



Summary of 2022 MISO State of the Market Report

Presented to:

MISO Board Markets Committee

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June 28, 2023



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; and
 - ✓ 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 2022 SOM Report:

**Market
Performance
in 2022**

**Operational
Challenges**

**Future Market
and System
Needs**

**Recommended
Improvements**



Competitive Performance and Areas of Focus

- The MISO markets performed competitively – the “price-cost mark-up” was effectively 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 in these areas.
- However, we identify opportunities to lower costs and improve MISO’s market performance, some of which will be critical as its generation portfolio transitions toward heavier reliance on renewable resources.
- This presentation focuses on our recommendations to improve:
 - ✓ The ability of the system to navigate the transition of its generation fleet;
 - ✓ Network utilization to lower congestion costs and improve reliability;
 - ✓ Market and system operations, including 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.

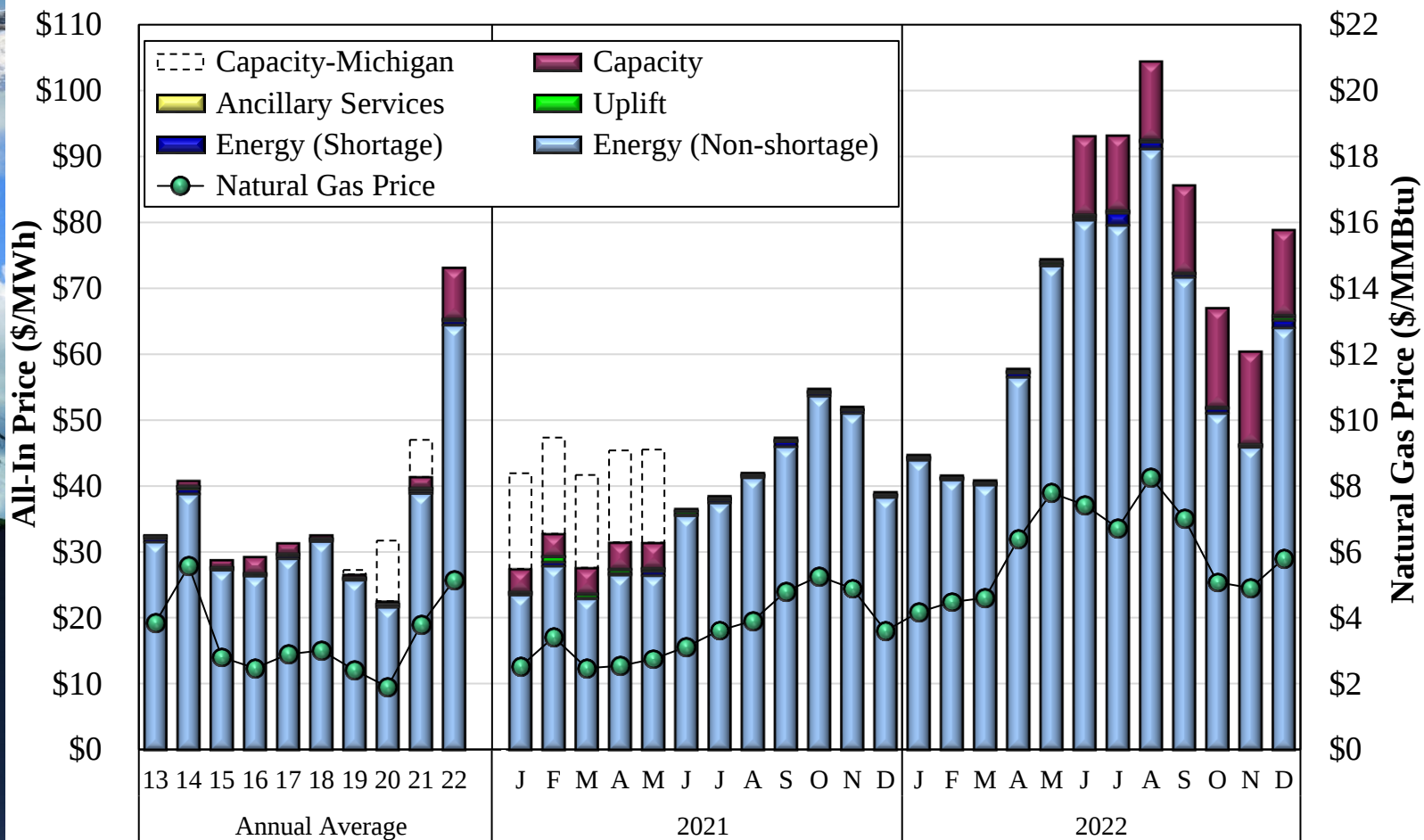


Market Highlights: Load and Prices

- The all-in price in 2022 rose 77 percent to average \$73 per MWh.
 - ✓ Energy prices rose 65 percent, driven by:
 - 2 percent higher average load, a 36 percent increase in natural gas prices,
 - Coal conservation measures that began to ease in the fall, and
 - Shortage pricing during Winter Storm Elliott in December.
 - ✓ The higher all-in price reflects the contribution of the shortage price in the capacity market in the Midwest from June 2022 to May 2023.
 - ✓ MISO's all-in price remains lower than all other eastern markets and Texas, except for SPP, due to (i) its relatively lower gas prices and its (ii) understated capacity prices and shortage pricing.
- Despite higher gas prices that made coal much more profitable to run, the energy output share of coal fell from 2021 because of coal supply chain constraints that reduced coal production.
- Controlling for the change in gas prices, the implied marginal heat rate measure of prices was relatively unchanged from 2021, increasing slightly due to Winter Storm Elliott in December.

