IMM Quarterly Report: Fall 2016 – *Draft**

MISO Independent Market Monitor

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Potomac Economics

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* This draft contains market data through November 22 and settlement data (RSG and other make-whole payments) through November 15.

POTOMAC ECONOMICS

Highlights and Findings: Fall 2016

- The MISO markets continued to perform competitively and reliably this fall.
  - ✓ Natural gas prices remained low but increased 13 percent from last fall, which contributed to a 15 percent increase in real-time energy prices.
  - ✓ Market power mitigation remained infrequent and conduct was generally competitive.
- Growth in wind production contributed to higher congestion and price volatility compared to the prior year.
  - ✓ Consistent with seasonal patterns, wind output rose 64 percent from the summer and 4 percent over last year, and set new record in late November.
- High quantities of generator outages and increased wind output contributed to higher congestion the day-ahead and real-time markets relative to last year.
  - ✓ MISO South generation outages increased from 18.2 percent in Fall 2015 to 31.6 percent in Fall 2016, not including deratings.
  - ✓ Day-ahead congestion increased by 18 percent to $202.7 million.
  - ✓ Real-time congestion increased by 9 percent over last year to $345.1 million.

Quarterly Summary

Dashboard to be provided in the final report once the data is complete

Highlights from Fall 2016

Wind Generation (Slides 20 and Appendix)

- Wind output continued to grow, driven by a 1.3 GW year-over-year increase in nameplate wind capacity.
  - ✓ On November 28, wind output reached an all-time high of 13.3 GW.
  - ✓ Wind volatility is also increasing. MISO lost 3.6 GW of wind in one hour during this quarter.
  - ✓ Wind continued to be under-scheduled in the day-ahead market, and virtual supply continues to partially offset this scheduling pattern.
- At the MISO MSC we presented our evaluation of real-time wind operations (attached as an Appendix to this report). In this report, we:
  - ✓ Found a strong bias toward deficient energy (producing less than MISO's dispatch instruction) because a number of wind suppliers are deliberately over-forecasting their real-time output.
  - ✓ Identified several inefficient incentives to over-forecast related to MISO's settlement of excess and deficient energy and the DAMAP payments.
  - ✓ Provided five recommendations to address this issue and have also been discussing the inaccurate forecasting with FERC Enforcement.

Highlights for Fall 2016

MISO South Outages, Congestion, and RDT Flows (Slide 16, 17, 32)

- In October, outages in MISO South led to several operational challenges and increases in day-ahead and real-time congestion.
  - ✓ Nearly 40 percent of the total generating capacity in MISO South was on outage in October.
    - Three-quarters of these were planned outages.
    - Forced outages in the South doubled from September to October.
    - An additional 3.4 GW of capacity was derated in the South in October.
  - ✓ On October 4 and 5, MISO issued Conservative Ops and a Max Generation Alert for the South Region and extended Conservative Ops through Oct. 6.
- The high level of outages in the South also led to a reversal in the typical pattern of flows to be primarily North-to-South after late September.
- Overall, congestion in the South increased 43 percent over last fall caused in part by a number of forced outages and the early return of a nuclear facility.

Highlights for Fall 2016

Congestion on SPP and PJM Flowgates (Slide 18)

- Congestion on PJM and SPP Flowgates accounted for a larger share of the congestion pricing in MISO's LMP.
  - ✓ Together, the external M2M constraints accounted for almost one quarter of all congestion pricing in MISO, up from roughly 10 percent in the summer.
  - ✓ Most of this increase was associated with constraints that were not managed under conventional M2M coordination.
- These departures from conventional M2M coordination including using overrides, safe operating modes, TLRs or other processes to manage the congestion.
  - ✓ Although sometimes justified, these alternatives are generally less efficient and lead to higher congestion costs.
- Such departures are more commonly initiated by SPP for constraints that MISO dominates (which raises operational concerns for SPP).
  - ✓ These cases are usually most appropriately addressed by transferring control of the constraint to the non-monitoring RTO (MISO in this case).
  - ✓ This has been successful with PJM (because it allows continued reliance on more efficient M2M coordination
  - ✓ MISO is working on an MOU with SPP to agree to a similar procedure.

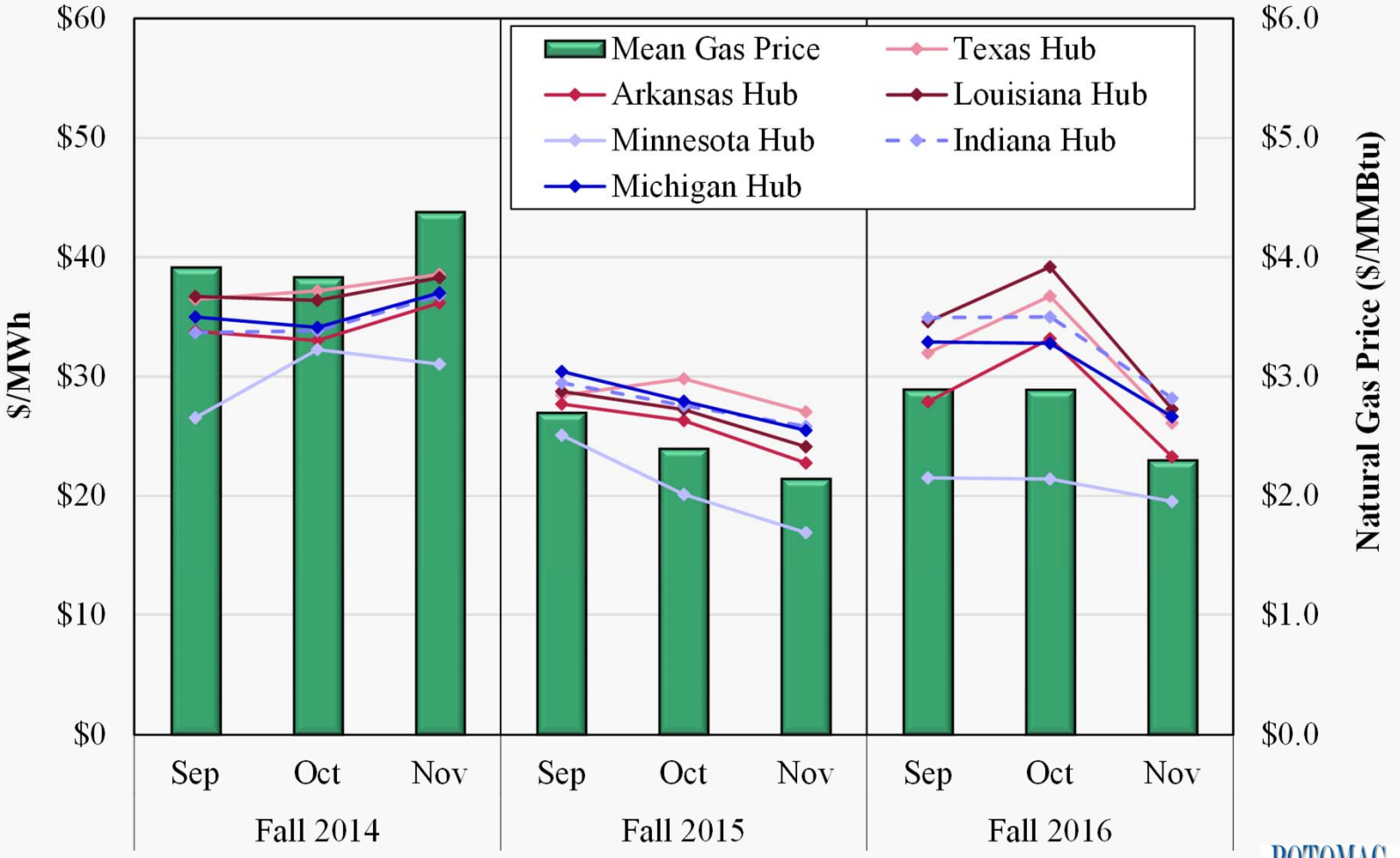
Submittals to External Entities and Other Issues

- We responded to FERC questions related to prior referrals and continued to meet with FERC on a weekly basis to discuss market outcomes.
  - ✓ We made referral of a market violation related to an unreported derate.
  - ✓ We also referred the conduct of resource that is partially pseudo-tied to PJM.
  - ✓ We continued to provide information related to a referral of conduct that may have been intended to avoid physical withholding mitigation.
- We made a number of presentations at the MISO MSC during the quarter.
  - ✓ In October, we presented our recommendations to improve the settlement thresholds for generator deviations that we proposed in our 2015 SOM.
    - These thresholds will help improve generator performance.
  - ✓ In November, we presented the results of a review of wind performance and we discussed a number of recommendations.
- We to continue to work with MISO and transmission owners to improve transmission ratings to more fully utilize the network, including expanding a pilot program to use temperature-adjusted transmission ratings.

Submittals to External Entities and Other Issues

- We met with FERC (together with MISO) prior to the filing of the Competitive Retail proposal to discuss our serious concerns with the proposal.
  - ✓ We plan to file a detailed protest later this month in an effort to address these concerns and avoid the unintended consequences we've identified.
- We continued to be very concerned about the increasing quantities of MISO generators that are pseudo-tying to PJM.
  - ✓ There were a number of events during the quarter where congestion management was negatively impacted by pseudo-tied resources.
  - ✓ We continue to support developing procedures for firm capacity delivery as a more efficient and reliable alternative to pseudo-tying resources to PJM.
- We made a presentation to Resource Adequacy Subcommittee to clarify that the mitigation measures should apply only to internal generating resources (excluding EER, DR, and external resources).
  - ✓ We are working with MISO to clarify Module D prior to the next PRA.
  - ✓ We also met with stakeholders to discuss our recommended change to apply the physical withholding conduct threshold to affiliates jointly.

Day-Ahead Average Monthly Hub Prices
Fall 2014–2016



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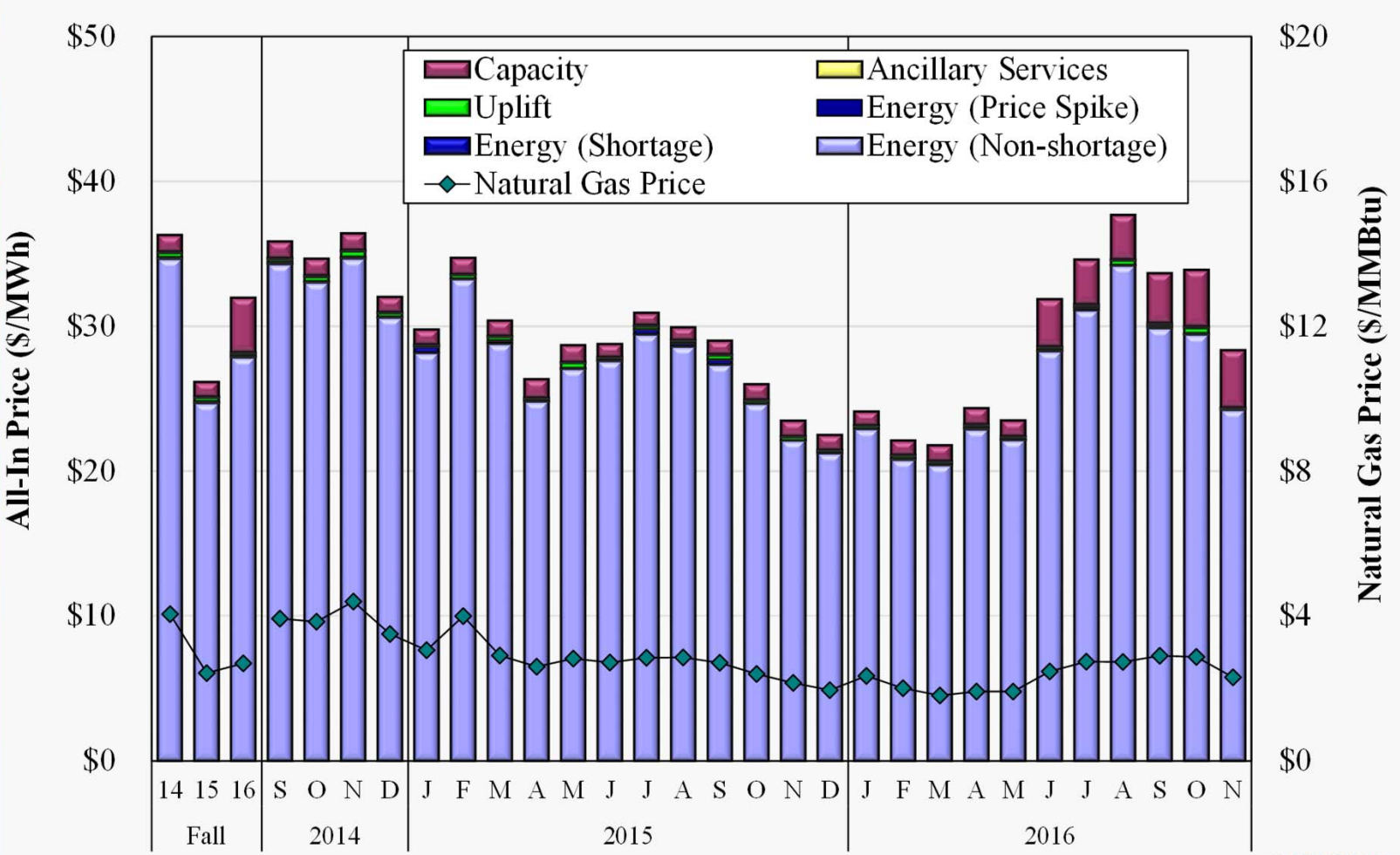
All-In Price
Fall 2014 –2016



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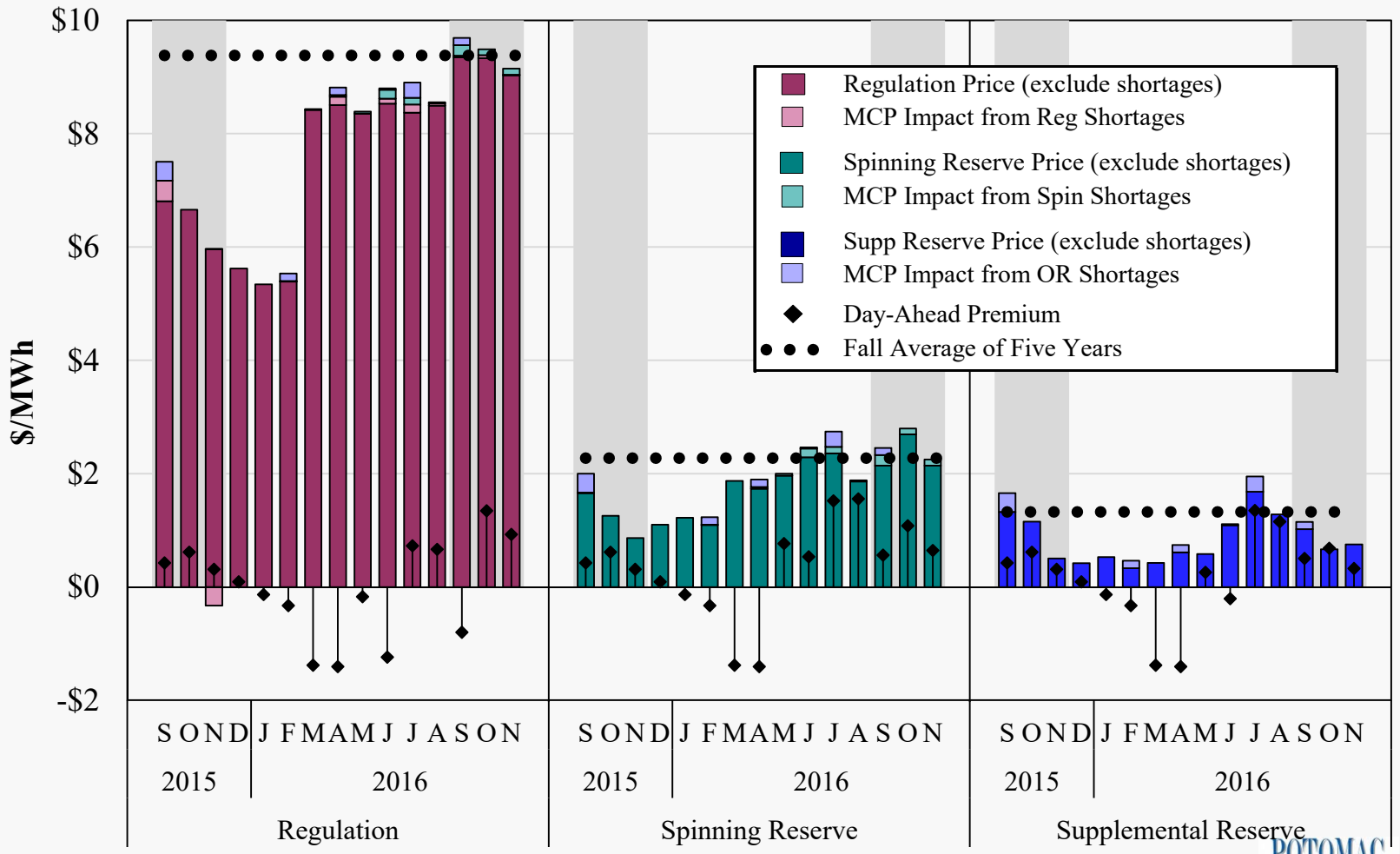
Monthly Average Ancillary Service Prices
Fall 2015 –2016



