Gas/Electric Coordination: RTO Operations, Planning, and Strategic Perspectives

Panhandle Eastern &Trunkline Gas Customer Meeting

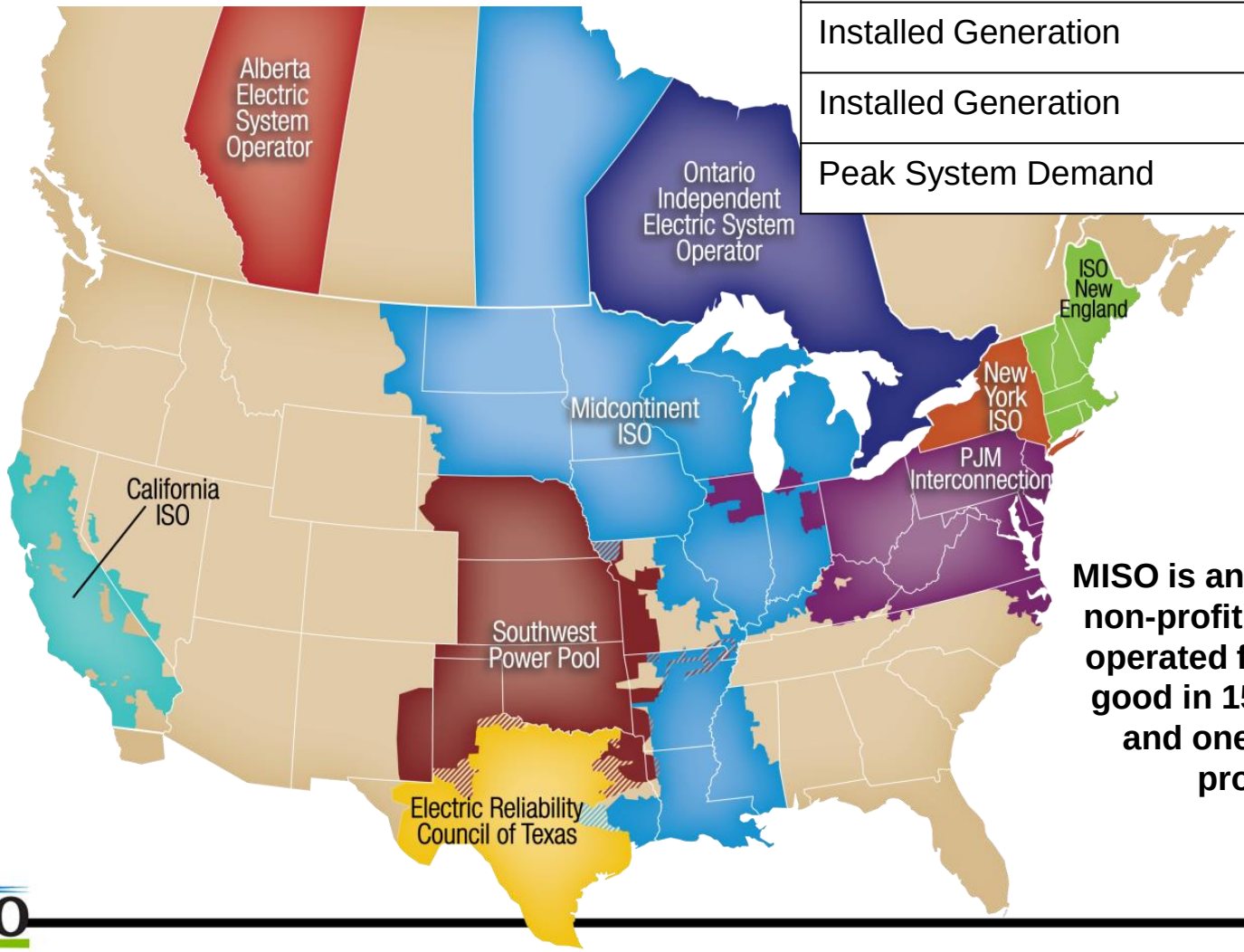
May 12, 2015

Geographically, MISO is the largest regional transmission organization and independent system operator, of nine, in North America

MISO's Mission

Drive value creation through efficient reliability / market operations, planning and innovation

Midcontinent ISO	
High Voltage Transmission	65,853 Miles
Installed Generation	177,388 MW
Installed Generation	1,594 Units
Peak System Demand	127,125 MW



MISO is an independent, non-profit organization operated for the public good in 15 U.S. States and one Canadian province

