IMM Quarterly Report: Spring 2022

MISO Independent Market Monitor

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Potomac Economics

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Highlights and Findings: Spring 2022

- The MISO markets performed competitively this spring – market power mitigation was infrequent and conduct was competitive overall.
- Energy prices more than doubled this quarter, largely because gas prices increased around 140 percent over last spring in the Midwest and South.
  - ✓ Coal supply limitations became more pronounced later in the quarter, as resources employed conservation measures in preparation for the peak summer months.
- Average load increased by 5 percent and peak load rose 6 percent.
  - ✓ Warmer than normal mid-May temperatures increased cooling demand.
- MISO's Planning Resource Auction cleared at CONE in the Midwest as the region was short of capacity by 1.2 GW.
- Transmission congestion roughly doubled because of higher fuel prices and rising wind-related congestion, accounting for half of all real-time congestion.
- Day-ahead RSG rose 38 percent, while real-time RSG rose 162 percent.
  - ✓ Only 30 percent of the real-time RSG appeared necessary.
  - ✓ Improvements in the commitment process should reduce MISO's RSG costs.

Quarterly Summary

Spring		Value	Change[1] Prior Qtr.	Change[1] Prior Year
RT Energy Prices ($/MWh)		$57.40	*38%*	*124%*
Fuel Prices ($/MMBtu)				
Natural Gas - Chicago		$6.26	*54%*	*142%*
Natural Gas - Henry Hub		$6.44	*53%*	*141%*
Western Coal		$0.93	*-36%*	*37%*
Eastern Coal		$5.06	*43%*	*291%*
Load (GW)[2]				
Average Load		71.2	*-9%*	*5%*
Peak Load		104.1	*3%*	*6%*
% Scheduled DA (Peak Hour)		97.1%	98.7%	97.7%
Transmission Congestion ($M)				
Real-Time Congestion Value		$1046.7	*39%*	*136%*
Day-Ahead Congestion Revenue		$656.0	*42%*	*137%*
Balancing Congestion Revenue[3]		$49.9	-$4.0	$6.7
Ancillary Service Prices ($/MWh)				
Regulation		$17.56	*27%*	*55%*
Spinning Reserves		$3.81	*49%*	*11%*
Supplemental Reserves		$0.47	*-30%*	*-33%*

		Value	Change[1] Prior Qtr.	Change[1] Prior Year
FTR Funding (%)		103%	102%	100%
Wind Output (MW/hr)		12,886	*-1%*	*23%*
Wind Curtailed (MW/hr)		1,297	*68%*	*33%*
Guarantee Payments ($M)[4]				
Real-Time RSG		$36.1	*88%*	*145%*
Day-Ahead RSG		$15.0	*-38%*	*28%*
Day-Ahead Margin Assurance		$13.6	*52%*	*104%*
Real-Time Offer Rev. Sufficiency		$1.5	*49%*	*14%*
Price Convergence[5]				
Market-wide DA Premium		2.0%	1.6%	-2.5%
Virtual Trading				
Cleared Quantity (MW/hr)		25,098	19%	42%
% Price Insensitive		54%	54%	33%
% Screened for Review		3%	3%	2%
Profitability ($/MW)		$1.7	$0.9	$0.8
Dispatch of Peaking Units (MW/hr)		771	854	648
Output Gap- Low Thresh. (MW/hr)		84	255	73

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 Spring 2022

Rising Gas Prices, Coal Limitations, and Energy Prices (Slides 11, 13, 15-16)

- Energy prices more than doubled this spring, driven by much higher natural gas prices and coal conservation measures impacting the market supply.
- Gas prices increased more 140 percent over last year, reaching the highest levels in more than a decade (often exceeding $8 per MMBTU in May).
  - ✓ Below normal gas storage inventories, record high demand for LNG exports, and labor supply shortages in natural gas extraction were contributing factors.
- Higher than normal temperatures late in the quarter drove up cooling demand.
- Amidst rising gas prices, coal resources continued to be very economic based on contract coal prices, but ongoing supply chain limitations lowered output.
  - ✓ Coal resource net revenues rose fourfold from $5 per MWh last spring to $24 per MWh this year, yet coal generation fell 5 percent due to fuel constraints.
  - ✓ We demonstrate the impacts of coal conservation on the supply curve (slide 16) and the corresponding impact on the system marginal price for the peak.
    - Approximately 13 GW of coal are currently impacted.
  - ✓ We are maintaining reference levels reflecting ongoing conservation measures.

Highlights for Spring 2022

High Quarterly Congestion (Slides 19-22)

- Congestion roughly doubled over last spring with the value of real-time congestion exceeding one billion dollars during the quarter.
  - ✓ Higher natural gas prices contributed to the higher congestion by increasing the marginal cost of moving generation to manage system flows.
  - ✓ Wind output continued to be a primary cause of MISO's congestion, contributing to more than $500 million of congestion during the quarter.
    - – Wind output was curtailed almost 10 percent on average over the quarter.
- MISO deployed an efficient reconfiguration during emergency days that freed up some stranded MWs and reduced congestion significantly.
  - ✓ We continue to encourage MISO to develop reconfiguration options that can be used to manage congestion economically.
- Wide-spread use of ambient-adjusted ratings and emergency ratings would also have substantially reduced wind curtailments and lowered congestion.
  - ✓ These ratings would have produced almost $100 million in savings this Spring.
  - ✓ They would also have unlocked up to 700 MW of wind output that could have helped serve the system's real-time capacity needs in the tightest hours.

Highlights for Spring 2022

High Temperatures and Uplift Costs (Slides 24-27)

- High temperatures and congestion led to tight conditions in mid-May.
  - ✓ Between May 11-13, temperatures in the Midwest were hotter than typical and planned outages were high as is typical during the Spring shoulder months.
  - ✓ High wind and sub-optimal commitments contributed to up to 2.6 GW of stranded conventional MWs (units behind constraints) on those days.
- MISO incurred $6.3 million in real-time RSG between May 11 and 13. Our evaluation of this RSG raised the following issues:
  - ✓ Only 22 percent of this RSG was needed and an additional 14 percent appeared to be needed based on MISO's forecasts.
  - ✓ Some resources were committed behind constraints that exacerbated congestion and increased the RSG needed to make these resources whole.
  - ✓ Most fast-start resources (<30 min) were started even though they can provide reserves while offline, increasing RSG without improving reliability.
  - ✓ Issues related to enforcing headroom requirements led to unnecessary commitments—STR replaces the need for headroom requirements.
- We have been discussing these improvements with MISO, which are important because these issues raise costs and undermine the markets' performance.

2022-2023 Planning Resource Auction

Planning Resource Auction Results (Slide 17)

- In the 2022-2023 Planning Resource Auction, the Midwest cleared in shortage.
  - ✓ The Zone 3 CONE value of $236.66 per MW- day set the clearing price.
  - ✓ Multiple factors contributed to the shortage:
    - The load forecast increased over the prior year; and
    - Multiple conventional resources that retired were replaced by the addition of renewable resources that are less reliable due to their intermittent nature.
- We conducted an analysis that illustrates how capacity auction results in previous years contributed to the 2022-2023 Midwest capacity shortage.
  - ✓ Since 2019, MISO has lost almost 5 GW of resources that would have been economic if MISO had employed a reliability-based (sloped) demand curve.
  - ✓ Our estimated auction clearing prices in prior capacity auction years would have covered the net going forward costs of most of these resources, which would likely have allowed MISO to avoid the current capacity shortage.
- This is a market design failure – if reliability is an imperative, MISO's markets must facilitate the long-term decisions that will meet its reliability needs.
  - ✓ This requires adoption of a reliability-base demand curve.

2022 Summer Assessment

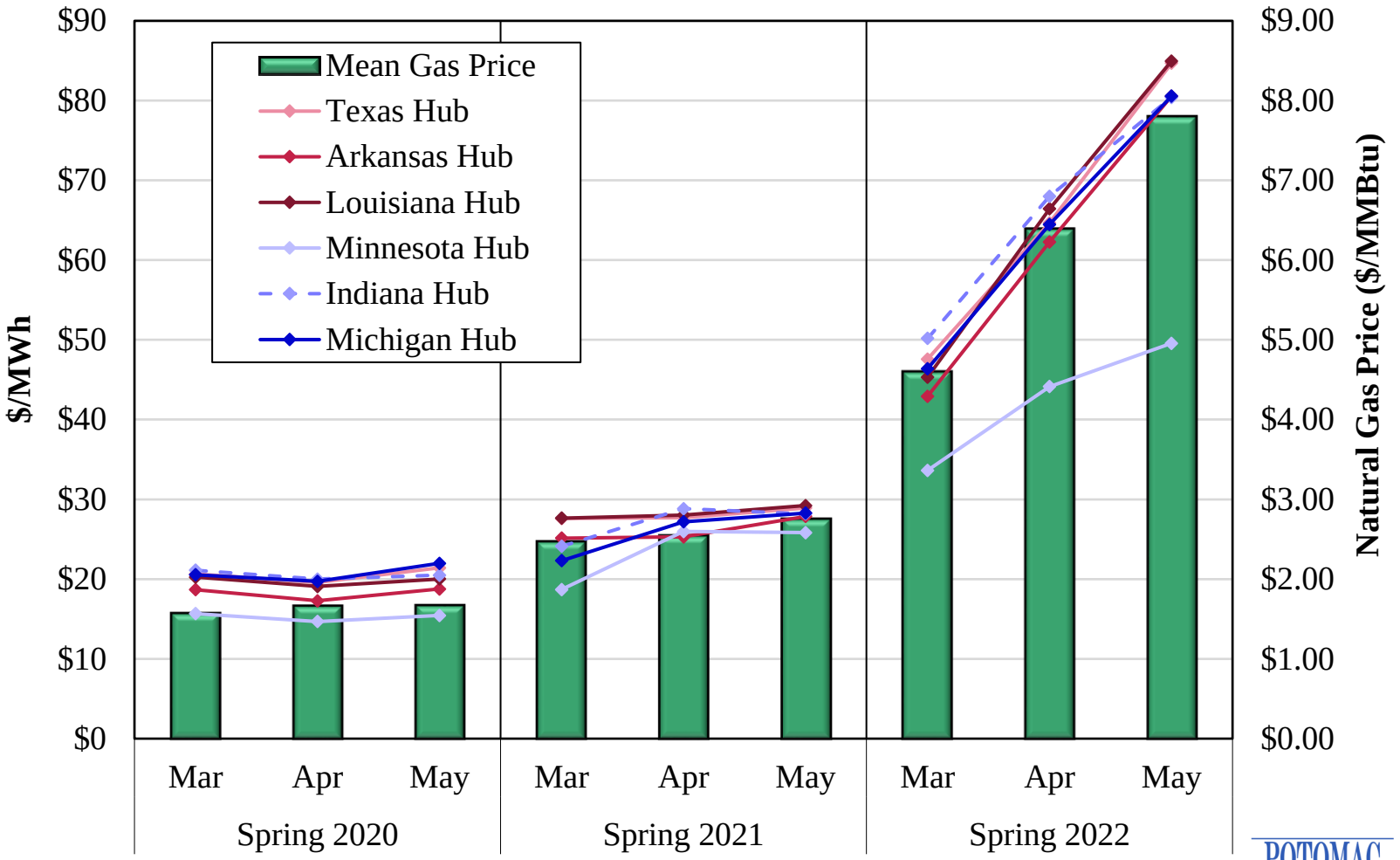
MISO Summer Resource Assessment (Slide 18)

- Although the capacity auction was in shortage in the Midwest, we find MISO should be sufficient during the upcoming summer.
  - ✓ Our projected margin in the Base Case equals MISO's ICAP minimum requirement of 17.9 percent margin.
    - Roughly 1.4 GW of resources scheduled to retire after the Summer are included in our assessment even though they did not participate in the PRA.
  - ✓ In the realistic scenario (assuming typical planned outages during the summer and 75 percent response by LMRs), the margin falls to 9.8 percent.
    - This is sufficient to satisfy the system's needs under normal projected peak conditions and forced outages.
    - However, because 10 percent of MISO's resources are only accessible during emergencies, more frequent emergencies are likely to occur this summer.
- If much hotter conditions occur, MISO may not be able to meet its full system needs because these conditions simultaneously raise load and reduce supply.
  - ✓ MISO has the unique advantage of having substantial import capability from virtually every direction –improvements to MISO's emergency pricing should incent more imports during emergencies.

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 an additional referral regarding conduct by DR resources causing them to receive substantial payments for no actual demand curtailments.
- In April, we met with MISO and a TO working group on Order 881 compliance filing status and related issues on AARs and Emergency Ratings.
  - ✓ We continue to encourage implementation that begins with real-time ratings.
  - ✓ The current framework can capture a most of the potential benefits.
- In April, we presented our Winter Quarterly Report to the Market Subcommittee.
- In April, we made a presentation to the RASC on the application of mitigation measures in the 2022/2023 PRA and monitoring results from prior years.
- We continue to meet with states on the need to reform MISO's PRA demand curve to satisfy the Reliability Imperative.
- In May, we presented to the Illinois Commerce Commission on the 2022/2023 PRA results and recommended improvements.

Day-Ahead Average Monthly Hub Prices
Spring 2020–2022



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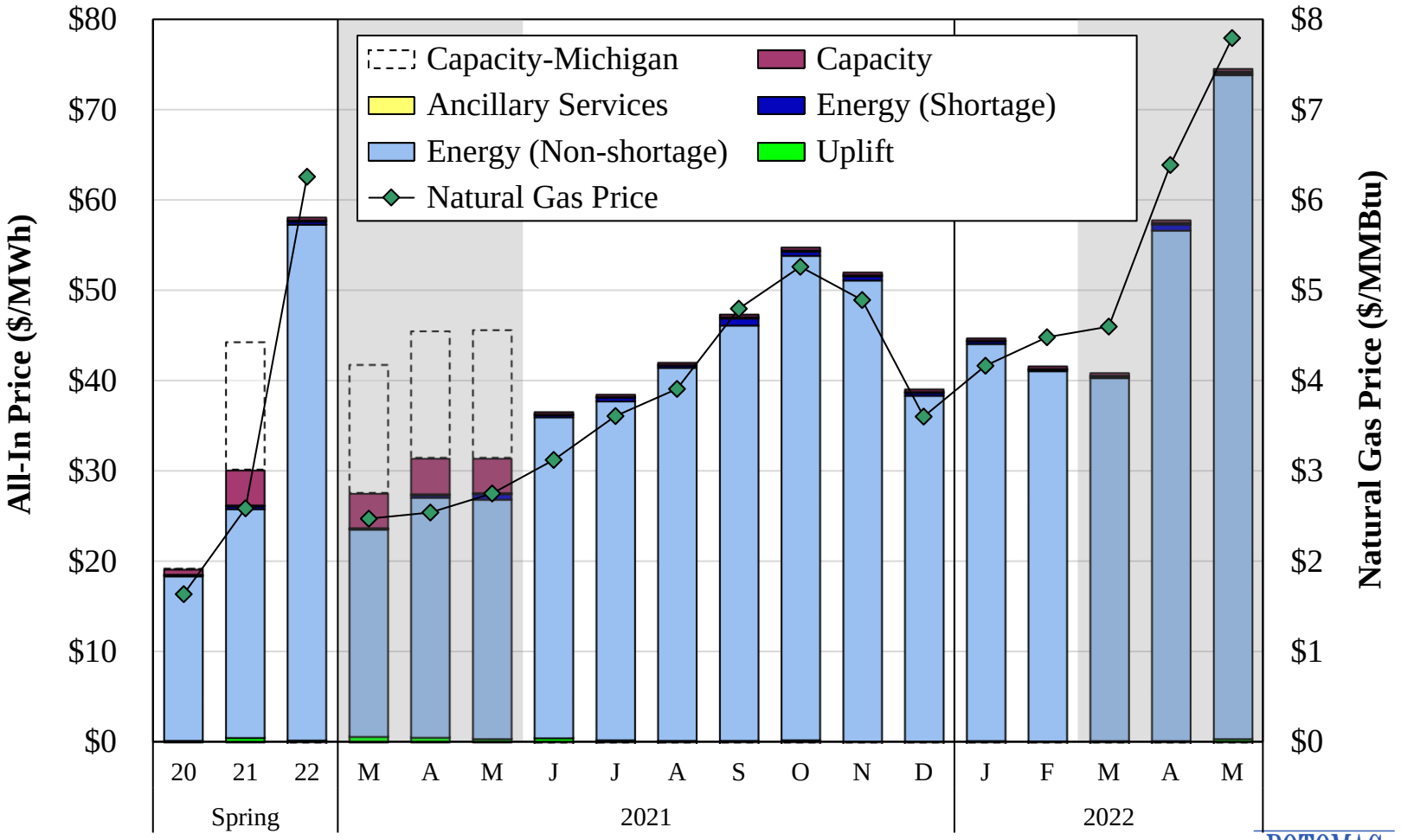
All-In Price
Spring 2020 – 2022