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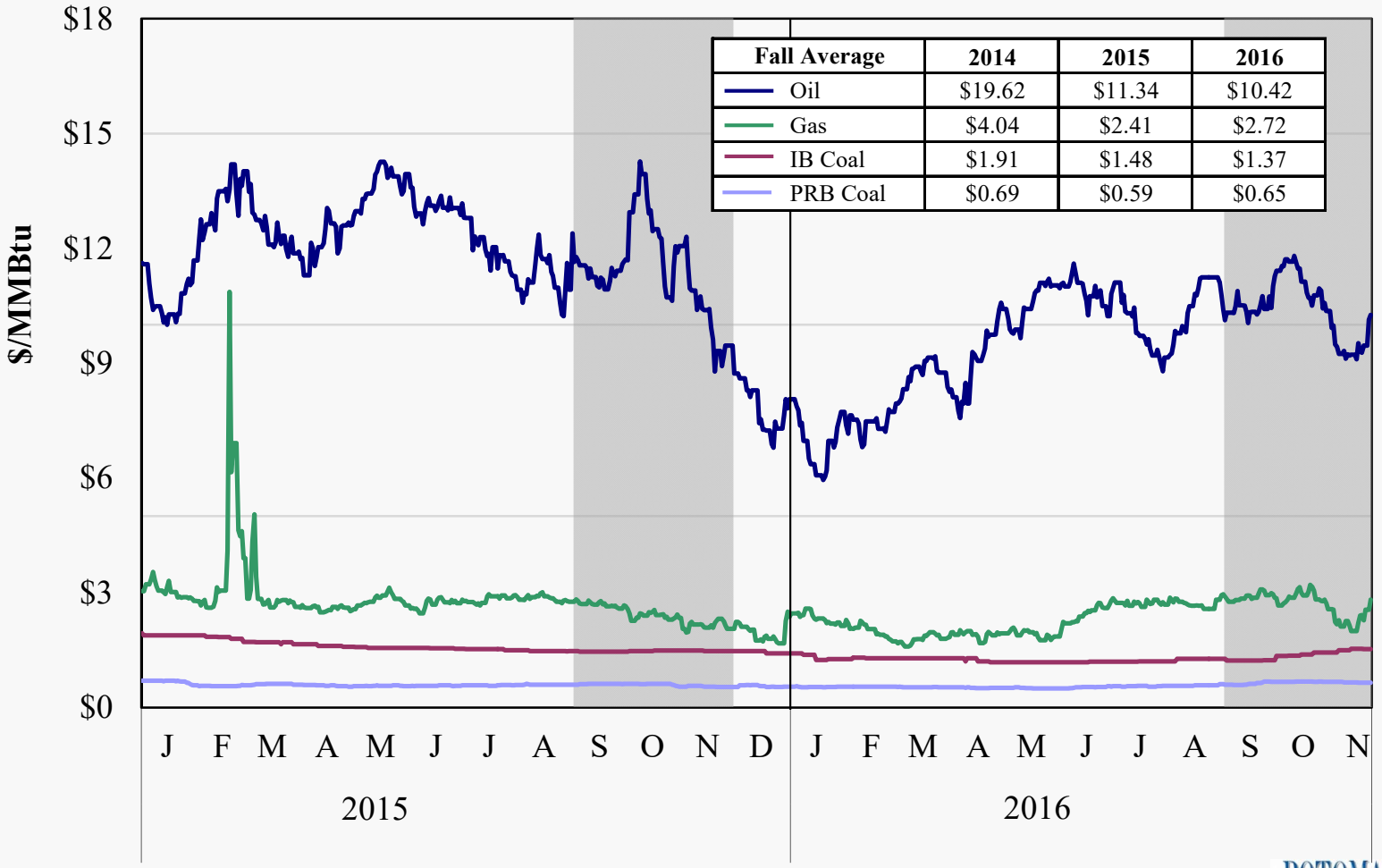
MISO Fuel Prices
2014–2016

Fall Average	2014	2015	2016
Oil	$19.62	$11.34	$10.42
Gas	$4.04	$2.41	$2.72
IB Coal	$1.91	$1.48	$1.37
PRB Coal	$0.69	$0.59	$0.65



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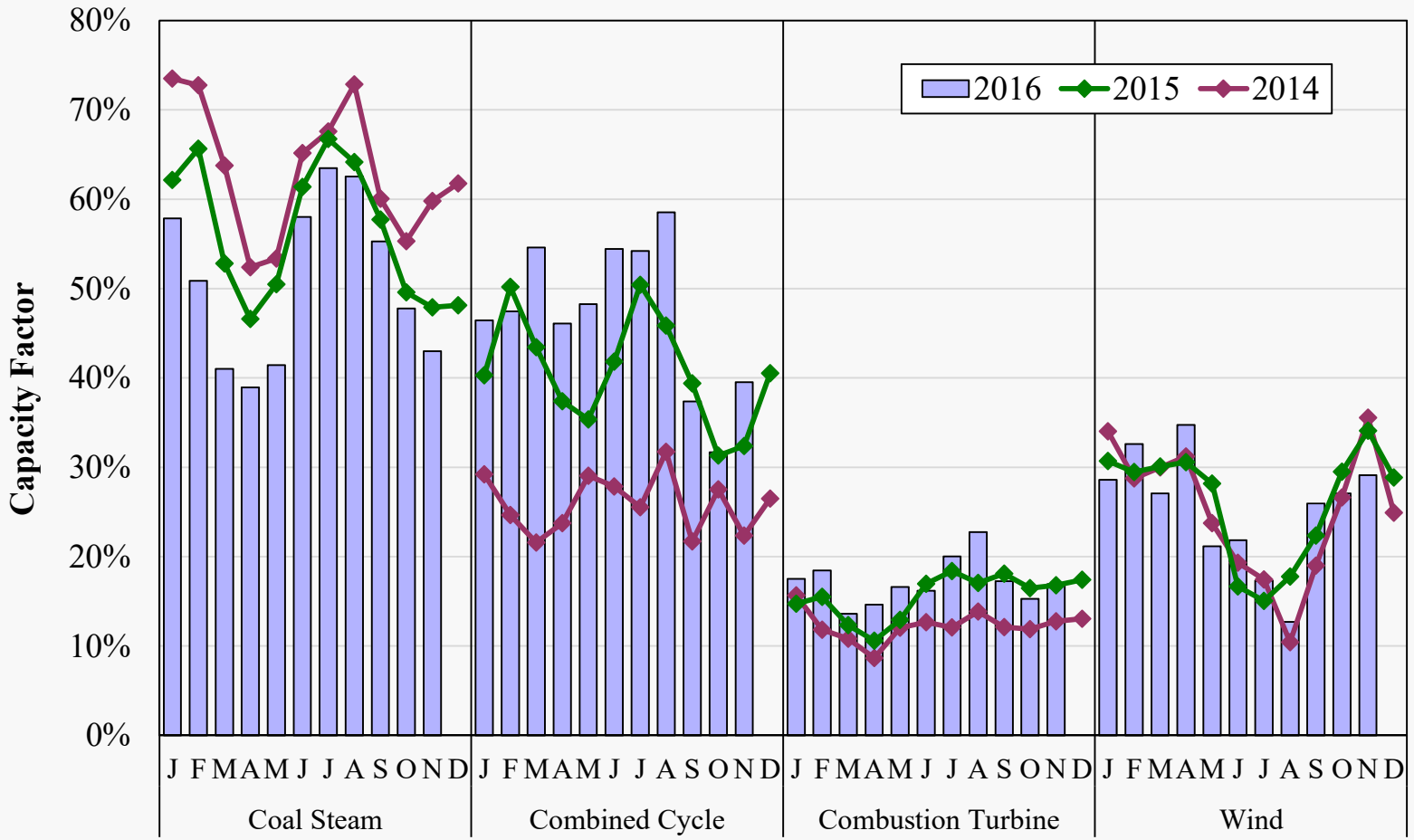
Capacity Factors By Fuel Type
2014–2016



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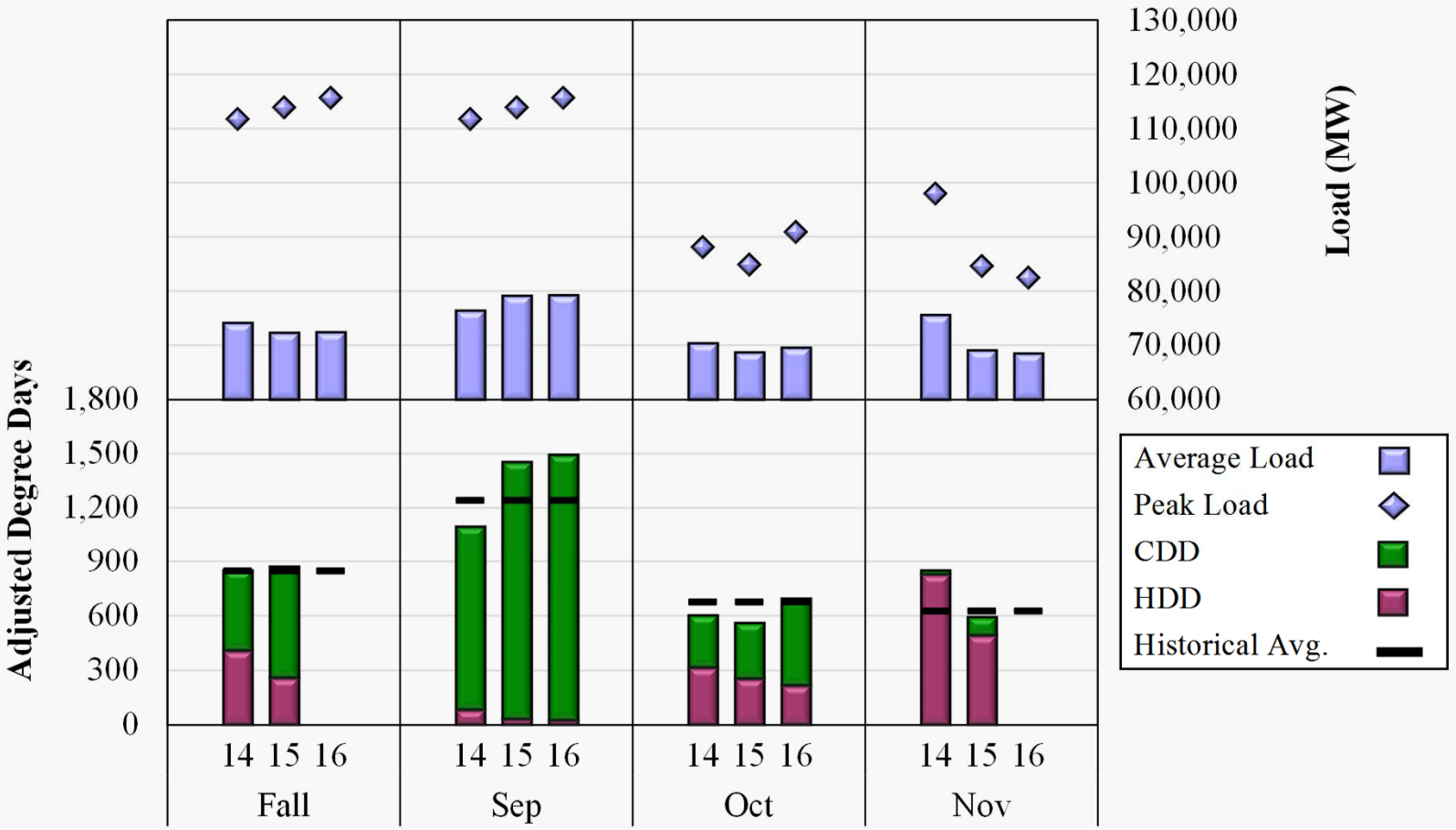
Load and Weather Patterns
Fall 2014–2016



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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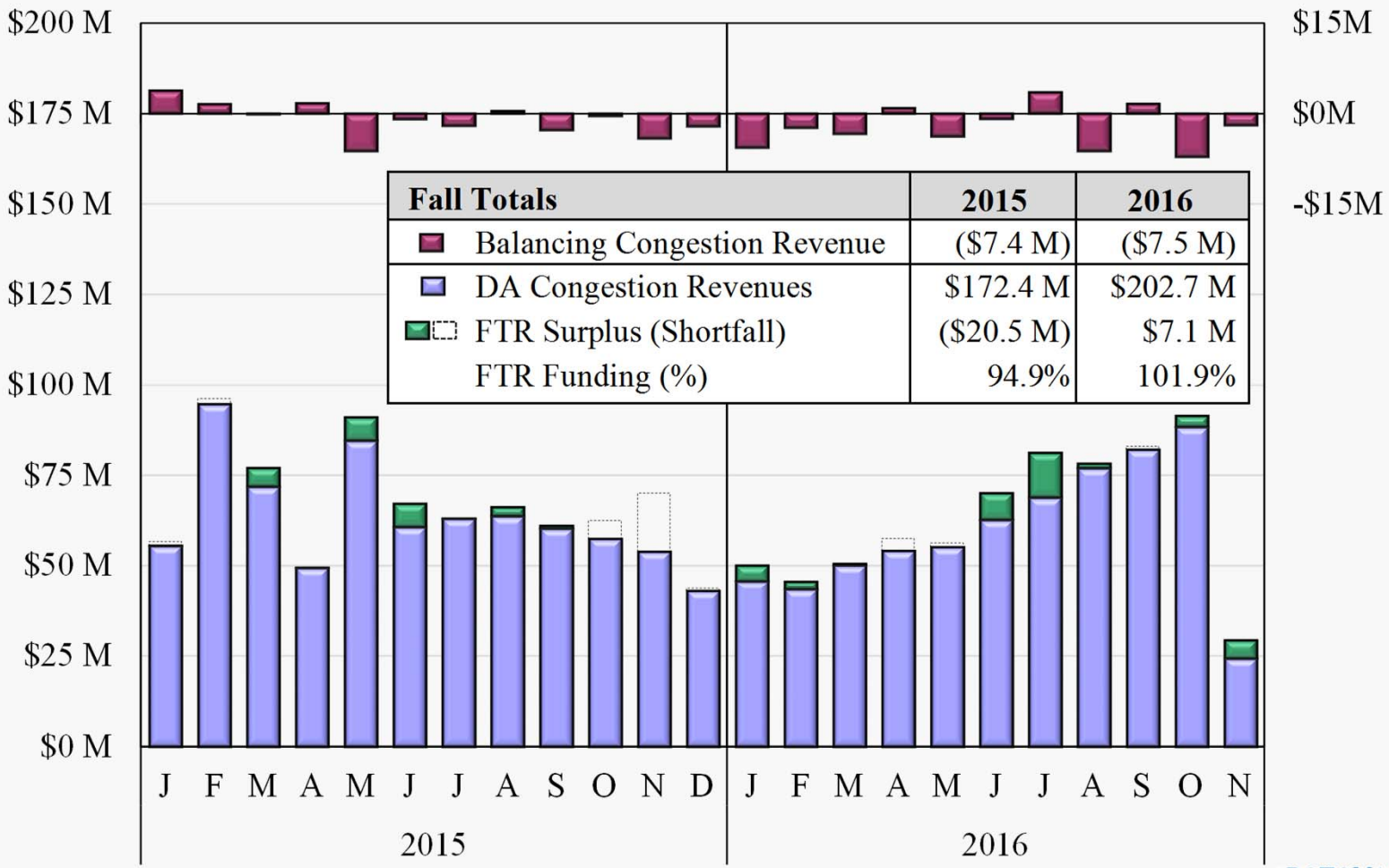
Day-Ahead Congestion, Balancing Congestion and FTR Underfunding, 2015–2016



