission flows, etc.
  - ✓ Offline units that can't start in time to respond should not set prices.

ELMP Evaluation

Analysis of Online Pricing

Alternative ELMP Methods	Avg. Price Increase ($/MWh)	% of Fast-Start Peaker Eligible	% of Intervals Affected
Current Phase II	$0.58	6.8%	11.4%
Plus Day-Ahead Units	$1.31	12.5%	23.1%
No Ramp Limitation	$2.02	13.7%	27.7%
Plus DA Units & No Ramp Limit	$2.77	28.5%	32.6%

Analysis of Offline Pricing

	Economic*	Started	Economic & Started
Operating Reserve Shortages	10%	13%	**3%**
Transmission Shortages	15%	2%	**1%**

**Does not include units that were never started, which would increase the values to: 13% for OR shortages and 26% for Tx shortages.*

POTOMAC ECONOMICS

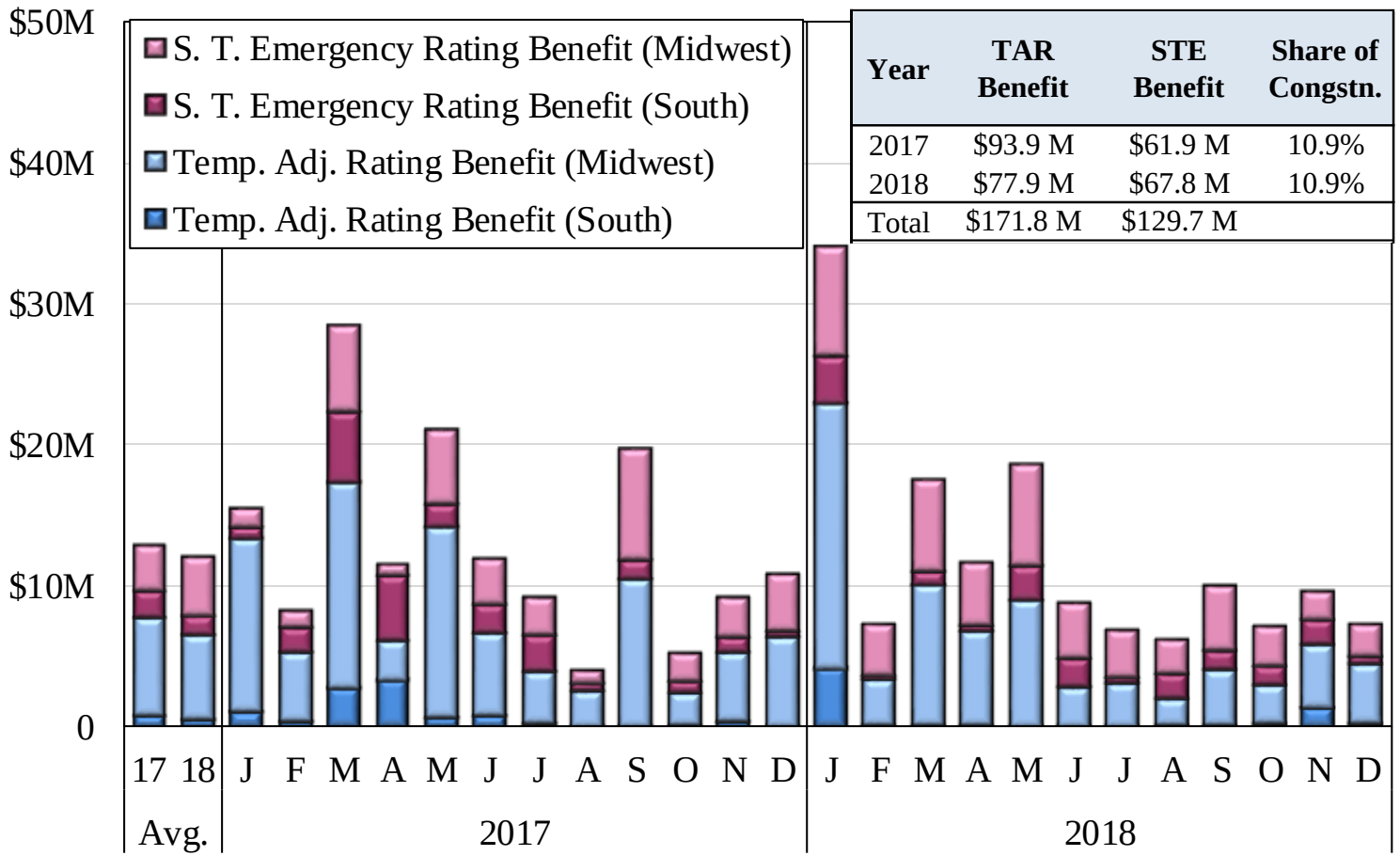
Transmission Congestion Management

POTOMAC ECONOMICS

Improving Congestion Management

- Given the magnitude of congestion in MISO, small improvements in its management can produce large benefits.
