MARKET REFORMS CAN POWER THE ENERGY TRANSITION IN MISO

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EXECUTIVE SUMMARY

Wind, solar, and battery storage resources can revolutionize how grid operators keep the lights on, thanks to their power electronics, fast controls, and other advanced technologies. Electricity market rules play an essential role in unleashing those capabilities while ensuring an orderly transition from today's resources and operating practices. This report recommends reforms that will create a level playing field in the market for any resource that can provide needed services, facilitating and enabling a reliable and efficient transition to new resources. These recommendations seek to maximize the use of markets, recognizing that well-designed markets are the most efficient way to aggregate dispersed information and translate it into a price signal for performance that reflects the value of reliability. We encourage states and other stakeholders to work with MISO to implement these reforms.

This report primarily focuses on reforms that can be implemented by the Midcontinent Independent System Operator, Inc. ("MISO"), which operates the wholesale electricity market and power grid for all or part of 15 states stretching from the Dakotas to Indiana and south to Louisiana, while a companion report focuses on the PJM Interconnection LLC ("PJM"), the grid operator in the Great Lakes and Mid-Atlantic states. However, many of these recommendations are broadly applicable in all regions, as grid operators across the country are seeing similar changes in their generation mixes and market needs due to the same fundamental economic and technological factors. More detail on these recommendations, as well as similar recommendations for the California Independent System Operator, can be found in comments ACORE and other clean energy organizations filed on January 18, 2023, in the Federal Energy Regulatory Commission's ("FERC's") Docket No. AD21-10-000 on modernizing wholesale electricity market design.[1]

1 Available at https://acore.org/clean-energy-associations-comments-on-energy-ancillary-service-.

This report offers the following recommendations for reforms MISO can implement:

I. Use markets to reduce out-of-market actions, and ensure that the market rules do not reward resources for their inflexibility

a. More accurately characterize the capabilities of all resources in the energy market, but do not reward inflexibility

b. Adopt more efficient unit commitment processes

c. If needed, create new markets or market products

II. Increase energy market price caps to better reflect the value of reliability and incentivize real-time performance and flexibility

III. Improve market transparency and efficiency by using more direct mechanisms to counter market power

IV. Improve transmission utilization both within MISO and at seams with neighboring grid operators to decrease congestion costs, curtailment, and market power

V. Reform MISO's voluntary capacity market to better incentivize performance and flexibility

The recommendations will further improve market reforms and operating practices MISO has successfully implemented over the last 15 years that have made it a leader in reliably integrating large amounts of renewable energy. Most electricity is purchased through bilateral contracts outside the centralized wholesale markets, but the prices in wholesale markets provide the economic foundation for all electricity transactions. As a result, it is essential for those markets to send efficient price signals, which the reforms discussed in this report to improve operations and minimize inflexibility are designed to achieve. For further background on these recommendations, we point to a comprehensive list of recommended market design changes we published several years ago,[2] with specific recommendations for MISO.[3]

2 Wind-Solar Alliance, "Customer Focused and Clean – Power Markets for the Future" (November 2018) at 5, available at: https://gridprogress.files.wordpress.com/2019/03/power-markets-for-the-future-full-report.pdf.

3 Wind Solar Alliance, "Customer Focused and Clean – Power Markets for the Future – MISO FOCUS" (Nov. 2018), available at: https://gridprogress.files.wordpress.com/2019/03/power-markets-for-the-future-miso-focus.pdf.

I. USE MARKETS TO REPLACE OUT-OF-MARKET ACTIONS

MISO's filing in FERC's proceeding on market design, as well as the MISO Independent Market Monitor's ("IMM's") annual list of recommended reforms to market design, correctly highlight the benefits of using markets to the maximum extent possible to replace out-of-market operator actions and compensation mechanisms affecting generator commitment and dispatch. While some operator actions and out-of-market compensation will still be needed, there are benefits from maximizing the use of markets because well-functioning markets efficiently and fairly drive generator behavior, while out-of-market payments distort prices and incentives.[4] The mechanisms for moving these actions into markets include **(1) more accurate characterization of the capabilities of all resources in the energy and ancillary services markets; (2) more efficient unit commitment processes; and (3) the potential creation of new markets or market products.** To better understand what market reforms are needed, it is also important for MISO to keep better records of the factors driving out-of-market actions and payments (known as "uplift").[5] There should be transparency regarding the reasons for out-of-market payments so that stakeholders and market participants are confident that the prices reflect market conditions and that the market is operating efficiently.

A. Better characterize resources' capabilities, but do not reward inflexibility

We offer the following five principles for how resources should be characterized in commitment and dispatch decisions.

1. Ensure accurate and detailed resource bid parameters.

MISO should adopt market rules that improve the accuracy of the minimum generation levels and ramp rates submitted by generators for dispatch determinations. In many cases, these submitted generator bid parameters understate the flexibility of the units, such as the use of ramp rate, startup time, or minimum output limits for generator constraints that are not actually physical limits, but rather economic costs associated with more flexible dispatch. Expressing the capabilities and limits of flexible and inflexible supply and demand resources as costs would facilitate more accurate pricing of inflexibility. Bid parameters that understate a unit's actual flexibility contribute to excess payments to inflexible units. MISO needs to know each unit's actual ramp capability to be able to dispatch available resources effectively, but many conventional units' reported ramp parameters are inaccurate.

MISO has examined how to improve bid parameter reporting to improve system operational flexibility and price transparency. As part of this effort, MISO is attempting to reduce make-whole payments and other out-of-market compensation and replace them with transparent

4 For example, see Independent Market Monitor for the Midcontinent ISO ("MISO IMM"), 2021 State of the Market Report (June 2022) at 115, available at: https://cdn.misoenergy.org/20220622%20Markets%20Committee%20of%20the%20BOD%20Item%2004%20IMM%20State%20of%20the%20Market%20Report625261.pdf, stating: "This report indicates that out-of-market commitments by MISO and the associated RSG [Revenue Sufficiency Guarantee] costs increased substantially in 2021. Our analysis indicated that most of these commitments were not ultimately needed to satisfy MISO's energy, operating reserves, and other reliability needs. In addition to raising RSG costs borne by its customers, these excess commitments depress real-time prices and result in inefficiently lower imports from neighboring areas, inefficiently lower day-ahead procurements and resource commitments, and depressed long-term price signals. Therefore, it is important to curtail excess out-of-market commitments and the accompanying RSG costs.

5 For example, see *Id.* at 122.

prices. MISO can use more extensive and accurate bid parameters to improve actual flexibility performance, with or without new categories of reliability services.

