2019 Polar Vortex

Looking Back and Planning for the Future

MIPSYCON

November 12, 2019

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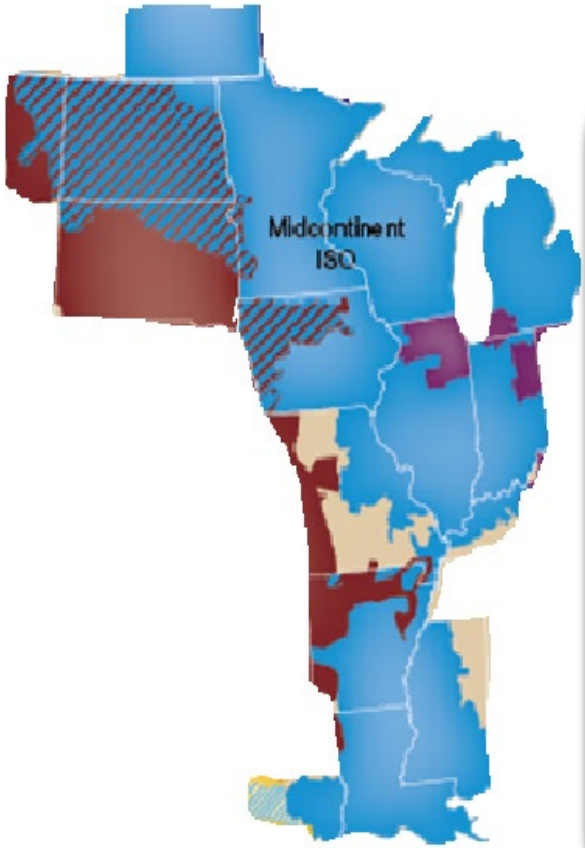
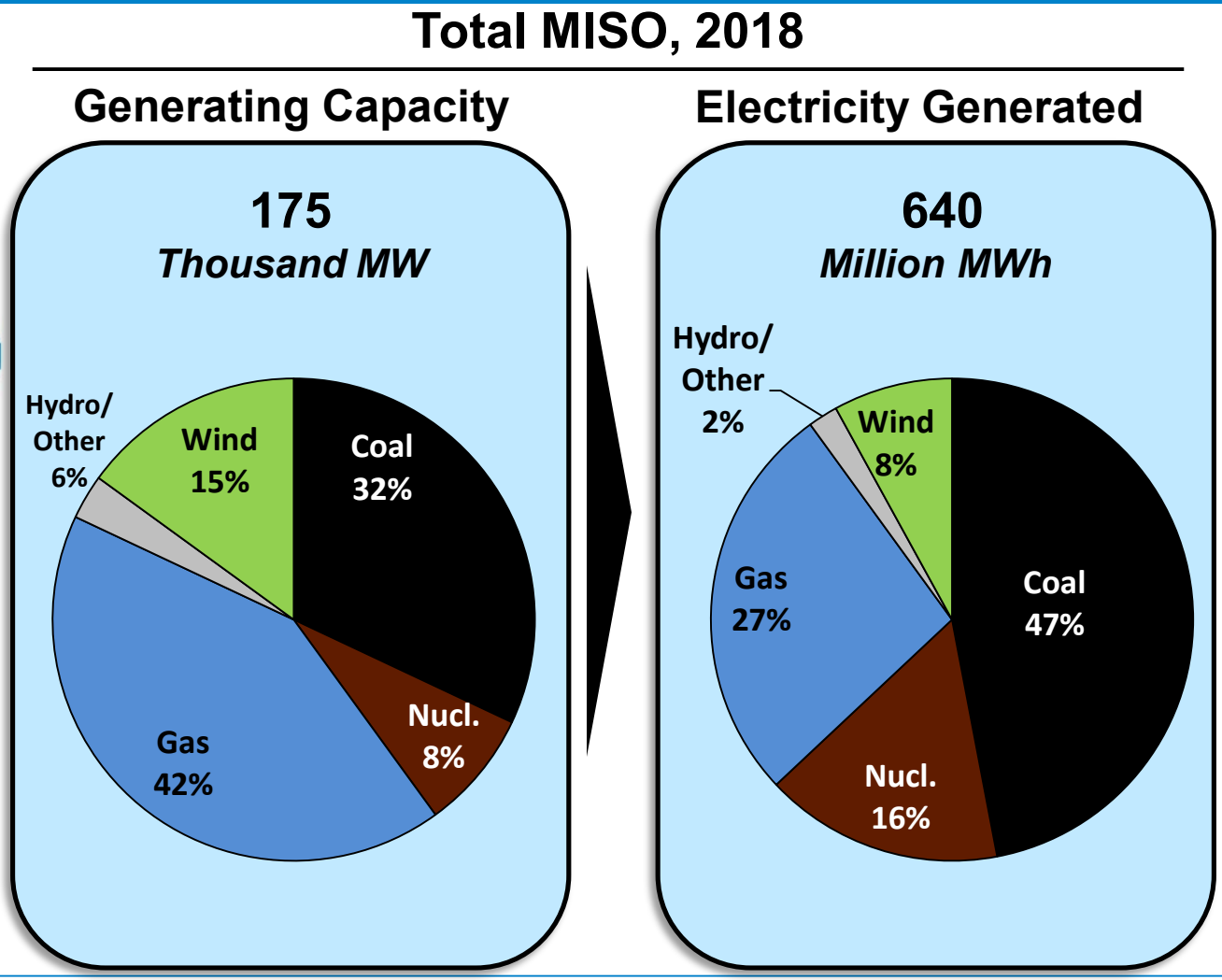
minnesota power

AN ALLETE COMPANY

EnergyForward

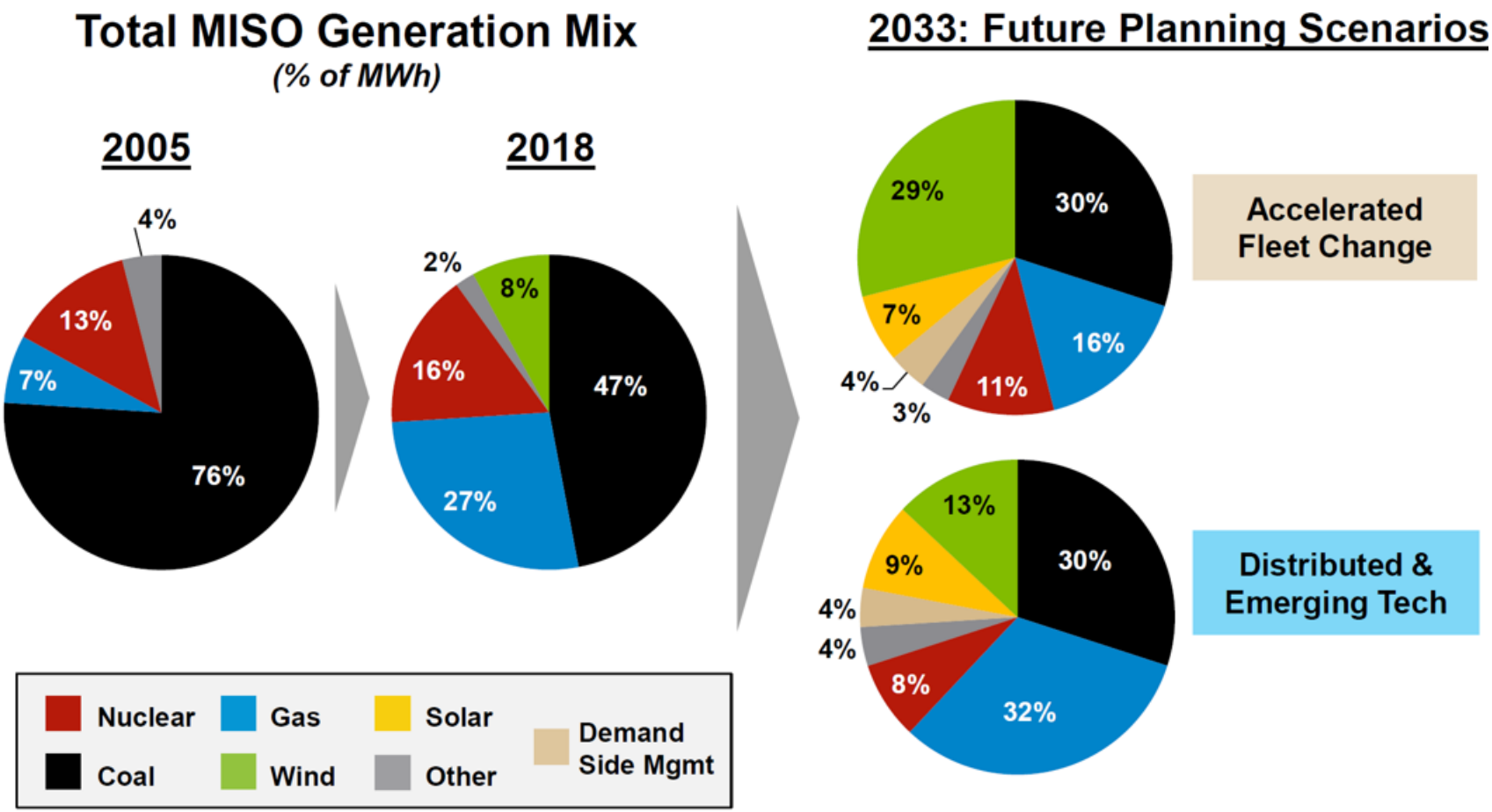
MISO connects a large, diverse generation fleet…