MISO's role is concentrated to a few key areas

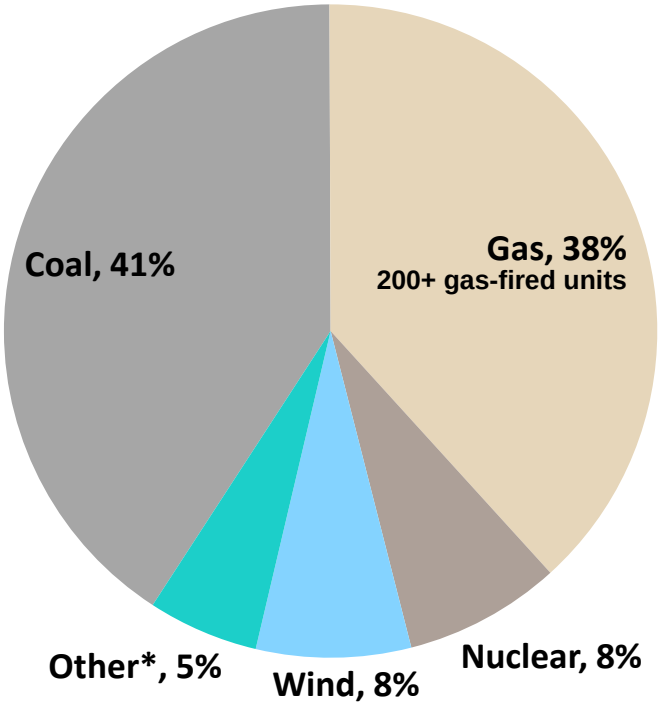
What We Do	Implications
Provide independent transmission system access	• Equal and non-discriminatory access • Compliance with federal access requirements • Eliminate transmission rate pancaking
Deliver improved reliability coordination through efficient market operations	• Improved regional coordination • Enhanced system reliability • Independent lowest cost unit commitment, dispatch, and congestion management
Coordinate regional planning	• Integrated system planning • Broader incorporation of renewables • Balance transmission and generation tradeoffs
Foster platform for wholesale energy markets	• Encourage prudent infrastructure investments • Facilitation of regulatory initiatives • Market price/value discovery

MISO works closely with its members and states in a collaborative process.

MISO is diverse by sub-region, with natural gas comprising 28% of installed capacity in MISO North/Central and 67% in MISO South

