IMM Quarterly Report: Fall 2018 - Revised*

MISO Independent Market Monitor

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Potomac Economics

December 4, 2018

* Revised report includes complete data for November.

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Highlights and Findings: Fall 2018

- The MISO markets performed competitively this fall.
  - ✓ Energy prices rose 15 percent over last year mainly due to higher fuel prices.
    - – Natural gas prices and coal prices rose 17 and 4 percent, respectively.
  - ✓ Market power mitigation was infrequent and offers were competitive overall.
- Tropical Storm Gordon in early September led to Severe Weather Alerts and Conservative Operations in the South – MISO operated the system reliably throughout this period.
- This report includes a detailed review of a Maximum Generation Event that occurred on September 15 – it highlights issues related to a) emergency pricing, b) LMRs, and c) procedures for declaring emergencies.
- Day-ahead and real-time congestion fell overall, which is likely partly due to improvements made in market-to-market coordination.
- MISO implemented the Reserve Procurement Enhancement (RPE) that has improved the dispatch of flows over the transfer constraint.
- We worked with MISO to file very important proposed changes to its Uninstructed Deviation and Price Volatility Make-Whole Payment rules that should significantly improve generator performance and lower costs.

Quarterly Summary

		Value	*Change*[1] Prior Qtr.	*Change*[1] Prior Year
RT Energy Prices ($/MWh)	🟢	$34.56	*8%*	*15%*
Fuel Prices ($/MMBtu)				
Natural Gas - Chicago	🟣	$3.36	*22%*	*17%*
Natural Gas - Henry Hub	🟣	$3.41	*18%*	*17%*
Western Coal	🟢	$0.70	*-1%*	*4%*
Eastern Coal	🟢	$1.77	*12%*	*19%*
Load (GW)[2]				
Average Load	🟢	75.4	*-13%*	*3%*
Peak Load	🟢	115.0	*-6%*	*0%*
% Scheduled DA (Peak Hour)	🟢	98.1%	98.7%	98.4%
Transmission Congestion ($M)				
Real-Time Congestion Value	🟢	$306.7	*0%*	*-32%*
Day-Ahead Congestion Revenue	🟢	$154.8	*-11%*	*-24%*
Balancing Congestion Revenue[3]	🟢	-$.7	-$12.7	-$12.8
Ancillary Service Prices ($/MWh)				
Regulation	🟢	$11.33	*12%*	*13%*
Spinning Reserves	🟢	$3.52	*32%*	*22%*
Supplemental Reserves	🟢	$0.93	*35%*	*26%*

		Value	*Change*[1] Prior Qtr.	*Change*[1] Prior Year
FTR Funding (%)	🟢	101%	110%	100%
Wind Output (MW/hr)	🟢	5,886	*44%*	*-7%*
Guarantee Payments ($M)[4]				
Real-Time RSG	🟢	$23.8	*4%*	*1%*
Day-Ahead RSG	🟢	$10.8	*105%*	*9%*
Day-Ahead Margin Assurance	🟢	$10.4	*35%*	*-12%*
Real-Time Offer Rev. Sufficiency	🟢	$1.3	*29%*	*-28%*
Price Convergence[5]				
Market-wide DA Premium	🟢	-2.7%	-0.4%	-3.0%
Virtual Trading				
Cleared Quantity (MW/hr)	🟢	15,636	*5%*	*5%*
% Price Insensitive	🟢	35%	36%	30%
% Screened for Review	🟢	1%	1%	1%
Profitability ($/MW)	🟢	$0.60	$0.33	$0.83
Dispatch of Peaking Units (MW/hr)	🟢	1,180	1562	1023
Output Gap- Low Thresh. (MW/hr)	🟢	117	75	95
Other:				

Key:
- 🟢 Expected
- 🟣 Monitor/Discuss
- 🔴 Concern

Notes:
1. Values not in italics are the values for the past period rather than the change.
2. Comparisons adjusted for any change in membership.
3. Net real-time congestion collection, unadjusted for M2M settlements.
4. Includes effects of market power mitigation.
5. Values include allocation of RSG.

Highlights for Fall 2018

<u>September 15 Maximum Generation Event in MISO South (Slide 16)</u>

- On September 15, MISO issued a Max Gen Event in MISO South because of:
  - ✓ A forced outage of the largest market resource the evening of Sept. 14; and
  - ✓ Unusually large under-forecasted day-ahead load, caused by temperature forecast errors. LBA forecast load and day-ahead scheduled load were lower.
- The following events unfolded during the operating day on September 15:
  - ✓ By the morning of September 15, the real-time load forecasts were accurate.
  - ✓ At 11:30 a.m., the Look-Ahead Commitment (LAC) cases began to indicate emergency conditions beginning at 1:30 p.m.
  - ✓ By 1:30 p.m., MISO had less than 150 MW of headroom in the South.
    - This should have raised serious capacity concerns because MISO's largest contingency in the South was roughly 1200 MW.
    - If this contingency had occurred, MISO's ability to respond was limited.
    - MISO declared an Alert at 1:05 p.m., but did not declare the Max Gen emergency event until 3 p.m.
  - ✓ The response of imports by 3 p.m. effectively resolved the capacity shortage.

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Highlights for Fall 2018

September 15 Maximum Generation Event in MISO South (Slides 17-18)

- MISO’s Maximum Generation Event announced at 2:45 to begin at 3:00 p.m. allowed MISO to access emergency generation and imports, and schedule LMRs.
  - ✓ Almost no LMRs were able to be utilized (6 MW) because of their notification times and the timing of the emergency declaration; and
  - ✓ Had MISO called the Event at 11:30 a.m., approximately 90 MW of additional LMRs would have been available.
- Pricing and the Market Response
  - ✓ The capacity tightness beginning at 1:30 made it difficult for MISO to hold the flow on the RDT, resulting in high prices in MISO South.
  - ✓ These prices prompted participants to increase imports into the South by roughly 1 GW from 1 p.m. to 3 p.m.
  - ✓ This market response rendered the emergency resources unneeded.
  - ✓ The price floor applied to the emergency MWs to set prices in an event was set too low ($119 per MWh) to prevent them from depressing prices.
  - ✓ Our simulation of a $500 price floor showed that efficient pricing would have been 36 percent higher during the event and not set by the emergency MWs.

Highlights for Fall 2018

<u>September 15 Event: Conclusions and Recommendations (Slides 16-18)</u>

- The Event that occurred on September 15 highlights a number of concerns regarding the market rules and processes that are described below.
- <u>LMRs</u>
  - ✓ Continued to provide very little value due to their lead times and the emergency declaration time.
  - ✓ Underscores past recommendations related to qualifying and utilizing LMRs.
- <u>Emergency Pricing</u>
  - ✓ Prices were inefficiently low after the emergency was called -- highlights the problems with allowing participants to set the emergency price floor.
  - ✓ We recommend MISO not allow the default price floor applied to emergency resources/imports in ELMP to drop below $500/MWh.
- <u>Emergency Procedures and Declarations</u>
  - ✓ We recommend MISO use the results of this event to evaluate its operating procedures related to declaring emergencies.
  - ✓ This should include a review of the tools, information and triggers for declaring various levels of Alerts and Events in MISO South.

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Highlights for Fall 2018

<u>Reserve Procurement Enhancement on RDT (Slide 22)</u>

- FERC approved application of the Reserve Procurement Enhancement (RPE) to the Regional Directional Transfer (RDT) in late August.
  - ✓ The RPE allows MISO to effectively hold 10 minute reserves on the RDT interface and improves the commitment of resources in the South.
  - ✓ This increases MISO's ability to limit exceedances to 30 minutes after the loss of the largest resource in MISO South.
    - – Currently MISO may only clear 10-minute reserves on the constraint.
    - – A 30-minute reserve product would better satisfy the requirements.
  - ✓ We evaluated the ex-ante price impacts of the RPE from Sep 1 – Nov 17.
    - – RPE bound on the RDT in approximately 4 percent of intervals;
    - – South LMPs were $0.15 per MWh higher on average, and ancillary service prices in the South rose $0.32 per MWh on average.
    - – Overall congestion increased by $1 million.
- The integration of the South region continues to provide tremendous benefits as transfer flows adjusted sharply in response to: large forced outages in the South, sub-regional load forecast errors, and volatile wind in the Midwest.

Highlights for Fall 2018

Natural Gas Prices (Slide 14)

- Natural gas prices rose by 17 percent this fall compared to last year, leading to a comparable increase in energy prices.
- Despite higher gas production, fall natural gas inventories were lower than normal and put upward pressure on gas prices. Low inventories are attributed to:
  - ✓ Colder temperatures last January leading to higher than normal withdrawals,
  - ✓ An unseasonably cold April delaying the start of the normal injection season, and
  - ✓ High summer electricity demand reducing storage injections.
- Colder than normal temperatures along with low storage in November put upward pressure on gas prices late in the quarter.
- Looking forward, there is a high probability of gas price volatility this winter.

Highlights for Fall 2018

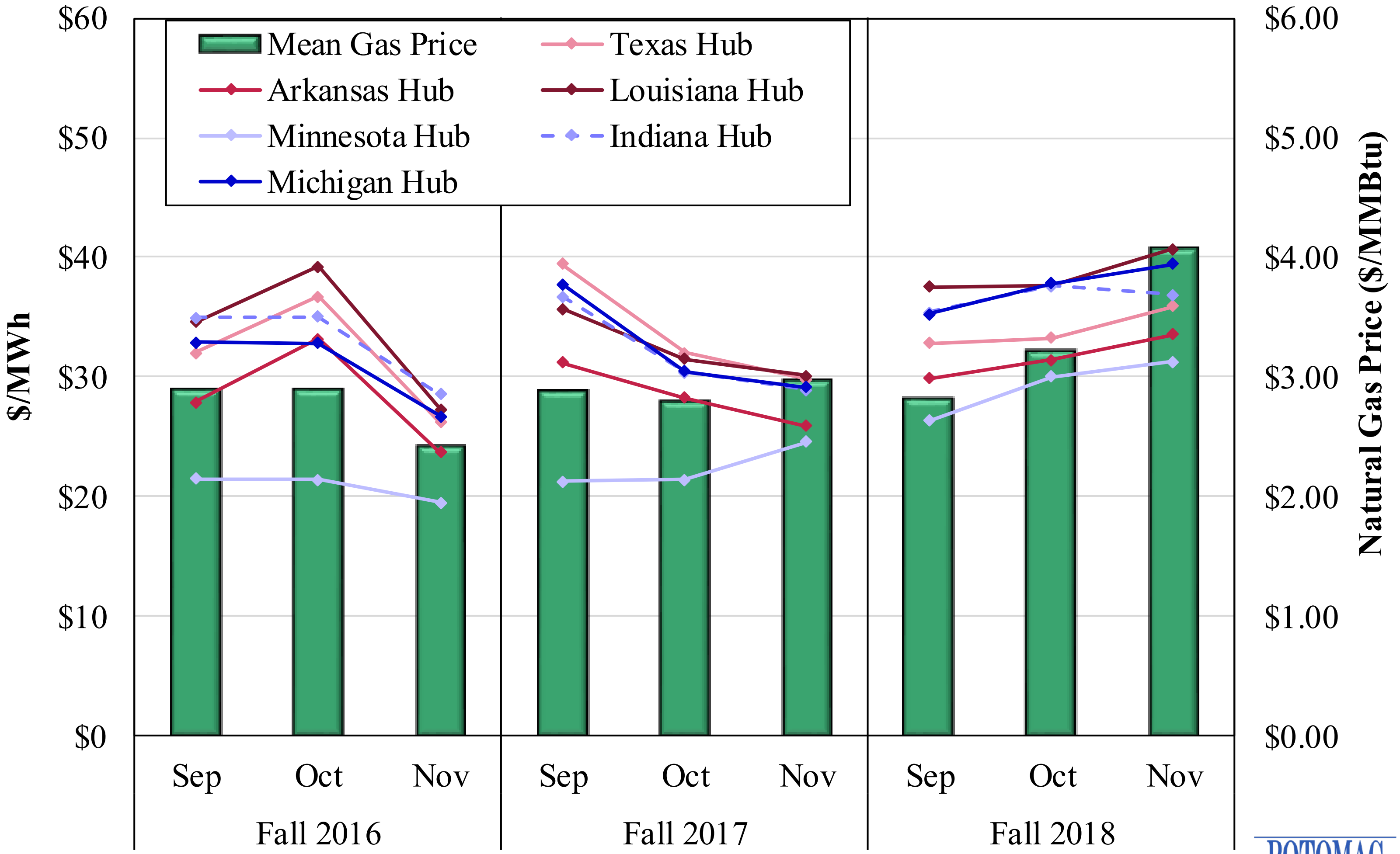
Outage Coordination (Slides 37, 38)

- Total outages this fall were comparable to levels in the past two years, averaging 26 and 24 percent in the Midwest and the South, respectively.
  - ✓ Of this total, almost one third was unplanned non-forced outages (short lead-time outages, extensions to planned outages, or unreported outages).
- This report also includes reported and unreported derates (partial outages).
  - ✓ The derates increased the total unavailable resources to roughly 34 percent in the Midwest and 32 percent in the South.
  - ✓ The majority of these derates are unreported to MISO.
- Unplanned and unreported outages and derates raise significant concerns:
  - ✓ They are not considered in the capacity qualification process causing MISO to over-estimate their availability; and
  - ✓ MISO's ability to plan for them operationally is limited.
- We continue to recommend that MISO improve its outage coordination, and enforce reporting requirements for these outages and derates.

Submittals to External Entities and Other Issues

- We responded to FERC questions related to prior referrals and continued to meet with FERC on a weekly basis. We submitted:
  - ✓ New referrals and updated prior referrals, including referrals of wind resources for not providing accurate offers due to chronic over-forecasting.
  - ✓ Several notifications of other potential Tariff violations.
- In FERC Proceedings, we:
  - ✓ Filed an affidavit in support of MISO's filed proposed Tariff revisions related to UD and PVMWP to improve generator performance in October.
  - ✓ Filed in support of MISO's Compliance Filing for Order 831 implementation.
- We presented a Market Report to the ERSC in November.
- In stakeholder processes, we:
  - ✓ Participated in stakeholder discussions and provided feedback on MISO's RAN initiatives.
  - ✓ Presented concerns with MISO's enforcement of deliverability requirements to the RASC.
- We continued working with MISO and Market Participants to clarify operating procedures related to timely updates to real-time offers.

Day-Ahead Average Monthly Hub Prices
Fall 2016 – 2018



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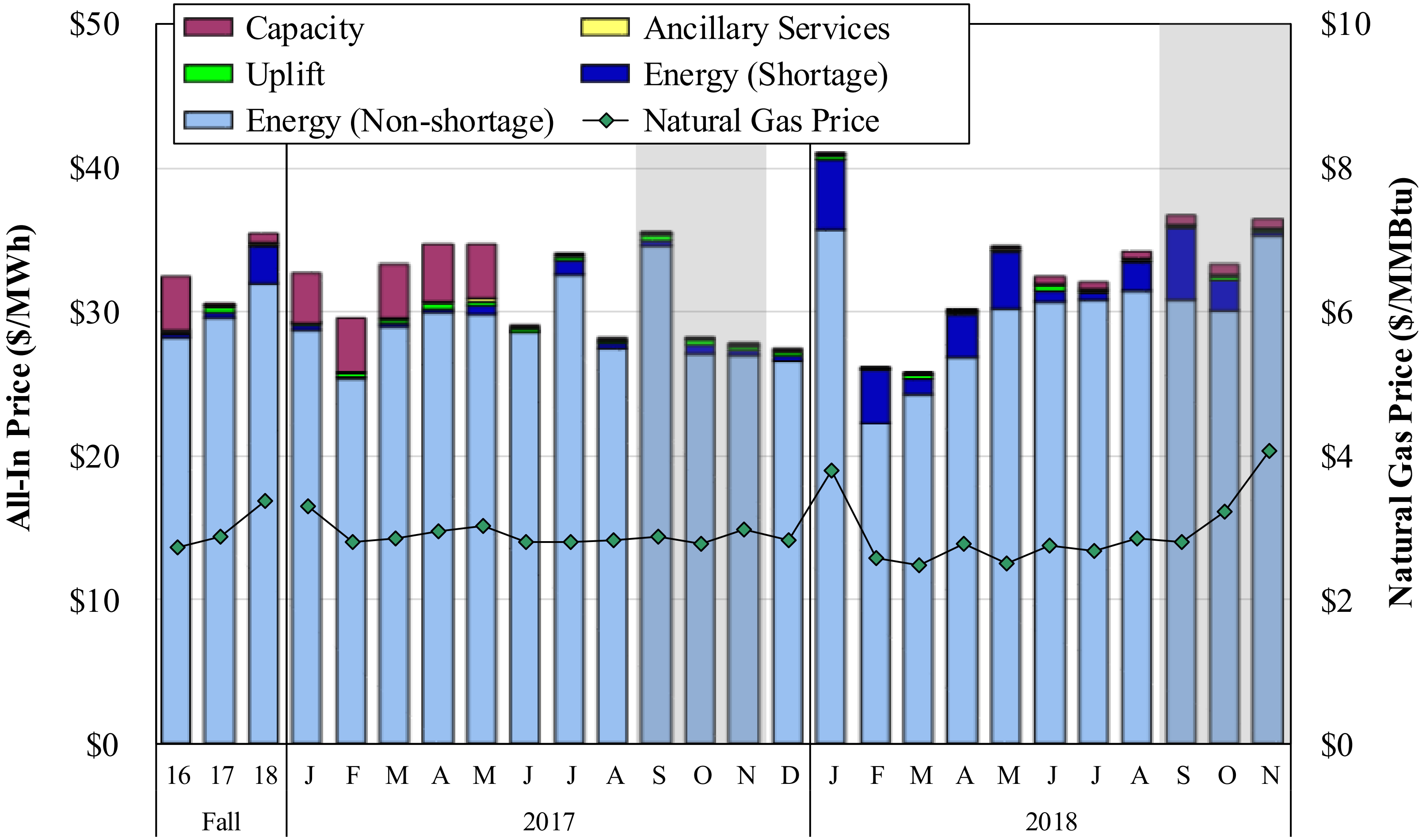
All-In Price
2017 – 2018