Fall Totals	2015	2016
Balancing Congestion Revenue	($7.4 M)	($7.5 M)
DA Congestion Revenues	$172.4 M	$202.7 M
FTR Surplus (Shortfall)	($20.5 M)	$7.1 M
FTR Funding (%)	94.9%	101.9%

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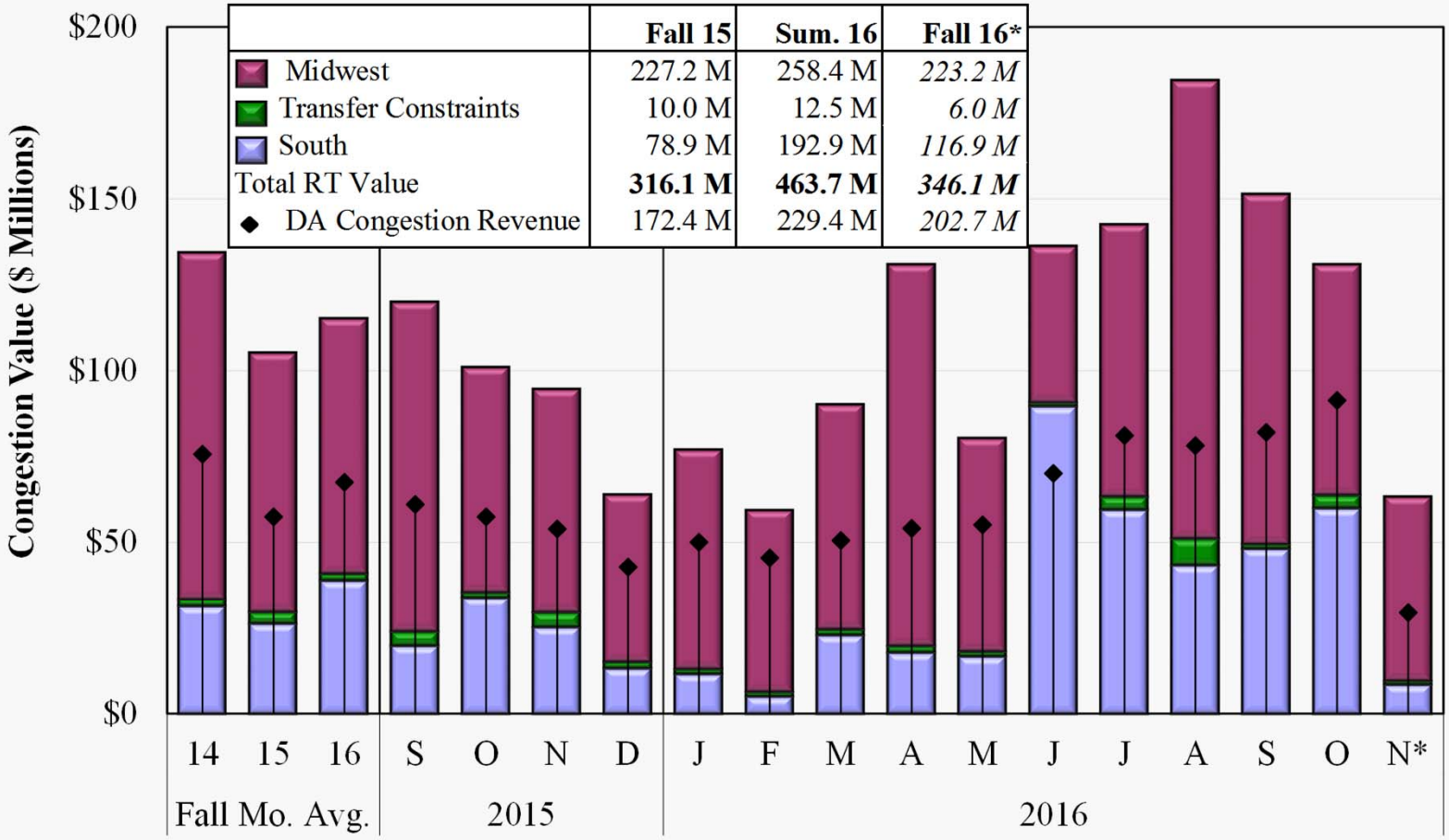
Value of Real-Time Congestion
Fall 2015–2016

	Fall 15	Sum. 16	Fall 16*
Midwest	227.2 M	258.4 M	*223.2 M*
Transfer Constraints	10.0 M	12.5 M	*6.0 M*
South	78.9 M	192.9 M	*116.9 M*
Total RT Value	**316.1 M**	**463.7 M**	***346.1 M***
◆ DA Congestion Revenue	172.4 M	229.4 M	*202.7 M*



*: Data are through Nov. 22

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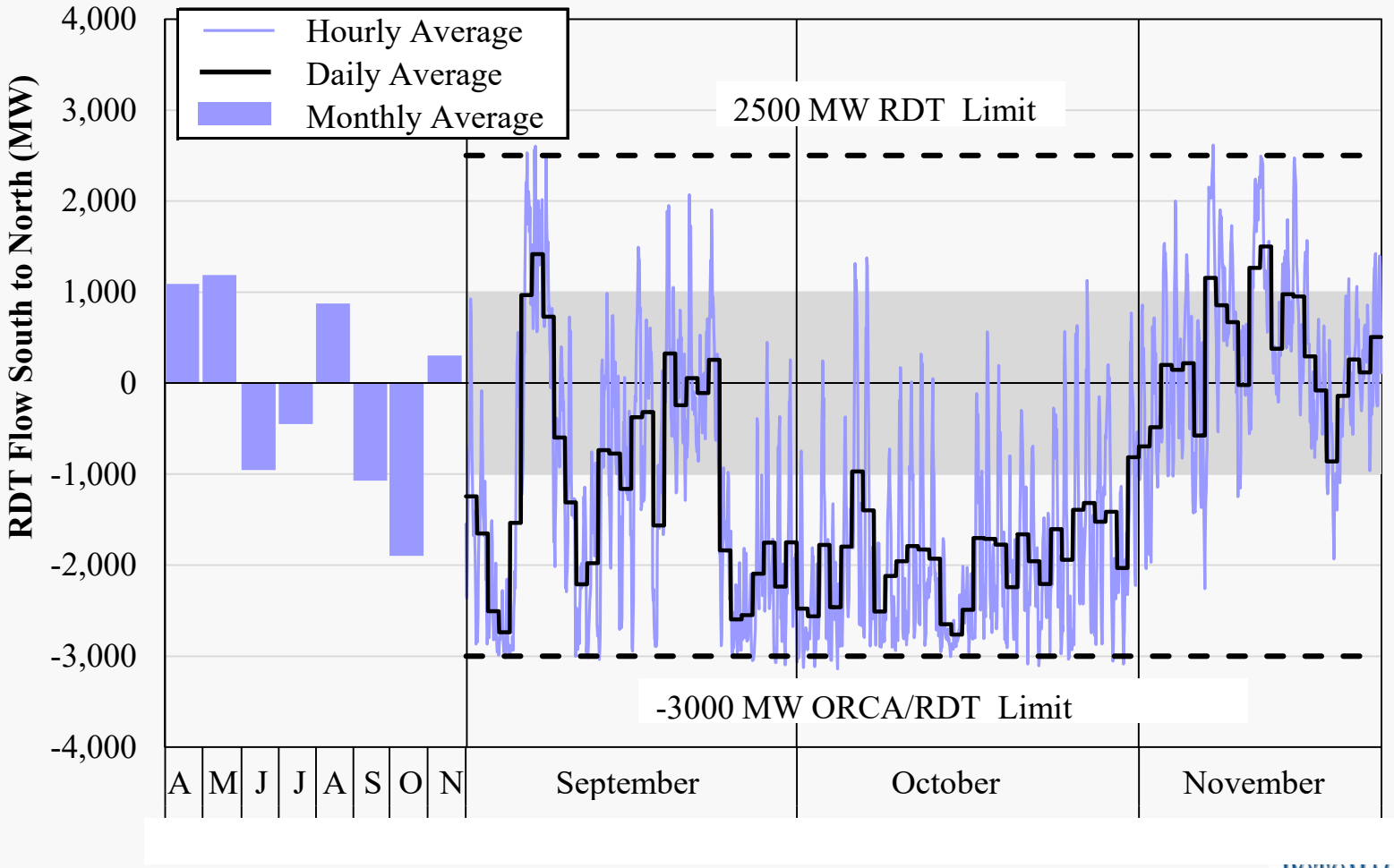
Real-Time Hourly Inter-Regional Flows
2016



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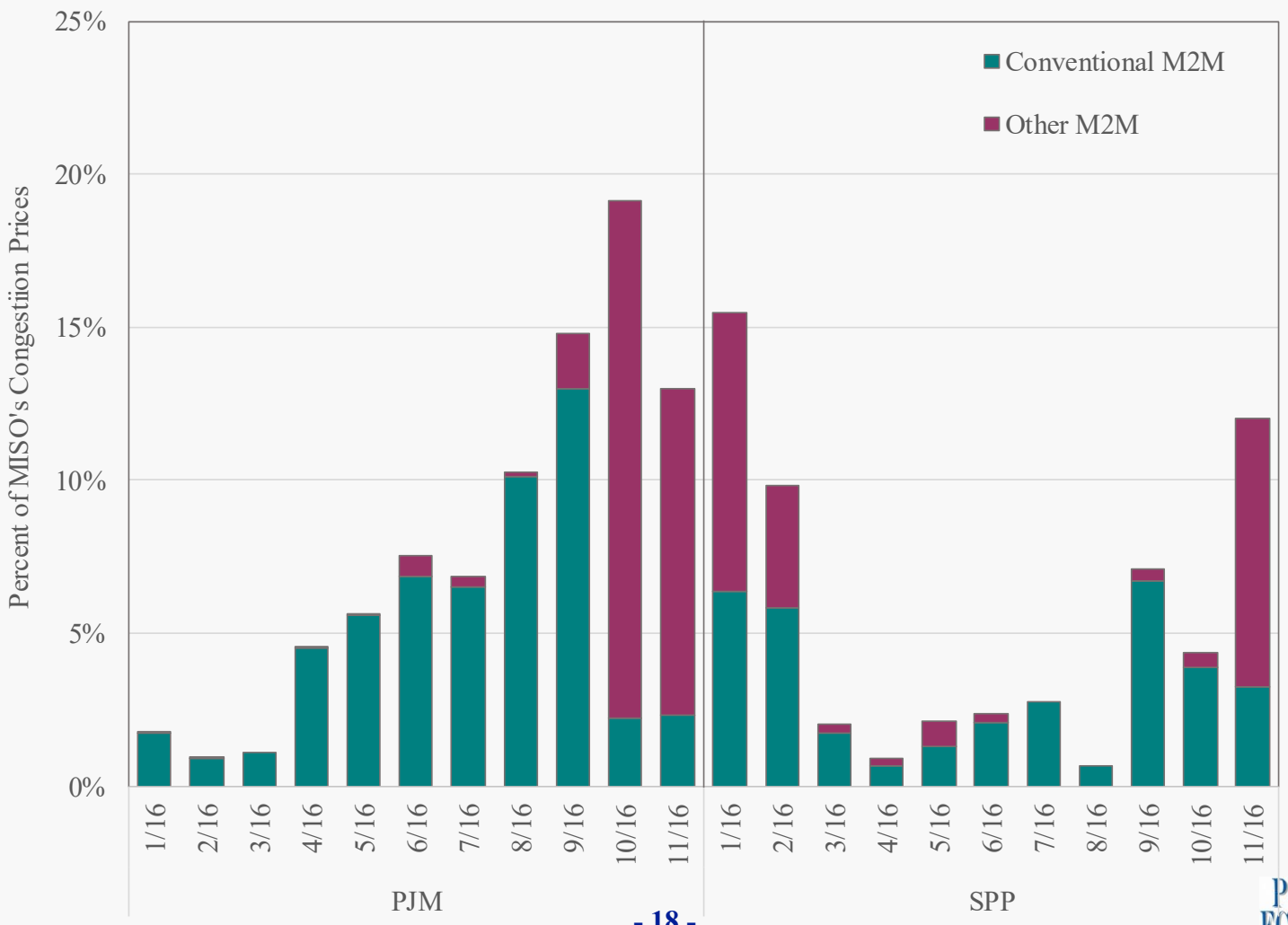
Congestion Costs on SPP Flowgates
2015 – 2016



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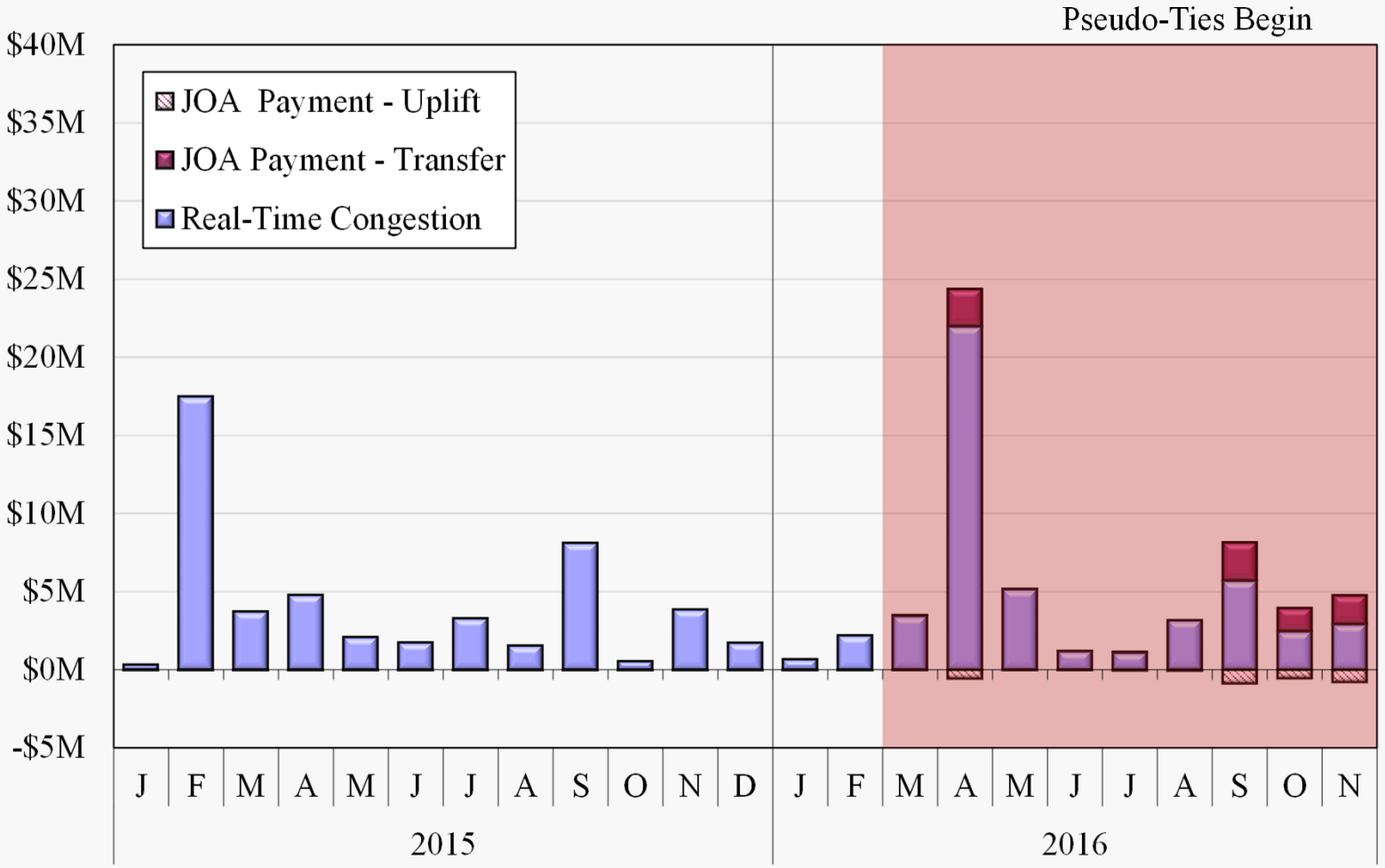
MISO Congestion Value and JOA Settlement Constraints Impacted by Pseudo-Ties