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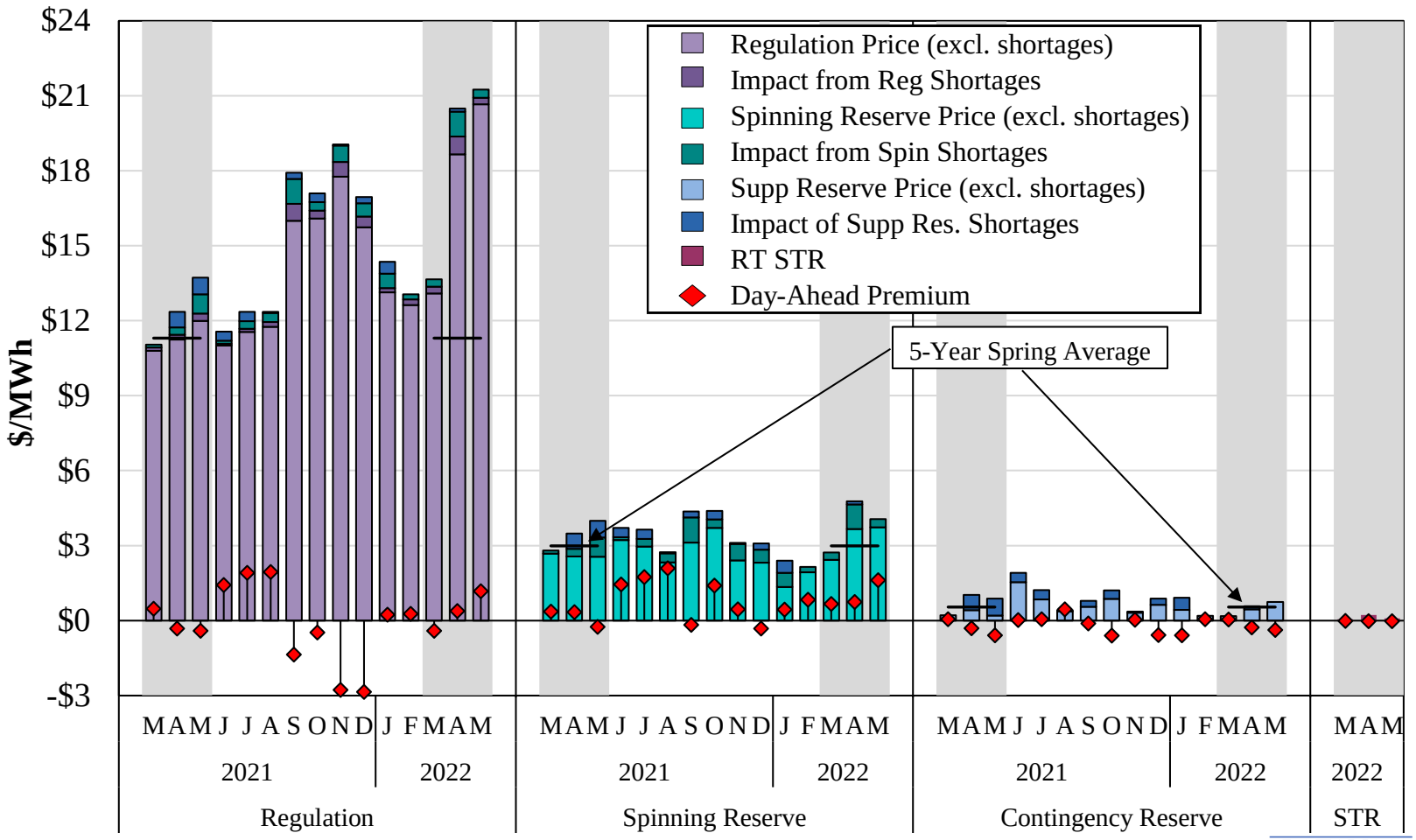
Ancillary Service Prices
Spring 2021–2022



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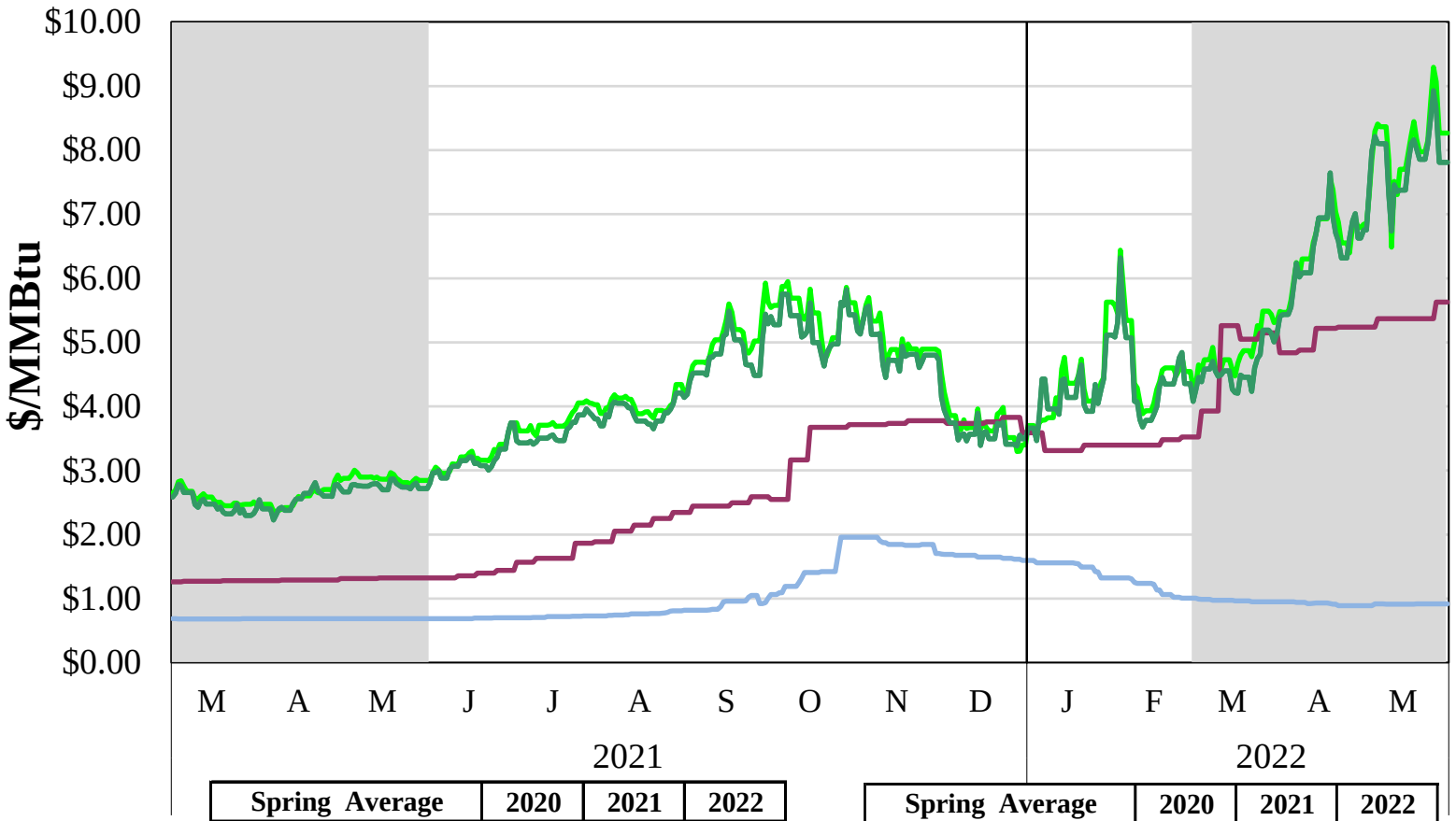
MISO Fuel Prices
2021–2022



Spring Average	2020	2021	2022
Chicago NG	$1.64	$2.59	$6.26
Henry NG	$1.71	$2.67	$6.44

Spring Average	2020	2021	2022
IB Coal	$1.22	$1.29	$5.06
PRB Coal	$0.69	$0.68	$0.93

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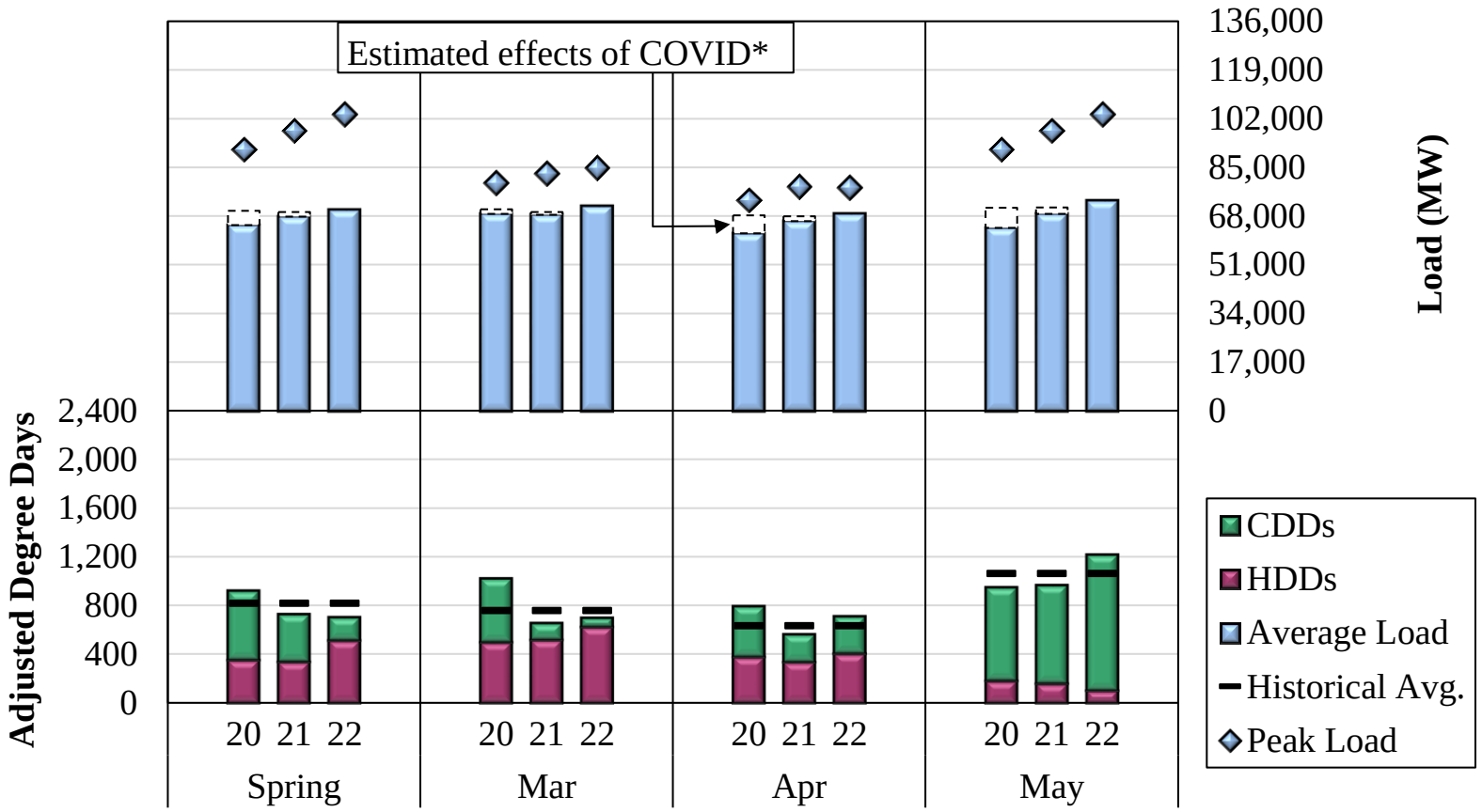
Load and Weather Patterns
Spring 2020–2022



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.

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Capacity, Energy and Price Setting Share
Spring 2021–2022

Spring	Unforced Capacity				Energy Output		Price Setting			
	Total (MW)		Share (%)		Share (%)		SMP (%)		LMP (%)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Nuclear	11,866	11,701	9%	9%	16%	14%	0%	0%	0%	0%
Coal	46,341	43,123	36%	34%	36%	31%	43%	20%	88%	44%
Natural Gas	58,334	59,901	45%	47%	28%	31%	56%	79%	97%	83%
Oil	1,636	1,474	1%	1%	0%	0%	0%	0%	1%	0%
Hydro	3,696	3,695	3%	3%	2%	2%	1%	1%	2%	2%
Wind	4,304	4,454	3%	3%	17%	20%	0%	0%	72%	82%
Solar	419	1,037	0%	1%	0%	0%	0%	0%	2%	6%
Other	2,603	2,734	2%	2%	1%	3%	0%	0%	7%	4%
Total	**129,199**	**128,120**								

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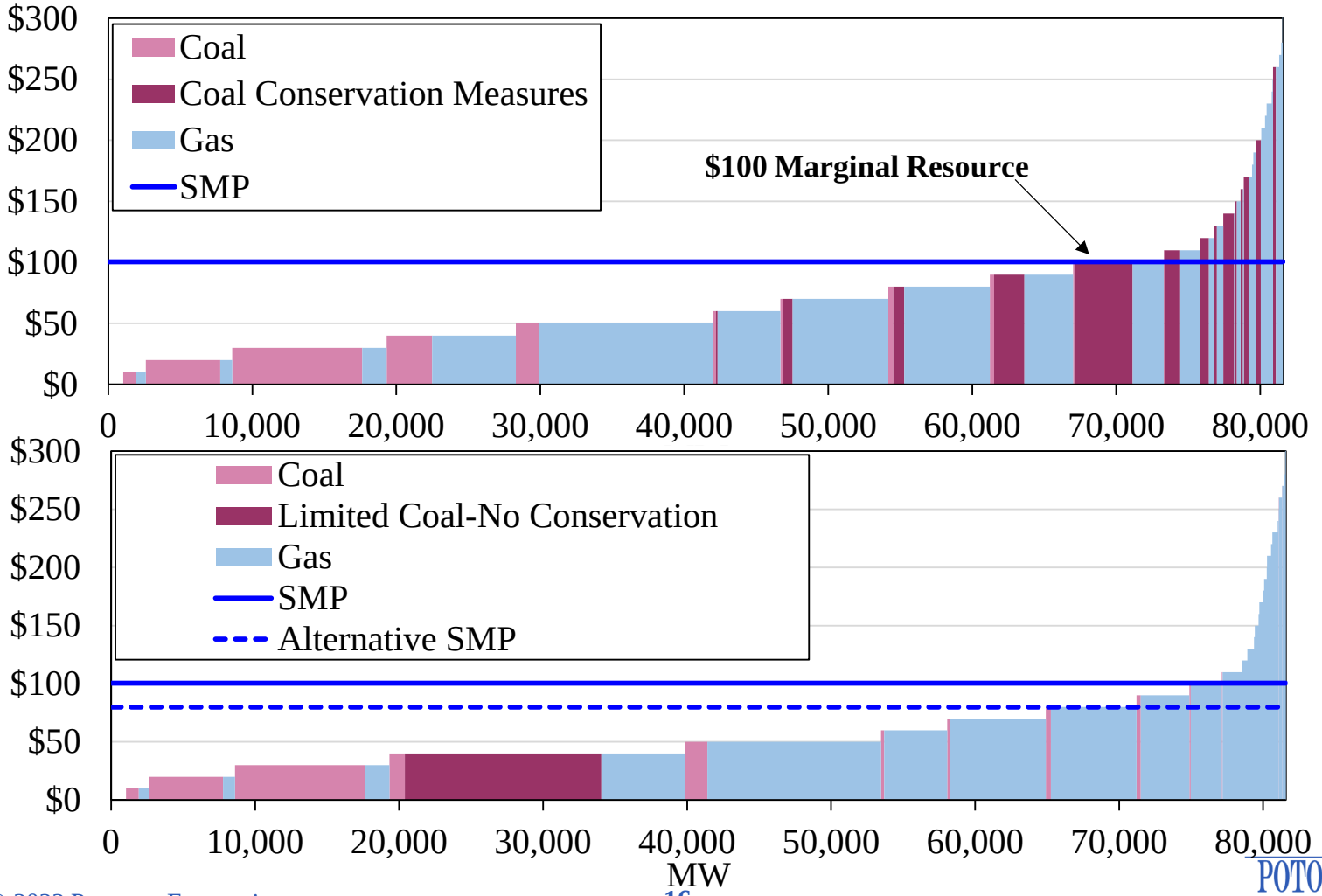
Effects of Coal Conservation Measures
May 12 Hour Beginning 16