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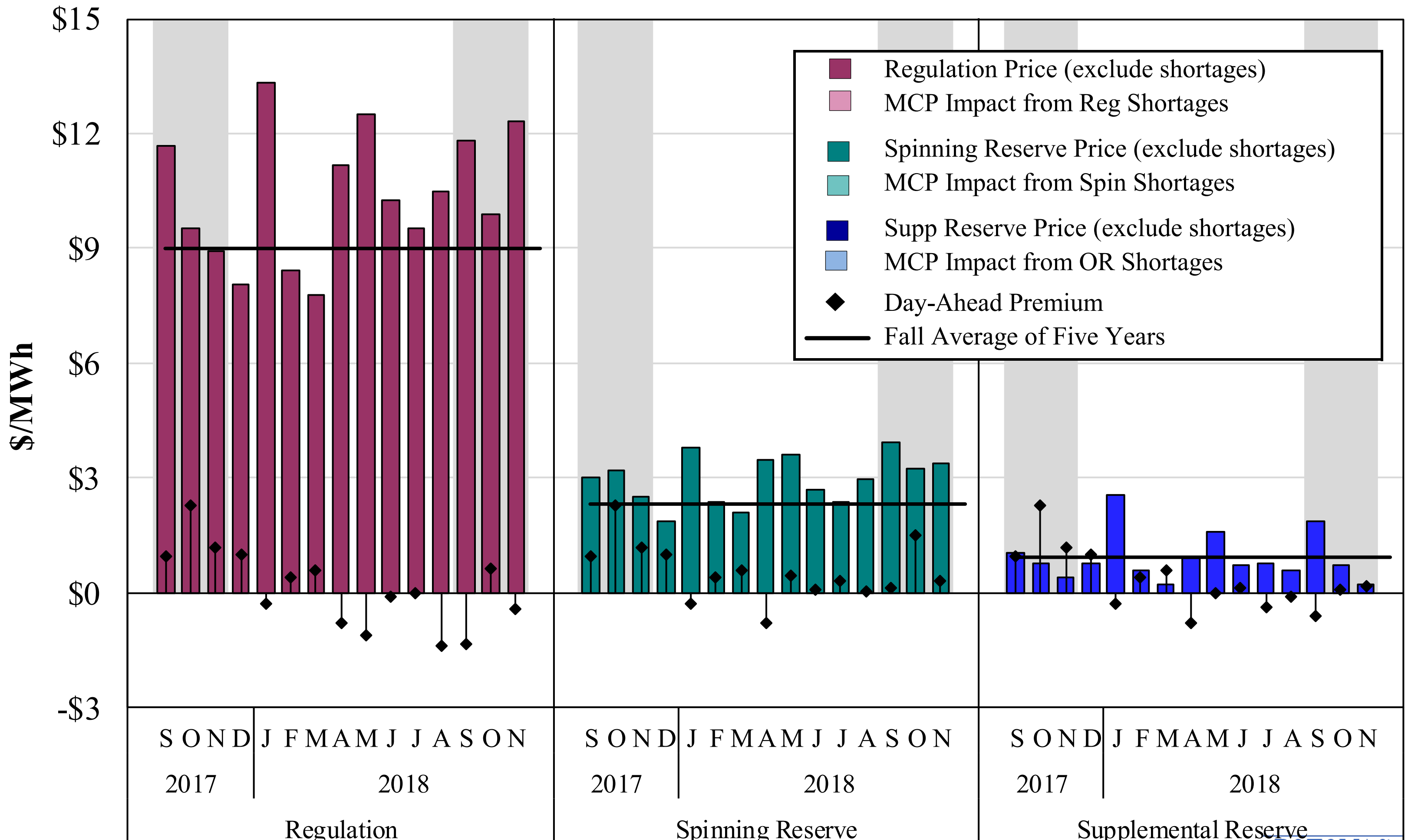
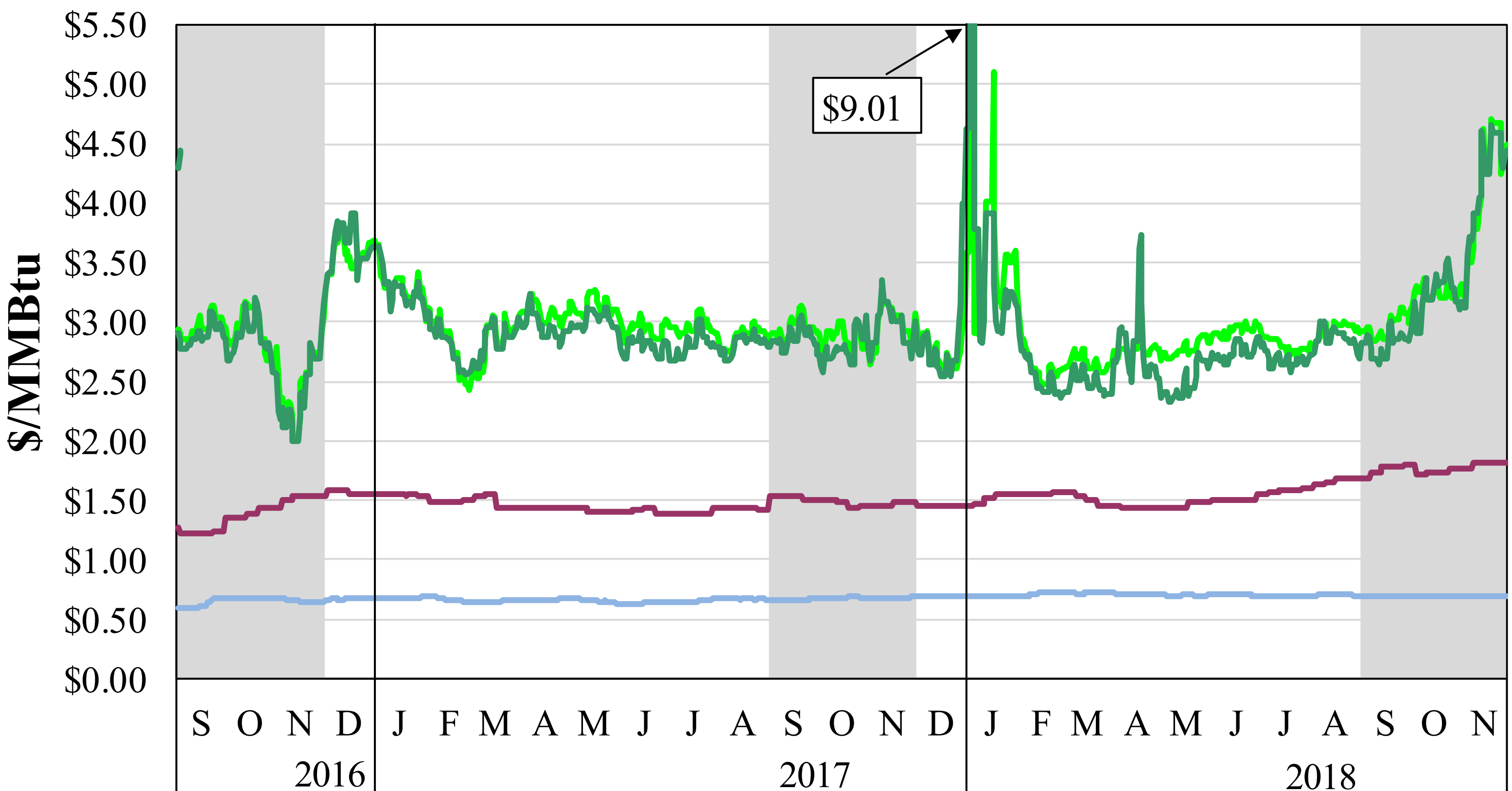
Monthly Average Ancillary Service Prices
Fall 2017 – 2018



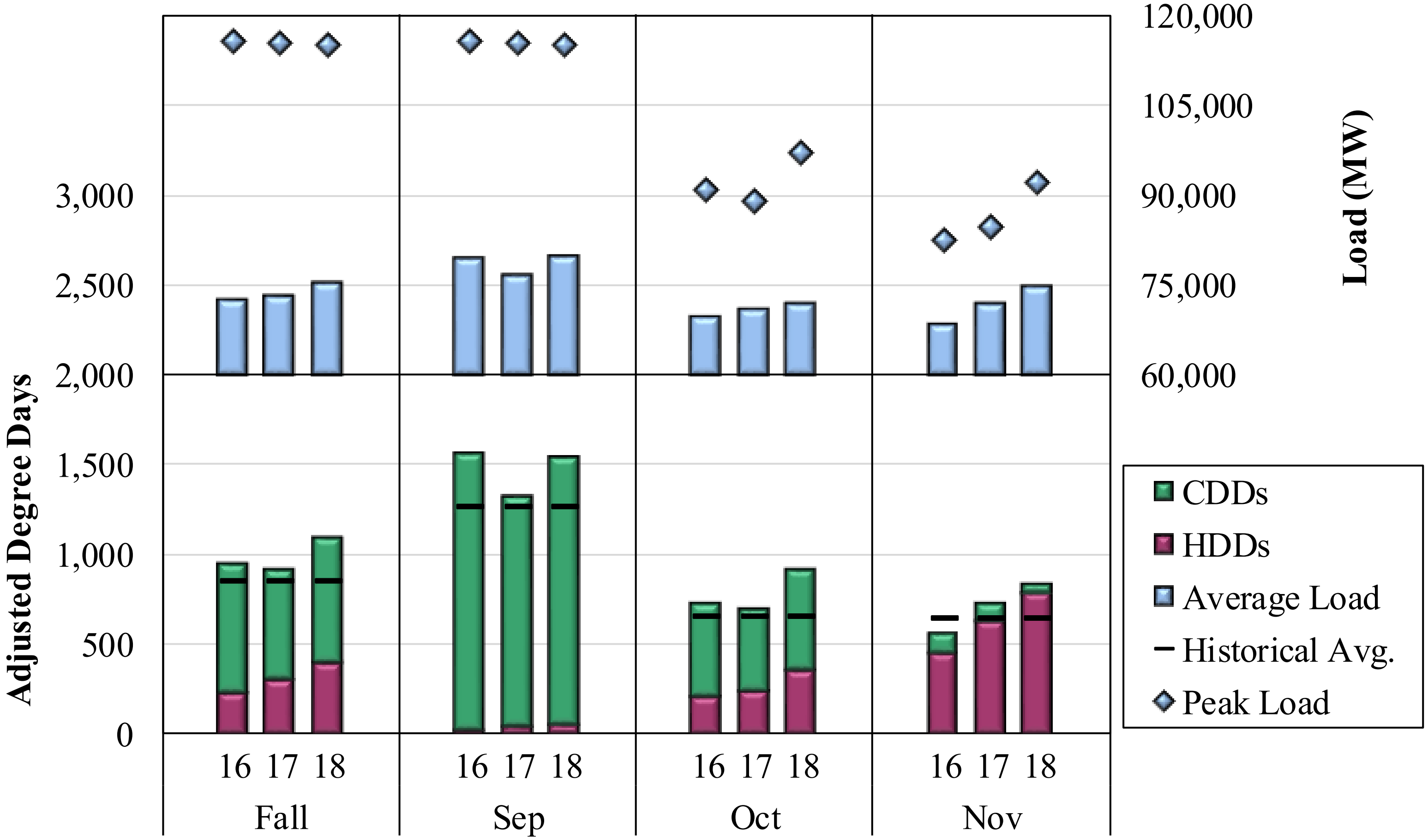
MISO Fuel Prices
Fall 2016 – 2018



Fall Average	2016	2017	2018
Chicago NG	$2.72	$2.87	$3.36
Henry NG	$2.79	$2.93	$3.42

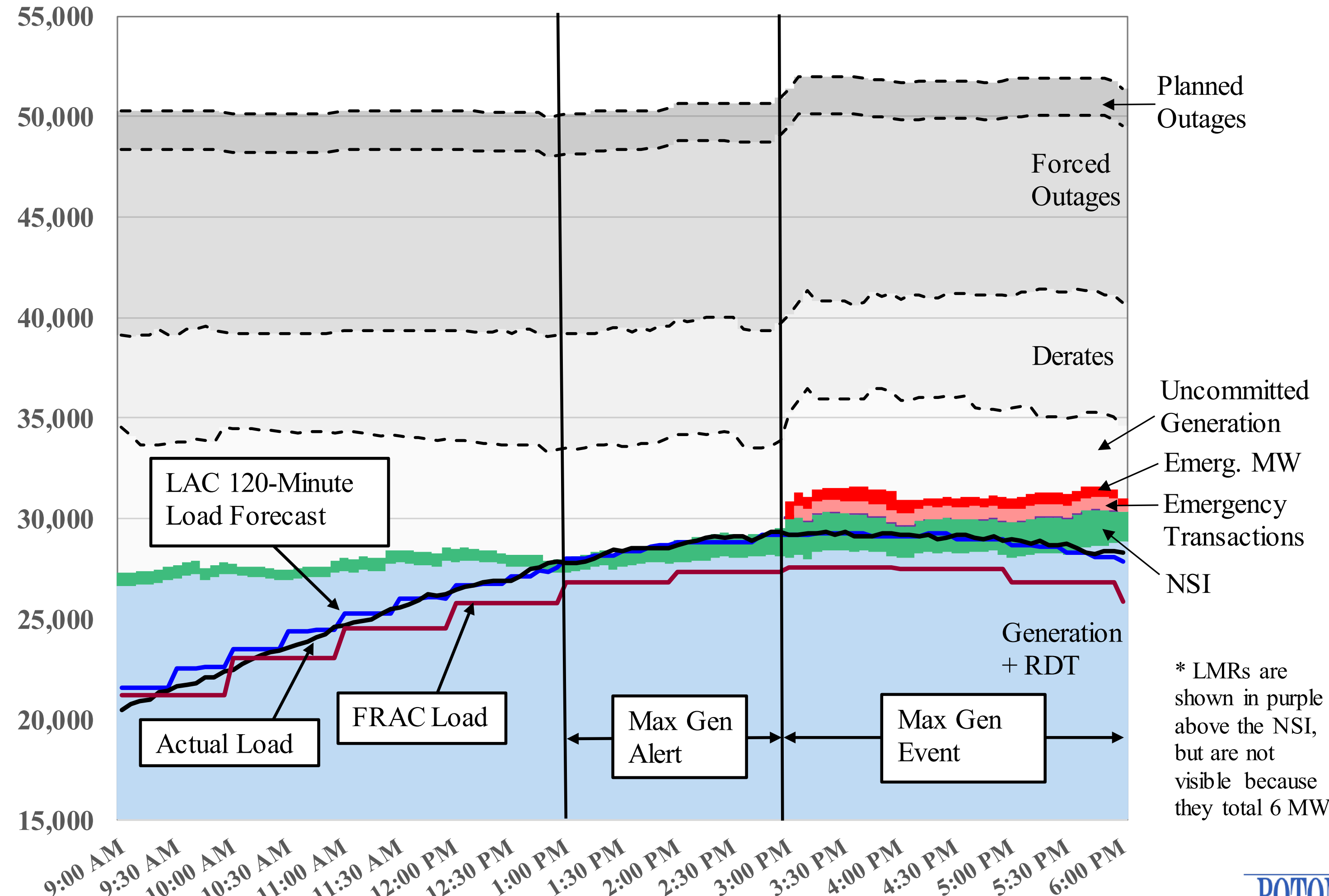
Fall Average	2016	2017	2018
IB Coal	$1.38	$1.49	$1.77
PRB Coal	$0.65	$0.67	$0.70

Load and Weather Patterns
Fall 2016 – 2018



Note: Midwest degree day calculations include four representative cities in the Midwest: Indianapolis, Detroit, Milwaukee and Minneapolis. The South region includes Little Rock and New Orleans.

Maximum Generation Event in MISO South September 15



* LMRs are shown in purple above the NSI, but are not visible because they total 6 MW.