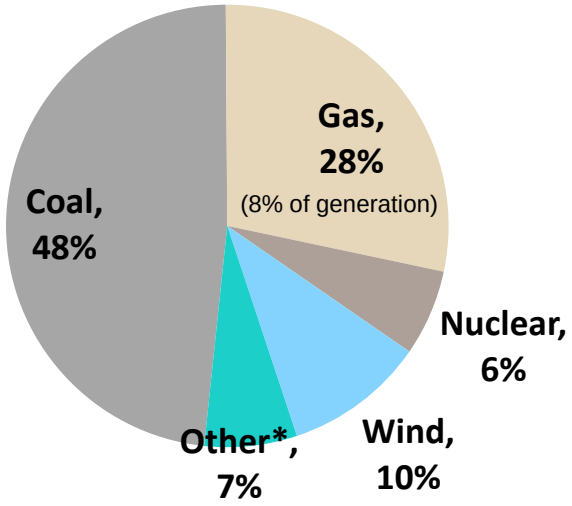
MISO

Total 177,000 MW



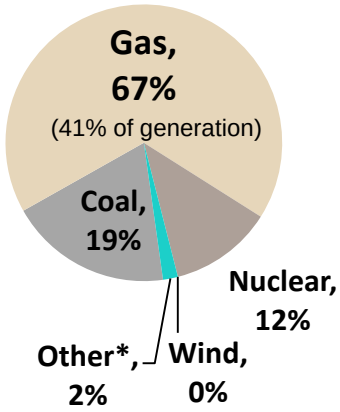
MISO North/Central

Total 132,000 MW



MISO South

Total 45,000 MW

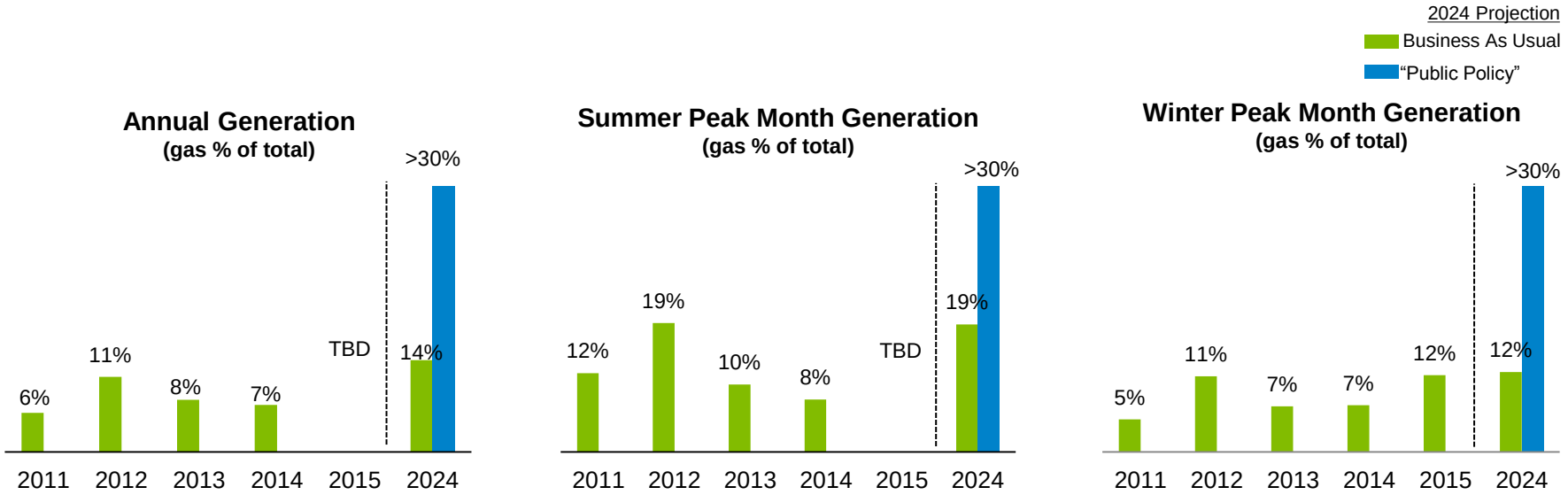


*Includes hydro, pumped hydro, oil, solar, other

Source: MISO MTEP13 Economic Assumptions document

MISO gas reliance is forecasted to grow. Notable increases exist in scenarios with more environmentally stringent public policies and sustained lower gas development and production costs

Gas Share of Electric Generation in MISO North/Central



- 2012 low gas prices ($2.75/MMBtu) and very warm summer

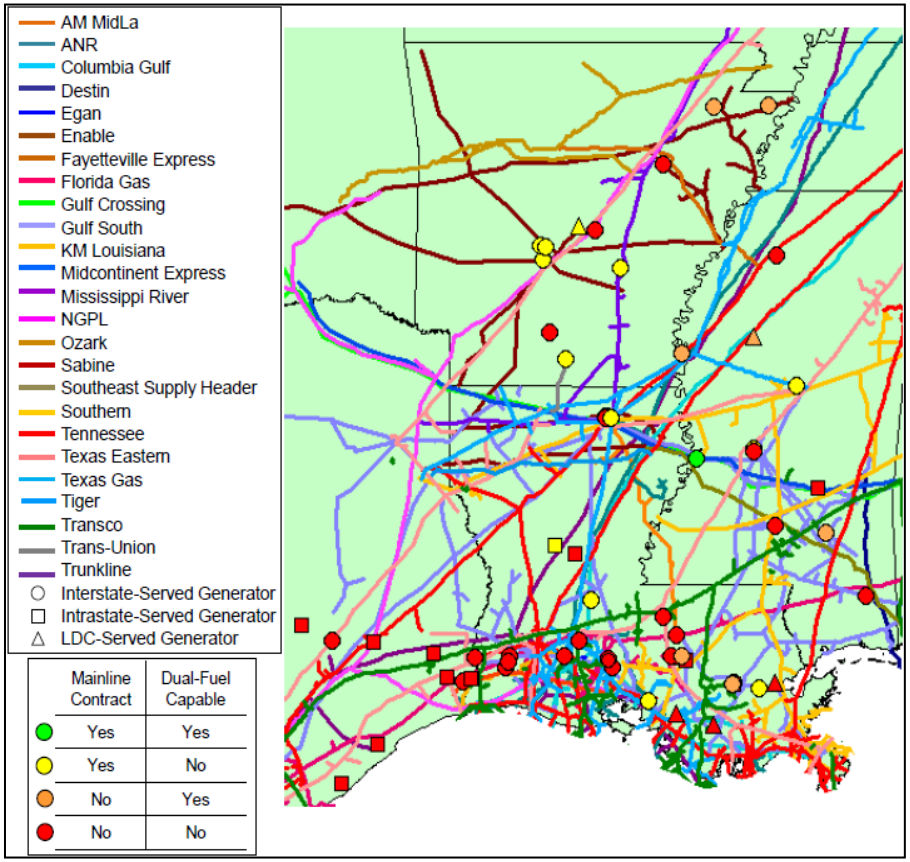
- 2012 summer low gas prices ($2.00/MMBtu) and very warm summer
- 2014 summer cooler than normal, higher gas prices

- 2012 winter low gas prices
- 2014 extreme winter weather and higher winter gas prices
- 2015 cold winter and low gas prices

Historicals per MISO Information Delivery and Market Analysis group through March, 2015. Summer defined as June-August. Winter defined as December-February, e.g., winter 2015 is December 2014 – February 2015.
Forecast figures based on MISO MTEP15 assumptions and models for two scenarios: 1) "Business As Usual," 2) "Public Policy" (assumes 23 GW coal retirement, 16 GW new gas-fired combined cycle, carbon tax $64/ton in 2024, MISO-wide RPS having 19% of total electric supply from RE in 2024). Forecast assumes normal weather.
The gas price forecast applicable to year 2024 has been updated to reflect recent NYMEX futures for Henry Hub gas prices at ~$4.25/MMBtu.