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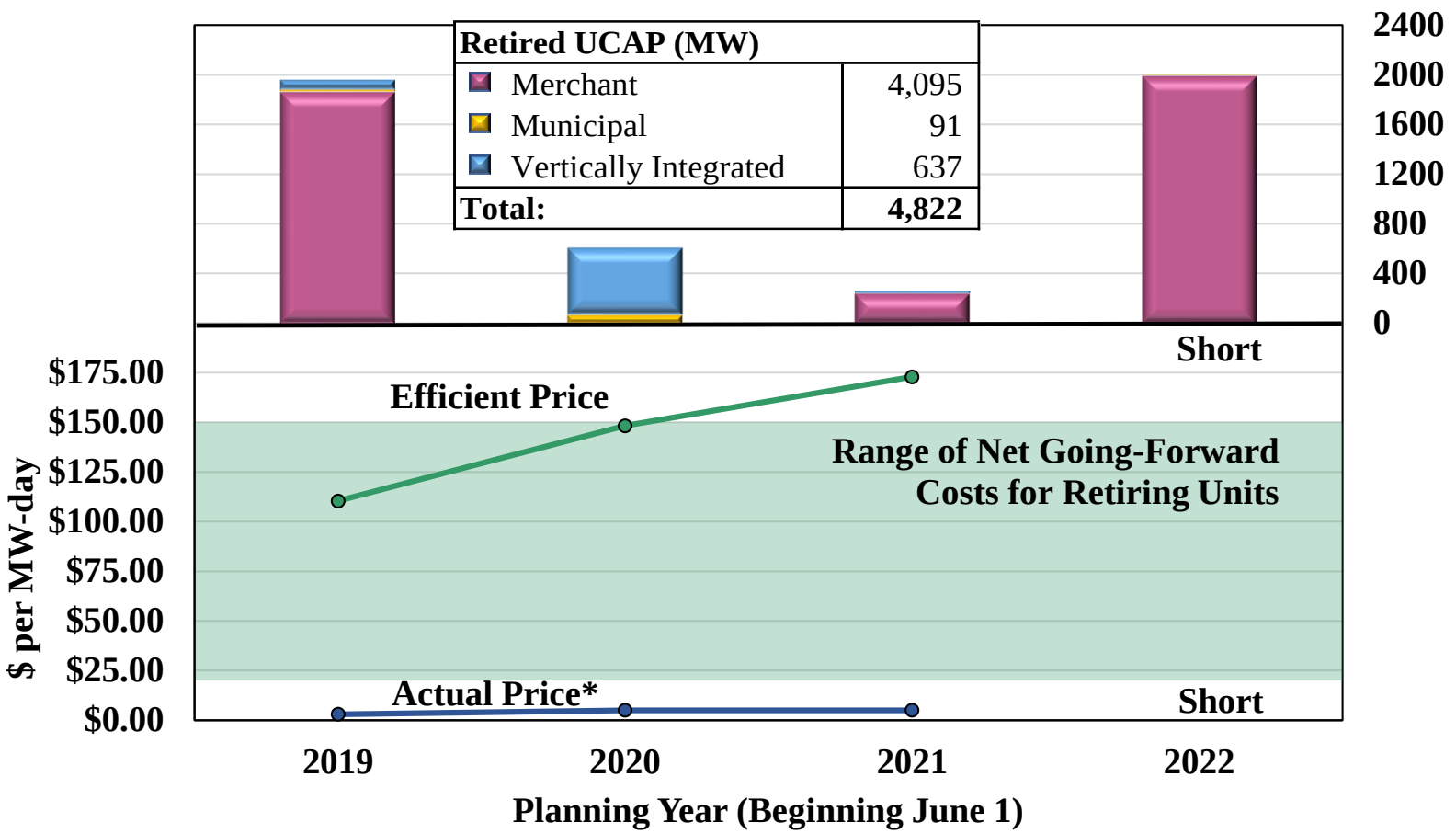
Midwest Capacity Shortage
2022-2023 PRA



* Actual prices are the unconstrained auction clearing prices of the Midwest. Zone 7 separated in 2019 and 2020.

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2022 Summer Assessment

	Base Scenario	Alternative IMM Scenarios*			
		Realistic Scenario	Realistic <=2HR	High Temperature Realistic Scenario	High Temperature Realistic <=2HR
Load					
Base Case	124,505	124,505	124,505	124,505	124,505
High Load Increase	-	-	-	6,974	6,974
Total Load (MW)	124,505	124,505	124,505	131,479	131,479
Generation					
Internal Generation Excluding Exports	131,726	131,726	131,726	131,726	131,726
BTM Generation	4,473	4,473	3,276	4,473	3,276
Unforced Outages and Derates**	-	(9,319)	(9,319)	(16,919)	(16,919)
Adjustment due to Transfer Limit	(1,329)	-	-	-	-
Total Generation (MW)	134,870	126,880	125,683	119,280	118,083
Imports and Demand Response* **					
Demand Response (ICAP)	8,181	6,136	3,042	6,136	3,042
Firm Capacity Imports	3,700	3,700	3,700	3,700	3,700
Margin (MW)	22,246	12,210	7,920	(2,364)	(6,654)
Margin (%)	**17.9%**	**9.8%**	**6.4%**	**-1.8%**	**-5.1%**
Expected Capacity Uses and Additions					
Expected Forced Outages****	(6,810)	(6,515)	(6,515)	(6,515)	(6,515)
Non-Firm Net Imports in Emergencies	4,293	4,293	4,293	4,293	4,293
Expected Margin (MW)	19,729	9,989	5,698	(4,585)	(8,876)
Expected Margin (%)	**15.8%**	**8.0%**	**4.6%**	**-3.5%**	**-6.8%**

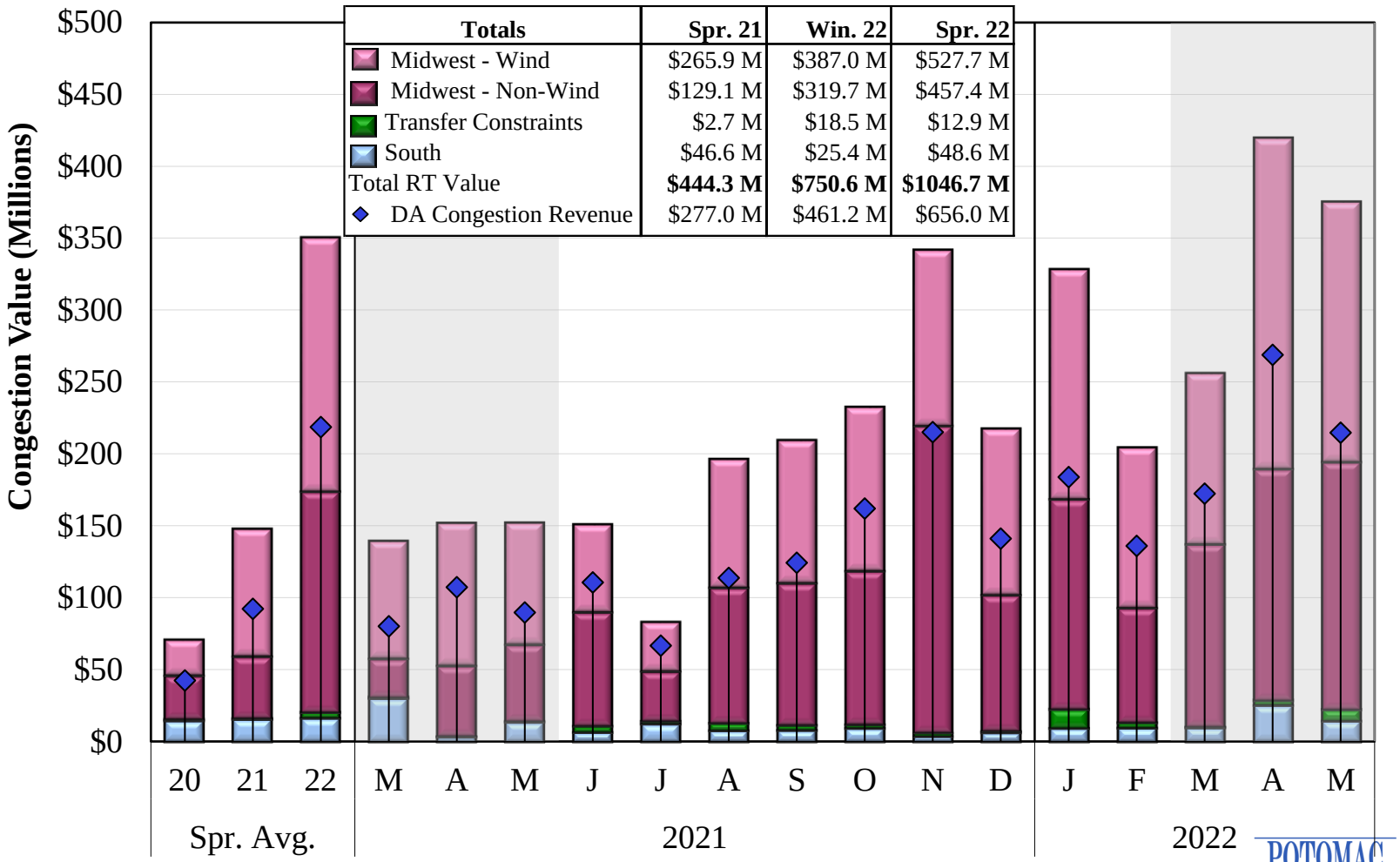
* Assumes 75% response from DR.

** Base scenario shows approved planned outages for summer 2022. Realistic cases use historical average unforced outages/derates during peak summer hours. High temp. cases are based upon MISO's 2022 Summer Assessment.

*** Cleared amounts for the 2022/2023 planning year.

**** Base scenario assumes 5% forced outage rate for internal and BTM generation. Alternative cases use historical average forced outages/derates during peak summer hours.

Value of Real-Time Congestion
Spring 2021–2022



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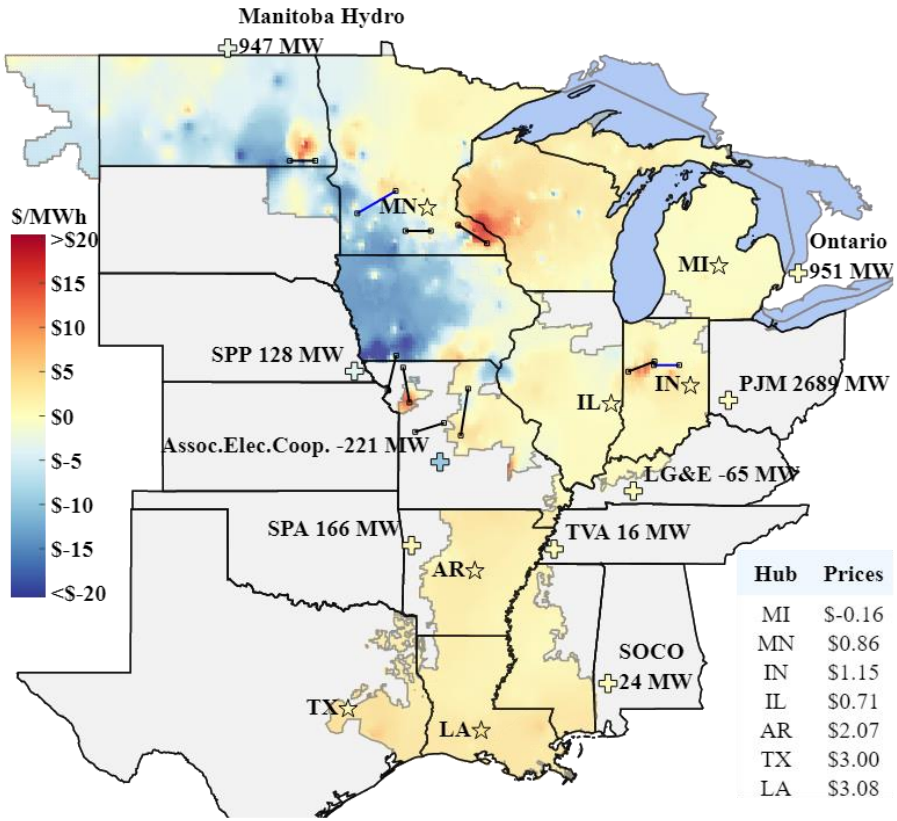
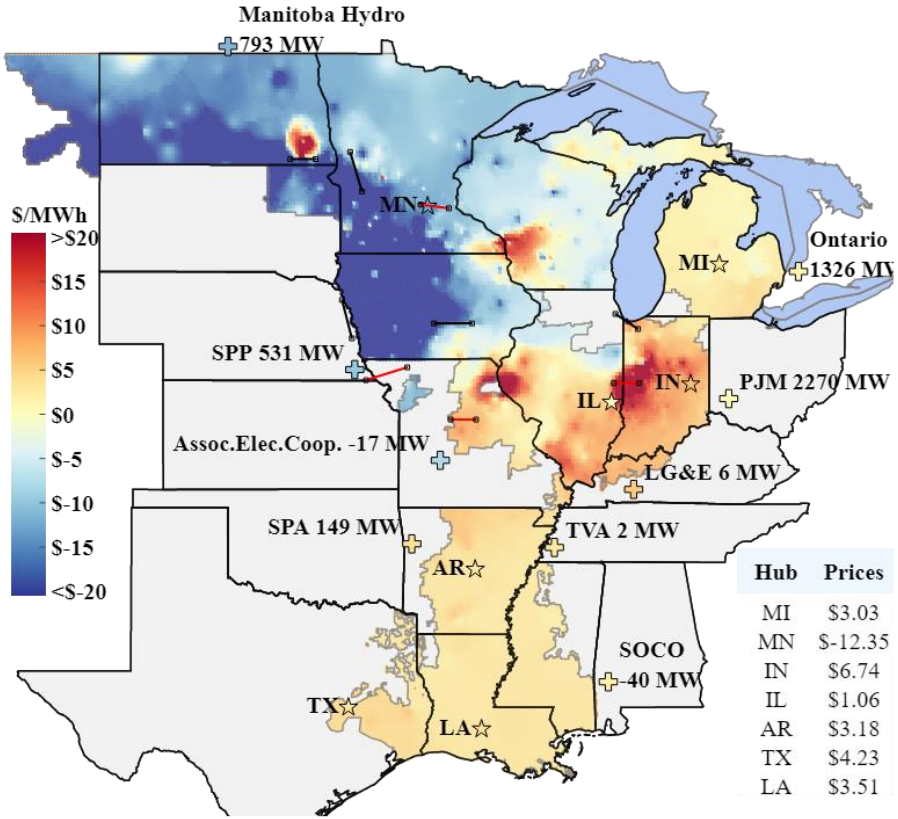
Average Real-Time Congestion Components
Spring 2021–2022

