Testimony of John Bear

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Subcommittee on Energy

"Building a 100 Percent Clean Economy:

Solutions for the U.S. Power Sector."

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Executive Summary

The electric industry is rapidly evolving, shifting to a generation fleet that is more heavily dependent on renewables than ever before. To help prepare for that future, MISO has identified and is studying three overarching trends that are reshaping the industry:

- De-marginalization refers to resources, such as wind and solar, that can provide the next needed, or "marginal" increment of energy at zero or low costs.

- Decentralization involves the shift away from large, central-station power plants to smaller, locally distributed resources.

- Digitalization is the revolution in information and communication technologies that is reshaping nearly everything in our economy, including energy services.

In anticipation of continued change, MISO is working to identify and understand the impact of increased reliance on renewables. Already, we have learned that renewable penetration of 30% would challenge our ability to maintain the planning reserve margin and operate the system within acceptable voltage and thermal limits. Maintaining reliability at the 40% renewable level becomes significantly more complex.

The implications are very real. Today, we face more frequent and less-predictable occurrences of tight operating conditions on the electric grid compared to just a few years ago, and the challenges continue to grow. The approaches that worked in the past will not meet our needs in the future. To ensure system reliability all 8,760 hours of the year, the electricity generating fleet of the future must become even more available, more flexible, and more visible.

Ultimately, the question of achieving 100% clean power does not have a simple "yes" or "no" answer. Renewable energy technologies are advancing rapidly, but none of us knows exactly where we will be technologically more than 30 years from now. Regardless of what the future holds, MISO remains committed to continued reliability and efficiency, and we appreciate the opportunity to help inform the discussion that will shape the path forward.

Introduction

Good morning Committee Chairman Pallone, Ranking Member Walden, Subcommittee Chairman Rush and Ranking Member Upton, and members of the Subcommittee. I am John Bear, Chief Executive Officer of the Midcontinent Independent System Operator, Inc., or MISO. It is a pleasure to be with you today as you consider the future of renewable energy and its impact on our nation, specifically our high voltage electric transmission system. I hope MISO's insights will be useful to your work of shaping U.S. energy policy.

I know this subcommittee is interested in hearing about the implications of the growth of renewable energy, including challenges associated with ensuring reliability, and the infrastructure and the technology innovations that will be necessary as our nation becomes more dependent on renewables. MISO is also concerned about these issues and strives to stay a step ahead of the challenges before us. That's why MISO commits significant resources to researching and assessing future scenarios, and to designing and implementing initiatives that improve our system planning, operations, markets and enable advancing technology.

MISO Overview

Before I share MISO's insights on some of these matters, I would like to provide a little background about our organization.

The Federal Energy Regulatory Commission's (FERC) Order 2000 established Regional Transmission Organizations (RTOs) to be independent entities that plan and operate the electric grid on a regional basis to maintain reliability and maximize efficiency. MISO was the first Independent System Operator to be recognized as an RTO, receiving FERC approval in 2001.

MISO puts a priority on maintaining our independence. We are fuel source and policy neutral, meaning we do not favor, prefer or advocate any particular fuel or policy outcome. That doesn't mean, however, that we are disinterested observers with respect to the topic of this hearing. MISO is a 501(c)(4) not-for-profit social welfare organization with responsibility for ensuring the reliability of the high-voltage electric transmission system and facilitating the delivery of

lowest possible cost energy to consumers. The integration of renewables has a direct impact on both the reliability of the system and the value created for customers.

The system that MISO manages includes almost 72,000 miles of high-voltage transmission and over 175,000 MW of generation, which we do not own or maintain but rather exercise functional control over with the consent of the asset owner. Our footprint is the largest in North America in terms of geographical scope, serving about 42 million people across all or parts of 15 states, stretching from the Canadian border to the Gulf of Mexico. Our energy markets are also among the largest in the world, with nearly $30 billion in annual gross market charges. A map of the MISO footprint is provided in the Appendix of this testimony (see Appendix, Figure 1).

Our work to maintain reliability, administer wholesale markets and conduct transmission planning on a regional scale generates substantial benefits. In 2018 alone we created approximately $3.5 billion in savings for the region, and nearly $25 billion since 2007.

Our vast footprint also provides significant diversity in terms of the types of resources, weather patterns, state policies, and notably, perspective and viewpoints across our stakeholder community that are critical to our solving today's complex challenges. MISO has a robust committee-driven stakeholder process in which asset owners, state regulators and other stakeholders provide input and guidance to MISO on a regular and ongoing basis. This is critical to solving today's complex challenges like the one that is the focus of this hearing – the ongoing growth of renewable energy in the power sector.

