us natural gas market evolution

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Energy Policy Seminar
Harvard Kennedy School
April 3, 2017
Views expressed are not necessarily those of the Commission
Early History

Gas and oil seeps have been part of religious and cultural practices for thousands of years.

1300 BC: Was the burning bush in Exodus a gas seep ????

1000 BC: was the flame at the Oracle at Delphi was built on natural gas seep?

500 BC: Chinese use bamboo “pipelines” to transport gas

1792: Great Britain gas was produced from coal

1885: Robert Bunsen’s burner opened new opportunities to use natural gas.
U.S. Natural gas markets changing the law and incentives

Era I 1816: manufactured gas; local then state regulation
Era II NGA 1938: federal regulation begins
Era III Supremes 1954: federal wellhead regulation begins
Era IV NGPA 1978: energy crisis new regulation
Era V Order 436 1986: market-based rates/voluntary open access
Era VI Order 636 1992: mandatory open access/unbundling
Era VII NEPA 2015: climate change
ERA I: Gas Manufactured from Coal for Lighting in U.S.

- 1817: the Gas Light Company of Baltimore
- 1860: 297 manufactured gas companies in the US
- 1870: manufactured gas used in engines
- Consumption grows
- Local then state regulation
- Natural gas vented and flared in producing areas
Natural Gas production

- Gas is cheap and plentiful (may have negative value)
- Associated with crude oil
- Non-associated without crude oil
- Natural gas from a well is produced with liquids
- Processors remove water, NGLs, crude oil and impurities
- Water and impurities are disposed
- Natural gas, NGLs and crude travel on separate pipelines to end users.
Era II: Natural Gas Displaces Manufactured Gas (1920-1938)

- Distribution infrastructure could be used for natural gas.
- Natural gas, electricity, and petroleum products drive manufactured gas out of the market.
- Pipeline joint ventures between producers and distribution companies to displace manufactured gas with natural gas.
Natural Gas markets grow

- Producers exit joint ventures
- Some Local Distribution Companies don’t
- Today The U.S. natural gas pipeline network
  - Thousands of producers
  - more than 210 pipeline systems.
  - More than 300,000 miles of pipelines
Conservation Commissions and the Interstate Oil and Gas Compact Commission

- In each producing state Conservation Commission for unitization of fields and pro-rationing
- three-member elected Railroad Commission of Texas
  - regulates the oil and gas; no longer regulates railroads.
  - 1950s it controlled over 40% of U.S. crude production and about half of estimated reserves
  - prorated well production to preserve producer 'equity'
  - Set oil prices in U.S. Model for OPEC
- The Interstate Oil and Gas Compact Commission ensures that U.S. oil and natural gas resources are conserved and maximized while protecting health, safety and the environment. Blah blah blah !!!!!!
Era III The New Deal Era: Birth Of U.S. Federal Energy Regulation

- Federal energy laws: to fill regulatory gaps
- 1935 Public Utility Holding Company Act
- 1935 Federal Power Act
- 1938: Natural Gas Act: regulation of natural gas in interstate commerce
  - transportation and sales for resale at just and reasonable rates with no undue discrimination
  - Certificates in public convenience and necessity
    - To build with Eminent Domain and
    - to abandon a pipeline
Natural gas wellhead prices in 2015$/mcf

Prices are going up
PHILLIPS PETROLEUM v. WISCONSIN
347 U.S. 672 (1954)

-The Phillips decision

Supreme Court: "the [wellhead] sale in interstate commerce of natural gas for resale" is within the meaning of the Act

wellhead sale in interstate commerce of natural gas for resale must be just and reasonable ...

Producers come to hate it with a passion
President Eisenhower's dilemma (1955)

- Eisenhower endorsed a bill to exempt the first sale of gas from federal regulation
- A Senator reported a large campaign contribution from a stranger with gas company connections
- Senator Prescott Bush (R-CN) was negotiating a “workable compromise”.
- A producer caused Bush’s son to lose considerable business
- Eisenhower wrote, “It is clear that there is a great stench around the passing of the bill....”
- Six days later he vetoed his own bill

- FPC regulates wellhead sales in interstate commerce
- Cost-of-service produces thousands of rate cases
- FPC moves to area rate caps
- Did not think of market-based rates
- Certificate approval for gas contracts
- 20 year contracts to justify new construction
- Bundled service rate design; Cradle to grave regulation
- Politics are producing v. consuming states
- Creates a separate interstate and intrastate markets
- Molecular theory of separation: If an intrastate methane molecular touches an interstate molecule, it and the pipeline become interstate.
Natural gas wellhead prices in 2015$/mcf

Is this depletion? Peak gas?

