Changing Reliability Requirements for an Evolving Fleet

Highlights

- The resource portfolio in the MISO footprint is undergoing significant transformation.
- Risk patterns for the region will change, driven by growing variability and uncertainty.
- Changes in planning, markets and operations will be needed.
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Reliability Imperative

MISO is facing a reliability imperative as the region undergoes transformational change, with sizeable segments of generation aging, the resource portfolio shifting to increasing amounts of wind and solar, and load shapes potentially changing with the advent of electrification. In the last ten years, over 23 GW of capacity has retired. According to the 2020 Organization of MISO States (OMS)-MISO survey indicates another 10 GW of planned retirements in the next 10 years, while the MISO Transmission Expansion Planning (MTEP) futures assumes higher levels of retirements ranging from 45 to 116 GWs. Public announcements by members indicate that over a third of production is shifting to wind and solar sources. Similarly, members within MISO’s footprint have initiatives underway to explore and advance electrification.

The potential for significant transformation has prompted MISO to evaluate how bulk electric system needs will change and how MISO might adapt planning, markets and operations to manage aging units, new types of supply, and new load shapes.

Transmission will play an important role in ensuring the deliverability of power to enable resources to work in concert with one another. Resource adequacy will provide insights on how resources work together and identify what is needed to ensure system-wide and regional adequacy throughout the year. Moving closer to the operating day, markets and operations will update information on system risks, signal areas of anticipated and real-time needs, and ultimately coordinate and compensate resources of varying capabilities to efficiently deliver balanced power.

“"We want to ensure that the lights stay on every day, not just three days in the summertime.”
President and Chief Operating Officer, Clair Moeller

Effective dialogue amongst stakeholders will be key to this transformation - identifying future needs and working with MISO to develop solutions that work across the footprint. MISO will leverage the forums where discussions are already underway.

As the MISO fleet continues to evolve to meet the reliability imperative, ongoing comprehensive analysis is needed to assess risks and inform change in MISO’s planning, markets and operations.

Together, Technology will be an important enabler. Advanced data analytics and visualization tools will enhance decision making and modern communications and state estimation will gather and synthesize an array of information to provide timely input for grid operators. Computational enhancements will enable advanced algorithms to better manage uncertainty and variability.

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As the MISO fleet continues to evolve to meet the reliability imperative, ongoing comprehensive analysis is needed to assess risks and inform change in MISO’s planning, markets and operations.

Executive Summary

This report outlines how load and supply trends might alter system risk profiles managed by grid operators, evaluates resultant areas of needs, and identifies critical change initiatives within MISO to address emerging needs.

While grid operators have managed variability and uncertainty in the system for decades, MISO expects these to become more pronounced, making it more challenging to manage the margins between supply, load and reserves. Ramping needs will grow in size and frequency and the largest ramps could occur at significantly different times of day and times of year. The frequency of hourly ramps of 5 GW or more could increase from under 10% of the time to up to 30% of the time. The impact of uncertainty will also grow, with the total gigawatts of forecast errors increasing as solar and wind increase and forced outages continuing as existing fleets age. If relative forecasting accuracy stays as it is today, the 95th percentile of wind forecast error could grow from as much as three percent of load to six percent of load. Solar forecasting errors also will be a new source of uncertainty in the MISO system that will grow as increasing amounts of solar come online. The increasing need for ramping capability combined with increased forecast errors will place greater emphasis on system flexibility.

Resource adequacy plays an important role in assessing system needs and taking early steps to begin addressing risks. Approaches that focus on summer peak load alone will no longer suffice.

Rather, resource adequacy analysis should better reflect patterns throughout the year, including enhanced consideration of wind, solar and hybrid resources, planned and forced outages, firm and non-firm external support, and should better reflect the magnitude of risks. Resource adequacy requirements should leverage enhanced risk analysis and, in conjunction with markets and operations enhancements, mitigate risk across current and future resource portfolios.