- In 2018, MISO greatly improved in identifying, testing, and coordinating M2M constraints – associated congestion costs fell nearly 75 percent.
- We remain concerned about other issues that reduce the efficiency of MISO's congestion management:
  - ✓ *Outage Coordination.* Multiple, simultaneous generation outages affecting the same constraint contributed to $347 million of real-time congestion.
  - ✓ *Improved Transmission Ratings.* Most transmission owners do not adjust their facility ratings to reflect ambient temperatures and wind speeds.
    - Broader adoption of temperature-adjusted ratings could have saved MISO an additional $172 million in production costs in the same period.
    - Additionally, if all TOs provided Short-Term Emergency Ratings, we estimated a potential savings of $130 million in 2017 and 2018.
    - In 2017 and 2018, the two TOs providing most of the temperature-adjusted ratings realized production cost savings of $51.3 million.

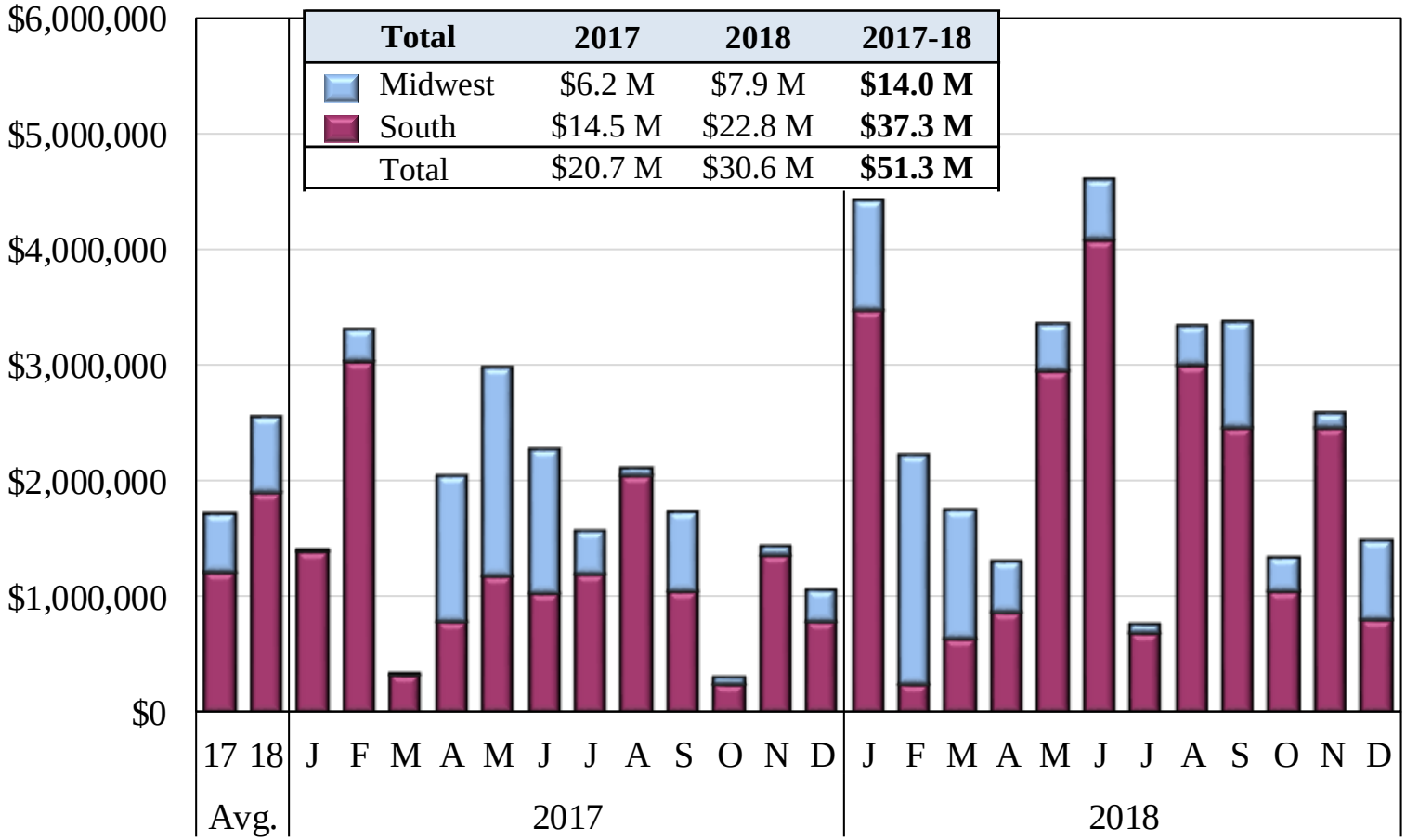
Congestion Management Concerns: Improvements in Ratings



