IMM Quarterly Report: Winter 2023

MISO Independent Market Monitor

David B. Patton, PhD.
Potomac Economics

March 21, 2023

POTOMAC ECONOMICS

Highlights and Findings: Winter 2023

- The MISO markets performed competitively this winter – market power mitigation was infrequent, and conduct was highly competitive overall.
- Energy prices rose 15 percent over last winter, largely attributable to the effects of Winter Storm Elliott ("the Event").
  - ✓ Excluding that Event, gas and energy prices were 10 and 11 percent lower.
- Average load fell 3 percent while peak load rose 6 percent to 107 GW on December 23 when MISO declared an emergency event.
  - ✓ Higher than average January temperatures throughout the entire footprint resulted in much lower heating degree days and lower average load.
- Real-time congestion rose 6 percent from last winter to almost $800 million.
  - ✓ However, outside of Winter Storm Elliott, real-time congestion fell 42 percent.
  - ✓ Day-ahead congestion fell 32 percent because congestion during the Event was not well-anticipated.
- Uplift costs rose as RSG costs during the Event exceeded $14 million and Day-Ahead Margin Assurance Payments ("DAMAP") exceeded $22 million.
  - ✓ Almost all the DAMAP was paid to manually re-dispatched resources. We are discussing changes with MISO to avoid manual re-dispatch in the future.

© 2023 Potomac Economics

Quarterly Summary

Winter		Value	Change [1] Prior Qtr.	Change [1] Prior Year
RT Energy Prices ($/MWh)		$47.60	*-17%*	*15%*
Fuel Prices ($/MMBtu)				
Natural Gas - Chicago		$4.11	*-27%*	*1%*
Natural Gas - Henry Hub		$3.85	*-39%*	*-8%*
Western Coal		$0.88	*-8%*	*-40%*
Eastern Coal		$4.92	*-34%*	*39%*
Load (GW)[2]				
Average Load		76.1	*6%*	*-3%*
Peak Load		107.1	*-1%*	*6%*
% Scheduled DA (Peak Hour)		98.4%	100.1%	98.7%
Transmission Congestion ($M)				
Real-Time Congestion Value		$795.7	*24%*	*6%*
Day-Ahead Congestion Revenue		$315.7	*-26%*	*-32%*
Balancing Congestion Revenue[3]		-$54.0	-$21.8	-$4.0
Ancillary Service Prices ($/MWh)				
Regulation		$16.14	*3%*	*16%*
Spinning Reserves		$4.76	*21%*	*86%*
Supplemental Reserves		$2.95	*356%*	*338%*

		Value	Change [1] Prior Qtr.	Change [1] Prior Year
FTR Funding (%)		103%	104%	100%
Wind Output (MW/hr)		12,491	*7%*	*-4%*
Wind Curtailed (MW/hr)		465	*-28%*	*-40%*
Guarantee Payments ($M)[4]				
Real-Time RSG		$35.6	*91%*	*86%*
Day-Ahead RSG		$11.7	*-53%*	*-51%*
Day-Ahead Margin Assurance		$31.0	*162%*	*247%*
Real-Time Offer Rev. Sufficiency		$0.8	*-54%*	*-19%*
Price Convergence[5]				
Market-wide DA Premium		-15.7%	2.0%	1.6%
Virtual Trading				
Cleared Quantity (MW/hr)		23,387	-7%	11%
% Price Insensitive		52%	59%	54%
% Screened for Review		2%	3%	3%
Profitability ($/MW)		$1.8	$0.7	$1.0
Dispatch of Peaking Units (MW/hr)		731	1,019	854
Output Gap- Low Thresh. (MW/hr)		136	158	255

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.

© 2023 Potomac Economics

POTOMAC ECONOMICS

Highlights for Winter 2023

Falling Natural Gas Prices and Net Revenues (Slides 13, 15, 28)

- Outside Winter Storm Elliott, gas prices at Chicago Citygate fell 10 percent.
- By the end of the quarter, gas prices were 74 percent lower than the 2022 summer high of $9.85 per mmbtu at Henry Hub, because of:
  - ✓ Falling demand for LNG exports to Europe, where a relatively mild winter lowered heating demand and natural gas inventories reached capacity.
  - ✓ Lower heating demand overall because MISO experienced a relatively mild winter, despite higher heating demand during Winter Storm Elliott.
- As energy prices fell, net revenues for most resource classes fell compared to the Fall, with some exceptions.
  - ✓ Wind output was high on December 23 when prices averaged roughly $2,000 per MWh in the Midwest for 3 hours, contributing to higher net revenues.
    - – Wind resources that were manually re-dispatched (MRD) to 0 MW during this period received nearly $13 million in DAMAP.
  - ✓ Coal net revenues fell despite improved supply chain conditions and reduced need for coal conservation.

© 2023 Potomac Economics

Highlights for Winter 2023

Winter Storm Elliott December 23-24, 2022 (Slides 18-20)

- Temperatures throughout MISO ranged from 20 to 35 degrees below normal on December 23.
- Winter Storm Elliott presented multiple operating challenges for MISO and several of MISO's neighboring areas, including PJM, TVA, SPP and AECI.
  - ✓ MISO and its neighbors experienced large load forecasting errors on Dec. 23, contributing to substantial capacity shortfalls in neighboring areas.
  - ✓ TVA experienced rolling blackouts and MISO provided extensive support.
- Many gas-fired resources were either unable to procure gas, had to manage limited gas supplies, or ran out of fuel, leading to 15 GW of fuel-related outages and derates by the end of December 24.
  - ✓ Frozen wells in the PA Marcellus shale area affected gas supply, and issues with compressors and loss of pipeline pressure compounded the problems.
  - ✓ Because it was a holiday weekend, gas trading was limited, and many resources were unable to procure gas or in some cases maintain continuous supply.
  - ✓ Several resources with low-temperature start cutoffs self-committed in the South in anticipation of the event, offsetting some effects of the forecast error.

© 2023 Potomac Economics

Highlights for Winter 2023

Winter Storm Elliott -- December 23 (Slides 21-23)

- Like in Winter Storm Uri, unusually large exports and wheels were scheduled that contributed to more than $350 million in real-time congestion.
- During the morning of December 23, MISO was requested to derate the RDT to 1500 MW, causing RDT to be violated and prices to spike in the South.
  - ✓ The derate prompted MISO to declare a Max Gen Warning in the South.
  - ✓ A large quantity of non-firm exports that load the RDT were not curtailed that could have mitigated the RDT violation and capacity issues.
- By the afternoon, MISO was exporting large quantities of power to many of its neighbors, particularly to TVA that was shedding load.
  - ✓ TVA requested additional exports – MISO called an EEA2 capacity emergency in order to curtail LMRs to accommodate TVA's event, although MISO indicated that it did not forecast a capacity shortage.
  - ✓ Unfortunately, the EEA2 led to substantial export curtailments, including curtailments of 1.4 GW of exports to TVA.
- Prior to the non-firm transaction curtailments, prices were set at shortage levels for a half hour due to the magnitude of the exports, and prices remained high throughout the Max Gen Warning and EEA1 and EEA2.

© 2023 Potomac Economics

Highlights for Winter 2023

Winter Storm Elliott -- December 24 (Slides 21, 24-27)

- On December 24, MISO's total net exports grew as net imports from PJM on December 23 fell and became substantial net exports from MISO to PJM.
- Although no MISO capacity emergencies or shortages occurred on December 24, MISO took unprecedented actions to maintain exports to its neighbors.
- MISO committed many resources to sustain the exports, even as the congestion caused an increasing number of resources to be "stranded" behind constraints.
  - ✓ These commitments generated more than $11 million in RSG.
- MISO responded to a number of substantial transmission violations by relying on manual redispatch ("MRD") that direct a unit's output to a fixed amount.
  - ✓ MRDs are necessary when the value of managing the flows on a transmission constraint is not high enough for the real-time dispatch to move the resources.
- MRD is problematic because it prevents the market from properly pricing the congestion, is often not efficient, and can generate large uplift costs.
  - ✓ Based on a simulated dispatch analysis, we found that less than half of the MRDs were efficient and in some cases caused congestion.
  - ✓ MRDs on Dec. 23-24 generated roughly $19 million in DAMAP payments.

© 2023 Potomac Economics

Highlights for Winter 2023

IMM Recommendations from Winter Storm Elliott

As with other significant events, Winter Storm Elliott provides opportunities for improvements in MISO's processes. Some key takeaways include:

1. We recommend MISO: (a) add higher-priced steps to the Transmission Constraint Demand Curves (TCDC) and (b) improve its procedures to increase TCDCs as needed to ensure that the dispatch model will reasonably manage network flows and violations under all conditions.
2. We recommend MISO strengthen its operating controls and logging regarding to minimize deviations from its operating procedures.
3. To the extent that operating actions will be taken in the future primarily to support neighboring areas, we recommend that MISO:
   a. Modify its operating procedures to specify these actions and the requisite criteria for taking each action; and
   b. Establish joint operating agreements so the neighboring areas incur the costs of these actions, which can be substantial as evidenced in this event.

© 2023 Potomac Economics

Highlights for Winter 2023

Transmission Congestion (Slides 29-33)

- MISO incurred almost $800 million in real-time congestion this quarter, roughly 45 percent of which was due to congestion during Winter Storm Elliot.
  - ✓ Congestion would have fallen by more than 30 percent from last winter if the event had not occurred because of significantly lower natural gas prices.
- The high levels of congestion continue to indicate extremely large benefits from improving the utilization of the network through:
  - ✓ Implementing Ambient-Adjusted Ratings and Emergency Ratings ($168 million in real-time value for the quarter); and
  - ✓ Utilizing economic re-configurations of the network.
- We have also noted in recent months an increase in transmission limit derates by MISO (using its "Limit Control" dispatch parameter).
  - ✓ This is generally done to account for uncertainty in constraint flows.
  - ✓ The value of the derates were $86 million during the quarter, up from $42 million last year.
  - ✓ We will be further evaluating the use of this parameter and have begun discussing more efficient approaches to addressing network flow uncertainty.

© 2023 Potomac Economics

Highlights for Winter 2023

Uplift Costs and MISO Unit Commitments (Slides 34-35)

- Nominal real-time RSG rose 86 percent over the prior year, although excluding December 23-26, RSG fell almost 40 percent.
  - ✓ MISO incurred around 70 percent of all quarterly RSG during the long Christmas weekend around Winter Storm Elliott.
  - ✓ Since multiple gas-fired units were unable to procure or maintain fuel supply, MISO started very expensive units, including 1 offering above the soft cap.
    - More than $10 million in RSG was paid to just 2 units between Dec. 23-26.
- Improvements in MISO's processes and generally mild weather conditions later in the quarter led to much lower monthly RSG in January and February.
  - ✓ In mid-January, MISO removed the "headroom requirement", which reduces its propensity to start offline 30-minute resources unnecessarily.
  - ✓ We continue to discuss MISO's use of "load and wind offsets" in LAC that causes it to recommend inefficient commitments of peaking resources.
- Day-ahead RSG fell 51 percent year-over-year, largely due to lower VLR.
  - ✓ RSG for Amite South and the DSG load pocket fell approximately 70 percent, while VLR RSG for the Southeast Texas interface fell around 80 percent.

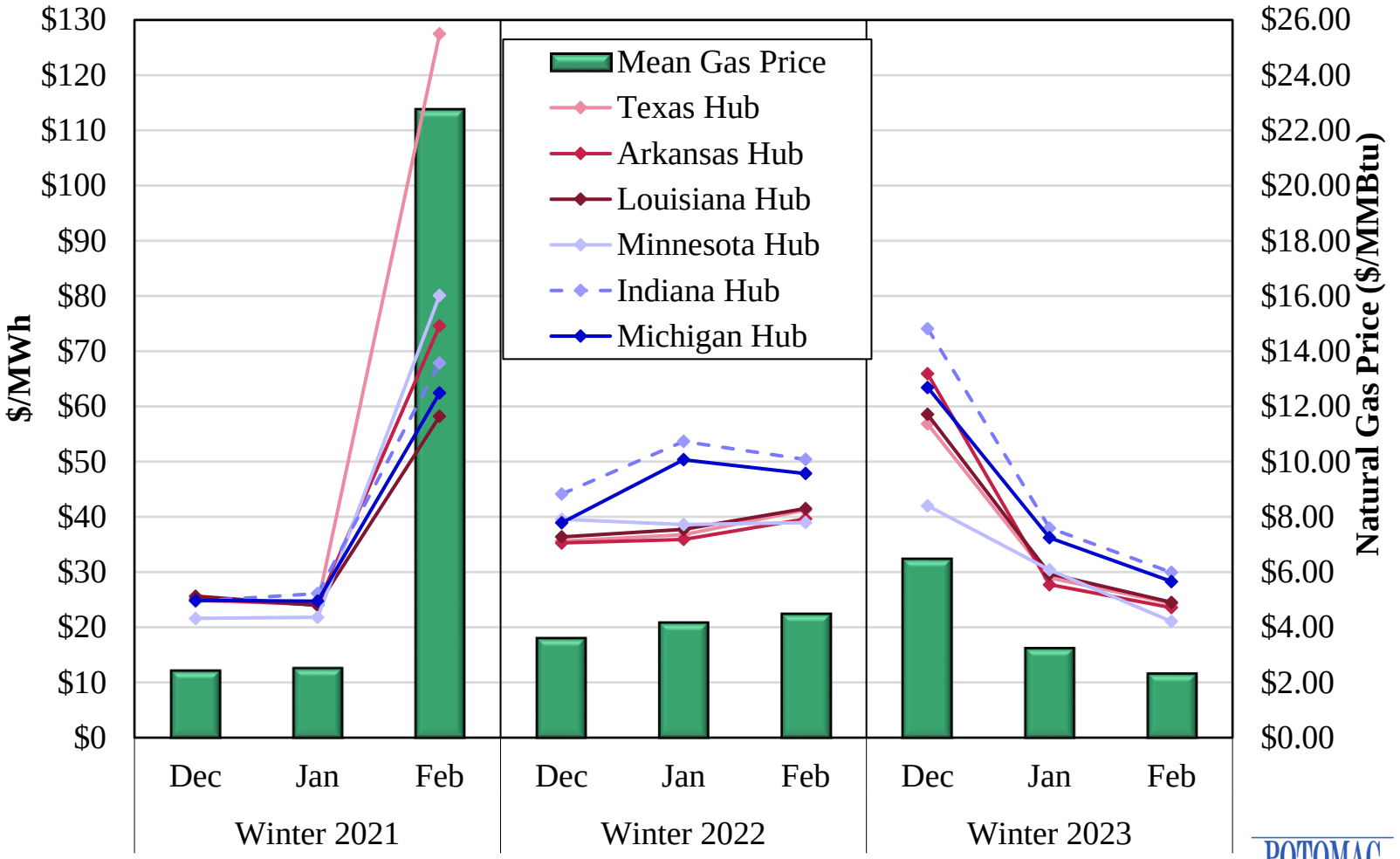
© 2023 Potomac Economics

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 made a referral of a TO for a potential tariff violation for failure to report planned transmission outages.
- We presented fall and early winter market results to the MSC and the ERSC.
- We are continuing to investigate unreported planned transmission outages that substantially affect FTR auctions and ARR allocations.
- We continue to meet with states and stakeholders on the need to reform MISO's PRA demand curve to satisfy the Reliability Imperative.
- In January and February, we presented material at the RASC describing 2023 PRA changes and revised IMM procedures and MP data requirements.
  - ✓ We have raised concerns about MISO's calculation of the availability-based accreditation, which will inflate supply by 2 to 7 GW in the four seasons.
  - ✓ MISO plans to improve this process in future PRAs.

© 2023 Potomac Economics

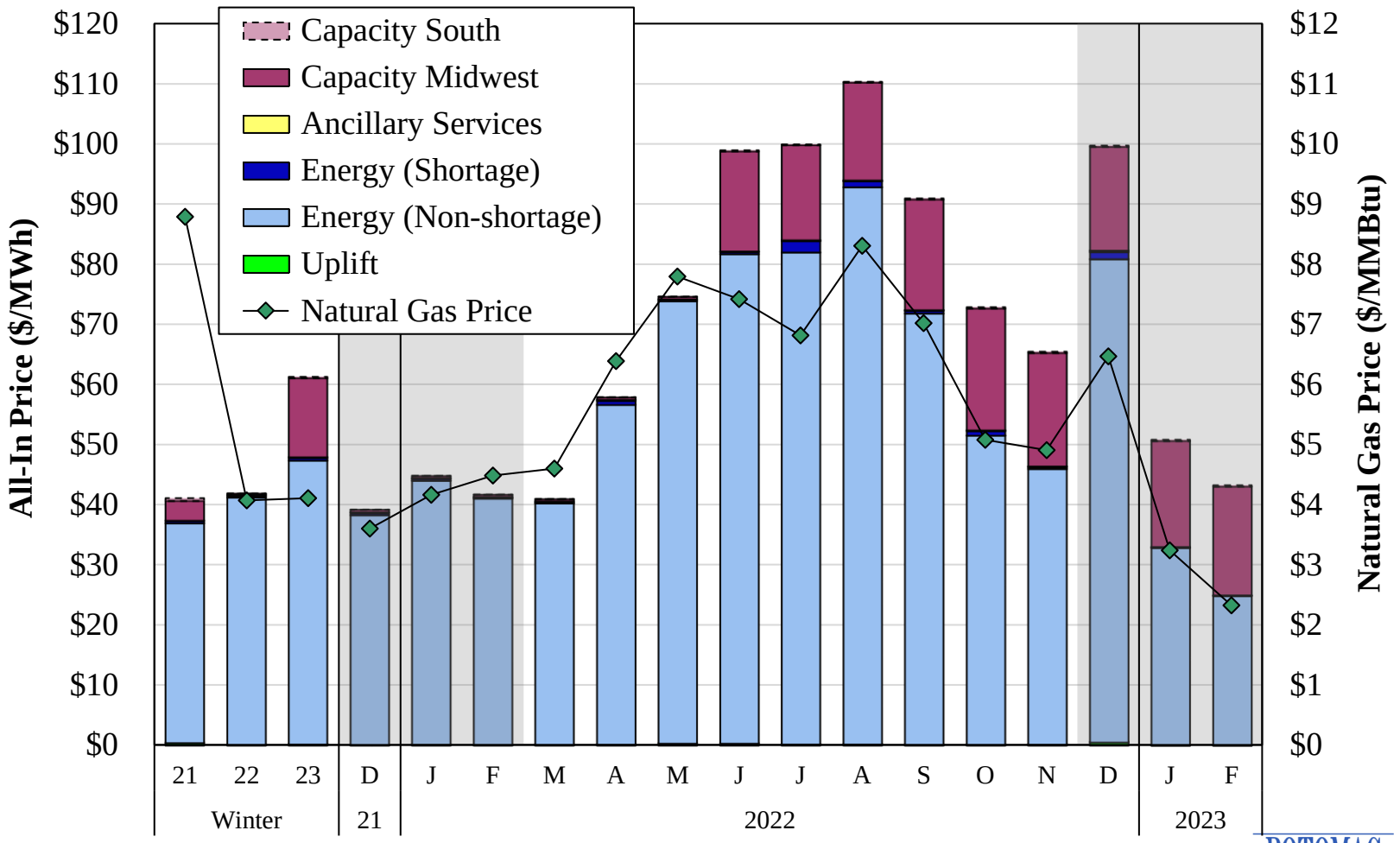
Day-Ahead Average Monthly Hub Prices
Winter 2021–2023



