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US Senate Committee on Energy and Natural Resources
July 13, 2022
Pathways to Lowering Energy Prices

Thank you for the opportunity to testify today. A special thanks to Sen. John Hoeven for inviting me to be part of this esteemed panel. I am honored to address you on this vital topic that is top of the mind for every American.

I will highlight three areas in my testimony— affordability, reliability challenges, and timing of this transition. Additional detail and references are included in attachments.

Affordability

Regardless of whether you are Republican, Democrat or Independent, I sense we can all agree on one thing: reliable and affordable energy is a necessity for our nation. Energy is the foundation for our economy, impacting every business from the smallest bakeries and body shops to the largest corporations. Energy costs are embedded in every single product we buy. These costs compound throughout the economy and punish vulnerable communities and people with low or fixed incomes the most. The AARP represents perhaps the largest group of individuals on fixed incomes in our nation: senior citizens. They regularly intervene in our rate cases at the North Dakota commission and their core message is always the same – higher energy bills are painful for our members.

Yet even in North Dakota, an electricity exporting state where rates are among the lowest in the nation, costs for energy are rising, in some cases substantially.

Natural gas customers in North Dakota have seen an increase of approximately 30 percent since 2016, a sure indication of the dual use of gas for home heating and electrical generation and the lack of planning and coordination needed to sustain both of those important priorities.

Our electric rates are also rising. Transmission costs in North Dakota have increased 388 percent since 2003. The impacts from these increases weigh heavily on rural areas and older residences that depend on electrical heat during winters that annually drop into the negative teens and at times drop to a temperature that even shuts down our extensive wind generation.

It is noteworthy that 35 percent of the energy consumed by North Dakotans last year came from renewable sources, one of the higher penetrations in the nation. Perhaps this explains why customers are growing leery of the promises of low-cost renewable energy. Our utilities have aggressively pursued green energy, assuring customers that it will save them money, and yet their bills are rising.

So, my first plea to you is this: we need to be honest with American citizens. Transitioning our grid to 100 percent renewable energy may be achievable and, for many, desirable, but it is not going to lower costs for anyone, especially in the next 25 years.

Reliability

As chair of the North Dakota commission, immediate past-president and current Resource Adequacy liaison for the Organization of MISO (Midcontinent Independent System Operator) states, and soon to be president of NARUC, I am intimately familiar with the challenges and opportunities facing the electric and gas industries during this massive technology transformation.

As important as affordability is, reliability trumps it. The reliability challenges in California, Storm Uri in the south and the numerous Max Gen events MISO is experiencing are a good reality check on how the electric system works.

These challenges are real and growing because the physics of the electric grid are stubborn and do not bend to our goals or deadlines.

Take for example that prior to 2016, MISO didn't have any grid events that required them to activate the use of its emergency procedures. Since 2016, MISO has had 41 MaxGen events requiring the use of emergency procedures.

According to their own reliability report, this is a key indicator of MISO's changing risk profile. "While the emergency protocols are a legitimate way for MISO to access additional resources, relying on such protocols much more frequently and in non-traditional times are evidence of MISO's changing risk profile," the MISO Reliability Imperative document states. (Attachment 3)

Rapid retirements of thermal units and a transmission system congested with 17 GW of new renewable generation since 2011 have converged into a concerning trend in MISO. It is illustrated the chart in Attachment 1 page 4.

Total installed generating capacity in MISO, illustrated by the blue bars, is increasing, but the *accredited* capacity is declining. Accredited capacity is generation that can be counted on to meet demand.

Please examine this chart (and others in Attachments 1 and 2) carefully. These are not sustainable trends.

My second plea today is this: listen to the grid operators. They are the independent third party. Their goal is maintaining a stable, reliable grid throughout this energy transition. Ignoring their advice will have serious consequences.

Timing

And this brings me to my final point: timing.

Let us consider for a moment what we are trying to accomplish. We are seeking to:

- Close existing facilities prematurely and require customers to pay for them regardless of their operation,
- Permit and build renewable generating resources to replace many times over the capacity of the retired assets and the current electric system,
- Permit and build billions of dollars in new transmission lines to connect these new resources to the grid,
- Figure out how to incorporate and operate the electric grid reliably with high penetrations of renewable resources, which function very differently than the traditional resources around which the grid was built and has been operating for a hundred years,
- Convert the entire transportation fleet to electric power and develop the charging stations and additional clean power supplies needed to keep them running,
- Convert 58 million home heating systems from gas to electricity and develop additional clean power supplies to keep them warm,
- Convert all industrial power systems from gas to electricity and generate the additional clean power sources to keep them running,
- And all the while, promising to save consumers money.

In short, we are reinventing and rebuilding the entire energy system that sustains the lives, work, travel and communication of every single person and business in the United States.

Considering the magnitude of this challenge, and the warning signs we are already seeing from our current approach, the solution I am going to suggest is quite simple. Most of this can be solved with one thing: patience. That's my final plea to you.

Clair Mohler, the head of operations for MISO, states it this way: Mind the Gap.

Where are these gaps?

There is a big gap in the megawatts being retired and megawatts being added.

Thirty-five percent (about 20 gigawatts) of MISO's coal fleet will retire within the next 5 years. Many more if you count those that could be impacted by new EPA regulations. Yet new generation in the MISO queue includes just 3.8 gigawatts of natural gas units to potentially replace this firm capacity. See Attachment 1, page 3.

The obvious way to bridge that gap is to extend the life of existing, already paid for resources that are operating and connected to the grid today. I urge you to require the EPA to coordinate with utilities and grid operators in the writing of any new regulations that could exacerbate the capacity crisis facing our electric industry.

Another big gap exists between the reliability attributes of wind and solar megawatts versus thermal megawatts. Technology needs to fix that gap and researchers need time to do that. Research and technology can also fix the emission problems of coal and natural gas through commercial scale carbon capture and storage so these fuels can be retained in a diverse, low-carbon mix for the future.

A massive gap exists between the availability of critical minerals today and the amount needed to support wind, solar and battery production. The International Energy Agency estimates that critical mineral production will need to increase by 400 percent by 2040 to hit Paris Accord Goals and 600 percent to be net-zero by 2050.

A disturbing gap exists between the environmental standards, the pay, and working conditions in countries where mining of critical minerals is occurring. That should be an important consideration in the environmental justice considerations of all policy makers.

Quite simply, there is a huge gap between the President's 2035 clean energy deadline and the permitting processes, supply chains, and construction timelines necessary to build the new generation and transmission infrastructure needed to meet that goal. This includes a massive gap between generation capacity to meet current demand (which is tenuous) and the capacity needed to electrify our transportation fleet, home heating, and industrial processes.

Energy policy is a wedge issue. Activists, interest groups, and politicians love to use it to brand people, divide us into opposing camps, and prohibit compromise. We cannot let that continue. These are issues that must bring us together. Americans are counting on us to figure this out.

We must forge a thoughtful, prudent path through this energy transition that keeps the power on, at all times, at prices people can afford.

Thank you.

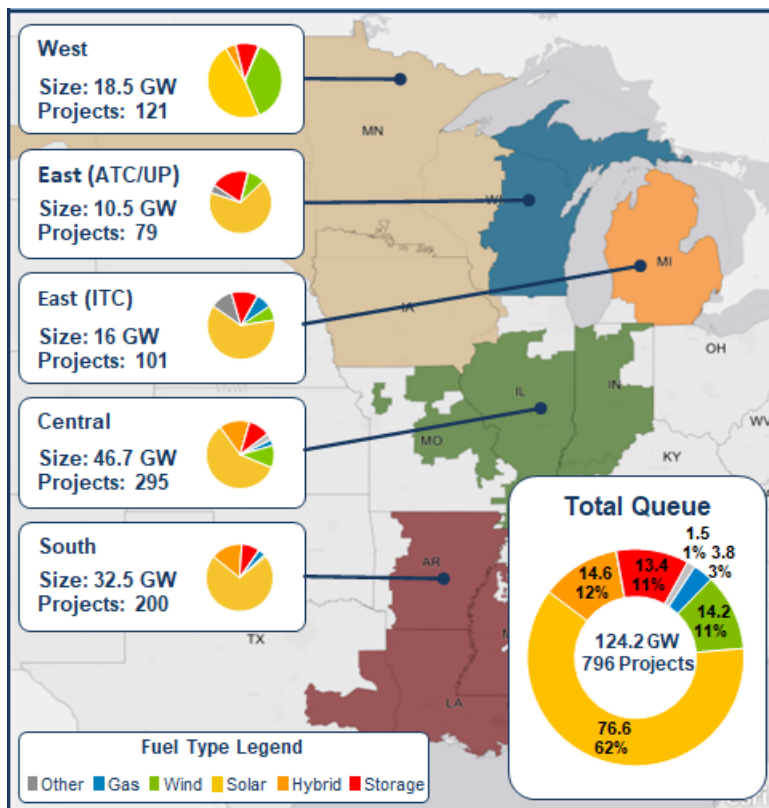


Excepts from:
Managing Reliability Risk in
the MISO Footprint

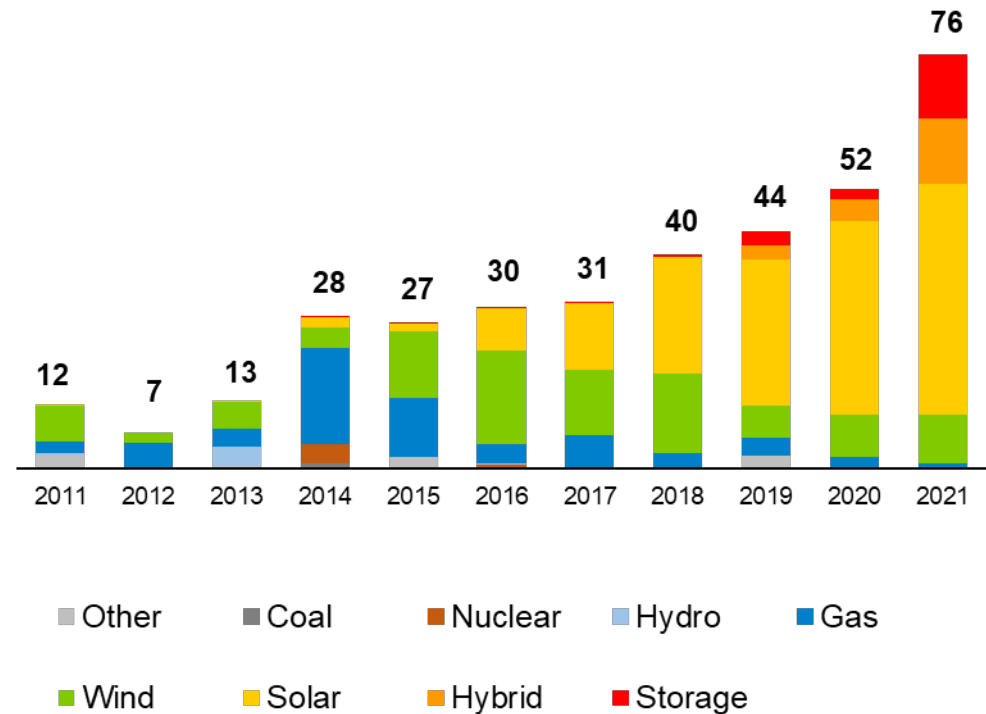
June 16, 2022

The interconnection queue reveals few resources with the controllable attributes with most being battery-based resources of limited (4-hour) duration