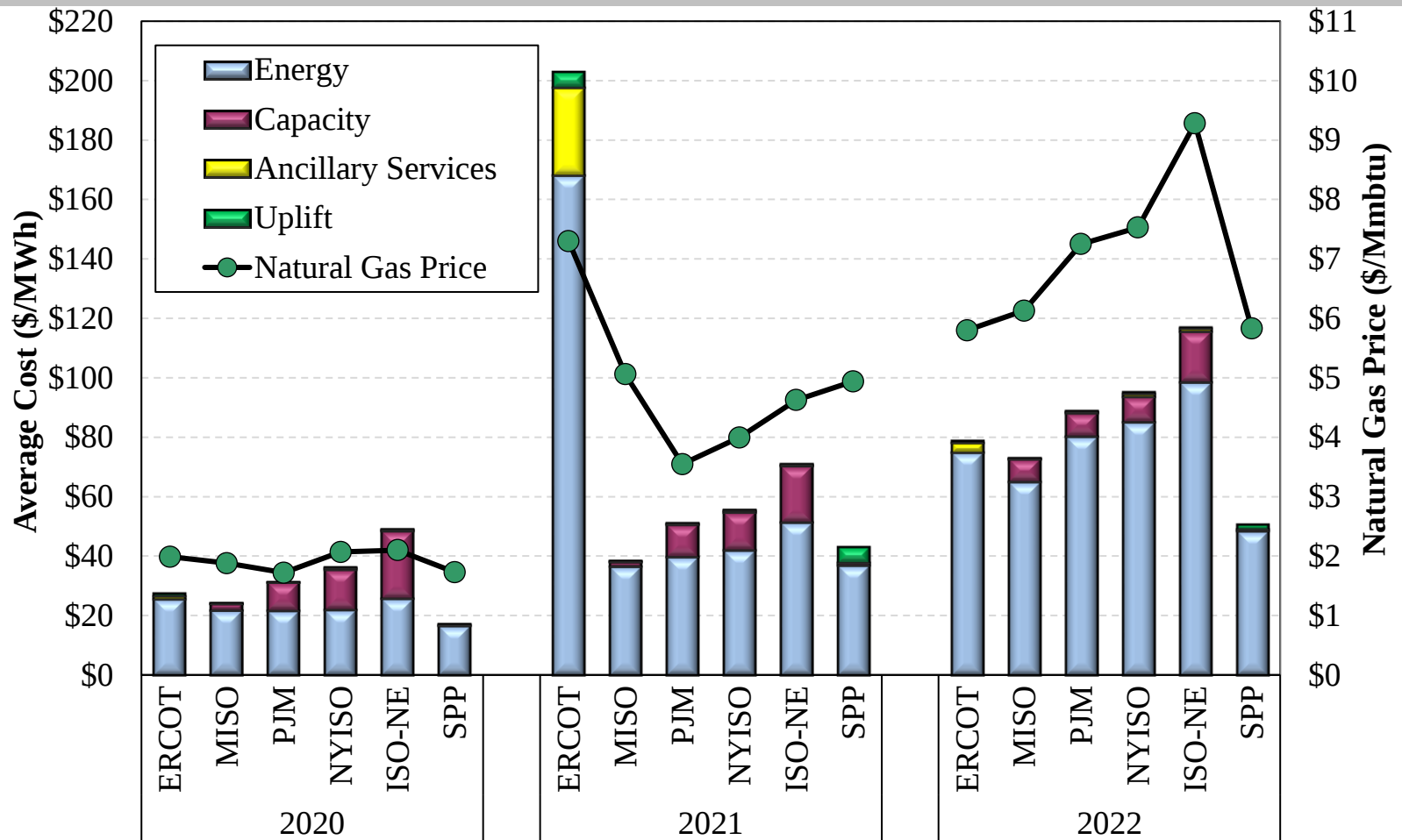


All-In Price



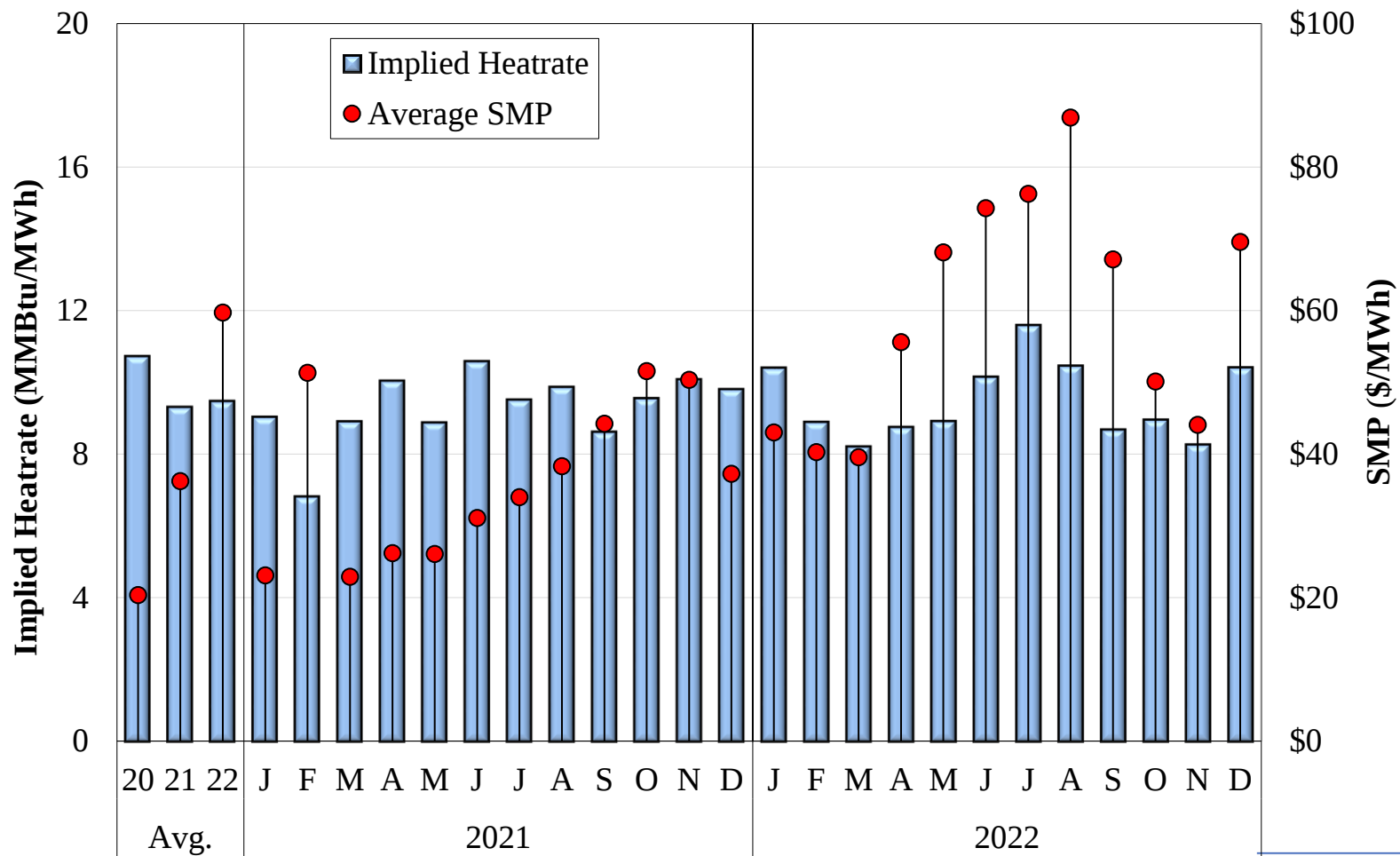


All-In Price Comparison





Implied Heat Rates





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 2022:
 - ✓ Day-ahead prices converged well with real-time prices, exhibiting a premium of less than one percent on average.
 - ✓ The report shows that virtual trading enhanced the efficiency of the market by improving the day-ahead market's coordination of resources.
- These results were 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 virtuals transactions.
 - ✓ This liquidity leads to good price convergence and low virtual profits.
 - ✓ 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.



Day-Ahead Market Performance

Market	Virtual Load		Virtual Supply	
	MW as a % of Load	Avg Profit	MW as a % of Load	Avg Profit
MISO	14.9%	\$1.00	15.5%	\$1.73
NYISO	5.9%	\$5.15	5.9%	\$0.10
ISO-NE	3.1%	-\$0.60	4.9%	\$2.84
SPP	9.4%	\$0.05	16.2%	\$7.83
PJM	5.7%	\$4.72	4.0%	-\$0.19

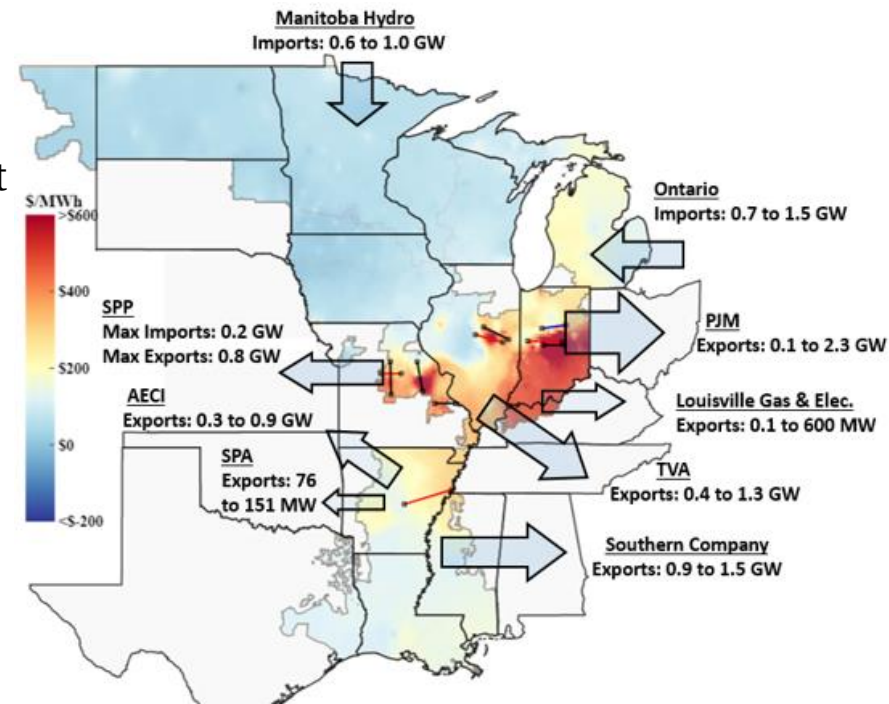


Winter Storm Elliott

Dec 23- 24, 2022

- Extreme cold led to emergencies throughout the Central U.S.
- MISO was exporting to all its neighbors during the events.
 - TVA and PJM were in the biggest trouble.
 - The high exports caused severe congestion.
- MISO took emergency actions to support its neighbors, including:
 - Manually dispatching generation
 - Calling emergency to cut LMRs.
 - Not curtailing non-firm exports as called for under procedures.
 - Making costly resource commitments, some of which were ultimately stranded behind constraints.
- These actions resulted in very high costs - \$350 in real-time congestion and \$30 million in uplift payments.