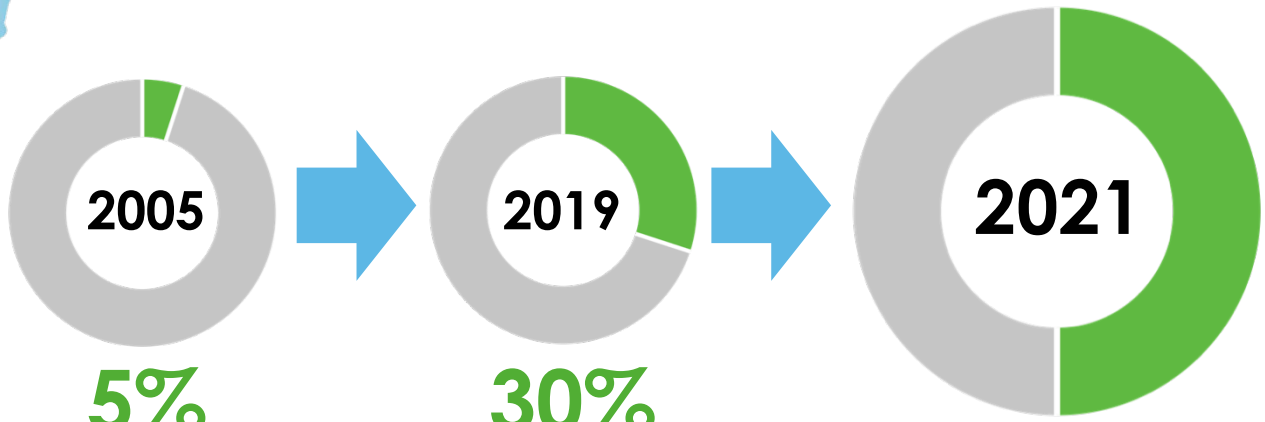
Source: Misoenergy.org website

The generation fleet has shifted, with the pace accelerating toward more renewable and conventional generation retirement



Minnesota Power

Significant Transformation



5%
Renewable

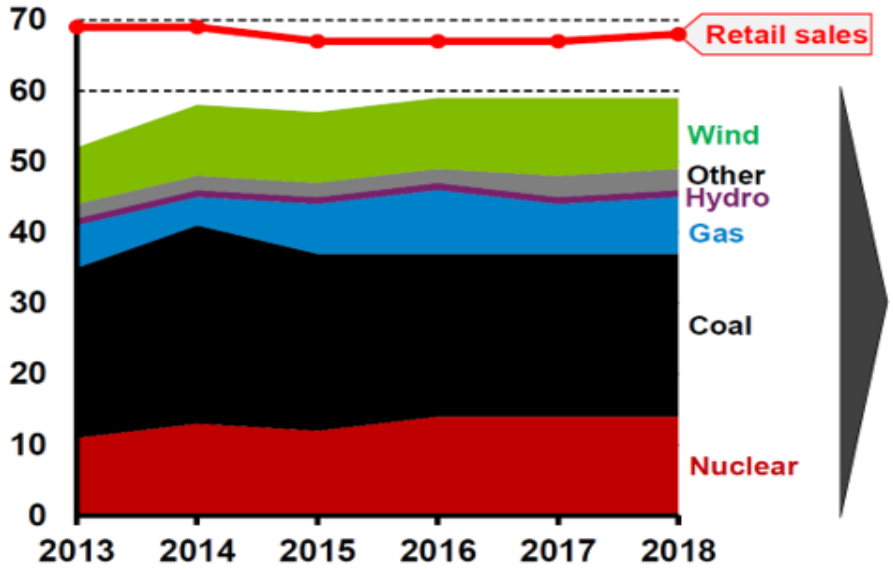
30%
Renewable

Leader in Region

50%
Renewable

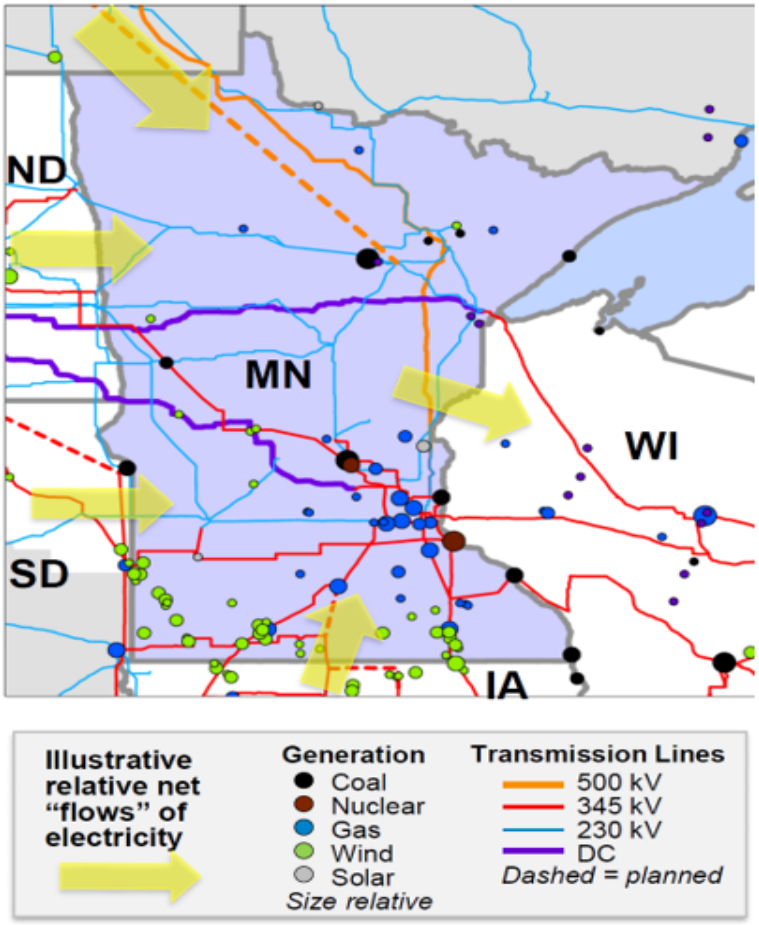
Within MISO, the State of Minnesota is a net importer of electricity, and a “crossroads”

Minnesota “In State” Retail Sales vs. Generation *(million MWh/yr)*



As a state, MN consumes more electricity than it generates within state borders; it is a net importer in the MISO system

Source: US Energy Information Administration (EIA)

