



MISO'S RESPONSE TO THE RELIABILITY IMPERATIVE

- UPDATED JANUARY 2023 -

Living Document

This is a “living” report that is updated periodically as conditions evolve, and as MISO, stakeholders, and states continue to assess and respond to the Reliability Imperative.



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A Message from John Bear, CEO

The decarbonized electric grid of the future is not a distant fantasy. Utilities and states are building it in the MISO region right now by putting steel in the ground and plans on the drawing board for carbon-free resources.

This transformation has been progressing at an astonishing pace in recent years. It will speed up even more due to the substantial financial incentives for clean energy that the U.S. government enacted in 2022.



As this evolution continues, society must decide how to balance three objectives when it comes to the electric system: (1) reliability, (2) sustainability, and (3) affordability. While reliability is a must-have priority for all of the utilities and states in the MISO region, not everyone gives the same importance and balance to sustainability and affordability—and that's OK. As a federally designated Independent System Operator whose primary “lens” is reliability, MISO provides visibility and insights that help utilities and states to better understand the reliability, sustainability, and affordability implications of their approaches.

Carbon emissions in the MISO region have declined more than 30% since 2005 due in part to MISO's efforts to help utilities and states achieve their goals, and much deeper reductions are expected in the coming years. MISO also helps foster affordability and sustainability by dispatching resources in order of economic merit—meaning renewables like wind and solar are typically called on first because they have no fuel costs.

Naturally, there is much interest in the eventual “end state” of the decarbonization efforts that many utilities and states are pursuing. However, the grid must also remain reliable and affordable *during the transition* to a more sustainable end state. And without question, the rapid fleet change occurring in the MISO region is giving rise to a host of urgent and complex reliability challenges. These challenges can be overcome—but only if utilities, states, and MISO work together to better understand and adjust to the reality that the new resources have different attributes than the resources they are replacing. There are a number of emerging technologies that show promise for addressing these challenges, but they are not yet commercially viable at scale.

And fleet change is not the only challenge we face. Extreme weather events are becoming more frequent and severe. Electric vehicles and electric heating in homes and businesses are also poised to grow, which could exert new pressures on the grid in hours of the day and seasons of the year that rarely posed risks in the past.

This report documents MISO's response to the Reliability Imperative—the shared responsibility that MISO, utilities, and states have to address the challenges to electric reliability in our region. We highlight how these challenges have evolved since we updated this “living” report last year. We also discuss how we revised parts of our Reliability Imperative framework to reflect the progress we've made to date and to prepare us for the new challenges we face going forward. Through this framework, MISO can help facilitate a planning process for all of the region's entities to collaboratively address the challenges we face, while also balancing the priorities of reliability, sustainability, and affordability.

The work that MISO, utilities, and states are doing is a big lift. The region's 45 million people are counting on us to get it right. Thank you for your interest in these important issues.

A handwritten signature in black ink, appearing to read "J. Bear".

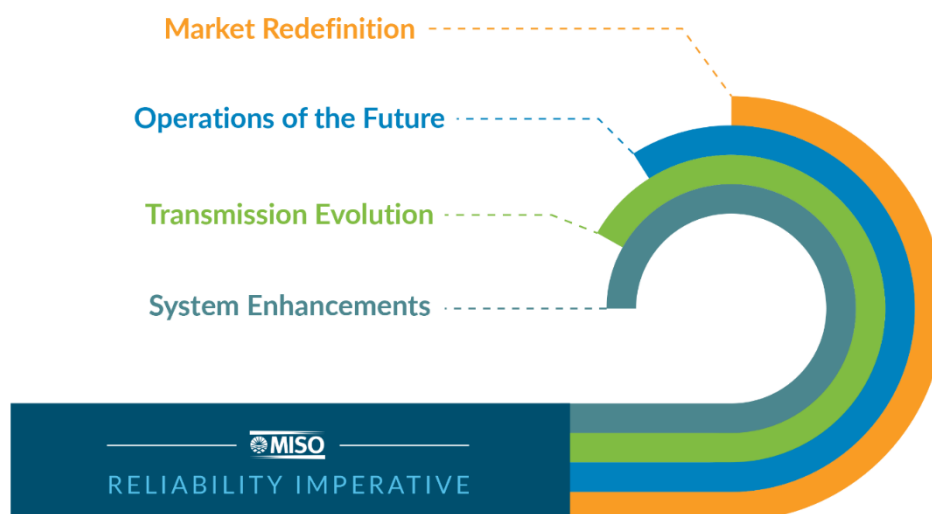


Executive Summary

RELIABILITY IMPERATIVE BASICS

The Reliability Imperative is the term MISO uses to describe the shared responsibility that MISO, its members, and states have to address the urgent and complex challenges to electric system reliability in the MISO region. MISO's *response* to the Reliability Imperative consists of a host of interconnected initiatives that aim to address the region's challenges in a comprehensive and prioritized fashion. These initiatives are organized into four primary pillars:

- **Market Redefinition:** Develops significant market enhancements and optimizations to ensure continued reliability and value in anticipation of the changing resource mix, more frequent extreme weather events, and increasing electrification.
- **Operations of the Future:** Focuses on the skills, processes and technologies needed to ensure MISO can effectively manage the grid of the future under increased complexity.
- **Transmission Evolution** (formerly called Long Range Transmission Planning): Assesses the region's future transmission needs and associated cost allocation holistically, including transmission to support utility and state plans for existing and future generation resources.
- **System Enhancements** (formerly called Market System Enhancements): Creates flexible, upgradeable, and secure systems that integrate advanced technologies to process increasingly complex information and evolve with the industry.





TWO PILLARS REDEFINED

When MISO first developed the Reliability Imperative framework in 2020, two of the four pillars were given names that differ slightly from what they are called today. Transmission Evolution was initially called Long Range Transmission Planning (LRTP), and System Enhancements was originally called Market System Enhancement (MSE). At the time, the names and scopes of these pillars reflected MISO's nearer-term business needs and strategic objectives in the two areas.

In late 2022, MISO gave the two pillars their current names and expanded their scopes in recognition of the significant progress that has been made in both areas. However, LRTP is still a key theme within Transmission Evolution, and MSE remains a theme in the Systems Enhancements pillar. This is discussed in more detail later in this report.





RELIABILITY, AFFORDABILITY, AND SUSTAINABILITY

As we all know, the power system is currently undergoing a once-in-a-generation transformation, which presents significant challenges but also tremendous opportunities. Through collaboration with our members and policymakers, we can collectively shape the future of electricity to enable the respective policy goals of our region.

Historically, the power system has been a behind-the-scenes industry, but with the urgency of addressing climate change, it is now an instrument for public policy, which crystalizes the need for robust analysis and information. A key role MISO plays is to provide independent, fact-based analysis with a regional view to help inform our members and policymakers as they move forward with their individual goals and policies.

That is why MISO is focused on partnering with stakeholders to conduct the work of the Reliability Imperative, and to provide visibility as members and states seek to balance **reliability, affordability, and sustainability**. While all three of these things are worthy priorities, there is often tension between them that can lead to unacceptable outcomes if they are not balanced appropriately.



For example, while utilities and states may want to build more wind and solar resources to achieve their sustainability goals, the affordability metric could swing out of balance if the intermittency is balanced by short duration and expensive batteries. On the flip side, a system that is reliant on existing fossil plants may not meet the sustainability goals of many customers, businesses, and states in the region. MISO helps inform utilities and states about the impact of their decisions by conducting engineering and economic studies. While MISO's jurisdiction is solely limited to the wholesale side of the industry, utilities and states can leverage MISO's region-wide insights to deliver affordability, sustainability, and reliability benefits to their end-use customers at the retail level.

As an independent grid operator with a region-wide view, MISO is uniquely situated to help utilities and states to better understand the trade-offs and consequences of policies that balance sustainability, affordability, and reliability in different ways. MISO will reliably operate whatever resource mix utilities and states decide to build, and MISO will analyze that portfolio to provide visibility into what will be needed to keep the system reliable.



DIFFERENT KINDS OF RELIABILITY CHALLENGES

MISO's response to the Reliability Imperative addresses a wide range of challenges to system reliability. Below is a brief look at some of them.

Fleet change

Many MISO members and states have set ambitious goals to partially or fully decarbonize their fleets of generating resources by future target dates. To be sure, utilities, states, and MISO must consider what the system will look like and how it will operate at the eventual "end state" of the decarbonization efforts that are playing out across the region.