Markets and operations will need to shift beyond focusing on load forecast error and N-1 contingency to explicitly account for a range of possible outcomes and planning actions to maximize expected value amidst sizeable uncertainty. Greater emphasis will also be placed on look-ahead periods to ensure the ability to efficiently ramp over multiple time periods while managing intra-hour variability. Markets will play an important role in signaling the need for flexibility, either planned over multiple intervals or sudden due to unexpected changes, and valuing resources timely contribution to managing flexibility, either locally at an individual site or across the grid over transmission. Transmission planning studies can help by explicitly valuing the flexibility that new investments can offer by further connecting diverse resources across the footprint during times of shifting risk.

Together, the MISO footprint can work towards adapting to the evolving risk profile, aligning resource availability with needs and maximizing value across the footprint.

System risk profiles will continue to change with evolution of the resource mix

• To date, risks have shifted in time periods other than summer peak and will continue to change

• The margin between available resources and total obligations will be more impacted by uncertainty and variability
Understanding the Risks

In 2017, in response to a series of emergency events that began June 2016, MISO established a Resource Availability and Need (RAN) program to identify ways to better convert committed capacity resources into energy during times of need. Five drivers were identified as major contributors of increasing emergencies and initial actions were taken to mitigate near-term risks. With the subsequent release of the 2019 and 2020 MISO Forward reports on emerging industry trends, the RAN program began to explore how reliability needs may change in light of these industry trends. Specifically, MISO began to assess the following questions:

• How will needs change?
• What are the patterns of system needs today and in the future?
• How predictable are the patterns?
• What drives these patterns?
• How can MISO adapt its planning, markets and operations processes to address changing risk?

This report is the first set of results from that exploration, one that will continue as the footprint’s transformation progresses.

Historically, MISO and other grid operators have focused on ensuring there is sufficient electricity supply in the peak hour of demand over the year — for MISO, this typically occurs on a sweltering day in July or August, when air conditioning load is extremely high — and assumes that sufficient peak hour capacity will translate to having sufficient capacity for all other hours of the year.

For years, the summer-focused planning construct worked well to ensure reliable operations on an annual basis. However, this is no longer the case.

As discussed in previous RAN whitepapers:

• Issues Statement
• Load Modifying Resources Evaluation
• Aligning RAN

The MISO region has experienced a sharp increase in grid emergencies in recent years, with the majority of these events occurring in spring, fall, and even winter months that almost never saw emergencies in the past. Multiple factors caused MISO’s risk profile to change, including the retirement of numerous coal units; higher outage rates of aging resources that remain in service; the growth of wind and solar that do not have the ability by themselves to generate energy in all hours; and the increasing reliance on resources that can only be used in certain seasons or emergencies.

Ultimately, the MISO region needs to understand the patterns and types of future risks to effectively manage them and maintain reliability. Better understanding of the risk patterns throughout the year will enable calculation of reliability targets that sufficiently mitigate the risks, even as the resource mix in the region evolves. The findings described in this paper are an important step in that understanding.
MISO’s methodology to identify emerging risks and subsequent needs uses a three-pronged path of inquiry:

- Industry trend assessment
- Stakeholder discussions
- MISO-conducted research and analysis

The 2019 MISO Forward report outlined three macro industry trends—de-marginalization, decentralization and digitalization. In 2020, MISO continued to learn from stakeholders about the diversity of business models and preferences that are forming across the region. These discussions drove the use of heterogeneous assumptions within MISO’s scenarios that represent multiple sources of change.

MISO uses scenarios to hedge the uncertainty of projecting the future and “bookend” a range of possibilities considering economic, political and technological drivers. Research and analysis into the evolution of the MISO system has identified six key components of system change reflected in the scenarios.

**WIND AND SOLAR GROWTH**

Public commitments from stakeholders, and corresponding activity in the queue, point to significant growth in solar and wind. MISO expects 5.6 GW of wind and 2.2 GW of solar to come online over the next year. Looking ahead, announcements from MISO market participants suggest that wind capacity may double or triple from current levels and solar capacity could grow to a similar or even larger quantity.

