Incentivize Flexibility for Managing Uncertainties under Evolving Resource Mix

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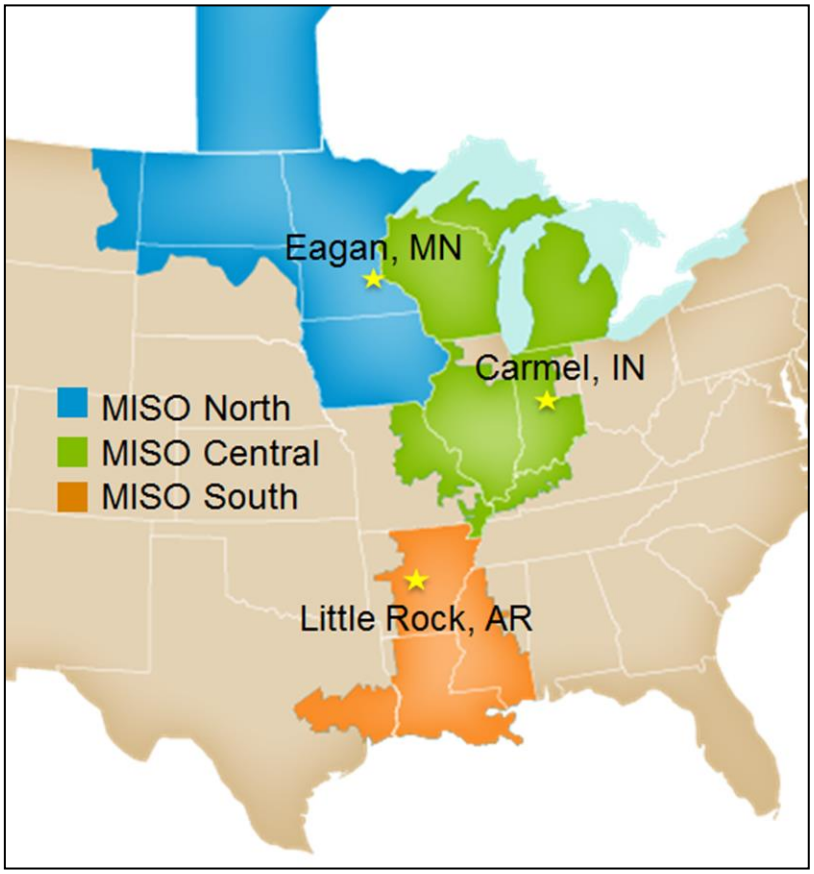
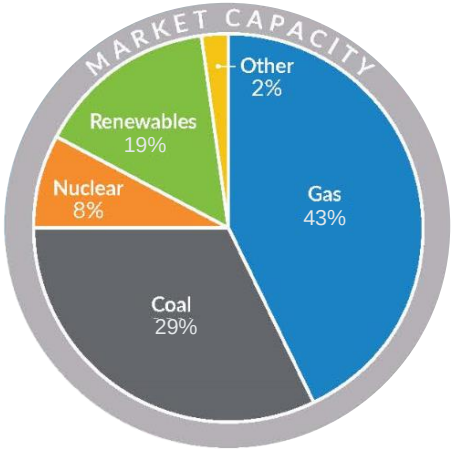
MISO drives value creation through efficient and reliable markets, operations and planning

