IMM Quarterly Report: Summer 2023

MISO Independent Market Monitor

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Potomac Economics

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Highlights and Findings: Summer 2023

- The MISO markets performed competitively this summer.
- Energy prices fell 60 percent compared to last summer because gas prices dropped 70 percent and coal conservation measures have effectively ended.
- Annual peak load was 3 percent higher than last summer and occurred on August 23, while average load fell by one percent.
  - ✓ MISO was forecasting a peak load over 127 GW for August 24 due to high temperatures footprint-wide, but real-time demand peaked at 123 GW that day.
  - ✓ Most regions experienced extremely hot temperatures in late July and August -- the South was the hottest since integration and set multiple record peak loads.
- Day-ahead and real-time congestion fell by half from last summer, consistent with lower gas prices, and congestion patterns in the North changed.
- MISO realized a significant reduction in uplift, largely because of lower gas prices and improvements in MISO's commitments.
  - ✓ Operators also manually re-dispatched units less frequently, adjusting transmission demand curves instead, which reduced DAMAP uplift costs.
- Average hourly wind output decreased by 17 percent, leading to less congestion and a 55 percent reduction in curtailments.

Quarterly Summary

Summer		Value	Change[1] Prior Qtr.	Change[1] Prior Year
RT Energy Prices ($/MWh)		$34.43	*30%*	*-60%*
Fuel Prices ($/MMBtu)				
Natural Gas - Chicago		$2.22	*6%*	*-70%*
Natural Gas - Henry Hub		$2.41	*10%*	*-69%*
Western Coal		$0.81	*-2%*	*-15%*
Eastern Coal		$2.12	*-26%*	*-70%*
Load (GW)[2]				
Average Load		85.4	*23%*	*-1%*
Peak Load		125.5	*22%*	*3%*
% Scheduled DA (Peak Hour)		100.4%	99.1%	99.1%
Transmission Congestion ($M)				
Real-Time Congestion Value		$378.8	*-32%*	*-57%*
Day-Ahead Congestion Revenue		$264.1	*-13%*	*-56%*
Balancing Congestion Revenue[3]		$19.7	$7.5	-$3.9
Ancillary Service Prices ($/MWh)				
Regulation		$10.25	*-8%*	*-46%*
Spinning Reserves		$2.45	*10%*	*-56%*
Supplemental Reserves		$0.67	*219%*	*-78%*

		Value	Change[1] Prior Qtr.	Change[1] Prior Year
FTR Funding (%)		101%	92%	114%
Wind Output (MW/hr)		6,198	*-50%*	*-17%*
Wind Curtailed (MW/hr)		128	*-86%*	*-55%*
Guarantee Payments ($M)[4]				
Real-Time RSG		$8.4	*28%*	*-83%*
Day-Ahead RSG		$6.9	*13%*	*-70%*
Day-Ahead Margin Assurance		$12.9	*69%*	*-46%*
Real-Time Offer Rev. Sufficiency		$0.9	*-42%*	*-63%*
Price Convergence[5]				
Market-wide DA Premium		4.3%	2.5%	-0.9%
Virtual Trading				
Cleared Quantity (MW/hr)		22,083	-19%	4%
% Price Insensitive		48%	44%	62%
% Screened for Review		2%	2%	3%
Profitability ($/MW)		$0.6	$0.7	$1.2
Dispatch of Peaking Units (MW/hr)		2,729	1,516	2,264
Output Gap- Low Thresh. (MW/hr)		26	120	283

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 2023

Lower Natural Gas Prices, Growth in Solar Resources (Slides 17, 19-20)

- Gas prices were 70 percent lower than last summer, impacting energy prices, coal resource dispatch, congestion, uplift, and resource net revenues.
  - ✓ Net revenues fell for all resources compared to the high values realized last summer, although, compared to the Spring, net revenues rose overall.
  - ✓ Day-ahead RSG fell by 70 percent while real-time RSG fell 83 percent.
    - – While we estimate that more than half the RSG was not needed, MISO has made significant improvements in its commitment processes.
  - ✓ Day-ahead and real-time congestion were 56 and 57 percent lower than last summer.
- MISO's solar capacity doubled this summer, and it delivered valuable output during peak conditions.
  - ✓ Solar output averaged around 2200 MW between hours 12 and 17 during the summer quarter.
  - ✓ On the Emergency days, solar output averaged around 2500 MW during the same hours and was as high as 2400 MW in the peak hour 16 on August 24th.

Highlights for Summer 2023

High temperatures and forecasted emergency conditions (Slides 21-22)

- During the quarter, MISO experienced extended periods of hot weather that led to multiple Hot Weather Alerts and Conservative Operations declarations.
- On the six peak days shown in late July and late August, MISO over-forecasted the load by 2 to 8 GW, averaging roughly 4 GW.
  - ✓ Some of the differences may be due to self-scheduled load-modifying resources (LMRs). Over 1 GW is typically scheduled in peak hours from behind the meter generation and more than 1 additional GW curtails on the tightest days.
  - ✓ Behind the meter solar may be creating errors as well.
  - ✓ Improving the forecasting of super-peak summer conditions would be valuable.
- In the third week of July, high forecasted temperatures and load in the Midwest led to an advance Maximum Generation Alert declaration for July 27th.
  - ✓ The 2-day advance Alert likely informed some of the participants' preparations.
  - ✓ Load scheduled at a high level and MISO realized a day-ahead premium of more than $130 per MWh at the peak hour.
  - ✓ Almost all resources online that day were scheduled in the day-ahead market so real-time RSG was low (less than $50,000).

Highlights for Summer 2023

Emergency Procedures and Maximum Generation Events - Background

- Emergency procedures allow MISO to access supply and demand that increase its reserve margin (supply – energy and operating reserve demand).
- Since they increase the margin outside of the market, they tend to distort market outcomes and should only be invoked when necessary.
- Emergency declarations provide the following results:
  - ✓ Alert: allows 4-hour online resources to set price in ELMP
  - ✓ Warning: Tier 1 emergency pricing in ELMP, curtail non-firm exports, call external capacity resources to import
  - ✓ Step 1: a) can commit emergency only units, b) activate emergency output ranges in the real-time dispatch (instantly available)
  - ✓ Step 2: a) Tier 2 pricing and LMRs available, b) emergency DR, c) emergency energy purchases from neighbors
  - ✓ Steps 3-5: Raise priority of transaction curtailments, call reserves from reserve sharing group, shed firm load
- Each level of declaration should be called only if and *when* the additional MWs in that level will be need to avoid a reserve shortage. *STR provides for uncertainty.*

Highlights for Summer 2023

Maximum Generation Event on August 24th (Slides 21-23)

- In the week leading up to Aug. 24th, MISO was forecasting peak annual load in excess of 130 GW that day based on extremely high temperature forecasts.
  - ✓ MISO raised STR requirements 900 MW in all markets from Aug. 21-25 to hold 2000 MW above its operating reserve levels in the peak hours.
  - ✓ MISO issued a Max Gen Alert two days in advance to allow MPs to prepare.
- Early on the 24th, MISO forecasted a sizable deficit in the peak hour.
  - ✓ MISO started sending commitment instructions to fast-starting turbines at 6 am.
  - ✓ MISO declared a Step 2A event at 8am to begin at noon – providing access to LMRs – but they were not needed so it was good that MISO did not call them.
  - ✓ 1300 MW of self-scheduled LMRs curtailed after the event declaration.
  - ✓ The timing of these actions was not ideal because most of the turbines, LMRs and emergency capacity would still have been available 5 to 6 hours later.
  - ✓ By 10 am, 2 hours before the start of the event, the forecasted load fell and led to a large surplus. Downgrading/retracting the event would have been ideal.
  - ✓ The surplus supply understated prices, although ELMP did mitigate this.
- Operators did decommit 1800 MW of the 3300 MW of peaking units it committed, which was very good and saved $1.6 million in RSG costs.

Highlights for Summer 2023

Max Gen Event on August 24th – Conclusions

- MISO operators made some very good decisions before and during the event:
  - ✓ Increasing the STR requirements to reflect the increased needs and uncertainty.
  - ✓ Not calling for the LMRs to curtail before it determined they were needed.
  - ✓ Canceling the commitment instructions for 60 peaking resources.
- The event indicates opportunities to improve/clarify the emergency procedures:
  - ✓ *The timing of actions is very important* – actions should only be taken when necessary given lead-time considerations. For example, the emergency ranges available under a Step 1 Event are available nearly immediately.
  - ✓ The lowest level event should be called *based on the quantity of MWs needed*.
  - ✓ The primary goal for all actions should be to *maintain a reserve margin of zero*. Seeking a positive margin to address uncertainty undermines the market.
    - Relying on STR to address uncertainty facilitates the market performance.
    - If uncertainties cause a negative margin, MISO can utilize up to 2 GW of STR to maintain its reserves – the STR shortage will sharpy raise prices.
    - Higher prices incent rising net imports that will address the shortage.

Highlights for Summer 2023

IMM Recommendations for Future Hot Weather Emergencies

- In the period leading up to the August 24th Max Gen Event and on that day, MISO worked to prepare members for potentially very challenging conditions.
  - ✓ MISO made efforts to inform members in advance of the projected emergency to ensure that resources could prepare for anticipated conditions.
  - ✓ Communication with MISO members is important ahead of and during events, so market participants can manage their own risk and respond to conditions.
- We recommend the following for future hot weather-related events:
  1. MISO should provide more information leading up to events: forecasted demand, available resources, NSI, and prices from long LAC cases.
     - This would allow MPs to better prepare and schedule NSI.
  2. Improve the operating procedures to:
     - Defer commitments of fast-starting resources based on their lead times;
     - Declare emergencies based on: a) a zero-reserve margin objective, b) event levels tied to the types of MWs needed, and c) timing based on the lead-times of the supply or demand actions; and
     - Improve detail and clarity to reduce operator discretion.

Highlights for Summer 2023

Congestion Patterns in MISO Footprint (Slides 24-28)

- Day-ahead and real-time congestion dropped by more than half compared to last year because of lower gas prices and lower average wind output.
- Power flows in the North were atypical, flowing east to west in many hours.
  - ✓ Forced outages of key fossil resources, lower wind output, and a decline of almost 50 percent in imports from Manitoba contributed to these changes.
- MISO incurred a net $20 million real-time congestion uplift on an SPP M2M constraint minimally impacted by MISO generation and load.
  - ✓ Almost all these costs are related to unjustified congestion payments made to imports/exports for the SPP constraint that are ignored in the M2M settlement.
  - ✓ We continue to recommend MISO eliminate the pricing of external constraint congestion from all its interface prices.
- MISO manually re-dispatched units less frequently to manage constraints and instead relied more frequently on transmission demand curve adjustments.
  - ✓ This has resulted in lower DAMAP and more efficient dispatch of the system.
- MISO's average transmission derate of 6.5 percent with the "limit control" parameter was higher than in prior years, which we are evaluating.

Highlights for Summer 2023

Recent FERC Enforcement Sanction – DRR Gaming

- A Demand Response Resource (DRR) that we referred to FERC for market manipulation has agreed to a settlement of more than $35 million, of which about $21 million is disgorgement that will be refunded to MISO customers.
  - ✓ The DR provider manipulated its baseline and offered phantom load reductions to consume at normal levels.
  - ✓ Between 2019 and 2021, the DRR provider received almost $24 million, about one third of DRR energy market payments.
  - ✓ We referred another DRR provider that collected over $35 million in payments from MISO for similar conduct.
- We have recommended MISO improvements in the DRR rules related to prevent similar gaming in the future.
  - ✓ Specifically, we recommended that MISO establish an offer floor for DRRs and that DRRs indicate their forecasted pre-curtailment expected consumption.
  - ✓ We are working with MISO to gain its support for these changes.