MISO Active Queue by Study Area

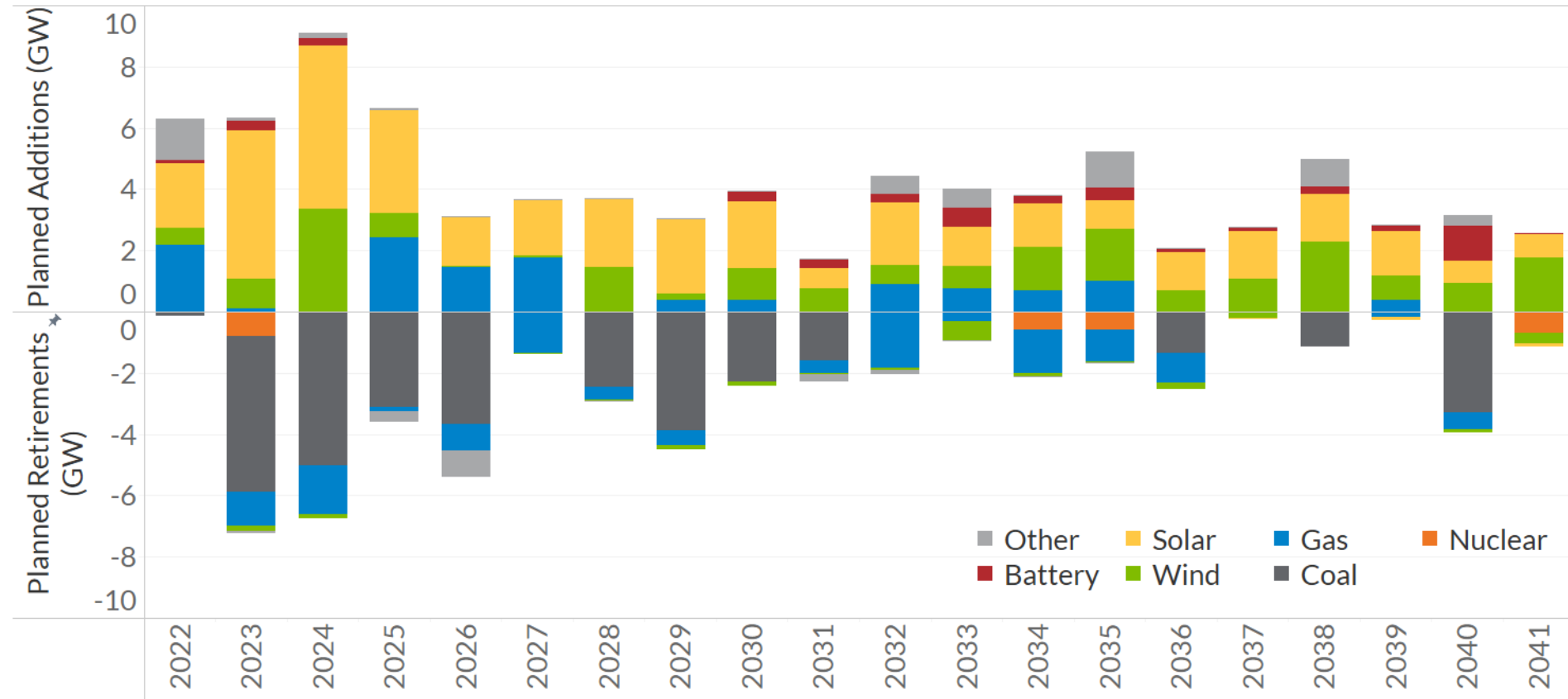


MISO Queue Historical Trend by Requested Generation (GW)



The preliminary 2022 Regional Resource Assessment shows addition of largely renewable resources, coupled with retirement of controllable resources...

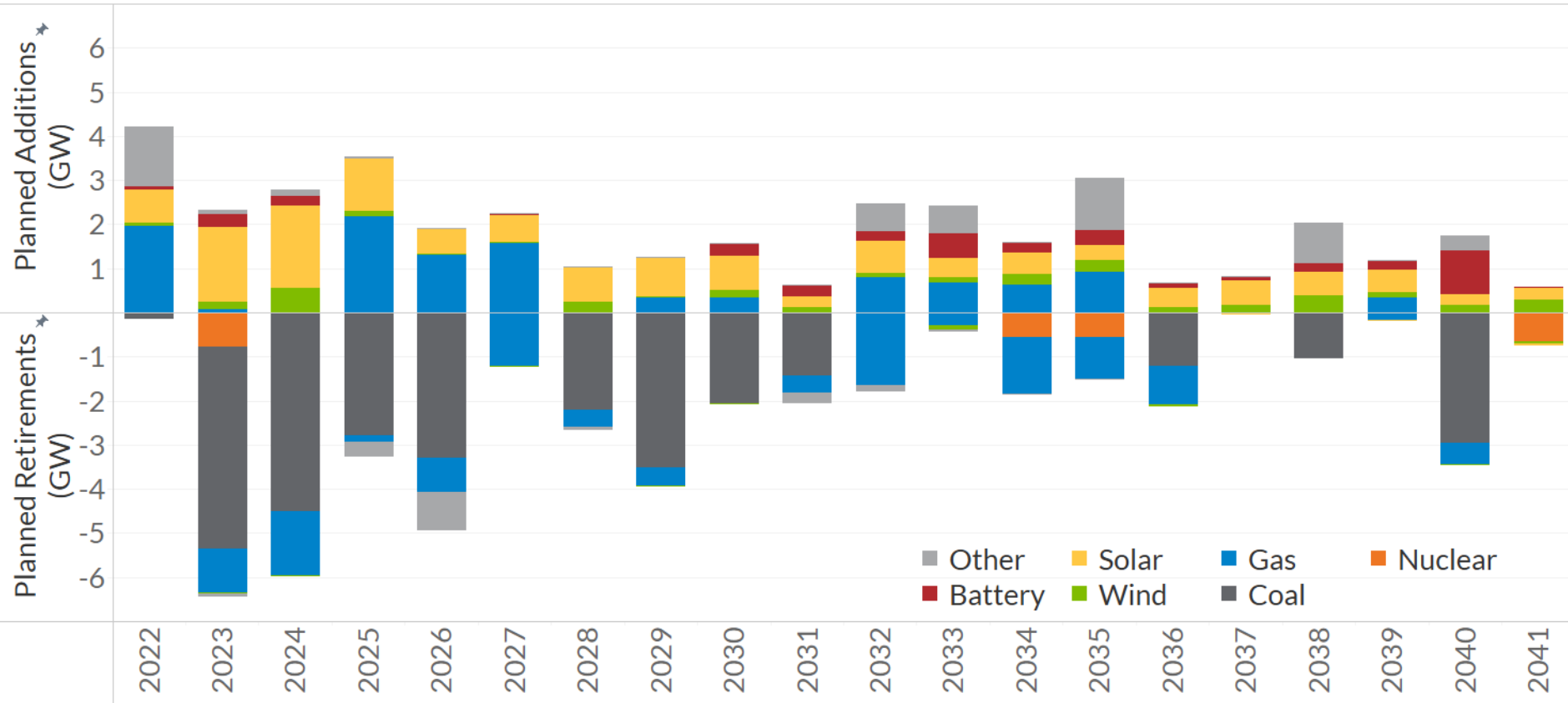
Nameplate Capacity
RRA 2022 Survey Results
Preliminary



The assessment includes information provided by members representing 75% of MISO's load

