Natural Gas Transmission and Distribution Module Requirements

Discussion about key natural gas market factors to include in redesigned model

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Overview

- The NGTDM Redesign Project
- History of natural gas market models at EIA
- Basic Requirements and needs specific to EIA
- Specific elements for discussion
  - Regional/seasonal detail
  - Pipeline tariffs and expansion costs
  - Flows and capacity expansion (foresight)
  - Imports/exports
  - Delivered prices

The NGTDM Redesign Project

- Requirements (draft paper, discussion, final paper)
- Review other models (draft paper, Network Workshop, final paper)
- Develop simple models to evaluate different model algorithms in isolated environment.
- Review existing data and potential expanded data (availability, cost, processing, and issues)
- Model component design report
  - Select basic algorithm
  - Design supporting pieces (potentially revise basic algorithm)

Natural gas market models at EIA

- Gas Analysis Modeling System (GAMS)
  - 300 nodes, extensive pipeline network, contracts (existing and new)
  - designed to address wellhead decontrol and market restructuring
  - become onerous to maintain and obsolete
- NGTDM (version 1)
  - greatly simplified network, capacity planning in separate look-ahead model
  - maximize consumer & producer surplus minus transport cost
  - did not align with history, response—added constraints, results—infeasibilities
- NGTDM (version 2)
  - same network, heuristic model to allow price averaging and initial tie to history
  - difficulty with reverse flows and large annual changes (e.g., Alaska pipeline)