Highlights for Summer 2023

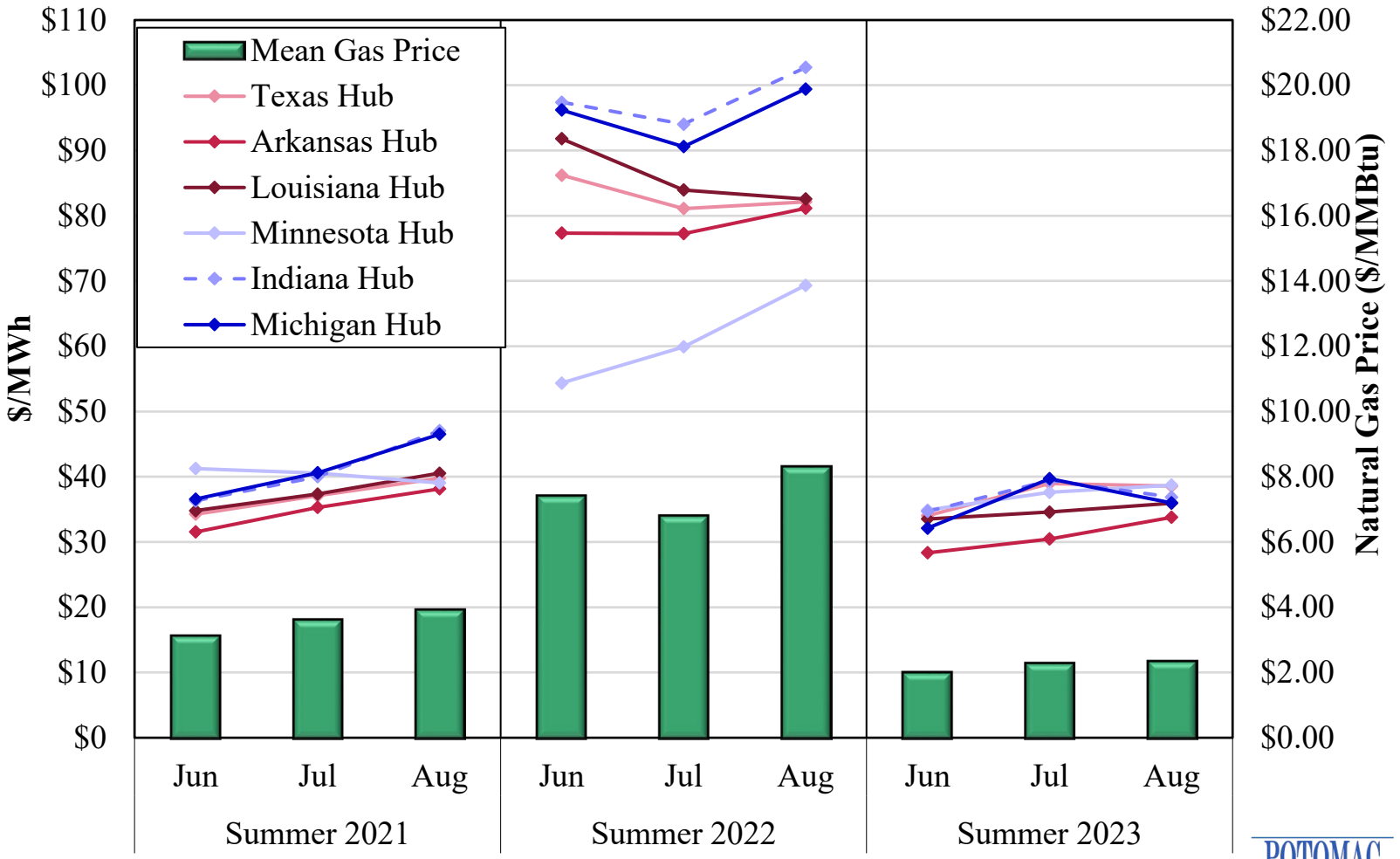
Other Costs Recovered for MISO Customers

- We identified multiple instances of unjustified payments related to participant conduct and MISO settlement issues, including:
  - ✓ Unjustified RSG associated with self-scheduling conduct: $187,000.
  - ✓ Unjustified DAMAP associated with a settlement flaw: $187,000.
  - ✓ Over-payments to a resource that submitted inaccurate meter data to MISO: $800,000.
- We also continue to administer market power mitigation measures that lower market costs when market power is detected.
  - ✓ Mitigation reduced RSG by more than $200,000 this summer, which is lower than the $1.8 million in RSG reductions in the summer of 2022.
  - ✓ MISO recently imposed a sanction that we recommended of $1.1 million.
  - ✓ Other recommended sanctions are pending disposition by MISO totaling more than $1.5 million.

Submittals to External Entities and Other Issues

- We responded to several FERC questions related to prior referrals and FERC investigations, and we responded to requests for information on market issues.
- We presented the IMM Spring Quarterly report to the MSC and the ERSC.
- We presented our SOM to FERC staff and to the MSC.
- We continued working with MISO to review proposals to revise the M2M "firm flow entitlement" allocation, which will have large economic impacts.
- We continued to meet with states and participants on reforming MISO's PRA demand curve and implement marginal accreditation of non-thermal resources.
- We worked with MISO on recommended operational improvements and produced memos and summaries of the recommendations.
- We participated in a meeting of U.S. market monitors at FERC in June.
- We met with OMS and the Planning Advisory Committee to discuss concerns with Future 2A and the benefit-cost analyses supporting Tranche 2 of LRTP with the continuing goal to:
  - ✓ Avoid inefficient costs for MISO's customers; and
  - ✓ Avoid undermining the performance of the wholesale markets.

Day-Ahead Average Monthly Hub Prices
Summer 2021–2023



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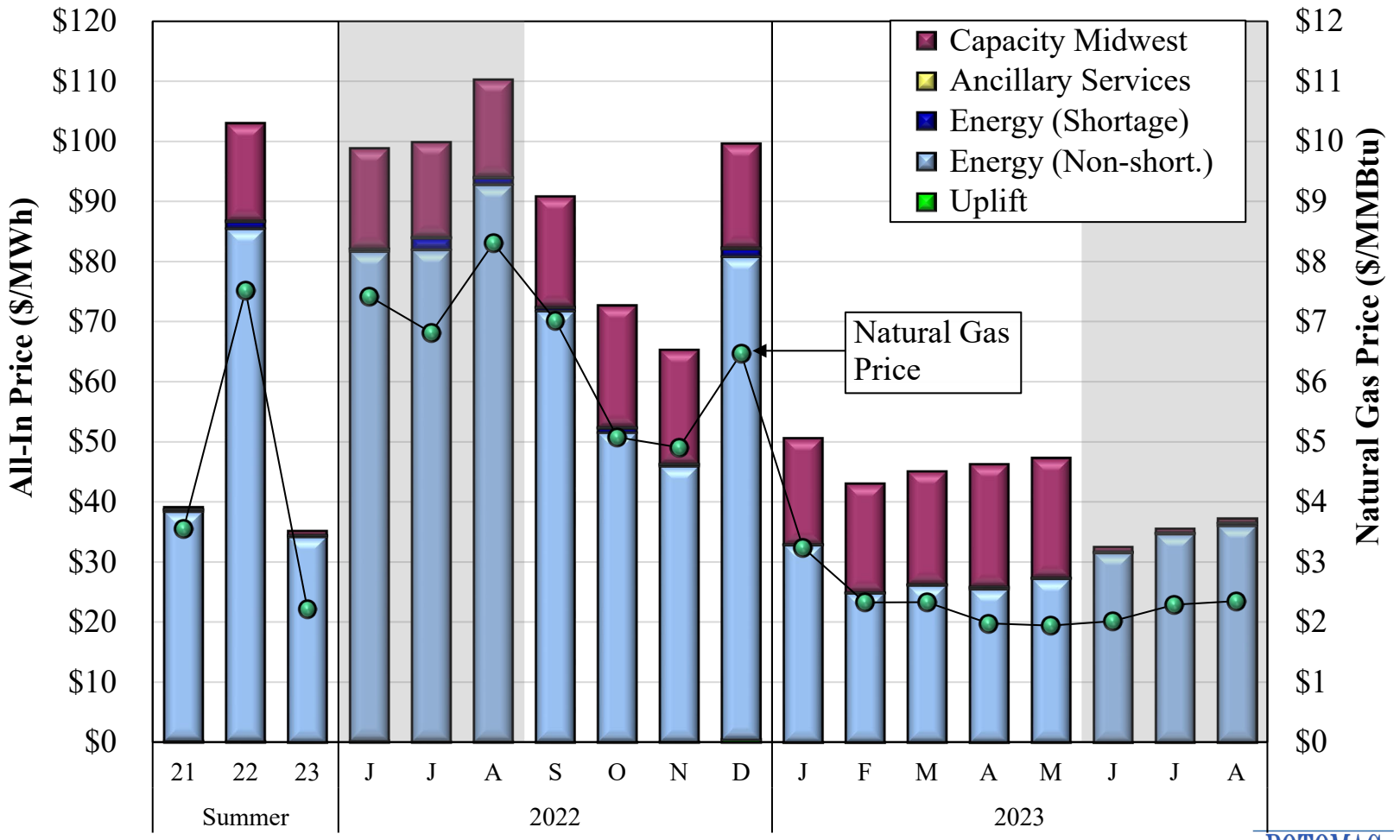
All-In Price
Summer 2021 – 2023



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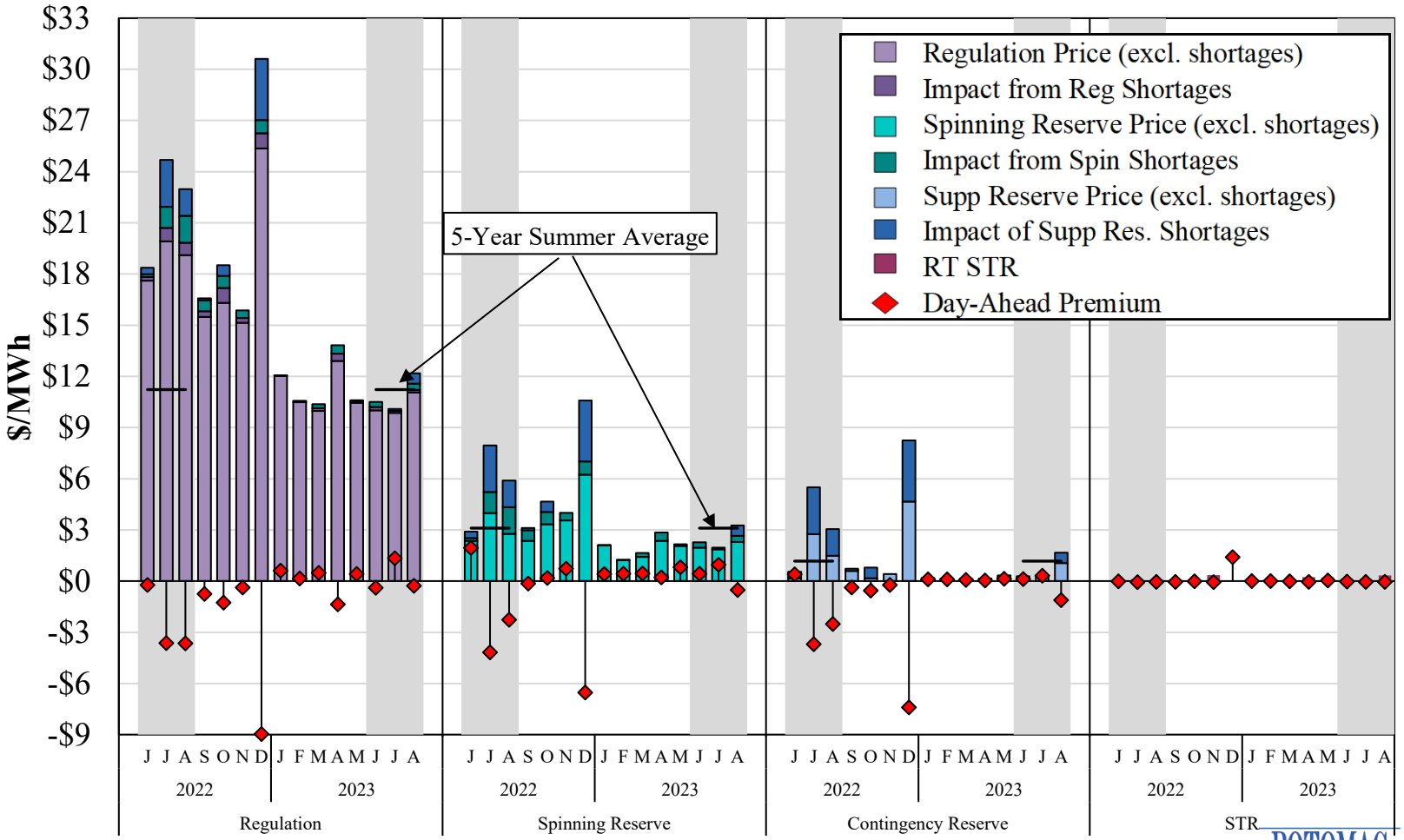
Ancillary Services Prices
Summer 2022–2023