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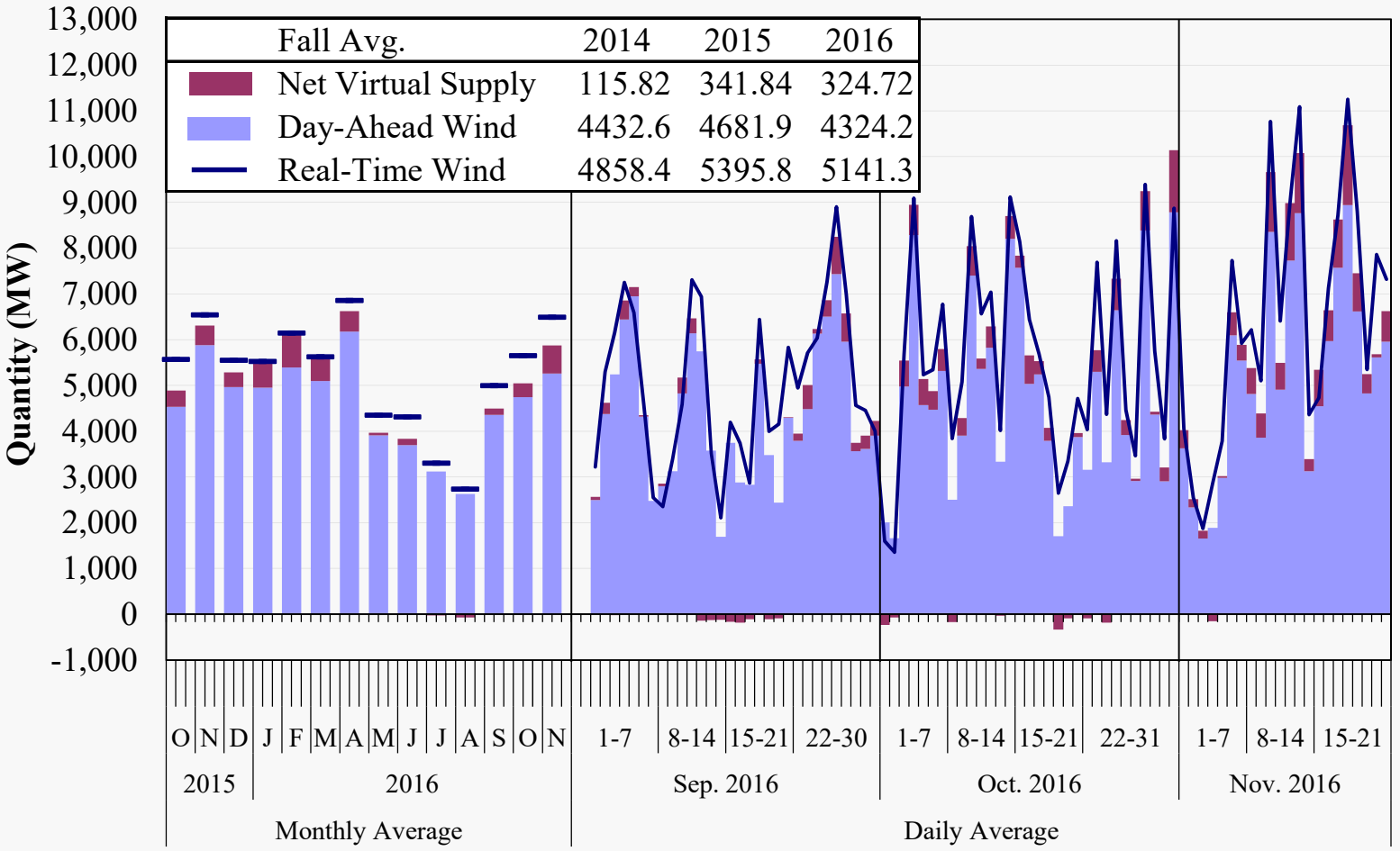
Wind Output in Real-Time and Day-Ahead Markets
Monthly and Daily Average



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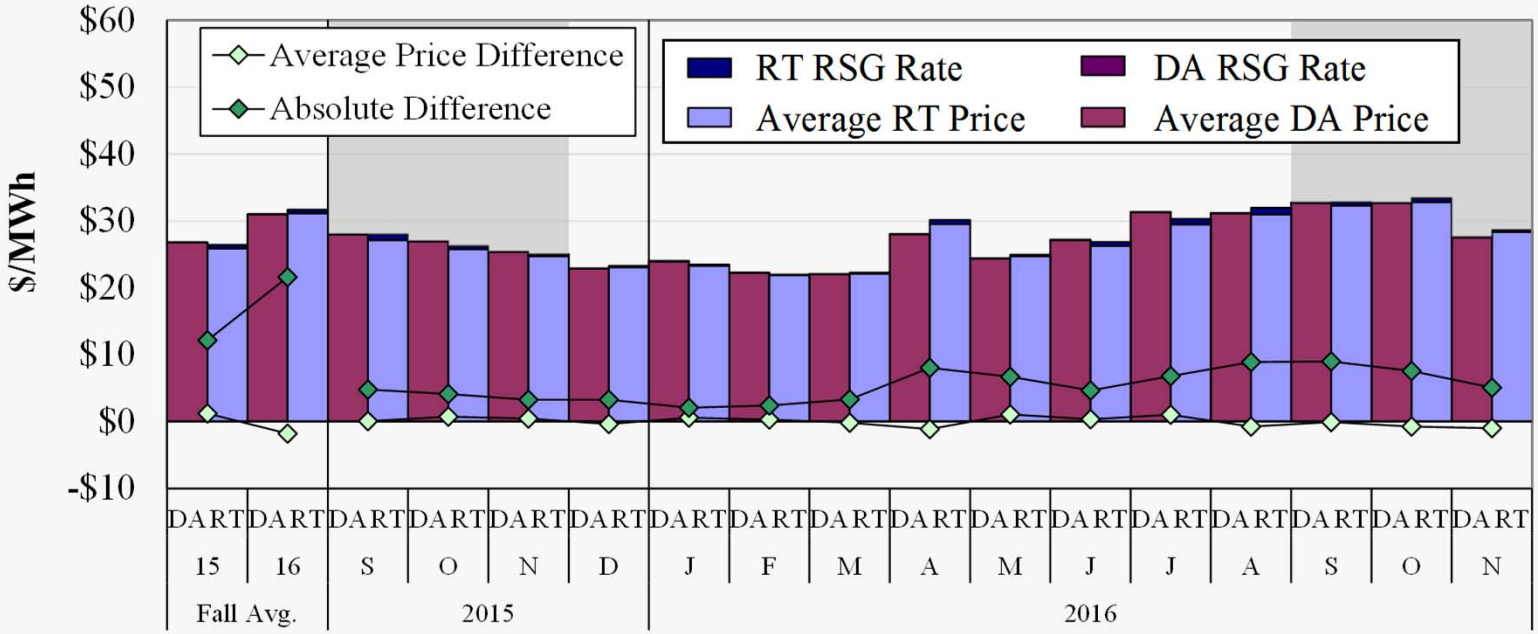
Day-Ahead and Real-Time Price Convergence
Fall 2015–2016



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

Indiana Hub	2	-2	0	3	2	-2	2	1	-1	-7	-2	1	3	-2	0	-2	-4
Michigan Hub	1	0	-3	2	3	0	4	3	-1	-6	4	0	5	-9	-2	4	-1
Minnesota Hub	6	1	-2	14	5	3	4	5	-3	2	7	-5	0	-6	-2	-2	6
WUMS Area	0	2	1	1	-1	0	4	3	0	0	0	-3	-5	-7	1	4	2
Arkansas Hub	2	-2	0	0	6	4	2	2	-3	-3	6	4	-1	0	-3	-2	-2
Louisiana Hub	0	1	0	0	-1	4	2	3	-2	2	0	-14	-1	-4	-3	1	6
Texas Hub	-10	3	-2	-12	-15	3	1	6	3	-19	12	2	-3	1	2	3	4

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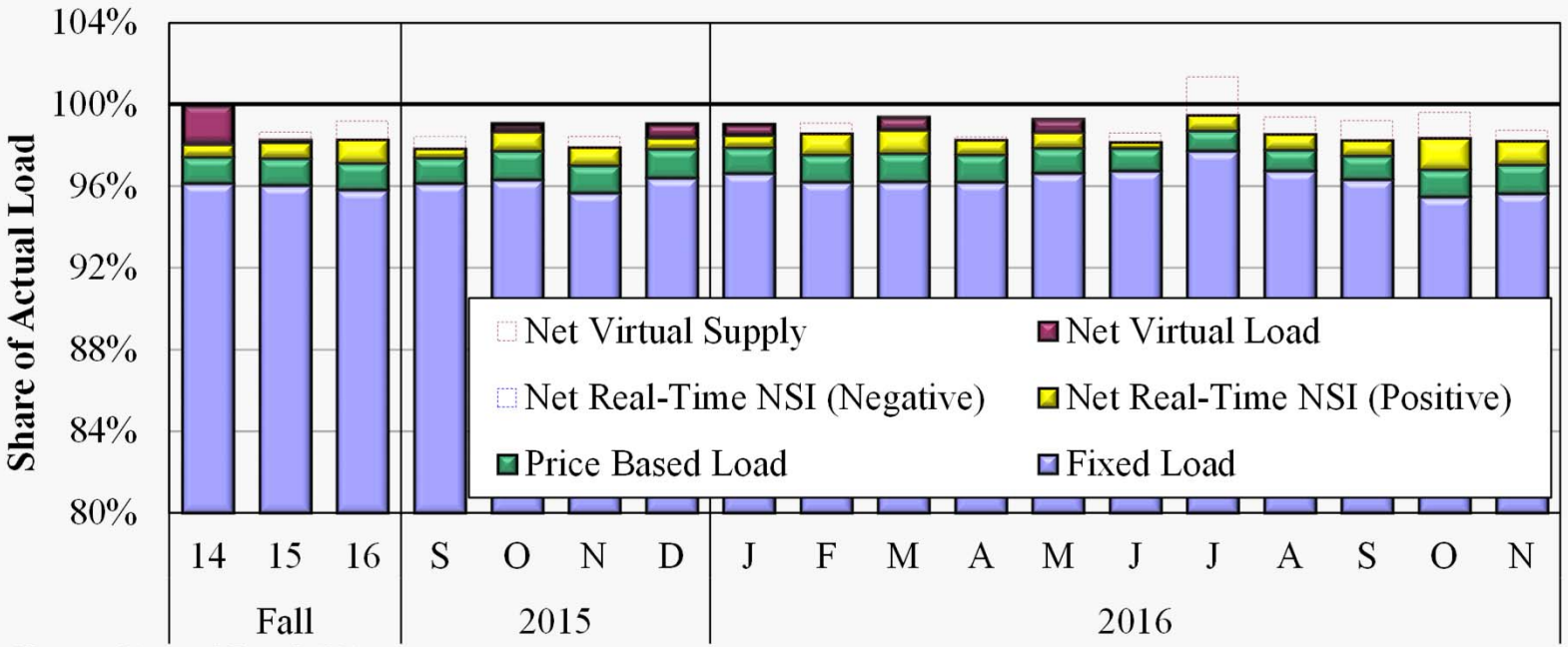
Day-Ahead Peak Hour Load Scheduling
Fall 2015–2016



Share of Actual Load (%)

	14	15	16	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
All Hours	100.1	98.2	98.4	98.5	98.2	97.9	98.4	99.0	98.2	98.3	98.7	99.6	98.6	100.1	99.4	98.3	98.5	98.3
Peak Hours Midwest	100.1	98.2	98.4	97.0	98.6	99.2	99.7	99.2	98.8	99.4	97.5	98.6	96.9	98.8	97.7	97.6	97.6	98.6
Peak Hours South	100.1	98.2	98.4	99.9	101.0	96.8	99.5	99.1	98.9	99.7	100.6	101.8	101.5	101.8	101.3	99.6	100.6	99.6

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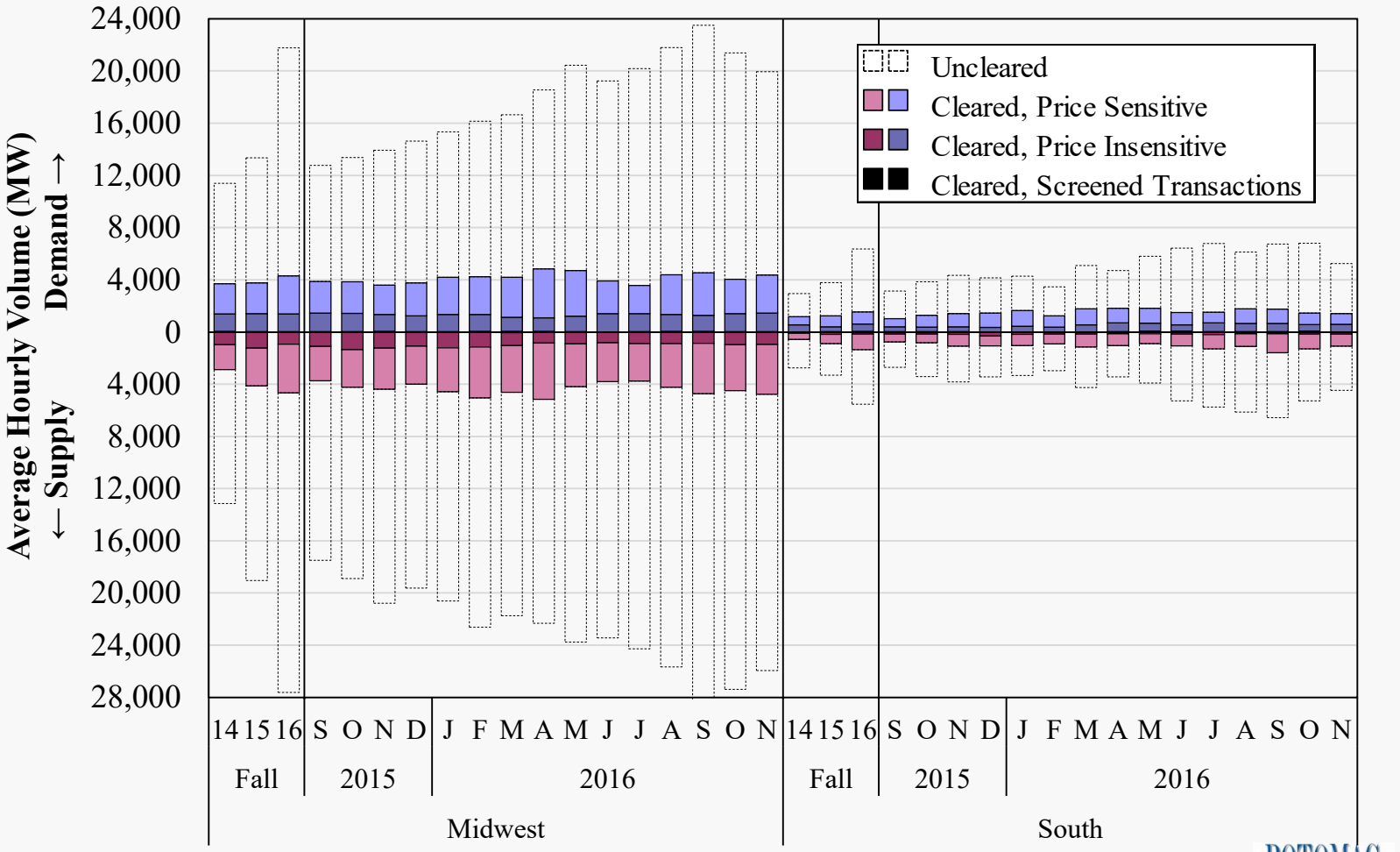
Virtual Load and Supply
Fall 2015–2016