**TRADITIONAL RESOURCE RETIREMENTS**

MISO’s stakeholders are signaling the acceleration of coal, gas and nuclear plant retirements. In the last 10 years, the MISO footprint retired over 23 GW of resources. Over the next 10 years, 17 to 116 GW may retire. According to MISO analysis and stakeholder input, the expected lifespan of a coal unit, for example, may fall from its historical average of 46 years to as low as 30 years.

**ENERGY STORAGE**

Pumped-hydro storage provides flexibility and capacity to the MISO region, but is limited by geographic constraints. Battery storage has the potential to provide additional flexibility throughout the footprint. Battery storage is currently being deployed in limited quantities across the region in stand-alone or hybrid configurations. Projections for MISO range up to 25 GW of battery storage over the next 20 years, driven by declining costs.

**DISTRIBUTED ENERGY RESOURCES (DERs)**

DERs are growing in numbers throughout the MISO region, the 2019 OMS DER survey lists 4,700 MW of DERs in the footprint today. An additional ~11 GW of Demand Response and Load Modifying Resources are registered with MISO.

**ELECTRIFICATION**

Electrification replaces technologies fueled by other resources with electricity. Many MISO members have electrification initiatives underway. Electrification could result in energy increases up to 50 percent, with the largest share from transportation. A 50 percent scenario reflects carbon mitigation strategies prompting increased electrification in buildings and the industrial sector.

**DECARBONIZATION**

Since 2005, CO₂ emissions are down approximately 25 percent largely based on coal retirements, falling gas prices and wind additions. This drop will likely continue as cities, states, and large commercial and industrial corporations continue to explore and enact decarbonization goals. Many sub-regions of MISO are targeting 50 to 80 percent carbon-free energy supply with some pockets aimed at 100 percent by 2050.
Managing operating margin is a key element of managing risk. Operating margin is the quantity of resources available to MISO above and beyond the level of resources needed to serve load and meet certain other obligations. In MISO, those “other obligations” consist primarily of: (1) maintaining a required level of operating reserves, and (2) accounting for the energy that is exported out of and imported into the region—a concept known as Net Scheduled Interchange, or NSI.

If the operating margin becomes too small ahead of real time, MISO may activate its emergency procedures to maintain reliability. Emergency procedures escalate as grid conditions become more tight, ranging from non-binding advisories to preemptive load shedding to prevent cascading system failures. Conversely, an operating margin that becomes unnecessarily large will reduce system efficiency and may lead to higher costs for end-use customers. The importance of properly managing the operating margin is reflected in MISO’s corporate vision: “The most reliable, value-creating RTO.”

IT WAS SIMPLER IN THE PAST

Historically, outages, load and NSI were the largest contributors of uncertainty and variability in managing operating margin. Contingency planning and the ability to reliably predict and allocate planned outages to periods of high margins successfully mitigated outage-related risks. Market processes and resource staging sufficiently managed load forecast errors. Additional efforts to coordinate with neighboring grid operators helped manage uncertainty and variability across MISO’s seams. With these sources and historical magnitudes of variability and uncertainty, MISO was able to monitor and manage operating margin across time and hold operating reserves to effectively manage system risk.

Conditions that have helped MISO effectively manage operating margin include:

- **Very few variable resources:** Fifteen years ago, the region’s level of variable resources, including wind and solar, was essentially zero, meaning MISO did not plan to manage the variability associated with those resources.

- **Predictable demand forecasts:** In the past, day-ahead demand forecasts were routinely accurate to within 1% to 2% of actual load. These forecasts were also predictable in how they generally increased by a modest, consistent amount year-over-year.

- **Capacity and seams congestion management:** Some imports and exports are scheduled by participants based on expected or forecasted conditions at MISO as well as our neighbors. With traditional resources mixes in all regions, system conditions were more predictable. In addition, less variable resource fleets led to more stable congestion management between regions.

