Subcommittee on Energy
Hearing on
"Building a 100 Percent Clean Economy: Solutions for the U.S. Power Sector"
October 30, 2019

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The Honorable Greg Walden (R-OR):

1. Given your diverse perspectives and pragmatic views on matters relating to electricity cost, grid reliability, and consumer choice.

   It can be easy to get caught up in all the hype and catchy press releases promising to fight climate change. However, once you drill down deeper, you realize that all these aspirational statements have a catch. If we really want to get serious about reducing emissions, we will need new natural gas plants, new pipelines, new electric transmission lines, renewed nuclear licenses, more windfarms, and more solar panels.

   a. Given that we had to import Russian LNG into Boston Harbor because you can't build a pipeline in New England, what confidence do you have that environmental activists and states like New York will allow the construction of all these new clean energy projects?

      RESPONSE:

      We strive to work cooperatively with federal, state and local authorities to ensure they have the information they need to make decisions relating to infrastructure. We cannot speak for other regions facing different infrastructure challenges, but we need additional electric transmission infrastructure to meet the identified clean energy goals of our members and states. It is our goal to ensure that we work collaboratively across all sectors, including MISO's Environmental Sector, to identify solutions that meet the reliability and policy needs of our region in a reliable, cost effective manner. We are concerned that a lack of electric transmission infrastructure will pose both a reliability challenge to our region and discourage the new clean energy projects our states and members would like to pursue.

   b. As you look over the horizon, what are the biggest challenges to the siting of renewables such as wind and solar?

      RESPONSE:

In the Midcontinent region the biggest challenge to the siting of renewable resources such as wind and solar is the challenge of developing and siting additional electric transmission infrastructure. The optimal locations for renewable resources are often distant from the actual electricity customers. Additional electric transmission investment is needed to connect resource rich renewable zones with load centers and enable controllable, flexible resources to respond to changes in renewable outputs and load changes in a reliable manner.

While we understand no one would volunteer to have a transmission line near them, more lines must be built if we want to continue to increase the renewable resources in our generation mix. Expanding the use of existing rights-of-way where electric transmission already exists is one potential solution to mitigate that challenge. Robust electric transmission infrastructure planning also provides asset owners and states with information on how best to reduce the all-in cost of electricity for consumers which includes both generation and electric transmission costs.

c. Would you agree that infrastructure permitting reform should be recognized as an essential component of any plan to reduce emissions and promote clean energy?

RESPONSE:

Yes, the infrastructure permitting process is one of several processes that must be addressed to streamline the path to reduced emissions. While we have seen challenges to the siting of transmission infrastructure in our region, and indeed the process is very time consuming, we find the biggest barrier to needed infrastructure development has been related to the identification of who should pay for needed electric transmission investments. A great deal of time and effort is spent within our stakeholder processes estimating the relevant benefits of and need for transmission investment, and then, trying to develop an equitable allocation of costs among: 1) those generators looking to connect to the system, 2) the local utility customers and 3) consumers from across a broader region. These cost allocation and beneficiary assessments result in a challenging process. Any policy solutions that can reduce that friction among interested groups relating to who pays for transmission investment across the interconnection would help ease the process to develop additional transmission infrastructure.

2. The climate debate is creating a disconnect in our energy policies. On one hand, our system is setup to ensure reliability—and economical dispatch. On the other hand, the climate related agenda is focusing on incentives to close plants down, and especially plants in regions that are reliant on fossil energy for affordable power.

a. Have RTOs been trying to avoid premature retirement of generation through capacity markets and other mechanisms?

RESPONSE:

Traditionally, MISO has only examined generation retirement decisions to ensure that they do not create any immediate reliability concerns. In those cases, we have a process to delay the retirement until the identified reliability issue can be addressed. These issues have tended to be localized.

However, as the region's resource portfolio continues to evolve towards a more renewables-based fleet, MISO is working to create new pathways to better inform both construction and retirement decisions.

Each generation resource type has a set of inherit characteristics. The growth of renewable generation provides the benefits of lower carbon output and low-cost energy production. However, renewable resources like wind and solar are only available when the wind is blowing, or the sun is shining. Therefore, they are more volatile, less controllable and less flexible than traditional generation resources. Due to the nature of their fuel sources, renewables introduce systematic risks (the risk of losing many units at once as weather patterns change or sunset approaches) that are much different than the random loss patterns associated with fossil fuel generation.

In order to maintain a reliable, efficient electric grid, we must rethink several key aspects of how the system is planned and operated. Therefore, MISO is working to understand how best to analyze and communicate the mix of these resource characteristics (including controllability and flexibility) that is needed to ensure reliability moving forward. This forward assessment process will forecast the flexibility and other resource attributes the system will need to reliably meet load in all hours of the year.

b. Would federal policies that incentivize closures exacerbate the reliability risks?

RESPONSE:

Policies that incentivize closures could exacerbate reliability risks if they do not consider the full range of attributes, like controllability and flexibility, that are needed to operate the system to serve load all hours of the year.

3. Could you describe the MISO Value Proposition that MISO does annually?

RESPONSE:

The MISO Value Proposition is our annual "scorecard" to demonstrate the value MISO provides by coordinating the planning and operation of the electric grid in the mid-continent region. From 2007 through 2020, it conservatively documents over $30 billion in net benefits for the region. These benefits are created by coordinating the planning and operations of all the assets in region for the benefit of the region, rather than the subsets represented by individual utilities.

These benefits are best represented in three broad categories:

- Improved Reliability – MISO's broad regional view and state-of-the-art reliability tool set enable improved reliability for the region as measured by transmission system availability. Our ability to identify issues and to move assets across the broad region is far more efficient and effective than an individual utility can accomplish with their much smaller set of assets. In 2019, this component provided about $400 million in regional benefits.
- More Efficient Use of Existing Assets – MISO's ability to commit and dispatch the entire fleet of resources in the footprint is more efficient than what each of our member utilities can accomplish with their individual resources. Historically, utilities sought these benefits through a merger with a neighbor. MISO provides these benefits over the entire region without the need for corporate action. In 2019, this component provided about $375 million in regional benefits.
- Reduced Need for Additional Assets – Because assets are not always available for use, each utility must build and maintain more capacity than the load they expect to serve. However, by operating the system as a whole, MISO can utilize assets in other parts of the footprint to reduce this requirement for our members. By sharing resources and taking advantage of the weather diversity that is inherit in a very large geographic footprint, MISO reduces the resource requirement for each of our members. In 2019, this component provided about $2,900 million in regional benefits.

In summary, MISO's operations create great value for the region we serve. In 2019, our most recent complete year study, MISO's Value Proposition conservatively documents a net benefit of $3.6 billion. It is also important to note that the cost to achieve this benefit is very low. Our gross benefits of $3.9 billion required less than $300 million to achieve. Appendix A contains a summary of MISO's 2019 Value Proposition.

4. What are the key factors influencing the price of electricity and to what extent are state policies driving price and reliability concerns?

RESPONSE:

The all-in price of electricity to customers has several key factors including the wholesale price of electricity which today represents the marginal cost of generating the next unit of energy. Other key factors include the capital costs of building generation facilities, the transmission costs of moving the energy from the generator to the load, and an increasing need for controllable flexibility from other sources to manage the variability in the output of those increasing levels of intermittent renewable units. Each of these factors are discussed in more detail in following responses.

Each state has its own regulatory structure through state utilities commissions which determines the price to be paid by residential, commercial and industrial customers. In our work with states in the MISO region, we encourage state policies recognize the need for all attributes required to maintain reliability along with those to meet other policy goals, such as carbon reduction, economic development and cost efficiency.

5. MISO represents areas with a differing mixes of energy resources, what are your thoughts on the challenge of ensuring regional access to the most affordable energy?

RESPONSE:

The MISO region is changing in big ways. MISO's electric system is increasingly fueled by wind and solar. This change is driven by favorable economics for energy production, technological advances, state policies, and consumer preferences for renewable energy, among other things.

Looking at the marginal cost of energy produced, wind and solar are lower cost than coal, nuclear, or natural gas generation. As a result, the growth of these renewable resources continues to replace the region's conventional baseload resources that constituted the backbone of the region's electric system for decades.

There are many system and societal benefits of these changes. Innovative generation and grid technologies have the potential to reduce customer rates and bring efficiencies to the system. The shift to cleaner fuels will benefit the health of our communities and is key to addressing the risks of a changing climate. With a diverse regional footprint and managing all of the connections with our seams neighbors, MISO is well-positioned to support our members as they transition their fleets. In fact, MISO's Value Proposition demonstrates that it is both more economic and reliable to pursue these benefits on a wide-scale basis than on a state-by-state or utility-by-utility level.

These changes will challenge system reliability. While MISO is policy-neutral on these and other trends, MISO has observed they pose several significant challenges for the region's

electric system, and we must adapt to maintain required and expected levels of reliability. As the independent system operator, MISO has a responsibility to maintain electric reliability, which it does by addressing the holistic needs of the system, including energy, capacity, resource adequacy and flexibility.

Each resource type provides a different mix of these capabilities. As the region's resource mix changes, we must understand what capabilities are needed to maintain reliability and ensure that sufficient amounts of those resource capabilities are available when needed.

- Wind and solar resources are not always available to provide energy during times of need.
- Conventional baseload resources that remain in service can be more prone to outages given their changed usage patterns and maintenance cycles, rendering them potentially unavailable when they are needed most.

MISO, members, state regulators, and other entities responsible for system reliability all have an obligation to work together to address these challenges. MISO calls this shared responsibility the MISO Region Reliability Imperative, because the reliability-enhancing work it requires cannot be delayed. This work will also enable utilities and states in the MISO region to invest in the type of infrastructure that is needed to meet energy needs and policy objectives going forward.

