IMM Quarterly Report: Summer 2017

MISO Independent Market Monitor

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Potomac Economics

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Highlights and Findings: Summer 2017

- The MISO markets performed competitively this summer.
  - ✓ Although natural gas prices rose 6 percent from last summer, real-time energy prices fell 5 percent due to milder temperatures and lower load.
  - ✓ Market power mitigation was infrequent and offer conduct was competitive.
- Despite multiple operating reserve shortages, MISO did not declare any Maximum Generation Events or Emergencies this summer.
  - ✓ The reserve shortages were caused by contingencies rather than high load.
- Capacity prices for the 2017/2018 planning year fell to essentially zero (less than 1 percent of the cost of new entry) because of its poor market design.
- Peak load of 120.6 GW was on July 20, well below the 125 GW forecast.
  - ✓ Although the peak load was similar to last year, MISO avoided emergency conditions this year because its day-ahead forecast was more accurate on peak days and its commitment of resources was more complete.
- Severe weather in June led to islanding in the North, but MISO was able to model the units in the islands and send appropriate prices during the events.

Quarterly Summary

		Value	Change[1] Prior Qtr.	Change[1] Prior Year
RT Energy Prices ($/MWh)	●	$29.90	*0%*	*-5%*
Fuel Prices ($/MMBtu)				
Natural Gas - Chicago	●	$2.80	*-5%*	*6%*
Natural Gas - Henry Hub	●	$2.92	*-3%*	*9%*
Western Coal	●	$0.65	*-1%*	*17%*
Eastern Coal	●	$1.41	*-3%*	*15%*
Load (GW)[2]				
Average Load	●	83.0	*19%*	*-4%*
Peak Load	●	121.3	*31%*	*0%*
% Scheduled DA (Peak Hour)	●	99.3%	98.5%	98.7%
Transmission Congestion ($M)				
Real-Time Congestion Value	●	$334.5	*-28%*	*-28%*
Day-Ahead Congestion Revenue	●	$171.3	*-26%*	*-25%*
Balancing Congestion Revenue[3]	●	-$8.0	$16.3	$3.6
Ancillary Service Prices ($/MWh)				
Regulation	●	$9.38	*-13%*	*7%*
Spinning Reserves	●	$3.06	*-20%*	*30%*
Supplemental Reserves	●	$1.20	*-39%*	*-18%*

		Value	Change[1] Prior Qtr.	Change[1] Prior Year
FTR Funding (%)	●	103%	103%	105%
Wind Output (MW/hr)	●	3,650	*-44%*	*6%*
Guarantee Payments ($M)[4]				
Real-Time RSG	●	$15.9	*-4%*	*-39%*
Day-Ahead RSG	●	$9.3	*-8%*	*5%*
Day-Ahead Margin Assurance	●	$9.8	*-26%*	*-19%*
Real-Time Offer Rev. Sufficiency	●	$1.8	*7%*	*-27%*
Price Convergence[5]				
Market-wide DA Premium	●	0.3%	-2.2%	-2.4%
Virtual Trading				
Cleared Quantity (MW/hr)	●	13,411	*0%*	*13%*
% Price Insensitive	●	29%	27%	29%
% Screened for Review	●	1%	1%	1%
Profitability ($/MW)	●	$0.72	$1.06	$0.69
Dispatch of Peaking Units (MW/hr)	●	1,390	874	2007
Output Gap- Low Thresh. (MW/hr)	●	61	105	78
Other:				

Key:
- ● Expected
- ● Monitor/Discuss
- ● Concern

Notes:
1. Values not in italics are the value 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.

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Highlights for Summer 2017

<u>Transmission Congestion (Slides 8, 13, 14)</u>

- The value of real-time congestion decreased roughly 30 percent compared to both last summer and last quarter, primarily due to lower congestion in MISO South and on the transfer constraints.
  - ✓ Temperatures and weather-dependent loads were lower than last summer.
  - ✓ Transmission upgrades provided more dispatch flexibility to the load pockets in east Texas.
  - ✓ The use of emergency, temperature-dependent ratings for additional lines reduced congestion this summer on these lines.
  - ✓ Some resources offered more flexible dispatch ranges, reducing congestion management costs during comparable conditions this summer.
- While congestion fell overall, transient conditions led to periods of high localized congestion:
  - ✓ Severe weather in the Midwest in June and in the South in August contributed to several days of very high congestion.
  - ✓ Forced transmission and generation outages in the South contributed to periods of high congestion in Texas and Louisiana throughout the summer.

Highlights for Summer 2017

Shortages and Shortage Pricing Recommendations (Slides 15, 16)

- There were 49 ancillary service shortage intervals this summer, including 9 shortages of total operating reserves (the most costly shortages).
  - ✓ The average shortage pricing was \$0.38 per MWh over all hours and \$207 per MWh in shortage intervals.
  - ✓ The 9 total reserve shortages were priced at an average of \$511 per MWh.
    - – These shortage prices would have been 60 percent higher under the IMM-proposed ORDC, a better reflection of the value of reliability.
- ELMP's offline price-setting continues to mute MISO's shortage pricing.
- Load adjustments (the "offset" value) can significantly affect shortage pricing.
  - ✓ Offset adjustments are often needed to account for unanticipated events.
  - ✓ We recommend that MISO develop clear procedures and more complete logging of offset values.
- Loss of the largest generator in MISO South would have led to RDT violations 1.2 percent of the time during the summer months.
  - ✓ The recommended 30-minute reserve product would price these shortages, and would lead to scheduling changes to substantially reduce them.

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Highlights for Summer 2017

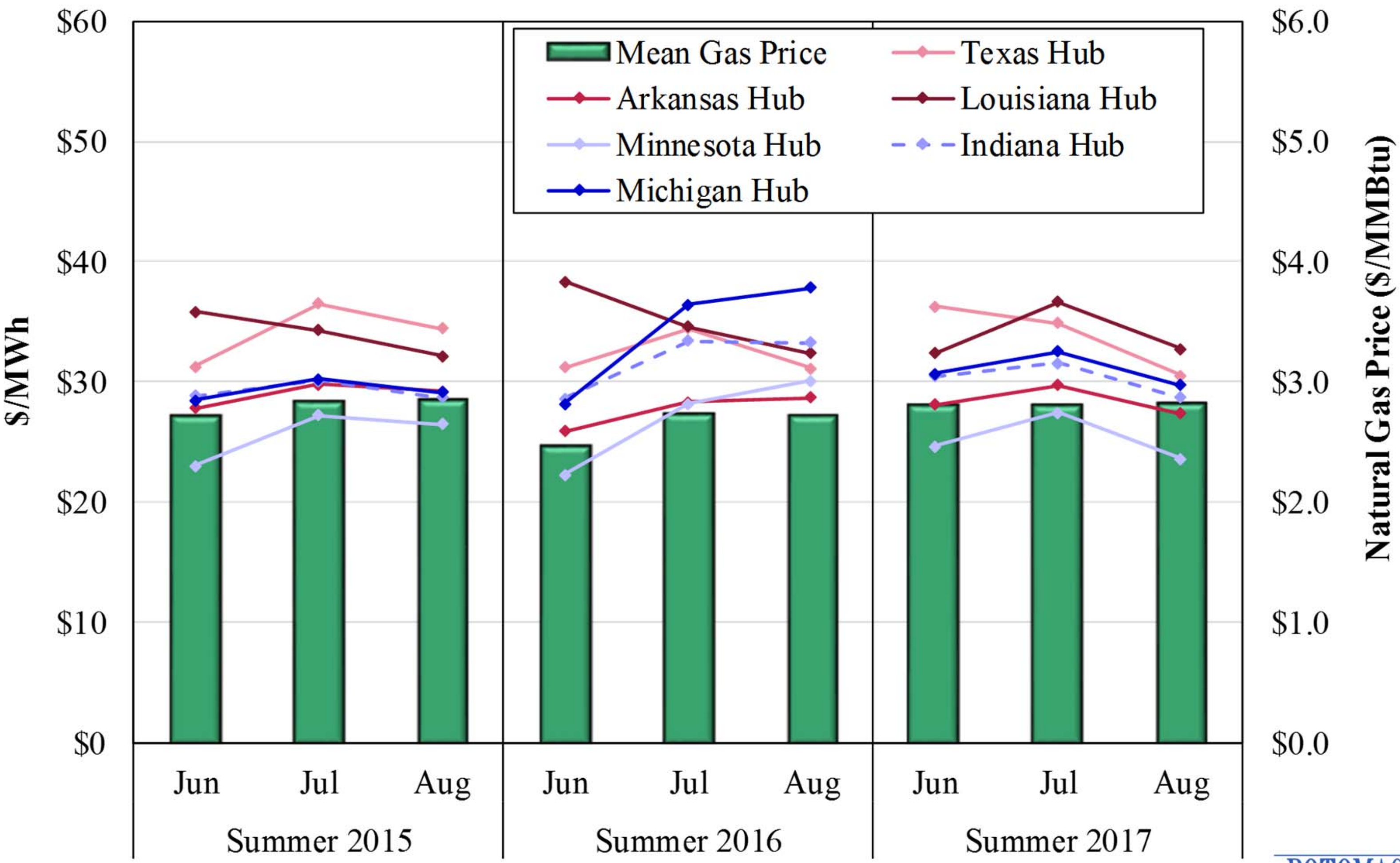
Real-Time Pricing and ELMP (17, 18)

- One of the most important price formation changes MISO has implemented recently is the Extended Locational Marginal Pricing (ELMP) pricing model.
  - ✓ ELMP allows the costs of deploying inflexible, high-cost peaking resources to be reflected in real-time prices.
- Even under the "Phase II" expansion of ELMP, it resulted in only a net price increase of $0.29 per MWh in the real-time energy market.
- The initial implementation was not very effective because of eligibility rules:
  - ✓ Initial rules: < 5 percent of MISO's peaking generation was eligible;
  - ✓ Phase II expansion on May 1: 17 percent were eligible this summer;
  - ✓ IMM has recommended expansion that would raise the eligibility to between 70 and 90 percent of MISO's peaking resources.
- We studied the high-load period of from July 18 to 21 in detail and found:
  - ✓ ELMP increased average LMPs by $2.16 per MWh and lowered RSG more than $300K.
  - ✓ The IMM expansion of ELMP raised LMPs an additional $7 per MWh, reflecting the costs of the peaking units utilized during this period.

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 to discuss market outcomes.
  - ✓ We responded to several data requests related to prior referrals.
  - ✓ We made several notifications of potential tariff violations.
- We supported the filing for Dynamic NCA market power mitigation in July:
  - ✓ We produced an affidavit supporting the recommended mitigation changes;
  - ✓ We continue to support MISO in responding to filed comments and FERC requirements for further clarifications of or revisions to the proposal.
- We continued to participate in a number of MISO working group meetings, including the MISO "Joint and Common Market" meetings with PJM and SPP.
- We also presented a number proposals for the MISO PRA related to our SOM recommendations to the RASC and the LOLEWG.
  - ✓ The changes will enhance both efficiency and reliability by bringing PRA modeling and results in line with how MISO actually operates the system.
- We filed additional protests related to proposed pseudo-tie tariff changes and we continue to recommend that FERC schedule a Technical Conference to review and discuss the extensive list of problems caused by pseudo-ties.