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MISO Fuel Prices
2022–2023

Summer Average	2021	2022	2023
Chicago NG	$3.55	$7.52	$2.22
Henry NG	$3.68	$7.86	$2.41

Summer Average	2021	2022	2023
IB Coal	$1.73	$7.14	$2.12
PRB Coal	$0.72	$0.96	$0.81

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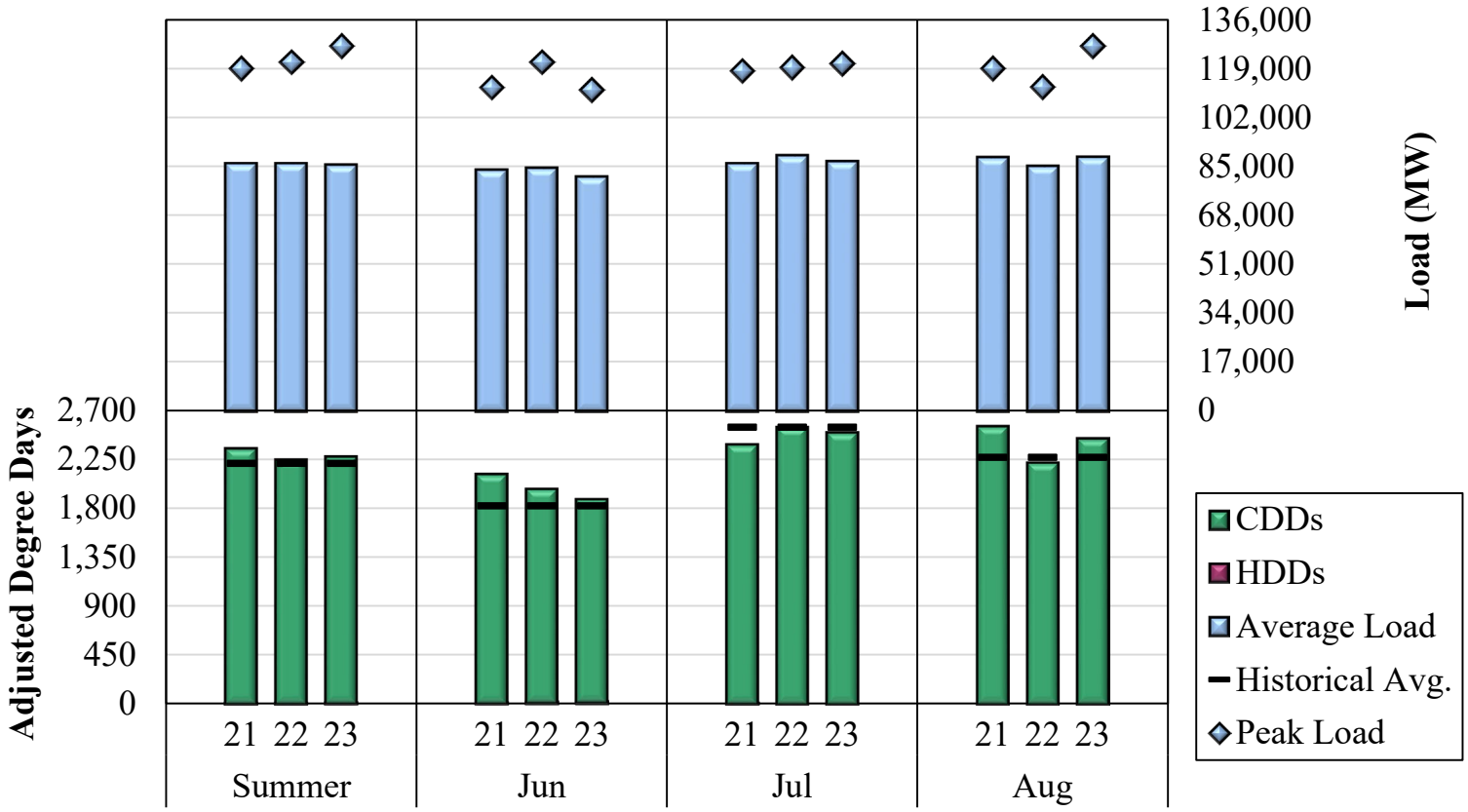
Load and Weather Patterns
Summer 2021–2023



Notes: Midwest degree day calculations include four reprentative cities: Indianapolis, Detroit, Milwaukee and Minneapolis. The South region includes Little Rock and New Orleans.

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Capacity, Energy and Price Setting Share
Summer 2022–2023

Summer	Unforced Capacity				Energy Output		Price Setting			
	Total (MW)		Share (%)		Share (%)		SMP (%)		LMP (%)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Nuclear	10,905	10,799	9%	9%	13%	14%	0%	0%	0%	0%
Coal	40,328	39,148	32%	31%	36%	32%	20%	33%	73%	82%
Natural Gas	60,530	61,438	48%	48%	38%	43%	79%	66%	93%	97%
Oil	1,459	1,335	1%	1%	0%	0%	0%	0%	0%	1%
Hydro	4,034	4,190	3%	3%	1%	1%	1%	1%	3%	2%
Wind	4,447	4,807	4%	4%	9%	8%	0%	0%	48%	35%
Solar	1,643	2,612	1%	2%	0%	1%	0%	0%	1%	15%
Other	2,767	2,682	2%	2%	2%	0%	0%	0%	3%	2%
Total	**126,111**	**127,012**								

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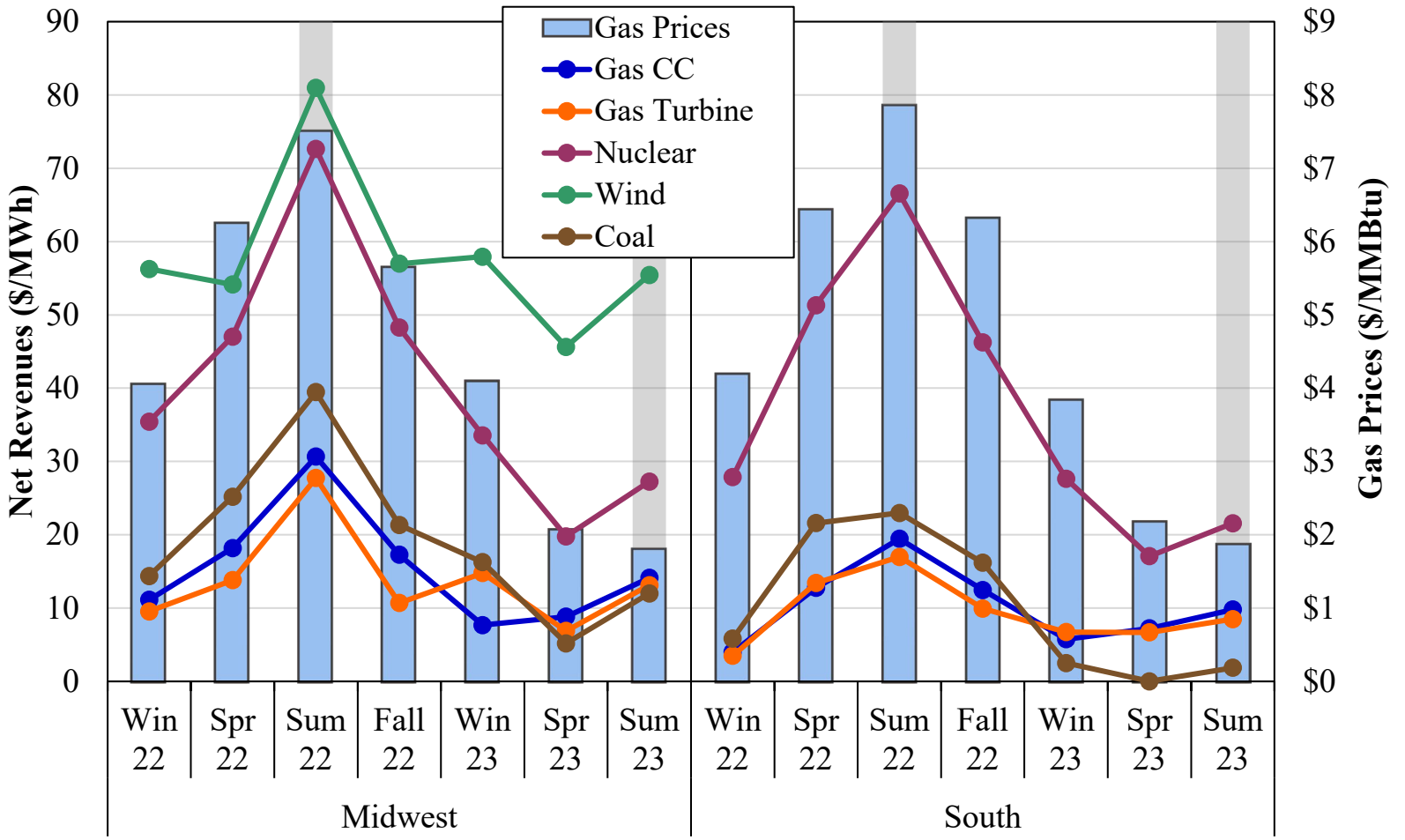
Net Revenues by Technology 2021-2023



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Temperatures During Hot Periods
July and August 2023

	Hist. Avg.	Jul-23			Aug-23						
		26	27	28	20	21	22	23	24	25	26
Minneapolis	**81**	93(83)	95(83)	89(83)	82(80)	77(80)	98(80)	97(80)	88(80)	90(80)	72(79)
Detroit	**81**	87(84)	86(83)	90(83)	89(81)	82(81)	75(81)	81(81)	88(80)	76(80)	80(80)
Indianapolis	**84**	88(85)	88(85)	91(85)	89(84)	91(84)	87(84)	90(84)	92(84)	92(84)	85(84)
Chicago	**83**	90(85)	91(85)	92(85)	89(82)	83(82)	87(82)	97(82)	100(82)	81(82)	75(82)
Little Rock	**91**	95(92)	98(92)	98(92)	100(91)	100(91)	99(91)	99(91)	101(91)	103(91)	106(90)
New Orleans	**91**	95(92)	94(92)	93(92)	96(91)	93(91)	95(91)	100(91)	99(91)	98(91)	102(91)
Houston	**93**	96(94)	94(94)	95(94)	106(93)	98(93)	95(93)	101(93)	106(93)	100(93)	103(93)

Notes: 93 (83) means 93 is actual highest temperature, and (83) is the 20-year highest daily average of temperature.

93(83) Means Above Historical Average by at lease 8 degrees Fahrenheit.

Data source: Weather Underground.

