The Growing Connectedness of the Electric and Natural Gas Systems

MIPSYCON | November 8, 2017 | St. Paul, MN

Mike Nygaard
Senior Engineer, Policy Studies, MISO
Geographically, MISO is the largest Independent System Operator in North America

- Transmission: ~66,000 miles
- Peak load: ~127,000 MW
- Generation capacity: ~175,000 MW
- Gross Market Charges: ~$25 billion (2016)
- 437 Market Participants serving 42 million people\(^1\)

---
\(^1\) Source: MISO Corporate Fact Sheet
The current resource mix in MISO is largely coal and gas, supplemented by nuclear and renewables.

“Other” category includes hydro, pumped hydro, oil, solar, and others.
Gas demand has grown and MISO’s evolving fleet will propel gas demand even higher

Gas Share (%) of MISO Electric Generation (MWh)

- MISO North / Central
- MISO Total (including MISO South)

<table>
<thead>
<tr>
<th>Year</th>
<th>MISO North / Central</th>
<th>MISO Total (including MISO South)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>2012</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>2013</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>2014</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>2015</td>
<td>12%</td>
<td>12%</td>
</tr>
<tr>
<td>2016</td>
<td>16%</td>
<td>16%</td>
</tr>
<tr>
<td></td>
<td>24%</td>
<td>24%</td>
</tr>
<tr>
<td></td>
<td>27%</td>
<td>27%</td>
</tr>
<tr>
<td>2030</td>
<td>42%</td>
<td>42%</td>
</tr>
</tbody>
</table>

Range of scenario outcomes:
- Gas prices
- Growth in renewables
- Impacts of coal retirements

High certainty gas burn (across a range of scenarios)

Installed gas capacity is projected to increase 8,000 MW in the queue through 2020

(Signed interconnection agreements 3,700 MW; final definitive studies 4,300 MW)

MISO MTEP17 sensitivities with range of gas prices (mid-case +/- 30%)
MISO Interconnection Queue as of October, 2017

Installed gas capacity is projected to increase 8,000 MW in the queue through 2020

(Signed interconnection agreements 3,700 MW; final definitive studies 4,300 MW)

Henry Hub $/MMBtu

<table>
<thead>
<tr>
<th>Year</th>
<th>Henry Hub $/MMBtu</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>$4.00</td>
</tr>
<tr>
<td>2012</td>
<td>$2.76</td>
</tr>
<tr>
<td>2013</td>
<td>$3.73</td>
</tr>
<tr>
<td>2014</td>
<td>$4.37</td>
</tr>
<tr>
<td>2015</td>
<td>$2.63</td>
</tr>
<tr>
<td>2016</td>
<td>$2.51</td>
</tr>
<tr>
<td>2030</td>
<td>$2.51</td>
</tr>
</tbody>
</table>
Significant changes in the gas industry are driving impacts in MISO

- Increased flows from Marcellus/Utica on new-build pipelines and pipeline reversals are improving supply diversity
- U.S. gas production gains continue to be favorable, causing lower (and flatter) prices
- Perceived long-term abundance is driving LNG exports from facilities like Sabine Pass in MISO South

Historic Flow Patterns and LNG Imports

Developing “Grid” Flow Patterns & LNG Exports
Gas/Electric reliability comes in many flavors, and requires coordination with a variety of stakeholders.

- Gas Pipeline Services and Products
- Emergency Procedures and Communications
- Operational Awareness and Coordination
- Transmission Reliability and Infrastructure Planning
Gas-fired capacity is important during ramping periods, especially as renewable generation drives ramp requirements even higher.
The Polar Vortex event on January 6-7, 2014 stressed MISO’s system with record peak demands and high forced outage rates.

- **Peak Load**: ~109,000 MW
- **Forced Outages**: ~18,000 MW
  - 75% Mech. Failure
  - 25% Gas-Related
- **Load Shed**: 0 Watts

4 – All data is for January 6, 2014
MISO’s Winter Fuel Survey provides a regional view on winterization and fuel supply practices

- 2016 survey included responses from ~87% of MISO’s gas-fired generators (representing 63,500 MW of capacity)
- Responses further the optimization of operational tools: pipeline notification website, fuel impact report, and electric/gas pipeline control room display
- Key Results
  - Survey participants reported an increased utilization of flexible gas services, such as no-notice (42%) and non-ratable subscriptions (66%)
  - 83% of Combined Cycle units in MISO North/Central and 100% in MISO South utilize Firm Transportation or a blend of Firm/Interruptible, but only 23% of MISO capacity has dual fuel capability
  - 70% of MISO North/Central generation is connected to one of 5 pipelines, either directly or via LDC/Gas Utility
It is critical for MISO’s operators to know what is happening on the gas system

Communication Coordination
- Operational contact list established with all pipelines in the MISO footprint
- Monthly—and as-needed—operational calls with major pipelines
- 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 tracking – CROW monitoring
Reliability of the integrated gas-electric system is a hot topic, with interest from a wide array of groups

- 2015 EIPC study\(^5\) investigated gas-electric contingency events
- NERC transmission planning standards (TPL-001-4) came into effect 2015/2016
  - Extreme Events analysis includes “Loss of two generating stations resulting from…loss of a large gas pipeline into a region”
- NERC Single Point of Disruption (SPOD) special assessment
  - Aims to identify potential risks to BPS as a result of disruptions on major natural gas infrastructure facilities
- Federal Task Force – *Ensuring Safe and Reliable Underground Natural Gas Storage*
  - Established in the wake of Aliso Canyon incident, identifies large gas storage facilities where an outage could affect on gas-fired generation reliability

