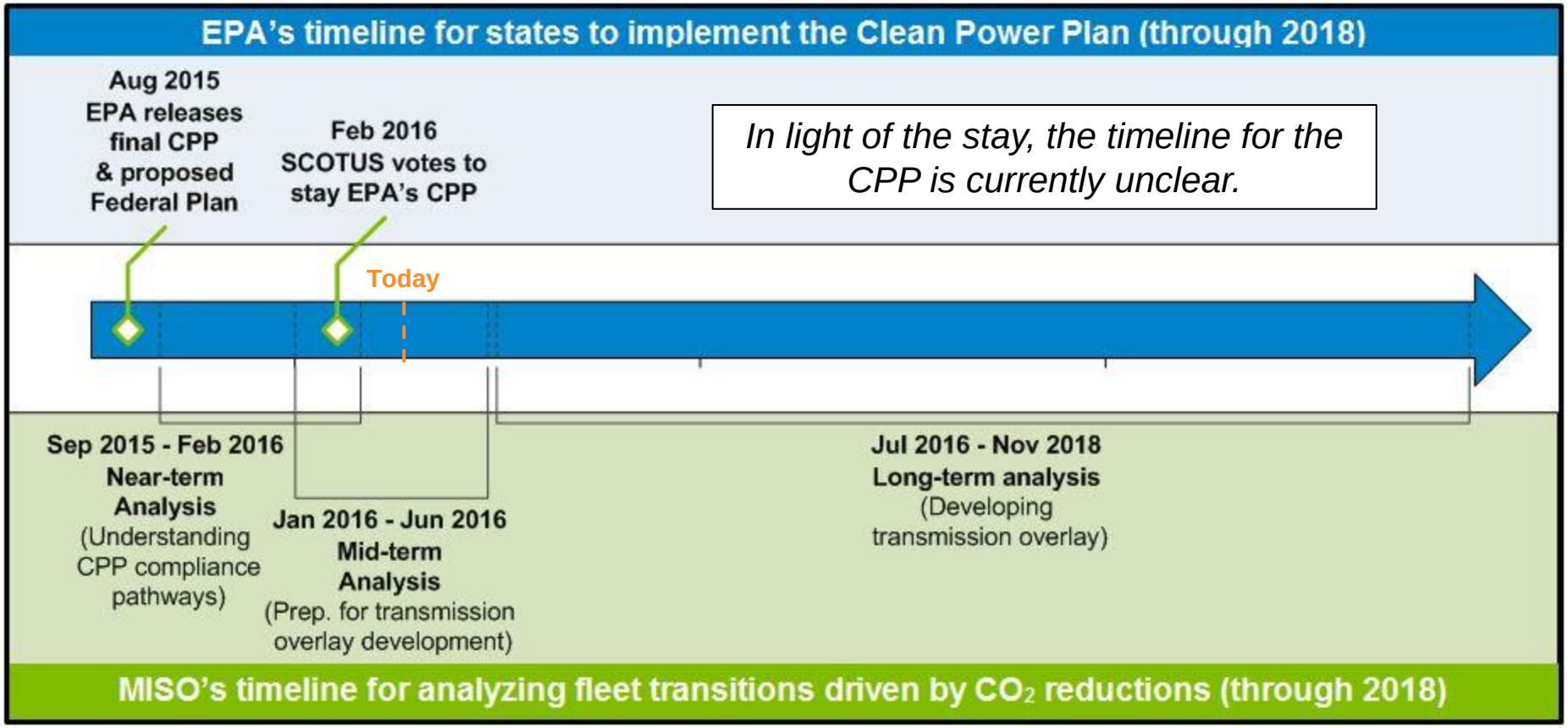
Results of MISO's Near-Term Analysis of EPA's Clean Power Plan

March 2016

Results of this study are not recommendations. Results are intended to provide information to help understand impacts of the CPP on the MISO system. Each state and utility should consider these results within the broader context of their CPP compliance objectives, policy goals and views about desired future resource mix.

MISO continues to study how CO_2 reductions impact electric generation and transmission expansion



MISO's goal in this on-going analysis is to enable the reliable, efficient implementation of policy decisions made by our member-states and asset-owners.

The final rule study evaluates CPP compliance pathways and will inform the transmission planning process

Near-Term Modeling
(Understanding compliance pathways)

- Rate/mass comparison
- Rate/mass interaction
- State/regional compliance
- Trading options
- Compliance sensitivities
- Relative compliance costs

Mid-Term Modeling
(Preparing for transmission overlay development)

- Potential generation retirements
- Optimal resource expansion
- Renewables penetration
- Renewables mix
- Renewables siting

Long-Term Modeling
(Developing transmission overlay)

- Will be informed by state compliance plans
- Will use futures formulated through MTEP17 process
- Updates to assumptions as needed over MTEP18 and '19 cycles

MISO's CPP Final Rule Study

MISO's near-term analysis does not attempt to recommend compliance pathways, optimize the resource mix, identify optimal electric transmission expansion, or identify optimal gas pipeline expansion.

Notes

Results of this study are not recommendations and are intended to provide information to help understand impacts of the CPP on the MISO system. Each state and utility should consider these results within the broader context of their CPP compliance objectives, policy goals, and views about desired future resource mix.

- **All models assume reliability is maintained through the addition of new resources**
- **Models reflect current generation, assumed retirements and resource expansion, including**
  - Units with signed Generator Interconnection Agreements (GIA)
  - Resources forecasted as part of the MTEP15 7-step process to meet planning reserve margins and renewable portfolio standards
- **Additional scenarios look at other possible resource changes beyond current trends with the assumption that the changes would occur regardless of the CPP**
- **Results in this presentation model:**
  - Trading ready sub-category rate and mass based compliance
  - Interstate energy and emissions trading across the Eastern Interconnect
- **Benefits of CO_2 allowances are assumed to go to load**
- **Generators are counted for compliance in the state in which they are physically located**

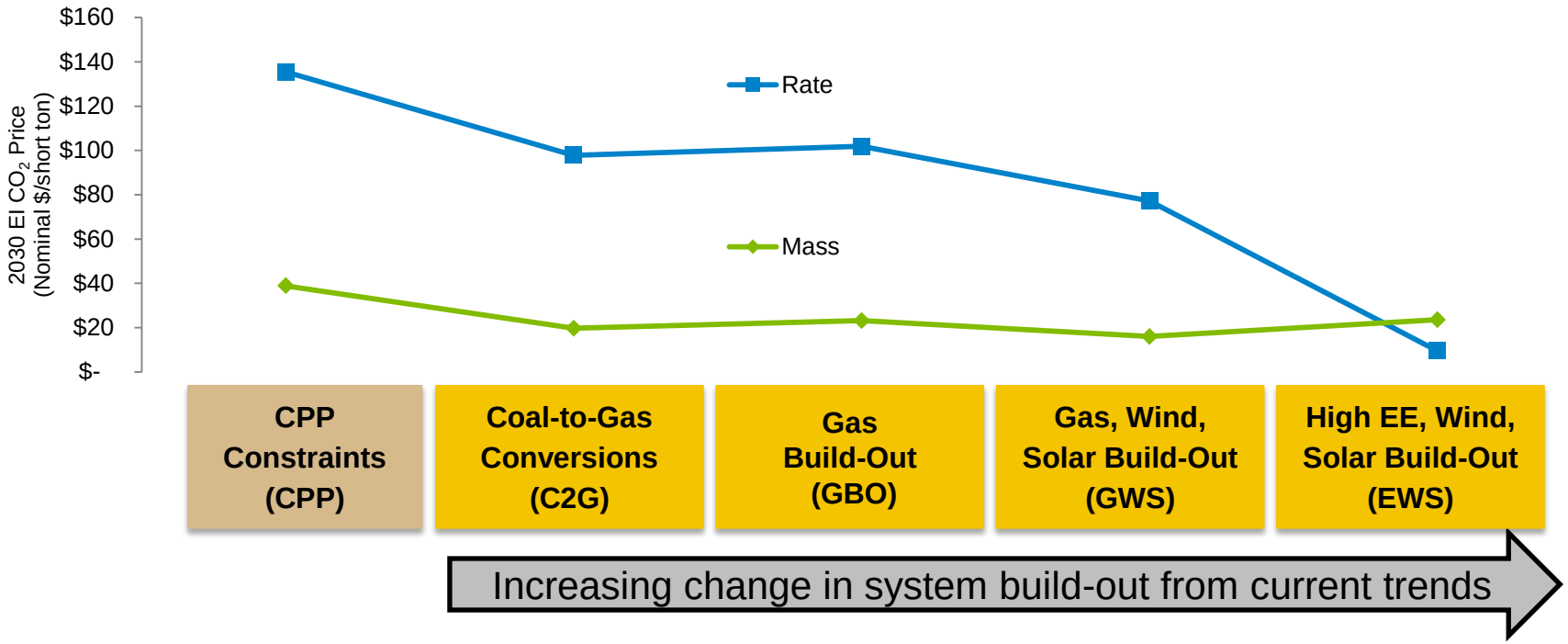
PLEXOS model produces optimal hourly economic dispatch considering generation, transmission, and environmental constraints for the following fixed capacity expansion scenarios