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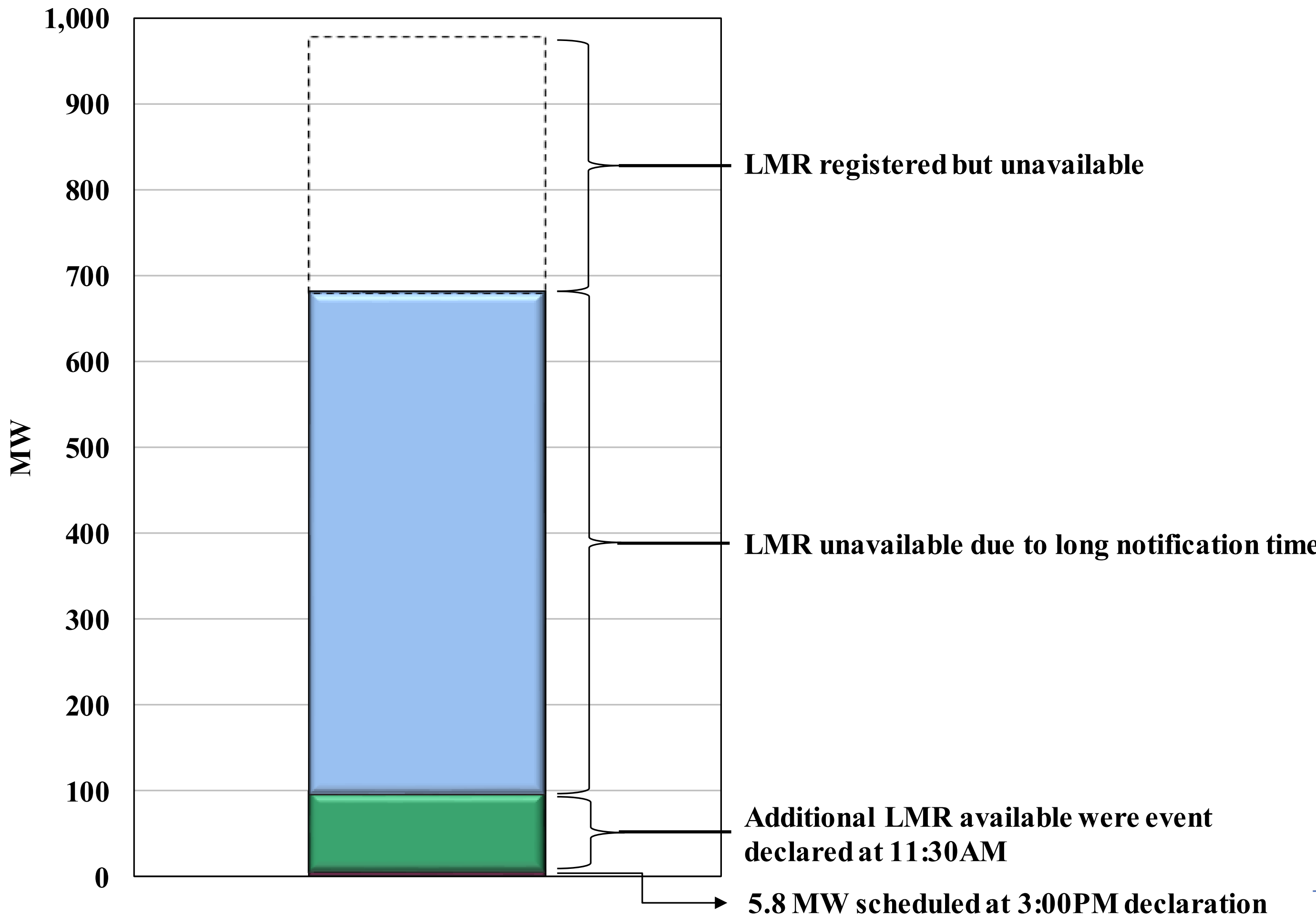
September 15: LMR Availability



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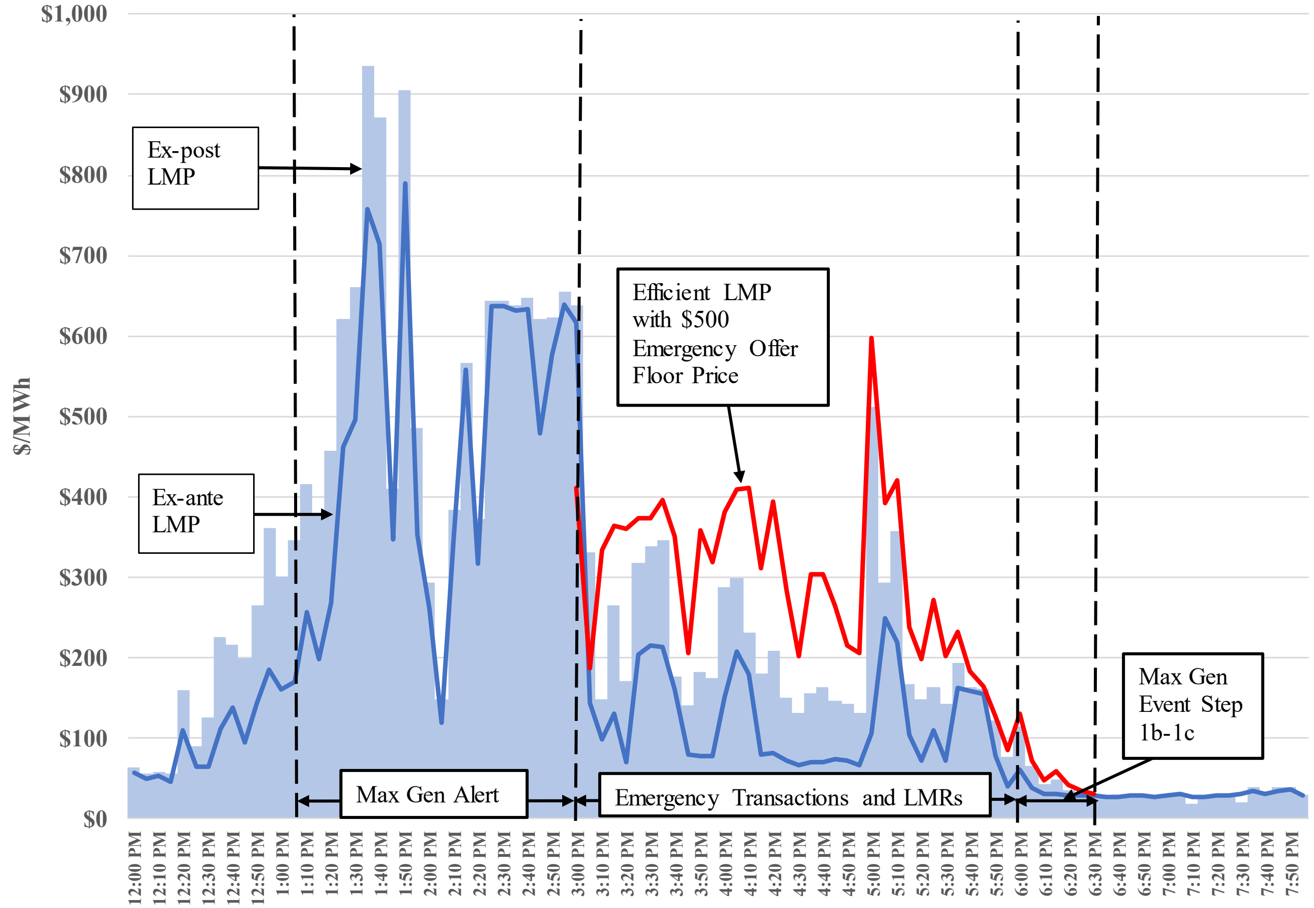
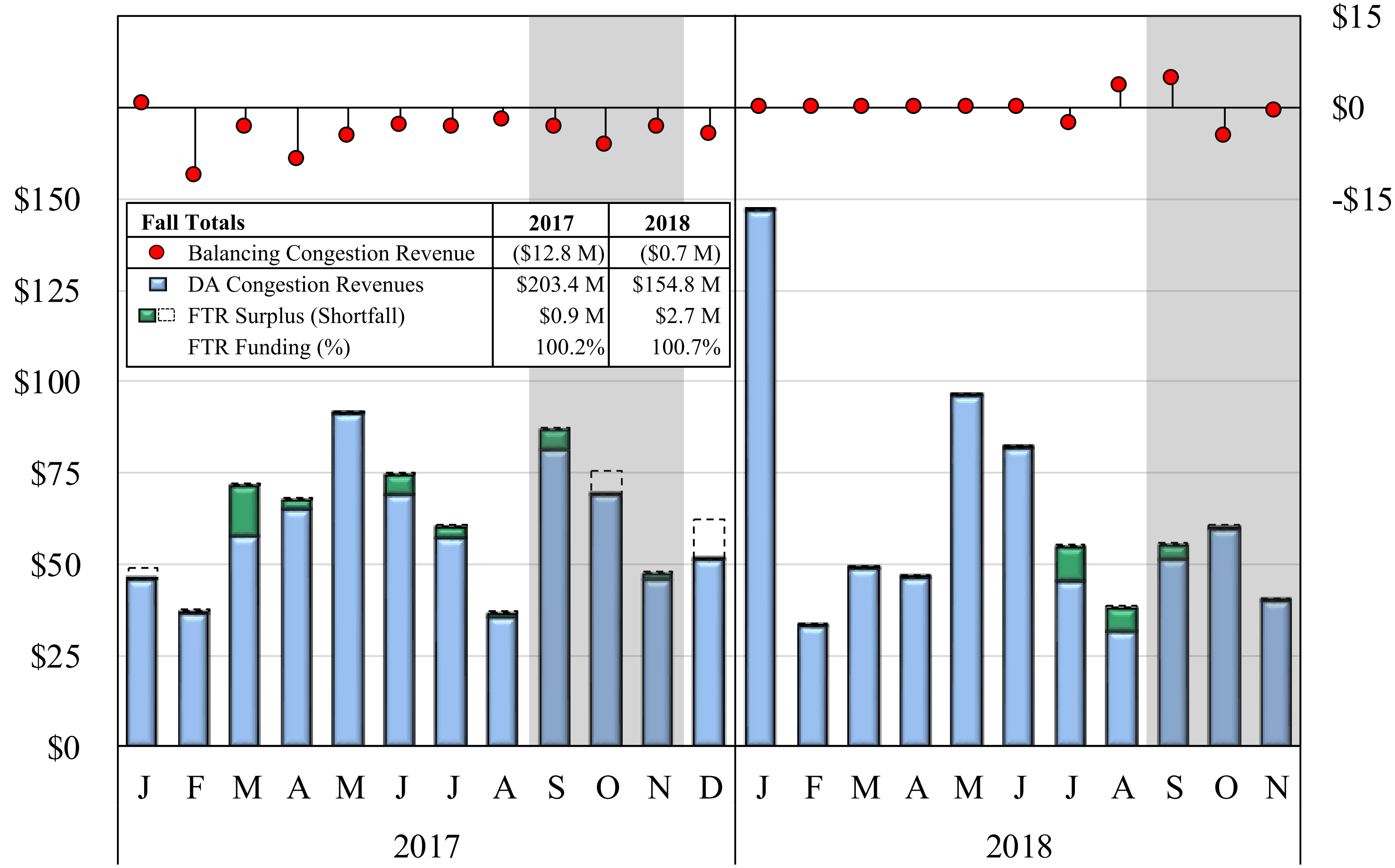
September 15: Real-Time Prices in MISO South



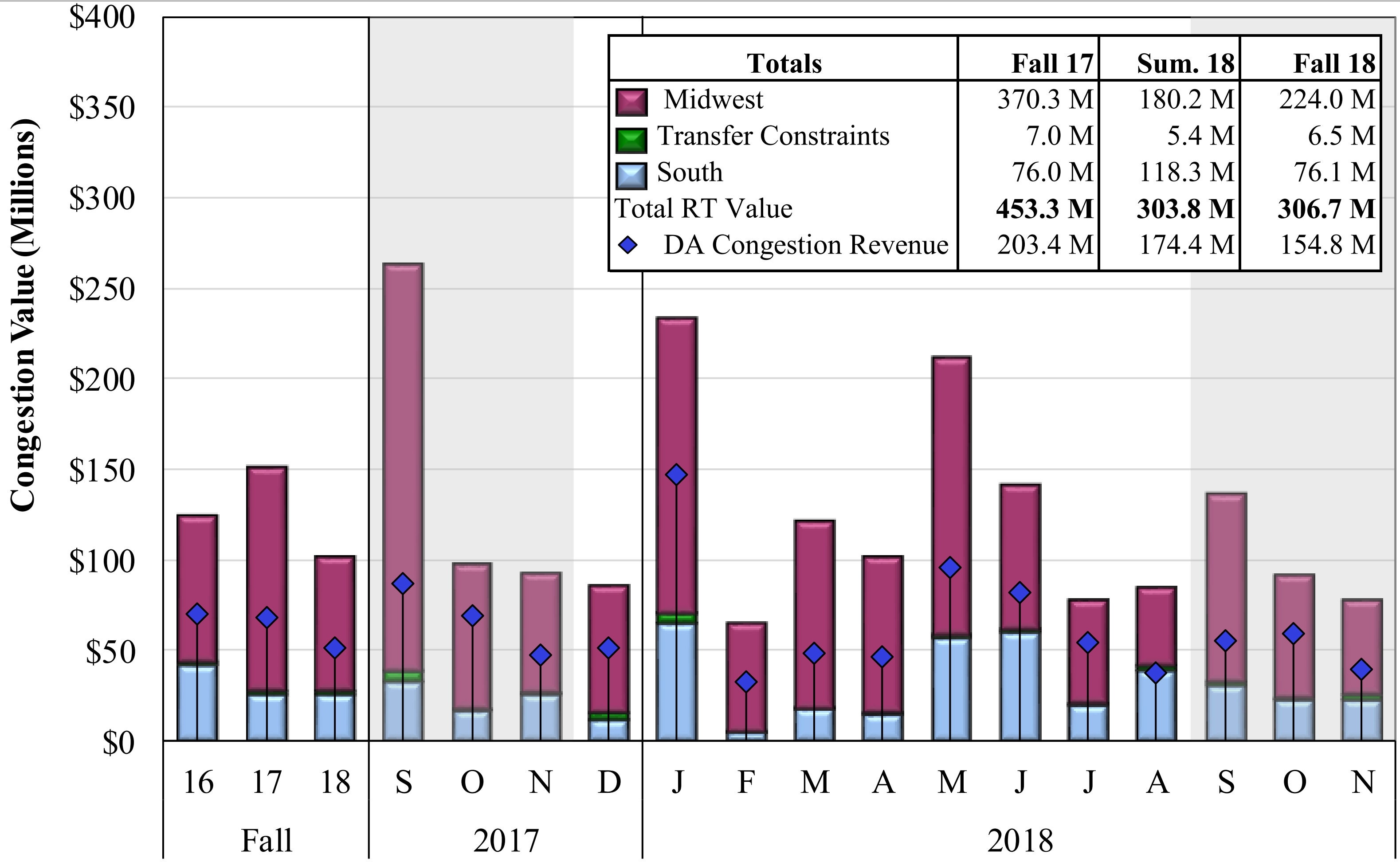
**5:00 p.m. interval averaged $1,430.76 ex-ante but was later re-priced due to excessive offset.*