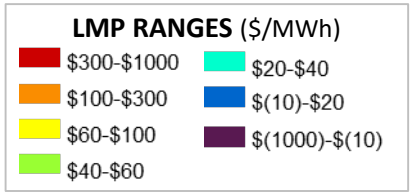


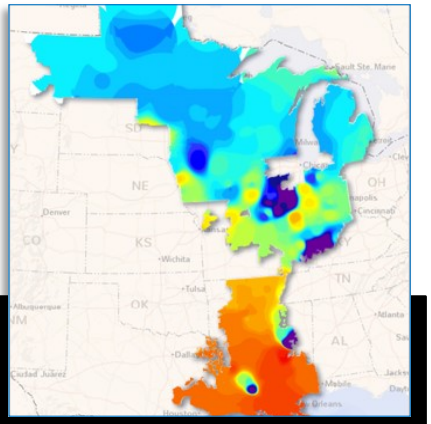
MISO

Weather Events & Changing Power System

- Extreme weather events increasing in frequency
- System transformation creating new operating dynamics
- Future system planning will need to consider new normal emerging

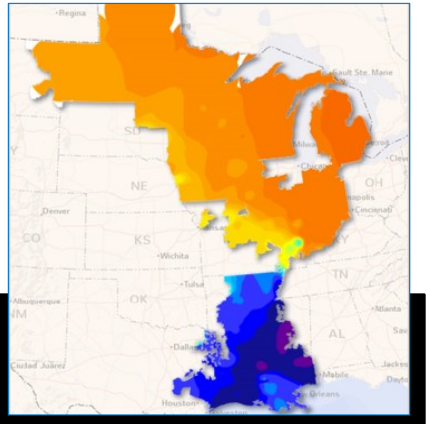
North/Central region experienced extreme cold weather this January, similar to the extreme cold weather in the South region last year





January 17, 2018
South Region

Minimum Temperature	13°F
System Peak Load	106 GW
Unplanned Outages	13 GW
Scheduled LMRs*	0.9 GW
Emergency Purchases	1.2 GW
RDT Max Flow & Direction	3.9 GW N-S



January 30-31, 2019
North/Central Region

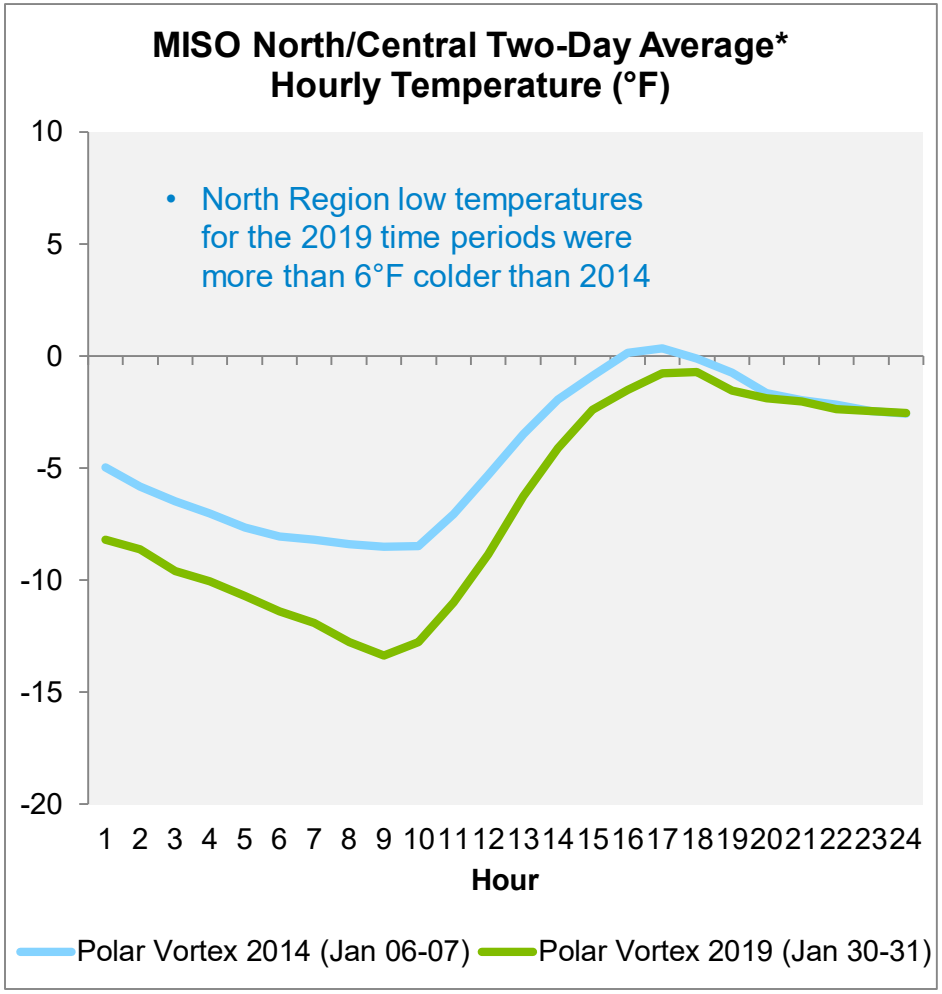
Minimum Temperature	-26°F
System Peak Load	101 GW
Unplanned Outages	29 GW
Scheduled LMRs*	2.5 GW
Emergency Purchases	Not Needed
RDT Max UDS & Direction	2.2 GW S-N

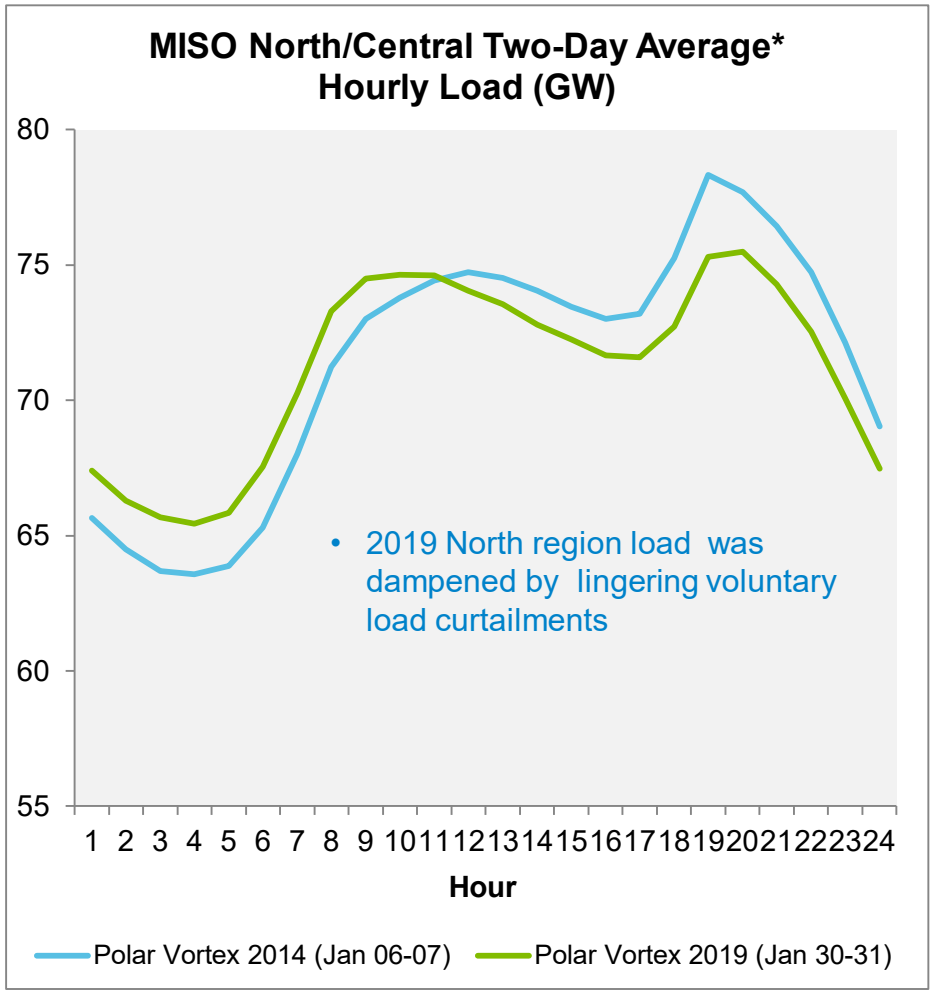
*LMRs = Load Modifying Resources

2019 Polar Vortex Key Points

- MISO and Members reliably managed operations during extreme cold, where temperatures fell below -30°F in some parts of the North and Central regions
- Resulting high load, unavailable generation, and uncertainty in both load and supply created challenges throughout the event
- Emergency procedures were implemented and maintained from early January 30 through the afternoon of January 31 to reliably manage the grid and maintain public safety
- Winter preparedness by MISO and its members ensured readiness for the extreme conditions, but, we note areas of needed improvement in load and wind forecasting, and voluntary load curtailment impacts