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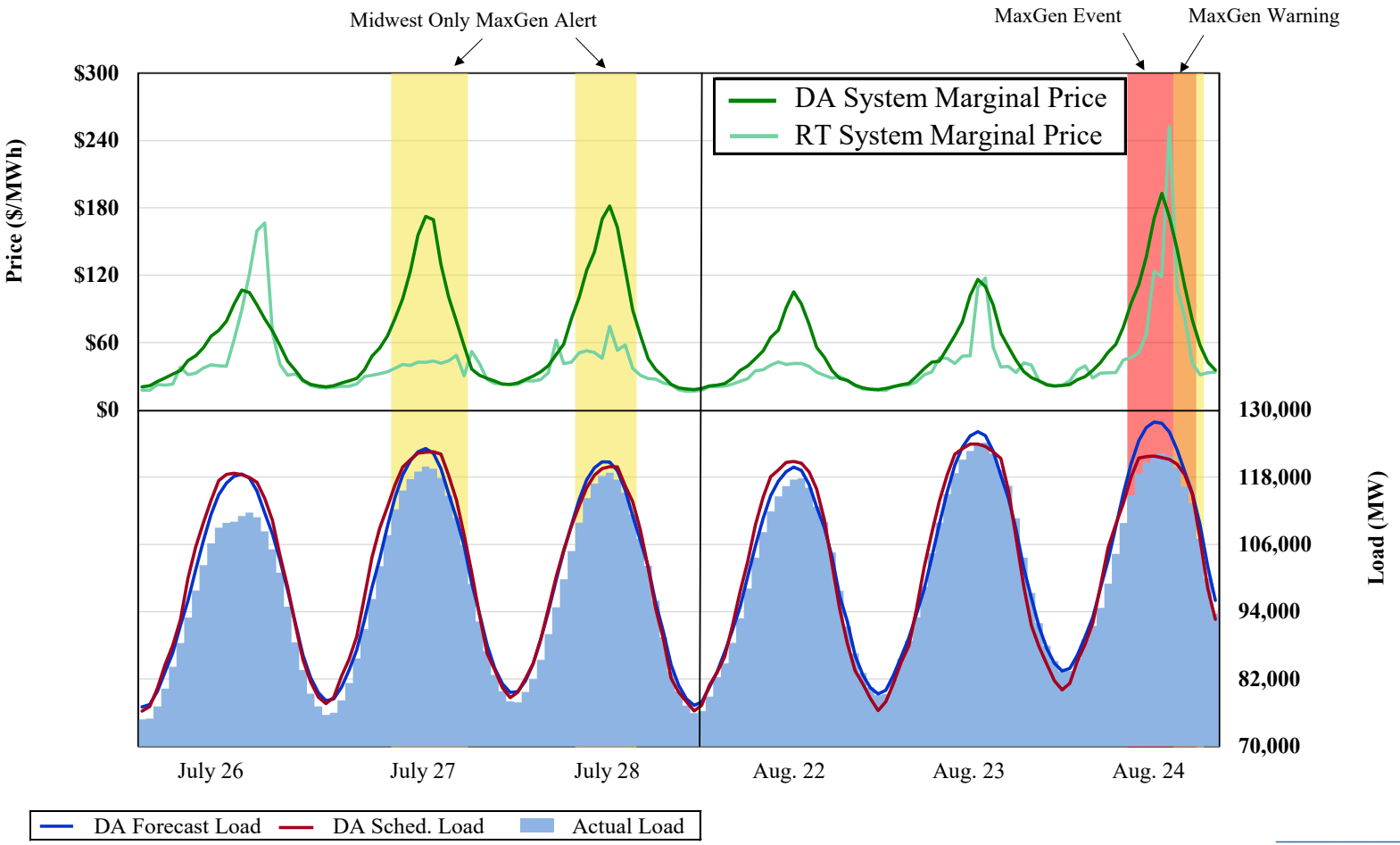
High Temperature Days in MISO
July and August 2023



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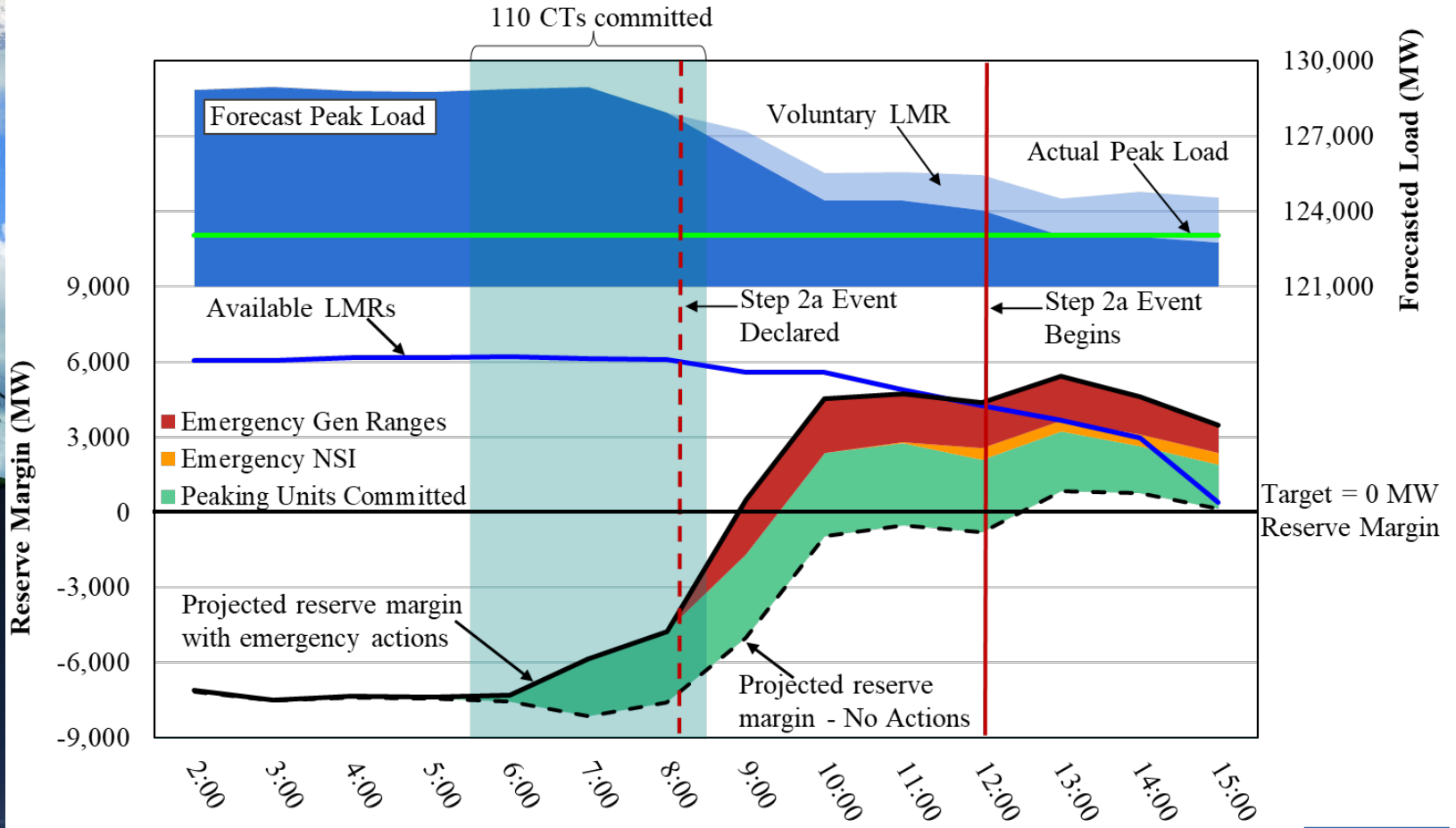
Forecast of the Peak Hour throughout the Day: 4 PM on August 24, 2023



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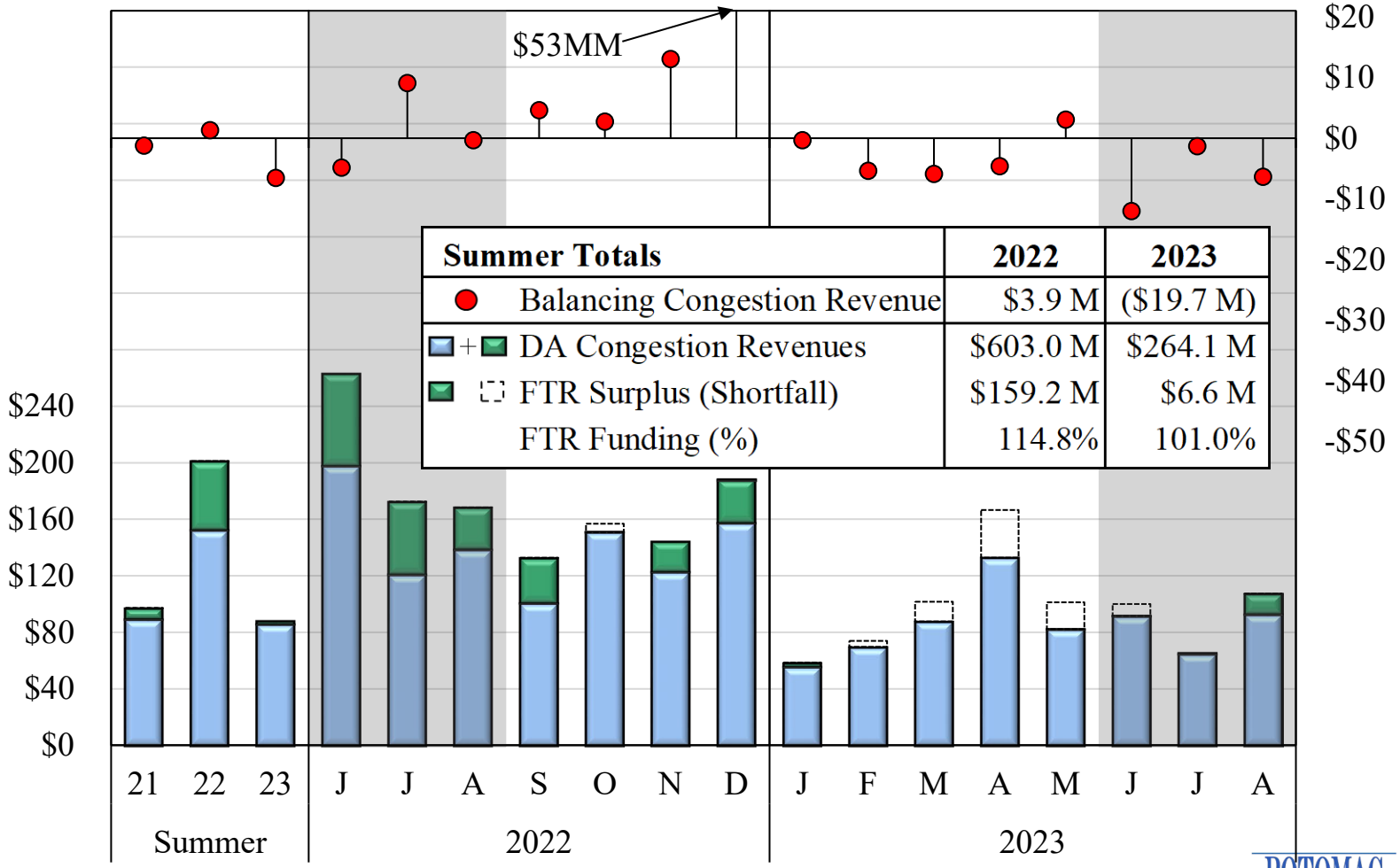
Day-Ahead Congestion, Balancing Congestion, and FTR Underfunding



Summer Totals	2022	2023
Balancing Congestion Revenue	$3.9 M	($19.7 M)
DA Congestion Revenues	$603.0 M	$264.1 M
FTR Surplus (Shortfall)	$159.2 M	$6.6 M
FTR Funding (%)	114.8%	101.0%

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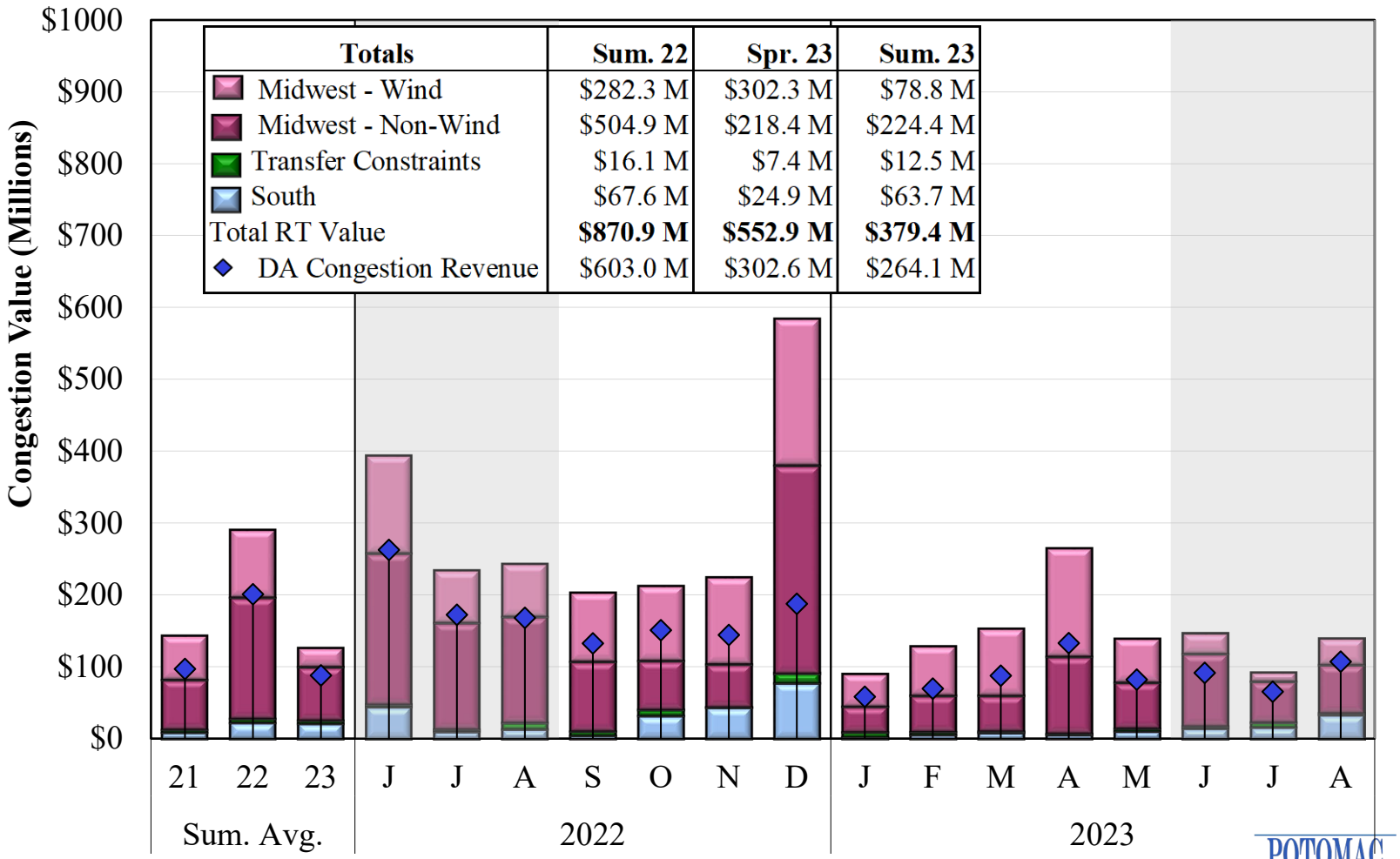
Value of Real-Time Congestion
Summer 2021–2023



