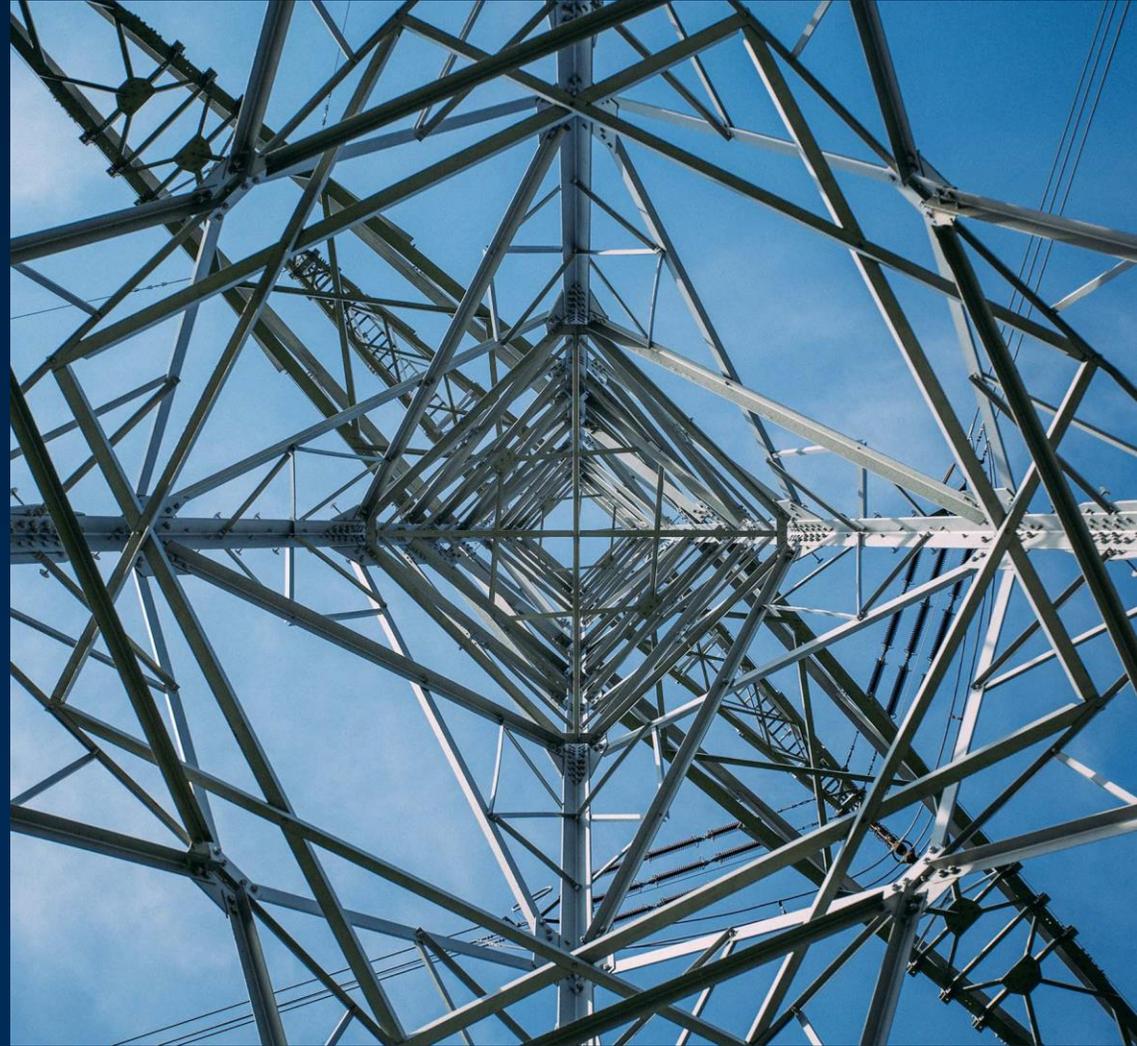


# North Plains Connector

Interregional Capacity Value

2024-04-30



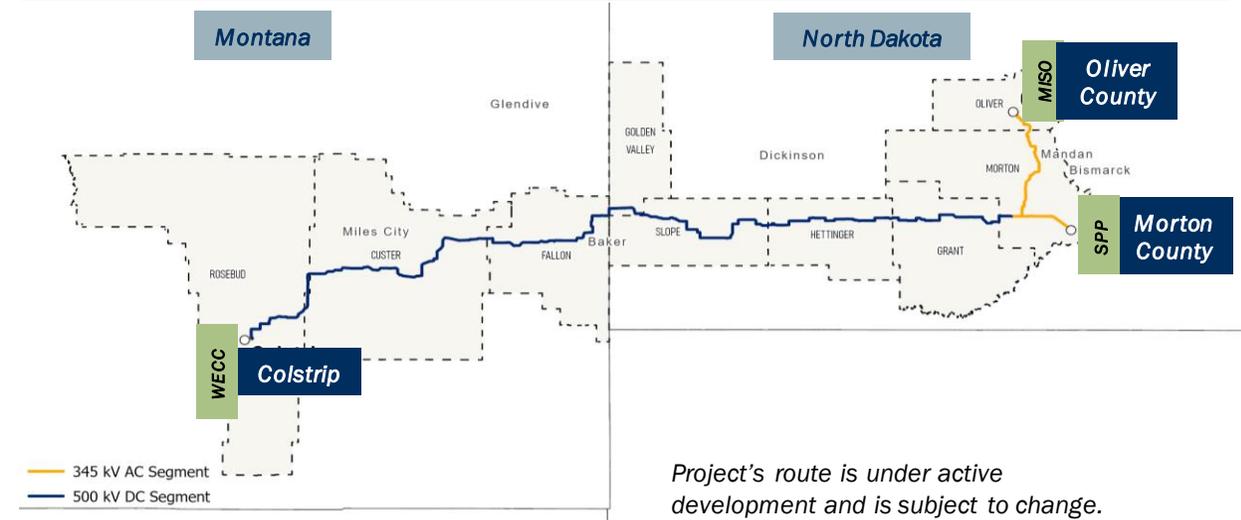
# North Plains Connector – Project Overview