Business-as-Usual (BAU)	CPP Constraints (CPP)	Coal-to-Gas Conversions (C2G)	Gas Build-Out (GBO)	Gas, Wind, Solar Build-Out (GWS)	High EE, Wind, Solar Build-Out (EWS)
• Assumptions consistent with MTEP15 BAU economic planning model • 12.6 GW of MATS-related coal retirements in MISO	• CPP constraints applied	• 25% of coal capacity per region is incrementally converted to run on natural gas	• 25% of coal capacity per region is incrementally retired • New gas-fired generators are built to compensate for retired capacity	• 30% of coal capacity per region is incrementally retired • 13% of the retired capacity is replaced by new gas units • 17% by wind + solar	• EE at 1.5% of energy sales beginning in 2020 with 1.5% year-over-year growth • 15% footprint-wide RPS

CPP constraints applied

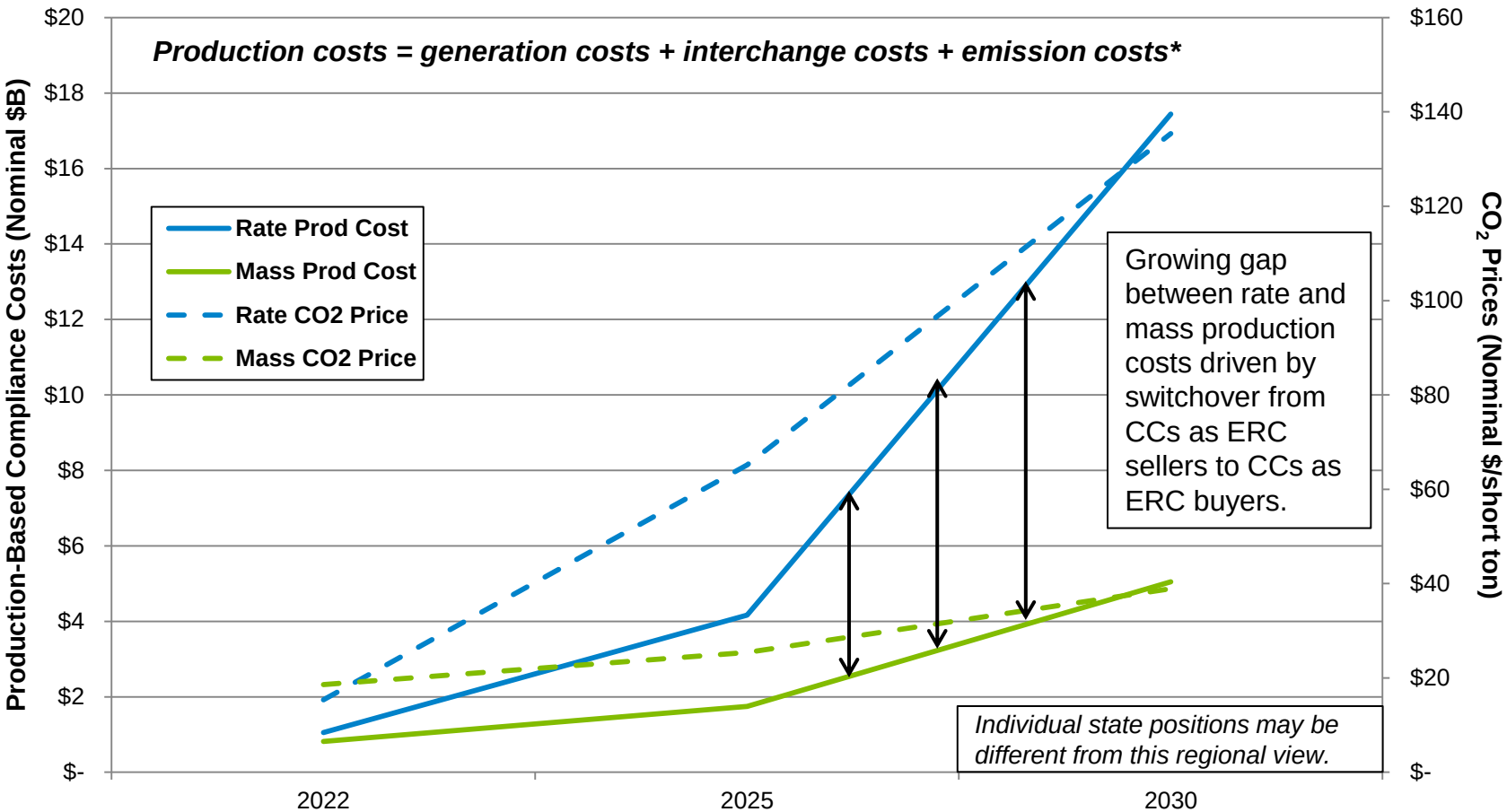
Assumptions applied across all scenarios

As new non-CO_2 emitting resource penetration increases, rate-based compliance becomes less expensive



Each scenario includes a resource mix that is assumed to have been built due to ***economic or policy drivers other than the CPP****, and compliance impacts are measured using this resource mix.*

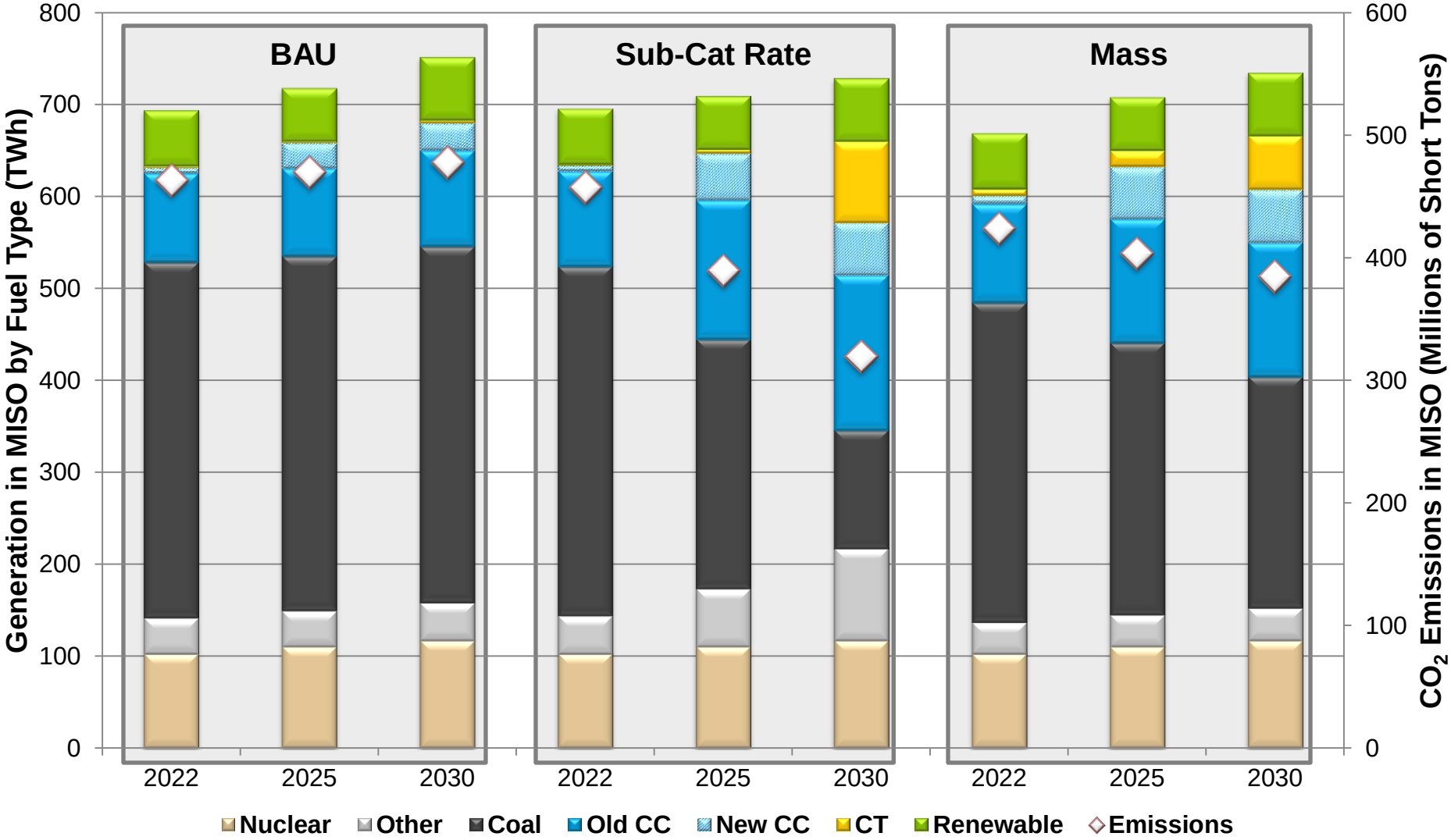
Regionally, in the CPP scenario, mass-based compliance is less expensive than rate-based compliance, with the gap increasing over time



Uptick in costs in the late 2020s is driven by Renewable Portfolio Standards reaching maturity, inability of coal to gas re-dispatch to further reduce CO_2, and the increasing stringency of the CPP targets.