December 24, 2022





Highlights for Winter 2023

IMM Recommendations related to Winter Storm Elliott

As with other significant events, Winter Storm Elliott provides opportunities to identify improvements in MISO's processes. We recommend that MISO:

1. Add higher-priced steps to the Transmission Constraint Demand Curves.
2. Improve its procedures to increase TCDCs as needed to ensure that the dispatch model will reasonably manage network flows and violations under all conditions.
3. We recommend MISO strengthen its operating controls and logging regarding to minimize deviations from its operating procedures.
4. 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.

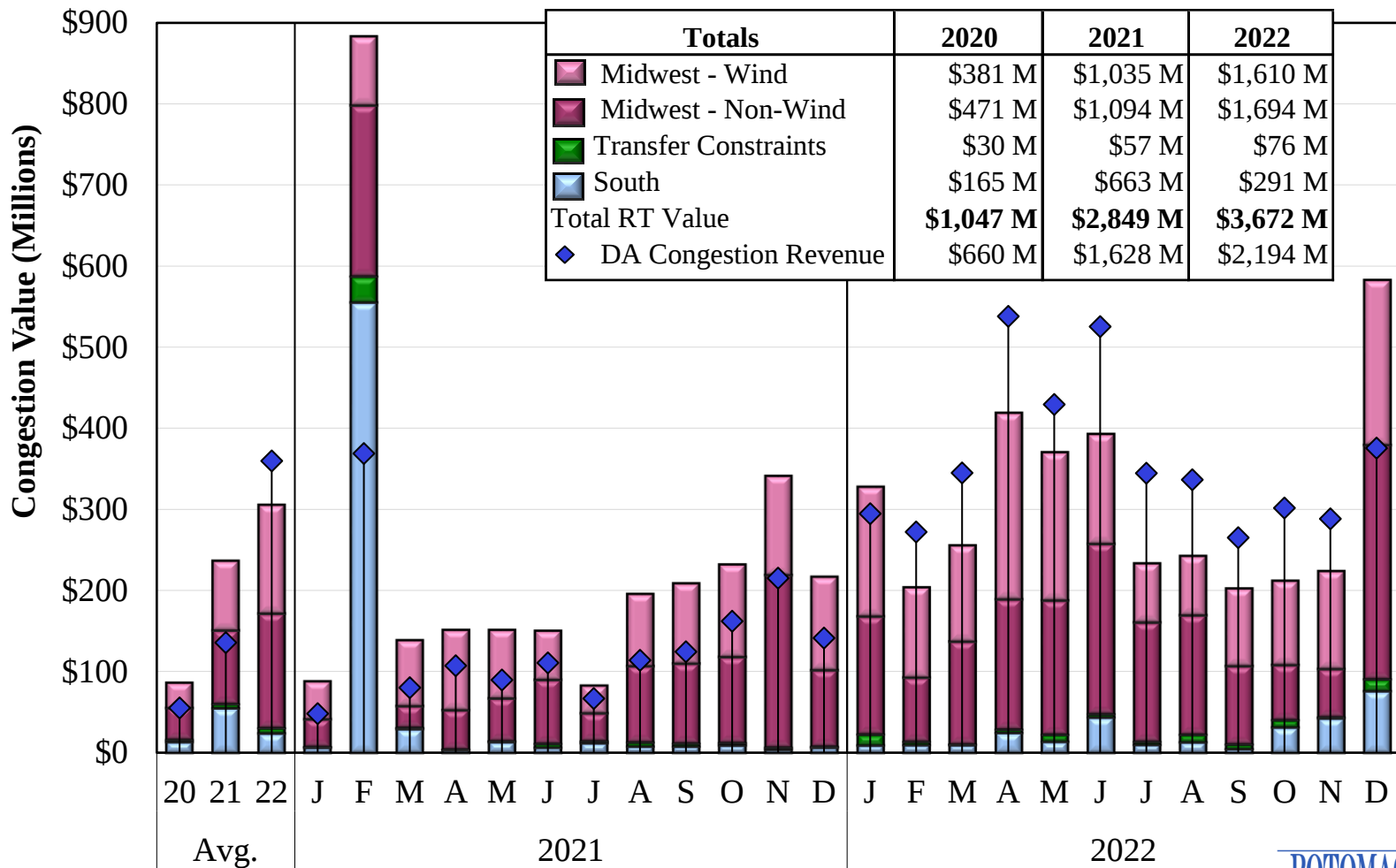


Real-Time Congestion

- Transmission congestion causes prices to vary throughout MISO – the price at every location reflects the marginal cost of delivery power there.
- The value of real-time congestion rose 29 percent to \$3.7 billion in 2022.
 - ✓ Rising gas prices, particularly in the Summer, contributed to much of this increase because it raised the cost of re-dispatching gas-fired generation.
- Transmission constraints loaded by wind resources accounted for 44 percent of real-time congestion – more than \$1.6 billion in 2022 because:
 - ✓ Continued entry of new wind resources in MISO, SPP, and PJM that increased loadings on key constraints in MISO; and
 - ✓ Relief on wind-related constraints has fallen in recent years because of retirements of key coal and gas-fired resources; and
 - ✓ Average imports from Manitoba increased in 2022 as drought conditions resolved early in the year.
- Day-ahead transmission congestion also increased to \$2.2 billion in 2022.



RT Congestion by Coordination Region





Recommendations: Improving the Utilization Transmission System

- Given the rising magnitude of these costs, we encourage MISO to prioritize the following recommended improvements to more fully utilize the network:
 1. Facilitating the use of transmission ratings that are adjusted for changes in ambient temperatures and of emergency ratings for contingent constraints;
 2. Working with TOs to identify and deploy economic transmission reconfiguration options (e.g., opening a breaker to redirect network flows);
 3. Adopting economic criteria to coordinate the scheduling of generation and transmission outages that can cause severe congestion; and
 4. Improving the process to define and coordinate market-to-market constraints.
- These improvements would likely have reduced congestion by 20 to 30 percent – nearly a billion dollars in 2022.
 - ✓ These recommendations promise the highest available short-term savings.
 - ✓ Improving the utilization of the network will be increasingly important as the fleet transitions and the volatility of the network flows grows.
 - ✓ More staff resources focused on these areas is likely needed.



Recommendation: Improve Transmission Ratings

- Most TOs do not adjust their ratings to reflect ambient temperatures, and many do not provide emergency ratings when feasible.
- The table below demonstrates the enormous available savings.
- In December 2021, FERC issued Order 881 requiring TOs to provide AARs and emergency ratings based on facility-specific evaluations within 3 years.
 - ✓ Near-term work to implement improved ratings has stalled after the Order.

		Savings (\$ Millions)			# of Facilities for 2/3 of Savings	Share of Congestion
		Ambient Adj. Ratings	Emergency Ratings	Total		
2021	Midwest	\$153.4	\$94.89	\$248.3	29	11.3%
	South	\$27.3	\$38.32	\$65.6	1	10.0%
	Total	\$180.7	\$133.2	\$313.9	30	11.0%
2022	Midwest	\$326.4	\$188.67	\$515.1	22	15.3%
	South	\$7.6	\$19.11	\$26.7	2	9.3%
	Total	\$334.0	\$207.8	\$541.8	24	14.9%



Market-to-Market Congestion Issues

- Market-to-market (M2M) coordination is critical for efficiently and reliably managing flows on constraints affected by neighboring RTOs.
 - ✓ Congestion on MISO M2M constraints almost doubled to \$2 billion.
 - ✓ Congestion on external M2M constraints fell 12 percent in 2022.
- M2M coordination has generally lowered the costs of managing the congestion, but recommend three key changes to improve its performance:
 - ✓ Improve the software used to determine the amount of relief requested from the non-monitoring RTO (over \$100 million in estimated annual savings).
 - ✓ Improve the test to define M2M constraints so it is based on relief the non-monitoring RTO can provide, which will focus coordination on the highest-value constraints.
 - ✓ Increase the automation of the M2M processes to improve the timeliness with which constraints are tested and activated.
- MISO is also in the process of renegotiating how “firm-flow entitlements” are calculated, which are the basis for M2M settlements.
 - ✓ MISO should simulate all proposed changes before agreeing to any changes.