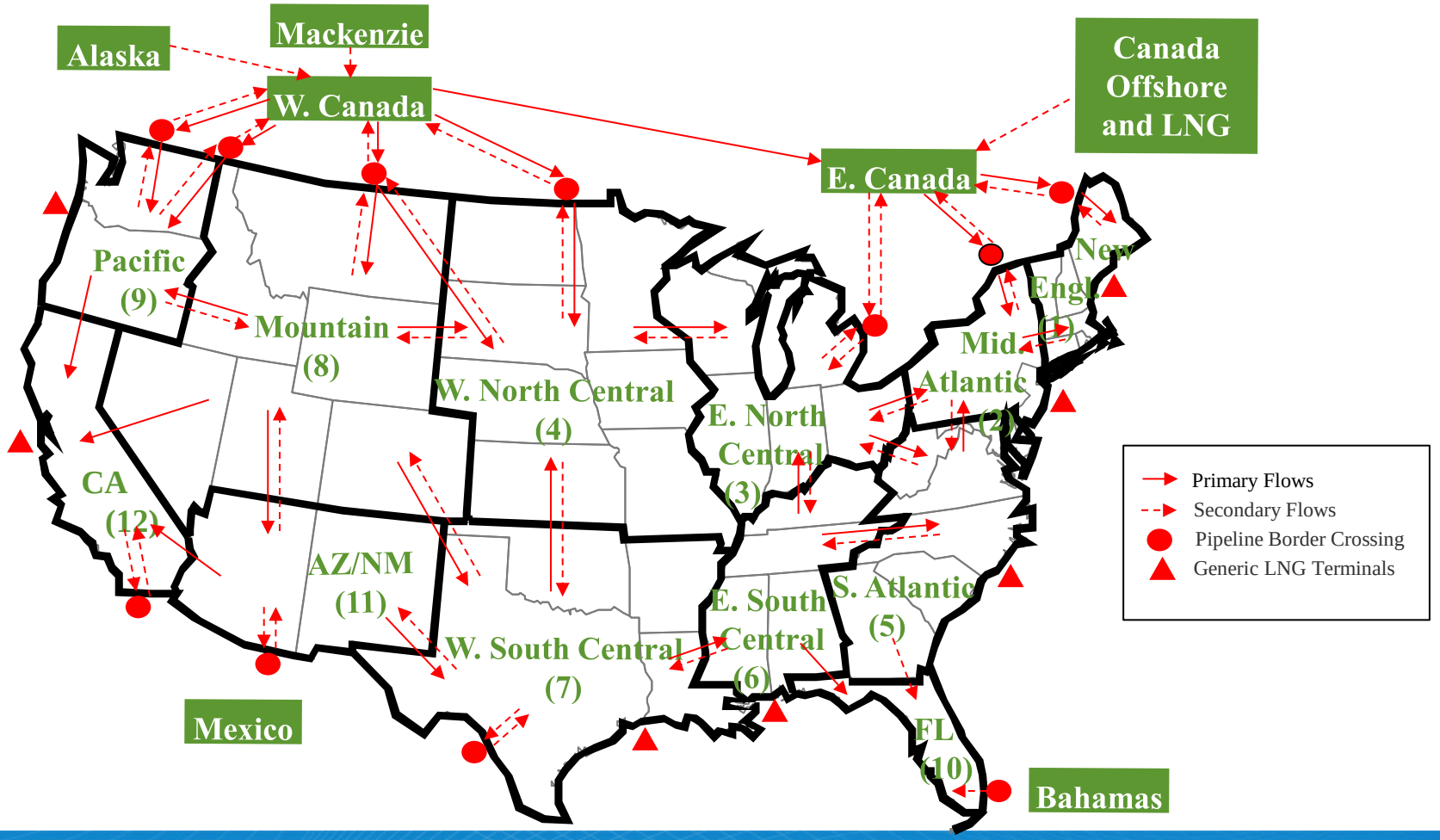
NGTDM primary inputs

- Residential, commercial, industrial, and vehicle natural gas annual consumption by Census division (industrial by energy intensive and non-energy intensive)
- Natural gas consumed by power generators by 17 regions in peak and off-peak periods
- Nonassociated dry natural gas supply curves by region (currently 20, easily more)
- Associated-dissolved dry natural gas production volumes by region
- Representative world oil price
- Miscellaneous macroeconomic indicators

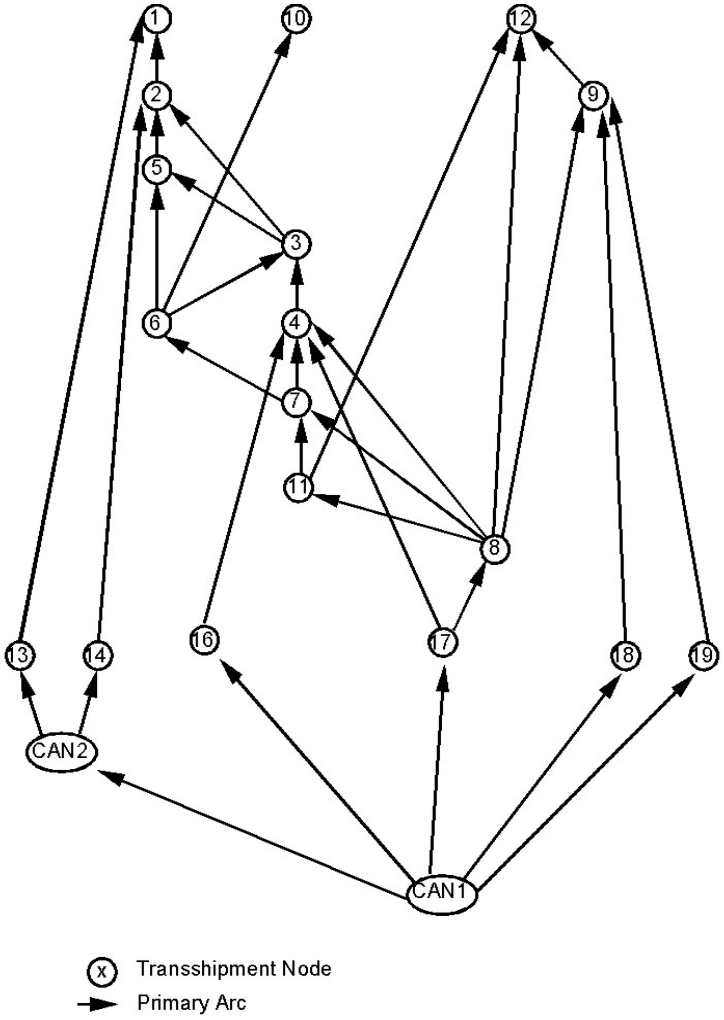
NGTDM primary outputs

- Delivered prices for each of the demand categories and breakouts described above
- Natural gas consumed at lease operations and at natural gas processing plants and as pipeline fuel
- Natural gas consumed at export liquefaction facilities and in association with the production of LNG for use in the transportation sector
- Nonassociated dry gas production and associated prices received by producers, which balance the market, by established supply region
- Natural gas pipeline and LNG import and export volumes and prices by border crossing
- Regional city gate prices and regional spot prices (not currently reported)
- Coal converted to synthetic natural gas by Census division
- Oil converted to natural gas by Census division
- Other supplemental supplies by Census division
- Interregional flows
- Interregional pipeline and storage capacities/builds