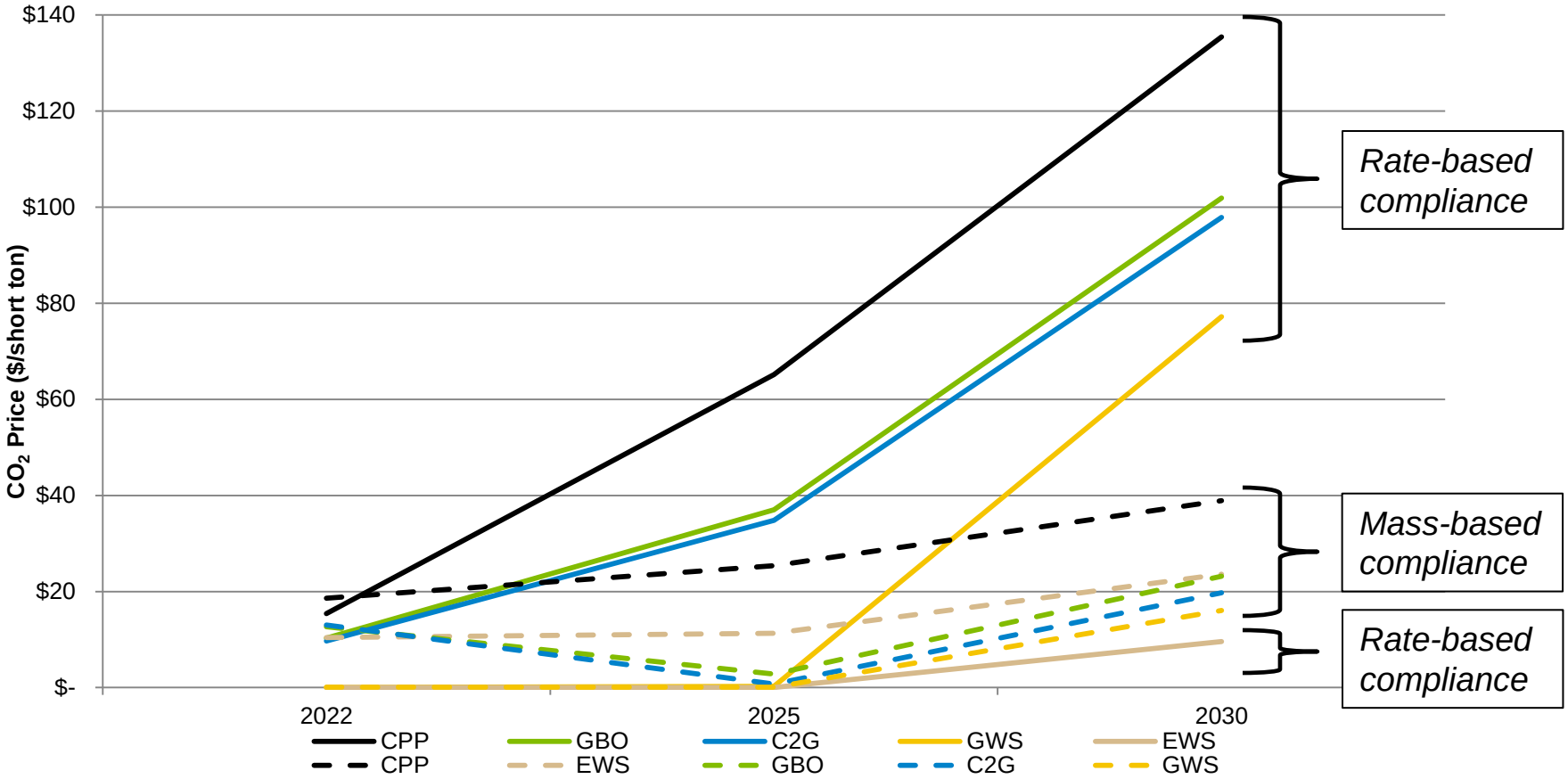
**This calculation does not account for capital costs, transmission infrastructure costs and gas infrastructure costs.*

In the CPP scenario, early compliance targets can be met through renewable portfolio standards and coal to gas re-dispatch, but comprehensive planning would be needed to meet increasingly stringent targets in the mid-2020s



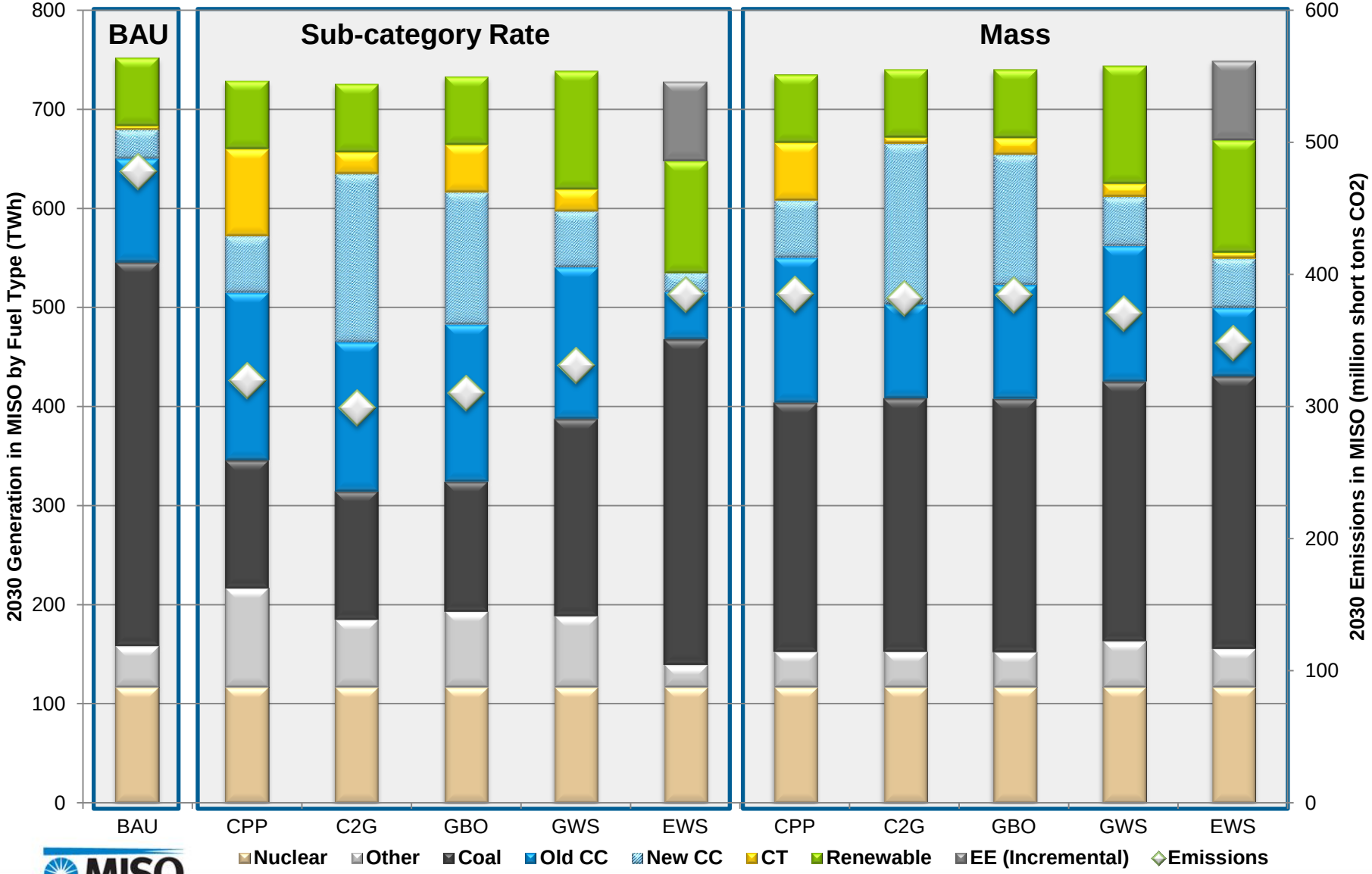
** Under mass-based compliance, MISO states comply under mass targets and non-MISO regions comply under mass + NSC targets

Under rate-based compliance, continued investment in non-CO_2 emitting resources is necessary to mitigate CO_2 price increases