MISO recently published a report on our website entitled "MISO's Response to the Reliability Imperative" (attached as Appendix B). MISO's response is holistic in approach, consisting of numerous efforts and initiatives that are designed to work in concert with each other to mitigate the challenges facing the region. MISO organizes this work into four main categories: (1) Market Redefinition, (2) Long Range Transmission Planning, (3) Operations of the Future, and (4) Market System Enhancements. Below is a brief look at each.

1. **Market Redefinition:** The initiatives in this category aim to ensure that resources with the types of capabilities and attributes the system needs will be available in all 8,760 hours of the year. This is important because as noted above, the region is increasingly facing reliability risks outside of the summer peak-load months that have historically posed the greatest challenges. Specific efforts in this area include providing a longer-term and deeper assessment of system needs across all hours of the year, including required capabilities such as flexibility, shifting to verifying sufficient generation adequacy across all hours of the year, improving how resources are accredited, ensuring that prices accurately reflect market conditions, especially during emergencies, and development of market products that provide the right incentives for resources to maintain system reliability.

2. **Long Range Transmission Planning:** This effort is designed to identify what electric transmission the region will need going forward as the electric industry continues to evolve. For example, building additional electric transmission is especially crucial to support the continued growth of large-scale wind and solar, since those resources are often located far from load centers. A robust electric transmission plan can also reduce the cost of electricity for consumers by signaling better locations for resource siting that deliver fuel cost savings, decarbonization, and flexibility.

3. **Operations of the Future:** This effort is designed to ensure that MISO will have the kinds of skills, processes, and technologies it will need to effectively manage both wholesale and retail connected resources. For example, this initiative will leverage artificial intelligence, machine learning and advanced analytics among other tools to help future MISO control-room operators effectively forecast, visualize, and manage grid uncertainty. It will also help MISO to better manage maintenance and "pre-position" the grid ahead of system changes such as weather.

4. **Market System Enhancements:** This category of work is designed to transform MISO's historical system—which was built in the early 2000's—into a more flexible and secure system that will meet the needs for years to come. Current systems and technology are not capable of accommodating the increasing demands for new, reliability-driven market enhancements and fully leveraging the opportunities of new resource types such as storage and residential generation options (like rooftop solar) to meet future challenges. This initiative will employ flexible architecture and analysis to support the evolving resource mix and future-state processes for operating MISO markets.

6. Figure 2, on page 12 of your testimony presents a scenario for build out to 40% renewables: can you walk through what the chart is showing us?

RESPONSE:

As part of its effort to understand and plan for a future with higher shares of renewable energy, MISO first needs to forecast such a system prior to conducting detailed analysis. The image on the left of Figure 2 presents the system in the near future where 10% of energy is served by wind and solar resources across the connected electric system (MISO is currently at 12% and was at 9% when this analysis was conducted), while the image on the right presents one where 40% of the energy is served by wind and solar. Detailed forecasting techniques were used to develop this scenario, as can be seen in the referenced document on the same page.

a. Is there an estimated timeframe for this build out?

RESPONSE:

MISO is operating 25GW of wind resources today, which accounts for approximately 10% of the annual energy mix. Additionally, 15GW of renewable resources (5GW of wind and 10GW of solar) have executed Generation Interconnection Agreements with MISO and are in various stages of construction and testing. Most of those resources are expected to be energized over the next three years, at which point renewables will account for approximately 20% of MISO's annual energy mix.

Based on the planning work we have conducted with our members and states, we currently forecast MISO reaching 40% of its annual energy between 2033 and 2040. The large time range is due to the uncertainty of items such as technological innovation, public policy, member and customer preferences, environmental regulation and other factors.

b. From the table, it looks like to meet the 40% renewable goal, a substantial amount of renewable generation would have to be constructed. Can you elaborate what it would take to connect all of this generation into the bulk power system?

RESPONSE:

It will take a significant investment in electric transmission infrastructure. MISO has the advantage of a diverse geographic footprint with some of the best wind and solar resources in the country, but still it takes a lot of wind and solar capacity to replace gas and coal generators. On a project-by-project basis, MISO is working with stakeholders to accelerate the interconnection study and contract timeline.

In some areas, particularly those with the strongest wind resource potential in the North region, MISO has already reached that interconnection limit. To address this barrier, MISO launched the Long-Range Transmission Planning (LRTP) effort to identify investments in transmission projects addressing all needs of the region as the resource fleet continue to evolve. The LRTP seeks to ensure an optimized MISO transmission system to enable the changing generation portfolio across the short- and long-term horizons. The LRTP initiative is intended to develop a comprehensive plan that uses a set of future scenarios (developed jointly with MISO stakeholders) to address regional and sub-regional transmission issues and needs. The initiative is intended to holistically incorporate reliability and economic planning processes and perspectives with future generation needs and expectations.

Along with physically connecting these new resources to the Bulk Electric System (BES) other integration challenges present themselves in the form of market and operational challenges. The unique nature of wind and solar resources requires MISO to focus on improving system flexibility, stability, visibility and availability. Diverse efforts are underway, and many more are needed, as part of MISO's Reliability Imperative to proactively solve these challenges to maintain and enhance reliability and value creation across the MISO region.

7. Figure 3 of your testimony at page 13 presents images to convey the "dynamic stability" and complexity. Can you walk through what this means for us?

RESPONSE:

This section is meant to highlight emerging risks to the electricity sector and specifically the MISO region. The most prominent emerging risk that presents new challenges to the way the power system needs to be planned and operated deals with "dynamic stability". "Stability" means that the physical phenomena of producing, transmitting and consuming electric power is done in a constant and predictable manner. "Dynamic" refers to the time-varying aspect of the physical phenomena. When the system is not stable it exhibits oscillatory behavior, which could lead to system blackouts.

The grid's ability to maintain a stable voltage will be challenged by the displacement of conventional units in a high-renewable penetration system, particularly in wind-rich remote areas. The current technology of wind and solar may not be able to mitigate voltage-related risks fully. Furthermore, the substitution of renewable resources for the existing conventional generation may compromise the system's ability to maintain reliable frequency after losing a large generator. It is likely that multiple non-traditional technologies will need to be developed and deployed to address these concerns and maintain reliability.

System integration complexity in the general sense is the work needed to plan for and operate new resources as they connect to the grid. All resources cause a change in system complexity, but the type and volume of change manifests itself differently depending on the unique attribute of the new resource. MISO's work seeks to measure this change to get a holistic understanding of how renewable wind and solar resource integration will affect the power system. For the purpose of discussion, complexity needs to be quantitatively measured in order to compare across various drivers of complexity, along with understanding its relative magnitude. MISO's work finds that as the integration of wind and solar renewable resources grows, the type and magnitude of complexity changes and increases significantly after 30% of the load is served by wind and solar resources. For a detailed description of the

work, please see: https://www.misoenergy.org/planning/policy-studies/Renewable-integration-impact-assessment/#t=10&p=0&s=&sd=.

a. What does this mean for the electricity consumer?

RESPONSE:

It is uncertain what the ultimate impacts on consumers will be. However, these changes will be costly and could impact reliability, if not done thoughtfully. Integrating renewable wind and solar resources into the grid presents unique challenges due to their unique physical and operational characteristics. In order to reliably and efficiently integrate larger amounts of renewable resources into the system, the way in which the grid is planned and operated must change.

MISO views it as imperative that proactive change occurs and is supported before large amounts of wind and solar are connected, in order to prevent future issues. The integration of wind and solar carries with it many costs and benefits. MISO is not in a position to determine what the future generation fleet should be or what the resulting impacts are to consumer prices. However, MISO can help inform the transition to ensure it is done in as reliable and value-creating a manner as possible.

8. You present the large challenges for building out to 40% renewables, how do these challenges increase as you move to 50%?

RESPONSE:

As the percentage of renewables grow on the system, the challenges continue to increase. It is important to note that this is not a linear progression, but more of an exponential increase in the level of the challenge. So, moving from zero to 10% renewables is relatively simple, while moving up each 10% step after that, in a manner than maintains equivalent levels of reliability, is substantially more difficult than the prior step.

As the annual share of renewable energy reaches 50%, more frequent periods are seen with nearly all the load is met by wind and solar. During these periods, the need to actively manage renewable variability coupled with load variability becomes paramount.

Traditional fossil generators have large rotating equipment that effectively smooth the output of the units and establishes the system's 60 hertz frequency. The size of these units' rotating

components acts as a natural stabilizer for the grid. In contrast, renewable generation uses electronic controls to establish their 60 hertz frequency output. The nature of these electronic controlled renewables allows them to come on and offline very rapidly. The system-wide effect of replacing rotating machines with electronically control renewables is increased concern with system frequency-based reliability issues. These changes lead to very different reliability risks than those we experience today at about 10% renewables, but an intensification of the risks that will be present when we are at 40% renewables.

The risk of not having enough available resources to serve load becomes highly concentrated into periods of low renewable availability and relatively high load conditions. These are late evening, hot summer, high air conditioning periods and early morning, cold winter, high heating periods. Additional resources are needed to make up these deficient periods, leading to a lowering capacity value for wind and solar resources.

This period (40% – 50%) of renewable growth is not so much characterized by new risks emerging on the system, but rather the continued intensification of issues that emerged in prior periods of renewable growth. The value of effectively and efficiently solving for these risks greatly increases.

a. How do they increase as you move to 80%?

