Managing Reliability Risk in the MISO Footprint

June 16, 2022

Executive Summary

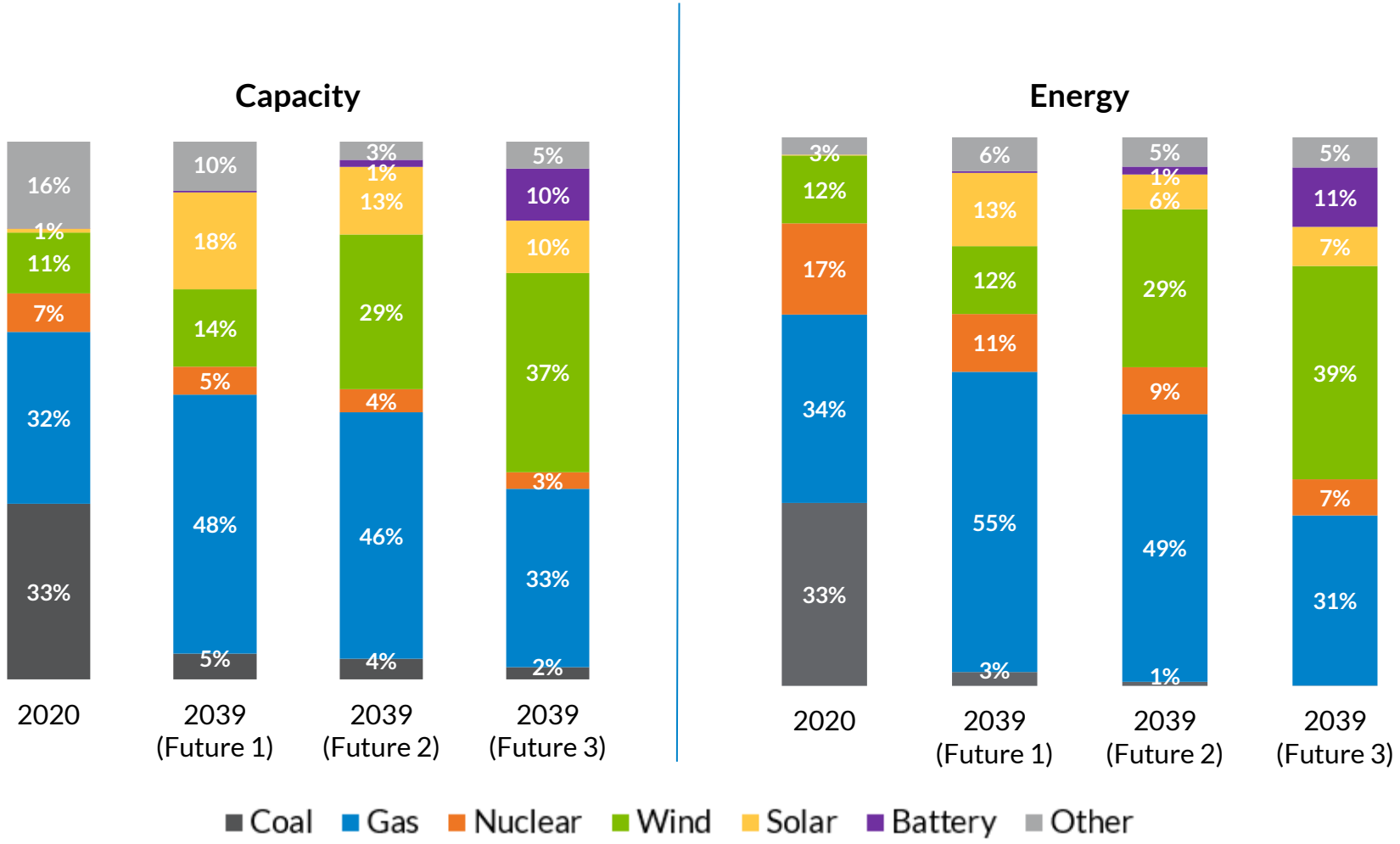
- In order to ensure energy sufficiency across all hours and at all locations, we must ensure sufficient resources are available to provide that energy - accreditation examines each resource's ability to do so
- Installed capacity in the MISO region is increasing while accredited capacity is falling 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

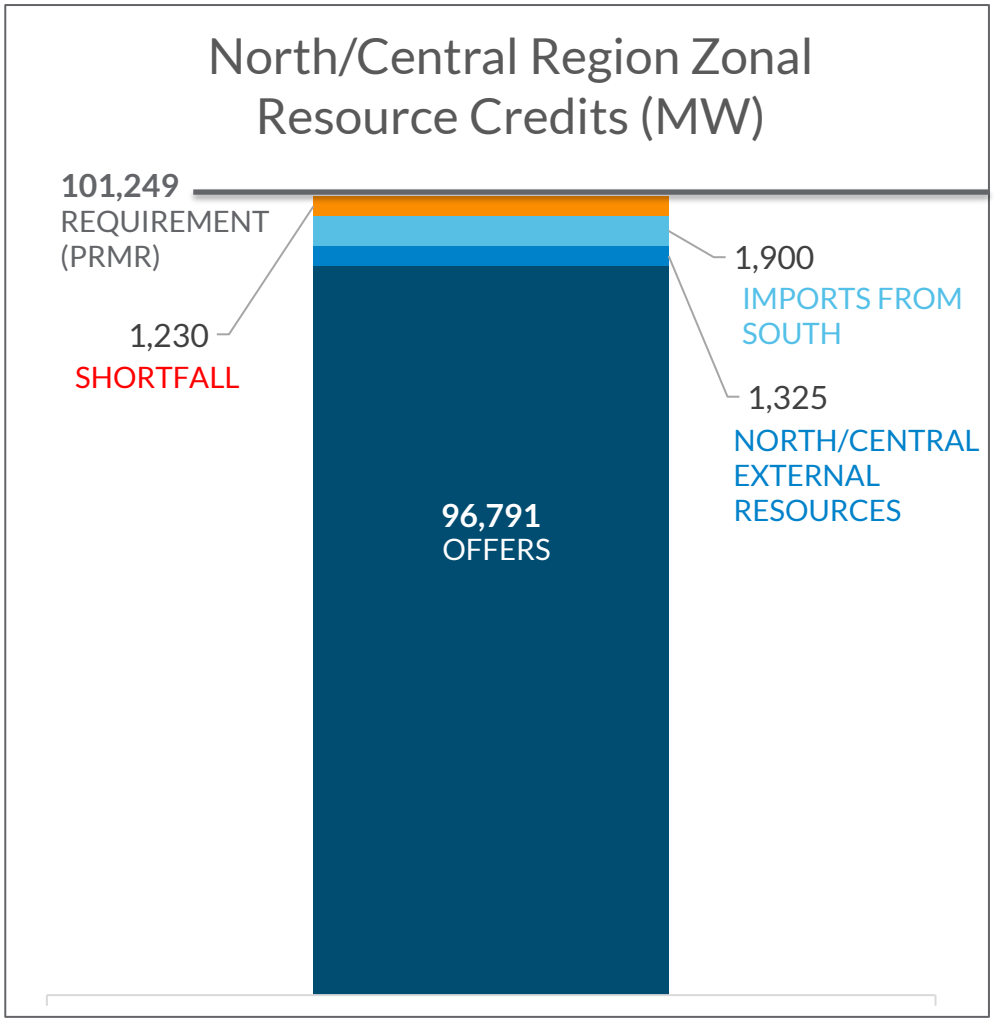
INDUSTRY GROUP/ENTITY	HOW THEY DEFINE "RELIABILITY"
RTO	No cascading outages
Distribution Company	Minimize frequency and duration of distribution outages
End Use Customer	Lights/outlets work EVERY TIME