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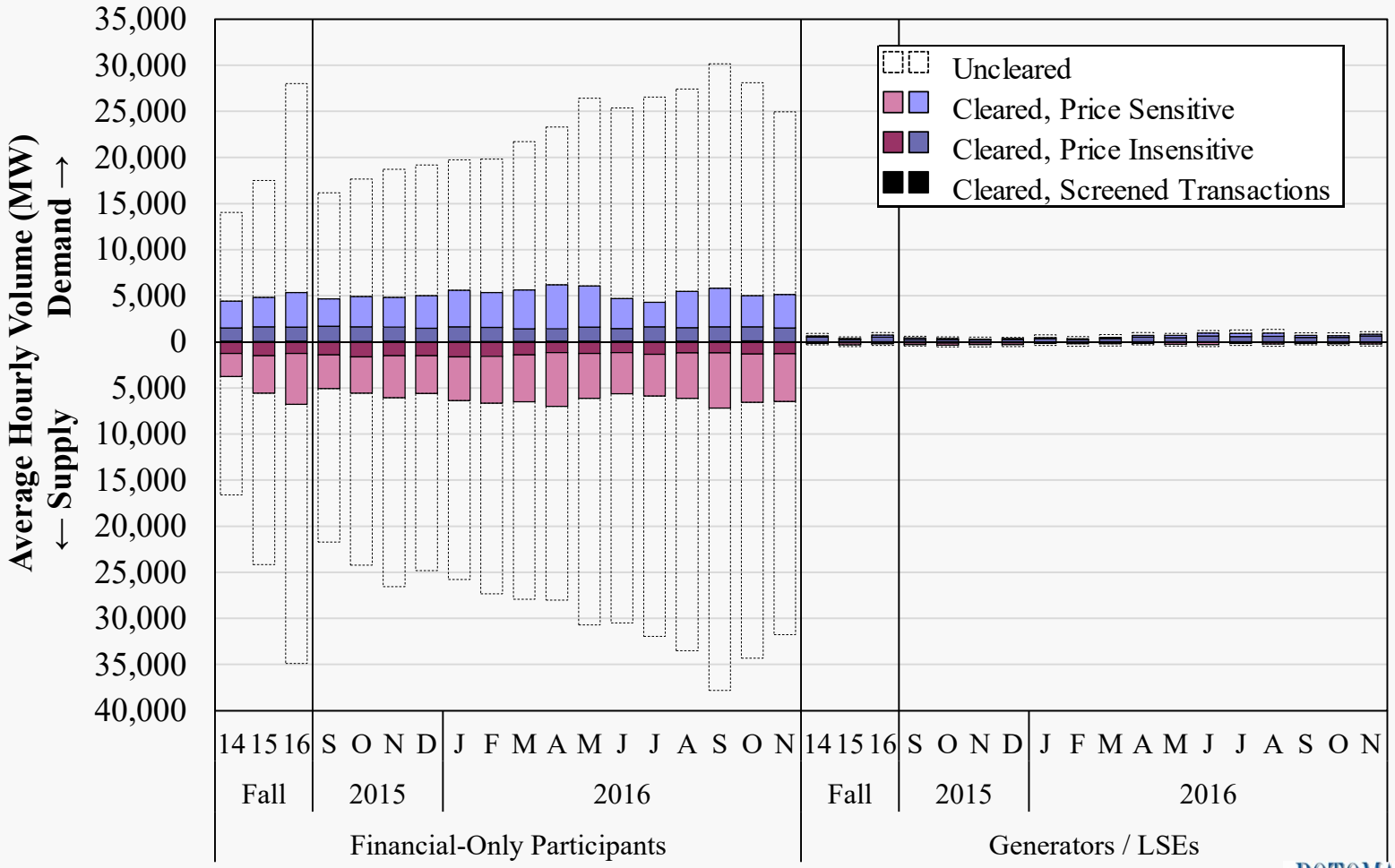
Virtual Load and Supply by Participant Type
Fall 2015–2016



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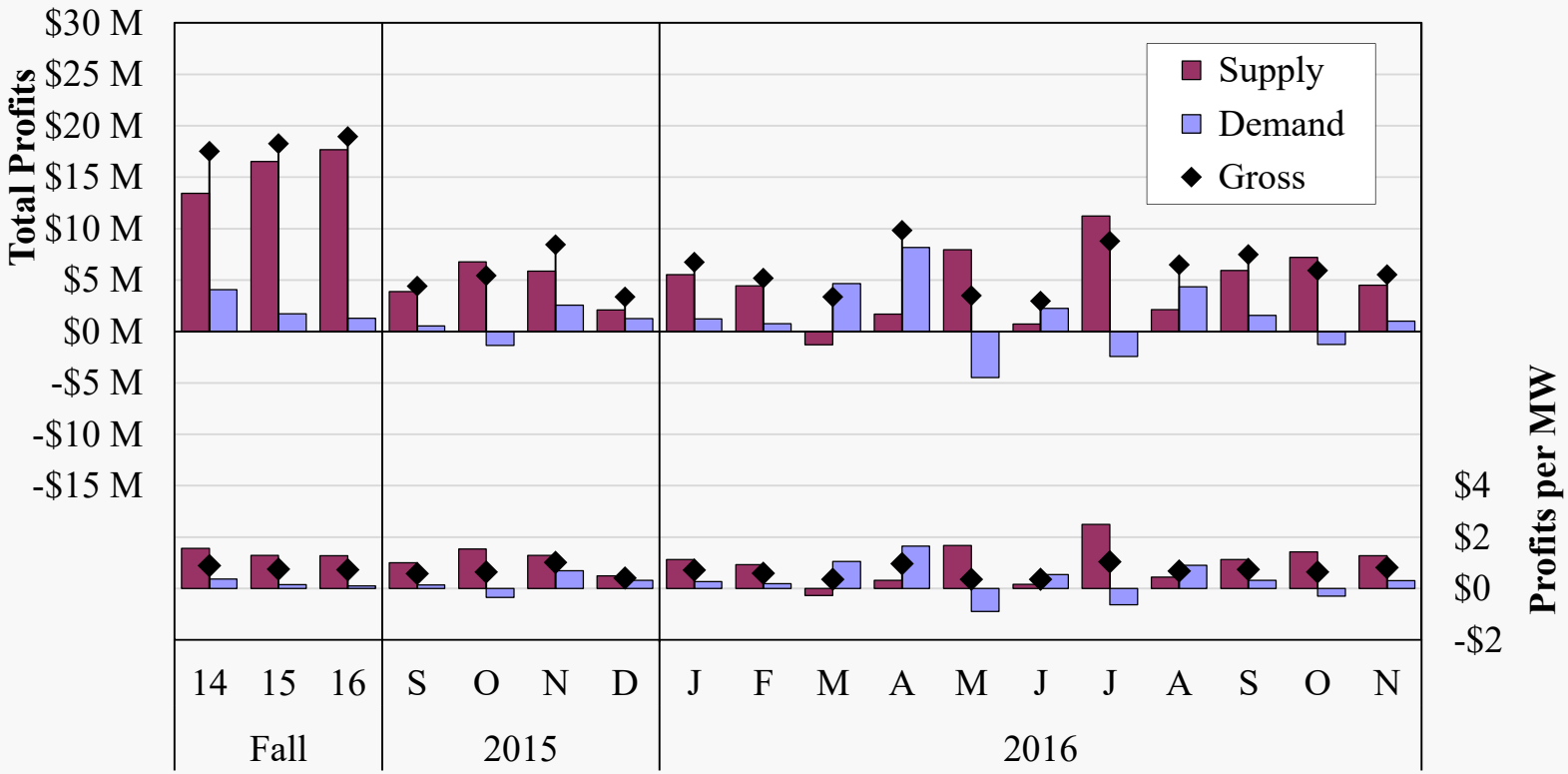
Virtual Profitability
Fall 2015–2016



Percent Screened

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

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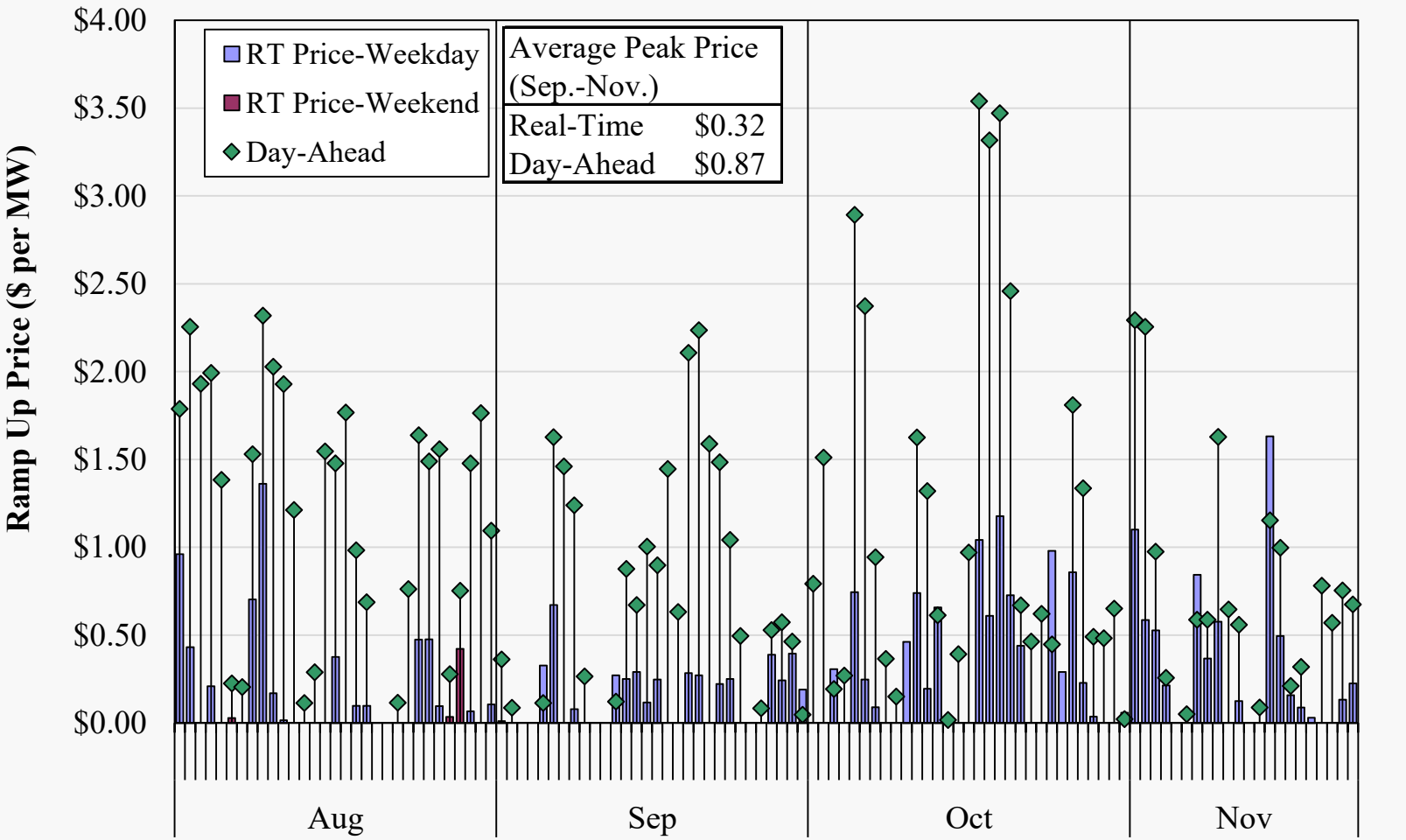
Ramp Up Price
August – November 2016



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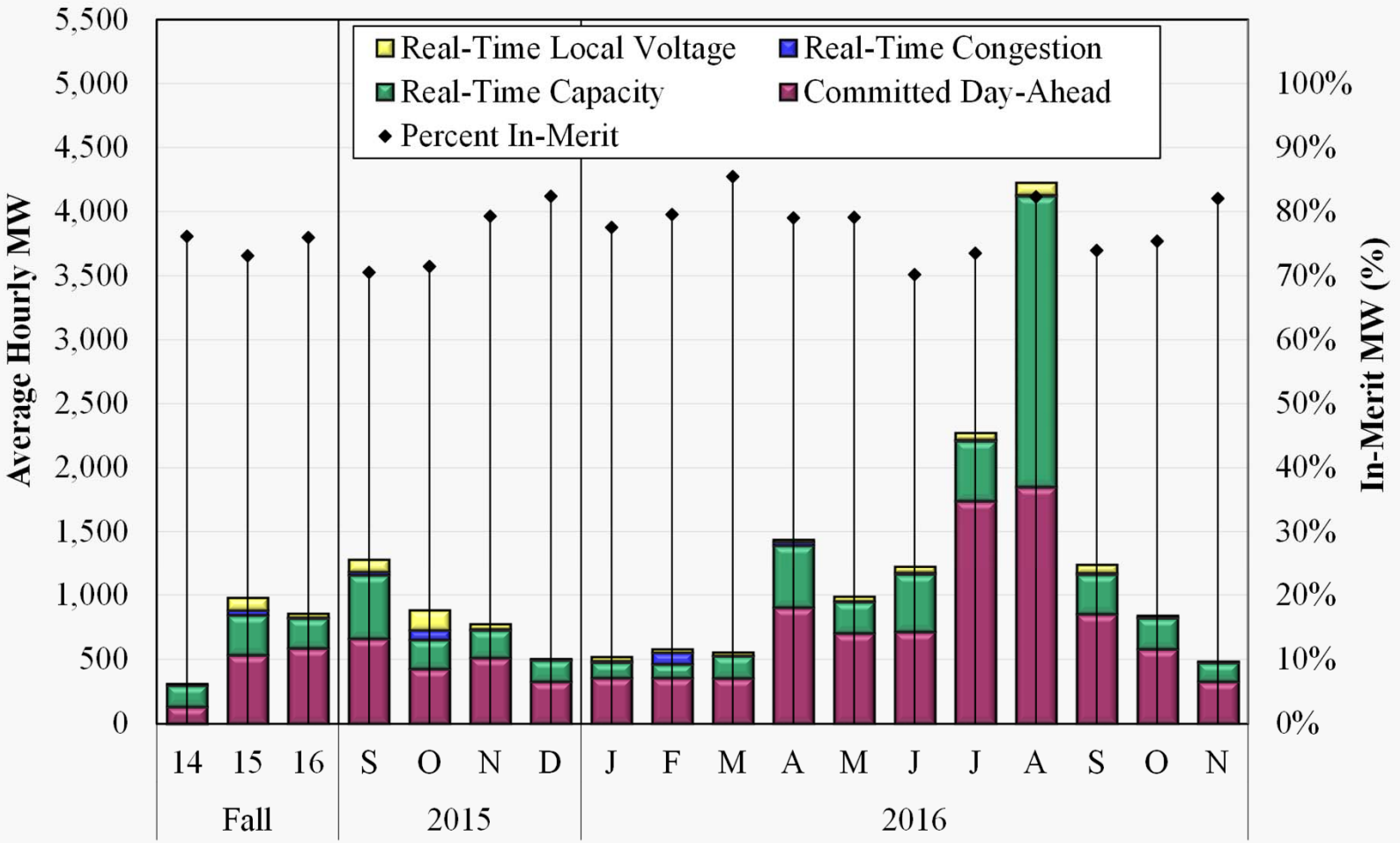
Peaking Resource Dispatch
2015–2016