RESPONSE:

As mentioned above, each increase in renewables level is substantially more difficult than the prior level. MISO has done very limited work looking at levels as high as 80%. However, utilizing technologies that are available today, it is unlikely that the system could be reliably operated with this level of renewable generation. While technologies such as green hydrogen generation and long-term storage batteries are under development, time will tell as to whether they can enable this level of renewable penetration.

b. What are the challenges you see as the penetration of renewables increases further?

RESPONSE:

MISO anticipates that challenges will increase, and new ones will emerge. MISO engages broadly with government agencies, research labs, academia, and industry partners to understand future system challenges. Examples of challenges seen by that work for high share renewable systems include long periods of low wind and solar

output, and systems designed with nearly all devices being inverter-based rather than rotating machines, leading to stability and control issues.

9. It appears from the chart you shared in your testimony that the 40% renewable scenario will require a tremendous amount of new construction. In the MISO footprint alone, you would need about 20 times more wind capacity and about 14 times more solar capacity, not to mention the hundreds, if not thousands, of miles of new transmission lines to connect to the grid.

    a. Do you expect challenges associated with infrastructure siting and land use?

    RESPONSE:

    Yes, while the responsibility for siting lies with the Transmission Owners and States, we do expect siting of new electric transmission will remain a significant challenge. The amount of land required to move to a more carbon free energy infrastructure will be significant. To that end and to reduce the cost of transmission investments, where practical, MISO will seek to utilize existing right of way in the development of its Long Range Transmission Plan. This also will provide an opportunity to improve grid reliability and resiliency by replacing aging lower voltage facilities with higher capacity new construction.

10. As an RTO/ISO, MISO doesn't have the luxury of setting the policy, but you still have to make sure the lights stay on. With 15 States setting different policies with different goals in mind, how do you approach your responsibilities?

RESPONSE:

While our region's diversity can at times be a challenge, it also affords great opportunity. Each state and region within the MISO footprint is blessed with a different set of natural resources. Some areas such as Iowa and western Minnesota have an abundance of good quality wind resources. While others like our Gulf Coast states, have access to low cost gas. Still others have good solar resources or ready access to low-cost coal. By aggregating across a broad region, MISO can take advantage of a diverse resource mix that leverages the characteristics and advantages of each resource while simultaneously mitigating the disadvantages of each. This integration works to make the integrated whole more reliable, more cost effective and over time much less carbon intensive than is possible if the different utilities and states aren't leveraging their local resources effectively or are trying to do so independently of each other.

To this end, we leverage a robust stakeholder process and a regional executive model in our organization for maintaining a close understanding of the needs and policies across the footprint. This is not intended to minimize the challenge we face, which is indeed significant. Our Reliability Imperative program is a comprehensive framework to meet the emerging challenges we see with the significant portfolio changes we are experiencing. Our Reliability Imperative report further describes the many interconnected efforts that MISO is pursuing in the realms of markets, operations, planning, and systems to meet the challenges we face from the changing industry and policy landscape.

a. Are there ways that the Federal government, acting through FERC, could support your efforts?

RESPONSE:

FERC's support is most valuable in the flexibility it affords us to accommodate our unique regional challenges. We have appreciated efforts by FERC to continue to allow our states to retain primary responsibility for the regions' resource adequacy solutions. As previously mentioned, we currently face a Reliability Imperative to meet the challenges of the changing resource mix and policy goals of our member utilities and states. As part of that effort, we intend to work cooperatively with stakeholders in our Reliability Imperative initiative to identify changes needed in our markets to help support this transition. FERC has been very supportive of this effort thus far, and we hope that support continues with the approval of some significant proposals we intend to bring forward in 2021.

As states exercise their responsibility for resource adequacy, it is important that they can address the transmission challenges as a component of that task. Any effort to separate those efforts makes each task substantially more difficult. We would urge FERC to enable the states to fulfill these tasks concurrently. For example, implementation of Order 1000 has greatly complicated the transmission planning, siting and development issue. We expand further, with question 11, on some of the challenges associated with the implementation of Order 1000.

We would encourage increased flexibility by FERC to allow regions to identify cost allocation, planning and competitive transmission frameworks that may more effectively advance transmission infrastructure development needs. The strict construction of Order 1000 can limit the flexibility to identify potential solutions that can gain widespread support among key stakeholders and state policy makers.

Flexibility by FERC in the implementation timelines of their mandatory rules involving emerging technologies is also helpful. We are currently upgrading our computer technology systems that provide the foundation of our market and reliability operations. At the same time, we need to prioritize incremental tools to address reliability and market challenges we are facing on this existing, overburdened platform. We have appreciated the flexibility afforded thus far by FERC to prioritize projects of the most urgent reliability and market value given our footprint's unique make up.

We are working with several sister RTOs to develop that more robust and flexible platform which will be well-suited to effectively incorporate the new technologies and market operations that will help us meet future reliability challenges. We are excited about the long-term capabilities of storage resources and distributed energy resources. As FERC continues to mandate new requirements on RTOs, we would appreciate their continued sensitivity to the resource constraints of our current systems as we strive to make the transition to a new, robust platform.

Finally, we would encourage FERC to be thoughtful when it creates rules that are different for RTO regions and non-RTO regions. While there are large consumer benefits to RTO membership, there are many utilities and regions that are looking for reasons to avoid joining. The creation of increased regulation on RTO regions provides them with just the rationale they need to avoid membership.

11. Just before FERC issued Order 1000, MISO approved about $6 billion in new transmission called Multi Value Projects. Could you describe that process and the results? Does FERC Order 1000 make something like the MVP process easier or harder?

RESPONSE:

MISO's value-based planning process contemplates planning for transmission needs over multiple horizons. The Multi Value Projects (MVPs) were the result of MISO and stakeholder's efforts to take a long term look at what was needed to enable the resource portfolio evolution we contemplated in 2006.

MISO's long term planning process looks out fifteen to twenty years and is designed to periodically assess whether industry trends, such as those driven by changing economics and public policy objectives, are creating the opportunity or need for large-scale, regional transmission plans, and to inform nearer-term investment decisions. A scenario-based approach is employed, using a range of potential outcomes to "bookend" the uncertainty associated with various factors that can influence future system needs and thus transmission

system design. Variables that are assessed across those different potential outcomes, or futures, include: fuel prices; electricity demand growth forecasts; generation retirements; state and federal policy impacts; and capital costs of new generation. Futures are created or refreshed on an annual basis to provide a range of views on where the generation mix may evolve. Transmission is planned against these future scenarios, benefits are quantified, and projects whose benefits exceed costs by predetermined thresholds across the scenarios are considered no-regrets investments as they hold up economically against various potential future states, mitigating policy uncertainty.

The process concludes with cost allocation determined by assessment of beneficiaries consistent with the project driver or purpose. The MVPs were determined to provide effectively equivalent benefits to all regional entities due to the high capacity and regionally distributed portfolio. Thus, costs were widely shared across the region in what became known as the postage stamp. Where costs are shared between multiple parties, amounts are based on how much each entity benefits from the project. Ultimately, this question of who pays is the most challenging aspect of the regional planning process. Recommending any large transmission project requires a robust business case and a fairly high level of alignment among stakeholders; specifically, MISO stakeholders must be aligned in the belief that the project will provide the expected benefits, and that the expected distribution of the costs will fairly match the expected distribution of the benefits.

As states in the Midwest were passing Renewable Portfolio Standard mandates and goals, we recognized the growing need for transmission to more economically and reliably deliver the new resource mix that was occurring due to the policy changes. However, a lack of clarity regarding future policy direction and decisions made investing in long-lead transmission lines risky. The planning process described above, in conjunction with Midwest Governor and State Regulator leadership on assessing transmission need, and determining how to share the costs, was essential to the success of the MVPs. The leadership and engagement from the states provided a path to facilitate needed grid investments despite that uncertainty. The approach sought to provide regional backbone transmission in advance of a specific resource need (“build it and they will come”) to ensure greater efficiency in transmission build by thinking about the transmission needs holistically. This approach also provided hope that transmission, which has a longer lead time than generation, could be available to meet generator needs. The MVPs which were made up of seventeen projects, with most states in MISO’s North and Central Regions being home to at least one, were approved by the MISO Board of Directors in 2011. Sixteen of the seventeen projects have been placed in service.

Although MISO’s administration of the competitive bidding process has been successful, the introduction of competitive bidding for transmission through FERC Order 1000 created new

business interests and created different paradigms for projects with cost allocation versus those without. Competitive bidding would have created additional challenges to developing the MVPs. The success of the MVPs depended on collaboration and consensus. These efforts become increasingly difficult if the parties involved are competing.

For reasons such as these, along with a broad sense of uncertainty for the future, finding consensus among so many diverse viewpoints on system needs, and who should pay for those system changes, is a significant challenge in planning for additional large scale transmission investment in the MISO region. Based on our experiences, the MVP portfolio would not have been possible if the process had begun under the constraints of Order 1000.

Finally, it is important to note that when the MVP process was completed, MISO had not yet integrated its Southern Region. The addition of another region with its own unique political and operational characteristics further complicates the planning process.

Nonetheless, MISO currently has two studies underway that will again address a significant resource portfolio shift. MISO is developing a Long Range Transmission plan which will utilize the steps outlined in the MISO long term planning process to develop transmission projects that will enable the resource portfolio changes currently contemplated by our members. MISO also recently initiated a joint study with The Southwest Power Pool (SPP) to address long standing issues along our Nebraska-Iowa and Kansas-Missouri seams. We look forward to working creatively with stakeholders and state policy makers to identify paths forward to address concerns surrounding identification of beneficiaries, allocation of costs and the determination of transmission project developers.