Day-Ahead Average Monthly Hub Prices
Summer 2015–2017



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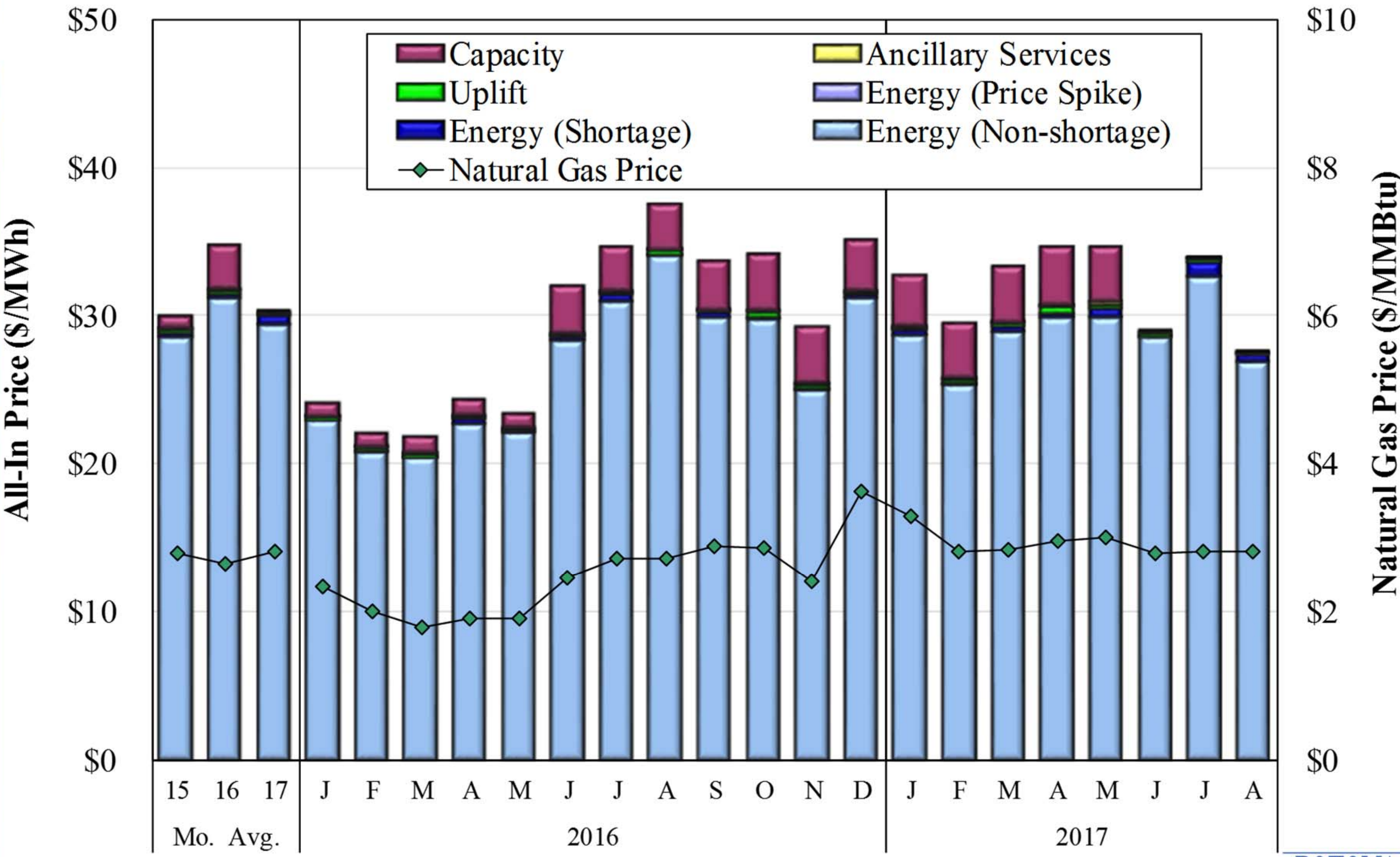
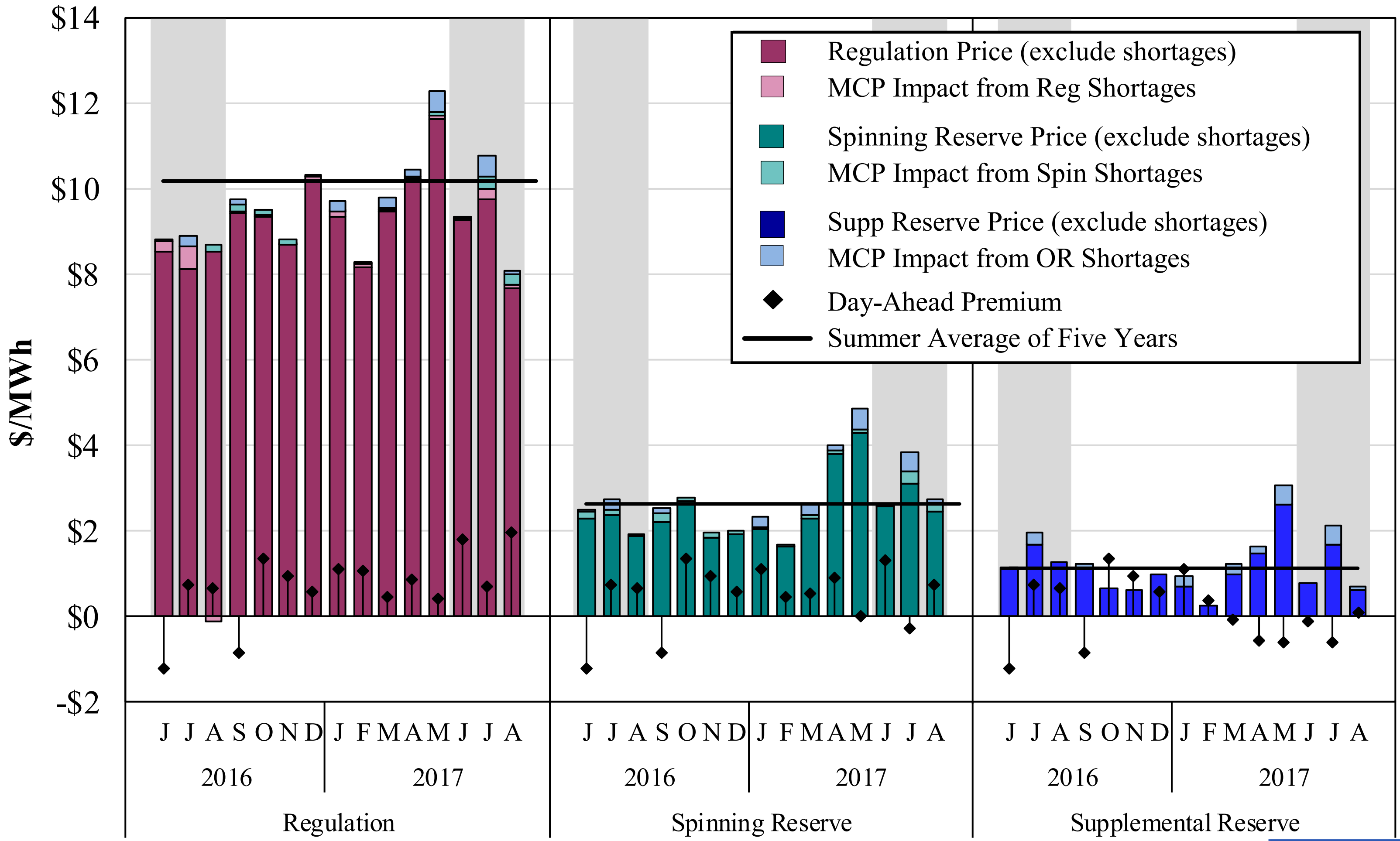
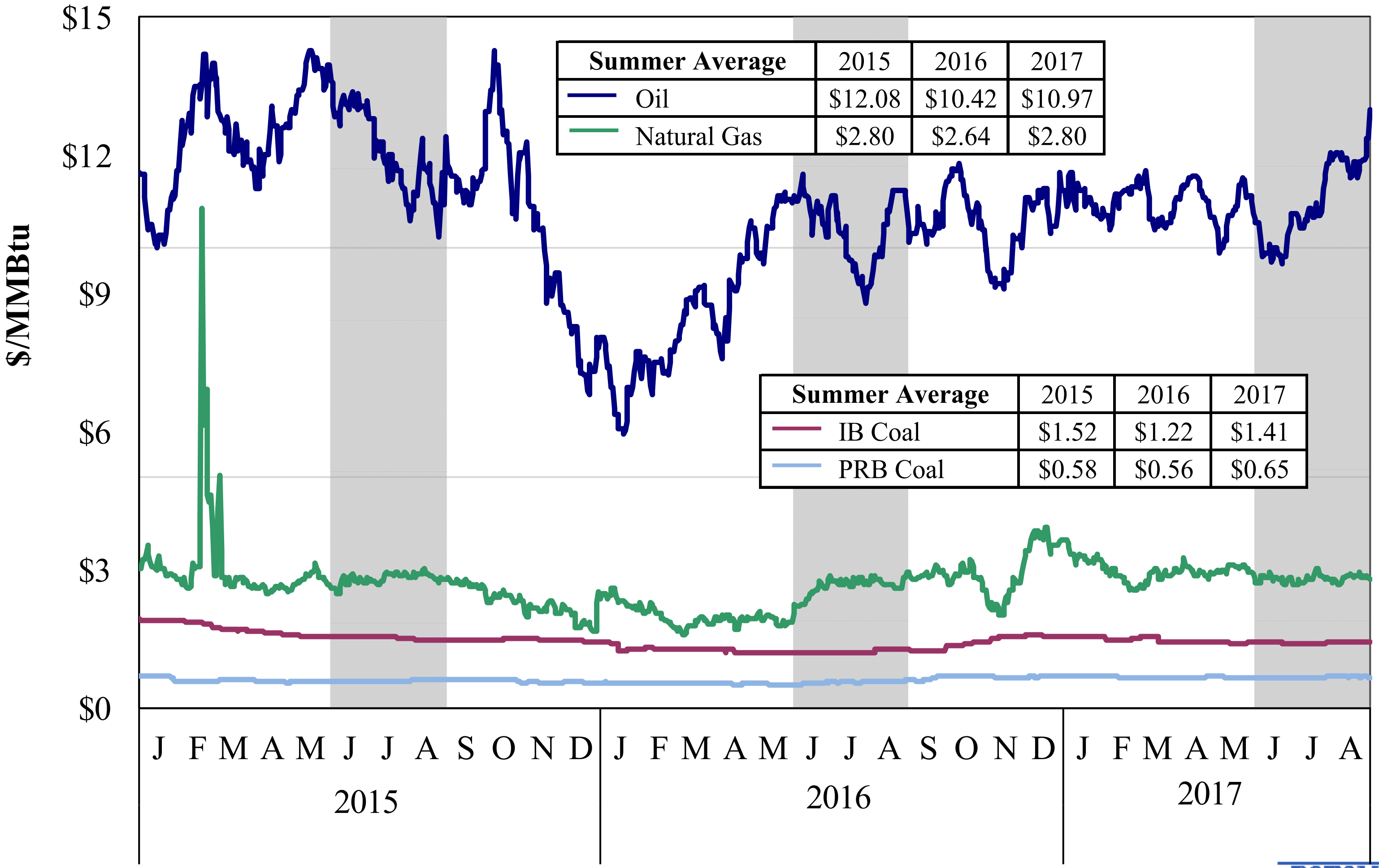
All-In Price
Summer 2015 –2017



Monthly Average Ancillary Service Prices
Summer 2016 –2017



MISO Fuel Prices
2015–2017



Summer Average	2015	2016	2017
Oil	$12.08	$10.42	$10.97
Natural Gas	$2.80	$2.64	$2.80

Summer Average	2015	2016	2017
IB Coal	$1.52	$1.22	$1.41
PRB Coal	$0.58	$0.56	$0.65

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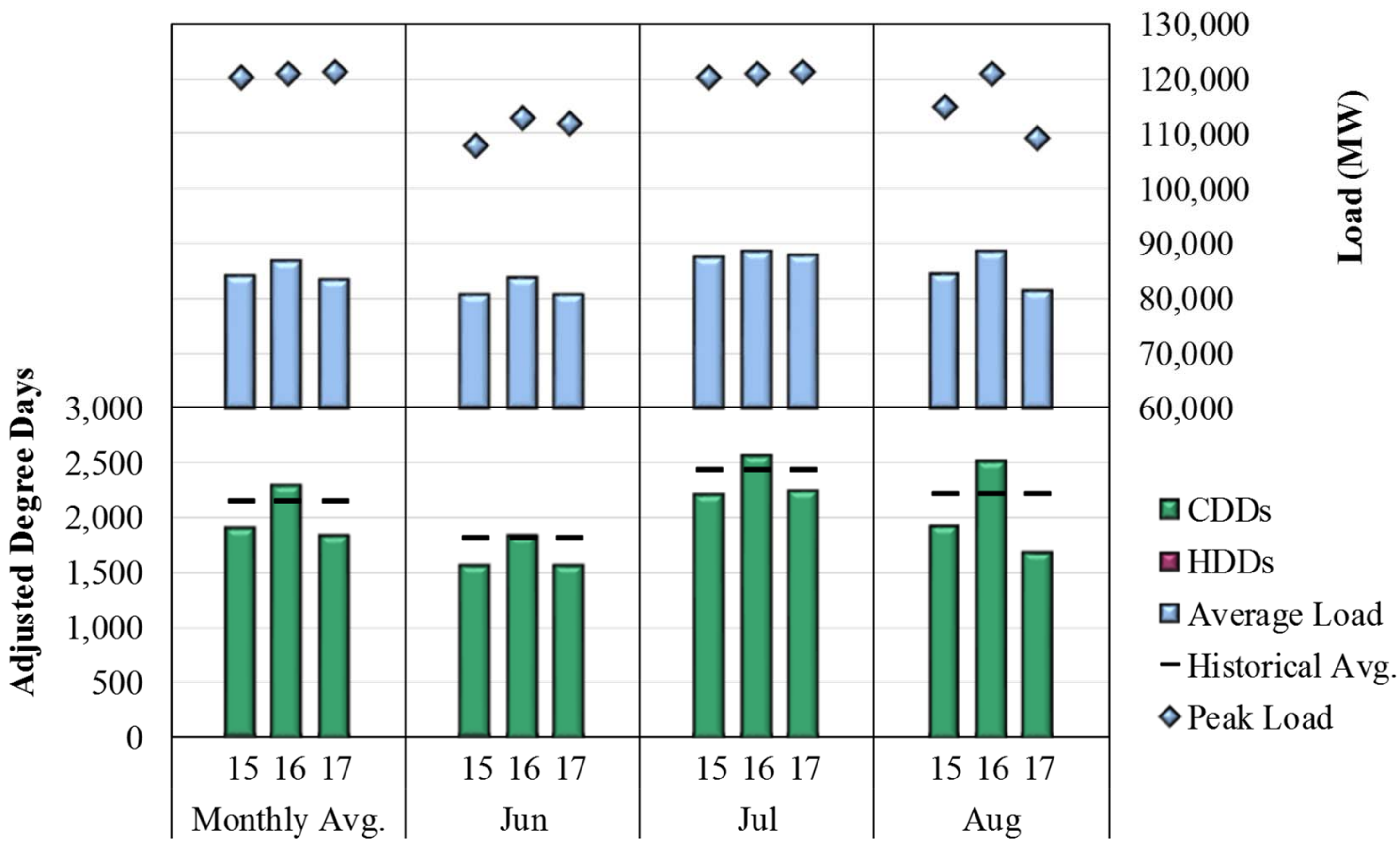
Load and Weather Patterns
Summer 2015–2017



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.

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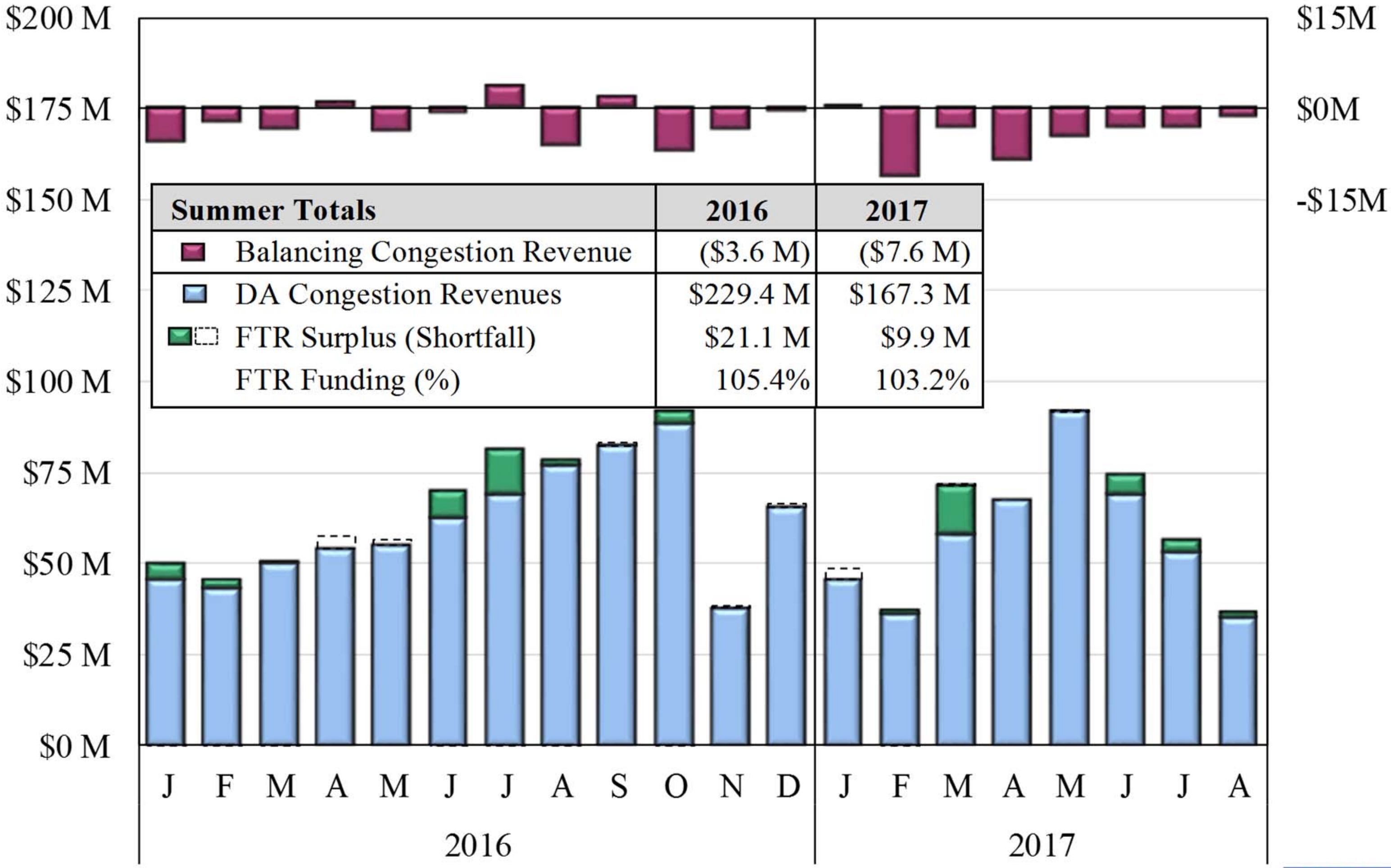
Day-Ahead Congestion, Balancing Congestion and FTR Underfunding, 2016–2017



Summer Totals	2016	2017
Balancing Congestion Revenue	($3.6 M)	($7.6 M)
DA Congestion Revenues	$229.4 M	$167.3 M
FTR Surplus (Shortfall)	$21.1 M	$9.9 M
FTR Funding (%)	105.4%	103.2%