Portfolio Evolution – Drivers and Implications

The evolution of the generation portfolio is something MISO has been experiencing for some time due to a confluence of factors, including economics, policy and regulation, aging power plants, and customer preferences. In 2005, the MISO region received nearly 80% of its energy from coal-fired units, very little from natural gas, and a negligible amount from renewables. As recently as 2011, we were still receiving about 75% from coal. That percentage recently fell below 50%, with natural gas now providing close to 30% of our energy, and renewables about 8%.

Several data points provide evidence that this shift will continue. States across the country are considering or have announced mandates or aspirational goals for higher renewable energy contributions. Growing corporate and consumer desires for clean energy are affecting utility's future resource plans. Over 80% of the requests we currently have for new resources to connect to the power grid are from renewable generation. The future planning scenarios that MISO develops in collaboration with stakeholders to provide bookends of potential future scenarios indicate a continued transition to higher renewables.

To be prepared for a future that looks very different from the past and present, we must fully understand the change drivers and associated implications. Through this process, we have identified three overarching trends that are reshaping the future of the industry in profound ways. We call these trends the 3Ds:

- De-marginalization refers to resources that can provide the next needed or "marginal" increment of energy at zero or low additional costs, due to their non-existent or very low fuel costs. This includes wind and solar.

- Decentralization involves the shift away from large, central-station power plants to smaller, often variable resources that are located on local, low-voltage electricity distribution networks, such as at homes and businesses.

- Digitalization is the revolution in information and communication technologies and platforms that will continue to disrupt nearly everything in our economy, including energy services.

Recognizing these trends, we launched a study three years ago to identify the "inflection points" at which the existing system would need to undergo significant structural and/or operational changes as it becomes increasingly reliant on intermittent renewables (see Appendix, Figures 2 and 3). Intuitively, we've always known that the growth of intermittent resources like wind and solar would increase the complexity of system planning and operations, and this initiative is providing data that helps us understand the challenges and implications at different penetration levels.

Already we have learned from that study that renewable penetration of 30% would present challenges in terms of our ability to maintain the planning reserve margin and operate the system within acceptable voltage and thermal limits. The study indicates that maintaining grid reliability at the 40% renewable penetration level becomes significantly more complex. In addition to the challenges described at the 30% level, we would encounter the need to balance the system over a very large area to reduce renewable curtailments and regional transmission reliability issues. The system stability issues would drive the need for non-traditional transmission devices like High Voltage Direct Current (HVDC) lines or other advanced technologies. We are currently looking at the implications of a 50% renewable penetration level.

We have also engaged with industry groups from other countries that are grappling with the same challenges related to integrating renewables, and have gained valuable insights from those conversations.

In addition to our study and information gathering, our own experience has also informed our learnings. I outlined previously how the makeup of the generation fleet in our footprint has changed since the launch of our markets in 2005, but that hasn't been the extent of the impacts. Retirements have contributed to declining reserve margins, aging plants to degradation of generating unit performance and availability and increased reliance on variable generation types to system risk.

The implications have been very real. Tight operating conditions, and more specifically the need to utilize emergency procedures to manage reliability risk, used to occur very rarely and only during peak demand periods. We now experience those situations on a much greater periodicity and during the non-peak periods when risk was historically very low. These outcomes, along with our extensive assessment of the holistic challenges associated with the 3D trends, have led to our identification of three key future needs to ensure reliability with the fleet of the future: improved availability, flexibility and visibility.

The path forward to continued reliability

Achieving these needs will require a shift in market processes and protocols. For decades, electricity providers in all 15 states in the MISO region generally used the same basic approach to serve their customers and maintain grid reliability. This approach, which is still largely in use today, includes concepts such as:

- Reserve margins and resource plans that are based on demand in the "peak hour" of the year, which typically occurs on an exceptionally hot and humid summer day when customers run their air conditioners full-tilt;

- Generic capacity credits that do not always reflect actual resource capabilities; and

- Marginal cost pricing, in which wholesale energy prices are based on the costs of the particular resource—such as a coal plant, for example—that provides the marginal, or "next needed," unit of energy.

Today, states in the MISO region are diverging sharply in their energy and environmental policies. Some have adopted aggressive de-carbonization policies, which are prompting utilities within their borders to retire and replace numerous coal and gas resources with intermittent renewables. But other MISO states continue to rely heavily on their legacy fossil resources for various reasons, including reliability concerns, jobs, and a desire to not impose new infrastructure costs on their ratepayers.