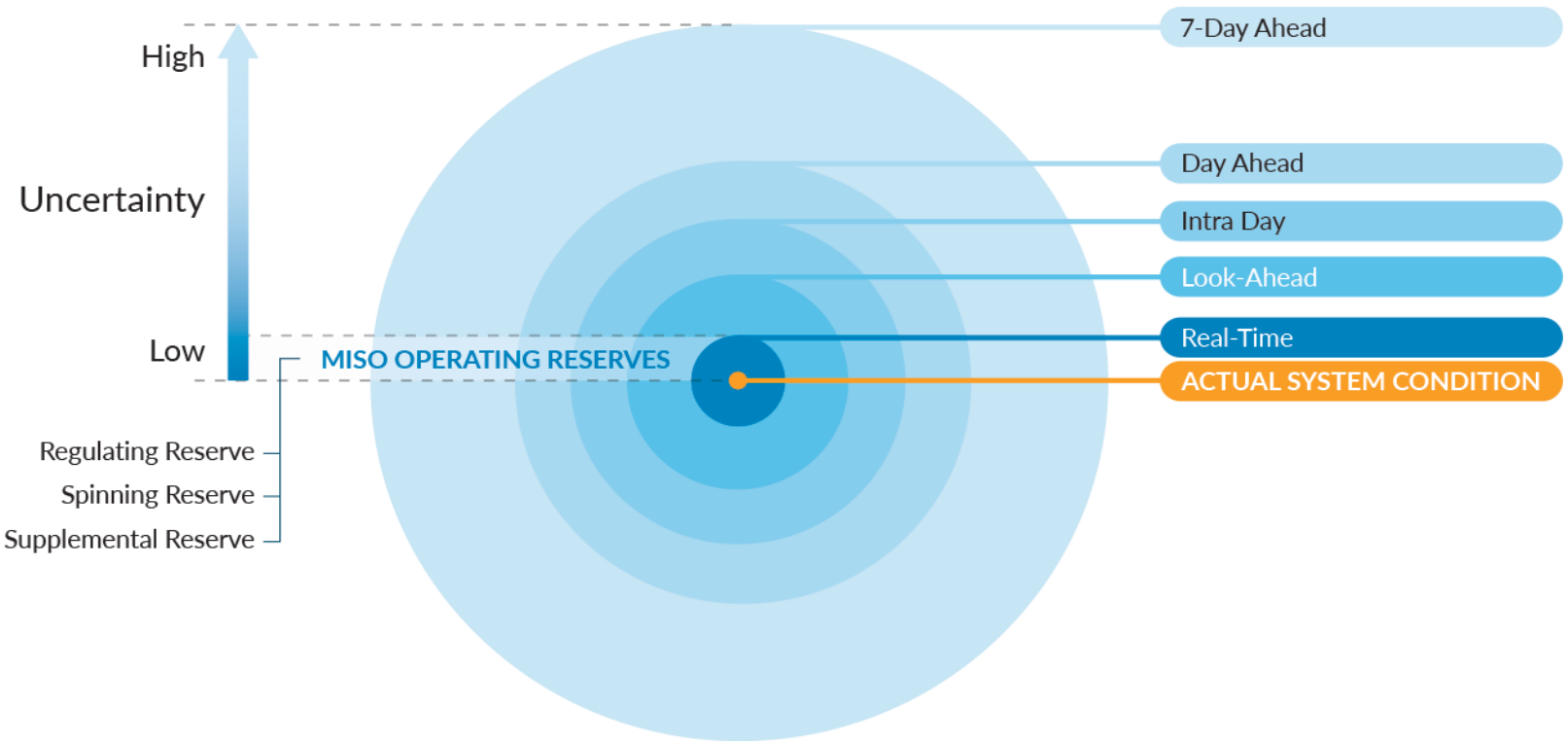
MISO's vision: Be the most reliable, value-creating RTO



MISO by-the-numbers	
Transmission	65,800 miles
Generation Capacity	184,287 MW
Peak Summer System Demand	127,125 MW
Customers Served	42 Million



MISO uses market products and operator tools and processes to manage uncertainty across time