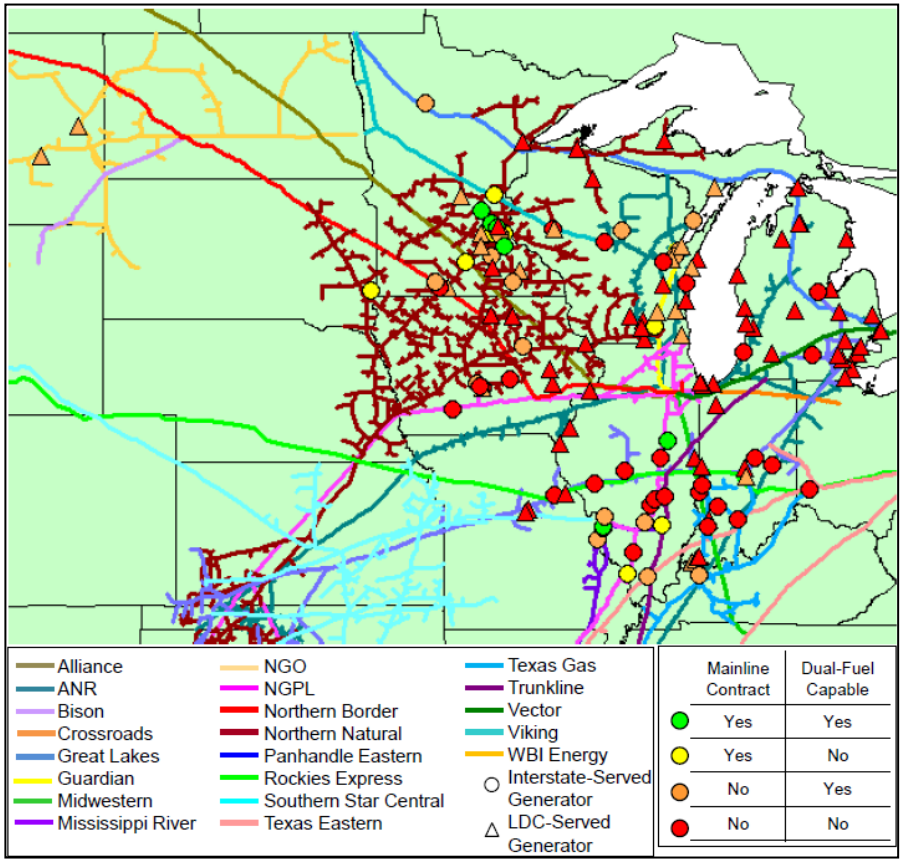
Over 200 gas-fired generators in MISO with 30+ pipelines in the North/Central and South regions, plus connections to LDCs

MISO South



- ~40% of MISO South gas-fired capacity is connected to two or more pipelines (including intrastate pipelines)