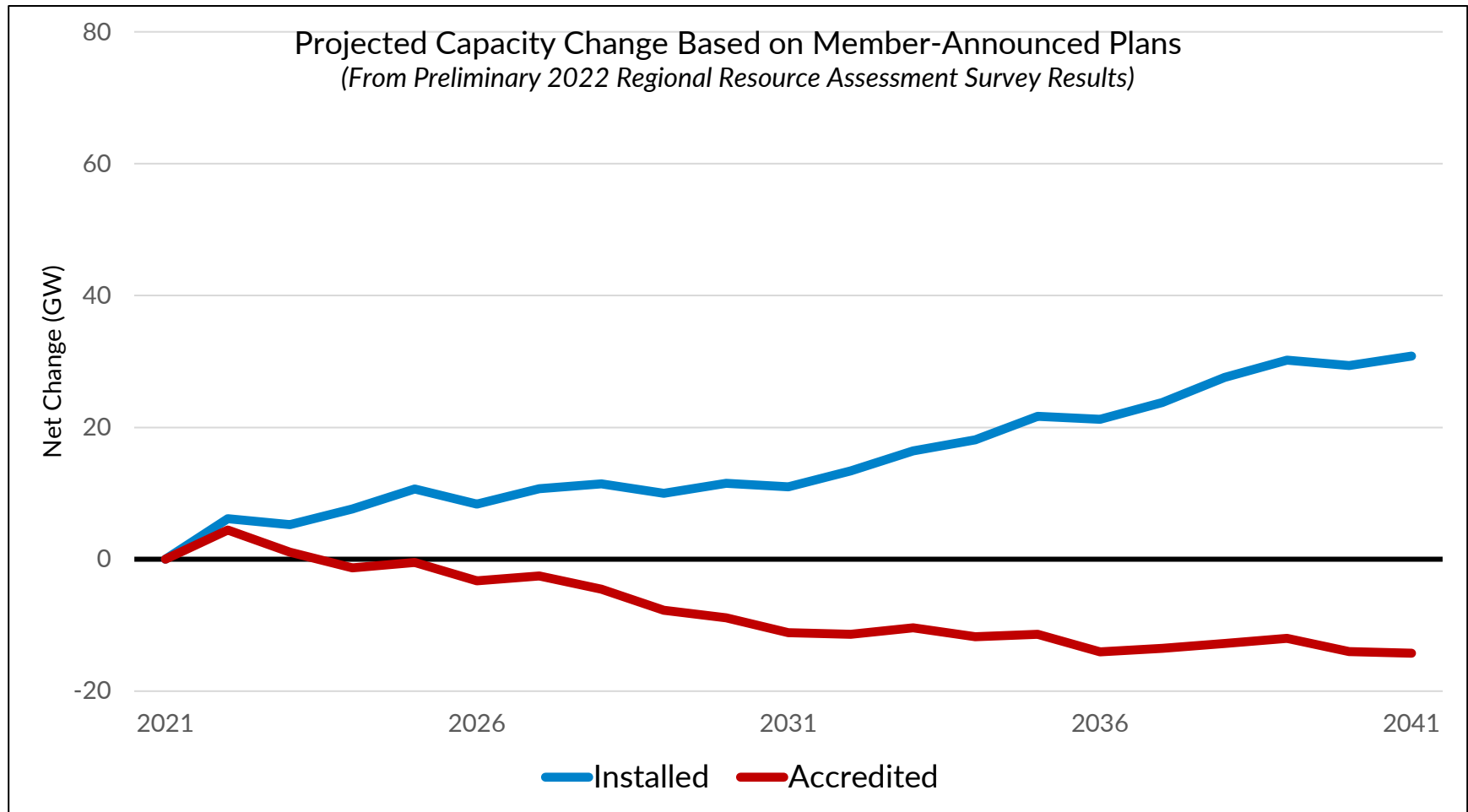
Looking at accredited capacity, planned additions are not on pace to make up for planned retirements

Estimated Accredited Capacity
RRA 2022 Survey Results
Preliminary



Estimated accredited capacity: 16.6% for wind; 35% for solar, 87.5% for battery, 90% for coal, 90% for gas, and 95% for nuclear

...accredited capacity is declining due to the rapid pace of retirements of controllable resources



DRIVERS & RISKS

Influx of renewables & resulting volatility

Generation retirements

Increased probability of outages due to extreme temperatures & fuel supply issues

Changing load shapes & volatility

Persistent operational issues & capacity shortfalls in recent years

PLANNING RESERVE MARGIN

LOLE is the expected number of days per year an area does not have enough capacity to meet load

Planning Reserve Margin is designed to determine the amount of capacity necessary to reliably serve the forecasted peak demand in a planning horizon to a desired reliability target

- Based on a probabilistic Loss of Load Expectation (LOLE) study typically performed to determine the amount of capacity needed to meet a desired reliability target
 - SPP currently maintains a 1 day in 10 years industry practice threshold as a reliability target (equivalent to 0.1 days/year)

STUDY YEAR 5 LIMITATIONS

Electrification generally increases energy usage and flattens peaking load patterns, which could result in a higher PRM

- While the PRM shows a reduction in 2026 (Year 5), SPP staff believes year 5 load forecasts may change due to potential increases of unconventional load and energy patterns
 - Uncertainty of load variability due to the unknown impacts of electrification and unconventional load
 - Unknown impacts from the projected growth in Demand Response
- Year 5 study includes very few resource changes (additions, retirements)
 - From 2023 to 2026, study changes include
 - Decrease of total available capacity by 669MWs
 - Incremental retirements of 878MWs
 - Increase in demand of 1,537MW
 - Study does not include resource planning assumptions beyond LRE submitted resources
 - Due to the study timeline the PRM impacts caused by resource changes may be lagging

RELIABILITY METRIC CONSIDERATIONS

For example, a shortfall of 1 percent of load for 10 hours is measured the same way as a shortfall of 10 percent of load for 10 hours. These disparate events are not differentiated by conventional resource adequacy metrics even as they represent dramatically different situations in terms of options for meeting demand in today's power system

- The 1 Day in 10 Year LOLE Metric was developed in the 1960s
 - Based on risks acceptable to the load at that time (1960s)
 - Load characteristics in the 1960s are quite different from today
 - Based on a thermal resource fleet with 100% capacity factor
 - LOLE is an opaque metric when used in isolation
 - It does not characterize the magnitude, duration, or frequency of specific outage events
- New metrics should address the increase in energy limited resources and quantify the specific characteristics of outage events, including frequency, duration, and magnitude
- Moving forward, measurements beyond the 1-in-10 metric should be considered (i.e. EUE)
 - Further evaluate the need for energy adequacy in Resource Adequacy and what additional metrics are needed



MISO'S RESPONSE TO THE RELIABILITY IMPERATIVE

- UPDATED JANUARY 2022 -

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

A lot has happened in the MISO Region since we published the first version of this report in late 2020. MISO has made significant progress in responding to the Reliability Imperative – the shared responsibility that MISO, our members, and the states have to address the complex and urgent challenges to electric system reliability in our region.



Despite progress we have made, we still have much to do. Our region's fleet of generating resources continues to evolve in ways that are creating new system needs that we must address, driven by factors such as utility and state policies to reduce carbon emissions.

Another driver of the Reliability Imperative that came into sharp focus in 2021 is the increasing frequency and severity of extreme weather events, which is posing additional challenges.

In the first version of this report, we introduced the four major efforts MISO is undertaking to respond to the Reliability Imperative: Market Redefinition, Long Range Transmission Planning, Operations of the Future, and Market System Enhancements. In this updated version, we discuss what we've learned throughout 2021, our accomplishments to date, and our focus areas going forward.

One clear takeaway from 2021 is that the Reliability Imperative is critical. The work we are doing is not optional – to maintain system reliability, we must respond to the unprecedented change we all face and to avoid the severe health, safety, and economic impacts of prolonged outages. This work cannot be put off for months or years – much of it has long lead times, so we need to act now. And our stakeholders are counting on us – regulatory agencies, utilities, and other entities are looking to MISO to identify problems and find solutions. We appreciate all of the collaboration from stakeholders and are counting on continued support and dialogue as we confront these challenges and opportunities together.

Thank you,

A handwritten signature in black ink, appearing to read "John Bear". The signature is fluid and cursive, with a long horizontal stroke at the end.



Executive Summary

INTRODUCTION

MISO is making significant progress addressing the Reliability Imperative – the shared responsibility that MISO, our members, and the states have to address the urgent and complex challenges to electric system reliability in the MISO Region.

MISO first outlined its response to the Reliability Imperative in the initial version of this report published in December 2020. This updated version highlights the progress we have made since then, new learnings and insights we have developed, additional challenges we see emerging, and our focus areas going forward.

A year after we first published the Reliability Imperative report, we can confirm the urgency of the work and our focus on the four workstreams: (1) Market Redefinition, (2) Long Range Transmission Planning, (3) Operations of the Future, and (4) Market System Enhancements.

FLEET CHANGE CONTINUES TO POSE CHALLENGES

As we discussed in the initial report, many of the challenges we face stem from the changes that are transforming the region’s fleet of generating resources. To briefly recap, these challenges include:

- Declining reserve margins and fewer always-on “baseload” resources, due to retirements of thermal units.
- Aging coal resources that remain in service can be more prone to outages, rendering them potentially unavailable when they are needed most.
- Wind and solar resources are not always available to provide energy during times of need. Additionally, renewables must sometimes be curtailed due to transmission constraints.
- The growing fleet of natural gas resources may not be able to procure all the fuel they need at key times, often seasonally based, because of limitations in contractual gas services, lack of dual fuel capabilities, and reliance on a pipeline system that is shared with heating and manufacturing uses.
- The region’s penetration of distribution-level and behind-the-meter resources is increasing, yet MISO does not have functional control or visibility into how these resources may affect the larger grid system.

The aggregate impact of these and other challenges has altered the region’s historical summer-centric risk profile, making it more prone to grid emergencies in winter and shoulder-seasons that rarely posed risks in the past.



ADDITIONAL DRIVERS AND CHALLENGES ARE EMERGING

While fleet change challenges continue to drive MISO's response to the Reliability Imperative, several additional drivers have become evident since we published the first version of this report. They include:

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.

- Recent examples of these kinds of impacts in the MISO Region include Hurricanes Laura, Delta and Zeta in 2020, Winter Storm Uri in February 2021, and Hurricane Ida in August 2021. These events reinforced the need for MISO's work under various parts of the Reliability Imperative. For example, [Winter Storm Uri](#) illustrated the need to better weatherize generation resources, continued gas/electric coordination improvements, and to improve real-time control room decisions, all of which align with efforts MISO is pursuing under the **Operations of the Future** workstream.
- Recent extreme weather events also underscored the need for the **Long Range Transmission Planning** workstream. For example, even though the MISO Region had an adequate supply of generation during Winter Storm Uri, MISO's ability to move even more energy to specific areas was hindered by increased unplanned generation outages and derates, transmission constraints and overloaded lines, and the contractual transfer limit between the MISO South subregion and the rest of the footprint. Uri also illustrated the importance of transfer capability in moving power; robust regional and interregional transmission capacity resulted in limited impacts in MISO's North and Central Regions.
- The recognition of more frequent and severe weather events also aligns with the major efforts executed in the **Market Redefinition** workstream in 2021, wherein MISO led efforts to shift from the summer-focused Resource Adequacy construct to a new 4-season construct, which better reflects the risks in non-summer seasons. MISO [submitted the proposal](#) to the Federal Energy Regulatory Commission in late 2021, along with an accompanying proposal to align the accreditation of thermal resources to their availability in high-risk hours. MISO plans further work to continue in 2022.