However, we must first ensure that the system remains reliable and affordable *during the transition* to that end state—and the rapid transition of the region's fleet of generating resources is giving rise to a host of urgent and complex reliability challenges. These challenges include:

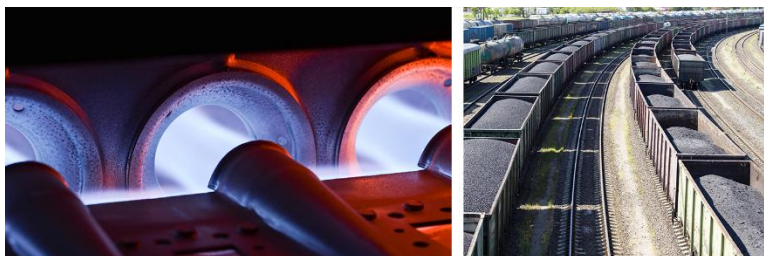
- The region's level of "accredited" generation capacity is declining because the new resources that are being built—primarily wind and solar—have lower accreditation values than the conventional thermal resources that are retiring. The resulting lower reserve margins mean that the region has fewer reserve resources to call on in emergencies or other types of tight grid conditions.
- Aging conventional resources that remain in service can be more prone to outages, potentially rendering them unavailable when they are needed most.
- Wind and solar resources are not always available during times of need due to their intermittent, weather-dependent nature.
- Due to the region's projected increasing reliance on solar generation, the system's need for controllable resources that can rapidly ramp up their output when solar becomes unavailable could triple by 2031 and quadruple by 2041 compared to current levels.
- Some fast-ramping resources may be critically needed going forward to back up intermittent renewables, but because they may not run very often, there may be little economic incentive for utilities and states to build new resources of this type, or to keep existing resources with these attributes in service.



- The region is becoming increasingly reliant on Load Modifying Resources that MISO can currently only access by engaging its emergency operating procedures.
- Distribution-level and behind-the-meter resources are becoming more prevalent, yet MISO does not yet have visibility into how these resources may affect the larger grid system.

Fuel assurance

Another challenge that is related to fleet change is the issue of fuel assurance. For example, natural gas resources may not be able to procure all the fuel they need at key times because of limitations in contractual gas services and



reliance on a pipeline system that is shared with heating and manufacturing uses. Coal resources typically keep large stockpiles of fuel onsite, but coal supplies have tightened in recent years due to changing economics, supply chain issues, and other factors. Coal resources can also be affected by extreme weather. And while renewable energy resources such as wind turbines do not use “fuel” per se, they are sometimes unavailable due to multi-day “wind droughts” and other weather-based events.

More frequent and severe extreme weather events

While extreme weather has always been commonplace in the MISO region, there is evidence that severe weather events that impact electric reliability have been increasing since the early 2010s. For example, in January 2021 the [Electric Power Research Institute found](#)



that hurricanes are increasing in intensity and duration, extreme heat events are increasing in frequency and intensity, and cold events are increasing in frequency. Examples of these kinds of impacts in the MISO region include Winter Storm Elliott in December 2022, Winter Storm Uri in February 2021, Hurricane Ida in August 2021, and Hurricanes Laura, Delta and Zeta in the summer and fall of 2020. These events highlight the need for the type of transmission development that MISO is pursuing as part of the Reliability Imperative. This work will enable MISO to move additional energy to parts of the region that may be impacted by weather-related generation outages and overloaded lines, among other things.



Electrification of adjacent industries

While year-over-year demand for electricity in the MISO region has been fairly flat for many years, it is expected to increase going forward due to the electrification trends in other sectors of the economy. Electric vehicles are growing in popularity, and the residential and commercial building sectors are increasingly using electricity for heating and cooling purposes—with the desire to source this new electric load from renewables. These trends will likely accelerate even more due to the substantial financial incentives for electric vehicles, rooftop solar systems, and electric appliances that Congress included in the 2022 Inflation Reduction Act.



The impacts of these trends could be significant. In MISO’s 2021 [Electrification Insights report](#), MISO found that electrification could transform the region’s grid from a summer-peaking to a winter-peaking system, and that uncontrolled vehicle charging and daily heating and cooling load could result in two daily power peaks in nearly all months of the year.

EMERGING TECHNOLOGIES SHOW PROMISE

A number of emerging technologies are currently being developed that could potentially be used in the coming years to address the challenges described above. They include long-duration battery storage, carbon capture, small modular nuclear reactors, and “green” hydrogen produced from renewable resources, among others. These technologies appear to have capabilities



and attributes the system needs to remain reliable during tight conditions, such as dispatchability, flexibility, and long duration—while also having the zero-carbon properties that many utilities and states need to achieve their decarbonization goals.

However, while these technologies show promise for the future, they are not yet commercially viable to be deployed at scale. MISO is actively engaged in tracking the progress of these technologies and is preparing to incorporate them into the system if/when the opportunity arises. More information on emerging technologies is available in MISO’s [2022 Regional Resource Assessment \(RRA\) report](#).



MISO IS ADDRESSING THESE CHALLENGES

Through the four pillars of the Reliability Imperative, MISO is addressing the challenges posed by fleet change, extreme weather events, and other trends in a comprehensive and prioritized manner. Some examples of MISO's recent accomplishments and planned next steps include:

As part of **Transmission Evolution**, the first of four planned portfolios of LRTP projects was [approved by the MISO Board of Directors](#) as LRTP Tranche 1 in July 2022. This tranche of 18 projects represents a total investment of \$10.3 billion—the largest portfolio of transmission projects ever approved by a U.S. Regional Transmission Organization. These projects will integrate new generation resources that utilities and states build in the North and Central parts of the MISO region and will support the reliable and affordable transition of the fleet and further harden the grid against extreme weather events. The quantifiable benefits of these projects will exceed their costs by a factor of at least 2.1. Work is currently underway on LRTP Tranche 2, with Tranches 3 and 4 to follow.



In addition to LRTP projects, the Transmission Evolution pillar also encompasses transmission projects that are initiated under the [MISO Transmission Expansion Plan \(MTEP\)](#) that MISO develops every year. MTEP projects are more locally focused than LRTP projects, analogous to





how local roads serve different purposes than interstate highways. [MTEP22](#) proposes 382 new projects spread over 14 states, representing \$4.3 billion in total investment.

Additionally, as part of this pillar, MISO is also exploring how to improve its processes for evaluating resource retirements.

Under **Market Redefinition**, the Federal Energy Regulatory Commission (FERC) in August 2022 approved MISO's Seasonal Accredited Capacity (SAC) proposal to shift from its summer-focused Resource Adequacy construct to a new 4-season construct that will better reflect the risks the region now faces in winter and shoulder seasons that did not pose problems until recent years. SAC also aligns the accreditation of thermal resources to their availability in high-risk hours throughout the year. Evaluation of accreditation reforms for non-thermal resources is underway and will continue in 2023. Other accomplishments and initiatives that MISO is pursuing under the Market Redefinition include:

- Introduction of the Electric Storage Resource (ESR) to MISO's market portfolio, enabling storage resources to participate in MISO's Energy and Operating Reserves Markets as supply and demand.
- Launch of a new Short-Term Reserve (STR) market product which improves the procurement and market signals for flexible energy resources that can provide energy within a relatively short period of time (e.g. 30 minutes).
- Starting a conversation about critical reliability attributes that are becoming scarce because of the fleet transition and differences in the attributes of new versus retiring generators.
- Exploring options for a Reliability-Based Demand Curve that may reduce the risk of a capacity shortfall by sending stronger price signals in MISO's Planning Resource Auction.

In the realm of **Operations of the Future**, MISO will pursue a number of initiatives in 2023 and beyond to ensure that it has the people skills, processes, and technology to anticipate and respond to operational opportunities and challenges. This work is organized into five themes: (1) operations preparedness, (2) operations planning, (3) uncertainty & variability (4) situational awareness & critical communication, and (5) operational continuity.

System Enhancements has achieved a number of accomplishments in recent years, including Model Manager Phase 1, which transforms how MISO models the electrical system, and the Market User Interface, which updated the interface that stakeholders use to participate in the market. In addition, MISO upgraded its Energy Management System, which enhances functionality while aligning with industry technology standards. Moving into 2023, MISO is broadening the emphasis on transformational work that is flexible, upgradeable, and secure to better enhance systems to meet the region's longer-term needs.



CONTINUED STAKEHOLDER INPUT IS CRUCIAL

Much of the work cited in this living report is already underway, and much of the work has appeared in some form in the prior versions of this Reliability Imperative report. Many of the ideas and proposals in this report reflect a great deal of technical input from stakeholders. For example:

- MISO proposals to improve the resource adequacy construct, including how resources are accredited, are discussed in the [Resource Adequacy Subcommittee](#).
- Initiatives to improve price signals and other market mechanisms reflect input at the [Market Subcommittee](#).
- Work on the LRTP initiative and other parts of the Transmission Evolution pillar taking place in the [Planning Advisory Committee \(PAC\)](#), and cost allocation issues are discussed in the [Regional Expansion Criteria and Benefits Working Group \(RECBWG\)](#).

As MISO has emphasized over the course of the last few years, the Reliability Imperative is not intended to replace existing initiatives with which stakeholders are already familiar. Instead, it pulls together a number of strategic initiatives under a single framework for the purpose of ensuring more alignment, reinforcing the sense of urgency, and highlighting the connections among the workstreams. The Reliability Imperative also figures prominently in the [MISO Roadmap](#), which lays out MISO’s strategic priorities and a proposed path to address them in the stakeholder process. The MISO Roadmap is discussed in more detail later in this report.