Day-Ahead Congestion, Balancing Congestion and FTR Underfunding, 2016 – 2018



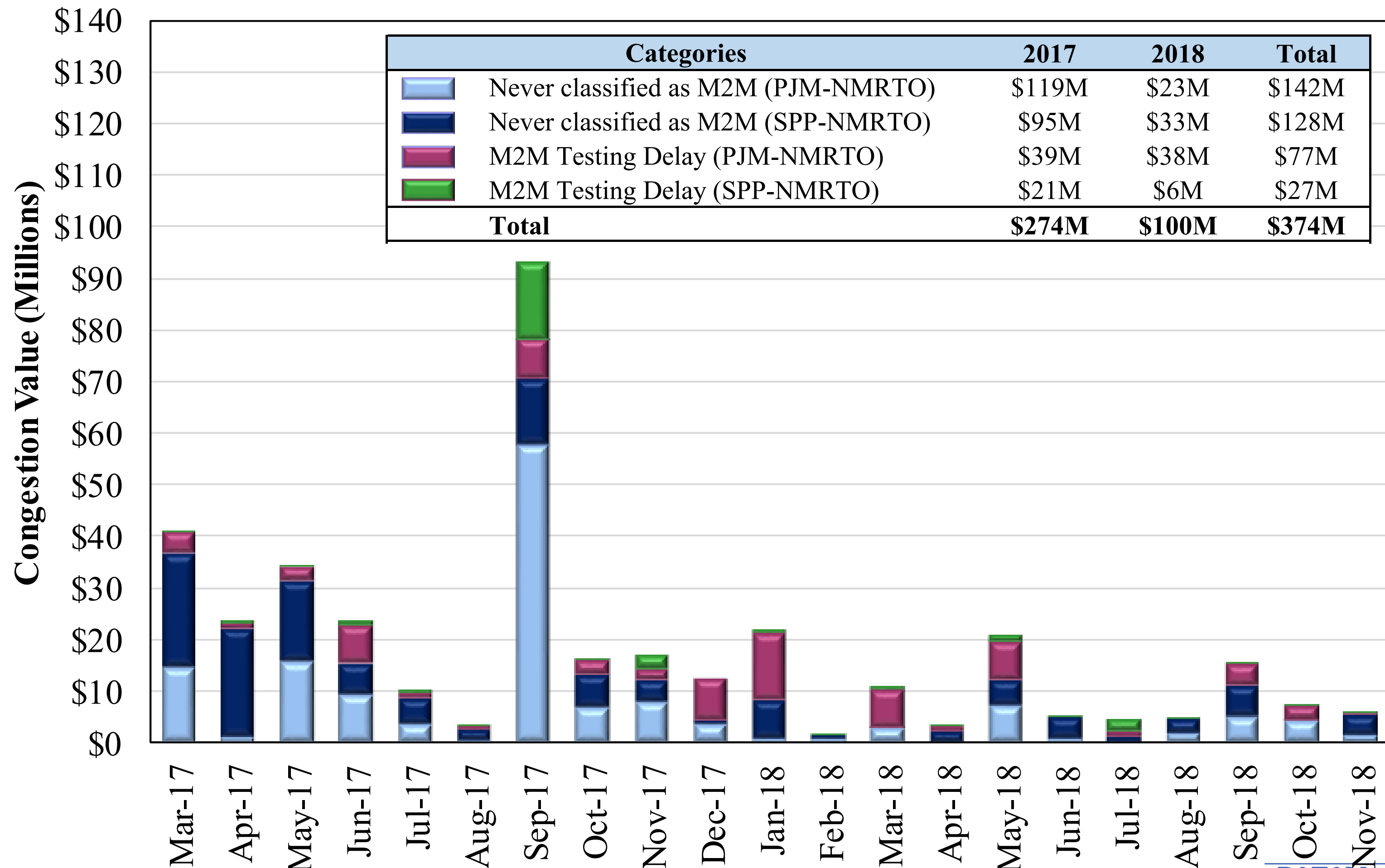
Fall Totals	2017	2018
Balancing Congestion Revenue	($12.8 M)	($0.7 M)
DA Congestion Revenues	$203.4 M	$154.8 M
FTR Surplus (Shortfall)	$0.9 M	$2.7 M
FTR Funding (%)	100.2%	100.7%

Value of Real-Time Congestion
Fall 2017 – 2018



Totals	Fall 17	Sum. 18	Fall 18
Midwest	370.3 M	180.2 M	224.0 M
Transfer Constraints	7.0 M	5.4 M	6.5 M
South	76.0 M	118.3 M	76.1 M
Total RT Value	**453.3 M**	**303.8 M**	**306.7 M**
DA Congestion Revenue	203.4 M	174.4 M	154.8 M

Inefficient Market-to-Market Congestion



Categories	2017	2018	Total
Never classified as M2M (PJM-NMRTO)	$119M	$23M	$142M
Never classified as M2M (SPP-NMRTO)	$95M	$33M	$128M
M2M Testing Delay (PJM-NMRTO)	$39M	$38M	$77M
M2M Testing Delay (SPP-NMRTO)	$21M	$6M	$27M
Total	**$274M**	**$100M**	**$374M**

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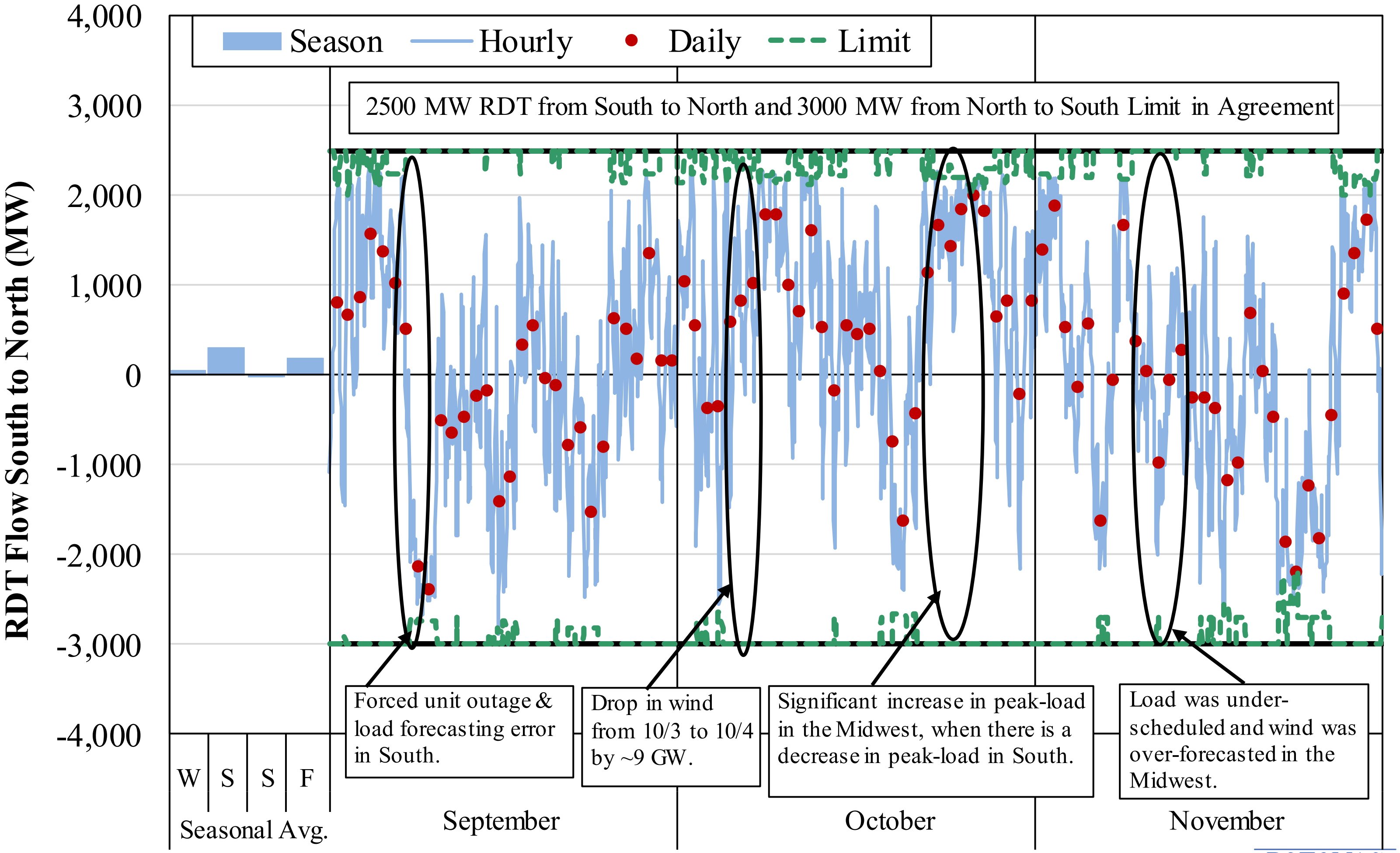
Real-Time Hourly Inter-Regional Flows
Fall 2018



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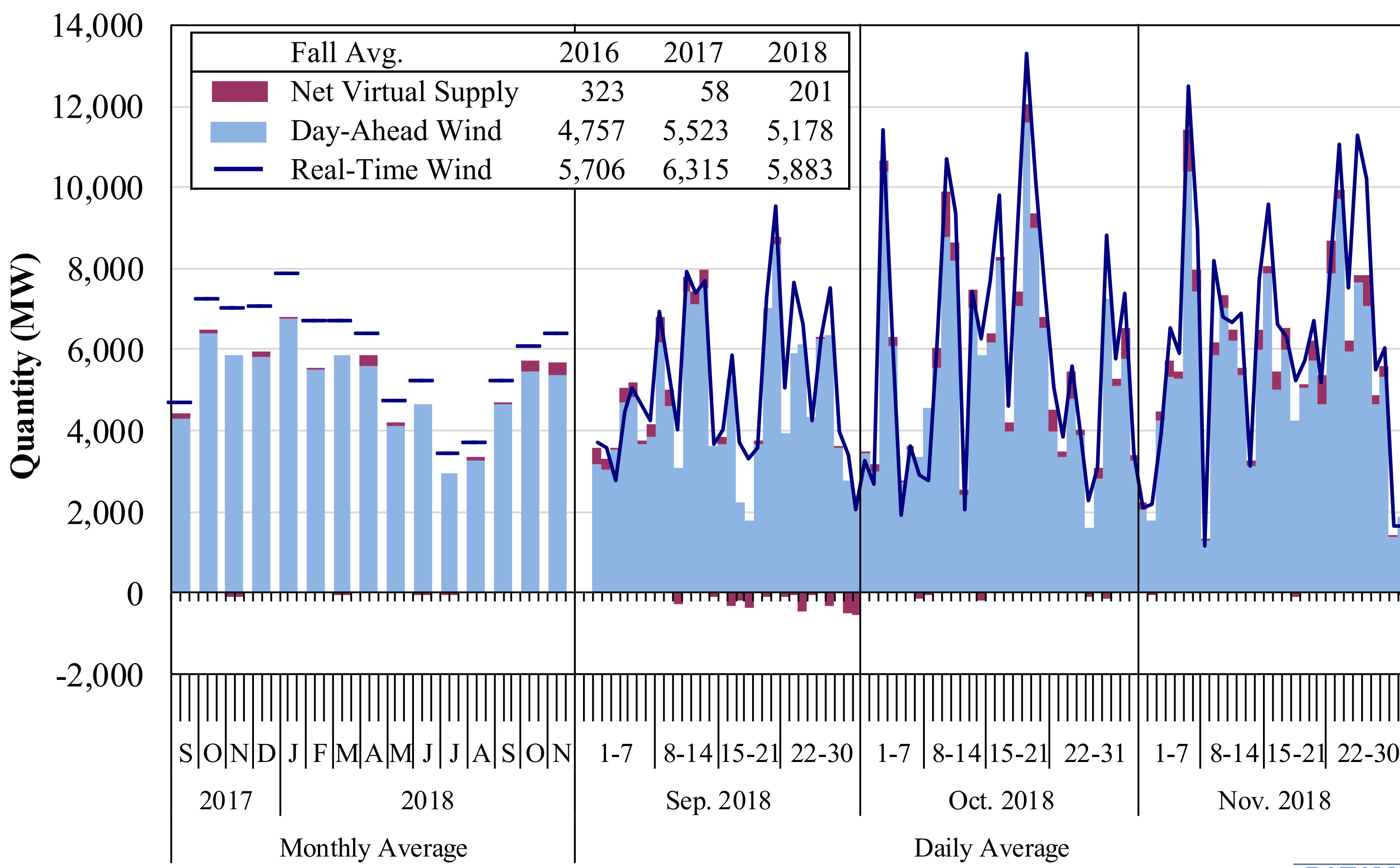
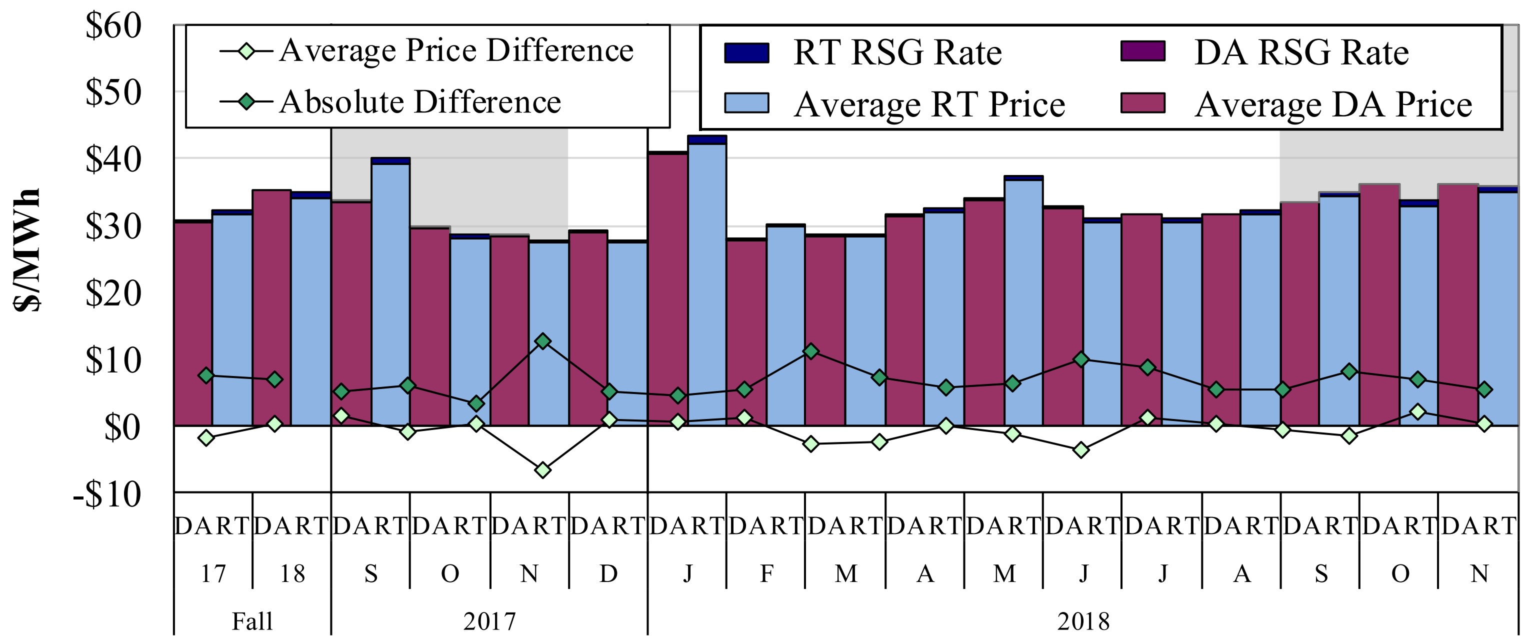
Wind Output in Real-Time and Day-Ahead Monthly and Daily Average



Day-Ahead and Real-Time Price Convergence
Fall 2017 – 2018

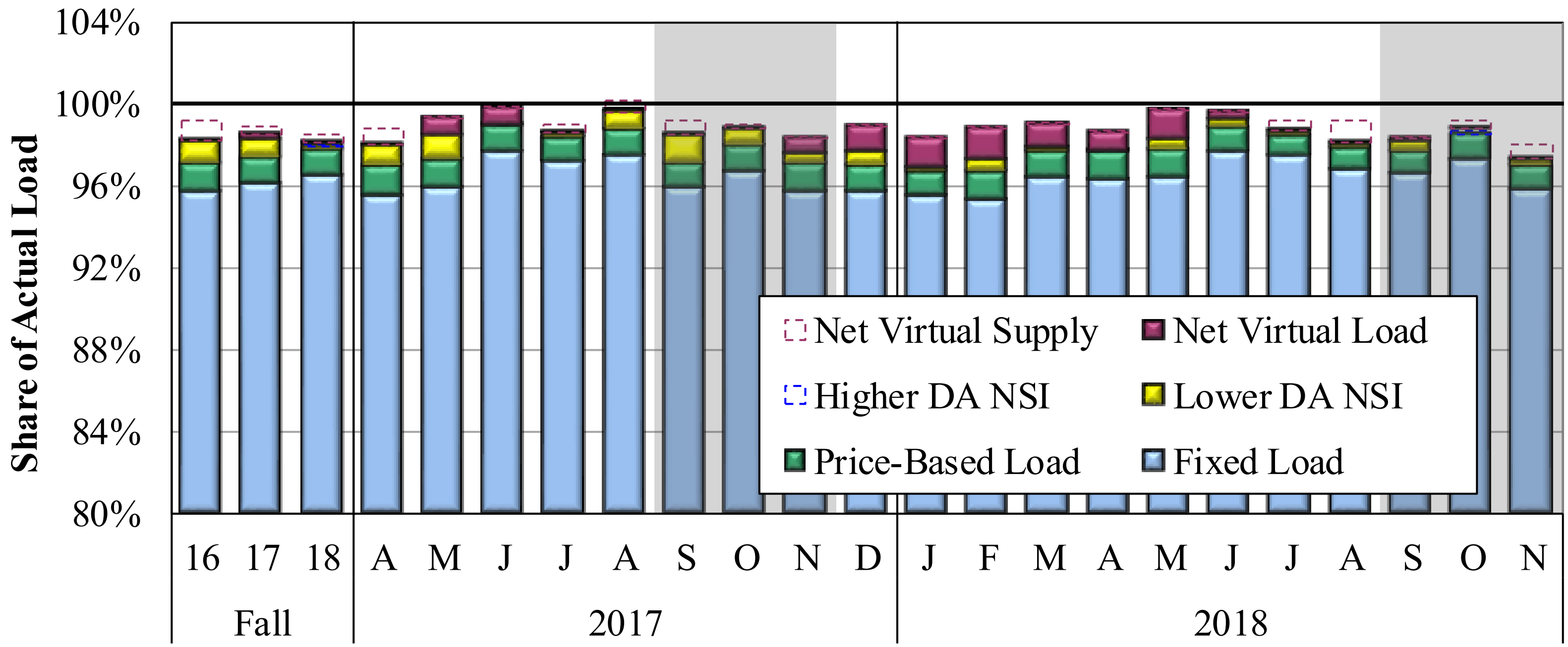


Average DA-RT Price Difference Including RSG (% of Real-Time Price)

Indiana Hub	-4	1	-16	3	2	4	-6	-8	0	-4	-10	4	2	-2	-5	7	1
Michigan Hub	-4	-1	-11	-1	0	2	-2	1	-1	-2	-9	4	1	-4	-5	4	-2
Minnesota Hub	-5	-1	-7	-10	3	0	3	-6	1	0	-4	-2	3	-4	-6	2	1
WUMS Area	-3	0	-11	0	0	2	2	-3	0	-6	-1	-2	-8	1	-4	3	0
Arkansas Hub	0	-3	-2	5	-3	1	-7	-1	0	-4	4	4	3	-4	-11	3	-1
Texas Hub	1	-4	1	8	-6	4	-5	-1	0	-5	8	2	4	-5	-12	2	-1
Louisiana Hub	0	-6	-1	7	-5	5	3*	3	0	-3	10	-13	9	-12	-18	4	-6

* Excluding Jan. 17-18, 2018.