MISO has considered how margins could be affected if changing system conditions, including those associated with the factors listed above, had their greatest possible impact on the system. MISO does this in conjunction with stakeholders assessing the risk factors across the planning and operating horizons. For forced outages, MISO has built in operating margin that accounts for the single largest contingency that could occur during operations, such as the unexpected loss of a larger generating unit or transmission line. This is accounted for years to minutes ahead. For demand forecasts, that has meant building a margin on top of the expectation for system peak demand, since volatility of peak demand is typically greatest.

MORE ACUTE AND NEW CHALLENGES

The evolution of the region’s resource portfolio has increased the complexity of managing operating margins. Part of this is due to preexisting issues that have become more acute over time. For example, demand forecasts have also become more volatile due to changing weather and load-response patterns. Forced generation outages have become more volatile due to the ever-increasing age of the legacy thermal resources that remain in service. This is further exacerbated by an increase in extreme weather events that disrupt pipeline deliveries of fuel to gas-fired power plants. Similarly, scheduled imports and exports have become more volatile and difficult to predict at times due to the portfolio evolution that is occurring in neighboring ISOs/RTOs.
In addition to those preexisting challenges becoming more acute, new issues have also emerged to increase the complexity of managing the operating margin. They include:

- Increasing reliance on variable resources: Wind now provides a significant portion of the region’s total energy, and this resource comes with uncertainty and variability in output. And while the region does not currently have a large amount of solar, it is expected to grow in the coming years, adding an additional source of uncertainty and variability to the system.

- Increasing transmission constraint volatility: The number of transmission constraints that MISO must plan for and operate around will increase as more diverse resources interconnect to the system.

- Increasing subregional challenges: Due to limited fast-start capability and high forced outage rates, the MISO South subregion has experienced significant operating risks. Meanwhile, the North/Central subregion, where most wind is concentrated, has experienced extreme cold weather events and wind forecast errors. Additionally, while the operating margin may be sufficient on a system-wide basis, capacity could be trapped in one subregion due to a contractual transfer limit or other local/regional constraints.

MISO is committed to addressing these challenges in collaboration with its stakeholders.

The largest one percent of up- and down-ramps shorter than one hour are predicted to be 40 - 150 percent larger in future scenarios than they are today. These fast ramps may require more fast-ramping resources to be online because they may occur too fast for offline resources to start up.

Note: Differences in scale for different ramp scenarios.

10 minute to 8 hour ramps will become more frequent than they are utilized today.
Changing Risk Patterns

SHIFTING PERIODS OF RISK

Analysis of future scenarios suggests that loss of load risk will shift to new time periods. In particular, increasing amounts of solar will shift risk toward the evening. The highest risk historically, when excluding the impact of planned outages, is concentrated between 14:00 and 17:00. Increasing solar pushes risk further into the evening, between 18:00 and 22:00 for scenario 1. The risk of not serving load also increases in non-summer months as solar penetration increases. The highest risk historically, when excluding the impact of planned outages, is concentrated in June and July. Increasing amounts of solar pushes risk into other months, including May through August and elevates risk in winter.

In fact, peak net-load, the maximum of total electric load minus production from unmodified wind and solar resources, becomes a useful indicator of risk as compared to peak load. Peak net-load represents the maximum remaining load to be served after unmodified wind and solar resources. The need to cover load with other resources is high at these times. For example, solar generation may offset a significant amount of gross load in the afternoon but not cover gross load in the evening during sunset. Higher levels of remaining net-load can occur during sunrise hours, when gross load starts to increase, wind ramps down, and solar availability is still low. These effects create what is called the “duck curve,” where the peak net-load is shifted away from the peak gross load, intensifying morning and evening ramps.

This modified risk pattern of increasing intensity in morning and evening net-load ramps increases the need for flexibility. This flexibility takes the form of up and down ramp capability but also the ability to ramp multiple times within a day. For example, the system may have to ramp up or down rapidly before and after peak net-load hours and at the same time manage and respond to days-, hours-, and minutes-ahead of uncertainties.

