Natural Gas Transmission and Distribution Module Component Design Report

Discussion of model design

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Requirements

- *Primarily: Project delivered, wellhead, import, and export prices given delivered volumes and a set of regional supply curves. Balance market and establish production, imports, and exports, as well as lease, plant, and pipeline fuel, and supplemental supplies.*

- *Secondarily: Project region-to-region flows and pipeline capacity.*

- *Must align well with history, but capture likely future market behavior*

- *Must be relatively easy to maintain, update, and modify*

Other models

- *LP vs NLP (quadratic in Obj) vs MCP vs Agent-based*
- *Different levels of granularity regionally and temporally*
- *International and domestic*

Concluded:

- **For competitive market, no practical difference in algorithms, so pick one easiest to mange**
- *Speed of quadratic comparable to LP*
- *Greater granularity preferable, but balance w/overhead*

General approach

- *Nonlinear optimizer (NLP), quadratic objective function*
  - *Max consumer plus producer surplus minus variable transportation costs, s.t. mass balance constraints*
  - *Output volumes and flows and marginal prices (fixed charges not reflected)*
- *Pricing Submodule*
  - *NLP flows used to create hierarchical network*
  - *Trace prices through network adding reservation fees*
  - *Determine regional delivered prices*

Regional and sectoral detail

- *Hub in each state, state-to-neighboring state transport*
  - *Some production represented at substate*
- *Limited international nodes*
- *Probably run monthly, with capacity limits set before the model is solved each year.*
- *Additional runs for peak periods to determine pipeline capacity expansion given extreme weather demands*
- *Each month balanced separately, no connection between months.*

Pipeline tariffs

- *Based on difference between region/state spot prices and difference in citygate prices*
- *Components of basis differentials*
  - *Pipeline fuel charge*
  - *Variable Tariff*
  - *Fixed charges*
- *Assumptions*
  - *Differences in spot charges are pipeline fuel and variable charges*
  - *Difference between spot and citygate prices are the fixed charges*
- *Variable tariff set in the NLP using a curve for each arc, function of utilization*
- *Curve held constant throughout forecast, unless assumed otherwise*
- *Tariff curves based on flow one direction will be assumed to be the same for flow in opposite direction*
- *Assumptions about reservation fees with and without pipeline expansion*

Pipeline expansion

- *Initial years set to capacity under construction and highly likely to be constructed*

- *Later years determined by running NLP for colder than normal day and a hotter than normal day*

- *No MIP, continuous builds as opposed to projects*

- *Build as you go. If capacity is added, it is included in model run for that year and fixed charges are increased*

- *Use reservation fee when calculating? (from previous iteration)*

- *Setting of hurdle rates*

Pipeline Expansion – Cont.

- *Ability to incorporate all components (e.g., pipe sizes, storage trade-off, costs) is limited, so looking for half-way measure to capture look ahead.*

- *Influence of expected consumption and expected supply (half way measure)*

Storage

- *Key assumptions*
  - *Weather is normal*
  - *Annual net storage withdrawals are zero except for STEO years*
  - *Storage decisions are not purely economic*
  - *Not trying to model storage decisions – just account for storage use and cost*
- *Storage will be set outside of NLP and included as fixed, based on monthly supply/demand load*
- *Net storage for each month based on previous year or iteration*
  - *Deviation of the monthly consumption minus monthly supply from the corresponding average monthly level for the year*
  - *Allocate across regions/states (based on data analysis)*
  - *Accounting for storage costs in delivered prices?*

Electric/Gas interaction

- *Level of disaggregation*

- *As interruptible customer, potential as firm customer (separate out like before)*

- *Natural gas is priced on a daily basis. However, could EMM benefit from seeing monthly numbers rather than just seasonal?*

- *Feasible to interface with EMM at close to state level? Adding convergence issues? Price data by state limited due to NA.*

- *Sandy – need clarification*
  - *" I will again urge that demand profiles by sector would make it possible to provide price profiles and allow the system requirements to change over time in response to changing sector demand growth."*

Imports and exports

- *Ultimate goal is to represent Canada and Mexico with same level of detail as U.S. as data and resources permit and to make consistent with Global Hydrocarbon Supply Model (GHSM)*

- *LNG trade representation will also change with GHSM, probably involve adding limited international nodes.*

- *Initially use representation in current NGTDM for all imports/exports*

- *At the minimum expect "demand curves" for LNG exports.*

- *LNG imports set at a minimum level into New England in most cases*

Demand – lease, plant, pipeline fuel

- *Assume lease plus plant fuel is a percentage of dry gas production*

- *Significance of movement from oil to CNG/LNG in lease operations*

- *Plant fuel use as a function of NGPL, efficiencies driving things down? Pressures?*

