POTOMAC ECONOMICS

Summary of 2024 MISO State of the Market Report

Presented to:

MISO Market Subcommittee

David Patton, PhD
MISO Independent Market Monitor

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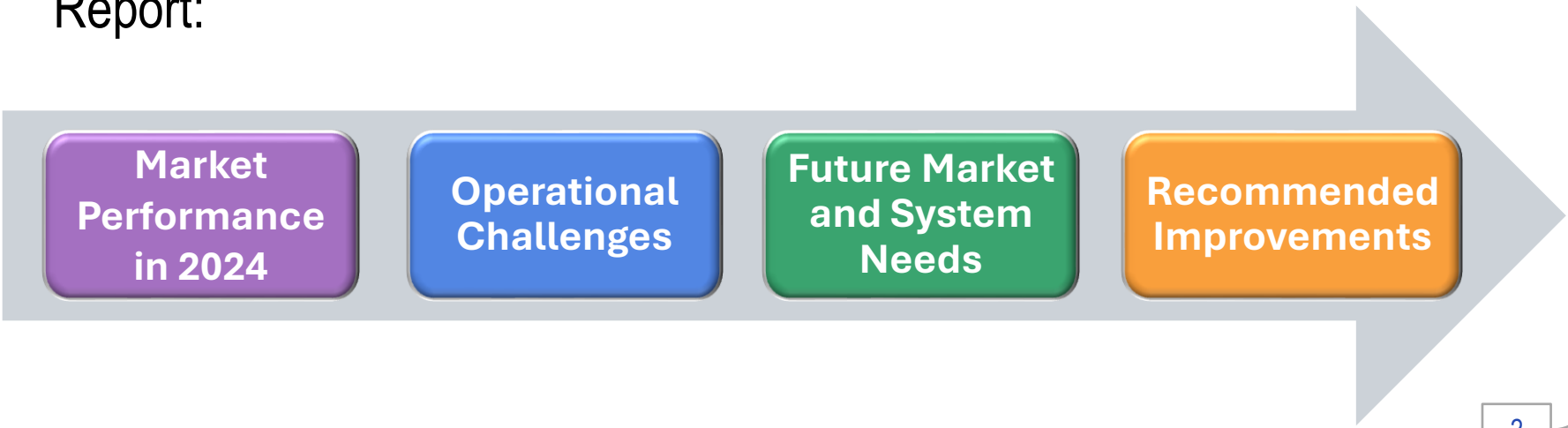
Introduction

- As the Independent Market Monitor (IMM) for MISO, we:
  - Monitor the performance of the market, the market operator, and the conduct of the market participants
  - Investigate and evaluate issues in these areas to develop remedies, needed improvements, sanctions or other market power mitigation measures, and manipulation referrals to FERC
  - Produce reports that summarize our key findings, the most extensive of which is our Annual State of the Market (SOM) Report
- This presentation summarizes the following aspects of our 2024 SOM Report:



Competitive Performance and Areas of Focus

- The MISO markets performed competitively – the "price-cost mark-up" was close to zero – indicating that offers were highly competitive
- In many respects, MISO's markets are more advanced and well-developed than other RTOs leading to superior performance
- We identify opportunities to lower costs and improve MISO's market performance, many of which will be critical in the coming years as its generating fleet evolves and system uncertainty rises
- The report recommends important improvements in these key areas:
  - Changes needed to successfully navigate the clean energy transition
  - Network utilization to lower congestion costs and improve reliability
  - Market and system operations, including minimizing out-of-market actions
  - Real-time pricing and the incentives it provides for good generator performance, availability and flexibility, and
  - Alignment between the capacity market and MISO's reliability needs