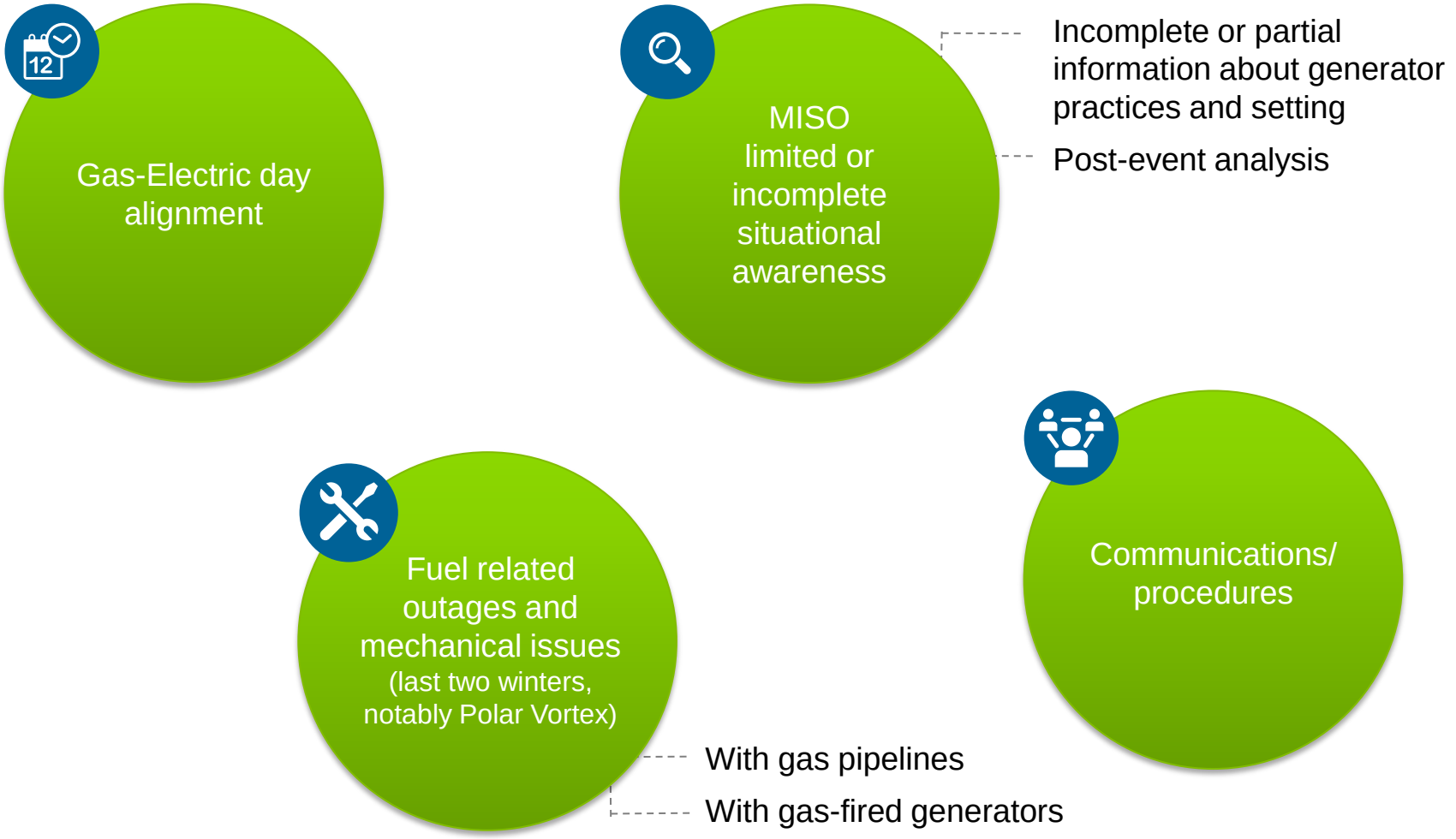
MISO North/Central



- Over 50% of MISO North/Central gas-fired capacity is connected to interstate pipelines and the remainder is connected to local gas utilities

Source: EIPC Target 1 report for plants over 15 MW

Key Electric/Gas Challenges



MISO Electric/Natural Gas Coordination

- Gas-electric market day alignment (FERC Order 809)
- Establishing direct communications with gas pipeline operators
- Surveying gas-fired generators
- Expanding real-time mapping tools
- Studying how the impacts of EPA's Clean Power Plan

Leveraging MISO's Electric and Natural Gas Coordination Task Force to identify and address issues at the gas-electric interface (issue papers, discussions, etc.)

Order 809 issued April 15, 2015

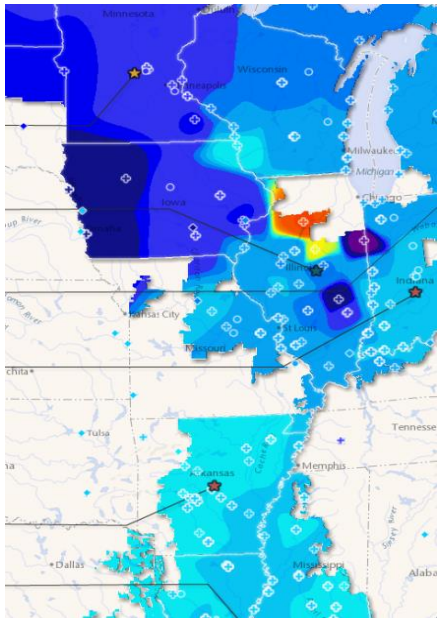
While MISO is still evaluating the full implications of the Order, several aspects are clear:

- No change to the nationwide Gas Day Start (900 Central)
- Timely Day-Ahead Nomination Deadline moved from 1130 Central Clock Time (CCT) to 1300 CCT
- Increased flexibility for Intra-day scheduling
- FERC reinforced its directive for ISOs/RTOs to align Electric Market with Gas Market
- Gas Nomination Cycle changes Effective April 1, 2016
- Compliance filing due 90 days after publication in Federal Register (July 23, 2015)

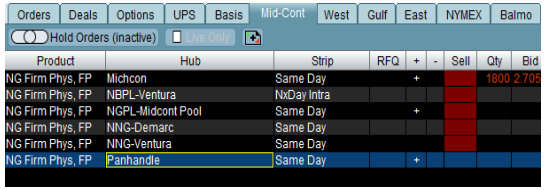
Summer 2015 Electric/Gas Initiatives

Communication Coordination

- Building Operational Contact List With All Pipelines in the MISO Footprint
- Expanding Monthly Operations Call
- Sharing of MISO Public Data with Pipelines
  - DA Wind Forecast & RT Wind Generation
  - LMP Contour Map