- *Significance of impact of penetration of electric compressor stations on pipeline fuel use? Pricing implications?*

Price responsive supply

- *Primarily nonassociated dry gas production*
- *Curve is based on expected production (p0,q0) from OGSM*
- *Change in production is less responsive at volumes above (p0,qo) and more responsive below (p0,q0)*
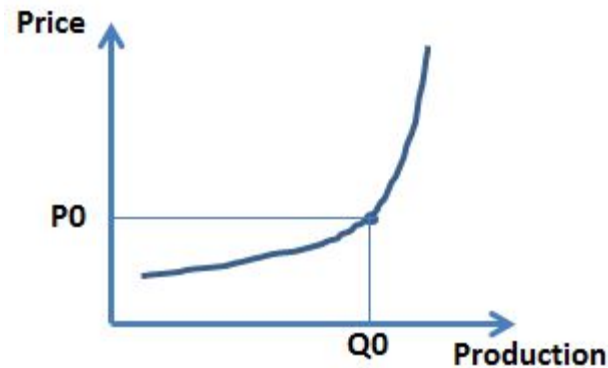
Price drivers

- *Sandy's comment*
  - *"The response of producers to short term fluctuations in demands due to daily and seasonal demand patterns seems should be a large part of explaining the variation in natural gas price as seen in historical data. Ideally I would like this curve(s) to reflect a bid strategy / marginal cost of production at variety of supply levels."*

Pricing submodule

- *Used to add fixed charges to the spot prices to determine citygate price*

- *Use flows from NLP to create hierarchical acyclic network*
  - *Flow gas through the network and add fixed charges*
  - *Flow down the network to determine flow associated with consumers paying fixed charges for weighting reservation fee*
  - *Flow up network adding the fixed charges*

Delivered prices

- *Apply distributor tariffs to wholesale prices*
- *Residential and commercial and some industrial are firm customers with price based off citygate*
- *Other sectors priced based off spot price*
- *Options for setting delivered prices*
  - *Estimate distributor tariffs based on volumes (e.g., consumption per household), add to wholesale prices*
  - *Estimate distributor tariffs based on volumes and wholesale prices (if statistically significant), add to wholesale prices*
  - *Directly set as a function of wholesale prices and other variables*

Primary outputs

- *Average annual delivered prices by sector and Census Division, except electric generators (2-3 seasons, 18 regions)*

- *Prices – to producers, import/export, citygate, and spot*

- *Nonassociated dry gas production by state/substate*

- *Supplemental supplies by Census Division*

- *Imports/exports – pipeline (Canada, Mexico) and LNG*
  - *Production in Canada and Mexico*

- *Interregional flows*

- *Interregional pipeline capacity (and possibly expenditures)*

- ***Question for discussion: Suggested ways of analyzing results given multi-dimensions?***

EXTRA SLIDES

Benchmarking

- *Run model in historical years*
  - *Determine benchmark factors where feasible (e.g., align to historical prices as necessary)*
- *STEO*
  - *NGTDM results must be within 2% of STEO*
  - *Run NGTDM multiple times to achieve STEO convergence*
  - *Phase out benchmark factors over forecast years*

Demand (cont)

- *Alaska/Hawaii -separate submodule, same as current NGTDM*
  - ***Any thoughts on modeling shifts in demand in Alaska if supplies from the North Slope should become available? Can much be done short of an exogenous assumption?***

- *Discrepancy (balancing item)*
  - *Determined in routine which fills in missing historical values*
  - *Held constant throughout forecast*

Demand

- *Disaggregate annual sectoral levels from NEMS into state and season*
  - *Residential, commercial, industrial function of population and HDD*
  - *Electric sector function of population and cooling degree days*
  - *Fixed consumption in NGTDM (option to include curves)*

Fixed supply

- *Associated-dissolved domestic production (from OGSM)*
- *Eastern Canada production*
- *LNG imports (?)*
- *Mexico imports*
- *Alaska production*
- *Supplemental supplies*
- *Model will have allow for an option of using a supply curve instead of fixed supply*

Assumption about pipeline rates

- *Cost of fuel captured through loss on line*
- *Assume rates are same to or fro on bidirectional lines*
- *For variable rate attempt to approximate economic rent when capacity constrained*
- *Change in reservation fee with no cap additions?*
- *Change in reservation fee with cap additions?*
- *Weight reservation fees on res/com/ind/eu firm mix*

Hierarchical network example