12. Could you describe the value-based pricing you mentioned? Does it require FERC approval?

RESPONSE:

When wholesale electricity markets were developed in the early 2000's, coal accounted for three quarters of regional generation, with the remainder primarily from nuclear and gas. Markets were designed to send price signals that were equal to or greater than the operating cost of those traditional generators, thereby giving an incentive for generators to provide energy and grid supporting services when needed. Market prices also signaled the types of resources and capabilities that would be needed in the future. Wind and solar have zero operating cost and result in much lower market prices, in some cases prices that are below the operating cost of additional resources needed to supply energy when wind and solar generation is insufficient to meet total system demand. Market prices in such instances do not provide the necessary incentive for these needed additional resources operate and supply

the grid. Markets must be reformed to ensure prices reflect the value of all resources needed for reliable operations thereby ensuring supply is available to meet demand and reliably operate the grid in every hour.

These changes will require FERC approval. As these changes are considered, it is important to recognize that markets are complex and must be looked at as a comprehensive, coordinated system. As FERC considers individual market changes, it must take into account that complete system including where that system is moving- going forward.

13. The Southwest Power Pool, the RTO next to MISO, reported this summer a record output of 16,283 MW of wind power that served 48 percent of its load on one day in December this year. A day later, wind shrank to 17 percent of its generation mix, which required other sources like coal and gas to ramp up to serve load. In another instance in March, SPP reported a swing of 13 gigawatts of electricity in just 22 hours.

    a. What is your experience with wild swings in wind generation?

    RESPONSE:

    The largest contribution wind has provided to MISO system load is 33% of the load (this is an hourly integrated number) and that occurred on November 15, 2020 when MISO set a new instantaneous wind production high with 18.9 GW of wind output. The largest absolute swing of production over a 24 period has been a 14.7 GW reduction in production. The following table provides generation swing information for various time frames. These swings may be dampened because of curtailment of wind production to manage congestion on the system.

	1 HR CHANGE	4 HR CHANGE	8 HR CHANGE	24 HR CHANGE
MAX UP **(GW)**	3.1	9.2	10.5	13.8
MAX DOWN (GW)	5.1	11.6	12.3	14.7

Although not a “wild swing” in wind generation, we have seen a 20+ GW fleet produce less than 100 MW for 40 hours straight in January 2020 with some of those hours being negative due to auxiliary power needs for cold weather packages on the turbines.

Forecasts are usually adequate to allow us to anticipate production changes. However, during the polar vortex impacts of January 2019, extreme cold temperatures created "cold weather cutouts" and forecasts missed that production reduction by 7 GW.

As we add additional wind resources and begin to integrate similar levels of solar resources into the generation mix, this variability and volatility will continue to grow.

b. Does this demonstrate the value of a diverse fuel mix to ensure reliability under different circumstances?

RESPONSE:

Absolutely. As growing levels of renewables increase the level of variability and volatility on the system, controllable, flexible resources are needed to manage reliability and to meet the demands of load. Among currently available resources, gas generation best meets this growing need. It is the most flexible, economic and plentiful of the available resources. Coal can meet some of the need, but it typically requires more lead time to respond and is not as flexible. Hydro is another source of flexibility but is not plentiful in our region. Finally, storage is other potential source. However, current storage technologies are relatively very expensive and are significantly time limited in their ability to sustain their output to meet the needs of the system. For instance, think of the 40-hour period referenced in 13a when virtually no wind output was available. A battery that is depleted in four hours is not an effective solution.

c. How does transmission expansion address this?

RESPONSE:

Transmission expansion can enable you to leverage the diversity of resources available across the region to increase both reliability and cost efficiency. A robust transmission system allows us to use generation from our wind rich northern states to provide low cost energy to our southern states when the wind is blowing. It also allows us to reverse those flows in periods when the wind is not blowing, importing energy produced by low-cost Gulf Coast gas to serve load in the northern states.

Transmission is a necessary means to ensure reliability in a high renewable penetration energy system. Regional connectivity through transmission provides the ability of the system to reliably respond to the rapid fluctuations in resources over short periods of time. High penetration levels can be met reliably with appropriate

additions of transmission and regional siting of resources. Our current long-range transmission planning initiatives are a part of our comprehensive planning processes and are identifying the transmission needed to reliably meet these high levels of renewable-based energy. MISO's transmission planning process examines the near, mid, and long-term aspects of transmission expansion. The process also includes the evaluation of transmission alternatives to address system issues. On a near term basis we look at system needs in the 1 to 10-year horizon. These are typically projects that are needed to meet reliability standards, and or to replace aging infrastructure. These projects are typically implemented within 2 – 5 years. On a mid-term basis we assess system congestion over the 5 – 15-year horizon and develop transmission plans that reduce or eliminate the congestion to enable customer access to lower cost electricity through the market. Long term planning considers the 20 year and beyond horizons to ensure an efficient build over time. A transmission system that is robust and diverse is essential to support the types of fluctuations we expect to see with the changing resource mix.

14. You state that "we can no longer be confident that the traditional approach of marginal cost pricing will provide adequate financial incentives to prompt utilities…to build the kinds of resources—with the right kinds of attributes—that the system needs to keep operating reliably going forward."

    a. Do the wholesale markets associated with your system need reform to address future reliability?

    RESPONSE:

    Yes. As discussed in 12, MISO's current market design uses marginal operating costs as the basis for its primary price signal to generators. This worked well to optimize the commitment and dispatch of traditional generators, but as noted above it does not work well as the number of renewable generators with near zero marginal operating costs are entered into the mix.

    A further issue is that our current market and reliability planning is focused on ensuring adequate resources are available during the peak load period for the year. This was appropriate given the characteristics of a traditional generation fleet. However, the characteristics of renewable generators is much different, and we must adjust our planning to account for those changes.

A focus of MISO's Reliability Imperative's Market Redefinition initiative ensures that resources with the types of capabilities and attributes the system needs will be available in all 8,760 hours of the year. This is important because as noted above, the region is increasingly facing reliability risks outside of the summer peak-load months that historically posed the greatest challenges. Specific efforts in this area include providing a longer-term and deeper assessment of system needs across all hours of the year, including required capabilities such as flexibility; shifting to verifying sufficient generation adequacy across all hours of the year; improving how resources are accredited; ensuring that prices accurately reflect market conditions, especially during emergencies; and development of market products that provide the right incentives for resources to maintain system reliability. Markets must be reformed to ensure prices reflect the value of all resources needed for reliable operations thereby ensuring supply is available to meet demand and reliably operate the grid in every hour.

b. This Committee in the last Congress started looking at these issues, during its Powering America hearing series. Would it make sense for Congress, where appropriate, to address these issues and "fix" the system before imposing whole new mandates and incentives on the system?

RESPONSE:

It would not make sense to 'fix' an issue and then issue a new mandate or incentive that then negates the work done to implement the 'fix.' But that is not to say that immediate fixes of some things are not appropriate. What should be remembered is that grid assets are long-lived, so what is done today may be around for another forty years. It also takes time to change the electric system, and new generation, new transmission and new technology will be needed to operate an advanced system. In addition, there should be a consensus about the direction to move the system because different end goals will change what kind of system is developed over time. Finally, the electric system must be looked at holistically - changes to the generation mix drive changes to the transmission system and vice versa, and both require will new technologies and operating procedures to operate the system reliably, efficiently and cost effectively. This is the reason for the Reliability Imperative program that MISO is engaged in now.

Finally, MISO would encourage Congress to continue to monitor and guide the role of FERC. We believe FERC is at its best when it: 1) respects states' rights particularly with regards to resource adequacy and transmission; 2) acknowledges and respects regional differences and the solutions those differences require; and 3) consistently applies rules between RTO and non-RTO regions.

MISO'S RESPONSE TO THE RELIABILITY IMPERATIVE

- DECEMBER 2020 -

Living Document

MISO is releasing this report as a "living" document which will be updated over time as conditions evolve and as MISO, stakeholders, and states continue to learn about the Reliability Imperative

misoenergy.org

Contents

A Message from John Bear, CEO

The electric industry is changing in profound ways.

The industry's longtime reliance on conventional baseload power plants is declining sharply, driven by economic factors and consumer preferences for clean energy, among other things.

Meanwhile, the grid is becoming increasingly reliant on wind and solar resources that are available only when the wind is blowing, or the sun is shining.

To be sure, there are upsides and opportunities associated with these trends. But the changes we are seeing also pose a host of complex and urgent challenges to electric system reliability in the MISO region.

Utilities, states, and MISO all have roles to play to address these challenges. MISO calls this shared responsibility the **Reliability Imperative.** We think the word "imperative" is appropriate for several reasons. First, the work we are doing is not optional—to maintain system reliability, we must respond to the unprecedented change we and our members face. Second, this work cannot be put off for months or years—much of it has long lead times, so we need to act now. And third, our stakeholders are counting on us—regulatory agencies, utilities and other entities are looking to MISO to identify problems and find solutions.

This report describes the many interconnected efforts that MISO is pursuing in the realms of markets, operations, and planning to meet that charge. The report is also designed to be "living" so it will be regularly updated and expanded as we learn more and our path forward becomes clearer.

The energy industry and our region are changing in big ways, and MISO is planning for what lies ahead. We hope you will find this report to be engaging and useful as we confront these new challenges and opportunities together.

Thank you,

Executive Summary

THE REGION IS CHANGING IN BIG WAYS

The electric system is increasingly fueled by wind and solar, driven by favorable economics for energy production, technological advances, state policies, and consumer preferences for carbon-free energy, among other things.

