IMM Quarterly Report: Summer 2019

MISO Independent Market Monitor

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Potomac Economics

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Highlights and Findings: Summer 2019

- The MISO markets performed competitively this summer, market power mitigation was infrequent, and offers were competitive overall.
- A significant drop in natural gas prices had multiple impacts on the markets:
  - ✓ Real-time energy prices fell by 19 percent compared to last year;
  - ✓ Ancillary services prices fell between 11 and 24 percent; and
  - ✓ Real-time RSG payments fell by almost 40 percent.
- MISO's annual peak load of 120.9 GW occurred on July 19, 600 MW lower than last year's peak and well below the forecast peak of 125.5 GW.
  - ✓ Average summer load fell by 4 percent compared to last year.
- Price volatility make-whole payments fell substantially due partly to a number recommended improvements MISO implemented over the past.
- FTR shortfalls occurred in June and July due to multiple transmission outages that were not modelled in the FTR auctions.

Quarterly Summary

		Value	Change [1] Prior Qtr.	Change [1] Prior Year
RT Energy Prices ($/MWh)		$25.84	*-1%*	*-19%*
Fuel Prices ($/MMBtu)				
Natural Gas - Chicago		$2.07	*-24%*	*-25%*
Natural Gas - Henry Hub		$2.27	*-16%*	*-21%*
Western Coal		$0.70	*-1%*	*-1%*
Eastern Coal		$1.52	*-10%*	*-4%*
Load (GW)[2]				
Average Load		83.7	*19%*	*-4%*
Peak Load		121.4	*24%*	*-1%*
% Scheduled DA (Peak Hour)		99.3%	98.2%	98.7%
Transmission Congestion ($M)				
Real-Time Congestion Value		$269.4	*43%*	*-12%*
Day-Ahead Congestion Revenue		$146.0	*30%*	*-16%*
Balancing Congestion Revenue[3]		$4.8	$2.5	-$12.7
Ancillary Service Prices ($/MWh)				
Regulation		$7.66	*-16%*	*-24%*
Spinning Reserves		$2.17	*-12%*	*-19%*
Supplemental Reserves		$0.62	*50%*	*-11%*

		Value	Change [1] Prior Qtr.	Change [1] Prior Year
FTR Funding (%)		96%	99%	110%
Wind Output (MW/hr)		4,257	*-41%*	*4%*
Guarantee Payments ($M)[4]				
Real-Time RSG		$14.7	*3%*	*-36%*
Day-Ahead RSG		$5.8	*-41%*	*10%*
Day-Ahead Margin Assurance		$4.0	*-25%*	*-48%*
Real-Time Offer Rev. Sufficiency		$0.7	*-12%*	*-33%*
Price Convergence[5]				
Market-wide DA Premium		0.0%	0.0%	-0.4%
Virtual Trading				
Cleared Quantity (MW/hr)		15,991	*-15%*	*8%*
% Price Insensitive		35%	36%	36%
% Screened for Review		1%	1%	1%
Profitability ($/MW)		$0.35	$0.39	$0.33
Dispatch of Peaking Units (MW/hr)		1,775	709	1824
Output Gap- Low Thresh. (MW/hr)		45	103	75
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.

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Highlights for Summer 2019

Low Gas Prices, RDT Flows, Congestion Patterns (Slides 14, 17, 18)

- Natural gas prices at the Chicago and Henry Hubs both fell by more than 20 percent over last summer due to record levels of natural gas production.
  - ✓ Outlet for gas in the Permian Oil region in West Texas is constrained toward Houston Ship Channel and Henry Hub resulting in higher Henry Hub prices.
    - Completion of the Gulf Coast Express Pipeline will alleviate this constraint, which is set to enter service in early October.
- Despite lower gas prices in the Midwest, RDT flows were generally in the South to North direction after June.
  - ✓ Multiple units in the South extended planned outages into late June.
  - ✓ In July, higher load in the Midwest and lower load in the South relative to last year contributed to higher South to North flows.
- In July, congestion increased by nearly 50 percent over last year, returning to more normal levels:
  - ✓ Wind production increased by 24 percent over last July;
  - ✓ Generation and transmission outages and suspended baseload capacity contributed to $11 million in congestion on a single constraint.

Highlights for Summer 2019

Improvements in Generator Performance and PVMWP Costs (Slides 34, 35)

- MISO implemented a number of IMM recommendations recently that have:
  - ✓ Improved generator performance, reducing deviations by 18 percent.
  - ✓ Contributed to a decrease in price-volatility make-whole payments of nearly 50 percent, from $8.7 million last summer to $4.6 million this summer.
- The recommendations that contributed to these improvements included:
  - ✓ Changes to the PVMWP rules implemented on May 1 that provide better incentives to follow MISO's setpoints.
    - Payments are now proportionately paid based on resource performance.
    - Generator deviations fell by as much as 27 percent during the morning ramp hours.
  - ✓ A recommendation that MISO implemented in July 2018 closed a loophole that eliminated unjustified DAMAP payments to wind resources.
  - ✓ MISO implemented a recommended regulation commitment enhancement in May that contributed to lower price volatility and the reduction in PVMWP.

Highlights for Summer 2019

Uninstructed Deviation Changes and Wind Forecasting (Slides 21, 22)

- Uninstructed deviation changes have prompted most wind suppliers to use the MISO forecast.
  - ✓ This adoption of the MISO forecast has reduced absolute forecast error by 20 percent over last summer and reduced directional forecast bias by 3 percent.
- Although the MISO forecast is better than the prior participants', its current methodology still leads to sizable forecast errors that could be reduced.
- The current MISO forecast methodology has an over-forecast bias (although by less than MP forecasts) because it uses the greater of:
  - ✓ Its vendor forecast, and
  - ✓ The current output – commonly referred to as a "persistence" forecast.
- This results in predictable over-forecasts, which are most prominent when aggregate wind output is declining.
  - ✓ The current average absolute forecast error exceeds 200 MW (50% of the regulation requirement) in almost 40 percent of market intervals.
  - ✓ Assuming the current output would be significantly better and applying a trend to the current output would reduce this frequency to 4 percent.

Highlights for Summer 2019

Hot Weather Prices in ERCOT and Impacts on WOTAB (Slide 19)

- Between August 12 and 16, ERCOT experienced a record peak load, multiple shortages and extremely high prices, and declared EEA1 on two days.
  - ✓ Prices exceeded $9,000 per MWh for multiple hours during those days.
  - ✓ On August 13, ERCOT requested units in MISO's Western Load Pocket on the seam switch to serve ERCOT, but conditions were tighter in MISO:
    - A transmission derate and loss of a critical unit brought MISO to the edge of having to shed load in the load pocket, which MISO was able to avoid.
- Prices at MISO's Texas Hub ranged from $500 to $800/MWh because of the transmission violation, but prices in ERCOT were $9,000/MWh.
- This event underscores the importance of a number of our recommendations:
  - ✓ Improving shortage pricing so prices reflect the expected value of lost load, preventing inefficient incentives to export power during shortages.
  - ✓ Implementing Short Term Reserves (STR) in the load pockets, which will allow the market to price local shortages like this one on August 13.
  - ✓ Defining local zones based on constraints and local reliability requirements -- all of the load pockets in Texas and Louisiana are grouped together in the same capacity zone, so the value of resources in each pocket are obscured.

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 provided input and feedback to FERC staff regarding Staff Paper on Dynamic Transmission Ratings and we will be participating in Technical Conference on this topic.
- We submitted comments in FERC Notice of Inquiry on Transmission incentives promoting incentives for more efficient transmission ratings and transmission investment.
- We worked with MISO staff on Module D revisions, participated in pre-filing discussions with FERC staff, and presented the revisions to the MSC in July.
- In July, we presented summary of MISO South market results and issues to the Entergy Regional State Committee.

Submittals to External Entities and Other Issues

- We began working with the SPP MMU and MISO on the Tier 1 items prioritized for study.
  - ✓ These include 2 tasks led by the IMM and 1 led by the SPP MMU.
  - ✓ There may be a delay in 1 of these tasks due to SPP concerns about data access/confidentiality.
- We worked with MISO on reviewing Emergency Event procedures and details of adjustments for resources unavailable due to transmission constraints.
- In August, we presented training to the MISO Learning Program on Module D and IMM procedures and in July we presented on Default Technology-Specific Avoidable Costs and on monitoring of LMR BTMG to the RASC.

Capacity, Energy and Price Setting Share
Summer 2018 – 2019

Summer	Unforced Capacity				Energy Output		Price Setting			
	Total (MW)		Share (%)		Share (%)		SMP (%)		LMP (%)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Nuclear	12,225	12,225	10%	9%	15%	16%	0%	0%	0%	0%
Coal	48,775	48,578	38%	38%	48%	41%	47%	52%	87%	94%
Natural Gas	55,240	56,786	43%	44%	30%	35%	52%	45%	97%	97%
Oil	1,691	1,683	1%	1%	0%	0%	0%	0%	2%	1%
Hydro	3,966	4,036	3%	3%	1%	2%	1%	2%	2%	4%
Wind	3,005	3,214	2%	2%	5%	5%	0%	1%	21%	23%
Other	2,678	2,599	2%	2%	2%	1%	0%	0%	3%	2%
Total	**127,580**	**129,120**								

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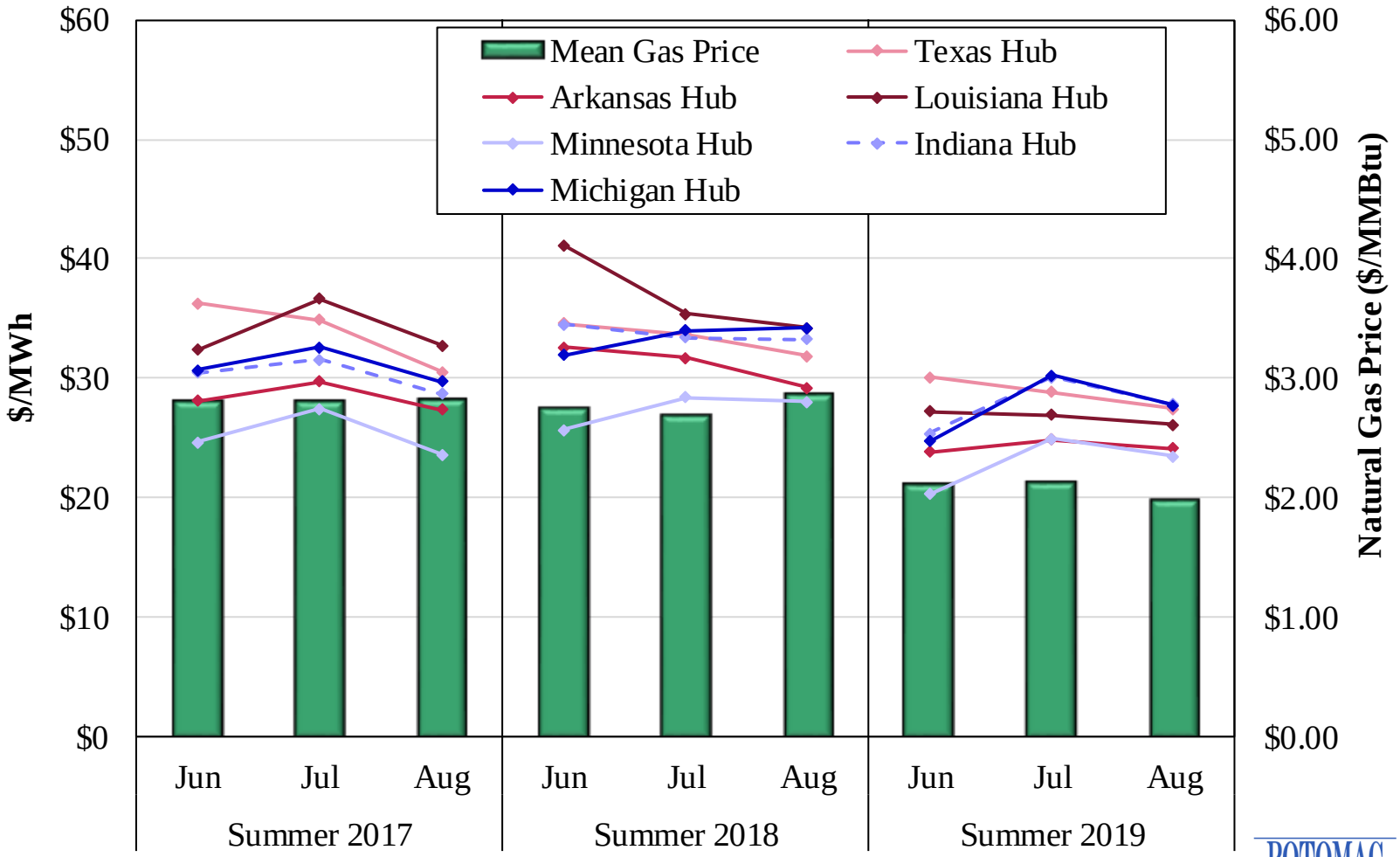
Day-Ahead Average Monthly Hub Prices
Summer 2017 – 2019