Spring 2021



Hub	Prices
MI	$-0.16
MN	$0.86
IN	$1.15
IL	$0.71
AR	$2.07
TX	$3.00
LA	$3.08

Spring 2022



Hub	Prices
MI	$3.03
MN	$-12.35
IN	$6.74
IL	$1.06
AR	$3.18
TX	$4.23
LA	$3.51

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Day-Ahead Congestion, Balancing Congestion and FTR Underfunding

Spring Totals	2021	2022
Balancing Congestion Revenue	($6.7 M)	($49.9 M)
DA Congestion Revenues	$277.0 M	$656.0 M
FTR Surplus (Shortfall)	($2.3 M)	$45.3 M
FTR Funding (%)	99.7%	102.5%

$240
$200
$160
$120
$80
$40
$0

$10
$0
-$10
-$20
-$30
-$40
-$50

20 21 22 M A M J J A S O N D J F M A M

Spring 2021 2022

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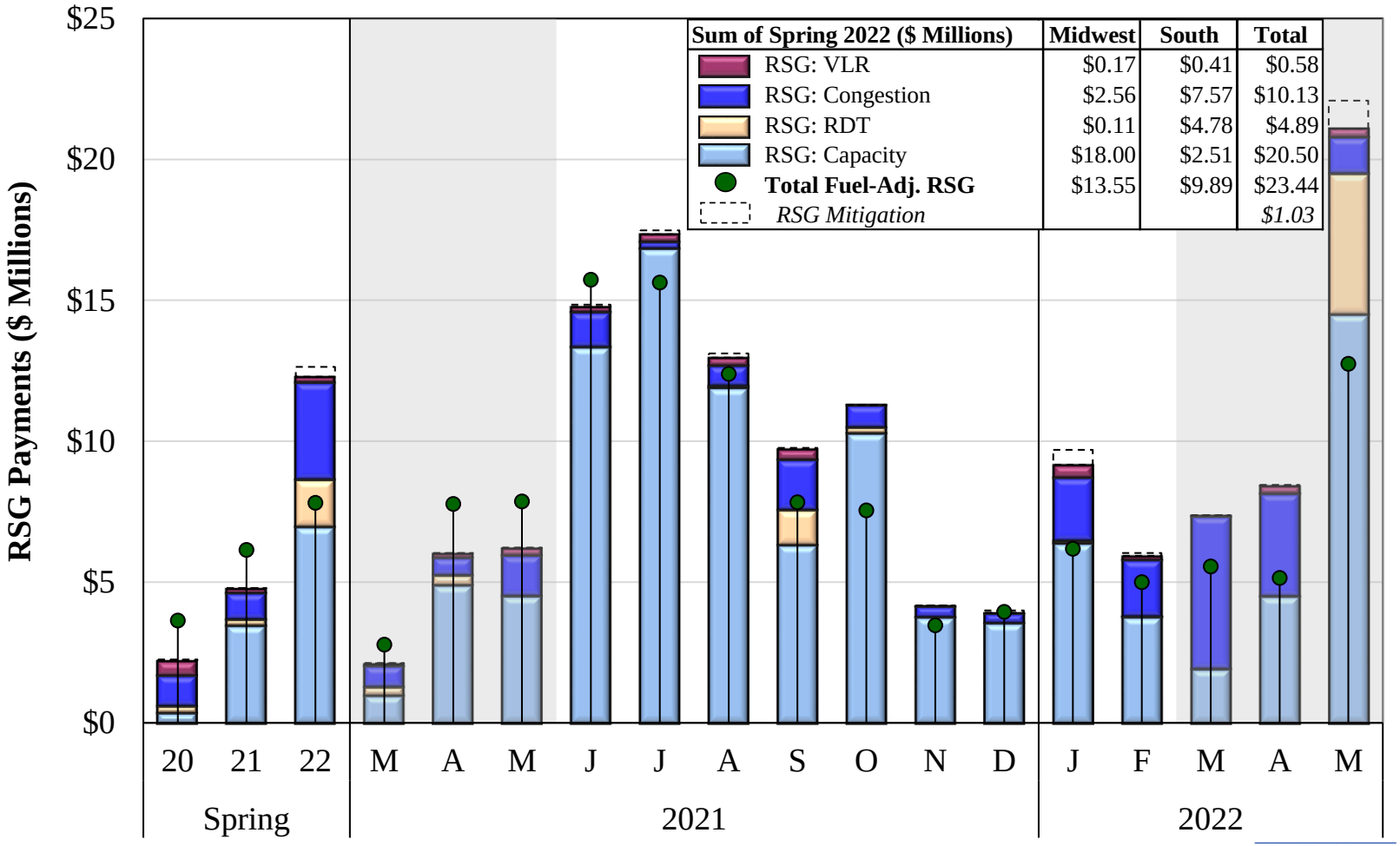
Benefits of Ambient-Adjusted and Emergency Ratings Spring 2021–2022

Spring		Savings ($ Millions)			# of Facilites for 2/3 of Savings	Share of Congestion
		Ambient Adj. Ratings	Emergency Ratings	Total		
2021	**Midwest**	$29.8	$18.87	$48.7	8	11.9%
	South	$0.8	$1.79	$2.6	1	5.7%
	Total	**$30.6**	**$20.7**	**$51.3**	**9**	**11.2%**
2022	**Midwest**	$75.1	$52.34	$127.4	5	13.1%
	South	$0.1	$1.40	$1.5	2	4.7%
	Total	**$75.2**	**$53.7**	**$128.9**	**7**	**12.8%**

Real-Time RSG Payments
Spring 2021–2022



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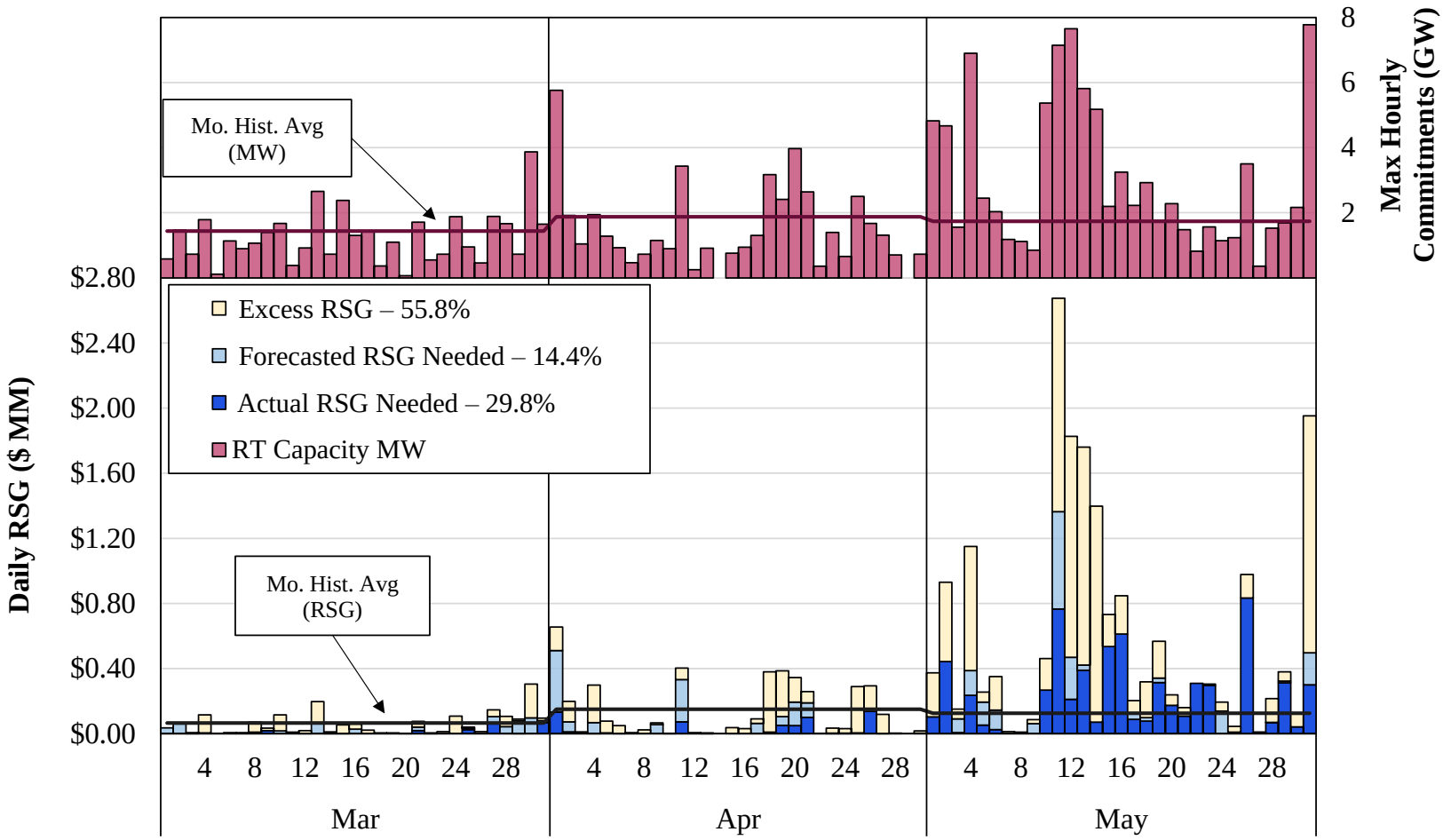
Real-Time Capacity Commitment and RSG



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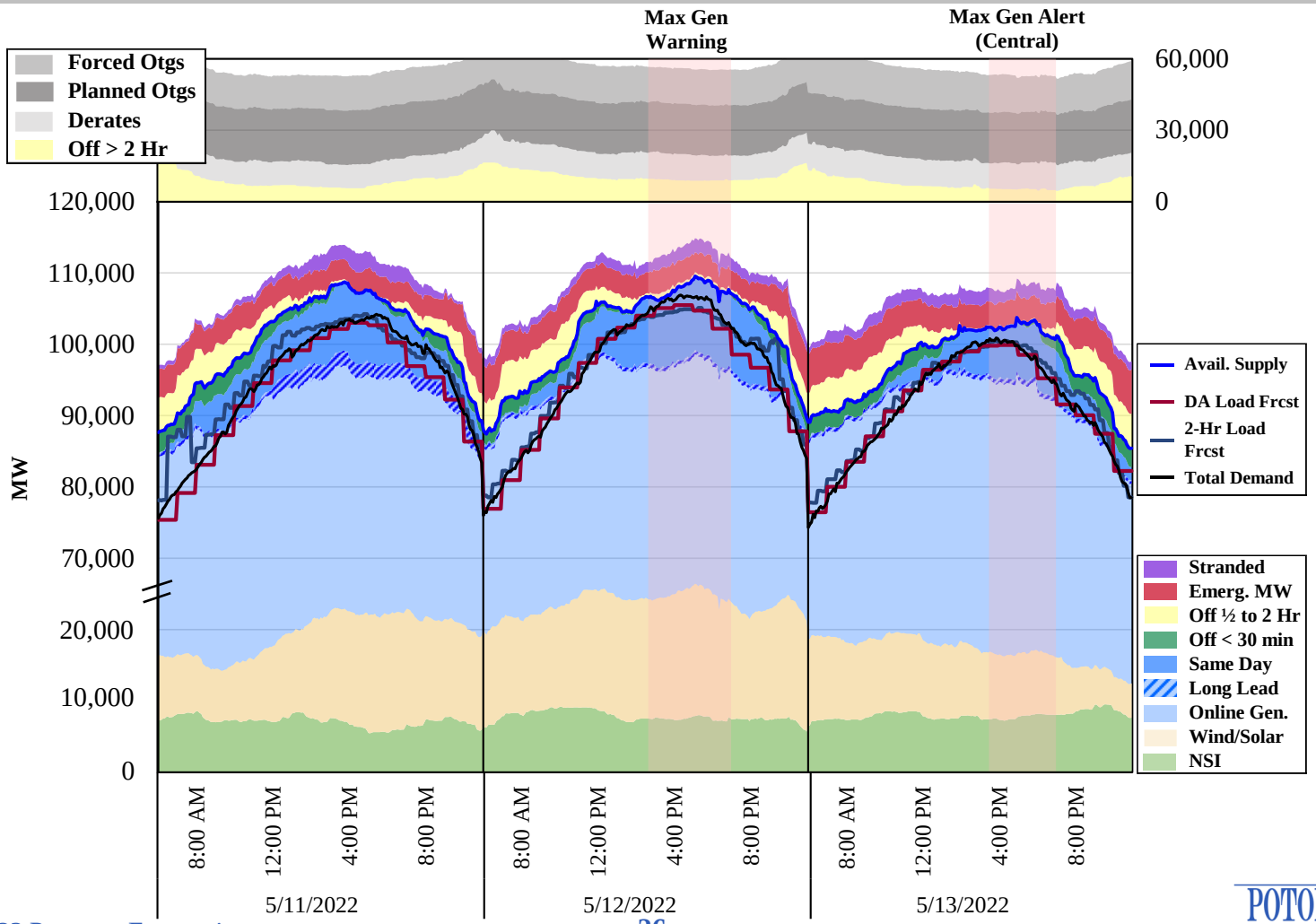
Average Daily High Temperatures

	May-22				
	10	**11**	**12**	**13**	**14**
Minneapolis	80(65)	79(62)	92(62)	75(65)	75(68)
Detroit	80(69)	82(65)	86(64)	82(66)	81(68)
Indianapolis	86(73)	89(72)	87(69)	85(70)	87(71)
Chicago	89(68)	90(65)	91(63)	89(68)	86(68)
Little Rock	90(79)	94(79)	94(78)	97(80)	89(78)
New Orleans	86(85)	89(85)	92(85)	87(85)	88(85)
Houston	89(87)	89(85)	90(84)	91(85)	91(85)

Notes: 80 (65) means 80 is actual high temperature in degrees Fahrenheit, and (65) is the 20-year average high daily temperature.