## Value Proposition

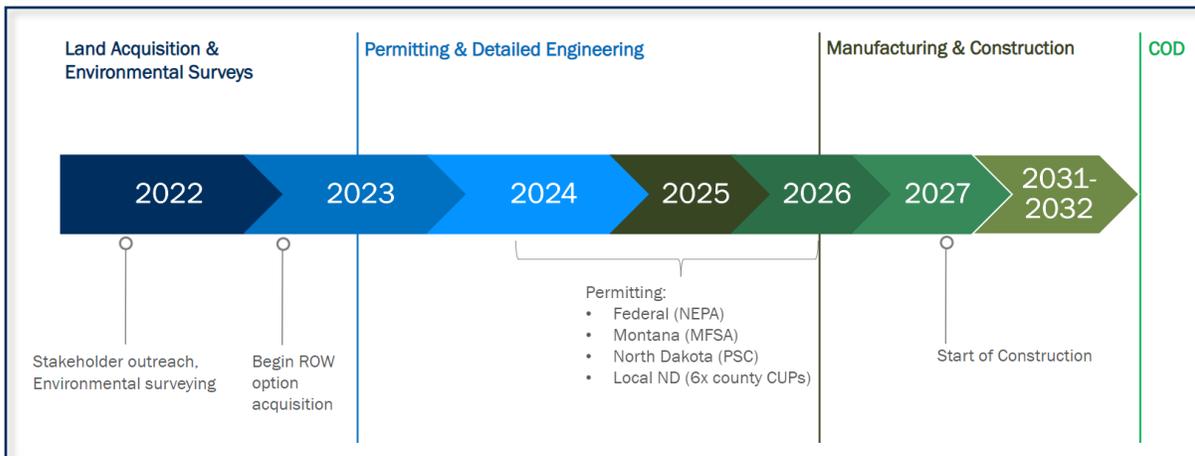
- North Plains Connector (NPC) is a bi-directional, 3,000 MW, HVDC transmission project connecting the U.S. eastern and western grids.
- NPC's interregional reach integrates diverse resources, yielding a wide-array of high-impact benefits and a value proposition that appeals to a wide range of customers.

Reliability & Resilience		Economics		
Reduced Loss of Load Probability	Improved Grid Operations Utilizing HVDC Capabilities	Reduced Reserve Margin	Reduced Ancillary Service Costs	Insurance-like Value for Low Probability Events
		Reduced Impact of Load & Renewables Forecast Error		
Access to Geographically & Technologically Diverse Resources		Reduced Cost and Impact of Extreme Weather	Mitigated Impact of Complying with Future Policy, Market Changes	
		Bidirectional Transfer of Power		