Electrification of adjacent industries: While year-over-year demand for electricity in the MISO Region has been 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.



- In MISO’s Electrification Insights April 2021 [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.
- The four focus areas of the Reliability Imperative seek to ensure that markets, transmission, operations, and systems – all of which will be directly impacted by electrification – are ready for the coming transition.

HELPING UTILITIES AND STATES MEET THEIR GOALS

The first version of this report outlined the multiple trends that are driving the transformation of the region’s resource fleet, such as consumer preferences for clean energy, changing economics, and technological advancements.

While all those trends continue to drive fleet change, perhaps the most notable and important driver is that utilities and states are increasingly adopting policies and goals that reflect and embrace consumers’ preferences for clean energy. As of late 2021, for example, 17 of the region’s utilities (representing approximately 80% of the region’s total load) had committed to reducing their carbon emissions by at least 80% by 2040 or sooner. The federal government has also set ambitious goals to decarbonize the electric sector by 2035, the economy by 2050, and specific goals related to vehicle and building electrification.

Although MISO as an Independent System Operator does not set policy, MISO has an important role in enabling member and state policy goals. MISO uses its markets, planning processes, and operational functions to help its members achieve their policies and goals – and the Reliability Imperative provides a framework to do that.

For example, the **Long Range Transmission Planning** workstream is identifying investments in transmission solutions that will help MISO’s members and states meet their ambitious carbon-reduction goals – as many promising locations to build new renewables are not currently served by transmission or otherwise experience constraints. And the **Market Redefinition** workstream will craft necessary revisions to the current market construct and develop the market products that are needed to incentivize and fairly compensate emerging technologies such as battery storage. To account for the uncertainty in policy outcomes and timing, MISO is utilizing the [Futures process](#) to model several different policy trajectories and identify least regrets actions.



STAKEHOLDER INPUT IS CRUCIAL

Much of the work cited in this report is already underway. Many of the ideas and proposals in this report reflect a great deal of technical input from stakeholders. For example:

- MISO proposals to revise the Resource Adequacy construct and to improve how resources are accredited are discussed in the [Resource Adequacy Subcommittee](#).
- Similarly, MISO initiatives for scarcity pricing and the Market System Enhancement effort reflect input at the [Market Subcommittee](#).
- Long Range Transmission Planning is taking place in the [Planning Advisory Committee](#), and cost allocation discussions in the [Regional Expansion Criteria and Benefits Working Group](#).

As we emphasized in the first version of this report, 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.

We designed this to be a “living” report that that we will continue to update as needed as conditions change, and as we learn more about how to best respond to the challenges the region faces from ongoing fleet change, extreme weather events, and other risk factors.

MISO appreciates all of the helpful feedback we have received on the Reliability Imperative, and we look forward to continuing the dialogue with our stakeholders going forward. Urgent attention and action is necessary.





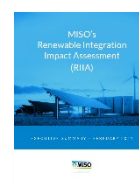
Informing and Responding to the Reliability Imperative

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:

MISO FORWARD: This report series, launched in 2019, identifies and assesses key trends that are reshaping the electricity sector. The inaugural FORWARD report focused on the need to enhance resource Availability, Flexibility and Visibility. The 2020 report looked at how different types of members will require different things in their interactions with MISO and the 2021 FORWARD report examined adjacent industries that are expected to exert new demands on the grid going forward. Subsequent iterations will continue to share insights informed by customer and industry interviews.



Renewable Integration Impact Assessment (RIIA): This technical 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 more difficult when more than 30% of the 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, our members, and the states coordinate closely on the advanced actions that would be needed.



The February (2021) Arctic Event: This report discusses lessons learned from the extreme winter weather event, also referred to as Winter Storm Uri, that affected the MISO Region and other parts of the country in February 2021. MISO and its members took emergency actions during that event in order to prevent more widespread grid failures, which underscores the urgency of MISO's Reliability Imperative efforts. The February 2021 event is just one example of how extreme weather is becoming more frequent and severe in the region, and we are seeing that the impacts of these events can be further exacerbated by the changes that are transforming the region's resource mix. For these reasons, preparing for extreme weather events is a significant part of MISO's response to the Reliability Imperative.





Resource Availability and Need (RAN): This initiative was launched in 2017 to address multiple reliability issues that have emerged due to the region’s changing resource mix, declining reserve margins, and other factors. RAN’s focus areas included improving processes for resource outages and resource accreditation, as well as transitioning from MISO’s summer-focused Resource Adequacy construct to a new seasonal construct that better reflects the region’s risk profile. This work is discussed in five RAN whitepapers, and the proposed solutions were filed with the Federal Energy Regulatory Commission (FERC) in 2018, 2019, and 2021. Following the late 2021 FERC filing, RAN was folded into the Market Redefinition workstream of the Reliability Imperative.



MISO Futures: A product of continued collaboration between MISO and its stakeholders, the three MISO Futures provide a set of bookends to explore a wide range of future outlooks. Updated in late 2021, these forward-looking planning scenarios are being used throughout the organization to prioritize and pace the Reliability Imperative work.



Regional Resource Assessment (RRA): The RRA is a new recurring study based on the plans and goals MISO’s 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 in order to meet utilities’ stated objectives. The view the RRA produces is designed to help MISO, our members, and state regulatory agencies to better plan and operate the system in a reliable, cost-effective manner.



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 report presents a timeline of reliability needs that aims to answer the question: “What will be needed and by when?” The needs are presented in four broad categories: (1) Uncertainty and Variability; (2) Resource Models and Capabilities; (3) Location; and (4) Coordination. The report also outlines a transparent path forward for market solutions that anticipate and meet the changing needs.





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 residential and commercial buildings. Among other things, the report indicates that electrification could transform the grid in the MISO Region 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. These and other implications of electrification are addressed through the efforts that MISO is mounting under the Reliability Imperative.



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.





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

Many utilities and states in the MISO Region have announced ambitious plans and goals to reduce some or all of their carbon emissions by some future date. There is also discussion at the national level about how to decarbonize the electric sector and the economy as a whole. So naturally, there's much discussion about what the "end state" of the region's electrical system would look like if these plans and goals are realized.

While MISO also cares about the eventual end state, we are currently focused on — and concerned about — the **transition** that is required to achieve a lower-carbon or zero-carbon end state, because this transition may cause reliability challenges as we learn how to accommodate new resource types and as a large portion of today's generation fleet retires.

Chief among these risks is the region's declining levels of generation capacity and reserves. Today, MISO operates with less excess capacity than in the past because MISO's large footprint has facilitated the sharing of reserve capacity, a direct benefit to customer rates. Nevertheless, many thermal resources have recently retired from service due to economic, regulatory, and environmental pressures, and the aging thermal assets that remain in service may be more prone to unplanned outages and face supply chain issues. While MISO believes it is certainly possible to reliably operate the system with substantially lower levels of thermal resources, we need to ensure that the resources that replace them provide the commensurate capabilities 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 — but which are not inherently part of wind or solar generation. Our markets can and will adapt to require, incent, and/or procure those capabilities, but developing those new market mechanisms will take time and stakeholder collaboration, as discussed more in the Market Redefinition section.

The transition to a lower/no-carbon end state also poses risks in the realm of fuel assurance. As the electric generation and fuel industries anticipate the changing fleet composition, there has been contraction in the coal industry. An expansion of renewable and energy storage resources is needed and underway, but during the transition to that new fleet, MISO has concerns about the fuel assurance related to conventional generators providing flexibility and reliability to the system.

- Coal resources have historically been considered very fuel-assure because large stockpiles of fuel can be stored on-site. However, as this report was being developed in late 2021, there were indications that coal supplies were tightening 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, natural gas prices increased significantly going into the winter of 2021-22, which in some instances made coal resources more



economic to dispatch than gas. These factors have combined to increase the risk that a coal plant will be dispatched but will be unable to perform due to fuel availability.¹ Beyond these factors, coal resources have occasionally experienced fuel-assurance issues in the past due to extreme winter weather freezing onsite coal inventories and/or impacting coal-handling equipment.

- Natural gas resources are also subject to fuel-assurance risks because they typically 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, situations sometimes arise when gas power plants 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. Typically, many gas generating resources do not have “firm” fuel-delivery contracts, opting instead for less costly “interruptible” pipeline service or a blend thereof.²
- Additionally, natural 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.

Fuel availability is also a challenge for wind resources, as the graphic below illustrates. The energy output of wind resources can fluctuate significantly on a day-to-day and even an hour-by-hour basis, which complicates MISO’s efforts to maintain system reliability. Additionally, when wind output is high, congestion on the transmission system may require MISO to curtail, or turn off, wind resources that could otherwise provide energy. The chart below illustrates how wind output in the region varied significantly in the fall of 2020. The orange areas show instances when high wind output had to be curtailed.

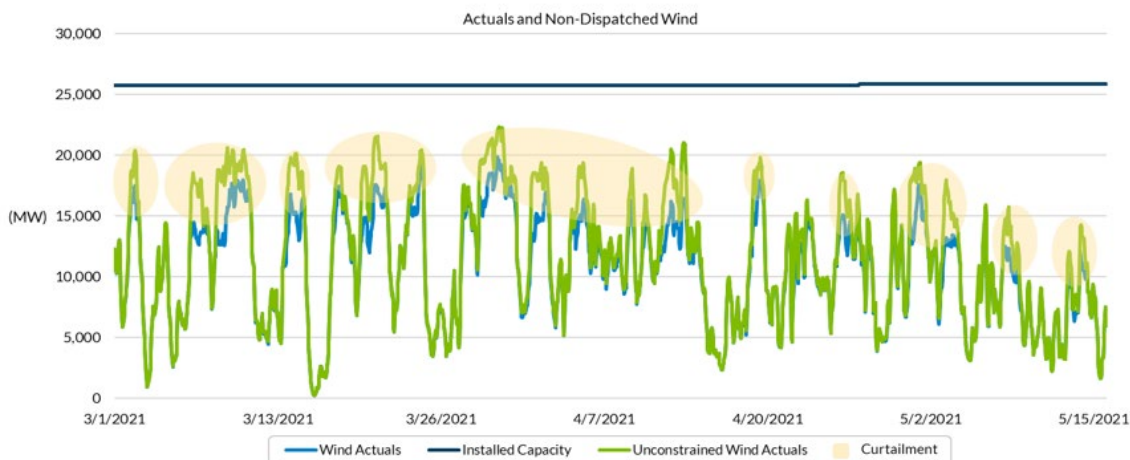
Another trend associated with the changing resource mix is that the region has become reliant on a category of resources that MISO can only access in emergencies. These assets, known as Load Modifying Resources (LMRs), comprise a significant portion of the resources that MISO members currently use to satisfy their Resource Adequacy Requirements.