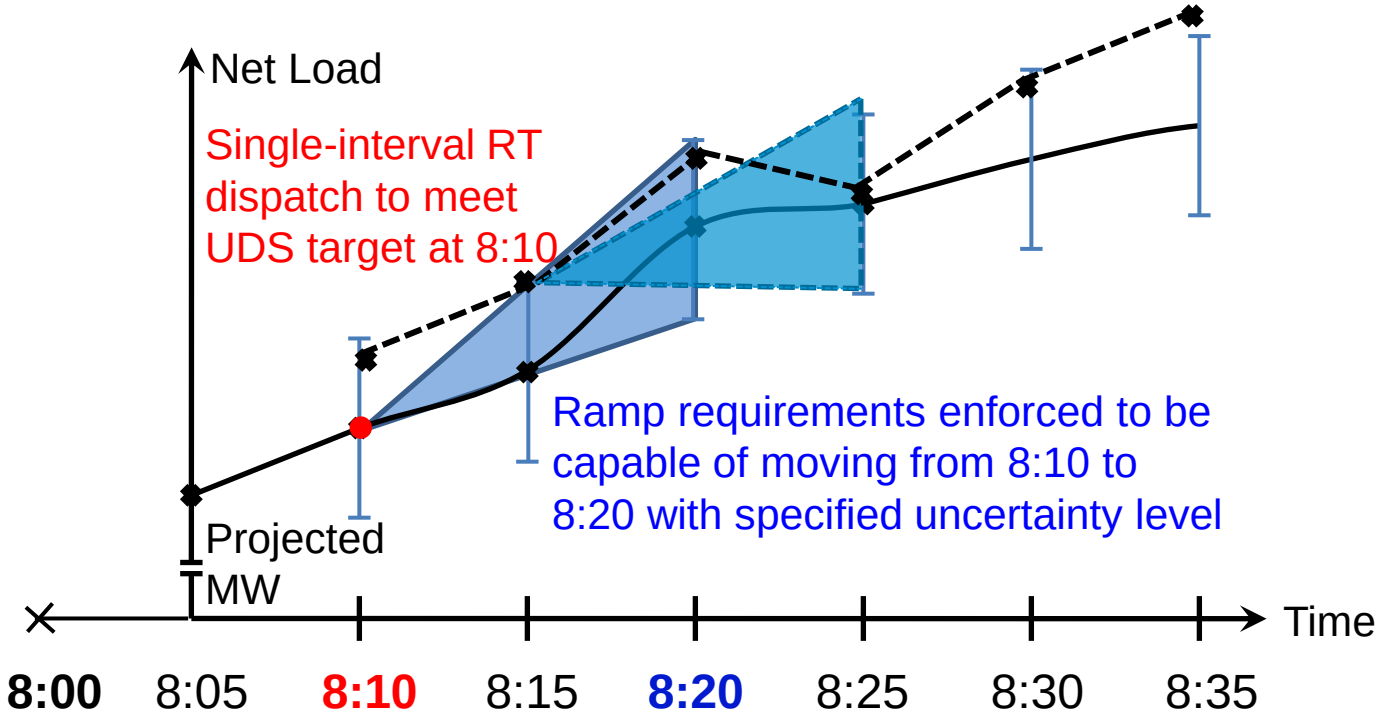


Operator Tools
- Multiple scenarios
- Headroom
- Offsets

Additional Market Products
- Ramp product
- Short-term reserves
- Reserve deliverability

The Ramp Capability Product manages net load variation and uncertainty 10 minutes beyond dispatch target

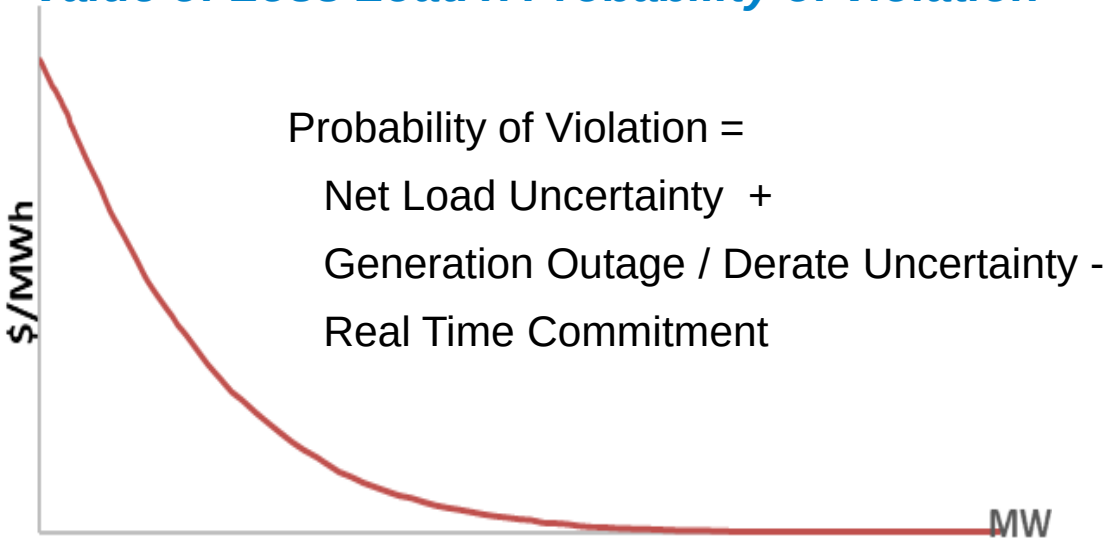
- Bi-directional. Up and down ramp requirements enforced independently with separate quantities
- System-wide. Deliverability captured through ramp procurement post-deployment transmission constraints