In this new era of widely divergent state energy policies, declining reserve margins, and the many implications of the 3D trends discussed above, it is clear that the region's electrical system and its associated wholesale markets require some significant changes. For example:

- We can no longer be confident that the system will be reliable for all 8,760 hours of the year based solely on utilities having enough generation capacity to serve load on the annual peak hour in the summer.

- We can no longer be confident that the region's evolving mix of resources will provide enough, and the right kinds of, critical attributes that are needed to keep the system operating in a reliable, steady state, such as frequency response, voltage control, and black-start capability, among other things.

- We can no longer be confident that the traditional approach of marginal cost pricing will provide adequate financial incentives to prompt utilities and other types of entities to build the kinds of resources—with the right kinds of attributes—that the system needs to keep operating reliably going forward.

- We can no longer be confident that the existing transmission system, which was primarily designed to deliver energy from large, always-on power plants to load centers, can adapt to the new paradigm of smaller, decentralized intermittent renewable resources—including those that are located on state-jurisdictional local distribution networks.

MISO has established three guiding principles to guide and shape our work going forward to ensure reliability in this era of a dramatically evolving system. They are:

1. Reliability Needs and Requirements: Reliability criteria must reflect required attributes in all horizons – "All Hours Matter."

2. Reliability Contribution: Members are responsible for meeting reliability criteria with resources that will be accredited based upon the resource's ability to deliver those attributes.

3. Alignment with Markets and Infrastructure: Market prices must be reflective of underlying system conditions and resources must be appropriately incentivized for the attributes they provide; infrastructure should enable efficient utilization of resources.

As I mentioned previously, MISO is fuel and policy neutral. We do not favor or advocate for any fuel or policy outcome. Instead, we offer our independent and objective analytical analyses to

decision- and policymakers to inform their efforts, and then we ensure a reliable implementation of the policies put in place. I hope my testimony helps to highlight that the question of achieving 100% clean power is not one that has a simple "yes" or "no" answer. The U.S. electric grid is often referred to as the most complicated machine humans have ever built, and there will be no shortage of very long and in-depth engineering conversations ahead as the many changes, developments and advances that will be required are explored and cultivated.

While we all know in a general sense that renewable energy technologies are advancing rapidly, none of us has a crystal ball that can tell us exactly where we will be technologically more than 30 years from now. For example, just 15 years ago—half the time we're talking about for the purposes of this hearing—we still had not perfected energy technologies like fracking and horizontal drilling, which eventually sparked the oil and natural gas boom that completely transformed those industries.

The resource mix is evolving across our footprint in different ways, and at different paces. Our role is to knit together all of these disparate pieces in a way that ensures the continued reliability of the Bulk Electric System and we will continue to work with our diverse stakeholder community to evolve our planning, markets and operations to fulfill that objective. MISO has a unique role in the industry and brings an insightful perspective to the challenges we face. We are committed to continued reliability and efficiency, and we appreciate the opportunity to help inform the discussions that will shape the path forward.

We will keep you informed of our progress, and I look forward to your questions.