© 2023 Potomac Economics

POTOMAC ECONOMICS

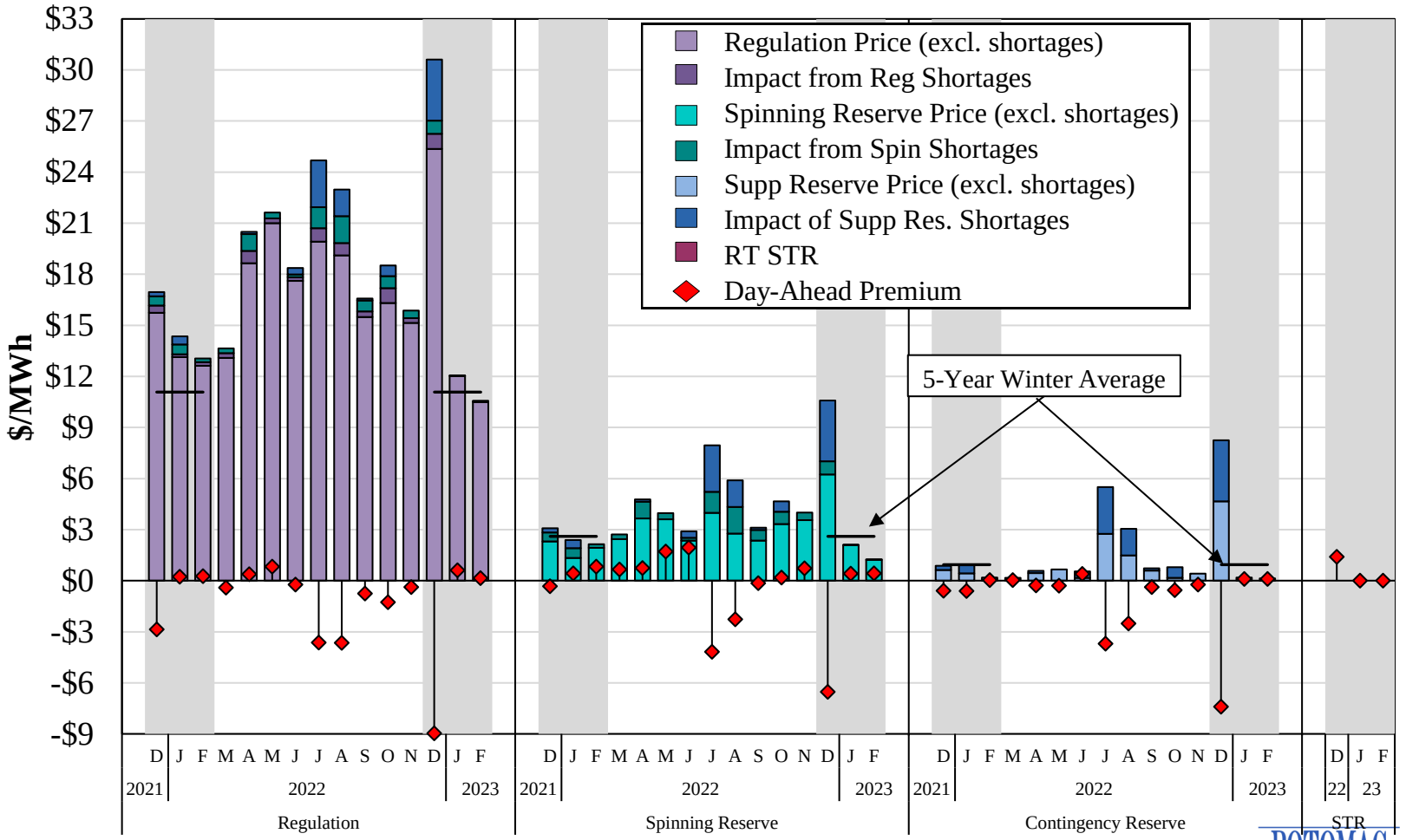
All-In Price
Winter 2021 – 2023



© 2023 Potomac Economics

POTOMAC ECONOMICS

Ancillary Services Prices
Winter 2022–2023



© 2023 Potomac Economics

POTOMAC ECONOMICS

MISO Fuel Prices
2022–2023

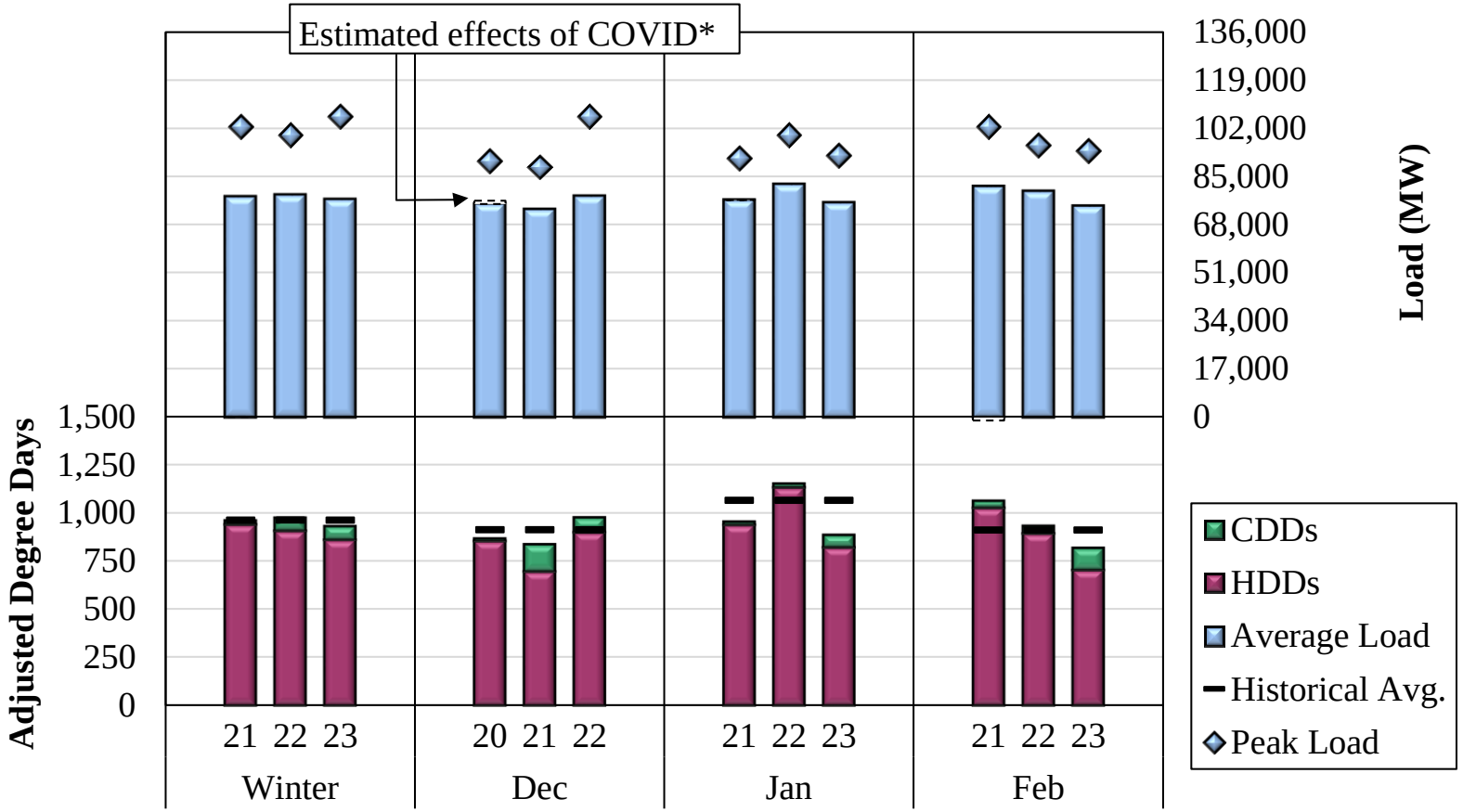
Winter Average	2021	2022	2023
Chicago NG	$8.79	$4.07	$4.11
Henry NG	$3.38	$4.20	$3.85

Winter Average	2021	2022	2023
IB Coal	$1.23	$3.53	$4.92
PRB Coal	$0.68	$1.45	$0.88

© 2023 Potomac Economics

POTOMAC ECONOMICS

Load and Weather Patterns
Winter 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.
*Effects estimated by MISO through back-casting using its load forecasting model.

© 2023 Potomac Economics

POTOMAC ECONOMICS

Capacity, Energy and Price Setting Share Winter 2022–2023

Winter	Unforced Capacity				Energy Output		Price Setting			
	Total (MW)		Share (%)		Share (%)		SMP (%)		LMP (%)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Nuclear	11,866	11,701	9%	9%	16%	16%	0%	0%	0%	0%
Coal	46,341	43,123	36%	34%	34%	31%	32%	30%	77%	71%
Natural Gas	58,334	59,901	45%	47%	29%	33%	68%	69%	93%	94%
Oil	1,636	1,474	1%	1%	0%	0%	0%	0%	0%	0%
Hydro	3,696	3,695	3%	3%	1%	1%	0%	1%	0%	2%
Wind	4,304	4,454	3%	3%	17%	17%	0%	0%	79%	65%
Solar	419	1,037	0%	1%	0%	0%	0%	0%	0%	1%
Other	2,603	2,734	2%	2%	3%	1%	0%	0%	10%	2%
Total	**129,199**	**128,120**								

© 2023 Potomac Economics

POTOMAC ECONOMICS

Daily Average and Low Temperatures
December 22 – 27, 2022

	Historical Daily Low Temperature Average	Dec. 2022					
		22	23	24	25	26	27
Minneapolis	**13**	-11	-12	-5	-4	2	3
Detroit	**24**	31	3	4	14	15	21
Indianapolis	**24**	-1	**-9**	0	4	15	21
Chicago	**23**	**-6**	**-9**	-1	2	12	8
Little Rock	**32**	7	**2**	14	22	29	0
New Orleans	**47**	47	27	25	32	30	41
Houston	**47**	22	**17**	23	28	31	38

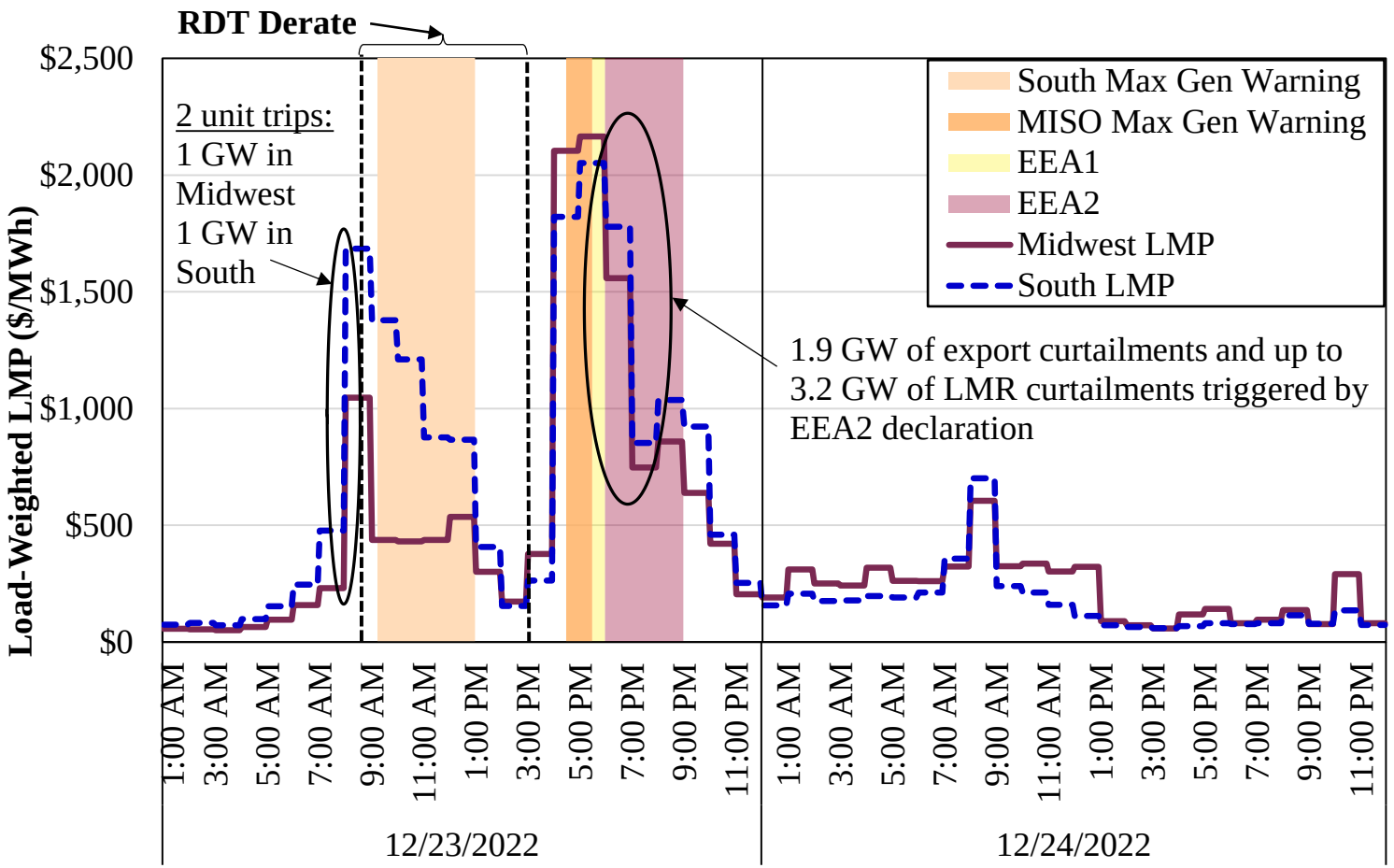
Notes: Temperature is daily low temperature.

Data source: Weather Underground.

© 2023 Potomac Economics

POTOMAC ECONOMICS

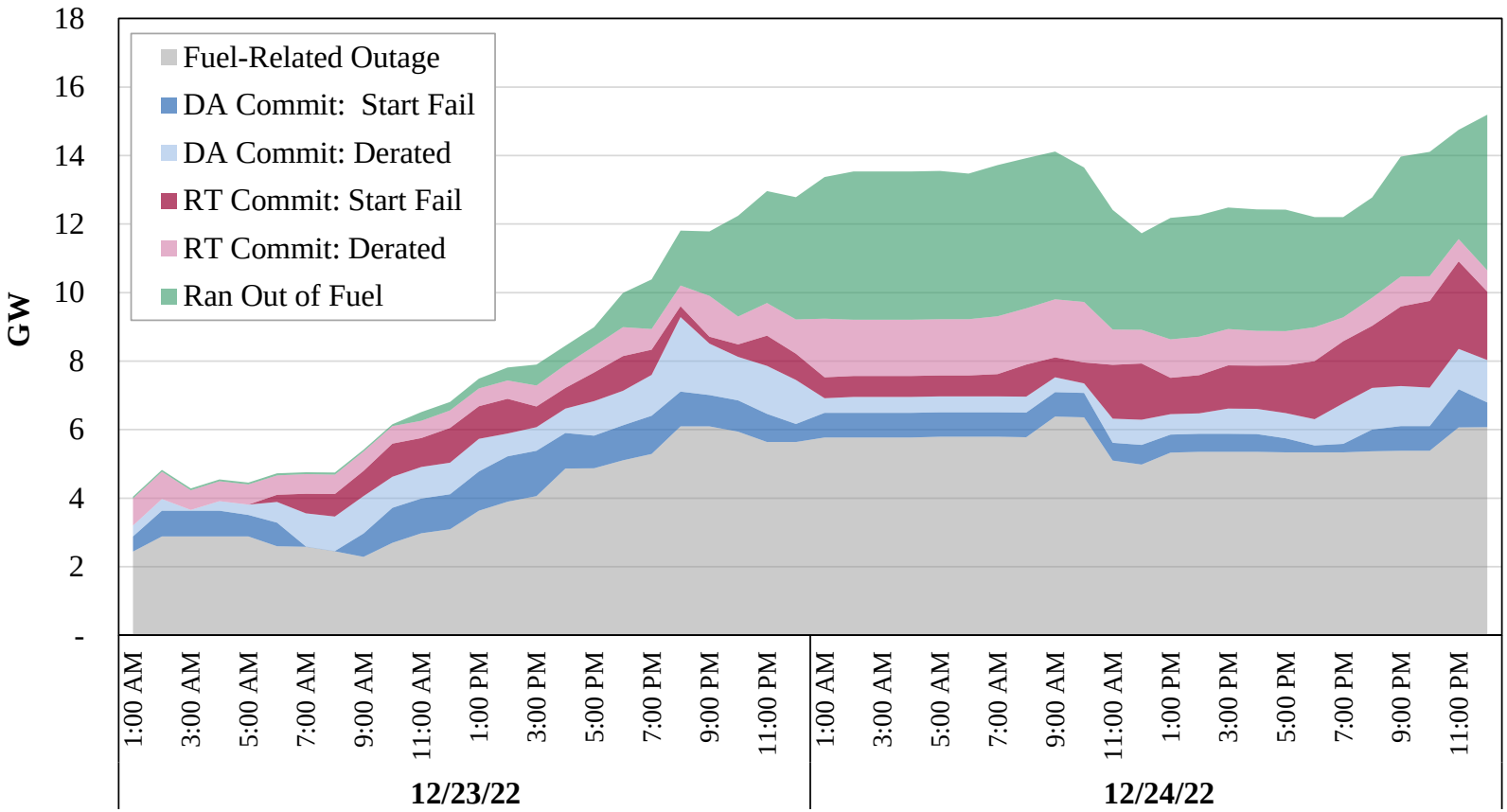
Market Prices and Emergency Declarations
December 23 – 24, 2022