## Preliminary Route



## Project Timeline

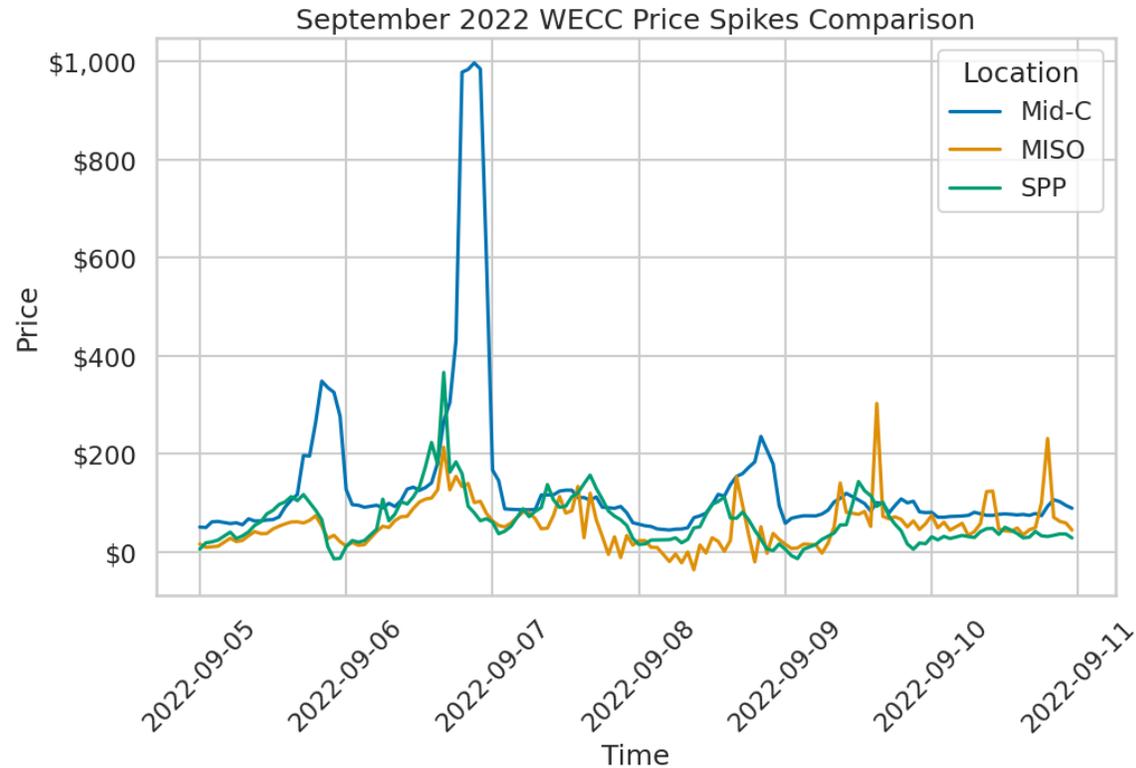


## Project Configuration

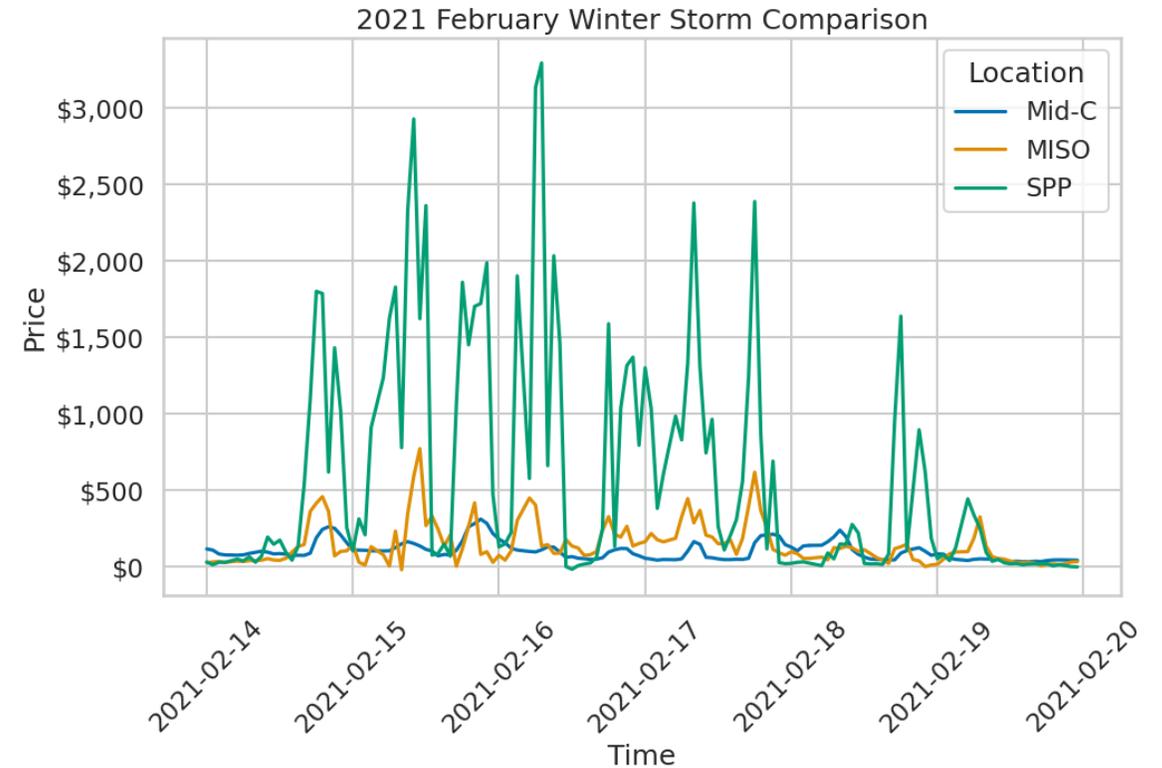
Development	Grid United and ALLETE
Length	~412 miles
Configuration	HVDC (VSC)   525 kV   3,000 MW   bi-directional
Interconnections	<ul style="list-style-type: none"> <li>WECC – 3,000 MW into Colstrip, MT 500kV system</li> <li>MISO – 1,500 MW (AC) to new substation in Oliver County, ND; connects to MN Power (an ALLETE company) upgrades at MISO endpoint</li> <li>SPP – 1,500 MW (AC) to new substation in Morton County, ND</li> </ul>
Timeline	Construction start – 2027 (expected) COD – 2030 – 2032 (expected)

# Interregional diversity is apparent during historic extreme weather events

Extreme weather can occur over a large area, but typically affects different regions at different times, leading to distinct impacts on prices in SPP, MISO, and WECC.