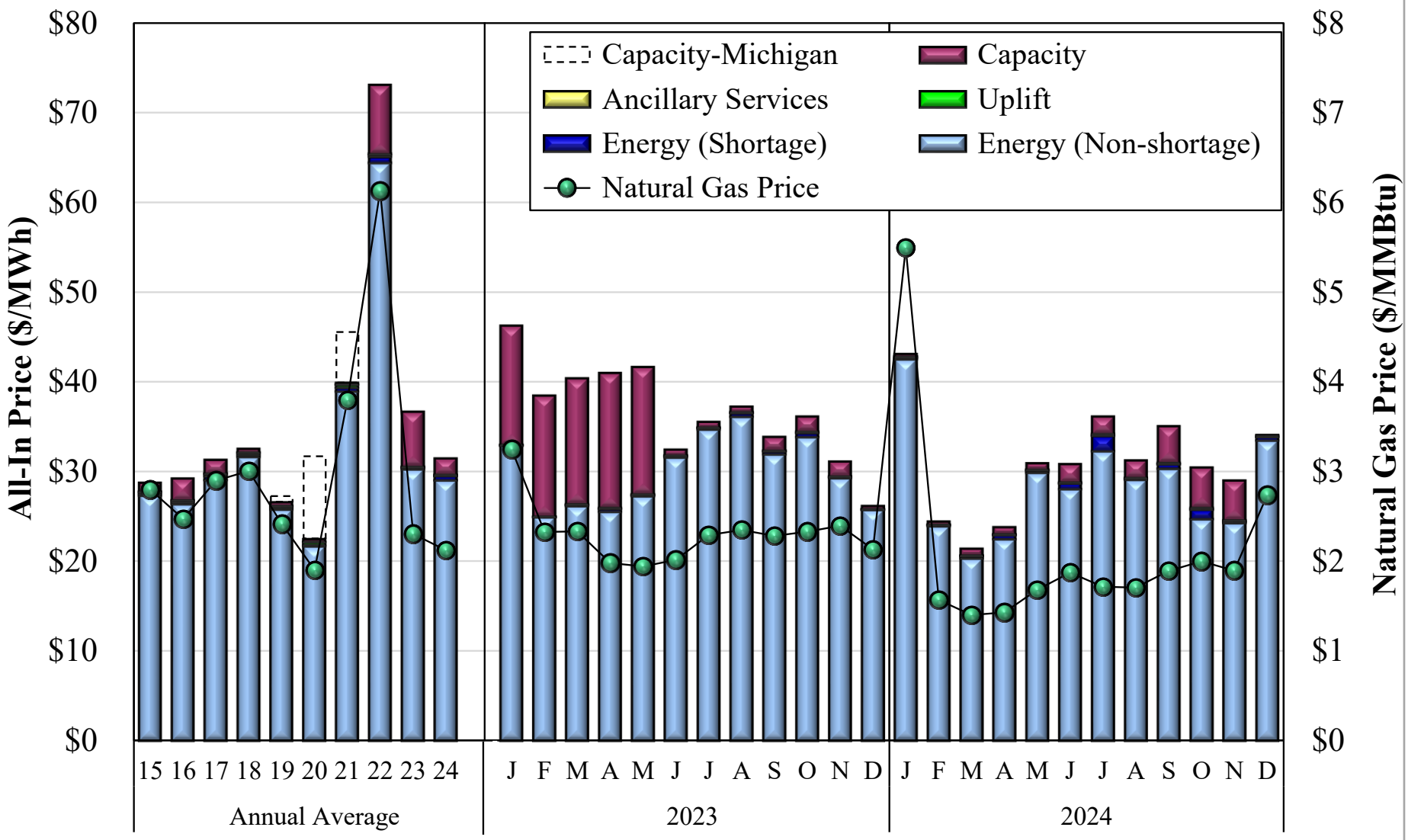
Competitive Performance and Areas of Focus

- MISO has continued to respond to past recommendations and implemented several key changes in 2024:
  - **Capacity Market:** MISO transitioned to a reliability-based demand curve in early 2025 and is reforming its resource accreditation to reflect resources' marginal contribution to the reliability of the system in the riskiest hours
  - **Energy Market:** MISO reformed its shortage pricing provisions to allow energy and ancillary service prices to better reflect the expected potential costs of load shedding
  - **Market Operations:** MISO made key changes in its commitment practices and operating procedures to manage congestion, which has greatly reduced inefficient uplift payments
- These changes will improve the performance of the markets and the operation of the system

