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## Living Document

This is a living document 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 utility and states are building 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. As a federally designated Independent System Operator, MISO provides visibility and insights that help utilities and states better understand the reliability, sustainability, and affordability implications of their approaches.

To help utilities and states achieve their goals, 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 MISO region from many utilities and states pursuing. However, the grid must also remain reliable and affordable during the transition to a more sustainable end state. Without question, the rapid 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 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 of 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 past risks in the past.

Utilities and states have to address the challenges to electric reliability in our region. We highlight how challenges have evolved since we updated our Reliability Imperative framework last year. We also discuss how we revised parts of our Reliability Imperative framework to reflect the challenges we face going forward. Through this framework, MISO can help facilitate a planning process for all of the utilities 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 important. We encourage you to get it right. Thank you for your interest in these important issues.



# 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. A response to the Reliability Imperative consists of a host of interconnected initiatives that aim to address the 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 increased complexity.
- Transmission Evolution (formerly called Long Range Transmission Planning) assesses the future needs and associated cost allocations, 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 differed from what they are called today. Transmission Evolution was initially called Long Range Transmission Planning (L RTP), and System Enhancements was originally called Market System Enhancement (MSE). At the time, the names and scopes of the pillars were defined by MISO's business needs and strategic objectives.

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, L RTP 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 major 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 through the respective policy goals of our region.

Historically, the power system has been a business 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, data-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 do the work of the Reliability Imperative, and to provide visibility to members and states seeking 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 not balanced by short duration and expensive storage. 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. We provide wide insights to deliver affordability, sustainability, and reliability benefits to their end customers at the retail level.

As an independent grid operator with a regional view, MISO is uniquely situated to help utilities and states to better understand the tradeoffs and consequences of policies that balance sustainability, affordability, and reliability in different MISO states. 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

As we address 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. As decarbonization efforts that are replaying out across the region



However, we must first ensure that the system remains reliable and affordable during the transition to that end state. The loss of generating resources is giving rise to a host of urgent and complex reliability challenges. These challenges include:

- ◀ 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.
- ◀ 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 as backup for 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 to keep existing resources with these attributes in service.



- ◀ The region is becoming increasingly reliant on 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 on contractual gas services and



reliance on a pipeline system that is shared with heating and manufacturing resources typically keep large stockpiles of fuel on-site, but coal supplies have tightened in recent years due to changing economic supply chain issues and other factors so all resources can also be affected by extreme weather. And while renewable energy resources such as wind turbines do not use fuel, they are sometimes unavailable due to multi-day 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 electrical reliability have been increasing since the early 2010s. For example, in January 2021 the [Electric Power Research Institute](#) found that



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 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 through 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 a 2021 [Electrification Insights report](#), 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 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.

A 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 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](#) 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 and utilities and states build in both North and Central parts of the MISO region and will support the reliable and affordable transition of the grid and further harden the grid against extreme weather events. 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, Tranche 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 and analogous to





how local roads served 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 issued a new Accredited Capacity (AC) proposal to shift from its summer-focused Resource Adequacy construct to a new 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 risk hours throughout the year. Evaluation of accreditation reforms for 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) – A new market portfolio enabling storage 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 provide energy within a relatively short period of time (30 minutes).
- < Starting a conversation about critical reliability attributes that are becoming scarce because of the fleet transition and differences in attributes of new versus retiring generators.
- < Exploring options for a Reliability-Based Demand Curve that may reduce the risk of a

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 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 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 digital, scalable and secure to



## CONTINUED STAKEHOLDER INPUT IS CRUCIAL

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

- < MISO proposals to improve resource adequacy construction including how resources are accredited are discussed in the [Resource Adequacy Subcommittee](#)
- < Initiatives to improve price signals and other market mechanisms reflect input from 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 a path forward and proposes ways to address them in the stakeholder process. The MISO Roadmap is discussed in more detail later in this report.

This document is a living document. 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 "capacity shortage" 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 the 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, and especially capacity with high accreditation value 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 a year'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), 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 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 utilities and states take certain actions in response to the shortfall that came to light in 2022. 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 a [Regional Resource Assessment \(RRA\)](#). The RRA models how the Y [ ] 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 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 in a reliable manner. For context, 100 GW of new capacity represents about 3% of the Y [ ] 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. 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 year (2020) totaling about 6 GW. These figures are expressed in terms of ICAP.



Other key insights from the 2022 RRA include:

Expected MW decline, even though CAP is expected to grow. Because the new resources that states plan to build primarily wind and solar have lower accredited values than thermal resources, the 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.

Wind and solar generation could serve nearly 30% and 60% of load by 2041. This would reduce emissions by nearly 80% 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 a RIA study which assesses the impacts of integrating increasingly higher levels of renewables into the MISO system. RIA identified an inflection point between renewable penetrations of 30% and 40% where planning and operating the grid will become significantly more complex. RIA found that renewable penetrations of 50% or higher could be reliably achieved in MISO, and states coordinate closely on advanced actions that will be needed.

To complement the expected growth of solar generation, ramp capability could triple by 2031 and quadruple by 2041 compared to current levels. As solar generation capacity grows, so does the challenge of 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 or fast-ramping resources are 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 real 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, 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 generators. These factors increase the risk that 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 actual 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 fuel-delivery contracts, opting instead for pipeline services for additional capacity. Only about 27% of the gas [Y b Y f U h] c b \ U h \ f 2020-2021 Generator Winterization Survey indicated it had firm transport contracts in place for all of their supplies during the 2020-2021 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 consecutive days of low wind output during Winter Storm Uri in February 2021. Additionally, when wind output is high,

























