Hourly modeling of the interactions of gross load, wind and solar impacts can identify when these periods might occur and reflect the changing contribution of wind or solar towards meeting gross load as wind and solar penetration increases. This approach in resource adequacy assessments can help capture these effects. Markets can signal the need for flexibility during these hours and explicitly consider the need for multiple up and down ramps within the day. Shifts in system risks from wind and solar resources can be countered where resources are configured to meet gross load at all hours – either through hybridization or the use of operating setpoints. Efforts to enhance markets, operations and planning should ensure such techniques are considered.

TRANSMISSION TO ADDRESS DELIVERABILITY

The transmission grid is essential for maximizing efficiency within the footprint by enabling resources to work in concert with one another to collectively meet needs. This ability to leverage footprint diversity currently provides $2.1-$2.7 billion in annual benefits and transmission plays a critical role. In turn, transmission constraints can limit power flows over the system and therefore the ability to share resources. By enabling or limiting resources to work together.
The grid’s frequency response could be impacted as the inertia and online headroom provided by conventional units to maintain adequate frequency response is reduced. Without further action, this could affect the ability of the transmission system to withstand large generation losses. This issue will likely arise as instantaneous penetrations of wind and solar resources reach 60% of interconnection-wide system demand. Finally, the grid’s ability to maintain strong voltage is adversely impacted by the displacement of conventional units, leading to the creation of weak-grid pockets. The current technology of wind and solar resources (i.e. inverter based) in such weak pockets may not have enough capabilities to mitigate voltage-related risks. Weak-grid issues start to increase at the 20% renewable energy penetration levels and become systematically severe beyond 30% energy penetration level.

Line-overloads and voltage issues may be addressed by increased flexibility in planning processes to adapt to non-traditional risk periods and evolving system flows and adopting a combination of complex technologies such as Voltage Source Converters for High Voltage Direct Current lines (HVDC), Synchronous Condensers and Flexible Alternating Current Transmission System (FACTS) devices. Frequency-related risks may be resolved where renewable resources maintain online headroom or are co-located with storage. Additional research and pilots into advanced technology, such as grid-forming inverters, should be pursued to help counteract these risks.

More accurately representing the actual behaviors of MISO resources reveals an increased risk than previously estimated, particularly in winter and summer afternoon hours.
RESOURCES ADEQUACY HIGHLIGHT

In its role to support resource adequacy for the region, MISO regularly conducts system risk assessments. These assessments, in turn, guide planning reserve margin targets and accreditation approaches. MISO currently uses a Loss of Load Expectation (LOLE) metric with a 1-in-10-year LOLE target that represents the probability of not being able to serve load for one event within ten years. Historically, the analysis used inputs that captured risks within summer months. For example, wind and solar were modeled as flat capacity throughout the year based on summer performance. Stakeholder discussions via the Loss of Load Expectation (LOLE) Working Group resulted in planned modifications to the assessment including modeling wind using monthly unit level effective load carrying capacity (ELCC) values.

As the region’s risk profiles evolves, MISO is continuing to evaluate further potential changes to the risk assessment and the use of additional risk metrics. Risk assessment options include modeling load, wind and solar with hourly profiles; varying forced outage assumptions throughout the year; and refining representation of non-firm export support among others. The intent is to better capture system risks by more accurately representing resource availability throughout the year. Trial analysis reveals that doing this can highlight that new periods of the year have higher risks than previously estimated. MISO is also considering additional reliability metrics, such as Expected Unserved Energy (EUE), to see if they can help capture more information about potential reliability events, including their duration, frequency and magnitude.

Discussions with stakeholders to provide input on needs and solutions will continue to be critical for evolving approaches to resource adequacy.