A strong arctic high pressure system brought historic cold to the North and Central Regions on January 30-31, driving temperatures below Polar Vortex 2014 levels

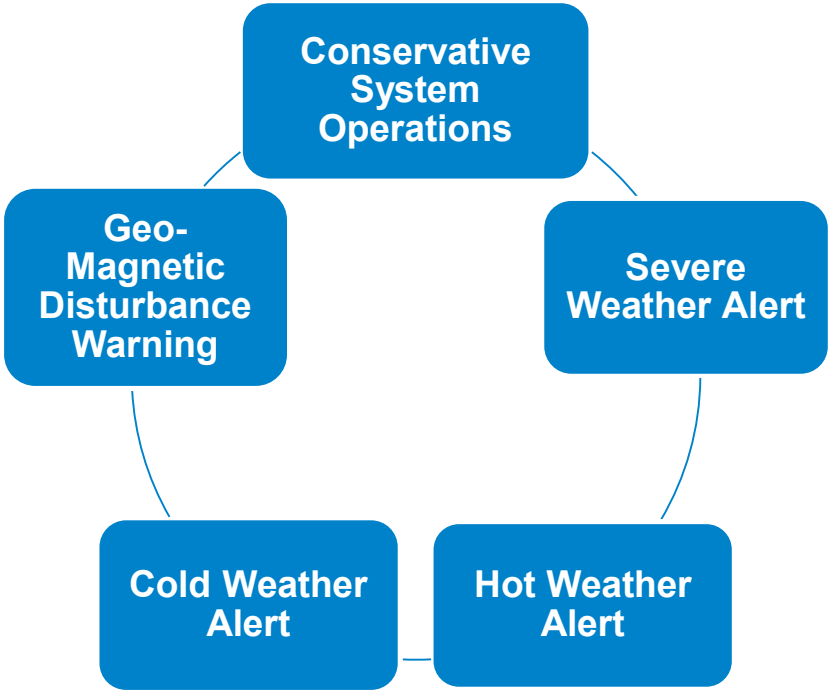




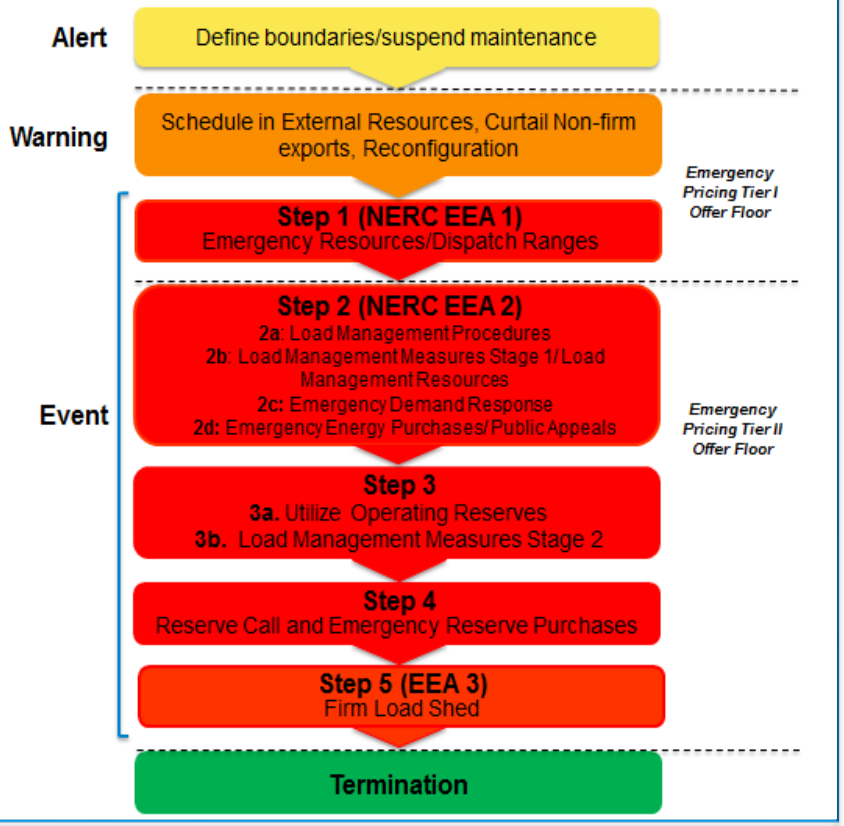
*Average is for the two days listed

MISO's operating procedures ensure reliability and gain access to additional resources during extreme situations.

Emergency Operating Procedures guide operator actions when an event has the potential to, or actually does, negatively impact system reliability