Oil Embargo 1973
1970s
Original Cost-of-Service Ratemaking Breaks Down

- Increasing gas prices lead to Purchase Gas Adjustment Clause cost trackers and a three year rate review
- Over-regulation (price suppression) leads to shortages and curtailments
- Resource depletion theories lead to bad forecasting
- Miss innovation
- High inflation: 7% per year
- Regulation breaks down
- Intrastate prices > interstate cap
- OCS gas is interstate
Bundled Natural Gas Rate Making

- Bundled transport and commodity sale at the city gate

- One-part tariff: all fixed costs put in commodity rate
  - Similar to State regulation
  - How is pipeline capacity rationed?
  - Full requirements tariffs (anti-competitive)

- Two part tariff: call option/capacity reservation and commodity charge used to manage consumption
  - Straight fixed variable (SFV)
  - Modified fixed variable (MFV); debt/equity
  - United: 75% of fixed costs in commodity
  - Seaboard 50% of fixed costs in commodity

- **Background**
  - 1970s: oil crisis and natural gas curtailments
  - Premise: running out of crude oil and natural gas

- The Powerplant and Industrial Fuel Use Act outlawed
  - New power plants using oil or natural gas
  - Oil and natural gas use in large boilers

- Natural Gas Policy Act (NGPA):
  - Preserve natural gas for high valued use
  - Only Title 3 is active

- Public Utility Regulatory Policies Act (PURPA):
  - Cogeneration and renewables
  - At avoided costs (early feed-in tariff)
Natural Gas Policy Act of 1978 Titles I-IV

- **Title I** system of wellhead price ceilings
  - Supply side Ramsey Pricing
  - Wellhead Decontrol Act (1989)

- **Title II** provided rules for allocating high-cost gas to customers based on alternative fuel (Ramsey pricing).

- **Title III** provided authority
  - In a gas supply emergency to allocate gas to high priority users and
  - Interstate/intrastate market integration.

- **Title IV** specifies curtailment priorities
Minimum Bill Order 380 (1983)

- Producer contracts have take-or-pay bill clauses.
- Pipeline tariffs have minimum bill clauses used to recover take-or-pay clauses in wellhead contracts.
- Order 380 eliminates minimum bill clauses.
- Scalia (DC Circuit) approves.
- Creates an imbalance in purchase and sales contracts.
- Creates choice.
- Large LDCs connected to two or more pipelines.
Natural gas wellhead prices in 2015$/mcf

Oops prices decline
NGPA in 1985

- 1985 'New natural gas' is deregulated at the wellhead
- 'Higher of' priced wellhead take-or-pay contracts
- Contracts called for a fly-up in 1985
  - The market didn't
  - After 1/1/85, prices continued downward
  - Contracts were out-of-market
- 1991 Columbia Gas files for bankruptcy protection
  - citing contracts that commit it to buy gas at prices of up to five times the current market price.
  - tactic to force renegotiation of the contracts?
Order 436 (1985) Voluntary Open Access
Making an aquarium from fish soup

азв training wheels for full commodity competition
азв Spot market development
азв commodity markets and interruptible transportation
азв Regulated commodity tariffs as a recourse
азв Decreasing energy prices lead to take-or-pay problems
азв New resource ‘depletion’ theories
азв technological progress
азв Lower inflation: 5% per year
азв New certificates prioritized (informal)
1987 Fuel Use Act repealed

- falling natural gas prices cause restricted natural gas use to be repealed
- consumption increases

<table>
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<th>Consumption in Tcf</th>
<th>1988</th>
<th>2002</th>
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<td>industrial consumption</td>
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</table>
Paradigm Change

Transitioning from planning and cost-based regulation to markets and market-based regulation
just prices not profits

Rethinking regulation

The law: just prices; no undue discrimination

- Scholastic philosophers cost-based vs market-based
- Congress: NGA/FPA
- Supremes in Hope: it is the end result that counts

Under cost-of-service low profits don’t imply low prices

- Efficient markets can increase profits and lower prices
- Inefficient markets can decrease profits and raise prices
- Monopoly rents increase profits and raise prices