Max Gen Warning & Central Alert
May 11-13, 2022



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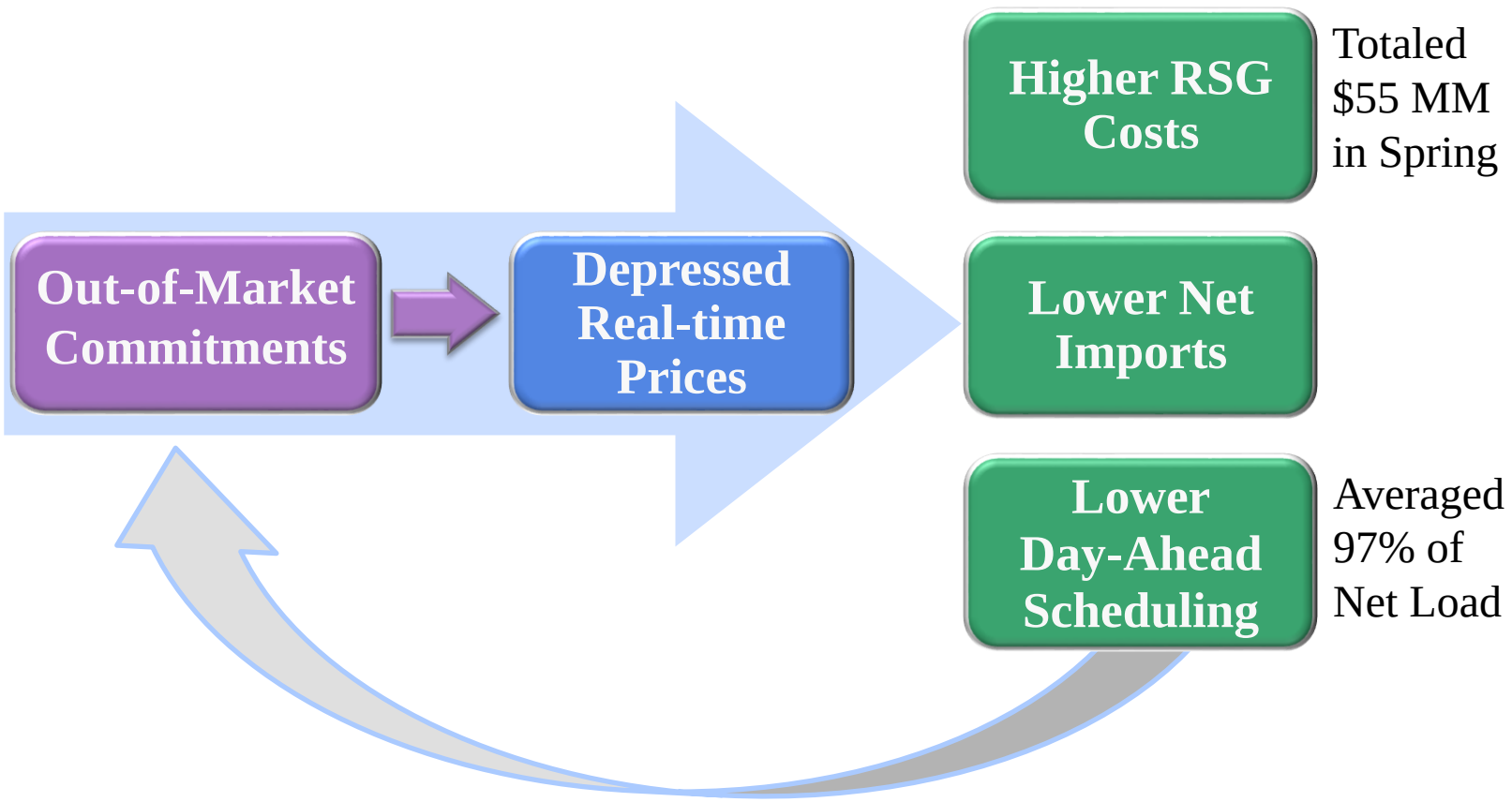
Feedback Effects of Out-of-Market Commitments



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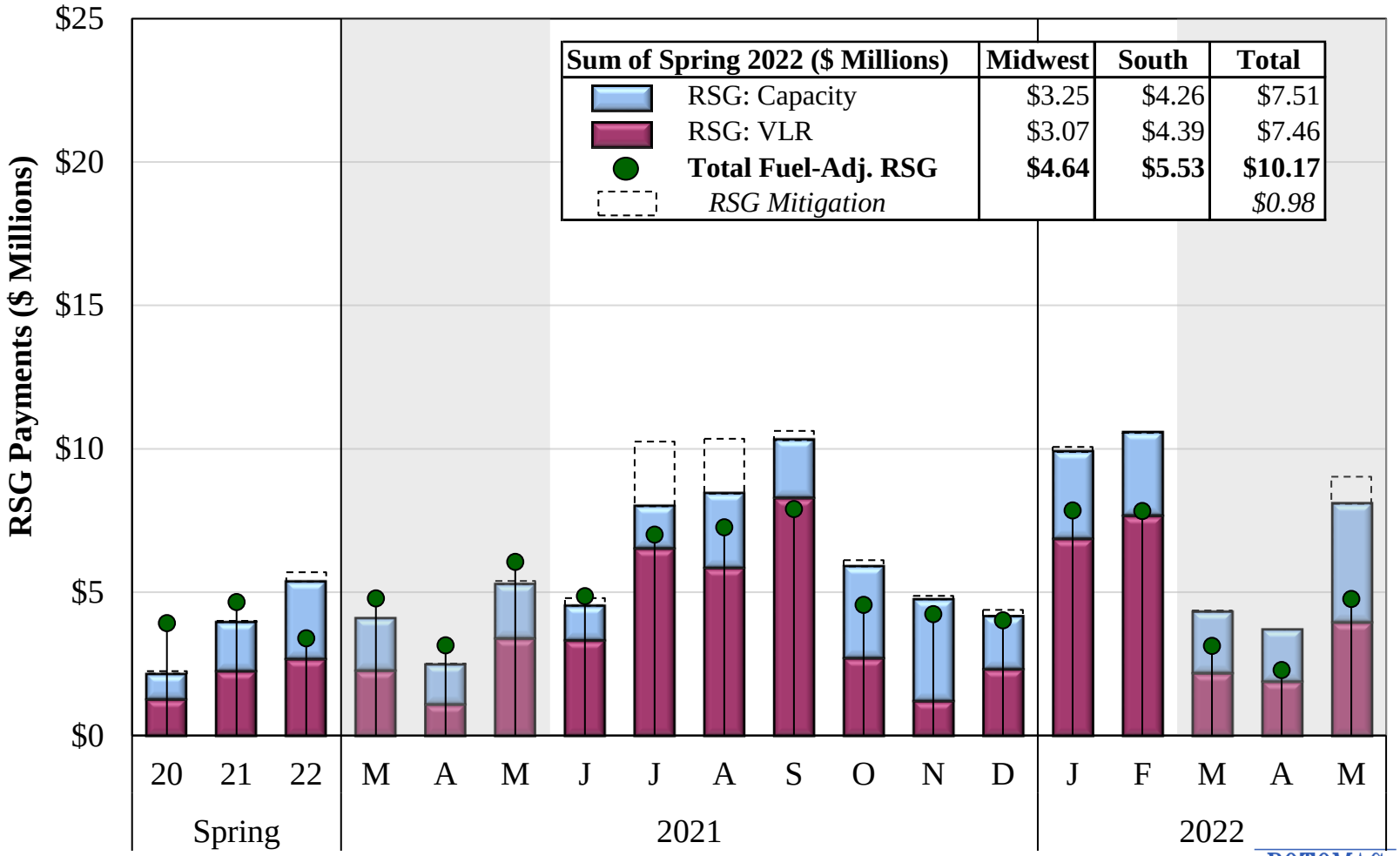
Day-Ahead RSG Payments
Spring 2021–2022



Sum of Spring 2022 ($ Millions)	Midwest	South	Total
RSG: Capacity	$3.25	$4.26	$7.51
RSG: VLR	$3.07	$4.39	$7.46
Total Fuel-Adj. RSG	**$4.64**	**$5.53**	**$10.17**
RSG Mitigation			*$0.98*

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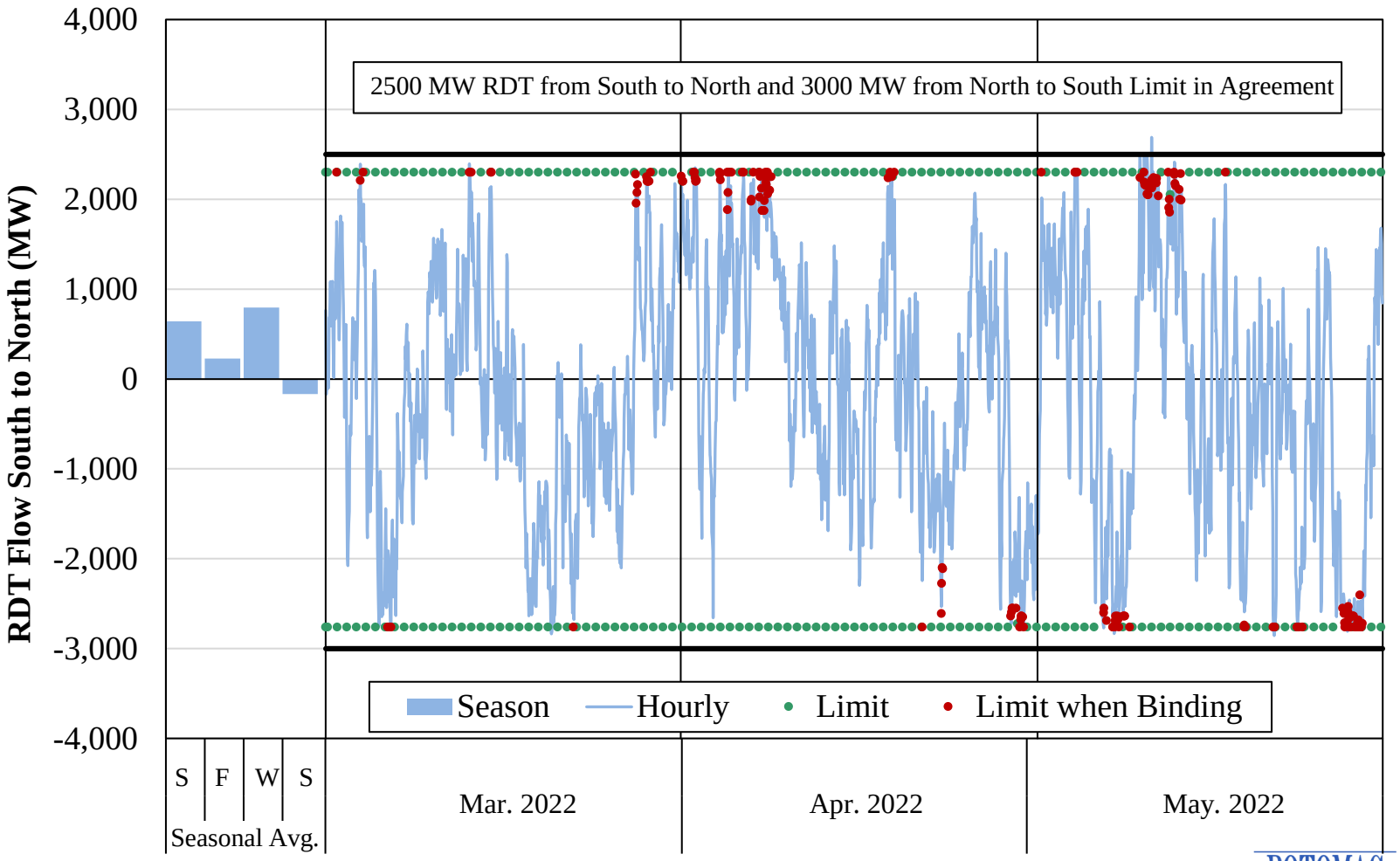
Real-Time Hourly Inter-Regional Flows
Spring 2022



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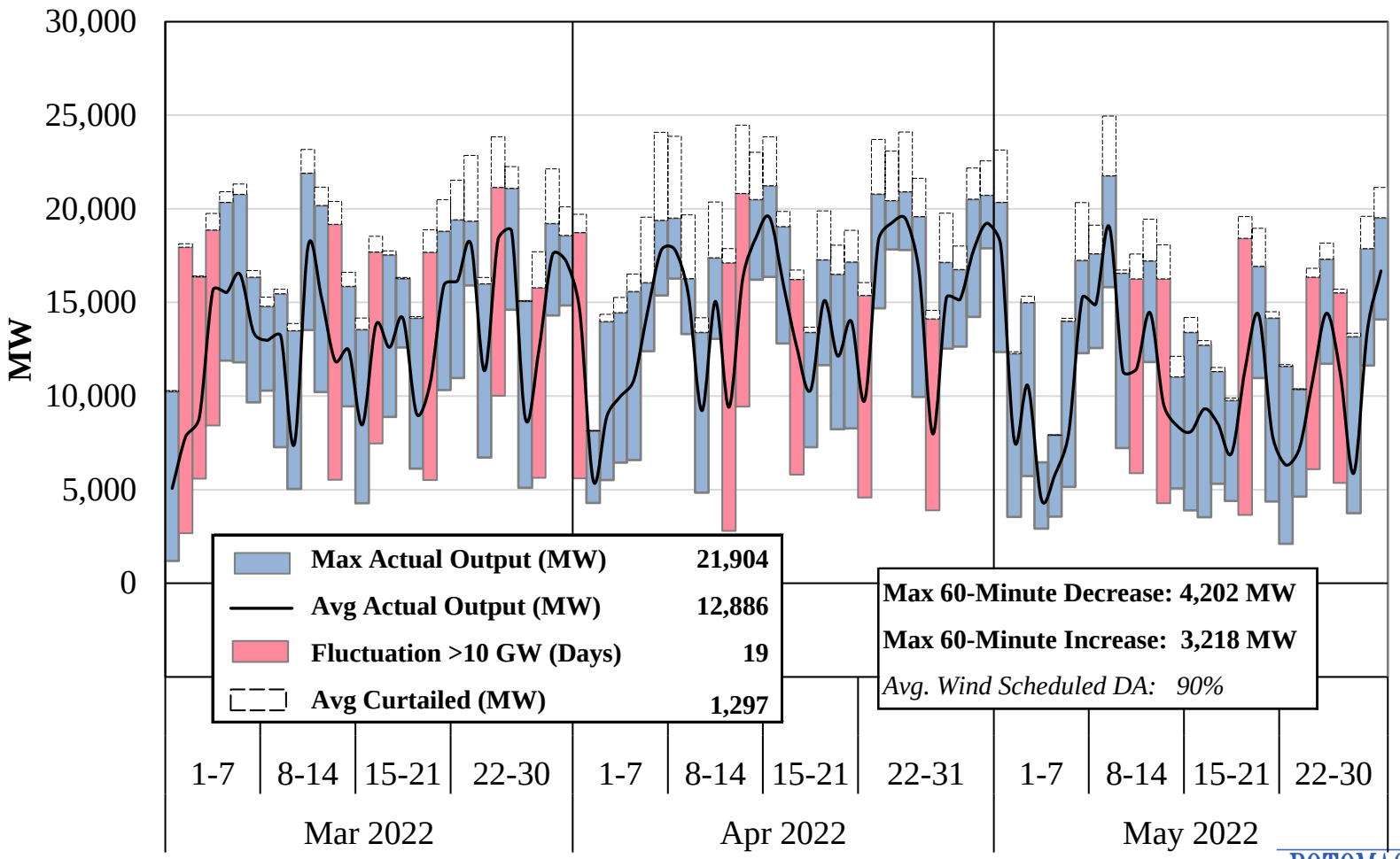
Wind Output in Real Time
Daily Range and Average