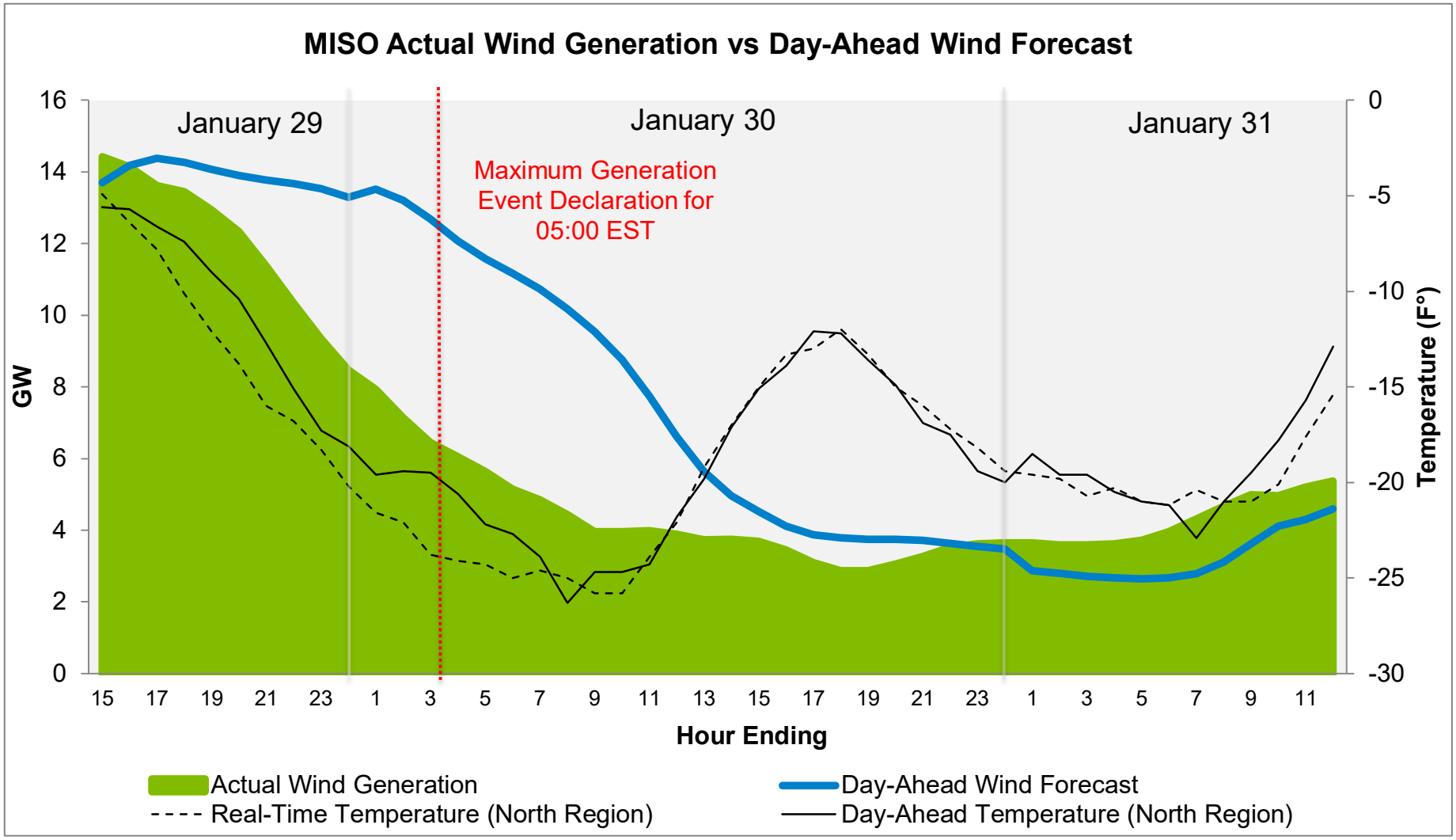


Maximum Generation Emergency Procedures

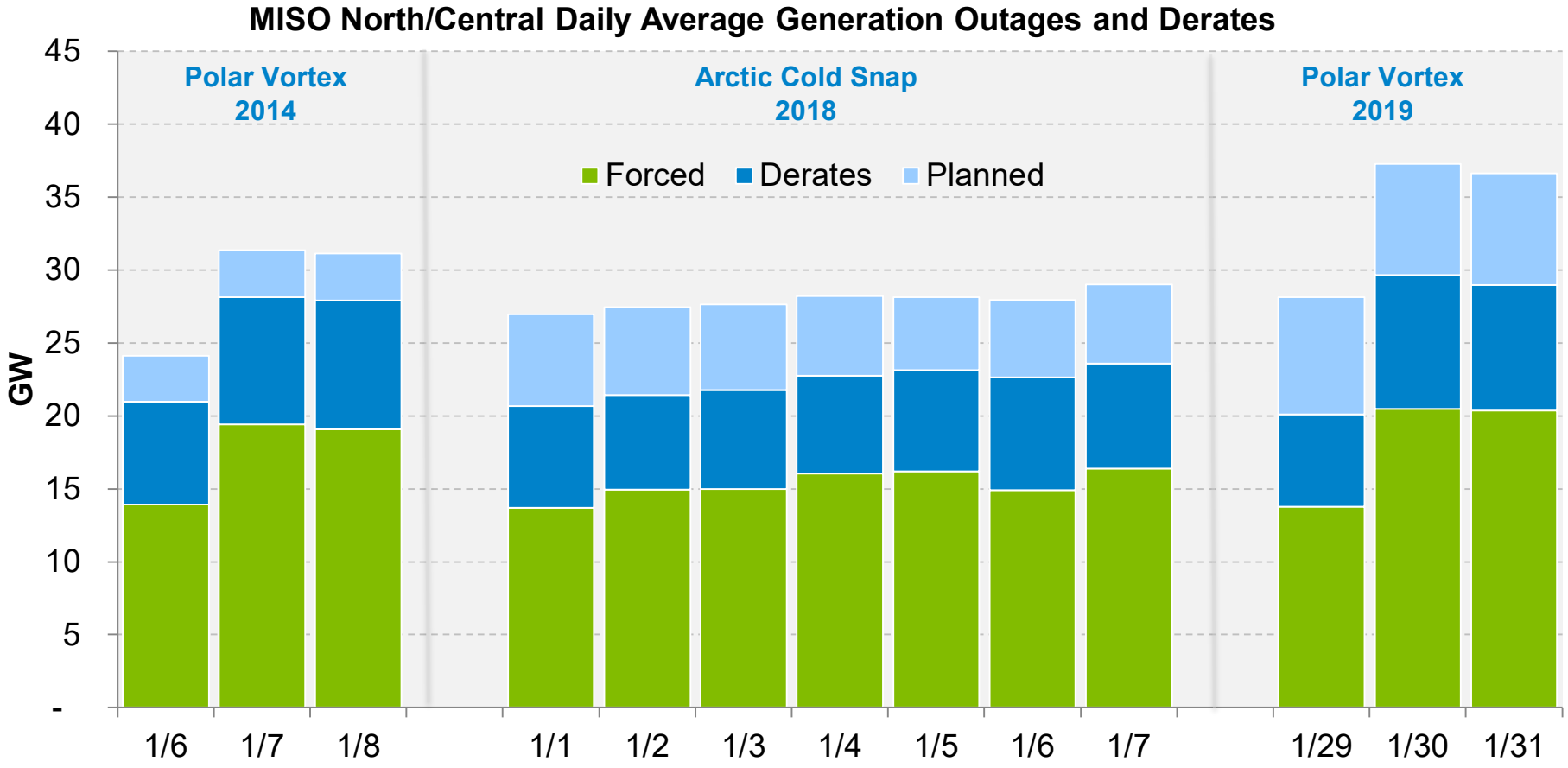


Data Source: SO-P-NOP-00-449 Rev 0 Conservative System Operations and SO-P-EOP-00-002 Rev 3 MISO Market Capacity Emergency procedures

An earlier than expected drop in wind output increased insufficiency risk early on the morning of January 30th



Total outages were higher than previous cold weather events with approximately 25% unavailable due to unplanned outages*



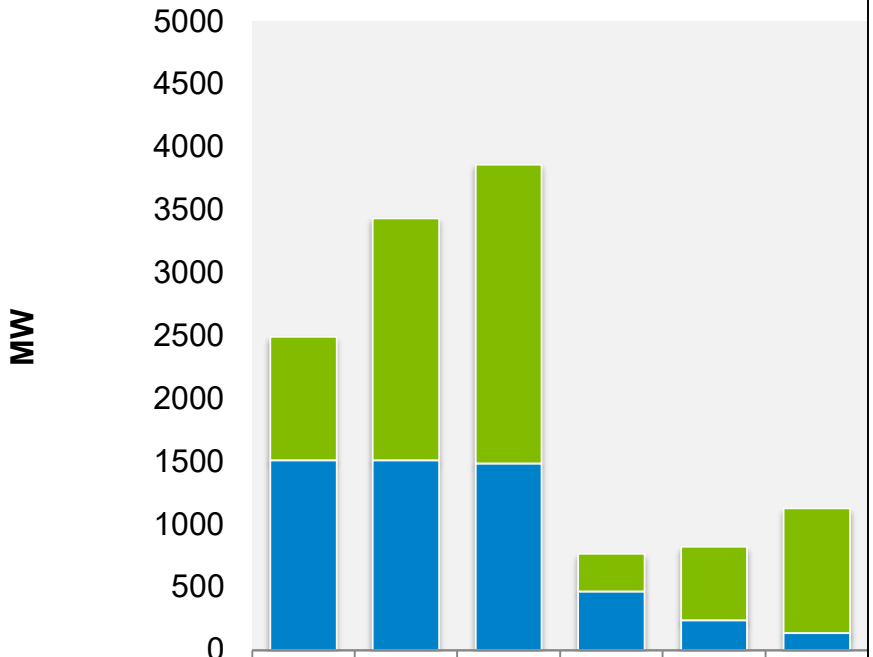
Unplanned Outages (GW)	**20.1**	**29.6**	**28.9**
% Unplanned^	**18%**	**26%**	**26%**

*Unplanned: Forced plus derates

The outage chart reflects the data as it resided in the CROW Outage system on Feb 11, 2019
Wind often reported as derate over the time period
^Percent based on PRA cleared generation plus uncleared internal MISO generation

Deployed and self-scheduled LMRs, school/business closings, and other voluntary load management across the North/Central Region aided in dampening demand below expectations