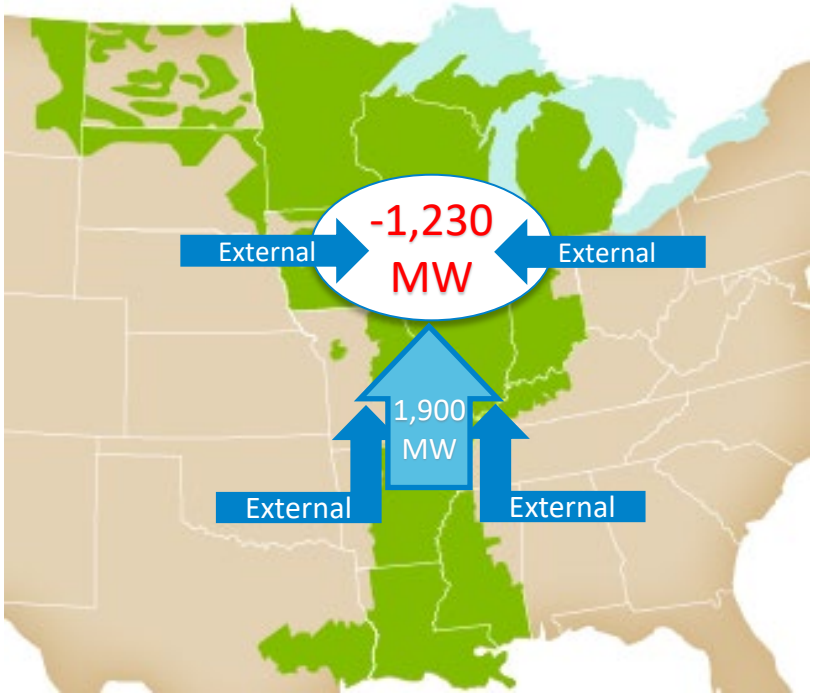
OUTAGE CAUSE	CUSTOMER REACTION
Lines down	Don't like it, but **understand because cause is visible**
Inadequate generation	Unacceptable, cause and responsible party **feel "unexplainable"**