¹ About 11 GW of coal capacity (approximately 20% of the region’s total coal capacity) reported being at high risk of experiencing coal supply issues in the 2021-2022 winter season, according to survey responses. See [MISO Reliability Subcommittee, December 2021](#).

² Less than 25% of the gas generation that responded to MISO’s [2021-2022 Generator Winterization Survey](#) indicated it had firm transport contracts in place for all of their supplies during the 2021-2022 winter season. See MISO Reliability Subcommittee, October 2021.



Recent examples of MISO wind generation variability and curtailment



The use of LMRs increased markedly in 2016, when the region's reserve margins began declining due to a combination of factors, including environmental regulation and economic considerations, among other things. Since then, LMRs (including Demand Resources and Behind the Meter Generation) have consistently comprised a little more than 8% of the total resources that have cleared MISO's annual Planning Resource Auction.

Under the MISO Tariff, MISO can only access LMRs to curtail or offset load by progressing through the steps of its emergency operating procedures and formally declaring a grid emergency. The Tariff also limits MISO's use of LMRs in other ways, such as capping how many times a year MISO can call them and requiring MISO to provide certain amounts of lead time before LMRs are expected to perform. Historically, some LMRs were afforded up to 12 hours of lead time before they were expected to perform, but under a MISO initiative that was approved by FERC in August 2020, the lead time for LMRs will be reduced to six hours or less, with 50% accreditation for LMRs with notice time greater than 6 hours in the Planning Year 2022/23 and disqualification beginning with MISO's 2023/24 Planning Year.

Emergency-only use of LMRs is a long-established planning practice in the utility industry. However, as the region's resource fleet continues to evolve and reserve margins continue to tighten, MISO is increasingly dependent on the successful deployment of LMRs to ensure capacity sufficiency. More frequent use of LMRs can result in a host of sub-optimal outcomes. For example, MISO may not be able to access LMRs in time to mitigate rapidly evolving system conditions. Even when LMRs attempt to respond in time, the performance of LMRs may fall short of what they were accredited for.

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. Lastly, given the



limited number of annual LMR calls per the MISO Tariff, a decision to call an LMR that is ultimately unneeded reduces the availability of that resource in future periods.

MISO has already made several improvements related to LMRs in recent years, such as enhancing LMR participation in MISO’s markets, implementing testing requirements to ensure that LMRs can actually curtail firm load, and improving how LMRs are accredited. MISO has also recently implemented improvements to emergency pricing which is in effect when LMRs are deployed. MISO intends to pursue additional improvements going forward as part of the Reliability Imperative’s Market Redefinition workstream.

In sum, trends such as thermal retirements and lower excess reserve margins, increasing reliance on LMRs, and the region’s increasing reliance on gas and renewable resources have altered the region’s risk profile – meaning the region now faces risks in seasons of the year and hours of the day that did not pose challenges in the past. A key indicator of this is the 41 MaxGen emergencies that MISO has had to declare since the summer of 2016. While the emergency protocols are a legitimate way for MISO to access additional resources, relying on such protocols much more frequently and in non-traditional times are evidence of MISO’s changing risk profile.

MaxGen Alerts, Warnings, and Events

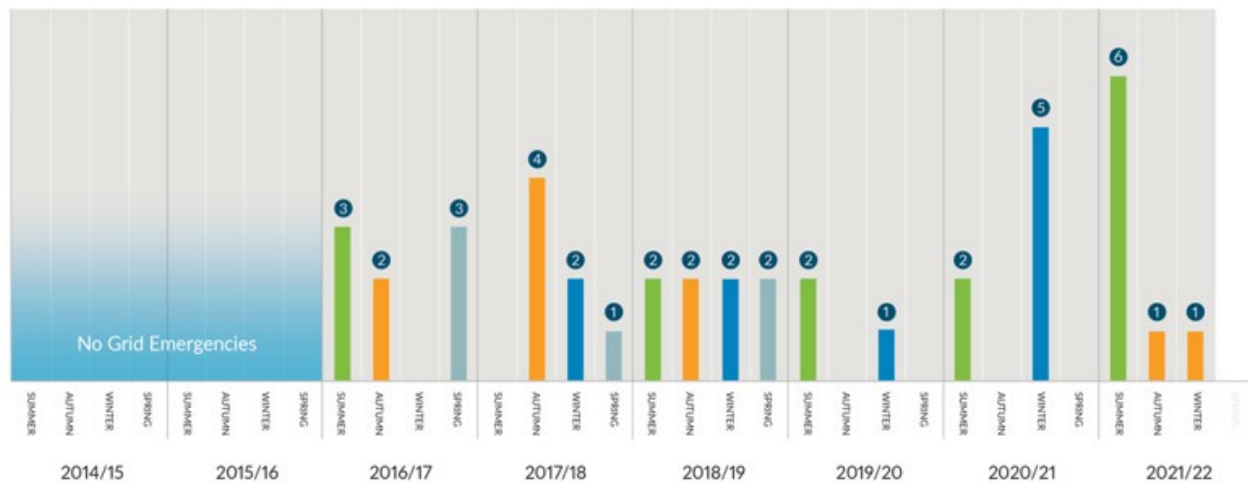


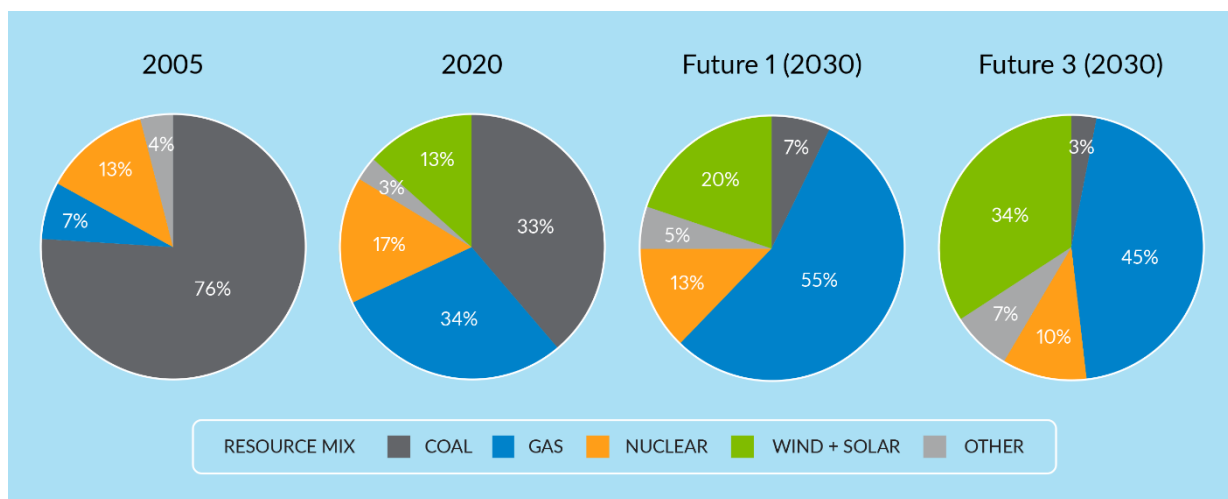
Chart indicates the number of days under a max gen alert, warning or event.



MISO expects reliability risks to increase going forward as the region’s resource mix continues to evolve. The figure below shows two scenarios of what the region’s resource mix could potentially look like in 2030. These scenarios are based on MISO’s forward-looking Futures, which use a range of economic, policy, and technological assumptions to create plausible “bookend” views of what the region’s resource mix could look like in 20 years. MISO uses the Futures to inform the development of transmission plans, including those under the Reliability Imperative’s Long Range Transmission Planning workstream.

Future 1 is the more “conservative” of these two Futures, as it assumes that state and utility decarbonization/renewable energy goals that are not legislated or otherwise binding are achieved at only 85% of their aspirational targets. Nevertheless, the direction and the magnitude of the continuing fuel-mix changes that are forecast in Future 1 would likely exacerbate the reliability challenges described above. Future 3 pictured above is even more aggressive in terms of forecasted thermal retirements and incorporating additional renewables, so this path would also foster additional reliability challenges. For a detailed look at the reliability challenges that could manifest as additional renewables are incorporated the system, see MISO’s [Renewable Integration Impact Assessment](#).