The 30-min, Short-Term Reserve (STR) requirement targets uncertainties within 10-minutes to 3-hours out

- STR identifies and reserves 30-min flexibility resources in Day Ahead and Real time markets and other commitments
  - Reserves flexible units to address uncertainties 10 minutes to 3 hours out
  - Varies requirement based on hour, season and system conditions
  - Evaluates both the system wide and sub-regional needs

Value of Loss Load x Probability of violation



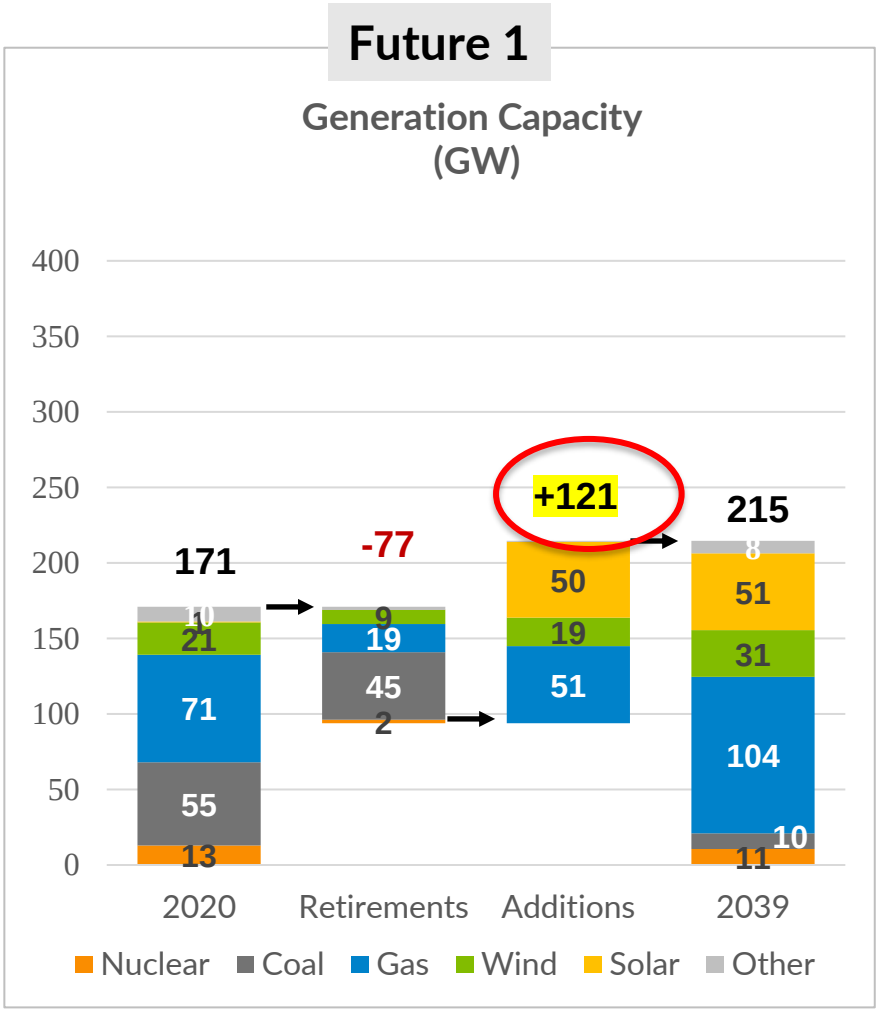
Probability of Violation =

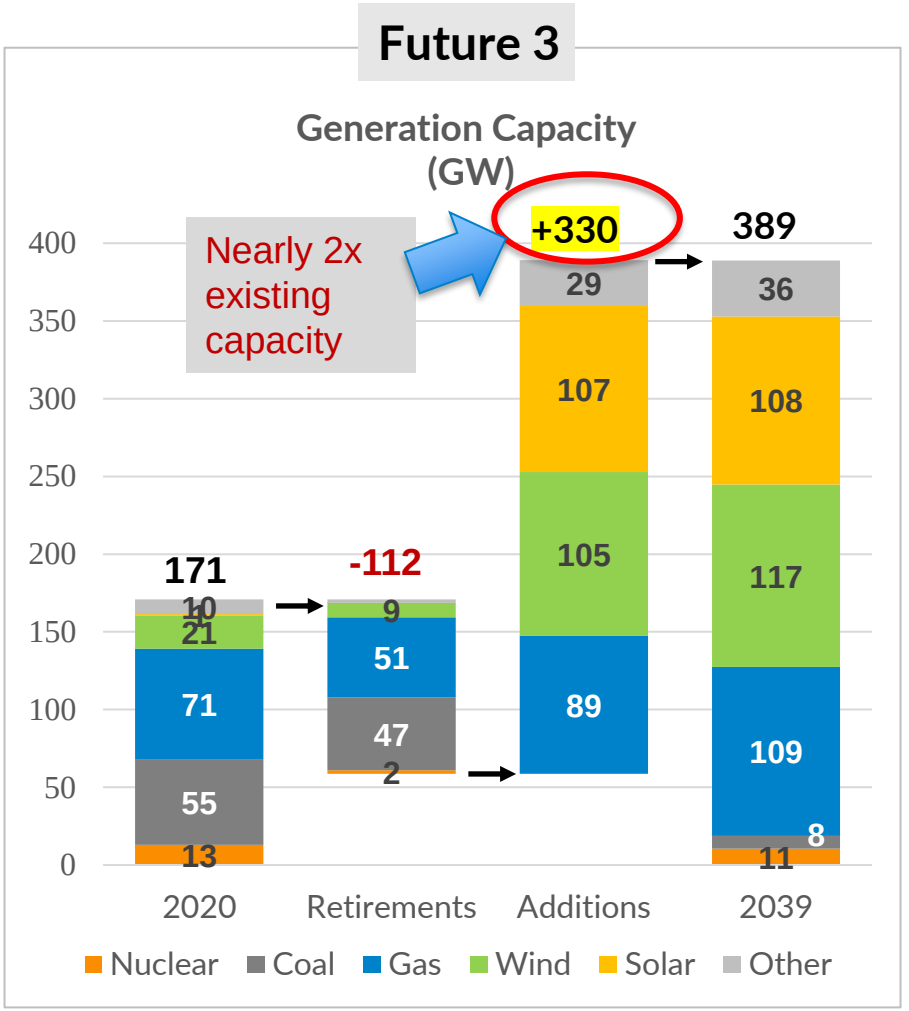
Net Load Uncertainty +

Generation Outage / Derate Uncertainty -

Real Time Commitment

MISO projects significant capacity retirements and additions based on member plans