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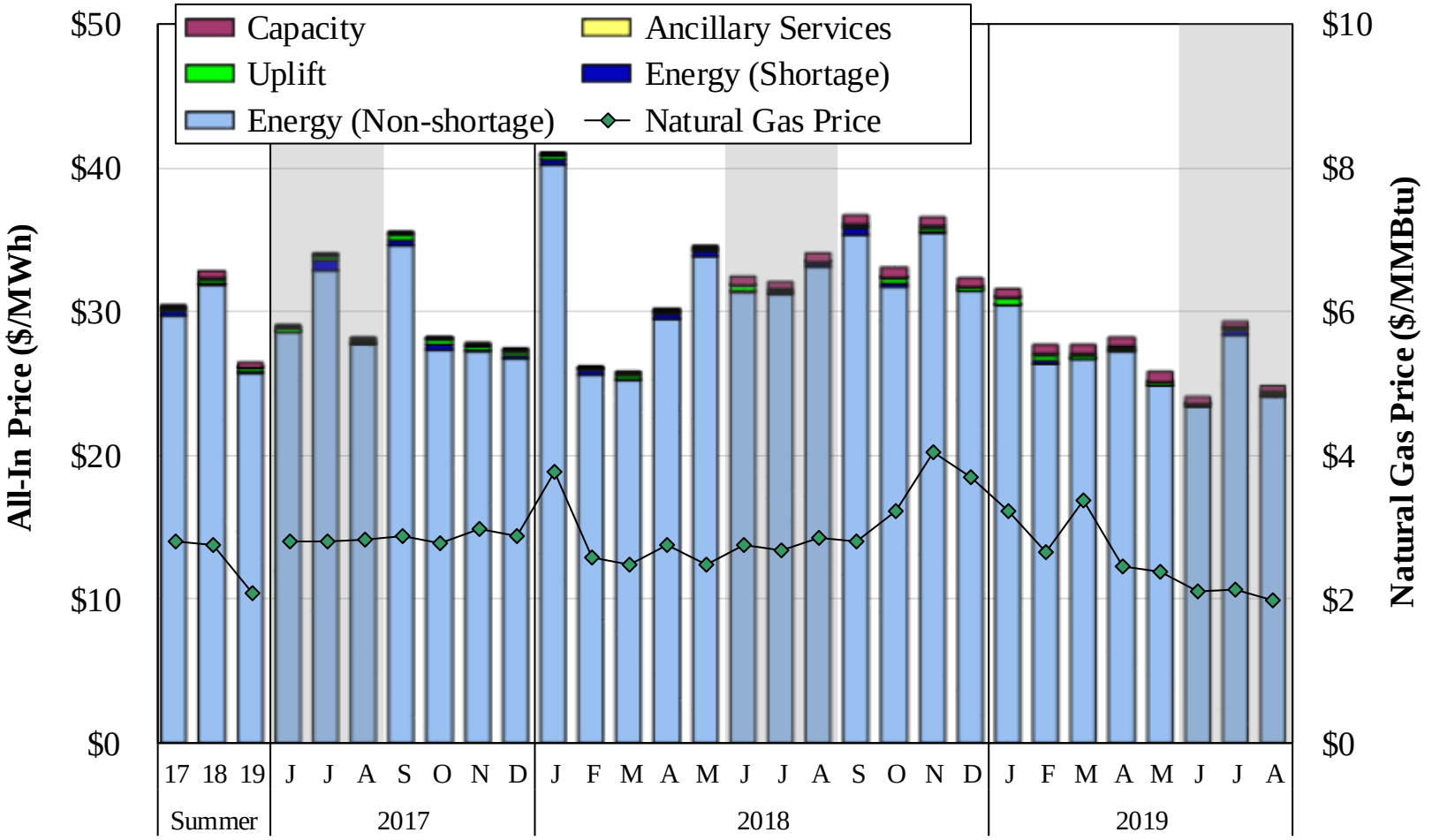
All-In Price
2017 – 2019



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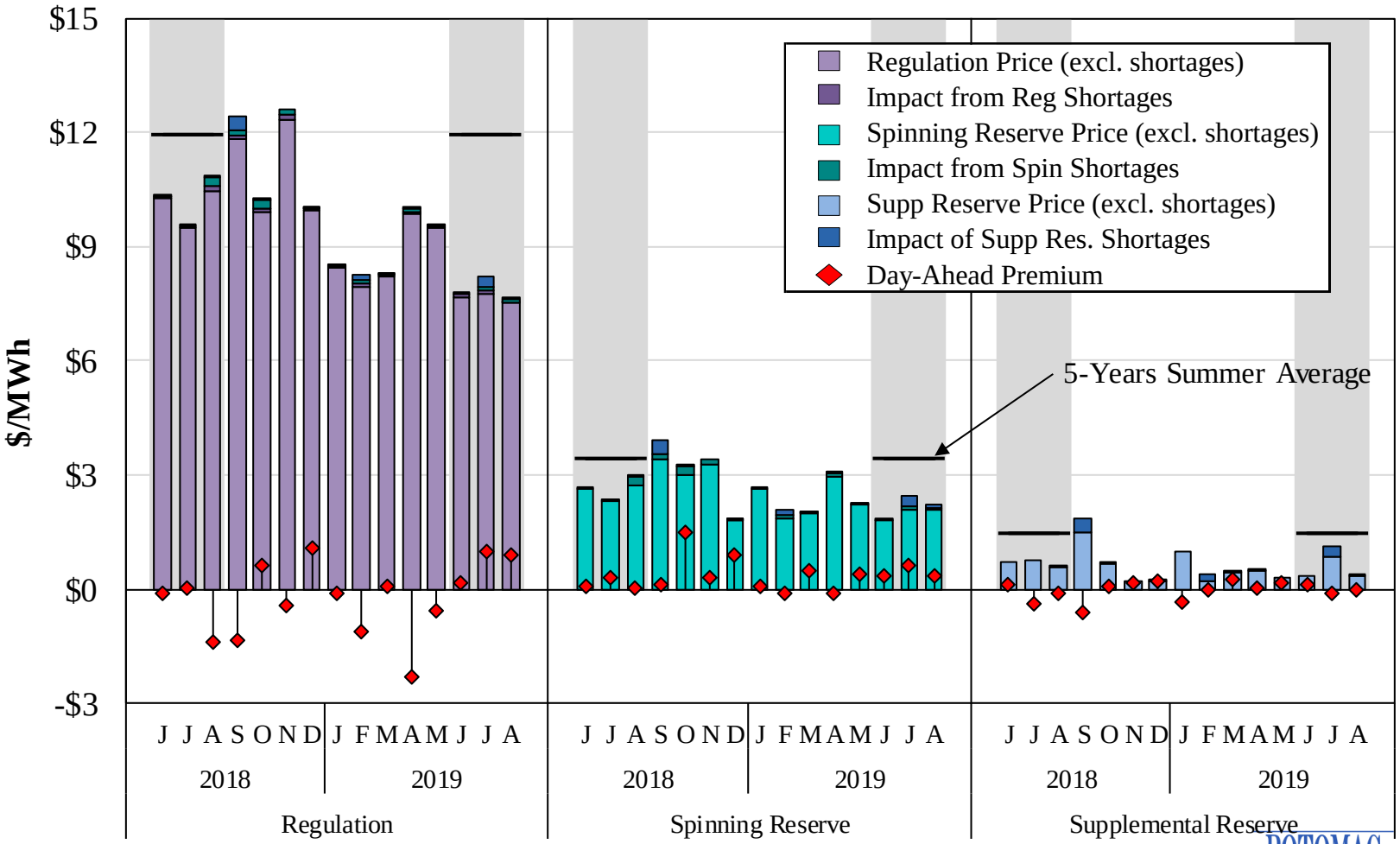
Monthly Average Ancillary Service Prices
Summer 2017 – 2019



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MISO Fuel Prices
Summer 2017 – 2019

Summer Average	2017	2018	2019
Chicago NG	$2.80	$2.76	$2.06
Henry NG	$2.92	$2.89	$2.26

Summer Average	2017	2018	2019
IB Coal	$1.41	$1.58	$1.52
PRB Coal	$0.65	$0.71	$0.70

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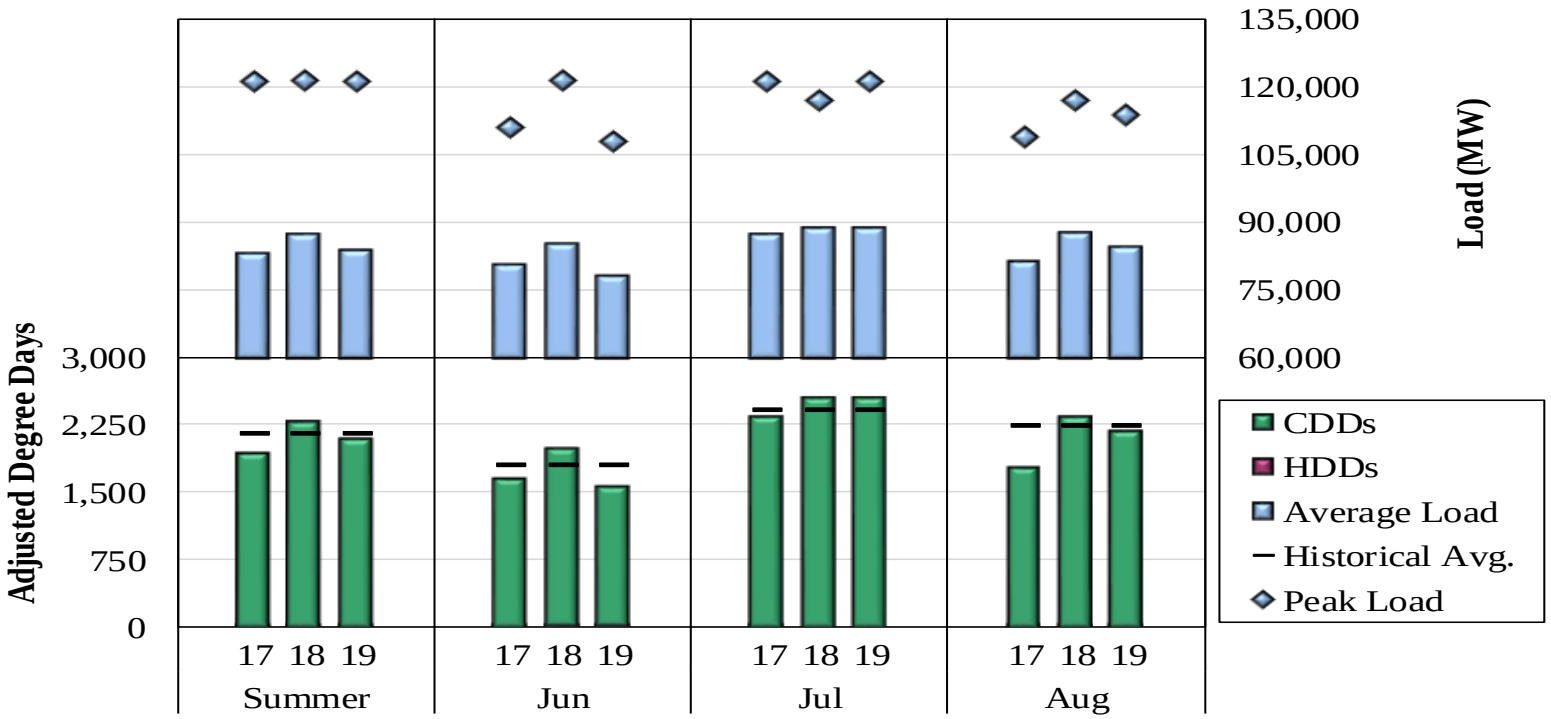
Load and Weather Patterns
Summer 2017 – 2019



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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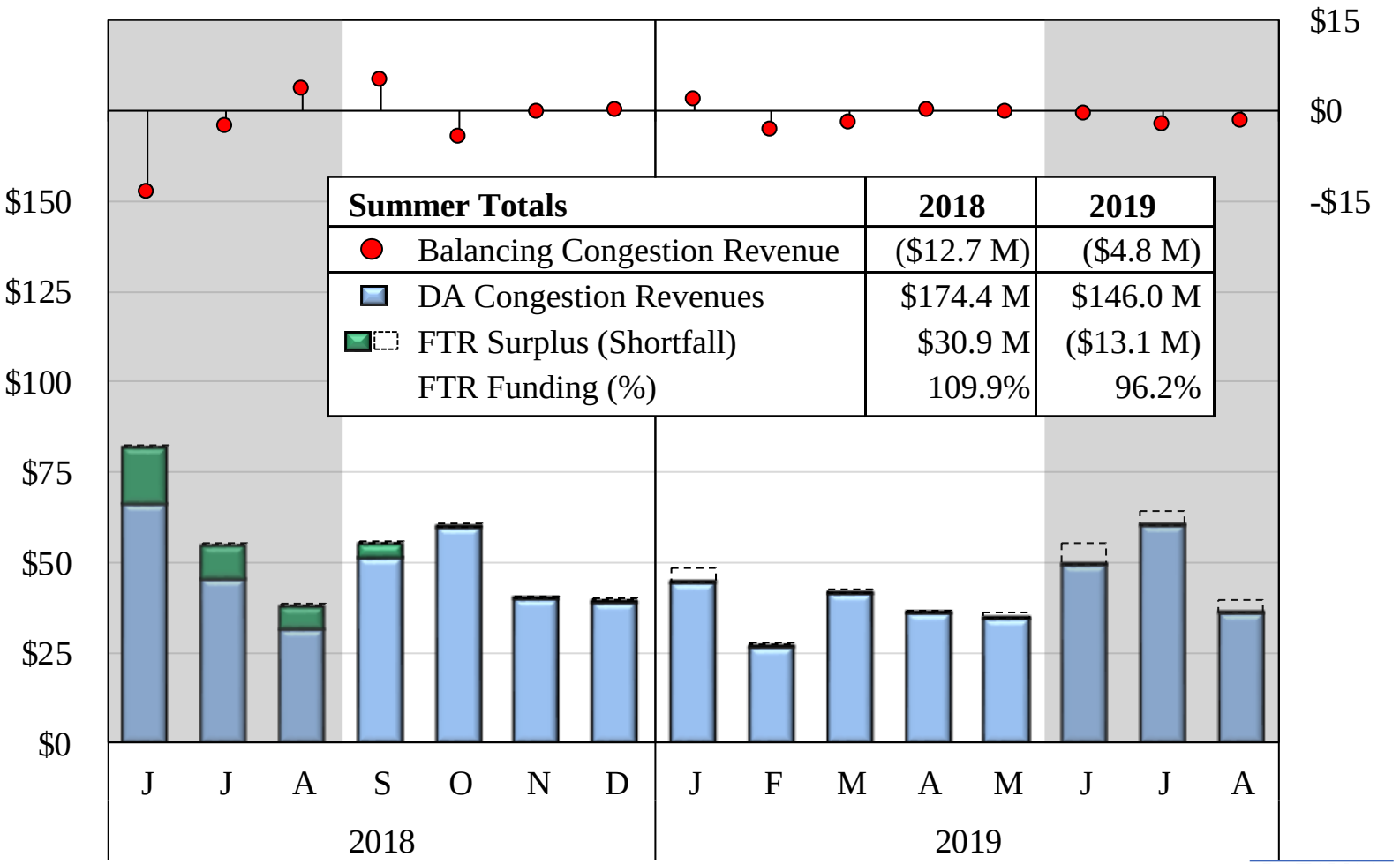
Day-Ahead Congestion, Balancing Congestion and FTR Underfunding, 2018 – 2019