Looking at the marginal cost of energy produced, wind and solar are lower cost than coal, nuclear, or natural gas generation. As a result, the growth of these renewable resources continues to replace the region's conventional baseload resources that constituted the backbone of the region's electric system for decades.

There are many system and societal benefits of these changes. Innovative generation and grid technologies have the potential to reduce customer rates and bring efficiencies to the system. The shift to cleaner fuels will benefit the health of our communities and is key to addressing the risks of a changing climate. With a diverse regional footprint and managing all of the connections with our seams neighbors, MISO is well-positioned to support our members as they transition their fleets.

THESE CHANGES WILL CHALLENGE SYSTEM RELIABILITY

While MISO is policy-neutral on these and other trends, MISO has observed they pose a number of significant challenges for the region's electric system and we must adapt to maintain required and expected levels of reliability. As the independent system operator, MISO has responsibility to maintain electric reliability, which it does by addressing the holistic needs of the system – for example for energy, capacity, resource adequacy, and flexibility.

Each resource type provides a different mix of these capabilities. As the region's resource mix changes, we must understand what capabilities are needed to maintain reliability and ensure that sufficient amounts of those resource capabilities are available when needed.

- Wind and solar resources are not always available to provide energy during times of need.
- Conventional baseload resources that remain in service can be more prone to outages given their changed usage patterns and maintenance cycles, rendering them potentially unavailable when they are needed most.

As the system relies more on renewables, the region is also becoming more dependent on resources connected to local distribution systems or located behind customer meters, as well as

on demand-side resources that currently are only used in emergencies. Generation fleet change and extreme weather are increasing risk across the entire year (not just in the summer). MISO's Renewable Integration Impact Assessment concludes that the complexity of planning and operating the grid increases exponentially beyond 30% of the load being served by wind and solar, requiring more coordination and advanced action to maintain grid stability at higher renewable penetration levels. Already there are areas within the MISO system where local renewable penetration is above 30%.

WE HAVE A RELIABILITY IMPERATIVE TO ADDRESS THESE CHALLENGES

MISO, members, state regulators, and other entities responsible for system reliability all have an obligation to work together to address these challenges. MISO calls this shared responsibility the MISO Region Reliability Imperative because the reliability-enhancing work it requires cannot be delayed. This work will also enable utilities and states in the MISO region to invest in the type of infrastructure that is needed to meet energy needs and policy objectives going forward.

This report lays out MISO's response to the Reliability Imperative. MISO's response is holistic in approach, consisting of numerous efforts and initiatives that are designed to work in concert with each other to mitigate the challenges facing the region. MISO organizes this work into four main categories: (1) Market Redefinition, (2) Long Range Transmission Planning, (3) Operations of the Future, and (4) Market System Enhancements. Below is a brief look at each.

1. **Market Redefinition:** The initiatives in this category aim to ensure that resources with the types of capabilities and attributes the system needs will be available in all 8,760 hours of the year. This is important because as noted above, the region is increasingly facing reliability risks outside of the summer peak-load months that historically posed the greatest challenges. Specific efforts in this area include providing a longer-term and deeper assessment of system needs across all hours of the year, including required capabilities such as flexibility; shifting to verifying sufficient generation adequacy across all hours of the year; improving how resources are accredited; ensuring that prices accurately reflect market conditions, especially during emergencies; and development of market products that provide the right incentives for resources to maintain system reliability.

2. **Long Range Transmission Planning:** This effort is designed to identify what transmission the region will need going forward as the electric industry continues to evolve. For example, building additional transmission is especially crucial to support the continued growth of large-scale wind and solar, since those resources are often located far from load centers. A robust transmission plan can also reduce the cost of electricity for consumers by signaling better locations for resource siting that deliver fuel cost savings, decarbonization, and flexibility.

3. **Operations of the Future:** This effort is designed to ensure that MISO will have the kinds of skills, processes, and technologies it will need to effectively manage both wholesale and retail connected resources. For example, this initiative will leverage artificial intelligence, machine learning and advanced analytics among other tools to help future MISO control-room operators effectively forecast, visualize, and manage grid uncertainty. It will also help MISO to better manage maintenance and "pre-position" the grid ahead of system changes such as weather.

4. **Market System Enhancements:** This category of work is designed to transform MISO's historical system—which was built in the early 2000's—into a more flexible and secure system that will meet the needs for years to come. Current systems and technology are not capable of accommodating the increasing demands for new, reliability-driven market enhancements and fully leveraging the opportunities of new resource types such as storage and residential generation options (like rooftop solar) to meet future challenges. This initiative will employ flexible architecture and analysis to support the evolving resource mix and future-state processes for operating MISO markets.

PURPOSE OF THIS REPORT

The purpose of this report is to provide MISO stakeholders with an organization-wide view of MISO's plan to address the Reliability Imperative amidst a rapidly changing energy landscape. The goal of this "living" report is to lay out the context for critical Reliability Imperative initiatives, how they fit together, feedback plans and project timing. This "living" report will be updated with accompanying materials as specific plans mature and additional information is gathered.

While grid operators have managed uncertainty for decades, and MISO has continuously pushed to improve and evolve since day one, we are preparing for an unprecedented pace of change. By actively pursuing this strategic collection of coordinated initiatives, MISO will ensure ongoing system reliability while enabling members' future plans. There is a huge amount of work to do and we will only succeed if we move forward transparently, collaboratively and swiftly.

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 assess resource adequacy more than once a year and to improve how resources are accounted for are discussed at the MISO Resource Adequacy Subcommittee.
- Similarly, MISO initiatives for emergency pricing and the Market System Enhancement effort reflect input at the MISO Market Subcommittee.
- Member plans and stakeholder input shaped the MISO Futures planning scenarios over multiple workshops.

Other proposals in this report are not in the stakeholder process because they are in development and not yet ready to be discussed with stakeholders or they are focused on internal MISO processes.

THE RELIABILITY IMPERATIVE DOES NOT REPLACE EXISTING INITIATIVES OR PROGRAMS

This report, and the initiatives it describes, should not be viewed as a brand-new effort by MISO. The Reliability Imperative is not intended to replace existing initiatives that stakeholders are already familiar with. Instead, this report brings together a number of strategic initiatives with the purpose of ensuring more alignment and highlighting the connections.

That said, this report is written from MISO's perspective. Not every proposal and initiative in this report will be supported by every one of MISO's stakeholders, given the range of policy goals, business models, and other interests. MISO welcomes feedback on this report but MISO also recognizes that the Reliability Imperative warrants an immediate response. The time to act is now.

Informing MISO's Response to the Reliability Imperative

MISO's response to the Reliability Imperative has been informed by years of conversations with our stakeholders. Additionally, MISO has performed extensive modeling of the changing risk profile. To review:

MISO Forward 2019: The first of the Forward series described the implications of a changing resource mix, including how the '3Ds' – de-marginalization, decentralization, and digitalization – led to MISO's focus on enhancing Availability, Flexibility and Visibility ("AFV"). You will find these themes in the Reliability Imperative initiatives. These AFV themes have informed much of the following MISO work.

MISO Forward 2020: The MISO Forward 2020 report shows that changes will not be the same across all members, as different states and utilities adopt a range of business models and generation, all of which MISO will support through the Reliability Imperative work.

Renewable Integration Impact Assessment (RIIA): MISO's 4-year initiative to understand the impacts of increasing renewables on the MISO system. The key conclusion is that planning and operating the grid becomes more difficult beyond 30% of the footprint-wide load being served by wind and solar, and that with coordination and advanced action the MISO region could achieve 50% or higher. The workshop materials are available now, and a report will be published in early 2021.

Resource Availability and Need (RAN) Initiative: Ongoing analysis of MISO's changing risk profile and evolving system needs as outlined in five whitepapers. The analysis has informed changes to the value of wholesale load that can respond to the market and plant outage coordination, and development of resource adequacy changes. Because Resource Adequacy must compliment market design and real-time tools/process, the work is central to the Reliability Imperative effort.

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 this year with the annual transmission

planning cycle, these forward-looking planning scenarios are being used throughout the organization to prioritize and pace the Reliability Imperative work.

MISO Forward 2021: To be published early 2021, the next report in the Forward series will focus on what changes are needed from MISO as adjacent industries, such as buildings and transportation, evolve how they interact with the electric ecosystem. The Reliability Imperative will remain closely in step with these expectations.

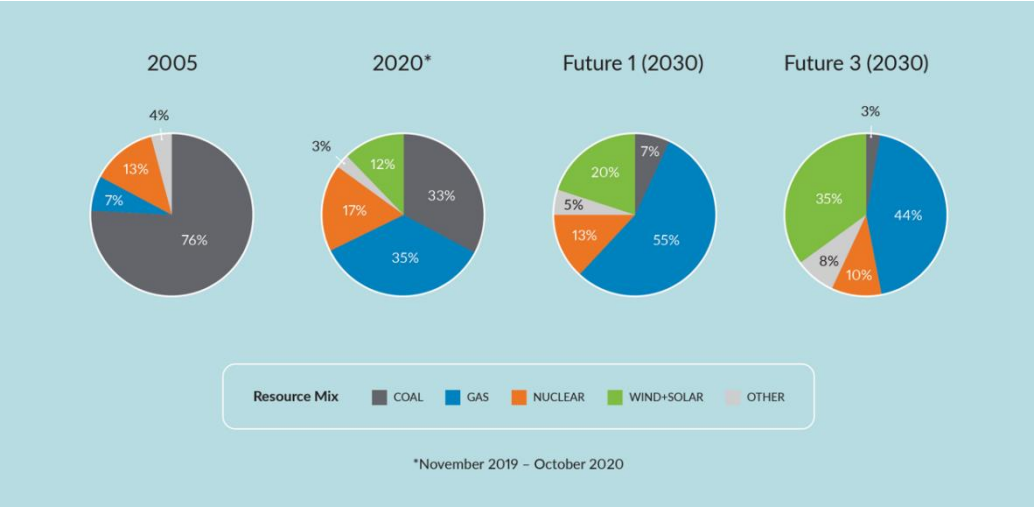
MARCH 2021 RELEASE

From this groundwork, we know that there are challenges ahead. But we can also see that there is opportunity for the large, interconnected footprint that MISO provides. We are determined to do the hard work required to ensure all of our members and their end consumers benefit from MISO membership.