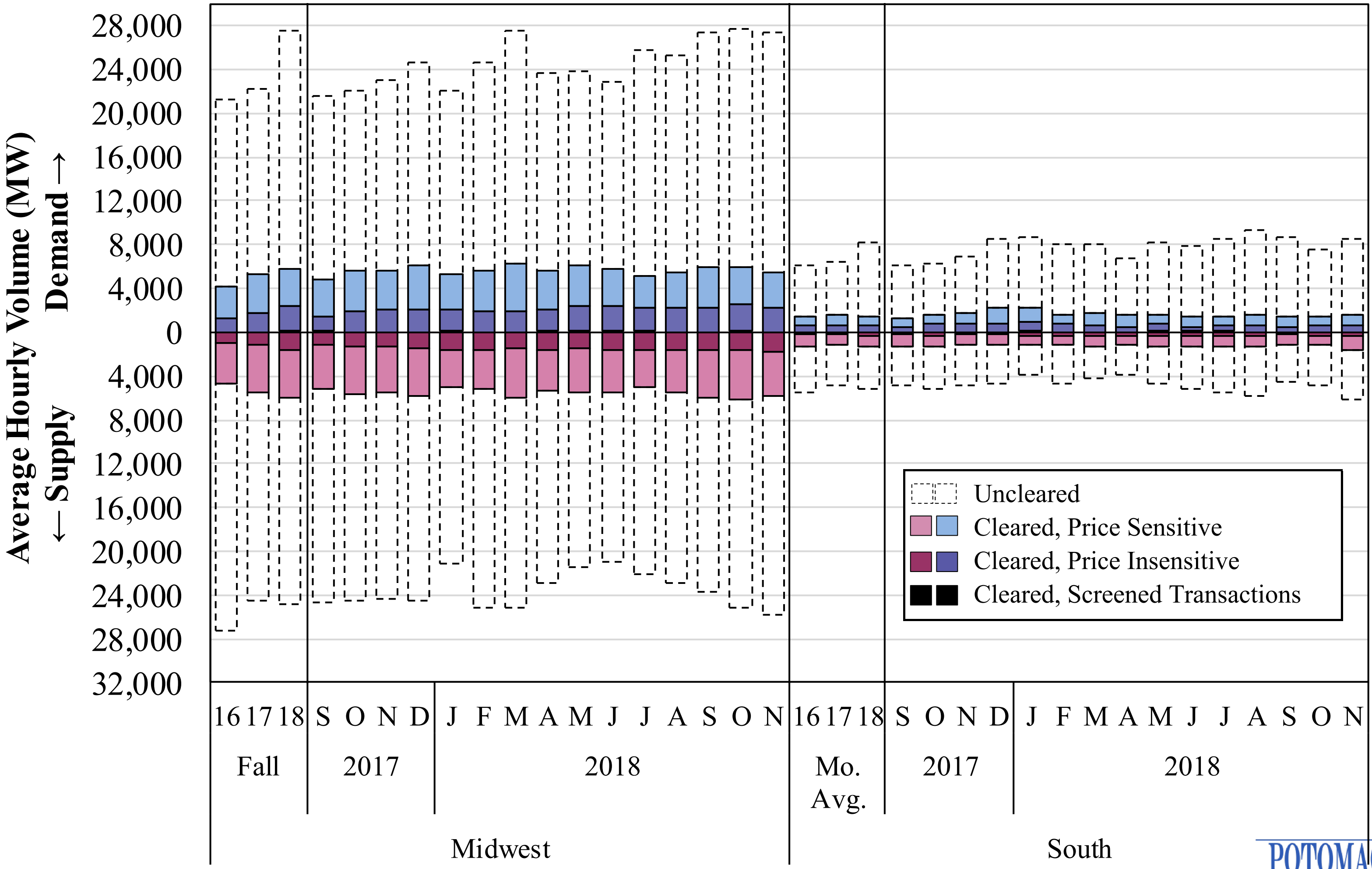
Day-Ahead Peak Hour Load Scheduling
Fall 2017 – 2018



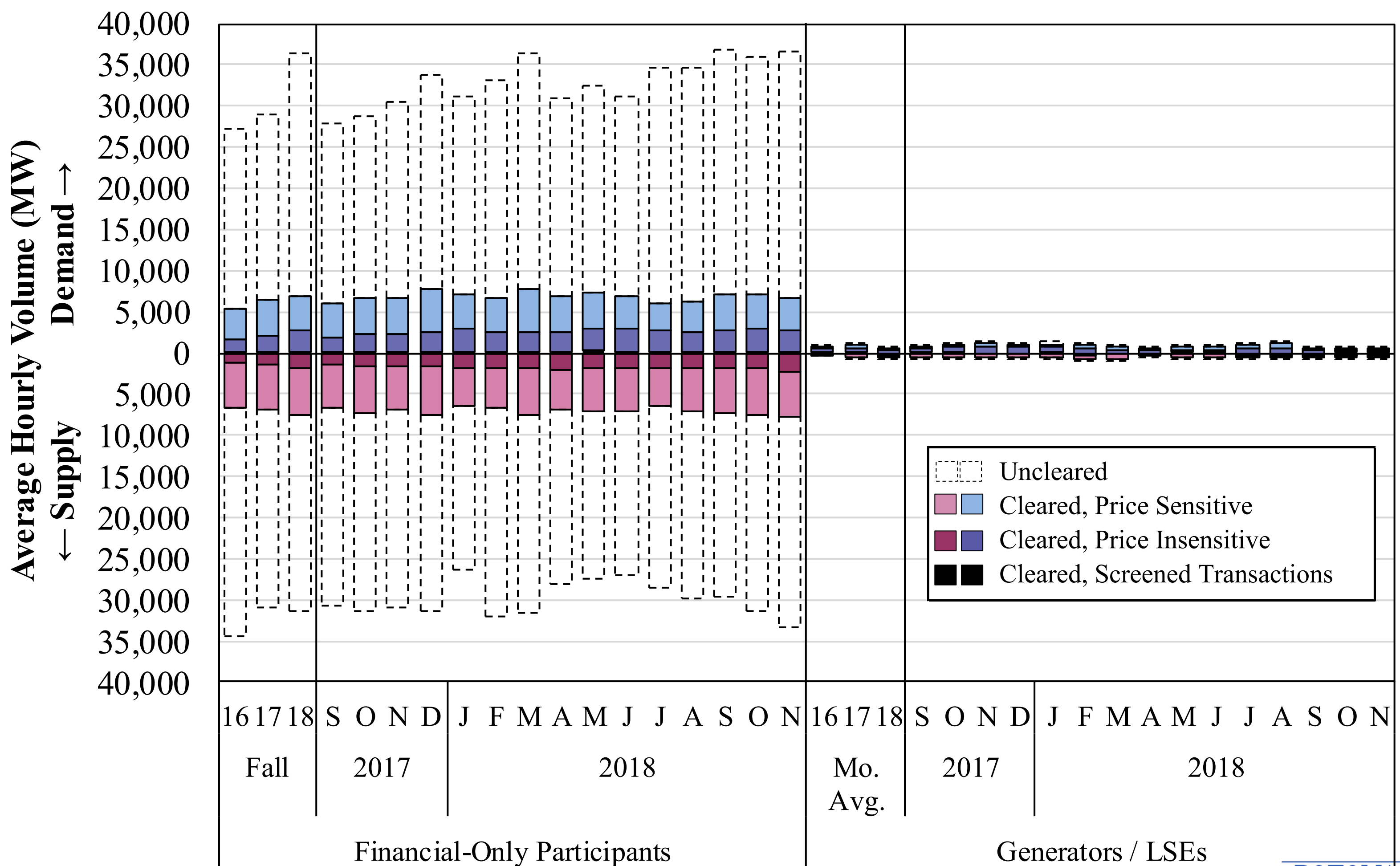
Share of Actual Load (%)

All Hours	98.2	98.8	98.5	98.5	99.3	100.2	99.6	99.9	98.9	98.8	98.6	99.2	98.7	98.6	99.3	98.6	100.0	99.7	99.4	99.3	98.9	99.1	97.5
Peak Hours Midwest	97.7	98.4	97.6	97.0	97.8	99.5	97.3	98.0	98.9	97.6	98.6	98.8	98.1	97.8	99.5	98.3	99.4	99.3	97.9	97.1	97.6	98.1	97.1
Peak Hours South	99.9	100.6	101.2	100.3	102.3	103.2	102.2	102.9	97.4	103.0	101.4	102.1	101.2	102.3	102.0	101.3	101.5	100.4	100.9	100.6	101.0	102.5	100.1

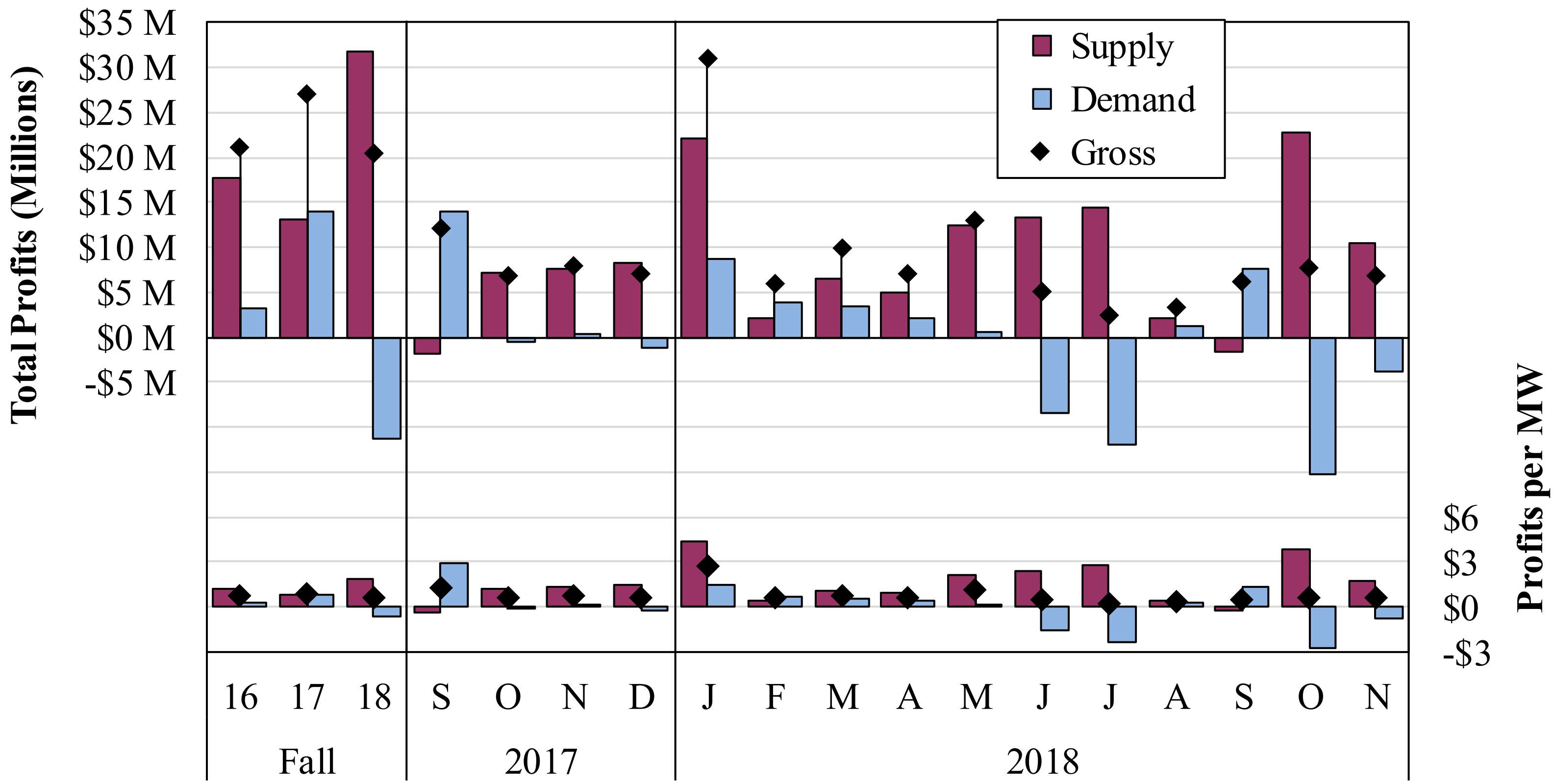
Virtual Load and Supply
Fall 2017 – 2018



Virtual Load and Supply by Participant Type
Fall 2017 – 2018



Virtual Profitability
Fall 2017 – 2018



Percent Screened

Demand	1.2	1.2	1.4	1.7	1.4	0.7	0.6	2.3	0.6	1.2	1.3	3.1	2.7	2.3	0.8	1.2	1.9	1.1
Supply	0.4	0.4	0.3	0.5	0.4	0.2	0.3	0.9	0.2	0.3	0.4	0.5	0.5	0.4	0.1	0.2	0.4	0.4
Total	0.8	0.8	0.9	1.0	0.9	0.5	0.4	1.6	0.4	0.7	0.8	1.9	1.6	1.3	0.4	0.7	1.1	0.7

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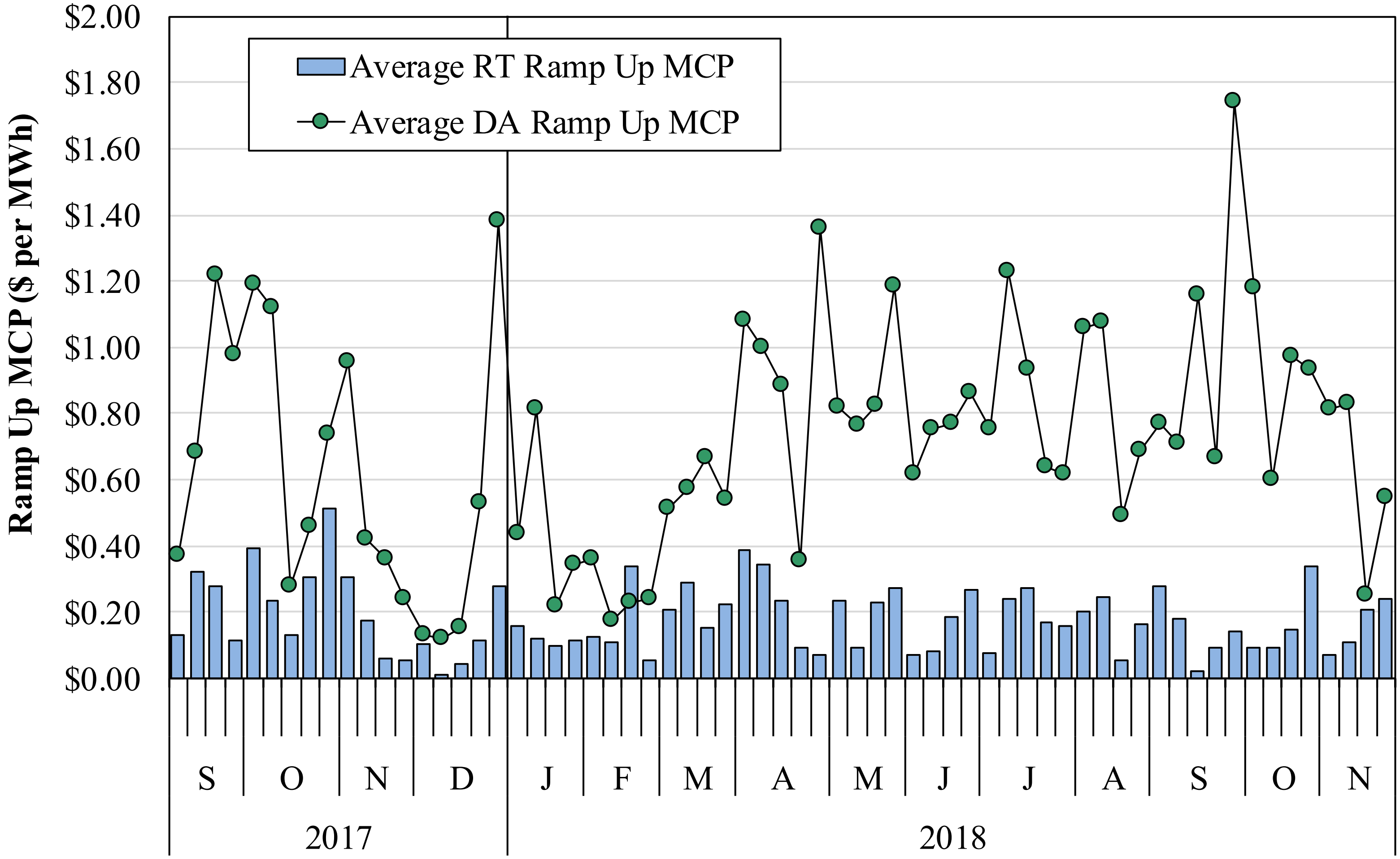
Day-Ahead and Real-Time Ramp Up Price 2017 – 2018