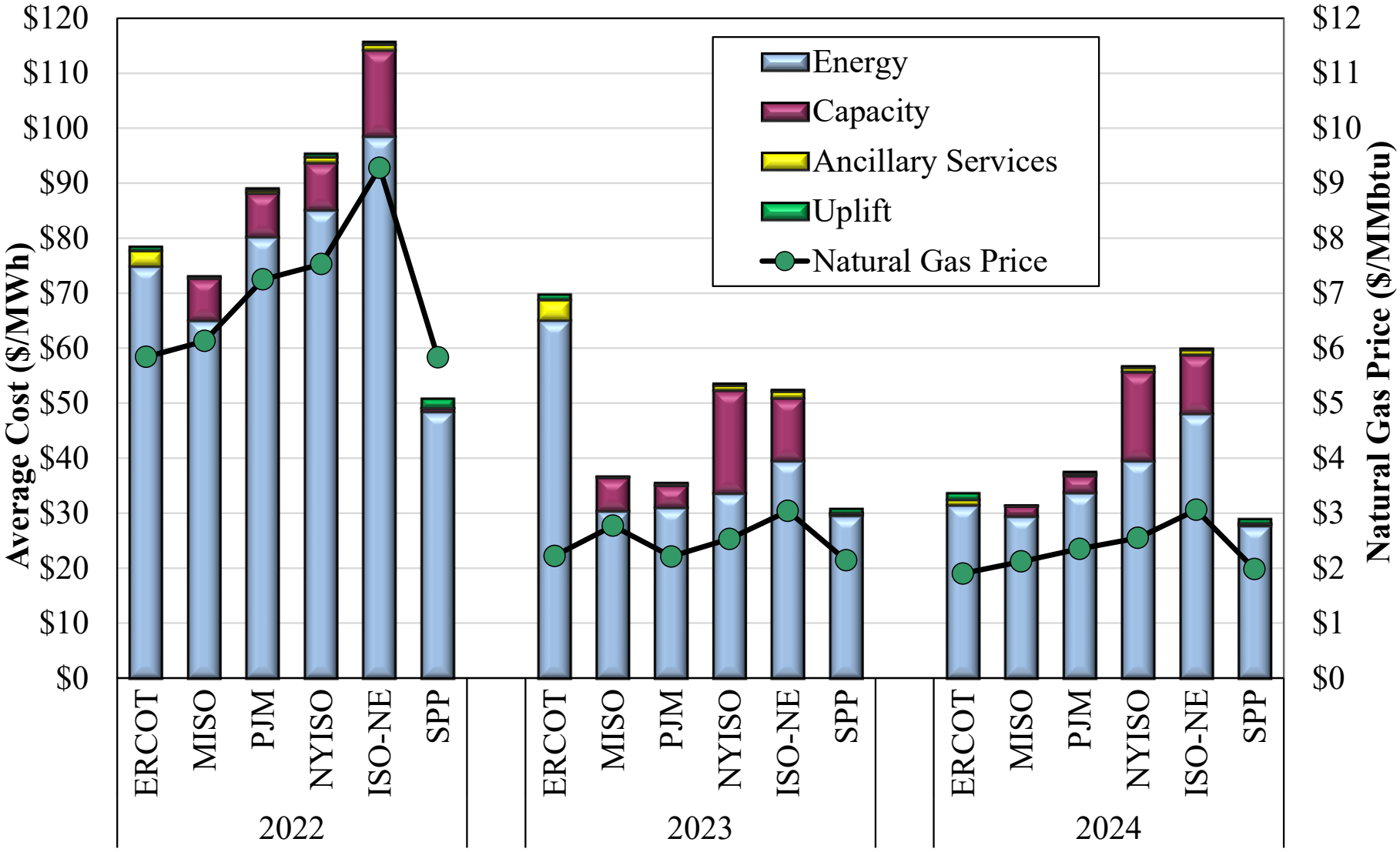
Market Highlights: Load and Prices

- The all-in price in 2024 shows a 14 percent reduction to average $31/MWh.
  - The decrease in energy prices was driven by an 8 percent decrease in natural gas prices with little change in average load
- Real-time transmission congestion fell by just 1 percent to $1.8 billion
  - Slightly higher wind output offset the decline in the natural gas prices
- However, real-time congestion and wind curtailment are still higher than optimal because of several key congestion management issues:
  - Conservative static ratings by most transmission owners
  - Defining and coordinating market-to-market constraints
  - MISO's operating actions (transmission derates and manual re-dispatch)
  - MISO's limited authority to coordinate outages
- We continue to recommend several improvements to lower the cost of managing congestion on MISO's system

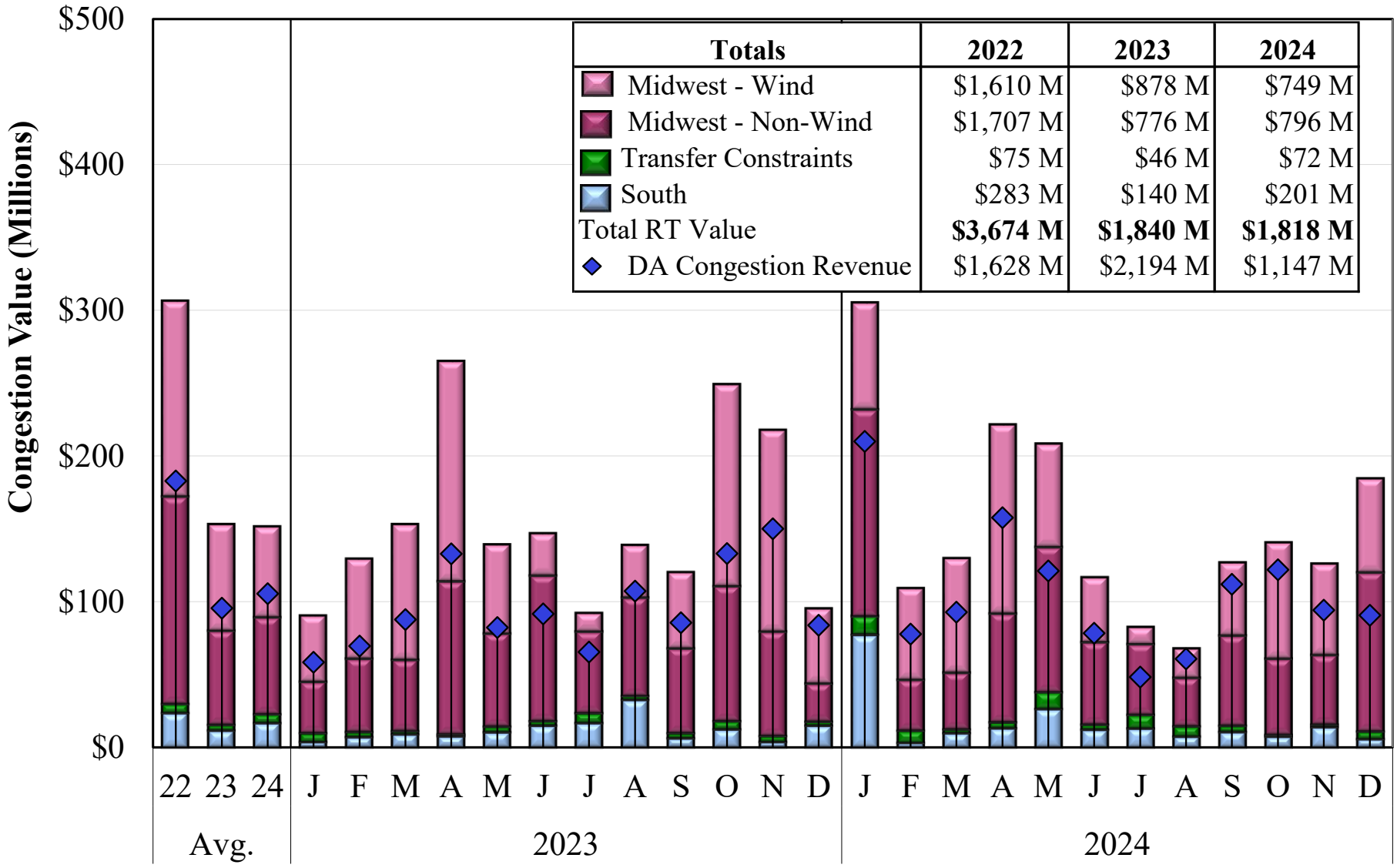
All-In Price



All-In Price Comparison



Real-Time Value of Congestion in MISO



Totals	2022	2023	2024
Midwest - Wind	$1,610 M	$878 M	$749 M
Midwest - Non-Wind	$1,707 M	$776 M	$796 M
Transfer Constraints	$75 M	$46 M	$72 M
South	$283 M	$140 M	$201 M
Total RT Value	**$3,674 M**	**$1,840 M**	**$1,818 M**
DA Congestion Revenue	$1,628 M	$2,194 M	$1,147 M