This document is a “living” report that MISO will continue to update as needed. MISO appreciates the helpful feedback that stakeholders have provided on the Reliability Imperative, and we look forward to continuing the dialogue with our stakeholders going forward.





Current Reliability Challenges Will Become More Significant, and New Ones Will Emerge

For much of the last decade, the MISO region has been inching ever closer to experiencing a shortfall in electricity-generating capacity due to widespread retirements of conventional resources, not enough replacement capacity coming online, and other factors. For the purposes of this report, the term “shortfall” means not having enough resources to meet expected load plus the required level of reserve resources.

SHORT TERM RISKS

In April 2022, that risk manifested as a planning shortfall. As part of the Planning Resource Auction (PRA) that MISO holds every year, a large swath of the region fell short of its minimum capacity requirements by 1,230 megawatts (MW). That figure is expressed in terms of accredited capacity, as described in the box on this page. The shortfall will remain in effect through MISO’s 2022-2023 Planning Year, which began on June 1, 2022 and concludes on May 31, 2023.

This shortfall is not cause for panic. But it does mean that a large part of the region is at a higher risk of MISO having to implement its emergency operating procedures to maintain system reliability during tight grid conditions. This could include having to import energy from neighboring systems or deploying emergency-only reserve resources, among other things. In the worst-case scenario, MISO may have to implement temporary controlled load sheds in order to prevent uncontrolled, cascading outages.

Fortunately, as of the publication of this report in January 2023, MISO has not had to implement temporary load sheds due to the capacity shortfall that became evident in April 2022. However, unless more generating capacity is built—especially capacity with high accreditation values and attributes that enable it to quickly mitigate tight system conditions—the risk will continue and get worse going forward.

Capacity terminology

This report uses different terms to quantify generation capacity. The terms apply to both existing and planned/modeled capacity.

It is important to understand what these terms mean, as they differ in their definitions and their implications for the MISO region experiencing capacity shortfalls and/or surpluses.

- **Installed Capacity (ICAP):** The maximum amount of capacity, expressed in MW, that a resource can produce based on a recent test. While not exactly the same, ICAP is sometimes called "nameplate" capacity.
- **Accredited capacity:** The amount of capacity, expressed in MW, that is assigned to a resource after accounting for its historical availability for the purpose of meeting MISO’s resource adequacy requirements.



MEDIUM TERM RISKS

The risks the region faces are further illustrated by a yearly planning tool called the OMS-MISO Survey, which asks utilities to provide information over the next five years on new generation they plan to build and existing resources they plan to retire. MISO administers the survey in partnership with the Organization of MISO States (OMS), which consists of state regulatory agencies in the region.

The 2022 OMS-MISO Survey projects that a large part of the MISO region could have a capacity deficit of 2.6 gigawatts (GW) below its required reserve margin for the 2023-2024 Planning Year, which runs from June 1, 2023, through May 31, 2024. The survey indicates that this potential deficit will increase in subsequent years, reaching 10.9 GW in 2027.

Alternatively, the survey also indicates a possibility that the region could have a surplus of up to 2.4 GW in 2023/2024 if load does not increase as much as expected, and/or if utilities and states take certain actions in response to the shortfall that came to light in the 2022 PRA. Those actions include procuring additional capacity and deferring planned retirements, among other things. All of the figures cited from the OMS-MISO Survey are expressed in terms of accredited capacity.

LONGER TERM RISKS

The risk of a capacity shortfall and other reliability challenges facing the MISO region are also illustrated in MISO's [Regional Resource Assessment \(RRA\)](#). The RRA models how the region's fleet of generating resources might evolve over a 20-year time horizon based on the goals that utilities and states have publicly announced to reduce their carbon emissions and/or increase their use of renewable energy. The RRA also models public announcements that utilities and states make to retire specific existing resources and to build new resources going forward.

The 2022 RRA indicates that utilities and states may need to build more than 100 GW of new generation capacity on an ICAP basis within the next 10 years in order to achieve their publicly announced plans and goals in a reliable manner. For context, 100 GW of new capacity represents about 53% of the region's current generation fleet. To date, only about 56 GW of that 100+ GW has been publicly announced. That is not surprising, since utilities and states do not typically finalize and publicly announce their resource plans 20 years in advance. Still, it would be unprecedented for utilities and states to build 100+ GW of new generation in the next 10 years, since, on average, they have only added about 3.4 GW per year since 2014, with the largest-ever year (2020) totaling about 6.6 GW. These figures are all expressed in terms of ICAP.



Other key insights from the 2022 RRA include:

The region's level of accredited capacity is expected to decline, even though ICAP is expected to increase. Because the new resources that utilities and states plan to build—primarily wind and solar—have lower accredited values than the thermal resources they plan to retire, the region's estimated level of accredited capacity is expected to decline going forward. The capacity contribution of solar generation is forecast to decline rapidly as more solar capacity is added to the system, additionally impacting the region's overall capacity outlook.

Wind and solar generation could serve nearly 30% of MISO's annual load in the next five years and 60% of load by 2041. This would reduce emissions by nearly 80% by 2041 relative to 2005 levels, but also sharply increase the complexity of reliably operating and planning the system. These levels of renewable penetration are significant due to the findings of MISO's RIIA study, which assessed the impacts of integrating increasingly higher levels of renewables into the MISO system. RIIA identified an "inflection point" between renewable penetrations of 30% and 40% where planning and operating the grid will become significantly more complex. Still, RIIA found that renewable penetrations of 50% or higher could be reliably achieved if MISO, its members, and states coordinate closely on advanced actions that would be needed.

To compliment the expected growth of solar generation, the system's need for controllable up-ramp capability could triple by 2031 and quadruple by 2041 compared to current levels. As the solar generation capacity grows, so does the challenge of steeper ramping needs for the non-solar generation fleet. At sunset, MISO will increasingly need controllable resources that can rapidly turn on and ramp up their output when generation from solar becomes unavailable. The need for fast-ramping resources is expected to vary by season and be most prominent in the winter months.

FUEL ASSURANCE RISKS

The transition to a lower/no-carbon electric grid also poses risks in the realm of fuel assurance. These risks impact conventional coal and natural gas resources that provide reliability attributes such as flexibility that may be becoming scarce due to fleet change.

Coal resources have historically been considered fuel-assure because large stockpiles of fuel can be stored on-site. However, coal supplies have tightened in recent years due to a confluence of factors, including contraction of the mining and transportation sectors and supply chain issues related to the COVID-19 pandemic. Additionally, because gas prices have increased significantly in recent years, coal resources are sometimes more economic to dispatch than gas-fired generators. These factors increase the risk that coal plants will be unable to perform due to a lack of fuel availability. Beyond these factors, coal resources can also be affected by extreme winter weather freezing onsite coal piles and/or impacting coal-handling equipment.



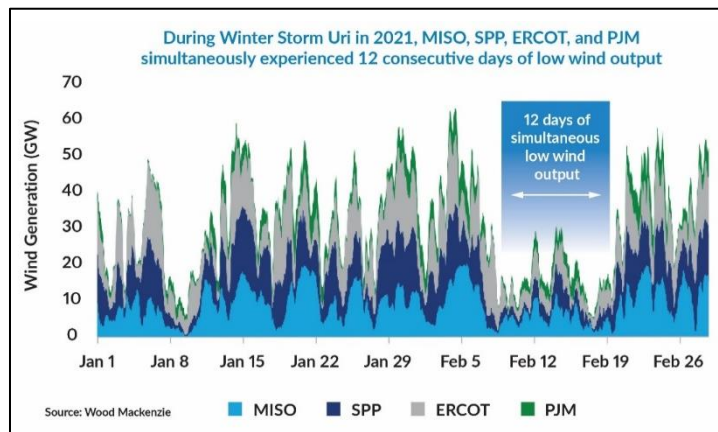
Gas-fired resources are also subject to fuel-assurance risks because they rely on pipelines to deliver gas to them when they need it. However, because the gas pipeline system was largely built for home-heating and manufacturing purposes, gas power plants sometimes cannot procure all the fuel they need due to contractual issues related to delivery priorities. In the MISO region, this has historically occurred during extreme winter weather events that drive up home-heating needs for gas. Many gas generators in MISO do not have “firm” fuel-delivery contracts, opting instead for less costly “interruptible” pipeline service or a blend thereof. Only about 27% of the gas generation that responded to MISO’s [2022-2023 Generator Winterization Survey](#) indicated it had firm transport contracts in place for all of their supplies during the 2022-2023 winter season.

Additionally, gas power plants, gas pipelines, and coal generators can be forced out of service by icing and other effects of severe winter weather—as occurred in the MISO region and elsewhere during the February 2021 Arctic event.