The timing of much of the Reliability Imperative work will be impacted by the pace of new generation coming on the system. MISO has multiple views on the future generation fleet and, importantly, the speed of change being set by our members. MISO is currently operating a 25,000 MW wind fleet which, in MISO's most recent 12-month history generated 12% of the electricity mix (solar less than 1%). MISO is preparing for an additional 15,000 MW of renewables (10,000 MW of solar and 5,000 MW of wind) on the system in the next few years.

Beyond that, MISO looks to the MISO Futures modeling to capture the bookends of resource mix possibilities. The figure below shows 2030 planning scenarios for the conservative pace of change (Future 1) and the more aggressive pace (Future 3):

MISO Generation Mix (% of MWh)

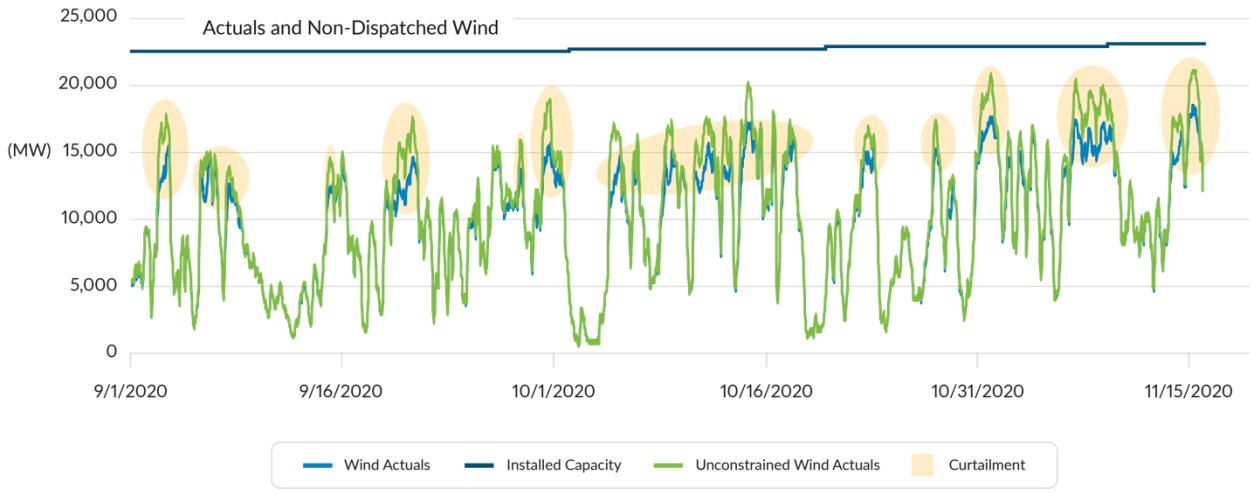


Current Reliability Challenges Will Become More Significant

> "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

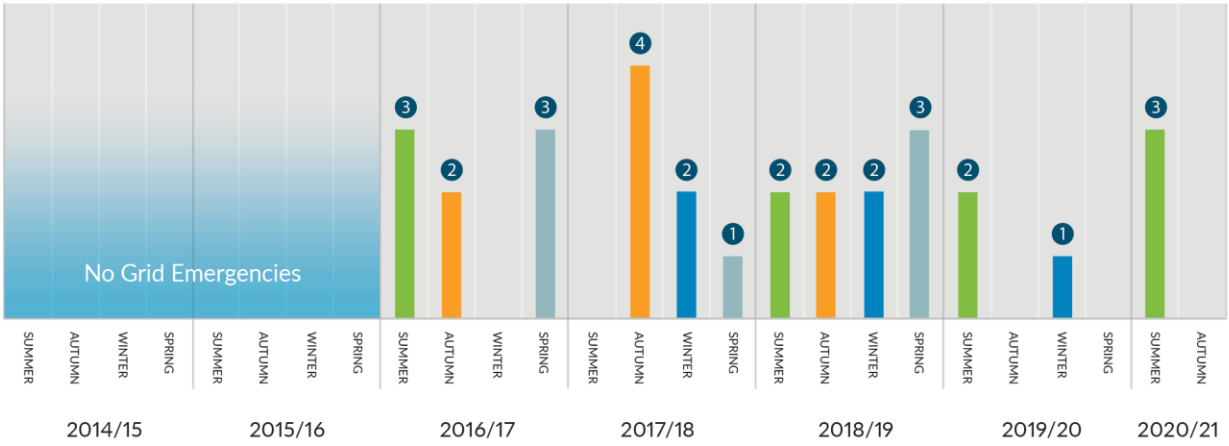
Real-time conditions in the last few years have been significantly different than the first 10 years of MISO operations. Power plant retirements, lower overall reserve margins, and increasing outage levels of conventional generation have required MISO to operate with less available capacity than in the past. A growing fleet of renewables that operate differently and, as the graphic below illustrates, can fluctuate on a day-to-day and even an hour-by-hour basis. At times of high wind output, transmission congestion is leading to increased levels of curtailment (highlighted by the orange circles in the chart below). Additionally, non-traditional resources such as load that can respond to system needs and energy efficiency are increasingly being used. And as the climate changes, history becomes a less reliable predictor of future conditions.

Recent Examples of MISO wind generation variability and curtailment



MISO has declared an increasing number of emergencies since the summer of 2016. While the emergency protocols are a legitimate way for MISO to access additional resources and not a direct indicator of a reliability issue, calling on them more and in non-traditional times are evidence of MISO's changing risk profile.

MaxGen Alerts, Warnings, and Events



Most events are the result of multiple factors happening at the same time. Factors include more planned and/or unplanned generation and transmission outages, high demand conditions, and more extreme temperatures and storms.

Market Redefinition

Generation mix evolution increases the focus on having enough energy for every hour of 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. Markets can provide useful signals across multiple time frames.

Resource Assessments: In the investment and planning timeframe, MISO should provide information to all members about the impact of their plans in aggregate. Today, planning is focused on the summer peak hour for the coming year or two. The voluntary Organization of MISO States (OMS) survey looks at several years ahead, but confidence is lower in the later years. Additionally, the OMS survey only focuses on capacity, but increasingly the system will need a forecast of flexibility and other attributesGoing forward, MISO is developing the ability to provide forward resource assessments and long-term resource adequacy reports to better inform future investment and retirement decisions.

Meeting Forecasted Needs: Currently, MISO utilizes both planning requirements and energy market price signals to inform investment decisions and pay resources for providing energy when most needed. Since 2017, the Resource Availability and Need (RAN) initiative has focused on near-term improvements in both planning requirements and energy markets. MISO, and the electric industry in general, are also considering the right balance between planning requirements and energy markets in ensuring energy is available in every hour of the year; for now MISO is focused on 'no regrets' modifications for both planning and markets. One important group of changes looks at updating how resources are accredited – including conventional, intermittent, and emergency-only resources.

Resource Adequacy Construct: In the planning horizon, MISO is looking to better reflect the changing risk profile. MISO's construct was designed around a conventional fleet of resources. In this system, outage risk was concentrated during the summer. Since the early 2000s, the fleet has moved to more renewable resources that are variable and outage risk has expanded beyond the summer months. MISO's mechanisms must be updated to reflect the changing risk. In the near term, MISO plans to make the Planning Resource Auction a "sub-annual" construct to reflect the changing risks. Importantly, the future Resource Adequacy construct will also need to be adaptable as the portfolio and risk profiles continue to evolve.

Increased Reliance on Energy Market Pricing: MISO is working to update prices to more accurately reflect the value of additional energy during times of system constraints. MISO is in

the process of improving emergency and scarcity prices to more accurately convey system conditions and help incent and ensure reliability in tight grid conditions. MISO will continue to evaluate the changing risk profile to assess the effectiveness of energy market products and pricing and will explore potential new products and approaches.

> "Market Redefinition means we need to consider the broad and transformative implications of the rapidly changing risk profile in MISO. This is driving our agenda to re-think the methods by which we assess reliability risk in the planning and operating horizons and the ways in which our markets incent and ensure availability and flexibility."
>
> Richard Doying, MISO EVP Market & Grid Strategy

MARKET REDEFINITION ACTIONS (BASED ON CURRENT INFORMATION)

	Explore	Decide	Do	Done
Resource Adequacy Construct	• Regional resource assessments of changing reliability risk profile	• Reliability requirements & metrics • Sub-annual construct • Accreditation enhancements		• Enhanced deliverability for conventional and intermittent capacity resources (Installed Capacity filings) • Load Modifying Resources Accreditation
Energy Market Signals	• Uncertainty and variability management • Emerging technology participation (e.g. hybrid and Distributed Energy Resources) • Optimize transactions at the seams (transmission & distribution interface, and bulk electric system)	• Improve scarcity pricing and price formation • Enhancements for long-lead units and self-commitments • Multiple Configuration Resources • FERC Order 2222 (Distributed Energy Resource) compliance plan • Enhance market-to-market coordination process	• Enhance emergency pricing • Build Short-Term Reserves product • FERC Order 841 (storage participation) product	• Multi-day Operating Margin forecast • Distributed Energy Resource Visibility and Communication whitepaper • Improvements to MISO-SPP & MISO-PJM market-to-market process

Long Range Transmission Planning

Renewables such as wind and solar work with the transmission system very differently than conventional power plants. For this reason, the ongoing trend of conventional resources retiring from service as intermittent renewables continue to grow poses significant challenges to the reliability of the transmission system in the MISO region. These challenges are framed up in MISO's Renewable Integration Impact Assessment work.