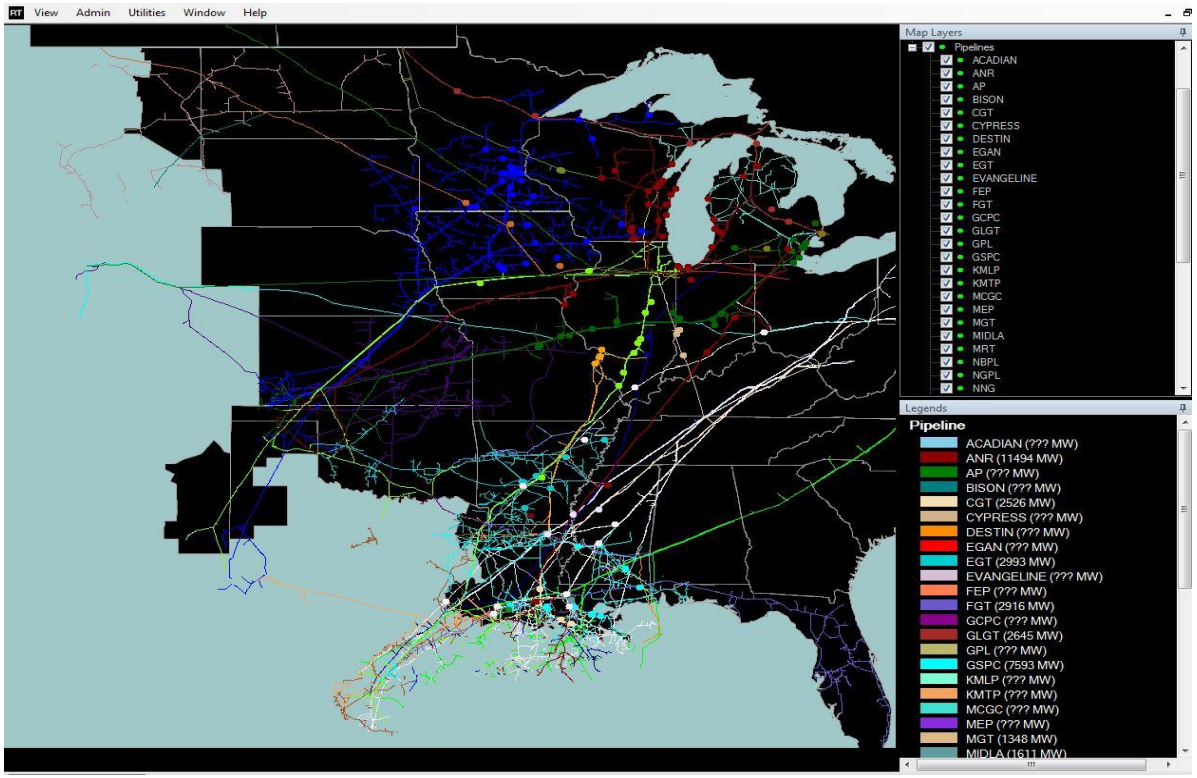
- **Gas Market/ Situational Awareness**
  - MISO Pipeline Notification Website
  - Monitoring Market Condition
    - Intercontinental Exchange Subscription
  - Gas Industry Internal Training
  - Daily Gas Outage Report – CROW