© 2023 Potomac Economics

POTOMAC ECONOMICS

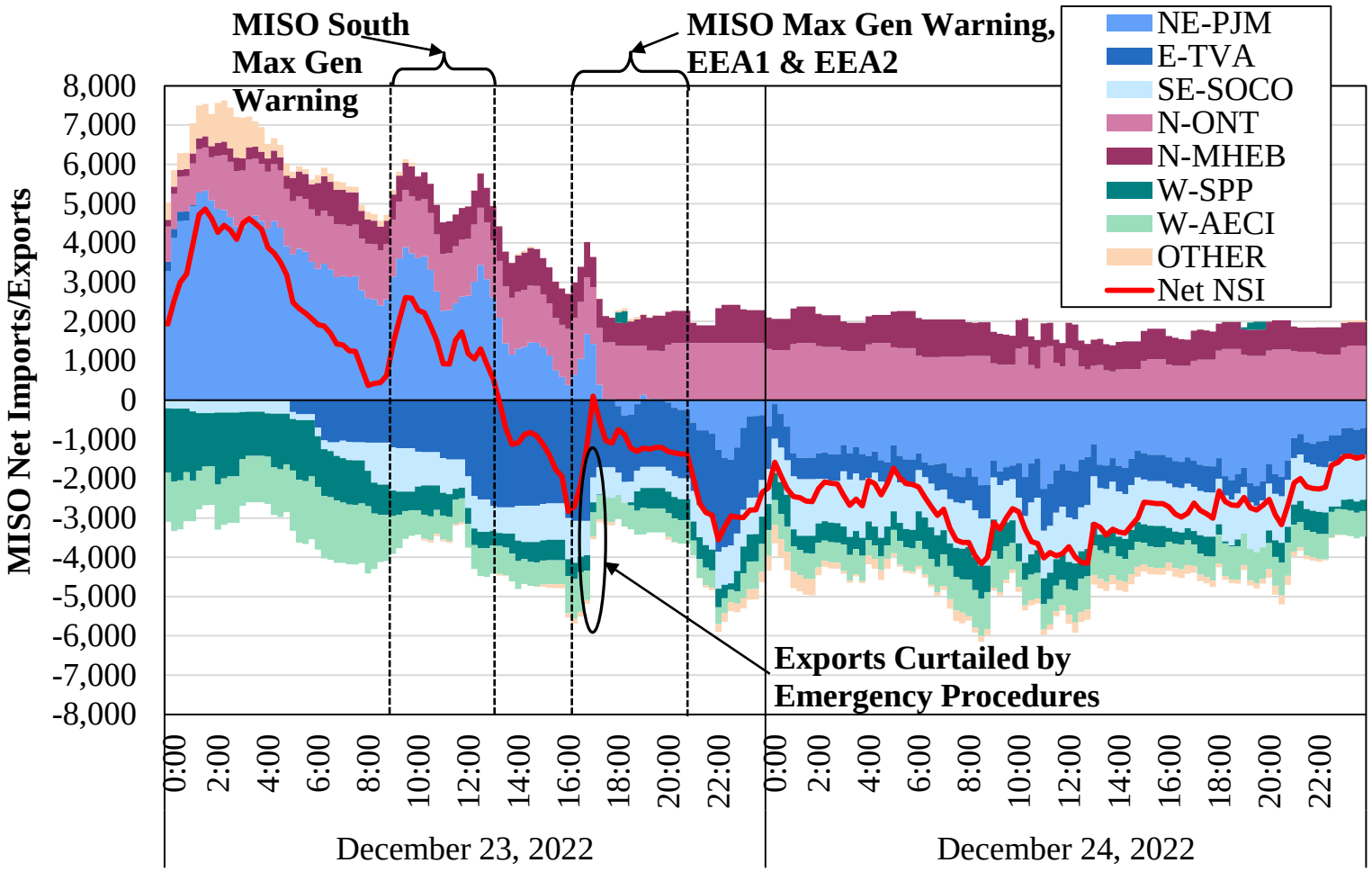
Gas-Fired Generation Outages
December 23 - 24, 2022



© 2023 Potomac Economics

POTOMAC ECONOMICS

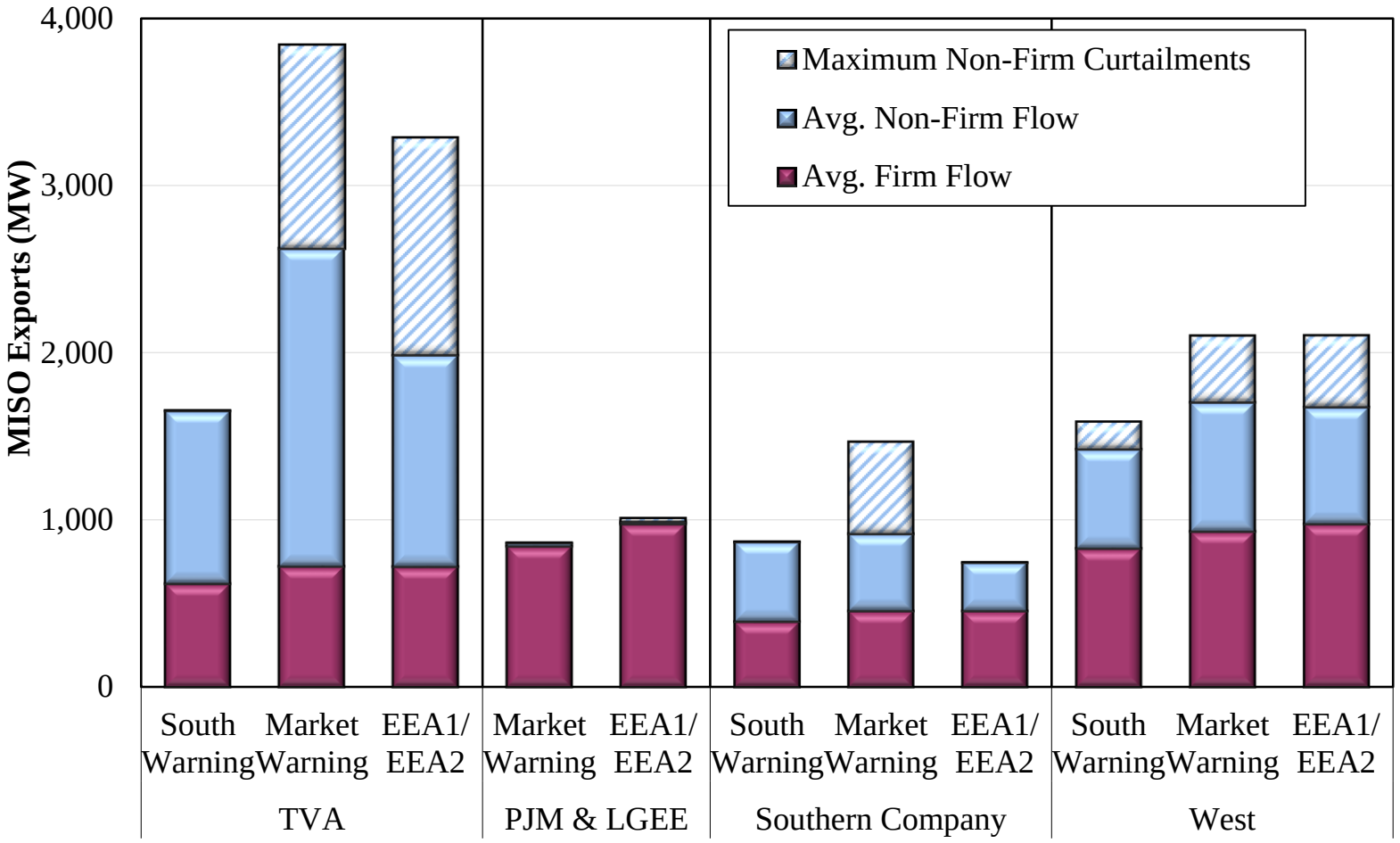
Net Scheduled Interchange
December 23 – 24, 2022



© 2023 Potomac Economics

POTOMAC ECONOMICS

External Transactions on December 23, 2022

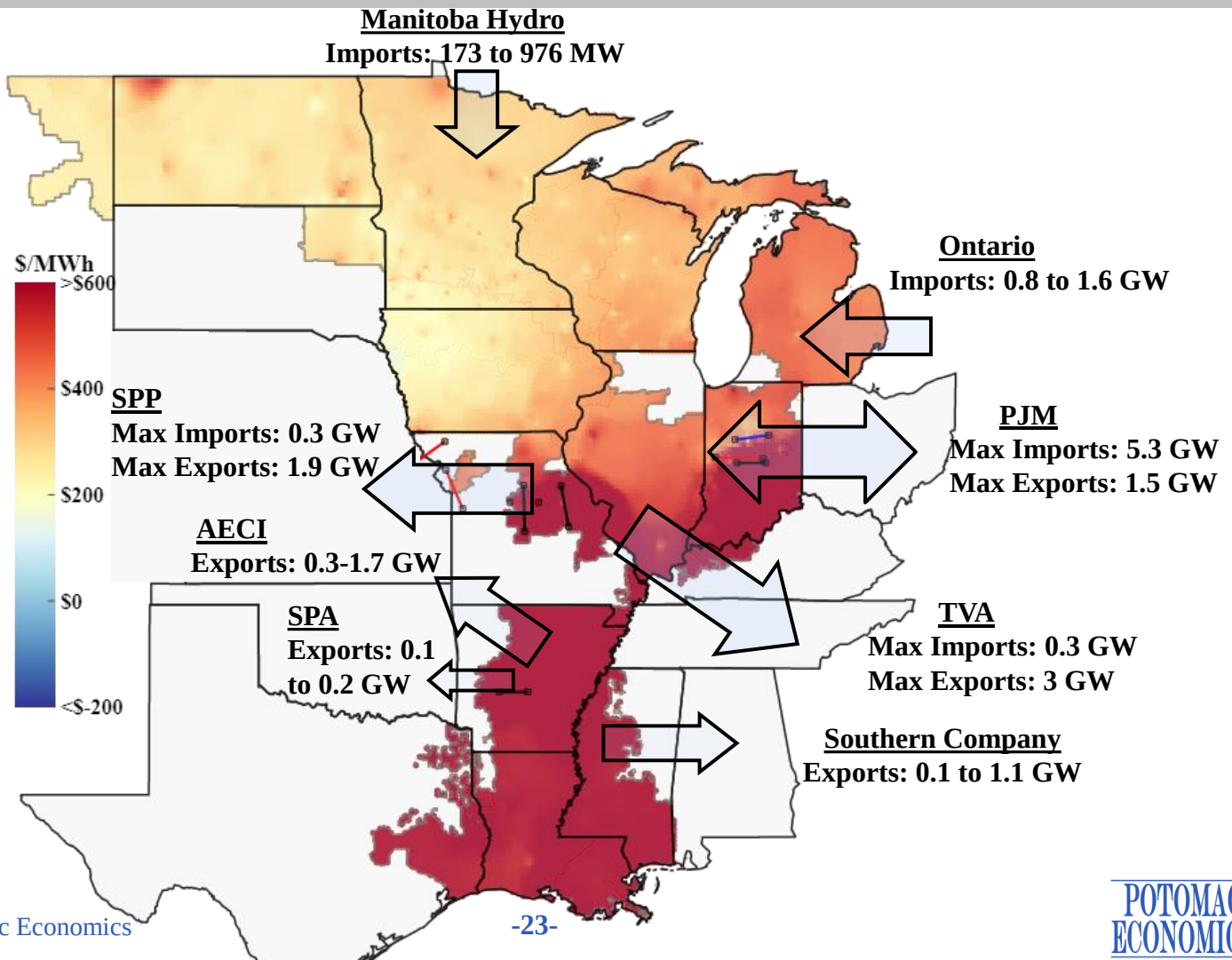


*West includes AECI, SPP, and SPA.

© 2023 Potomac Economics

POTOMAC ECONOMICS

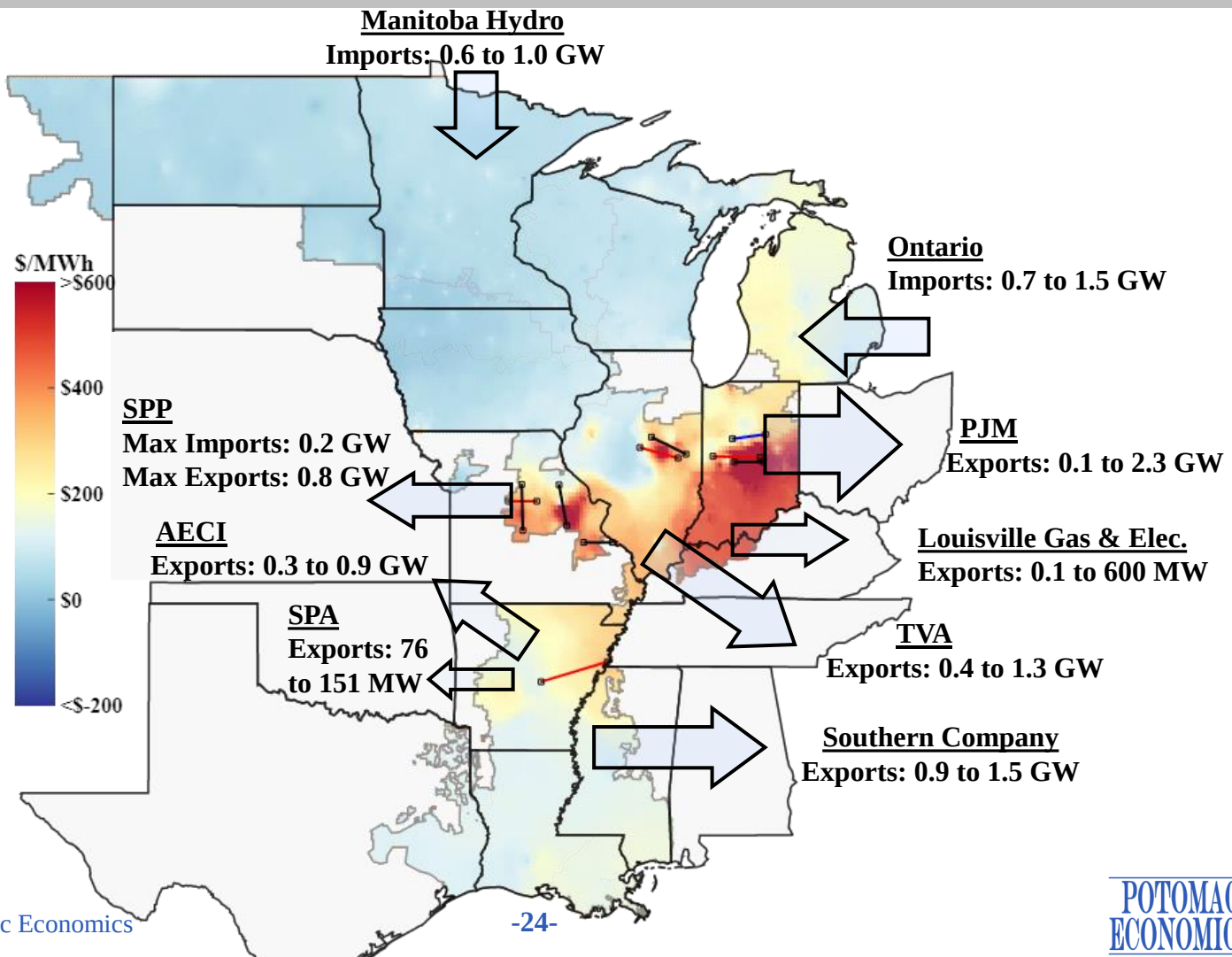
Average Real-Time LMPs and NSI
Dec 23, 2022



© 2023 Potomac Economics

POTOMAC ECONOMICS

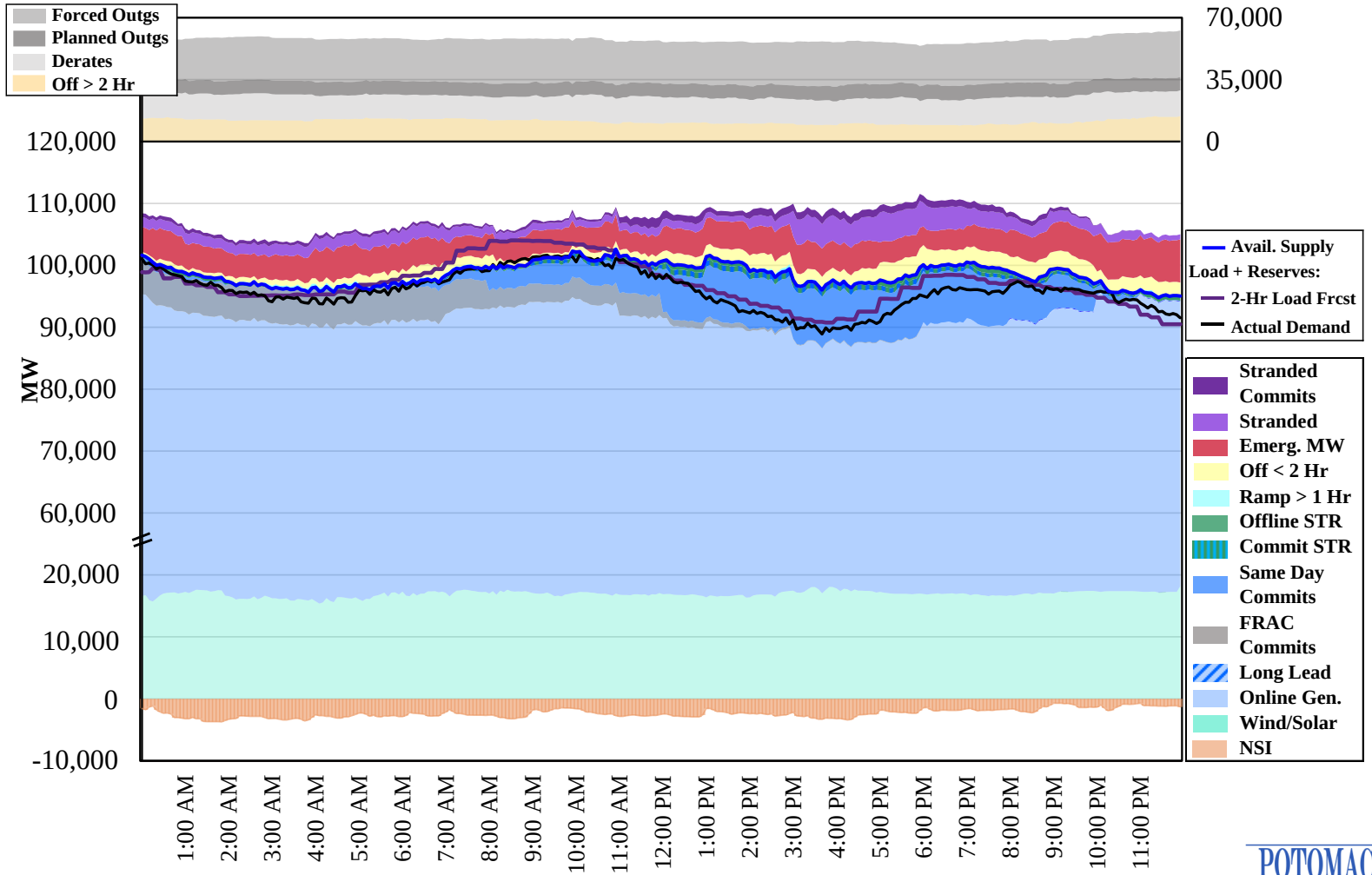
Average Real-Time LMPs and NSI
Dec 24, 2022