Year	TAR Benefit	STE Benefit	Share of Congstn.
2017	$93.9 M	$61.9 M	10.9%
2018	$77.9 M	$67.8 M	10.9%
Total	$171.8 M	$129.7 M	

POTOMAC ECONOMICS

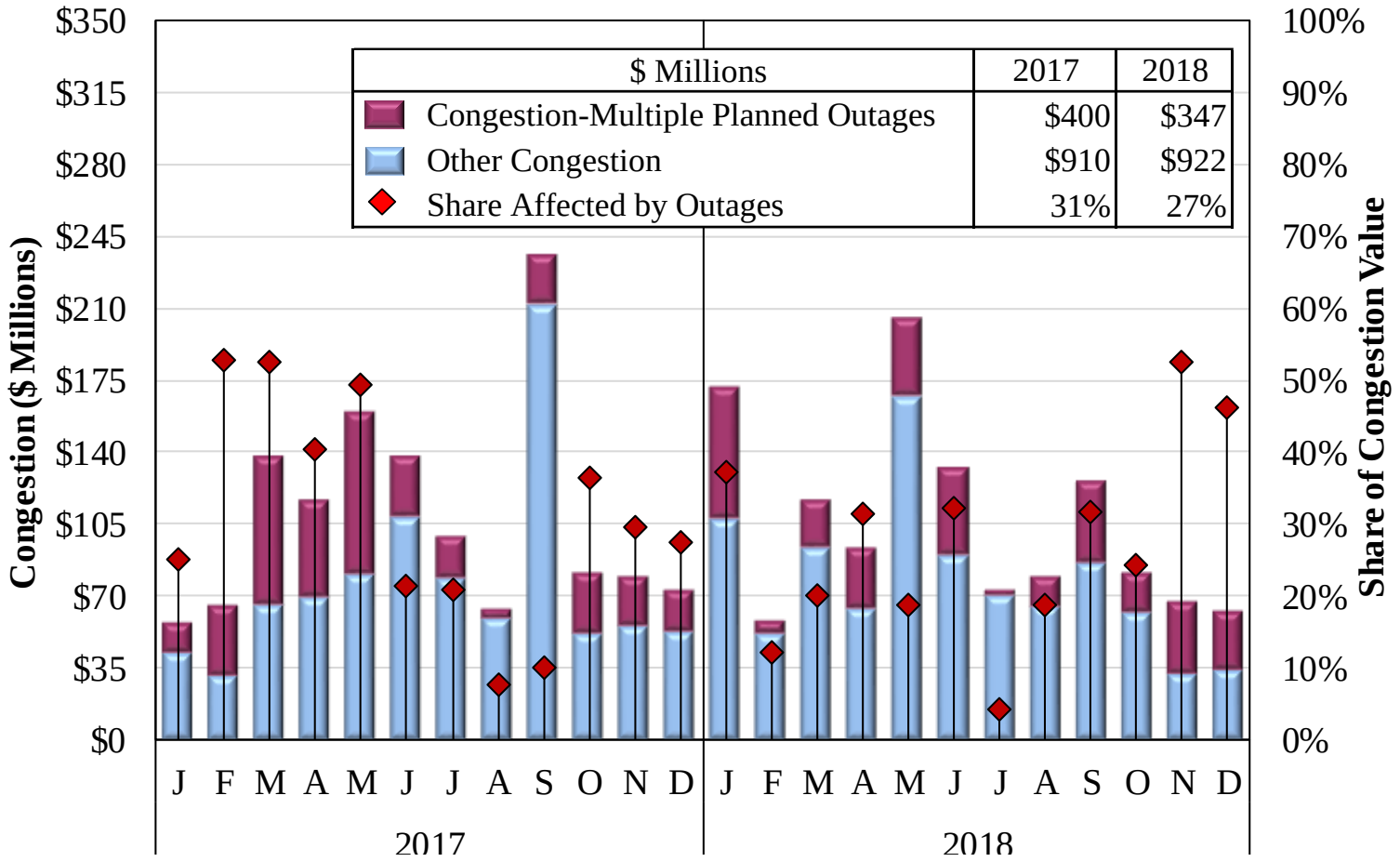
Temperature-Adjusted Ratings Program
Actual Savings 2017 - 2018