Summer Totals	2018	2019
Balancing Congestion Revenue	($12.7 M)	($4.8 M)
DA Congestion Revenues	$174.4 M	$146.0 M
FTR Surplus (Shortfall)	$30.9 M	($13.1 M)
FTR Funding (%)	109.9%	96.2%

Note: Data has been scaled for last two days of the quarter due to data transfer lag.

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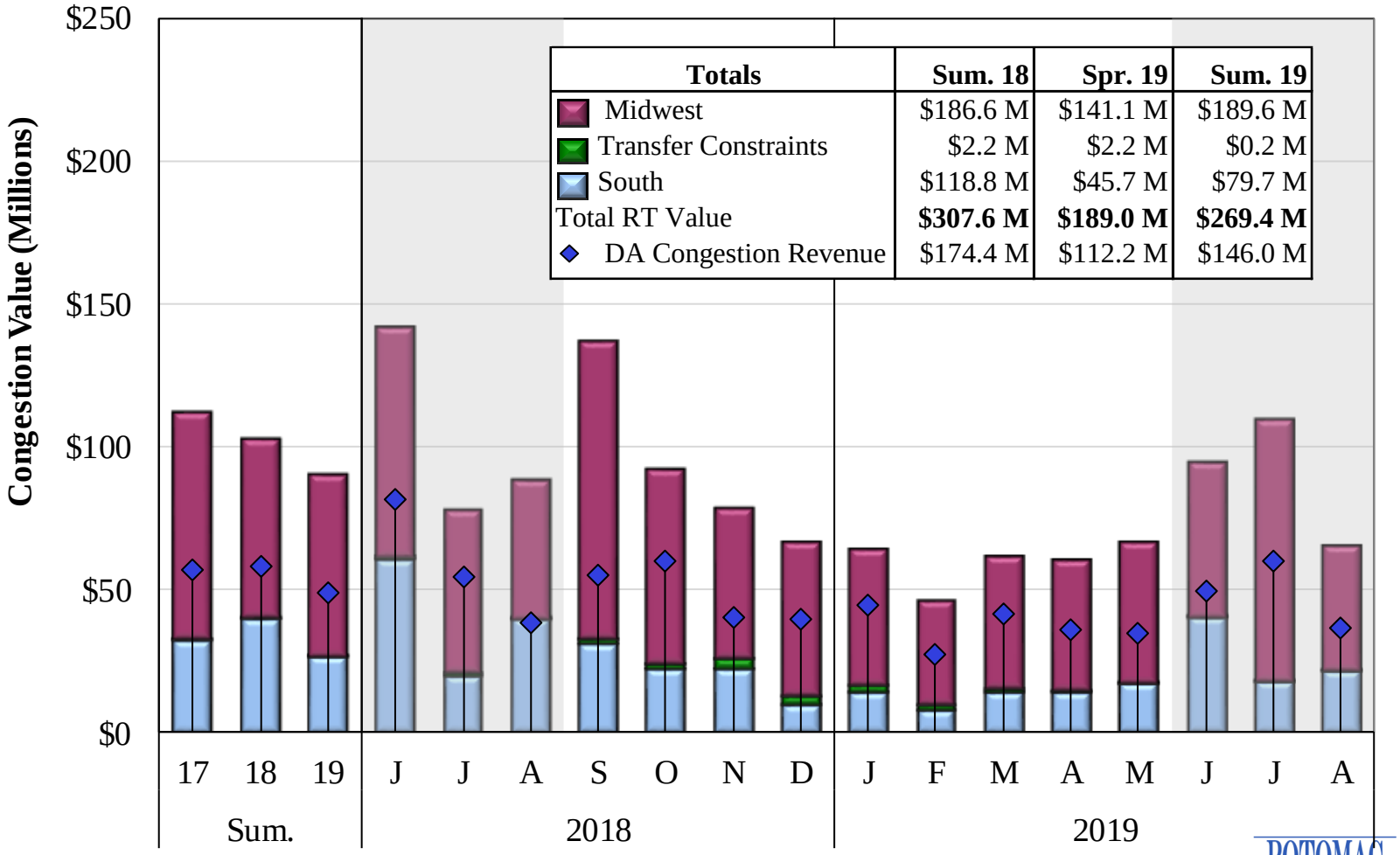
Value of Real-Time Congestion
Summer 2018 – 2019



Totals	Sum. 18	Spr. 19	Sum. 19
Midwest	$186.6 M	$141.1 M	$189.6 M
Transfer Constraints	$2.2 M	$2.2 M	$0.2 M
South	$118.8 M	$45.7 M	$79.7 M
Total RT Value	**$307.6 M**	**$189.0 M**	**$269.4 M**
DA Congestion Revenue	$174.4 M	$112.2 M	$146.0 M

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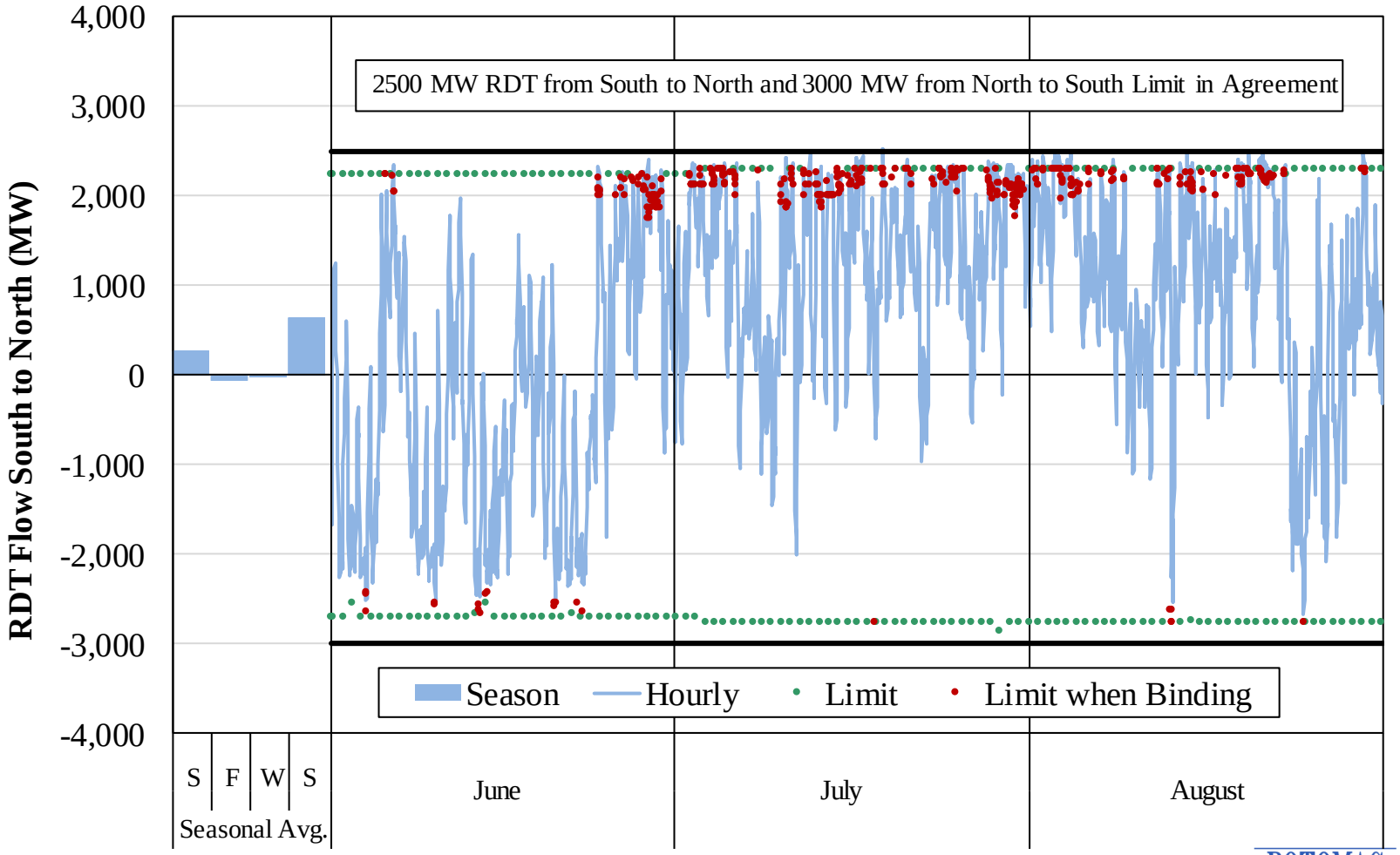
Real-Time Hourly Inter-Regional Flows
Summer 2019



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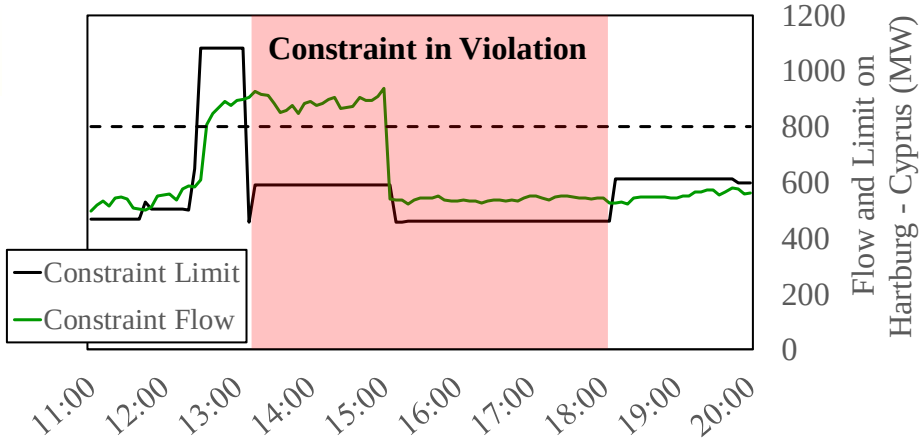
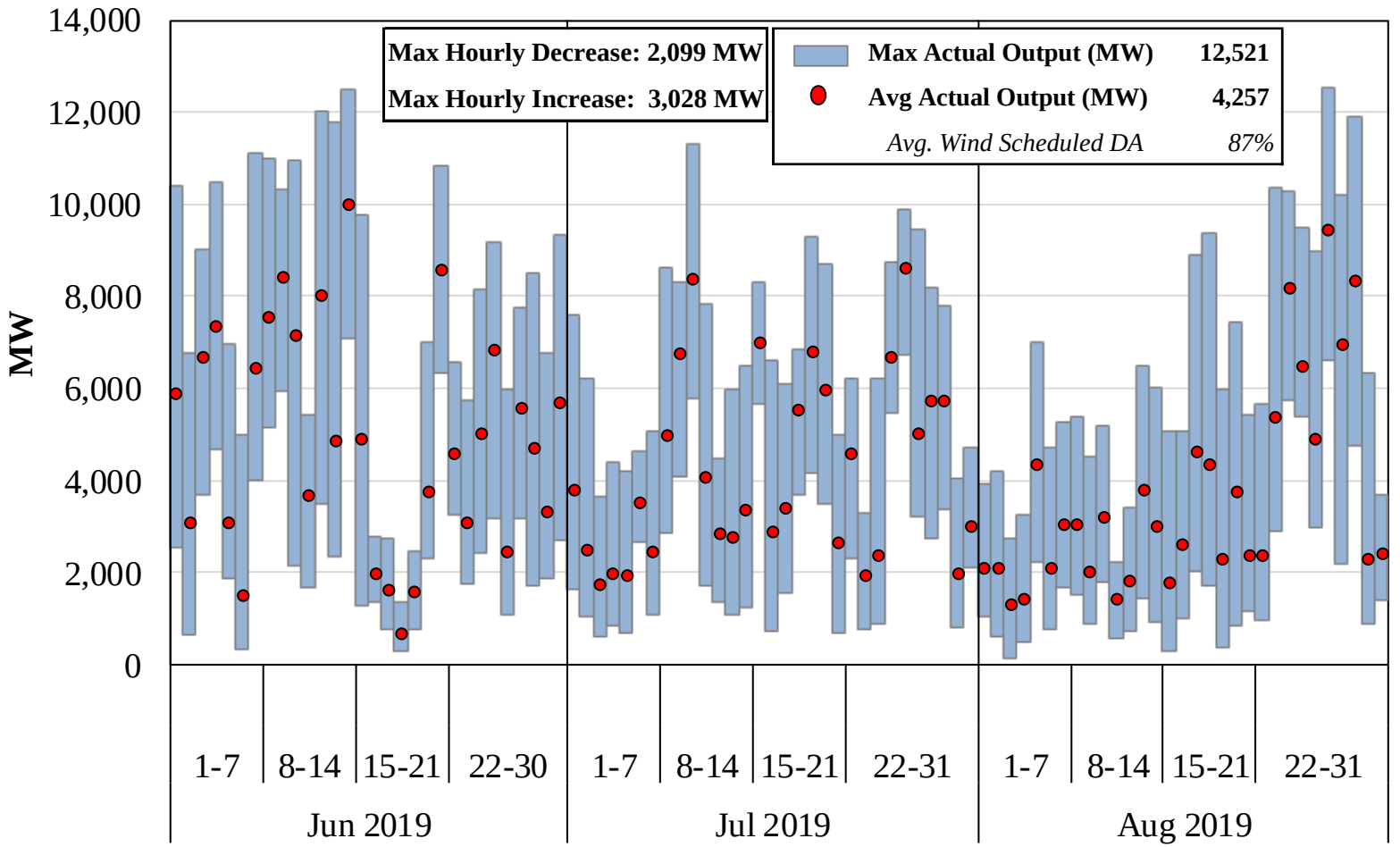
Market Event on August 13
4:00 pm to 6:00 pm EST