© 2023 Potomac Economics

POTOMAC ECONOMICS

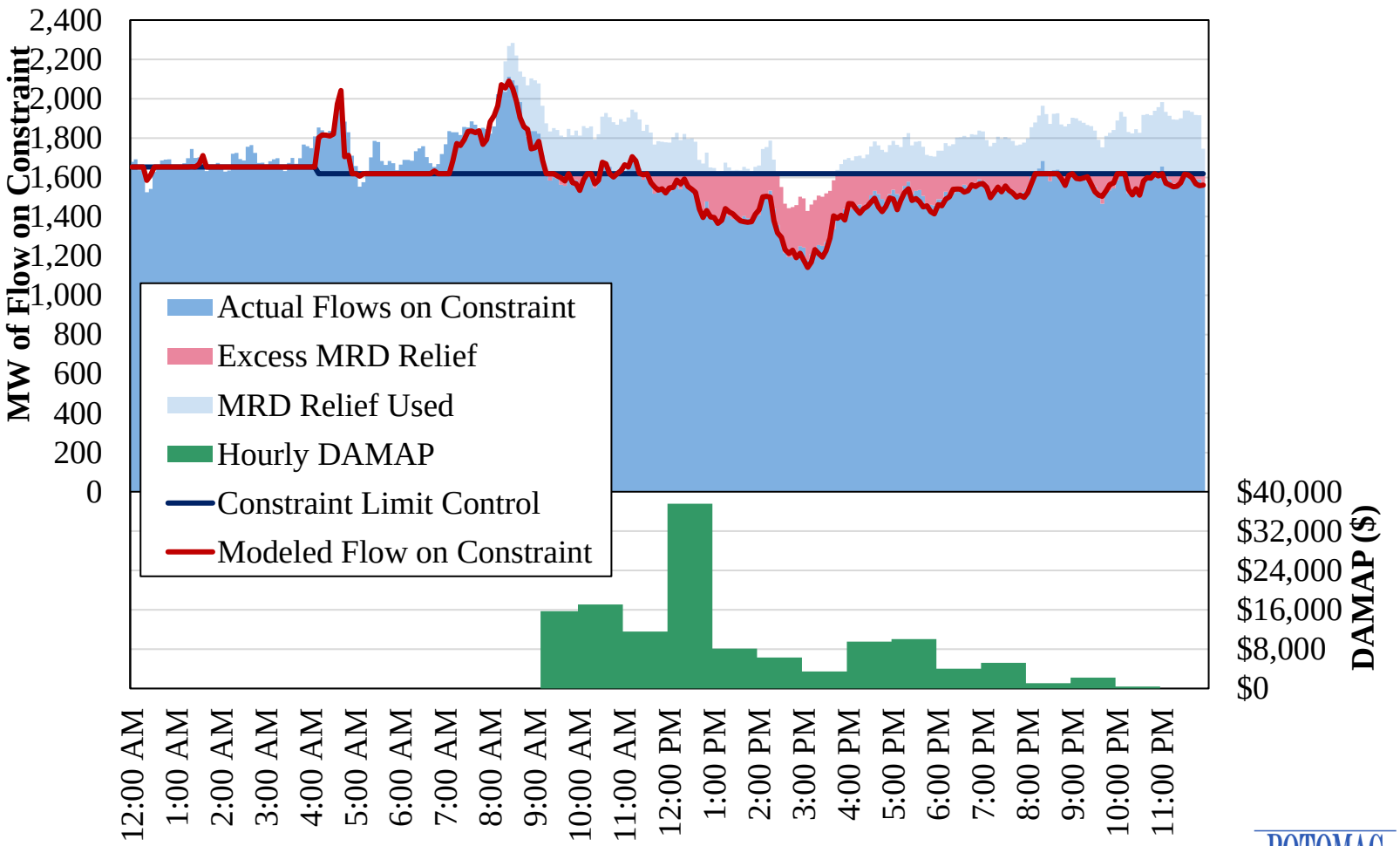
MISO Capacity Balance
December 24, 2022



© 2023 Potomac Economics

POTOMAC ECONOMICS

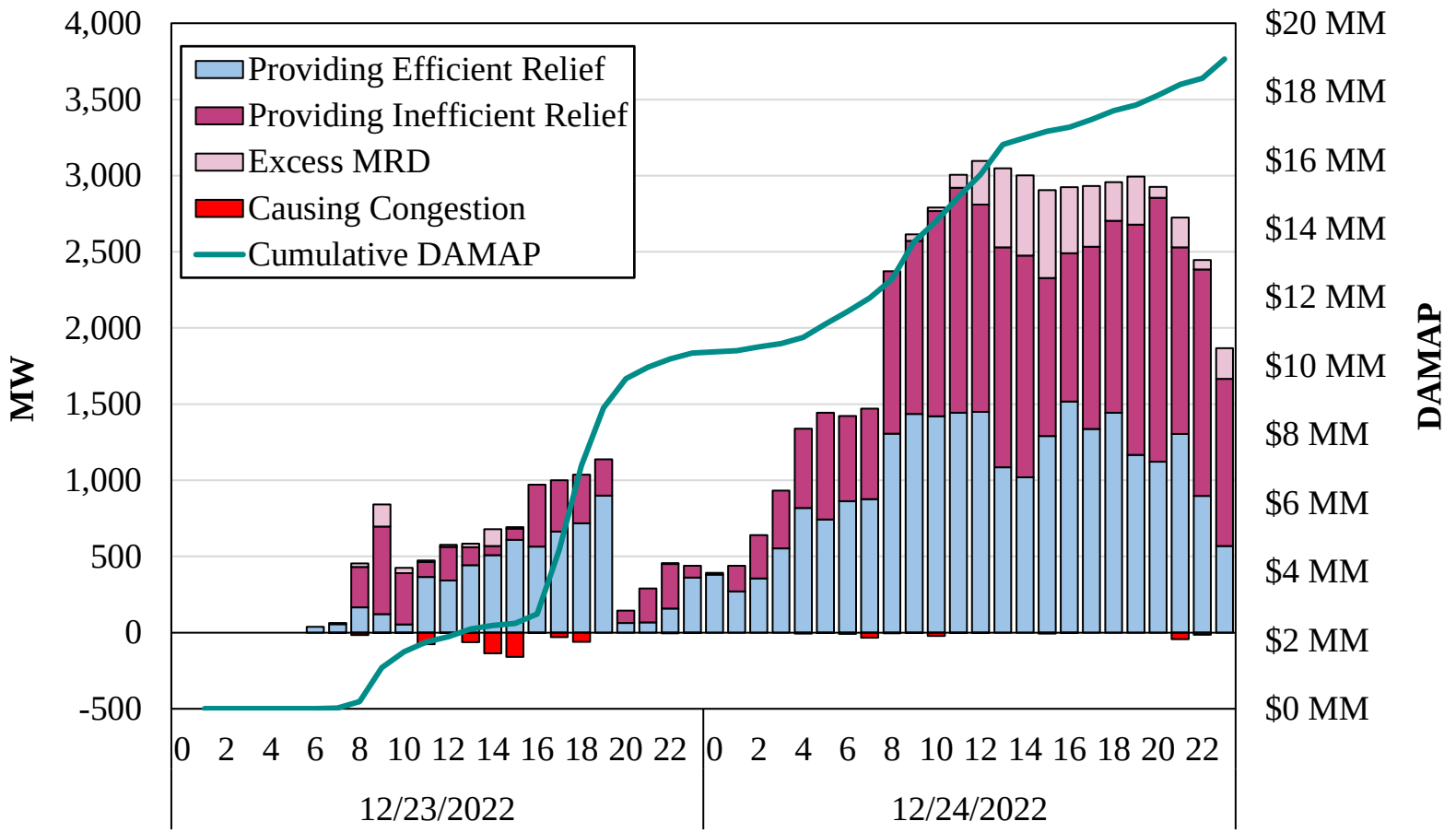
MRD Relief on Key Constraint
December 24, 2022



© 2023 Potomac Economics

POTOMAC ECONOMICS

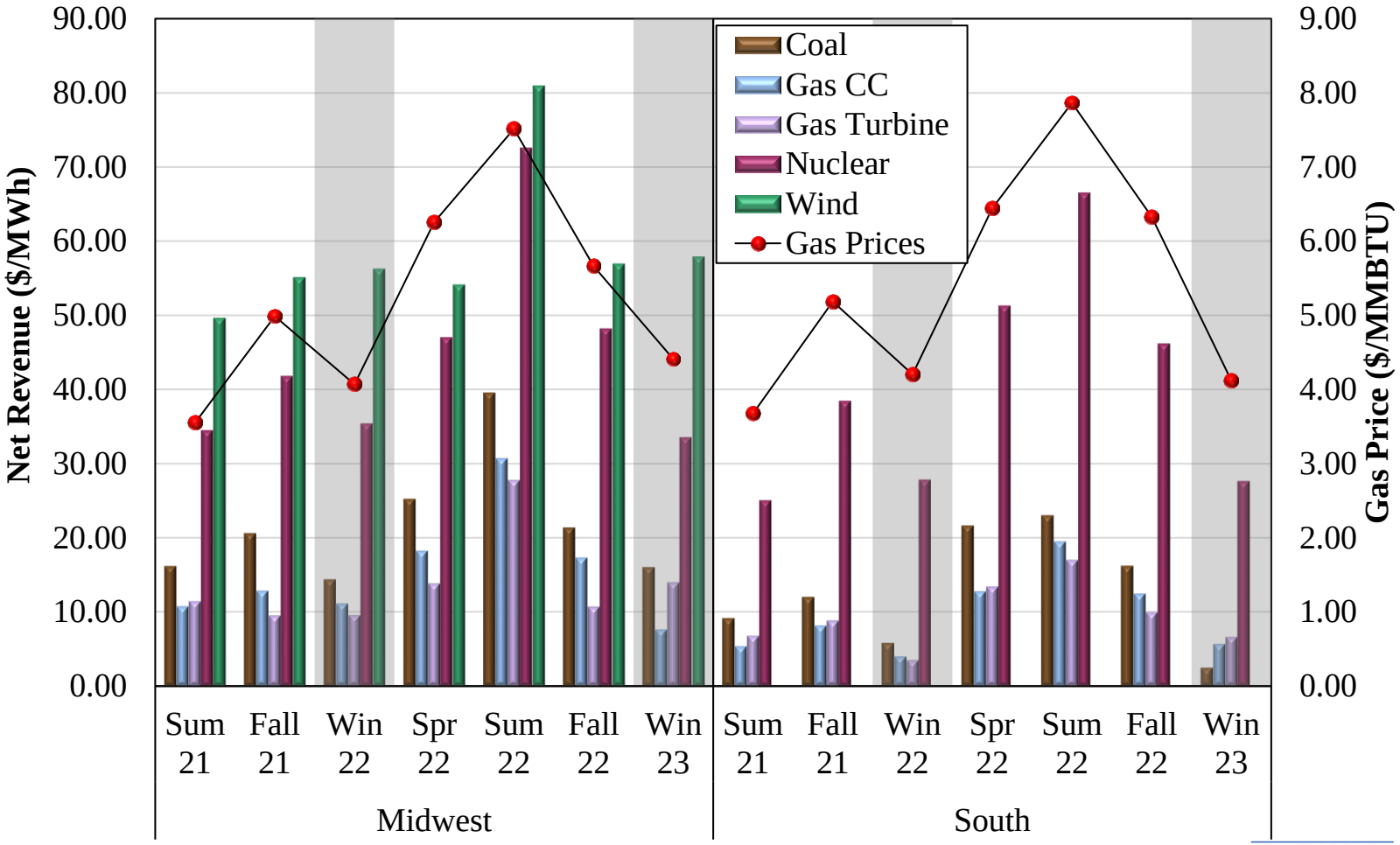
Manual Re-Dispatch and Cumulative DAMAP
December 23 – 24, 2022



© 2023 Potomac Economics

POTOMAC ECONOMICS

Net Revenues by Technology 2021-2023

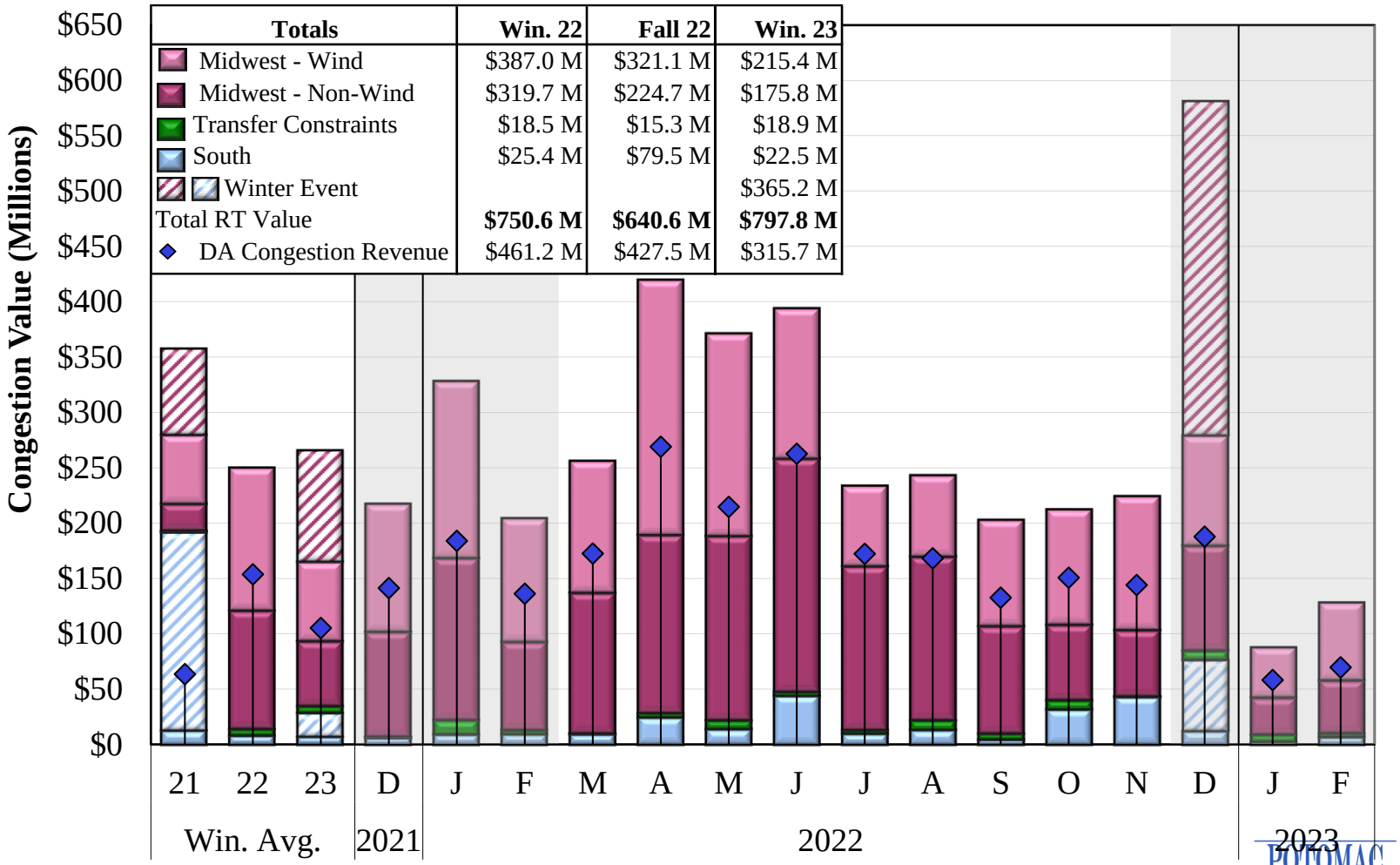


© 2023 Potomac Economics

POTOMAC ECONOMICS

Value of Real-Time Congestion
Winter 2021–2023

Totals	Win. 22	Fall 22	Win. 23
Midwest - Wind	$387.0 M	$321.1 M	$215.4 M
Midwest - Non-Wind	$319.7 M	$224.7 M	$175.8 M
Transfer Constraints	$18.5 M	$15.3 M	$18.9 M
South	$25.4 M	$79.5 M	$22.5 M
Winter Event			$365.2 M
Total RT Value	**$750.6 M**	**$640.6 M**	**$797.8 M**
DA Congestion Revenue	$461.2 M	$427.5 M	$315.7 M

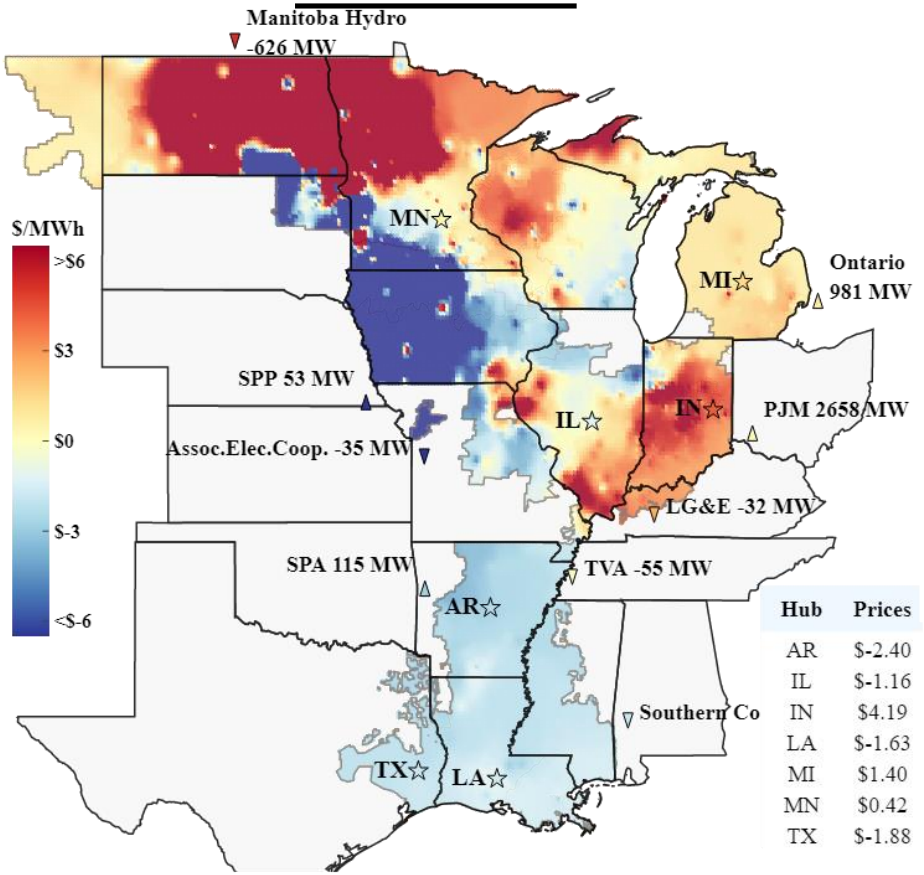


© 2023 Potomac Economics

POTOMAC ECONOMICS

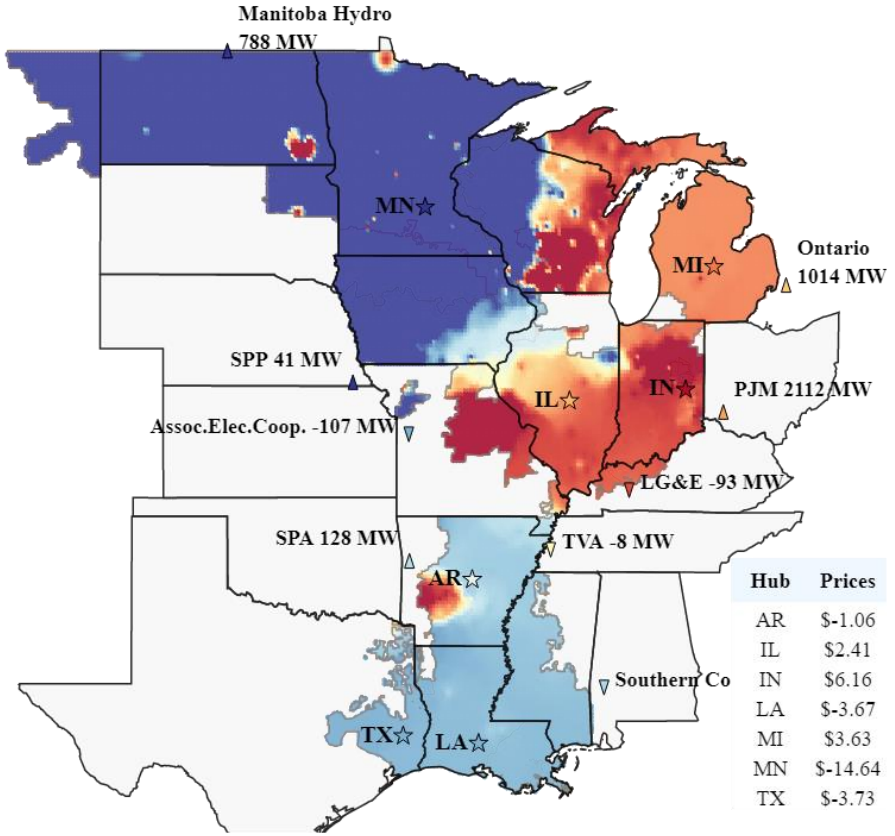
Average Real-Time Congestion Components
Winter 2022–2023

