



Managing Reliability Risk in the MISO Footprint

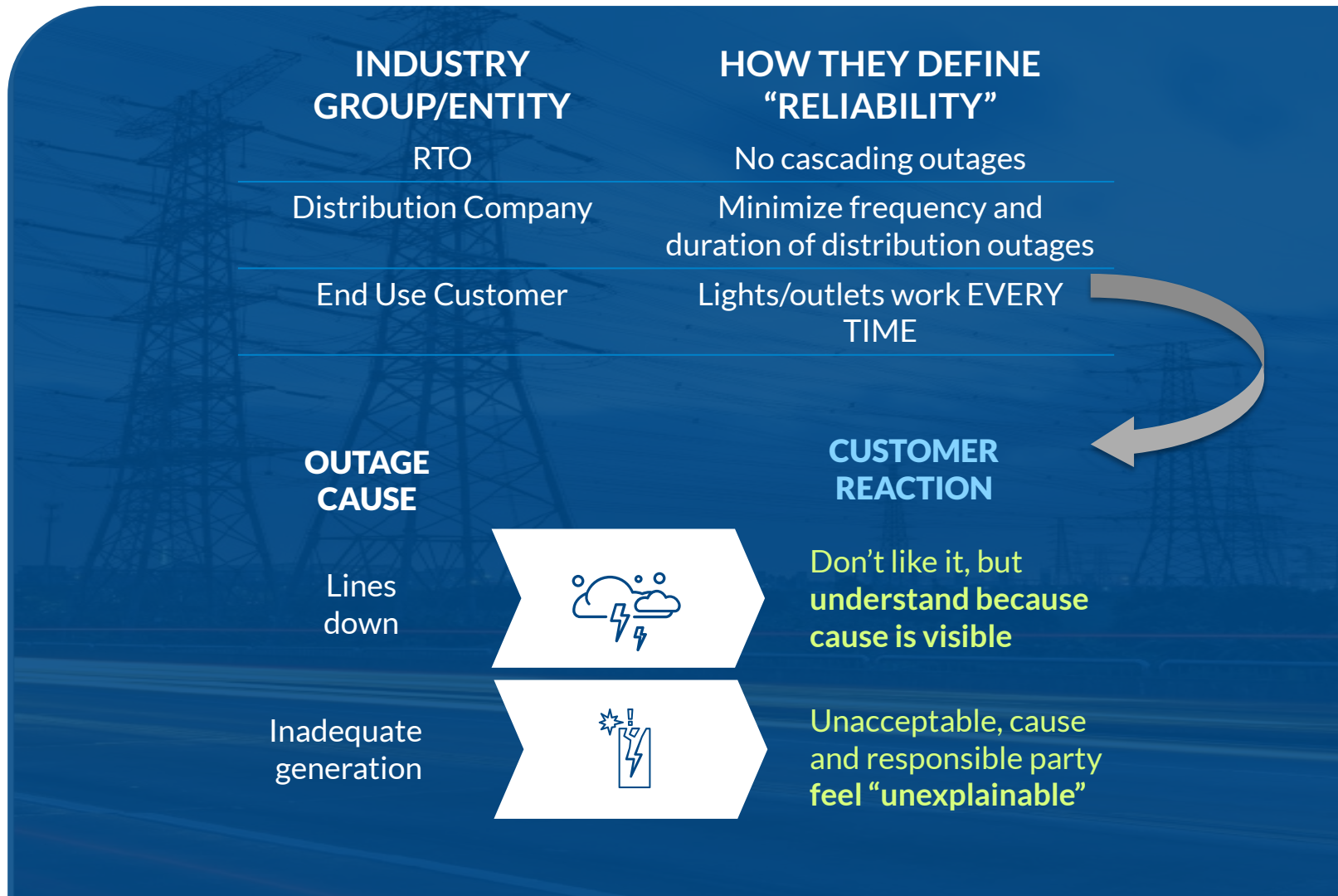
June 16, 2022

Executive Summary

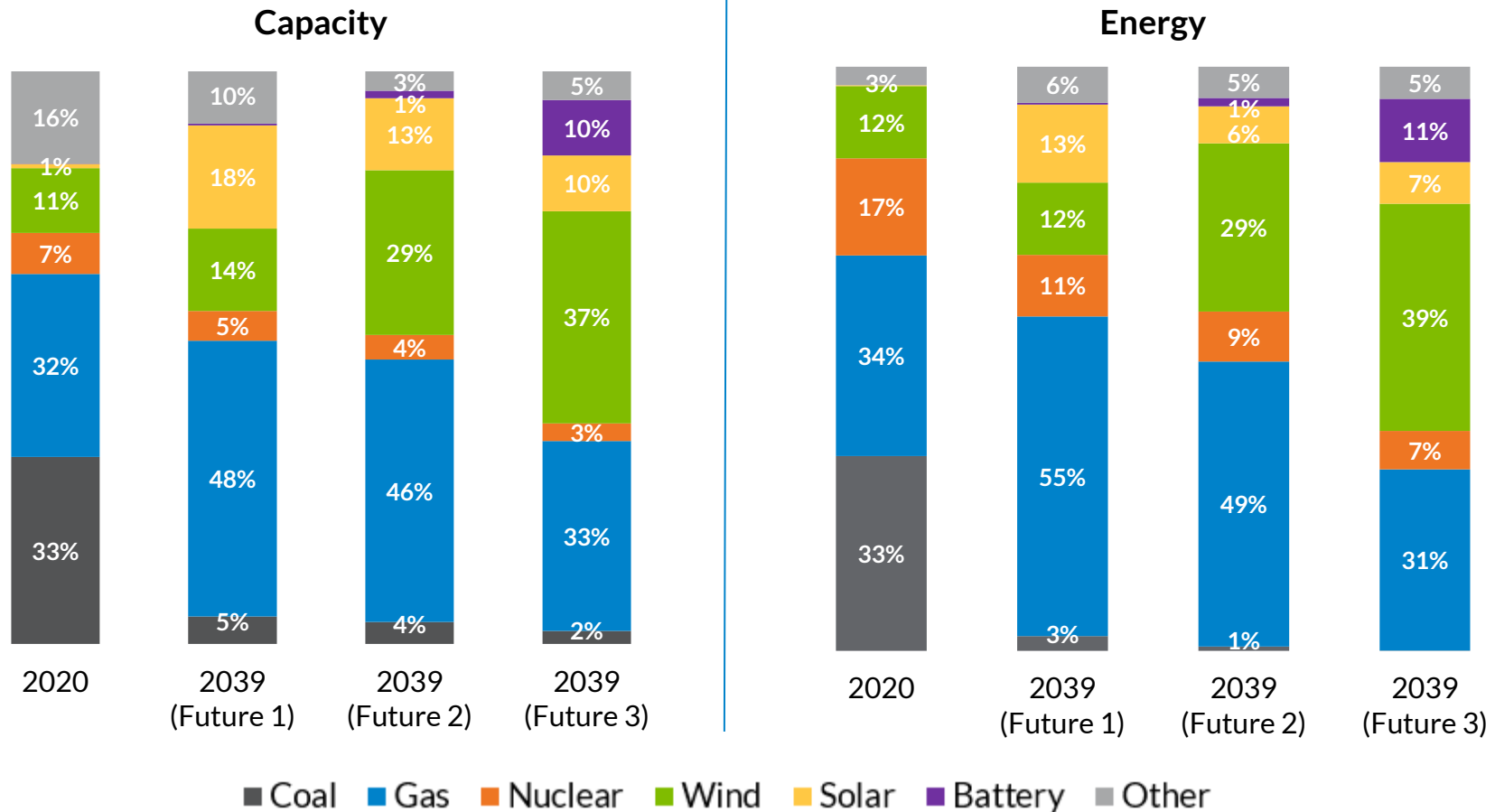


- In order to ensure energy sufficiency across all hours and at all locations, we must ensure sufficient resources are available to provide that energy - accreditation examines each resource's ability to do so
- Installed capacity in the MISO region is increasing while accredited capacity is falling resulting in growing reliability risk
- The MISO Region is on the front edge of insufficient supply and coordinated action is needed to ensure sufficient resources with accredited attributes are available throughout the fleet transition