Goal: fair and efficient prices/quality service
cost-of-service/return on equity regulation

- Problems of command and control
  - return on equity creates false perception of precision
  - requires a forecast. Continue to pretend we can.
  - information is asymmetric
  - prudence is a blunt instrument
  - Use trial like procedures to resolve disputes

- Understand and use incentives
  - carrots and sticks
  - keep the good parts (information for benchmarking)
  - introduce contracts and honest risk consideration
  - Deregulate secondary markets in pipeline capacity
  - Use trial like procedures as a last resort
BENCHMARKED incentives get good results: win-win

↑ good information is essential
  ↑ measure performance over time
  ↑ measure performance over companies
↑ risk/reward symmetry; S&P 500 benchmarks
↓ bad incentives: uplift, penalty revenues
  → overbuilding, withholding, waste
↑ INCENTIVES compatible with desired behavior
  → lower just prices
  → higher quality service
  → higher profits—the old fashion way: earn them
Order 636 (1993) mandatory open access

- Strong affiliate rules (not perfect)
- Full unbundling of sales and transportation
- Straight fixed variable (SFV) rate design
- Fully comparable secondary trading
- Required “Electronic Bulletin Boards” for transparency
- Encourages Market Centers
- PGA eliminated
- No three year rate reviews

Incentive And Choice-based Ratemaking

- Negotiated rates with Recourse rates
- Win-win should include smart electronic trading
- Market-based Rates
  - Storage: lack of market power
  - Production area transportation
  - Secondary capacity market called Capacity Release
- Performance-based regulation
  - RPI-X: problems in Britain; windfall profits!
  - Current: RPI-RPI until the firm chooses
Market Centers Enhance Efficiency And Reliability

- Increasing access to sources of gas
  - A pipeline often has highly correlated demand
  - Makes short-term deals and long-term deals easier
  - Creates deeper more liquid markets
- Lowering transactions costs
  - Reduced search costs and faster market response
  - Real price information
  - Simplifying multiple pipeline exchanges
- Lowering reaction time in emergencies
- Using multiple system responses
  - Greater aggregation through market centers
  - One storage facility can serve many pipelines
The Henry Hub

SOURCE: Sabine Pipeline Rev. 4/01

* - Intrastate pipeline
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<tr>
<th>region</th>
<th>high</th>
<th>low</th>
<th>average</th>
<th>change</th>
<th>volume</th>
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<td>$2.68</td>
<td>$2.54</td>
<td>$2.63</td>
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<td>820,700</td>
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<td>Col Gas TCO</td>
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<td>Marcellus</td>
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<td>Houston S Ch</td>
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<td>1,200</td>
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</table>
Undergrads born
Natural Gas Pipeline Construction

- Natural Gas Act Certificate (License)
  - Grants a Right of Federal Eminent Domain
  - Blanket Certificate less than $8 million
  - Prior (45-day) Notice between $8 and $22 million
  - Case Specific Section 7(c) Certificate
- NGPA section 311
  - No Federal Eminent Domain

Certificate of public convenience and necessity
New certificate policy
Sept. 15, 1999

- Policy Statement
  - Foster Competition
  - Consider Captive Customers
  - Achieve Optimal Amount of Facilities

- Rolled-in pricing bias may lead to:
  - Subsidization by existing customers
  - Distortion of competition between pipelines

- Apply ‘Higher of’ Test: Incrém or Rolled-in

- Environmental issues
  - Landowner issues: NIMBY
  - Rights of way and eminent domain

- Negotiates rates for risk sharing
  - Iroquois rates: pre-construction $.40; post-construction $.80
  - One shipper choose certainty
comments and protests switch from rates to environment and eminent domain issues
Market-based contracts

¬ Risk/reward must be balanced
  ¬ ex-ante risk assignment
  ¬ pre-construction rates: create good incentives
  ¬ cost overrun incentives: Kern River/Iroquois
  ¬ term-differentiated rates: compensate for risk
  ¬ tradable rights contracts reduce risks
¬ contract rights: tradability creates competition
  ¬ price risk protection
  ¬ segmentation/flexible receipt & delivery points increases tradability
Order 637 (2000) (clean up of 636)