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

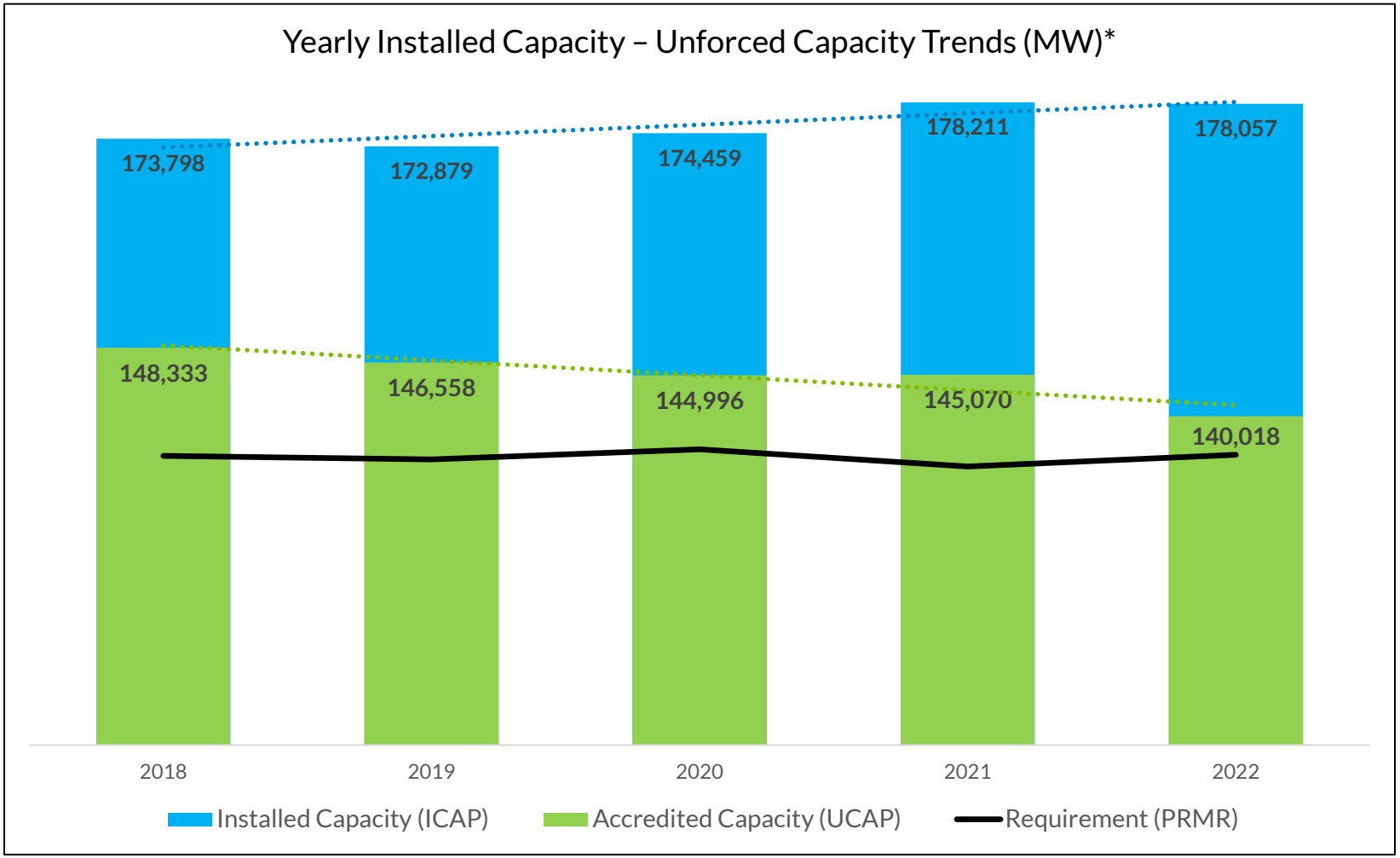




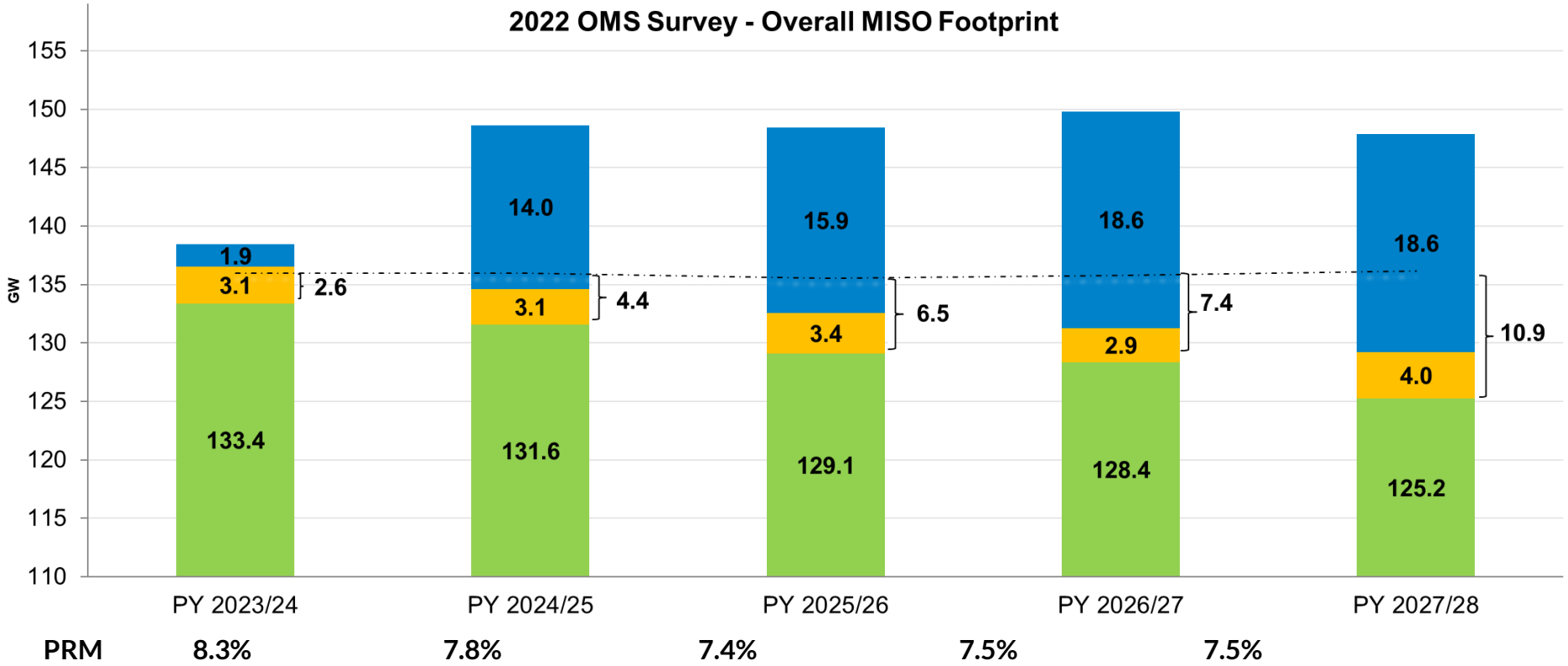
Insufficient capacity in the North and Central Regions increases Loss of Load Expectation from 1 day in 10 years to 1 day in 5.6 years

PRMR = Planning Reserve Margin Requirement

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



Notes:

- *RDT limit of 1900 MW is reflected in this chart*
- *Bracketed values indicate difference between Committed Capacity and projected PRMR*
- *Potential New Capacity projected per methodology consistent with past years. Actual accredited New Capacity is expected to be 2 GW to 3 GW annually.*

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

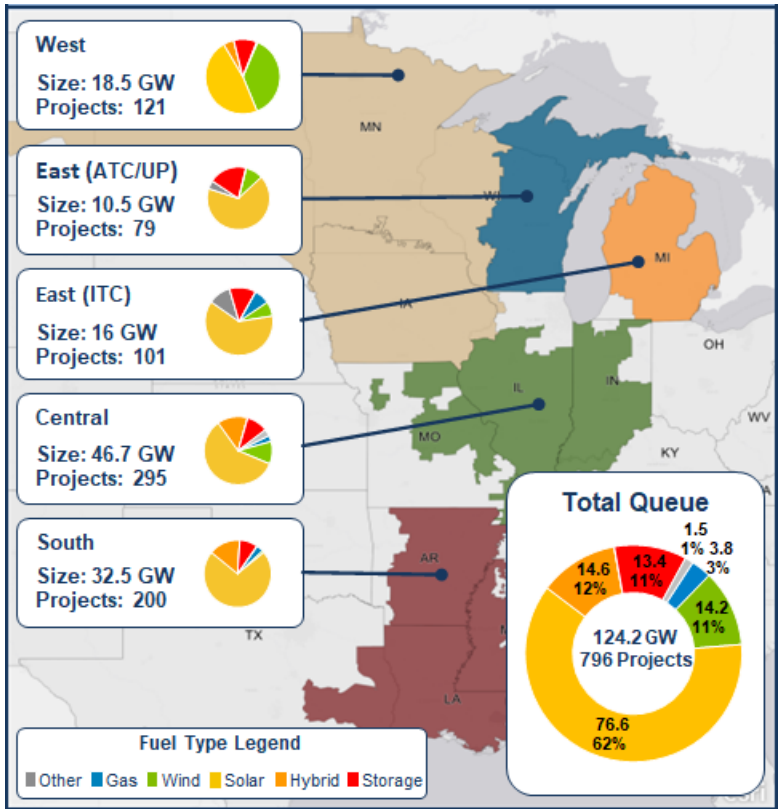
Challenges	
Accelerated retirements	●
Delayed additions of new generation	◕
Difficulty in bringing new gas generation on-line	◕
Challenged gas-electric coordination	◑
Load increases from electrification	◕
Increased forced outage rates for existing units	◑
Lack of interregional planning	◑
Increasing frequency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

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

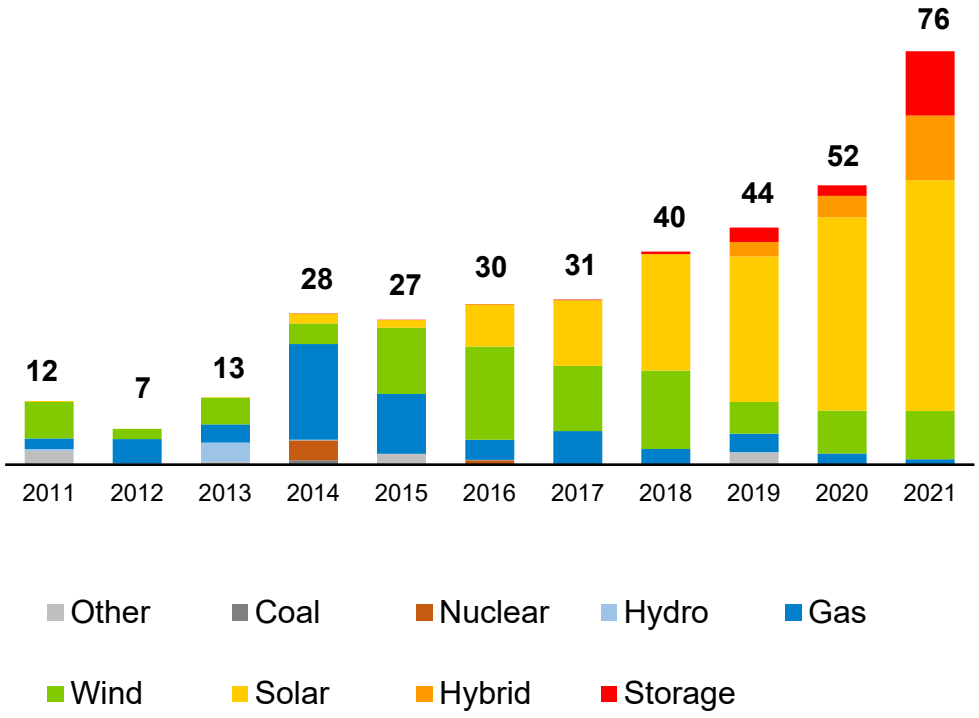
Key: Limited Challenge / Opportunity - ◔
Significant Challenge / Opportunity - ●