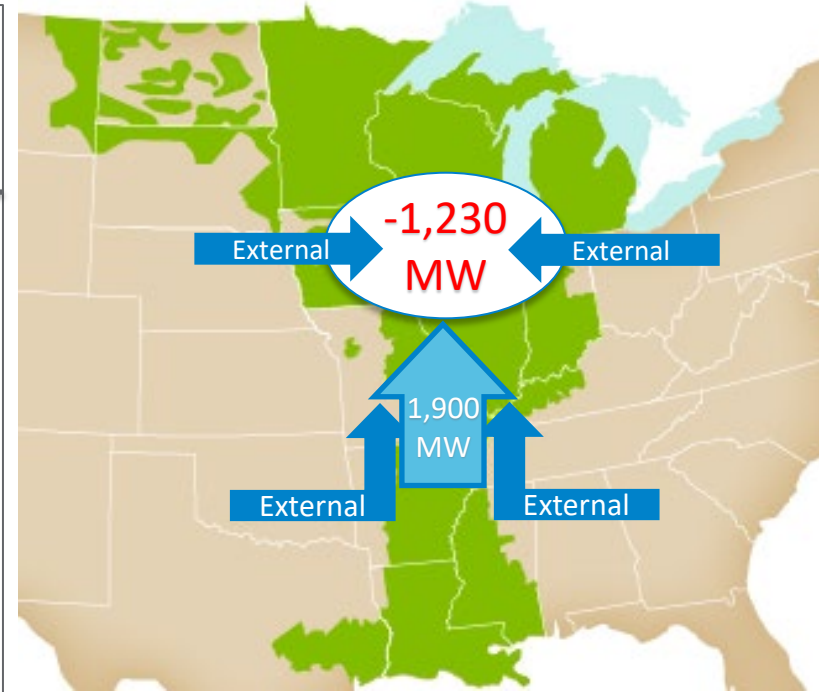
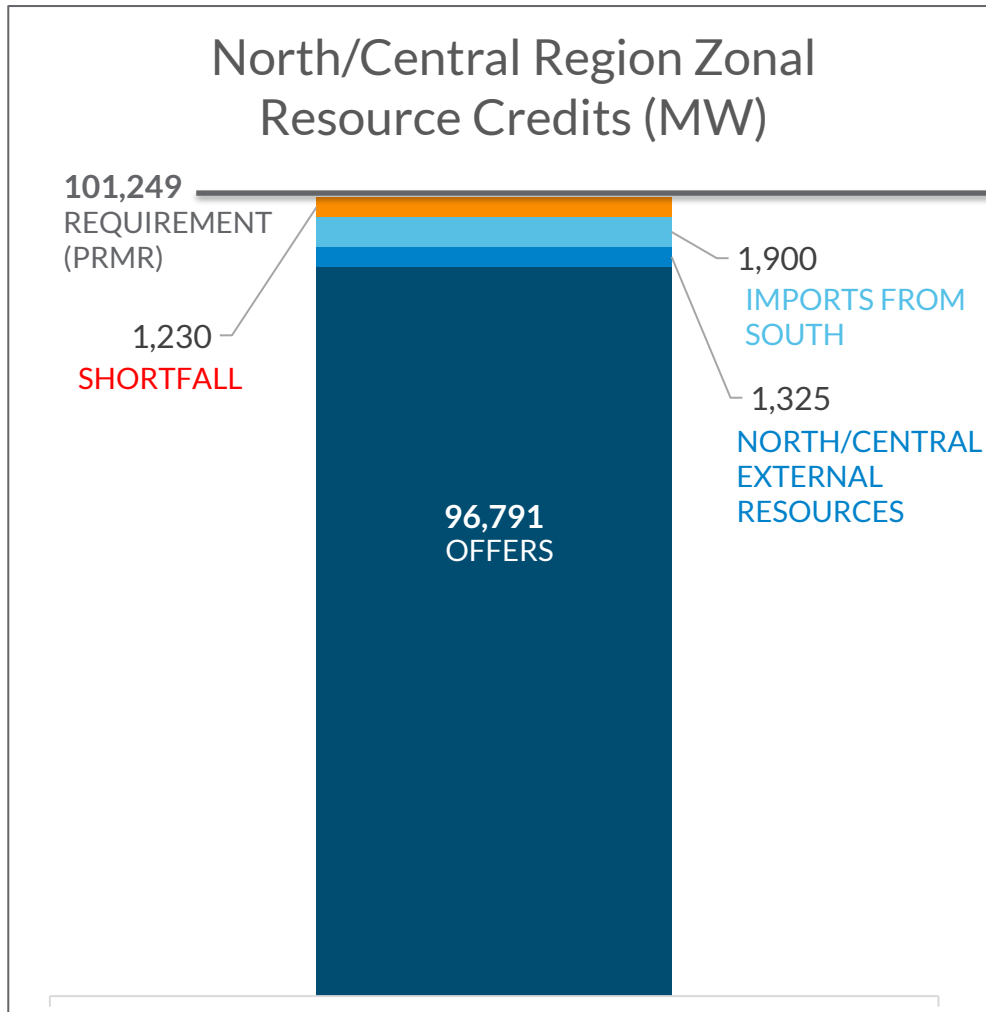
There are different definitions of reliability and different customer reactions to outage depending on causes



MISO's resource portfolio is on track for continued decarbonization in the future, necessitating controllable resources to balance weather-dependent resources