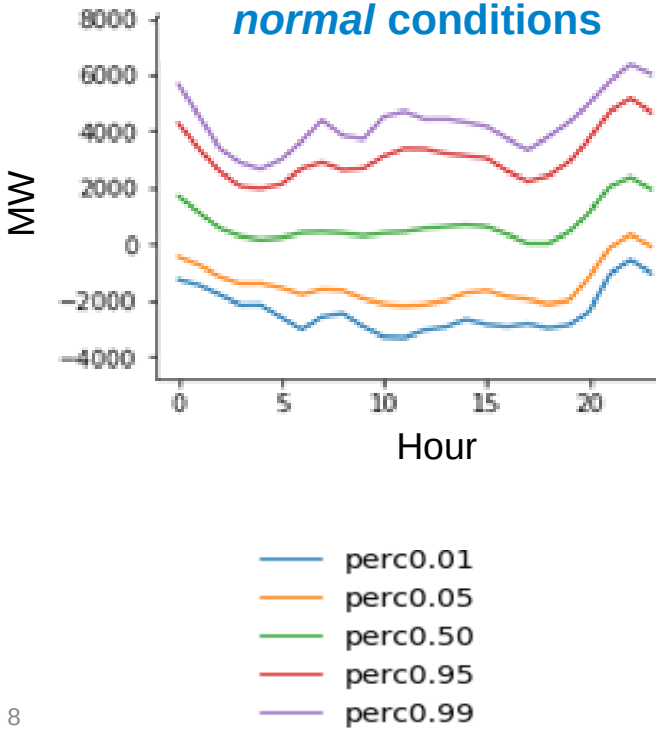
The resource mix prompt market adaptations

- Large penetration of weather-dependent resources combined with more extreme weather events increases uncertainty and variability
- Increasing interdependence among resources and changing transmission usage increases emphasis on ensuring the ability to meeting local reliability needs
- Emerging distributed energy resources, storages and multi-configuration resources requires new or enhanced resource models
- Lack of information exchanges introduce challenges on market-to-market coordination and uncertainties on available transactions

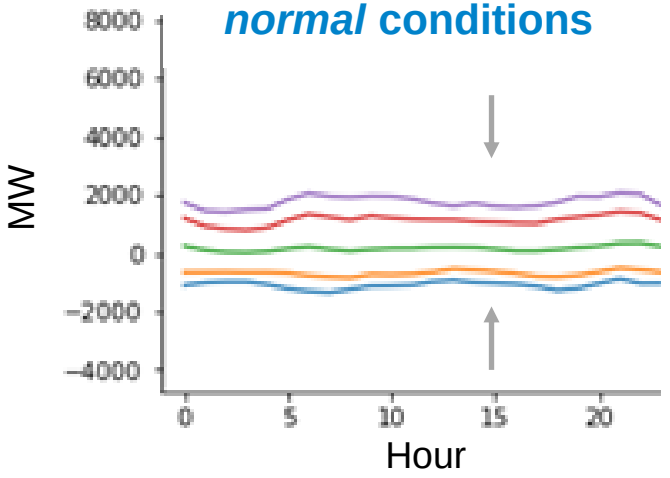
Market products and operator tools need to account for variation in uncertainty amounts and impacts

Uncertainty drops over time and can grow in emergency conditions

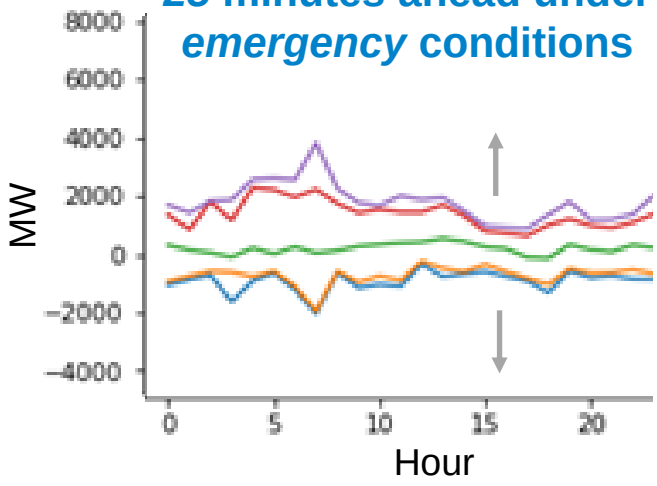
175 minutes ahead under *normal* conditions



25 minutes ahead under *normal* conditions



25 minutes ahead under *emergency* conditions



MISO is enhancing its market design to improve reliability under growing uncertainty and variability