Totals	Sum. 22	Spr. 23	Sum. 23
Midwest - Wind	$282.3 M	$302.3 M	$78.8 M
Midwest - Non-Wind	$504.9 M	$218.4 M	$224.4 M
Transfer Constraints	$16.1 M	$7.4 M	$12.5 M
South	$67.6 M	$24.9 M	$63.7 M
Total RT Value	**$870.9 M**	**$552.9 M**	**$379.4 M**
DA Congestion Revenue	$603.0 M	$302.6 M	$264.1 M

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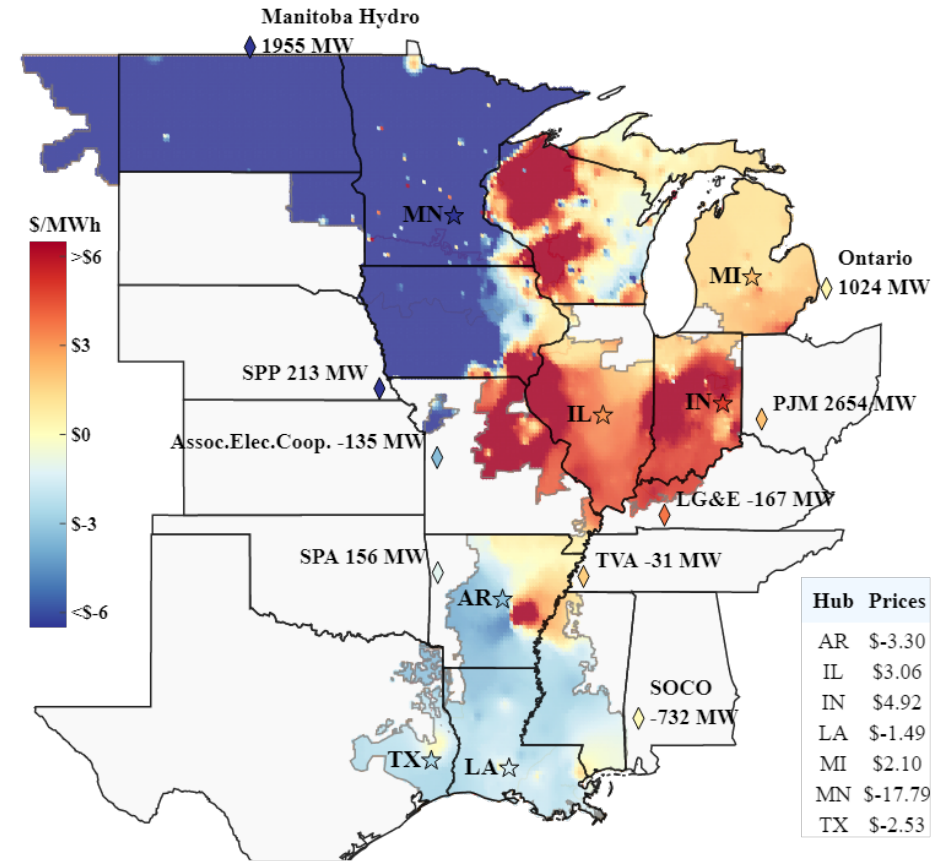
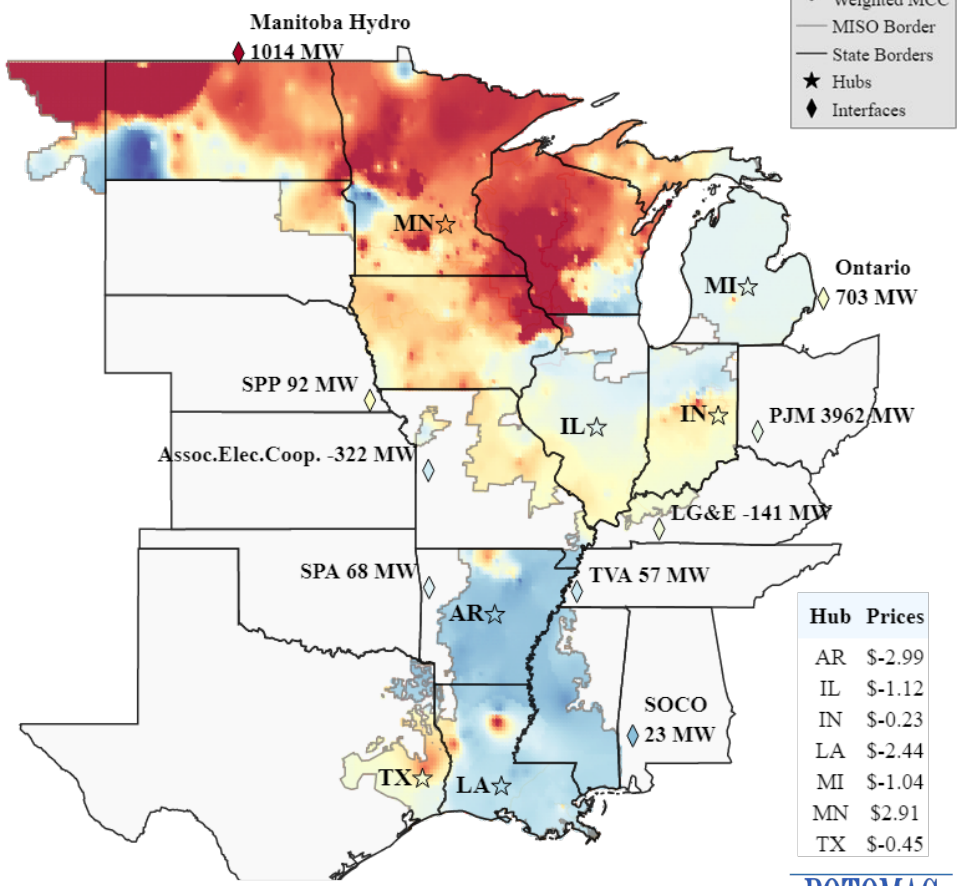
Average Real-Time Congestion Components
Summer 2022–2023

Summer 2022



Hub	Prices
AR	$-3.30
IL	$3.06
IN	$4.92
LA	$-1.49
MI	$2.10
MN	$-17.79
TX	$-2.53

Summer 2023



Hub	Prices
AR	$-2.99
IL	$-1.12
IN	$-0.23
LA	$-2.44
MI	$-1.04
MN	$2.91
TX	$-0.45

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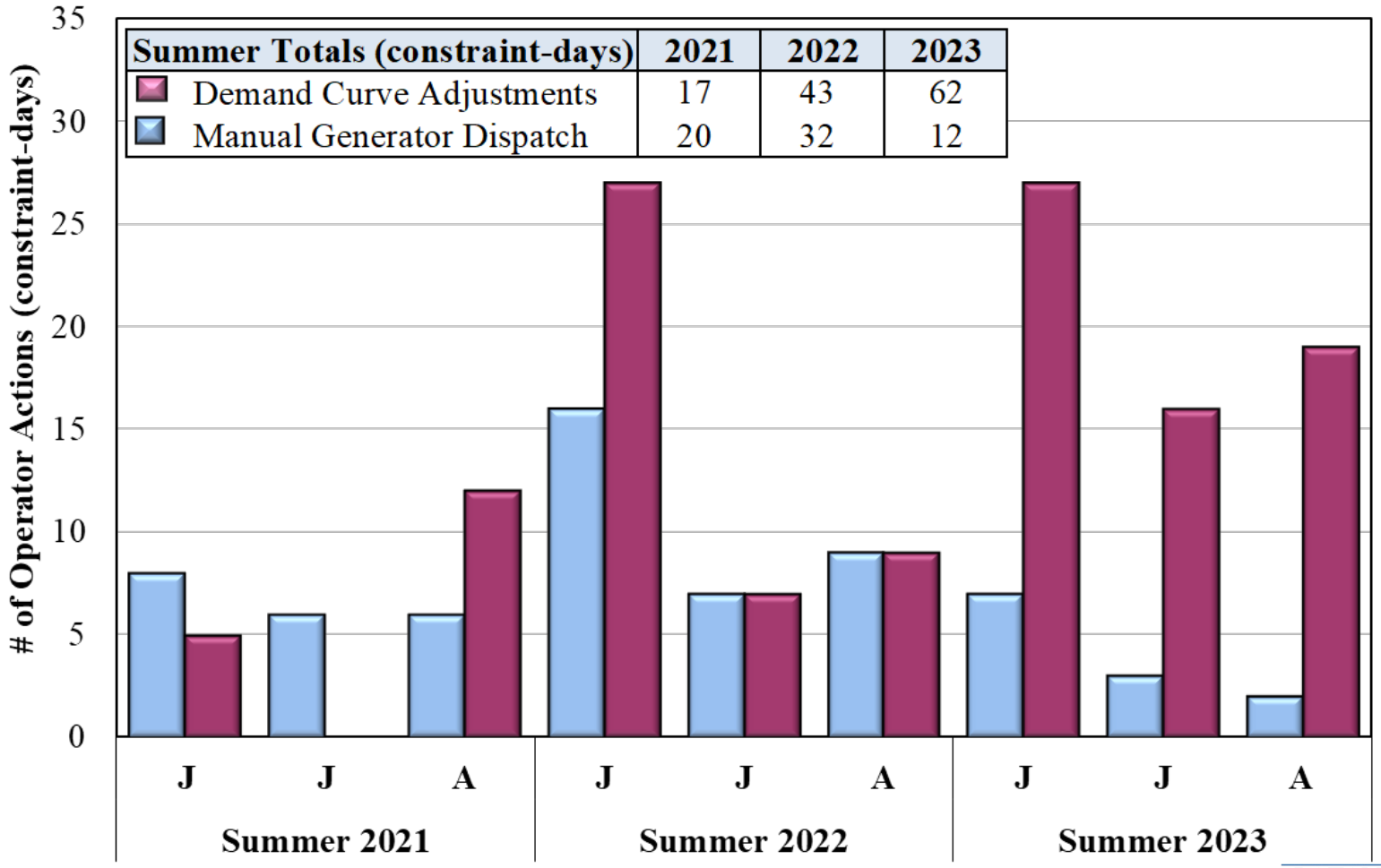
Changes in MISO Operator Actions For Congestion Management