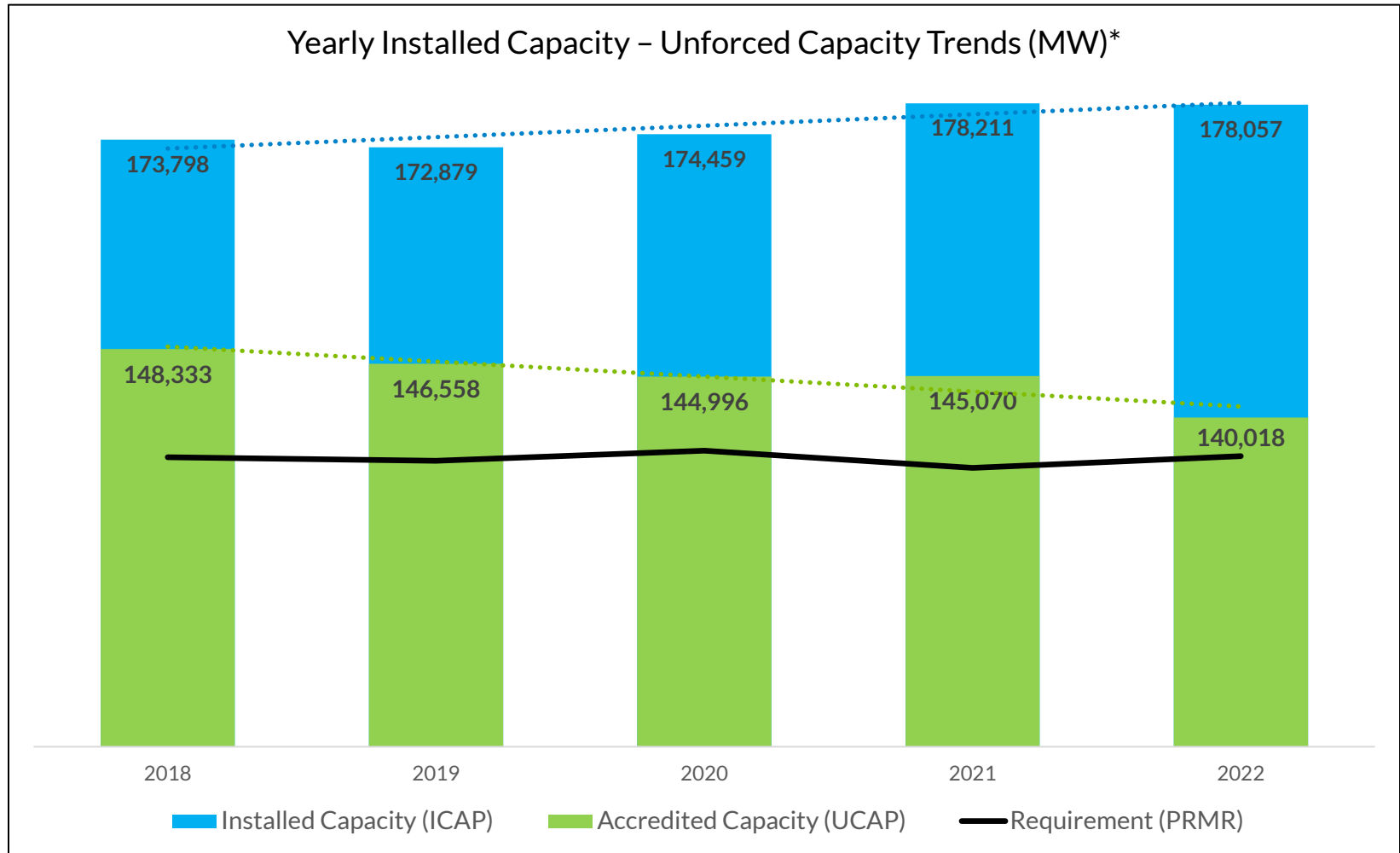


Capacity deficit in the recent Planning Resource Auction points to accelerating fleet change and increased risk

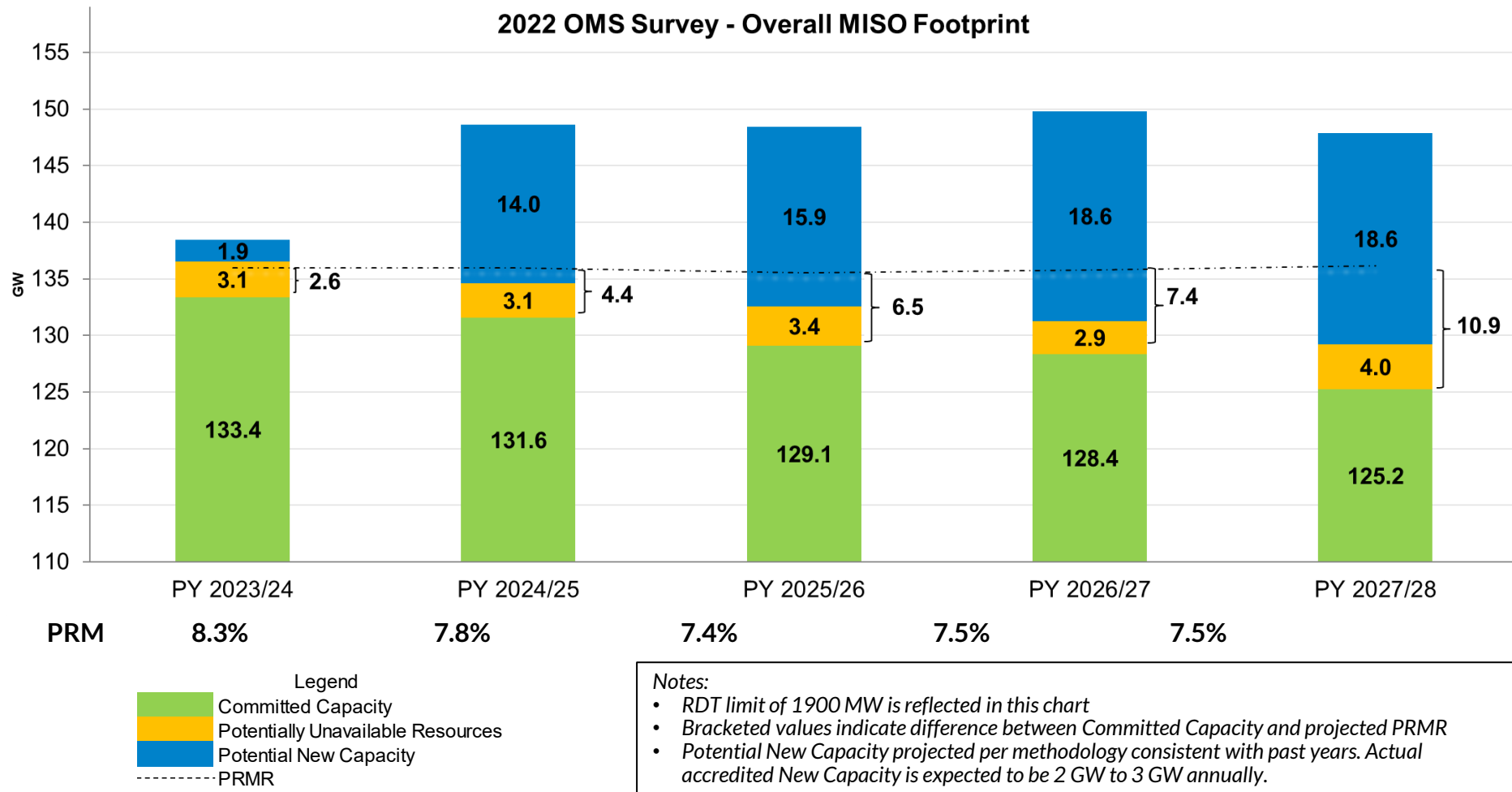


Insufficient capacity in the North and Central Regions increases Loss of Load Expectation from **1 day in 10** years to **1 day in 5.6** years

While total installed capacity has steadily trended up, accredited capacity is moving in the opposite direction due to the capabilities of the resource types selected



Committed accredited capacity projections show deficits starting in 2023, with increasing shortage over survey period



Maintaining accredited capacity at sufficient levels is facing significant challenges and the risks need attention before they create increased reliability risk

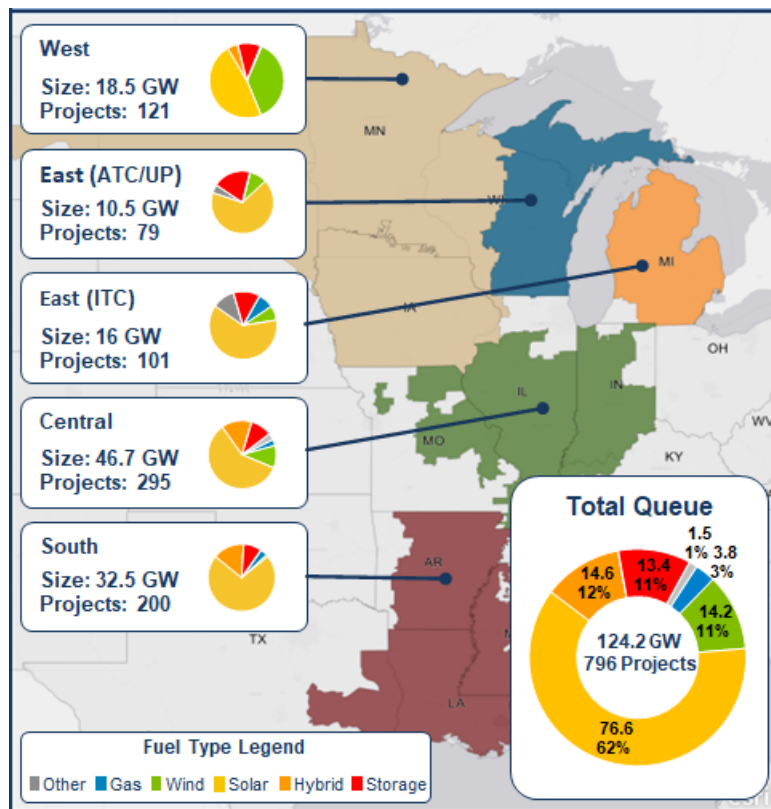
Challenges	
Accelerated retirements	●
Delayed additions of new generation	◐
Difficulty in bringing new gas generation on-line	◐
Challenged gas-electric coordination	◐
Load increases from electrification	◐
Increased forced outage rates for existing units	◐
Lack of interregional planning	◐
Increasing frequency and severity of extreme weather	◐