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

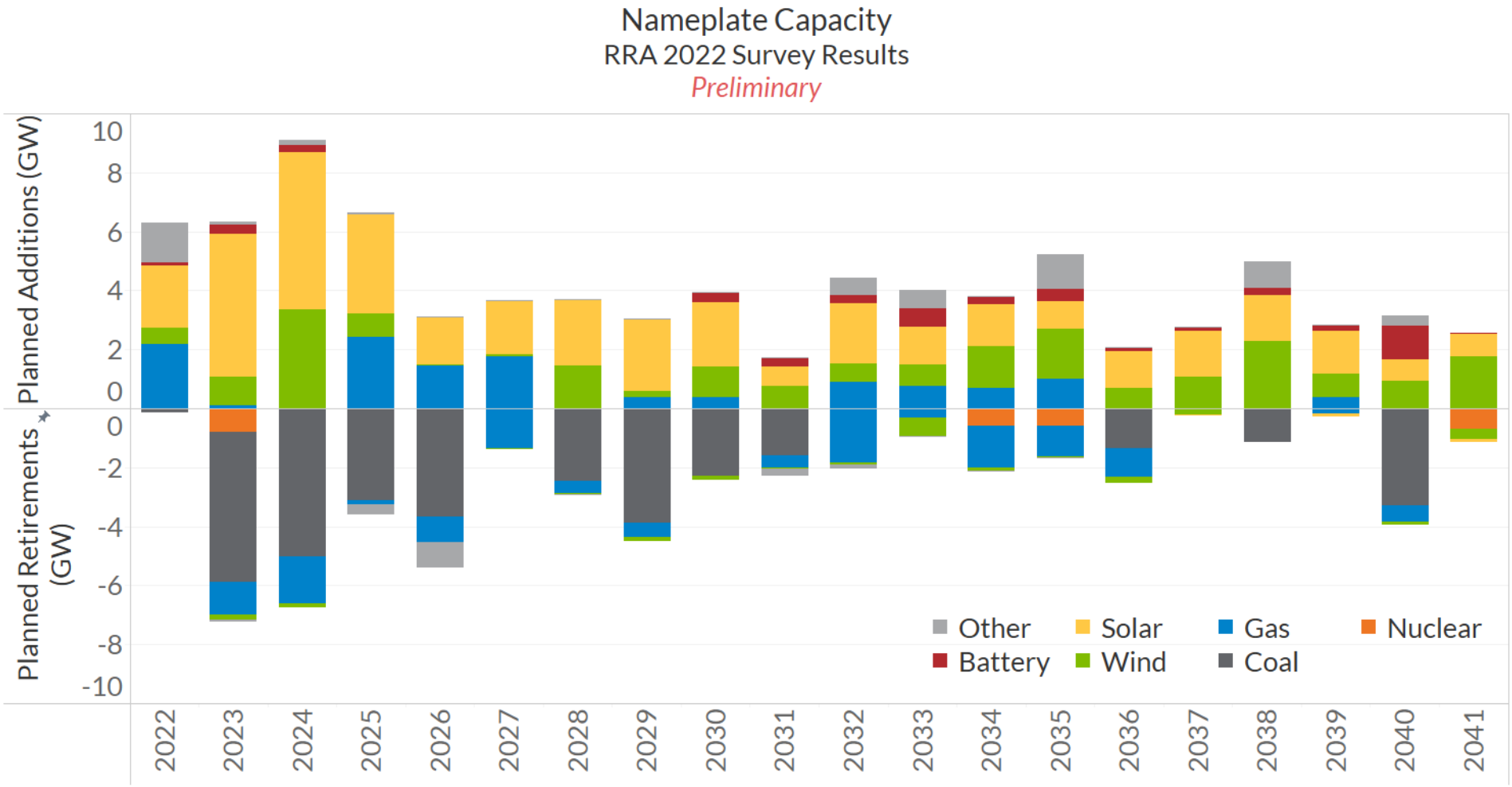


MISO Queue Historical Trend by Requested Generation (GW)



Queue data as of 5/16/2022

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



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

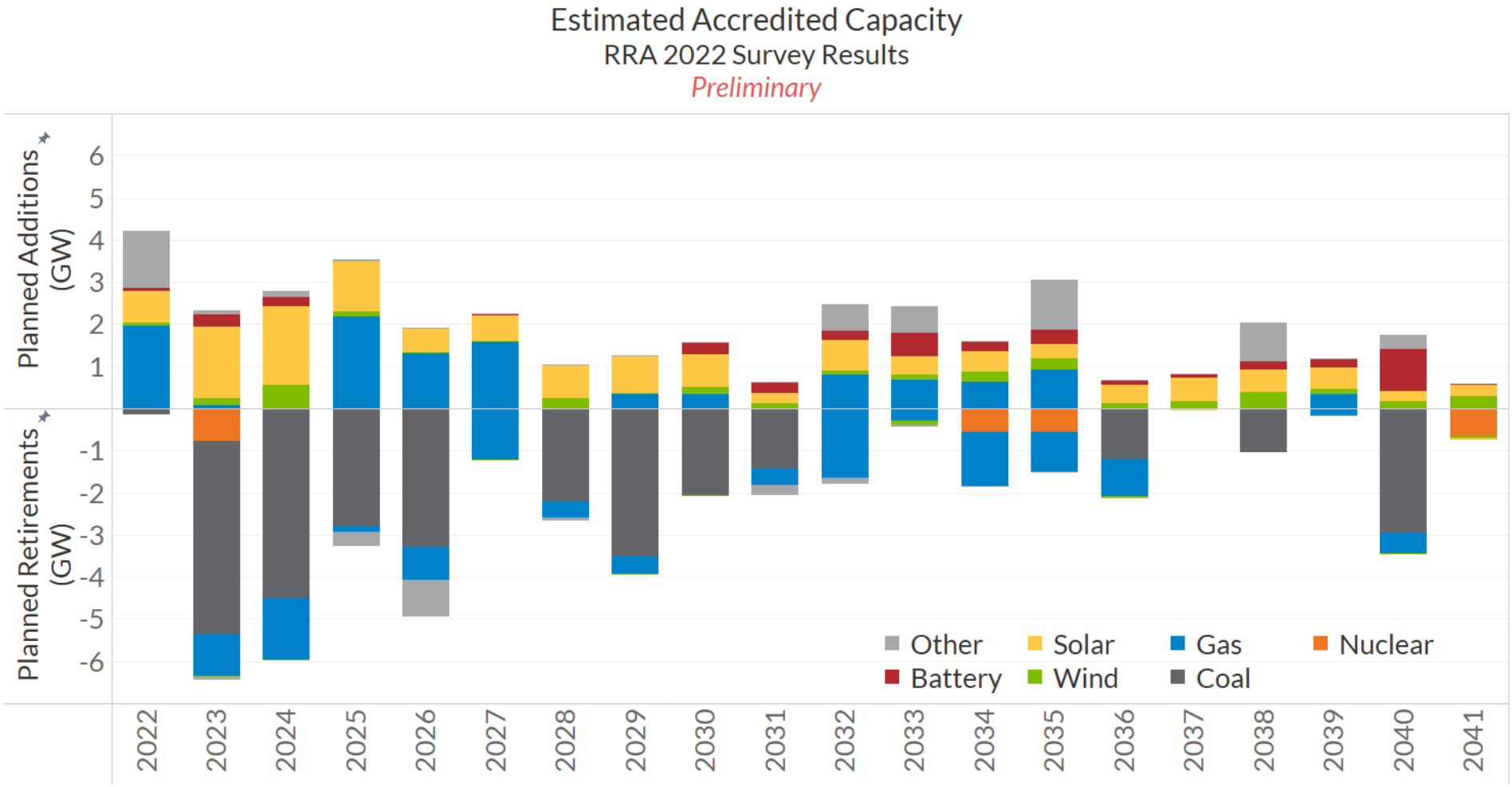
…the view of which must be modified through the lens of accreditation – work that must advance rapidly