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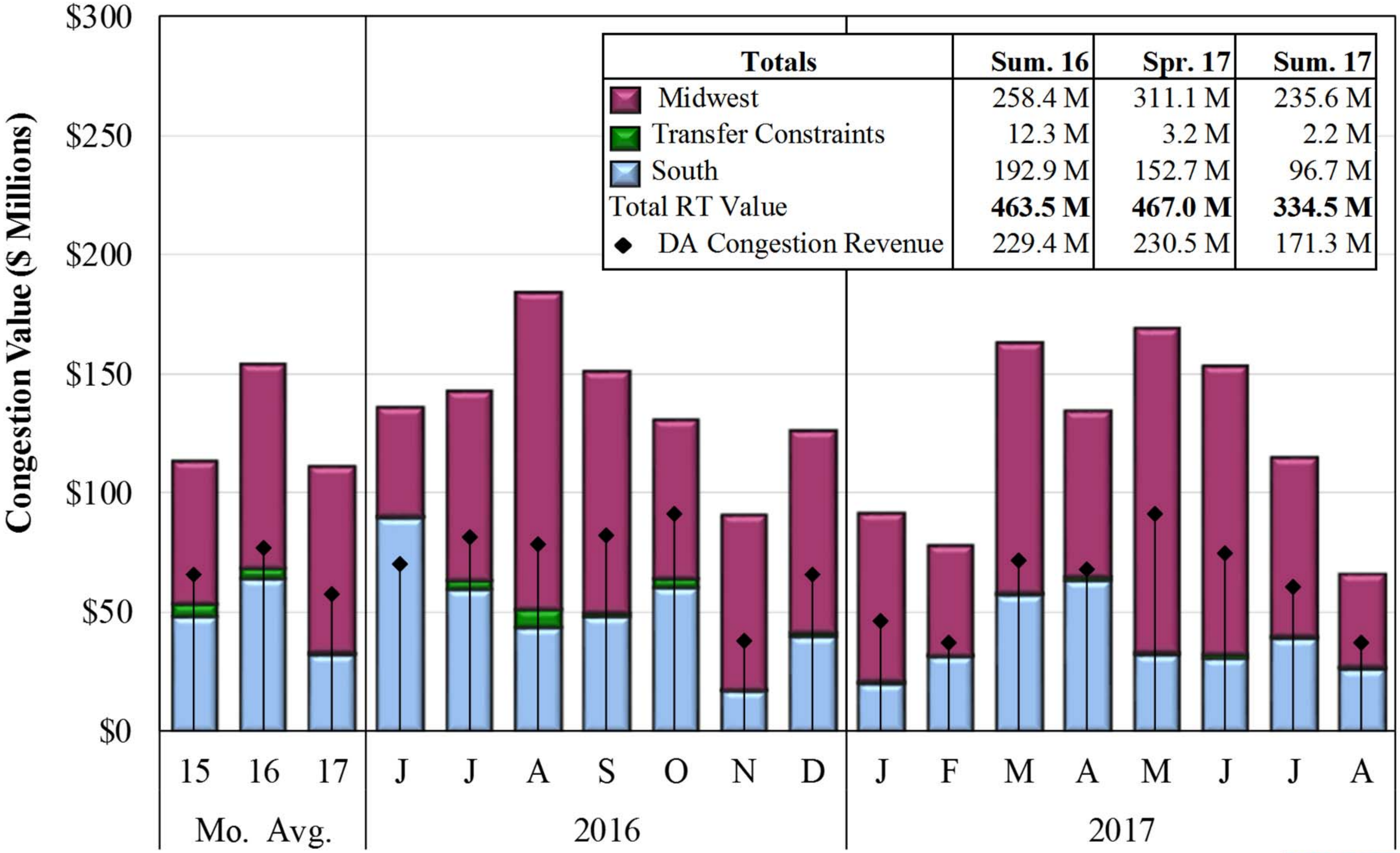
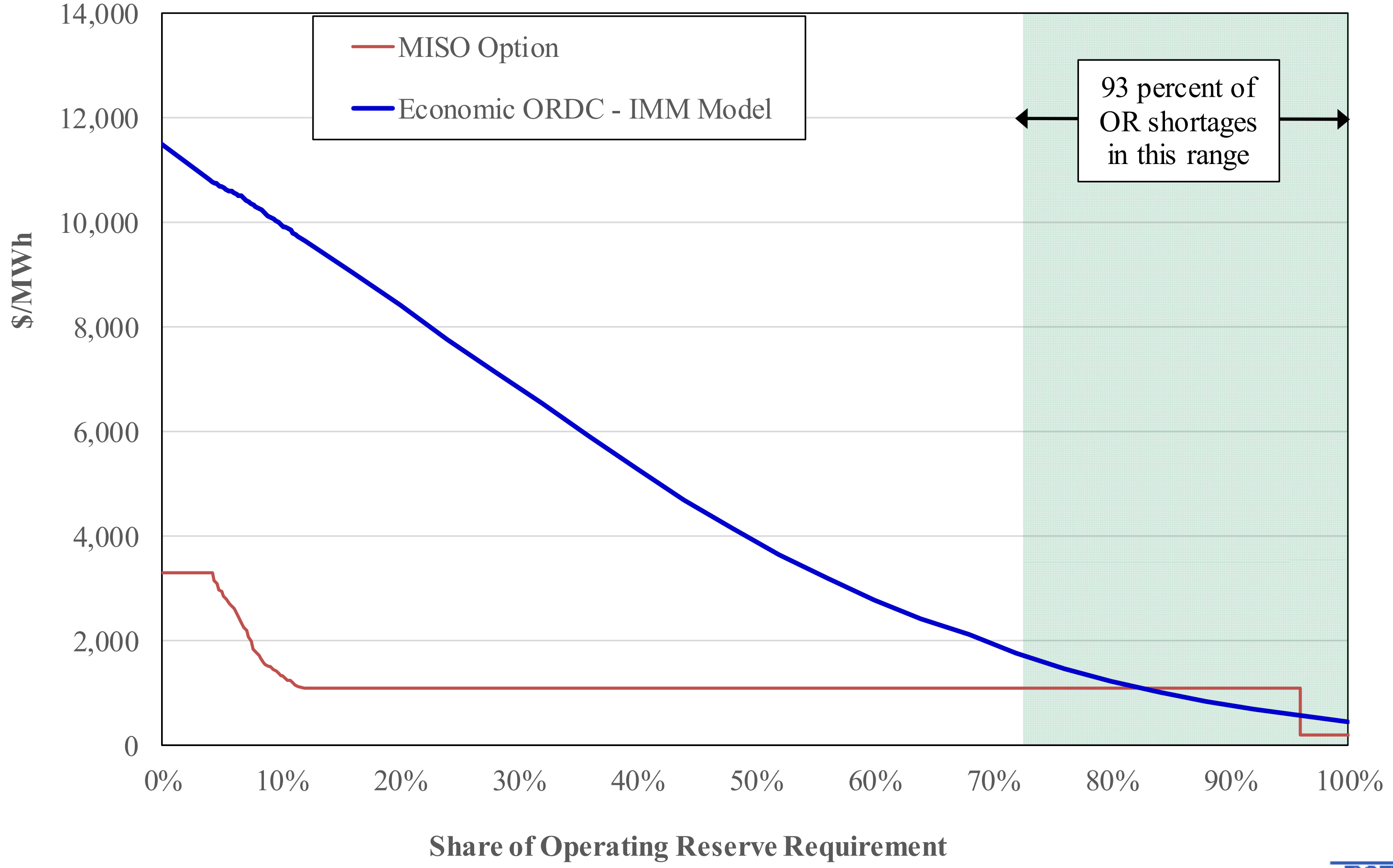
Value of Real-Time Congestion
Spring 2016–2017



IMM Economic ORDC Recommendation and Current MISO ORDC



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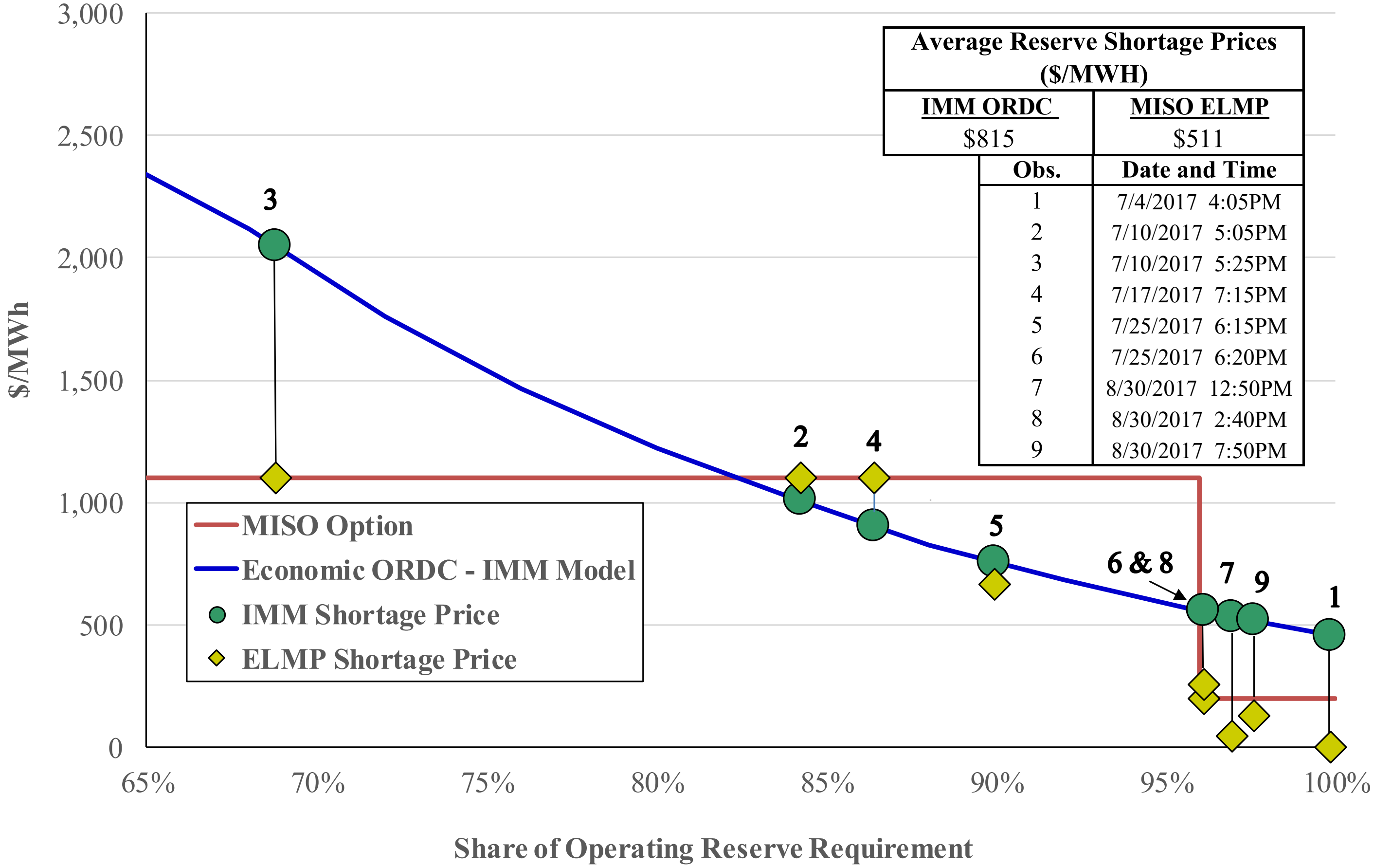
Shortage Pricing Periods Summer 2017
MISO ELMP Pricing vs. IMM Economic ORDC Pricing



Average Reserve Shortage Prices ($/MWH)	
IMM ORDC	MISO ELMP
$815	$511

Obs.	Date and Time
1	7/4/2017 4:05PM
2	7/10/2017 5:05PM
3	7/10/2017 5:25PM
4	7/17/2017 7:15PM
5	7/25/2017 6:15PM
6	7/25/2017 6:20PM
7	8/30/2017 12:50PM
8	8/30/2017 2:40PM
9	8/30/2017 7:50PM

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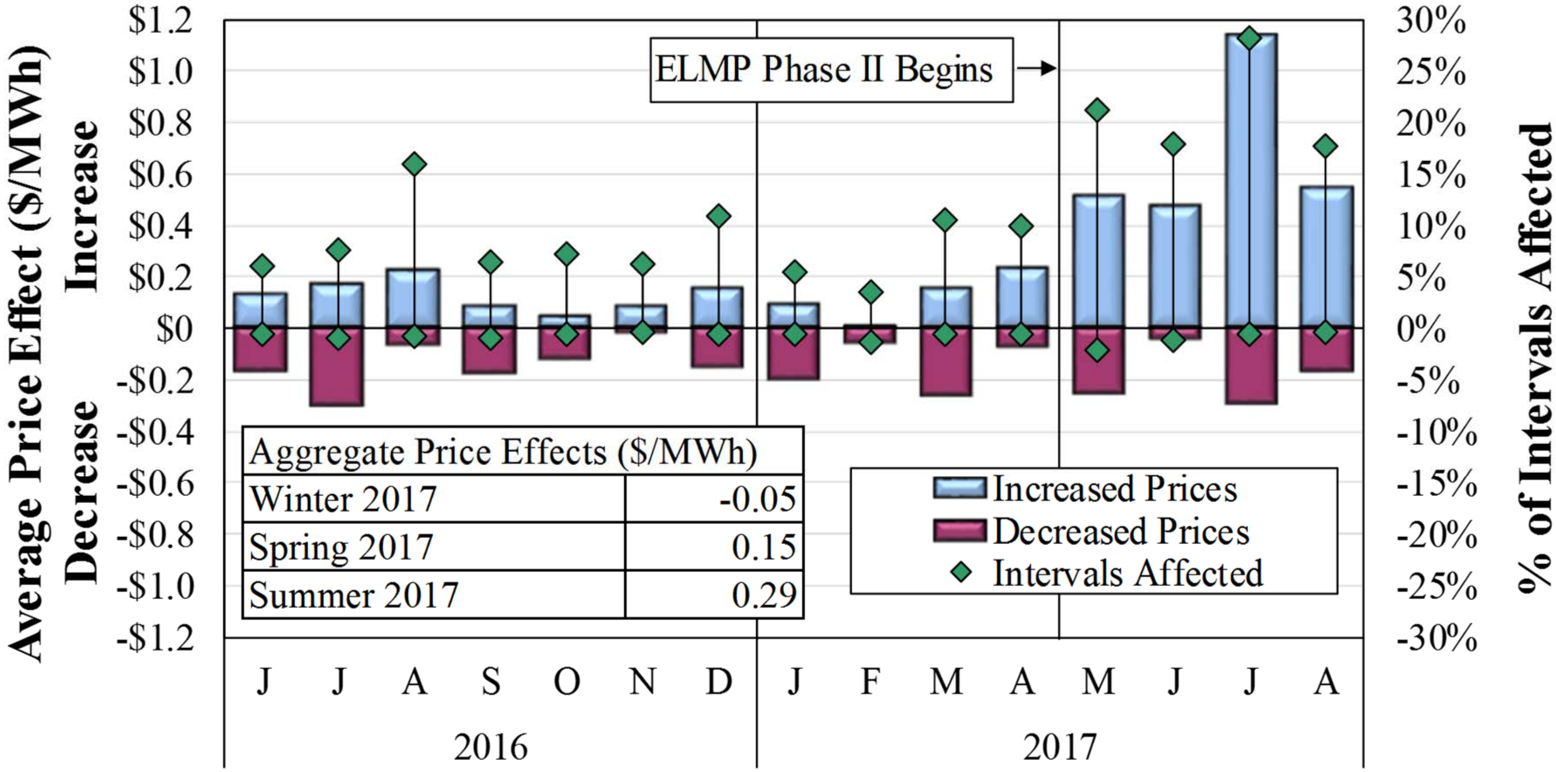
ELMP SMP Impacts
2016 – 2017



Change in Affected Intervals ($/MWh)

	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
SMP Increase	2.2	2.3	1.4	1.3	0.7	1.4	1.4	1.8	0.2	1.5	2.4	2.4	2.7	4.0	2.9
SMP Decrease	-26.4	-29.7	-10.5	-18.6	-19.0	-7.5	-23.9	-37.3	-4.7	-41.4	-14.6	-12.2	-3.9	-51.4	-71.5