MISO has implemented a variety of tools and processes to develop situational awareness around and mitigate fuel assurance-related reliability issues, such as engaging in direct communications with generation and pipeline operators and using real-time mapping tools and other means to increase situational awareness of potential problems.

Wind resources can also experience “fuel” availability challenges in the form of highly variable wind speeds correlated with weather patterns. The energy output of wind resources can fluctuate significantly on a day-to-day and even an hour-by-hour basis including multi-day periods of low wind output. The chart below illustrates how the MISO, Southwest Power Pool (SPP), Electric Reliability Council of Texas (ERCOT), and PJM regions all experienced 12 consecutive days of low wind output during Winter Storm Uri in February 2021. Additionally, when wind output is high,





congestion on the transmission system may require MISO to curtail, or turn off, wind resources that were otherwise forecasted to provide energy.

INCREASING RELIANCE ON LOAD MODIFYING RESOURCES

Another trend associated with the changing resource mix is that the region has become more reliant on a category of resources that MISO can only access by progressing through the steps of its emergency operating procedures and formally declaring a grid emergency. These assets, known as Load Modifying Resources (LMRs), are used to curtail or offset load. In addition to their emergency-only use, LMRs also have other limitations that MISO must follow, such as caps on how many times a year MISO can call them, and minimum lead times before they are expected to perform.

The use of LMRs increased markedly in 2016, when the region's reserve margins began declining due to environmental regulations, economic considerations, and other factors. Since then, LMRs have consistently comprised a little more than 8% of the total resources that have cleared MISO's annual PRA.

While the emergency-only use of LMRs is a long-established practice in the utility industry, MISO has become increasingly dependent on LMRs to ensure capacity sufficiency—which can result in sub-optimal outcomes. For example, MISO may not be able to access LMRs in time to mitigate rapidly evolving system conditions. Even when LMRs do respond in time, their performance may fall short of what they were accredited for. Moreover, the long lead times of some LMRs can also require MISO operators to make difficult decisions. If operators do not make a required emergency declaration ahead of time, they risk not having the LMRs needed to meet obligations. If they do make a declaration and dispatch LMRs, they may create uplift and reduce the efficiency of market outcomes in pursuit of reliability.

MISO has already made several improvements related to LMRs in recent years, such as implementing testing requirements to ensure that LMRs can curtail firm load and improving how LMRs are accredited. MISO has also implemented improvements to emergency pricing which is in effect when LMRs are deployed.

MISO will continue to pursue both near and long-term improvements as part of the Reliability Imperative's Market Redefinition workstream. Near-term work includes further alignment of LMR accredited capacity value with the resources' seasonal availability and lead time, and improving locational information so MISO operators can more efficiently manage emergency conditions. The long-term improvements include creating a path to market participation for LMRs outside of emergencies events.



EMERGING RISKS IN NON-SUMMER SEASONS

In the past, resource adequacy planning in the MISO region focused on procuring sufficient resources to meet demand in the peak hour of the year, which normally occurs on a hot and humid summer day when air conditioning load is very high. If utilities had enough resources to reliably meet that one peak hour in the summer, the assumption was they could operate reliably for the other 8,759 hours of the year.



This is no longer the case. Factors such as widespread retirements of conventional resources, lower reserve margins, more frequent and severe weather events, and increased reliance on emergency-only resources and weather-dependent renewables have altered the region's historic risk profile, creating risks in non-summer months that rarely posed challenges in the past.

This changing risk profile is why in November 2021, MISO proposed to shift from its annual, summer-focused resource adequacy construct to a new framework that establishes resource adequacy requirements on a "seasonal" basis for four distinct seasons: summer (June-August); fall (September-November); winter (December-February); and spring (March-May).

This new seasonal construct also seeks to ensure that resources will be available when they are needed most by aligning resource accreditation with availability during the highest risk periods in each season. The new construct does this by determining a Seasonal Accredited Capacity (SAC) value for certain classes of resources. The SAC methodology also includes a tiered weighting structure to determine individual resource accreditation by season based on each resource's real-time offered availability, accounting for coordinated planned outages.

FERC [approved](#) MISO's proposed seasonal resource adequacy construct on August 31, 2022. MISO intends to implement the new framework for the 2023-2024 PRA.



Redefining Two of the Reliability Imperative Pillars

In 2020, when MISO first developed the Reliability Imperative framework, two of the four pillars were given names that differ slightly from what they are called today. Transmission Evolution was called Long Range Transmission Planning, or LRTP for short, and System Enhancements was called Market System Enhancements, or MSE for short. Since that time there has been some confusion, as these names are also used for specific defined initiatives within MISO. Given that confusion, we have switched to the new names for the Reliability Imperative pillars, and below describe how the LRTP and MSE work fits into the pillars.

The LRTP pillar was expanded to Transmission Evolution to encompass the work MISO does in a system planning context beyond the four planned tranches of LRTP projects which are helping MISO members achieve their decarbonization goals and other policy objectives. The two other themes, in addition to LRTP, are Planning Transformation, which encompasses the tools and modeling data needed within the planning context, and Resource Utilization, which highlights the work being done around resource interconnections and retirements.

The Market System Enhancements pillar evolved to System Enhancements to acknowledge the transformative technology-related work MISO is undertaking beyond the specific MSE program, which MISO launched in 2017 to transform its legacy market platform into a more flexible and secure system to better accommodate the region's evolving resource mix and advancing technologies. The System Enhancements pillar now contains an additional theme called Technology of the Future, which includes technology security, information technology infrastructure transformation to a hybrid cloud environment, and new capabilities within data and analytics.

CONNECTIONS BETWEEN PRIORITIES AND WORKSTREAMS

MISO's strategic priorities, such as those embodied in the Reliability Imperative's workstreams, are connected and build upon each other. Success in one area depends on progress in another, so efforts must be coordinated and sequenced. For example, achieving reliable and economically efficient grid operations requires new tools and processes to be developed under the Operations of the Future workstream, and market enhancements to be developed under the Market Redefinition workstream. Similarly, the ability to interconnect renewable resources may be constrained by the existing transmission system and is therefore dependent on some of the changes being contemplated in the Transmission Evolution workstream.

That said, MISO recognizes that not everything can be accomplished at once. Transitioning to the grid of the future is a complex task, so making steady, incremental progress is still progress and advisable. Although taking multiple transformational leaps at the same time may be desired, MISO is committed to transparently working with utilities and states to develop a sequenced,



comprehensive approach to the region’s challenges. And as we do so, we should strive for progress, not perfection. In other words, we must not allow the perfect to be the enemy of the good.

By documenting our future vision in this report and outlining next steps across the four main workstreams, MISO is facilitating an important dialogue about how to prioritize different work efforts. As we continue to update this “living” document, the Reliability Imperative will note dependencies and impacts of any future schedule changes. MISO plans to continue the dialogue by regularly updating stakeholder committees on the Reliability Imperative.

“Minding the gap” during the fleet transition

You may have heard MISO use the term “Mind the Gap” when discussing MISO efforts to prevent shortfalls or “gaps” in needed reliability capabilities due to factors such as environmental regulations and economic considerations that are prompting utilities and states to retire conventional resources even faster than they had initially planned.

MISO’s Mind the Gap work is all housed within the Reliability Imperative. Mind the Gap is not a “fifth pillar” of the Reliability Imperative.

Mind the Gap is about identifying shortfalls in needed system capabilities and trying to prevent them from jeopardizing grid reliability as utilities and states continue to shift from conventional resources to weather-dependent renewables and emerging technologies such as battery storage.



Market Redefinition

MISO is working with its stakeholders to reexamine and redefine market constructs and products to ensure that the system remains reliable in the face of fleet change, more frequent and extreme weather events, and increasing electrification. MISO's analysis in the [Markets of the Future report](#) shows that the foundational market constructs that are in place today will continue to be effective in the future, but only with significant revisions. This work is occurring under four distinct themes within the Market Redefinition pillar of the Reliability Imperative, as discussed below.

UNCERTAINTY & VARIABILITY

In the planning horizon, MISO is looking to better reflect the changing risk profile and send effective market signals for forward-looking investments. MISO's original resource adequacy construct was designed for a conventional fleet of resources, where reliability risk was concentrated during the typical summer peak periods.

This is no longer the case. Factors such as aging conventional resources, more frequent and severe weather events, and increased reliance on weather-dependent renewables have altered the region's historic risk profile, creating risks in non-summer months that rarely posed challenges in the past. As the generation mix further diversifies, the "accreditation" process of evaluating each generator's contribution to the system is a key reliability and planning mechanism.

In 2022, FERC approved MISO's proposal to shift from the original, annual, summer-based resource adequacy construct to a new construct with four distinct seasons. The new seasonal construct also aligns the accreditation of thermal resources with availability in the highest risk periods. These changes will be implemented in the 2023-2024 PRA.

Evaluation of potential paths for non-thermal accreditation methodology reforms was completed in 2022 for wind, solar, and LMRs to ensure that the accredited capacity value reflects the capability and availability of the resource during the periods of highest reliability risk. MISO intends to complete the non-thermal resource accreditation initiative in 2023. MISO and stakeholders will also evaluate accreditation methodologies for storage and hybrid resources.