ERCOT:
$8800/MWh

Western:
$560/MWh



Wind Output in Real-Time Daily Range and Average



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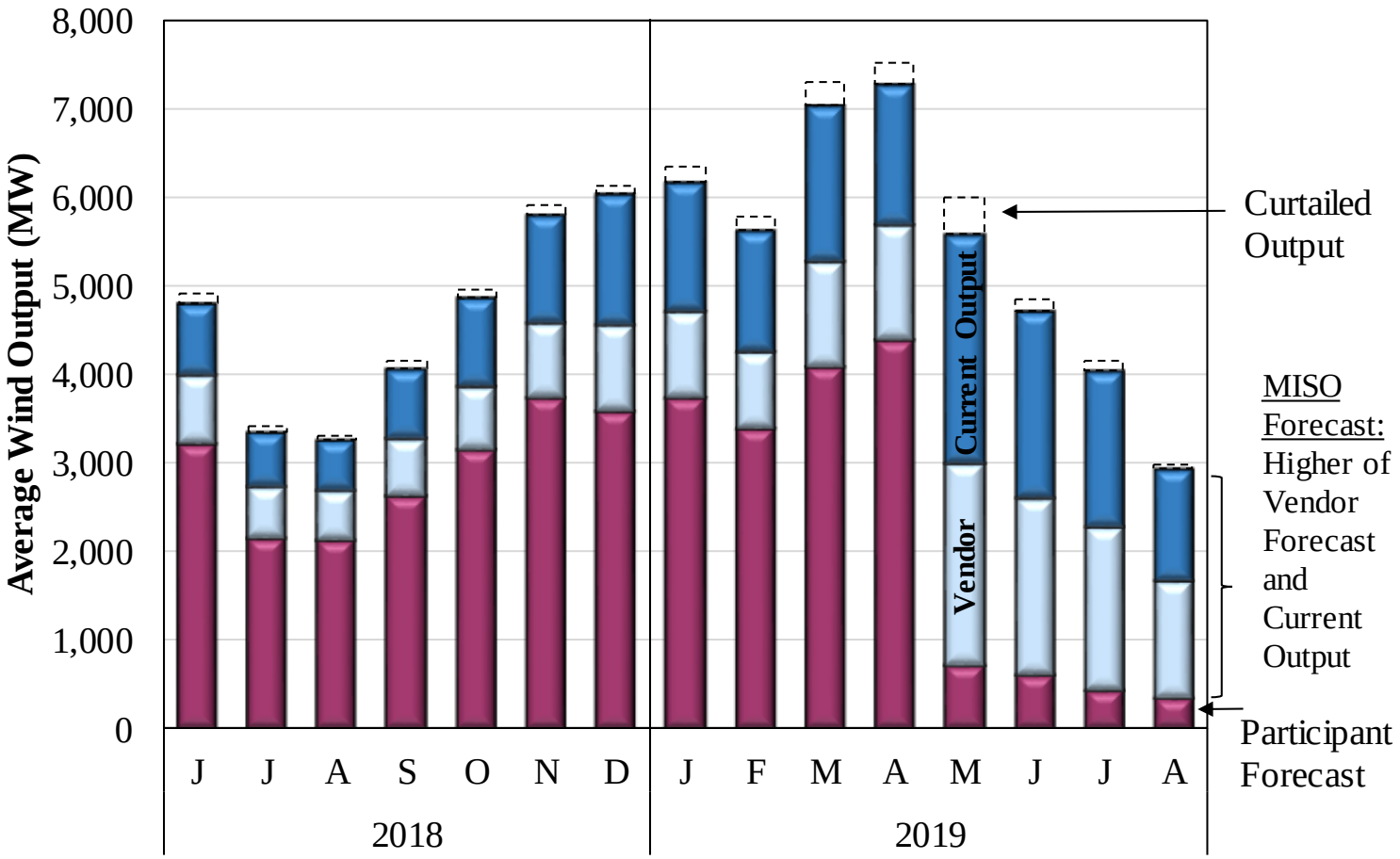
Average Wind Forecasts by Source
2018 - 2019



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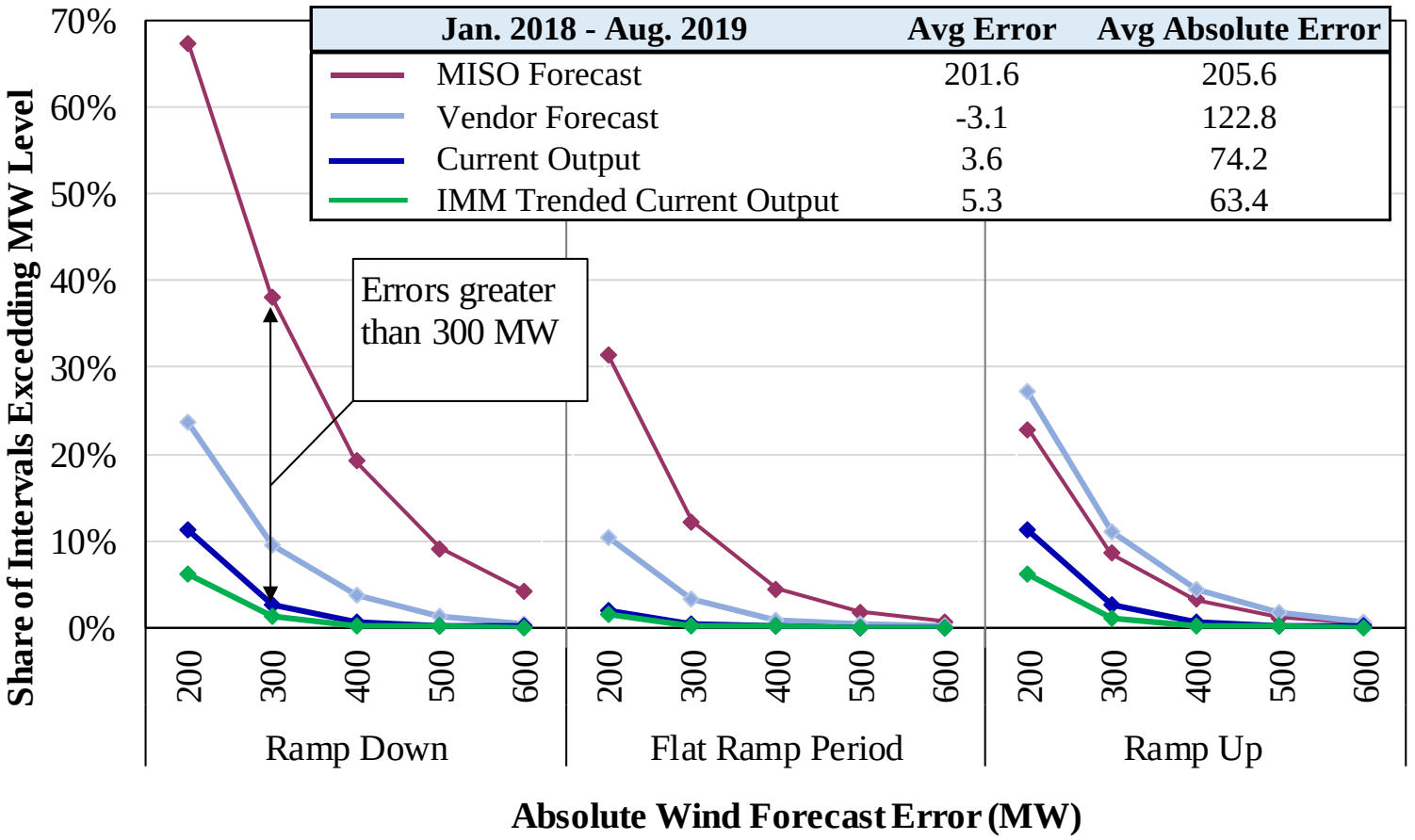
Wind Forecasting Error by Forecast Type
January 2018 – August 2019

Jan. 2018 - Aug. 2019	Avg Error	Avg Absolute Error
MISO Forecast	201.6	205.6
Vendor Forecast	-3.1	122.8
Current Output	3.6	74.2
IMM Trended Current Output	5.3	63.4



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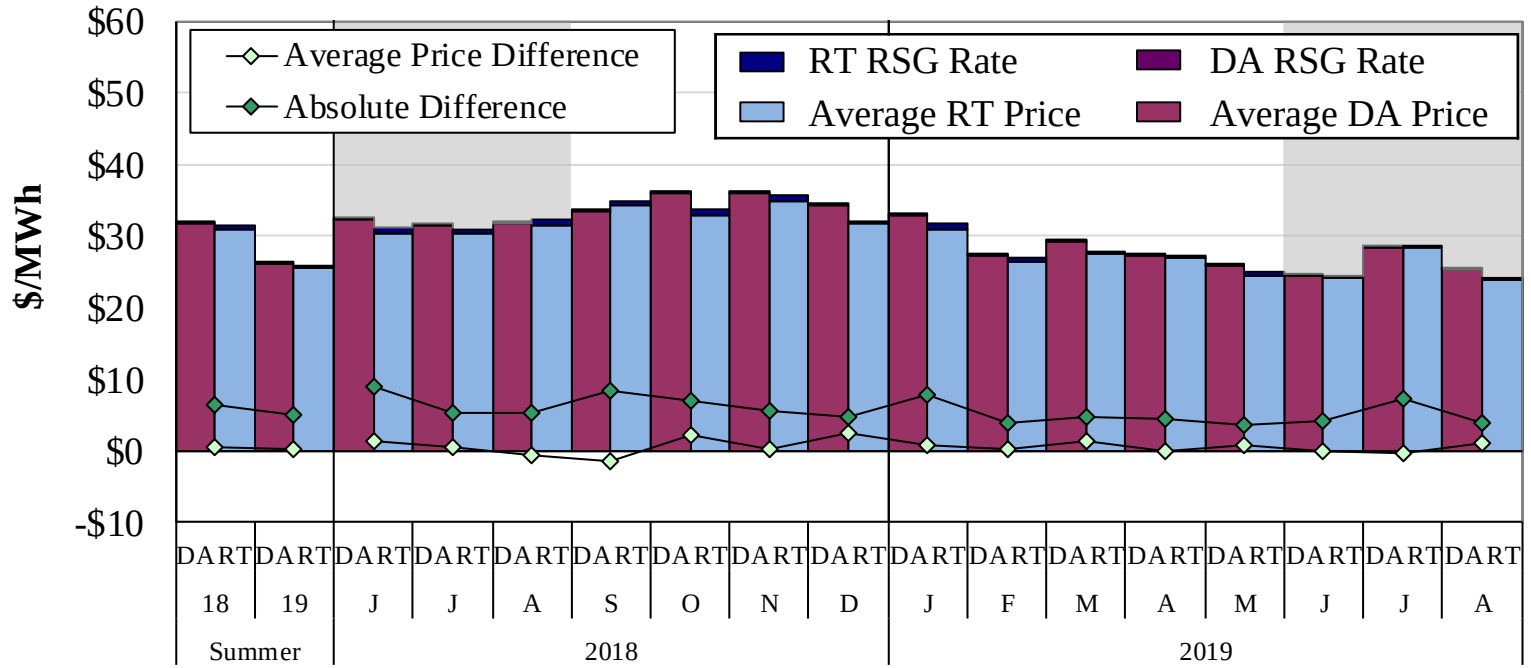
Day-Ahead and Real-Time Price Convergence Summer 2018 – 2019