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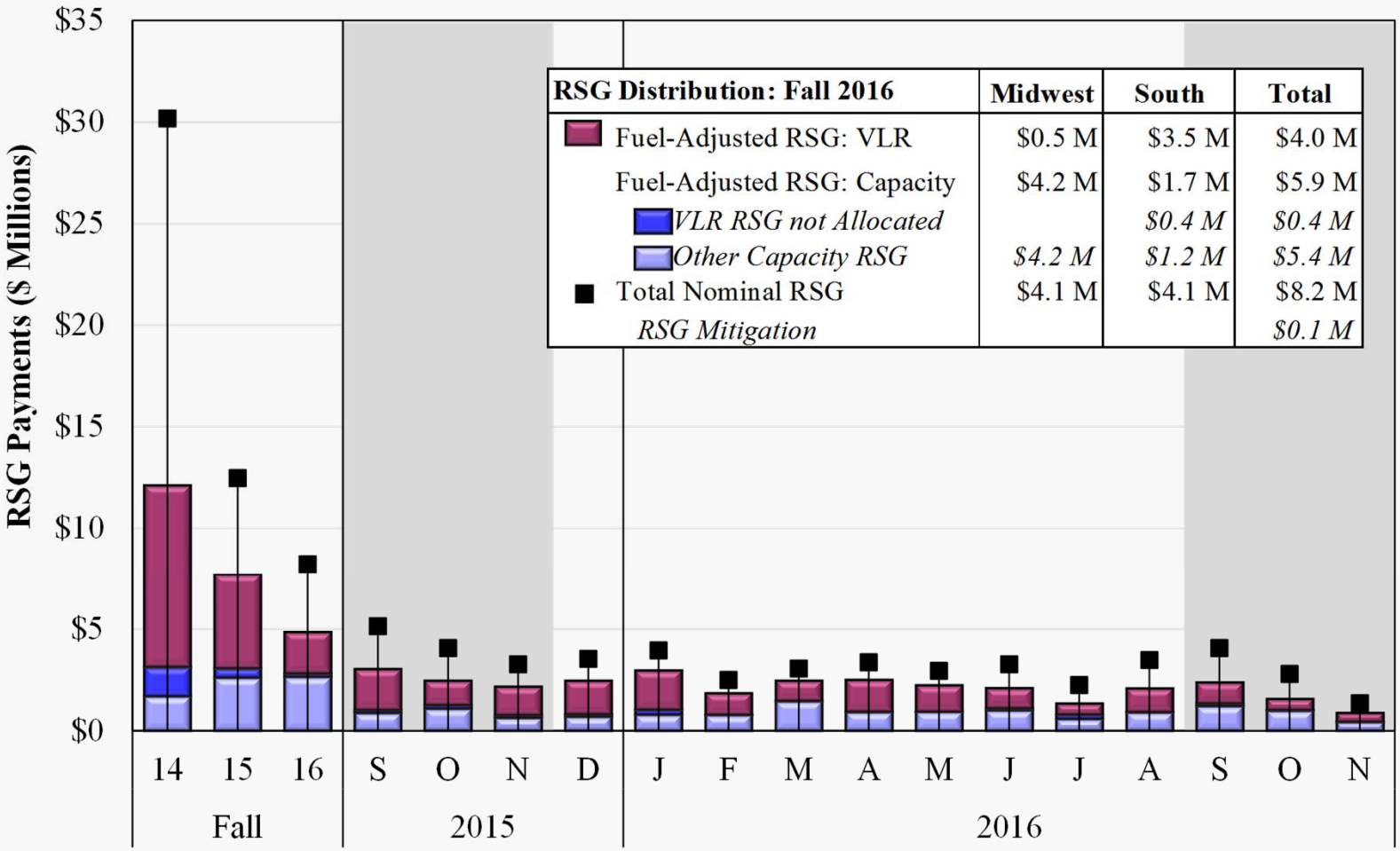
Day-Ahead RSG Payments
2015–2016



RSG Distribution: Fall 2016	Midwest	South	Total
Fuel-Adjusted RSG: VLR	$0.5 M	$3.5 M	$4.0 M
Fuel-Adjusted RSG: Capacity	$4.2 M	$1.7 M	$5.9 M
VLR RSG not Allocated		*$0.4 M*	*$0.4 M*
Other Capacity RSG	*$4.2 M*	*$1.2 M*	*$5.4 M*
Total Nominal RSG	$4.1 M	$4.1 M	$8.2 M
RSG Mitigation			*$0.1 M*

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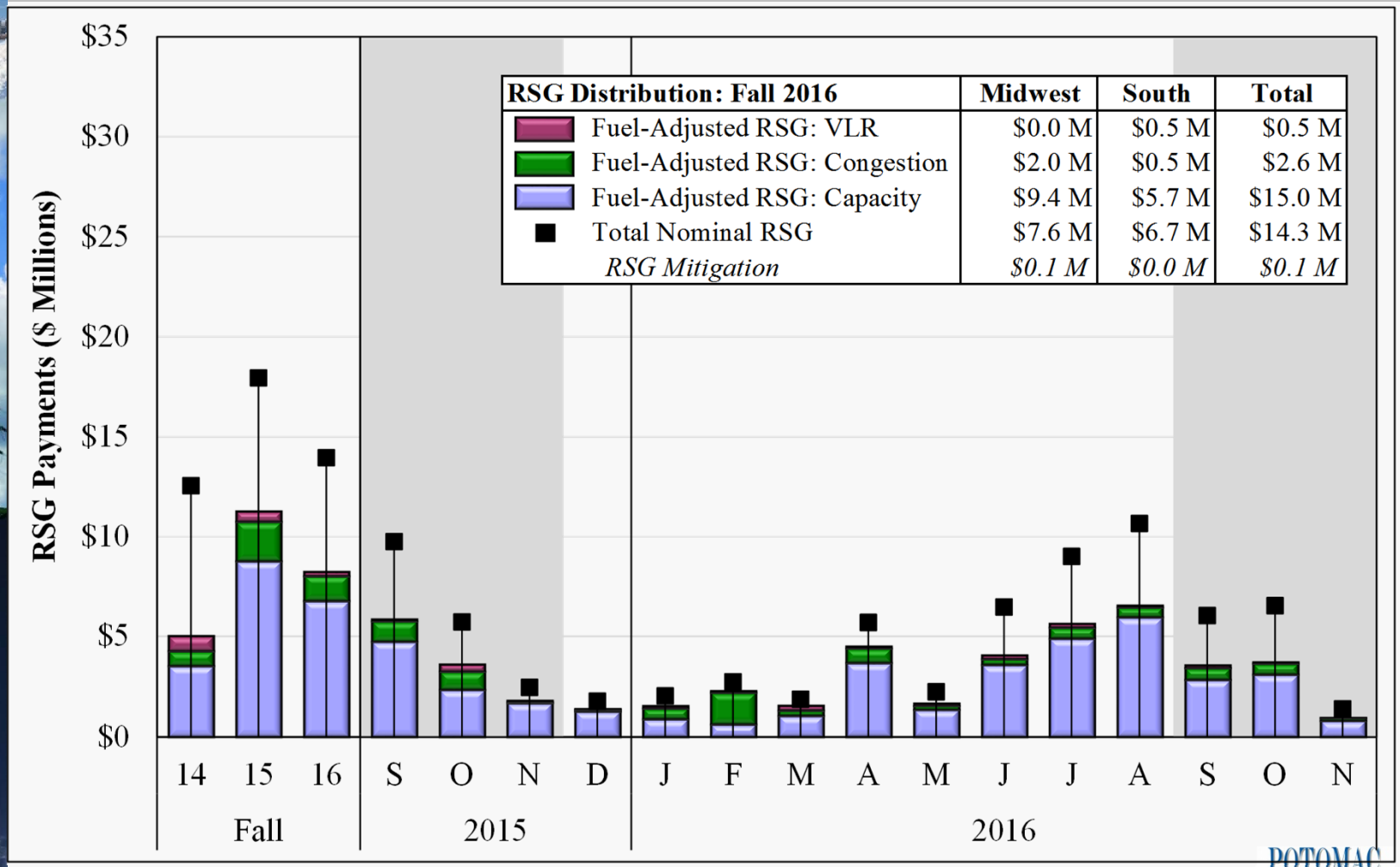
Real-Time RSG Payments
2015–2016



RSG Distribution: Fall 2016	Midwest	South	Total
Fuel-Adjusted RSG: VLR	$0.0 M	$0.5 M	$0.5 M
Fuel-Adjusted RSG: Congestion	$2.0 M	$0.5 M	$2.6 M
Fuel-Adjusted RSG: Capacity	$9.4 M	$5.7 M	$15.0 M
Total Nominal RSG	$7.6 M	$6.7 M	$14.3 M
RSG Mitigation	*$0.1 M*	*$0.0 M*	*$0.1 M*

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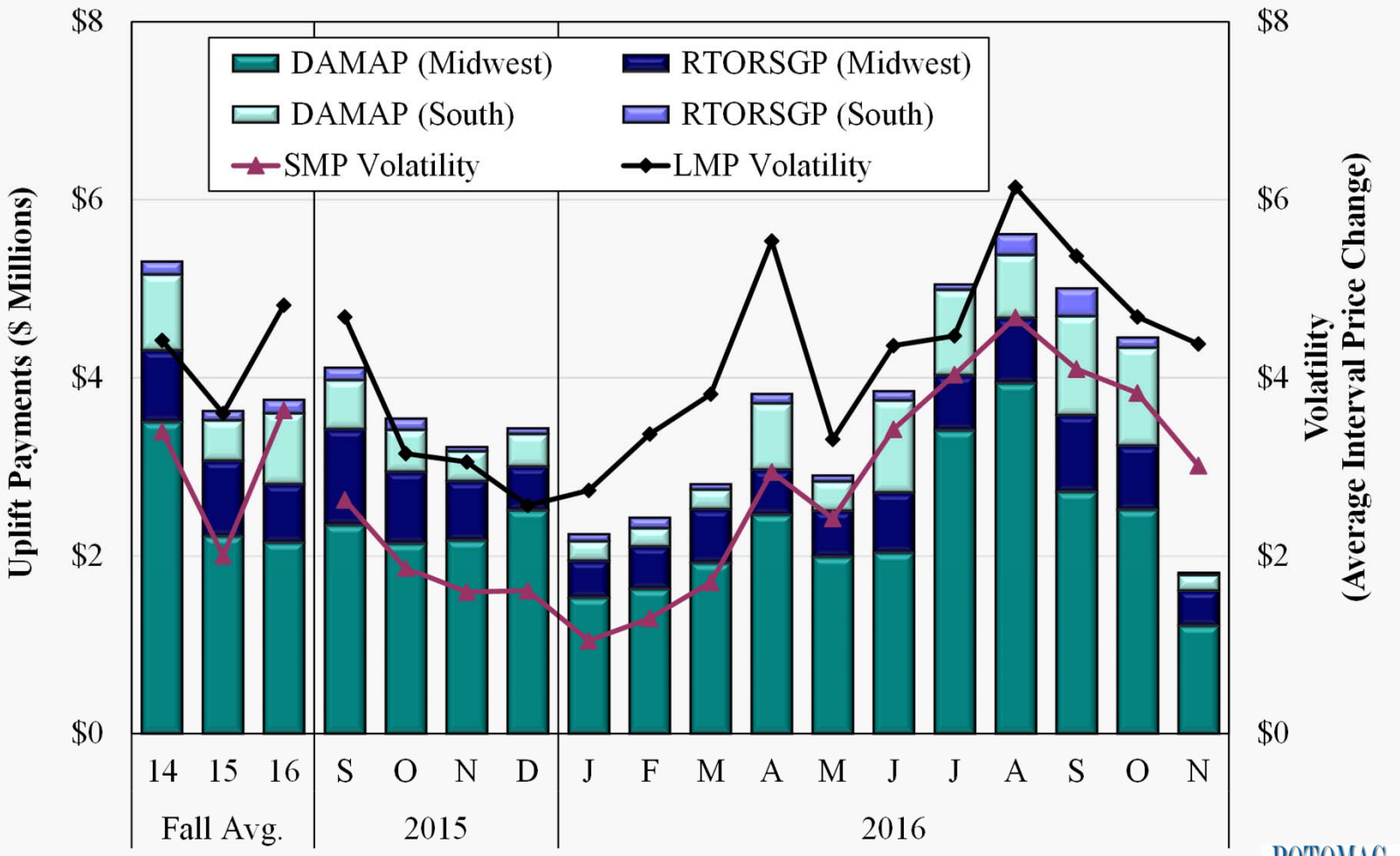
Price Volatility Make Whole Payments 2015–2016



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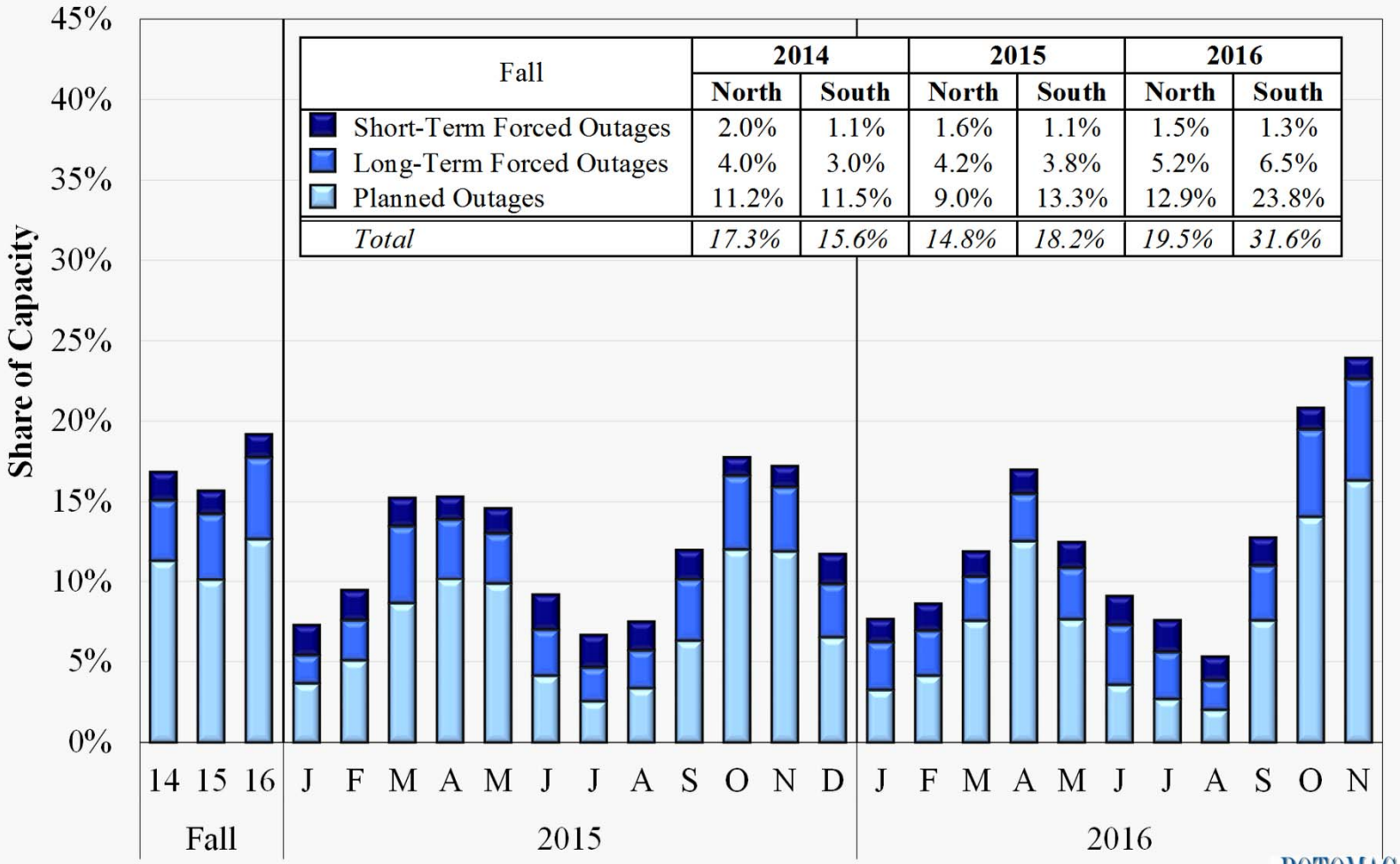
Generation Outage Rates
2015–2016

Fall	2014		2015		2016	
	North	South	North	South	North	South
Short-Term Forced Outages	2.0%	1.1%	1.6%	1.1%	1.5%	1.3%
Long-Term Forced Outages	4.0%	3.0%	4.2%	3.8%	5.2%	6.5%
Planned Outages	11.2%	11.5%	9.0%	13.3%	12.9%	23.8%
Total	*17.3%*	*15.6%*	*14.8%*	*18.2%*	*19.5%*	*31.6%*