\(^5\) http://www.eipconline.com/gas-electric-documents.html
New modeling tools allow for a view into the interactions between the gas and electric systems

GPCM

About:
- Standalone natural gas model, built on MS Access database foundation
- Used for long-term look into pricing and pipeline flow trends

Pros:
- Well-regarded in gas industry
- Benchmarked against historical data
- Forecast dataset (included) is accurate and easily modified

Cons:
- Monthly data granularity
- No integrated electric model

PLEXOS

About:
- Co-optimized Gas/Electric production cost modeling platform
- Electric model has been used for many MISO studies, including CPP analysis

Pros:
- Capable of very granular detail
- Integrated gas/electric co-optimization
- Familiar tool for MISO

Cons:
- Minimal support for gas model
- No gas model dataset included
These models can tell stories about macro- and micro-effects of increased reliance on gas-fired generation.

- GPCM results highlight **financial** impacts of increase in gas usage.
- PLEXOS results highlight **operational and reliability** impacts of increase in gas usage.

*Charts are for illustrative purposes only.*
Reliance on gas-fired generation continues to grow in MISO and across the country

- Natural gas generation has risen from 18% of MISO's energy in 2014 to 27% in 2016
- Nearly 8,000 MW of gas-fired generation projects in advanced stages of MISO's GI queue
- MTEP17 Futures forecasted between 20-28 GW of additional gas-fired generation by 2031 in MISO

Market Point Price Basis: 2011 vs 2016

- Emerson 2011: $0.08, 2016: $-0.22
- Leidy 2011: $0.39, 2016: $-0.65
- MichCon 2011: $0.32, 2016: $0.08
- Ventura 2011: $0.07, 2016: $-0.11
- Carthage 2011: $-0.18, 2016: $-0.10
- Chicago 2011: $0.18, 2016: $0.00
- TX E, ETX 2011: $-0.24, 2016: $-0.13
- Transco Z5 2011: $0.71, 2016: $0.23
- Henry Hub 2011: $0.49, 2016: $0.47
Traditional representation of the natural gas transportation system in electric analyses is simplified

- A base Henry Hub gas price is developed, with basic high/low sensitivities assigned
- Fixed cost to transport gas from Henry Hub to one of a few dozen Market Points (Ventura, Carthage, Chicago, etc.)
  - Bases vary by month and year, **but not by Future scenario**
  - Based largely on historic flow patterns and pricing
- Fixed cost to transport gas from Market Points to state-wide Natural Gas Pools (NG Indiana, NG Louisiana, NG Minnesota, etc.)
  - Intended to represent cost to get gas to a unit’s “burner tip”
  - All generators in the state-wide pool see the same gas price
This effort involves development of more granular gas prices in the MTEP study process.

Price adders change over time

Price adders change over time AND by scenario
MISO’s new process models the impacts of our study assumptions on the gas pipeline system

**Previous process**

- Henry Hub price
- Resource Forecasting Model
- Production Cost Model

**Enhanced process**

- Gas supply assumptions
- RCIT* gas demand assumptions
- DRAFT unit-specific gas prices
- Gas Model
- Production Cost Model
- Resource Forecasting Model
- Gas demand from expansion units
- FINAL unit-specific gas prices

**Table: Old Process vs. New Process**

<table>
<thead>
<tr>
<th>Generator Pricing Points</th>
<th>Old Process</th>
<th>New Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>33 (statewide pools)</td>
<td>(One for each gas-fired plant in the model footprint)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gas System Variables</th>
<th>Old Process</th>
<th>New Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Henry Hub price</td>
<td>Henry Hub price, gas supply &amp; demand, pipeline congestion charges, fuel contract types</td>
<td></td>
</tr>
</tbody>
</table>

*RCIT: Residential, Commercial, Industrial, & Transportation (all demand except Electric Generation)
As gas-fired generation continues to grow in MISO, we’re considering the following with our stakeholders:

• Understanding changes in gas flows patterns and infrastructure utilization

• Future infrastructure requirements

• Implications of gas generation in winter

• Gas supply flexibility
  – Hourly variations (including gas takes during short or specific portions of the day)
  – Load following and ability to ramp up/down for varying load or renewable energy changes
  – Short-notice ability to make changes

• Impacts of gas pipeline contingency events

• Capabilities/limitations of pipeline/LDC services and terms

• Regulators’ role as we move forward
Questions?

Mike Nygaard
Senior Policy Studies Engineer, MISO
mnygaard@misoenergy.org
(651) 632-8487
Appendix
Midcontinent Independent System Operator (MISO) Facts & Functions

- **MISO:**
  - Is an independent, not-for-profit entity
  - Does not own any electric transmission or generation assets
  - Manages one of the world’s largest energy and operating reserves markets using security-constrained economic dispatch of generation
  - Ensures reliable operation of the bulk electric transmission system
  - Coordinates long-term regional planning of the transmission system

- **MISO’s mission:**
  - Work collaboratively and transparently with our stakeholders to enable reliable delivery of low-cost energy through efficient, innovative operations and planning
The Gas Pipeline Notifications Page on MISO’s website compiles notices from our region’s pipeline EBBs.
Pipeline maps in our control rooms give operators a sightline into the gas system

MISO Control Rooms / Real Time Display
Internal Tool for Real Time Operations