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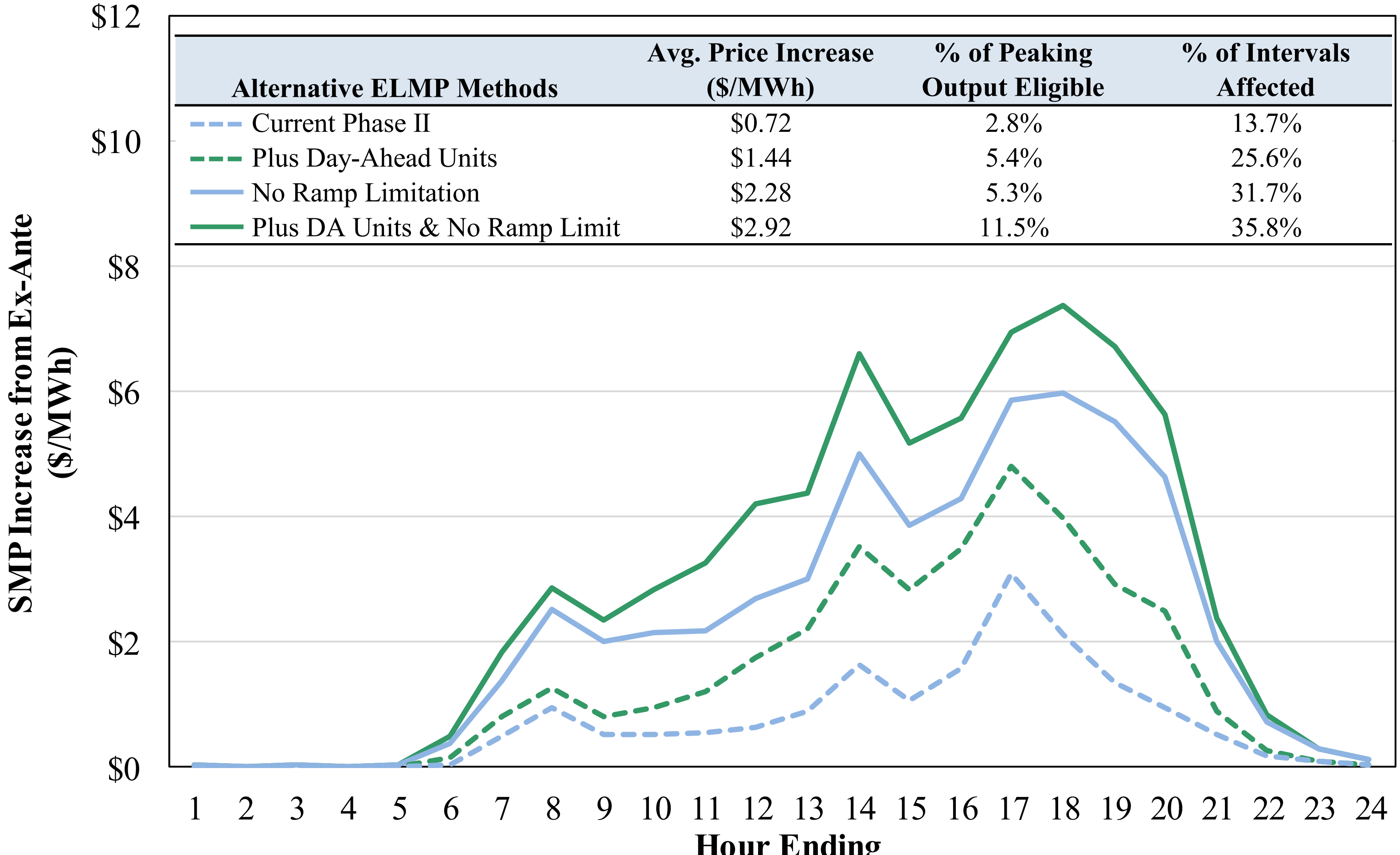
Evaluation of ELMP Assumptions Fall 2018



Alternative ELMP Methods	Avg. Price Increase ($/MWh)	% of Peaking Output Eligible	% of Intervals Affected
Current Phase II	$0.72	2.8%	13.7%
Plus Day-Ahead Units	$1.44	5.4%	25.6%
No Ramp Limitation	$2.28	5.3%	31.7%
Plus DA Units & No Ramp Limit	$2.92	11.5%	35.8%

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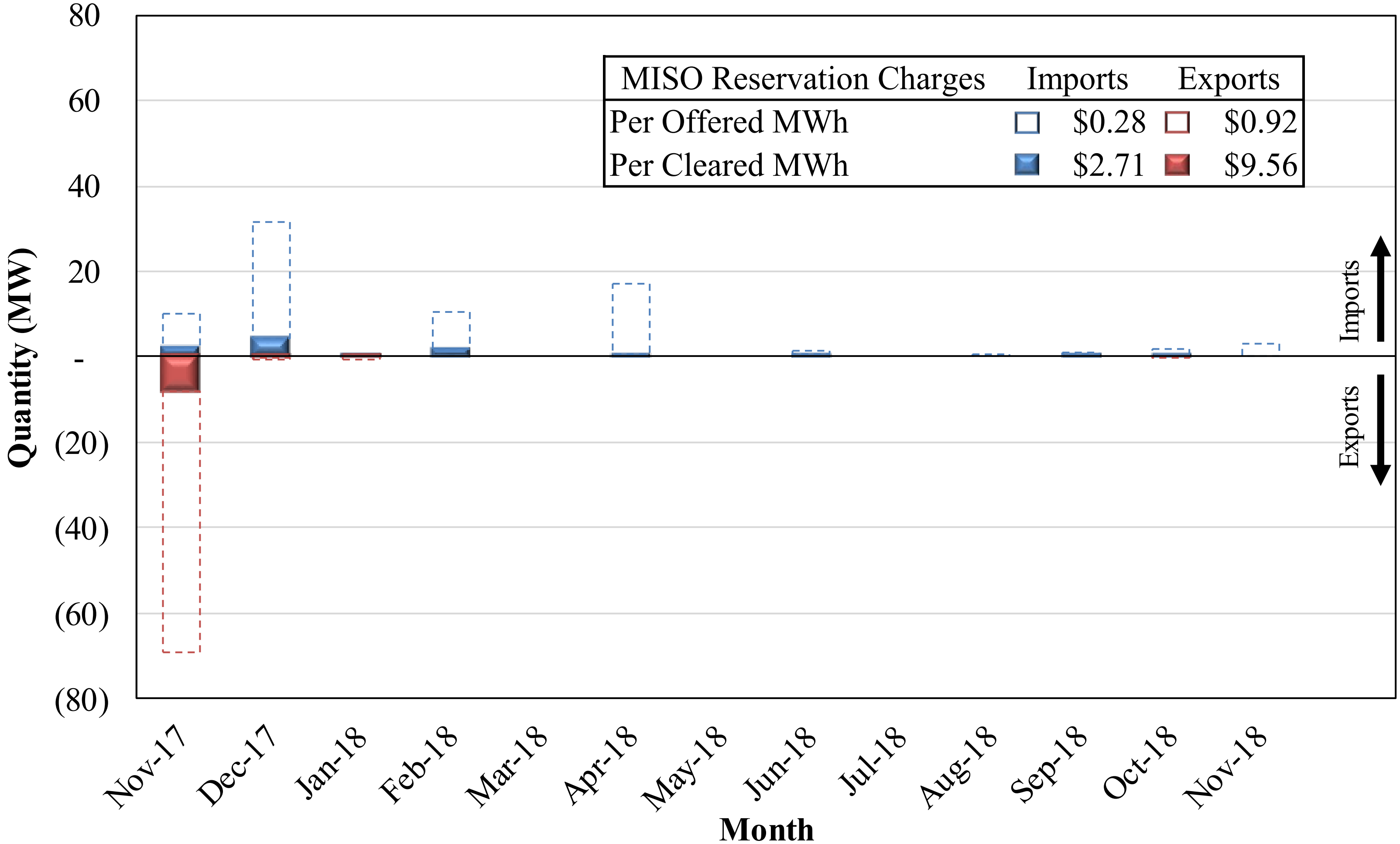
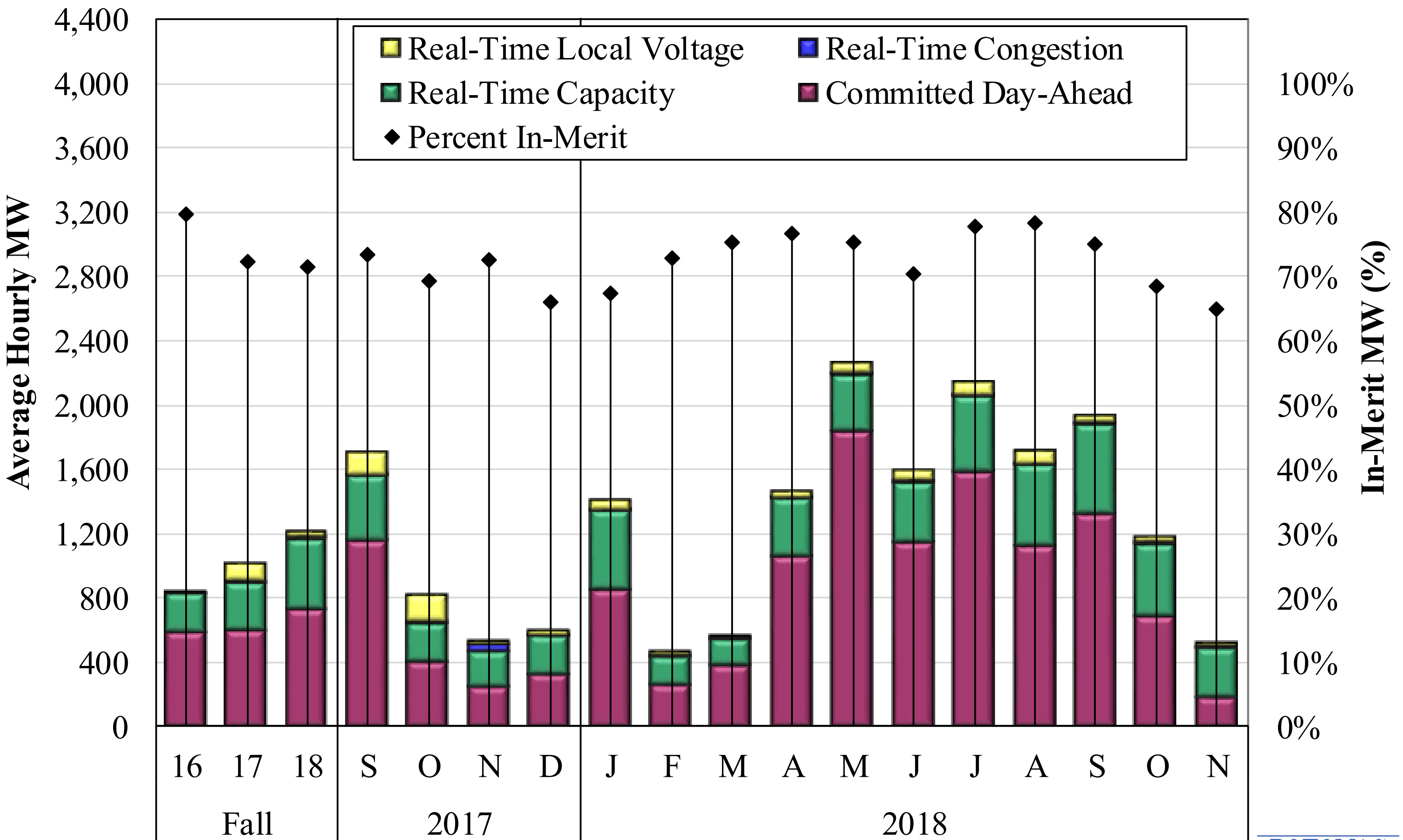
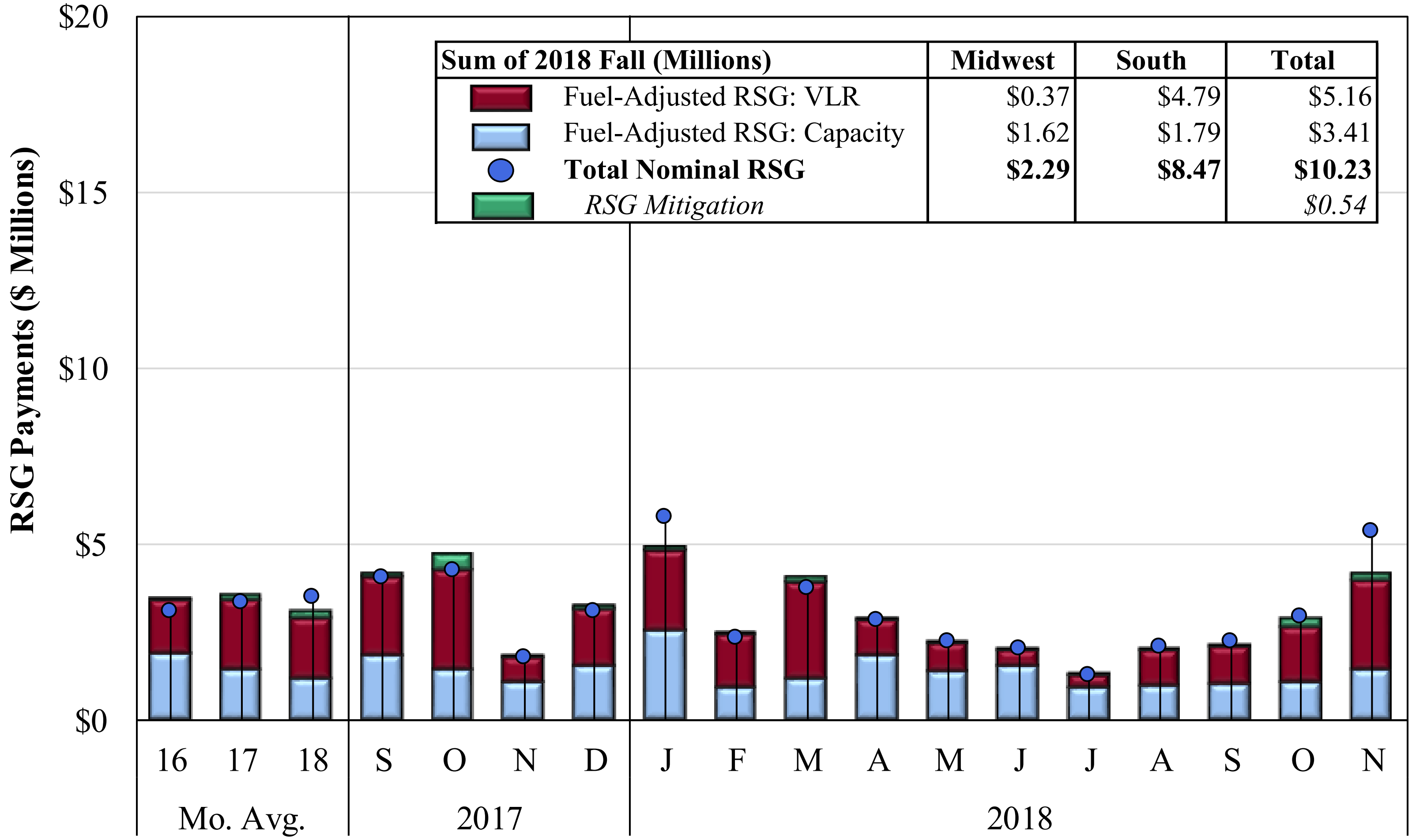
Coordinated Transaction Scheduling (CTS) Fall 2017 - 2018