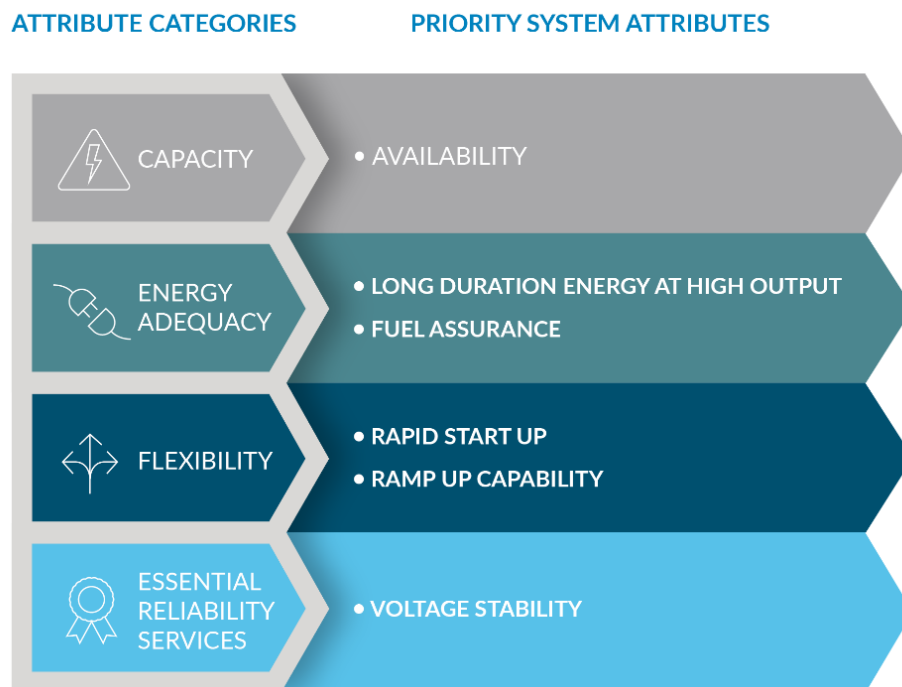
Another area of focus is to improve the design of the Planning Resource Action (PRA) itself. The PRA was not originally designed to utilize the type of demand curve that would set higher clearing prices for capacity as the magnitude of a capacity shortfall increases. This lack of a "warning signal" can instill a false sense of calm among PRA participants, masking an imminent shortfall—as occurred with the 2022 PRA. To address this issue, MISO is working with its stakeholders to design a "Reliability-Based Demand Curve" (RBDC) that will improve price signals in the PRA.



RESOURCE MODELS & CAPABILITIES

MISO studies show it is possible to reliably operate the system with substantially lower levels of thermal resources. However, the new resources that are built to replace retired thermal resources must provide the commensurate capabilities that are needed to ensure reliable operations. Historically, MISO has depended on some of the capabilities that are bundled in thermal generation, such as dispatchable flexibility and inertia. However, not all of these attributes are inherent to the new types of resources that are being built across the region.

In the fall of 2022, MISO launched an initiative in the public stakeholder process to identify which **critical system attributes** may become scarce due to fleet change. The first priority of this attributes work is to increase visibility into the magnitude and timing of any shortfall. This work will identify which critical attributes the system needs without favoring any particular type of generation technology. MISO and its stakeholders will seek to quantify how much of each critical attribute the system will need as it continues to evolve, and the timetables for when those attributes will be needed. This work will also explore different options for ensuring critical but scarce attributes. While this initiative is still in its early stages and no final decisions have been made, MISO has proposed to initially focus on six “priority system attributes” in four categories, as shown in the figure below.





Currently, the work that MISO and its stakeholders are doing on system attributes is taking place primarily in the Resource Adequacy Subcommittee (RASC), but this initiative could expand to different stakeholder forums going forward.

As another part of the Resource Models & Capabilities theme, MISO will work with its stakeholders to improve locational information for Load Modifying Resources (LMR) so MISO operators can more efficiently manage emergency conditions. Planned near-term improvements include utilizing the Demand Side Resource Interface (DSRI) to accredit LMRs during defined seasonal hours and require improved locational information. Planned long-term improvements include creating a path to market participation for LMRs outside of emergencies while tightening the criteria for emergency-only LMRs to ensure they are highly reliable and flexible.

IDENTIFYING LOCATIONAL NEEDS

The financial transmission rights (FTR) market is another area of focus for the Market Redefinition effort. Congestion in the MISO region has been increasing since 2019, and FTR serves as a financial hedge against the uncertainties of day ahead congestion. MISO has engaged stakeholders and industry experts in an analysis of the efficiency of MISO's auction revenue rights (ARR) mechanism and FTR market. The evaluation work has identified gaps and is exploring potential areas of improvement, including updating approaches for the allocation of ARRs, more granular time periods, and exploration of ways to incentivize outages that better align with day ahead energy models.

ENHANCING COORDINATION

As part of this theme, MISO will continue to facilitate the adoption of ambient-adjusted ratings (AARs) and seasonal ratings on transmission lines in the region, per the requirements of FERC Order 881. While the use of more accurate line ratings does not obviate the need to build new transmission infrastructure, having the most accurate line rating information can help ensure that the region's transmission system is fully utilized and delivers its maximum value to end-use customers. MISO has engaged in extensive discussions with its Transmission Owners and consulted with other interested stakeholders to develop a compliance approach that meets the requirements of FERC Order 881, and which is consistent with MISO's Tariff framework.

“Our market products and the signals they send need to evolve and reflect the new realities and trends that we are experiencing. Input and support from our stakeholders will be key in the effective and timely implementation of these changes.”

Todd Ramey, MISO Senior Vice President, Markets and Digital Strategy



Operations of the Future

MISO operations will also be challenged by the different types of resources connecting to the grid including at the residential level, and the increased frequency and severity of extreme weather events that we have experienced in recent years. In addition to implementing lessons-learned from past events such as Winter Storm Uri and Hurricane Ida in 2021, forward-looking work is underway to ensure that MISO has the capabilities, processes, and technology to anticipate and respond to operational opportunities and challenges. This work, termed Operations of the Future, is focused on five large buckets of work: (1) situational awareness and critical communications, (2) operations preparedness, (3) uncertainty and variability, (4) operations planning, and (5) operational continuity.

SITUATIONAL AWARENESS AND CRITICAL COMMUNICATIONS

Situational awareness and critical communications will become even more important as operating risks are becoming less predictable and more difficult to manage in day-to-day operations. New control room technologies and capabilities, improved real-time data capabilities, and more complex operating conditions, driven by new load and generation patterns, will require MISO and its members to communicate even more quickly and efficiently.

Today, MISO operations rely heavily on the expertise of its operators. While operators have access to significant amounts of data related to weather, load, and other things, they must manually synthesize data into useable information. While this has worked well historically, solutions must envision a future with more complex information and operators who may not possess the same historical knowledge.

In the future, MISO operations will need an integrated toolset for operators that leverages artificial intelligence and machine learning, combined with additional data and analytics. Techniques to improve how MISO sees and navigates will give operators important information automatically. Systems will provide situational awareness insights for operators based on their function in the control room. Operators will analyze information and create new displays in real-time to quickly assess different impacts of an operational situation. Dynamic views of the state of the system will ensure operators can maintain the appropriate level of situational awareness when managing the system and will reduce operator burden and automate key communication requirements with the appropriate audience-level information, especially during critical events.

Additionally, enhancements to communications protocols, such as system declarations, will ensure that MISO and member control rooms have the information they need when they need it. Automated messaging triggered by specific process/procedure actions will reinforce compliance with North American Electric Reliability Corporation (NERC) standards.



OPERATIONS PREPAREDNESS

Operations preparedness is critical to manage rapidly shifting or challenging operating conditions. Tomorrow's control room will be very different from today. System operators are facing more rapidly changing system conditions, increased volumes of data, and enhanced technologies and tools. To ensure that control room personnel are ready to manage reliability effectively and efficiently in this new and continually evolving operations environment, MISO is developing improved operations simulation tools and enhancing operator training. In the future, operator and member training and drills will leverage a robust simulator that mirrors productions and is able to quickly incorporate and maintain real-time event scenario simulations, with broad, controlled access capabilities.

“In the past, predicting load and generation were relatively straightforward. In the future, the operating environment will be much more variable, and we need the people, processes, and technology to deal with that variability.”

Jennifer Curran, MISO Senior Vice President, Planning & Operations
and Chief Compliance Officer

UNCERTAINTY AND VARIABILITY

The increase in variable generation such as wind and solar has introduced increased uncertainty, and it is critical that operators possess the capabilities necessary to manage a growing risk profile to ensure reliability in all operating horizons. Today, operators use a variety of market products, as well as other analytics-based tools to manage uncertainty and variability and ensure reliability. As operational complexity grows, MISO is focused on advancing its capability to quantify the uncertainty using probabilistic forecasts and advanced analytics. With a more complete view of uncertainty, operators will be able to create daily risk assessments that—when coupled with new dynamic reserve requirements—will further incentivize efficient commitment decisions.