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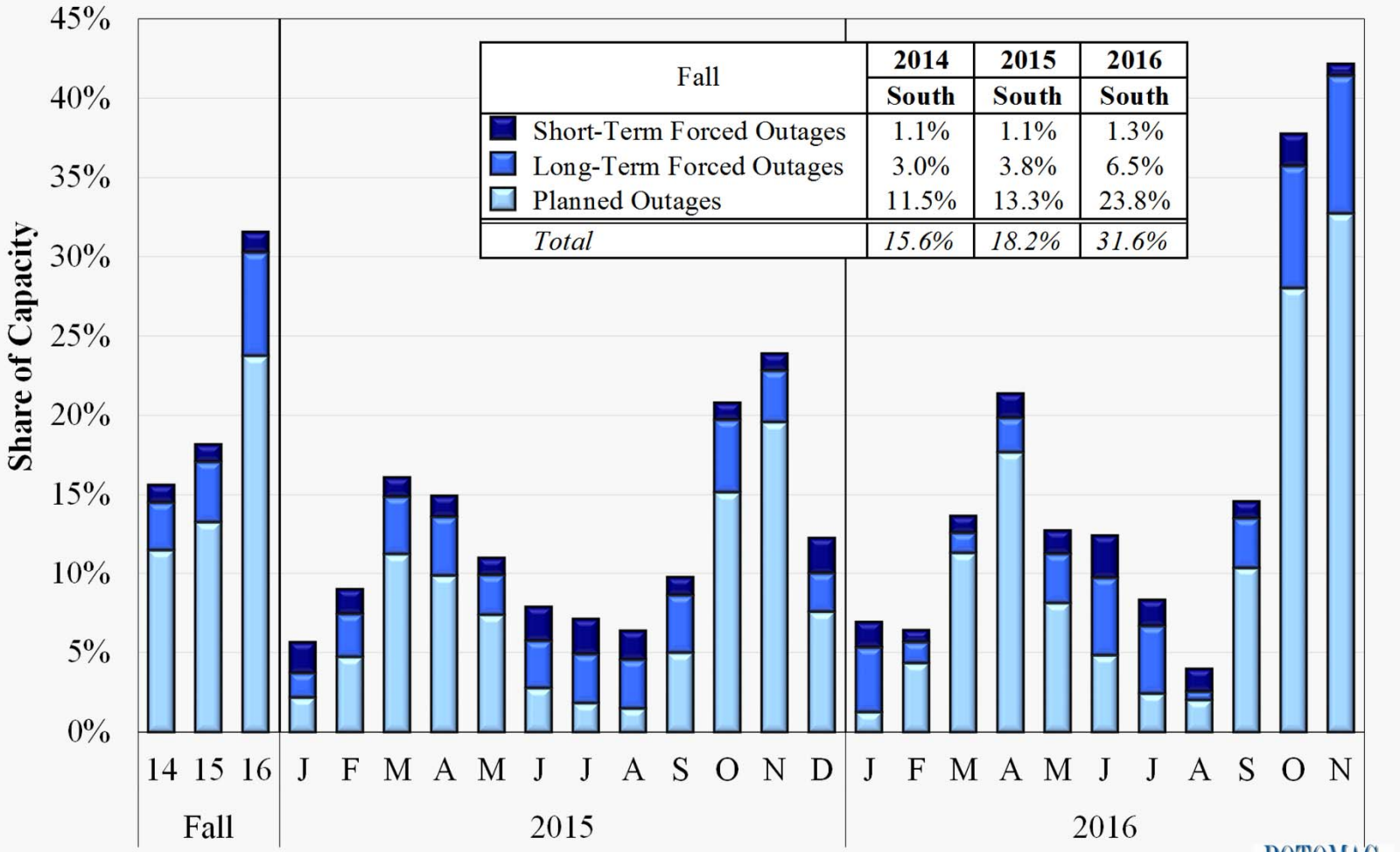
Generation Outage Rates
South, 2015–2016



Fall	2014 South	2015 South	2016 South
Short-Term Forced Outages	1.1%	1.1%	1.3%
Long-Term Forced Outages	3.0%	3.8%	6.5%
Planned Outages	11.5%	13.3%	23.8%
Total	*15.6%*	*18.2%*	*31.6%*

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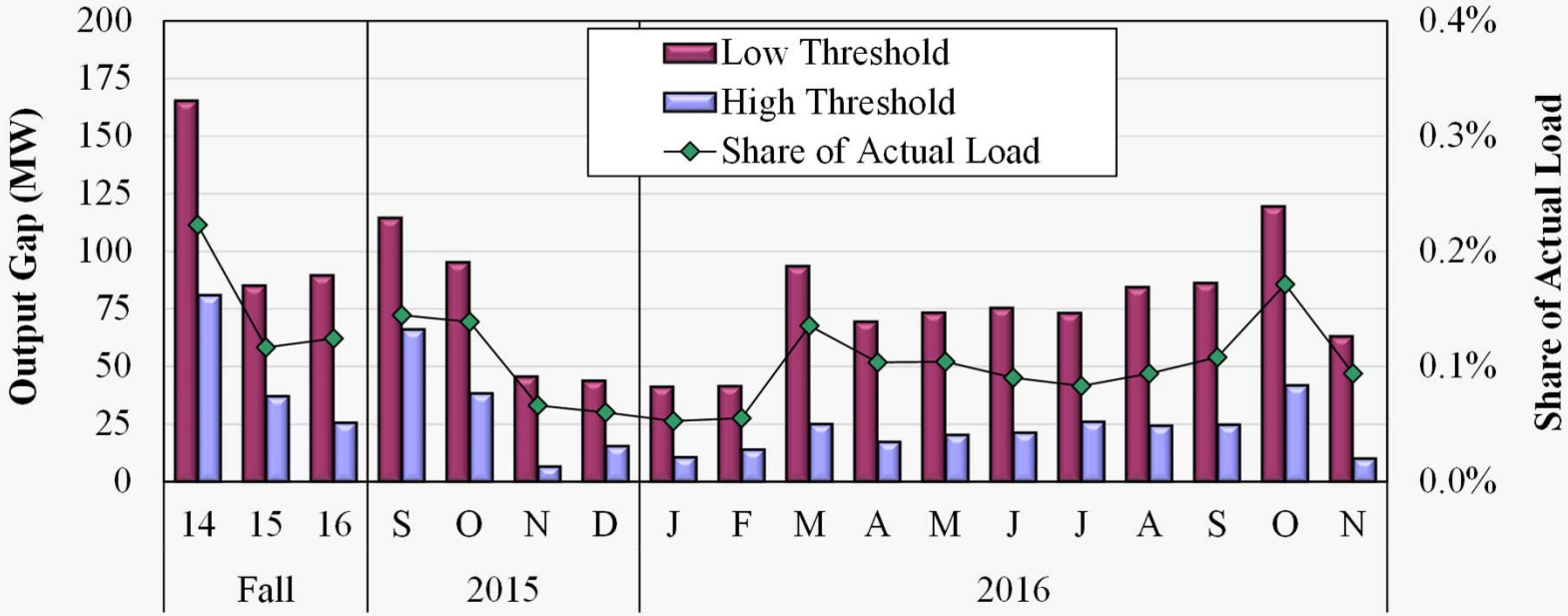
Monthly Output Gap
2015–2016



High Threshold Results by Unit Status (MW)

Offline	16	25	13	50	25	0	7	5	10	0	1	0	1	15	11	11	26	3
Online	65	12	12	16	14	6	8	6	5	25	16	20	20	11	14	14	16	8

Low Threshold Results by Unit Status (MW)

Offline	22	30	15	57	32	0	10	6	11	0	1	0	1	15	13	13	30	3
Online	143	55	74	57	63	45	34	36	31	94	69	73	74	58	72	73	89	60

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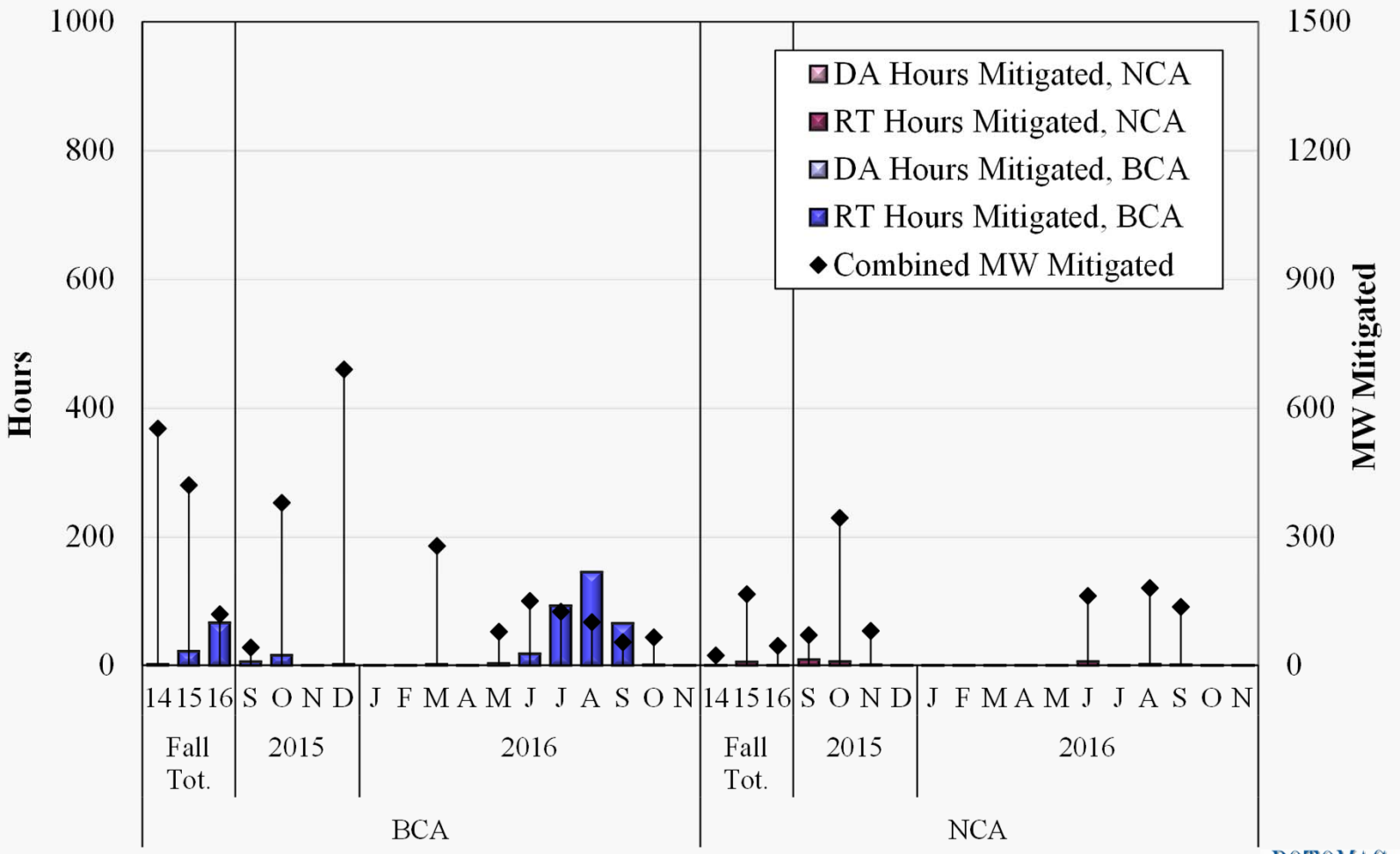
Day-Ahead And Real-Time Energy Mitigation 2015–2016



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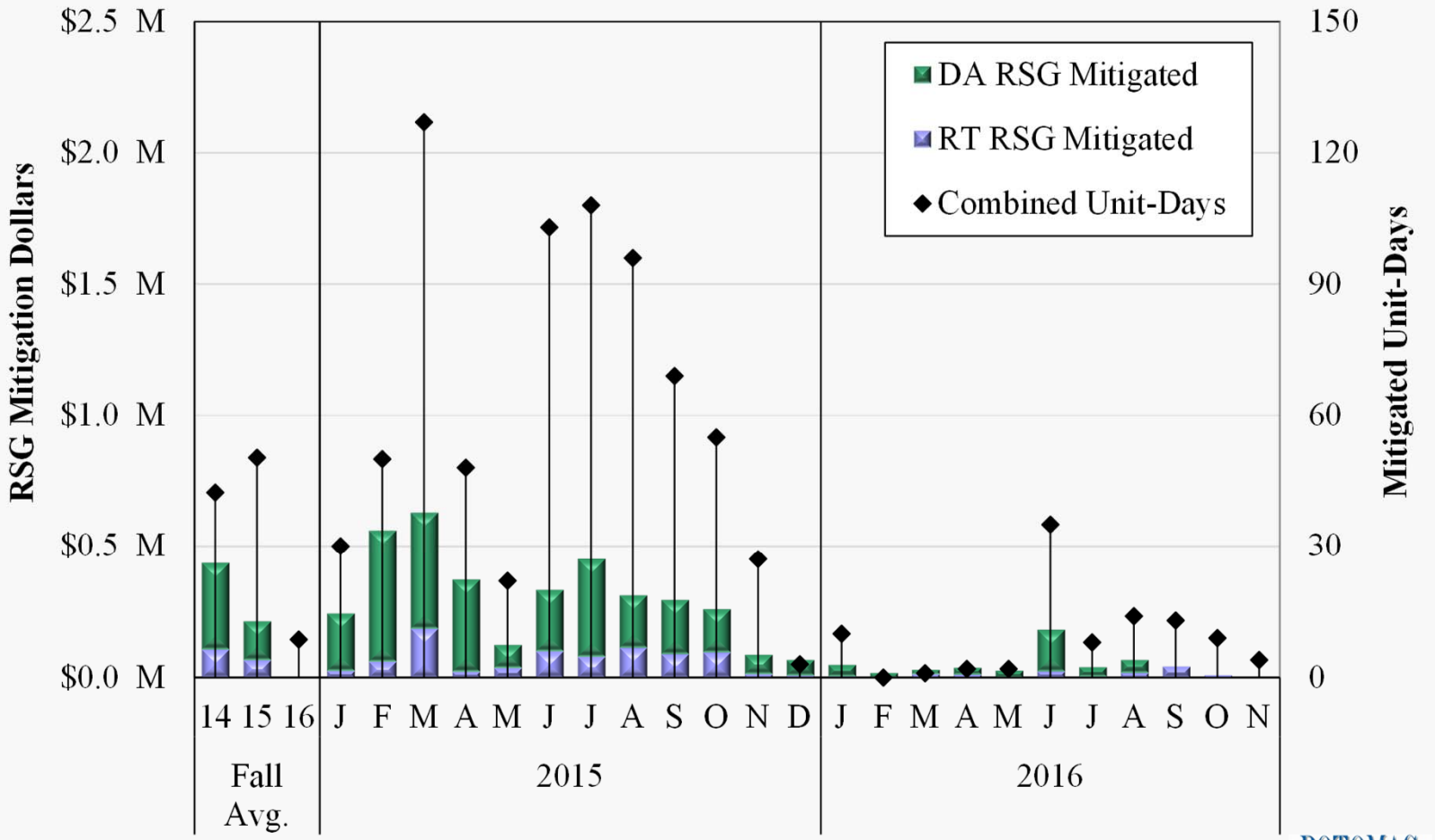
Day-Ahead and Real-Time RSG Mitigation 2015–2016



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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
- 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
- ORCA — Operations Reliability Coordination Agreement
- 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
- SRPBC — Sub-Regional Power Balance Constraint
- TLR — Transmission Line Loading Relief
- TCDC — Transmission Constraint Demand Curve
- VCA — Voluntary Capacity Auction
- VLR — Voltage and Local Reliability
- WPP — Weekly Procurement Process
- WUMS — Wisconsin Upper Michigan System

Appendix:
Wind Evaluation

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Update on IMM Wind Evaluation and Initial Recommendations

Presentation to:

MISO Market Subcommittee

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POTOMAC ECONOMICS

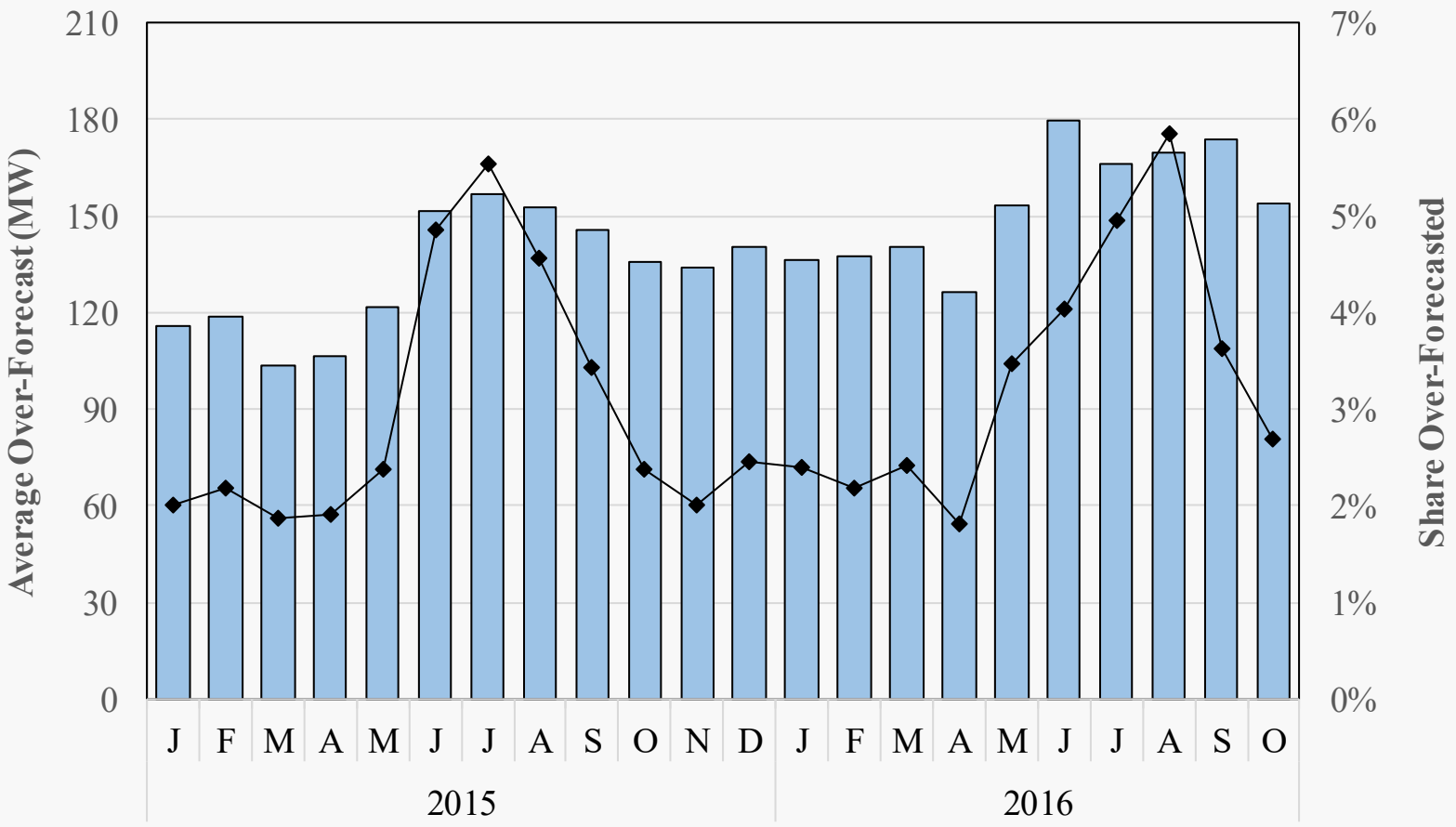
Wind Forecasting and Dispatch in MISO

- As noted in the Oct. 4 MSC presentation discussion on generator deviations, average deviations by wind units are larger than any other class of resource.
  - ✓ These deviations occur because a number of wind units tend to substantially over-forecast their output, which is used by MISO to establish wind units' dispatch maximum and (because there offers are low), their dispatch level.
  - ✓ Because they cannot achieve this output level, they produce less energy than the MISO dispatch instruction.
  - ✓ The deviations are much larger in ramping hours and in the spring and fall.
- These results raise concerns because they:
  - ✓ Undermine the efficiency of MISO dispatch and may lead to unjustified payments to the wind resources; and
  - ✓ May violate the obligation to provide accurate information to MISO.
- Hence, we initiated an evaluation of this issue and present our initial findings and recommendations in this presentation.

Wind Forecasting and Dispatch in MISO

- The following figure shows the average deviations by DIR resources by month in 2015 and 2016.
  - ✓ These resources deviate by average of 146 MW on average in all hours (excluding effects from economic curtailment and manual redispatch).
  - ✓ However, the figure shows that the over-forecasting percentages are highest in the summer season. This is likely due to the fact that the higher summer prices increase the incentive to maximize production by over-forecasting.
- The deviations by wind resources that results from over-forecasting their output has a number of impacts on MISO operations and on settlements by:
  - ✓ Increasing congestion and under-utilizing the transmission system as MISO dispatches the system to make room for the over-forecasted energy;
  - ✓ Causing supply-demand imbalances that result in MISO deploying more regulating reserves or making broad adjustments in energy demand (offset);
  - ✓ Increasing unjustified DAMAP payments to wind resources when their day-ahead schedule is higher than their actual real-time output; and
  - ✓ Causing non-wind resources to be dispatched at inefficient output levels.

Monthly Wind Deviations
2015-2016



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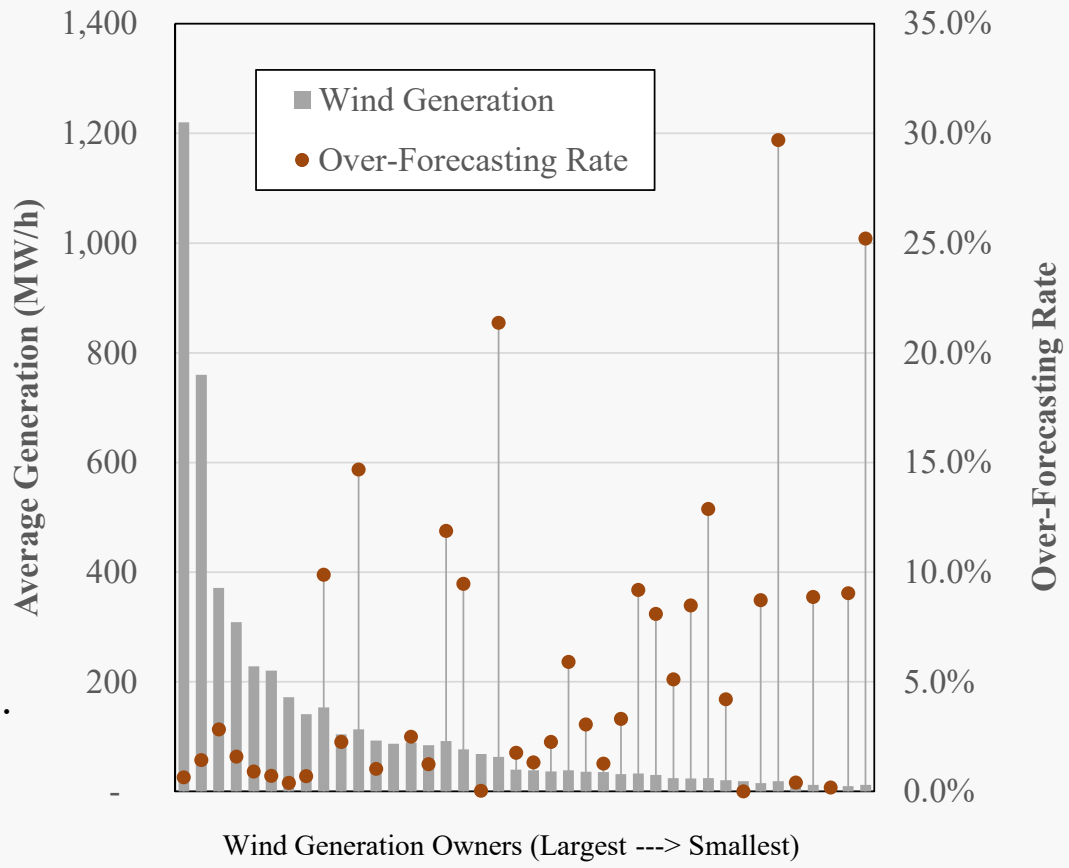
Wind Forecasting and Dispatch in MISO 2015-2016

- This figure shows the average net forecast error by size of wind supplier.
- Most wind units over-forecast to some extent.
- Larger wind producers generally have a less-biased forecasting error.
- However a number of large and small wind suppliers exhibit large sustained forecast biases.



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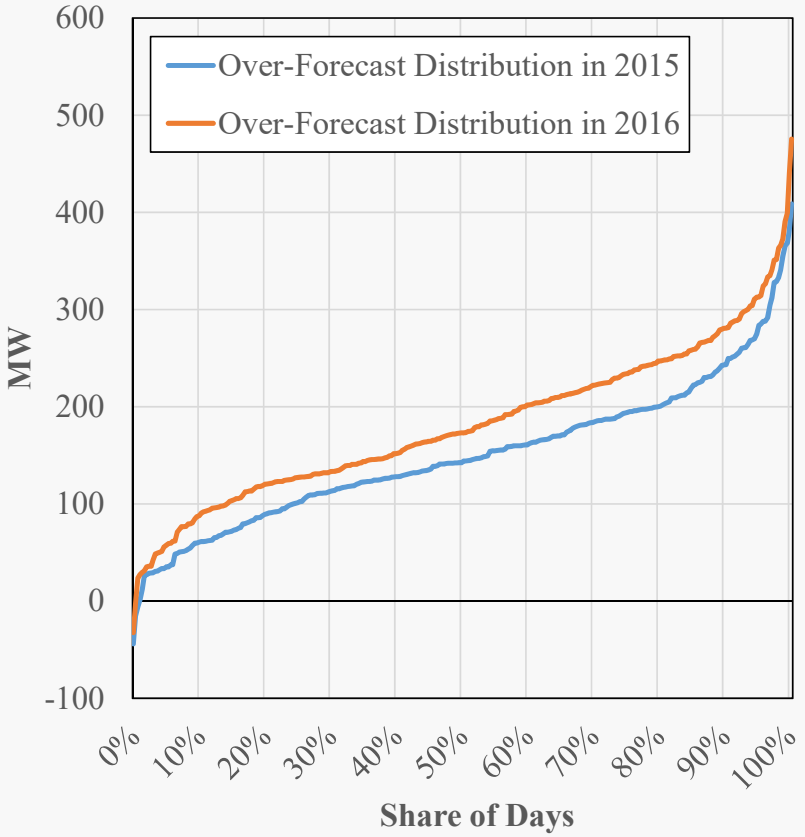
Impacts on Energy Balance
Hour Ending 8

- This figure shows the net over-forecast in hour-ending 8 in 2015 and 2016.
- Median 2016 wind deviation is 173 MW in hour-ending 8.
- Forecast error greater during 2016 than 2015 because of:
  - ✓ Higher wind output
  - ✓ Higher expected production tax credits (PTCs).
    - – Wind PTCs expired at the end of 2014
    - – In December 2015, wind PTCs were retroactively extended for 5 years beginning Jan. 1, 2015.



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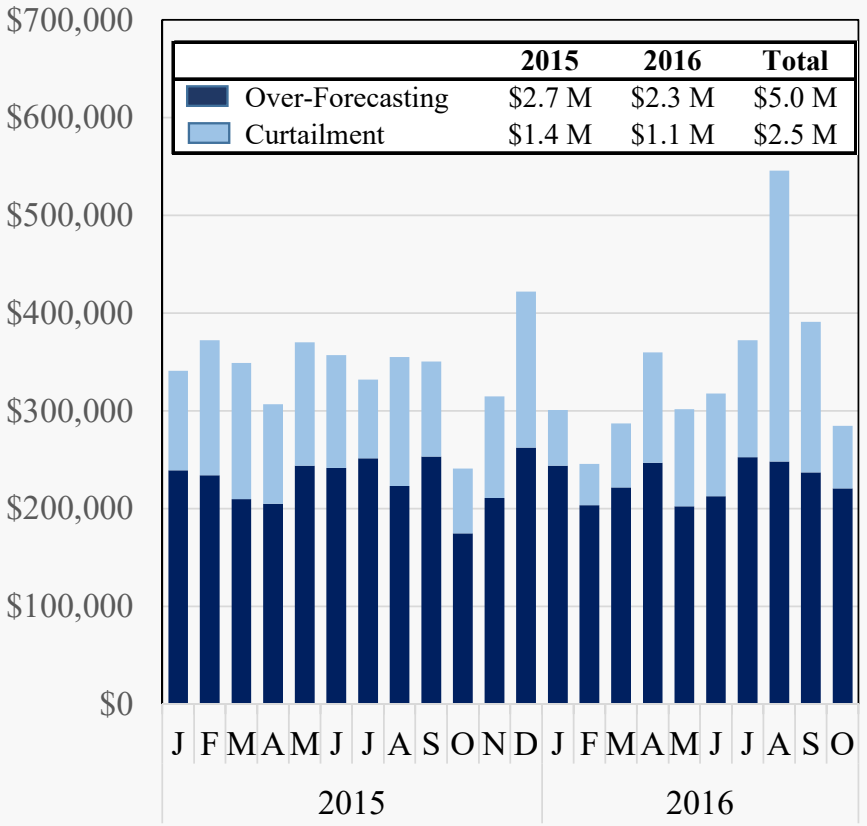
Wind Resource Settlements
Day-Ahead Margin Assurance Payments

- This figure shows the DAMAP paid to wind units and why they received it.
- Only one-third of all DAMAP was paid to units ramping to manage congestion.
  - ✓ These payments provide incentives to follow market and reliability directives.
- Two-thirds of DAMAP was paid to units with infeasible forecasts (within the deviation thresholds).
  - ✓ These payments are unjustified and raise costs to other MISO participants.



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Why are Wind Resources Over-Forecasting?

- Given the low cost of wind and the PTCs, wind resources have a strong incentive to produce as much as they can.
  - ✓ Over-forecasting helps ensure they receive a dispatch signal that does not limit their output.
- Under-forecasted leading to excess energy output is discouraged.
  - ✓ Wind resources can produce above their dispatch signal, but this has been discouraged by MISO and can result in excess energy penalties.
  - ✓ MISO settlement rules treat deficient energy (over forecasting) more favorably than excessive energy (under forecasting) for wind resources.
- DAMAP rules create an adverse incentive for wind resources to over-forecast.
  - ✓ When a wind resources schedules at a higher level day ahead than its real-time output, it can retain the day-ahead profit by over-forecasting its output at the day-ahead level.
  - ✓ MISO will make a DAMAP payment to guarantee the day-ahead profit.
  - ✓ The wind resource will also avoid RSG charges in this case.

Details on Settlement Incentives

- Settlement rules favor erring on the side of biasing wind forecasts high.
- Some charges for Excessive and Deficient Energy are similar:
  - ✓ Day-Ahead Headroom and Deviation Charges ~ $0.50 per MWh,
  - ✓ Constraint Management Charges ~ $0.05 per MWh,
  - ✓ Excessive-Deficient Energy Deployment Charges ~ $0.04 per MWh, and
  - ✓ Loss of PVMWPs and RSG eligibility (variable).
- However, Excessive Energy and Deficient Energy settlements are designed so resources earn no energy margin on that output -- this provides unbiased incentives for most unit types, but wind is an exception.
  - ✓ Excessive Energy is paid the lesser of LMP and as-offered cost, which is generally negative for wind because of PTCs. This cost can average over $40 per MWh.
  - ✓ However, Deficient Energy results in no lost revenue for wind units since the deficiency is a lack of capability, which carries no margin opportunity.

Objectives

- We are evaluating a number of recommendations on potential revisions to:
  - ✓ MISO Operations including dispatch and forecasting validation/backstops.
  - ✓ MP Forecast submissions and DIR Base/Set Point information.
  - ✓ MISO Settlements, in particular the EXE formula and inputs.
- Our recommendations balance the following objectives:
  - ✓ Maximize wind production since it is generally the lowest-cost resource.
  - ✓ Provide incentives for suppliers to submit accurate 50/50 wind forecasts.
  - ✓ Manage congestion reliably.
  - ✓ Eliminating any potential gaming incentives and excess unjustified costs.
- The current rules do not achieve these objectives.
- By balancing these objectives appropriately, the incentives of the wind suppliers and MISO's operating objectives will be in alignment.

IMM Proposals for Wind

- Make the excessive energy (EXE) thresholds for wind responsive to congestion and provide this information to wind resources in real time.
  - ✓ When the system is unconstrained, the threshold/penalty could relaxed to allow wind units more latitude to produce as much output as they can.
  - ✓ When the system is constrained, a tighter threshold/penalty could apply.
  - ✓ To address cases where excess wind energy could cause constraints to start binding, a post-processor for UDS could calculate the potential additional flow due to forecast errors and tighten the EXE threshold.
- Automate the validation of market participant forecasts.
- Develop procedures for correcting the dispatch signals using the MISO forecasts or SE results.
- Eliminate DAMAP for MISO wind DIR resources once 5-minute settlements in implemented.
  - ✓ Once 5-minute settlements are implemented, almost all of the DAMAP paid to wind resources will be for forecast errors.
  - ✓ This eliminates potential gaming incentives.