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)

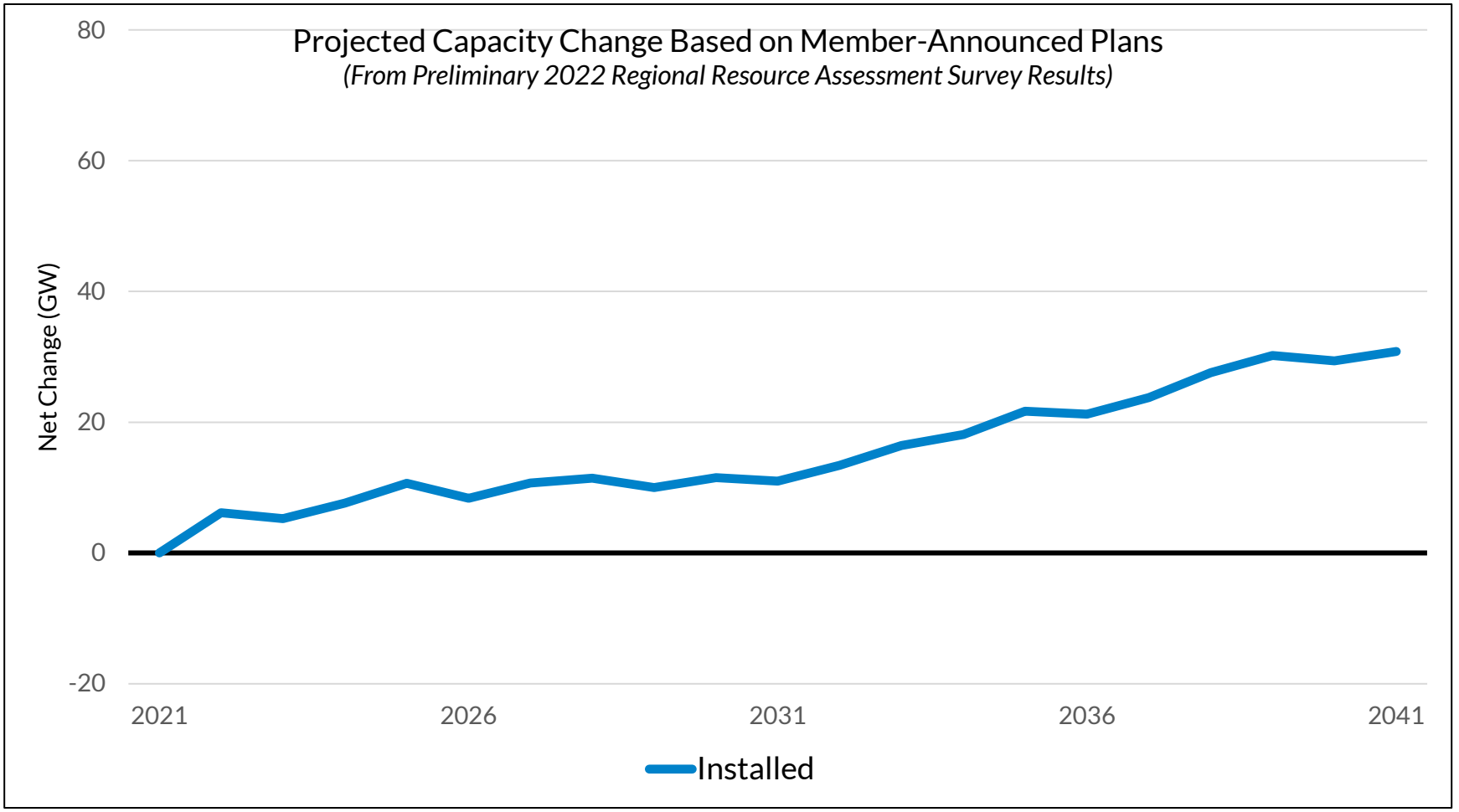
Note – future accreditation values are currently under development. These assumed values are directionally correct but preliminary.

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



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

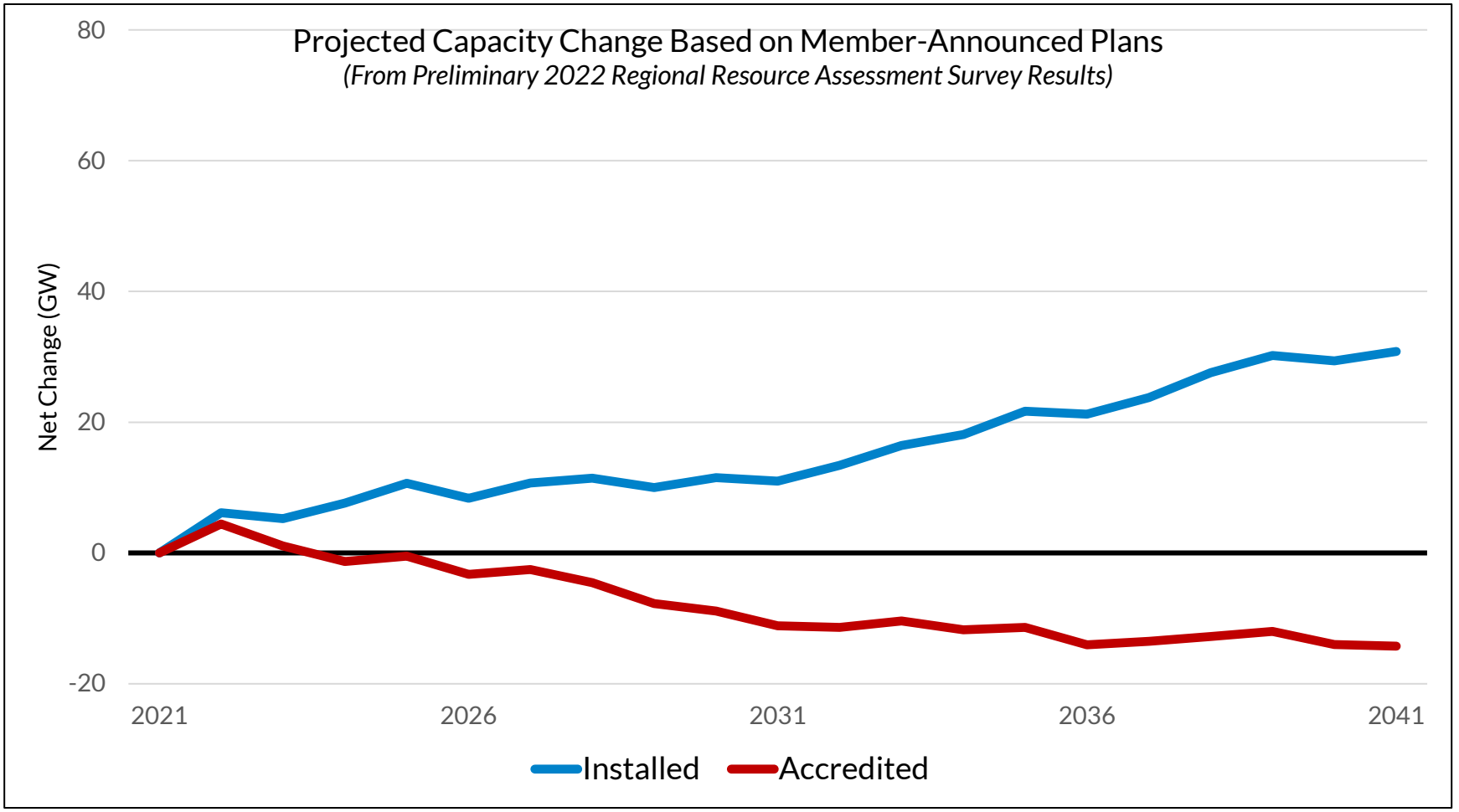
Although installed capacity is growing with the addition of weather dependent resources…