Growing Flexibility Needs

GROWING UNCERTAINTY

The scale and complexity of uncertainties in the MISO system will increase based on a number of factors. Uncertainty will increase as the fleet becomes more weather dependent. Though MISO’s wind forecasting accuracy has improved over the past few years, the total amount of forecast error, in gigawatts, has grown due to the increase of wind penetration. If relative forecasting accuracy stays as it is today, the 95th percentile of wind forecast error could grow from as much as three percent of load to as much as six percent of load. Solar forecasting errors also will be a new source of uncertainty in the MISO system that will grow as increasing amounts of solar come online. Furthermore, the nature of this uncertainty is different than wind, with forecasting errors and sudden shifts occurring on shorter time horizons. Who manages this growing uncertainty will depend on the resource configurations and operating approaches used by members. For example, co-location of wind and solar with storage at hybrid plants could manage some of this uncertainty locally. In addition to wind and solar forecasting error, load forecasting will continue to be a source of uncertainty. Changes in load forecast error will depend on end-user trends, including electrification and the adoption of energy supply and management technologies, and how effectively customers and grid operators coordinate across the system. Uncertainty about forced generation and transmission outages will also continue.

Managing uncertainty is central to grid operations. In fact, grid operators have developed a variety of tools over time to help them do this. Examples of tools used at MISO include the day ahead and real time markets, including energy, reserve and ramp capability products; and forward reliability assessment commitment (FRAC) and look-ahead commitment (LAC) reliability processes that incorporate headroom, reliability margin and the use of multiple scenarios. In managing uncertainty, grid operators are constantly making forward-looking decisions to maintain margins and ultimately keep the system reliable as efficiently as possible.

Day Ahead Wind forecast error contribution to operational risk management

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<th>Month</th>
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Uncertainty about non-average conditions, in particular, can be quite impactful. Operation planning, for example, explicitly works to mitigate N-1 and G-1 contingencies. Grid operators must also manage, however, the confluence of forecasting errors and unit outages. The combination of low probability, extreme events will be a growing reality that system operators must prepare for. Realizations of multiple extreme unexpected errors seem unlikely to happen but are impactful when they occur. A September event in 2018 illustrates this scenario. On September 15th, MISO experienced the largest load forecasting error in its history (7.6 GW system wide and 1.8 GW in the south region), combined with the largest unit trip in the MISO south region (1.4 GW). The combined errors cut into operating margins and prompted emergency actions to manage margins back to normal.

With uncertainties growing in size and complexity, it is essential for MISO to understand the collective impacts and work with stakeholders to adapt risk management strategies accordingly. These include both local and system-wide strategies to mitigate risk.

**THE FREQUENCY AND MAGNITUDE OF LARGE RAMPS INCREASES**

Independent of growing uncertainty, MISO expects system variability to increase. Growing amounts of wind and solar will increase ramps both in frequency and magnitude. To estimate changes in system ramping, MISO calculated net-load, or total electric load minus production from wind and solar, over a variety of future scenarios and historical data. Based on the scenarios studied, net-load ramps with durations from 10 minutes to 8 hours will become more frequent than they are.
TIMING OF THE LARGEST RAMP SHIFTS

The largest ramps could occur at significantly different times of day and times of year in future scenarios than the present. Historically, the largest up-ramps occur in the early mornings during the summer and winter and the largest down-ramps occur in summer nights. In future scenarios with significant solar penetration, the largest up-ramps will shift to the afternoon and some of the largest down-ramps will shift to the morning. Wind generation does not affect the largest extreme net-load ramps at a consistent time of day or year, though it can cause large ramps at idiosyncratic times when weather fronts pass over the primary wind generation areas.

Growing amounts of wind and solar will increase net-load ramps both in frequency and magnitude.
Next Steps: Explore, Decide, Do, Done

Due to a combination of changing outage profiles, growth in variable resources and changing load profiles, risk profiles for the region are and will continue to change. The grid will likely face tight margins between available resources and total obligations at new times and months within the year. Margins will also become more impacted by uncertainty and variability. Flexibility needs will grow as net-load ramps and uncertainty increase.

The potential for significant changes has prompted MISO to evaluate ways to adapt its planning, markets and operations. Some of the changes will be transitional; however, others will be transformational. MISO has outlined initiatives to prepare for the future.