Winter 2022



Hub	Prices
AR	$-2.40
IL	$-1.16
IN	$4.19
LA	$-1.63
MI	$1.40
MN	$0.42
TX	$-1.88

Winter 2023*



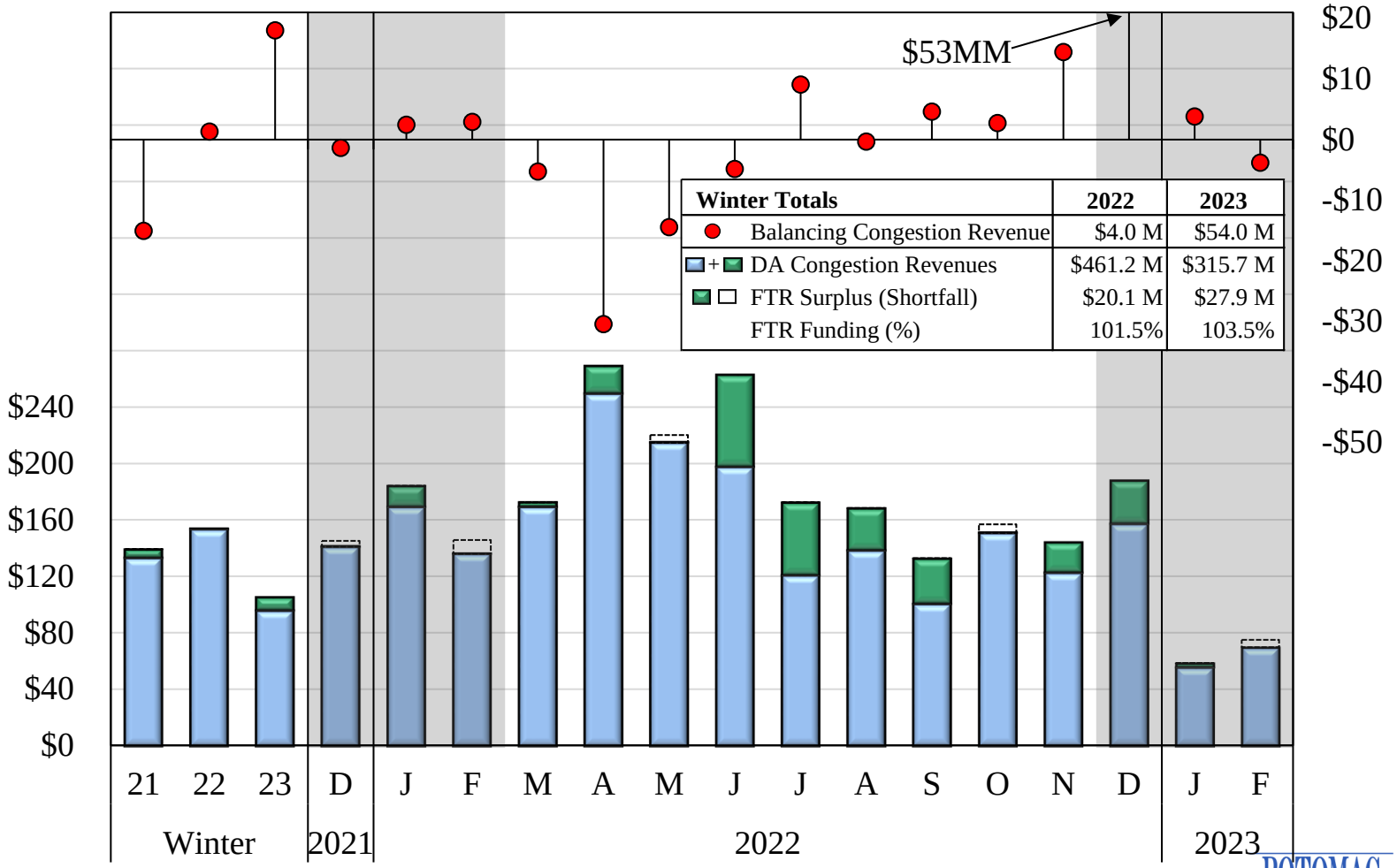
Hub	Prices
AR	$-1.06
IL	$2.41
IN	$6.16
LA	$-3.67
MI	$3.63
MN	$-14.64
TX	$-3.73

*Note: Winter 2023 excludes the effects of Winter Storm Elliott

© 2023 Potomac Economics

POTOMAC ECONOMICS

Day-Ahead Congestion, Balancing Congestion, and FTR Underfunding



Winter Totals	2022	2023
Balancing Congestion Revenue	$4.0 M	$54.0 M
+ DA Congestion Revenues	$461.2 M	$315.7 M
FTR Surplus (Shortfall)	$20.1 M	$27.9 M
FTR Funding (%)	101.5%	103.5%

© 2023 Potomac Economics

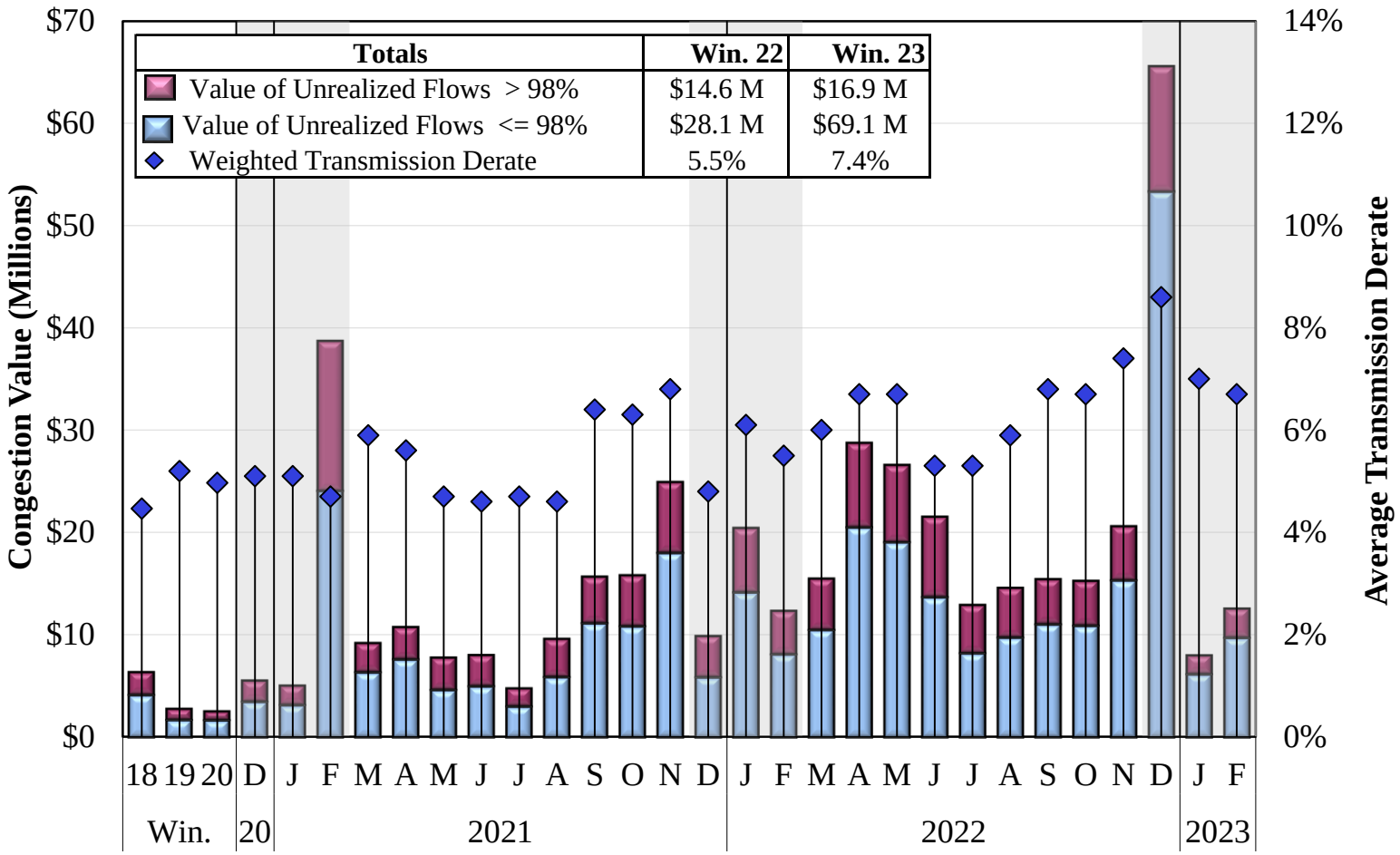
POTOMAC ECONOMICS

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

Winter		Savings ($ Millions)			# of Facilites for 2/3 of Savings	Share of Congestion
		Ambient Adj. Ratings	Emergency Ratings	Total		
2022	Midwest	$93.9	$35.05	$128.9	7	18.2%
	South	$0.7	$1.14	$1.8	2	12.9%
	Total	**$94.6**	**$36.2**	**$130.8**	**9**	**18.1%**
2023	Midwest	$110.3	$42.55	$152.8	7	21.7%
	South	$4.7	$10.13	$14.8	1	13.9%
	Total	**$115.0**	**$52.7**	**$167.7**	**8**	**20.7%**

© 2023 Potomac Economics

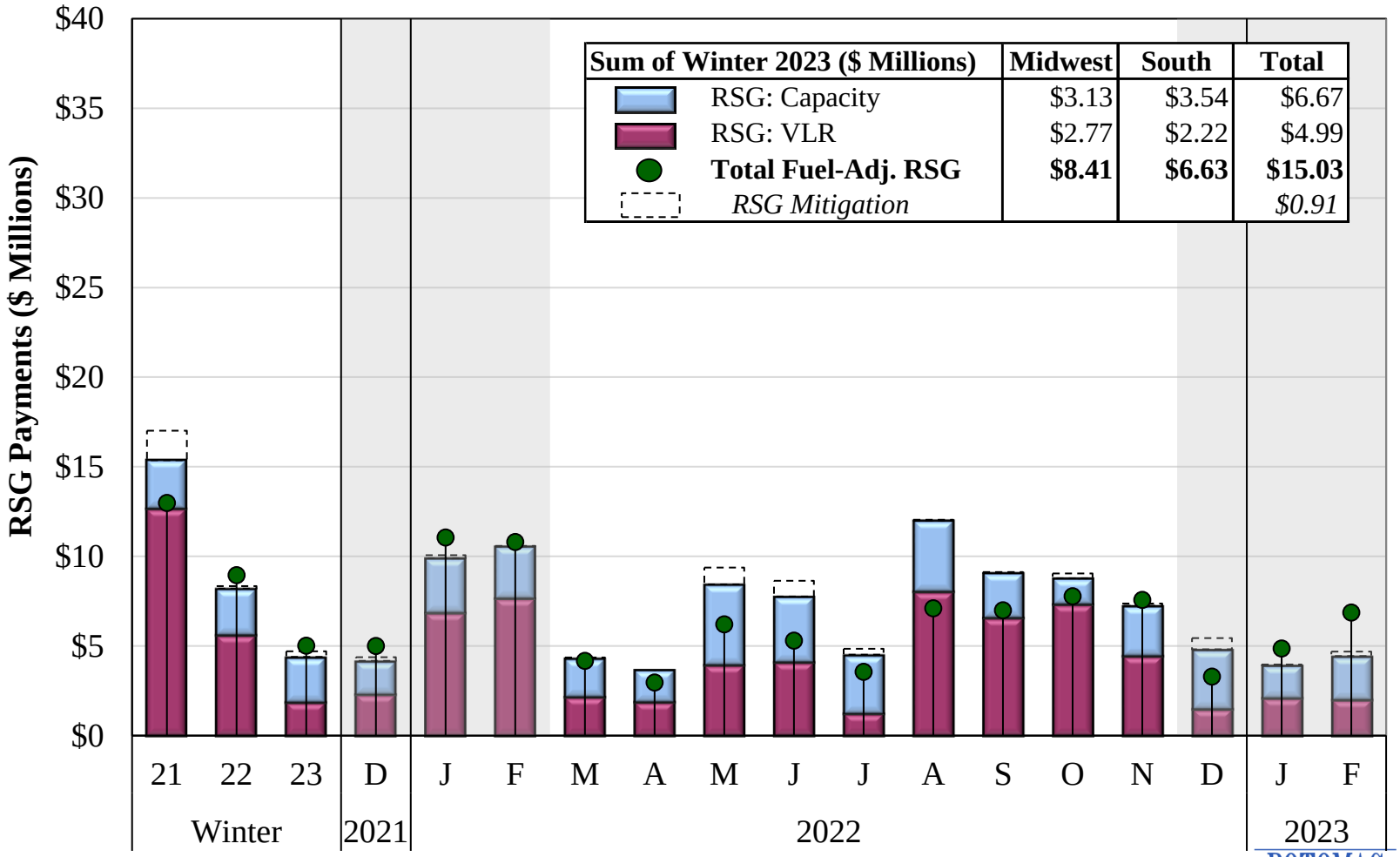
Value of Unrealized Transmission Flows Due to Use of Limit Control



© 2023 Potomac Economics

POTOMAC ECONOMICS

Day-Ahead RSG Payments
Winter 2021–2023

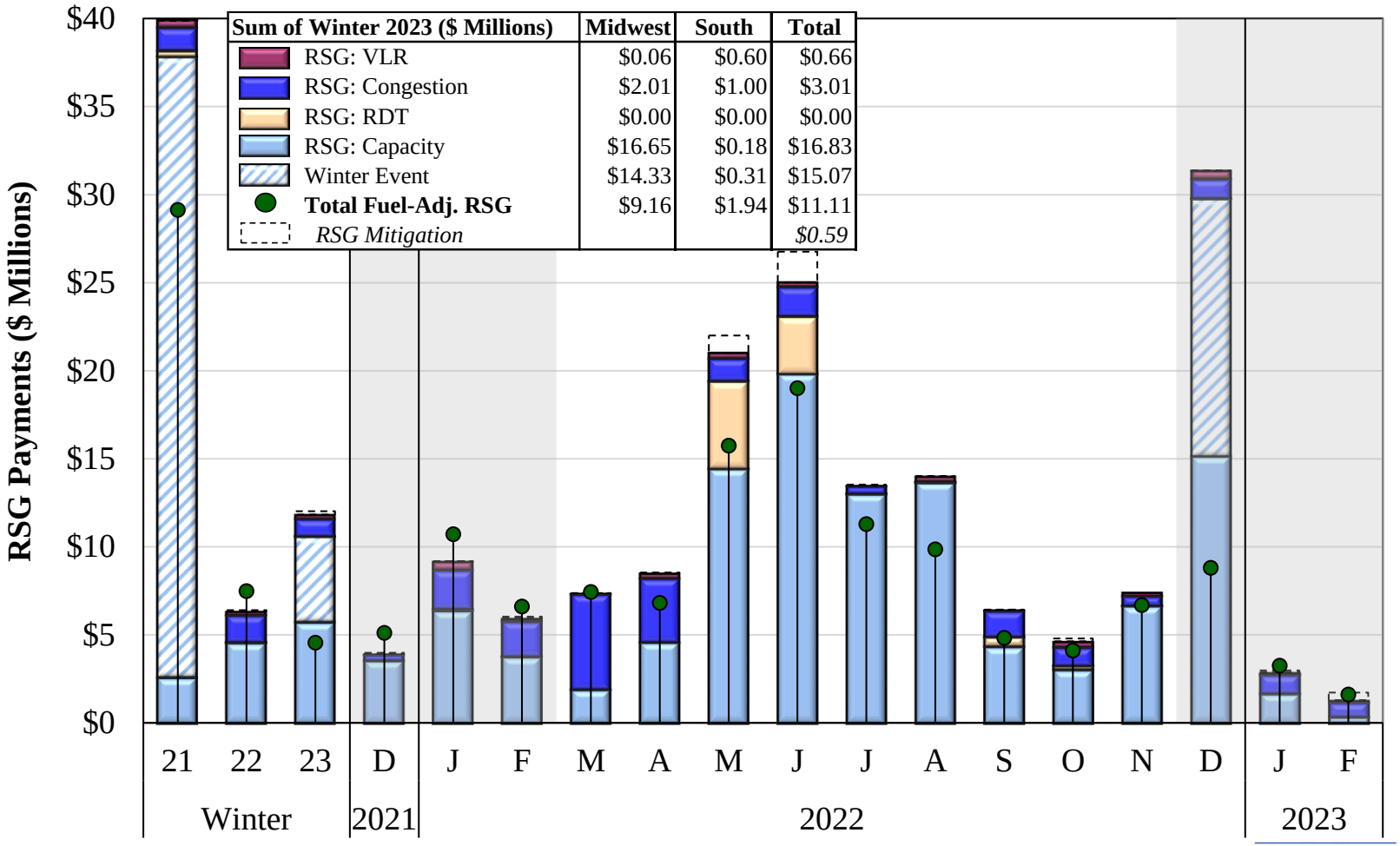


Sum of Winter 2023 ($ Millions)	Midwest	South	Total
RSG: Capacity	$3.13	$3.54	$6.67
RSG: VLR	$2.77	$2.22	$4.99
Total Fuel-Adj. RSG	**$8.41**	**$6.63**	**$15.03**
RSG Mitigation			*$0.91*

© 2023 Potomac Economics

POTOMAC ECONOMICS

Real-Time RSG Payments
Winter 2021–2023

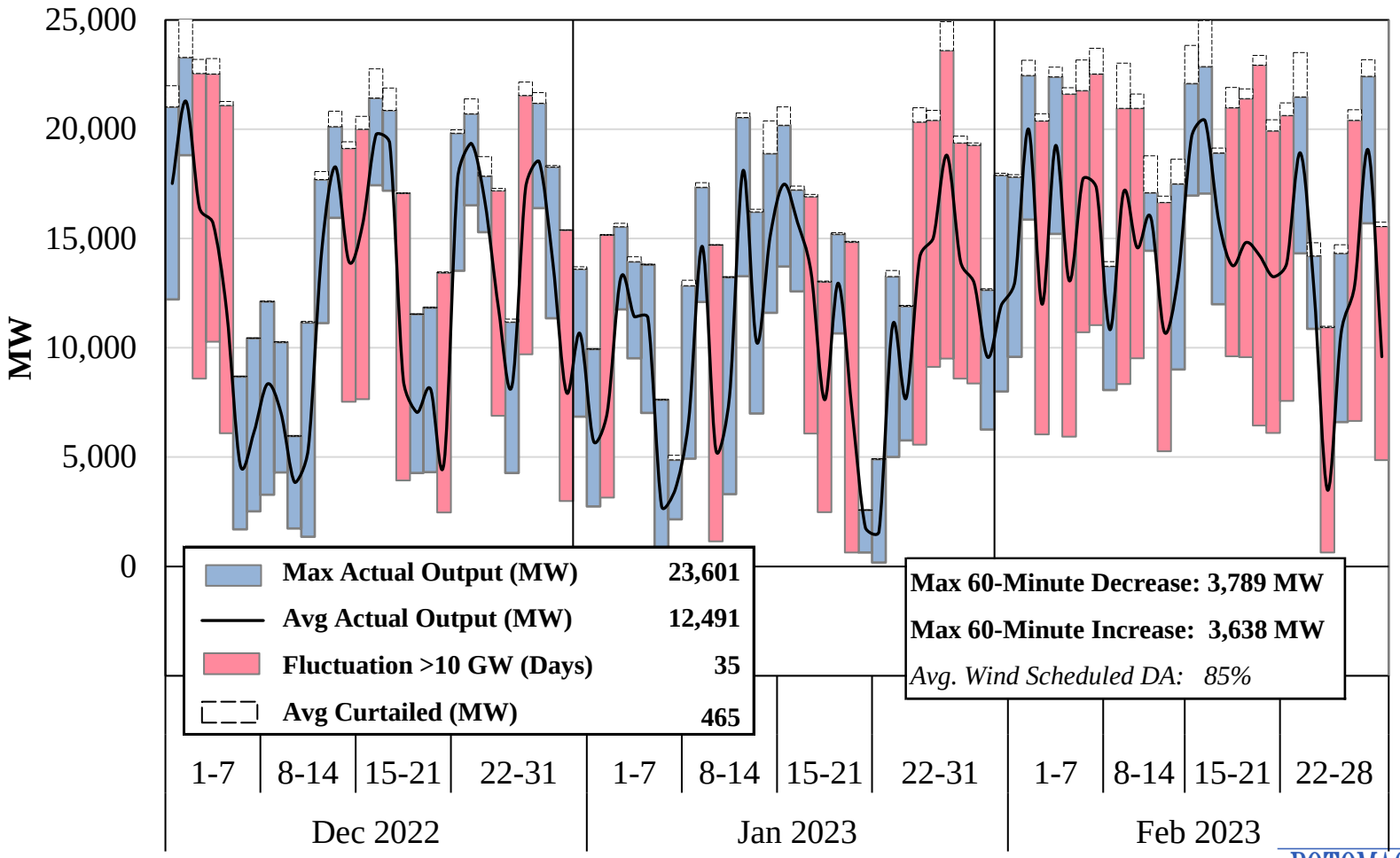


Sum of Winter 2023 ($ Millions)	Midwest	South	Total
RSG: VLR	$0.06	$0.60	$0.66
RSG: Congestion	$2.01	$1.00	$3.01
RSG: RDT	$0.00	$0.00	$0.00
RSG: Capacity	$16.65	$0.18	$16.83
Winter Event	$14.33	$0.31	$15.07
Total Fuel-Adj. RSG	$9.16	$1.94	$11.11
RSG Mitigation			*$0.59*