Mitigation Opportunities	
Potential for emerging clean dispatchable technologies	◑
Capacity from neighboring regions	◑
Long Range Transmission Planning / Additions	◑

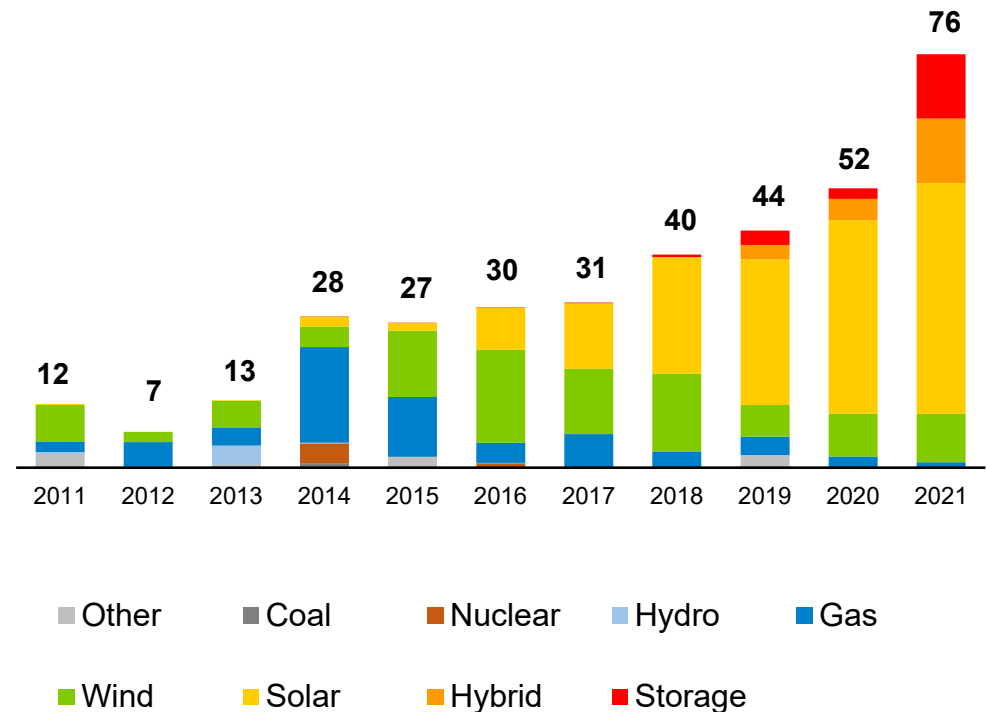
Key: Limited Challenge / Opportunity - ◑
 Significant Challenge / Opportunity - ●

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

MISO Active Queue by Study Area

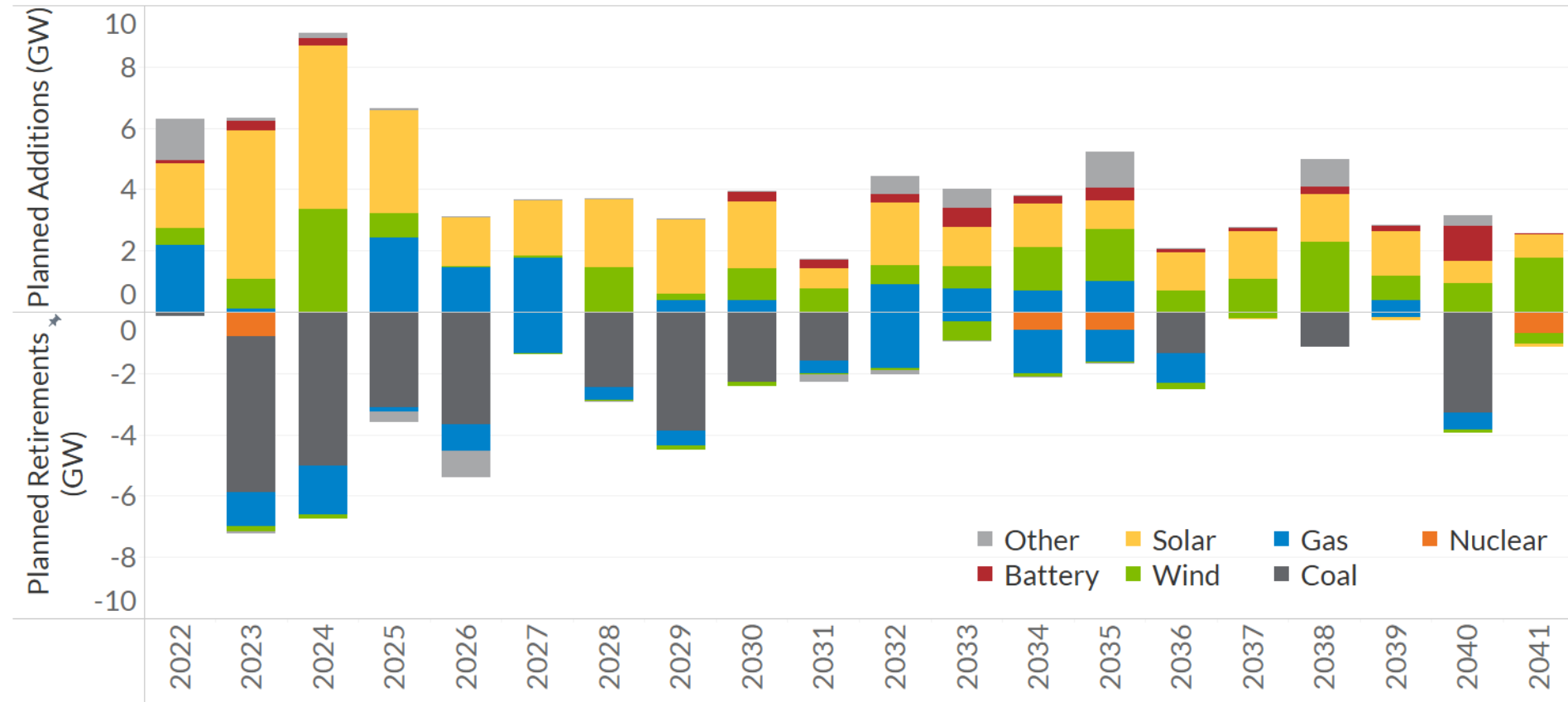


MISO Queue Historical Trend by Requested Generation (GW)



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

Nameplate Capacity
RRA 2022 Survey Results
Preliminary



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

...the view of which must be modified through the lens of accreditation – work that must advance rapidly