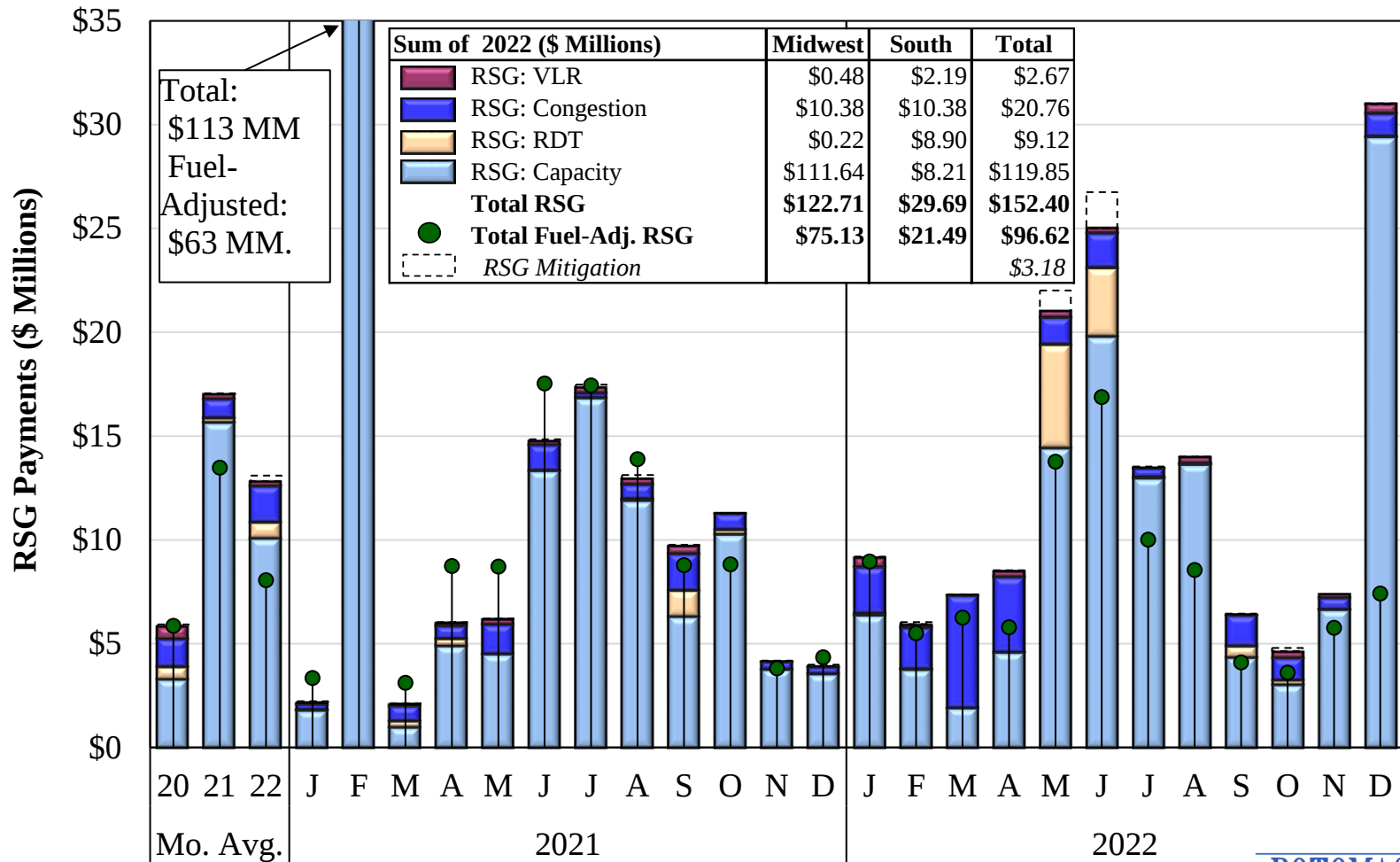


Uplift Costs and Real-Time Commitments

- Nominal day-ahead and real-time RSG payments fell 25 and 40 percent, respectively – partly due to very high RSG during Winter Storm Uri in 2021.
- In 2021, we identified a pattern of increasingly conservative capacity-related commitments beginning in the summer months that continued in 2022.
 - ✓ Roughly 7.5 percent of the capacity commitments were actually needed.
 - ✓ Over half of the excess commitments were not forecasted to be needed.
- We have been working with MISO to improve its out-of-market commitments to reduce costs and prevent price suppression, suggesting MISO:
 - ✓ Defer commitment of fast-starting units that can provide reserves offline.
 - ✓ Improve inputs into its commitment models.
 - ✓ Adjust STR requirements to address periods of higher uncertainty.
 - ✓ Implement a probabilistic assessment of multiple uncertainties.
- In early 2023, MISO eliminated headroom requirements that are now redundant with the STR needs, which lowered its average commitments.
 - ✓ We are working with MISO on other recommended improvements.