© 2023 Potomac Economics

POTOMAC ECONOMICS

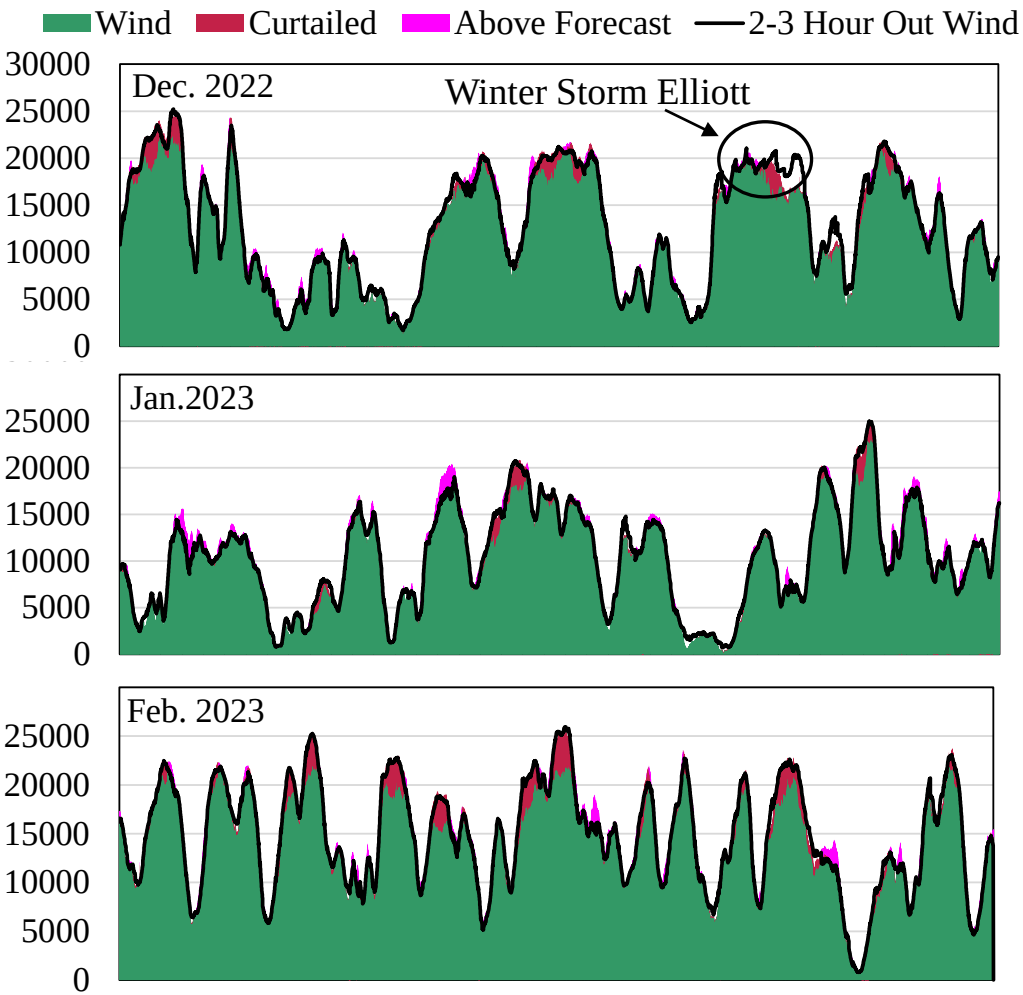
Wind Output in Real Time
Daily Range and Average



© 2023 Potomac Economics

POTOMAC ECONOMICS

Wind Forecast and Actual Output
Winter 2023

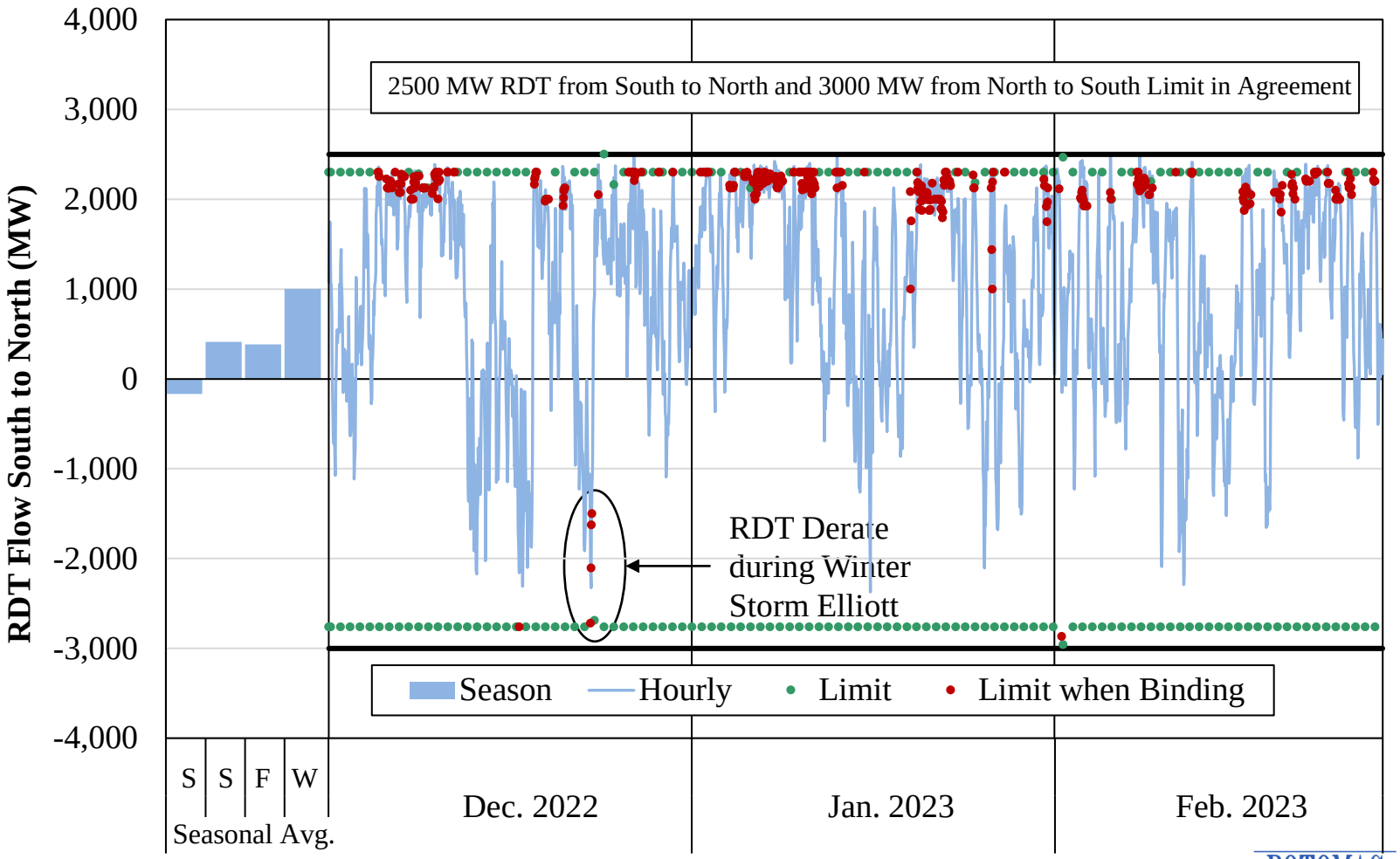


Winter 2023	
Real-Time Wind (MW)	12,491
Day-Ahead Wind (MW)	10,579
Avg Curtailments (MW)	446
Forecast Errors (%)	0.8%
Absolute Errors (%)	7.5%
Winter 2022	
Real-Time Wind (MW)	13,072
Day-Ahead Wind (MW)	11,124
Avg Curtailments (MW)	774
Forecast Errors (%)	-0.6%
Absolute Errors (%)	6.6%
Fall 2022	
Real-Time Wind (MW)	11,637
Day-Ahead Wind (MW)	10,678
Avg Curtailments (MW)	642
Forecast Errors (%)	0.3%
Absolute Errors (%)	7.9%

© 2023 Potomac Economics

POTOMAC ECONOMICS

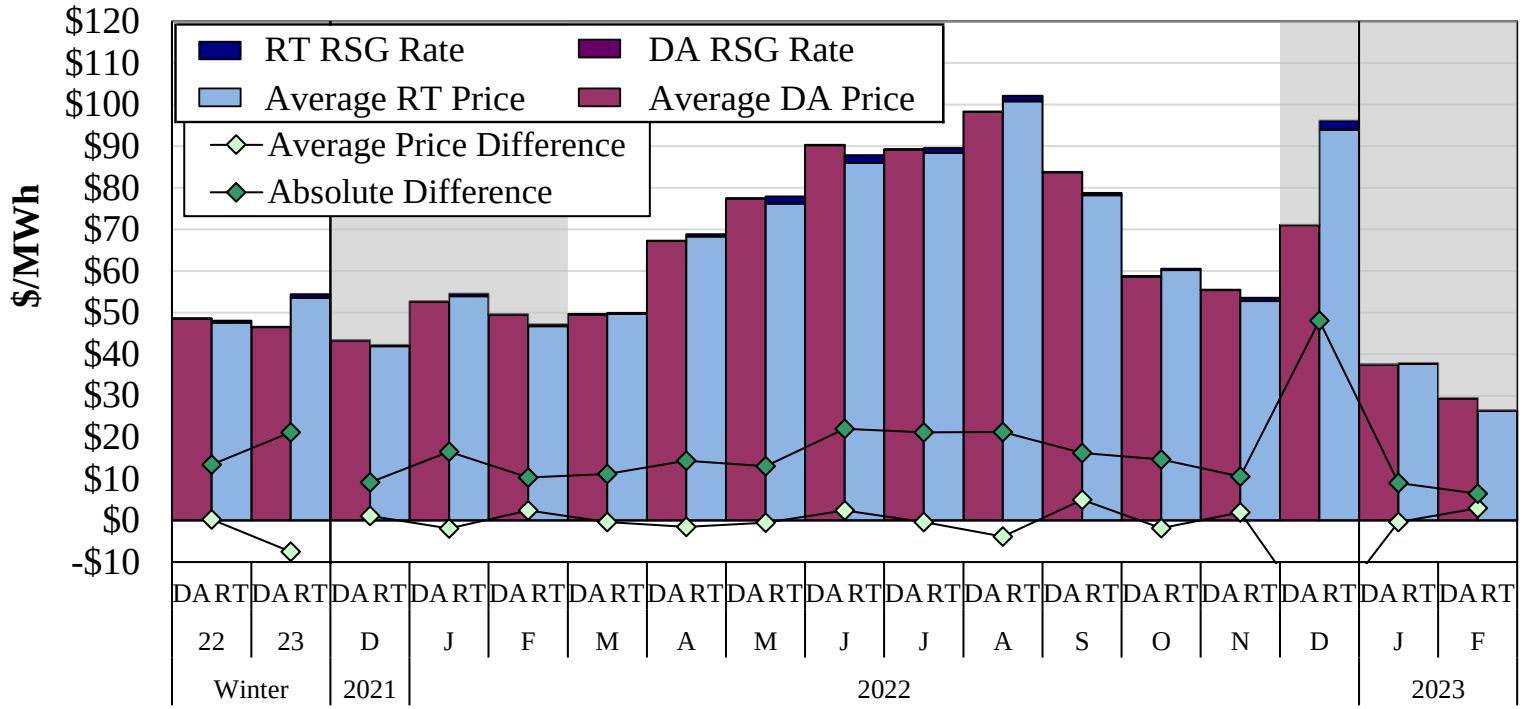
Real-Time Hourly Inter-Regional Flows
Winter 2023



© 2023 Potomac Economics

POTOMAC ECONOMICS

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



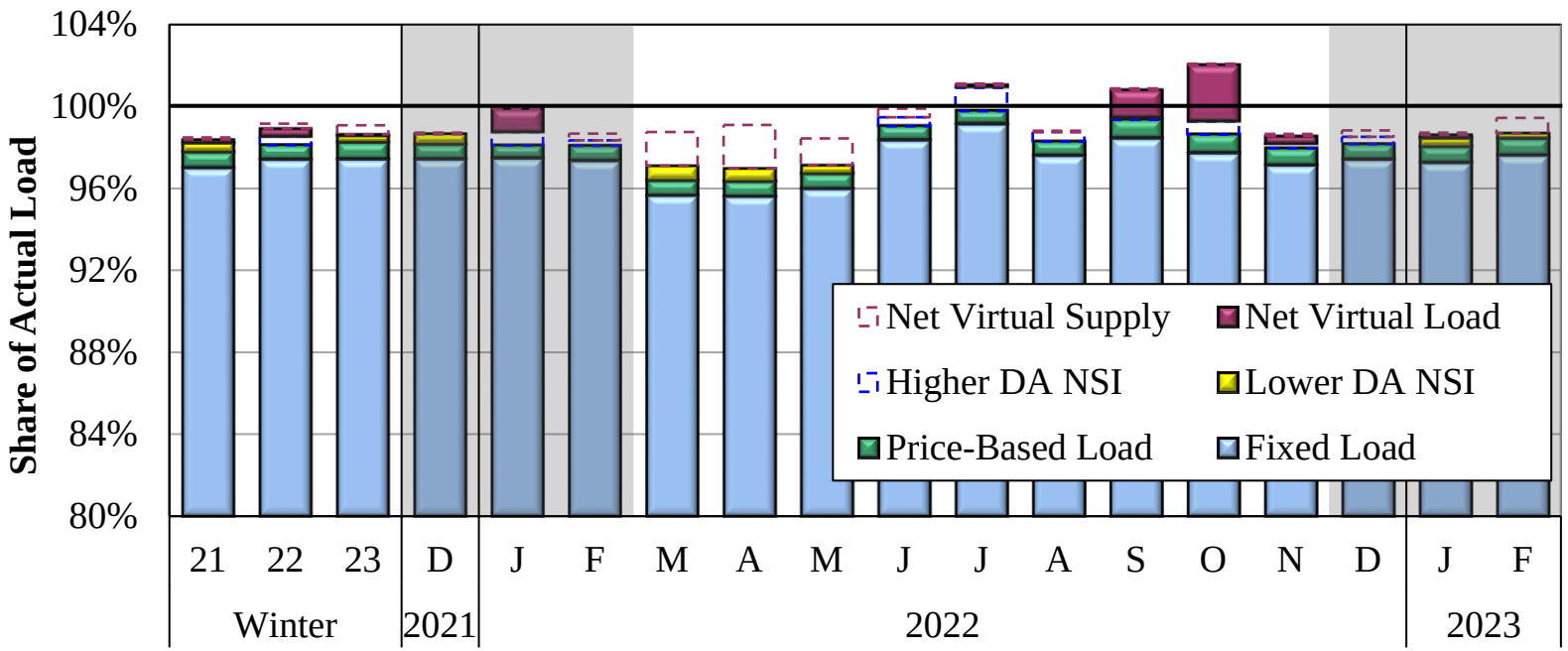
Average DA-RT Price Difference Including RSG (% of Real-Time Price)

Indiana Hub	1	-5	3	-3	5	-1	-2	-1	3	0	-4	6	-3	4	-26	-1	11
Michigan Hub	2	-1	1	-3	6	3	-3	5	6	-1	-3	7	1	4	-21	5	12
Minnesota Hub	4	-8	0	3	8	8	2	-1	10	-2	-5	7	0	3	-17	-1	-7
Arkansas Hub	0	-5	-2	-2	3	3	3	6	3	-5	-7	4	-3	-3	-18	-1	3
Texas Hub	0	-5	-1	-4	4	4	1	9	4	-2	-7	4	-1	-2	-24	1	7
Louisiana Hub	0	-6	-1	-3	5	4	4	8	5	0	-7	3	-1	-1	-23	0	6

© 2023 Potomac Economics

POTOMAC ECONOMICS

Day-Ahead Peak Hour Load Scheduling
Winter 2021–2023



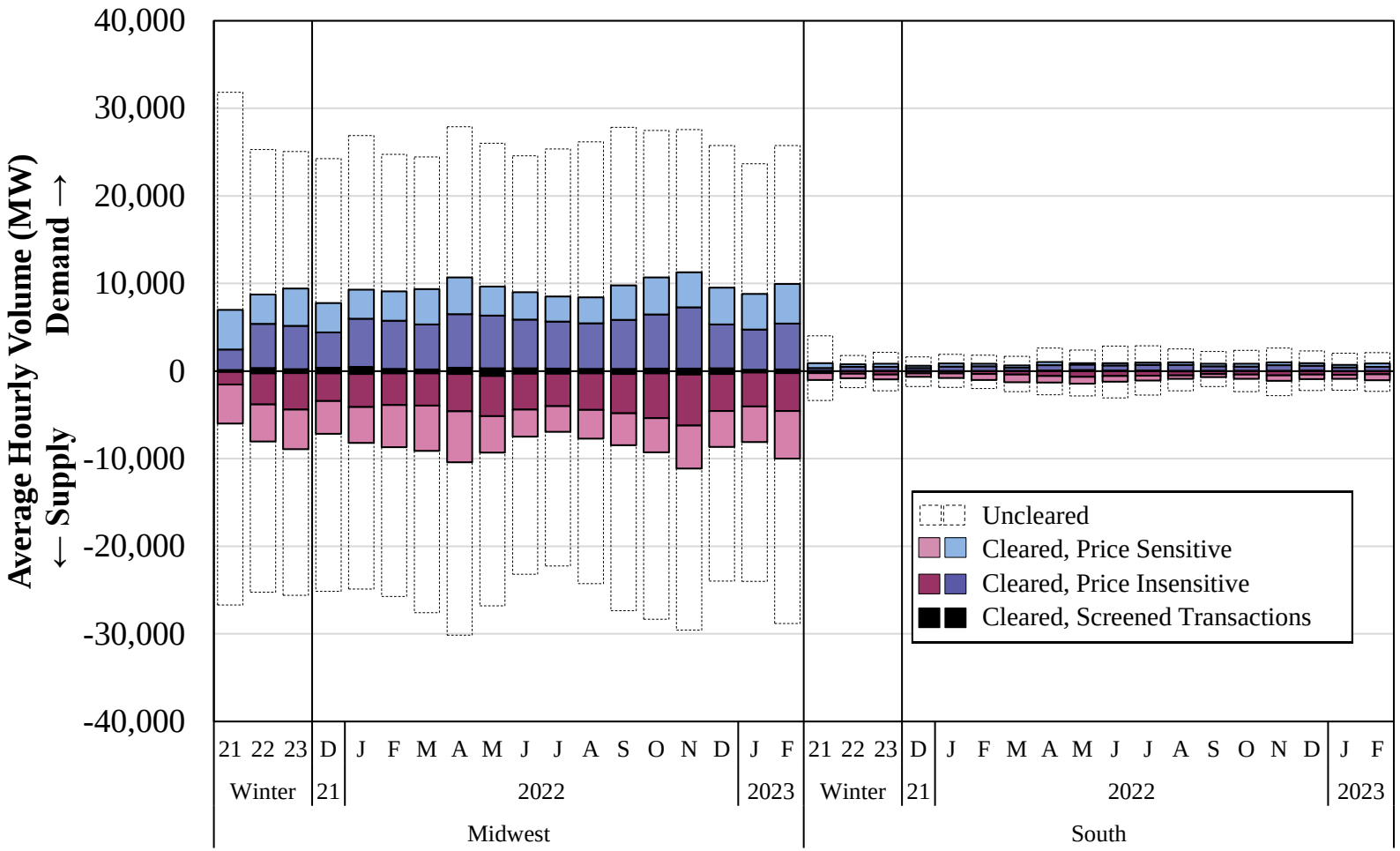
Share of Actual Load (%)