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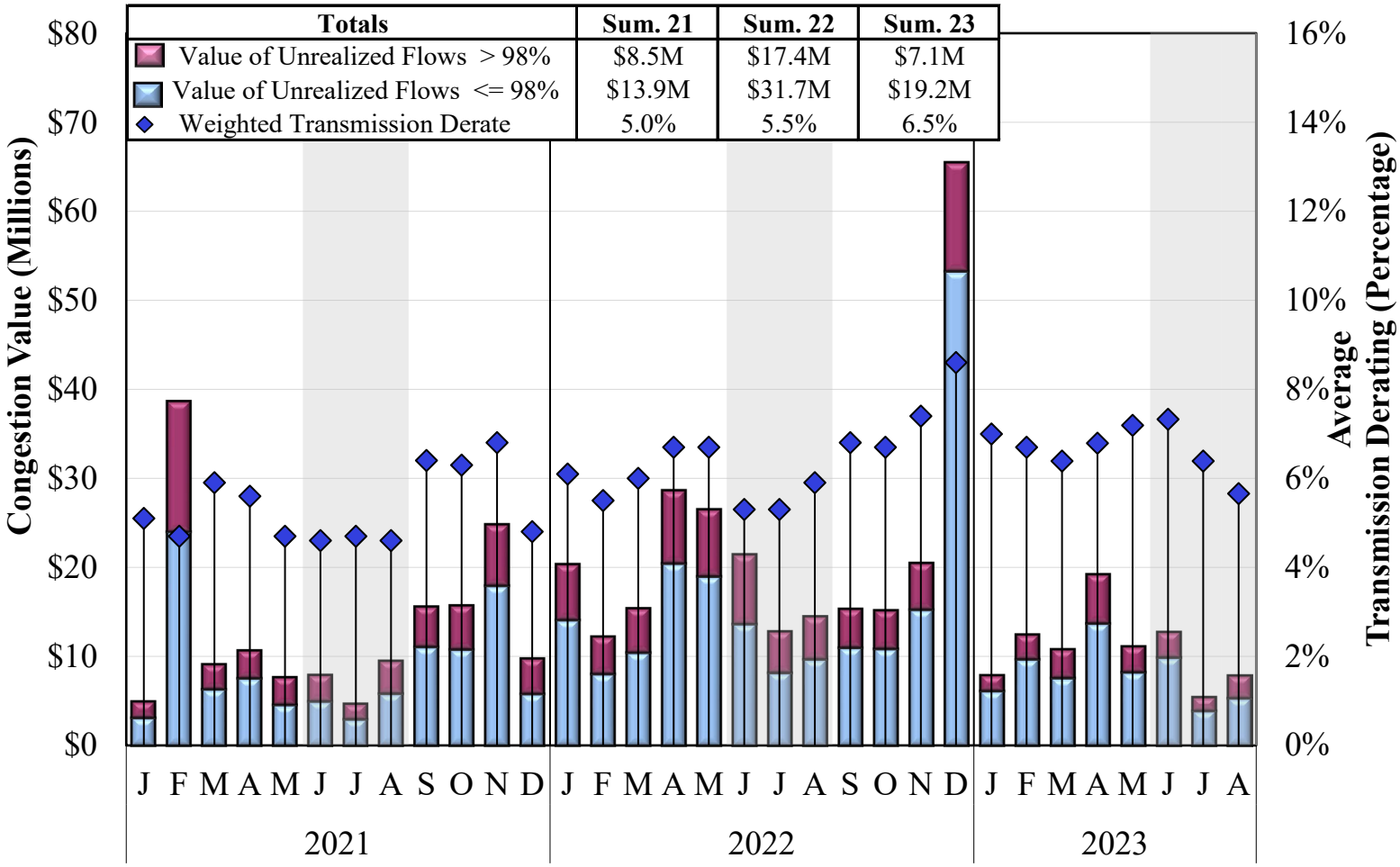
Value of Unrealized Transmission Flows Due to Use of Limit Control

Totals	Sum. 21	Sum. 22	Sum. 23
Value of Unrealized Flows > 98%	$8.5M	$17.4M	$7.1M
Value of Unrealized Flows <= 98%	$13.9M	$31.7M	$19.2M
Weighted Transmission Derate	5.0%	5.5%	6.5%



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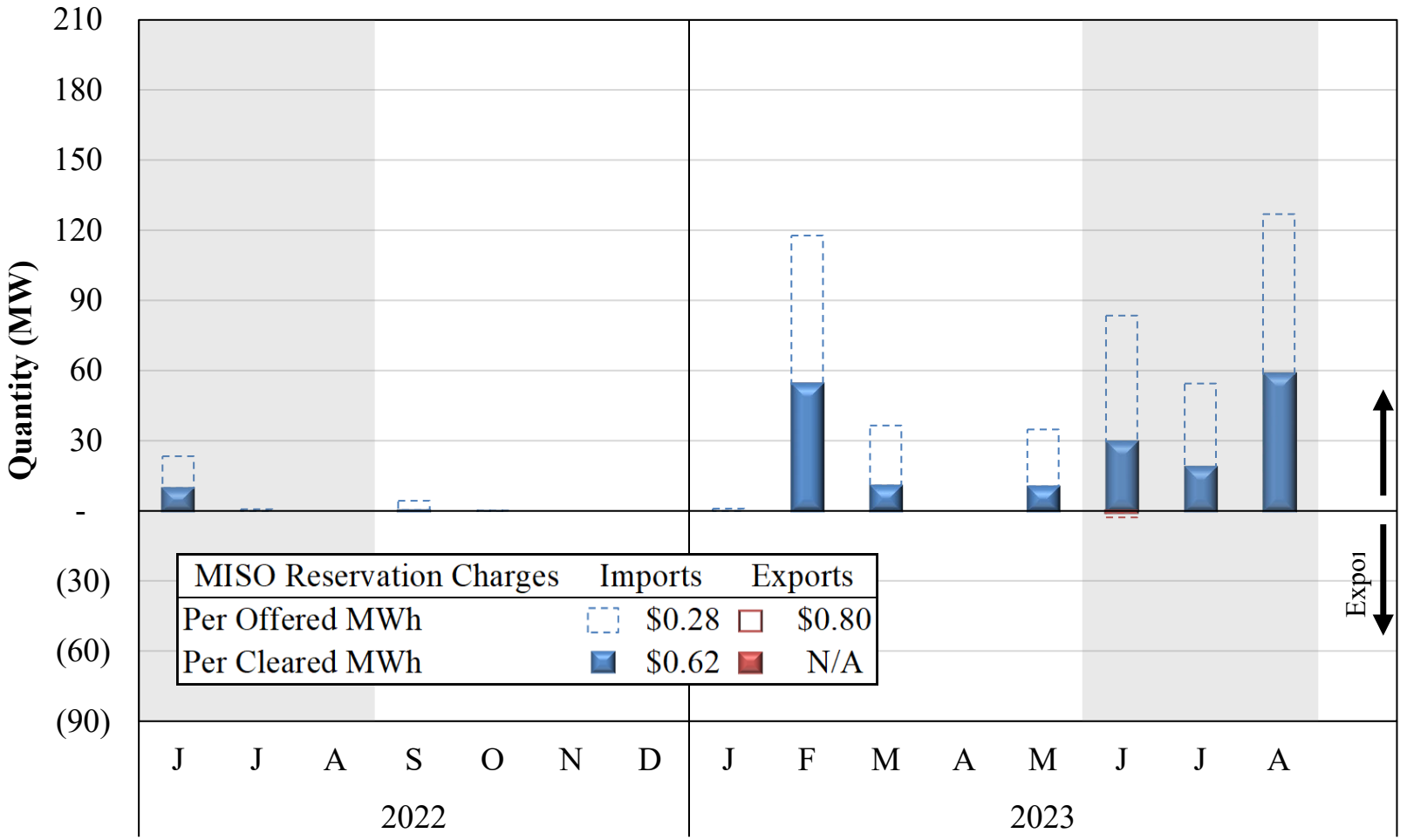
Benefits of Ambient-Adjusted and Emergency Ratings Summer 2022–2023

Summer		Savings ($ Millions)			# of Facilites for 2/3 of Savings	Share of Congestion
		Ambient Adj. Ratings	Emergency Ratings	Total		
2022	**Midwest**	$56.7	$47.54	$104.3	12	13.2%
	South	$0.6	$4.06	$4.6	2	6.9%
	Total	**$57.3**	**$51.6**	**$108.9**	**14**	**12.7%**
2023	**Midwest**	$14.0	$14.06	$28.0	13	9.9%
	South	$0.5	$3.64	$4.2	2	6.6%
	Total	**$14.5**	**$17.7**	**$32.2**	**15**	**9.3%**

Coordinated Transaction Scheduling (CTS)
Summer 2021–2023



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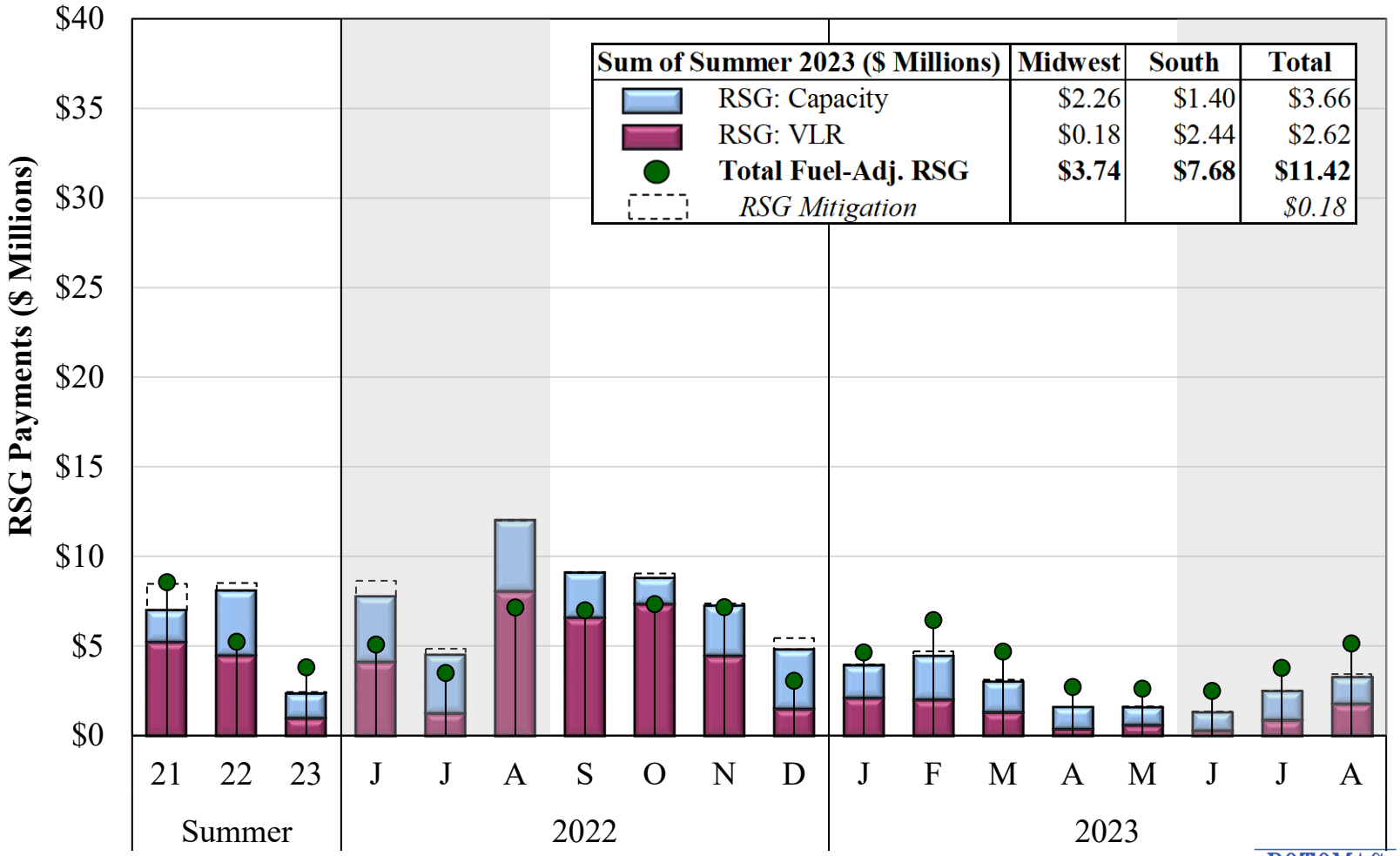
Day-Ahead RSG Payments
Summer 2021–2023



Sum of Summer 2023 ($ Millions)	Midwest	South	Total
RSG: Capacity	$2.26	$1.40	$3.66
RSG: VLR	$0.18	$2.44	$2.62
Total Fuel-Adj. RSG	**$3.74**	**$7.68**	**$11.42**
RSG Mitigation			*$0.18*