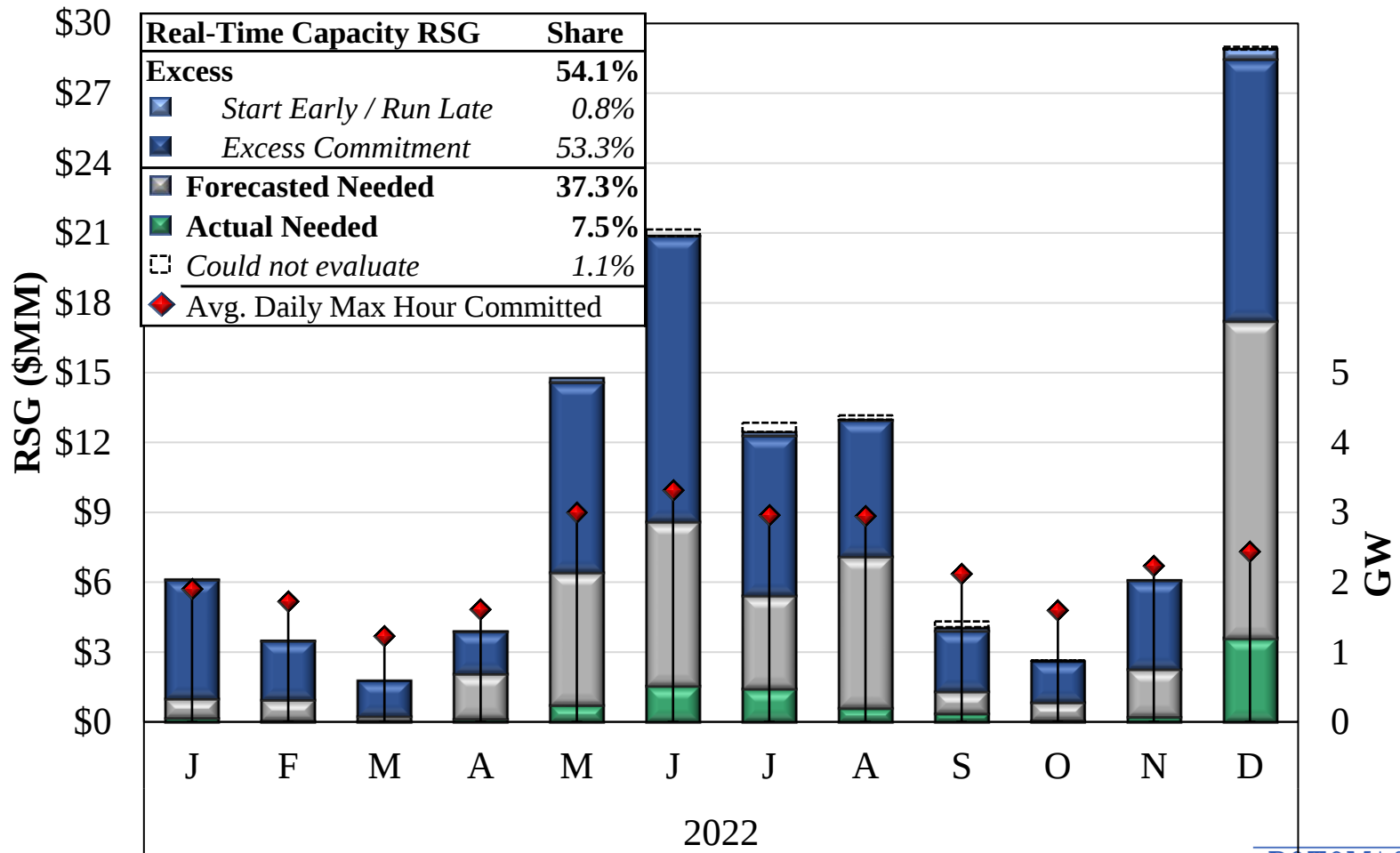


Real-Time RSG Costs





Evaluation of Real-Time Capacity Commitments and RSG Costs





Evolving the MISO Markets



MISO's Changing Resource Mix and Associated Challenges

- The MISO system is in the midst of a rapid transition.
 - ✓ Over the past decade, wind resource penetration in MISO has increased as coal resources have operated at reduced capacity factors or retired.
 - ✓ MISO's interconnection queue consists of more than 1400 active projects totaling over 240 GW, and more than half of these are solar projects.
 - ✓ These changes have already created significant operational challenges discussed in this section.
- MISO's markets are robust and well-structured to handle these changes with a few key changes we recommend in this section related to:
 - ✓ Operating and dispatch improvements to manage intermittent resources;
 - ✓ Energy and ancillary services markets improvements to efficiently compensate resources that complement the renewable resources.
 - ✓ Capacity market improvements to maintain a resource base that can satisfy MISO's reliability needs; and
 - ✓ Planning improvements to form more accurate expectations of changes coming and system needs.



Operational Challenges of the Growing Renewable Portfolio

- The following figures illustrate the operational challenges MISO faces.

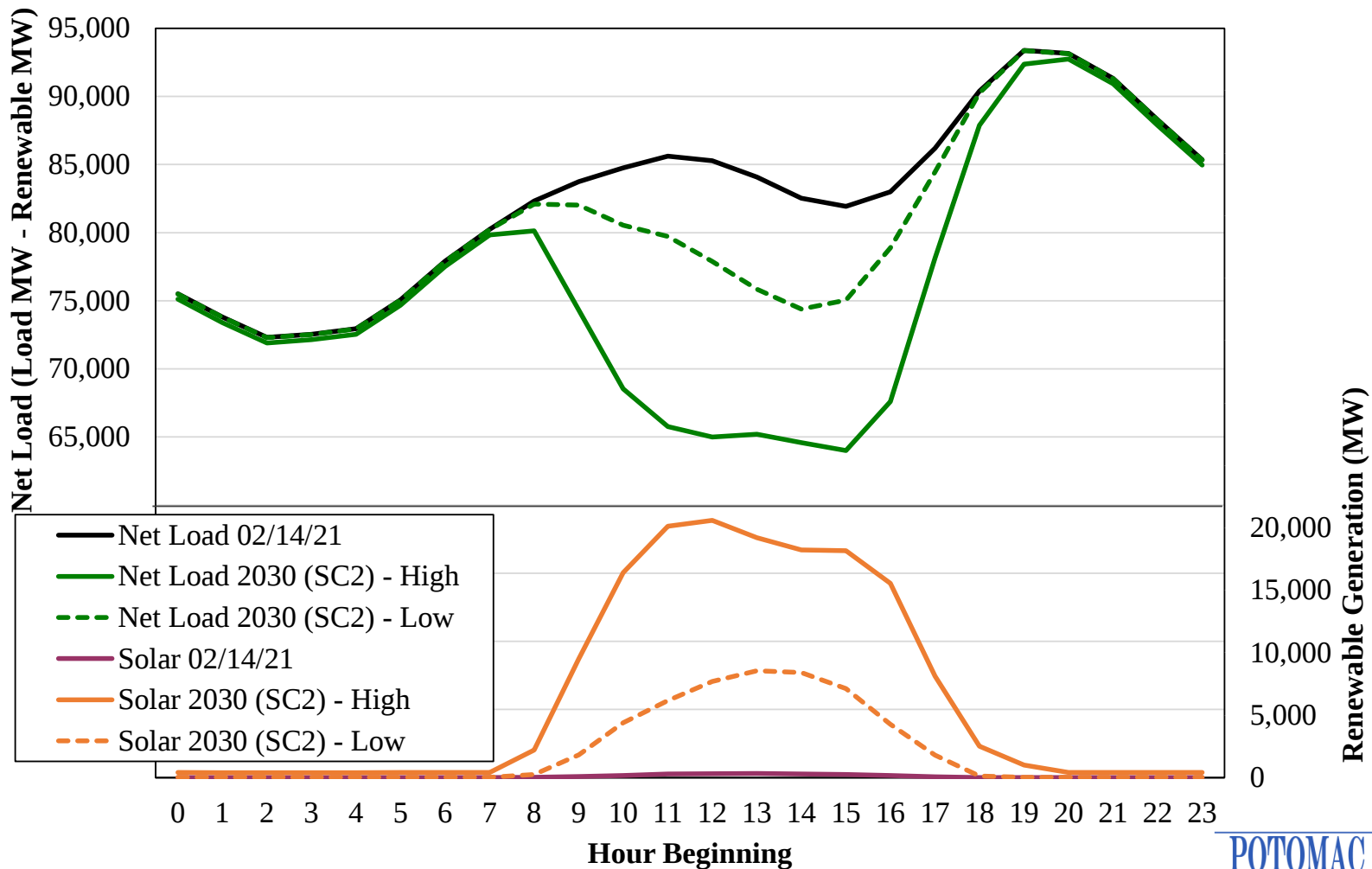
Solar Challenges

- Given the timing of expected increases and decreases in solar output, large quantities of solar will likely lead to significant changes in ramping needs.
- These ramping needs will increase the value of dispatchable resources.

