AEO 2018 Review & AEO 2019 Plans

For
Natural Gas Working Group
May 23, 2018 | Washington, D.C.

By
Katie Dyl, Natural Gas Markets Team

WORKING GROUP PRESENTATION FOR DISCUSSION PURPOSES
DO NOT QUOTE OR CITE AS RESULTS ARE SUBJECT TO CHANGE
Outline

• Brief overview of new Natural Gas Markets Module (NGMM)

• Evaluation and discussion of results from AEO 2018

• Current plans and expectations for AEO 2019+
  – AEO 2019: short-term NGMM improvements to fix issues identified from AEO 2018
  – Post-AEO 2019: long-term NGMM improvements that require more time and resources to implement
  – STEO: changes in the Short Term Energy Outlook that will impact NGMM near-term projections in AEO 2019
Transition to new Natural Gas Markets Module (NGMM)

- The NGMM will replace the Natural Gas Transmission and Distribution Module (NGTDM) in NEMS to serve the same following functions:
  - **Represent** the transmission, distribution, and pricing of natural gas in North America, with representations of Canada, Mexico, and LNG trade.
  - Given annual regional/sectoral natural gas consumption and short-term regional supply curves, **balance** supply and demand across the network on marginal cost basis
  - **Determine** annual interregional flows, production, imports, exports, and associated wellhead and delivered natural gas prices
  - **Include** seasonal storage, transmission and distribution pricing, pipeline capacity and expansion, as necessary to capture the impact on the primary outputs
  - **Produce** projections that both align well with history and capture likely future market behavior

- NGMM was designed to solve for flow reversals, is significantly more granular to improve results (particularly marginal pricing), and balances supply/demand with a quadratic program, rather than the heuristic used in the NGTDM
Decision to redesign NGTDM

- Being too constrained to previous year, limits ability to respond to larger annual changes in the market

- Limitations in modeling flows, capacities, and pricing at such an aggregate level – some calibration factors too large

- Heuristic algorithm limited in ability to represent bidirectional flows and changing primary flows

- Model has become difficult to modify and update after many incremental code and data changes, complicating the need for it to be managed by new people
NGMM model requirements

• Project delivered, wellhead, import, and export prices given delivered volumes and regional short-term supply curves

• Balance market and establish production, imports, and exports, as well as lease, plant, and pipeline fuel, and supplemental supplies

• Project region-to-region flows and pipeline capacity

• Produce reasonable projections, align well with history, but capture likely future market behavior (such as under different scenarios)

• Be easier to maintain, update, debug, and learn
NGMM Network and Structure

- Transshipment nodes (hubs) at each Lower 48 state, in Canada (2), in Mexico (5), and at each border crossing, including generic LNG points at coastal states.

- Solves for monthly/state spot prices at each hub and associated flows between neighboring regions based on variable transport costs and capacity.

- Twelve months (solved independently with no interrelationships).
Quadratic program (QP) (with linear constraints)

- Max consumer plus producer surplus minus variable transportation costs, subject to mass balance constraints
- Variable transportation costs include pipeline fuel charge and variable tariff
- Variable supply, flows, and marginal prices (fixed charges post-processing)

Decision variables:
- Supply
- LNG exports
- Flow between nodes (supply, hub, demand, LNG exports, storage)
- Tariff curve quantity (variable transportation costs)

Primary Constraints:
- Mass balance for all node types
- Flows between nodes limited to previously projected pipeline capacity
Variable tariff curves

- Based on historical spot price differentials between states/regions
- Components of basis differentials
  - Pipeline fuel charge
  - Variable Tariff
- Assumptions
  - Differences in spot prices are pipeline fuel and variable charges
  - Difference between spot and city gate prices are the fixed charges
- Variable tariff set in a QP using a curve for each arc, function of utilization
- Extended beyond existing capacity when projecting capacity expansion, reflecting the consideration of reservation fees
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U.S. natural gas production and consumption continue to increase in most cases

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018
Natural gas prices remain relatively low compared to historic values.

Natural gas spot price at Henry Hub
2017 dollars per million British thermal units

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018
Regional Supply Prices

Natural gas supply price
2017 dollars per thousand cubic feet

![Graph showing natural gas supply price from 2010 to 2050, with projected growth from 2017 (36¢) to 2050 (57¢).]

- Basis between East (Marcellus) and Gulf Coast (Henry Hub) supply prices grow from 36¢ in 2017 to 57¢ in 2050
  - Consistent with tariff charges on pipelines
  - Historical 2017 differential larger than projection
- Why does this narrow in the near-term through 2020?
  - Historical calibration
  - STEO benchmarking

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018
General expectation is that regional flows will be out of the Northeast, into the East North Central (Midwest) and Southeast, and down to the Gulf Coast.
Regional flows into and out of Midwest illustrate NGMM likely underestimating flows from Appalachia to Gulf Coast in near- to mid-term

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018
The United States is a net natural gas exporter in the Reference case because of near-term export growth and continued import decline.