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

Indiana Hub	1	1	4	2	-2	-4	7	1	7	3	1	5	-1	4	0	-1	4
Michigan Hub	0	0	4	1	-4	-5	4	-2	5	-6	0	4	-2	3	0	-5	4
Minnesota Hub	-1	1	-2	3	-4	-6	2	1	4	-4	-1	4	0	4	1	-3	6
WUMS Area	-3	-4	-2	-8	1	-4	3	0	7	1	1	7	-12	6	-7	-11	6
Arkansas Hub	1	3	4	3	-4	-11	3	-1	4	0	-3	5	1	6	7	-1	2
Texas Hub	1	-4	2	4	-5	-12	2	-1	3	1	1	7	0	9	1	5	-18
Louisiana Hub	-5	5	-13	9	-12	-18	4	-5	4	3	0	15	9	11	10	0	6

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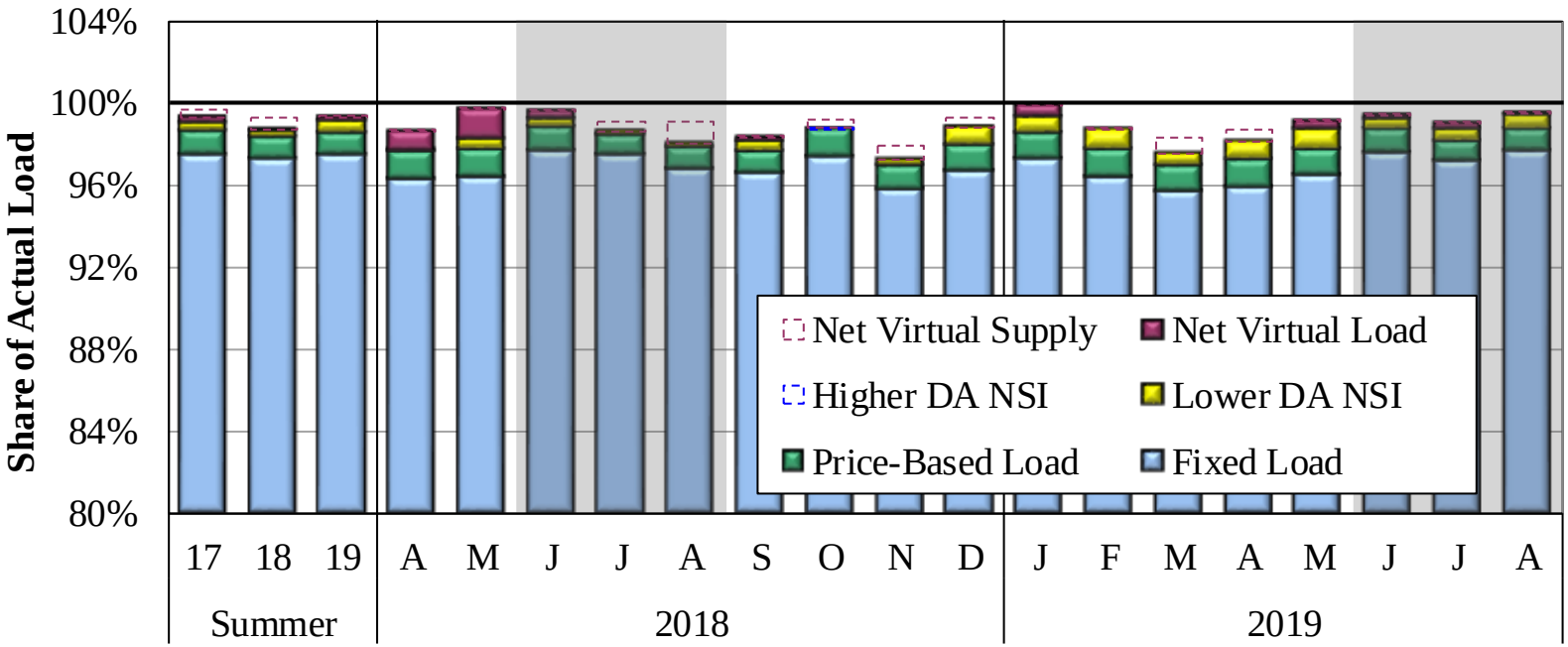
Day-Ahead Peak Hour Load Scheduling
Summer 2018 – 2019



Share of Actual Load (%)

	17	18	19	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
All Hours	99.9	99.5	99.8	98.6	100.0	99.7	99.4	99.3	98.9	99.1	97.5	98.8	99.7	98.8	98.1	98.5	99.0	99.6	99.9	100.0
Peak Hours Midwest	98.3	98.1	99.0	98.3	99.4	99.3	97.9	97.1	97.6	98.1	97.1	98.7	99.2	97.9	97.1	97.4	98.8	98.8	98.6	99.6
Peak Hours South	102.8	100.6	100.0	101.3	101.5	100.4	100.9	100.6	101.0	102.5	100.1	102.2	102.6	100.8	99.3	99.9	98.5	100.9	100.2	99.0

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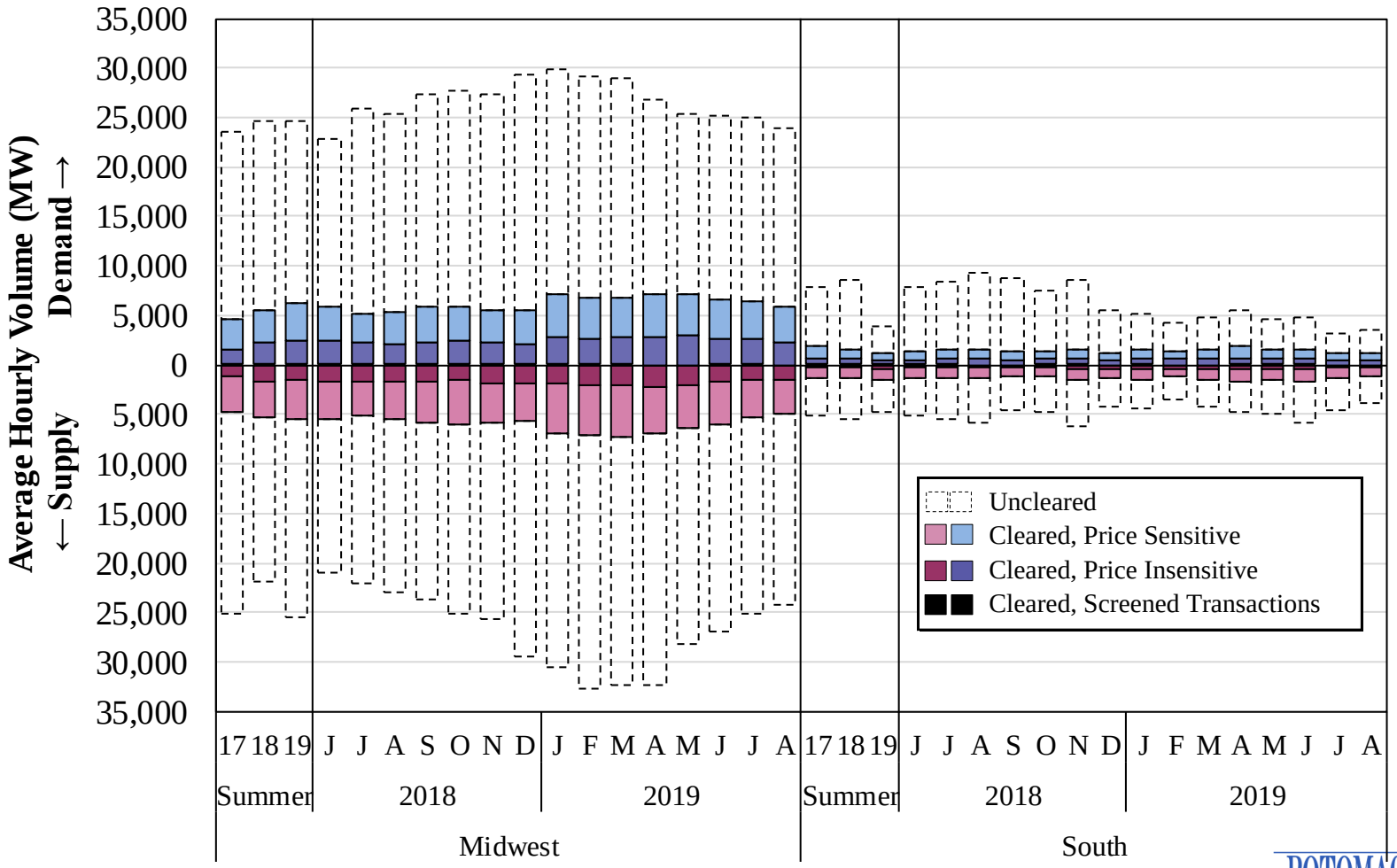
Virtual Load and Supply
Summer 2018 – 2019



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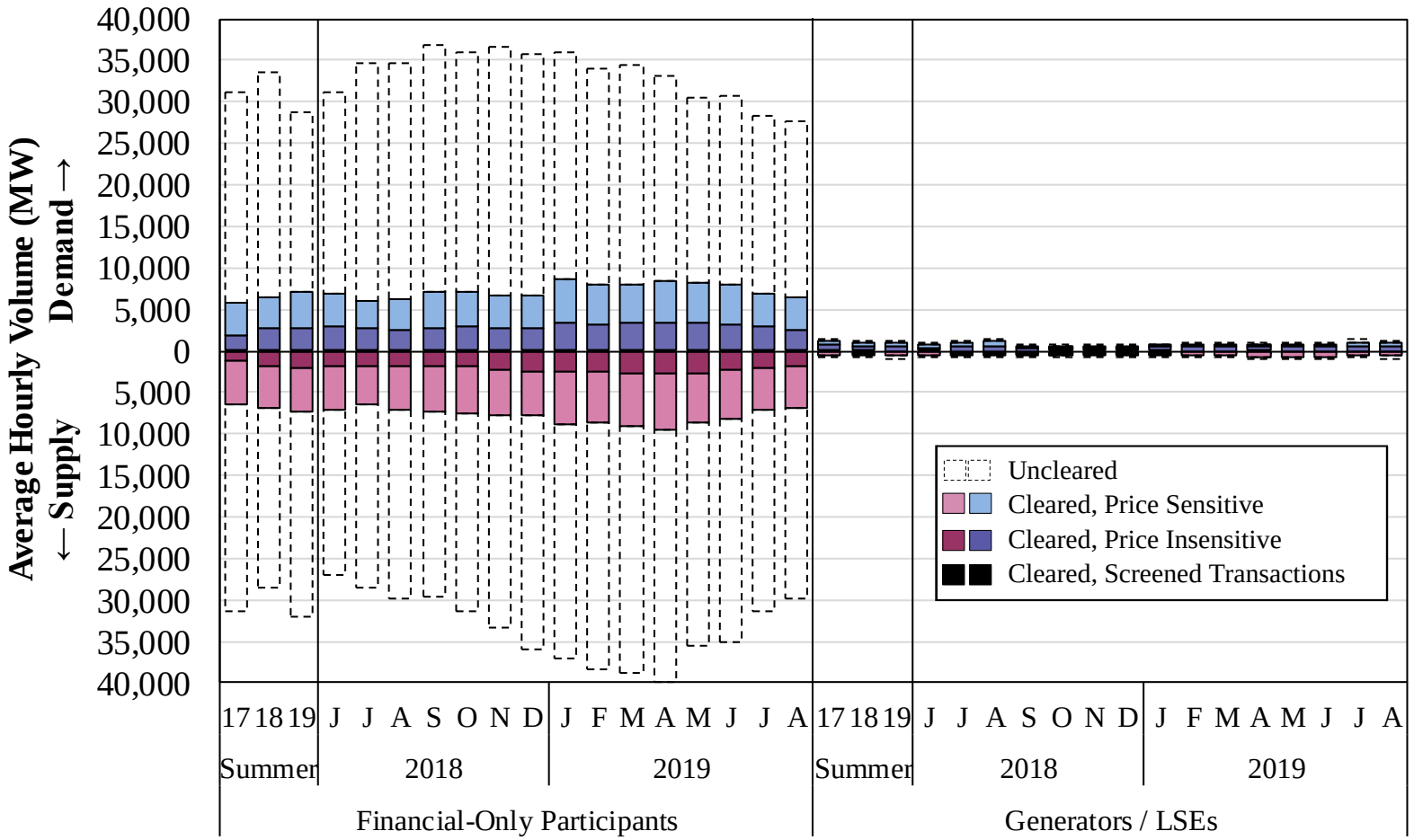
Virtual Load and Supply by Participant Type
Summer 2018 – 2019