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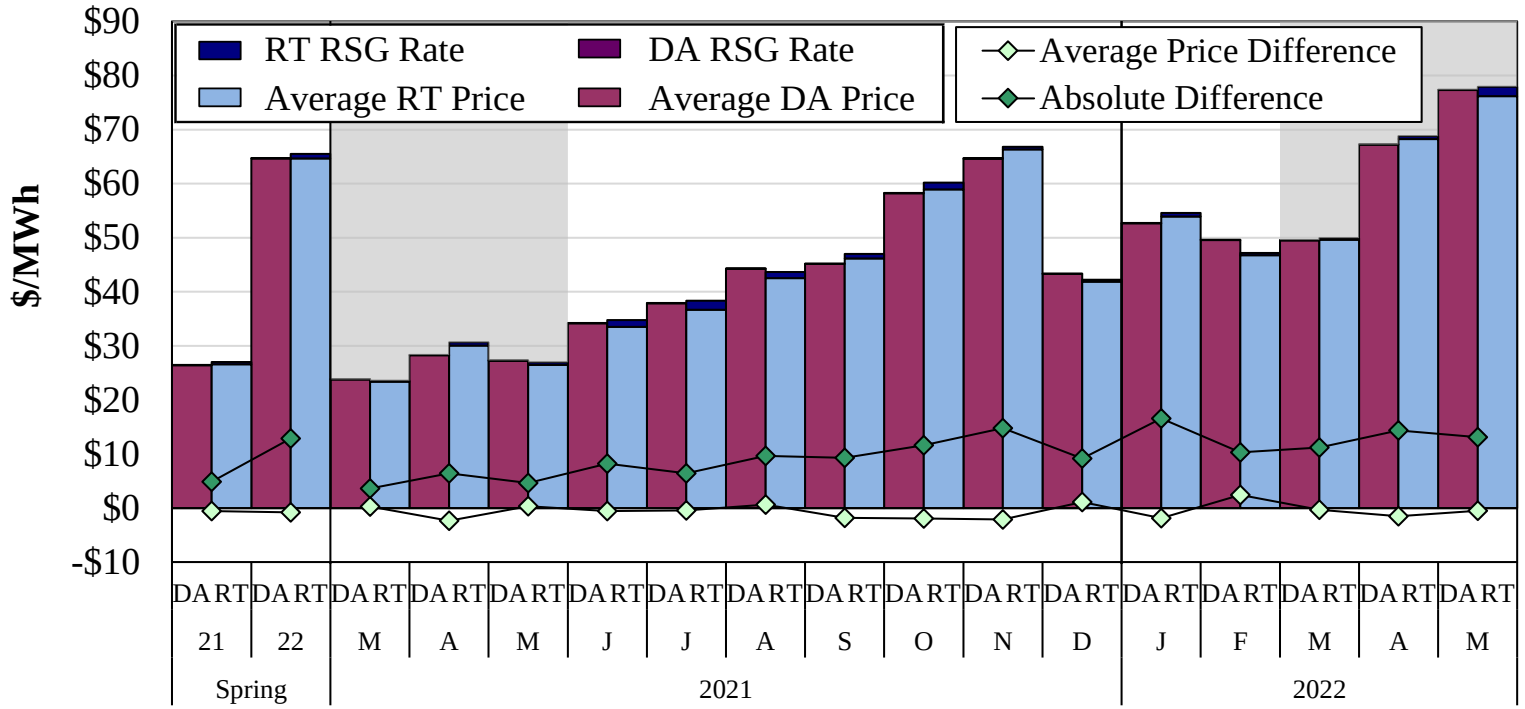
Day-Ahead and Real-Time Price Convergence
Spring 2021–2022



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

Indiana Hub	-2	-1	1	-8	1	-2	-1	1	-4	-3	-3	3	-3	5	-1	-2	-1
Michigan Hub	-1	2	-1	-4	1	-3	0	1	-3	-1	-1	1	-3	6	3	-3	5
Minnesota Hub	-7	3	3	-15	-9	-5	1	1	-7	-2	2	0	3	8	8	2	-1
Arkansas Hub	-3	4	-3	-6	-1	1	-5	3	-5	-2	5	-2	-2	3	3	3	6
Texas Hub	-3	5	-6	0	-2	4	-1	3	-4	2	6	-1	-4	4	4	1	9
Louisiana Hub	-3	5	-10	0	1	2	0	8	-5	3	3	-1	-3	5	4	4	8

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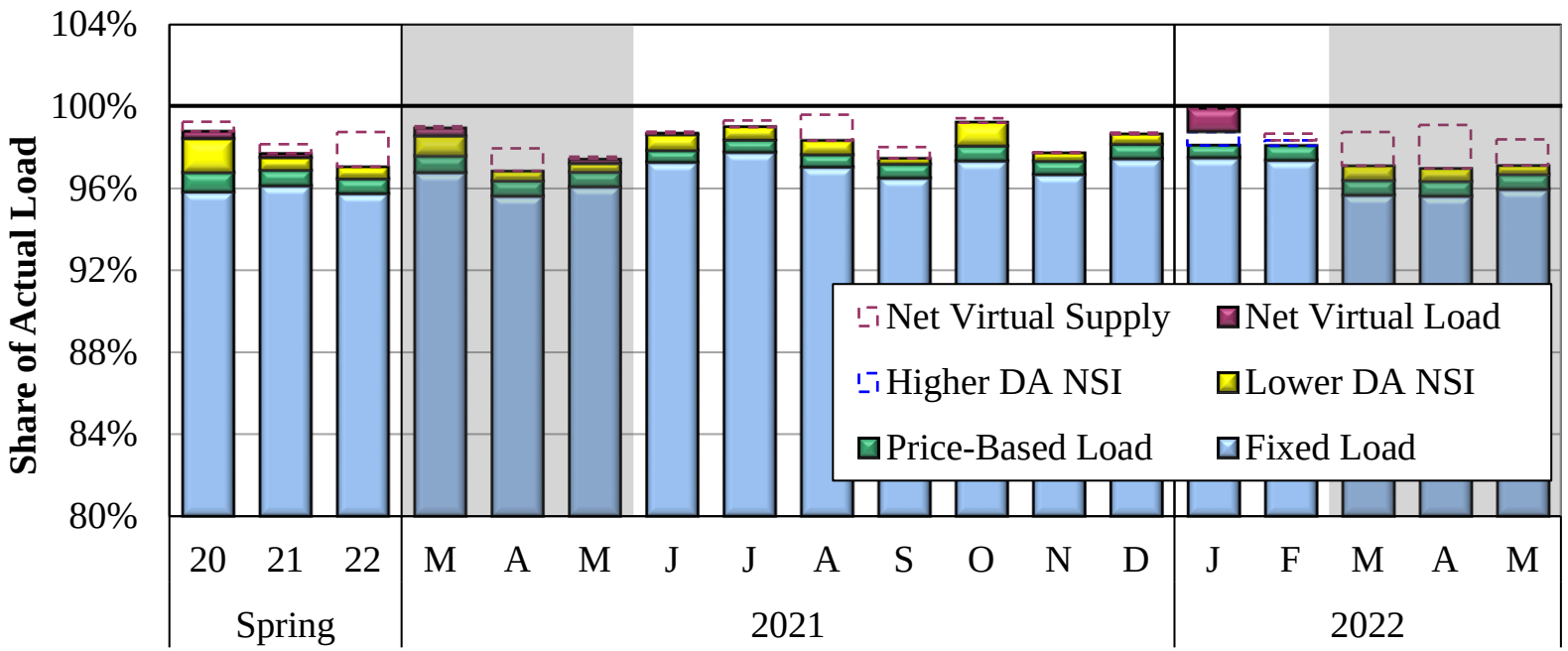
Day-Ahead Peak Hour Load Scheduling
Spring 2021–2022

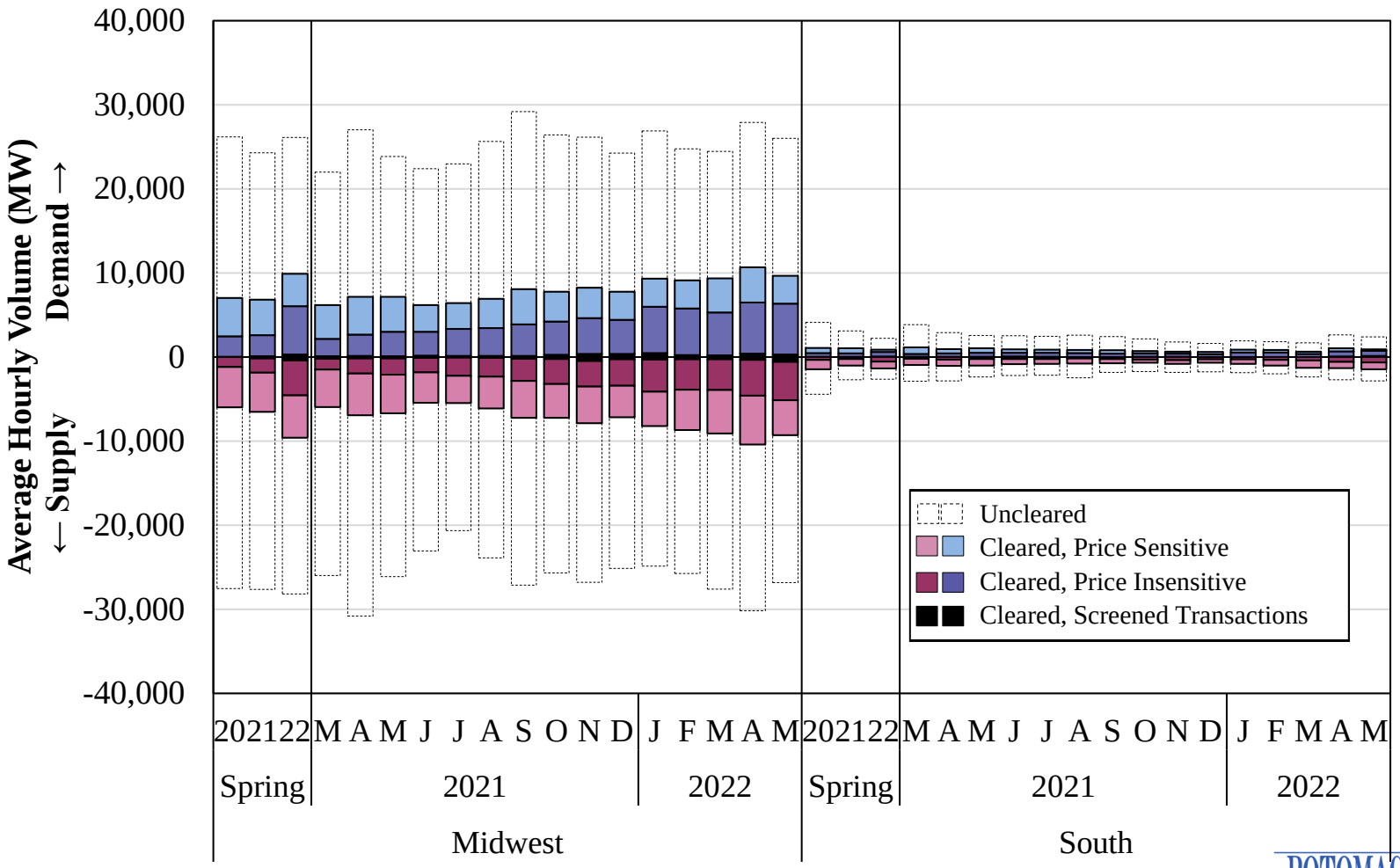


Share of Actual Load (%)

All Hours	99.2	97.8	97.5	98.3	97.2	97.7	98.9	99.7	99.8	98.3	99.2	97.8	98.9	98.9	97.8	97.3	97.5	97.6
Peak Hours Midwest	98.9	96.6	96.2	97.3	96.0	96.5	97.6	98.3	96.9	97.0	98.7	97.6	99.0	99.8	98.1	96.5	96.0	96.1
Peak Hours South	100.2	100.6	99.0	102.3	100.3	99.2	101.6	100.9	101.8	99.3	100.2	101.4	101.3	98.8	100.0	98.8	99.1	99.0

POTOMAC ECONOMICS

Virtual Load and Supply
Spring 2021–2022



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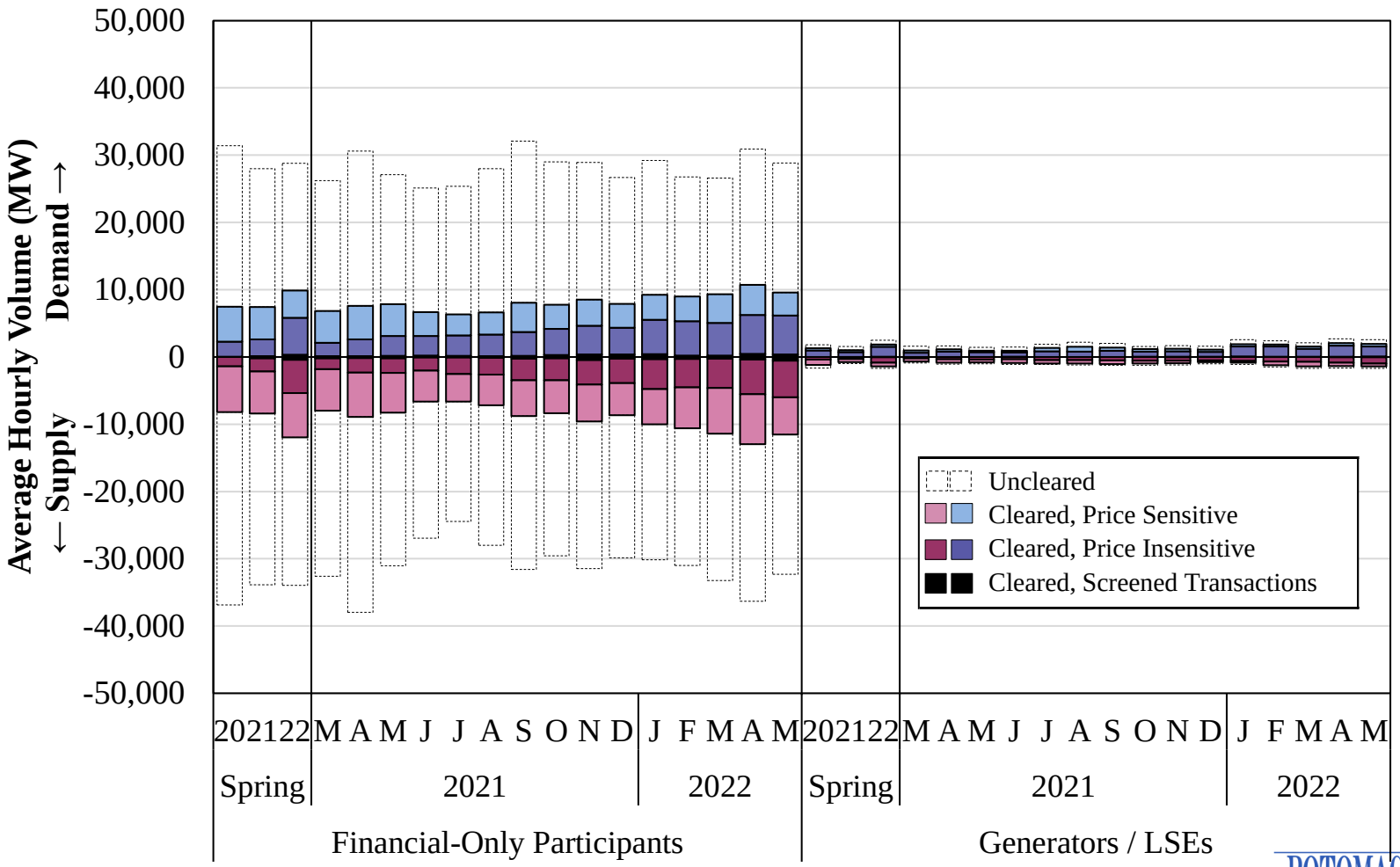
Virtual Load and Supply by Participant Type
Spring 2021–2022