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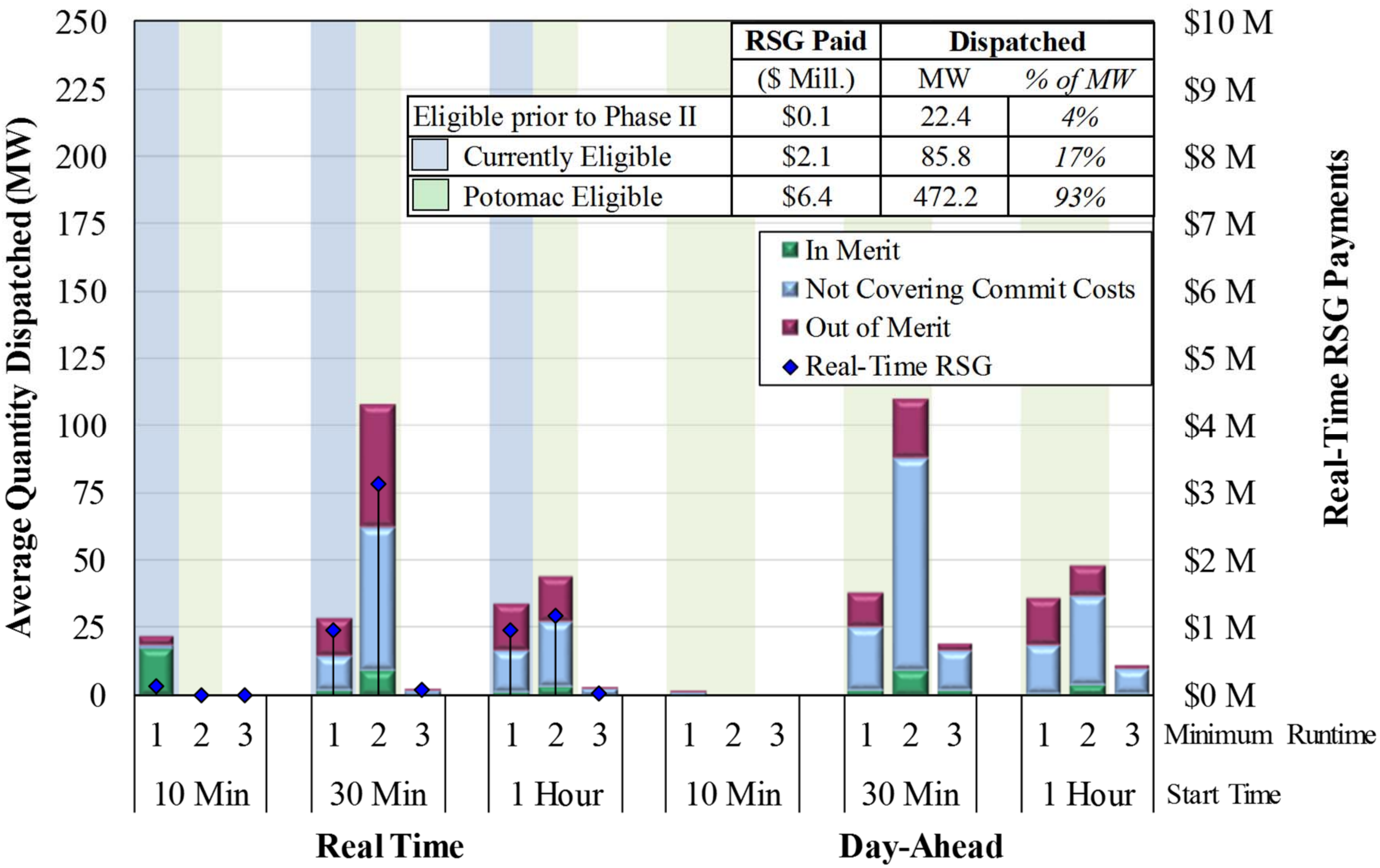
ELMP Phase II RSG Impacts
Summer 2017



	RSG Paid ($ Mill.)	Dispatched MW	Dispatched % of MW
Eligible prior to Phase II	$0.1	22.4	*4%*
Currently Eligible	$2.1	85.8	*17%*
Potomac Eligible	$6.4	472.2	*93%*

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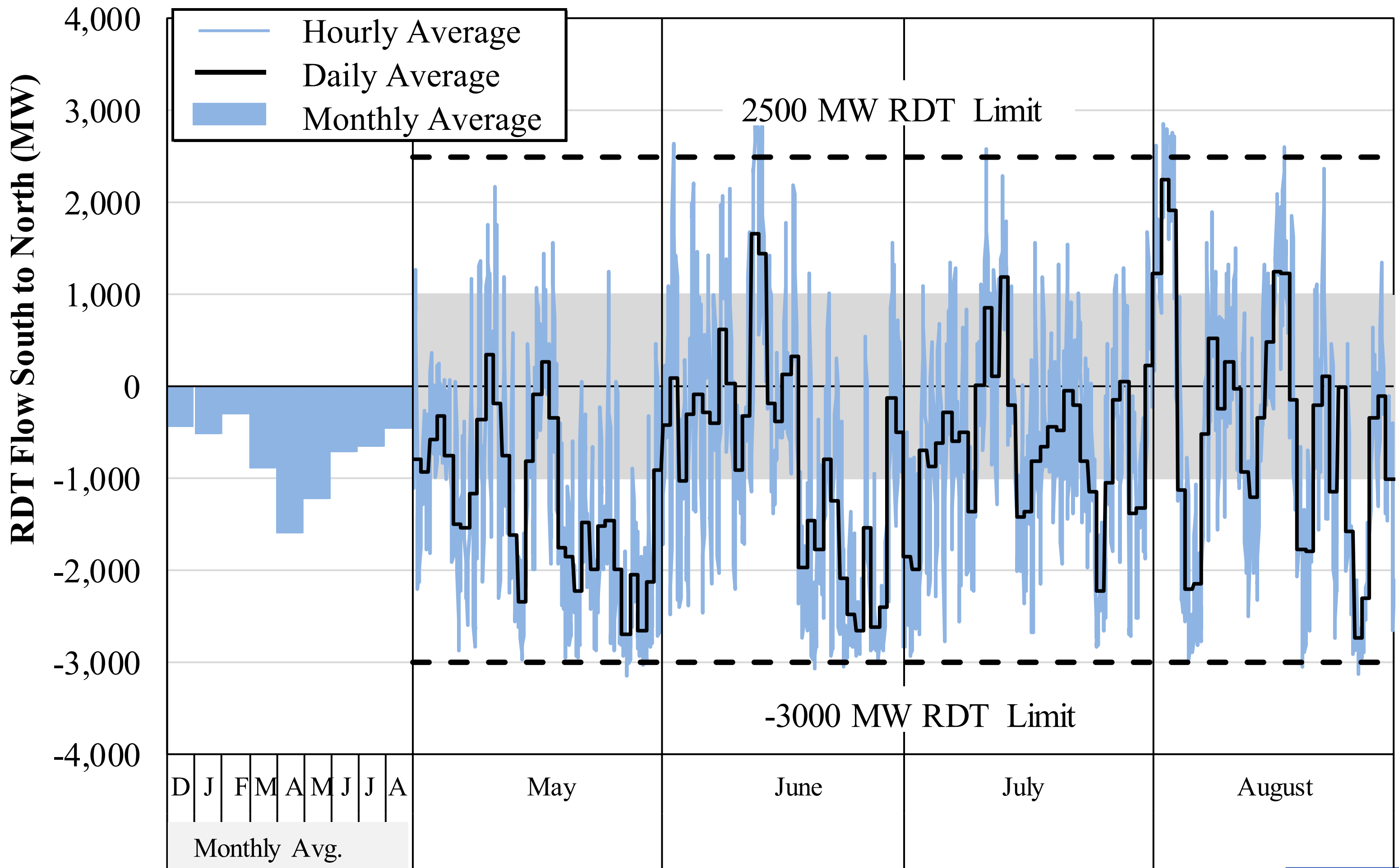
Real-Time Hourly Inter-Regional Flows 2016 - 2017



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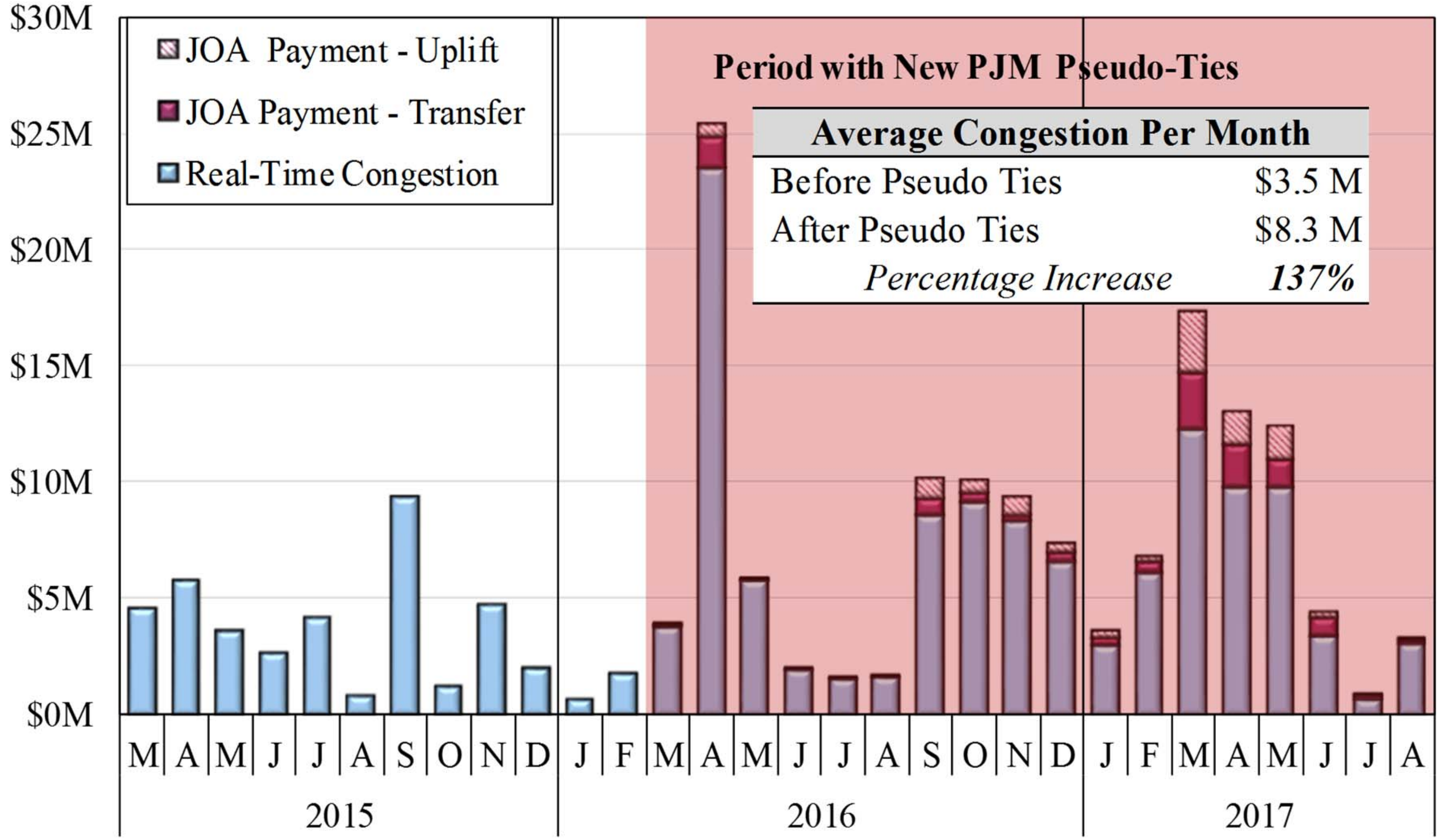
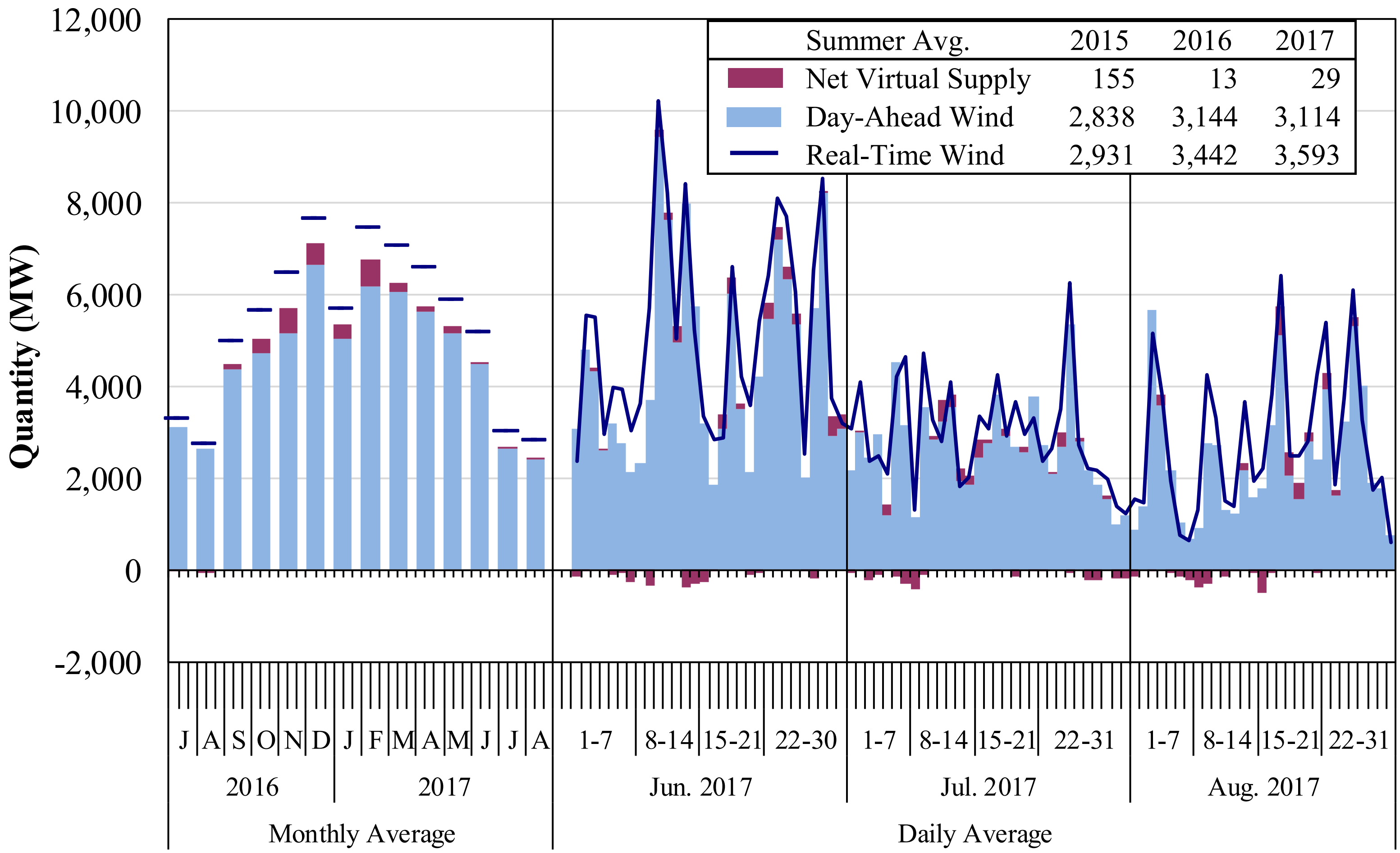
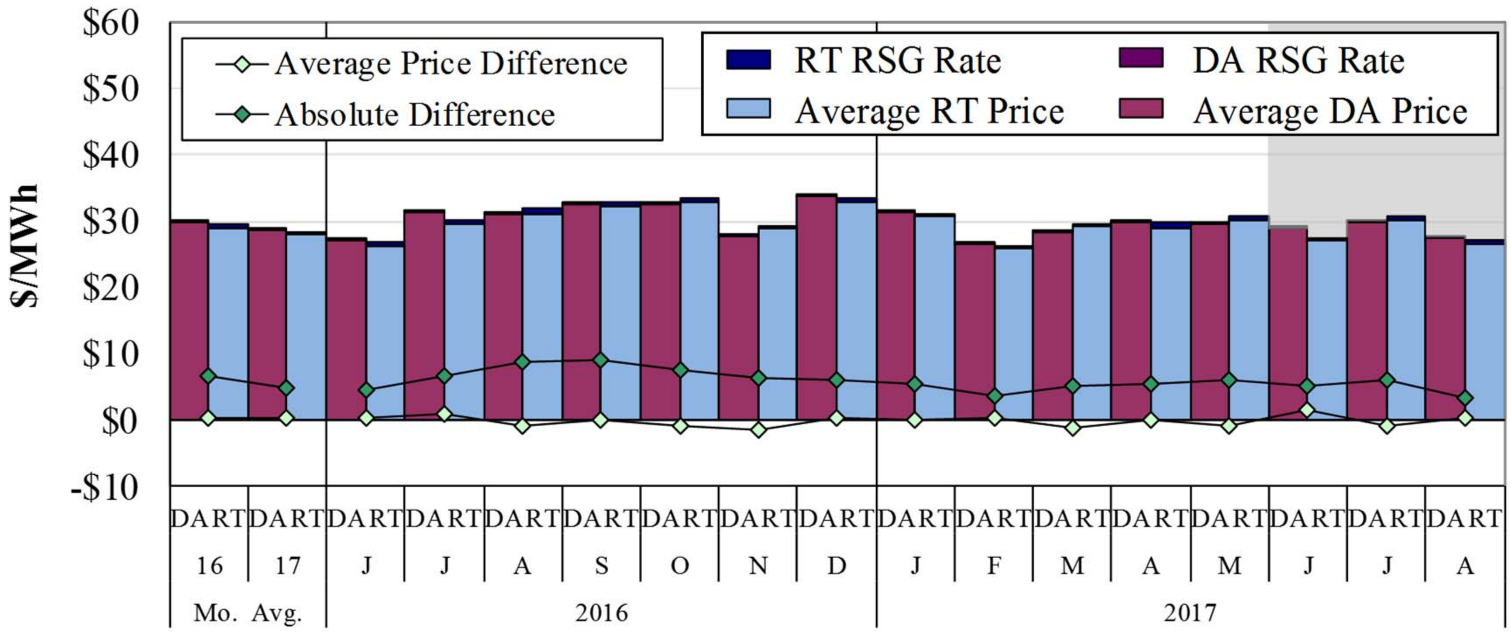
MISO Congestion Value and JOA Settlement Constraints Impacted by Pseudo-Ties