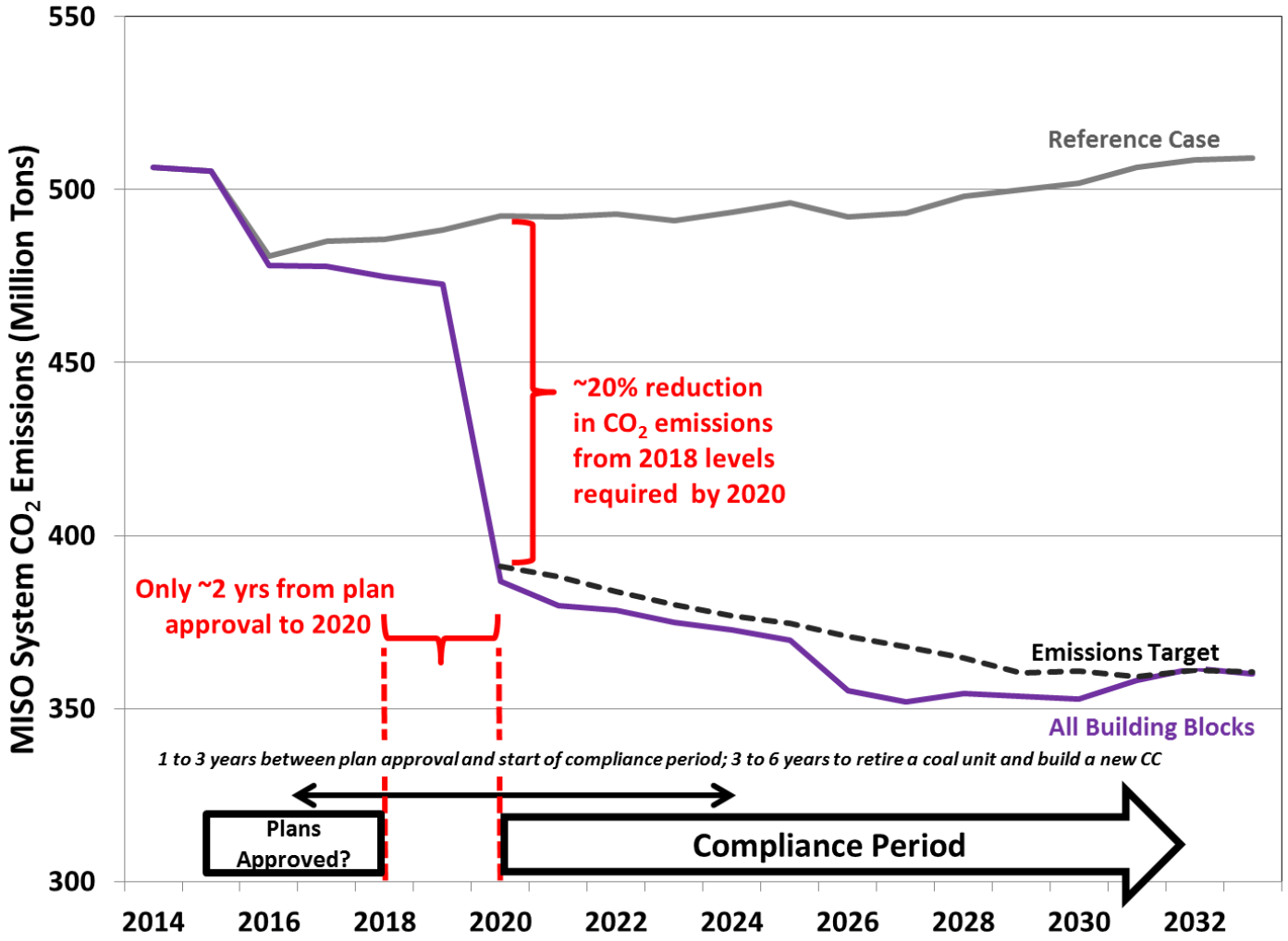
Electric/Gas Pipeline Display Project

MISO Control Rooms / Real Time Display

Internal Tool for Real Time Operations (Phase 1 Completed)



The rule's "interim performance period" will require significant CO2 cuts to be made as early as 2020



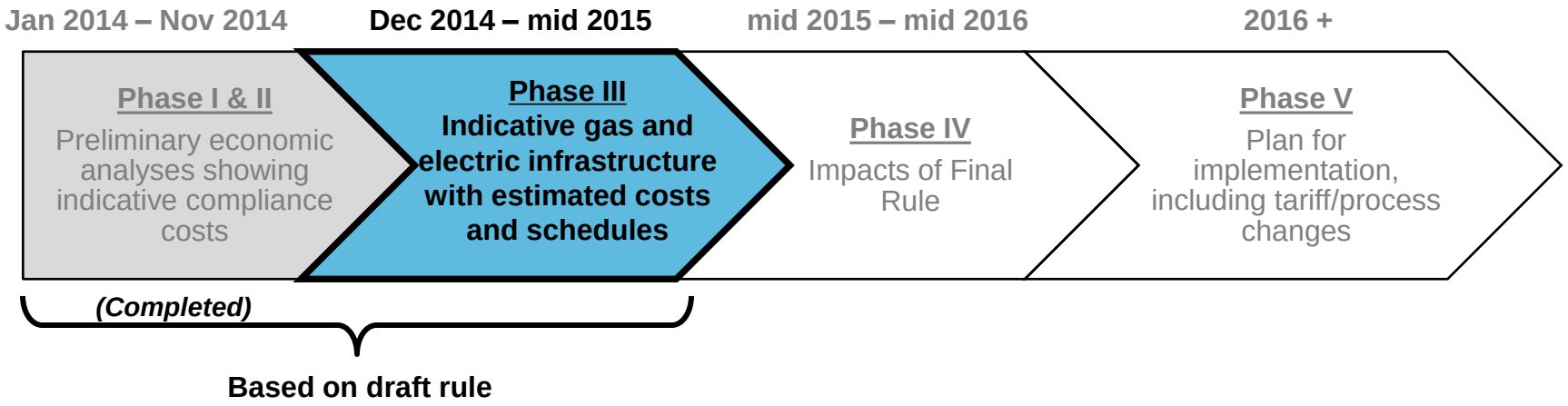
MISO has completed analysis of CPP with some key findings:

- Just as there are economic benefits to operating the electrical grid on a regional basis as opposed to a Balkanized, state-by-state approach, there are also economic benefits to be gained by taking a regional MISO-wide compliance approach to the CPP.

- MISO analysis indicates that taking a regional, footprint-wide compliance approach to CPP could reduce aggregate compliance costs by approximately 40 percent.

- The regional-related cost savings indicated in MISO's analysis of the Clean Power Plan do not include the costs of new transmission lines, natural gas pipelines and other infrastructure that may need to be built as a result of EPA's rule.

Analyzing need for new or expanded electric and gas infrastructure under CPP



- Inform stakeholders as they evaluate paths to compliance
- Incorporates state-level CO_2 compliance, expanded reliability assessment, production cost analysis and *proof-of-concept integrated gas-electric modeling*