Wind Challenges

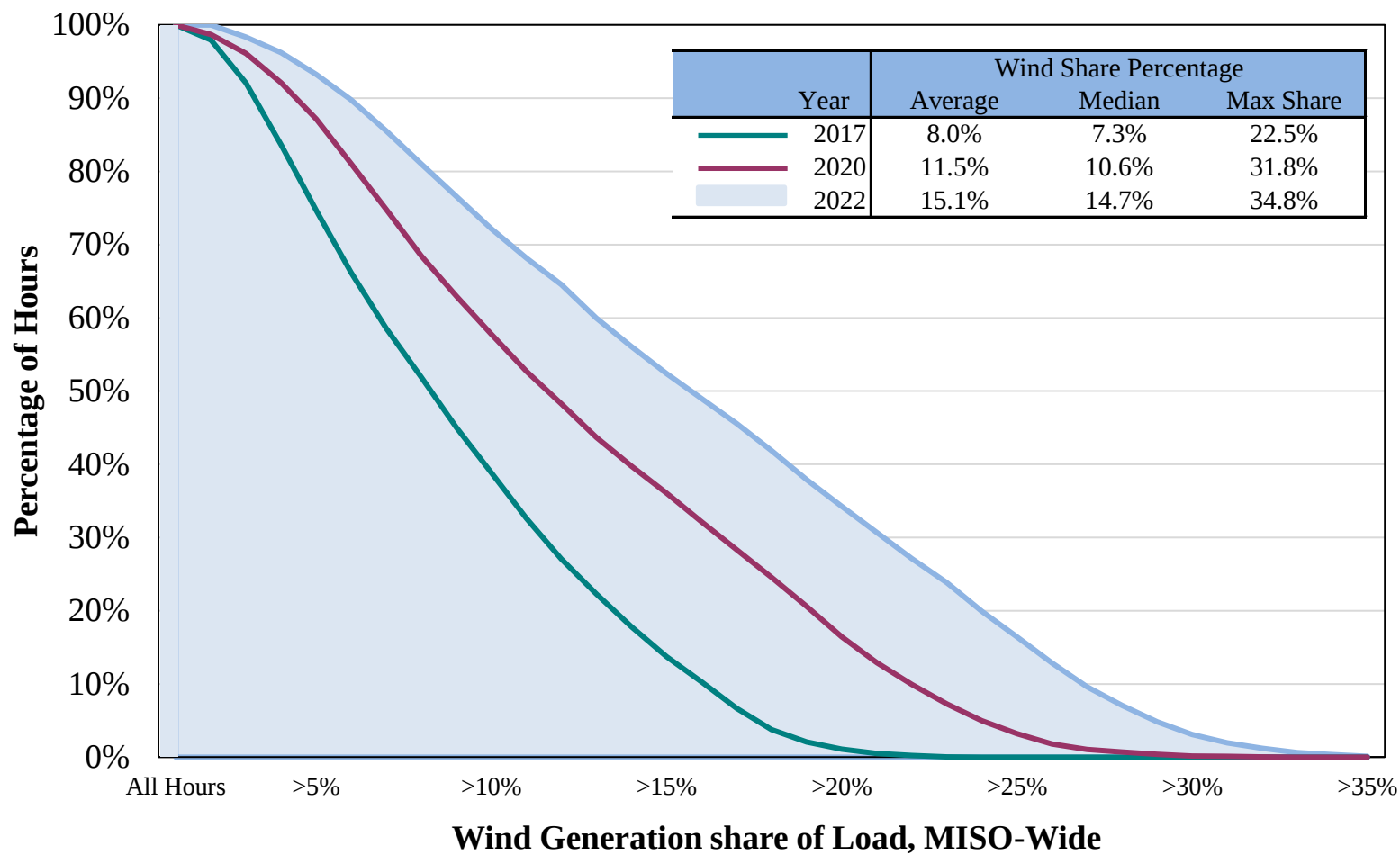
- Average hourly wind output grew 23 percent over 2021 and served an average of 23.8 percent of hourly load in the Midwest, up from 18.1 percent in 2020.
 - ✓ Wind fluctuations have grown as output has increased—the figure shows that wind varied by more than 10 GW on 34 days during September to December.
 - ✓ It has also led to more congestion and increased operational uncertainty.
- In addition, wind units sometimes do not follow dispatch because they often are economically indifferent – this can cause severe transmission violations.
 - ✓ Recommendation: improve deviation penalty using the marginal congestion component (MCC) of the price at the generator's location.

Net Load in MISO on a Representative Winter Day



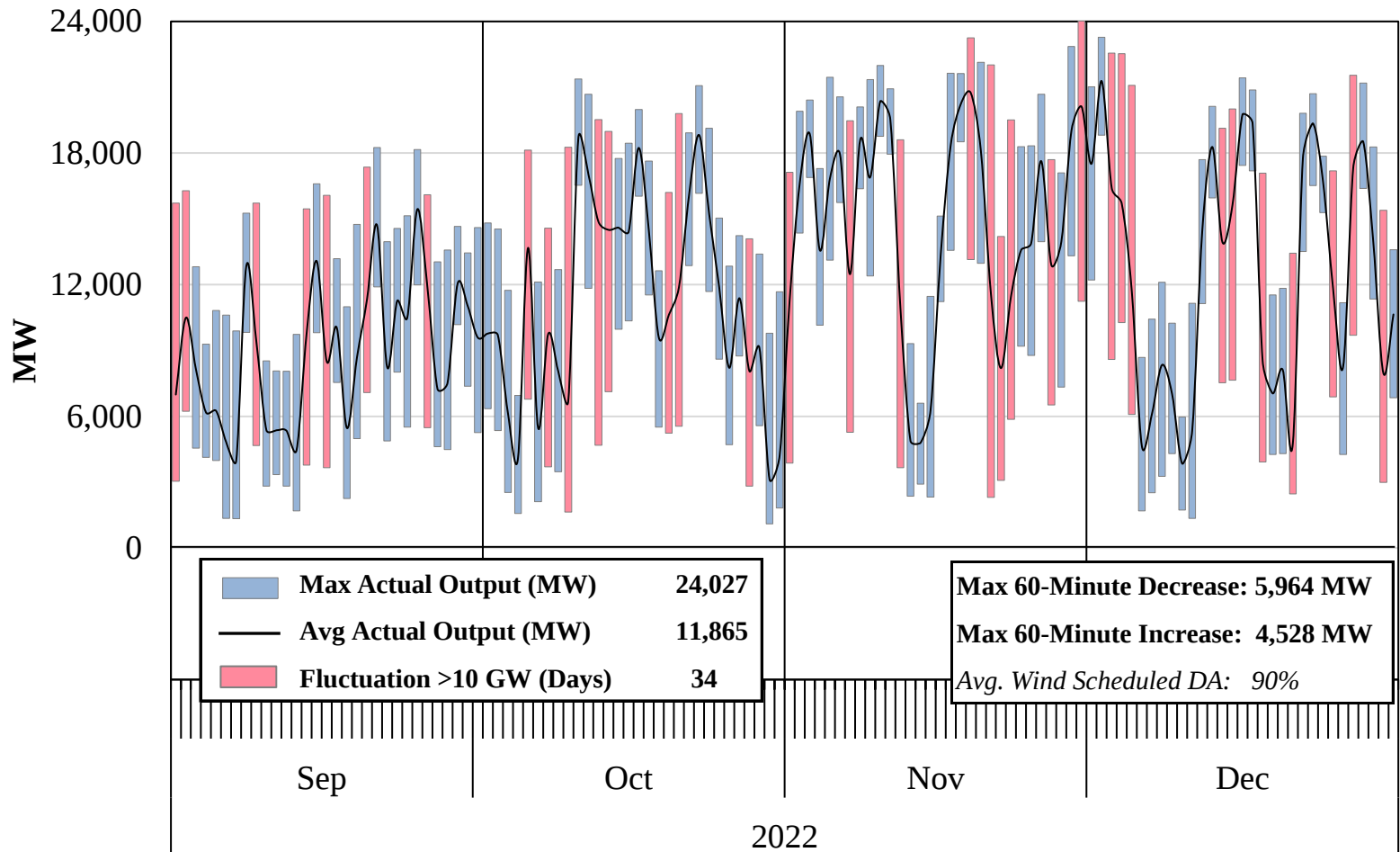


Share of Load Served by Wind Generation 2017 - 2022





Daily Range of Wind Generation Output September - December 2022



* Pink bars represent the 34 days when daily wind output fluctuated by more than 10 GW.