Natural gas trade
trillion cubic feet per year

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018

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Canada results in detail:
U.S. imports from Canada continue to decline while U.S. exports to Canada rise due to increased pipeline capacity from the Northeast into eastern Canadian and Midwestern markets

U.S. natural gas trade with Canada
trillion cubic feet per year

Flows out of Western Canada
billion cubic feet per day

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018
**Mexico results in detail:**

U.S. exports to Mexico continue current growth trajectory in short- to mid-term, leveling off as reforms to Mexico’s energy market take hold.

**U.S. exports to Mexico** (trillion cubic feet per year) and **Mexico dry natural gas production** (billion cubic feet per day) are depicted in the graphs.

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**Source:** U.S. Energy Information Administration, Annual Energy Outlook 2018

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The United States becomes a net exporter of natural gas before 2020, although the level of LNG exports is uncertain, resulting in a wide range of expected U.S. LNG export levels.

Liquefied natural gas exports
trillion cubic feet per year  billion cubic feet per day

Oil-to-natural gas price ratio
energy-equivalent terms

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018
Delivered prices to consumers: Markups off of both city gate and spot prices as well as estimations using updated historical data series

Delivered natural gas prices by sector
2017 dollars per thousand cubic feet

- **Residential**: Number of households, city gate price
- **Commercial**: Floor space, city gate price
- **Industrial**: Industrial-weighted spot price
- **Electric power**: Electric-weighted spot price
- **Transportation**: EERE historical data and city gate price for personal and fleet vehicles, industrial price for rail and marine

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018
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AEO 2019: Miscellaneous planned improvements

• Re-evaluate and modify select variable tariff curves
  – Improve regional flows
  – Ensure tariffs produce reasonable flow patterns throughout projection
  – “Placeholder” for more thorough and permanent fix long term

• Assess interaction with Electricity Market Module (EMM) to improve convergence
  – Understand what is driving oscillations in some regions (e.g. disparate regionality between the two models, competition with renewables)
  – Analyze seasonal patterns and interactions between NGMM/EMM
  – Assess natural gas price sensitivity of EMM
AEO 2019: Supply curve optionality

- Currently there is only one form, or set of parameters, to define the short term supply curve for all OGSM districts (84)

- Code already includes optionality for up to 3 different forms of the supply curve, as well as fixed supply

- Testing in conjunction with OGSM to allow for different supply elasticities for different types of regions
  - Improve more granular results
  - Allows different types of nonassociated supply (i.e. offshore, Marcellus, western Canada) to respond to price differently
Post-AEO 2019: Historical Calibration

- Adapt code to run in historical years
  - NGMM validation/backcasting
  - Calibrate spot prices, flows, and tariff curves for use in projection

- Roadblocks to completion in AEO 2018/9
  - Data quality
    - Pipeline capacities by month historically
    - Pipeline fuel use data by state highly variable; subject to respondent error
  - Resources and time required
  - Gross vs. net flows
  - Granularity of model not at market level
    - Texas acts as 3+ regions
    - Rockies/Mountain region too granular
STEO: Henry Hub prices are forecast to average $3.01/MMBtu in 2018 and $3.11/MMBtu in 2019

Henry Hub natural gas price
dollars per million British thermal units

Source: EIA Short-Term Energy Outlook, May 2018, and Thomson Reuters.
STEO: EIA forecasts marketed natural gas production to grow by a record 7.4 Bcf/d on average in 2018

U.S. marketed natural gas production
billion cubic feet per day

Components of annual change
billion cubic feet per day

Source: EIA Short-Term Energy Outlook, May 2018.
For more information
Annual Energy Outlook | www.eia.gov/aeo
Short-Term Energy Outlook | www.eia.gov/steo
International Energy Outlook | www.eia.gov/ieo
Monthly Energy Review | www.eia.gov/mer
Today in Energy | www.eia.gov/todayinenergy
State Energy Profiles | www.eia.gov/state
Drilling Productivity Report | www.eia.gov/petroleum/drilling/
International Energy Portal | www.eia.gov/beta/international/?src=home-b1
Supplemental Slides
Regional flows into and out of TX, OK, AR, LA illustrate that NGMM is underestimating east-to-west flows in the United States

**Flows out of West South Central into**

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<th>Rockies</th>
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Source: U.S. Energy Information Administration, Annual Energy Outlook 2018
While global conditions lead oil price projections, resource size and technology assumptions drive U.S. natural gas prices.

**North Sea Brent oil price**
- 2017 dollars per barrel

**Henry Hub natural gas price**
- 2017 dollars per million Btu

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018