Total	2017	2018	2017-18
Midwest	$6.2 M	$7.9 M	**$14.0 M**
South	$14.5 M	$22.8 M	**$37.3 M**
Total	$20.7 M	$30.6 M	**$51.3 M**

POTOMAC ECONOMICS

Congestion Management Concerns: Outage-Related Congestion



POTOMAC ECONOMICS

Congestion Management Concerns: M2M Coordination and TVA Coordination

Market-to-Market Coordination Issues

Item Description	PJM ($ Millions)		SPP ($ Millions)		Total ($ Millions)	
	2017	2018	2017	2018	2017	2018
Never classified as M2M	$85	$5	$109	$15	$194	$21
M2M Testing Delay	$19	$22	$11	$8	$31	$29
M2M Activation Delay	$6	$11	$12	$7	$18	$18
Total	$110	$38	$133	$30	$243	$68

Coordination with TVA

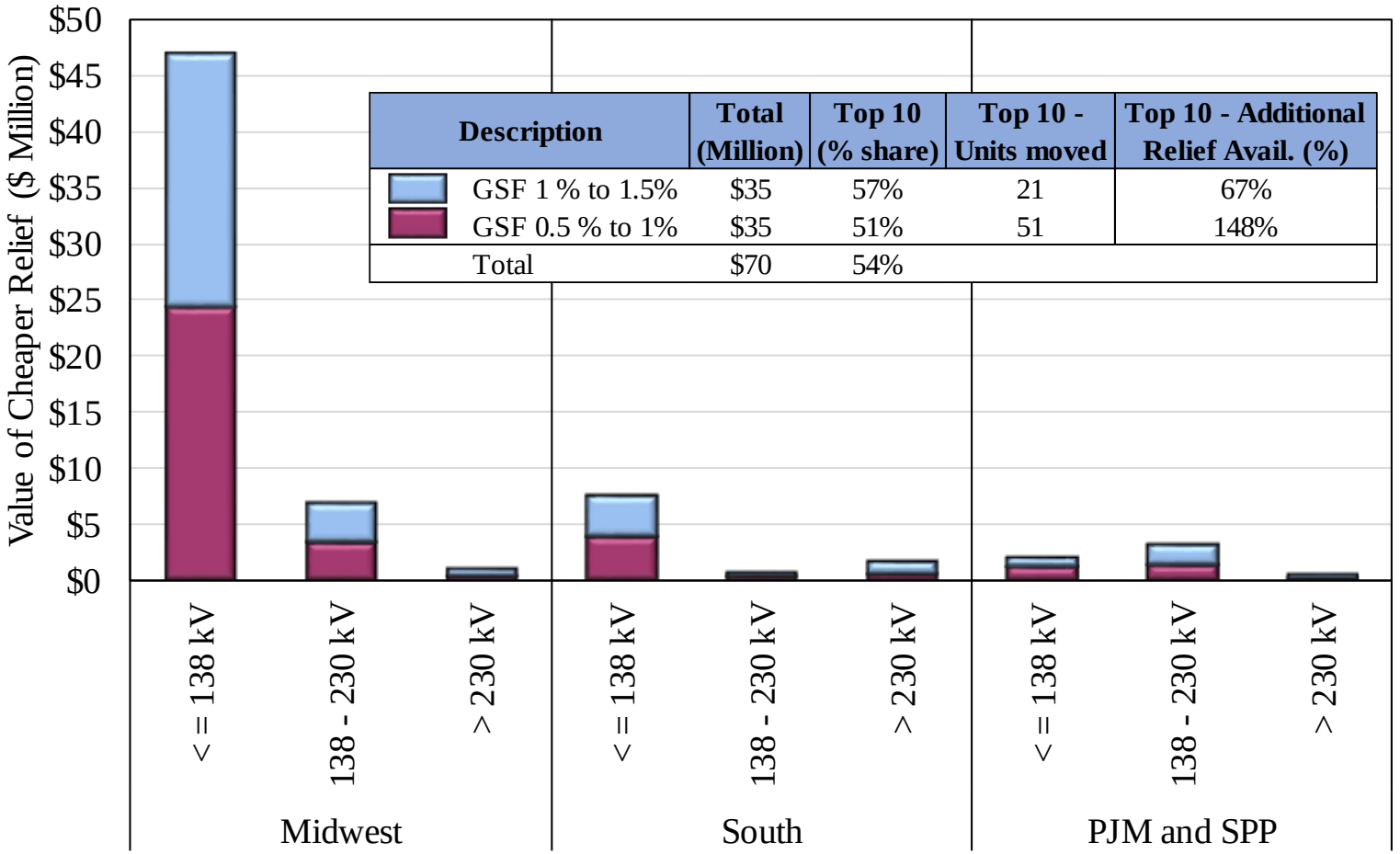
Status	Total Congestion Value ($ Millions)	Re-dispatch Savings ($ Millions)
MISO Constraints	$272.5 M	$26.8 M
TVA (TLR) Constraints binding in MISO	$3.3 M	$2.0 M
Total	$275.8 M	$28.8 M

POTOMAC ECONOMICS

Lower GSF Cutoff for Constraints with Limited Relief

- MISO currently employs a 1.5 percent Generator Shift Factor ("GSF") cutoff to identify which generators to optimize in its dispatch when managing the flows on a transmission constraint.
  - ✓ Limits the number of generators that are assumed to substantially affect the flows on a constraint.
  - ✓ Ensures that the dispatch model will solve in a reasonable amount of time.
  - ✓ For a limited number of lower-voltage constraints, this eliminates almost all of the economic relief available to manage the constraint.
- Our analysis shows $70 million of incremental economic relief would be available if the GSF cutoff were reduced to 0.5 percent.
  - ✓ Most of the benefits would be concentrated on a few low-voltage constraints and external M2M constraints.
  - ✓ MISO could capture 54 percent of the benefits if they implemented a 0.5 percent GSF cutoff for just ten constraints.
- This would also address significant FTR underfunding because the FTR auction does not employ a GSF cutoff.