MISO Generation Mix (% of total annual energy by fuel type)



EMERGING RELIABILITY NEEDS

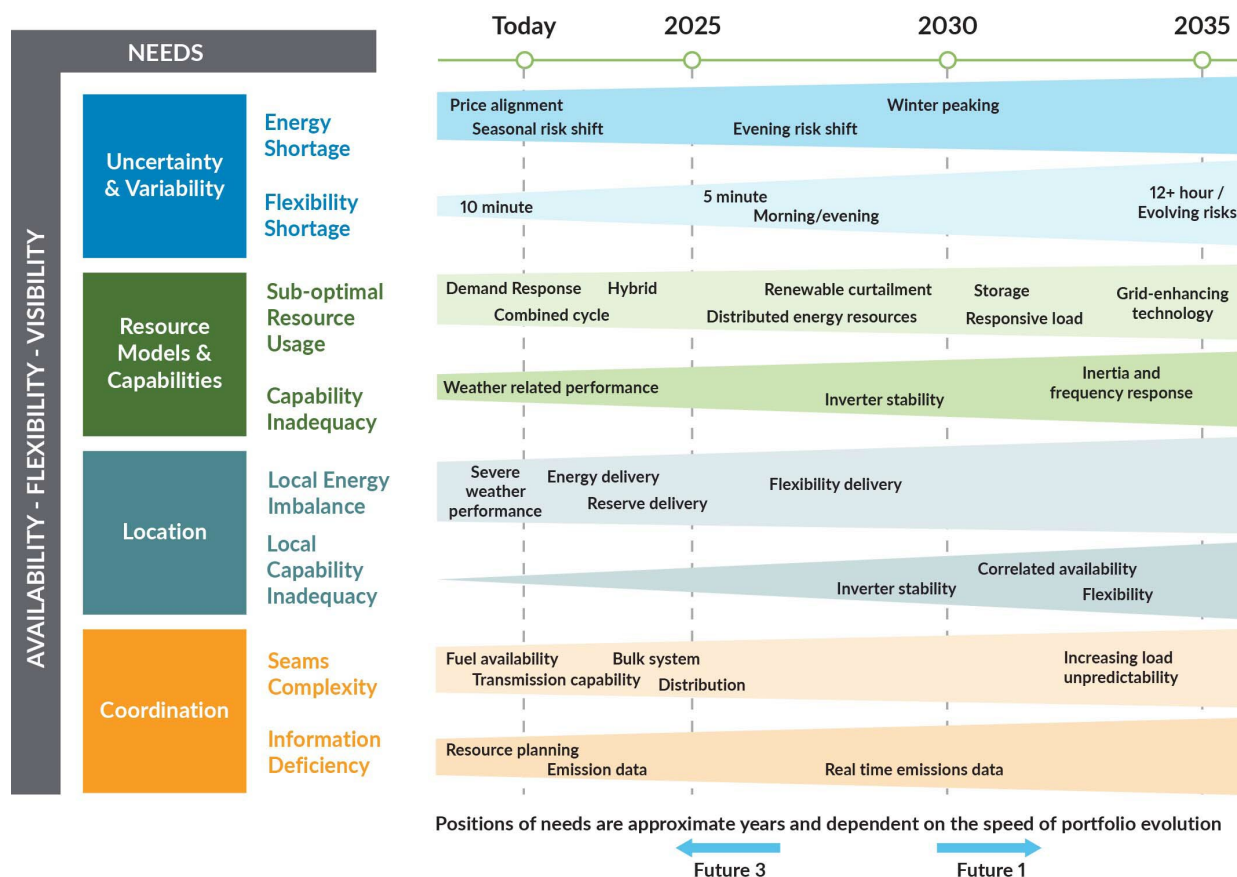
MISO has distilled the system’s emerging and shifting reliability needs into four categories: **Uncertainty and Variability** considers new and growing risks, spotlighting energy and flexibility shortages; **Resource Models and Capabilities** considers the optimal use of resources and their inherent capabilities; **Location** examines regional differences and transmission limitations; and **Coordination** explores complexity along the seams (bulk power system *and* transmission-distribution) and information needs to enhance collaboration and shared visibility.



“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

Having gathered insights from MISO’s modeling, Futures analyses, operational experience, and customer conversations, MISO’s 2021 [Markets of the Future report](#) put forward a comprehensive view and sequencing of emerging and shifting needs. The growing risks illustrated in the figure below serve as a guidepost for the Reliability Imperative work, informing priority and pace. Efficient risk mitigation requires a coordinated response from markets, operations, and technology workstreams.



This figure shows future needs by category and estimated timing of emergence or significant shift in need for the region. Detailed descriptions of each need can be found in the [Markets of the Future](#) report. Expanding colors are illustrative of relative size of aggregated category risk over time. Future arrows indicate potential shift in timing depending on the pace of change.



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. The 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 MISO considers to be 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.





--- MISO Roadmap ---

MARKET REDEFINITION INITIATIVES		2022				2023			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Managing Uncertainty & Variability									
	Implementation of Seasonal Construct and Conventional Accreditation								
	Recommend Accreditation Reforms for Renewables, Hybrids and Storage								
	Update Ancillary amounts and Short-term Reserves								
	Enhance Internal Risk Information Management								
	Improve Scarcity Pricing								
	Assess Severe Weather Implications								
Resource Models & Capabilities									
	Increase Effectiveness of Demand Response and Load Modifying Resources								
	Implement Energy Storage Resource Participation - FERC Order 841 Compliance								
	File Distributed Energy Resources (DER) - FERC Order 2222 Compliance and Begin Implementation Plan								
	Assess Hybrid Resource Participation								
Identifying Locational Needs									
	Update Regional Constraints Based on Conditions								
Enhancing Coordination									
	Facilitate Ambient Adjusted Line Ratings Adoption								
	Enhance Regional Resource Assessment								

OPERATIONS OF THE FUTURE INITIATIVES		2022				2023			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Situational Awareness									
	Real Time Display Replacement								
	Advance Synchrophaser Applications Evaluation								
Operations Planning									
	Look Ahead Commitment Needs Definition								
	Operations and Planning Models Alignment								
	Outage Coordination Analysis Processing								
Operations Preparedness									
	Operations Simulation								
	Operator in Training Programs								
Critical Communications									
	MISO Communications System Declarations								
	Operator Logging Needs Evaluation								
Business Continuity									
	Conduct Business Impact Assessment to Identify Needs to Mitigate Emerging Threats								

LONG RANGE TRANSMISSION PLANNING INITIATIVES		2022				2023			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Futures / Policy Consensus									
	Continue to Understand Evolving Member Plans, IRP Trends, and Policy Objectives								
Planning and Business Case Development									
	Plan, Analyze and Recommend Robust Transmission Solutions								
	Develop Methodologies to Better Quantify Resiliency and Other Benefits								
	Complete Holistic Cost and Benefit Analysis for Business Cases								
Cost Allocation									
	Explore New Sustainable Cost Allocation Mechanisms to Fit Future Transmission Needs								
Other Planning Efforts									
	Enhance Joint Transmission Planning with Seams Partners								
	Explore a Better Aligned Planning Process								
	Develop a Customer Self-Service Portal for Planning Customers								

MARKET SYSTEM ENHANCEMENT INITIATIVES		2022				2023			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Market System Enhancements									
	Market User Interface								
	Model Manager (Phase 1)								
	Energy Management System (EMS) Upgrade								
	Day-Ahead Market Clearing Engine (DA-MCE)								
	Real-Time Market Clearing Engine								

The MISO Roadmap is a living document that will be revised as necessary to reflect MISO's strategic priorities and timelines. In addition, for your convenience the document will include links to additional information contained in the MISO Dashboard (previously known as the Issue Tracking Tool). The work to update the Dashboard and links is currently underway, and the functionality will be evolving through the late-February timeframe. We appreciate your patience and understanding as we work to ensure the continued ability to track key work efforts.



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 both new tools and processes being developed under the Operations of the Future workstream, and market enhancements being 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 Long Range Transmission Planning workstream.

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





Market Redefinition

The transformation of the generation mix increases the complexity of ensuring sufficient resources during the highest risk periods across the year. MISO is addressing this changing risk profile across markets, planning, and future-looking studies. As the generation mix changes, it is important for MISO to provide signals about what will be needed to ensure reliability, and to give the right price incentives when the system is in need. MISO's analysis in the [Markets of the Future report](#) shows that the foundational market constructs in place today will continue to be effective in the future, but only with significant market and operational enhancements and optimizations.

Resource Assessments: In the investment and planning timeframe, MISO is looking to provide information to members about the impact of their individual plans in aggregate. Today, planning is focused on the summer peak hour for the coming year or two. The Resource Adequacy survey that MISO conducts in partnership with the Organization of MISO States (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 developing the ability to provide forward resource assessments and long-term Resource Adequacy reports to better inform future investment and retirement decisions.

- In 2021, MISO published the first iteration of the *Regional Resource Assessment (RRA)* by aggregating publicly announced utility plans and goals to develop an indicative view of regional fleet evolution and model what new reliability needs and gaps may arise.
- Next up: Customer engagement, surveying, and workshops planned for this year aim to improve the accuracy and broaden the application of the next iteration of the RRA. 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 assess and incorporate severe weather risk into its assessments.

Resource Adequacy Construct: In the planning horizon, MISO is looking to better reflect the changing risk profile and send correct market signals for forward-looking investments. MISO's existing Resource Adequacy Construct was designed for a conventional fleet of resources, where reliability risk was concentrated during the typical summer peak periods. Since the early 2000s, the fleet has moved to more renewable resources that are variable and more uncertain. 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 late 2021, MISO filed [proposed Resource Adequacy reforms](#) with FERC, which are currently pending review. MISO's proposal includes three primary objectives: (1) to change from the current annual summer-based construct to four distinct seasons, (2) to align thermal resource accreditation with availability in the highest risk periods, and (3) to



require at least 50% of capacity to be secured for each Load Serving Entity prior to the Planning Resource Auction.

- Next up: Accreditation for non-thermal resources will be a focus in the coming year, including wind, solar, battery storage, hybrid generators, and Load Modifying Resources.

Energy Market Pricing and Products: MISO will continue to evaluate the changing risk profile to assess the effectiveness of energy market pricing and products and will explore potential new products and approaches.

- MISO successfully launched the Short-Term Reserve (STR) product in December 2021. This new ancillary service, which is included in both the Day-Ahead and the Real-Time Market, co-optimizes all Energy and Operating Reserves products. The STR product provides reserved and rampable 30-minute capacity, and adds needed flexibility to help manage uncertainty on the system.
- MISO's proposed reforms to emergency pricing and initial reforms to scarcity pricing were accepted by FERC and implemented in 2021. The reforms better align prices during emergencies and tight operating conditions with underlying system risk and provide more effective price signals to help incent resource availability.
- Additionally, MISO increased the Up Ramp Capability requirement by 500 MW to address the trend of increasing operating reserve scarcity by adjusting the 'uncertainty component' that is included in the requirement's formula.
- Next up: Continued evaluation of scarcity pricing reforms, including possible reforms to reserve demand curves, the Value of Lost Load, and the Locational Marginal Pricing price cap. Continued evaluation of dynamic reserve requirements to help manage increasing uncertainty.