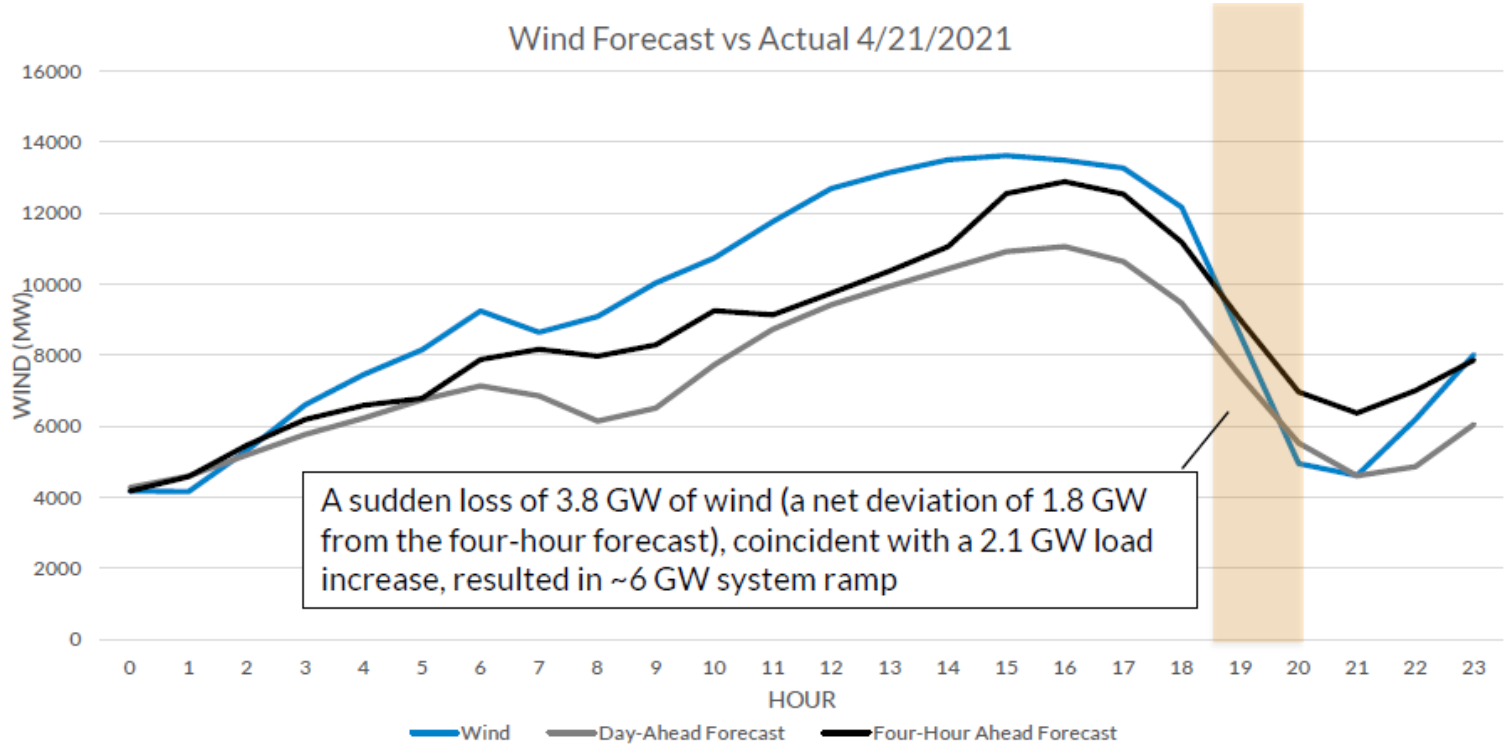
Observations	Market enhancement needs
Decisions about long-lead units are made when uncertainty is relatively high. Increasing the availability of flexible units enables action when uncertainty is lower. This must be balanced against carrying excessive reserves.	• How to reflect required headroom for managing uncertainty into market products?
The need for reserves varies within the footprint and most emergencies happen at a sub-regional or zonal level first.	• How to ensure proper amount of reserve to be procured at the right location? ✓ Improvement on reserve deliverability constraints
The cost of longer-lead commitment for emergencies needs to be reflected in prices.	✓ Recent extended locational marginal price (ELMP) enhancement to reflect cost of commitment into pricing
The cost of deployed emergency resources and self-responding resources outside of the market are not reflected into the price signals.	✓ Approved emergency pricing filing on emergency offer floor • How to incorporate emergency resources into the market clearing processes?