While West prices spiked during the September 2022 heat wave, SPP and MISO prices were unaffected.



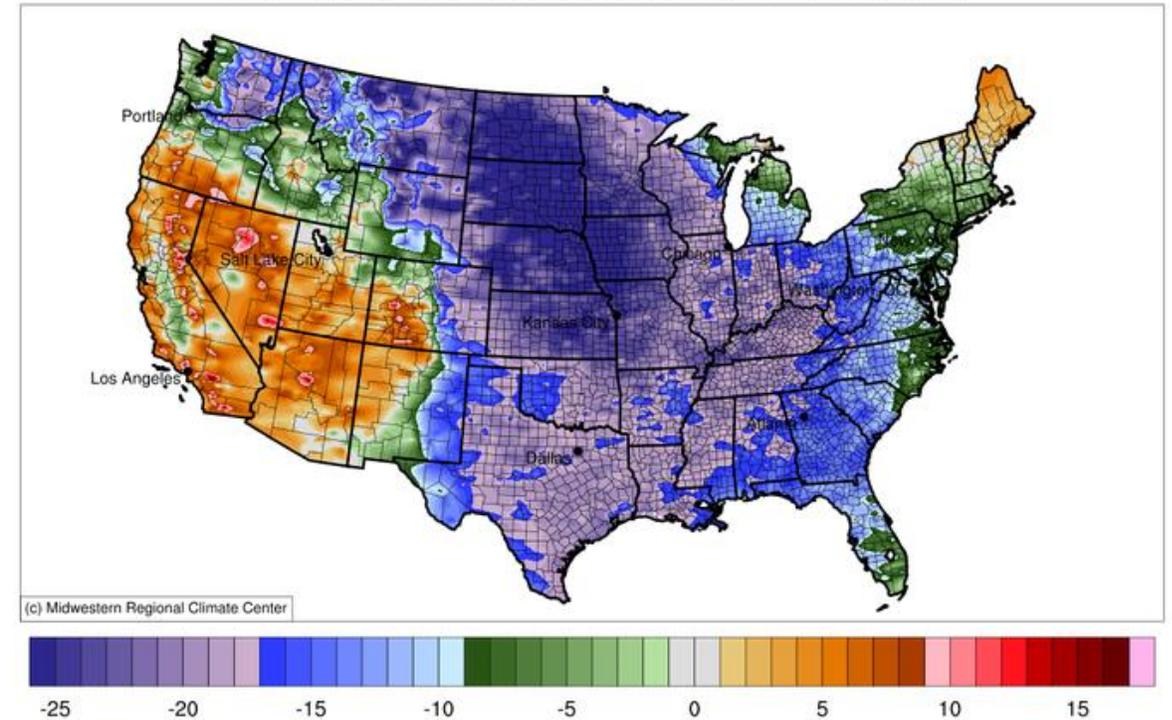
When MISO and SPP prices spiked due to gas prices and high demand during Winter Storm Uri, the West was largely unaffected.