2. Create a universal participation model.

In their reports in FERC's wholesale electricity market reform docket, various RTO/ISOs discuss their efforts to better reflect the operational characteristics and capabilities of resources including steam, natural gas combined cycle, battery storage, and distributed resources in their commitment and dispatch processes.[6] While such efforts are valuable, MISO should also explore the feasibility of a more elegant and durable solution in which all resource types can express their capabilities through a universal participation model. Under this concept, all resources could describe their capabilities relative to a theoretical perfectly flexible resource.[7] Another long-term approach would be to encourage resources to become closer to perfectly flexible resources by becoming hybrid resources.[8] This could result in considerable longer-term simplifications to market designs by expecting more of market participants.

3. Give resources the option to control their own commitment and dispatch.

Centralized RTO/ISO spot markets are extremely valuable for aggregating dispersed information from different participants and incentivizing participants to develop more accurate forecasts. To the maximum extent possible, RTO/ISOs should not interfere with market participants' use of their commitment and dispatch preferences to reveal expectations that set efficient prices for all market participants. This includes giving battery storage operators the option of managing their state-of-charge at all times. Some RTO/ISOs have proposed direct RTO/ISO control of storage state-of-charge to address instances of inefficient charging and discharging,[9] though in many cases those problems are symptoms of other market failures discussed below, such as when low price caps cause batteries to discharge earlier than would be optimal. However, there may be value in offering market participants the option of allowing the RTO/ISO to manage their resource for them, as long as they have the right to opt out and manage it themselves.

4. Remove barriers to energy and ancillary services market participation.

Market rules should treat generation resources comparably and allow all generation resources capable of providing a product or service to do so and be fairly compensated. MISO should evaluate its existing ancillary service and ramping product rules to ensure they are non-discriminatory. As noted above, today wind and solar may or may not be the most cost-effective resources to provide certain services given the opportunity cost of curtailing

6 For example, see PJM Report at 28, available at https://www.pjm.com/-/media/documents/ferc/filings/2022/20221018-ad21-10-000.ashx. Also see PJM IMM (2022) at 90: "The MMU recommends that PJM model generators' operating transitions, including soak time for units with a steam turbine, configuration transitions for combined cycles, and peak operating modes."

7 Mark Ahlstrom, "The Universal Market Participation Model" (April 5, 2018), available at: https://www.esig.energy/blog-the-universal-market-participation-model/.

8 Derek Stenclik, Michael Goggin, Erik Ela, and Mark Ahlstrom, "Unlocking the Flexibility of Hybrid Resources" (March 2022), available at: https://www.esig.energy/unlocking-the-flexibility-of-hybrid-resources/.

9 CAISO Department of Market Monitoring (CAISO DMM), Annual Report on Market Issues and Performance (July 27, 2022) at 28, 293, available at: https://www.caiso.com/Documents/2021-Annual-Report-on-Market-Issues-Performance.pdf.

renewable generation. However, as the renewable penetration increases, curtailment will increase, and the opportunity cost of foregone energy production will decline so that renewables may increasingly become cost-effective sources of ancillary services and flexibility in the upward as well as downward direction.[10] MISO must design its markets and products to allow these services or products to be provided on a non-discriminatory basis by all capable resources.

MISO's Tariff and business practices currently prohibit wind, solar, and battery hybrid resources from providing the operating reserves that are used to balance electricity supply and demand on a sub-hourly basis, like frequency regulation, spinning, and supplemental reserves.[11] Preventing wind and solar resources from providing those ancillary services reduces competition and harms consumers.[12]

Batteries, wind,[13] and solar[14] plants all use fast and flexible power electronics that allow them to provide those services, and more generally meet or exceed the ancillary services contributions of conventional generators.[15] FERC now requires new wind, solar, and battery resources to match the reactive power[16] and frequency response[17] capabilities of conventional

10 Energy + Environmental Economics, Inc., "Investigating the Economic Value of Flexible Solar Power Plant Operation" (Oct. 2018) at 34, available at: https://www.ethree.com/wp-content/uploads/2018/10/Investigating-the-Economic-Value-of-Flexible-Solar-Power-Plant-Operation.pdf.

11 SEIA, "Complaint of Solar Energy Industries Association v. Midcontinent Independent System Operator, Inc. under EL23-28," January 2023, available at https://elibrary.ferc.gov/eLibrary/filelist?accession_number=20230131-5452&optimized=false

12 Advanced Energy United, et. al., "Comments of Advanced Energy United, et. al. in Support of Complaint under EL23-28," March 2023, available at https://elibrary.ferc.gov/eLibrary/filelist?accession_number=20230303-5150&optimized=false

13 National Renewable Energy Laboratory, "Active Power Controls from Wind Power: Bridging the Gaps" (January 2014), available at: https://www.nrel.gov/docs/fy14osti/60574.pdf.

14 National Renewable Energy Laboratory, "Demonstration of Essential Reliability Services by a 300-MW Solar Photovoltaic Power Plant" (March 2017), available at: https://www.nrel.gov/docs/fy17osti/67799.pdf.

15 Milligan et al, "Alternatives No More: Wind and Solar Power Are Mainstays of a Clean, Reliable, Affordable Grid," IEEE Power and Energy Magazine (Volume: 13, Issue: 6, Nov.-Dec. 2015), available at: https://ieeexplore.ieee.org/document/7299793.

16 Reactive Power Requirements for Non-Synchronous Generation, 155 FERC 61,277 (June 16, 2016), available at: https://www.ferc.gov/sites/default/files/2020-06/RM16-1-000.pdf.

17 Essential Reliability Services and the Evolving Bulk-Power System—Primary Frequency Response, 162 FERC 61,128 (February 15, 2018), available at: https://www.ferc.gov/sites/default/files/2020-06/Order-842.pdf.

generators. These power electronics can even use grid power to provide voltage and reactive power support when the plant is not producing power, such as solar plants providing reactive power at night.[18] In contrast, many conventional generators provide little or no flexibility, frequency response, and other needed reliability services.[19] Curtailed renewables are likely to be a growing source of ancillary services, and the rapid growth of battery and hybrid resources will also likely meet any increase in need for ancillary services.