Resource Participation Models and Capabilities: Enhancements to MISO's suite of resource participation models are needed to realize the full advantages of increasingly complex resource capabilities. Work to enhance existing products and design new market products is an ongoing Market Redefinition priority.

- In 2021, MISO made enhancements to the Multi-Day Operating Margin forecast that included more granular wind and solar forecast information, emergency capacity forecasts, and sub-regional breakouts (North, Central, South), improving situational awareness for market participants and operators.



- Next up: MISO is working toward a June 2022 implementation date for the new Electric Storage Resource participation model that recognizes the unique characteristics of this resource type. Additionally, MISO will submit its compliance filing to FERC regarding Distributed Energy Resources (DERs) by April 2022. Further, discussion of enabling Storage As Transmission-Only Assets (SATOAs) to provide market services will continue in the Market Subcommittee.

“Meeting the objectives of market redefinition will require a longer-term strategy, improved transparency, and sustained engagement from the MISO stakeholder community.”

Richard Doying, MISO EVP Market & Grid Strategy





Long Range Transmission Planning

The ongoing trend of conventional power plants retiring from service as intermittent renewables continue to grow is posing significant challenges to the reliability of the transmission system in the MISO Region. MISO's Long Range Transmission Planning (LRTP) initiative is designed to address these challenges, in concert with other elements of the Reliability Imperative framework.

One focus of LRTP is 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. The need for improved transfer capability is underscored by two major trends that are playing out across the region. The first is that the best sites to build new renewable generation may be located far from existing transmission infrastructure and load centers. The second is that extreme weather events are becoming more frequent and severe in the MISO Region. For example, the [Arctic Weather Event](#) that impacted the MISO Region and other parts of the country in February 2021 showed the crucial need for a robust, “backbone” regional transmission system to move power from where it is generated to where it is needed.

Fortunately, MISO can leverage its large geographic footprint and diversity of resources to ease some of these challenges. One of the keys will be transmission infrastructure that supports these new resources and enhances transfer capability in the region. LRTP is designed to assess the region's future transmission needs in concert with utility and state plans for future generation resources.

Another focus of LRTP relates to maintaining grid stability. The U.S. transmission system is designed to operate at a frequency of 60 hertz. Historically, conventional power plants have played a key role in keeping the grid stable at that level because they have heavy rotating components that are synchronized to spin at the same frequency as the grid. This rotational kinetic energy, or inertia, helps stabilize the grid when a system failure, or contingency, occurs. The new wind, solar, and battery resources that are increasingly being built in the region, however, do not inherently provide rotational inertia in the traditional sense. It is possible for these new resource types to provide the same capabilities, but ensuring that they do will require changes to transmission specifications and compensation mechanisms. More details on how MISO is addressing this and other challenges are available in MISO's [Renewable Integration Impact Assessment \(RIIA\) study](#).

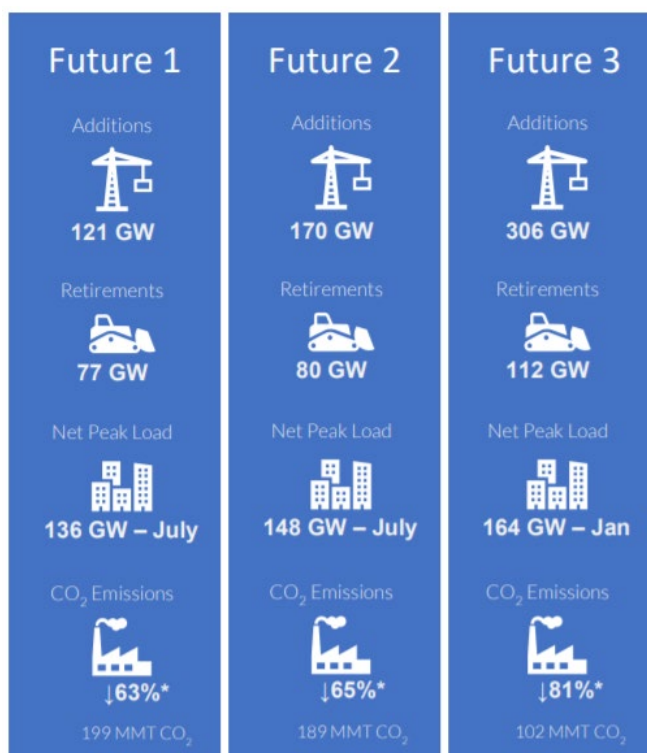


It is important to keep in mind that LRTP does not replace other transmission-planning efforts that have long existed at MISO, such as the annual studies already contained in the MISO Transmission Expansion Plan, or MTEP. LRTP coordinates closely with those efforts, and it is also part of the transparent and cooperative MISO Stakeholder Process. This LRTP effort is most analogous to MISO's previous work on the [Multi-Value Project](#) (MVP) portfolio, as both are policy-driven. MISO's Board of Directors approved the 17 projects that comprised the MVP portfolio in 2011.

Futures / Policy Consensus: MISO's LRTP work is driven by changing policy and evolving resource fleet trends discussed earlier in this report. LRTP is grounded in the three robust future scenarios updated over the past year. MISO's LRTP efforts will prioritize meeting the reliability challenges embedded in Future 1, while ensuring that outcomes do not foreclose Futures 2 and 3. Future 1 tries to reflect current MISO member plans across the footprint and various policy objectives of the states. Futures 2 and 3 reflect increasing levels of electrification (e.g., more electric vehicles) and renewables.

LRTP is a comprehensive "transmission roadmap" that will identify and drive investments in transmission projects addressing all needs of the region as the resource fleet continues to evolve. In addition to identifying solutions needed to reliably operate a system with significantly more renewable resources, we are also considering other current challenges. This includes the opportunity to enhance renewable integration in the upper Midwest, as the MVPs have become fully subscribed; addressing import/export limitations in Michigan and other areas; increasing the transfer capability across North and Central MISO and between the Central and South Regions; and other policy and reliability-driven issues.

We expect projects to be approved in tranches, with the first and second tranches focused on the North and Central portions of the footprint, while the third tranche is focused on the South subregion, and the fourth on the North/South subregion interface. The roadmap will be updated as needed to align with evolving resource fleets and business plans, state energy/environmental policies and other dynamic factors that affect the region's transmission needs. As solutions are identified through LRTP, they will be moved into the ongoing MTEP process for final approval by MISO management and Board of Directors. MISO anticipates delivering the first round of suggested LRTP solutions to the Board of Directors in June 2022.





Business Case Development: MISO is developing robust business cases for LRTP projects by analyzing multiple benefits relative to the costs and building on the methodologies developed for the 2011 MVP portfolio. The business cases will reflect the need for transmission to ensure reliability of the system, in addition to any economic benefits, given the policy and fleet transition objectives of MISO members and states. This includes helping stakeholders consider both generation and transmission costs and benefits on a holistic basis, including the value of flexibility that transmission provides. Additionally, MISO is looking at how to quantify the resiliency benefits associated with the LRTP portfolio of projects.

Cost Allocation: A key aspect of LRTP will be to ensure that the costs of new transmission projects are allocated fairly. Within the MISO Stakeholder Process, the primary forum for this important work is the [Regional Expansion Criteria and Benefits Working Group \(RECBWG\)](#), which was established to discuss existing or proposed criteria and cost allocation policies for regional and interregional cost-shared transmission projects. OMS has a [working group](#) that focuses specifically on transmission cost allocation issues and has also been engaged in the RECBWG. MISO is committed to continuing to work with its stakeholders on cost-allocation issues in both of these forums.

MISO has put forward a proposal to utilize the MVP methodology in a bifurcated manner that recognizes subregional differences of MISO South and MISO North and Central regions to ensure a roughly commensurate “beneficiaries pay” cost allocation where costs are roughly commensurate with benefits. The MISO proposal also includes commitments for future studies of benefits associated later tranches and to maintain and preserve future options.

“If you love renewables, you’d better love transmission.”

John Bear, MISO Chief Executive Officer

Other Planning Efforts: In addition to the significant work specifically associated with the LRTP study and the normal annual MTEP processes, MISO is also engaged in other transmission planning-related efforts. In parallel to the LRTP we have partnered with the Southwest Power Pool (SPP) on a joint targeted study to identify transmission enhancements required to enable the interconnection of low-cost resources along the seam, where the transmission system is currently at its capacity. A cost allocation framework to equitably allocate the cost of the portfolio of projects to both Regional Transmission Organizations is currently under development.



This joint study is an example of the work we have done, and will continue to undertake, to enhance our planning with all of our seams partners. Process improvement work is also internally focused. We are exploring the potential to better integrate the different aspects of our value-based transmission planning process. One example of the results of this work would be the ability to assess the potential market efficiency benefits of Generator Interconnection Projects to factor into the business case.





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, like the 2021 Arctic Event and hurricanes, forward-looking work is underway to ensure that MISO has the people skills, 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, (2) operations preparedness, (3) critical communications, (4) operations planning, and (5) business continuity.

Situational awareness can be improved to turn data into actions. The shift to more weather-dependent, intermittent renewables and distributed resources means that system peaks and operating risks are becoming less predictable and more difficult to manage in day-to-day operations. Today, MISO Operations relies heavily on the expertise of its operators. While operators have access to significant amounts of data (e.g., weather, load), they must manually synthesize data into useable information. This has worked well historically, but as the system changes the solution must envision a future with more complex information and less experienced operators. In the future, MISO Operations needs an integrated toolset for operators that leverages artificial intelligence and machine learning, combined with enhanced data such as Ambient Adjusted Ratings, to provide improved information on system status and capabilities. Techniques to improve how we see and navigate will give operators important information automatically.

Operations preparedness is critical to manage rapidly shifting or challenging operating conditions. Tomorrow's control room will be very different from today's. In the future, system operators will face 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 simulations tools and enhancing operator training.