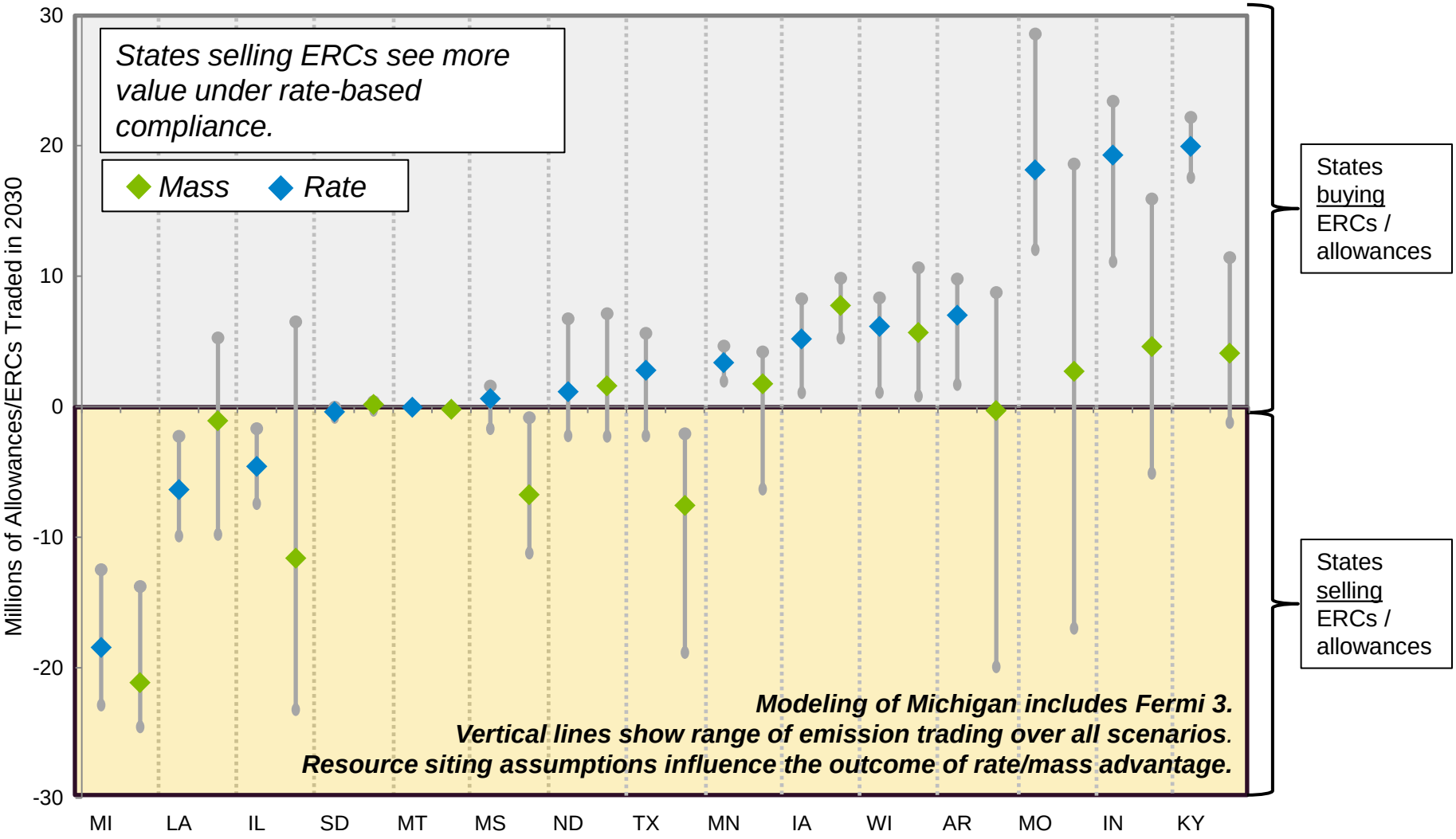


- Less stringent initial compliance targets lead to lower CO_2 prices in early years
- Early deployment of renewables drives down CO_2 prices under rate-based compliance
- Continued deployment of renewables is needed to sustain these lower prices
- Coal retirements have a bigger impact on CO_2 prices under mass-based compliance

System dispatch faces relatively less change under mass-based compliance



Mass-based compliance produces a more balanced mix of buyers and sellers within MISO



Most states see a mass-based compliance advantage unless a regional heavy penetration of renewables and energy efficiency is achieved

2022 ***2025*** ***2030***

Increasing change in system build-out from current state

State	CPP	C2G	GBO	GWS	EWS
IN					
SD					
IL					
IA					
MO					
MN					
LA					
TX					
MI					
MS					
KY					
WI					
AR					
ND					

State	CPP	C2G	GBO	GWS	EWS
IN					
SD					
IL					
IA					
MO					
MN					
LA					
TX					
MI					
MS					
KY					
WI					
AR					
ND					

State	CPP	C2G	GBO	GWS	EWS
IN					
SD					
IL					
IA					
MO					
MN					
LA					
TX					
MI					
MS					
KY					
WI					
AR					
ND					

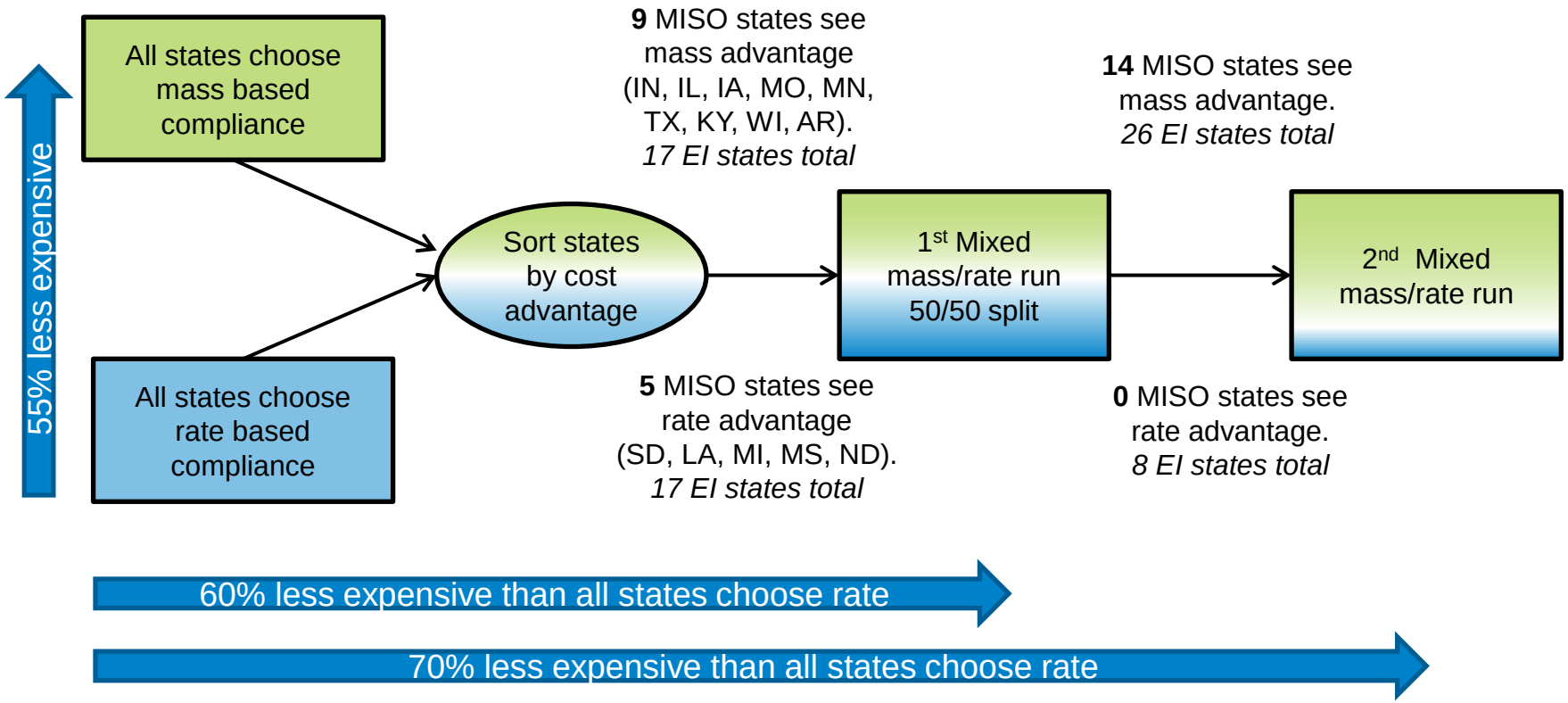
Blue *indicates lower production costs under sub-category rate compliance.*
Green *indicates lower production costs under mass compliance.*

Gradient charts show the relative difference between rate-based production costs and mass-based production costs, when all states use the same compliance mechanism.

If all states move towards non-CO_2 emitting resources the rate/mass advantage holds, but if a small number of states move towards non-CO_2 emitting resources they will see a rate advantage.

Under a 'patchwork' mix of both rate & mass compliance, states with a rate advantage may lose that benefit if other states go mass

Patchwork models use the 2030 CPP scenario.



As the process of creating patchwork model is iterated, individual states without a strong advantage between rate and mass will tend toward the regional compliance advantage.

Under current capacity trends, all MISO states have a mass based compliance advantage

(R) indicates a state is modeled under rate compliance,
(M) indicates a state is modeled under mass compliance

A **dark green** box indicates that **mass** costs are less expensive.

A **dark blue** box indicates that **rate** costs are less expensive.

State	CPP	CPP 1st Mixed	CPP 2nd Mixed
IN		*(M)*	*(M)*
SD		*(R)*	*(M)*
IL		*(M)*	*(M)*
IA		*(M)*	*(M)*
MO		*(M)*	*(M)*
MN		*(M)*	*(M)*
LA		*(R)*	*(M)*
TX		*(M)*	*(M)*
MI		*(R)*	*(M)*
MS		*(R)*	*(M)*
KY		*(M)*	*(M)*
WI		*(M)*	*(M)*
AR		*(M)*	*(M)*
ND		*(R)*	*(M)*

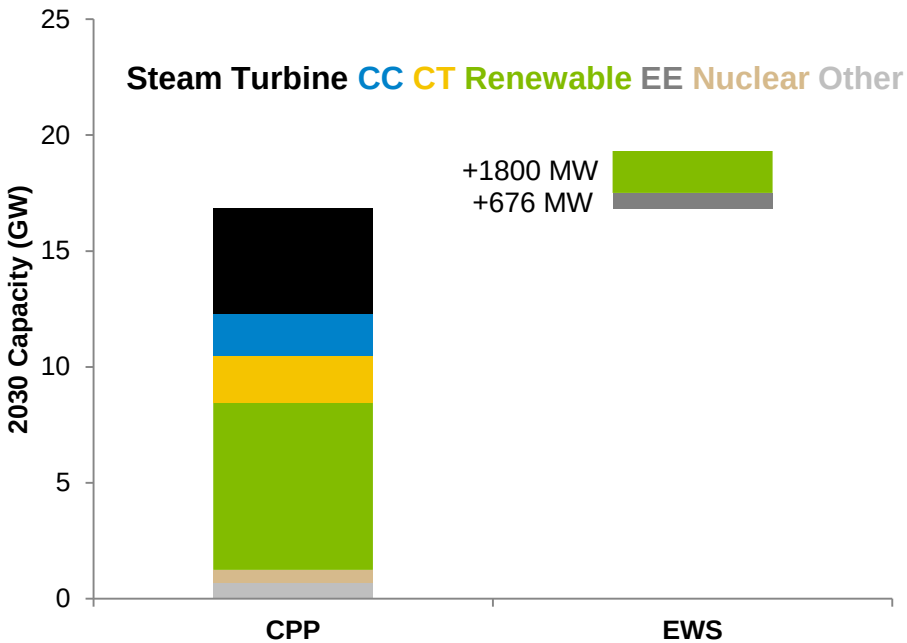
A change in cell color across columns indicates a change in compliance advantage.