MISO's report in the AD21-10-000 proceeding at FERC also reveals an outdated understanding of the reliability services capabilities of renewable and storage resources, which may play a role in the retention of outdated rules that are preventing those resources from providing those services. MISO's report understates the ancillary services contributions of inverter-based resources while overstating the contributions of legacy resources: "In addition, as intermittent resources continue to make up a greater share of MISO's system, increasing curtailment of those resources may be necessary to manage congestion and keep resources needed for ancillary services online. Such curtailment along with the dispatch of potentially more expensive resources that can supply ancillary services will challenge market efficiency… Over time, ancillary service shortages are expected to increase in size and frequency."[20]

MISO also writes that "By the 2030 timeframe, resource usage and capability inadequacy needs emerge for inverter-based resources and transmission. Research and development are needed to enable ancillary services from inverter-based resources by this time to address inverter stability and inertia and frequency response needs."[21] MISO is correct that research and development and expanded deployment of grid-forming inverters will further increase the ancillary services capabilities of renewable and battery resources and address weak grid stability concerns that are emerging in some parts of the grid. Battery storage and curtailed renewables are excellent sources of frequency response and can even provide fast frequency response that displaces the need for inertia.[22] For example, the 150 megawatt (MW) Hornsdale battery in South Australia has provided fast frequency response to stabilize the grid within seconds of major real-world grid disturbances.[23]

Grid-forming inverters that further expand the reliability services contributions of renewable and battery resources are increasingly being used today. The Dalrymple Substation Battery project in South Australia started commercial operation in December 2018 and has demonstrated that grid-forming batteries can provide short-circuit current contribution, fast frequency response, blackstart, and islanded operation.[24] Batteries have been used to

18 Alice Grundy, "Light Source BP delivers night time reactive power using solar in 'UK First'," Solar Power Portal (November 25, 2019), available at: https://www.solarpowerportal.co.uk/news/lightsource_bp_delivers_night_time_reactive_power_using_solar_in_uk_first.

19 Michael Milligan, "Sources of Grid Reliability Services," The Electricity Journal, Volume 31, Issue 9, November 2018, at 1-7, available at: https://www.sciencedirect.com/science/article/pii/S104061901830215X.

20 MISO Report to FERC at 28, available at https://elibrary.ferc.gov/eLibrary/filedownload?fileid=897EF372-978A-C67A-9DEA-83EBE6200000.

21 MISO Report at 40-41.

22 NERC Inverter-Based Resource Performance Task Force, "Fast Frequency Response Concepts and Bulk Power System Reliability Needs" (March 2020), available at: https://www.nerc.com/comm/PC/InverterBased%20Resource%20Performance%20Task%20Force%20IRPT/Fast_Frequency_Response_Concepts_and_BPS_Reliability_Needs_White_Paper.pdf.

23 Giles Parkinson, "'Virtual machine': Hornsdale battery steps in to protect grid after Callide explosion," Renew Economy (May 27, 2021), available at: https://reneweconomy-com-au.cdn.ampproject.org/c/s/reneweconomy.com.au/virtual-machine-hornsdale-battery-steps-in-to-protect-grid-after-callide-explosion/amp/.

24 "A 30MW Grid Forming BESS Boosting Reliability in South Australia and Providing Market Services on the National Electricity Market," in Proc. 18th Int'l Wind Integration Workshop (October 2019), available at https://www.electranet.com.au/wp-content/uploads/2021/01/Wind-Interation-Workshop-30MW-BESS-October-2019.pdf.

provide blackstart service in multiple islanded microgrids around the world.[25] A recently announced 185 MW battery project in Hawaii will fully replace the grid services currently provided by a nearby retiring coal plant by providing blackstart, fast frequency response, and grid-forming services.[26] Renewable plants can also be designed to provide blackstart and other services. In Great Britain, controls of an existing 69 MW wind farm were modified to be grid-forming, and the wind farm then successfully provided fast frequency response, blackstart, and islanded operation capability.[27]

5. Price resources' inflexibility.

Allow more resources to include fixed costs in their bids. Currently, FERC allows only fast-start resources to include start-up and no-load costs in their bids. Some experts argue that rules around price formation need to evolve so that resource types other than fast-start resources can include start-up and other fixed costs in their bids, as this will incorporate the cost of meeting reliability needs in energy market prices instead of recovering them through out-of-market payments.[28]

At present, energy market prices and dispatch do not perfectly incorporate the fact that most conventional generators have "non-convex" costs, which are essentially fixed costs that occur at various points on the resource's output curve and are notably higher at unit startup and lower output levels. While these costs are accounted for in unit commitment decisions, there is active RTO/ISO stakeholder debate about whether these costs should be reflected in energy market prices or be allocated as uplift costs outside the market-clearing Locational Marginal Price (LMP) calculation. This debate has focused on which convex costs should be incorporated into price (start-up and no-load costs, or other fixed costs as well), and for which units (quick-start units, only on-line resources, etc.).

An example of an inefficient solution that subsidizes inflexible resources can be seen in a 2017 proposal from PJM to allow a range of fixed costs to be included in the market-clearing price that would be set by many inflexible units.[29] This proposal would have allowed on-line coal and nuclear plants to set prices well above their true marginal cost of producing electricity. This proposed form of Extended LMP would inefficiently support generators that are not providing flexibility, imposing an unjust and unreasonable cost burden because it charges customers a premium without delivering any reliability benefits, while insulating inflexible conventional plants from the cost of their inflexibility. However, alternative formulations that only reward resources offering flexibility can be efficient.

While most types of flexible duration-limited resources do not have start-up and no-load costs and therefore, their bids would not be directly affected, other resources' inclusion of those

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25 Oliver Schömann, "Experiences with large grid-forming inverters on various island and Microgrid projects," Hybrid Power Systems Workshop (May 2019), available at: https://hybridpowersystems.org/wp-content/uploads/sites/13/2019/06/3A_3_HYB19_017_presentation_Schoemann_Oliver_web.pdf.

26 Julian Spector, "Hawaii building huge new battery, bidding farewell to coal," Canary Media (August 18, 2021), available at: https://www.canarymedia.com/articles/hawaii-building-huge-new-battery-bidding-farewell-to-coal/.

27 A. Roscoe, et. al., "Practical experience of providing enhanced grid forming services from an onshore wind park," in Proc. 19th Wind Integr. Workshop (November 2020).

28 P. Gribik et al., "Extended Locational Marginal Pricing (Convex Hull Pricing)" (June 2, 2010), available at: https://cms.ferc.gov/sites/default/files/2020-05/20100530130229-Gribik%2C%2520Zhang%2C%2520Midwest%2520ISO%2520-%2520Extended%2520LMP.pdf.

29 PJM Interconnection, LLC, "Proposed Enhancements to Energy Price Formation" (November 15, 2017), available at: https://pjm.com/-/media/library/reports-notices/special-reports/20171115-proposed-enhancements-to-energy-price-formation.ashx.

costs in their bids would increase market clearing prices and thus infra-marginal revenues for resources that do not have those costs. To avoid perversely subsidizing inflexible resources, those costs should not be recoverable through make-whole or other out-of-market payments to those resources but should be included in prices to provide accurate short- and long-run incentives to all resources.

Do not reward resources for their inflexibility. Today RTO market mechanisms routinely provide uplift to committed generators that cover costs associated with their inflexibility. If poorly designed, these payments can perversely incentivize resources to remain inflexible. A better solution is reducing out-of-market subsidies for inflexibility and instead directly accounting for these costs in commitment and dispatch processes, to the maximum extent possible.