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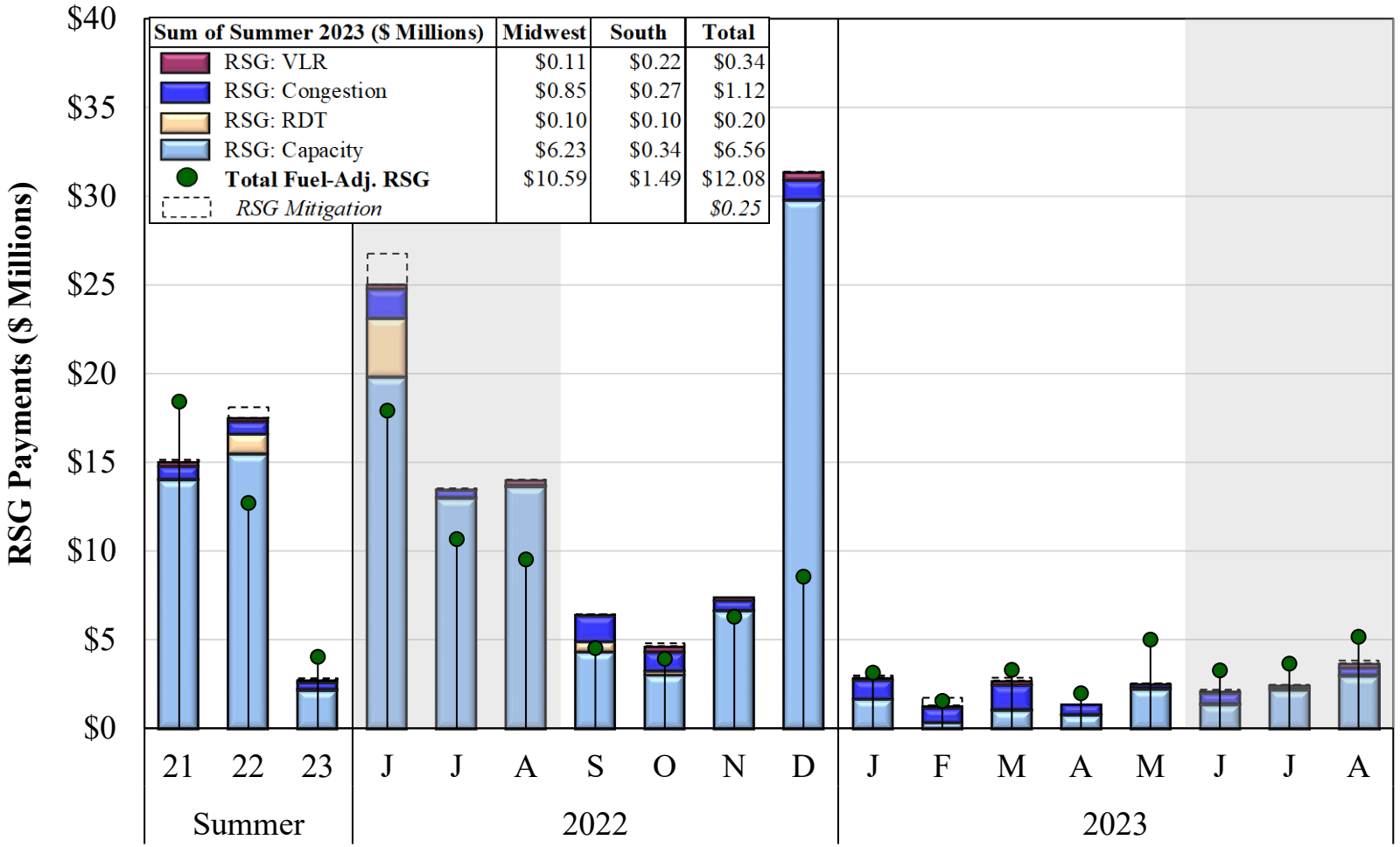
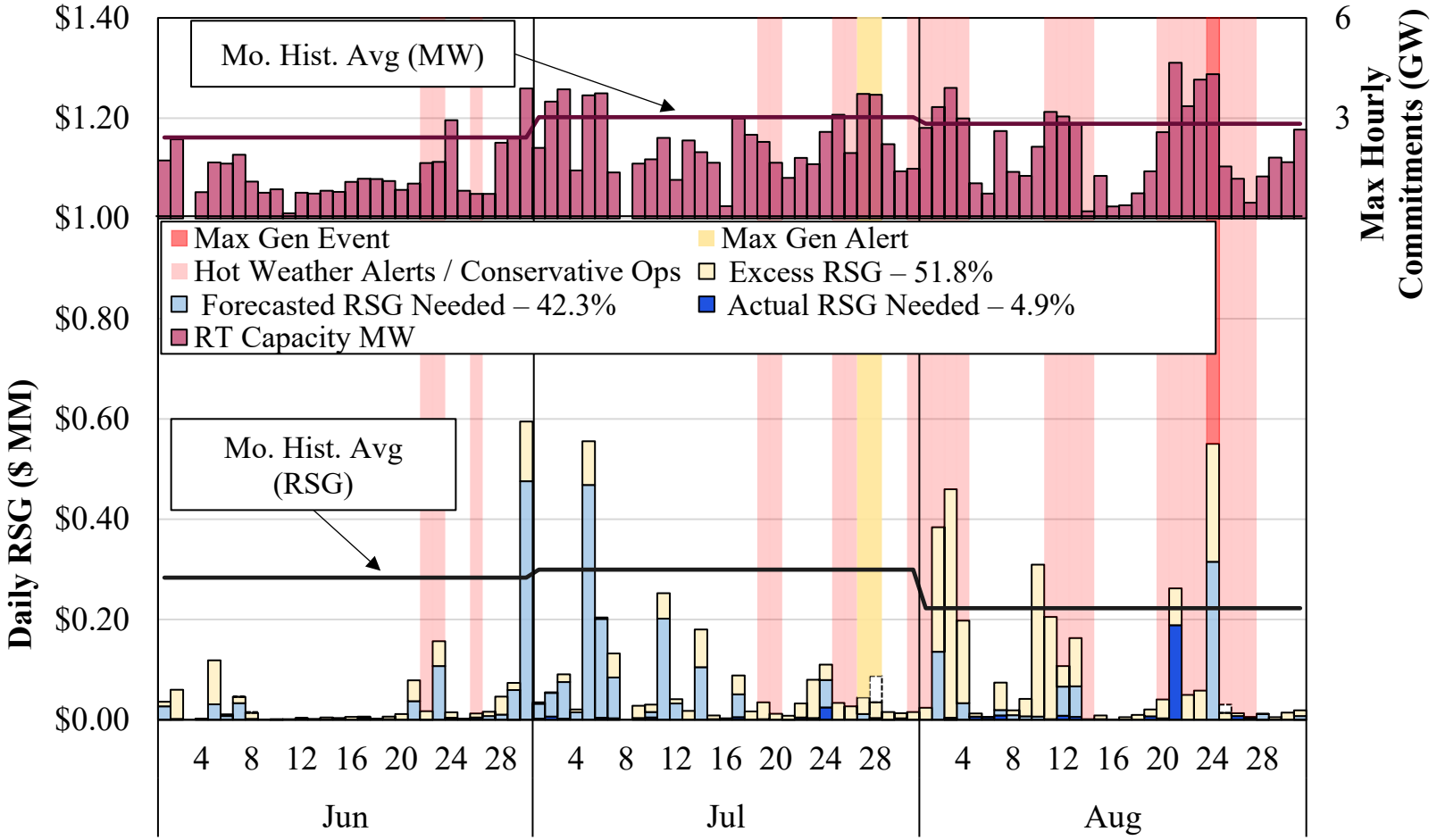
Real-Time RSG Payments
Summer 2021–2023



Sum of Summer 2023 ($ Millions)	Midwest	South	Total
RSG: VLR	$0.11	$0.22	$0.34
RSG: Congestion	$0.85	$0.27	$1.12
RSG: RDT	$0.10	$0.10	$0.20
RSG: Capacity	$6.23	$0.34	$6.56
Total Fuel-Adj. RSG	$10.59	$1.49	$12.08
RSG Mitigation			*$0.25*

POTOMAC ECONOMICS

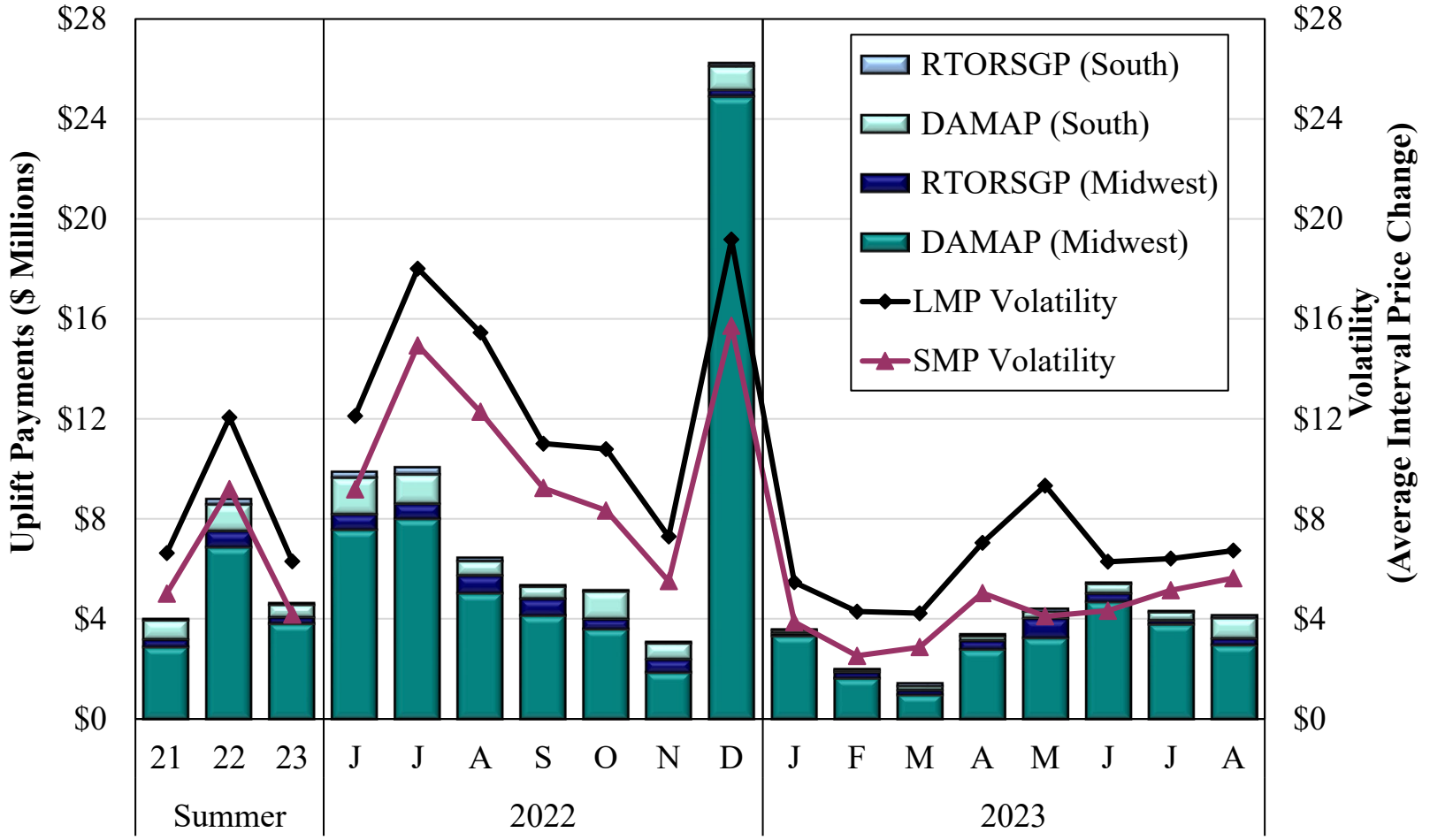
Real-Time Capacity Commitment and RSG



* 1% of the RSG could not be classified due to gaps in market data and is shown in the transparent bars.