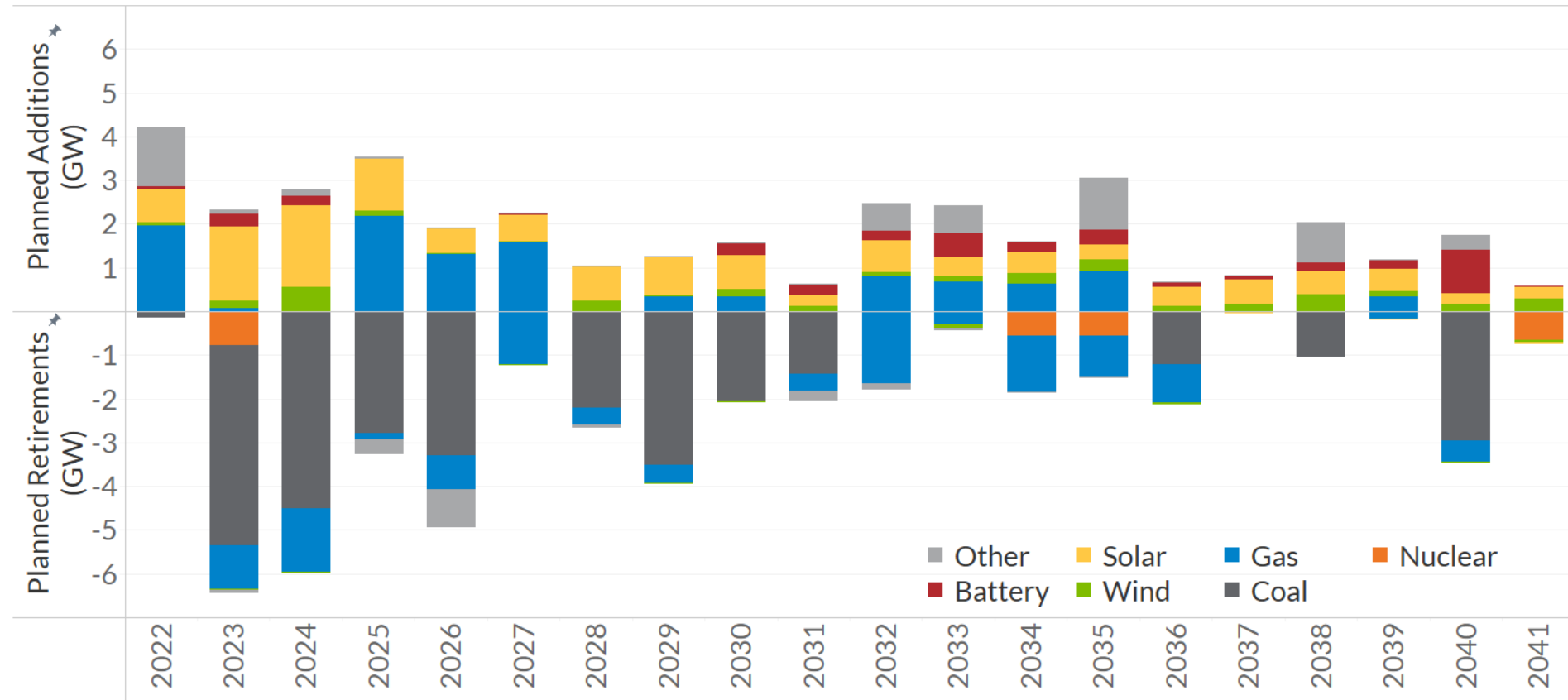
Resource type	Assumed accreditation	Impacted Seasonally
Nuclear	95%	No
Coal	90%	Small
Gas	90%	Small
Battery	87.5%	No
Solar	35%	Yes
Wind	16.6%	Yes

- Accreditation needs to be seasonal and adapt over time to account for actual performance during times when the resources are needed.
- Forced outage rates have trended upward, averaging 8% over the last five years, but are significantly higher during system emergency events:
 - 16% - MaxGen Event for North/Central (June 2021)
 - 37% - Winter Storm Uri (February 2021)
 - 22% - Polar Vortex (January 2019)
 - 17% - Cold Snap (January 2018)

*Note – future accreditation values are currently under development.
These assumed values are directionally correct but preliminary.*

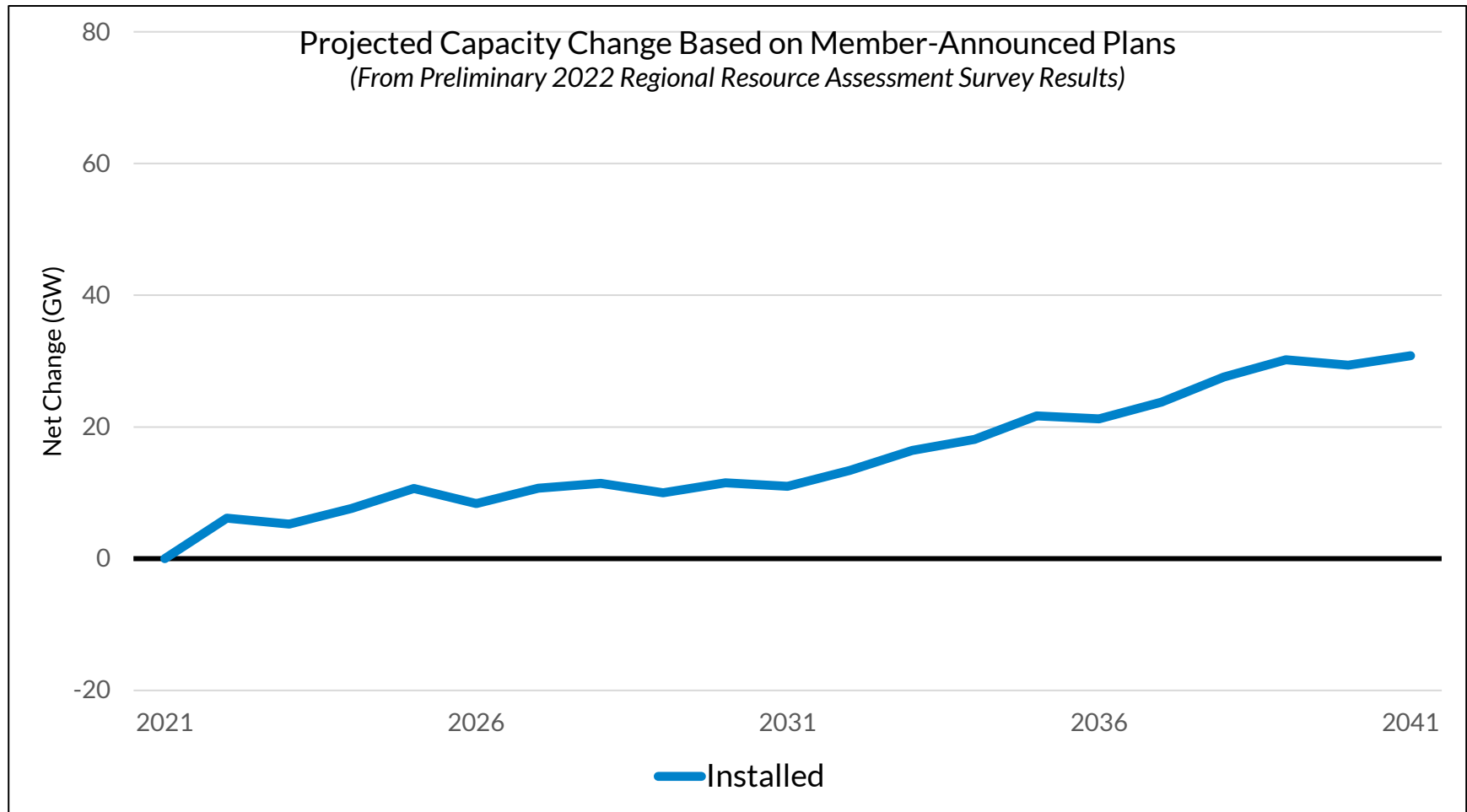
Looking at accredited capacity, planned additions are not on pace to make up for planned retirements