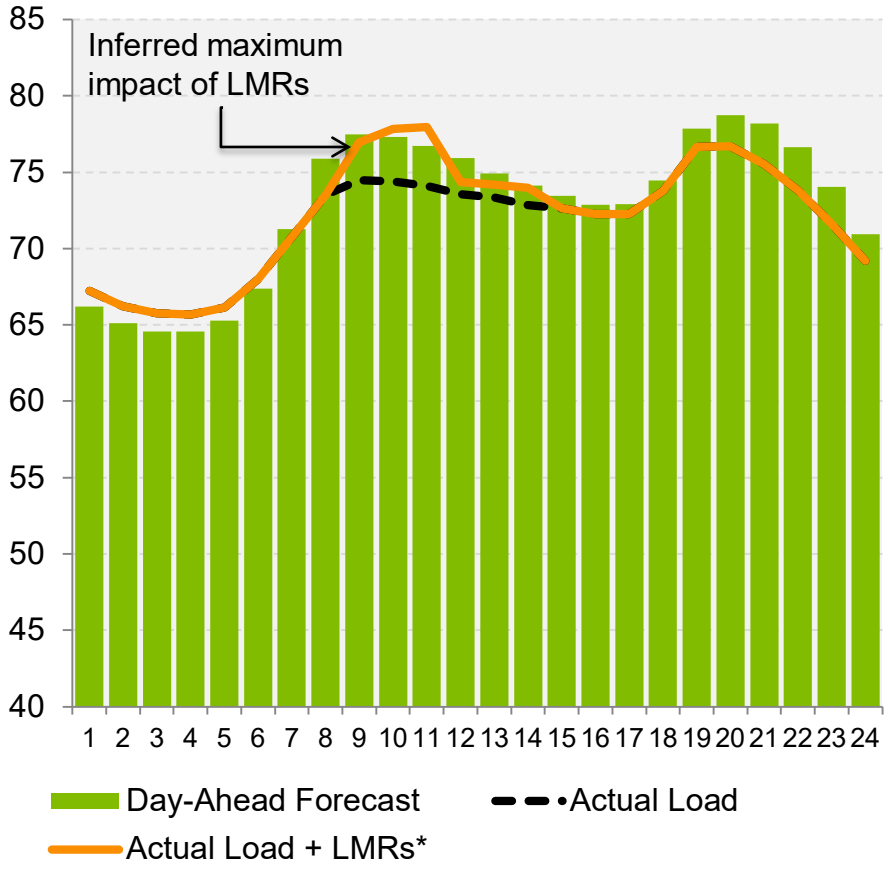
MISO North/Central Load Management Resources (LMRs) for Jan 30



	9	10	11	12	13	14
LMR/LMM	983	1923	2373	300	588	990
Self Sched LMR	1512	1514	1488	470	237	138

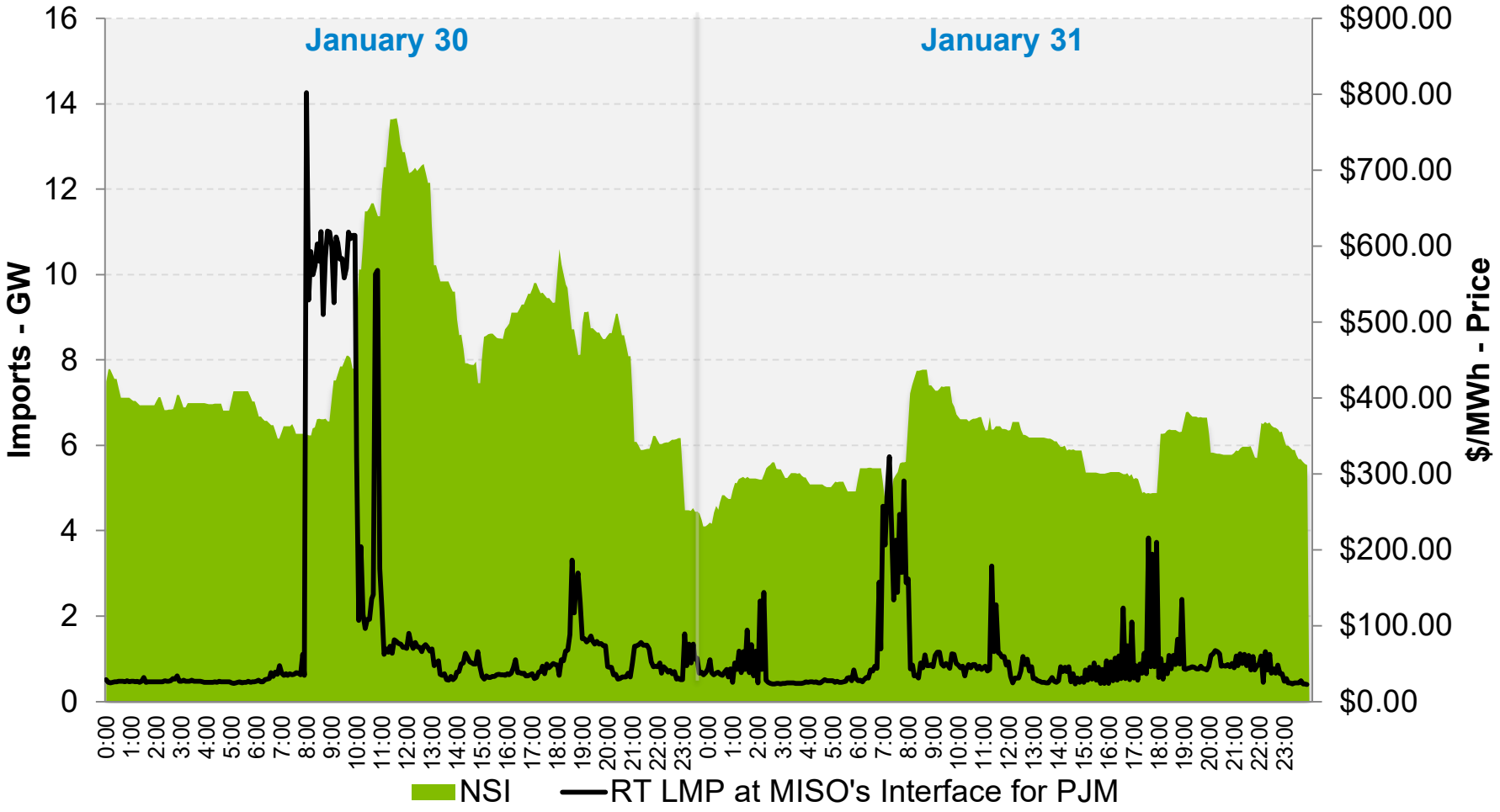
- LMR performance to be evaluated after receipt of meter data towards the end of March