*Future projections calculated as change from Future 1 2022 assumptions

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

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



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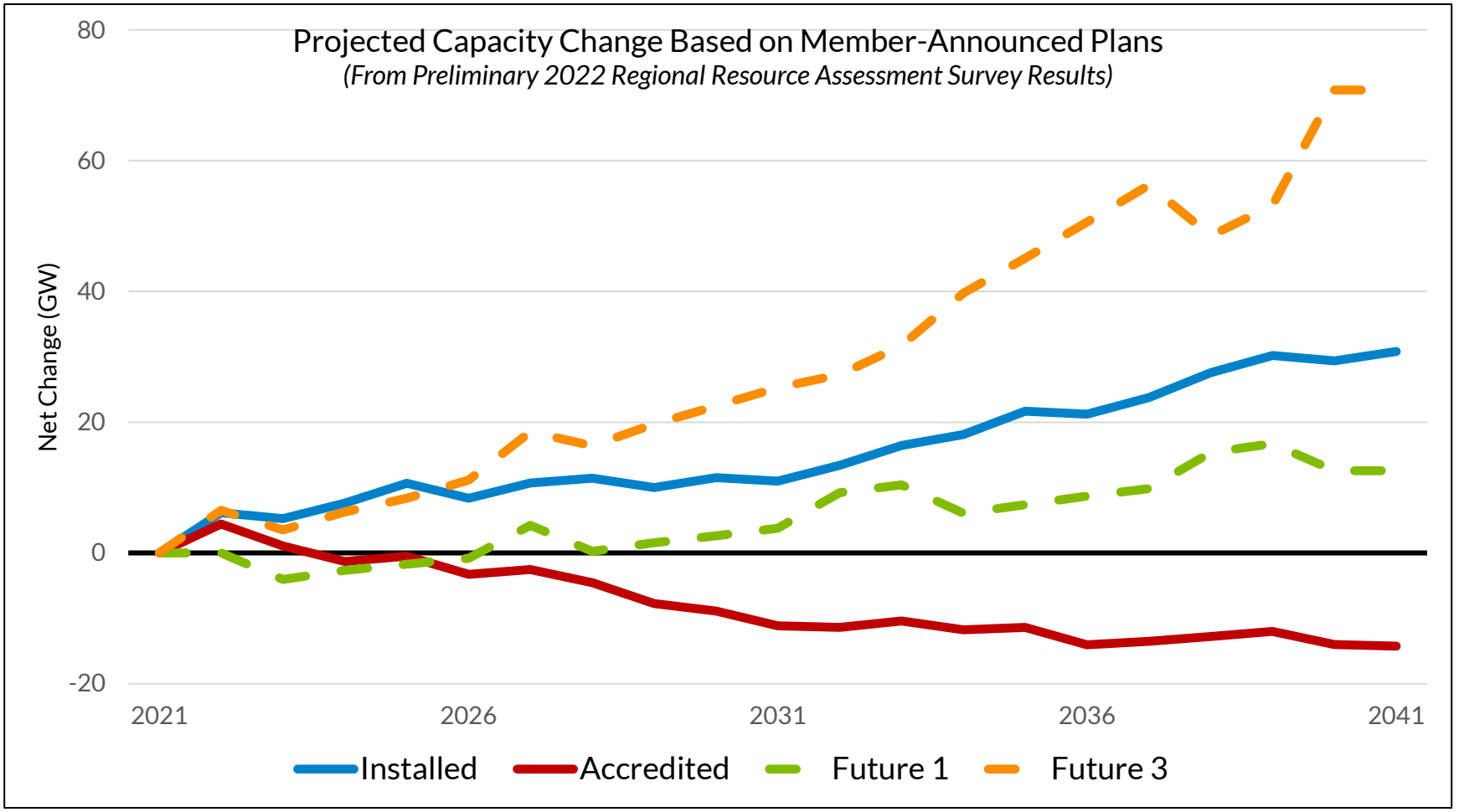
Declining accredited capacity combined with growing load will exacerbate risk of supply shortfalls



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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.