Estimated Accredited Capacity
RRA 2022 Survey Results
Preliminary

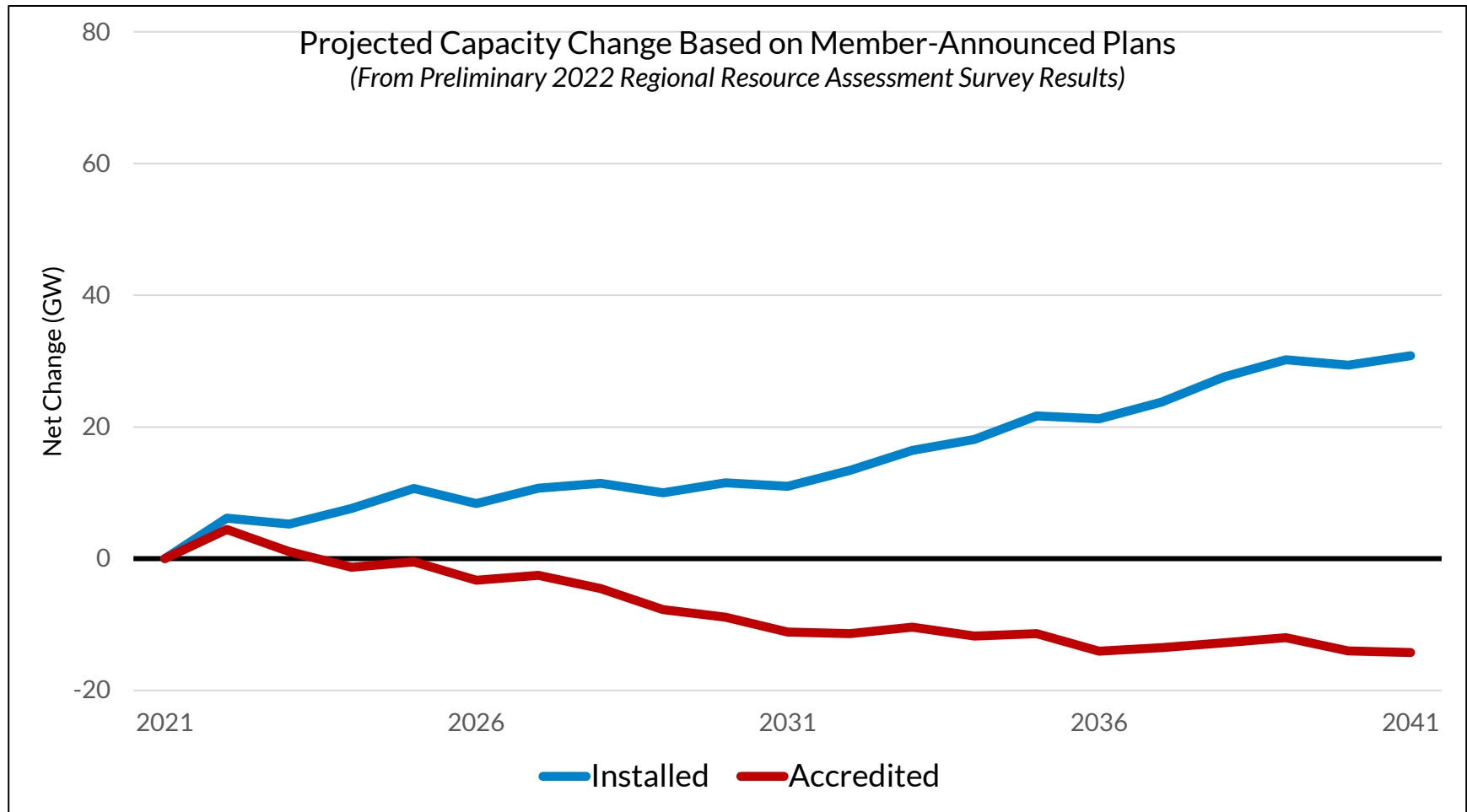


Estimated accredited capacity: 16.6% for wind; 35% for solar, 87.5% for battery, 90% for coal, 90% for gas, and 95% for nuclear

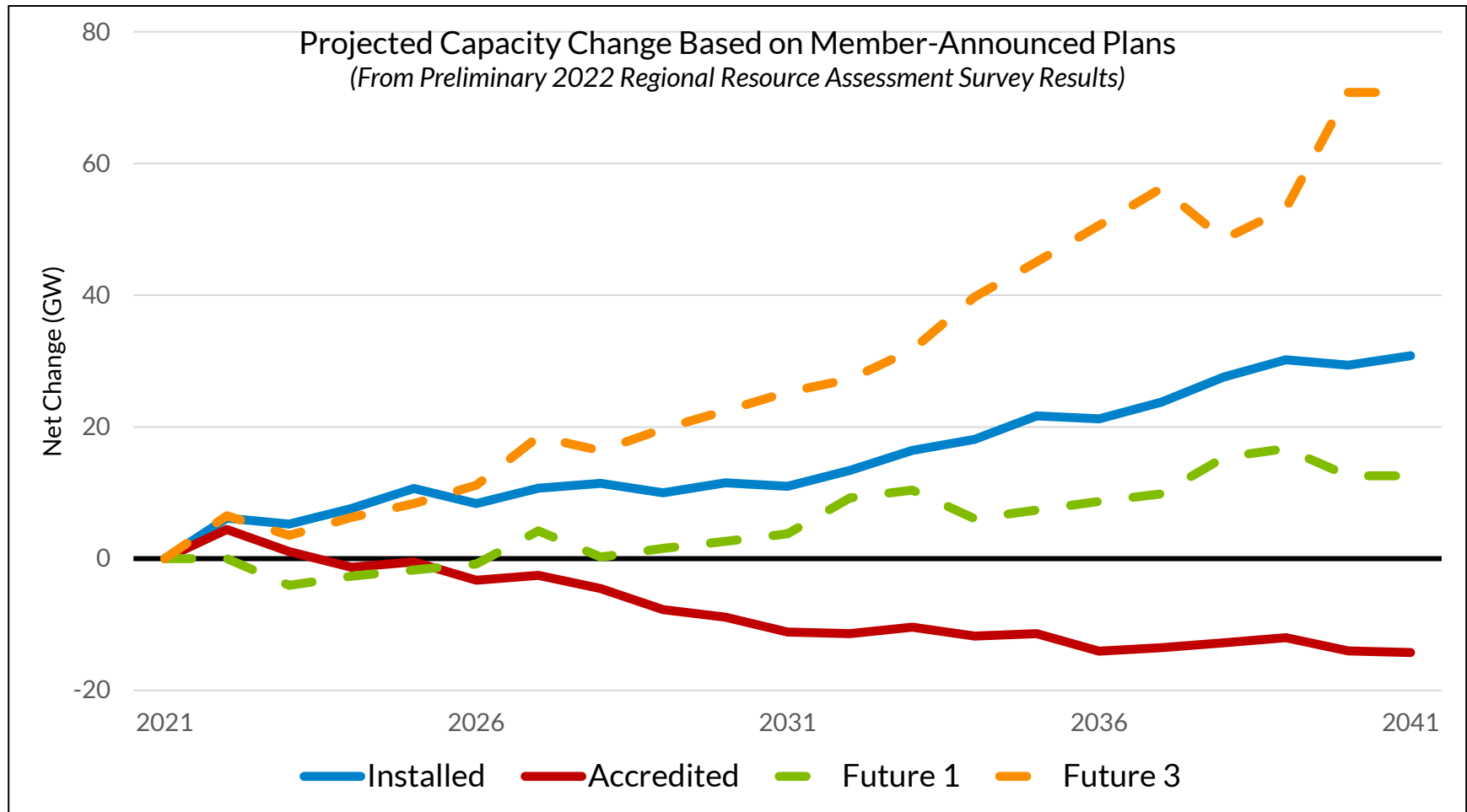
Although installed capacity is growing with the addition of weather dependent resources...