MISO North/Central Hourly Load for Jan 30



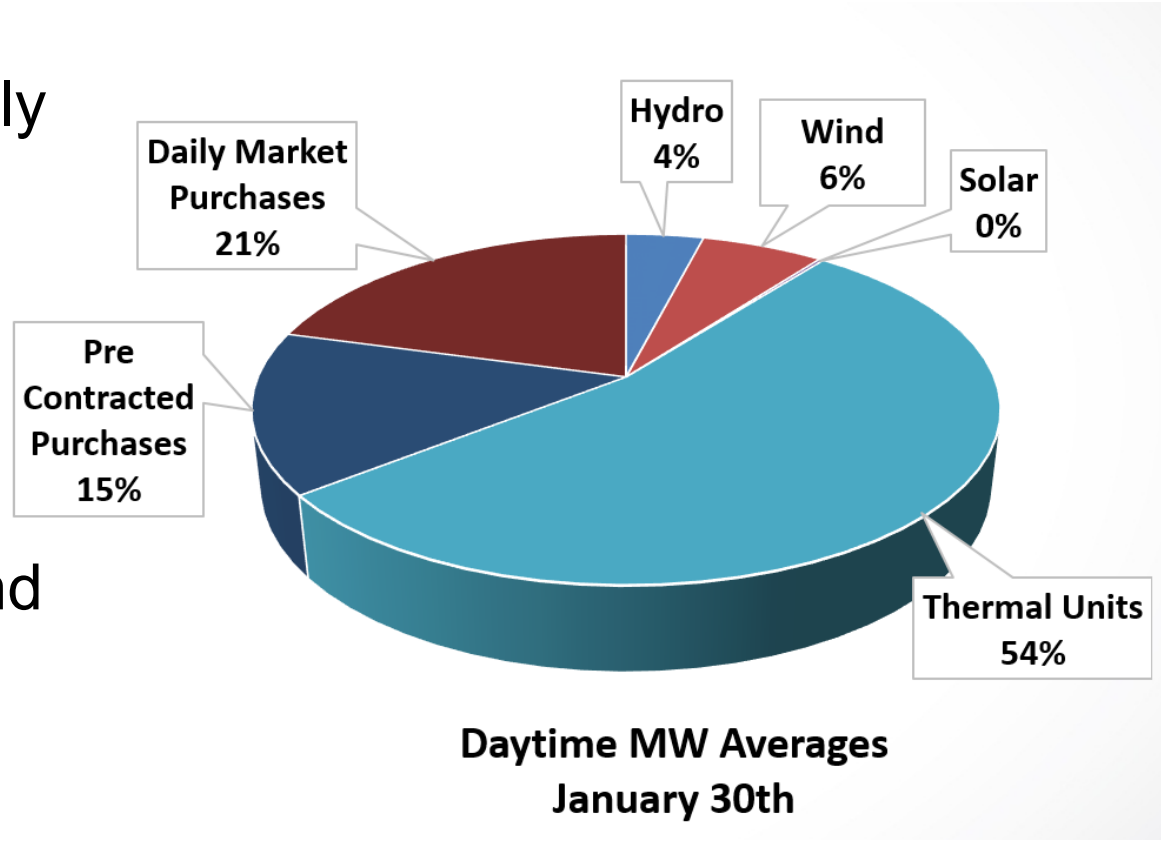
* Does not include impact of closings not accounted for in forecast

Imports responded to emergency price signals, registering well above 5 GW through the evening peak and Jan 31 morning peak



Minnesota Power – Polar Vortex

- Diverse power supply supports system reliability
- Regional support and import of energy required to maintain balance

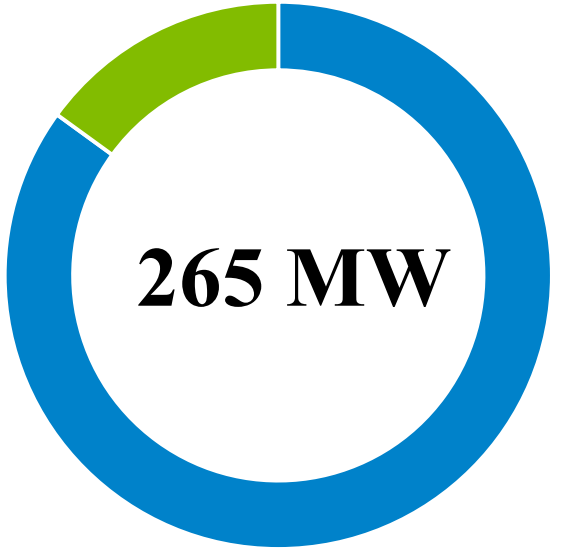


MP Customer Demand Response Programs
Called Upon Full Suite

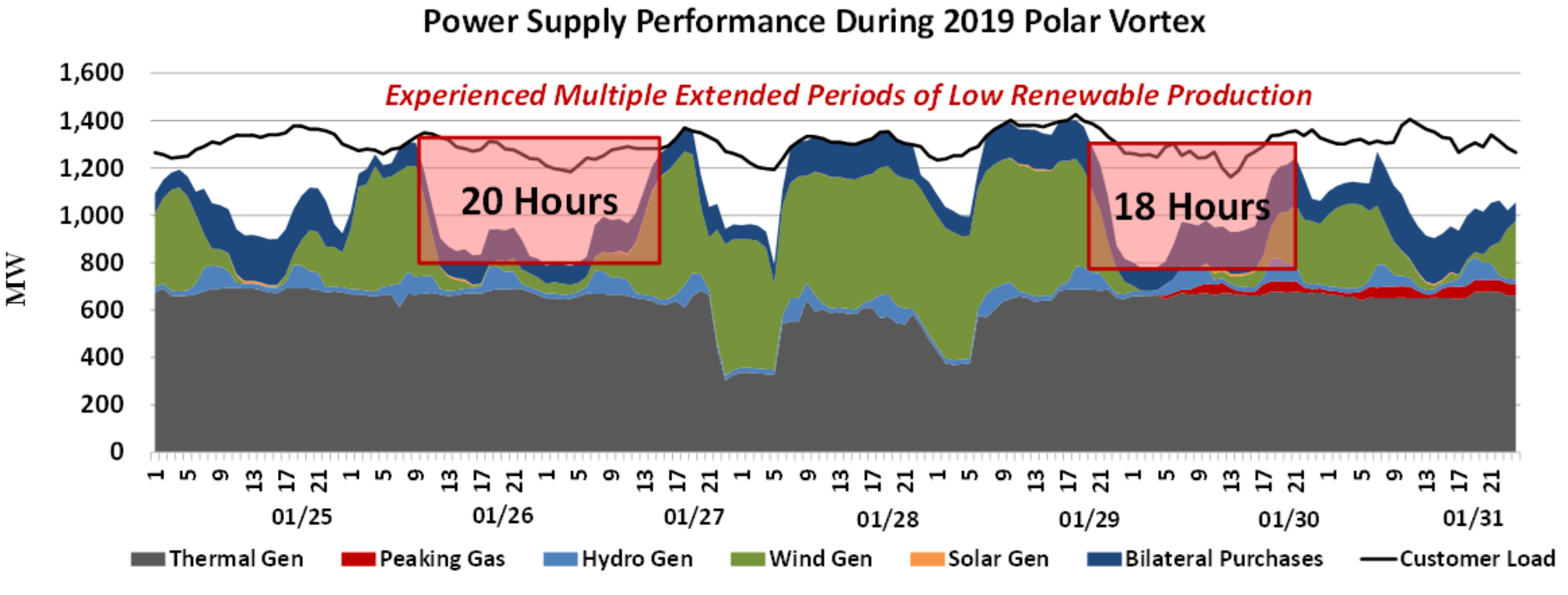
- **Residential Programs**
  - Heating Load Curtailment Program "Dual Fuel"
  - Time of Day Usage –price signal notification to pilot participants
- **Commercial and Industrial Programs**
  - Interruptible and Curtailment Programs
    - Economic
    - Emergency

MISO called an Energy Emergency Alert 2B on January 30th, MP entered Emergency operations, 200 MW of emergency capacity curtailed

Customer Demand Response Programs Available



Minnesota Power Vantage Point



More extreme weather events + intermittent renewables = grid reliability more important than ever

Experience provided lessons learned that will enable us to improve future operational performance