An (R) in a green box indicates that although the state previously saw an advantage with rate, that advantage is lost when a group of other states choose mass compliance.

The CPP 2nd mixed rate/mass model results show that all input advantages match the output advantages, indicating the system has reached an equilibrium.

State Summary - Iowa

Scenario Inputs



Scenario Outputs

Year	CPP	C2G	GBO	GWS	EWS
2022					
2025					
2030					

Blue *indicates lower production costs under sub-category rate compliance.*
Green *indicates lower production costs under mass compliance.*

- Although the resource mix changed significantly on a regional level, Iowa's resource mix was not altered in most scenarios.
- With few incremental renewables to produce ERCs under rate-based compliance, mass-based compliance is less expensive.
- The increase in renewables and energy efficiency in the EWS scenario leads rate-based compliance to be less expensive than mass-based compliance.

MISO's Analysis of the final Clean Power Plan

MISO's CPP Workshop – What is in the final rule?

https://www.misoenergy.org/_layouts/miso/ecm/redirect.aspx?id=211452

CPP Analysis Scope document:

https://www.misoenergy.org/_layouts/MISO/ECM/Redirect.aspx?ID=211503

CPP Analysis Scope presentation:

https://www.misoenergy.org/_layouts/MISO/ECM/Redirect.aspx?ID=211504

Regional near-term modeling results presentation:

https://www.misoenergy.org/_layouts/MISO/ECM/Redirect.aspx?ID=216573

State impacts from regional results of near-term modeling presentation:

https://www.misoenergy.org/_layouts/MISO/ECM/Redirect.aspx?ID=218325

EPA regulations webpage

https://www.misoenergy.org/WhatWeDo/EPARegulations/Pages/111(d).aspx

Additional questions? Please contact:

Jordan Bakke at jbakke@misoenergy.org

Appendix 1:
Additional Model Inputs and Outputs

Modeled 66 cases to reflect a range of potential compliance actions and pathways

Reference case (BAU) (3 runs)

- Business-as-usual (BAU) model includes known and forecasted resource plans
- 3 years (2022, 2025, 2030)

BAU + CPP constraints (39 runs)

- No change in capacity (MW) from BAU
- CPP constraints applied at state, regional and Eastern Interconnection levels
- Average rate, sub-category rate, mass, mass/NSC*, mixed mass**

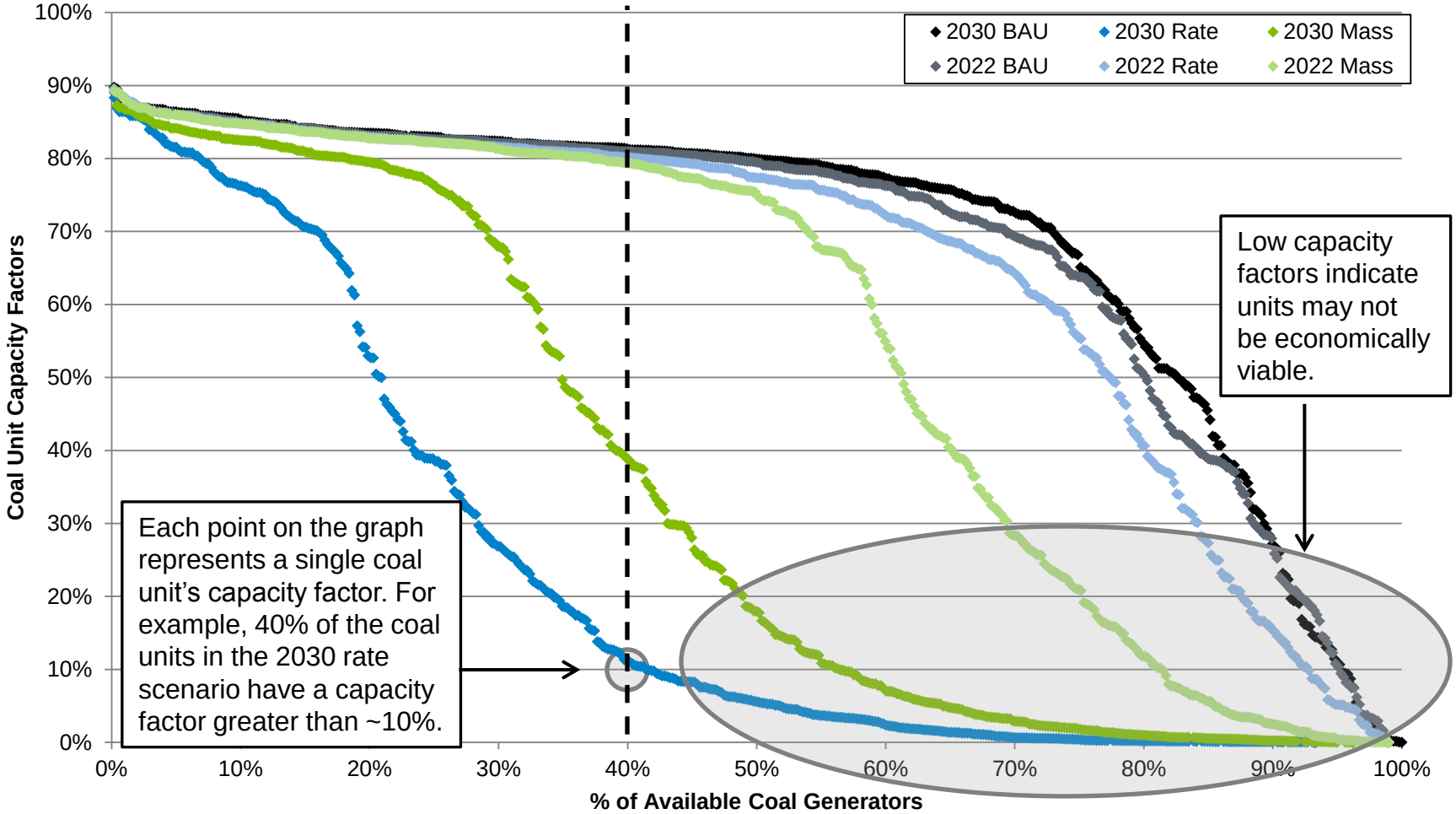
Alternative resource scenarios + CPP constraints (24 runs)

- Change in capacity (MW) from BAU
- CPP constraints applied at the Eastern Interconnection level
- Sub-category rate, mixed mass**

* NSC = New Source Complement

** Mixed mass = MISO states comply under mass target and non-MISO regions comply under mass + NSC targets

Under current resource trends, coal unit capacity factors decrease greatly over time under the CPP, more dramatically with a rate-based implementation



Coal units run more in the near term under rate-based compliance and in the long term under mass-based compliance.