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



Day-Ahead and Real-Time Price Convergence Summer 2016–2017

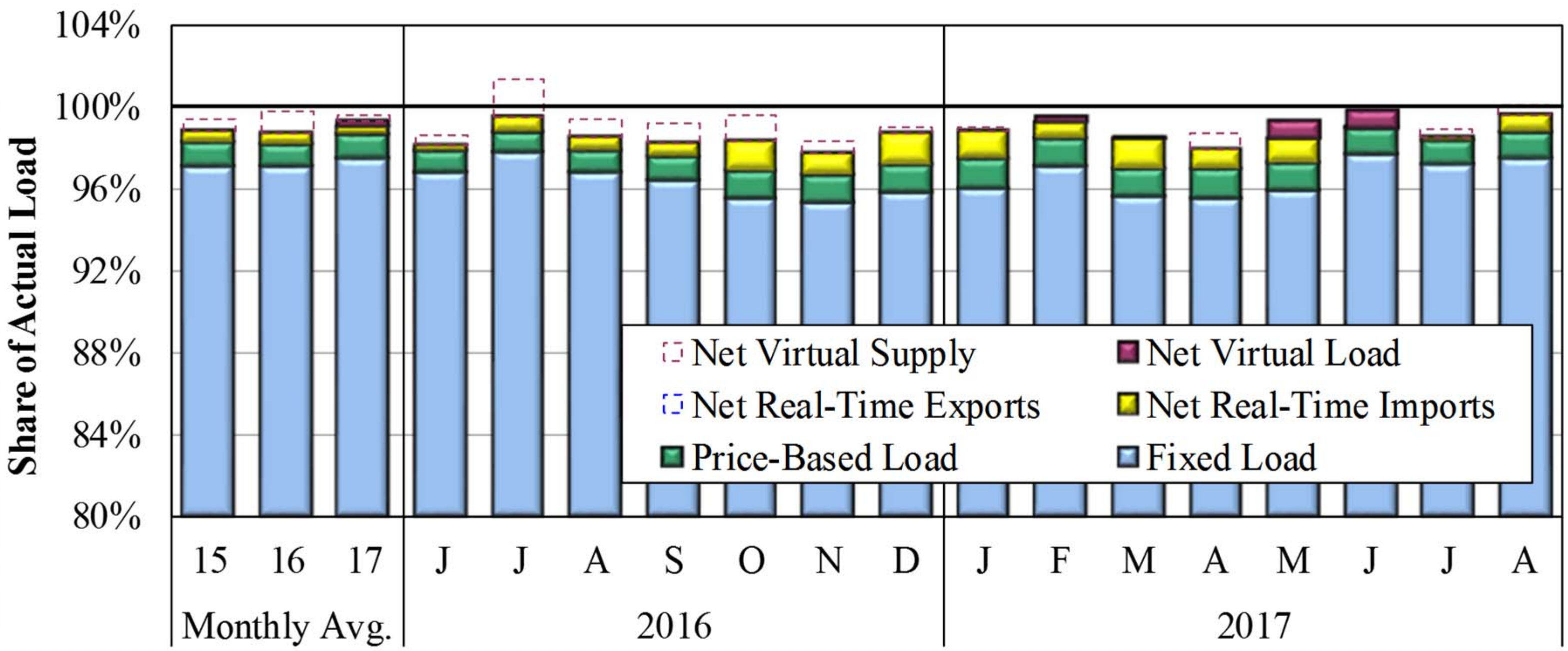


Average DA-RT Price Difference Including RSG (% of Real-Time Price)

Indiana Hub	1	1	1	3	-2	0	-2	-5	1	0	1	-4	0	-3	5	-3	1
Michigan Hub	-1	-1	0	5	-9	-2	4	-1	2	1	1	-6	-1	-1	0	-3	1
Minnesota Hub	-4	0	-5	0	-6	-2	-2	2	-6	3	3	-1	-5	1	5	-7	2
WUMS Area	-5	-1	-3	-5	-7	1	4	1	-6	-1	-2	3	-1	3	3	-8	3
Arkansas Hub	1	0	4	-1	0	-3	-2	-6	0	1	3	-3	0	2	5	-7	2
Texas Hub	0	0	2	-3	1	2	3	-1	2	-2	3	-2	3	4	-1	-1	2
Louisiana Hub	-6	-9	-14	-1	-4	-3	1	0	1	1	-2*	2	-4	3	-1	-9	-6

* Excluding Feb 7, 2017.

Day-Ahead Peak Hour Load Scheduling
Summer 2016–2017



Share of Actual Load (%)

	15	16	17	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
All Hours	99.2	99.4	99.9	98.6	100.1	99.4	98.3	98.5	97.8	98.9	99.2	98.7	99.1	98.5	99.3	100.2	99.6	99.9
Peak Hours Midwest	98.2	97.9	98.3	97.2	98.8	97.7	97.6	97.6	98.0	97.8	98.0	98.3	97.5	97.0	97.8	99.5	97.3	98.0
Peak Hours South	100.2	101.5	102.8	101.5	101.8	101.3	99.6	100.6	99.3	103.1	103.1	106.4	102.9	100.3	102.3	103.2	102.2	102.9

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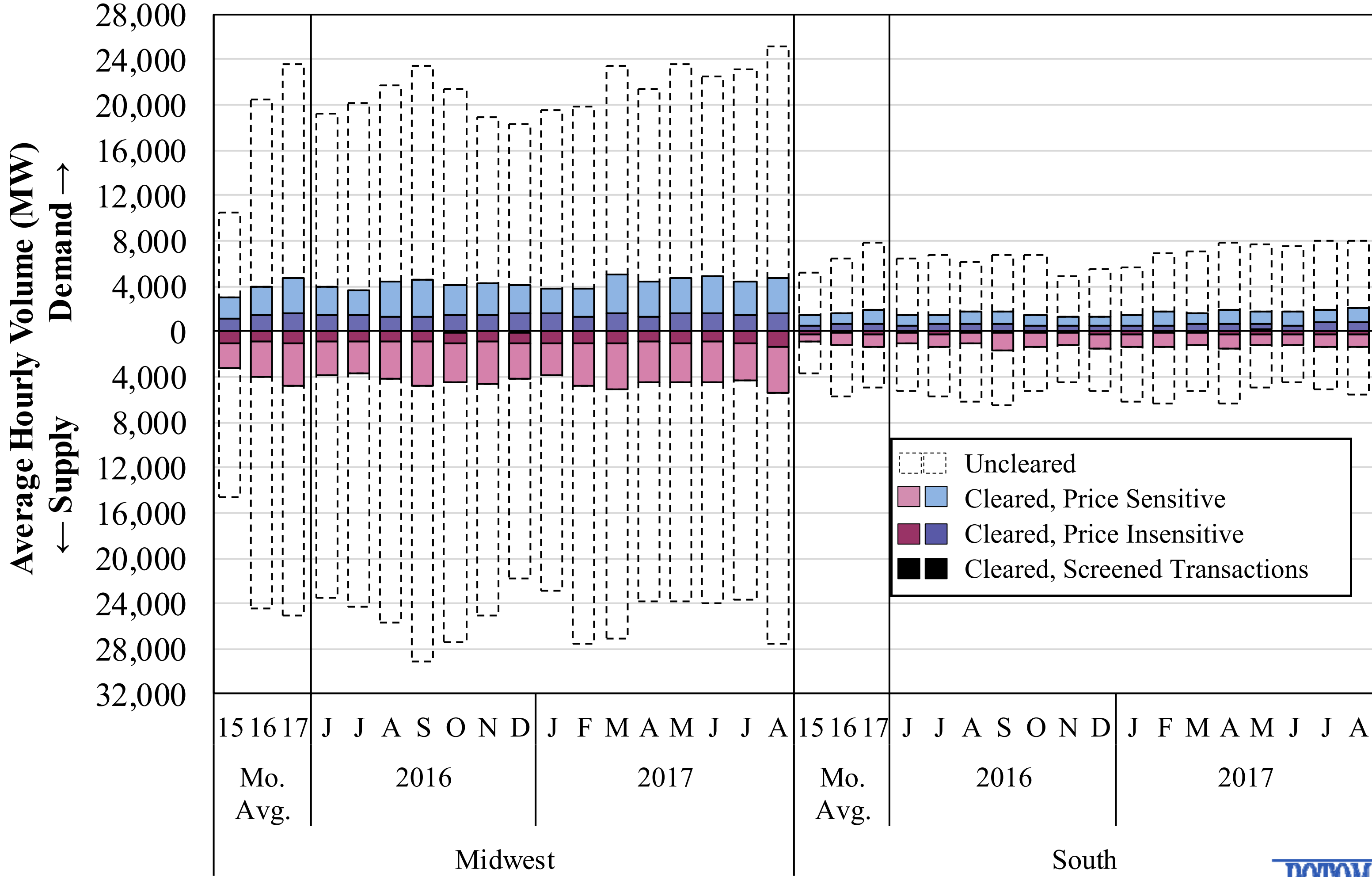
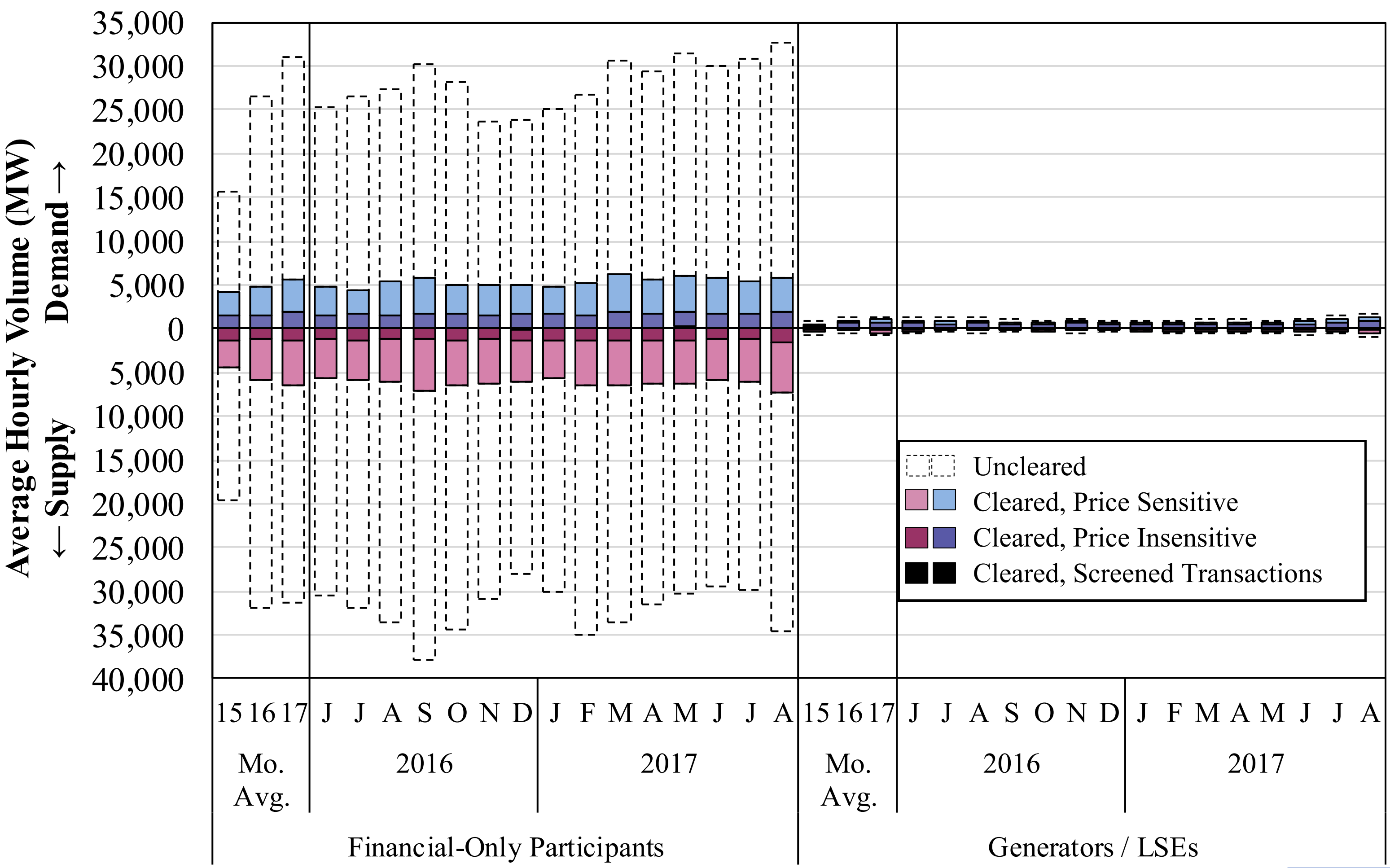
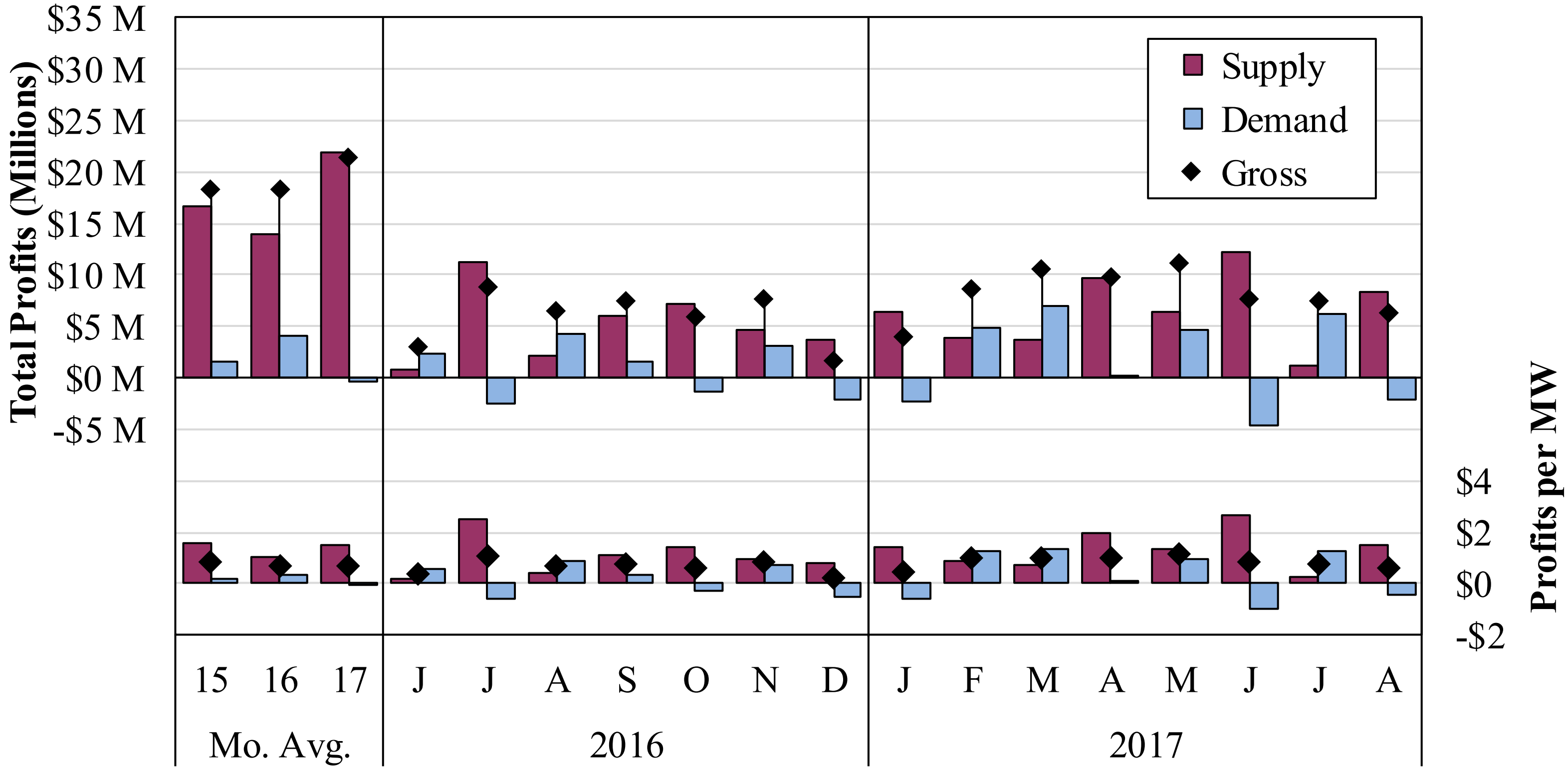
Virtual Load and Supply
Summer 2016–2017