In the future, operators will need to reliably and efficiently manage the grid through tight margins, high-ramping periods, and increased variability by optimizing a risk management framework that accurately provides a risk profile based on net uncertainty impacts and by leveraging predictive economic impact analysis and power system studies.



OPERATIONS PLANNING

Operations planning enables MISO to remain a step ahead of the shifting energy landscape. System operators need to quickly access insights into the future and processes that enable the continued reliable and efficient operation of the bulk electric system. In the future, it will be more important than ever to leverage information in new ways. Being able to quickly model and analyze realistic planning scenarios will enable the development of and modifications to the operating day plans from start to execution. Operators will be better prepared to manage increased uncertainty in resource availability with operational planning processes that are centralized and streamlined, and outages that are proactively scheduled leveraging predictive economic impact analysis and power system studies.

OPERATIONAL CONTINUITY

Operational continuity capabilities need to evolve to align with the changing technologies, resource portfolio, and threat landscape. Improved tools and updated processes are vital to ensuring that MISO can reliably operate the grid, mitigate risks, and, if necessary, recover quickly in the event of disruptions to toolsets or control centers.





Transmission Evolution

The ongoing shift in the resource fleet is posing significant challenges to the design of the transmission system in the MISO region. MISO's Transmission Evolution work addresses these challenges, in concert with other elements of the Reliability Imperative framework.

When MISO first established the Reliability Imperative framework in 2020, the Transmission Evolution pillar was called Long Range Transmission Planning, or LRTP. In late 2022, MISO changed the name of the pillar to Transmission Evolution to better reflect the broader scope of work that is necessary to usher in the new resource fleet planned by MISO members. But LRTP has not gone away; it continues to be an important part of the larger Transmission Evolution pillar.

Under Transmission Evolution, MISO is still focused on holistically assessing the region's future transmission needs in concert with utility and state plans for existing and future generation resources, while considering the allocation of transmission costs. This work is intended to result in an integrated transmission plan that reliably enables member goals while minimizing the total cost of the fleet transition. It is also intended to improve the transfer capability of the region's transmission system—meaning the system's ability to effectively and efficiently move energy from where it is generated to where it is needed.

LONG RANGE & INTERREGIONAL TRANSMISSION PLANNING

LRTP continues to be an important part of the larger Transmission Evolution pillar along with interregional transmission planning. The LRTP effort is developing four “tranches” of new backbone transmission to support MISO member plans for the changing fleet. In July 2022, the MISO Board of Directors [approved](#) Tranche 1 LRTP projects as an addendum to MTEP21. The 18-project portfolio of least-regret solutions is focused on MISO's Midwest Subregion, representing \$10.3 billion in investment with benefit-to-cost ratios ranging from 2.2 to 4.4.

The LRTP projects in Tranche 1 will provide a wide range of value across the Midwest portion of the MISO footprint, including congestion and fuel savings, avoided capital costs of local resources, avoided transmission investments, resource adequacy savings, avoided risk of load shedding, and decarbonization.

“We see very little risk of over-building the transmission system; the real risk is in a scenario where we have underbuilt the system. Similarly, across markets and operations, our job is to be prepared.”

Clair Moeller, MISO President



This transmission investment hinges on appropriate allocation of the associated costs. MISO's Tariff stipulates a roughly commensurate "beneficiaries pay" requirement that must be met while balancing the divergent needs of MISO's subregions. Because Tranche 1 focuses on the MISO Midwest Subregion, costs will only be allocated across this subregion according to benefits. This cost allocation approach will continue through Tranche 2, as the focus remains on the Midwest Subregion. However, as MISO progresses to Tranche 3 and 4, other approaches, including a more granular allocation of costs based on benefits, may be considered based on stakeholder discussion.

Futures refresh

To lay the groundwork for Tranche 2, MISO in mid-2022 launched an initiative to update or [refresh](#) the three MISO Futures. These updated Futures, labeled 1A, 2A, and 3A, will be used to better understand potential future needs, and to analyze the Tranche 2 candidate projects. This refresh will update information that informs the potential resource mix, such as state and member plans; capital, operating and fuel costs; resource additions and retirements considering the generator interconnection queue and the Attachment Y resource retirement process; and Planning Reserve Margin and resource accreditation. The load forecast will remain constant.

Future 2A is intended to represent the full goals of MISO members. Preliminary Future 2A results indicate that fleet change will increase in velocity and will come close to resembling the type of resource mix envisioned in Future 3, which reflects stronger renewable energy mandates, carbon reduction goals, and other policies that drive resource changes.

Future 2A adds 270 GW of new resources and forecasts 115 GW of retirements. Further, Future 2A preliminary results project wind and solar energy generation reaching 30% in the MISO footprint ten years earlier than the previous Futures, and continued decarbonization reaching a 90% reduction in carbon emissions by 2042.

Other visibility tools

As the system becomes more interdependent and interconnected, MISO is looking to provide information to members about the outcomes and impact of their individual plans when studied in the aggregate. Anticipating and communicating changing risks and future systems needs within the planning horizon is key. The resource adequacy survey that MISO conducts in partnership with OMS looks several years ahead, but confidence is lower in the later years. Additionally, the OMS-MISO Survey only focuses on capacity, but increasingly the system will need a forecast of flexibility and other attributes. MISO is working to provide forward resource assessments and long-term resource adequacy reports to better inform our members' and stakeholders' discussions and investments in needed solutions.

In 2022, MISO published the [second iteration of the Regional Resource Assessment \(RRA\)](#), improving the quality of the input data by collecting information directly from members through a



new RRA survey. The survey solicited information about members' investment and retirement plans, as well as decarbonization goals over a 20-year planning horizon. The RRA aggregates publicly announced utility plans and goals to develop an indicative view of regional fleet evolution trends and pacing, and models what new reliability needs and gaps may arise.

MISO will continue to look for ways to streamline processes for collecting and sharing data for purposes of the RRA and other assessments. Additionally, MISO will explore ways to leverage the RRA to inform and advance the attributes workstream.

Interregional initiatives

MISO is also working with neighboring Regional Transmission Organizations (RTOs) on needed transmission solutions. For example, MISO is partnering with SPP, an RTO to the south and west, on an initiative called the Joint Targeted Interconnection Queue (JTIQ). This effort



identifies a portfolio of proposed transmission projects that aligns with each RTO's respective interconnection process. These projects will create additional capability to enable generator interconnections in both RTOs. Work continues to develop cost allocation for JTIQ projects. Once agreement on cost allocation is reached, MISO will file proposed tariff changes at FERC and the JTIQ projects will proceed to the Boards of each RTO for approval.

PLANNING TRANSFORMATION

Planning Transformation, another component of the Transmission Evolution pillar, will develop aligned, adaptable, and flexible processes over the next five to 10 years to recognize and address emerging transmission threats and risks identified in markets and operations.

Some of these measures—such as the use of the Generator Interconnection Portal and technology evaluation of the MTEP platform and resource siting—are already underway. Others are planned for the future. These include evolving technology for the resource transition, adapting planning criteria to enhance system resiliency and robustness, and integrating model data.

RESOURCE UTILIZATION

The final Transmission Evolution pillar, Resource Utilization, focuses on developing a dynamic retirement process and streamlining the interconnection process even further to accommodate smaller projects. Fleet change is requiring MISO to revise its processes to interconnect new generating resources to the grid and to evaluate retirement requests for existing resources. In December 2022, MISO filed a [proposal](#) with FERC to extend the notice for retirement requests from 26 weeks to 1 year. MISO's proposal would also establish quarterly retirement studies.



Going forward, additional measures will include increasing visibility of resource retirements on resource adequacy; determining how to collect more accurate forecast information; considering the impact of future attributes (when defined); and matching regional or subregional new accredited capacity before retirements.

System Enhancements

MISO's ability to respond to the Reliability Imperative is enabled through continued system enhancements and modeling refinements. As the electric industry landscape continues to evolve, systems and technology must be enhanced and updated to meet many of the new, reliability-driven market improvements, manage the growing complexity of the transition toward renewable resources, and fully leverage new resources such as storage and DERs.

MARKET SYSTEM ENHANCEMENT (MSE) PROGRAM

The [Market System Enhancement \(MSE\) program](#) was initiated in 2017 to transform MISO's market platform into a more flexible, upgradeable, and secure system that will better accommodate the region's evolving portfolio and technology changes while helping to ensure security and reliability for the electricity grid of the future.

"MISO's System Enhancement work ensures we deliver flexible, upgradeable and secure systems that integrate advanced technologies to process increasingly complex information in order to keep pace with the velocity of changes coming to our industry."