More to the point—market participants today have a variety of technologies at their disposal to meet the needs of the power system, including flexibility. MISO should consider ending the use of uplift payments and other out-of-market payments if a generator could meet the required availability and performance with the use of a better or different technology. For example, generators that are not able to ramp down and up quickly enough to meet the needs of the grid could instead use fast-ramping technologies like battery storage in combination with existing resources to cover that liability, rather than impose that cost on load.

B. Establish more efficient unit commitment processes

Unit commitment is the process by which generators are selected to operate ahead of the real-time market, which is primarily achieved through the day-ahead market. Because the vast majority of energy is transacted in the day-ahead market and inefficient commitment imposes costs on consumers while distorting price signals, there is considerable benefit to improving the efficiency of the commitment process.

1. Increase the use of probabilistic unit commitment.

Probabilistic unit commitment refers to processes that directly incorporate information about uncertainty in electricity supply and demand forecasts into unit commitment decisions. Today, operators make conservative unit commitment and dispatch decisions in part because they recognize that their deterministic methods and forecasts are not fully accounting for uncertainty and risk.[30] Using more rigorous quantitative methods to account for that risk would produce more efficient, lower-risk operations.

For example, commercially available renewable output and electricity demand forecasts typically include detailed information about the uncertainty of those forecasts, but it is common for only the median (p50) value to be used as the deterministic input for committing and dispatching other resources. Most forecast vendors can quantify the uncertainties around a production forecast, such as uncertainty about the magnitude of a

30 Even with these conservative assumptions, RTOs/ISOs may not always accurately predict tail-end events, such as MISO's inability to accurately forecast both load and available reserves during Winter Storm Elliott. See: https://cdn.misoenergy.org/20230117%20RSC%20Item%2005%20Winter%20Storm%20Elliott%20Preliminary%20Report627535.pdf.

weather event (e.g., the distribution of temperature, irradiance or wind speed outcomes) and the timing of an event (e.g., when a front resulting in abrupt temperature, wind speed, or cloud cover changes will arrive). Probabilistic unit commitment tools that incorporate such uncertainties would yield more efficient commitment of resources based on risk-managed inter-temporal solutions, especially considering that many of the uncertainties have correlated impacts on both supply and demand. For example, if forecasts indicate a significant chance of both very high load and very low renewable output, operators will likely want to commit more resources. However, because those risks are not reflected in the median value for either forecast, current deterministic methods do not automatically incorporate them into commitment decisions, forcing operators to attempt to subjectively incorporate them.

While human operators have many advantages relative to computers due to their deep knowledge of the system developed over years of experience, operators can benefit from greater use of decision support tools that identify statistical patterns and use probabilistic methods to make better, lower-risk commitment and dispatch decisions. Moreover, the use of subjective judgement can be time-consuming during critical events. The use of such tools would minimize inefficient dispatch and uplift costs and reduce generation overcommitment. Many resource owners and power traders use probabilistic methods to make decisions about the dispatch of energy-limited resources like energy storage, and therefore MISO operators would also benefit from the use of those tools.

> **MISO's report to FERC correctly notes the benefits of using probabilistic tools:**
>
> MISO's operators must continue to make real-time decisions and commitments based on recommendations based on data analysis inside of their tools. Real-time decisions are often made to mitigate reliability risks and may sacrifice efficiency. But we are working to better quantify the uncertainty around various risk factors so that we can continue to improve these tools, the operator decisions they inform, and over the long term, identify and implement market products to maintain reliability and efficiency (see the two other key workstreams of MISO's Reliability Imperative, MSE and Operations of the Future). Another way to better quantify the risks is to create probabilistic forecasts that account for the uncertainty…[31]

However, MISO does not currently use probabilistic tools.

> **MISO's comments propose first creating a daily risk assessment to inform operator decisions, and eventually progressing to directly incorporating probabilistic analysis into unit commitment through a Dynamic Reserve Requirement:**
>
> As MISO is able to better quantify the uncertainty, it will be able to use advanced data analytics, to visualize risks from weather, load, wind, solar and so forth to aggregate net load, do advanced scenario analysis, and extend foresight. This work is needed to create a daily risk assessment, in essence, showing us the risk we need to manage on a given day and what is needed to mitigate it. Then, based on the use of the daily risk assessment,

31 MISO Report at 24.

we'll be able to use dynamic reserve requirements to reduce operator commitments and inform additional market design changes that incentivize the resource attributes at the right time and location. This would allow MISO to create Dynamic Reserve Requirements, operationalizing and automating analytical and meteorological expertise… At a more structural level and over time, such information will help inform and improve market product demand curves and align them with systemwide, regional, or local reliability requirements.[32]

We encourage MISO to quickly move towards directly incorporating probabilistic tools into unit commitment. While the interim step of using probabilistic tools to inform grid operators provides value, directly incorporating probabilistic analysis into unit commitment greatly exceeds the capabilities of human operators to automatically synthesize different types of risk (e.g., magnitude vs timing) as well as correlations among load and the output of different types of generators across a lengthy historical record, and optimally mitigate that risk.

2. Decrease the lead time for unit commitment.

Because forecast error for electricity supply and demand significantly decreases as one reduces the forecast horizon,[33] there is a significant benefit in making or updating unit commitment decisions as close to real-time as possible. As discussed below, one solution for achieving this is eliminating out-of-market payments that perversely reward or at least hold harmless resources that are inflexible or otherwise require lengthy lead times to start up, procure fuel, or undertake other processes. Grid operators can also use multi-interval or rolling unit commitment processes to schedule as many resources as close to real-time as possible.

While MISO uses multi-interval commitment processes today, there is significant room for improvement in their processes.[34]

As the MISO Independent Market Monitor (IMM) has noted:

MISO has developed and implemented a Look-Ahead Commitment (LAC) model to optimize the commitment and decommitment of resources that can start in less than three hours. Our evaluation of the LAC results in 2019 and 2020 indicates that the commitment recommendations are not accurate. In 2020, 65 percent of the LAC-recommended resource commitments were ultimately uneconomic to commit at real-time prices and in 2019 it was 69 percent. We also found that operators only adhered to 17 percent of the LAC recommendations in 2020, which may be attributable to the inaccuracy of the recommendations. We recommend that MISO identify and address other sources of inaccuracies in the LAC model and, in conjunction with the IMM, develop logging and other procedures to record how operators respond to LAC recommendations.[35]

32 MISO Report at 26.

33 For example, see the increase in wind forecast error at greater time horizons in R. Widiss and K. Porter, "A Review of Variable Generation Forecasting in the West July 2013 — March 2014" (March 2014) at 4, available at: https://www.nrel.gov/docs/fy14osti/61035.pdf.