Fortunately, MISO can leverage its large footprint and resources to ease some of the challenges. One of the keys will be transmission projects that support these new resources in the region.

MISO is doing this through a Reliability Imperative initiative called Long Range Transmission Planning, or LRTP. LRTP is designed to assess the region's future transmission needs, starting from a base of the utility and state plans on where to site and build new resources.

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 contained in the MISO Transmission Expansion Plan, or MTEP. LRTP will coordinate closely with those efforts, and it will also be a transparent and cooperative part of the MISO stakeholder process.

Futures / Policy Consensus: The LRTP work is grounded in the three robust future scenarios developed over the past year. MISO 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.

Business Case Development: MISO will help stakeholders assess the business case for LRTP projects by analyzing multiple benefits relative to the costs. The business case should 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 stakeholders. This includes helping stakeholders consider both generation and transmission costs and benefits on a holistic basis, including the value of flexibility that transmission provides. For example, we will need to assess: (1) congestion points that limit energy imports into certain zones; (2) constraints between the MISO South subregion and the North/Central subregions; and (3) energy transfers between MISO and neighboring systems, such as Southwest Power Pool and PJM.

Cost Allocation: A key aspect of LRTP will be to ensure that the costs of new transmission projects are allocated fairly. This means MISO and stakeholders will work together to adjust

existing or develop new cost-allocation methods. The Organization of MISO States (OMS), which represents our state regulatory agencies, has established a working group to focus specifically on transmission cost allocation issues. MISO is committed to working with that OMS group and other stakeholders on this important topic.

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. 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 December 2021. Specific projects in the Explore, Decide, Do table will inform recommendations.

> "If you love renewables you'd better love transmission."
>
> John Bear, MISO Chief Executive Officer

LONG RANGE TRANSMISSION PLANNING ACTIONS (BASED ON CURRENT INFORMATION)

	Explore	Decide	Do	Done
Futures / Policy Consensus			• Continue to understand member plans, Integrated Resource Plan trends, state policy objectives	• Update MISO Futures
Business Case Development	• Study non-transmission alternative solutions • Determine increased potential for High Voltage Direct Current (HVDC) lines	• Conduct special zonal studies • Deliver first round of suggested Long Range Transmission Plan solutions to MISO's Board	• Increase MISO North/South transfer capabilities • Enhance renewables integration in the upper Midwest (MWEX-area) • Address import / export limitations in Michigan • Improve seams via Joint Study with SPP	• Multi-Value transmission projects • Ongoing improvements to the generation interconnection process
Cost Allocation	• Benefits/Cost allocation for identified Long Range Transmission Plan projects			

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. Work is underway to ensure that the people, processes, and technology allow MISO to respond. This work, termed Operations of the Future, is initially focused in the near-term on two large buckets of work – operational planning and situational awareness.

Operations planning improvements can help manage supply and demand variability in every hour. The shift to more weather-dependent, intermittent renewables and distributed resources mean that system peaks and operating risks are becoming less obvious and more difficult to manage in day to day operations. The planning assumption that most days follow predictable load profiles is also being challenged given the rise of demand responding to market prices. With the changes in the system, better forecasting will capture more unknows into operations and market decisions. Outage coordination will also be enhanced to determine and approve planned maintenance outages, thus providing more windows of opportunity. MISO is further investigating enhanced 'look-ahead' commitment of both generation and demand to capitalize on the flexibility of the grid to meet various system conditions. Finally, MISO is seeking improved methods to position the grid ahead of system challenges such as volatile weather patterns and improve our preparation and management of grid events.

> "In the past, most days were the same. In the future, most days will be different and we need the people, process and technology to deal with that variability.
>
> Jennifer Curran, MISO VP System Planning and Chief Compliance Officer

Situational awareness can be improved to turn data into actions. Today, MISO Operations relies heavily on the expertise of its operators. While operators have access to lots 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 is looking

to have an integrated toolset for operators that leverages artificial intelligence and machine learning. Techniques to improve how we see and navigate will give operators important information automatically.

OPERATIONS OF THE FUTURE ACTIONS (BASED ON CURRENT INFORMATION)

	Explore	Decide	Do	Done
Situational Awareness	• Advanced MISO visualization techniques • Intelligent alarming • Decision support systems leveraging artificial intelligence / machine learning	• Smart transmission technologies (e.g. ambient adjusted and dynamic line ratings) • Advance synchrophasor applications	• Real time display replacement	• Assessment of real-time displays and energy management displays to inform the visualization roadmap
Operations Planning	• Look-ahead commitment products • Predictive scenario analysis • Outage coordination changes	• Enhanced forecasting		• Dispatchable Intermittent Resources forecasting
Operations Preparedness	• Operations simulation • Reliability product testing			
Critical Communications	• Operations communications • Event/operator logging			

Market System Enhancements

MISO's ability to respond to the Reliability Imperative will be enabled through continued market system enhancements and modeling. Current systems and technology are not capable of meeting the new, reliability driven market improvements and fully leveraging new resources such as storage and distributed energy resources. Even minimal changes to the market systems today require significant resources. The new system will allow more timely improvements to meet MISO's evolving needs.

Today, MISO's legacy system has limitations. Recent upgrades (e.g., MISO's Private Cloud launched in July 2020) will help inform future investments. The Market System Enhancement, or MSE Program, was formed in 2017 to transform our current market platform into a more flexible and secure system. The work is ongoing, but already has reached important milestones including extending the life of legacy systems, improvements to the Energy Management System while the larger upgrade is in-flight, and launching the Readiness Application for the Market User Interface (which will go into production in 2021).

> "MISO's Market System Enhancement Program will provide the platform for faster adoption of new technologies into the market and better accommodate the region's changing resource mix to ensure reliable and efficient operations for our customers."
>
> Todd Ramey, VP and Chief Digital Officer

Building on the MSE Program progress, flexible design, advanced data analytics, and model management will help MISO to meet the Reliability Imperative. In contrast to the current legacy 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. Across the various workstreams of the Reliability Imperative, MISO is establishing a portfolio management function to ensure that investments align with the long-term strategy, including meeting the risks of the changing resource fleet.

MARKET SYSTEM ENHANCEMENT ACTIONS (BASED ON CURRENT INFORMATION)

	Explore	Decide	Do	Done
Market System Enhancement		• Real-Time Market Clearing Engine	• Market User Interface • Model manager / data governance • Energy Management System (EMS) Upgrade • Day-Ahead Market Clearing Engine	• MISO Private Cloud • Extend life of legacy system
Technology and Portfolio Needs	• Develop and deploy data analytics • External Self-service data • Module E Capacity Tracking (MECT) tool assessment	• Update the MISO Communication System (MCS)		

Connections Between the Workstreams

The work described here is organized across four main workstreams – market redefinition, long range transmission planning, operations of the future, and market system enhancements. These workstreams are connected and build on each other. Also, success in one area depends on progress in another, so efforts must be coordinated and sequenced.

For example, given the changing resource fleet, providing reliable and economically efficient grid operations requires both new tools and process being developed under the Operations of the Future workstream, and market enhancements being developed under the Market Redefinition workstream. Additionally, the ability to interconnect renewable resources may be constrained by the existing transmission system and therefore dependent on some of the changes being contemplated in LRTP. In a similar vein, the ability for MISO to deploy enhanced situational awareness depends on the quality of our data deployed through MSE.

By documenting our future vision in this report, and outlining next steps across the four main workstreams, MISO is starting an important dialog 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 dialog by updating stakeholder committees regularly on the Reliability Imperative.

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 right information.

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 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 diverse resource fleets. MISO is in the early stages of investigating how to calculate these new sources of value in an evolved, future-looking Value Proposition. Given changes to fleet, grid, market, 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. It lays out MISO's proposals to address the challenges associated with the region's changing resource mix. As an independent, FERC-approved system operator, MISO is responsible for the reliability of the Bulk Electric System and has the authority to act.

But the responsibility for the Reliability Imperative is certainly not MISO's alone. Utilities, electric cooperatives, and other load-serving entities serve the load and own the region's transmission lines, generating units, and other infrastructure. State regulatory agencies also play an important role in overseeing how load-serving entities carry out their responsibilities.

Internal and external input

While this report focuses on MISO's ideas and proposals, it was heavily informed by technical and policy-related input we received from our members and other entities described above. Much of that input came from the formal MISO stakeholder process and its committees, which have expertise in markets, operations, and planning. MISO also received input from industry trade groups, consultants, and other entities with insights into the challenges that are facing our region.

MISO is committed to working closely with its stakeholders as we identify, design, and implement the Reliability Imperative. We believe that by doing so, we can continue to operate the system reliably and efficiently while also working with the differing utility business models and state energy policies in our region.

A Message from Clair Moeller, President

Utilities, states, and other stakeholders in the MISO region differ widely in terms of their policy goals, business models, and other interests. MISO knows that not all stakeholders will support every view, recommendation, and initiative that MISO lays out in this report. Concerns are sure to be raised in the stakeholder process, and perhaps beyond it as well.