# Those same events demonstrate the importance of existing interregional connections



## Average Temperature (°F): Departure from 1991-2020 Normals

December 22, 2022 to December 25, 2022



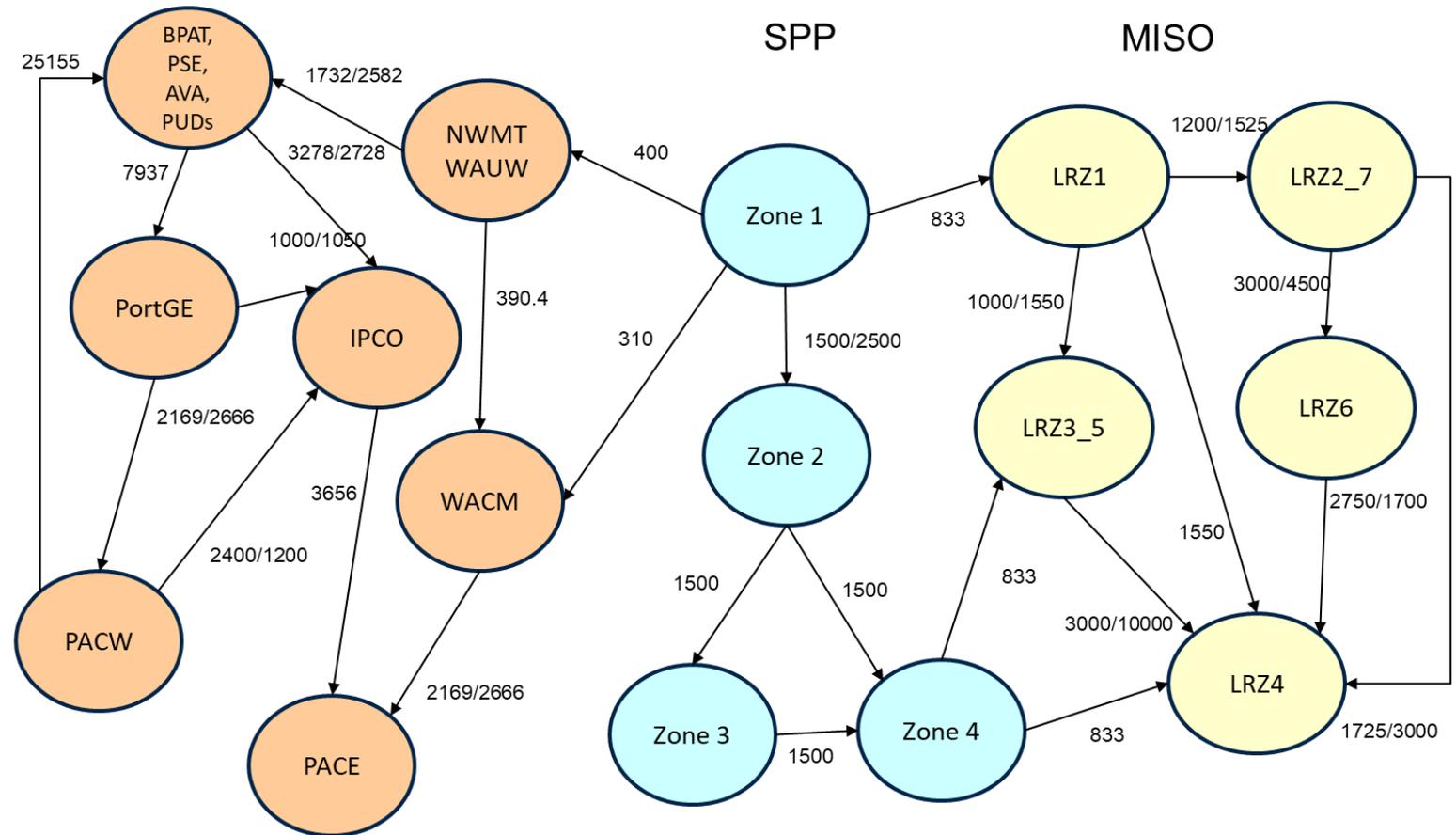
Existing interregional connections are integral to MISO's ability to support and be supported by its neighbors during wide-ranging weather events like Winter Storm Elliott in December, 2022 which affected much of the eastern half of the country.

Source: [MISO Winter Storm Elliott Report](#); Midwestern Regional Climate Center

# GU worked with Astrape Consulting to quantify this diversity from a resource adequacy perspective

GU commissioned Astrape Consulting to run a Loss of Load study between the PNW, SPP and MISO

- 2032 study year
- Generation inputs from available public datasets and utility IRPs
- PNW topology from California PUC RA study
- SPP/MISO topology estimated from publicly available data
- Limited MISO and SPP to northern footprints



# What we set out to accomplish and how

## Goals

1. Proof of concept study quantifying the resource adequacy value of interregional transmission
2. Thread the needle between three resource adequacy constructs to produce a study applicable to multiple regions

### Build Regions

MISO, SPP, PNW  
generators, load, and  
transmission  
networks for  
2032 from public  
datasets

### Calibrate

Calibrate systems to  
1 day in 10 years  
reliability standard

Add or remove  
generation as  
needed

### Rerun

Add North Plains  
Connector Project,  
return simulations

### Recalibrate

Recalibrate each  
region to 1 day in 10  
years standard by  
adding load back to  
the system

## Methodology

- Analyze all three regions concurrently using industry standard methods and software
- 43 years of weather data, load forecast scenarios, generator outage scenarios = **1,290 annual simulations**

# MISO sees the most risk in summer afternoons

MISO		Month												
		1	2	3	4	5	6	7	8	9	10	11	12	
Hour of Day	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	5	0.0%	0.5%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	0.0%	0.0%
	6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	9	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	12	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%
	13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	0.0%	0.0%	0.0%	0.0%
	14	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%	0.0%	0.0%	0.0%	0.0%
	15	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	1.0%	0.0%	0.0%	0.0%	0.0%
	16	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%	1.3%	0.0%	0.0%	0.0%	0.0%
	17	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	6.9%	0.0%	0.0%	0.0%	0.0%
	18	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.1%	7.9%	0.0%	0.0%	0.0%	0.0%
	19	0.2%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	6.4%	4.2%	0.0%	0.0%	0.0%	0.0%
	20	0.1%	0.9%	0.2%	0.0%	0.0%	0.0%	0.0%	3.0%	4.4%	0.0%	0.0%	0.0%	0.0%
	21	0.1%	0.8%	0.9%	0.0%	0.0%	0.0%	0.0%	5.0%	14.6%	0.0%	0.0%	0.0%	0.0%
	22	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%	3.5%	0.0%	0.0%	0.0%	0.0%
	23	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	2.7%	0.0%	0.0%	0.0%	0.0%
	24	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	1.6%	1.9%	0.0%	0.0%	0.0%	0.0%

Table shows the percentage of total curtailed load occurring in each hour of each month across all model runs