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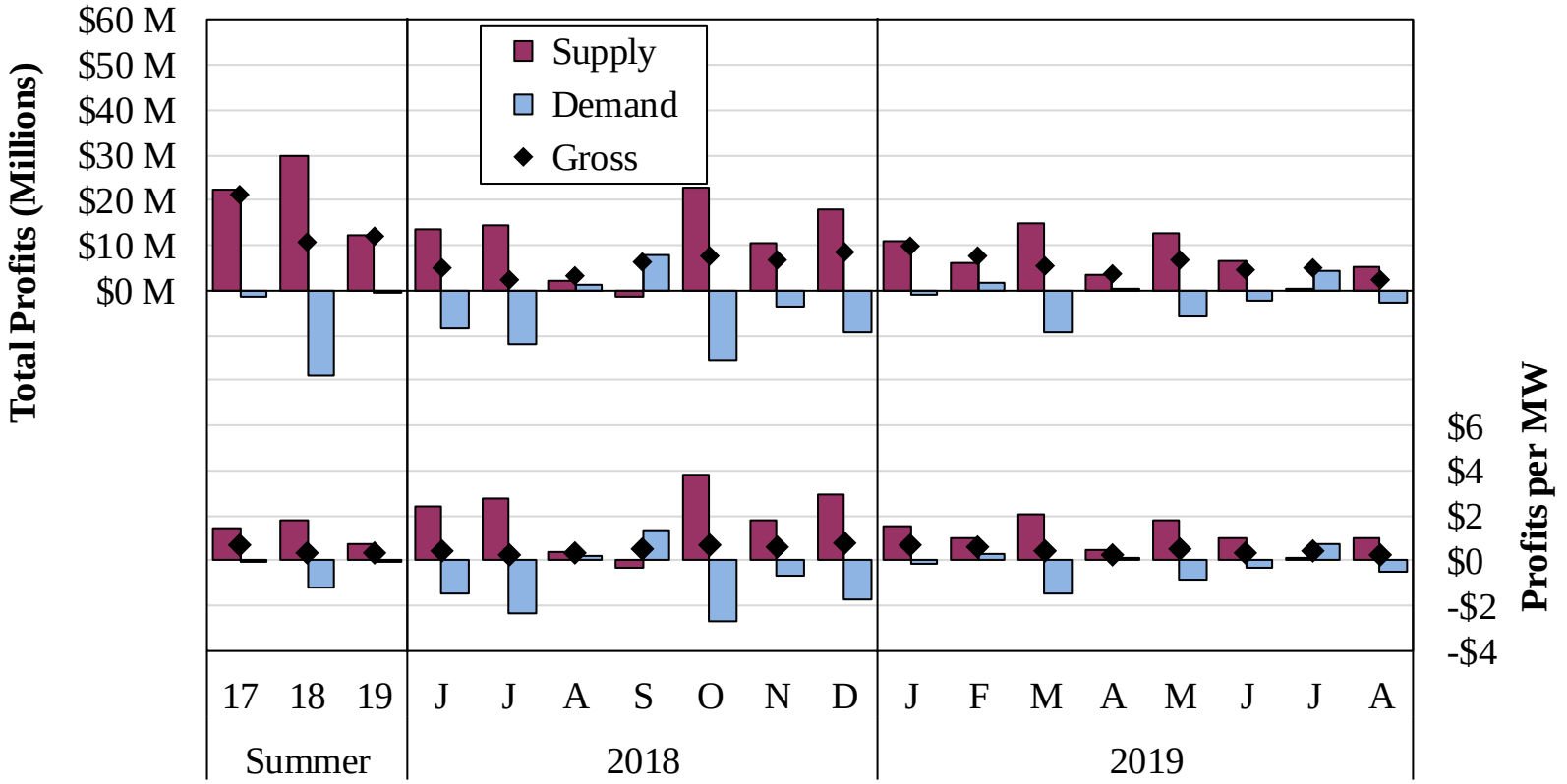
Virtual Profitability
Summer 2018 – 2019



Percent Screened

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

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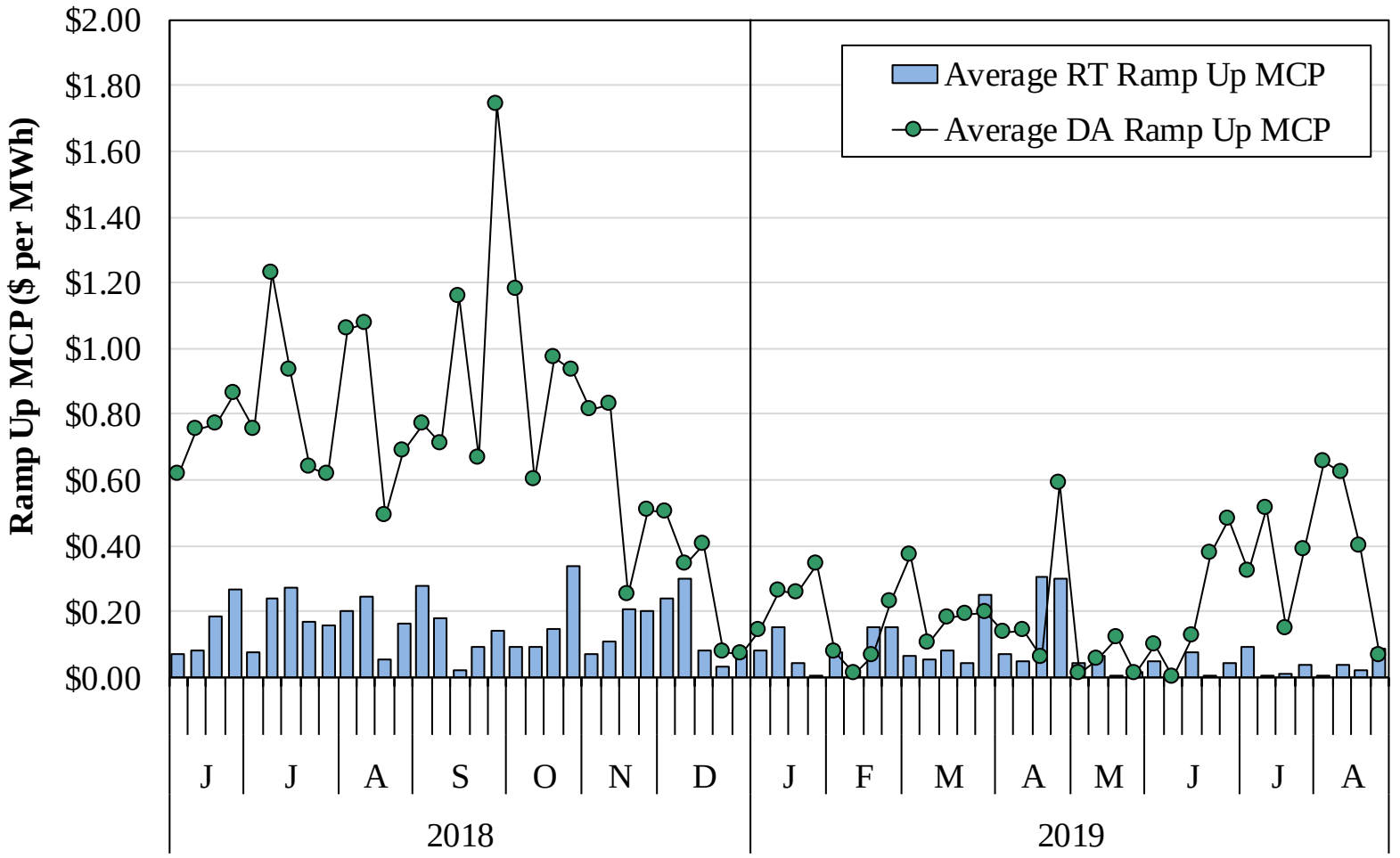
Day-Ahead and Real-Time Ramp Up Price 2018 – 2019



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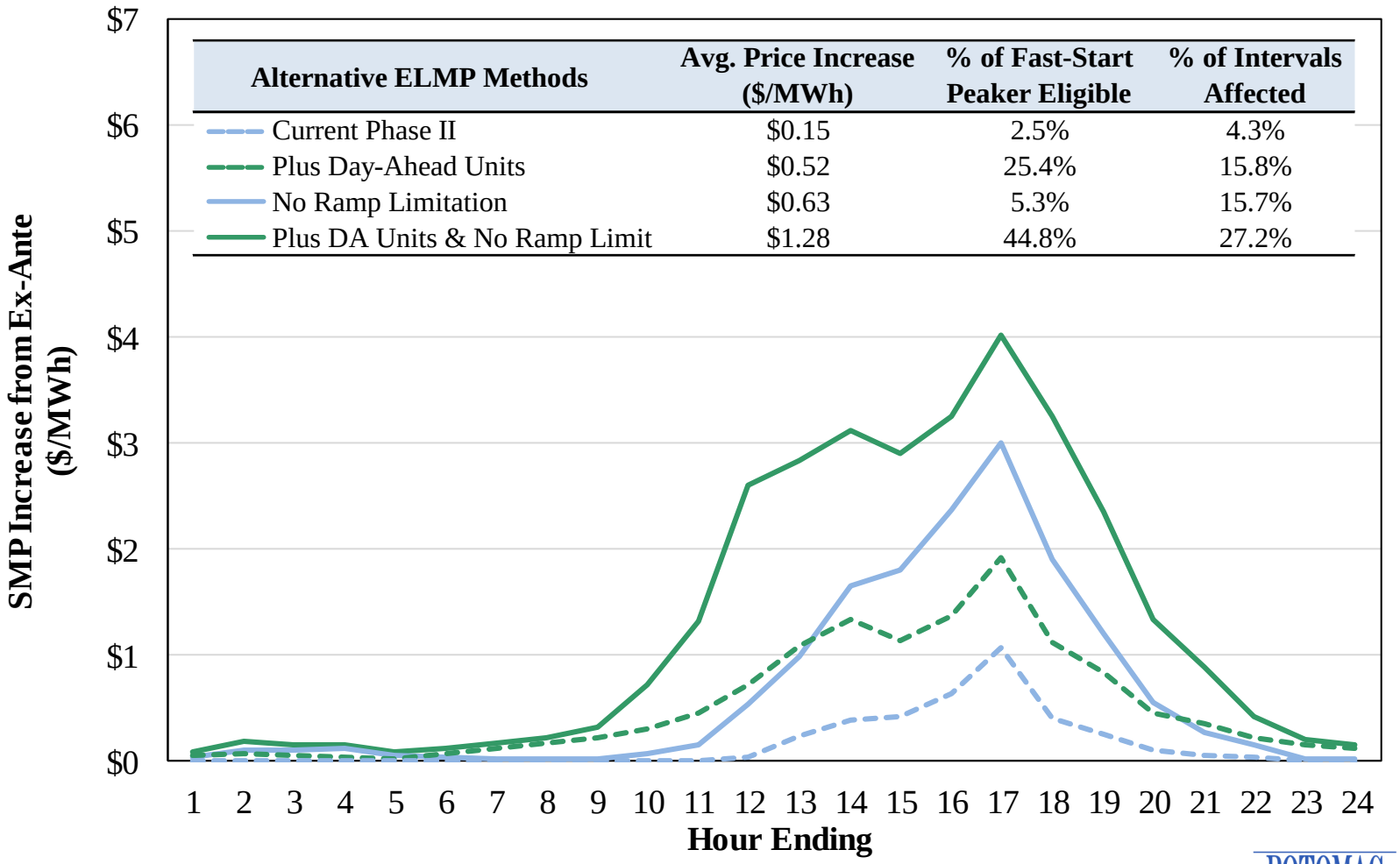
Evaluation of ELMP Assumptions
Summer 2019

Alternative ELMP Methods	Avg. Price Increase ($/MWh)	% of Fast-Start Peaker Eligible	% of Intervals Affected
Current Phase II	$0.15	2.5%	4.3%
Plus Day-Ahead Units	$0.52	25.4%	15.8%
No Ramp Limitation	$0.63	5.3%	15.7%
Plus DA Units & No Ramp Limit	$1.28	44.8%	27.2%



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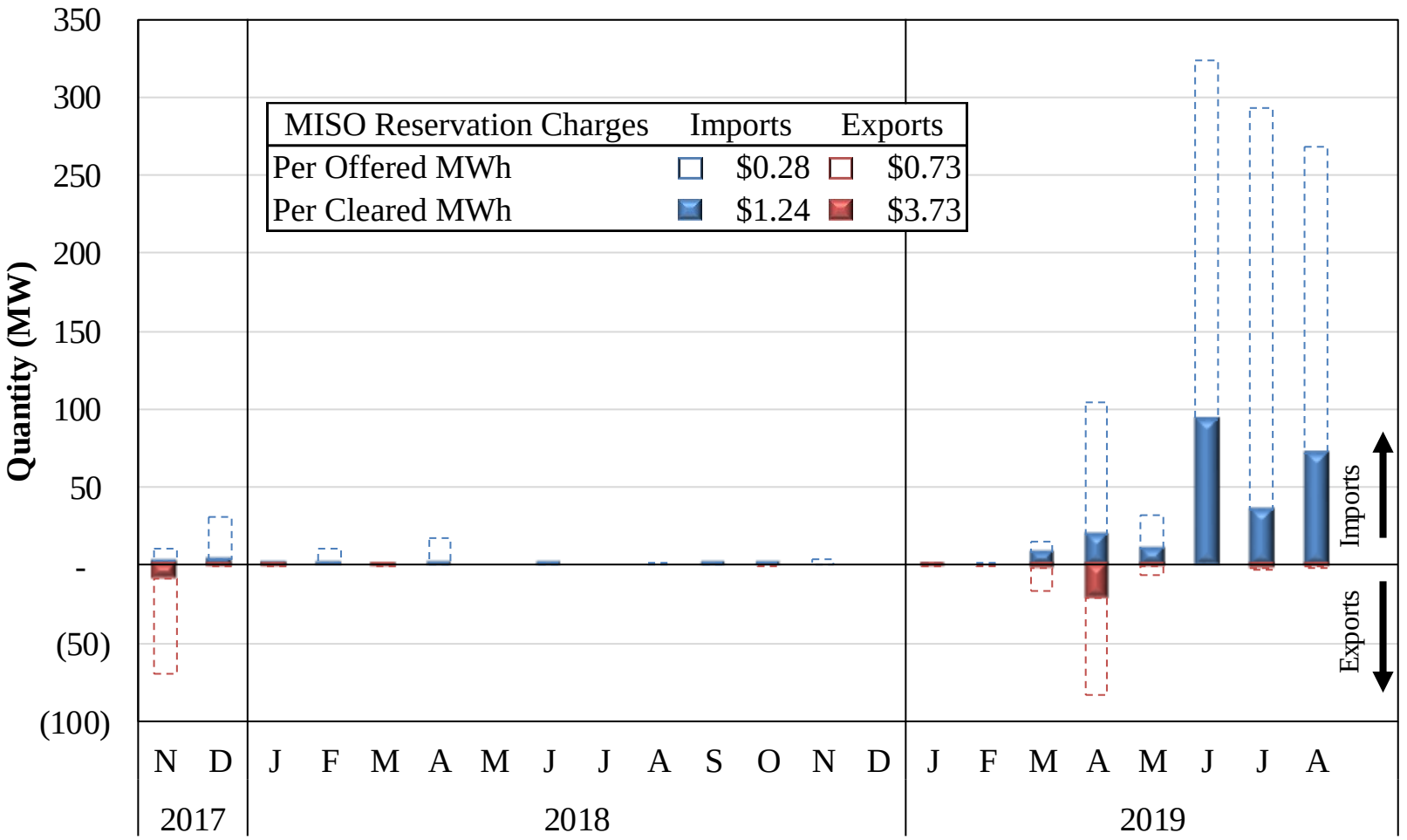
Coordinated Transaction Scheduling (CTS)
Summer 2018 – 2019