34 B. Neuven et al, "Stochastic Look-Ahead Commitment: A Case Study in MISO," 2021, available at https://optimization-online.org/wp-content/uploads/2021/10/8660.pdf

35 MISO IMM (2021) at 123.

Using probabilistic tools to increase the accuracy and value of demand and supply forecasts will not only yield value in the day-ahead market, but also in shorter-term unit commitment processes.

C. Evaluate new market products

Another solution to minimize out-of-market actions and to better use the new resources interconnecting to the grid is to create new ancillary service or other market products for needed services. In their filings in FERC's wholesale market design docket, many grid operators expressed an interest in new flexibility market products to address variability and uncertainty in electricity supply and demand. The design of any new products must adhere to the other two principles delineated in this section, and the creation and design of such products must be balanced with accurately pricing the needed services, and a recognition of the growth of storage and hybrid resources and optimal price signals for those technologies. For example, storage requires real-time price signals that it can respond to quickly along with a longer-term horizon for determining optimal charging and discharging.[36] Ongoing large-scale additions of highly flexible battery storage and hybrid resources, combined with effective energy market price formation, may obviate the need for the new uncertainty product proposed by MISO. Battery and hybrid resources will provide the needed flexibility simply by following the incentives for charging and discharging in real-time market prices. It is important that new market products aimed at flexibility not suppress those price signals. Similarly, it is important that price caps not interfere with optimal dispatch.

Market operators have tried several different approaches to procuring flexibility through ramping products. MISO has reported success in its implementation of a 10-minute ahead Ramp Capability Product in which MISO assesses likely variability and uncertainty over the next 10 minutes and then procures enough flexibility to meet that need. MISO currently allows renewables and other resources to provide the service and has seen 95-97% of eligible resources participating. Pricing is based on a resource's opportunity cost, a ramp capability demand curve, and incentives for performance in following dispatch. But MISO may dilute the effectiveness of this product by its consideration of a blanket exclusion of renewable resources, despite their requirement to be dispatchable, from eligibility to provide ramping.[37]
MISO and its IMM have expressed interest in developing an additional market product to address uncertainty between the day-ahead and real-time markets.

36 See for example, CAISO's statement in its report that a longer-term ramp product could "support optimizing the state of charge of energy storage over a longer time horizon than the current real-time market multi-interval optimization." CAISO Report to FERC at 28-29, available at https://elibrary.ferc.gov/eLibrary/filedownload?fileid=B6CEB7B6-5A3D-C669-9348-83ECC4800000

37 MISO Markets Subcommittee, "Ramp Product Enhancements" (December 1, 2022) at 20-22, available at: https://cdn.misoenergy.org/20221201%20MSC%20Item%2006%20Ramp%20Product%20Enhancements627169.pdf.

MISO's IMM recommends that MISO:

> Develop a real-time capacity product for uncertainty: We recommend MISO evaluate the development of a real-time capacity product in the day-ahead and real-time markets to account for increasing uncertainty associated with intermittent generation output, NSI, load, and other factors. Such a product should be co-optimized with the current energy and ancillary services products. These capacity needs are currently procured out of market through manual commitment by MISO's operators. Clearing this product on a market basis would allow MISO's prices to reflect the need and reduce RSG [Revenue Sufficiency Guarantee].[38]

Using a market to procure flexible capacity to address uncertainty is more efficient than the status quo approach of over-committing resources without regard to their flexibility, which can perversely incentivize inflexible resources. To that end, MISO and other RTO/ISOs should structure such uncertainty products so their pricing and selection of resources efficiently reflects the ability of a resource to cost-effectively provide flexibility. As discussed below, make-whole payments can perversely reward resources for their inflexibility. RTO/ISOs should also allow duration-limited resources, like battery storage and curtailed variable renewables, to provide this uncertainty product. Renewable resources are unlikely to be the most economic sources of flexibility during most intervals today, but at higher renewable penetrations curtailed renewable resources will be a primary source of flexibility.

Another potential solution to concerns about increasing uncertainty at higher penetrations of variable resources is to make spinning and non-spinning contingency reserves available for unexpected renewable drop off events. Today contingency reserves are used to restore system supply and demand following the loss of a large conventional generator, typically with a mix of fast-acting spinning resources (faster than 10-minute response) and slower-responding non-spinning resources (less than 30-minute response). The cost of these reserves is currently socialized to load rather than assigned to generators, even though the need for these reserves is driven by large conventional generator failures and these reserves are not activated for abrupt drops in renewable output or load forecast errors. While renewable output generally changes gradually and predictably, at high penetrations a large, unexpected drop-off in wind or solar output over a fraction of an hour can occur several times per year. Outside of RTO/ISO footprints, grid operators like Public Service Company of Colorado have obtained FERC approval to hold non-spinning operating reserves for large and unexpected drops in renewable output, and the type and performance of resources that provide those reserves is identical to the non-spinning reserves that are used for conventional generator contingencies and load forecast shortfalls. Because conventional generator failures and sudden renewable output drops have similar impacts on short-run grid operations for reliability, drawing from a common set of reserves may be more efficient than holding separate reserves for each type of event.

Some grid operators have expressed interest in creating market products for inertia or fast frequency response. While the Eastern and Western Interconnections have abundant inertia today, which would likely result in market prices being zero for the foreseeable future, the

38 MISO IMM (2022) at 116

growth of asynchronous renewable and battery storage resources is likely to eventually make such markets valuable. Renewable and storage resources can offset the need for inertia by providing fast frequency response, which is orders of magnitude faster than the typical primary frequency response of conventional generators to a grid frequency disturbance. Fast frequency response can displace much of the need for inertia by stabilizing frequency in the initial seconds following the loss of a large generator (inertia is instantaneous and determines the rate of change of frequency after a disturbance, while fast frequency response provides additional supply and is therefore not a complete substitute for inertia). NERC has recommended allowing renewable and hybrid resources to exceed a transmission line's emergency operating limit to provide fast frequency response, as this response is only needed for a short period of time and so would not risk damage to the transmission system. That would potentially create a large opportunity for battery storage, curtailed renewables, or hybrid resources with excess capacity behind the point of interconnection to provide significant amounts of fast frequency response service at low cost.[39]

MISO should work with FERC, NERC, Reliability Coordinators, transmission service providers, and others to: (1) examine the feasibility of removing impediments to a resource temporarily exceeding its injection limit to provide fast frequency response in the pro forma interconnection agreements, NERC Standards, and MISO operating practices and rules; and (2) determine the best design for a frequency response market, including learning from ERCOT's experience with implementing a fast frequency response market.[40] As noted above, fast frequency response service also allows the grid to operate reliably with less inertia, so such a market can help postpone the need for an inertia market and reduce headroom requirements for the rest of the generation fleet.