Peaking Resource Dispatch
Fall 2017 – 2018

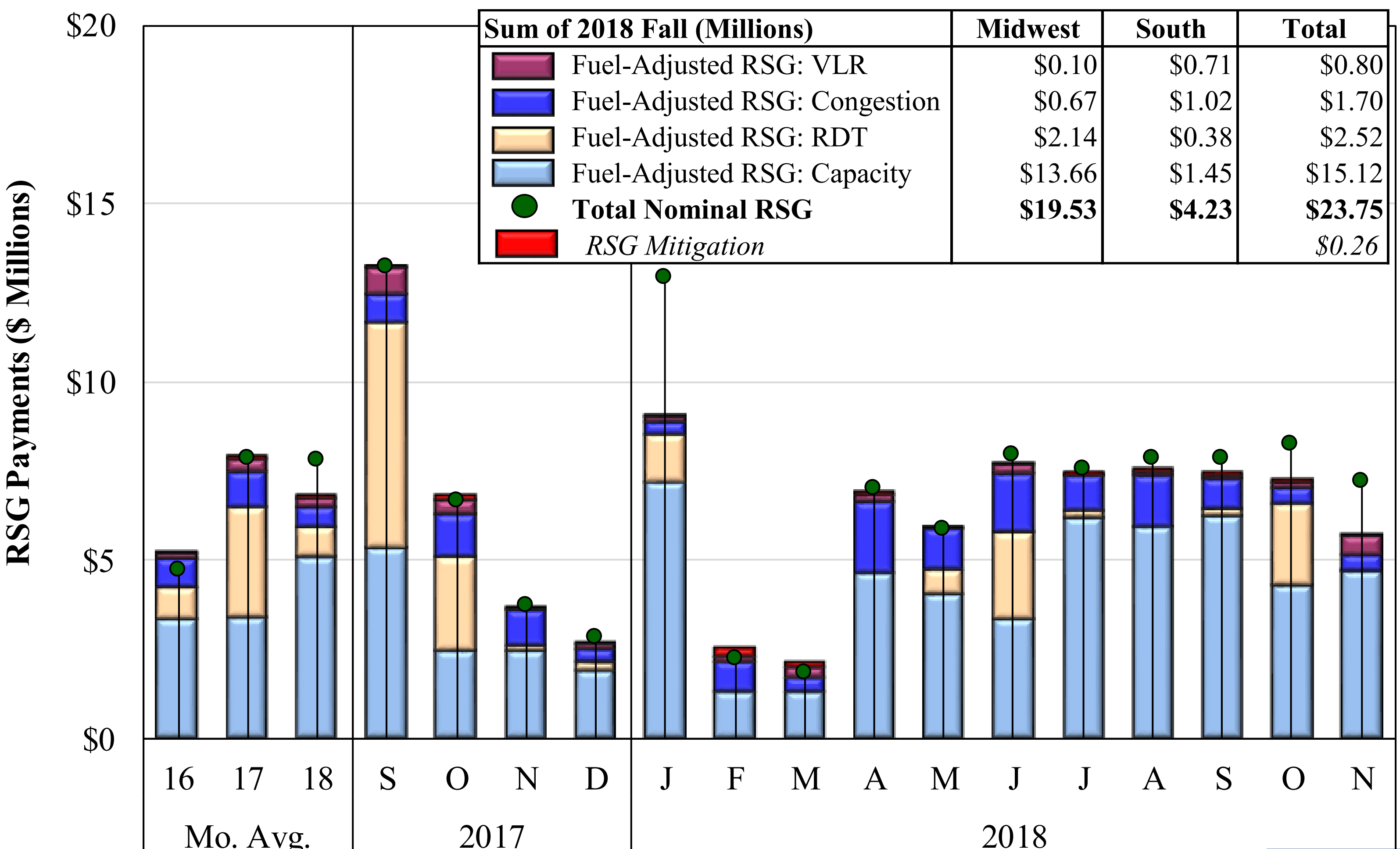


Day-Ahead RSG Payments
Fall 2017 – 2018



Sum of 2018 Fall (Millions)	Midwest	South	Total
Fuel-Adjusted RSG: VLR	$0.37	$4.79	$5.16
Fuel-Adjusted RSG: Capacity	$1.62	$1.79	$3.41
Total Nominal RSG	**$2.29**	**$8.47**	**$10.23**
RSG Mitigation			*$0.54*

Real-Time RSG Payments
Fall 2017 – 2018



Sum of 2018 Fall (Millions)	Midwest	South	Total
Fuel-Adjusted RSG: VLR	$0.10	$0.71	$0.80
Fuel-Adjusted RSG: Congestion	$0.67	$1.02	$1.70
Fuel-Adjusted RSG: RDT	$2.14	$0.38	$2.52
Fuel-Adjusted RSG: Capacity	$13.66	$1.45	$15.12
Total Nominal RSG	**$19.53**	**$4.23**	**$23.75**
RSG Mitigation			*$0.26*

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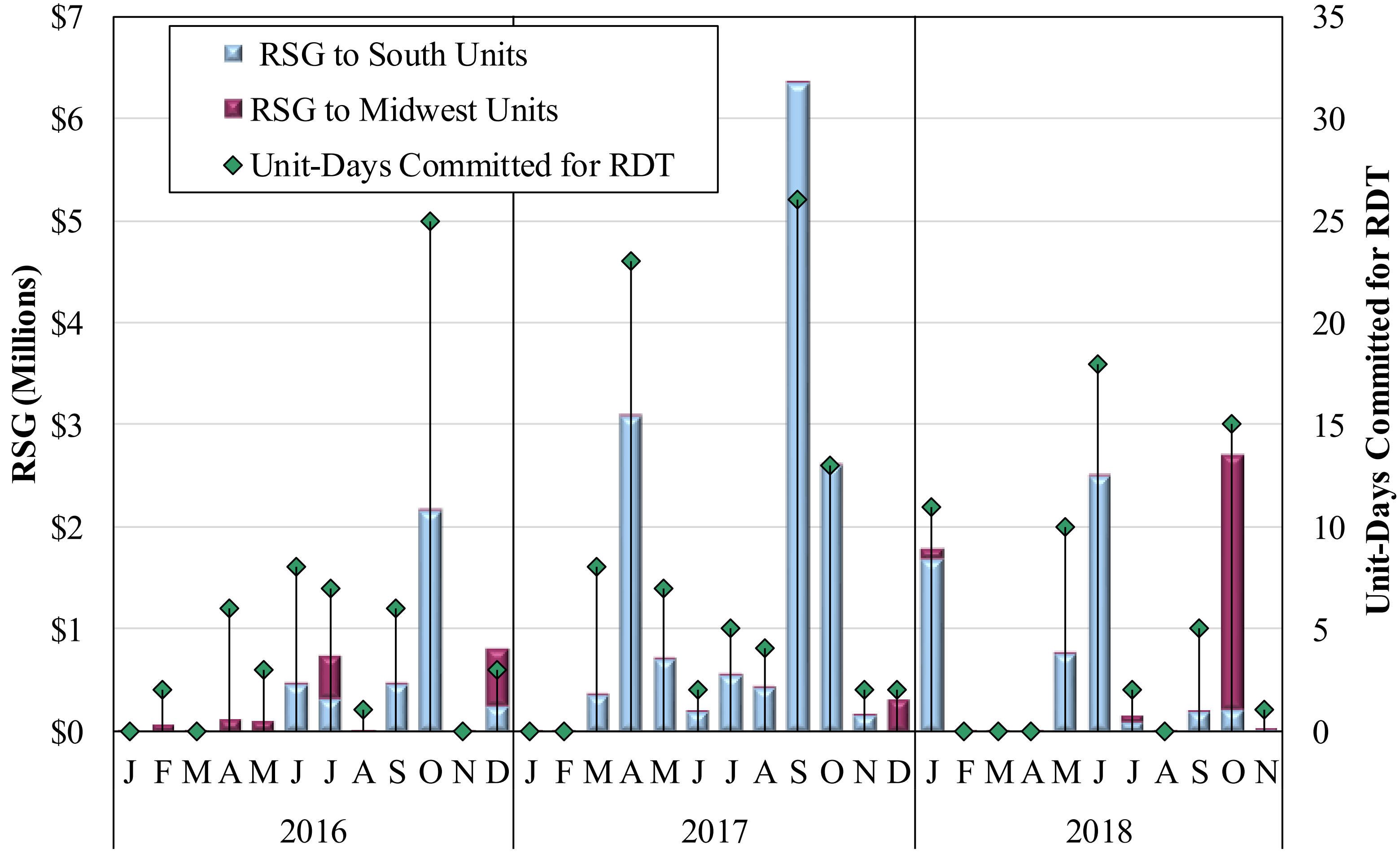
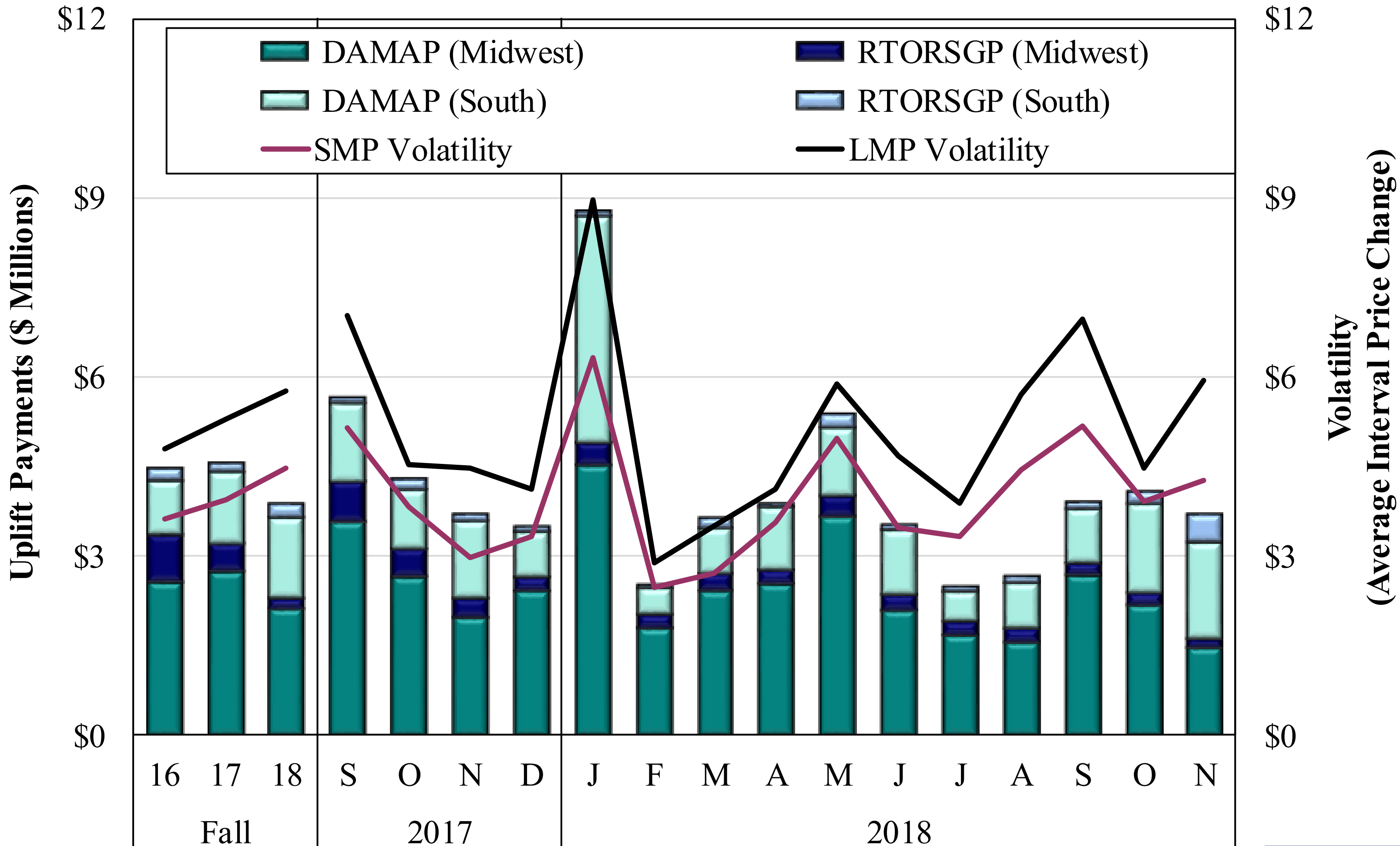
RDT Commitment RSG Payments
2016 – 2018



Price Volatility Make Whole Payments Fall 2017 – 2018



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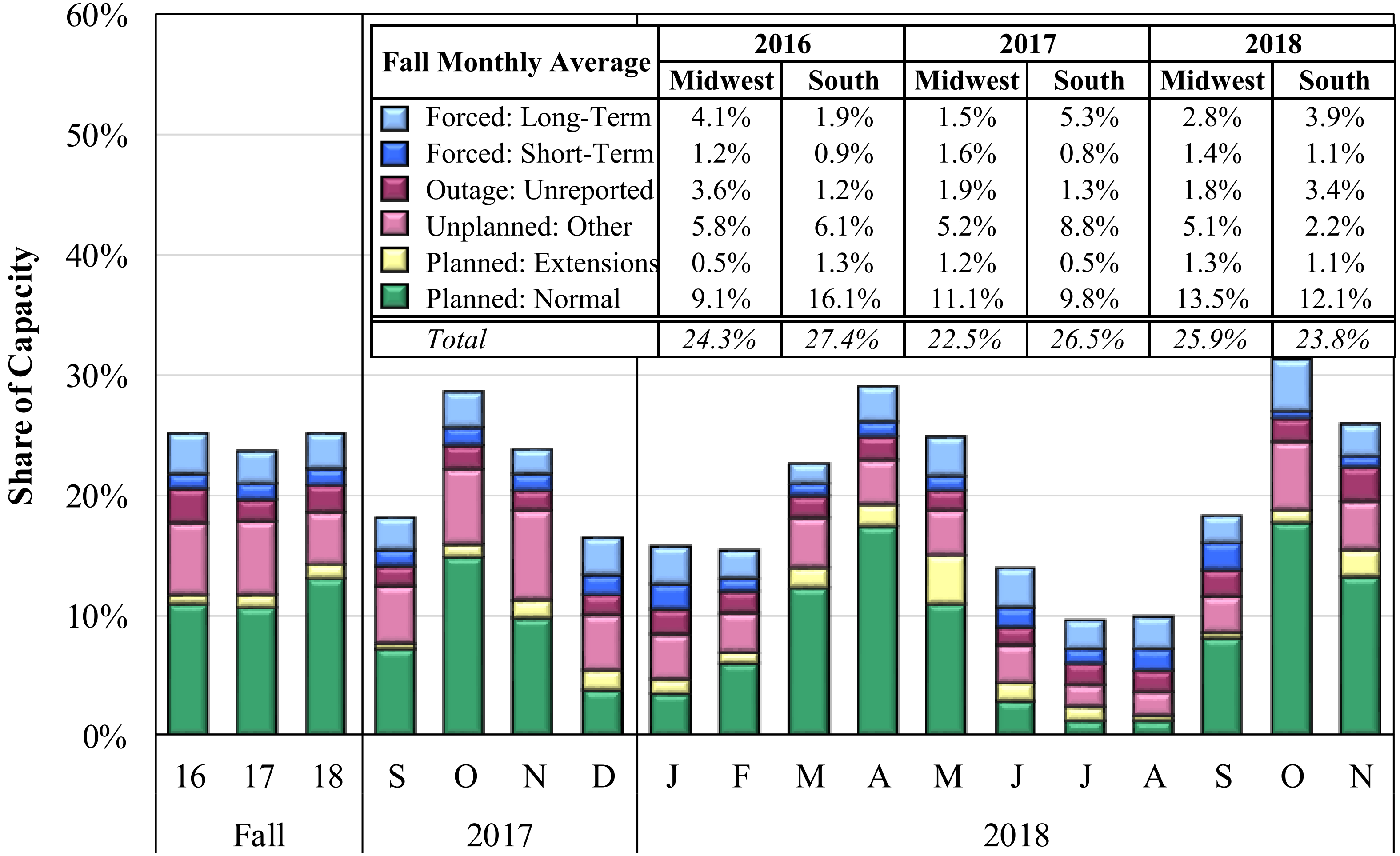
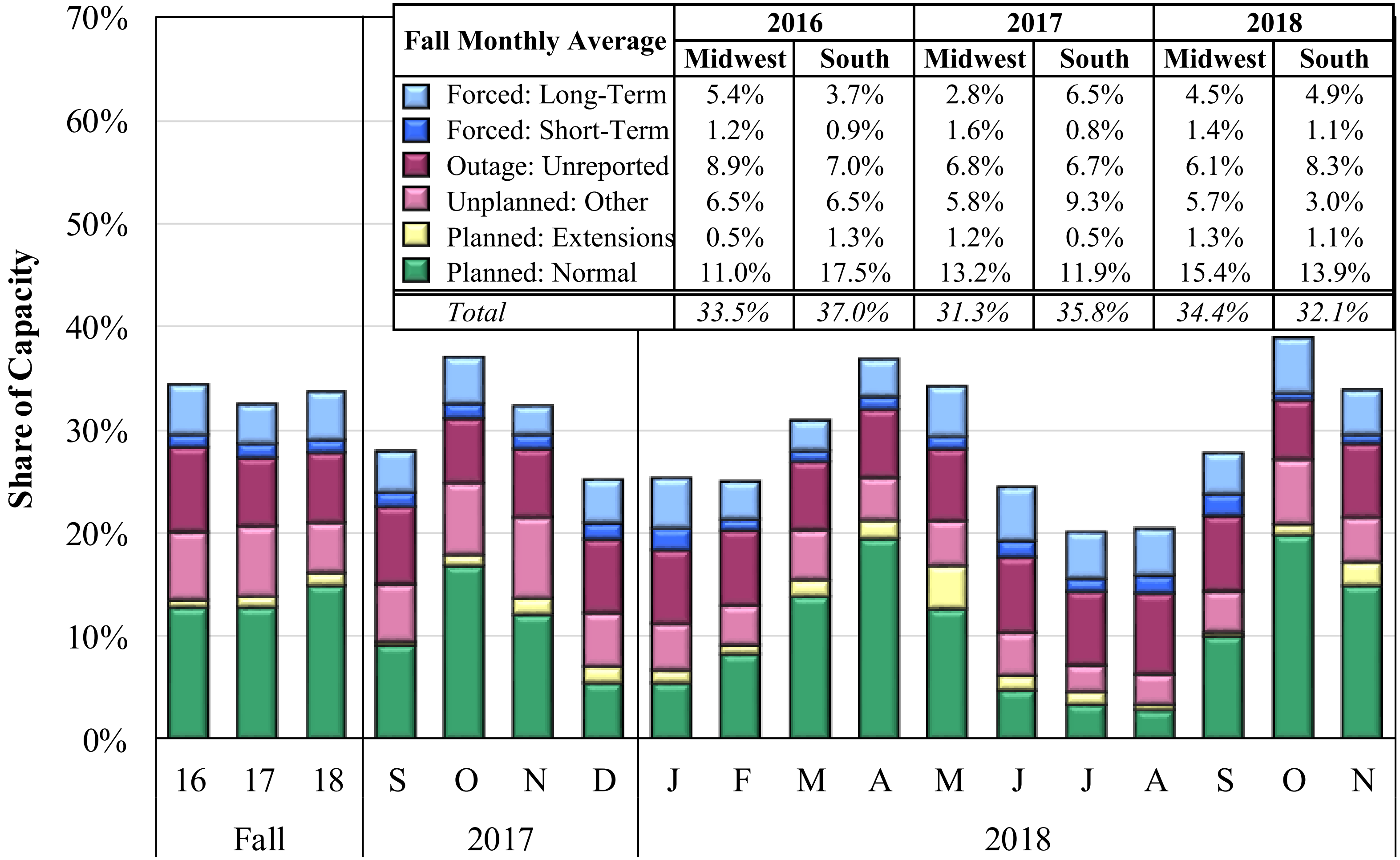
Generation Outage Rates 2017–2018