Virtual Load and Supply by Participant Type
Summer 2016–2017



Virtual Profitability
Summer 2016–2017



Percent Screened

Demand	1.6	1.3	1.0	1.5	1.2	1.3	1.2	2.1	0.4	1.1	0.9	1.3	1.4	2.1	2.8	1.4	1.2	0.5
Supply	0.3	0.3	0.2	0.2	0.3	0.3	0.3	0.6	0.4	0.6	0.3	0.2	0.4	0.4	0.5	0.3	0.1	0.2
Total	1.0	0.8	0.6	0.8	0.7	0.8	0.7	1.2	0.4	0.8	0.6	0.7	0.9	1.2	1.6	0.8	0.7	0.3

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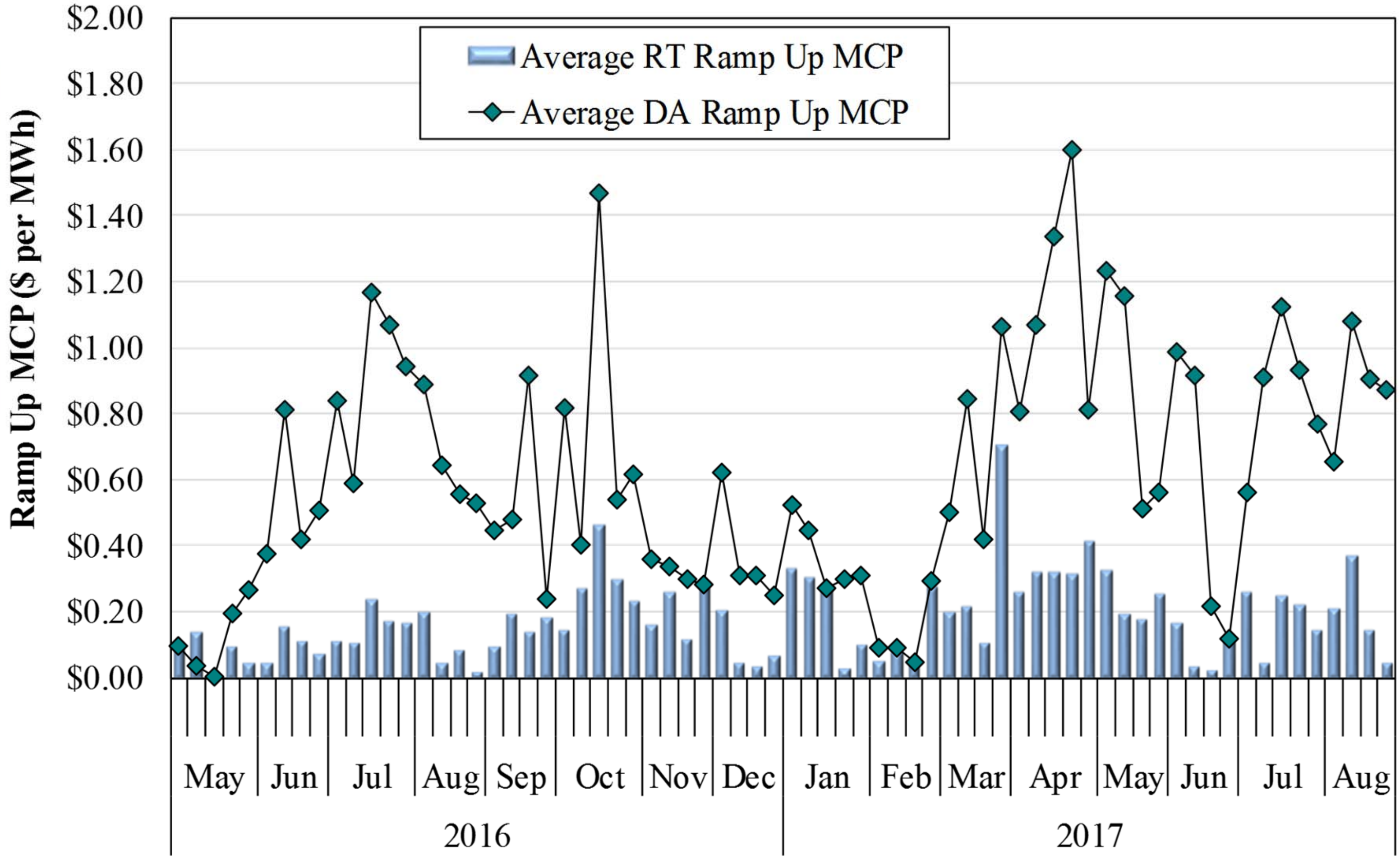
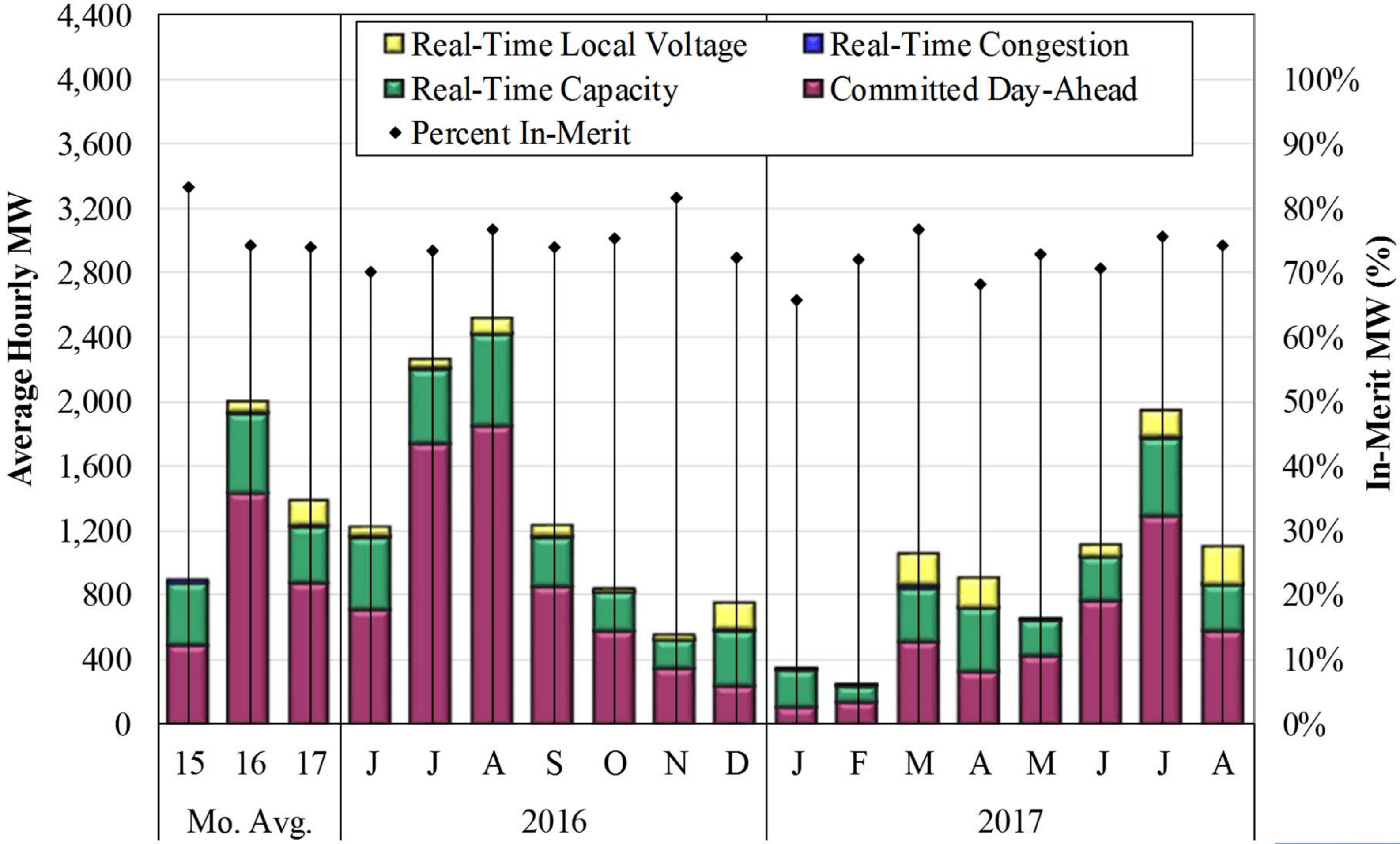
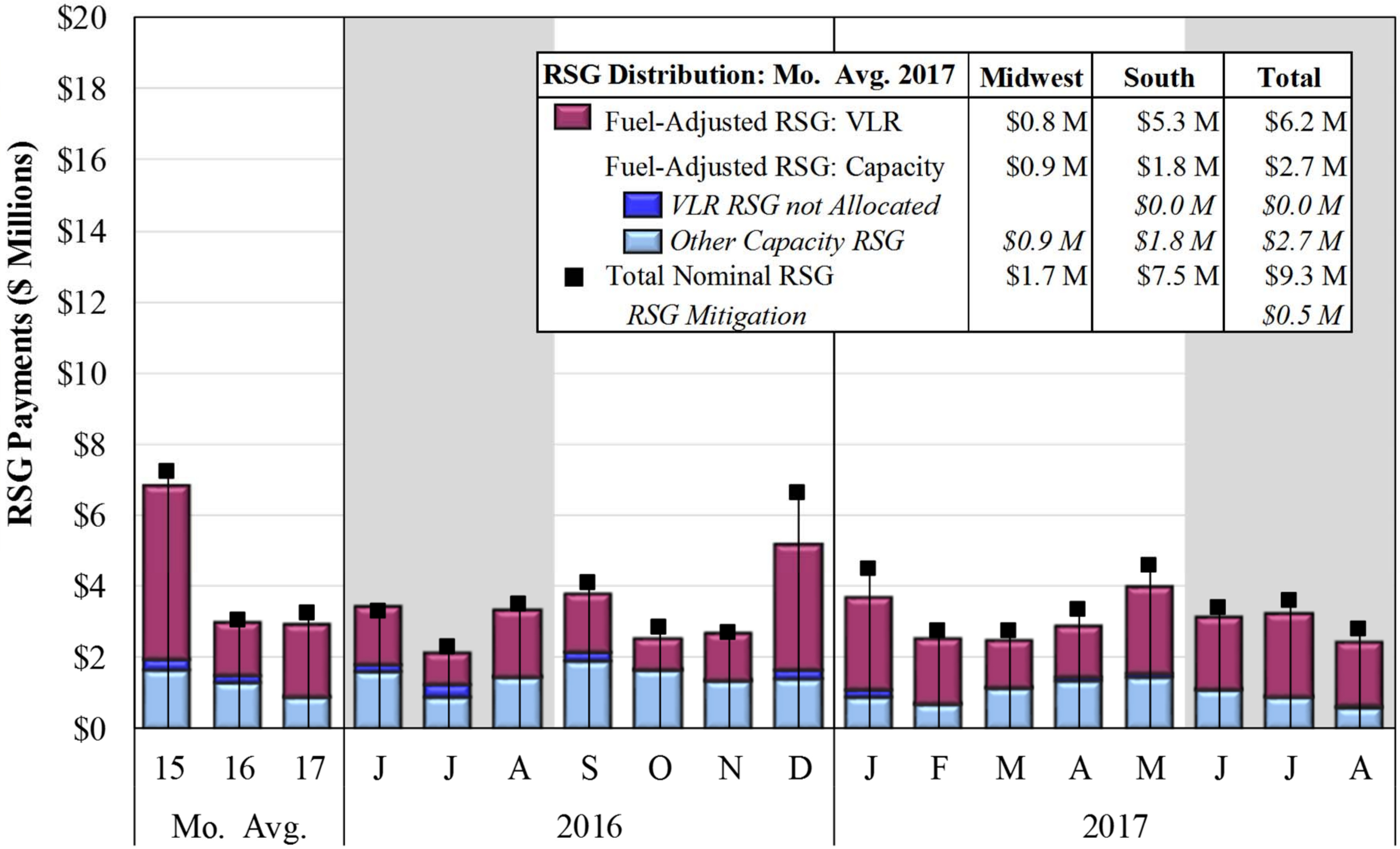
Day-Ahead and Real-Time Ramp Up Price 2016 – 2017