Coal units face increased risks under CPP compliance

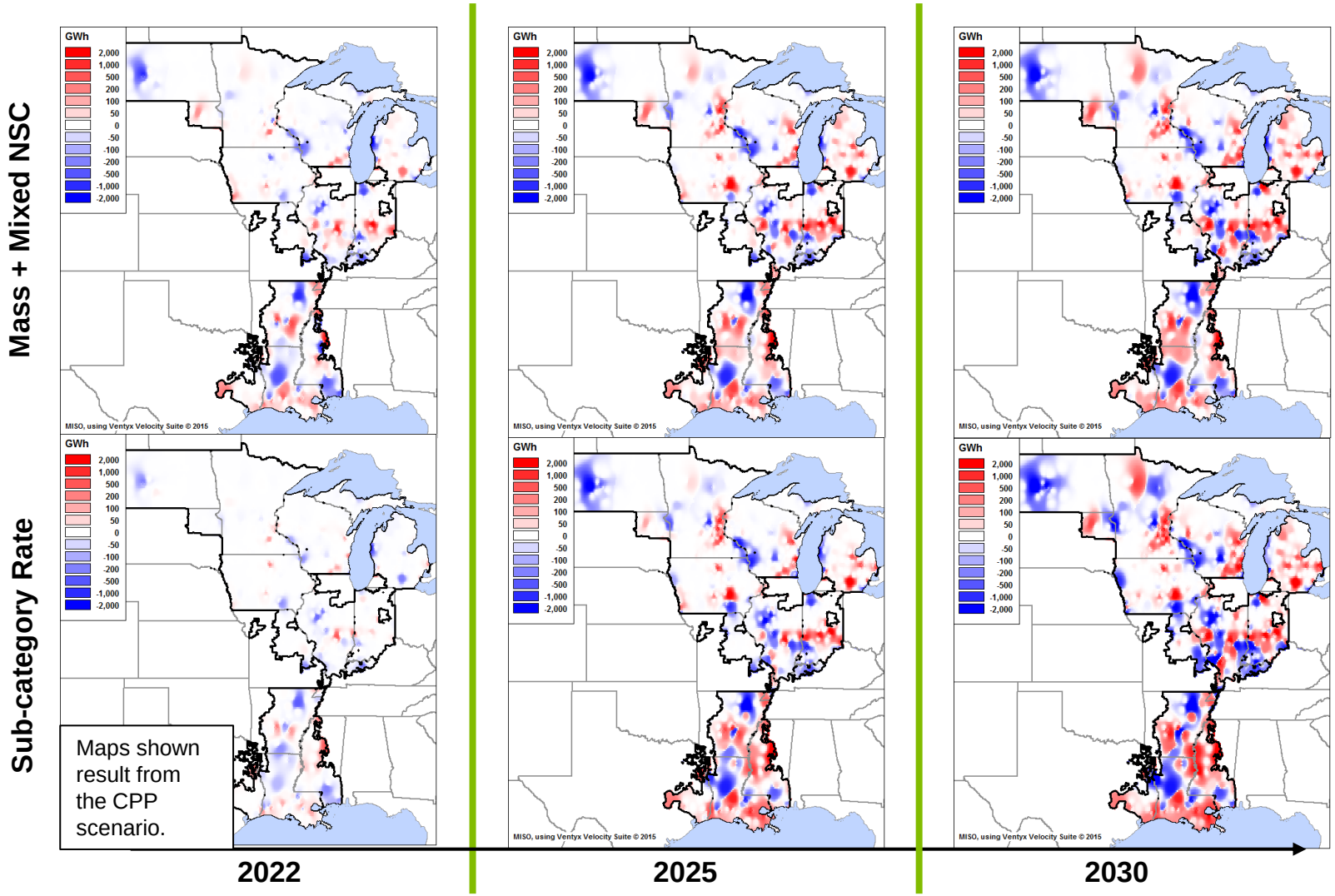
	Definition	2022 Mixed Mass/NSC	2022 Sub-category Rate	2030 Mixed Mass/NSC	2030 Sub-category Rate
Cycling*	Number of unit starts	58%	-29%	71%	55%
Ramping*	Total MW traveled (ramp up + ramp down)	11%	2%	30%	7%
Hours offline*	# of hours of zero generation	68%	3%	157%	246%
Total MWh*	Total generation	-10%	-2%	-36%	-68%
Units idled	# of units offline all year	0	0	6	9

**Percent change from BAU scenario.*

- In 2030, both compliance pathways increase coal cycling, ramping, hours offline and units idled compared to the BAU.
- As the stringency of compliance increases, coal units move from dispatching as baseload to intermediate to peaking units.
- Intermediate units tend to see the most operational performance impacts.
- Coal units cycle and ramp less in rate-based compliance because they are running less often.

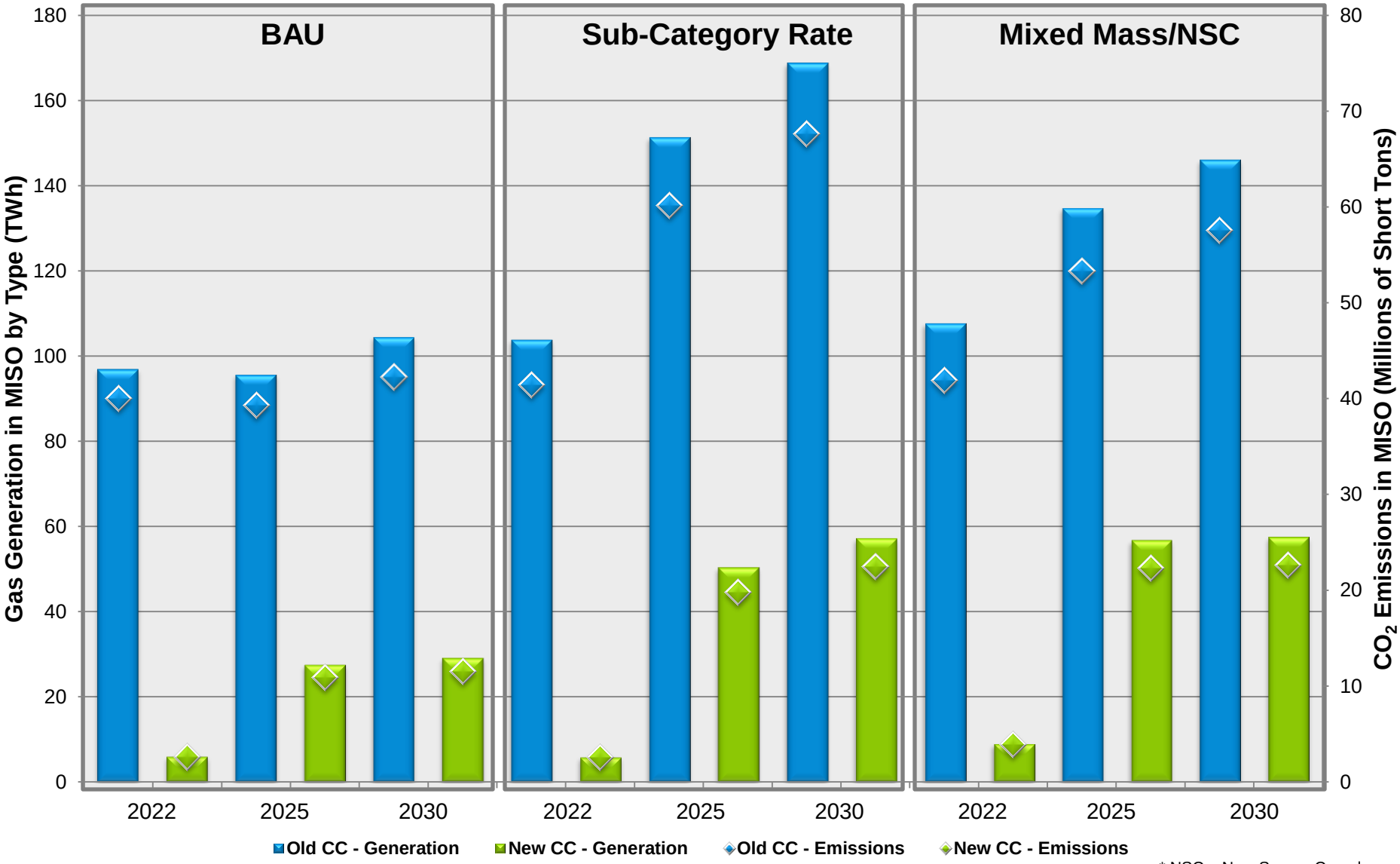
PLEXOS modeling includes certain coal unit operating constraints: minimum up time, minimum down time, ramp rates, start costs, min/max capacity, heat rate curves, variable O&M, maintenance and outages.

Generation will rise/fall in similar locations under both rate & mass, so transmission expansion, if needed, will be similar under both



While the magnitude and location of impacts on generation change with varying capacity expansion scenarios, within each scenario the impact of rate and mass compliance are similar.