Day-Ahead Market Performance

- Day-ahead market performance is key because it coordinates the commitment of MISO's resources and facilitates almost all settlements
- MISO's day-ahead market performed well in 2024:
  - Day-ahead prices converged well with real-time prices, exhibiting a premium of two percent on average
  - However, episodes of congestion caused by generation and transmission line outages led to transitory periods of divergence at various locations
  - Market power mitigation is infrequent in the day-ahead market because the market is extremely liquid and competitive
- The report shows that virtual trading enhanced the efficiency of the market by improving the day-ahead market's coordination of resources
- We have recommended a virtual spread produce for years that would facilitate arbitrage of congestion deviations with the real-time market and improve convergence

Virtual Participation in MISO and other RTOs

- The good performance of the day-ahead market was due in part to active virtual trading that provides essential liquidity in the day-ahead market
  - Virtual trading is more liquid as a percent of the load in MISO than in other RTO markets because other RTOs over-allocate costs to virtual transactions
  - This liquidity leads to good price convergence and low virtual profits

Market	Virtual Load		Virtual Supply	
	MW as a % of Load	Avg Profit	MW as a % of Load	Avg Profit
MISO	15.8%	$0.39	14.5%	$0.51
NYISO	6.3%	-$0.64	7.4%	$0.82
ISO-NE	2.7%	-$2.96	5.3%	$1.95
SPP	10.1%	$0.64	15.9%	$3.83
PJM	5.9%	$0.05	5.6%	$1.20

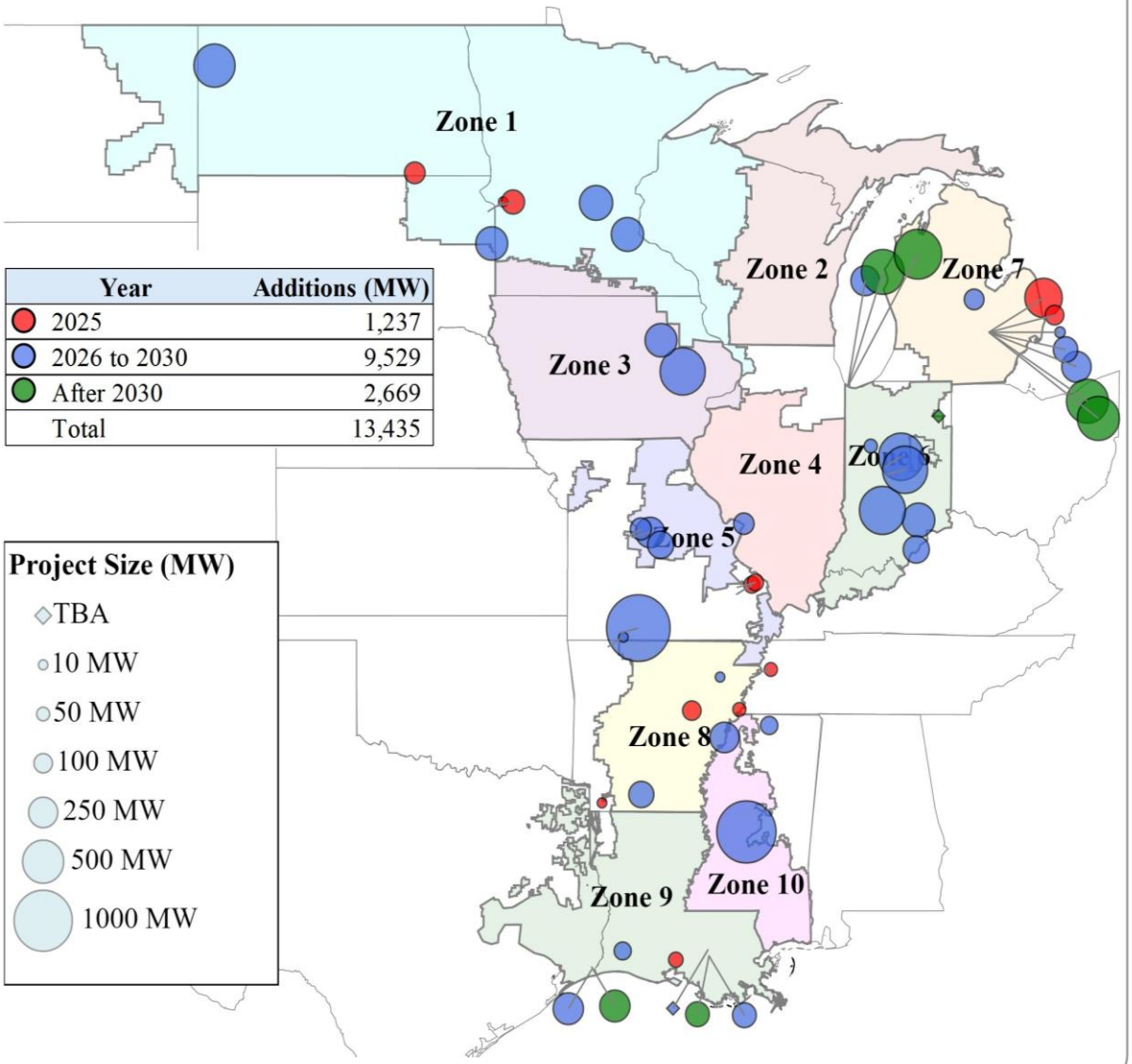
  - Almost all virtual transactions are submitted by financial participants
  - Virtual supply profits are higher because MISO efficiently allocates to virtual suppliers the RSG costs that they cause