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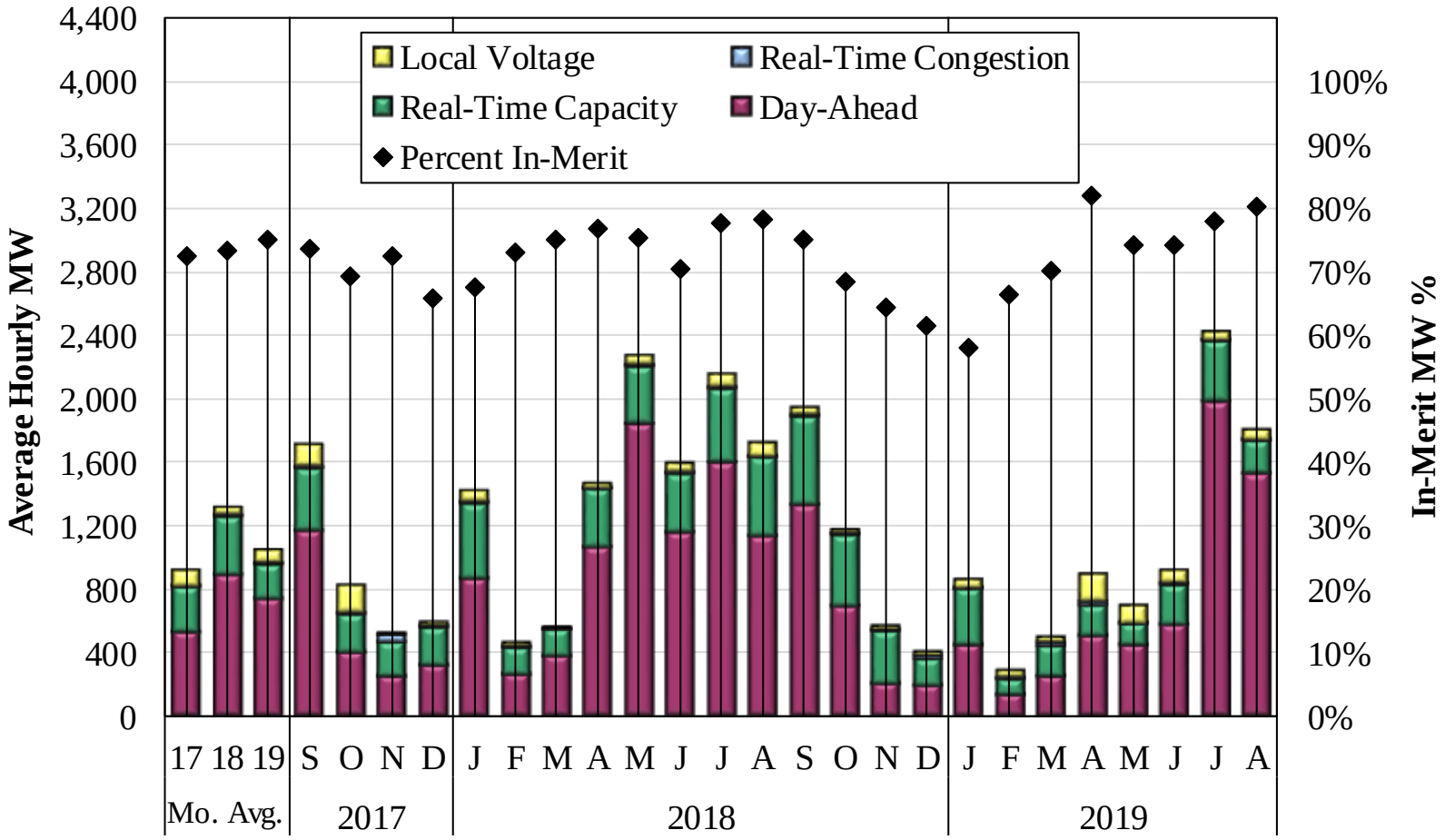
Peaking Resource Dispatch
Summer 2018 – 2019



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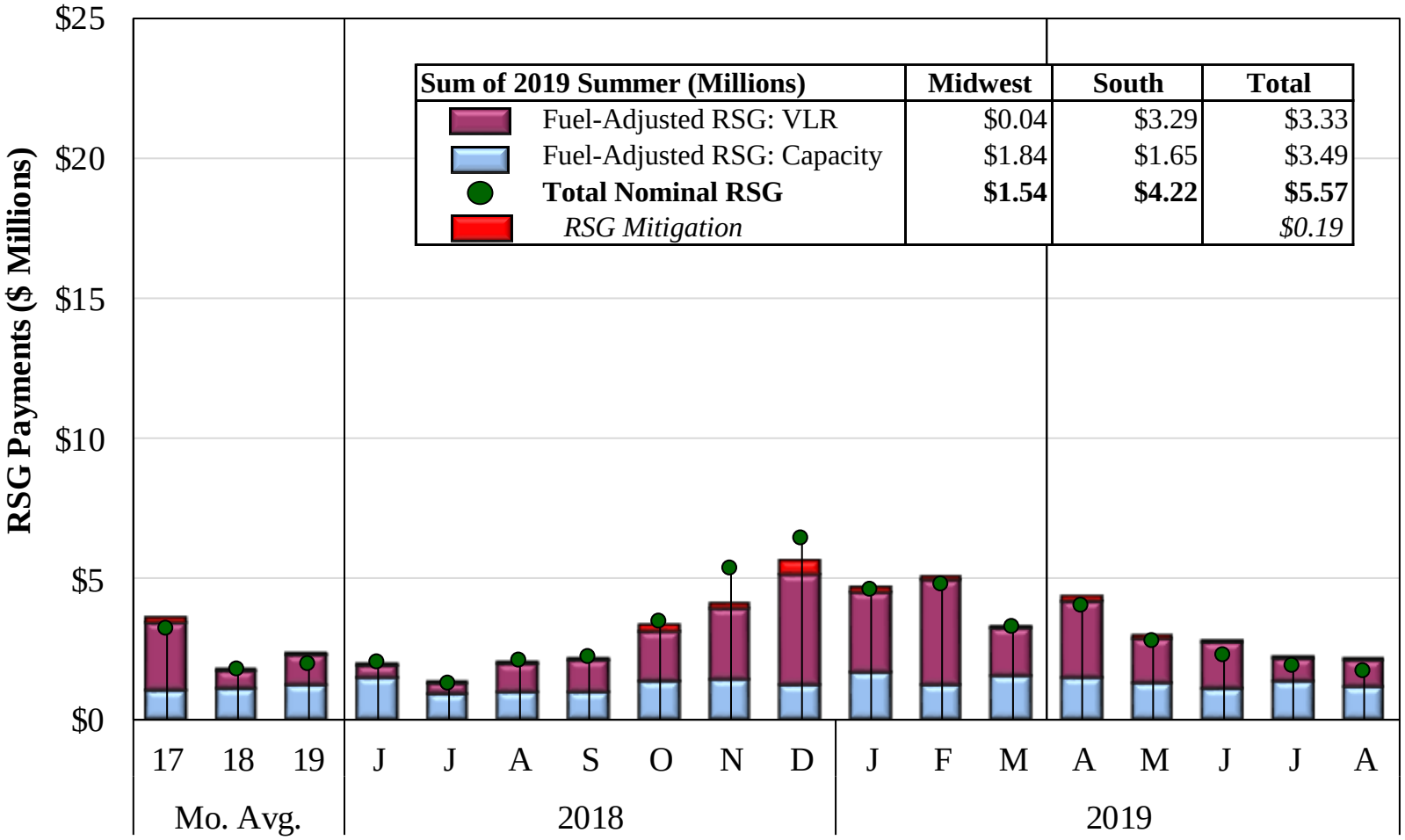
Day-Ahead RSG Payments
Summer 2018 – 2019

Sum of 2019 Summer (Millions)	Midwest	South	Total
Fuel-Adjusted RSG: VLR	$0.04	$3.29	$3.33
Fuel-Adjusted RSG: Capacity	$1.84	$1.65	$3.49
Total Nominal RSG	**$1.54**	**$4.22**	**$5.57**
RSG Mitigation			*$0.19*



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Real-Time RSG Payments
Summer 2018 – 2019

Sum of 2019 Summer (Millions)	Midwest	South	Total
Fuel-Adjusted RSG: VLR	$0.01	$0.65	$0.66
Fuel-Adjusted RSG: Congestion	$1.71	$0.59	$2.30
Fuel-Adjusted RSG: RDT	$0.01	$3.90	$3.90
Fuel-Adjusted RSG: Capacity	$8.22	$2.31	$10.52
Total Nominal RSG	**$8.39**	**$6.28**	**$14.13**
RSG Mitigation			*$0.54*

RSG Payments ($ Millions)

$25
$20
$15
$10
$5
$0

17 18 19 J J A S O N D J F M A M J J A

Mo. Avg. 2018 2019

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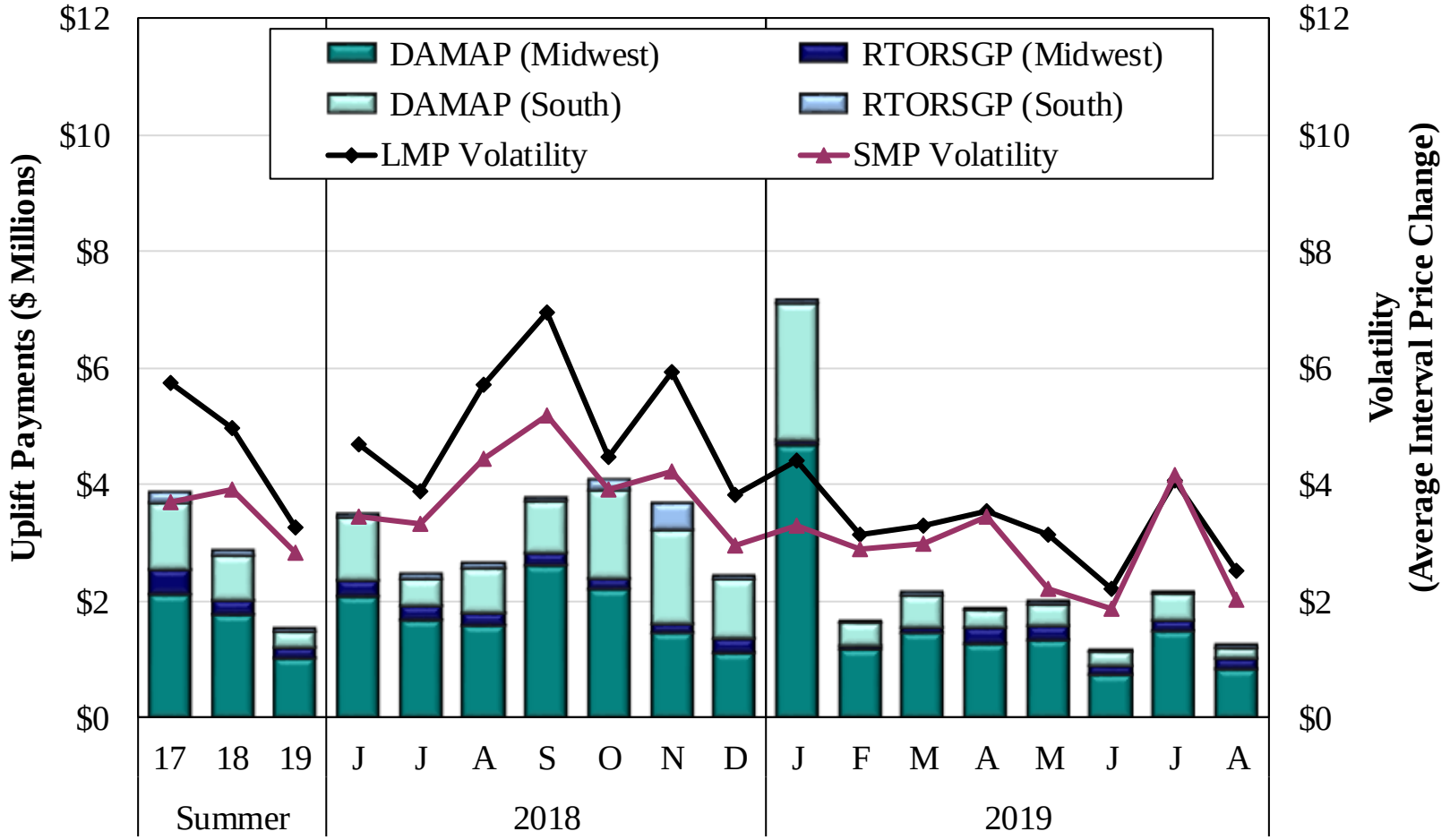
Price Volatility Make Whole Payments
Summer 2018 – 2019