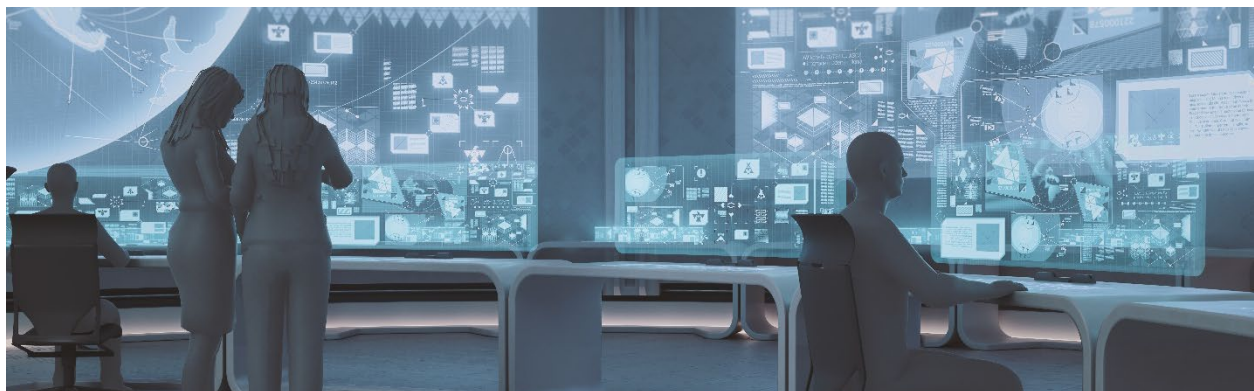
Critical communications will become even more important with the enhanced capabilities and complex operating environment of the future. New control room technologies and capabilities, improved real-time data capabilities, and more complex operating conditions driven by new load and generation patterns will require MISO and its members to communicate even more quickly and efficiently going forward. Enhancements to communications protocols, such as system declarations, are important steps to ensure that MISO and member controls room have the information they need when the need it.

“In the past, predicting load and generation were relatively straight-forward. 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 VP System Planning and Chief Compliance Officer

Operations planning enables MISO to remain a step ahead of the shifting energy landscape. System operators need 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, including aligning operations and planning models and improving outage coordination analysis processing capabilities.

Business 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.





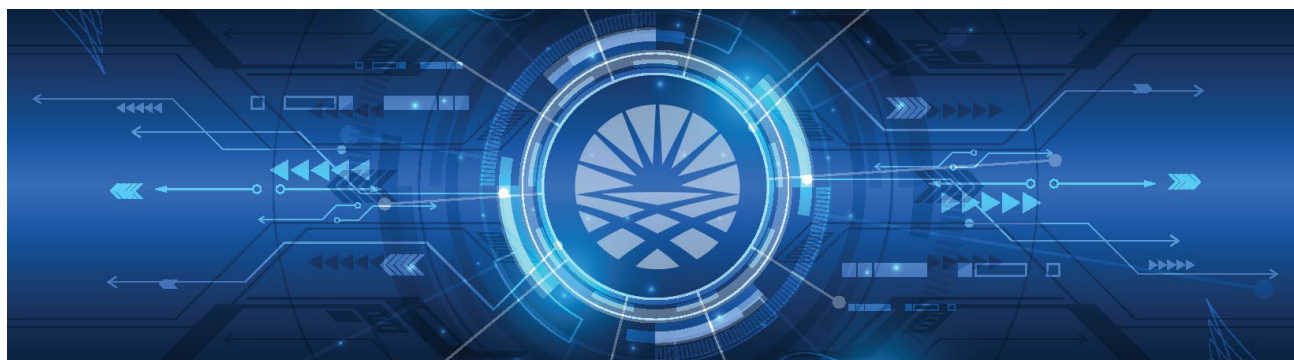
Market System Enhancements

MISO's ability to respond to the Reliability Imperative is enabled through continued market system enhancements and modeling refinements. Current systems and technology are not capable of meeting many of the new, reliability-driven market improvements and fully leveraging new resources such as Storage and Distributed Energy Resources. The Market System Enhancement (MSE) Program was initiated in 2017 to transform our current market platform into a more flexible 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.

The program remains focused on building and launching new systems with improved performance, security, and architectural modularity, which enhances our ability to deliver new market products more quickly and efficiently. In 2021, the program implemented several external-facing products. These products included Model Manager Phase 1, which transforms how we model the electrical system; the Market User Interface, which updated our interface for stakeholders to participate in the market; and a Short-Term Reserve market product, which is an additional Ancillary Services Market product that improves the procurement and market signals for flexible energy resources for meeting customer demand.

“MISO's Market System Enhancement Program is transforming our technology, processes, and people skills to enable faster adoption of new technologies into the market and better accommodate the region's rapidly changing resource mix to ensure reliable and efficient operations for our customers.”

Todd Ramey, MISO VP and Chief Digital Officer





Building on the MSE Program’s progress, flexible design, data analytics, and model management will help MISO to meet the Reliability Imperative. In contrast to the current technology, the future market platform will integrate technology and systems to better utilize data. Modern architecture means systems that provide flexibility for the evolving needs of the business. These enhancements will support and facilitate the ongoing transformation across the various workstreams of the Reliability Imperative, including Market Redefinition and Operations of the Future.





The Opportunity: Capturing the Value

As described in this paper, MISO sees the challenges of the changing resource fleet. We are facing a Reliability Imperative to prepare for the future, and MISO is hard at work on a number of key planning, operational and systems efforts.

The fleet change represents not just challenges, but also enormous opportunities for MISO to enable members, states, regulators, and consumers to meet their objectives reliably and affordably.

By listening and taking a system-wide view, MISO can help ensure that all stakeholders have the information they need to make informed decisions about their resources.

By helping forward planning, MISO will help members to develop generation and transmission portfolios that maintain system reliability without over-investing. As member portfolios materialize, MISO markets and operations will optimize the delivery of energy across the footprint. In addition, MISO will continue coordinating with our neighboring seams partners.

MISO has delivered substantial value to its members since its creation, as demonstrated by the annual Value Proposition calculation. Going forward, additional sources of value will emerge through the sharing of attributes across the region's diverse resource fleets. MISO is developing calculations for these new sources of value in an evolved, future-looking Value Proposition. Given changes to fleet, grid, markets, and operations, it is more important than ever that the MISO Region work together so that each member continues to realize the substantial benefits of our regional structure.

“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 VP Strategy & Business Development



Working Together to Address the Reliability Imperative

This is a report written from MISO's perspective. However, the Reliability Imperative is not MISO's alone. The resource mix in the MISO Region has evolved significantly and will shift further as many members evolve their fleets to meet decarbonization goals. The Reliability Imperative work is required to ensure the grid can continue to be operated reliably as those increasingly diverse member plans are implemented.

The work of the Reliability Imperative is focused on changes to MISO markets, operations, technical systems, and the grid to address the reliability risks resulting from the increasing pace of renewable integration and the increased frequency and severity of extreme weather events. And as an independent, FERC-approved system operator, MISO is responsible for the reliability of the Bulk Electric System and has the obligation to act. This work isn't performed in isolation, however. MISO engages with a broad range of stakeholders to share ideas and discuss potential solutions, including receiving input from industry trade groups, consultants, and other entities with insights into the challenges that are facing our region.

The Reliability Imperative work also involves 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. The MISO Roadmap, launched in January 2022, captures the strategic work needed across MISO's functions and processes to ensure preparedness for the future. The MISO Roadmap is currently organized according to the Reliability Imperative areas of focus. It will be updated as necessary, and we welcome continued stakeholder input on the process and the items MISO should prioritize.





MISO also recognizes that some action will fall outside of MISO's scope and role. For example, MISO's [report on the February 2021 Arctic Event](#) pointed out the need for improved weatherization of resources, which impacts MISO, but the responsive actions fall outside of our direct responsibility. In line with those findings, [FERC and the North American Electric Reliability Corporation \(NERC\) recently released their own findings](#) on that event and have proposed multiple changes to the way that resources prepare for and communicate about their weatherization. As a directly impacted party, MISO has and will continue to engage the industry in these weatherization practices and appreciates FERC's and NERC's recent actions.

An additional method of engagement that is extremely critical to MISO's near-term and longer-term planning is through the information gathering tools that MISO administers. This includes participation in MISO's annual [Generator Winterization Survey](#), as well as an ad-hoc survey related to the emerging risk related to coal supply. It also includes our work to aggregate member plans in the Regional Resource Assessment. Working together across all of these potential points of collaboration will best position the region to successfully and efficiently respond to the Reliability Imperative.





A Message from Clair Moeller, President

We need to get to the future before the future gets to us.

We need to move quickly to adapt our markets, planning processes, and operational protocols so grid reliability is not impaired by the changes that are fundamentally transforming our electrical system.

We've made some great progress since the initial version of this report in late 2020. For example, we've proposed revisions to our Resource Adequacy Construct that we think will mitigate some of the challenges we're increasingly experiencing due to factors such as fleet change and extreme weather events. We're seeking to revise certain processes in order to better incentivize resources with needed capabilities and attributes to be available when they are most needed. And through our Long Range Transmission Planning efforts, we're identifying transmission solutions that will enable members and states to achieve their policy objectives — many of which seek to increase renewables and/or reduce carbon emissions.



None of this work is easy. In fact, it's often stressful for our stakeholders, as well as 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.

We know that not everyone will support every view, recommendation, and initiative that MISO lays out in the Reliability Imperative — and that's OK. MISO welcomes stakeholder feedback on the proposals described in these pages, and if stakeholders have different ideas altogether, we want to hear them. Will we agree on everything? No. But that should not — and must not — stop us from 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 get to work,

A handwritten signature in black ink, appearing to read "Clair Moeller".



Acronyms Used in this Report

DER: Distributed Energy Resource

FERC: Federal Energy Regulatory Commission

LMR: Load Modifying Resource

LRTP: Long Range Transmission Planning

MISO: Midcontinent Independent System Operator

MSE: Market System Enhancement

MTEP: MISO Transmission Expansion Plan

MVP: Multi-Value Project

NERC: North American Electric Reliability Corporation

OMS: Organization of MISO States

RAN: Resource Availability and Need

RECBWG: Regional Expansion Criteria and Benefits Working Group

RIIA: Renewable Integration Impact Assessment

RRA: Regional Resource Assessment

SATOA: Storage As Transmission-Only Asset

SPP: Southwest Power Pool

STR: Short-Term Reserve