Future System Needs

Future System Needs

Expected Large Load Additions

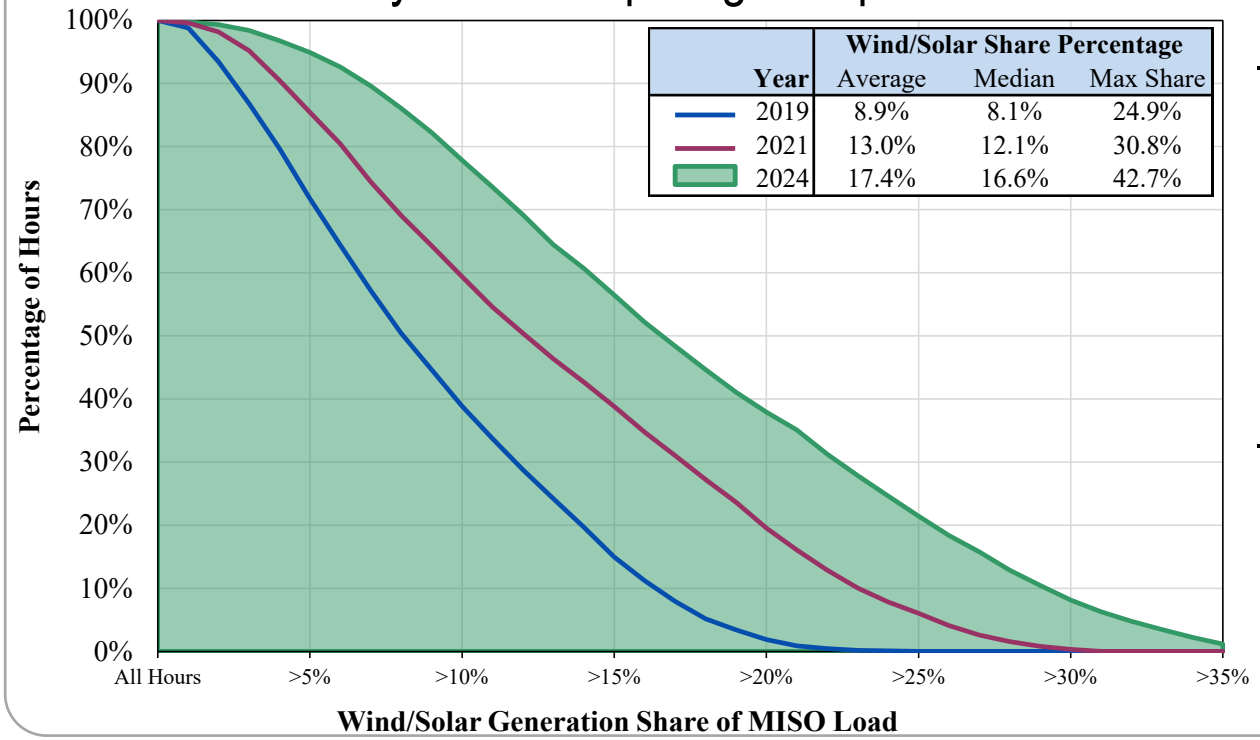
- Almost 11 GW of data centers and other large loads are announced for the next 5 years
- This has changed the long-term load forecasts over the past year
- The midpoint of the 10-year growth rate has grown from 11 to 21 GW
- Issues re: large loads:
  - Siting at weak network locations should be non-firm pending upgrades
  - Co-locating generation should not avoid tx rates



Future System Needs

Share of MISO Load Served by Renewable Resources

- The share of load served by renewables is growing considerably, peaking at over 40 percent in 2024
- This causes significant issues:
  - Increased ramp demand volatility requiring sufficient dispatchable resources and new processes for addressing ramp uncertainty
  - Reliability issues requiring new penalties to ensure units follow curtailments