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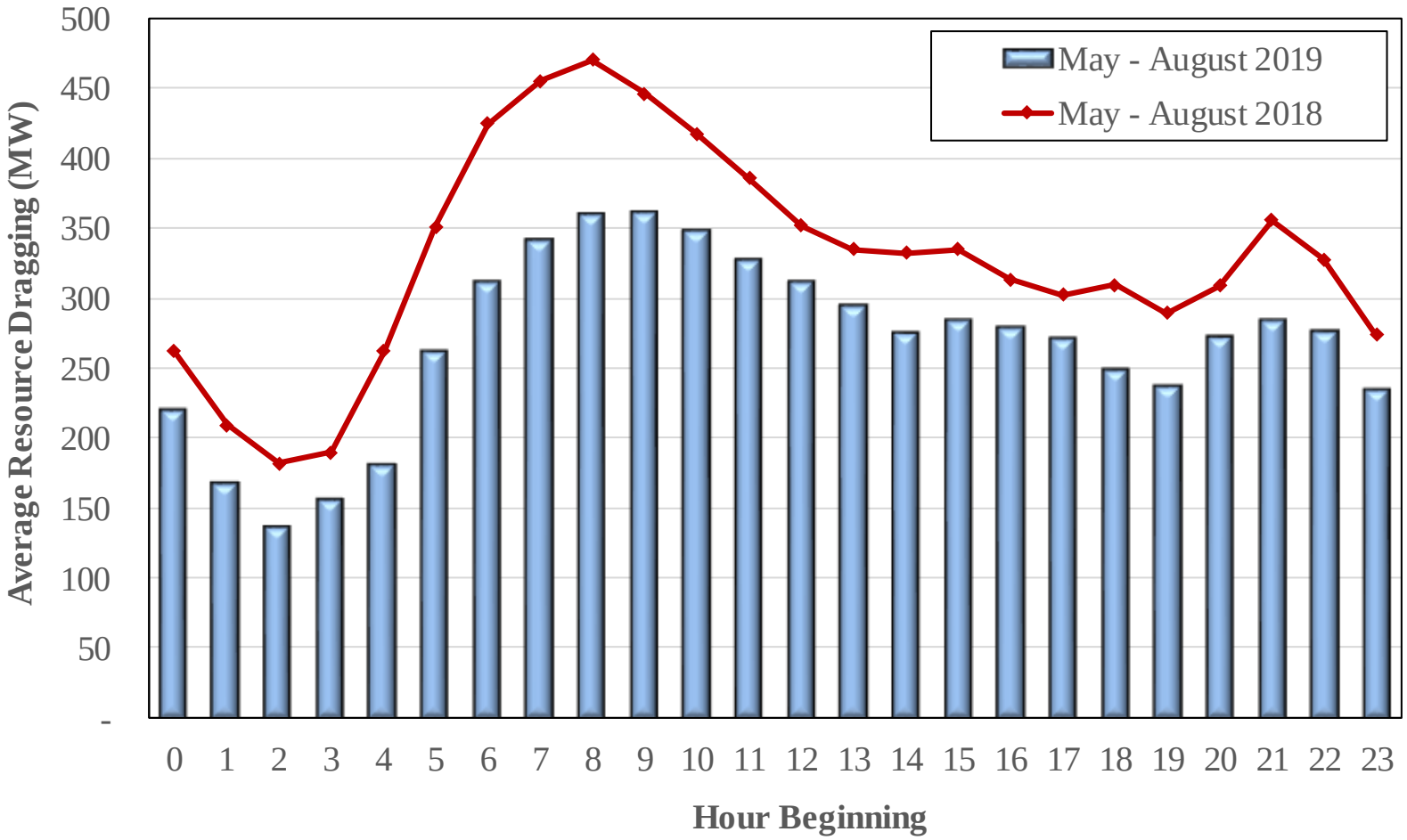
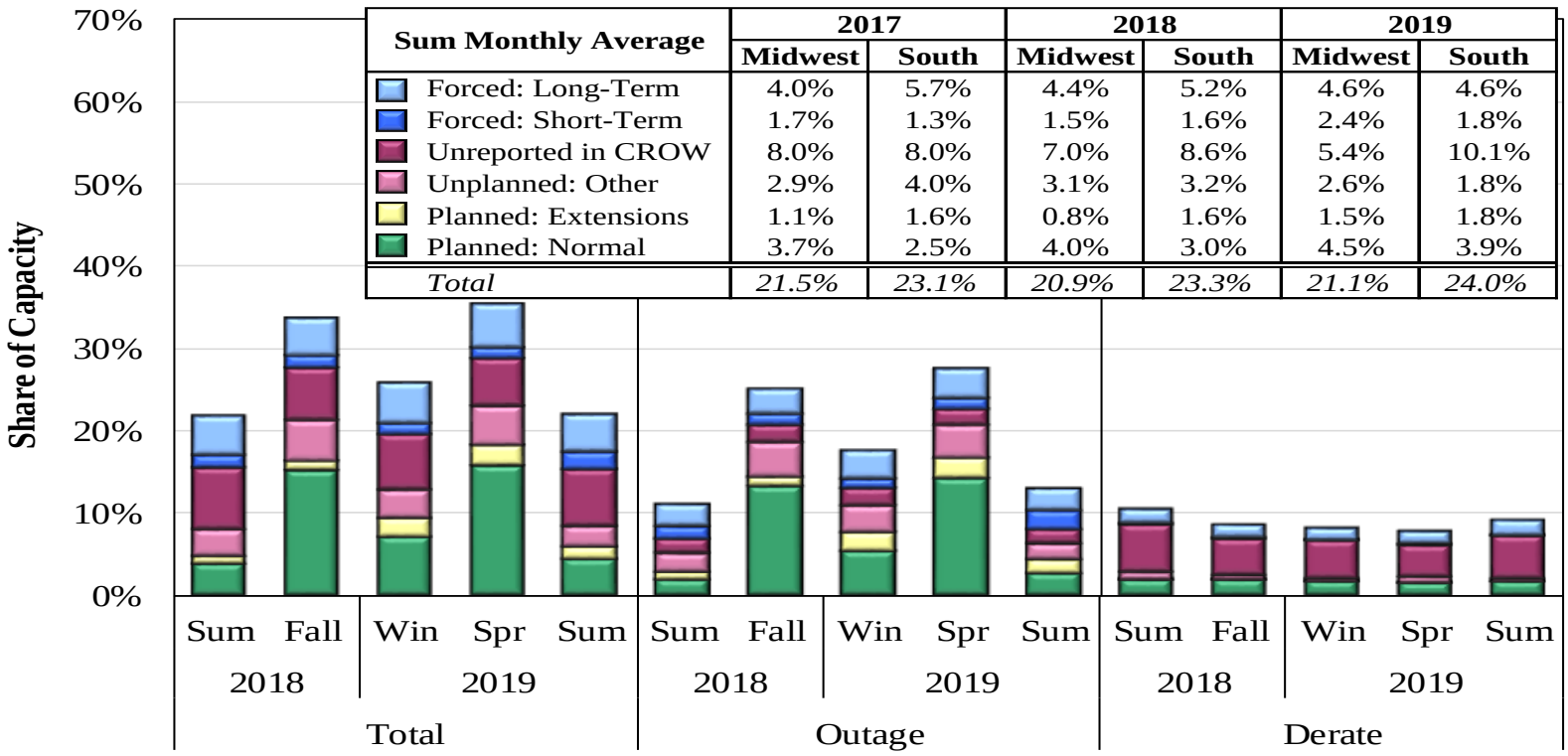
Average Resource Dragging by Hour
May - August



POTOMAC ECONOMICS

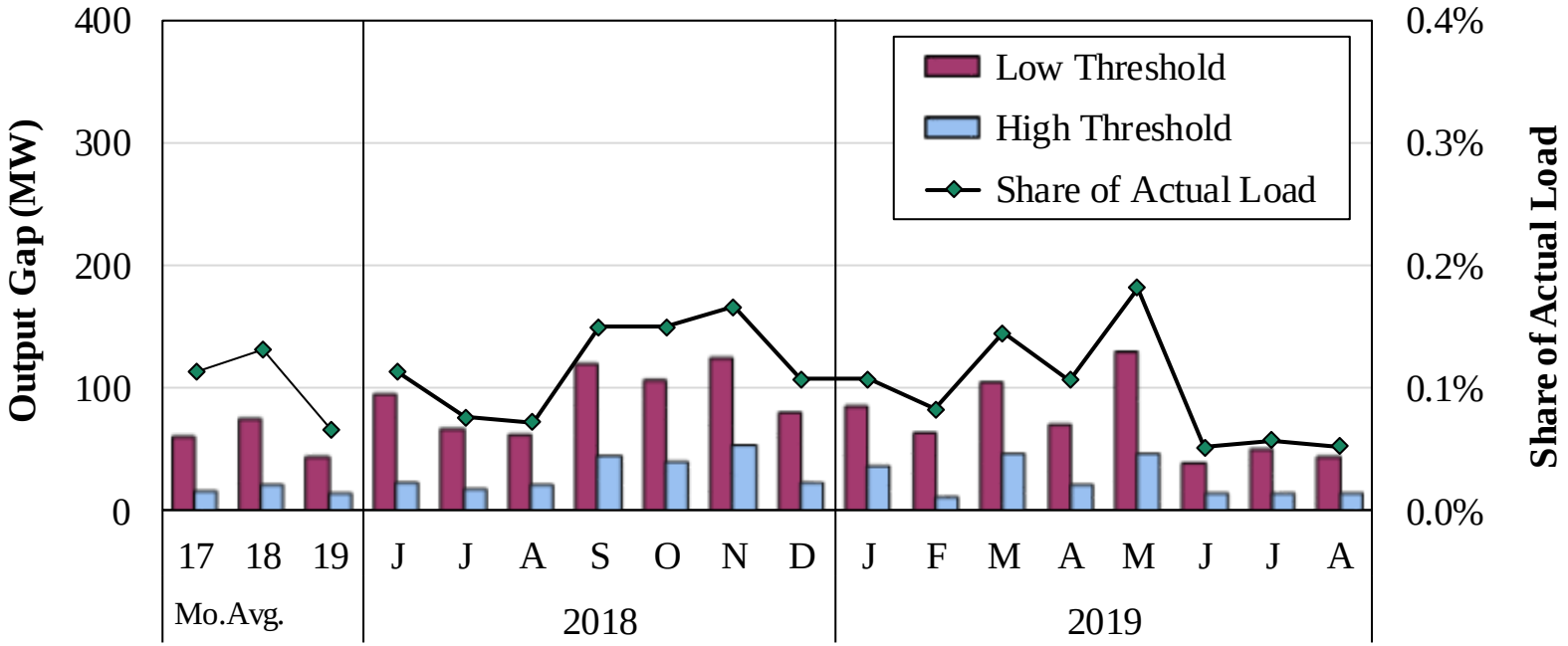
Generation Outage and Derate Rates
Summer 2018 - 2019

Sum Monthly Average	2017		2018		2019	
	Midwest	South	Midwest	South	Midwest	South
Forced: Long-Term	4.0%	5.7%	4.4%	5.2%	4.6%	4.6%
Forced: Short-Term	1.7%	1.3%	1.5%	1.6%	2.4%	1.8%
Unreported in CROW	8.0%	8.0%	7.0%	8.6%	5.4%	10.1%
Unplanned: Other	2.9%	4.0%	3.1%	3.2%	2.6%	1.8%
Planned: Extensions	1.1%	1.6%	0.8%	1.6%	1.5%	1.8%
Planned: Normal	3.7%	2.5%	4.0%	3.0%	4.5%	3.9%
Total	*21.5%*	*23.1%*	*20.9%*	*23.3%*	*21.1%*	*24.0%*



POTOMAC ECONOMICS

Monthly Output Gap
Summer 2018 – 2019



Low Threshold Results by Unit Status (MW)

	17	18	19	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
Offline	3	8	8	12	4	9	17	17	6	3	30	2	31	12	15	8	9	9
Online	58	67	37	84	64	54	102	90	118	78	56	63	75	60	114	33	42	36

High Threshold Results by Unit Status (MW)

	17	18	19	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
Offline	2	7	8	9	3	9	16	16	5	3	24	2	28	8	10	7	9	8
Online	15	14	8	15	15	13	30	24	48	21	13	11	19	15	36	9	8	7

POTOMAC ECONOMICS

Day-Ahead And Real-Time Energy Mitigation 2018 – 2019

Day-Ahead and Real-Time RSG Mitigation 2018 – 2019

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
- 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