39 NERC, "Utilizing the Excess Capability of BPS-Connected Inverter-Based Resources for Frequency Support" (September 2021) at 1-2; available at: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/White_Paper_IBR_Hybrid_Plant_Frequency_Response.pdf.

40 ERCOT, "Implementation Details for Fast-Frequency Response (FFR) Advancement Project" (July 25, 2022), available at: https://www.ercot.com/calendar/event?id=1658240344448.

II. INCREASE THE ENERGY MARKET BID CAP TO BETTER REFLECT VALUE OF LOST LOAD

MISO's energy market has a relatively low price cap of $3,500/MWh,[41] which can mute the incentive for performance during periods of extreme scarcity and result in under-investment in flexible generation that contributes to resource adequacy. In general, real-time energy market prices provide a much stronger incentive for resource performance than capacity market requirements, which often do not reflect the timing of need.

Low price caps can also cause unintended consequences in energy markets. For example, energy market price caps in CAISO caused many storage resources to prematurely discharge during early afternoon periods in the September 2022 heat wave, because once prices hit the $2,000/MWh cap storage resources had no incentive to retain their state of charge even though it was known that net load would be even higher later in the afternoon and evening.[42] Similarly, different price caps between RTO/ISOs or between RTOs/ISOs and non-RTO areas can cause inefficient transactions during periods of widespread scarcity. Such an inefficiency itself can result in unjust and unreasonable transactions, which the price caps were initially intended to prevent.

In its report to FERC, MISO notes that it is "continuing the evaluation of scarcity pricing reforms, including possible reforms to reserve demand curves, the Value of Lost Load, and the Locational Marginal Pricing price cap."[43]

> **MISO's IMM has gone further and argued that:**
>
> MISO's current ORDC does not reflect the reliability value of reserves, overstating the reliability risks for small, transient shortages and understating them for deep shortages. Additionally, PJM's pay-for-performance rules price modest shortages as high as $6,000 per MWh (sum of the shortage pricing and capacity performance settlement), which will lead to inefficient imports and exports when both markets are tight. Hence, we recommend MISO reform its ORDC by updating its VOLL assumption and determine the slope of the ORDC based on how capacity levels affect the probability of losing load. We have estimated that a reasonable VOLL for MISO would exceed $20,000 per MWh. Although the ORDC should be based on this VOLL, it would be reasonable to allow the ORDC to plateau at a lower price level for deep shortages, such as $10,000 per MWh. Although this price may seem high, almost all of MISO's shortages are likely to be in ranges that would establish shortage prices between $100 and $2,000 per MWh.[44]

It is important to note that load-serving entities and their consumers can and do use long-term contracts and other hedging mechanisms to avoid incurring extremely high energy market prices, particularly in markets with high price caps like ERCOT. The vast majority of energy is

41 PJM, Energy And Reserve Price Capping in other ISOs, April 2022, available at https://www.pjm.com/-/media/committees-groups/task-forces/epfstf/2022/20220420/20220420-item-04-energy-and-reserve-price-capping-in-other-isos.ashx.

42 The Public Advocates Office, "Preliminary Analysis of California's Resiliency During the September 2022 Heat Wave" at 8, available at: https://www.publicadvocates.cpuc.ca.gov/-/media/cal-advocates-website/files/reports/220922-caladvocates-sept-22-heat-wave-analysis---full.pdf.

43 MISO Report at 38.

44 MISO IMM (2021) at 112.

procured through those bilateral contracts, with most generators and load-serving entities only using the energy market to address marginal deviations in supply or demand. While retail electricity markets are regulated by states, retail markets play an important role in resource adequacy by ensuring that load-serving entities can and are incentivized to use contracts to hedge price risk and are not "free riding" on the power system's resource adequacy.[45]

FERC and MISO should work with the states to ensure value-based pricing along with hedging to protect consumers from high and volatile prices, and clarify that economic hedging is a state responsibility. States can elect to have the RTO/ISO enforce reserve requirements but recognize that it was never the purpose of RTO/ISOs to procure long term energy or manage price risk for consumers. States can and should ensure their retail structures enable and facilitate long-term contracting or other mechanisms to protect retail customers from high and volatile prices and to procure the types of power the state and state load serving entities and their customers wish to utilize. Some states have retail competition and allow more sophisticated customers to procure their own power, while some do not, and there are wide varieties of arrangements even within RTOs/ISOs. MISO and FERC should ensure that wholesale spot prices at all times and locations reflect the full value of reliability, while states work with their retail structures to ensure appropriate hedging.

III. IMPROVE TRANSPARENCY AND EFFICIENCY BY USING OTHER MECHANISMS TO COUNTER MARKET POWER

Market power mitigation rules that come into effect if resources fail the three pivotal supplier test generally limit resources' bids to their marginal operating costs (heat rate multiplied by fuel cost plus variable O&M costs for a typical fossil fuel plant). That method, while justified for conventional resources to achieve competitive prices where true supply and demand intersect, does not apply well to storage or demand resources, for which the marginal cost of production is based on a temporal opportunity cost rather than the cost of fuel. The opportunity cost of storage fluctuates widely over time and is not known to market monitors because it is based on expectations of future prices and dispatch. Therefore, storage and demand resources should not be subject to such operating cost-based bid caps.

Another potential improvement for the Commission and MISO to consider is to make planned generator and transmission outages transparent so they are priced in the market, rather than keeping them confidential to prevent the exercise of market power as is standard under MISO operating practice today. MISO, the market monitor, and FERC can instead use existing monitoring and regulatory oversight mechanisms (including market monitor review of conventional generator bids to ensure they reflect true marginal cost when markets fail pivotal supplier tests) to prevent a resource owner from exercising market power by withholding output when other generators or transmission lines are on outage. This would allow more efficient

45 See Wind Solar Alliance, "Who's the Buyer? Retail Electric Market Structure Reforms in Support of Resource Adequacy and Clean Energy Deployment" (March 2020), available at: https://gridprogress.files.wordpress.com/2020/03/whos-the-buyer.pdf.

commitment and dispatch of resources and market transactions in advance of and during those outages.

Another valuable reform is for RTOs to play a greater role in coordinating transmission and generation outages to reduce congestion costs. MISO's IMM has recommended just such a change, noting that: "ISO-New England does have the authority to examine economic costs in evaluating and approving transmission outages, which has been found to have been very effective at avoiding unnecessary congestion costs.46 We recommend MISO expand its outage approval authority to include some form of economic criteria for approving and rescheduling planned outages."[47]

IV. IMPROVE TRANSMISSION UTILIZATION WITHIN MISO AND AT ITS SEAMS

In its report to FERC, MISO correctly notes that stronger transmission and regional coordination are the solutions to many challenges,[48] as they provide geographic diversity in load and supply and access to a larger pool of resources. While transmission expansion is outside of the scope of this report, many aspects of how the existing transmission system is used in MISO are related to its wholesale market design, including seams issues at MISO's borders, accounting for congestion within MISO, and using ambient ratings and grid-enhancing technologies to reduce congestion.