All Hours	98.7	98.5	98.7	98.9	98.9	97.8	97.3	97.5	97.6	99.2	99.8	98.9	100.8	99.7	97.6	98.7	99.0	98.5
Peak Hours Midwest	98.3	98.8	99.0	99.0	99.8	98.1	96.5	96.0	96.2	98.2	99.7	98.4	101.0	101.5	99.0	98.5	99.2	98.9
Peak Hours South	102.1	99.9	99.1	101.3	98.8	100.0	98.8	99.1	99.0	99.7	99.7	98.7	101.8	100.1	98.1	100.8	99.7	98.5

© 2023 Potomac Economics

POTOMAC ECONOMICS

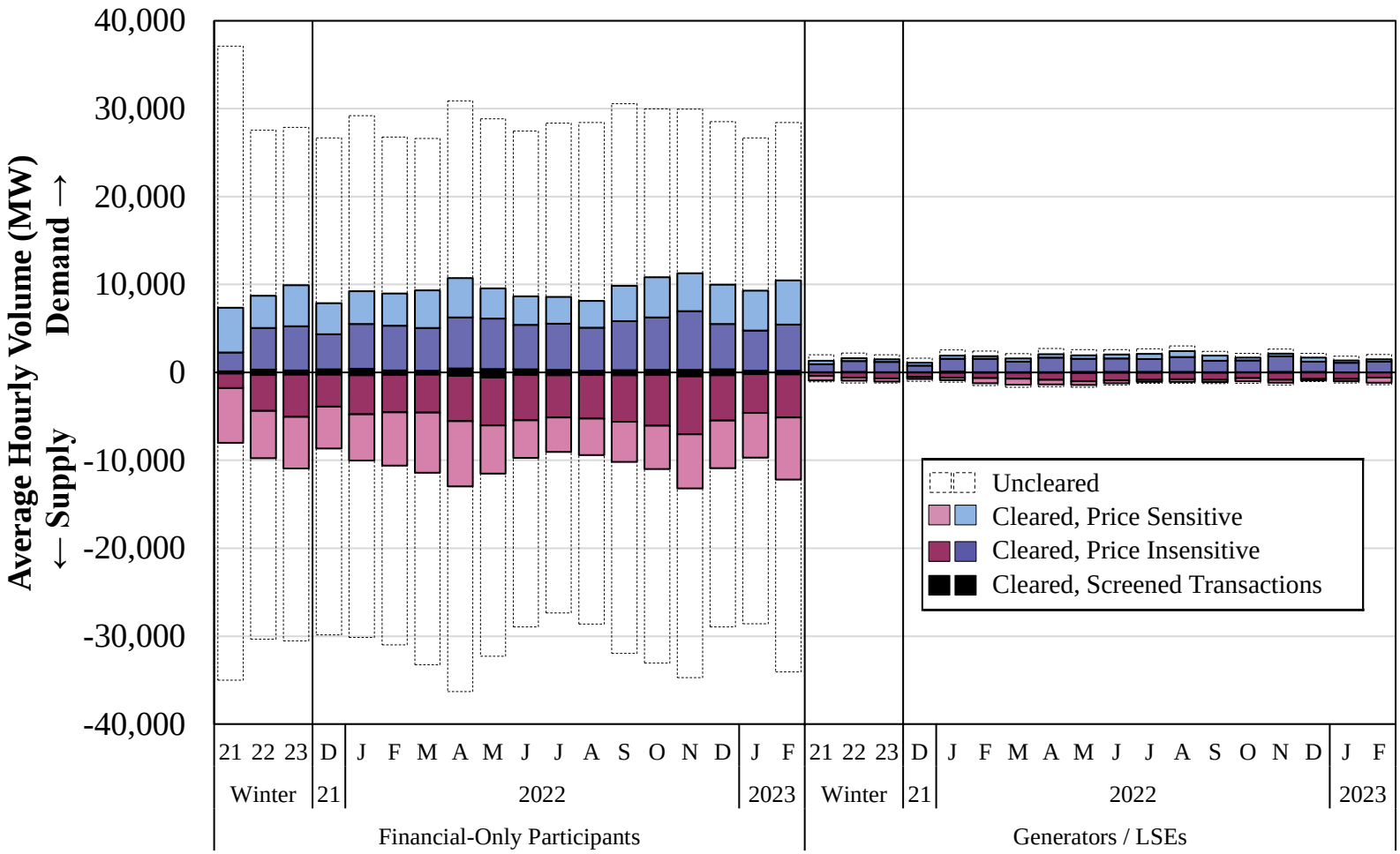
Virtual Load and Supply
Winter 2021–2023



© 2023 Potomac Economics

POTOMAC ECONOMICS

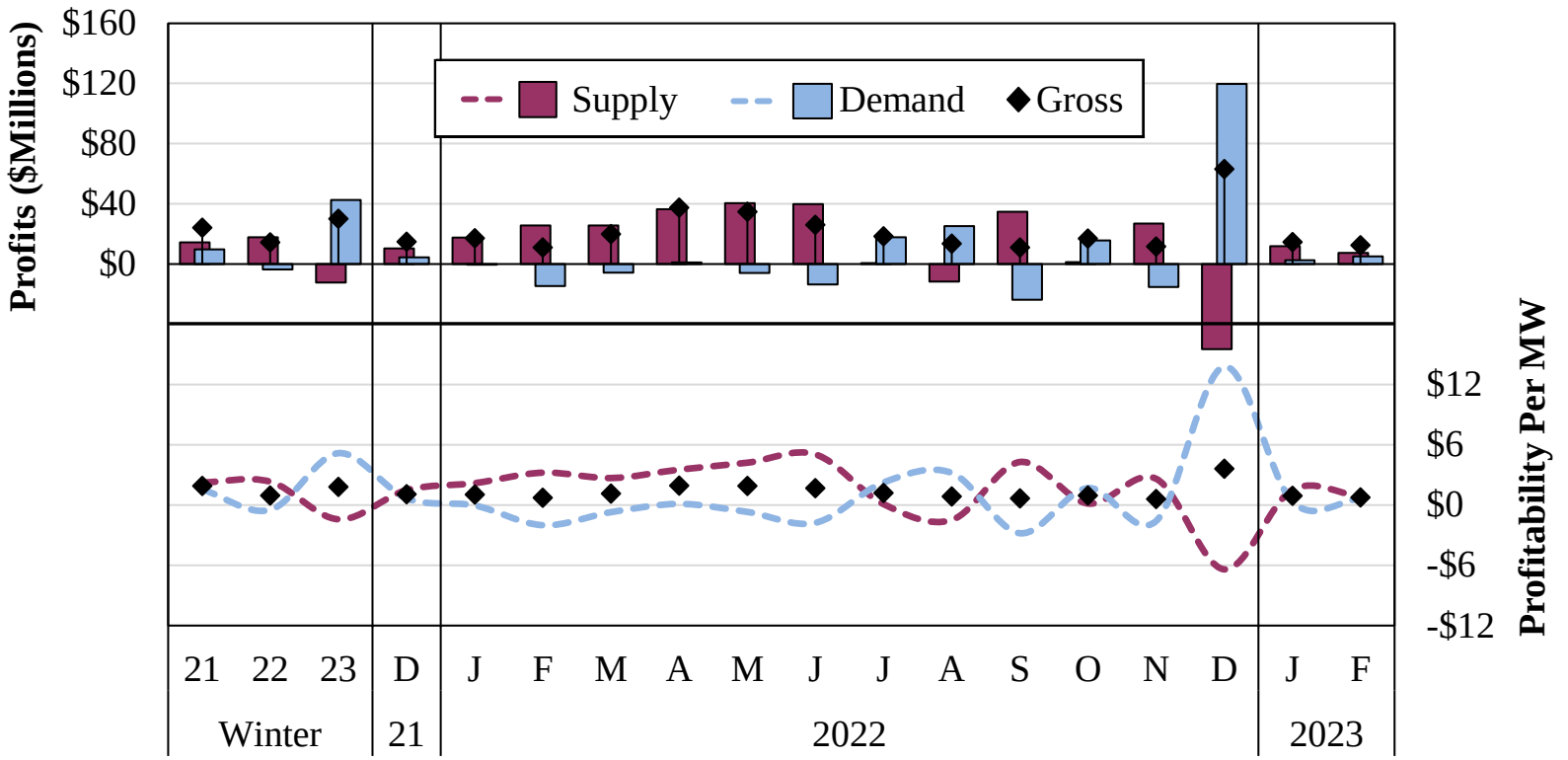
Virtual Load and Supply by Participant Type
Winter 2021–2023



© 2023 Potomac Economics

POTOMAC ECONOMICS

Virtual Profitability
Winter 2021–2023



Percent Screened

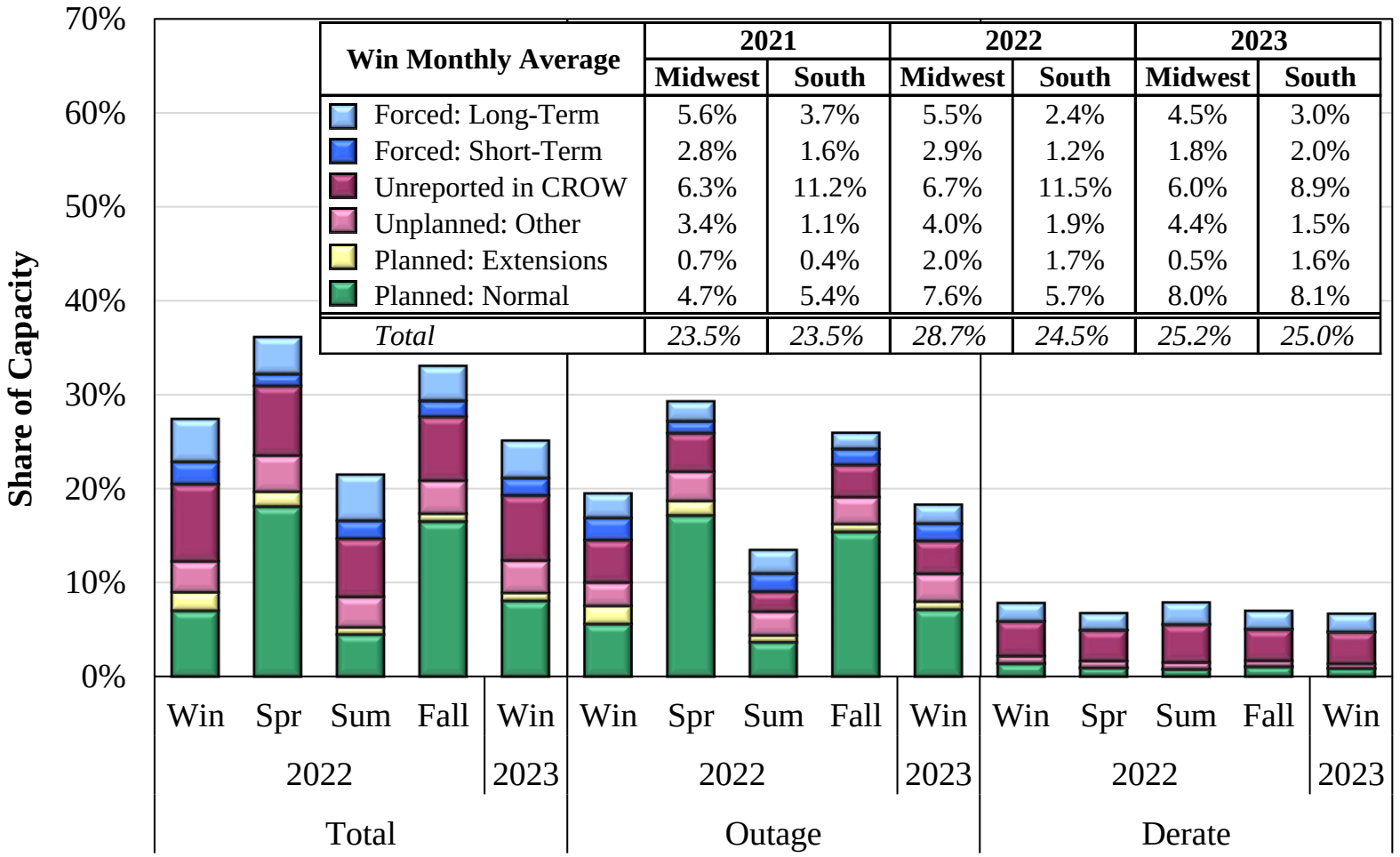
Supply	1.5	2.9	2.2	2.9	3.3	2.6	2.4	3.0	4.9	2.9	3.7	3.3	3.2	2.7	3.3	3.0	1.8	1.8
Demand	2.0	3.7	2.2	4.5	4.4	2.3	1.9	3.8	3.8	3.7	3.2	2.5	2.6	2.6	2.4	3.4	1.7	1.6
Total	1.7	3.3	2.2	3.7	3.9	2.5	2.2	3.4	4.4	3.3	3.4	2.9	2.9	2.6	2.9	3.2	1.8	1.7

© 2023 Potomac Economics

POTOMAC ECONOMICS

Generation Outages and Deratings
Winter 2021–2023

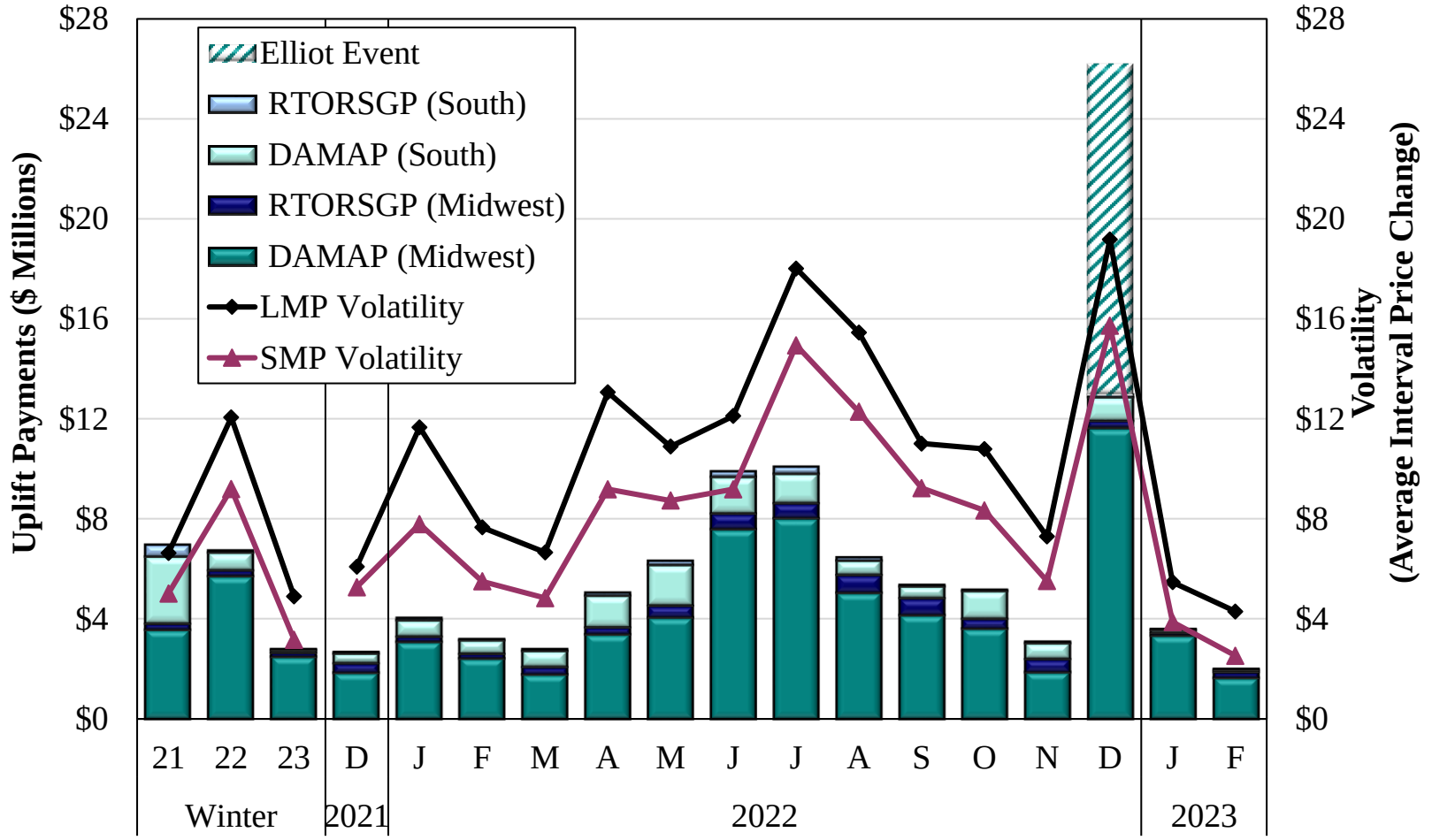
Win Monthly Average	2021		2022		2023	
	Midwest	South	Midwest	South	Midwest	South
Forced: Long-Term	5.6%	3.7%	5.5%	2.4%	4.5%	3.0%
Forced: Short-Term	2.8%	1.6%	2.9%	1.2%	1.8%	2.0%
Unreported in CROW	6.3%	11.2%	6.7%	11.5%	6.0%	8.9%
Unplanned: Other	3.4%	1.1%	4.0%	1.9%	4.4%	1.5%
Planned: Extensions	0.7%	0.4%	2.0%	1.7%	0.5%	1.6%
Planned: Normal	4.7%	5.4%	7.6%	5.7%	8.0%	8.1%
Total	*23.5%*	*23.5%*	*28.7%*	*24.5%*	*25.2%*	*25.0%*