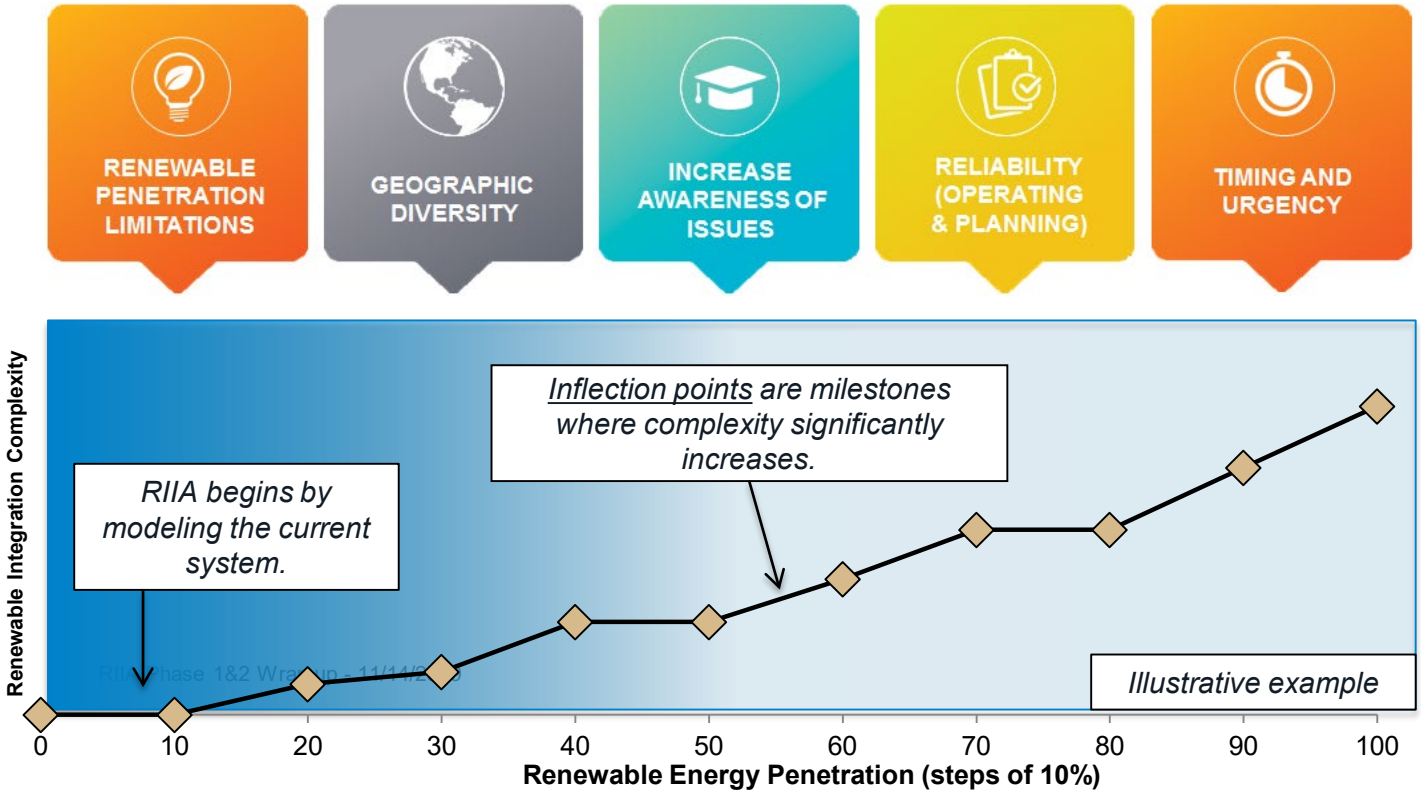
- Improve wind forecasting with additional resource parameters
- Incorporate facility closing impacts into load forecast
- Review emergency pricing rules
- Improve Load Modifying Resource availability & performance
- Improve generation availability & performance

- Advance Demand Response Programs for More Frequent Use
- Update Demand Response Process Coordination with MISO
- Review Energy Adequacy Needs for System with Higher Renewables
- Review weather package options generation

System Transformation Study and Policy in Progress

- Renewable Integration Impact Assessment (RIIA)
- Resource Availability and Need
- Market Design Evolution
- Minnesota Public Utilities Commission Baseload Generation Plans

Renewable Integration Impact Assessment (RIIA) seeks to find inflection points of renewable integration complexity



Focus Areas

RESOURCE ADEQUACY

Having the sufficient capacity of resources to reliably serve peak demand

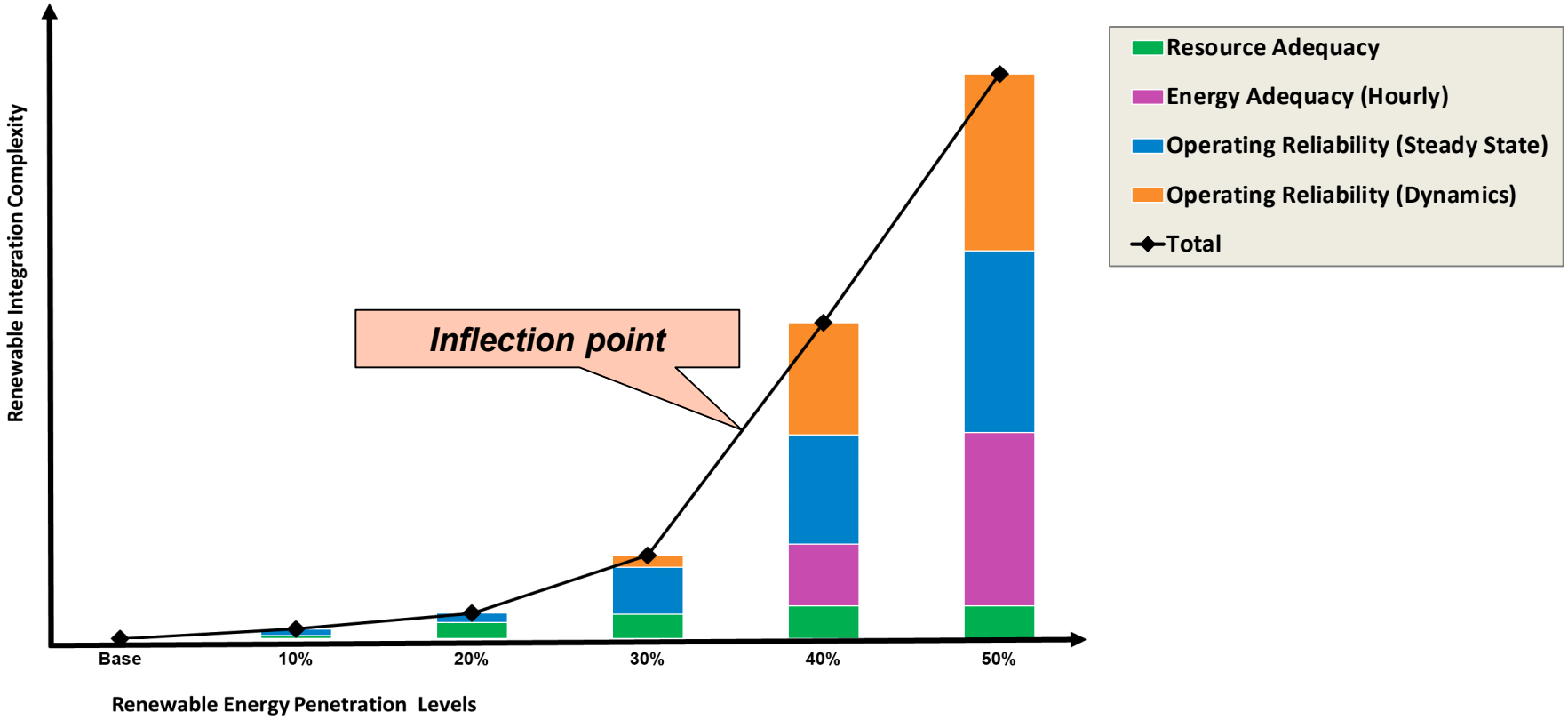
ENERGY ADEQUACY

Ability to provide energy in all operating hours throughout the year

OPERATING RELIABILITY

Ability to withstand unanticipated component losses or disturbances

Results indicate integration complexity increasing sharply from 30%- 40% renewable penetration



Overview Of MISO's Renewable Integration Impact Assessment (RIIA)

Context:

RIIA is an ongoing study conducted collaboratively with MISO members to identify MISO-wide renewable penetration levels at which integration complexity significantly increases.

Emerging Themes:

- **Up to 30% renewables, challenges appear manageable with regular, incremental transmission expansion**
- **By 40%, significant challenges begin**
  - **40% MISO-wide equates to 70-100% local penetration in wind-rich Iowa, Minnesota, North Dakota, South Dakota**
  - **Tradeoffs required between renewable curtailment & transmission investment**
  - **Increased flexibility requirements (ramping from conventional generation)**
  - **Increased system stability concerns**
- **Challenges can be addressed; however, least cost solutions require careful study and regional coordination across the MISO footprint**
- **The value of MISO-wide diversity and 'interconnectedness' are key**

Summary

- The generation fleet within MISO is evolving
- By 40% renewable penetration, significant integration challenges begin
- Utility system planning will need to integrate new scenarios, ensure energy adequacy in all hours
- Challenges can be addressed; however, solutions require careful study and regional coordination…diversity and interconnectedness are key