Purpose &
Key
Takeaways

Purpose:
Assess reliability needs as the resource portfolio in MISO evolves.

Key Takeaways:

• The resource portfolio in the MISO region is undergoing a sizeable change with more variable resources coming online.

• Preliminary analysis indicates that system risks will shift outside of summer peak load hours and flexibility needs will grow.

• MISO is exploring potential changes in both Resource Adequacy and Energy and Ancillary Service Market constructs to capture the changing risk needs.
The resource mix in the MISO region has been evolving and the pace of changes could be faster in the next 10 years.

**MISO Region Generation Portfolio Evolution (% of Energy)**

- **2005**
  - Renewables: 7%
  - Other: 4%
  - Nuclear: 13%
  - Coal: 76%

- **2018**
  - Renewables: 8%
  - Other: 15%
  - Nuclear: 27%
  - Coal: 47%

**Announced 2030 Members’ Generation Mix * (% of Energy)**

- Renewables
- Other
- Nuclear
- Gas
- Coal

**MISO GI (generation interconnection) Queue**

- Total Size GW: 63.9
- Requests: 418

* 2030 Energy projections (MWh) compiled from IRPs, investor reports and other sources
MISO is evaluating the impact of portfolio evolution on system reliability needs.

<table>
<thead>
<tr>
<th>Is there a problem?</th>
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<tbody>
<tr>
<td>• How do reliability needs change?</td>
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<td>• What are the patterns of needs today and tomorrow?</td>
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<td>• What drives these patterns?</td>
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<td>• Does today’s construct sufficiently capture risks across the year?</td>
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<td>• Will today’s construct be able to capture risks in future?</td>
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<td>• Will the needed attributes be properly and timely procured &amp; incentivized?</td>
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<th>MISO 2020 Focus</th>
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**Identify Reliability Needs**

• Develop analytic methods to define reliability criteria, and identify needed attributes in additional to peak hour MWs

**Planning Horizon**

• Evaluate robustness of current planning constructs
  - Evaluate sub-annual planning + Planning Resource Auction
  - Reform resource accreditation

**Operating Horizon**

• Ensure market prices reflect underlying system conditions
• Propose scarcity pricing reforms
MISO is using a combination of data analysis and simulation.

- Develop future scenarios with a range of resource combinations
- Use data analytics to deep dive into current portfolio and then extrapolate to the future
- Conduct early Resource Adequacy trials to understand different approaches and then move into more detailed analysis
- Use market simulation to confirm conclusions from data analytics and Resource Adequacy trials.
System Reliability Risk Patterns
Preliminary analysis indicates shift of risks outside summer peak load hours for existing portfolio.

Margins = supply resources - obligations

“All-in” Margin = Available non-intermittent generation + intermittent generation + RDT limit + Net Scheduled Interchange + Load Resources (BTMG + LMR + EDR) - Load - Operating Reserve

Credits: Victor Ni and Chen-Hao Tsai

RDT = Regional Dispatch Transfer | BTMG = Behind the Meter Generation
LMR = Load Modifying Resources | EDR = Emergency Demand Response
Adjustment to modeling assumptions can better capture risk across the year.

Modeled 2018 with LOLE target of 0.1

Loss of Load Expectation (LOLE) Pattern

Current Method

Trial Method (see Appendix)

Risks shift outside of summer months

Credits: Armando Figueroa-Acevedo and Chen-Hao Tsai
And the risk pattern changes seem to preserve for future resource mixes.

Loss of Load Expectation (LOLE) Pattern

0.1 Loss of Load Expectation

Risks shift outside of summer months & traditional peak hours

Proxy Operator Experience*

* LOLE targets is 0.6

Credits: Armando Figueroa-Acevedo
Flexibility needs
Team explored a range of future scenarios.

- The futures reflect many dynamics in the region
  - Changing fuel costs, clean energy commitments, aging fleet, electrification
- The analysis leveraged draft MTEPs (MISO Transmission Expansion Plan) as a starting point

MTEP 2019 AFC 2033
(760TWh)

- Less coal retirement
- Reflects member plans*

Future III, 2030**
(954 TWh)

- Gas in lieu of coal
- High load

Future 1 2040
(825 TWh)

- Higher solar
- Middle load growth

* As announced plans submitted to commissions
** Does not include very recent change in MTEP F3 that adjusts load growth from 60% to 50%.

Credits: Aditya Jayam Prabhakar and Hilary Brown
Ramping needs will grow for all timeframes within MISO footprint in future.

Credits: Steve Rose and Chen-Hao Tsai
While sub-hourly net-load ramp needs would increase for MISO system in all futures, high ramps in MISO south are particularly observed in solar-rich scenario.
Within a year, the largest ramping needs move from summer to shoulder seasons, particularly for a solar-rich scenario.
Increasing scale and complexity of uncertainties in future also indicate more challenges in shoulder months.

Monthly Average Aggregate Forecast Error *

3-year Historical

Future Scenarios

Load Forecast Error

Wind Forecast Error

Future I 2040 – High Gas, Higher Solar, Mid Load Growth

MTEP19AFC-2033 – Increasing Solar, Coal Drops Slightly

Future III 2030 – High Gas in lieu of Coal, High Load

*Forecast error reflects DA to RT differences. Reflects worst case scenario of additive errors.
And additional flexibility could be needed at particular hours of the day at same or opposite directions compared to today.
The analysis will inform further evaluation of resource adequacy, market and operational approaches

Next Steps

• Continued stakeholder discussion in subcommittees and workshops

• Publish whitepaper of reliability needs “framing” by end of July, 2020

• Publish whitepaper of market enhancement opportunities “framing” by end of December, 2020
Questions?
Appendix. Adjustments to summer-Focused LOLE Modeling Assumptions

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Current Approach</th>
<th>Trial Analysis Assumptions</th>
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<tbody>
<tr>
<td>• Intermittent resource capacity</td>
<td>Flat capacity throughout the year based on summer performance.</td>
<td>Using 8760 profiles corresponding to 2018 weather year.</td>
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<td>• Non-firm external support</td>
<td>Adjustment to the PRM based on imports during summer peak.</td>
<td>Using monthly average NSI from the last 3 years, assuming a perfect unit.</td>
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<tr>
<td>• Forced outage rates (FOR)</td>
<td>Modelled as a single average forced outage rate for the entire year.</td>
<td>Modeled with adders / subtractors at different date-hour based on temperature correlation model using 3-years of historical data.</td>
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<tr>
<td>• Planned outages</td>
<td>Optimized to avoid outages during peak summer load periods.</td>
<td>Scheduled using a 90% optimality (“best behavior”) assumption.</td>
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