**PLANNING**

Resource Adequacy

Resource adequacy provides important tools to gauge emerging risks and take early steps to prepare the system to mitigate them. Resource adequacy analysis should reflect patterns across the year, including enhanced consideration of variable resources, planned and forced outages and firm and non-firm external support. The analysis should better reflect the magnitude and duration of risks throughout all hours of the year. As part of the RAN 2020-2021 focus, MISO is evaluating various dimensions of the resource adequacy construct collectively including risk assessments and metrics, resource accreditation, planning reserve margins and planning resource auction reforms, recognizing the interdependent and complementary nature of enhancements.

**OPERATIONS**

Outage Coordination Enhancements

The number of megawatts MISO can gain or lose through outage coordination is a key contributor to resource availability at this time. Since 2017, through RAN efforts, various initiatives were implemented which have improved outage coordination. These initiatives include enhancements to the posting of the Maintenance Margin daily and by region (North, Central, and South) instead of the previous frequency of once a quarter. Also, the RAN Phase

**RESOURCE ADEQUACY HIGHLIGHT**

- Approaches to setting resource adequacy targets should leverage an enhanced risk calculation and, in conjunction with markets and operations, work to sufficiently mitigate risk under current and future portfolios. They should be able to include evolving resource technologies that can help mitigate risks.
- As MISO’s analysis of risks lacks visibility into state and local planning process, additional efforts to enhance coordination could benefit system-wide resource adequacy.

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**Explore**

- Outage coordination enhancements
- Uncertainty management
- Forward market mechanism

**Decide**

- Resource adequacy
- Sub-annual planning
- Planning Resource Auction reform
- Resource accreditation
- Scarcity and emergency pricing

**Do**

- Load Modifying Resource enhancements
- Increase call limit from five to ten
- Limit response time to six hour notification
- ICAP deliverability
  - Conventional resources
  - Intermittent resources
- Multiday Operating Margin forecast (additional enhancements)

**Done**

- RAN Phase 1
  - Outage coordination
  - LMR testing and year-around capabilities
- Multiday Operating Margin forecast
  - Sub-regional view
1 filing provided financial incentives to reduce short notice outages during times when the system is tight. Finally, the outage coordination team has streamlined their tools and processes to improve coordination with resources to better consider uncertainty and capacity margins when scheduling outages.

Despite these improvements, there are still opportunities for additional modifications including enhanced understanding of drivers of forced outages, greater coordination with congestion management and proactive identification of windows of opportunity for planned outages.

**Uncertainty Management**

From minutes ahead to days ahead, MISO has sufficiency planning processes to project operating margin based on available resources and the anticipated load and reserve obligations. In light of growing needs to manage uncertainty at the system and sub-regional levels, MISO has begun streamlining its tools to provide a dynamic and sub-regional view of operating margins across time periods. Further work has incorporated approaches to manage uncertainty within the Look-ahead commitment (LAC) and Reliability Assessment Commitment (RAC) reliability processes. MISO recently launched research into stochastic tools to feed LAC and RAC.

MISO is looking to enhance its uncertainty measurement by leveraging data analysis of forecast errors, forced outage rates, and potentially interchange transaction statistics. Such information can provide operators with not only situational awareness but also the confidence level of the projected system conditions. Over the past decades, MISO has developed tools and procedures to align transmission ratings and network model between Financial Transmission Rights, Day-Ahead and Real-Time markets. These improvements have reduced uncertainty related to future congestion patterns, leading to better market outcomes. With increasing wind and solar penetration and MISO footprint changes, transmission patterns may become more dynamic which introduces more congestion management uncertainties and calls for more operational innovation and enhancements. Effective coordination with MISO members and neighboring RTOs can mitigate the operational risks under stressful conditions. Demand Response tools such as the Market Communication System are being enhanced.

**Multiday Operating Margin Forecast**

MISO stakeholders want better information to help them identify potential operating day issues several days in advance. Until October 2019 stakeholders, generation and transmission owners/operators generally became aware of operating day issues only when MISO declared various advisories, alerts, emergencies and events via Emergency Operating Procedures. Since these procedures focus on real-time operations, notice is generally provided just hours in advance of a potential issue.