NGTDM network map



NGTDM hierarchical, acyclic network



NGTDM solution process

- Flow consumption levels (minus fixed supply) down tree
- Set incoming flow to satisfy consumption using sharing algorithm

$$SHR_{arc,t} = \frac{ARC\_SHRPR_{arc}^{-\gamma}}{\sum_{i=1}^{N} ARC\_SHRPR_i^{-\gamma}/N} * SHR_{arc,t-1}$$

- Given volume demanded, use supply curve to set wellhead price
- Flow prices up the tree, adding variable tariffs (with “hurdle” rate at or above existing capacity) and setting node prices at average over all incoming arcs.
- Tack on reservation fees to estimate city gate prices, benchmark these to historical levels, and add distributor tariffs for delivered prices. Price to electric generator based on just variable rates.

Primary requirements and limitations

- Primary Requirements
  - Given annual/regional consumption levels and supply response to price, determine production levels and supply and delivered prices that balance supply/demand.
  - Establish import/export levels (and associated prices) to Canada, Mexico, and as LNG
  - Endogenously set pipeline and storage capacity (of less importance)
  - Create a model with enough capability/flexibility to handle potential future market shifts and analyses that EIA might be called to perform.

- Limitations
  - Must operate in NEMS environment, interface with new Global model (implications for foresight, supply representation, execution time, software)
  - Estimated resources for maintaining ~ one person, half-time
  - Available to others to run and documentable by EIA

General issues related to competition

- The North American gas market is largely competitive, with the possible exception of Mexico
- Assuming a sufficiently detailed network, final solution should reflect no arbitrage opportunities. Agree?
- To what degree do contracts influence market behavior and impact prices? If they do, is it worth the effort to compile and include?
- Flow decisions are based on variable costs. Also true during peak periods when capacity is tight?
- What role does foresight play in decision process?

Demand/Supply Representation

- Demand
  - Potentially estimate state level consumption as a function of population and price, then scale to match NEMS values.
  - Seasonal consumption based on historical shares, potentially adjusted based on such things as share for space heating.
  - Probably use demand curves using assumed elasticities to speed convergence
- Supply
  - Probably not able to change information provided by upstream model, which is an annual supply curve by region, other than increasing number of regions
- Overlap
  - Presumably supply and demand regions need to align.

Regional detail

- What level of geographic detail is necessary to fulfill model's basic requirements, considering resource limitations.
- Issues related to using an aggregate network (i.e., what is missed)?
- Any issues related to generating an aggregate number from detail?
- Issues related to bidirectional flows? Solve for net flows?
- Importance of detail with pipeline and storage capacity builds?
- How important is getting capacity "right" to getting prices "right"?

Temporal detail

- What level of temporal detail is necessary to fulfill model's basic requirements, considering resource limitations.
- Does modeling at a monthly level provide significant improvements over seasonal. What is lossed/gained?
- What drives relationship between time periods? Solved simultaneously?
- Importance of detail with pipeline and storage capacity builds?

Capacity expansion and foresight

- What elements in the model could require foresight?
- Importance of foresight in capacity expansion decision? Can it result in over optimizing a system?
- How much is lost just using hurdle rate approach?
- Factoring in impact of peak day/month and role of planning for abnormal weather.
- Information on cost of expansions
- Interest in capacity expansion projection and ability to accurately project expenditures

Pipeline and storage tariffs

- Do variable rates largely reflect pipeline fuel usage?
- Can one glean information on variable tariffs from basis differentials, and their relation to pipeline congestion, or should one look at posted rates?
- What drives rate changes over time, particularly fixed charges, (e.g., depreciation of pipeline, increased costs) and importance of representing?
- Should the model continue to estimate revenue requirements and set reservation fees based on a regulate rate calculation? If so, how to verify reasonableness of results?

Delivered Prices

- Should the model attempt to represent gas flows and prices separately for firm versus interruptible customers?
- Or, set interruptible rates based on variable tariffs and associated spot prices and tack on reservation fees after the fact to arrive at city gas prices for firm customers?
- How might rates to electric generators reflect the potential need for them to purchase firm service?
- What is important to capture (or is an important driver) in setting distribution charges?

Canada/Mexico

- Can Canada/Mexico be considered just another region or are there special considerations to be included, particularly due to data?
- Should Mexico be considered a competitive market? Any special handling issues that distinguish Mexico markets from the U.S.?
- What regional representation makes sense?
- Factors that are different in modeling LNG imports/exports?

Other issues?

- Benchmarking
- LNG imports/exports
- Interface with Global Hydrocarbon Supply Model