Peaking Resource Dispatch
2016–2017



Day-Ahead RSG Payments 2016–2017



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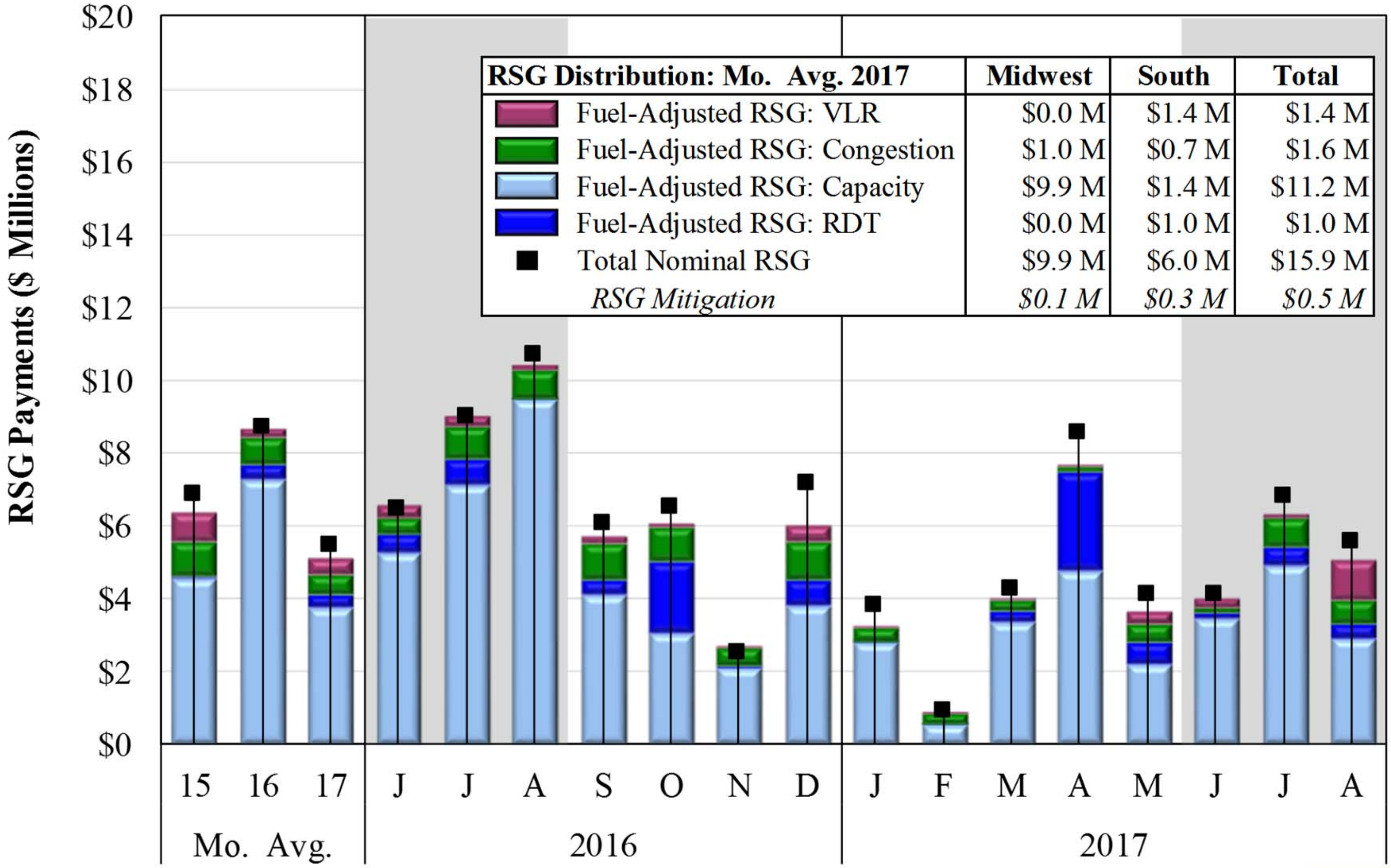
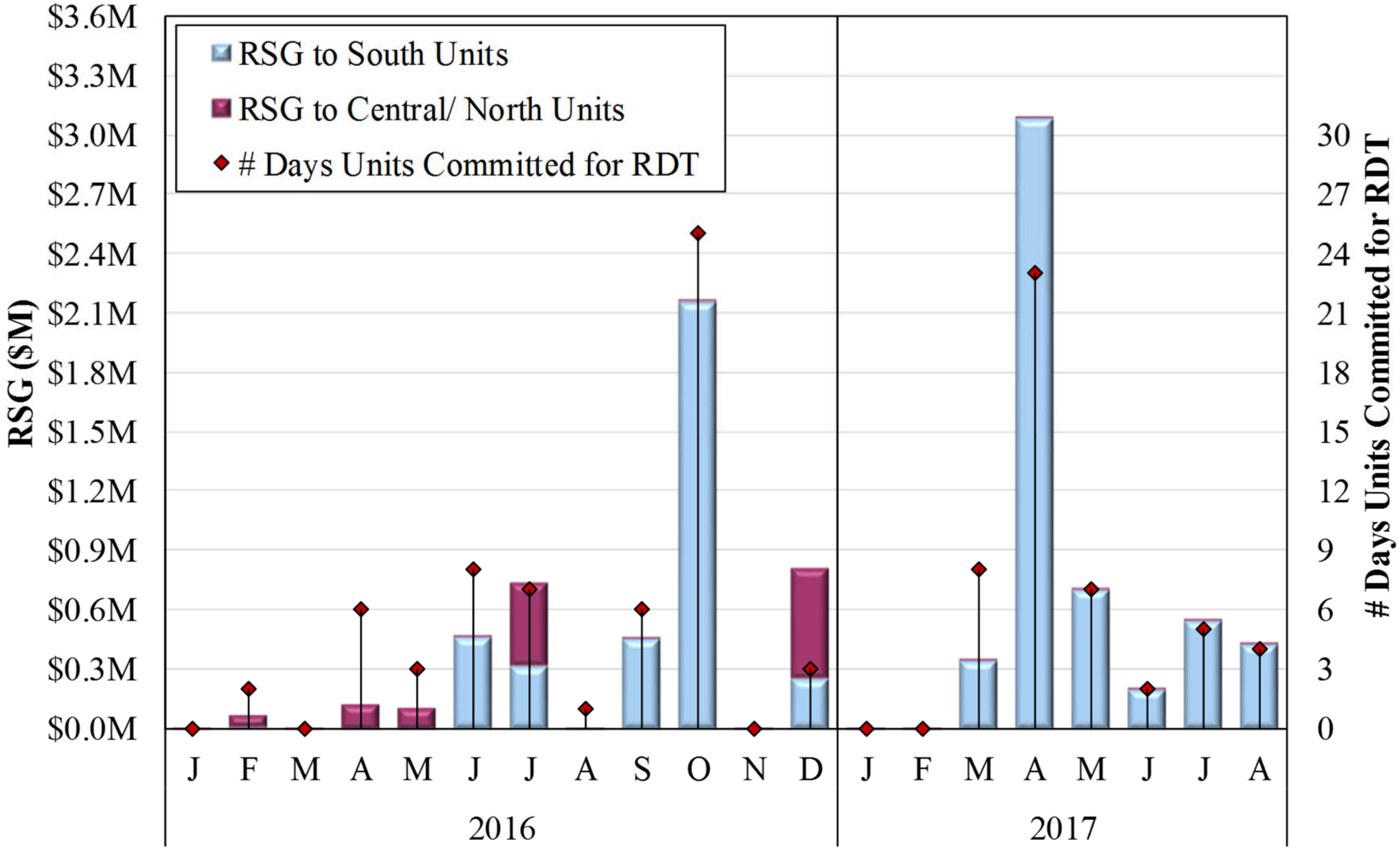
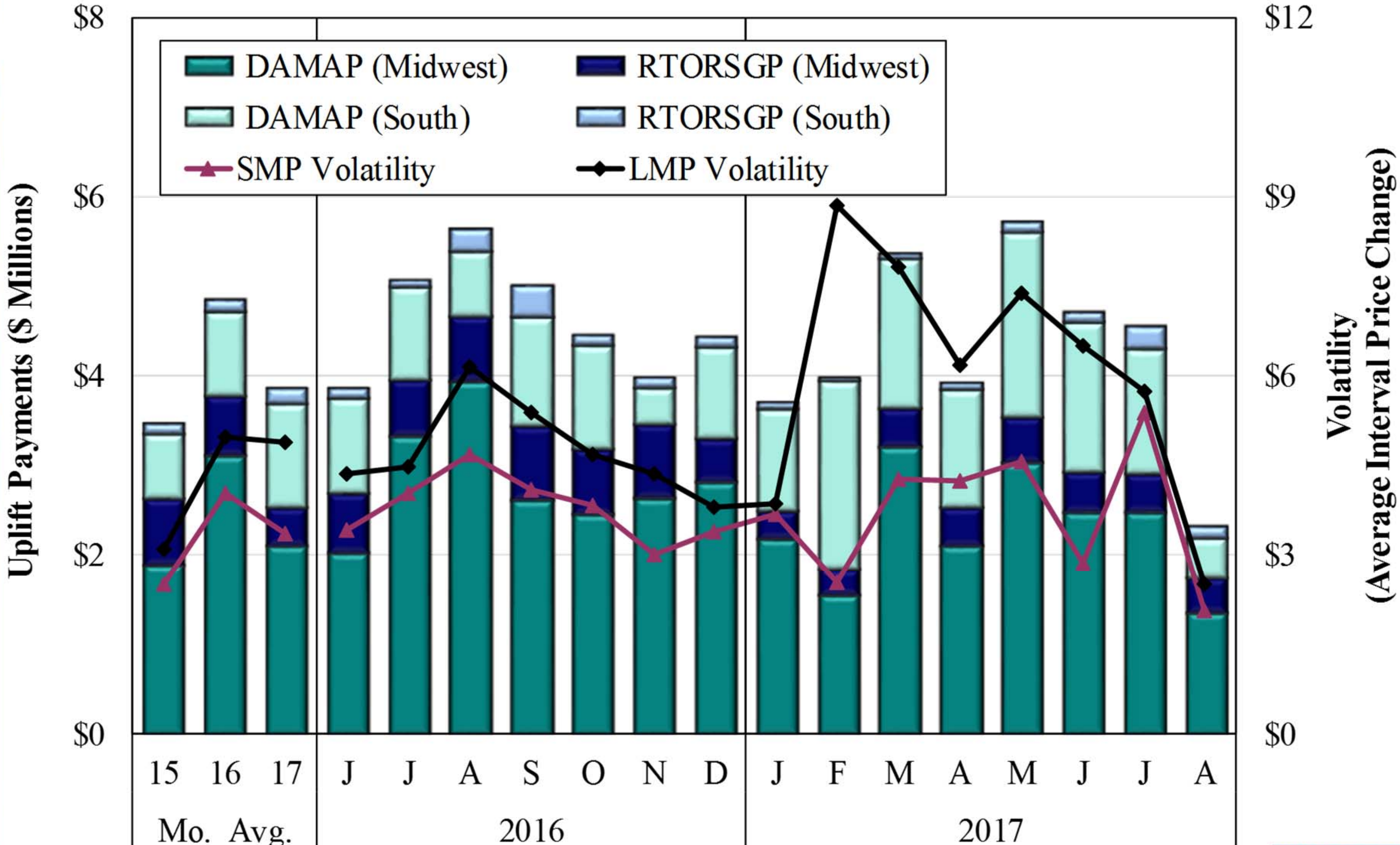
Real-Time RSG Payments 2016–2017



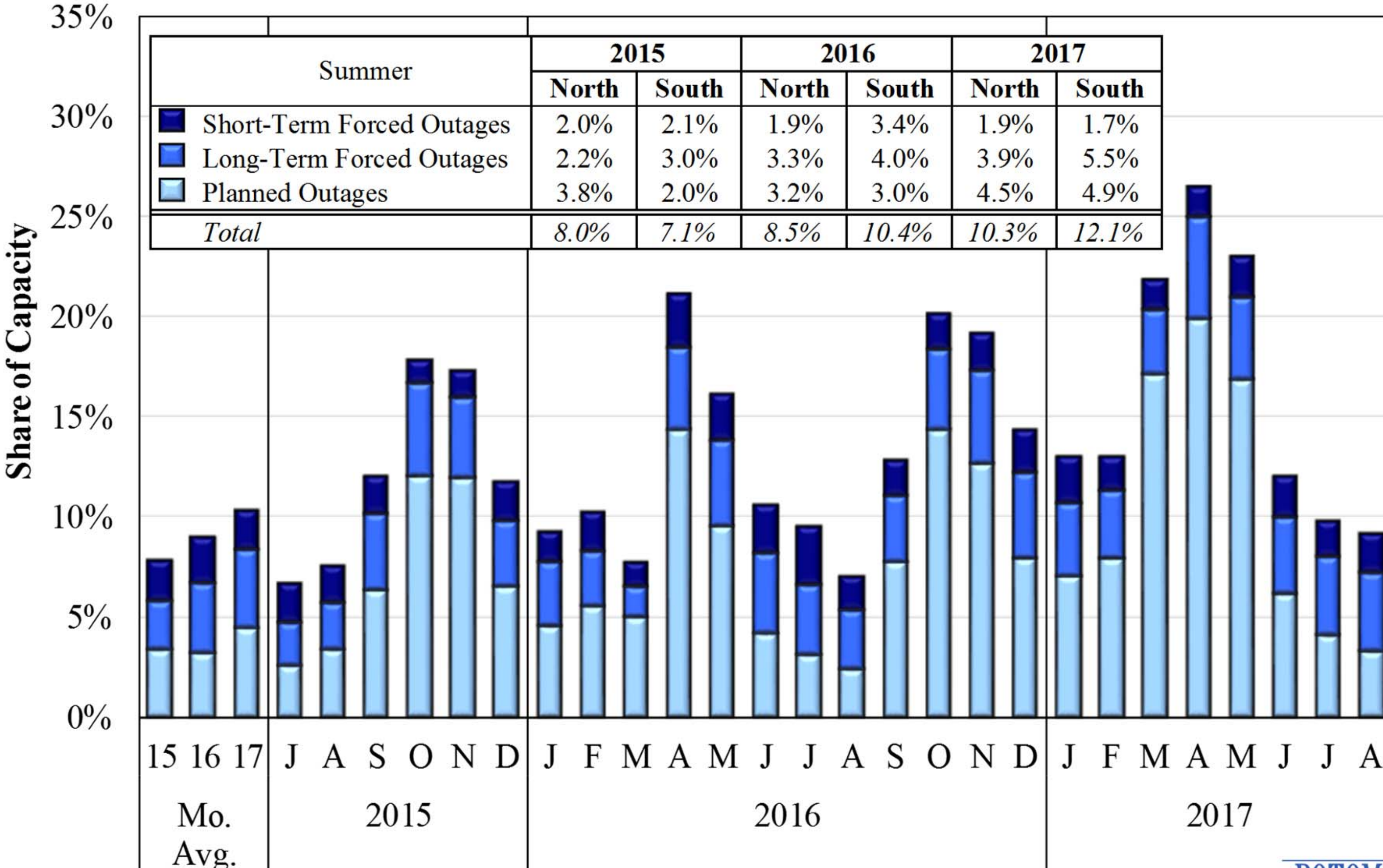
RDT Commitment RSG Payments 2016–2017



Price Volatility Make Whole Payments 2016–2017



Generation Outage Rates
2016–2017



Summer	2015		2016		2017	
	North	**South**	**North**	**South**	**North**	**South**
Short-Term Forced Outages	2.0%	2.1%	1.9%	3.4%	1.9%	1.7%
Long-Term Forced Outages	2.2%	3.0%	3.3%	4.0%	3.9%	5.5%
Planned Outages	3.8%	2.0%	3.2%	3.0%	4.5%	4.9%
Total	*8.0%*	*7.1%*	*8.5%*	*10.4%*	*10.3%*	*12.1%*