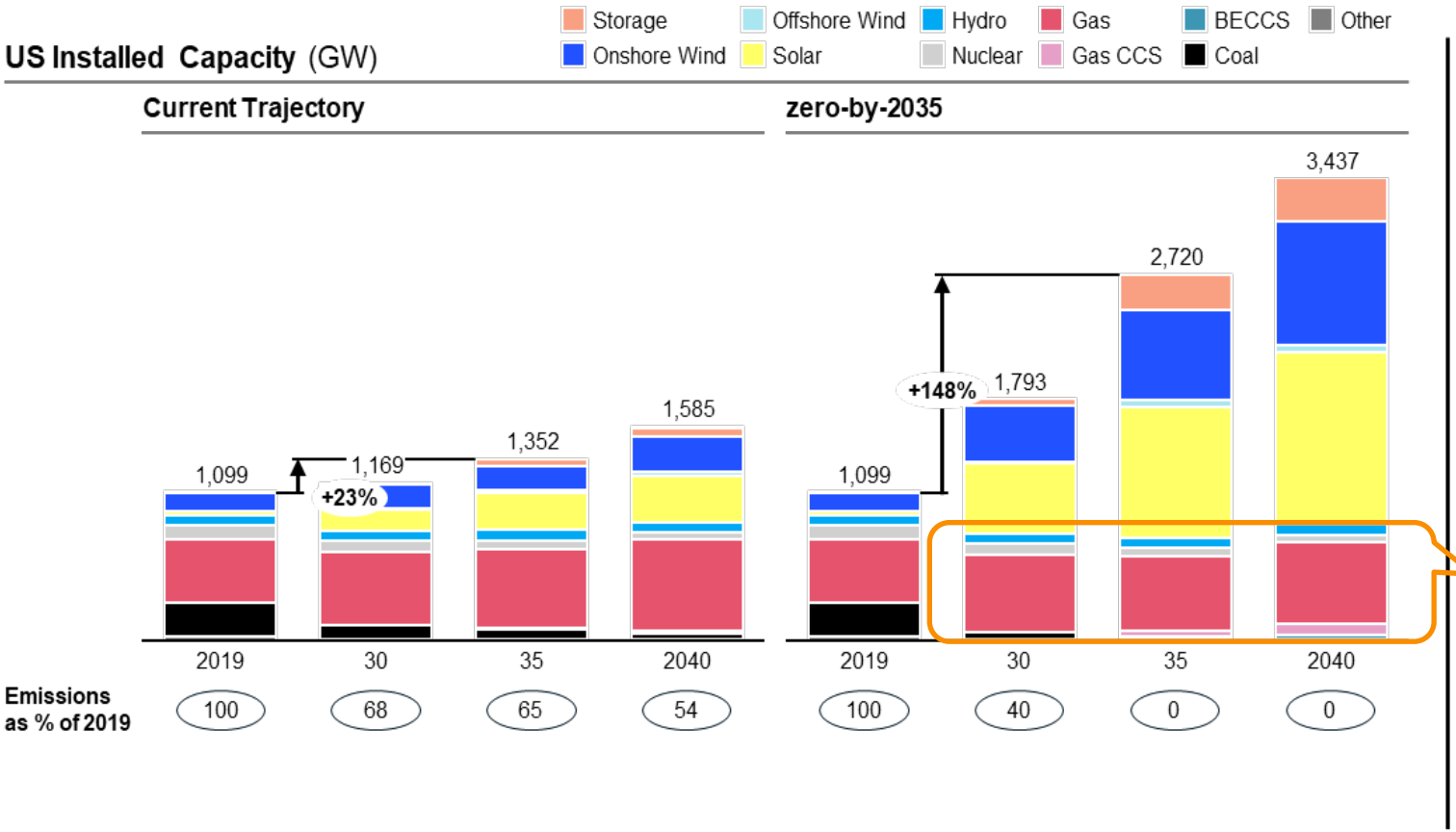
Different resource types each bring a unique mix of those attributes – while every resource does not need to bring all attributes, the system will need an "adequate" supply of each attribute

	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 - ●

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

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

Source: McKinsey EPNG practice; evaluation of net zero emissions for the power sector by 2035.

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

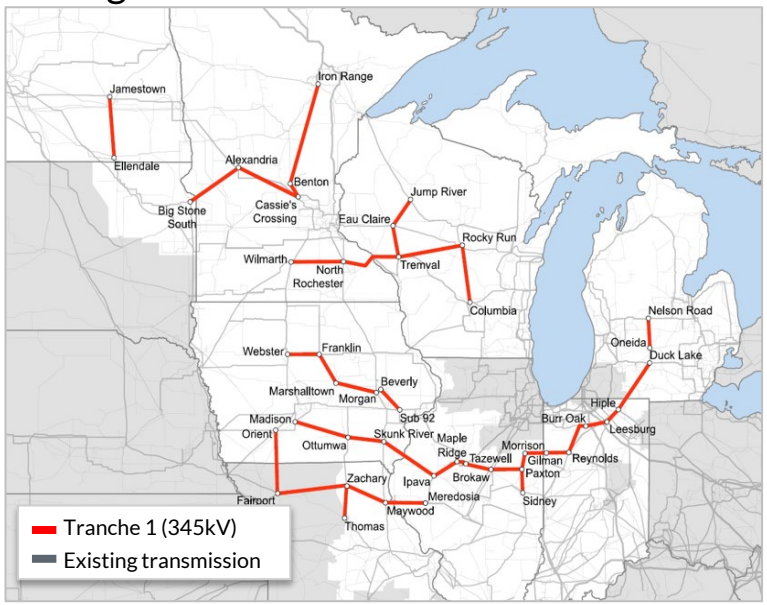
- Enhance transparency of resource evolution and regional outlook
- Improve Resource Adequacy construct
- Visibility into and reviewing impacts of resource retirements
- Inform the broader policy discussion with federal policymakers and agencies

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

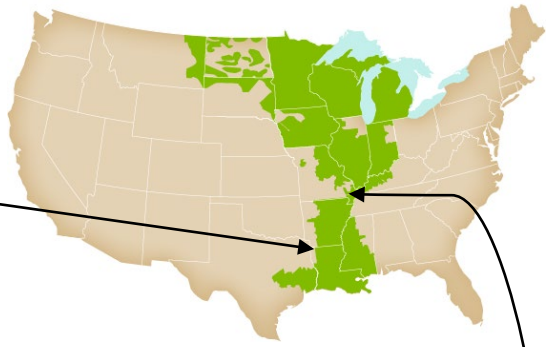
Filed at FERC	
Improved Resource Accreditation	➢ Thermal changes filed in 2021
Resource Adequacy Construct	➢ Proposed move from annual to seasonal filed in 2021
Pricing	➢ Initial scarcity price reforms were filed in 2021
Current Activities	
Improved Resource Accreditation	➢ Renewable and Load Modify 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

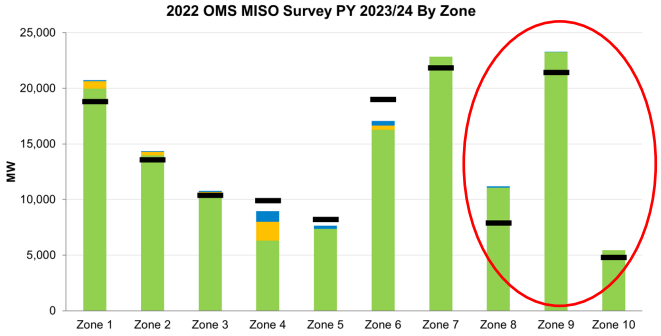
The Long Range Transmission Planning effort is increasing the ability to add and transfer carbon-free and flexible resources throughout the system