A multi-day operating margin and associated inputs provides better transparency to various stakeholders. Generation and transmission owners/operators are better able to assess their risk to adjust planned operations and outages on their own and better align their plans without having to wait for a request from MISO. This also provides generators better information to procure natural gas and make associated pipeline reservations multiple days in advance rather than the day prior to operations. MISO began posting multi-day peak hour operating margin in October 2019. This information, which is updated daily, is based on the information used by MISO Operations. MISO continues to enhance the information already being provided and intends to solicit stakeholder feedback to guide work efforts on subsequent iterations, adjustments and improvements.

**MARKETS**

Throughout its history, MISO has been adapting its markets to enhance price formation and better manage system needs. For example, MISO designed demand curves that reflect the value of services to customers; implemented an emergency pricing process; developed Extended Locational Marginal Pricing to better reflect resource operating costs and reduce uplift; and, incorporated regional needs in the clearing and pricing of reserves. Additional products such as the Ramp Capability Product and the Short-Term Reserves help to manage uncertainties and provide flexibility in the 10-minute and 30-minute time frames. MISO anticipates further opportunities to improve price formation as the region transforms. The focus for the immediate future includes further improvements to emergency pricing and the evaluation of approaches to enhance pricing before and during periods of scarcity; enhance information on forecasted operating margin for market participants and; explore market mechanisms in advance of the day ahead market. Further work will explore the potential for additional tools to help value flexibility and manage ramps over multiple time-periods.
Scarcity and Emergency Pricing

Prices play an important role to signal shortages or surpluses and incentivize market participants to make efficient operational and investment decisions in the short- and long-run. Emergency and scarcity conditions, however, can create challenges for price formation. Out-of-market actions taken during emergencies can lead to price suppression and the absence of price responsive demand requires MISO set prices administratively during shortages. Though MISO developed an emergency pricing framework and scarcity pricing mechanisms to address these issues, MISO is exploring additional potential improvements. In particular, certain prices during recent emergencies and shortages did not fully reflect scarce conditions. Moreover, the increased impact of variability and uncertainty will create additional reliance on effective emergency and scarcity pricing.

Going forward, MISO will continue to pair solid theoretical market pricing approaches with enhancements that are expected to incent needed actions during times of scarcity.

Forward Market Mechanism

While market-based unit commitment is an important efficiency enhancing component of the energy market, given the uncertainties and incentives faced by resource owners, decisions to schedule units also occurs prior to the Day-Ahead market based on owner operational, financial, and contractual considerations. For example, given practical operational considerations, nuclear units remain running while not on outage rather than wait for a Day-Ahead market-based unit commitment.

Driven in part by increasing variability and uncertainty, stakeholders have requested that MISO provide better information in advance of the Day-Ahead market to inform unit commitment decisions and consider additional market mechanisms or incentives. Exploration of forward market mechanism enhancements is another focus in this area. In addition, MISO is exploring whether market-based approaches between the day ahead and real time could also help to manage uncertainty.
About MISO

The Midcontinent Independent System Operator (MISO) is a 501(c)(4) not-for-profit organization with responsibility for ensuring the reliability of the high-voltage electric transmission system to deliver low-cost energy. MISO began providing reliability coordination and other services in December 2001, and is one of the 10 Independent System Operators (ISO) in North America.

MISO manages the largest power system in North America in terms of geographical scope, serving about 42 million people across all or parts of 15 states, stretching from the Canadian border to the Gulf of Mexico. MISO’s energy markets are among the largest in the world, with more than $24.4 billion in annual gross market charges. MISO also serves as the reliability coordinator for MISO entities in these 15 states and one Canadian province.

Currently, the MISO region contains about 66,000 miles of high-voltage transmission assets with an aggregate value of approximately $38 billion, as well as 175,000 megawatts of electricity-generating capacity. MISO does not own any of these assets. Instead, with the consent of its asset-owning members and in accordance with its FERC-regulated tariff, MISO exercises functional control over the region’s transmission and generation resources with the aim of managing them in the most reliable and cost-effective manner possible.