Lower GSF Cutoff for Constraints with Limited Relief Value by Region and Voltage



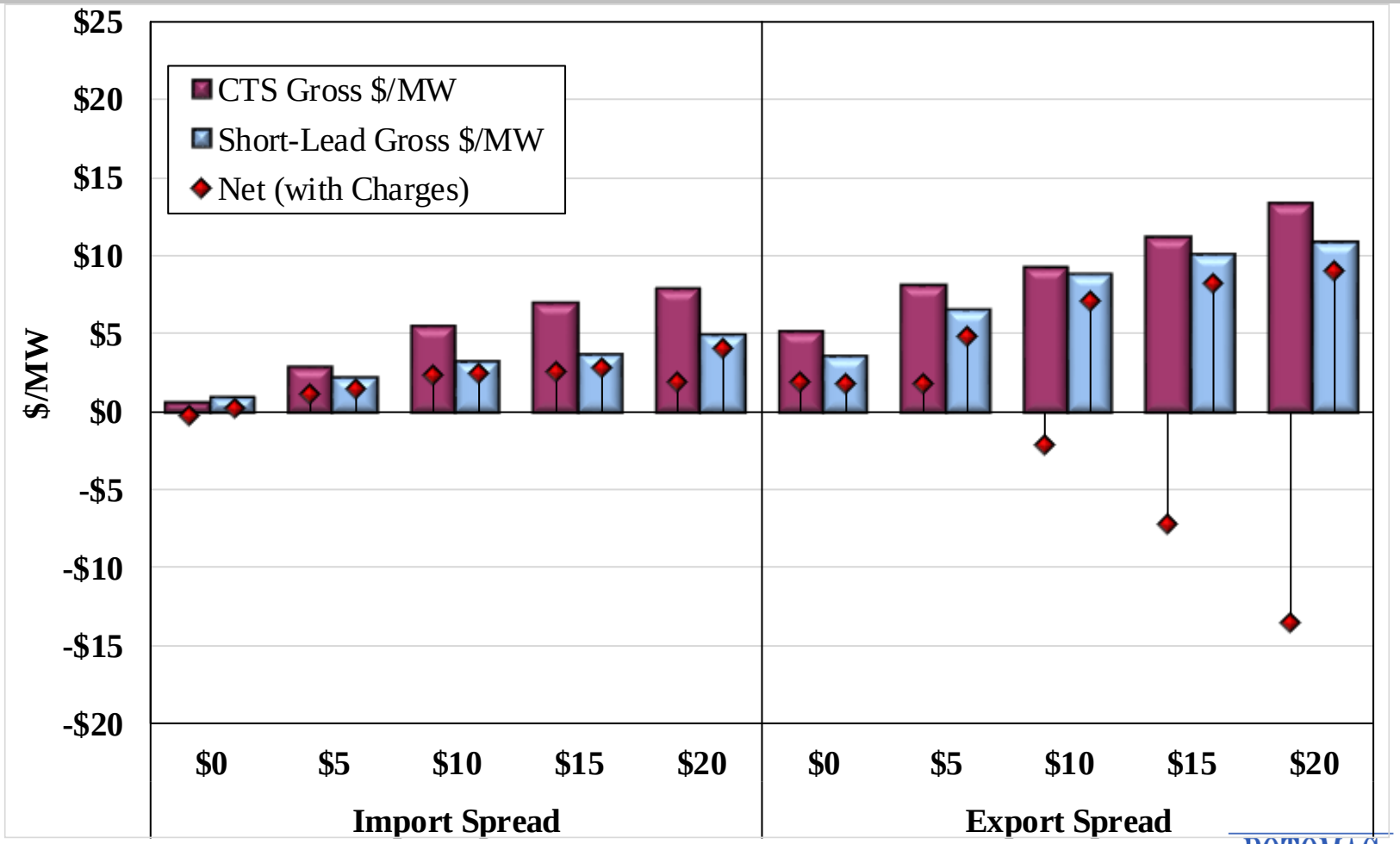
Description	Total (Million)	Top 10 (% share)	Top 10 - Units moved	Top 10 - Additional Relief Avail. (%)
GSF 1 % to 1.5%	$35	57%	21	67%
GSF 0.5 % to 1%	$35	51%	51	148%
Total	$70	54%		

POTOMAC ECONOMICS

Coordinated Transaction Scheduling (CTS)

- MISO implemented CTS with PJM in October 2017.
  - ✓ Participants submit offers to schedule imports and exports that clear intra-hour if forecasted price spreads between markets exceed offer prices.
  - ✓ The economic dispatch of external transactions through CTS can achieve sizable efficiency savings.
- Unfortunately, it was implemented in a manner that has removed the incentive for participants to submit transactions.
  - ✓ Participants pay transmission reservation fees to submit CTS offers, even if they do not clear.
  - ✓ Excluding these charges, the CTS transactions should be more profitable effectively because participants are able to submit an offer price.
- Consistent with expectations, our analysis shows that on a gross basis, the CTS strategies are *consistently more profitable* than conventional scheduling.
  - ✓ We recommend that MISO remove transmission reservation fees unilaterally and work with PJM to agree to eliminate their charges to CTS transactions.
  - ✓ This also underscores the importance of adhering to sound economic principles in developing new market products because this outcome was predictable.