A. Fix seams between MISO and neighboring grid operators.

MISO's market monitor has recommended several solutions to inefficient pricing at MISO's seams with neighboring grid operators. These incremental reforms are less ambitious than the PJM market monitor's recommendation for fully optimizing commitment and dispatch with neighbors through a joint dispatch solution,[49] though MISO should evaluate both types of solutions in concert with its neighbors. For incremental reforms, the MISO IMM recommends "that MISO eliminate all transmission and other charges applied to CTS [Coordinated Transaction Scheduling] transactions, while encouraging PJM to do the same…"[50] This change would produce more liquidity for CTS transactions and more efficient price formation. The MISO IMM also notes that inefficiencies in the calculation of interface prices incorrectly double congestion at MISO-SPP seam.[51] MISO's IMM also notes the use of a 30-minute ahead forecast for scheduling seams transactions costs tens of millions of dollars relative to more efficiently using prices from the latest 5-minute market interval.[52] The MISO IMM further notes that a

46 ISO-NE Market Rules: Section III, Market Rule 1 – Appendix G; Presentation by ISO-NE at June 25, 2012 FERC Staff Technical Conference on Increasing Real-Time and Day-Ahead Market Efficiency.

47 MISO IMM (2022) at 113.

48 MISO report at 12.

49 PJM MMU (2021) at 99, available at https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2021/2021-som-pjm-vol2.pdf

50 MISO IMM (2022) at 121.

51 MISO IMM, "OMS-RSC: Seams Study: Market-To-Market Coordination" (May 2020) at 91, available at: https://www.potomaceconomics.com/wp-content/uploads/2020/06/Seams-Study_MISO-IMM_M2M-Evaluation_Final.pdf.

52 MISO IMM (2021) at 89.

redispatch agreement with TVA and Ontario could greatly reduce congestion relative to the current practice of issuing transmission loading relief requests.[53]

Finally, the MISO IMM recommends that MISO:

"Remove external congestion from interface prices. When MISO includes congestion associated with external constraints in its interface prices, this congestion pricing is inefficient because it is generally not accurate and duplicates the congestion pricing by the external system operator. In addition, external operators provide MISO no credit for making these payments, neither through the TLR process nor through the M2M process. Hence, they are both inefficient and costly to MISO's customers. To fully address these concerns, we continue to recommend that MISO eliminate the portions of the congestion components of each of MISO's interface prices associated with the external constraints."[54] In short, MISO has a range of tools to improve pricing efficiency at its market seams.

B. Price congestion more efficiently.

Transmission congestion within MISO has been increasing.[55] While the ultimate solution is building more transmission, market reforms can more efficiently account for congestion.

In its report to FERC, MISO notes that it has been unable to accurately forecast transmission congestion in its renewable forecasts.[56] This uncertainty also challenges renewable developers and their power offtakers. MISO's IMM has proposed that MISO allow market participants to more efficiently price and hedge congestion through a virtual spread product: "Participants using such a spread product would specify the maximum congestion difference between two points they are willing to pay (i.e., by scheduling a transaction). This would reduce the risk participants currently face when they submit a price-insensitive transaction and avoid inefficient day-ahead congestion."[57]

C. Use ambient ratings and Grid-Enhancing Technologies

MISO's market monitor strongly endorses increasing transmission line ratings, stating that:

For years we have reported unrealized annual savings well in excess of $100 million that would have resulted from increased use of AARs [Ambient Adjusted Ratings] and Emergency Ratings. The first step to realize these savings is for the MISO TOs to commit to providing AARs and Emergency Ratings. However, MISO's current systems and processes would not allow it to capture all these savings. Our report identifies key recommended enhancements, including: **1. System Flexibility: MISO should enable more rapid additions of new elements to AAR programs. 2. Forward Identification: MISO should support identification of additions to AAR programs based on forward processes including outage coordination. 3. Forecasted**

53 *Id.* at 113.
54 *Id.* at 114.
55 MISO IMM (2021) at 57-74.
56 MISO Report at 25.
57 MISO IMM (2022) 114.

Ratings: MISO should enable use of forecasted AARs in the day-ahead market and Forward Reliability Commitment Assessment (FRAC). Currently, MISO does not have a process to receive or use forecasted ratings. [58]

The MISO market monitor also recommends use of topology optimization to relieve congestion:

We recommend MISO develop resources and processes to analyze and identify economic reconfiguration options for managing congestion and in coordination with the TOs. Today, transmission congestion is primarily managed by altering the output of resources in different locations. However, it can also sometimes be highly economic to alter the configuration of the network (e.g., opening a breaker). Today this done on a regular basis by Reliability Coordinators to manage congestion for reliability reasons under the procedures established in consultation with the transmission owners impacted by the reconfiguration. Such procedures should be expanded to relieve costly binding constraints that are generating substantial congestion costs. In our Summer 2021 Quarterly Report, we presented an analysis of one constraint that generated over $57 million in congestion during the quarter. The constraint primarily limits the output of wind resources in the North region. The constraint has a reconfiguration option that reduces the congestion in that path by roughly two-thirds and substantially reduces wind curtailments when used. Unfortunately, it is rarely used because the congestion on the constraint rarely raises reliability concerns.”[59]

V. REFORMING MISO’S CAPACITY MARKET

MISO operates a voluntary capacity market that utilities and other market participants can use to buy and sell incremental capacity needed to meet their resource adequacy obligations. Unlike PJM, MISO has many vertically integrated utilities that own generation that they use to meet their resource adequacy obligations, so a much smaller share of capacity is transacted in MISO’s voluntary capacity auction than in PJM’s mandatory market.

MISO’s capacity market has been criticized for large swings in market prices from one year to the next, with many experts recommending the use of a sloped demand curve that will result in more stable prices than the current vertical demand curve. This should benefit renewable and storage developers, as well as other market participants, by providing a more predictable forecast of capacity market prices and revenue.