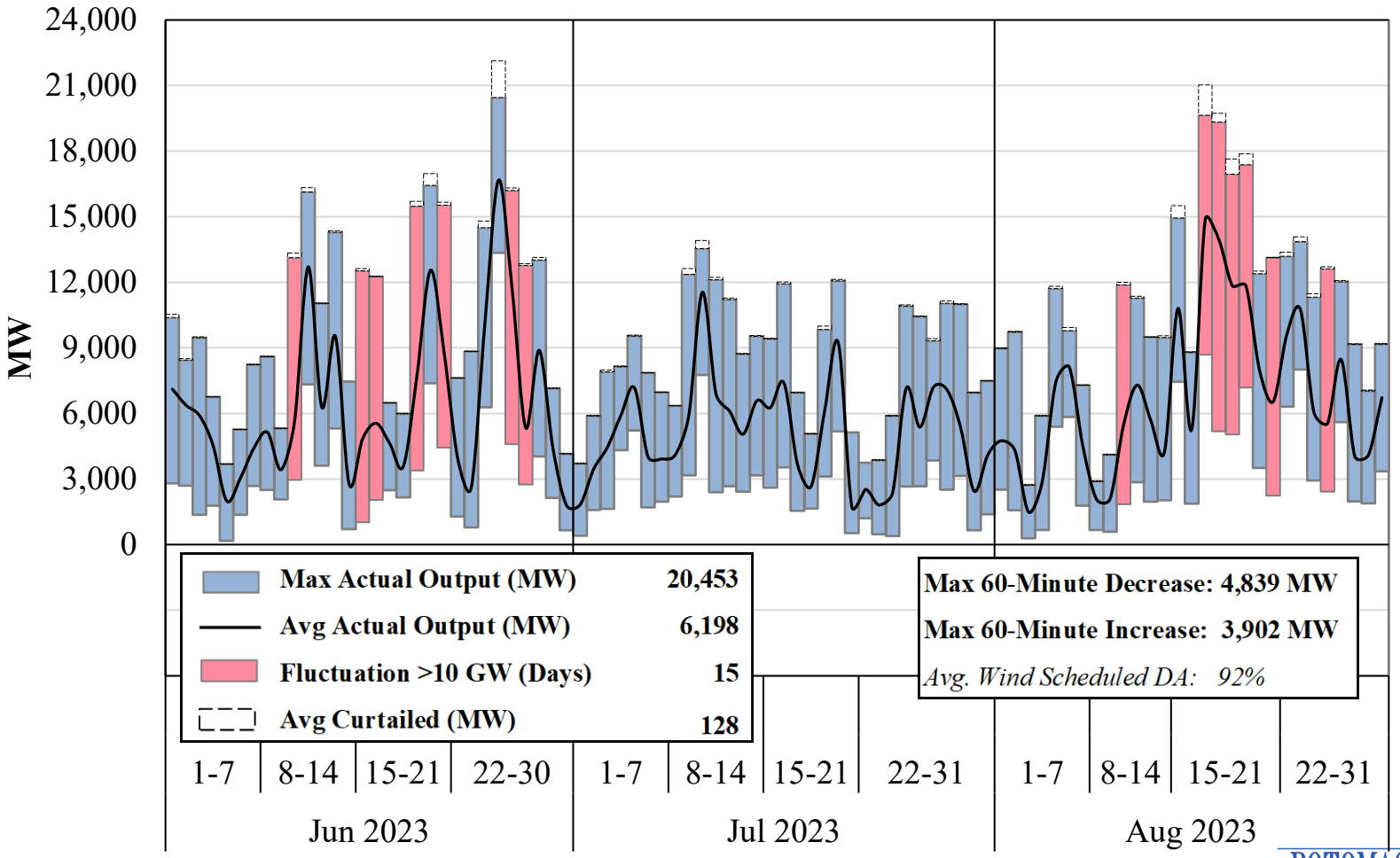
POTOMAC ECONOMICS

Price Volatility Make Whole Payments Summer 2021–2023



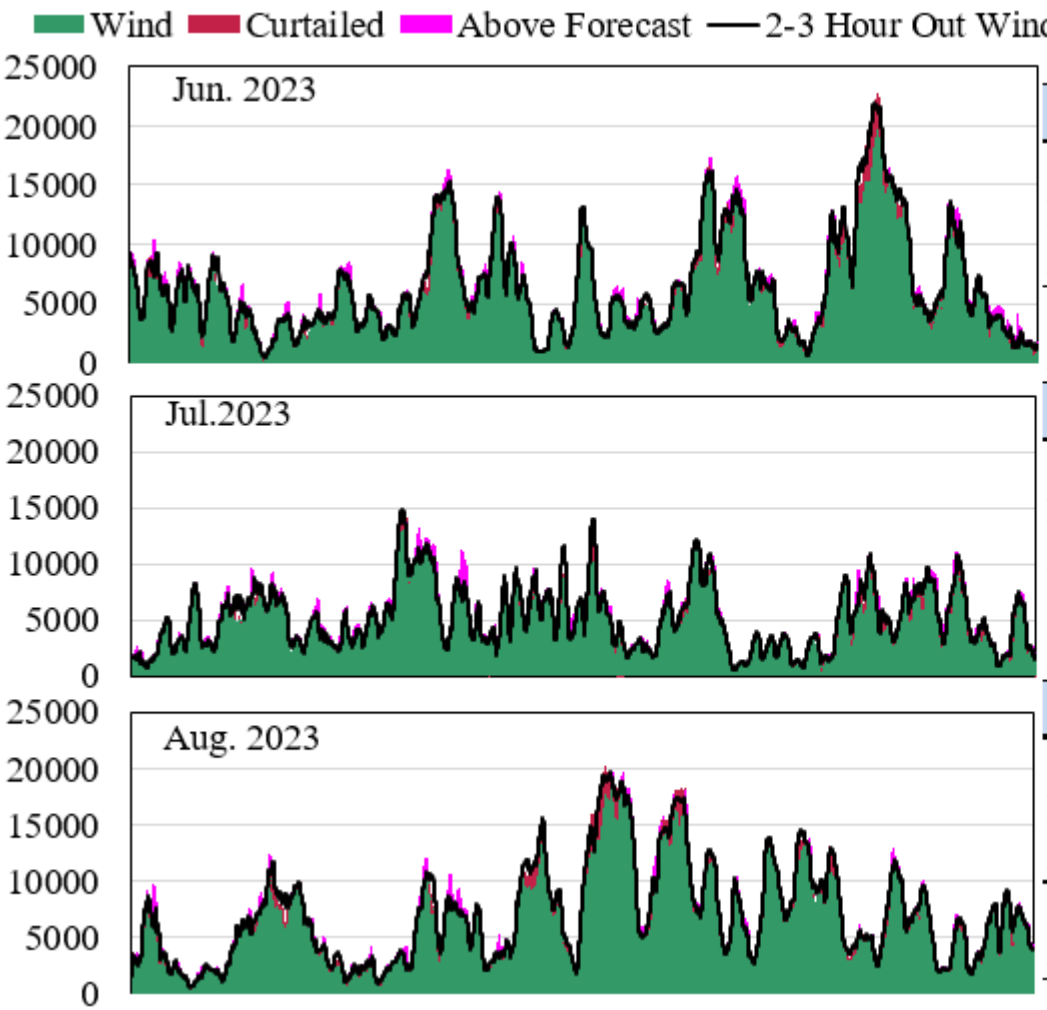
POTOMAC ECONOMICS

Wind Output in Real Time
Daily Range and Average



POTOMAC ECONOMICS

Wind Forecast and Actual Output
Summer 2023

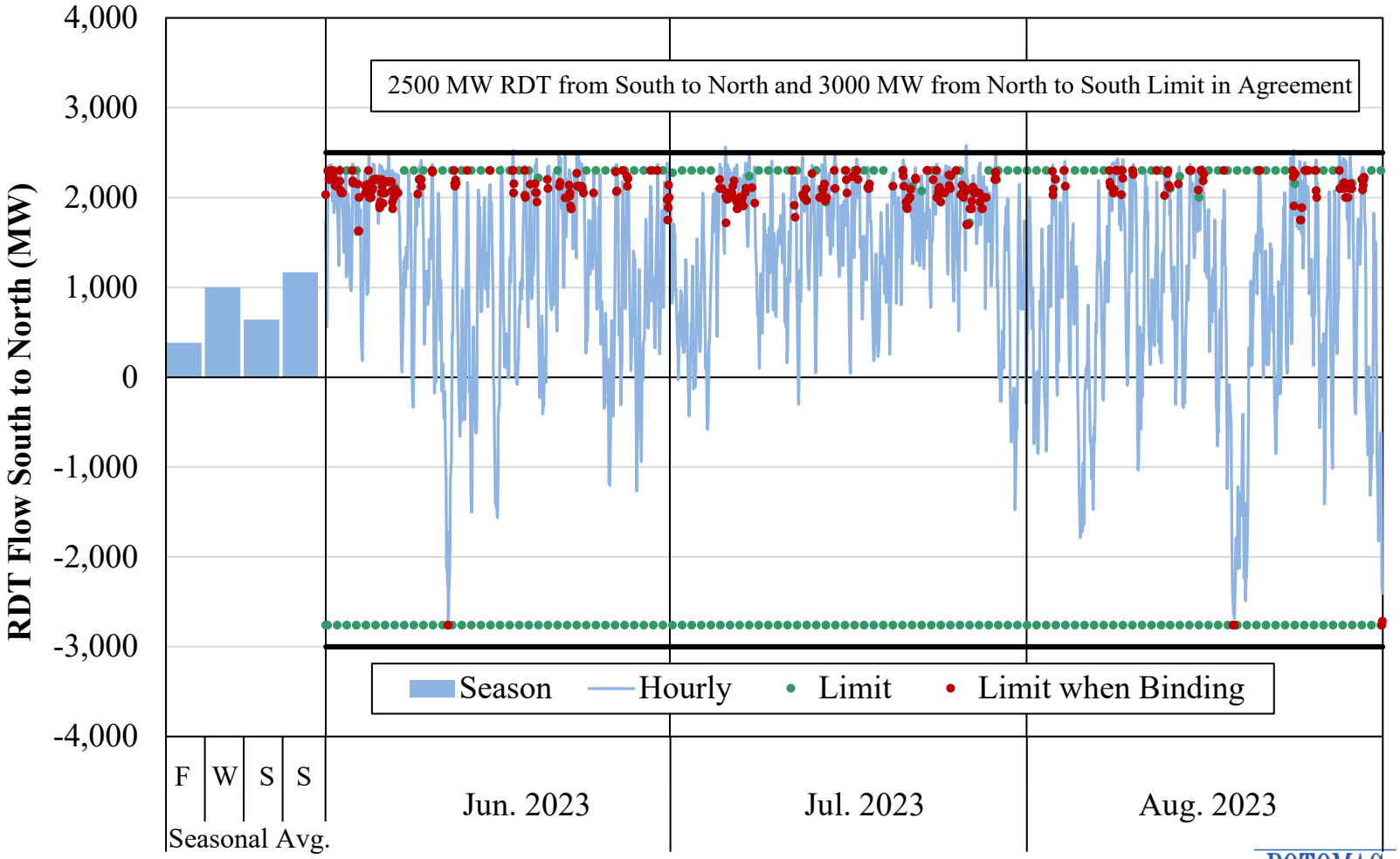


Summer 2023	
Real-Time Wind (MW)	6,198
Day-Ahead Wind (MW)	5,715
Avg Curtailments (MW)	128
Forecast Errors (%)	2.7%
Absolute Errors (%)	12.3%

Summer 2022	
Real-Time Wind (MW)	7,480
Day-Ahead Wind (MW)	6,794
Avg Curtailments (MW)	283
Forecast Errors (%)	3.8%
Absolute Errors (%)	13.0%

Spring 2023	
Real-Time Wind (MW)	12,324
Day-Ahead Wind (MW)	10,744
Avg Curtailments (MW)	910
Forecast Errors (%)	-1.2%
Absolute Errors (%)	7.0%

Real-Time Hourly Inter-Regional Flows
Summer 2023



POTOMAC ECONOMICS

Day-Ahead and Real-Time Price Convergence Summer 2022–2023

Day-Ahead Peak Hour Load Scheduling
Summer 2021–2023

Virtual Load and Supply
Summer 2021–2023

Virtual Load and Supply by Participant Type
Summer 2021–2023

Virtual Profitability
Summer 2021–2023

Day-Ahead and Real-Time Ramp Up Price
Summer 2022–2023

Generation Outages and Deratings
Summer 2021–2023

Monthly Output Gap
Summer 2021–2023

Day-Ahead And Real-Time Energy Mitigation
Summer 2021 - 2023

Day-Ahead and Real-Time RSG Mitigation
Summer 2021 - 2023

List of Acronyms

- AAR Ambient-Adjusted Ratings
- 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 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
- STE Short-Term Emergency
- STR Short-Term Reserves
- TLR Transmission Loading Relief
- TCDC Transmission Constraint Demand Curve
- UD Uninstructed Deviation
- VLR Voltage and Local Reliability
- WUMS Wisconsin Upper Michigan System