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



Declining accredited capacity combined with growing load will exacerbate risk of supply shortfalls



While energy and capacity are given significant attention, there are actually many critical attributes that are required to reliably operate the system

Illustrative Attributes	
Controllability	Ramp rate up
	Ramp rate down
	Rapid start up
	Minimum downtime
Certainty	Available in all seasons
	Fuel availability
	Energy adequacy / Output sustainability
	Run time limitations
	Inertia
	Carbon reducing

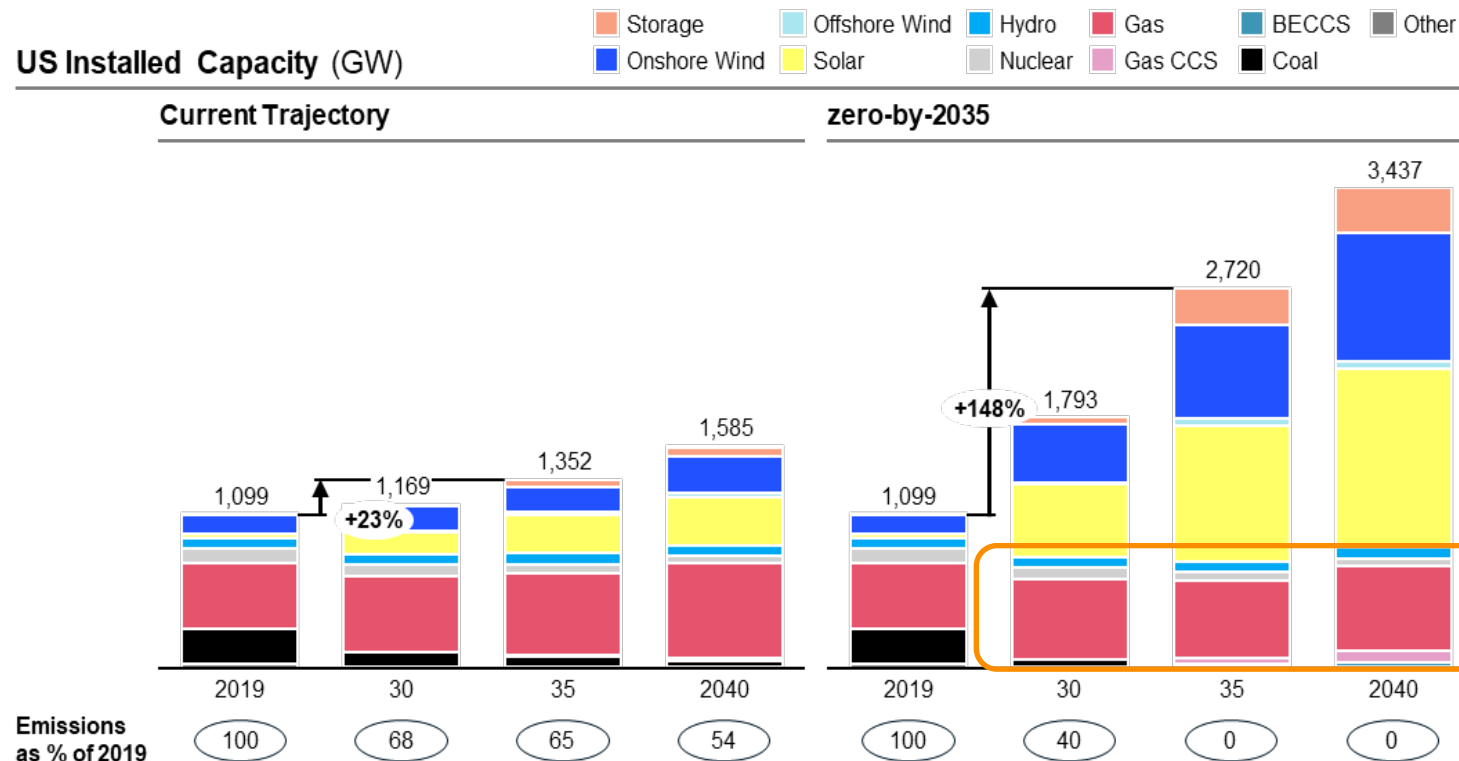
Note: MISO and the industry as a whole are still defining attributes. This list is illustrative and not exhaustive.

Different resource types each bring a unique mix of those attributes
 – while every resource does not need to bring all attributes, the system will need an “adequate” supply of each attribute

	Attribute	Battery	Coal	Gas	LMR	Nuclear	Solar	Wind
Controllability	Ramp rate up	●	●	●	◐	◐	◐	◐
	Ramp rate down	●	●	●	◐	◐	◐	◐
	Rapid start up	●	◐	●	◐	◐	●	●
	Minimum downtime	◐	◐	●	◐	◐	●	●
Certainty	Available in all seasons	●	●	●	◐	●	◐	◐
	Fuel availability	◐	◐	◐	◐	●	◐	◐
	Energy adequacy / Output sustainability	◐	●	●	◐	●	◐	◐
	Run time limitations	◐	◐	◐	◐	●	●	●
	Inertia	◐	●	◐	◐	●	◐	◐
	Carbon reducing	?	○	◐	●	●	●	●

Key: Weak Provider of Attribute - ◐
 Strong Provider of Attribute - ●

A McKinsey study of the U.S. power indicates that gas remains a critical source of reliable, dispatchable power – because it contains many of the attributes lacking in other resource types – but it will be utilized more rarely



Takeaways

The zero-by-2035 scenario sees a more significant increase in capacity than the base case in order to meet increased electric load and produce hydrogen

Legacy nuclear plants are likely to provide <5% of power capacity in 2040

Gas remains a critical source of reliable, dispatchable power, but is utilized more rarely

We collectively need to be prudent in our actions to ensure sufficient resources and flexibility during the fleet transition

States

- Factor regional consideration into state resource adequacy, resource attribute, and market construct requirements
- Inform the broader policy and statutory discussion at the state level
- Implement NERC recommendations for resiliency and reliability

Members

- Collaborate with MISO and States on timely resource adequacy, market enhancements and regional transmission
- Share resource plans with MISO to enable accurate regional view

MISO

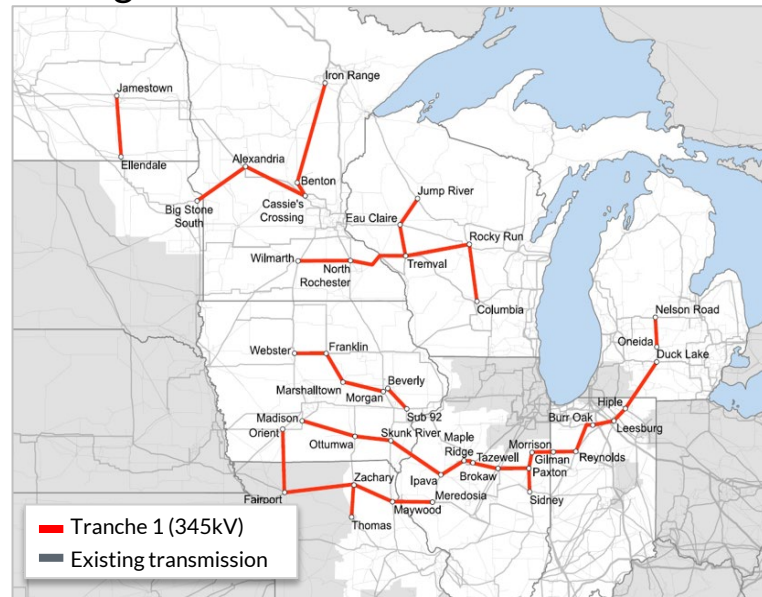
- Enhance transparency of resource evolution and regional outlook
- Improve Resource Adequacy construct
- Visibility into and reviewing impacts of resource retirements
- Inform the broader policy discussion with federal policymakers and agencies

A number of key changes have been proposed, or are in the Market Redefinition workplan