MISO can also better account for the availability of imports to meet its resource adequacy needs. MISO currently assumes that imports provide 2,331 MW towards meeting capacity needs.[60] However, during peak periods like Winter Storm Uri, MISO has imported as much as 13,000 MW. Relatedly, MISO should explore ways to credit capacity value to new interregional transmission lines that reduce the need for peak capacity by accessing diversity in electricity

58 MISO IMM (2022) at 111.

59 MISO IMM (2022) at 107-108.

60 MISO, “Planning Year 2022-2023 Loss of Load Expectation Study Report,” (Dec. 6, 2021) at 22; available at: https://cdn.misoenergy.org/PY%202022-23%20LOLE%20Study%20Report601325.pdf.

demand and supply with neighboring grid operators. Accessing and accounting for geographic diversity will become increasingly important at higher renewable penetrations, given geographic diversity in wind and solar output patterns.

Capacity markets also tend to be less efficient than real-time energy markets in sending price signals that drive performance during periods of need. Capacity markets shift revenue from the energy market to the capacity market, which suppresses energy market prices during periods of scarcity. This revenue shift reduces the earnings of renewable resources, which earn most of their revenue in the energy market, and suppresses the energy market price signal for all resources, particularly flexible resources like battery storage, to perform during periods of scarcity.[61]

The reduced incentive for flexible resources and impediment to the transition to cleaner resources is compounded by the fact that MISO's capacity market only procures capacity, and not flexible capacity. Flexible capacity from batteries and other resources is increasingly more valuable than inflexible capacity as the penetration of variable renewable resources increases, yet capacity markets do not distinguish between flexible and inflexible capacity.[62] Capacity markets also do not inherently incentivize the performance of resources during periods of scarcity, although MISO has recently reformed its capacity market to better incentivize performance by basing accreditation on performance during peak demand periods. However, energy markets are still the optimal means for incentivizing performance and flexibility during periods when those services are most needed.

Another important step to ensure capacity markets properly credit resources' contributions to resource adequacy is to account for correlated outages of all types of generators, including thermal generators. During extreme heat, cold, or widespread disruptions to fuel supply or cooling water, many conventional generators experience forced outages or derates at the same time. Correlated outages, including widespread loss of gas generators due to fuel

61 Grid Strategies, "Too Much of the Wrong Thing: The Need for Capacity Market Replacement or Reform" (November 2019) at 8-9, 12, available at: https://gridprogress.files.wordpress.com/2019/11/too-much-of-the-wrong-thing-the-need-for-capacity-market-replacement-or-reform.pdf.

62 Energy Systems Integration Group, "Beyond Capacity Adequacy" (September 5, 2018), available at: https://www.esig.energy/beyond-capacity-adequacy/.

supply interruptions, occurred in multiple regions during the 2014 and 2019 Polar Vortex events, the 2018 Bomb Cyclone, Winter Storm Uri in 2021, and Winter Storm Elliott in 2022. Astrapé Consulting found that in part of PJM, these outages can reduce the capacity value of conventional generators to around 85% in summer and 82% in winter, and as low as 76% if gas generator fuel supply interruptions are accounted for in winter.[63] NERC data indicate that correlated outages of thermal generators occur in all ISO/RTO markets.64

However, the impact of correlated outages on conventional generators' capacity value is not fully accounted for in MISO's method of capacity accreditation. The total accreditation to a fleet of resources fails to account for reductions in their total capacity contribution due to correlated outages, though individual resources' allocated share of that total fleetwide credit can be reduced if they fail to perform during peak periods. In addition to understating the resource adequacy risk posed by correlated outages from conventional generators, failing to account for correlated outages can bias market entry towards conventional generators and away from renewable and storage resources. Correlations in renewable and storage output patterns are accounted for by current methods, such as the Effective Load Carrying Capability ("ELCC") methodology MISO uses to assign capacity value to wind.

MISO should include all resources in a single capacity accreditation method instead of applying separate methods to thermal generation and to renewables and storage resources. This method should account for correlated outages and derates of conventional generators, including gas supply and transportation interruptions and shortfalls. For example, instead of using the reserve margin to cover unexpected failures of generating units, it is more efficient to reduce the reliability contributions accredited to resource types that experience widespread correlated failures.

> **As Astrapé explained in its recent report:**
>
> Overall, directly evaluating resource uncertainty on the supply-side delivers a more accurate accreditation of the reliability contributions from each resource type. Today, a portion of the thermal resource uncertainty is not being directly accounted for in its capacity accreditation, and therefore that uncertainty is being socialized to load. Accounting for the uncertainty categories in this report creates a more consistent approach for determining capacity accreditation between resources currently assessed via ELCC (wind, solar, storage) and thermal resources.

Capacity accreditation methods like ELCC should also account for changes in resource accreditations due to correlations across all resources in the portfolio, instead of looking at correlation within each resource type alone--i.e., just using a declining curve based on the penetration for each resource.[65] In particular, wind, solar, and storage resources have a large synergistic benefit that is often ignored in capacity market accreditation. Using a declining curve for each resource without accounting for offsetting synergistic benefits among resources

63 Astrapé Consulting, "Accrediting Resource Adequacy Value to Thermal Generation" (March 30, 2022), available at: https://info.aee.net/hubfs/Accrediting%20Resource%20Adequacy%20Value%20to%20Thermal%20Generation-1.pdf.

64 Murphy et al., "Resource adequacy risks to the bulk power system in North America," Applied Energy, Volume 212, 15 February 2018, Pages 1360-1376, available at: https://www.sciencedirect.com/science/article/pii/S0306261917318202.

65 Energy + Environmental Economics, "ELCC Concepts and Considerations for Implementation," Presentation to the NYISO Installed Capacity Working Group (August 30, 2021) at 29-35, https://www.nyiso.com/documents/20142/24172725/NYISO%20ELCC_210820_August%2030%20Presentation.pdf.

can significantly understate the capacity value of those resources and bias resource selection against resources that add positive interactions with other resources.

Capacity accreditation methods should also properly model the output patterns of the future renewable fleet. If the future fleet is modeled by scaling up historical renewable output profiles, benefits from expected performance improvements from technology advances and geographic diversity in the future renewable fleet should be accounted for. Scaling methods that miss geographic diversity benefits, such as the common error of linearly scaling the output of existing resources, should be avoided.[66] In general, using synthetic output profiles to model the addition of future resources avoids the errors from attempting to scale historical output profiles.

VI. CONCLUSION

The above recommendations seek to maximize the use of markets, recognizing that well-designed markets are the most efficient way to aggregate dispersed information and translate it into a price signal for performance that reflects the value of reliability. MISO should use technology-neutral market design that defines reliability needs and allows any resource capable of providing a needed service to offer to do so. This will create a level playing field in the market and enable a reliable and efficient transition to new resources by unleashing their capabilities. We encourage states and other stakeholders to work with MISO to implement these reforms.

66 National Renewable Energy Laboratory, "Cost-Causation and Integration Cost Analysis for Variable Generation" (June 2011) at 27-29, available at: https://www.nrel.gov/docs/fy11osti/51860.pdf.