Keri Glitch, MISO Vice President, Chief Digital Officer
and Chief Information Security Officer

As part of the larger System Enhancements pillar of the Reliability Imperative, the MSE program remains focused on building and launching new systems with improved performance, security, and architectural modularity, which enhances MISO's ability to deliver new market products more quickly and efficiently.

The MSE program implemented several key deliverables and external-facing products in 2022. These include Model Manager Phase 1, which transforms how MISO models the electrical system; the Market User Interface, which updated the interface for stakeholders to participate in the market; and the STR market product, which improves the procurement and market signals for flexible energy resources for meeting customer demand. The MSE program also developed a new



private cloud computing platform and expanded cloud storage capabilities that will ultimately improve security, performance, and future upgradeability.

Completion of the MSE program is a critical prerequisite to enabling Distributed Energy Aggregated Resources (DEARs) to participate in MISO's markets, in keeping with [FERC Order 2222](#). MISO cannot accommodate the significant impacts that could result from Order 2222's mandates using its legacy market systems, which were initially introduced to the industry in 1997 and put into production at MISO in 2005. MSE is also urgently needed to accommodate more of the DERs operating today, as MISO's legacy market systems are not sufficient to accommodate larger volumes of DER technologies due to their age, inflexibility, and performance limitations.

TECHNOLOGY OF THE FUTURE

As we look to the future, MISO must balance its 24/7 commitment to delivering secure, reliable, and efficient operations with its transformational work in creating flexible, upgradeable, and secure systems that integrate advanced technologies to process increasingly complex information and evolve with the industry. Because the MSE program has achieved many of its goals and continues progressing toward completing vital upgrades to MISO's market systems, we are broadening the emphasis of future work to better focus on and enhancing systems across the company to meet the region's longer-term needs. These enhancements will support and facilitate the ongoing transformation across the various workstreams of the Reliability Imperative.

The work in Technology of the Future is driven by many factors, including how fast MISO's members can go. Together, we face challenges in the pace of technology obsolescence, ever-growing amounts of data, advanced cyber security threats, and complex regulatory standards. To meet these challenges and ensure people and processes can meet future needs, MISO and others in the industry will be making significant investment in digital technology, security, automation tools, and data management.





The Opportunity: Capturing the Value

MISO creates substantial cost savings and other benefits every year by managing the grid system on a regional basis that spans all or parts of 15 states and one Canadian province. Before MISO was created, the system was managed by 39 separate Local Balancing Authorities (LBAs), which made it much more fragmented and far less economically efficient than it is today.

The benefits that MISO created in calendar year 2021 are calculated to be between \$3 billion to \$3.8 billion, according to the [Value Proposition study](#) that MISO performs every year. That represents a benefit-to-cost ratio of about 11:1 when compared against the fees that utilities pay to be members of MISO.

MISO creates benefits in a variety of ways, including through efficient dispatch and reduced need for additional assets. Since the Value Proposition study was launched in 2007, the cumulative benefits that MISO has created exceed \$36 billion for end consumers. And notably, that figure does not reflect all of the benefits that MISO creates due to the conservative approach that MISO uses to conduct the Value Proposition study.

While continuing to use this conservative approach, MISO anticipates that it will create even more benefits going forward by helping its members and states to achieve their ambitious decarbonization goals in a reliable manner. In June 2022, MISO looked at those anticipated future benefits in a supplemental report called the [Forward View of the Value Proposition](#). That report estimates the value that MISO will create going forward in two ways that are not specifically reflected in the “standard” Value Proposition study:

- The value of sharing carbon-free energy from areas with higher levels of renewables to regions with lower levels.
- The value of sharing flexibility attributes that are required to integrate those new renewables while maintaining reliability.

MISO found that by including these two additional value streams, MISO’s total benefit-to-cost ratio would increase from approximately 11:1 today to approximately 26:1 by 2040. This illustrates that while there are indeed many challenges associated with fleet change, there are also tremendous economic benefits that utilities and states can realize by pursuing their decarbonization goals as members of MISO.

Given the profound changes that are transforming the industry, it is more important than ever for utilities, states, and MISO to work together to realize the substantial benefits that stem from planning and operating the grid on a regional basis.



A Message from Clair Moeller, President

These are exciting times for the MISO region. Many utilities and states are pursuing ambitious carbon-reduction efforts. Our region's fleet of generator resources is rapidly evolving.

But we cannot just hope that the push to decarbonize the energy sector will not impact reliability. Similarly, we cannot just hope that we are properly preparing for extreme weather events, the growth of electric vehicles, and the increasing use of electricity in homes and businesses. Hope is not a plan, so we must develop a plan together.



Utilities, states, and MISO must all work together to address these challenges. The Reliability Imperative is MISO's plan to do that, as this report has outlined.

We've made some great progress since we established the Reliability Imperative framework in 2020. We are shifting to a seasonal accreditation and resource adequacy construct that better reflects the risks we now face. We advanced a \$10.3 billion portfolio of LRTP projects that will help meet our members' objectives of interconnecting additional renewable resources. We have launched an effort to better understand the timing and size of potential shortfalls in reliability attributes.

None of this work is easy. In fact, it's often stressful for our stakeholders and for MISO. But it's necessary work. Factors such as changing customer preferences, shifting economics, technological advancements, and increased severity and frequency of extreme weather events are creating a host of new and urgent challenges that we must address to maintain system reliability. These challenges are not anyone's "fault," but they are everyone's problem. That's why responding to the Reliability Imperative is a responsibility that's shared by MISO, our members, and the states.

I was struck at our recent Board and Advisory Committee meetings that there is tremendous support among our stakeholders that the transition is happening at an accelerated pace and that MISO has a unique role to play in identifying challenges and solutions. MISO welcomes continued stakeholder feedback on the work described in these pages, and we look forward to working together to meet the obligations of the Reliability Imperative.

The time to act is now and we must continue to bring our "A" game—the industry is changing, and MISO members are poised to drive exciting, necessary changes over the coming years. Given the regional Reliability Imperative, the MISO community must act quickly and deliberately to ensure that the planning, markets, operations, and systems keep pace with our members' plans.

Let's keep up the good work,

A handwritten signature in black ink that reads "Clair Moeller". The signature is fluid and cursive.



Appendix

MISO Roadmap

Increasing risks and challenges require MISO to act with more urgency. In response, MISO in early 2022 evolved what had been called the Integrated Roadmap into the MISO Roadmap.

As illustrated on the following page, the **MISO Roadmap** lays out MISO's strategic priorities and MISO's view on the path forward to address the urgent challenges we face. It resides on MISO's public website, providing a user-friendly and transparent way for stakeholders to learn about and stay apprised of MISO's strategic priorities.

Many items on the roadmap will be collaboratively undertaken in the Stakeholder Process, and MISO's attention and resources across those forums will be primarily allocated to those efforts. Where available, the MISO Roadmap links directly to additional detailed materials on MISO's priorities, including the venue, process, and timing for stakeholders to engage in these topics through the formal Stakeholder Process.

[The MISO Roadmap](#) focuses on what is most urgently needed to ensure that we reliably meet members' plans and goals. Currently, the MISO Roadmap is dominated by priorities related to the Reliability Imperative, and the MISO Roadmap will be a living document that is updated as new priorities and challenges emerge and as we get more clarity on the implementation plans of the initiatives.



Appendix

--- MISO Roadmap ---

MARKET REDEFINITION INITIATIVES		2023				2024			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Uncertainty & Variability	Implementation of Seasonal Construct and Conventional Accreditation	█							
	Accreditation Reforms for Renewables	█							
	Accreditation Reforms for Hybrids and Storage	█							
	Improve Scarcity Pricing	█							
	Assess Severe Weather Implications	█							
	Reliability Based Demand Curve	█							
Resource Models & Capabilities	Increase Effectiveness of Demand Response and Load Modifying Resources	█							
	Assess Hybrid Resource Participation	█							
	Attributes Assessment	█							
	Provide Attribute Visibility and Explore Market Design Enhancements			█					
Identifying Locational Needs	ARR/FTR Market Evaluation Process and Potential Next Steps	█							
Enhancing Coordination	Facilitate Ambient Adjusted Line Ratings Adoption - FERC Order 881	█							

OPERATIONS OF THE FUTURE INITIATIVES		2023				2024			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Operations Preparedness	Operations Simulation	█							
	Operator in Training Programs	█							
Operations Planning	Operations and Planning Models Alignment	█				█			
	Outage Coordination Analysis Processing	█							
Uncertainty & Variability	Quantify Net Uncertainty	█							
	Automate Unit Commitment Risk Management	█							
Situational Awareness & Critical Communication	Increase Operator Situational Awareness & Visualization	█							
	Advance Synchrophaser Applications Evaluation	█		█					
	MISO Communications System Declarations	█							
	Operator Logging Needs Evaluation	█		█					
	Operator Logging Enhancements					█			
Operational Continuity	Conduct Business Impact Assessment to Identify Needs to Mitigate Emerging Threats	█							