Fall Monthly Average	2016		2017		2018	
	Midwest	South	Midwest	South	Midwest	South
Forced: Long-Term	4.1%	1.9%	1.5%	5.3%	2.8%	3.9%
Forced: Short-Term	1.2%	0.9%	1.6%	0.8%	1.4%	1.1%
Outage: Unreported	3.6%	1.2%	1.9%	1.3%	1.8%	3.4%
Unplanned: Other	5.8%	6.1%	5.2%	8.8%	5.1%	2.2%
Planned: Extensions	0.5%	1.3%	1.2%	0.5%	1.3%	1.1%
Planned: Normal	9.1%	16.1%	11.1%	9.8%	13.5%	12.1%
Total	*24.3%*	*27.4%*	*22.5%*	*26.5%*	*25.9%*	*23.8%*

POTOMAC ECONOMICS

Generation Outage and Derate Rates 2017–2018



Fall Monthly Average	2016		2017		2018	
	Midwest	South	Midwest	South	Midwest	South
Forced: Long-Term	5.4%	3.7%	2.8%	6.5%	4.5%	4.9%
Forced: Short-Term	1.2%	0.9%	1.6%	0.8%	1.4%	1.1%
Outage: Unreported	8.9%	7.0%	6.8%	6.7%	6.1%	8.3%
Unplanned: Other	6.5%	6.5%	5.8%	9.3%	5.7%	3.0%
Planned: Extensions	0.5%	1.3%	1.2%	0.5%	1.3%	1.1%
Planned: Normal	11.0%	17.5%	13.2%	11.9%	15.4%	13.9%
Total	*33.5%*	*37.0%*	*31.3%*	*35.8%*	*34.4%*	*32.1%*

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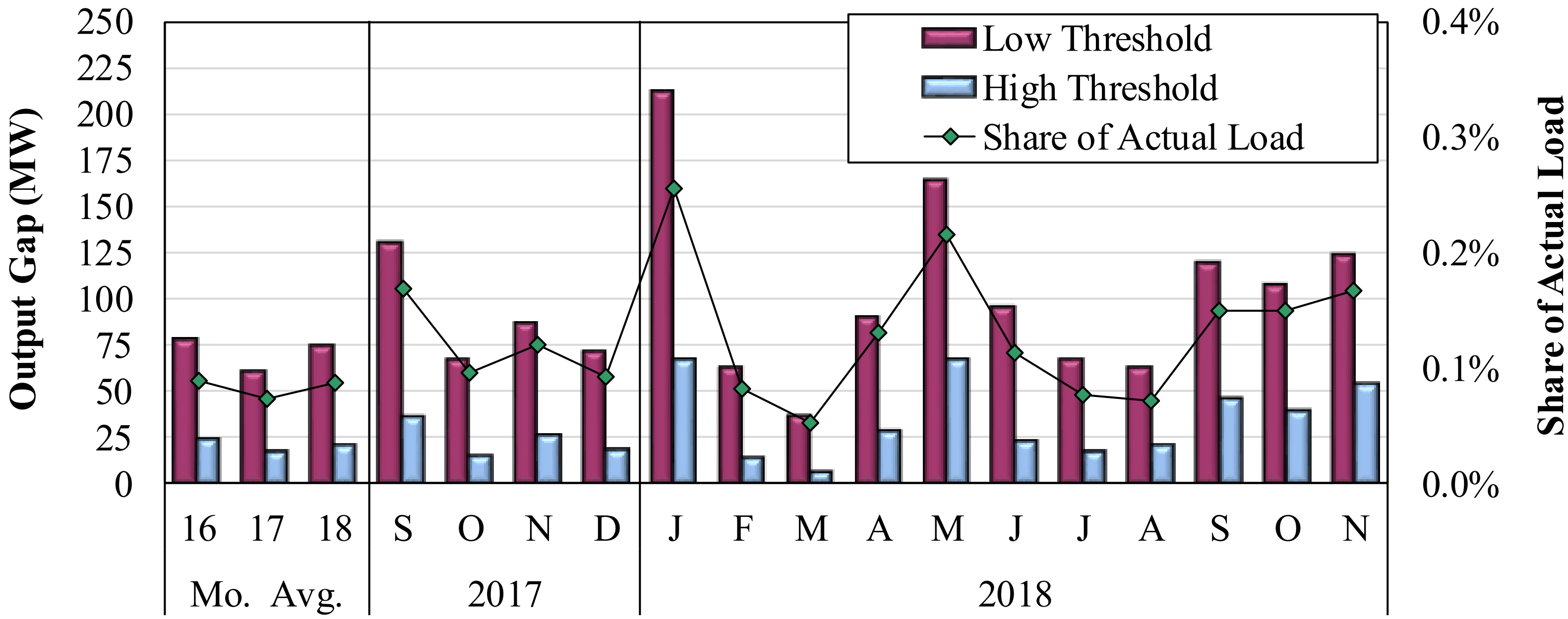
Monthly Output Gap
Fall 2017 – 2018



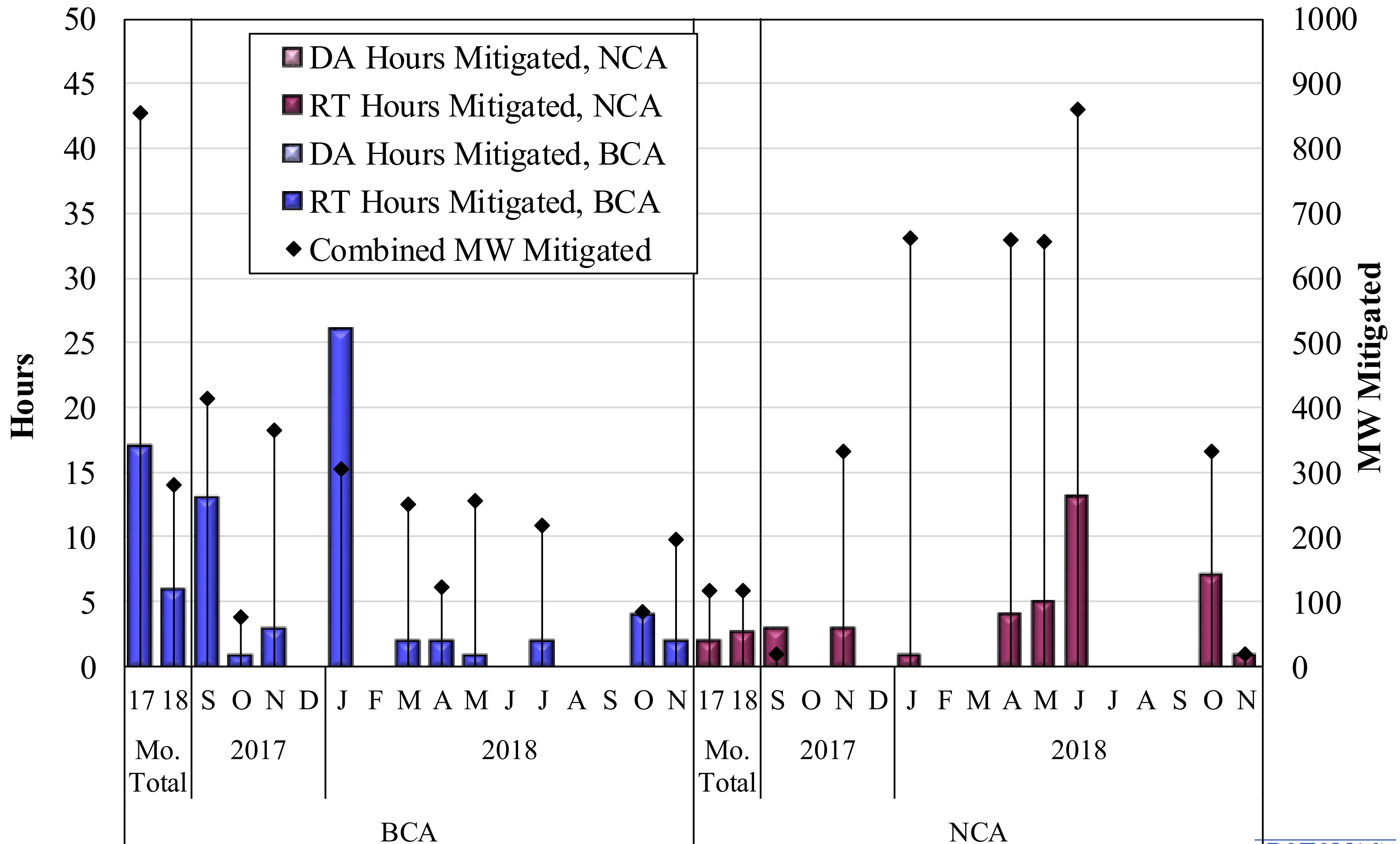
High Threshold Results by Unit Status (MW)

Offline	9	2	6	12	0	0	0	20	0	0	2	33	8	3	8	16	16	5
Online	15	15	14	24	15	26	19	46	14	7	26	33	15	15	13	30	24	48

Low Threshold Results by Unit Status (MW)

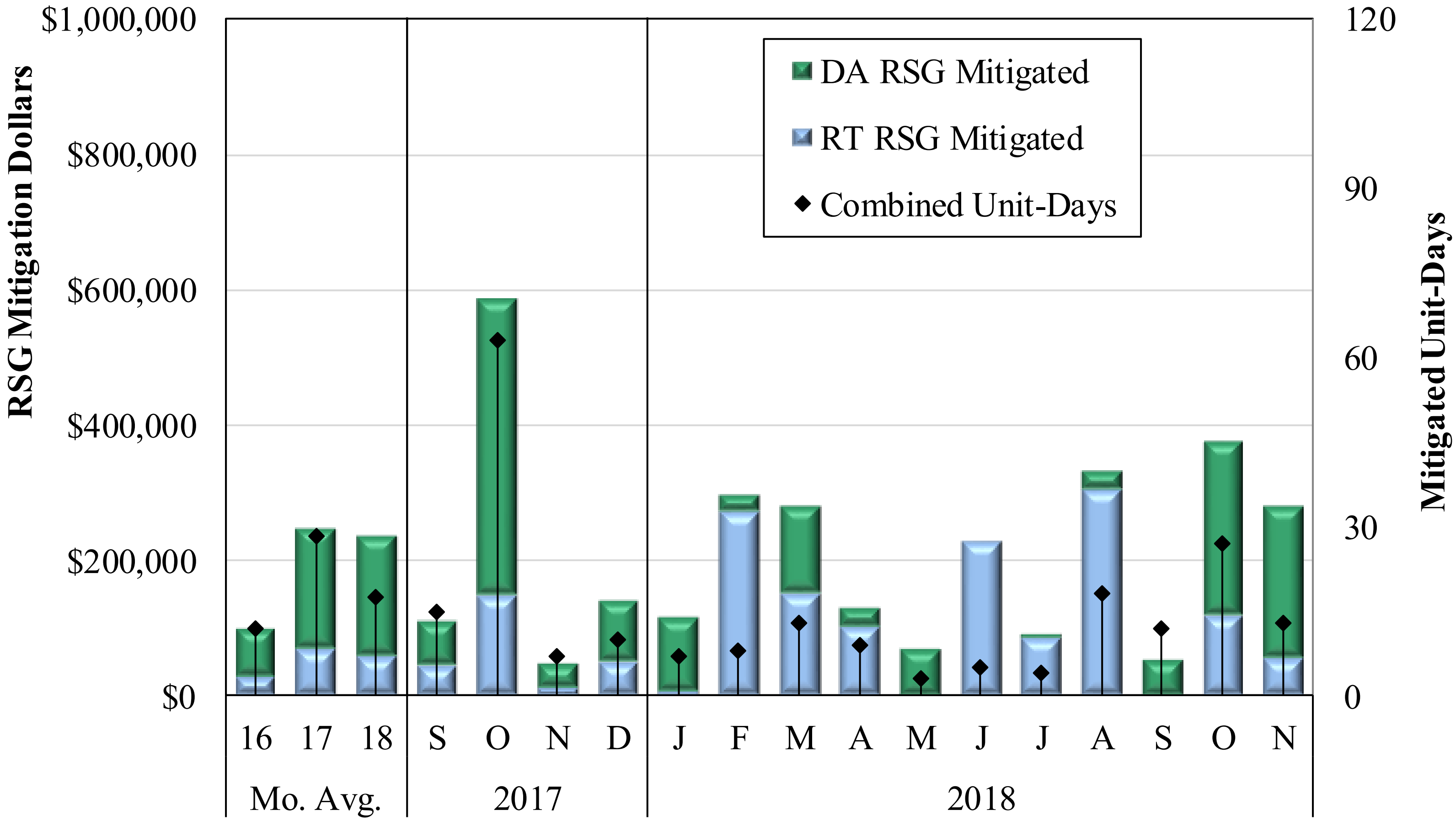
Offline	10	3	8	16	0	0	0	30	0	0	3	40	11	4	8	17	17	6
Online	68	58	68	114	68	86	72	182	63	37	88	124	85	64	55	102	90	118

Day-Ahead And Real-Time Energy Mitigation 2017 – 2018



POTOMAC ECONOMICS

Day-Ahead and Real-Time RSG Mitigation 2017 – 2018



List of Acronyms

- AMP Automated Mitigation Procedures
- BCA Broad Constrained Area
- CDD Cooling Degree Days
- CMC Constraint Management Charge
- CTS Coordinated Transaction Scheduling
- DAMAP Day-Ahead Margin Assurance Payment
- DDC Day-Ahead Deviation & Headroom Charge
- DIR Dispatchable Intermittent Resource
- HDD Heating Degree Days
- ELMP Extended Locational Marginal Price
- JCM Joint and Common Market Initiative
- JOA Joint Operating Agreement
- LAC Look-Ahead Commitment
- LSE Load-Serving Entities
- M2M Market-to-Market
- MSC MISO Market Subcommittee
- NCA Narrow Constrained Area
- ORDC Curve Operating Reserve Demand Curve
- PITT Pseudo-Tie Issues Task Team
- PRA Planning Resource Auction
- PVMWP Price Volatility Make Whole Payment
- RAC Resource Adequacy Construct
- RDT Regional Directional Transfer
- RSG Revenue Sufficiency Guarantee
- RTORSGP Real-Time Offer Revenue Sufficiency Guarantee Payment
- SMP System Marginal Price
- SOM State of the Market
- TLR Transmission Line Loading Relief
- TCDC Transmission Constraint Demand Curve
- VLR Voltage and Local Reliability
- WUMS Wisconsin Upper Michigan System