Gas generation & emissions under current resource trends

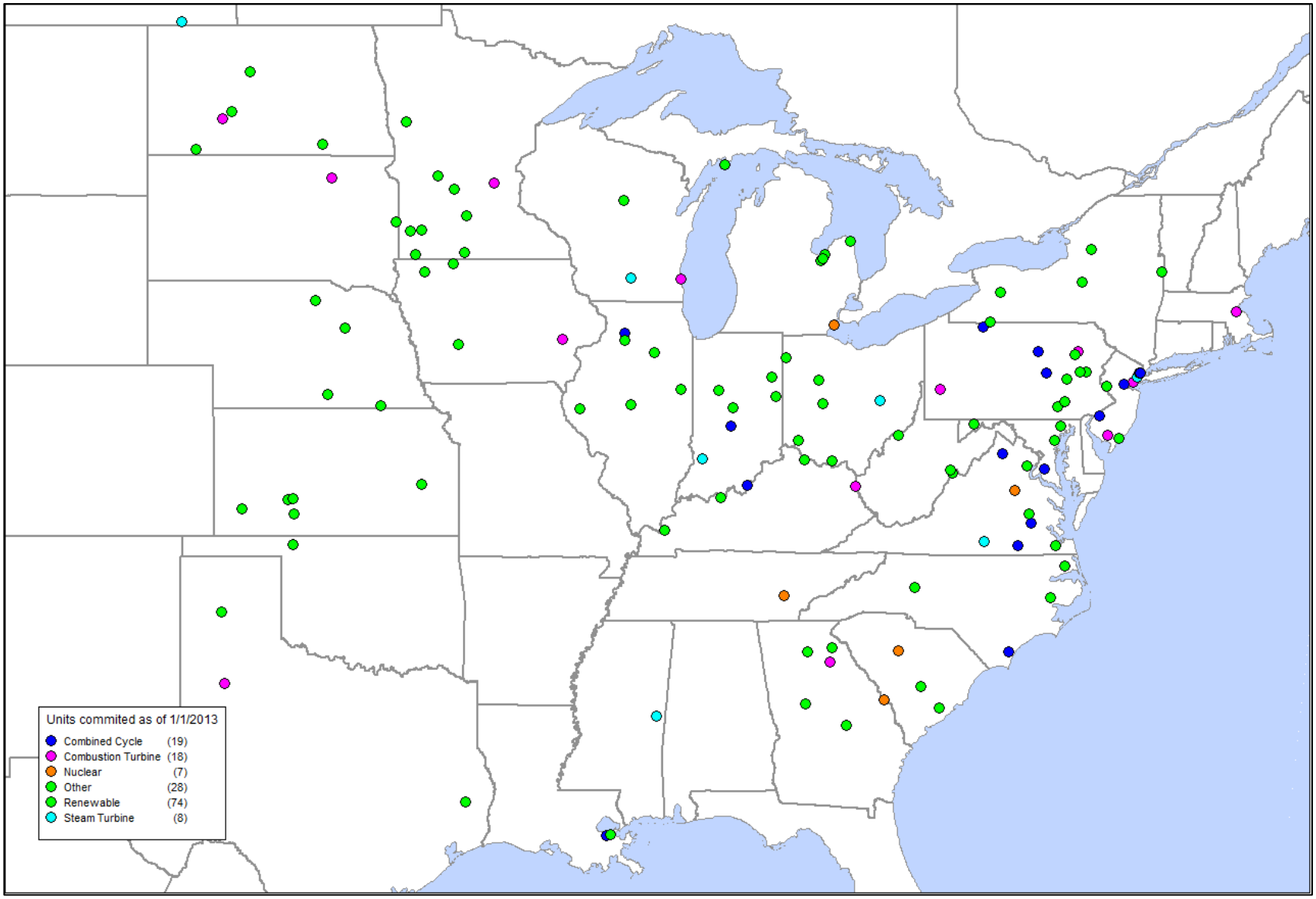


* NSC = New Source Complement

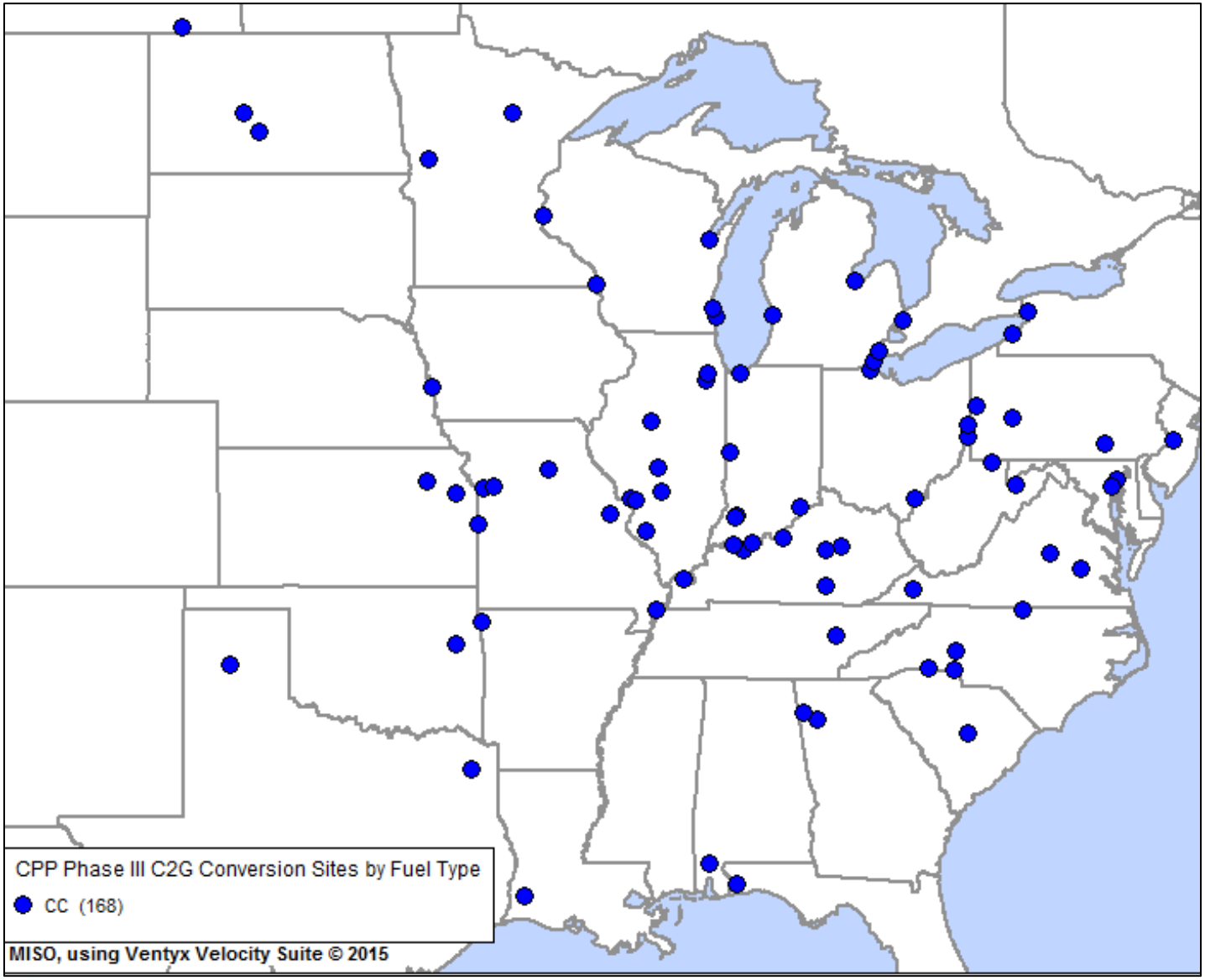
** Mixed mass = MISO states comply under mass target and non-MISO regions comply under mass + NSC targets

Appendix 2:
Capacity Retirements and Expansion

BAU and CPP expansion sites for 2013-2030

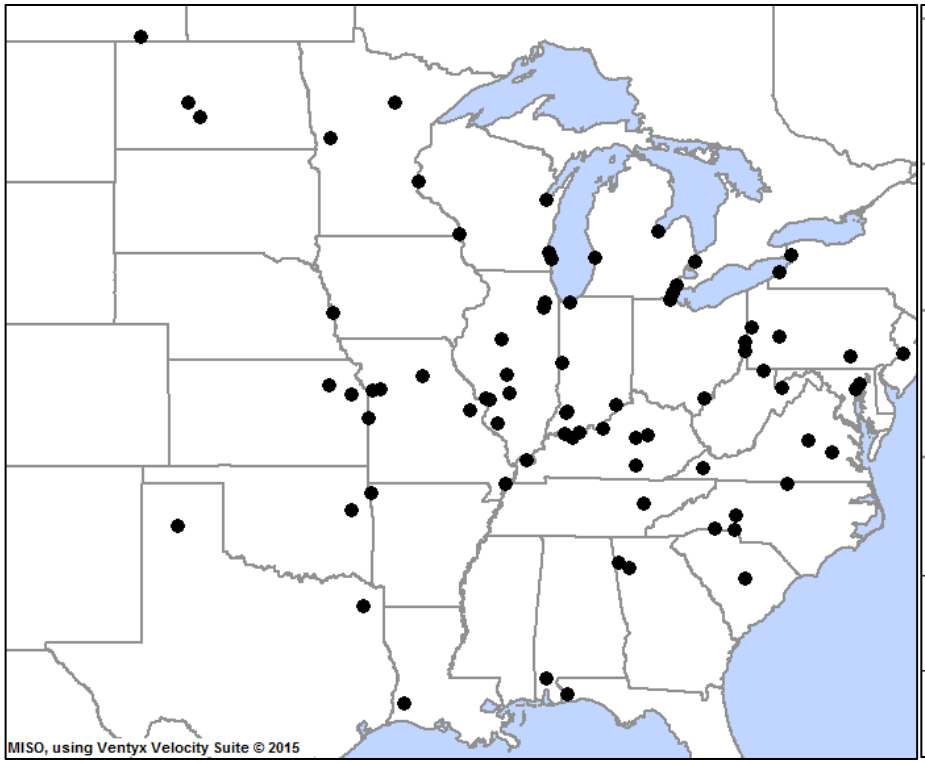


Coal-to-Gas (C2G) conversion sites

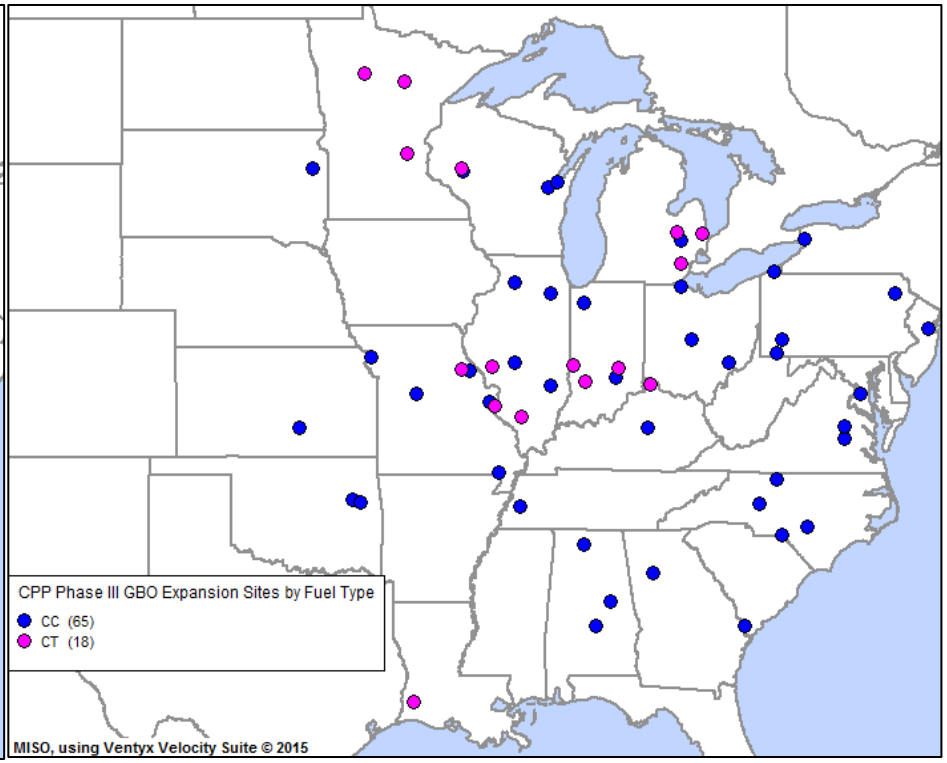


Gas Build-Out (GBO)