Coordinated Transaction Scheduling (CTS)



POTOMAC ECONOMICS

Summary of Recommendations

POTOMAC ECONOMICS

Recommendations

- Although the markets performed competitively in 2018, we make 29 recommendations in this report to further improve their performance.
  - ✓ Six are new this year, while 23 were recommended previously.
  - ✓ It is not unexpected that recommendations carry over from prior years since many require changes that can take years to implement.
  - ✓ MISO addressed four of our recommendations in 2018 and early 2019.
- The following table shows the recommendations organized by market area.
  - ✓ They are numbered to indicate the year in which they were introduced and the recommendation number in that year.
  - ✓ We indicate whether each would provide high benefits and whether it can be achieved in the near term.

List of Recommendations

SOM Number	Recommendations	High Benefit	Near Term
Energy Pricing and Transmission Congestion			
2018-1	Improve emergency pricing by establishing an efficient default floor and accurately accounting for emergency imports.	✓	
2018-2	Lower GSF cutoff for constraints with limited relief.		
2017-1	Improve the market power mitigation rules		✓
2017-2	Remove transmission charges from CTS transactions	✓	✓
2016-3	Enhance authority to coordinate transmission and generation planned outages		
2016-1	Improve shortage pricing by adopting an improved operating reserve demand curve reflecting the expected value of lost load	✓	✓
2015-2	Expand utilization of temperature-adjusted and short-term emergency ratings for transmission facilities	✓	
2015-1	Expand eligibility for online resources to set prices in ELMP and suspend pricing by offline resources	✓	✓
2014-3	Improve external congestion related to TLRs by developing a JOA with TVA		
2012-5	Introduce a virtual spread product		
2012-3	Remove external congestion from interface prices		

List of Recommendations

SOM Number	Recommendations	High Benefit	Near Term
Operating Reserves and Guarantee Payments			
2018-3	Procure reserves on the RDT and compensate the Joint Parties when the reserves are deployed.		
2016-4	Establish regional reserve requirements and cost allocation.	✓	
2014-2	Introduce a 30-Minute reserve product to reflect VLR requirements and other local reliability needs.	✓	
Dispatch Efficiency and Real-Time Market Operations			
2018-4	Clarify the criteria and improve the logging for declaring emergencies and taking emergency actions.		✓
2017-5	Assess the feasibility of implementing a 15-minute Day-Ahead Market under the Market System Enhancement.	✓	
2017-4	Improve operator logging tools and processes related to operator decisions and actions.		
2016-8	Validate wind resources' forecasts and use results to correct dispatch instructions.		✓
2016-6	Improve the accuracy of the LAC recommendations.		✓

POTOMAC ECONOMICS

List of Recommendations

SOM Number	Recommendations	High Benefit	Near Term
Resource Adequacy			
2018-5	Improve capacity accreditation to account for unforced and unreported outages and derates during tight supply periods.	✓	
2018-6	Modify the supply and demand inputs for capacity by: a) accounting for behind-the-meter process load, b) improving planning assumptions, and c) validating suppliers' data.		✓
2017-7	Establish PRA capacity credits for emergency resources that better reflect their expected availability and performance.		✓
2017-6	Require the ICAP of planning resources to be deliverable		✓
2016-9	Improve the qualification of planning resources and treatment of unavailable resources		✓
2015-6	Improve the modeling of transmission constraints in the PRA		
2015-5	Implement firm capacity delivery procedures with PJM	✓✓	
2014-5	Transition to seasonal capacity market procurements		
2010-14	Improve the modeling of demand in the PRA	✓✓	

POTOMAC ECONOMICS