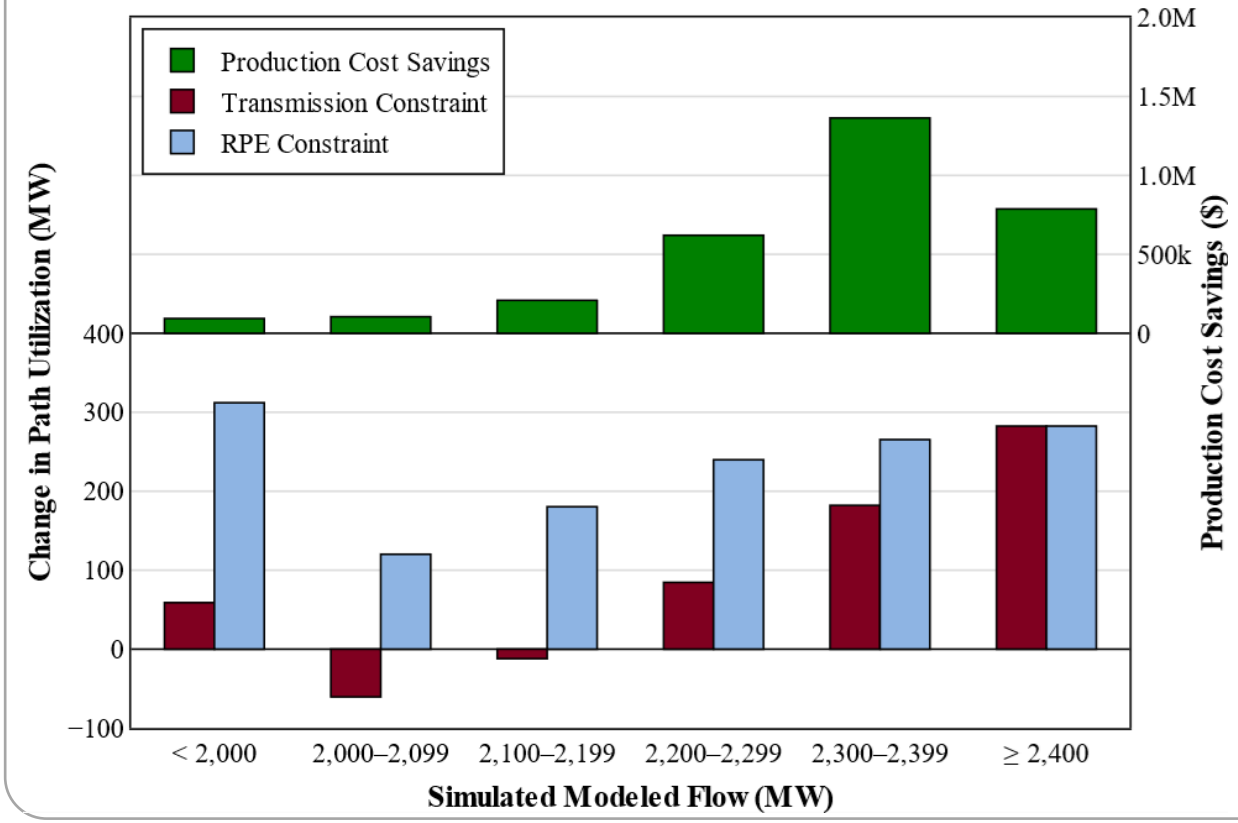
  - Voltage/system support limitations inherent with inverter-based resources – MISO is partly addressing with new interconnection requirements
  - Falling resource adequacy value – addressed with marginal accreditation that will change incentives and planning

New and High-Priority Recommendations by Area

Recommendations: Energy and Reserve Markets

2024-1: Modify RDT demand curve steps and RPE binding limits

- The RDT constraint limits transfers between MISO's Midwest and South subregions
- MISO derates the RDT to prevent unmodeled flows from violating the contract limit – this has caused widespread price impacts and reduces the RDT utilization to only 84 percent
- We recommend MISO modify the RDT's TCDC by adding lower-value steps and raising the energy plus STR limit to align with the highest penalty step



Under this demand curve:

- The dispatch will hold headroom on the RDT when it is not costly
- Increase RDT utilization when the value of transfers is high
- Reduce the burden on MISO operators to constantly monitor and adjust the RDT limit in the real-time market

Recommendations: Energy and Reserve Markets

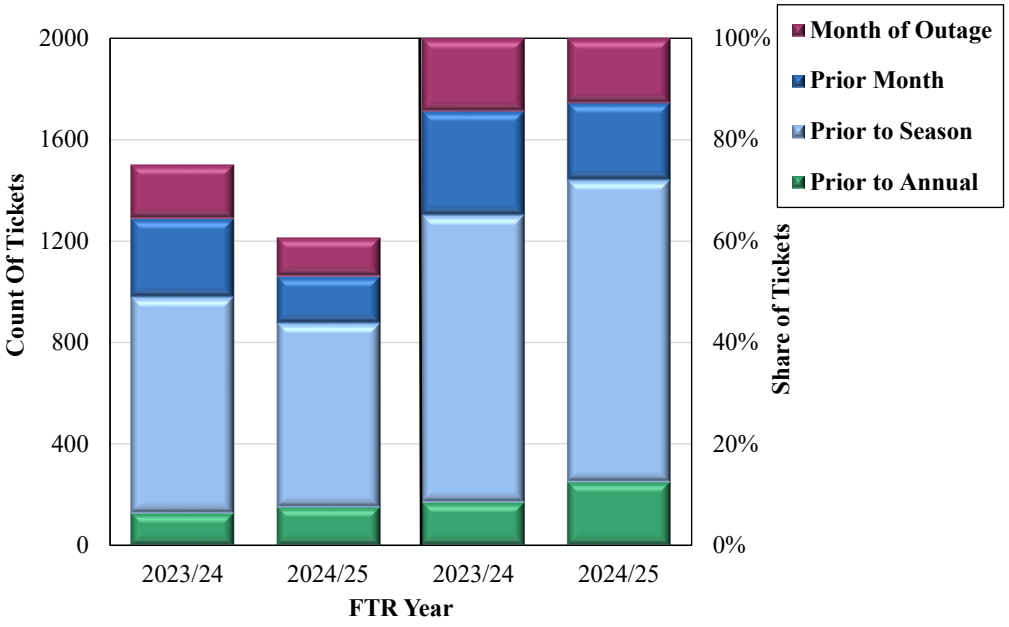
Other high-priority recommendations for the energy and reserve markets include:

- *2021-4: Develop a look-ahead dispatch and commitment model to manage fluctuations in net load and the use of storage resources*
  - The 5-minute dispatch does not efficiently manage upcoming ramp demands (e.g., over the upcoming 30-minutes) or utilize energy storage that has intertemporal limitations
  - This will be key in the long-term for facilitating the clean energy transition
- *2020-1: Develop a real-time capacity product for uncertainty*
  - Provides access to real-time resources through the market that can start in up to 2 or 4 hours and will set prices more efficiently when conditions are tight
  - By procuring and pricing this through the market, out of market actions and the associated RSG costs will be reduced

Recommendations: Congestion Management

2024-2: Shift capability from annual FTR/ARR to seasonal/monthly auctions

- MISO's seasonal/monthly FTR auctions often result in inefficient prices – delivering less net FTR revenues than the value of the day-ahead congestion
- This indicates low liquidity that may be due to a lack of participation by customers
- Transmission owners often report outages too late to be reflected in the annual FTR auction – the network is more accurately modeled in the monthly auction
- To improve FTR market performance, we recommend three fundamental changes:



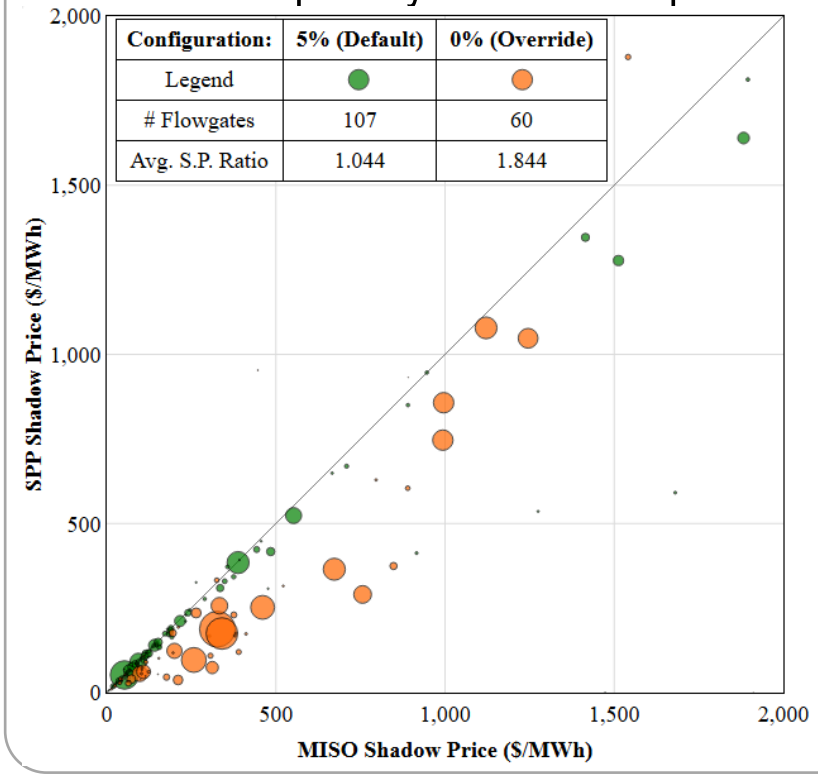
1. Shift much of the transmission capability from the annual to the seasonal/monthly auctions
2. Institute an ARR allocation process in the seasonal/monthly FTR timeframe
3. Consider a means to allocate much of the unallocated capability to customers based on their load and generation

Allowing customers to sell or convert ARRs will increase liquidity and set reservation prices for the FTRs

Recommendations: Congestion Management

2024-3: Limit acceptance of transferred M2M flowgates

- As part of the market-to-market (M2M) process, MISO and its partners can transfer monitoring responsibilities of a flowgate to the "non-monitoring RTO"
- Our analysis of these "reverse role" flowgates during last year shows:
  1. MISO has sometimes accepted flowgates from SPP for which it lacks economic relief
  2. SPP has requested MISO use the relief request software in a manner that understates the quantity of relief it requests from SPP, leading to costly lack of convergence



- Poor convergence generally leads to much higher M2M costs to MISO's customers
- To address these concerns, we recommend that MISO:
  1. Limit its acceptance of reverse role flowgates from SPP to only those where MISO has significantly more effective relief than SPP
  2. Require appropriate use and parameterization of the relief request software for all reverse role flowgates MISO agrees to monitor

Recommendations: Congestion Management

Other key recommendations to improve congestion management include:

- *2023-3: Develop tools to recommend decommitment of resources committed in the day-ahead market*
  - MISO does not decommit day-ahead committed units for economic reasons, even if they are contributing to severe congestion
  - We performed case studies showing that economic decommitments reduced congestion by as much as $1.7 million
- *2022-1: Expand the TCDCs to allow MISO's market dispatch to reliably manage network flows*
  - This will largely address MISO's increasing reliance on manual actions to manage congestion and lower costs
- Although not a formal recommendation, working with TOs to implement *real-time* ambient adjusted ratings in early 2026 as planned should be a very high priority
  - FERC granted an extension of the Order 881 deadline to the end of 2028 that was predicated on the changes needed to address obligations in the forward timeframes

Recommendations: Market and System Operations

- *2024-4 (New): Improve constraint management and dead bus criteria for Forced Off Asset (FOA) Events*
  - On July 8-9, 2024, Hurricane Beryl caused extensive forced transmission outages that disconnected most loads in the Southeast Texas (SETEX) Load Pocket
  - This failed to qualify as an FOA Event, which sets real-time prices equal to day-ahead prices, because the FOA Revenue Inadequacy criteria is defined too narrowly
  - To address this issue, we recommend MISO:
    - Limit the FOA dead bus criteria to only load buses, and
    - Combine Revenue Inadequacy and Price Volatility Make-Whole Payments in the financial criteria for FOA declarations
  - These two changes will ensure that prices in areas affected by transmission damage during extreme whether events are set at reasonable levels and avoid cost shifting