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



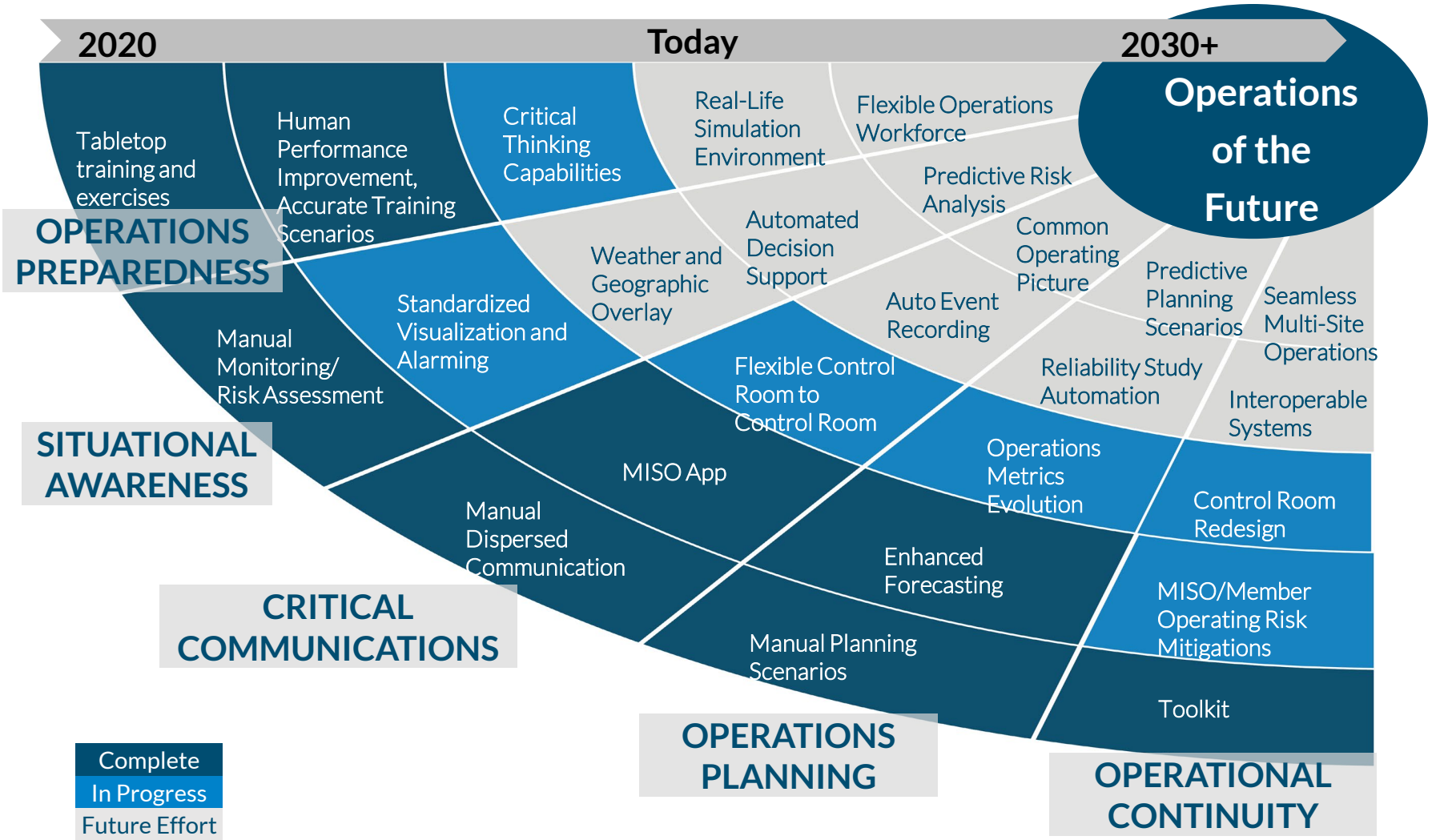
Tranche 3 will identify and address South Region needs…





…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

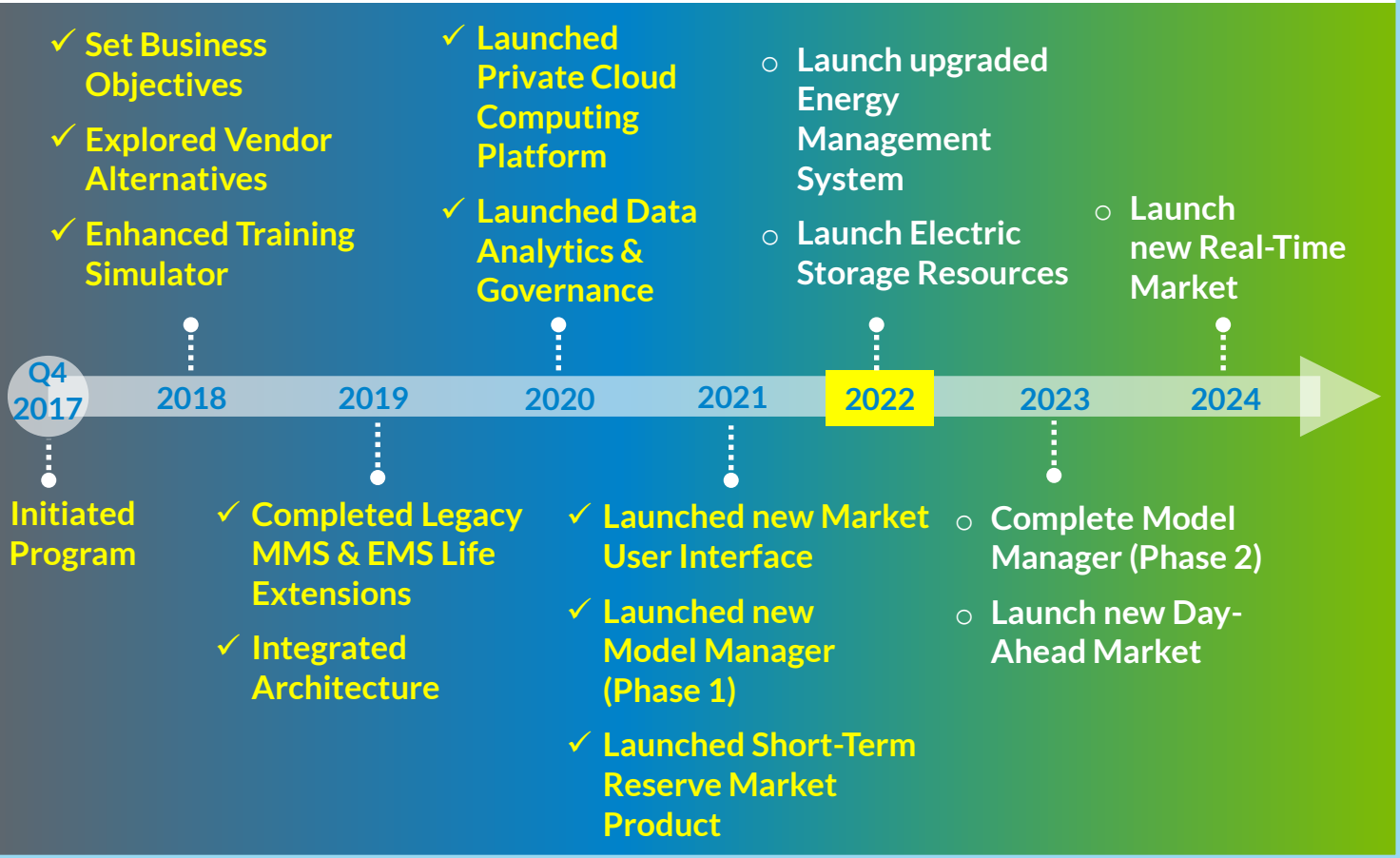


The MSE program is working on delivering several new external-facing products and is still on target to conclude in late 2024

Extend the life of the current system

Design a flexible, scalable adaptable system

Upgrade, build and launch a new market system



DELIVER THE MARKET SYSTEM OF THE FUTURE

Platform ready for future products and continued architectural upgrades

EMS = Energy Management System; MMS = Market Management System

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.

Note: all values are shown in 2022 dollars; cost of MISO membership grow at 2.4% real (4.9% nominal)