TRANSMISSION EVOLUTION INITIATIVES		2023				2024			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Long Range & Interregional Transmission Planning	L RTP Tranche 1: Midwest Least Regrets	█				█			
	L RTP Tranche 2: Midwest Continued Progression	█							
	L RTP Tranche 3: South Region			█		█			
	L RTP Tranche 4: Midwest/South Interconnection							█	
	Increase Visibility of Forward-Looking Load and Resource Possibilities	█							
	Enhance Joint Transmission Planning with Seams Partners	█							
	Explore New Sustainable Cost Allocation Mechanisms to Fit Future Transmission Needs	█							
Planning Transformation	Evolve Tools for Resource Transition	█							
	Enhance System Resiliency and Robustness	█				█			
	Integrate Planning Model Data (Model Manager Phase 3)	█							
Resource Utilization	Redefine Reliability Implications and Mitigation for Resource Retirements (Attachment Y)	█							
	Streamline Resource Interconnections	█							

SYSTEM ENHANCEMENTS INITIATIVES		2023				2024			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Market System Enhancements	Energy Management System (EMS) Upgrade	█							
	Day-Ahead Market Clearing Engine (DA-MCE)	█							
	Real-Time Market Clearing Engine	█							
Technology of the Future	High-Effort, High-Risk and Time-Sensitive Security Efforts	█							
	Transition from Legacy Infrastructure to Hybrid Cloud	█							
	Integrated Software Development to Reduce Vulnerabilities (DevSecOps)	█							
	Evolving Data & Analytics	█							



Appendix

Working Together to Address the Reliability Imperative

This report is written from MISO’s perspective. However, the responsibility for ensuring grid reliability and resource adequacy in the MISO region is not MISO’s alone. It is shared by Load Serving Entities (LSEs), states, and MISO, each of which have designated roles to play.

LSEs are utilities, electric cooperatives, and other types of entities that are responsible for providing power to end-use customers. In most (though not all) of the MISO region, LSEs have designated service territories and are regulated by state agencies. LSEs have exclusive authority to plan and build new generation resources and to make decisions about retiring existing resources, with oversight from state agencies as applicable by jurisdiction.

“MISO has the opportunity to help its States and Members reach their own policy goals in the most cost-effective way while also ensuring the reliable delivery of electricity to end-use customers.”

Wayne Schug, MISO Vice President, Strategy and Business Development

MISO performs certain transmission planning functions but does not plan or build new generation or decide which existing resources should retire. MISO exercises functional control of its members’ generation and transmission assets with the consent of its members and per the provisions of its tariff, which is subject to approval by the FERC. By operating these assets as efficiently as possible on a region-wide basis, MISO generates substantial cost savings and other reliability benefits that would not otherwise be realized.

MISO also establishes and administers resource adequacy requirements for LSEs and states, as applicable by jurisdiction. These include:

- A **Planning Reserve Margin (PRM)** that sets the level of contractually obligated resources that MISO can call into service when normally scheduled resources go offline for planned or unplanned reasons, or when demand surges due to extreme weather conditions or other factors. The PRM is set through MISO’s stakeholder process.



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- A **Planning Resource Auction (PRA)** that LSEs can use to procure needed resources or sell surplus resources. LSEs can “opt out” of the PRA by using their own resources or negotiating bilateral contracts with other entities.
- **Resource accreditation metrics** that determine how much “credit” various types of resources receive towards meeting resource adequacy requirements, based on factors such as their unplanned outage rates.
- **Locational procedures** that determine how much capacity is needed in certain parts of the MISO region for reliability purposes, and how much can be imported from and exported to other locations, among other things.

MISO engages with a broad range of stakeholders to share ideas and discuss potential solutions to the challenges facing the region. The Reliability Imperative work also involves a robust, collaborative dialogue across the many forums within the stakeholder process. The collaboration that takes place in these forums has provided valuable policy and technical-related feedback, and MISO is committed to continuing that engagement.



Appendix

Informing and Responding to the Reliability Imperative

MISO’s response to the Reliability Imperative has been informed by years of conversations with our stakeholders. MISO has also undertaken numerous studies to assess the region’s changing risk profile and to explore how reliability is being affected by other drivers such as electrification and extreme weather events. This work includes:

Renewable Integration Impact Assessment (RIIA): This study assesses the impacts of integrating increasingly higher levels of renewables into the MISO system. RIIA indicates that planning and operating the grid will become significantly more complex when more than 30% of footprint-wide load is served by wind and solar. However, RIIA also indicates that renewable penetrations of 50% or higher could be reliably achieved if MISO, its members, and states coordinate closely on the advanced actions that would be needed.



Regional Resource Assessment (RRA): The RRA is a recurring study based on the plans and goals that MISO members have publicly announced for their generation resources. The RRA aggregates these plans and goals—many of which seek to reduce carbon emissions—and uses them to develop an indicative view of how the region’s resource mix might evolve going forward to meet utilities’ stated objectives. The RRA aims to help utilities and states identify new and shifting risks years before they actually materialize, creating a window to develop cost-effective solutions.



MISO Futures: The MISO Futures utilize a range of economic, policy, and technological inputs to develop three future scenarios that “bookend” what the region’s resource mix might look like in 20 years. The Futures inform the development of transmission plans and help MISO prioritize work under the Reliability Imperative. MISO is currently updating the Futures to reflect new developments in the region, including impacts of the tax credits for clean energy technologies in the 2022 Inflation Reduction Act.





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Markets of the Future: This report illustrates how and when MISO’s existing market structures will need to evolve in order to accommodate the profound changes that are occurring in the energy sector. The needs are presented in four broad categories: (1) Uncertainty and Variability; (2) Resource Models and Capabilities; (3) Location; and (4) Coordination. This report helped establish the foundation for the work that MISO is currently doing to identify the critical system attributes that are becoming scarce due to fleet change.



The February (2021) Arctic Event: This report discusses lessons learned from Winter Storm Uri, which affected the MISO region and other parts of the country in February 2021. MISO and its members took emergency actions during the event to prevent more widespread grid failures. Uri illustrated how extreme weather, which has become more frequent and severe, can further impact the system being challenged by fleet change. Preparing for extreme weather is a major part of MISO’s response to the Reliability Imperative.



Electrification Insights: This report explores the challenges and opportunities the grid could face from the growth of electric vehicles and the increasing electrification of other sectors of the economy, such as homes and businesses. Among other things, the report indicates that electrification could transform the MISO grid from a summer-peaking to a winter-peaking system, and that uncontrolled vehicle charging and daily heating and cooling load could result in two daily power peaks in nearly all months of the year.



Resource Availability and Need (RAN): This initiative was launched in 2017 to address reliability issues related to fleet change and other factors. RAN’s focus areas included improving processes for resource outages and accreditation, as well as transitioning to a new seasonal Resource Adequacy construct that better reflects the region’s risk profile. This work is discussed in five whitepapers, and proposed solutions were filed with FERC in 2018, 2019, and 2021. Following the 2021 FERC filing, RAN was folded into the Market Redefinition workstream of the Reliability Imperative.



MISO FORWARD: This report series, launched in 2019, assesses key trends that are reshaping the electricity sector. The inaugural FORWARD report focused on resource Availability, Flexibility and Visibility. The 2020 report looked at how different types of members will interact differently with MISO,





and the 2021 report examined adjacent industries that are expected to exert new demands on the grid going forward.

From this groundwork, we know there are many challenges ahead. But we also believe we can respond to the Reliability Imperative in a manner that enables our members to achieve their plans and goals, such as increasing their use of renewables or reducing their carbon emissions. We are determined to do the hard work required to ensure all of our members and their end-consumers benefit from MISO membership.

Acronyms Used in this Report

DER: Distributed Energy Resource	MW: Megawatt
DSRI: Demand Side Resource Interface	NERC: North American Electric Reliability Corporation
ERCOT: Electric Reliability Council of Texas	OMS: Organization of MISO States
ESR: Electric Storage Resource	PAC: Planning Advisory Committee
FERC: Federal Energy Regulatory Commission	PRA: Planning Resource Auction
GW: Gigawatt	PRM: Planning Reserve Margin
ICAP: Installed Capacity	RAN: Resource Availability and Need
IMM: Independent Market Monitor	RASC: Resource Adequacy Subcommittee
JTIQ: Joint Targeted Interconnection Queue	RBDC: Reliability-Based Demand Curve
LBA: Load Balancing Authority	RECBWG: Regional Expansion Criteria and Benefits Working Group
LMR: Load Modifying Resource	RIIA: Renewable Integration Impact Assessment
LSE: Load Serving Entity	RRA: Regional Resource Assessment
LRTP: Long Range Transmission Planning	SAC: Seasonal Accredited Capacity
MaxGen: Maximum Generation	SPP: Southwest Power Pool
MISO: Midcontinent Independent System Operator	STR: Short-Term Reserve
MSE: Market System Enhancement	
MTEP: MISO Transmission Expansion Plan	

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