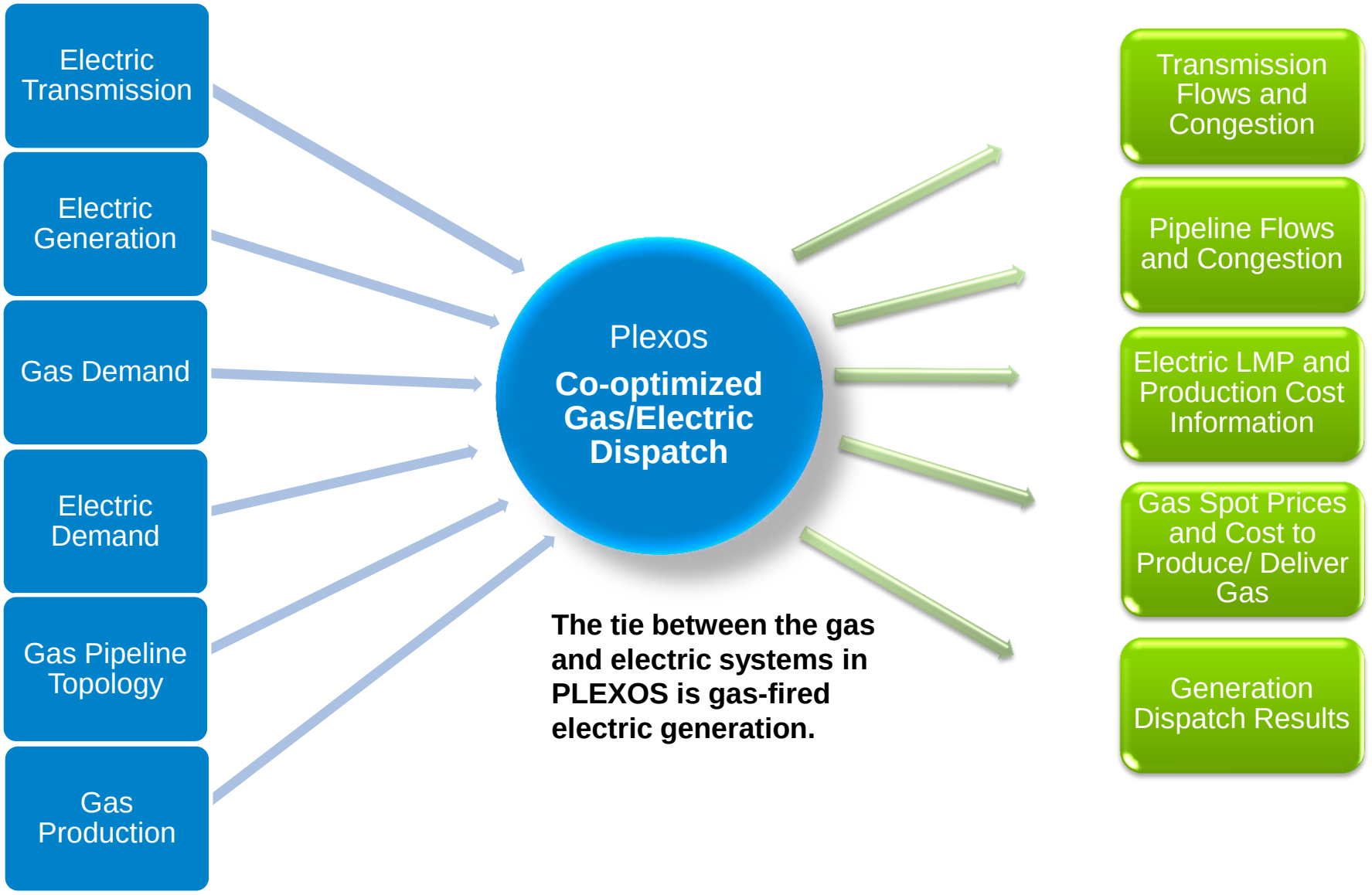
What is the integrated gas-electric model?

- PLEXOS (electric) production cost model with built-in gas infrastructure
- Simultaneously optimizes gas and electric system operations in an hourly chronological dispatch
- *Approximates* real-world gas and electric markets clearing in the same timeframe
- Does not account for pipeline dynamics or contractual rights.

Why are we incorporating integrated gas-electric modeling into the CPP Phase III study?

- Informs more comprehensive estimations of the cost to achieve compliance
  - Aligns with stakeholder requests to consider gas infrastructure in evaluation of CPP impacts
  - Lends analytics to gas infrastructure piece in the calculation of indicative compliance costs
- Enhances understanding of gas-electric interdependencies in the context of the CPP, as well as overall industry trends

High-Level Representation of PLEXOS Gas-Electric Modeling



The tie between the gas and electric systems in PLEXOS is gas-fired electric generation.

MISO continues to engage stakeholders throughout the CPP study process

March 2015

- Finalize scope
- Provide assumptions document
- Complete electric system models for PLEXOS and powerflow

April 2015

- Conduct analyses on electric system limitations and operational impacts
- Provide overview of gas modeling

May/June 2015

- Provide initial results on electric system limitations at **PAC**
- *Conduct analyses and provide initial results on gas system limitations* at **ENGCTF** and June workshop*
- Stakeholders provide solution ideas for electric transmission expansion

July 2015

- Test electric transmission expansion solutions
- Stakeholders provide solution ideas for gas transmission expansion

August 2015

- Provide results on electric and gas transmission expansion solutions testing
- Final report issued

Primary stakeholder involvement through Planning Advisory Committee and Electric and Natural Gas Coordination Task Force

* Model under development. Milestones subject to availability of underlying dataset.