\* values rounded for ease of interpretation

# The PNW sees the most risk in the winter

WECC		Month											
		1	2	3	4	5	6	7	8	9	10	11	12
Hour of Day	1	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.2%
	2	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%
	3	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.7%
	4	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%
	5	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	3.7%
	6	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	5.5%
	7	0.5%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	0.1%	8.2%
	8	1.1%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.1%	10.9%
	9	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.4%
	10	0.5%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%
	11	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%
	12	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
	13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	14	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	15	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	16	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
	17	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	2.0%
	18	0.8%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	5.1%
	19	1.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.3%
	20	1.3%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%
	21	1.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%
	22	0.9%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%
	23	0.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	5.1%
	24	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%

Table shows the percentage of total curtailed load occurring in each hour of each month across all model runs

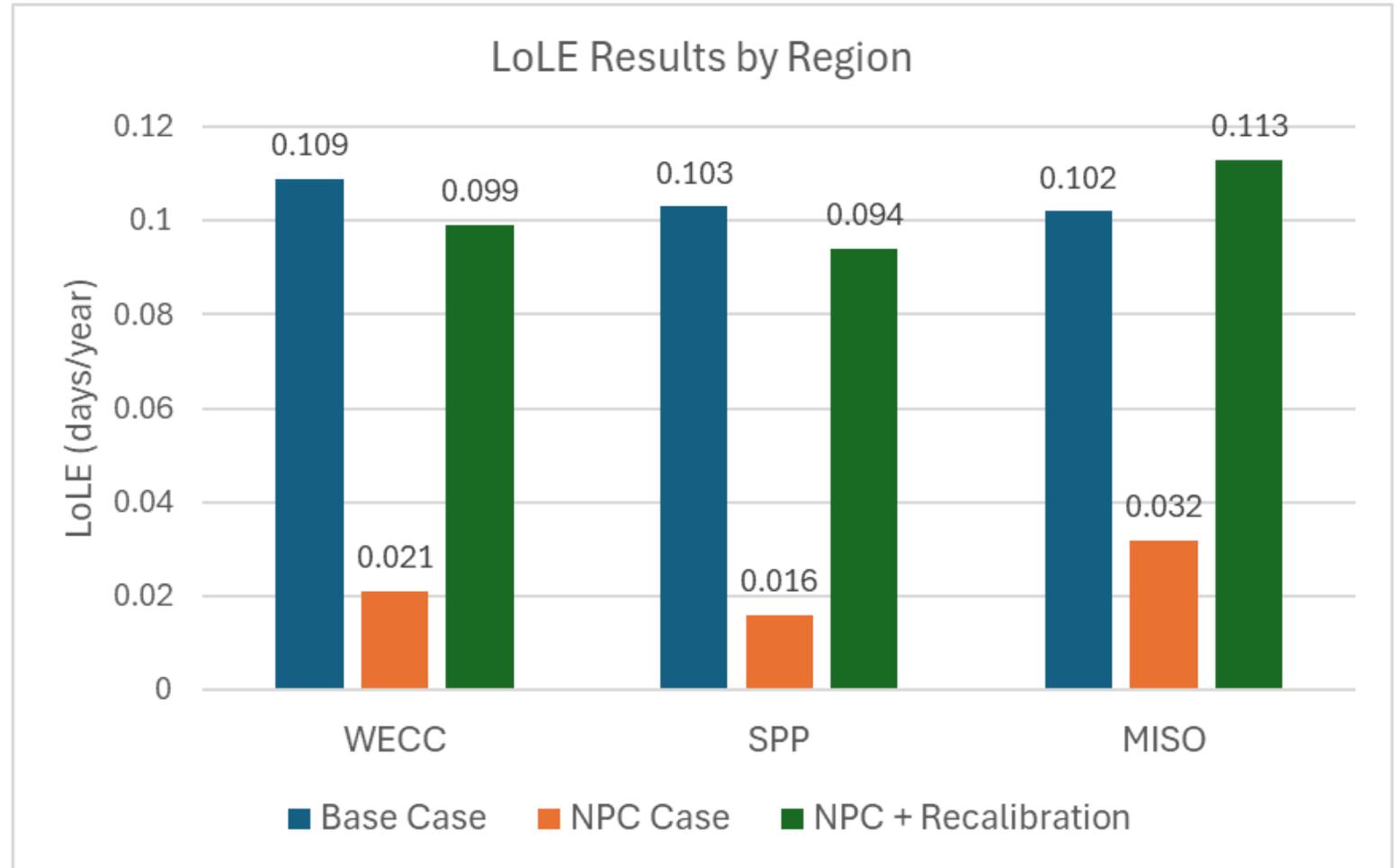
\* values rounded for ease of interpretation

# The addition of North Plains Connector substantially reduces LoLE in all regions

## Simulation steps:

1. Calibrate regions to 0.1 LOLE by adding/removing generation
2. Add NPC
3. Add around the clock load to each region until LOLE returns to 0.1.  
Amount of load added = NPC capacity value