APPENDIX

Figure 1: MISO Reliability Footprint

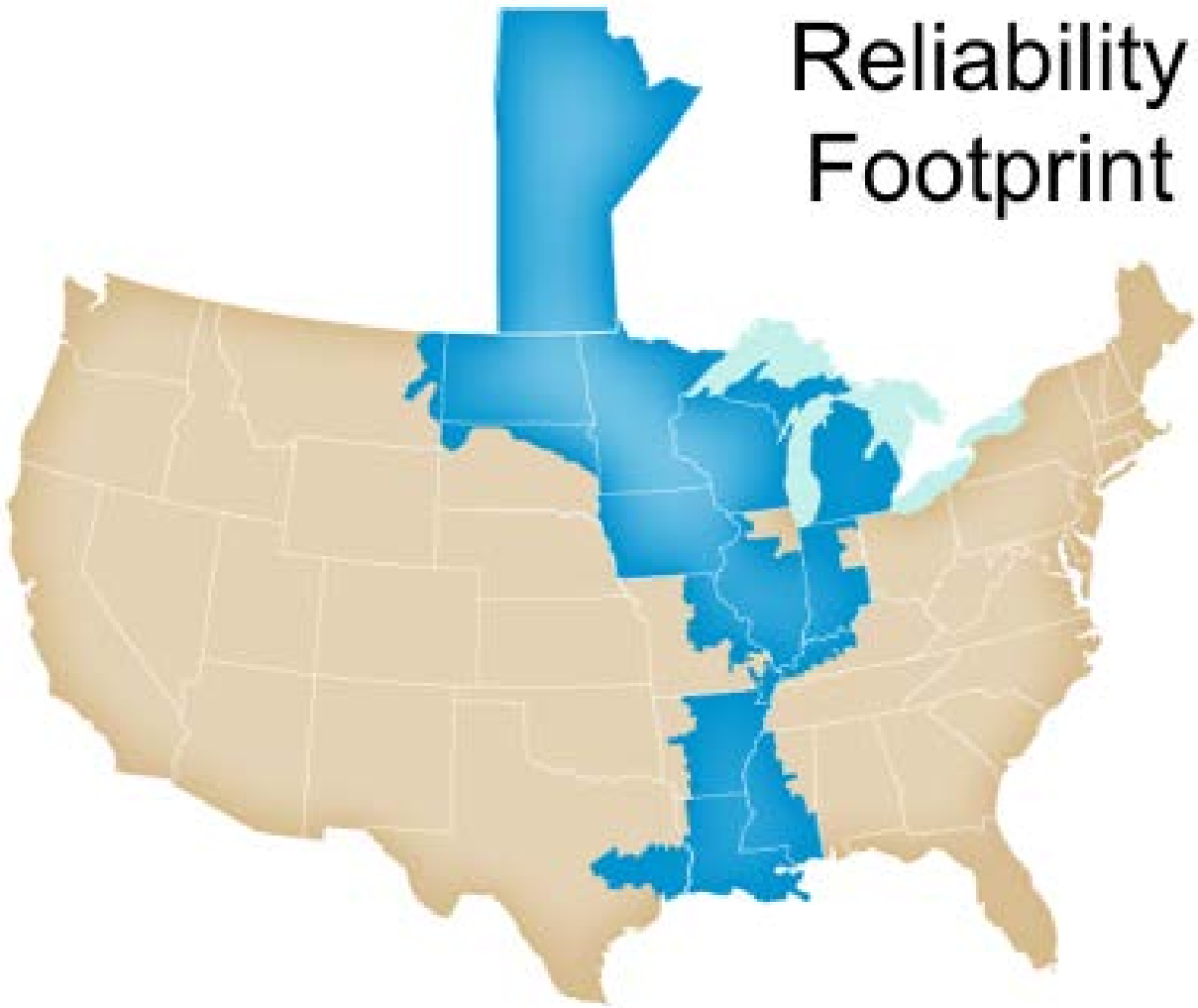
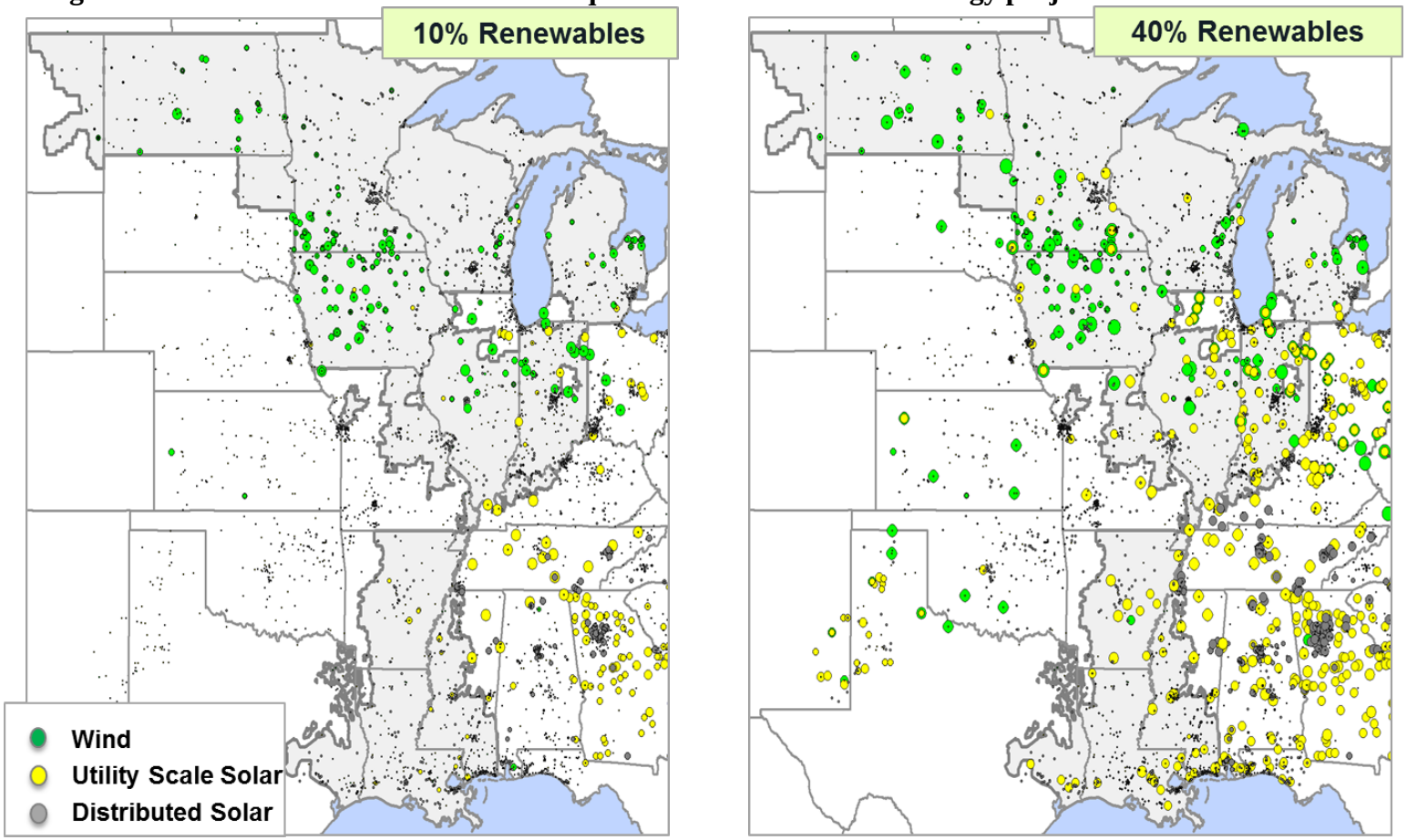