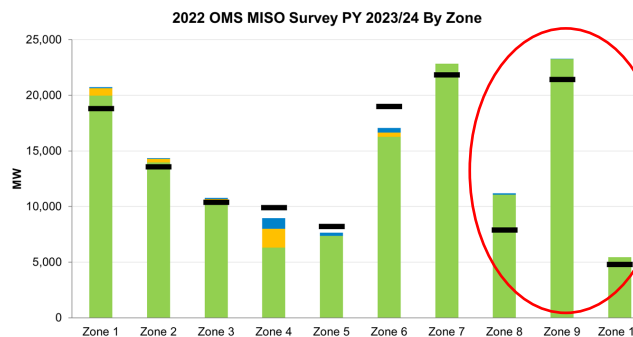
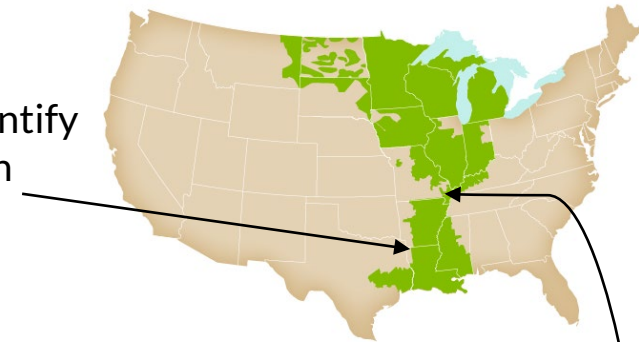
Filed at FERC	
Improved Resource Accreditation	➤ Thermal changes filed in 2021
Resource Adequacy Construct	➤ Proposed move from annual to seasonal filed in 2021
Pricing	➤ Initial scarcity price reforms were filed in 2021
Current Activities	
Improved Resource Accreditation	➤ Renewable and Load Modify Resources the focus in 2022
Resource Adequacy Construct	➤ Potential improvements to the Planning Resource Auction
Pricing	➤ Continued refinement of scarcity price reforms
Resource Attributes	➤ Considering approaches to valuing resource attributes critical to reliably operating the evolving portfolio
Future Activities	
Pricing	➤ Improved modeling, such as a sloped demand curve, to achieve more efficient market outcomes and price signals

The Long Range Transmission Planning effort is increasing the ability to add and transfer carbon-free and flexible resources throughout the system

Tranche 1 is \$10+ billion of investment in the North and Central Regions. **Tranche 2** will address additional needs in these subregions.

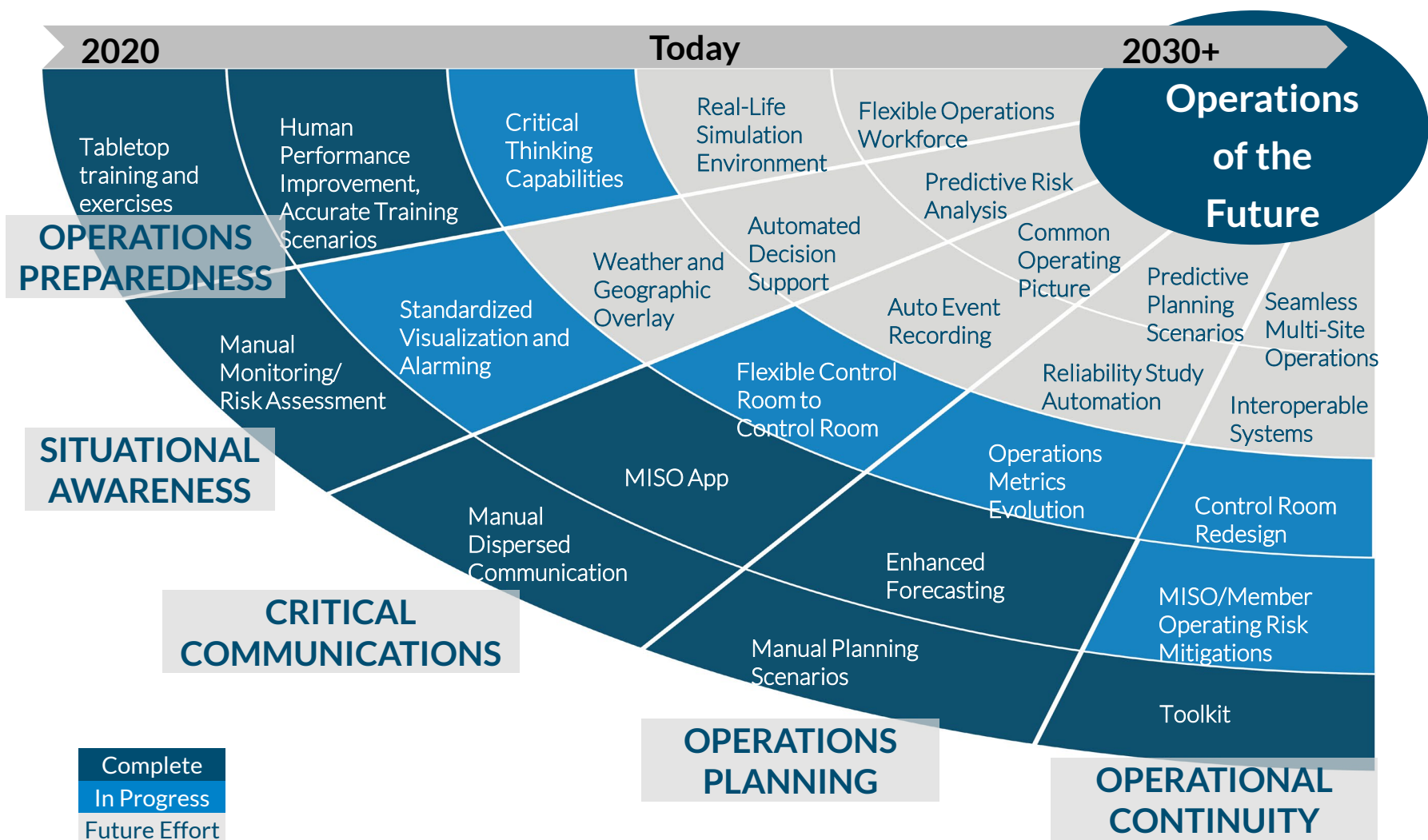


Tranche 3 will identify and address South Region needs...



...and **Tranche 4** will be focused on the North/South interface, which could free up any remaining capacity surplus in the South Region

Operational enhancements are vital to managing the grid of the future and mitigating fleet transition and electrification risks



The MSE program is working on delivering several new external-facing products and is still on target to conclude in late 2024



Extend the life of the current system



Design a flexible, scalable adaptable system



Upgrade, build and launch a new market system

- ✓ Set Business Objectives
- ✓ Explored Vendor Alternatives
- ✓ Enhanced Training Simulator

- ✓ Launched Private Cloud Computing Platform
- ✓ Launched Data Analytics & Governance

- Launch upgraded Energy Management System
- Launch Electric Storage Resources

- Launch new Real-Time Market



- ✓ Initiated Program

- ✓ Completed Legacy MMS & EMS Life Extensions
- ✓ Integrated Architecture

- ✓ Launched new Market User Interface
- ✓ Launched new Model Manager (Phase 1)
- ✓ Launched Short-Term Reserve Market Product

- Complete Model Manager (Phase 2)
- Launch new Day-Ahead Market

DELIVER THE MARKET SYSTEM OF THE FUTURE

Platform ready for future products and continued architectural upgrades

MISO has consistently delivered substantial value in excess of the cost of membership. In a high renewables future, membership is expected to be even more valuable

QUANTITATIVE BENEFITS

MISO provides approximately
**\$3.4 billion in annual
benefits** to members

QUANTITATIVE BENEFITS

By 2030, MISO will provide
approximately **\$4.3-\$5.8
billion in annual benefits**
to members

QUANTITATIVE BENEFITS

By 2040, MISO will provide
approximately **\$11.6-\$14.3
billion in annual benefits**
to members

As the complexity of the power grid grows, the benefit of sharing across the large MISO footprint will also grow – allowing all areas to meet their decarbonization and efficiency goals while enjoying continued reliability. Even using a conservative growth of MISO costs, the ratio of costs-to-benefits for MISO members is expected to increase from 1:11 to 1:26.