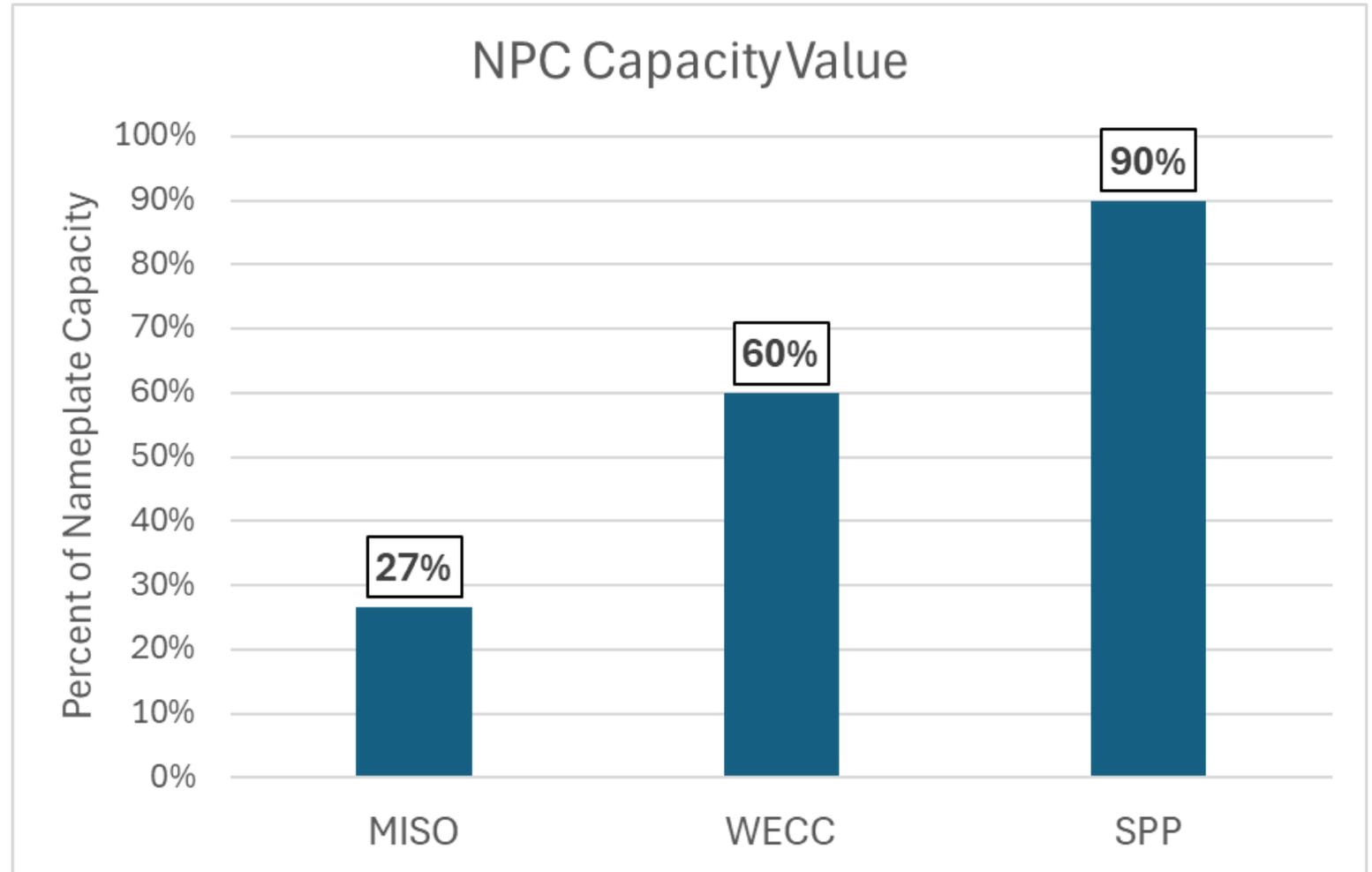
*Base and Recalibrated LOLEs do not always equal 0.1 because of breakpoints where additional changes to the supply/demand balance overshoot the 0.1 target*



# These LoLE reductions translate to ~3,550MW of load carrying capacity

Because the simulation ran all regions at once, values are additive

Value is sensitive to changes in winter/summer peaking: WECC and SPP are likely to move closer to MISO in later 2030s or higher renewable penetration scenarios