Recommendations: Market and System Operations

Other Key Recommendations in this area include:

- *2022-3: Improve excess and deficient energy penalties to improve generators' incentives to follow MISO's dispatch instructions*
  - Ensures that renewable resources have the incentive to obey curtailment instructions and to adhere to the new Uninstructed Deviation Enhancement flag
- *2019-4: Clear CTS transactions every five minutes through the UDS based on the RTOs' most recent five-minute prices*
  - Making more timely adjustments would achieve much larger savings and reduce price volatility caused by increasing ramp needs from renewable resources
  - Legacy CTS would otherwise have to be re-coded under the MSE platform
- *2016-6: Improve the accuracy of the LAC recommendations and record operator response to LAC recommendations*
  - MISO has improved the LAC model and it often identifies key commitments needed to manage constraints or system the system's capacity needs
  - MISO operators generally do not adhere to recommendations, which was sometimes costly in 2024

Recommendations: Resource Adequacy and Planning

Key existing recommendations to improve resource adequacy include:

- *2023-6: Implement zonal capacity demand curves and near-term improvements in local clearing requirements*
  - The inefficiently high shortage pricing in Missouri in the 2024/25, Planning Year highlights the importance of demand modeling in local zones
- *2022-4: Improve the LRTP processes and benefit evaluations*
  - Necessary to align investment in transmission and generation
- *2020-4: Develop marginal accreditation methodologies to accredit DERs, LMRs, and battery storage resources*
  - MISO's marginal accreditation framework will be implemented for the 2028/29 planning year but does not apply to DERs and battery storage
  - It is important to accredit all resources on a marginal basis
- *2019-5: Remove eligibility of Energy Efficiency to sell capacity*
  - MISO should prioritize removing EE before the 2026/27 auction

Full List of Recommendations

List of Recommendations

SOM Number	Recommendations	High Benefit	Near Term
Energy and Operating Reserves and Guarantee Payments			
2024-1	Modify RDT demand curve steps and RPE binding limits.		✓
2023-1	Align aggregate pricing nodes in the FTR market through real-time.		✓
2023-2	Enforce STR requirements in the load pockets.		
2021-2	Evaluate reintroducing LMR curtailments as STR demand in pricing models and UDS.		
2020-1	Develop a real-time capacity product for uncertainty.	✓	
2012-3	Remove external congestion from interface prices.		✓
2012-5	Introduce a virtual spread product.		

List of Recommendations

SOM Number	Recommendations	High Benefit	Near Term
Transmission Congestion			
2024-2	Shift a large share of transmission capability from the annual ARR allocation and FTR auction to seasonal and monthly auctions	✓	
2024-3	Limit acceptance of transferred M2M flowgates to those where MISO has more effective relief and require proper use of the relief request software		
2023-3	Develop tools to recommend decommitment of resources committed in the day-ahead market.		
2022-1	Expand the TCDCs to allow MISO's market dispatch to reliably manage network flows.	✓	✓
2021-1	Work with TOs to identify and deploy economic transmission reconfiguration options.		✓
2019-1	Improve the relief request software for M2M coordination.		
2019-2	Improve the testing criteria defining market-to-market constraints.		
2016-3	Enhance authority to coordinate transmission and generation planned outages.		
2014-3	Seek joint operating agreements with neighboring control areas to improve congestion management and emergency coordination.		

List of Recommendations

SOM Number	Recommendations	High Benefit	Near Term
Market and System Operations			
2024-4	Improve constraint management and dead bus criteria for Forced Off Asset Events		
2023-5	Require descriptions in new or updated CROW tickets.		
2022-3	Improve excess and deficient energy penalties to improve generators' incentives to follow MISO's dispatch instructions	✓	
2021-3	Evaluate and reform the unit commitment processes.		✓
2021-4	Develop a look-ahead dispatch and commitment model to optimally manage fluctuations in net load and the use of storage resources.	✓	
2020-2	Align transmission emergency and capacity emergency procedures and pricing.		✓
2019-4	Clear CTS transactions every five minutes through the UDS based on the RTOs' most recent five-minute prices.	✓	
2018-4	Clarify the criteria and improve the logging for declaring emergencies and taking emergency actions.		✓
2017-2	Remove transmission charges from CTS transactions.	✓	✓
2017-4	Improve operator logging tools and processes related to operator decisions and actions.		
2016-6	Improve the accuracy of the LAC recommendations and record operator response to LAC recommendations.	✓	✓

List of Recommendations

SOM Number	Recommendations	High Benefit	Near Term
Resource Adequacy and Planning			
2023-6	Implement zonal capacity demand curves and near-term improvements in local clearing requirements.	✓	
2022-4	Improve the LRTP processes and benefit evaluations.	✓	✓
2022-5	Implement jointly optimized annual offer parameters and improve outage penalty provisions in the seasonal PRA.		
2020-4	Develop marginal accreditation methodologies to accredit DERs, LMRs, battery storage, and intermittent resources.	✓	
2019-5	Improve the Tariff rules governing Energy Efficiency and their enforcement.		✓
2015-6	Improve the modeling of transmission constraints in the PRA.		
2014-6	Define local resource zones based on transmission constraints and local reliability requirements.		