That's OK. That's how it should work. That's how important issues like these should be debated. Our region is facing some very difficult and complex challenges, and no single entity—MISO included—has the perspective, experience, and wisdom to fix them singlehandedly. Everyone should be invested in the outcome. Everyone should offer up their ideas and their proposed solutions.

This report represents MISO's initial contribution to that effort—but it does not represent the last word on the subject. 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.

We also recognize that we will need to adjust our approach going forward as industry conditions and the needs of our stakeholders continue to evolve. We are committed to working cooperatively with all of our stakeholder sectors to address these long-term challenges. In the meantime, we will continue to address incremental enhancements needed to maintain reliable and efficient operations.

This report is a current, snapshot-in-time look at how we see the Reliability Imperative today, but we will revise our approach as we learn more.

The time to act is now – the industry is changing, and MISO members are poised to drive exciting, necessary changes over the coming years. Given the regional Reliability Imperative, MISO 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,

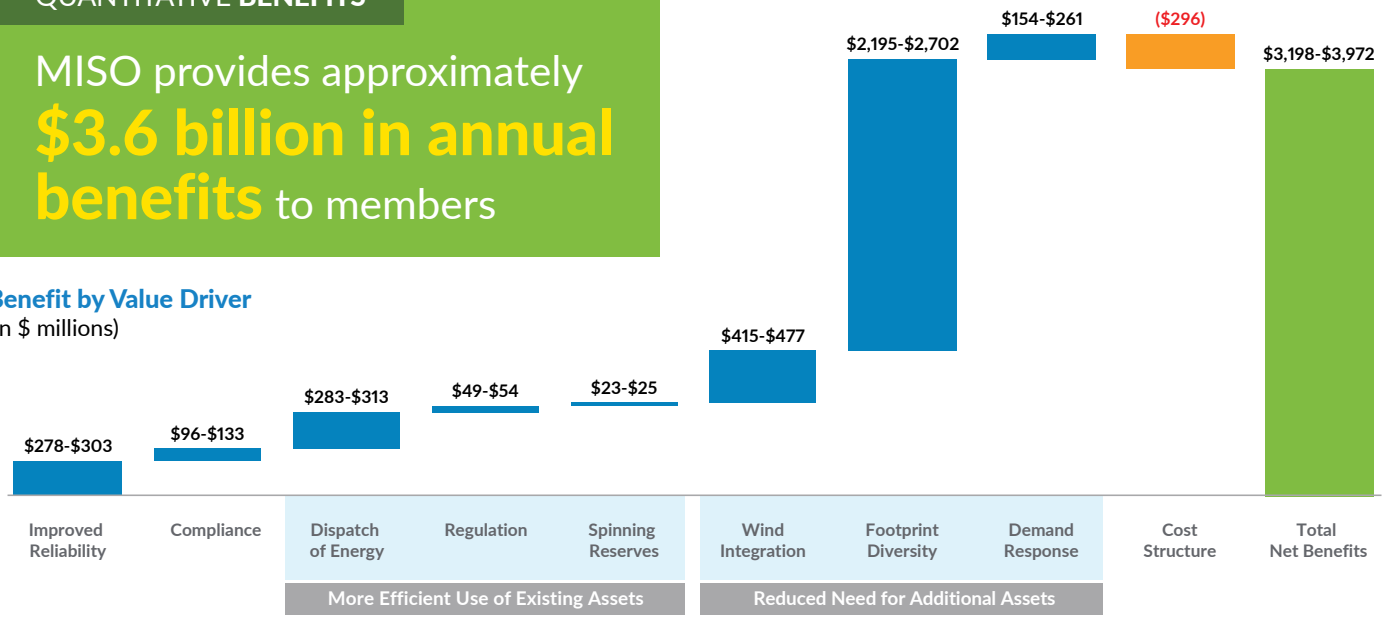
VALUE DELIVERED

MISO VALUE PROPOSITION **2019**

QUANTITATIVE **BENEFITS**

MISO provides approximately **$3.6 billion in annual benefits** to members

Benefit by Value Driver
(in $ millions)



IMPROVED RELIABILITY

MISO's broad regional view and state-of-the-art reliability tool set enable improved reliability for the region as measured by transmission system availability.

DISPATCH OF ENERGY

MISO's real-time and day-ahead energy markets use security constrained unit commitment and centralized economic dispatch to optimize the use of all resources within the region based on bids and offers by market participants.

REGULATION

With MISO's regulation market, the amount of regulation required within the MISO footprint dropped significantly. This is the outcome of the region moving to a centralized common footprint regulation target rather than several non-coordinated regulation targets.

SPINNING RESERVES

Starting with the formation of the Contingency Reserve Sharing Group and continuing with the implementation of the Spinning Reserves Market, the total spinning reserve requirement declined, freeing low-cost capacity to meet energy requirements.

WIND INTEGRATION

MISO's regional planning enables more economic placement of wind resources in the region. Economic placement of wind resources reduces the overall capacity needed to meet required wind energy output.

COMPLIANCE

Before MISO, utilities in the MISO footprint managed FERC and NERC compliance. With MISO, many of these compliance responsibilities have been consolidated. As a result, member responsibilities decreased, saving them time and money.

FOOTPRINT DIVERSITY

MISO's large footprint increases the load diversity, allowing for a decrease in regional planning reserve margins from 23.7% to 17.1%. This decrease delays the need to construct new capacity.

DEMAND RESPONSE

MISO enables demand response through transparent market prices and market platforms. MISO-enabled demand response delays the need to construct new capacity.

MISO COST STRUCTURE

MISO expects administrative costs to remain relatively flat and to represent a small percentage of the benefits.

QUALITATIVE **BENEFITS**

In addition to the quantitative benefits, MISO also demonstrates significant qualitative benefits that wholesale market participants receive from the operation of MISO, including:

- **Price/Informational Transparency**
- **Planning Coordination**
- **Seams Management**

VALUE PROPOSITION HISTORY

After launching the energy-only market in 2005, the value MISO adds to the region became apparent. To quantify this value, MISO – in collaboration with its stakeholders – created the MISO Value Proposition. The annual Value Proposition study began in 2007 and quantifies the value MISO provides to the region, including MISO market participants and their customers.

The Value Proposition breaks MISO's business model into recognized categories of benefits and calculates a range of dollar values for each defined category.

From 2007 through 2019, the Value Proposition studies revealed that the MISO region realized an estimated $26.9 billion in cumulative benefits.

The Value Proposition and its calculations, assumptions and supporting information are publicly available at www.misoenergy.org.

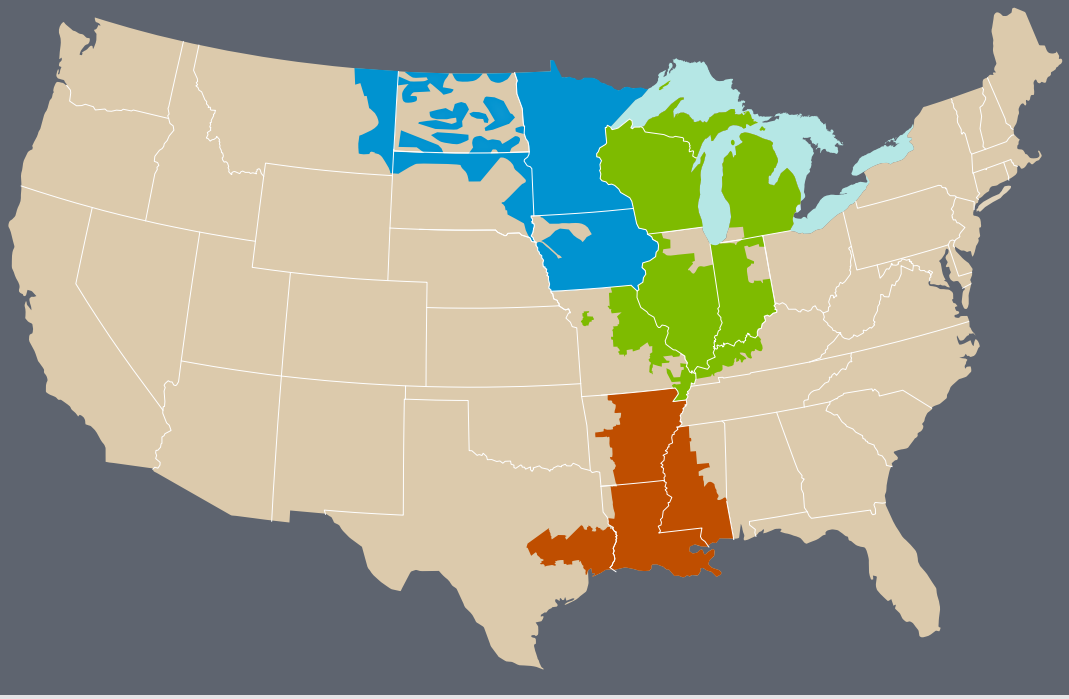
VALUE DELIVERED

MISO ensures reliable operation of and equal access to high-voltage power lines in 15 U.S. states and the Canadian province of Manitoba.

MISO manages one of the world's largest energy markets, covering 965,000 square miles and delivering over 700 terawatt-hours of energy annually to millions of homes. The not-for-profit 501(c)(4) organization is governed by an independent Board of Directors, and is headquartered in Carmel, Indiana.

MISO's Value Proposition continues to document the billions in annual savings its collective efforts unlock for the region. In 2019, those efforts provided between $3.2 billion to $4 billion in regional benefits, driven by enhanced reliability, more efficient use of the region's existing transmission and generation assets and a reduced need for the addition of new assets.

MISO's Value Proposition affirms its core belief that a **collective, region-wide approach** to grid planning and management delivers the greatest benefit.



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