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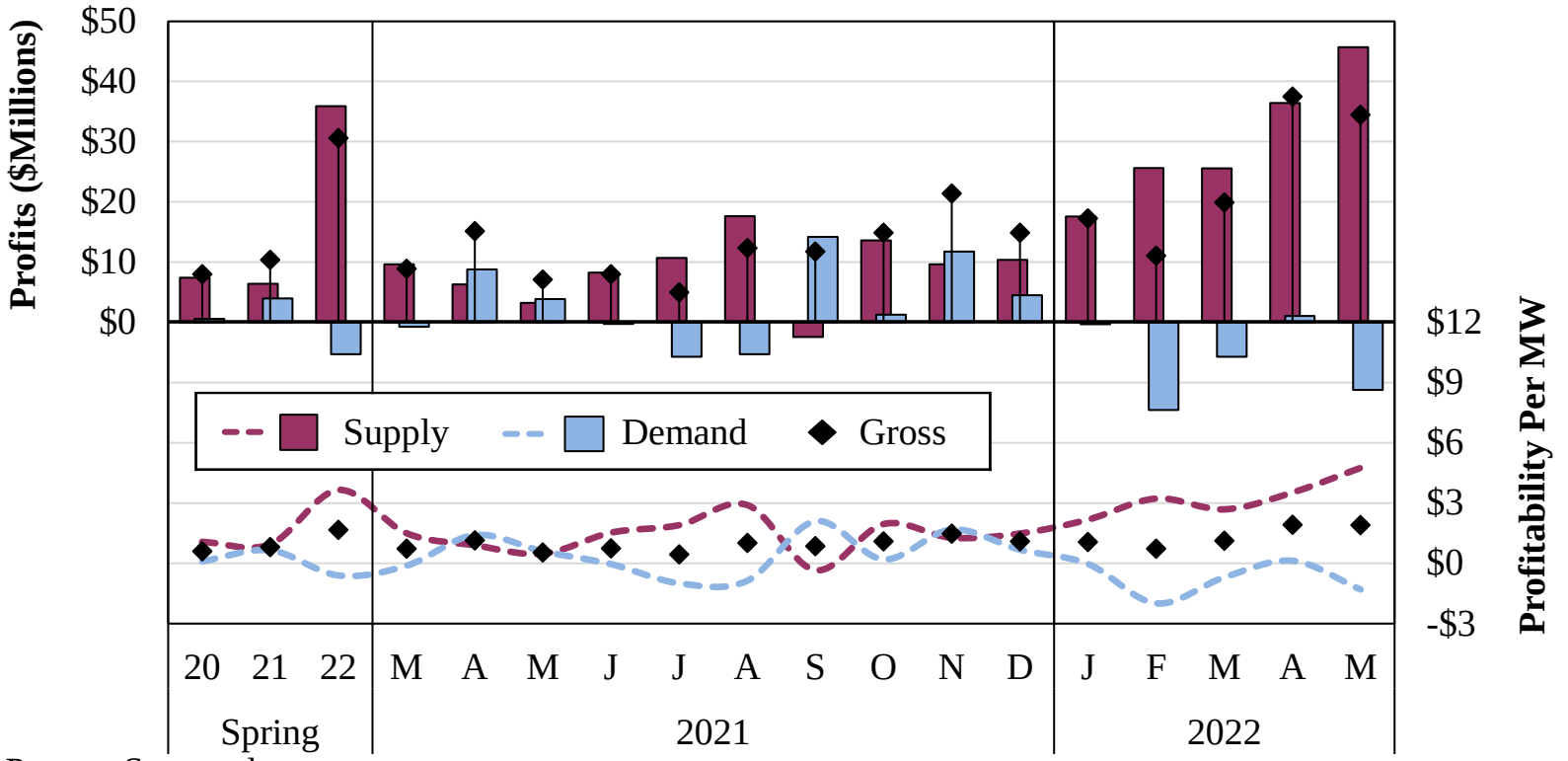
Virtual Profitability
Spring 2021–2022



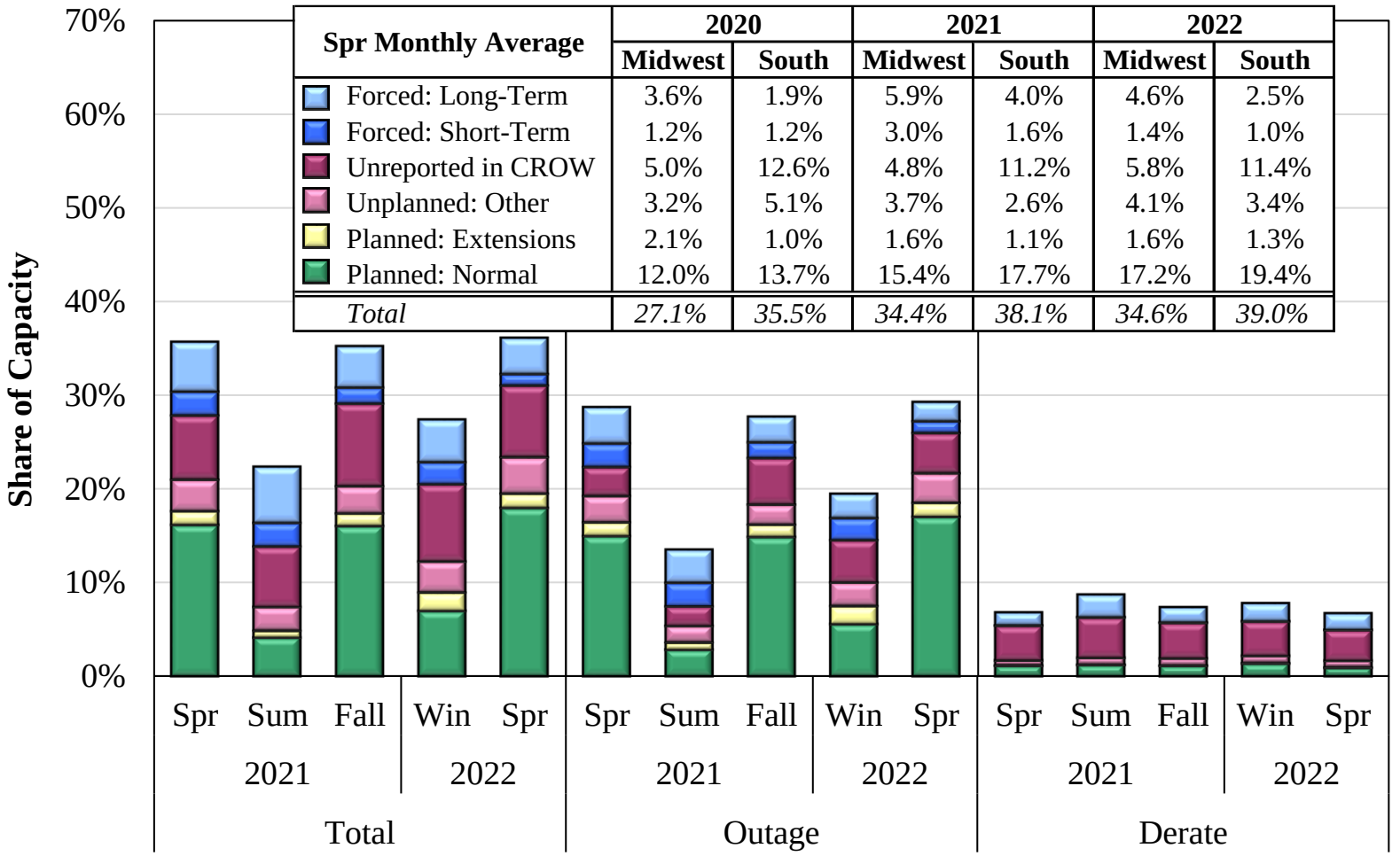
Percent Screened

Supply	0.3	2.3	3.4	2.5	2.0	2.4	1.4	1.4	1.6	2.8	2.7	4.9	2.9	3.3	2.6	2.4	3.0	4.9
Demand	0.6	1.6	3.3	1.4	1.7	1.8	3.0	2.0	1.6	1.7	3.5	4.3	4.5	4.4	2.3	1.9	3.8	3.9
Total	0.4	2.0	3.3	2.0	1.9	2.1	2.2	1.7	1.6	2.3	3.1	4.6	3.7	3.9	2.5	2.2	3.4	4.4

POTOMAC ECONOMICS

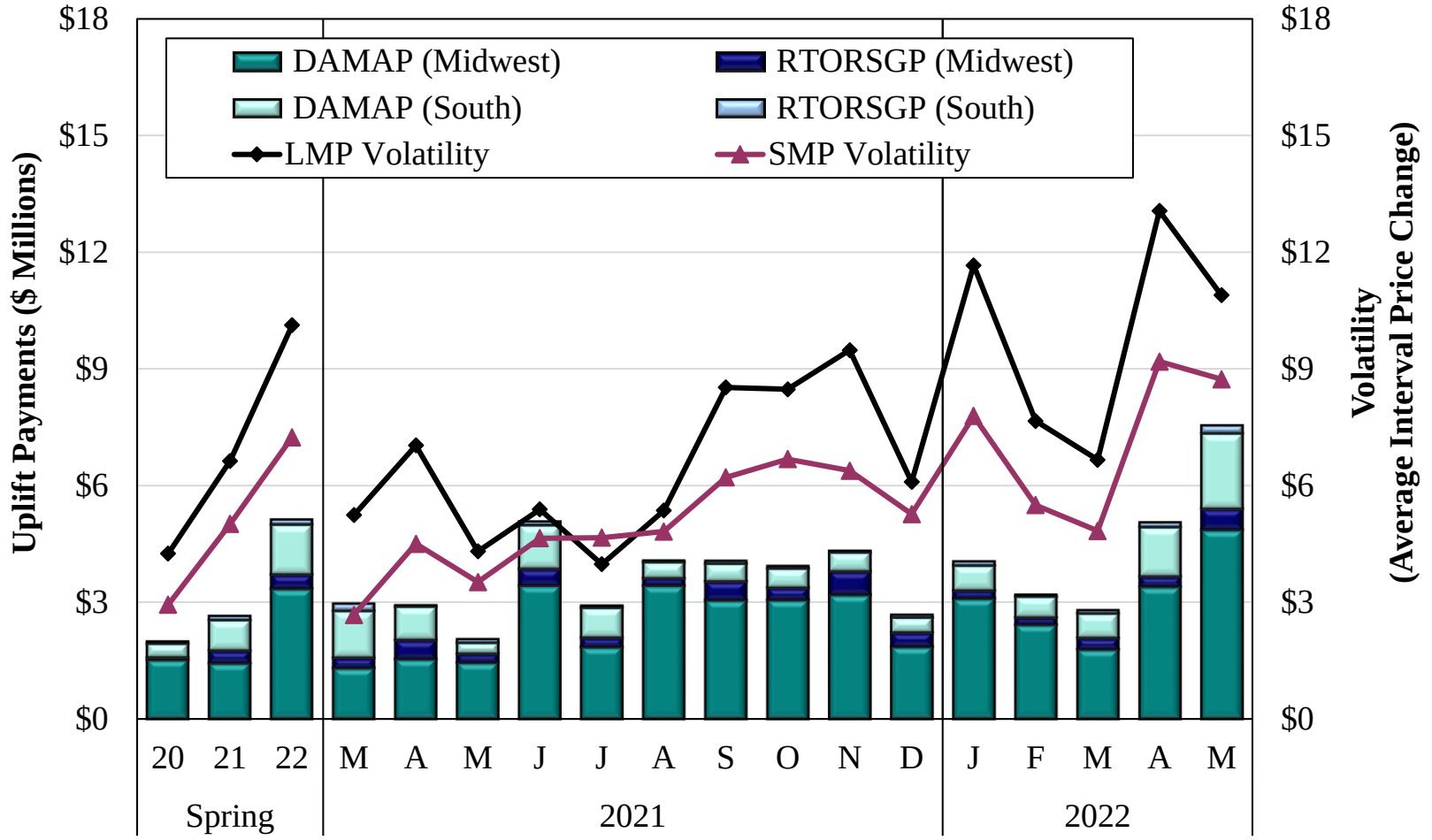
Generation Outages and Deratings
Spring 2021–2022

Spr Monthly Average	2020		2021		2022	
	Midwest	South	Midwest	South	Midwest	South
Forced: Long-Term	3.6%	1.9%	5.9%	4.0%	4.6%	2.5%
Forced: Short-Term	1.2%	1.2%	3.0%	1.6%	1.4%	1.0%
Unreported in CROW	5.0%	12.6%	4.8%	11.2%	5.8%	11.4%
Unplanned: Other	3.2%	5.1%	3.7%	2.6%	4.1%	3.4%
Planned: Extensions	2.1%	1.0%	1.6%	1.1%	1.6%	1.3%
Planned: Normal	12.0%	13.7%	15.4%	17.7%	17.2%	19.4%
Total	*27.1%*	*35.5%*	*34.4%*	*38.1%*	*34.6%*	*39.0%*