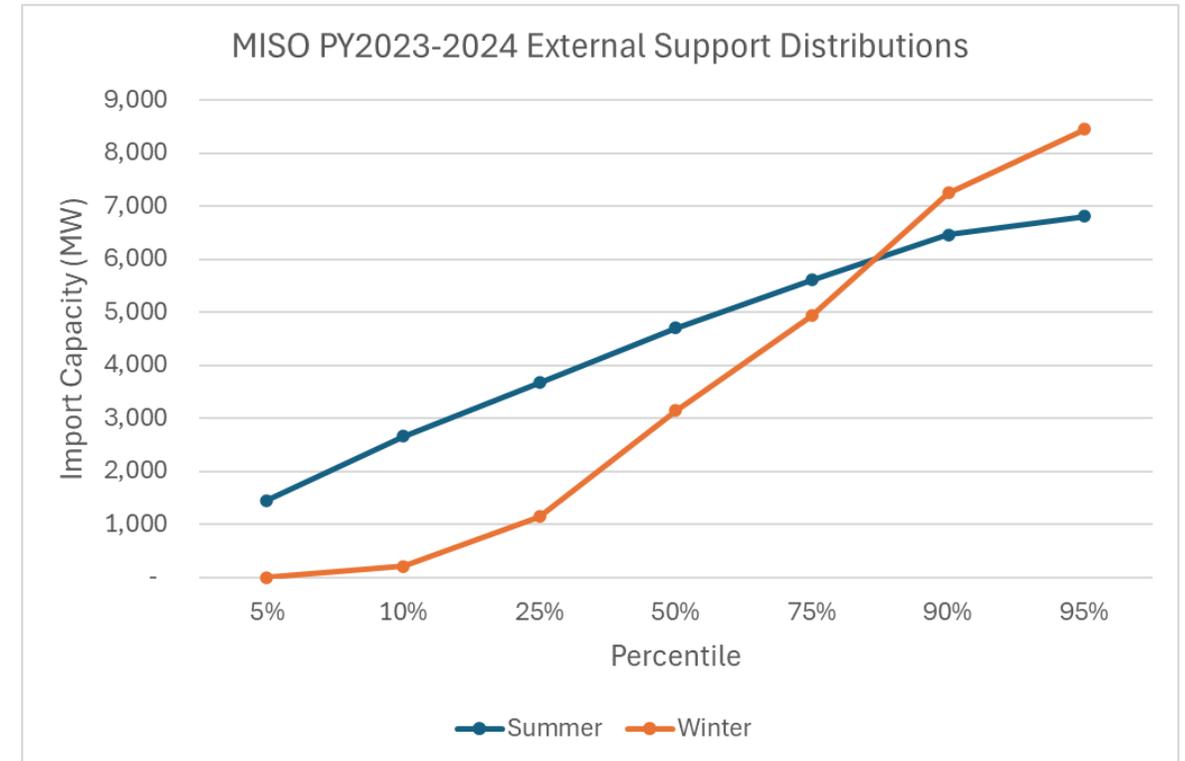


# Interregional transmission should be studied in a way that incentivizes new projects

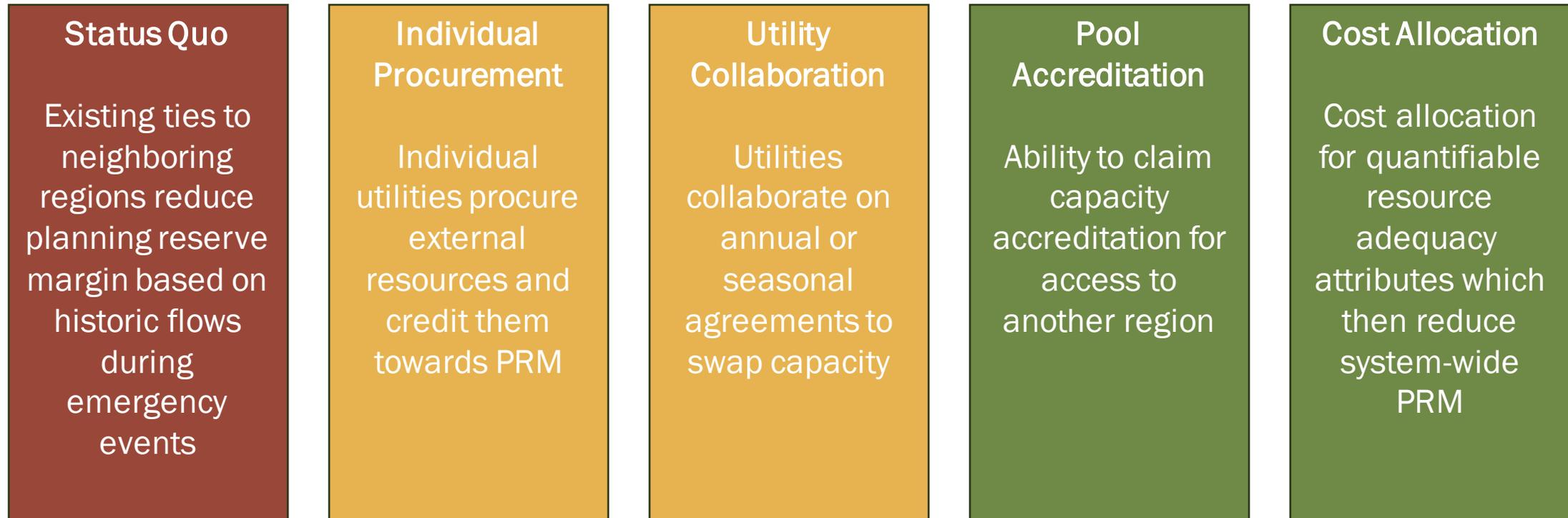
*Interregional transmission is expensive but has considerable reliability and economic benefits. All attributes must be accounted for to help justify projects.*

Recommendation #10 in NERC's 2023 inquiry into Winter Storm Elliott review suggests "joint-regional reliability assessments" to better understand the impacts of wide-scale winter storms.

MISO already uses a distribution of non-firm imports based on historical data in its LoLE studies. Need to expand thinking to be forward-looking about the value of new transmission



# There is a sliding scale of opportunities to capture new interregional diversity





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