Figure 2: Significant renewable buildout would be required to reach renewable energy projections under certain scenarios.



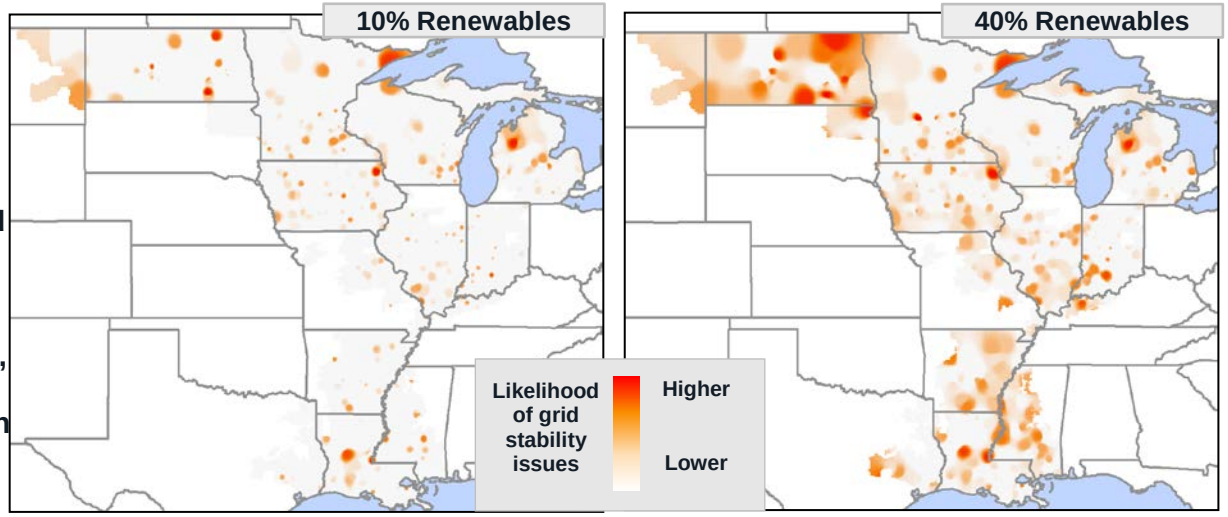
	10% Penetration Level	40% Penetration Level
Wind	1,993 MW	41,521 MW
Utility Solar	1,050 MW	23,125 MW
Distributed Solar	1,276 MW	12,457 MW
Total	4,319 MW	77,103 MW

https://cdn.misoenergy.org/RIIA%20Assumptions%20Doc_v6301579.pdf

Figure 3: Power system stability concerns and integration complexity require improvements to flexibility and visibility.

Dynamic Stability

- Stability concerns are driven by the reduction in conventional generation and the increase in inverter based (i.e., wind / solar/ battery) generation
- Additional system reinforcement is needed (e.g., more transmission, keeping more conventional generation online)



Complexity Index

- Integration complexity is measured as the approximate cost of the transmission fixes needed
- By 40% penetration, 18% of renewable energy could be curtailed; transmission fixes could reduce that to 9%