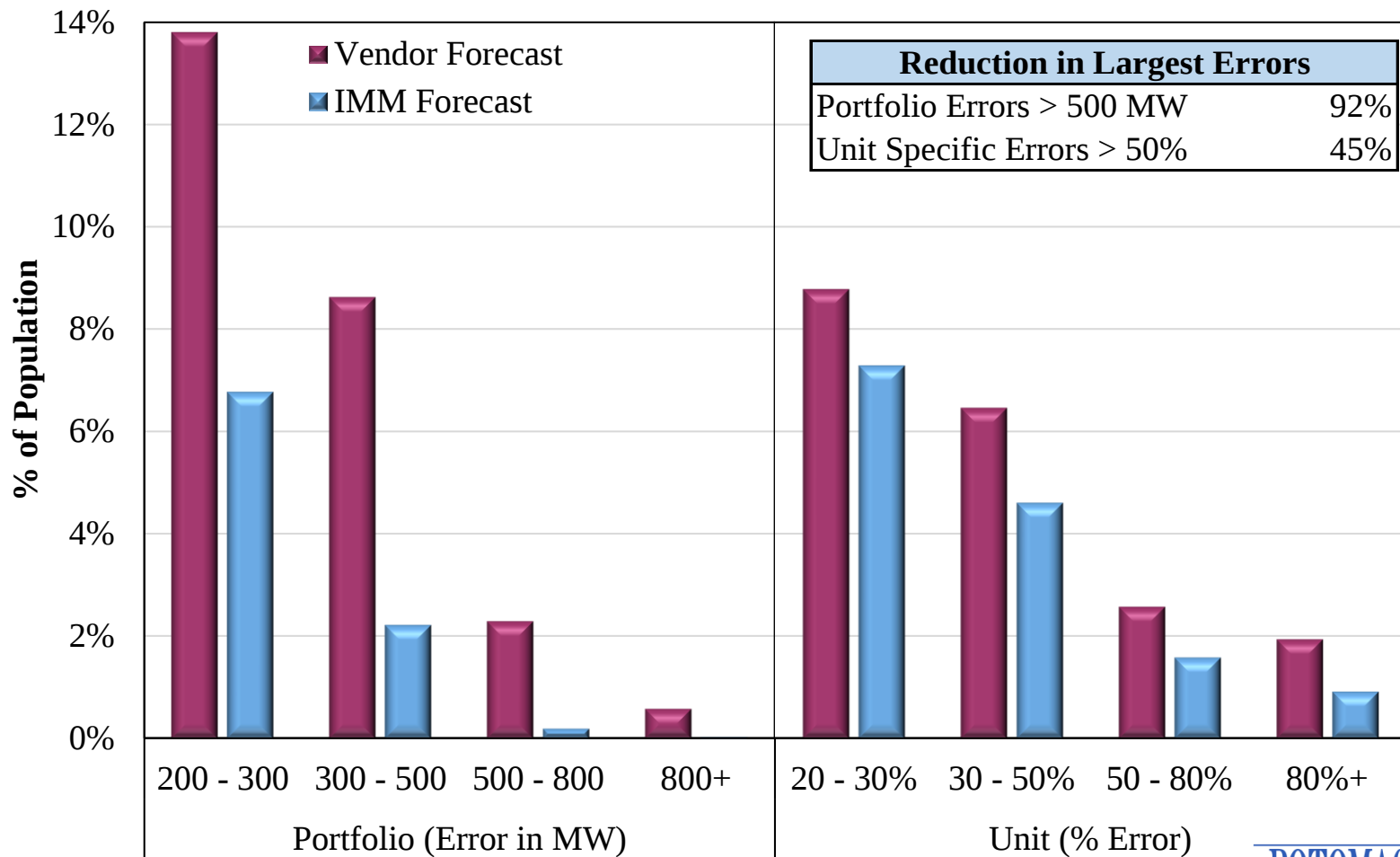


Operational Challenges of the Growing Renewable Portfolio

- As wind output grows, the effects of forecast errors grow and create larger operational effects.
- We encourage MISO to work with its vendor to improve its longer-term forecasts, but the most important one is the real-time forecast.
 - ✓ This forecast sets the maximum output level of each unit and, since most offer negative prices, it determines the dispatch instruction absent congestion.
- MISO uses a “persistence” forecast, assuming the most recent observation of each unit will be the output level 5-10 minutes in the future.
 - ✓ This produces a biased forecast when wind units are ramping up or down.
 - ✓ Since output changes are generally correlated, it can produce large aggregate fleet-wide errors.
- We developed a smart persistence forecast using the most recent output and the change in the unit’s output to project the unit’s near-term output.
- The following figure shows that this almost entirely eliminates the largest aggregate errors and reduces the cuts the largest unit-level by half.
- Recommendation: Implement a smart persistence forecast in real time.



Recommendation: Improve MISO's Real-Time Wind Forecast

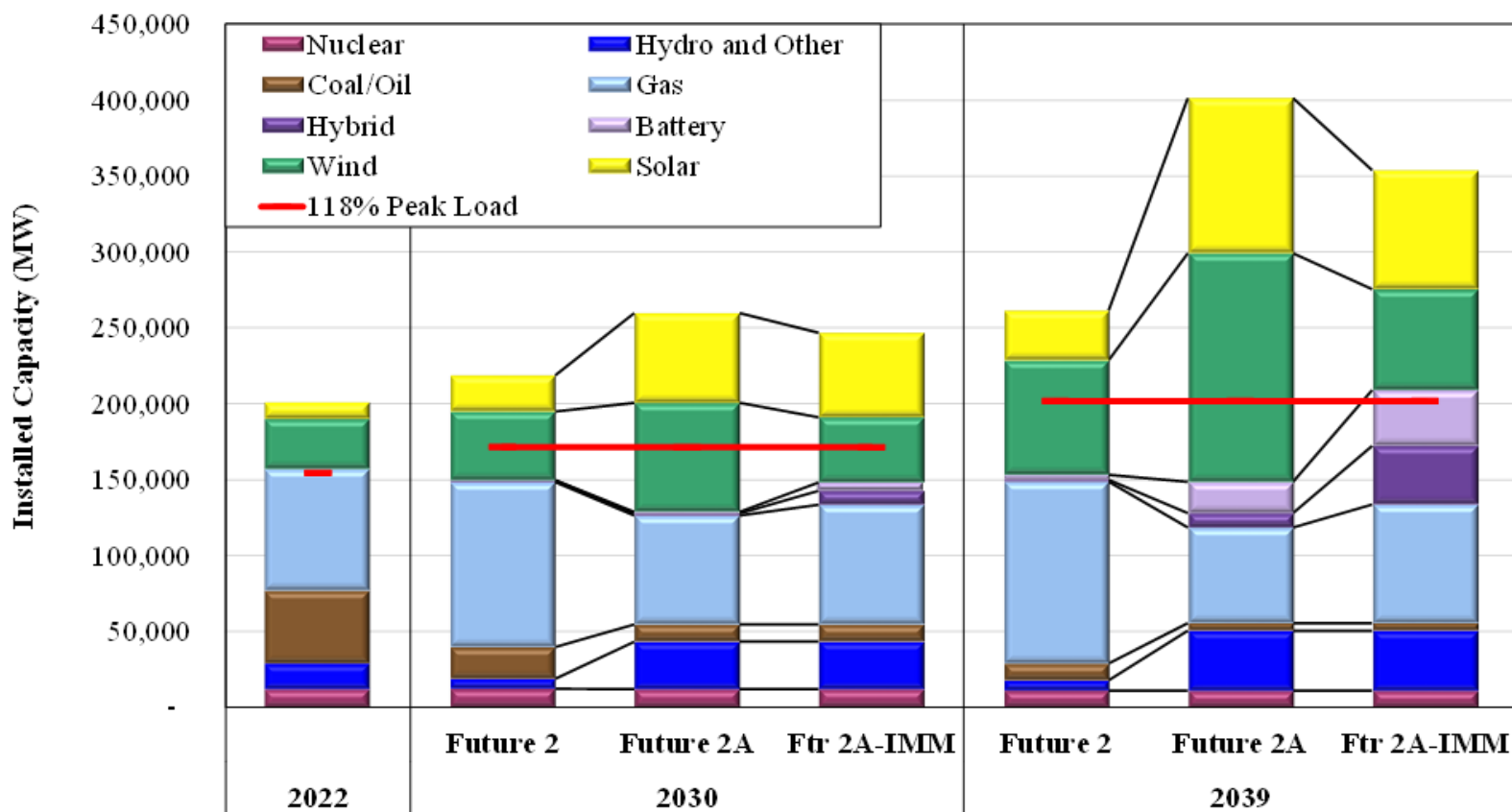




Expected Changes in the Generation Portfolio

- MISO's generation is changing rapidly – accurately forecasting this change is very important because it informs MISO's planning and operational changes.
- MISO is expecting a sharp increase in intermittent resources – its intermediate “Future 2” produced two years ago was revised this year in “Future 2A”.
 - ✓ Future 2A show more than twice the quantity of intermittent resources, an increase of roughly 140 GW from Future 2.
 - ✓ It also shows roughly half of the quantity of natural gas-fired resources.
- High assumed accreditation causes MISO's capacity expansion model to primarily select wind and solar when it needs resources for reliability.
 - ✓ Accurate marginal accreditation (close to zero by 2030) would cause the model to build resources with more valuable attributes.
 - ✓ We produced a more realistic case where the excess assumed reliability provided by intermittents is replaced by gas, hybrid resources, and batteries.
 - ✓ This case reduces intermittent capacity by 108 GW and lowers costs by more than *\$120 billion* even with the increase in hybrid resources.
- We believe the modified case is much more likely and recommend MISO reconsider the assumptions in Future 2A.