• On-going work
✓ Recent enhancements

Product requirements need to be updated as uncertainty profiles change

Ramp Example: April 4/21/2021

- Even with a ramp product, MISO had to deploy contingency reserves
- A look-back analysis identified increasing uncertainty and operating reserve scarcity
- MISO recently increased the ramp up requirement by 500 MW based on this uncertainty analysis and a cost-benefit assessment



MISO is planning additional modifications to adapt to the changing resource portfolio

Near term

- Enhance price signals under current design to further improve reserve demand curve and requirement (static with regular update)

Medium term

- Dynamic reserve requirement and demand curves
- Define system wide and zonal uncertainty event based on system condition and automated in the market clearing process
- Improve zone reconfiguration
- Scenario generation and real time stochastic simulation tools
- Incorporate emergency resources into the market clearing process

Long term

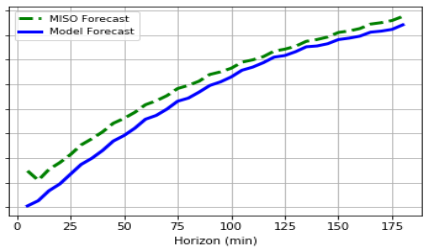
- Further product and price reform as needed
- Consider a new reserve product
- Consider a more granular reserves
- Multi-scenario stochastic market clearing?

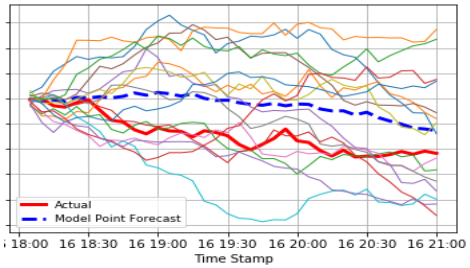
See MISO's *Markets of the Future* report

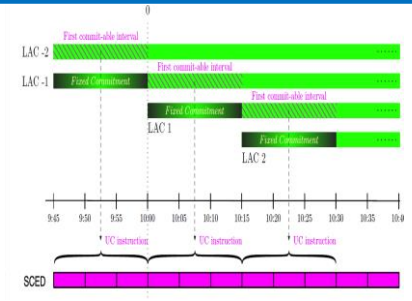
Sample research: Stochastic Look Ahead Commitment

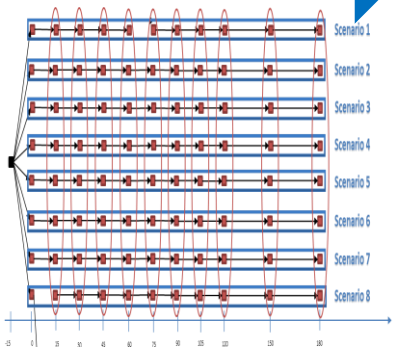
Funded by the U.S. Department of Energy, the project explores data analytics, scenario generation and stochastic optimization approaches

Uncertainty Analysis, point forecast improvement and Scenario Generation → **RT simulation** → **Stochastic LAC (SLAC)**









Improve prediction

- **Wind, load, NSI**
  Improve point forecast by considering recent forecast error
- **Generator uncertainty:**
  Predict unit start up and shut-down curves with machine learning

Identify range of probability

- **Scenario generation**
  Generate scenarios with trajectories for individual wind, load and interchange for 5-min intervals in the next 3 hours

Recommend actions (over a rolling window)

- **Rolling horizon RT simulation**
- **Reserves** Better determine reserve requirements (e.g., STR)
- **Commitment** Identify optimal commitment across scenarios to manage uncertainty

Thank you