© 2023 Potomac Economics

POTOMAC ECONOMICS

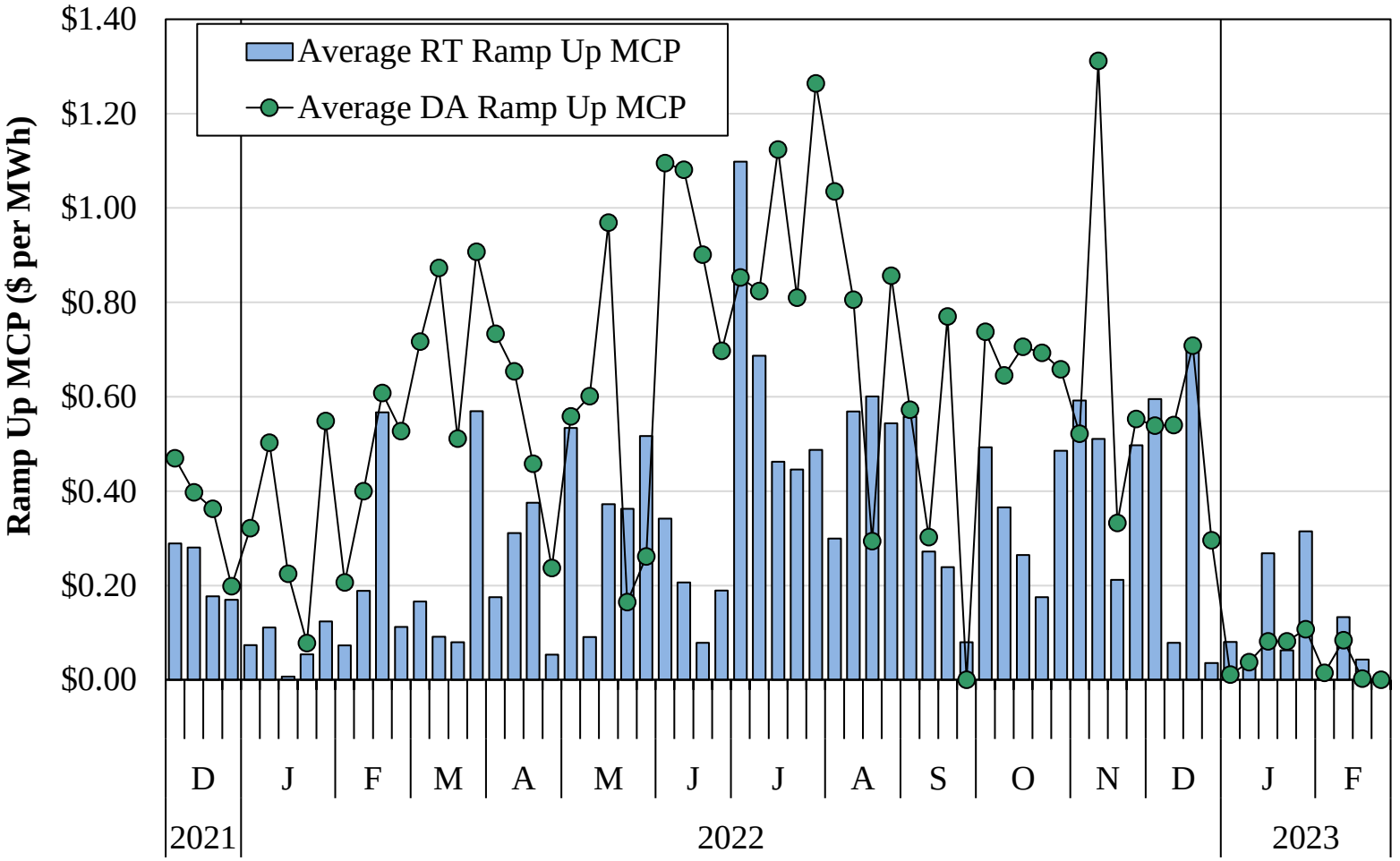
Price Volatility Make Whole Payments
Winter 2021–2023



© 2023 Potomac Economics

POTOMAC ECONOMICS

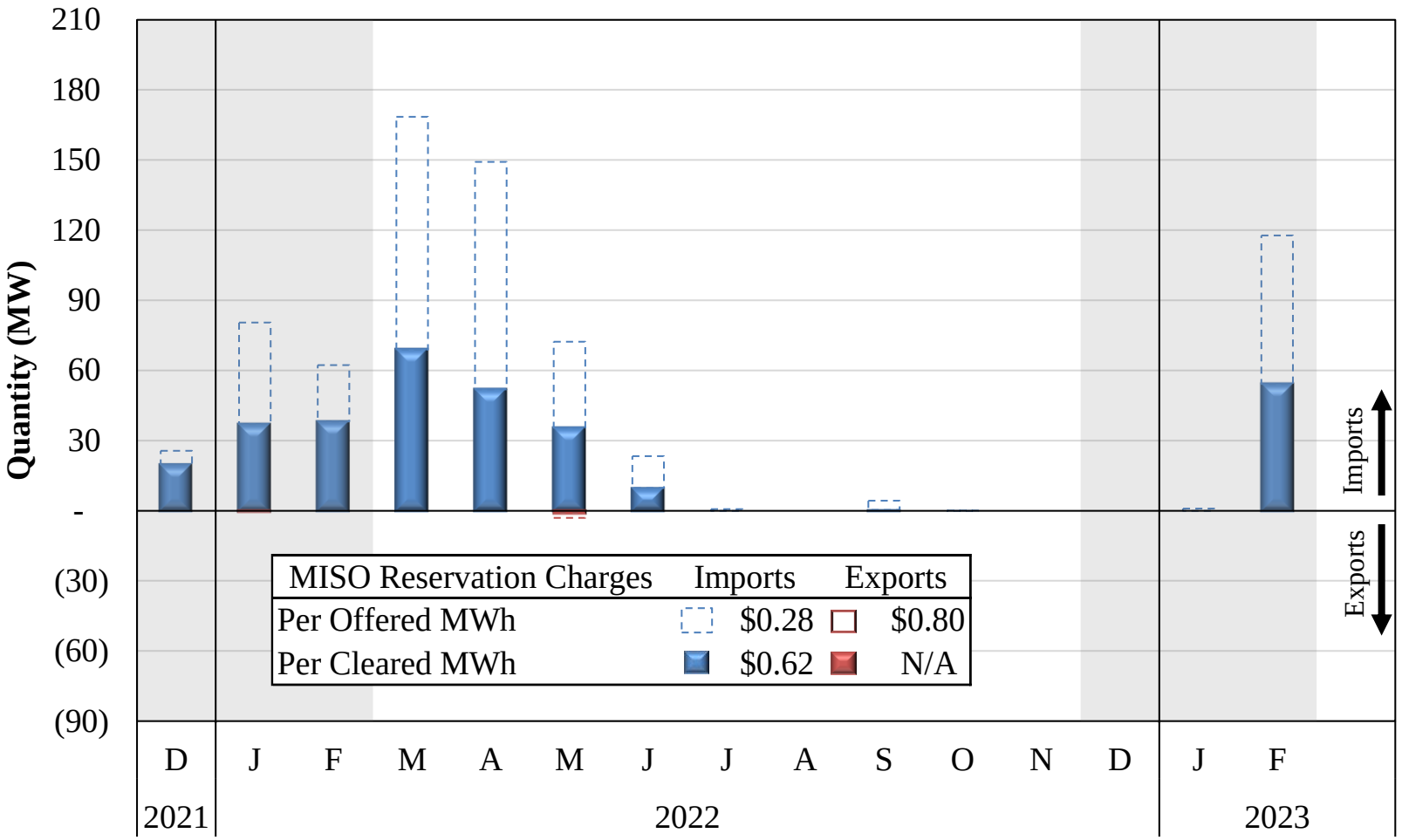
Day-Ahead and Real-Time Ramp Up Price Winter 2022–2023



© 2023 Potomac Economics

POTOMAC ECONOMICS

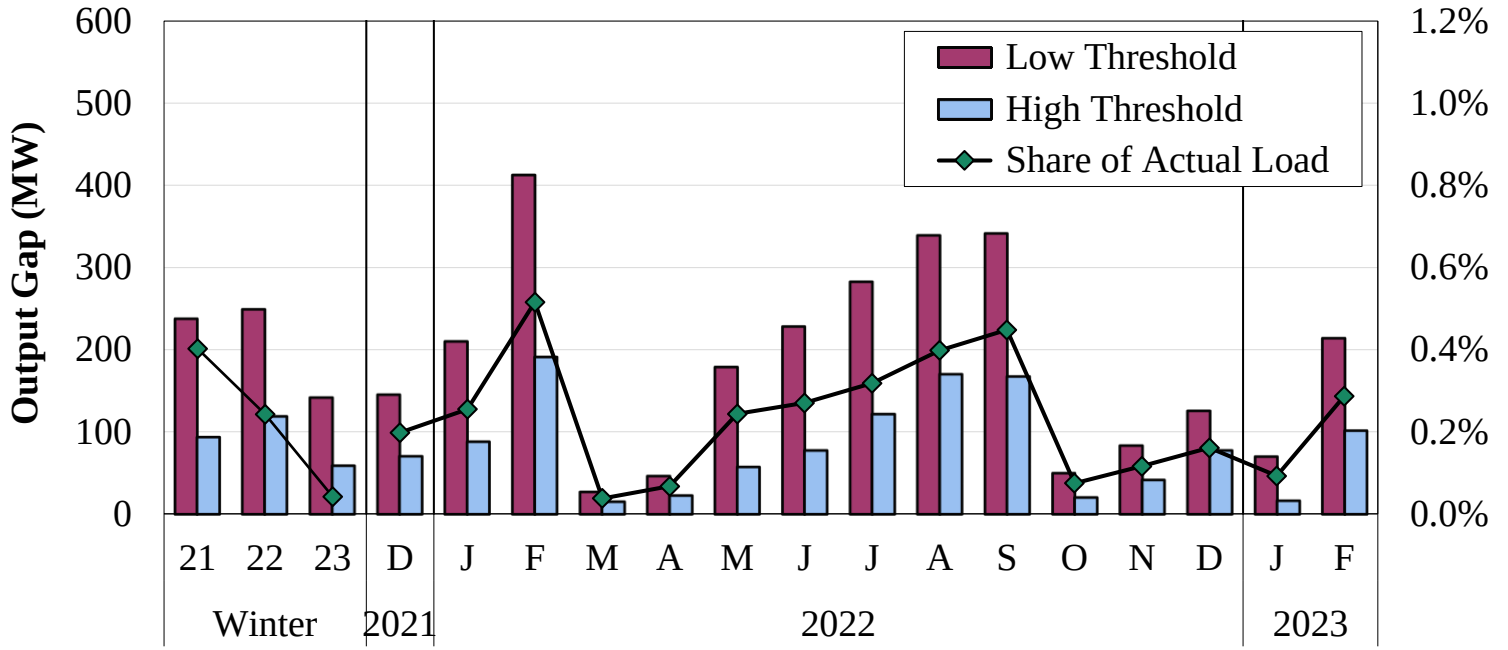
Coordinated Transaction Scheduling (CTS)
Winter 2021–2023



© 2023 Potomac Economics

POTOMAC ECONOMICS

Monthly Output Gap
Winter 2021–2023



Low Threshold Results by Unit Status (MW)

Offline	31	18	94	9	22	24	17	20	103	118	184	238	256	27	47	82	29	170
Online	207	237	43	136	188	387	11	27	75	110	98	100	84	23	36	43	41	43

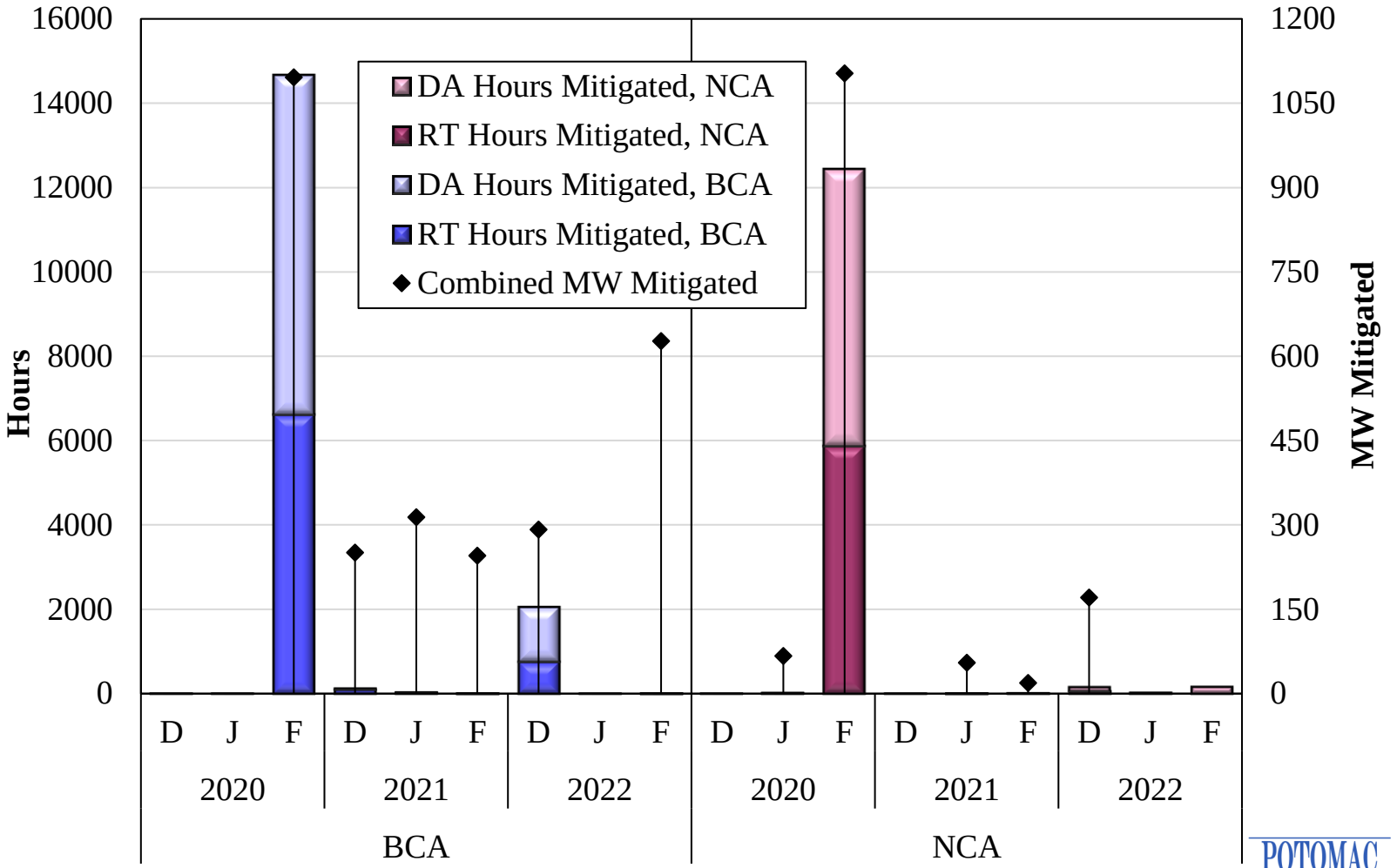
High Threshold Results by Unit Status (MW)

Offline	24	16	55	7	21	20	12	17	51	67	110	156	151	12	36	59	12	94
Online	55	101	10	64	67	171	4	6	7	10	12	14	16	8	6	19	5	7

© 2023 Potomac Economics

POTOMAC ECONOMICS

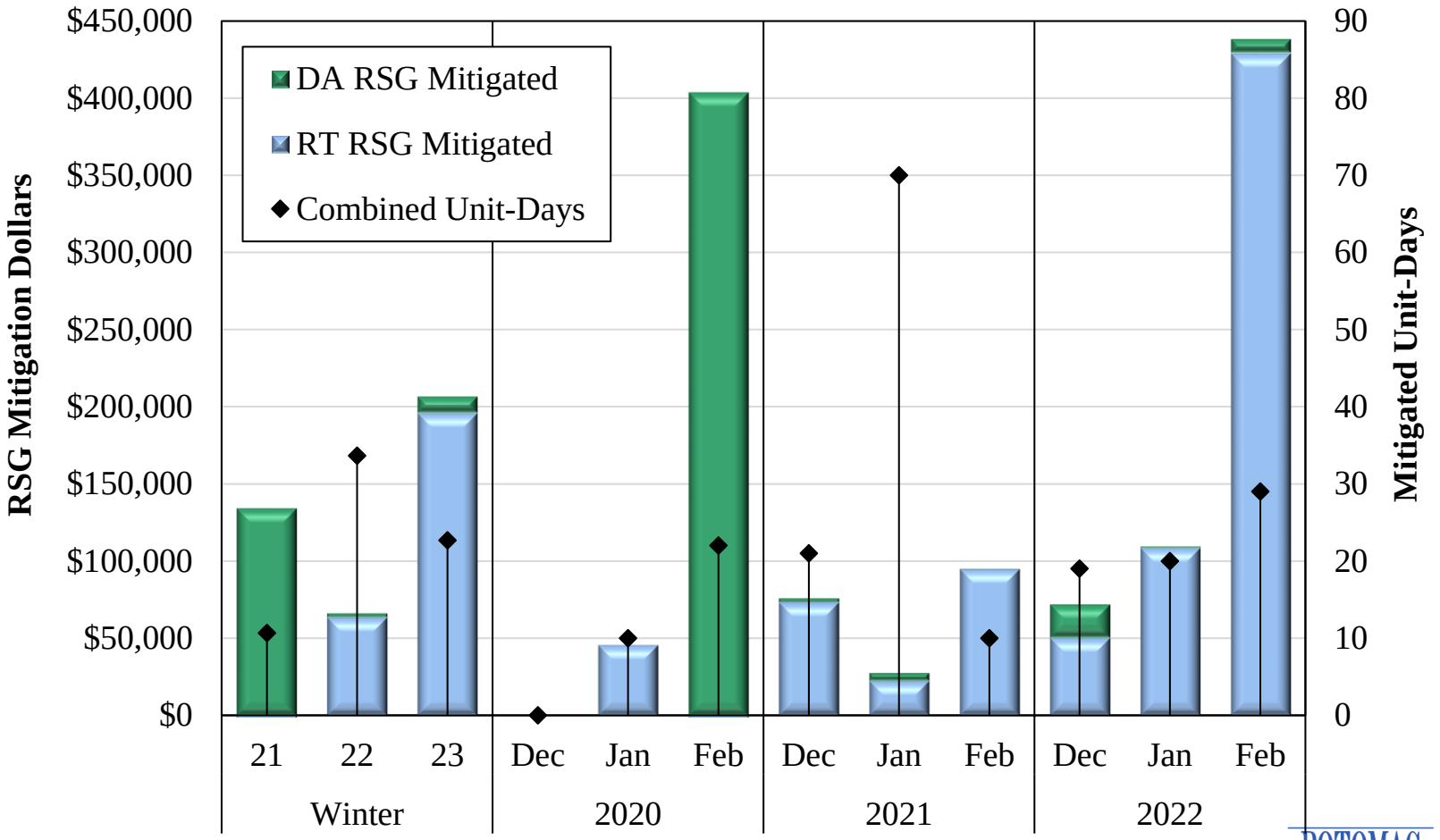
Day-Ahead And Real-Time Energy Mitigation
Winter 2021 - 2023



© 2023 Potomac Economics

POTOMAC ECONOMICS

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



© 2023 Potomac Economics

POTOMAC ECONOMICS

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
- VLR — Voltage and Local Reliability
- WUMS — Wisconsin Upper Michigan System

© 2023 Potomac Economics