Anticipated Transition in Resource Mix





Evolving MISO's Markets and its System Transitions

Energy and Ancillary Services Markets

- 1) *Efficient shortage pricing*: improving MISO's operating reserve demand curves that set prices during shortages.
- 2) *Uncertainty product*: long-lead reserve product to deploy when uncertain events arise in real time – uncertainty is currently managed with out-of-market commitments that raise RSG and distort prices.
- 3) *Look-ahead dispatch*: enabling MISO's five-minute real-time market model to optimize the dispatch over a longer time-frame to efficiently manage increasing ramp demands. This is a longer-term improvement.

Capacity Market

- 1) *Capacity market demand reform*: aligning the demand for capacity with MISO's reliability needs by employing a reliability-based demand curve.
- 2) *Marginal capacity accreditation*: aligning capacity accreditation with the reliability value the resources provide.

Planning Improvements

- 1) *Improve LRTP*: improve Future 2A case and the benefit analyses of new projects because uneconomic investment undermines market decisions and generates inefficient costs for MISO's customers.

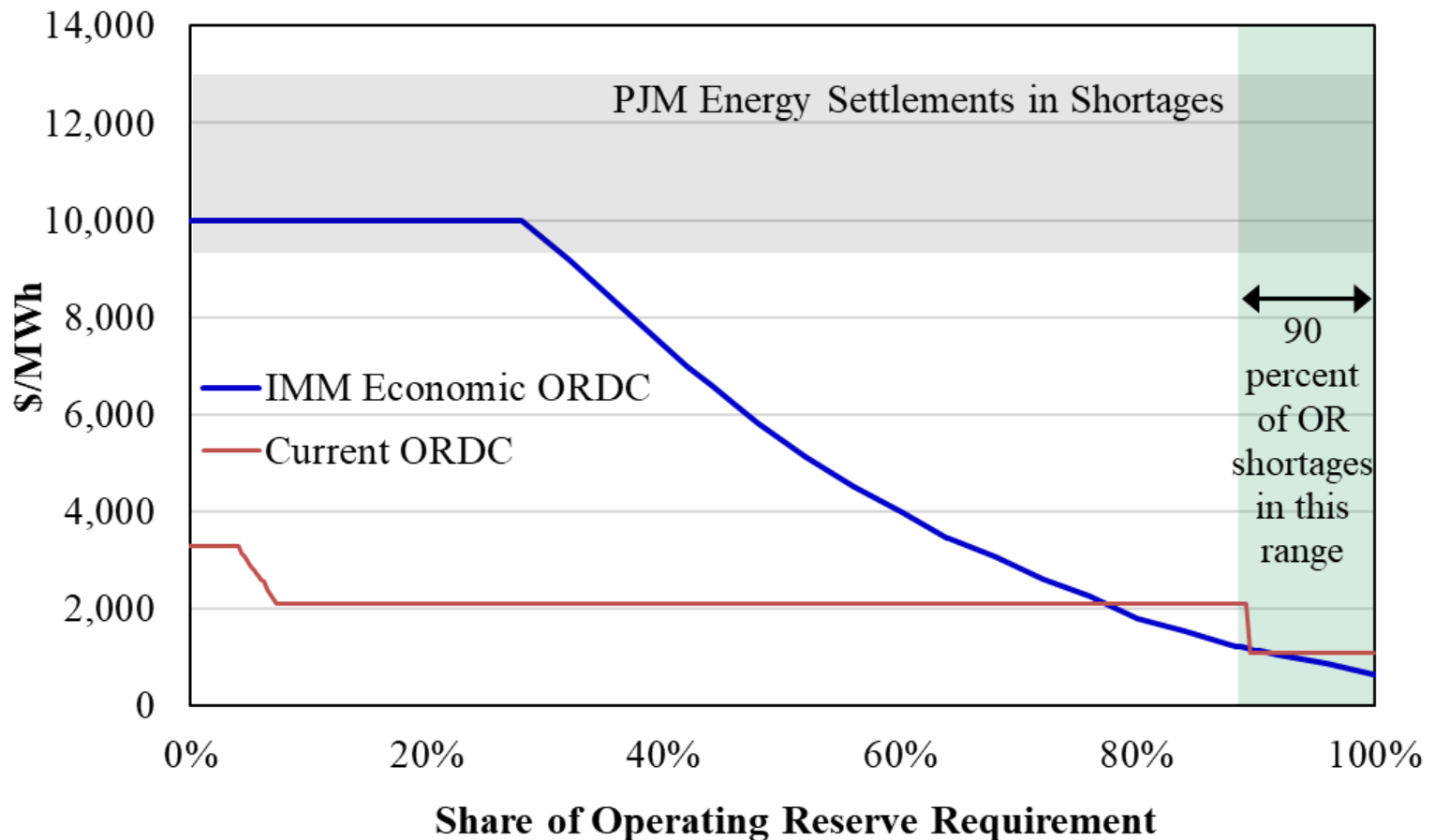


Recommendation: Efficient Shortage Pricing

- Shortage pricing provides critical economic signals for suppliers to be available and flexible – this is needed to accommodate long-term changes:
 - ✓ Expansion of renewable resources,
 - ✓ Greater reliance on demand response, and
 - ✓ Lower capacity margins.
- The Operating Reserve Demand Curve (ORDC) sets prices when MISO is short of reserves or the cost of procuring reserves exceeds its value.
 - ✓ Efficient shortage pricing requires that the ORDC equal the expected value of lost load = **Probability of Losing Load * Value of Lost Load (VOLL)**
- To achieve efficient shortage pricing, MISO will need to establish:
 1. A VOLL reflecting all classes of customers – we estimate \$25,000 per MWh.
 2. A slope reflecting the increasing probability of losing load as the operating reserve falls.
- Efficient shortage pricing will reduce the reliance on revenue from the capacity market to maintain resource adequacy.



Recommendation: Efficient Shortage Pricing





List of Recommendations



List of Recommendations

SOM Number	Recommendations	High Benefit	Near Term
Energy and Operating Reserves and Guarantee Payments			
2021-2	Evaluate reintroducing LMR curtailments as STR demand in pricing models and UDS.		
2021-5	Modify the Tariff to improve rules related to demand participation in energy markets.		✓
2020-1	Develop a real-time capacity product for uncertainty.		
2016-1	Improve shortage pricing by adopting an Operating Reserve Demand Curve reflecting the expected value of lost load.	✓	✓
2012-3	Remove external congestion from interface prices.		✓
2012-5	Introduce a virtual spread product.		
Transmission Congestion			
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 market-to-market coordination.		



List of Recommendations

SOM Number	Recommendations	High Benefit	Near Term
Transmission Congestion			
2019-2	Improve the testing criteria defining market-to-market constraints.		
2019-3	Develop improved capabilities to receive and validate current and forecasted dynamic ratings from transmission facilities.	✓	
2016-3	Enhance authority to coordinate transmission and generation planned outages.		
2014-3	Seek joint operating agreements with the control areas around MISO to improve congestion management and coordination during emergencies.		
Market and System Operations			
2022-2	Improve the real-time wind forecast by adopting enhancement to its current persistence forecasting methodology.	✓	✓
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.		✓



List of Recommendations

SOM Number	Recommendations	High Benefit	Near Term
Market and System Operations			
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.		✓
Resource Adequacy and Planning			
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 capacity market.		
2020-4	Develop marginal ELCC methodologies to accredit DERs, LMRs, battery storage, and intermittent resources.	✓	
2019-5	Improve the Tariff rules governing Energy Efficiency and their enforcement.		✓
2017-7	Establish PRA capacity credits for emergency resources that better reflect their expected availability and deployment performance.		



List of Recommendations

SOM Number	Recommendations	High Benefit	Near Term
Resource Adequacy and Planning			
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.		
2010-14	Improve the modeling of demand in the PRA by implementing reliability-based demand curves.	✓ ✓	✓