POTOMAC ECONOMICS

Price Volatility Make Whole Payments
Spring 2021–2022



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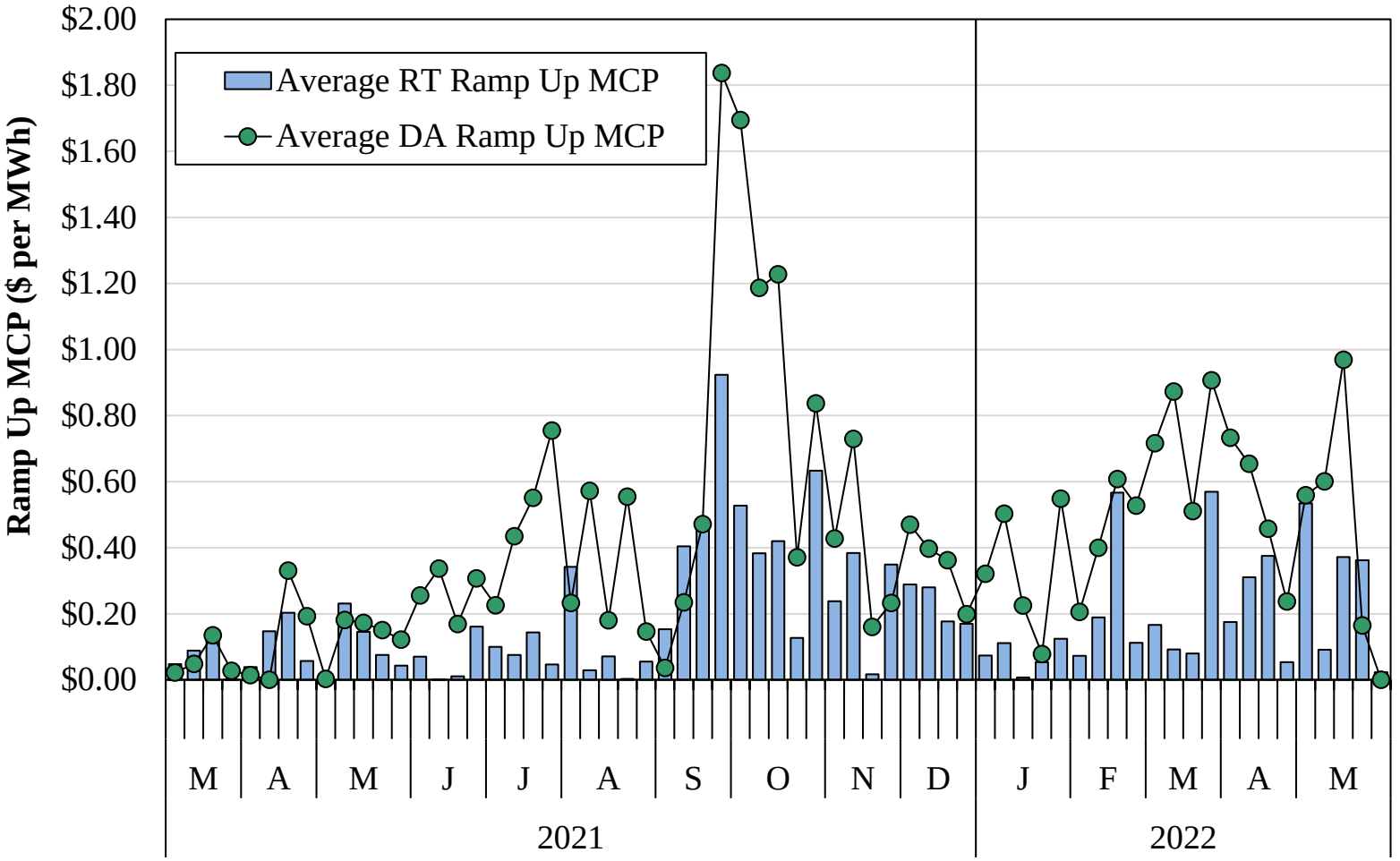
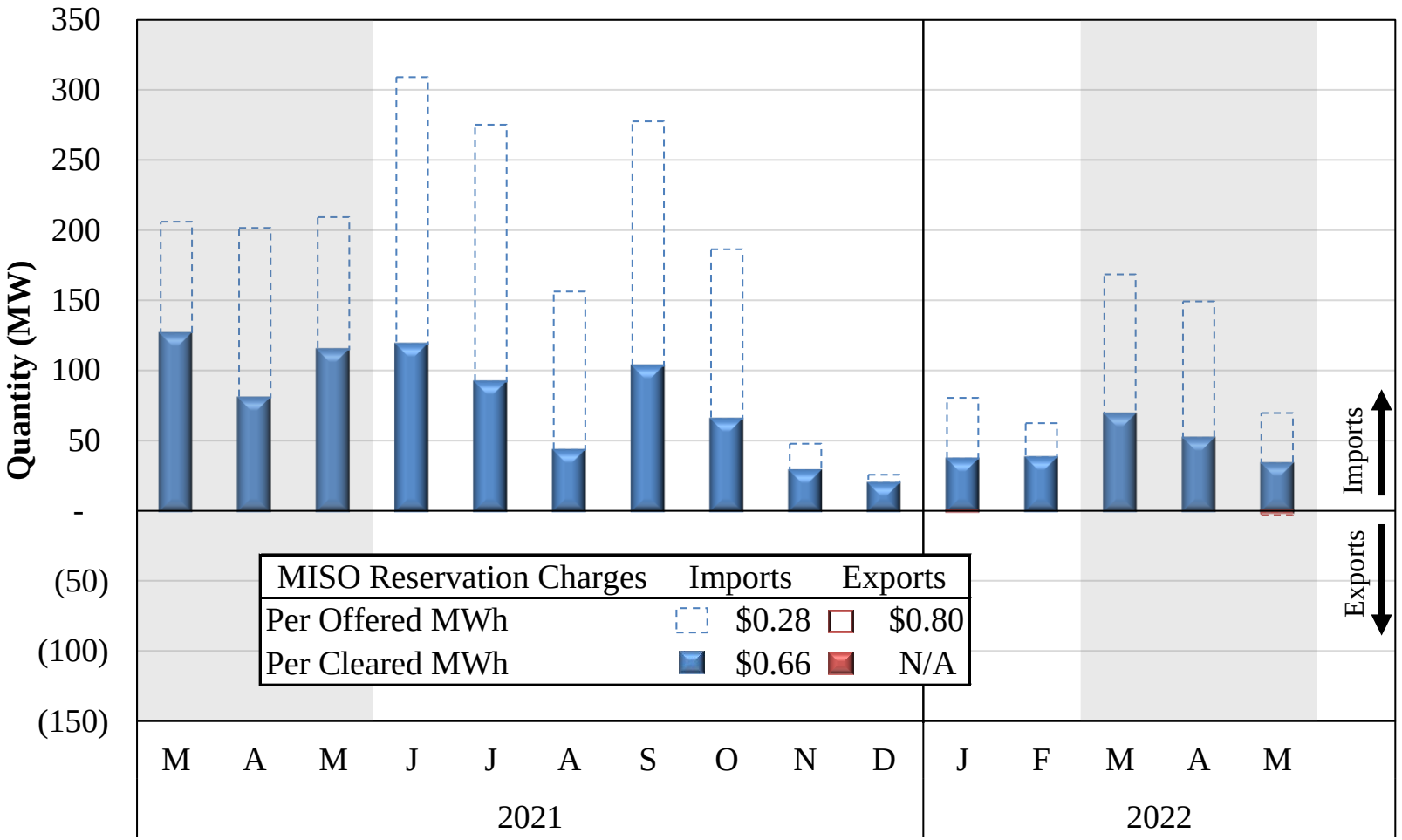
Day-Ahead and Real-Time Ramp Up Price Spring 2021–2022



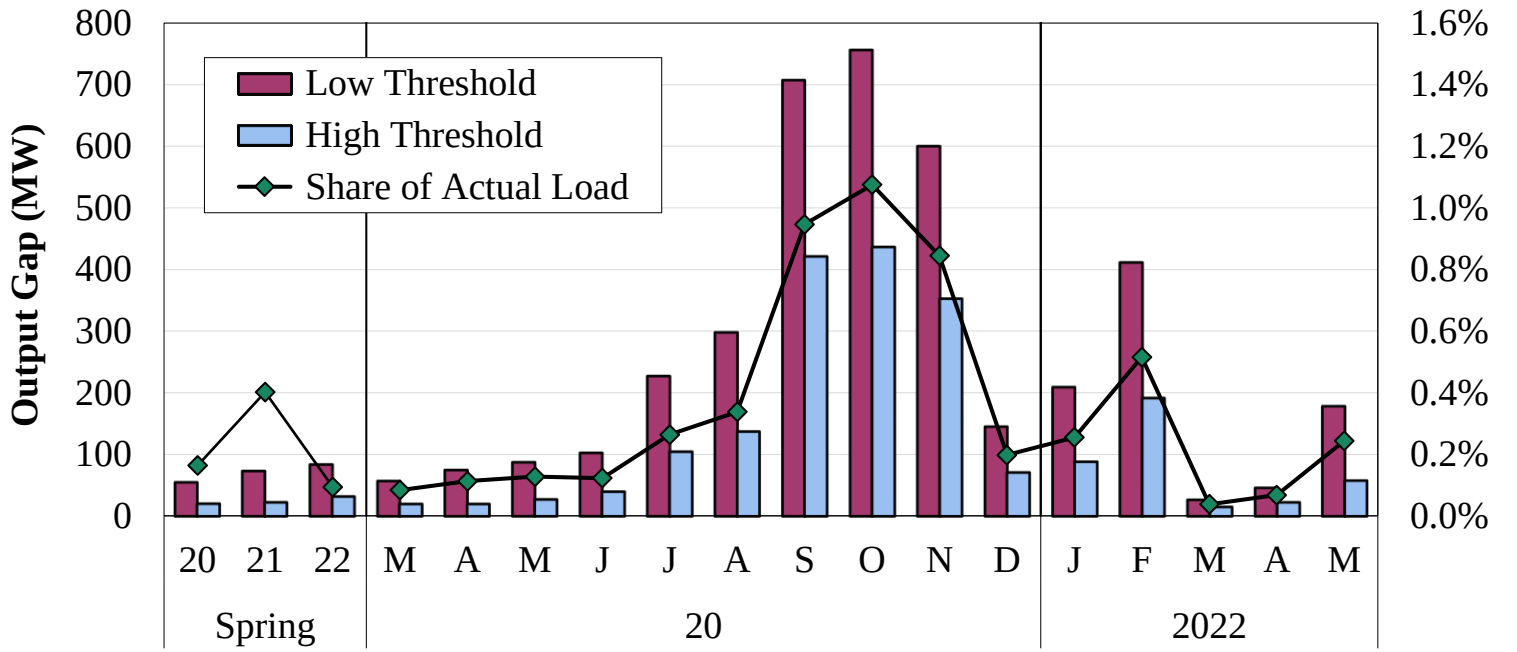
POTOMAC ECONOMICS

Coordinated Transaction Scheduling (CTS)
Spring 2021–2022



POTOMAC ECONOMICS

Monthly Output Gap
Spring 2021–2022



Low Threshold Results by Unit Status (MW)

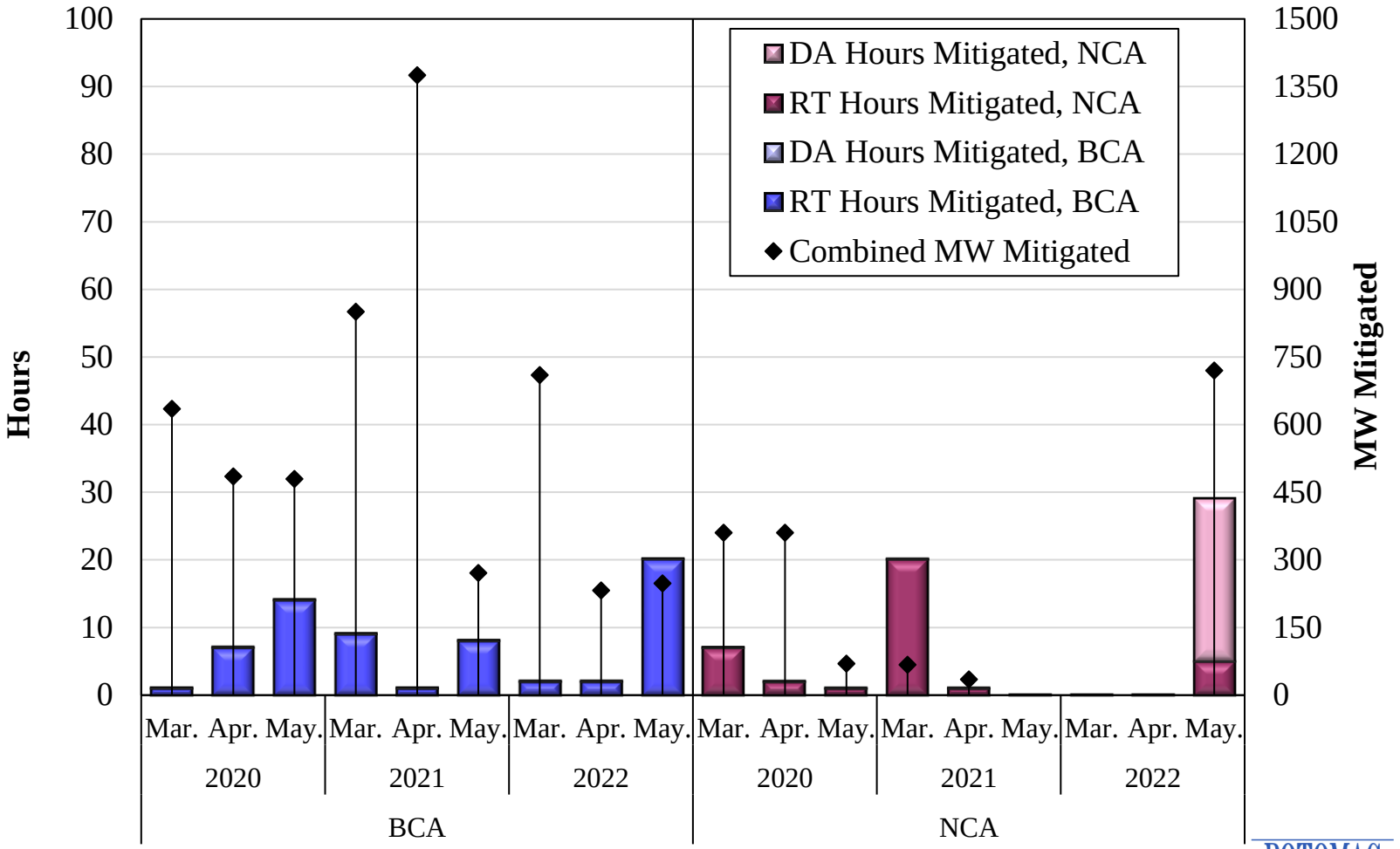
Offline	1	4	45	3	0	9	8	27	46	129	103	35	9	22	24	17	20	100
Online	54	69	38	55	75	79	96	201	252	577	652	565	136	188	387	11	27	75

High Threshold Results by Unit Status (MW)

Offline	1	3	27	2	0	8	7	22	38	98	62	19	7	21	20	12	17	51
Online	20	19	5	18	20	20	33	82	100	322	373	333	64	67	171	4	6	7

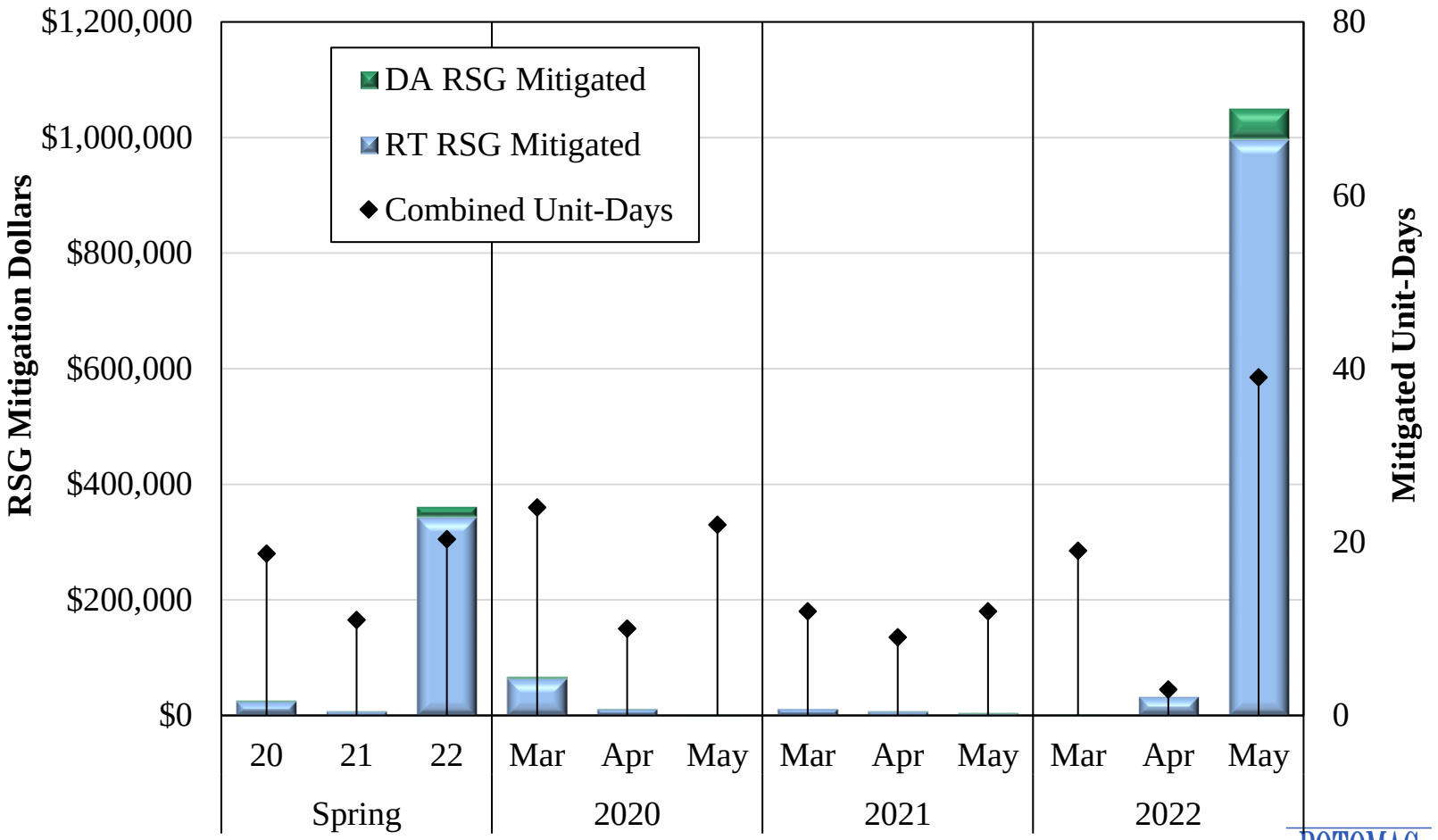
POTOMAC ECONOMICS

Day-Ahead And Real-Time Energy Mitigation
Spring 2021 and 2022



POTOMAC ECONOMICS

Day-Ahead and Real-Time RSG Mitigation
Spring 2021 - 2022



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