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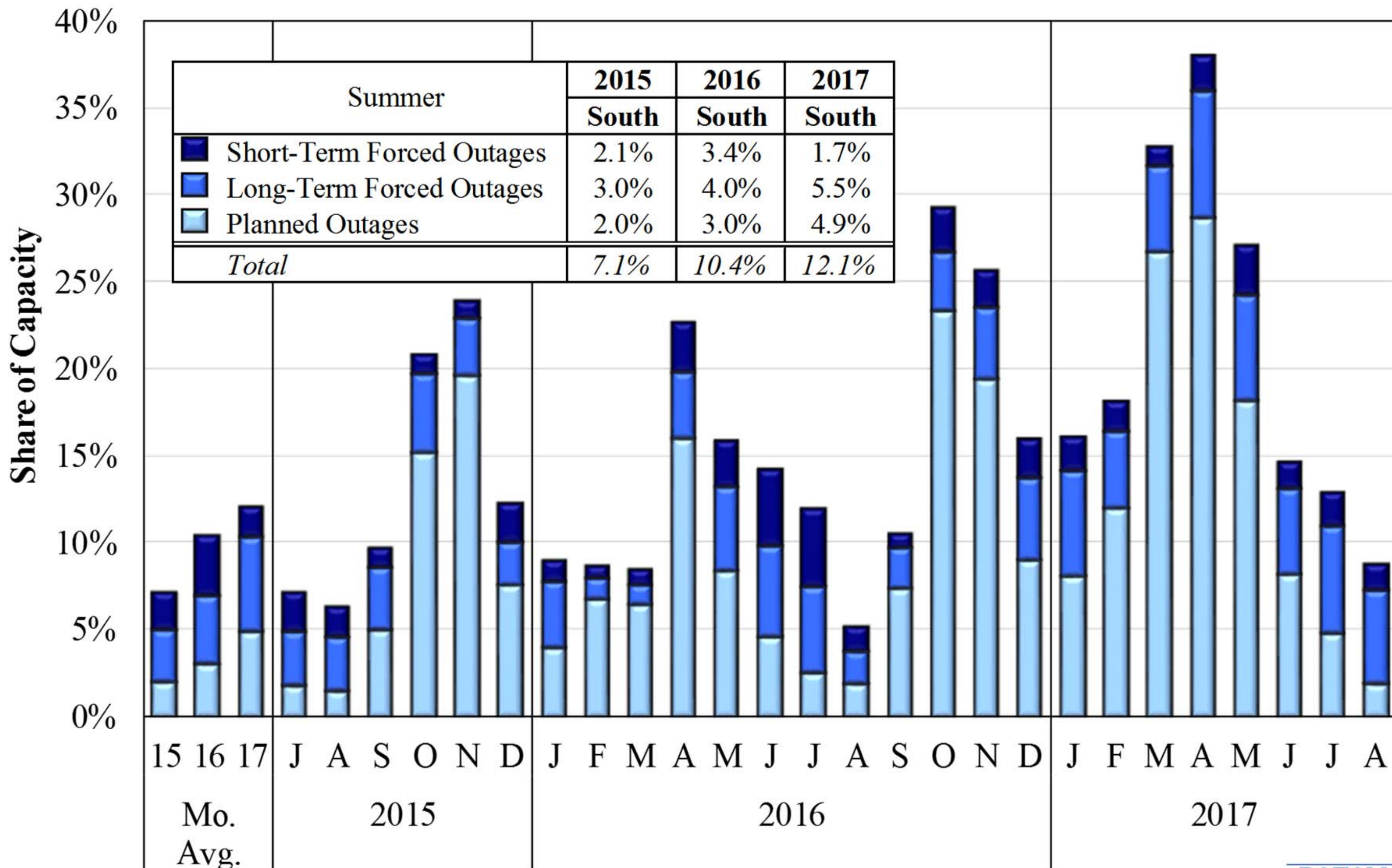
Generation Outage Rates
South, 2016–2017



Summer	2015 South	2016 South	2017 South
Short-Term Forced Outages	2.1%	3.4%	1.7%
Long-Term Forced Outages	3.0%	4.0%	5.5%
Planned Outages	2.0%	3.0%	4.9%
Total	*7.1%*	*10.4%*	*12.1%*

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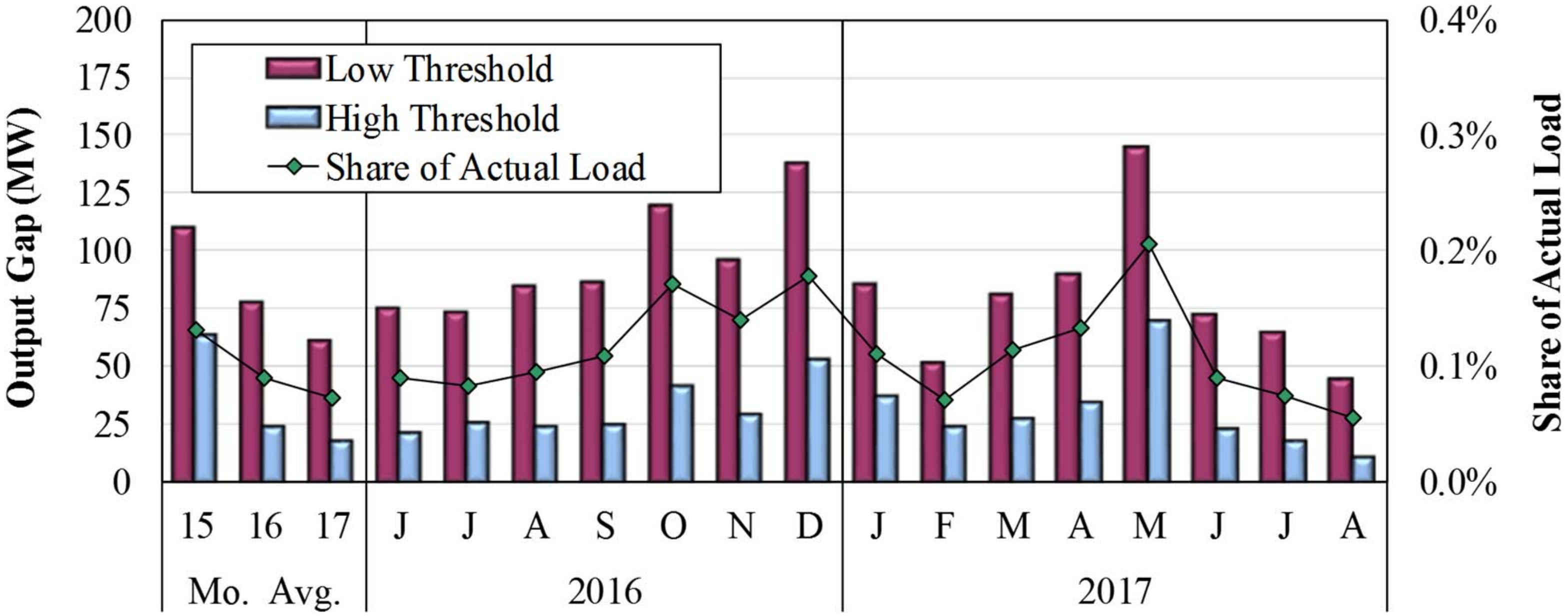
Monthly Output Gap
2016–2017



High Threshold Results by Unit Status (MW)

Offline	47	9	2	1	15	10	11	26	21	24	14	6	8	11	14	4	2	1
Online	16	15	16	20	11	14	14	16	8	29	23	19	19	24	55	20	16	10

Low Threshold Results by Unit Status (MW)

Offline	54	10	2	1	15	12	13	30	21	25	14	6	8	11	14	4	2	2
Online	56	68	59	74	58	72	73	89	75	113	72	46	73	79	130	69	63	44

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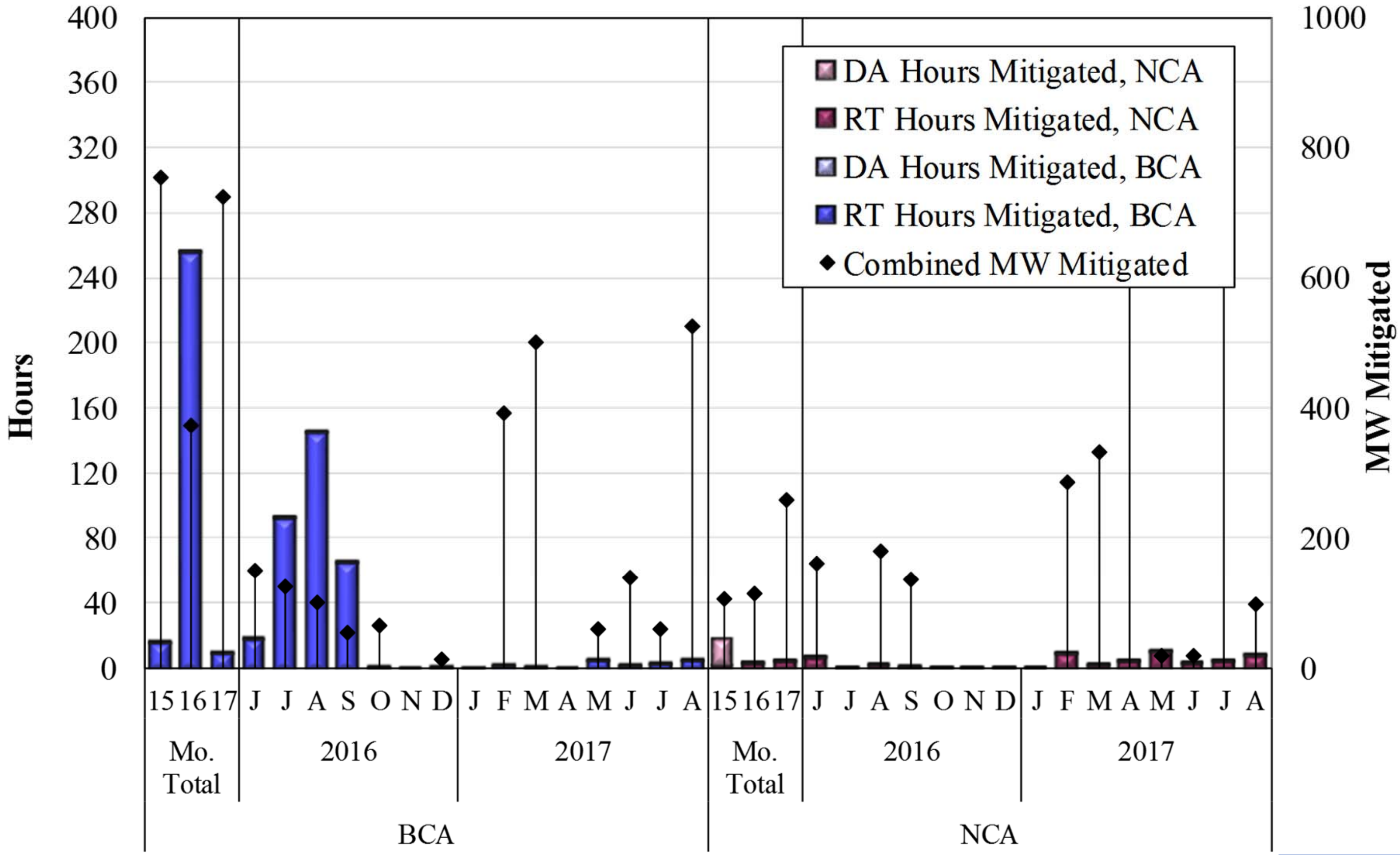
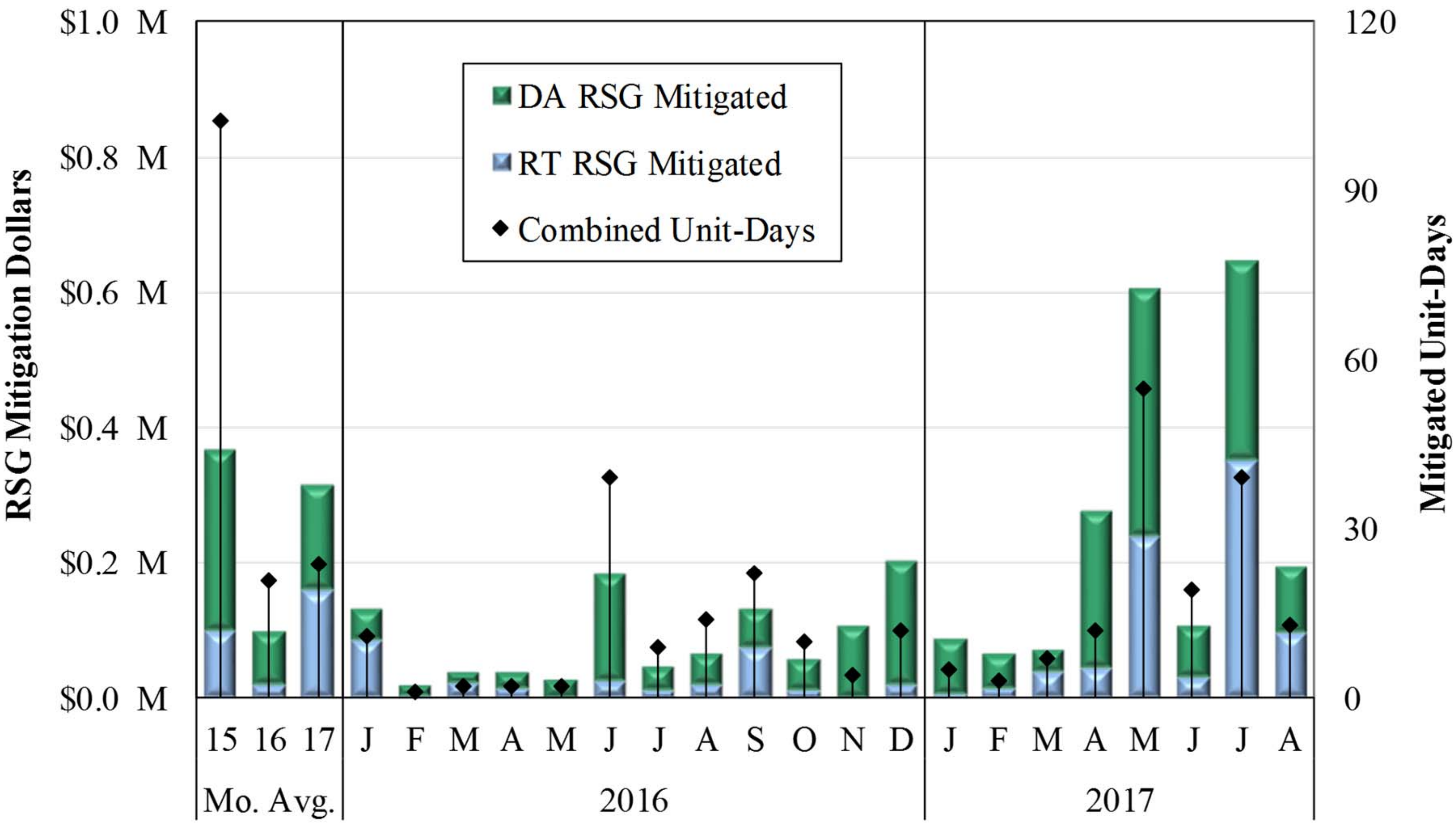
Day-Ahead And Real-Time Energy Mitigation 2016–2017



Day-Ahead and Real-Time RSG Mitigation 2016–2017



List of Acronyms

- AMP Automated Mitigation Procedures
- BCA Broad Constrained Area
- CDD Cooling Degree Days
- CMC Constraint Management Charge
- 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 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