Retirement Sites

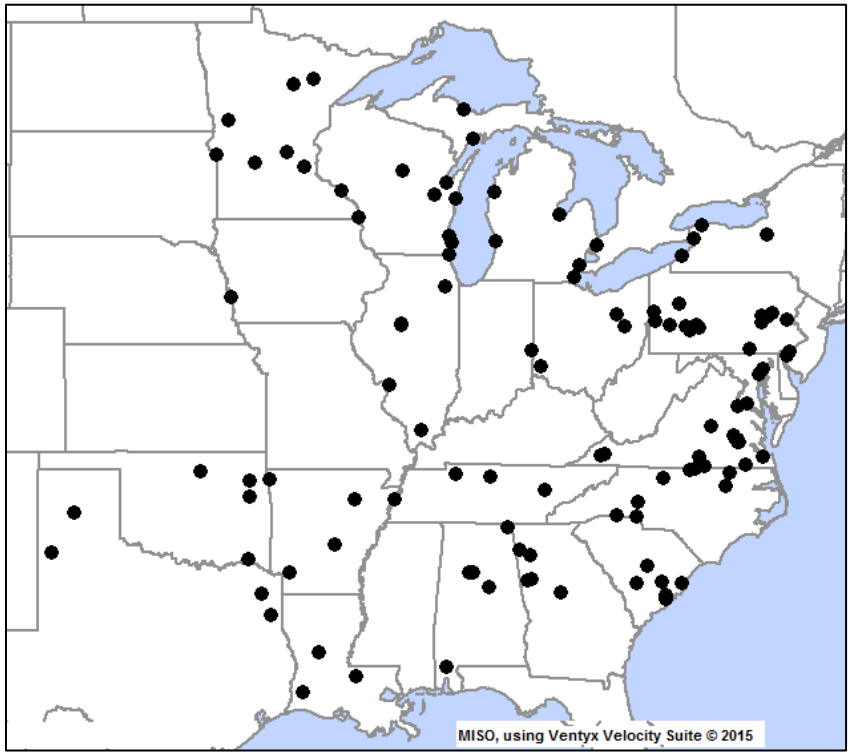


Expansion Sites

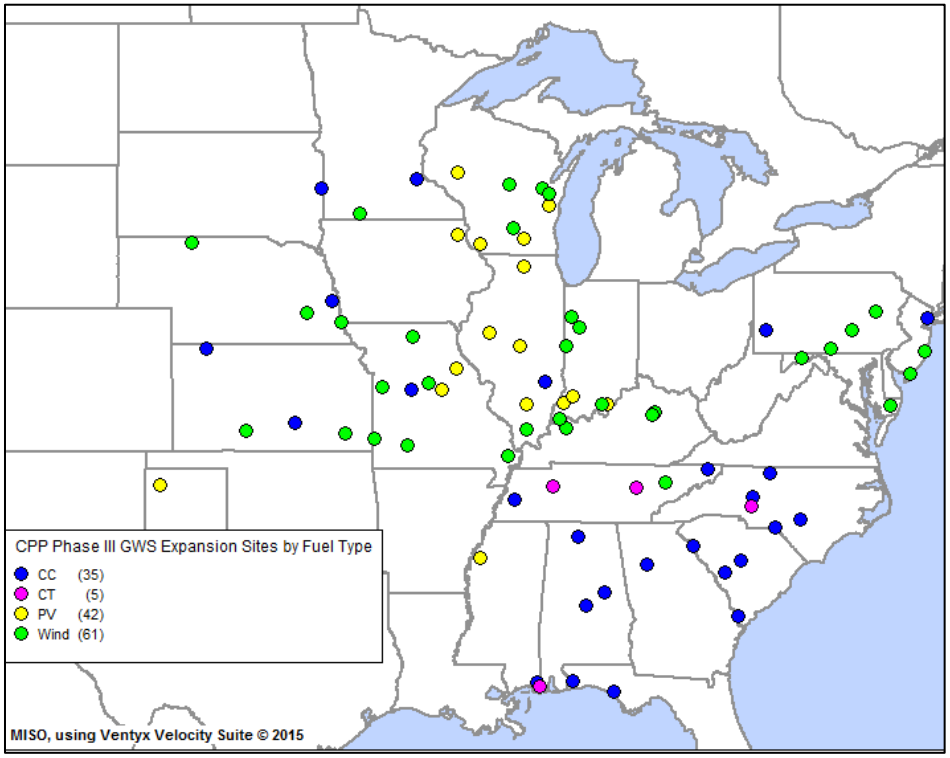
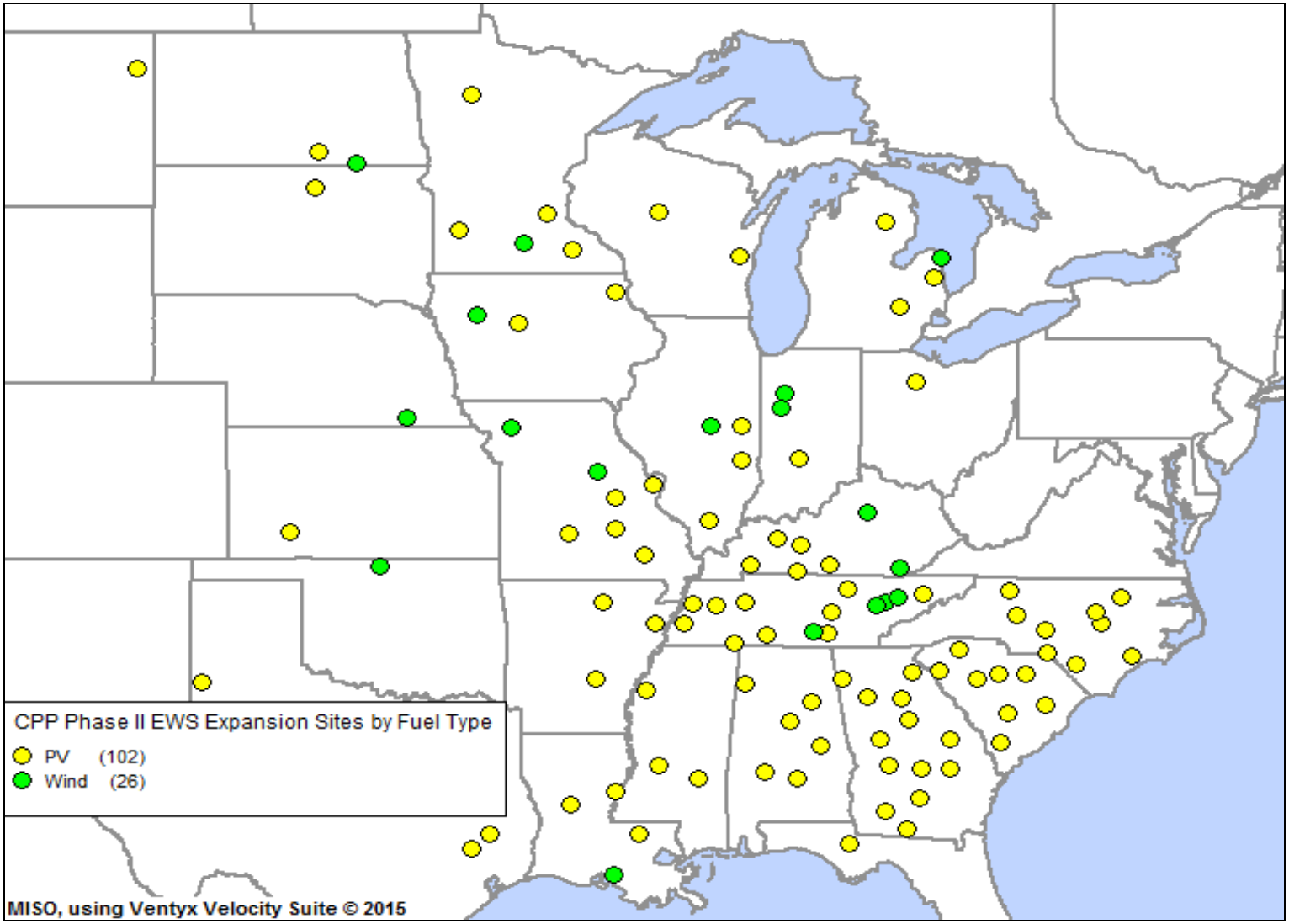


Gas/Wind/Solar (GWS)

Retirement Sites



Expansion Sites



EE/Wind/Solar (EWS) expansion sites