- e-commerce
  - Human and machine-to-machine
  - EBBs become Web sites:
  - Posting of daily transactions and capacity
- Efficient primary rates:
  - Term differentiated, seasonal
- Equality of secondary market
  - Encourages voluntary e-auctions
  - Segmentation if operationally feasible
  - Imbalance trading
Virtual pipelines

- Order 637 requires firm contracts to look like competing pipelines (straw in the pipeline)
- Segmentation equality/full tradability
- Nomination and confirmation equality
- Primary firm service is more attractive
- Better information
- Imbalance markets
- No harm/no foul penalties
- Incentives to limit curtailments
## Pipeline Regulation Structure

<table>
<thead>
<tr>
<th></th>
<th>Oil</th>
<th>Natural gas</th>
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<tbody>
<tr>
<td>Rates and Tariffs</td>
<td>FERC (ICC)</td>
<td>FERC (FPC)</td>
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<td>Carriage</td>
<td>Common</td>
<td>Contract</td>
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<tr>
<td>Safety</td>
<td>DOT</td>
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<td>Eminent domain</td>
<td>states</td>
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<td>Environment</td>
<td>EPA, states</td>
<td>EPA, states, FERC</td>
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<tr>
<td>Antitrust</td>
<td>DOJ, FTC</td>
<td>FTC</td>
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<tr>
<td>Supply Security</td>
<td>SPR</td>
<td>None</td>
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</tbody>
</table>

DOT = Department of Transportation  
DOJ = Department of Justice  
FTC = Federal Trade Commission  
SPR = Strategic Petroleum Reserve (Department of Energy)
Gas reforms and errors early 1980s to 1999

- Open access must fit the situation
- 1989 FERC staff proposes LMP-type auction model for gas
  - Proposal failed
- No restrictions on long-term contracts
- Existing sales contracts reformed
  - Bundled sales contracts become pipeline tariffs
  - By-pass of LDCs case-by-case
  - Wellhead contracts renegotiated
  - Transport tariffs are surcharged
- US-Canada-Mexico energy trade is market based
- The Mexican spot price is based on the Houston price
Electric reforms and errors early 1990s to today

- The vertical model did not work
- No restrictions on long-term contracts
- Generators sold off to merchants
- Generators become more efficient
- ISOs initial market designs failed and corrected
  - ISOs are still growing
  - Transmission rights are financial hedges
  - Natural gas displacing coal
  - High prices but the market clears
  - Bilateral contracts to hedge spot prices
- How do we balance high renewables?
Natural gas wellhead price roller coaster
Existing and Proposed North American LNG Import Terminals in 2005
Capacity Release
(2008 Order 712)

- Capacity is purchased with reservation charges under long-term contracts to serve end users on the coldest days.
- Firm shippers can resell their capacity for one year or less without restriction.
- Released capacity for more than one year must be sold at the maximum rate or to the person offering the highest rate.
- An asset manager or a marketer in a state-regulated retail access program need not comply with the bidding rules.
- Release notice must be provided on the pipeline's Web site.
Shale Gas Production

- Shale has low permeability.
- Production requires fractures to provide permeability.
- Horizontal drilling has laterals up to 2 miles in the shale to create maximum surface area for fracking.
- Fracking creates extensive artificial fractures.
- Cost has fallen by over 50% since 2005.

US gas production 2015 = 90 bcf/day
Shale Gas Formation Map
Domestic Natural Gas Shale Plays and Production

Source: U.S. Energy Information Administration, Drilling Productivity Report, March 2017
https://www.eia.gov/petroleum/drilling/pdf/dpr-full.pdf
Marcellus Play

*does not include all pipelines or pricing hubs
Domestic natural gas pipelines
2016

Legend
- Blue = Interstate Pipelines
- Red = Intrastate Pipelines

Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System
Climate change

zealots:
- shut down fossil fuels now
- It may be too late (secular Armageddon)

Middle:
- first replace coal with natural gas
- Coal is 50% carbon by weight and includes hydrogen, oxygen, nitrogen, ash, sulfur, sodium and rare earths
- Natural gas has half the emissions of coal

Not time yet:
- wait and see the evidence is changing
- May be a hoax
Do not rush through pipeline approvals
I'm writing to urge FERC to refrain from rushing through the approval of pipeline permits

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I'm writing to urge FERC to refrain from rushing through the approval of pipeline permits
Existing and Proposed North American LNG Export Terminals in 2015

Source: Energy Information Administration
U.S. Natural Gas Wellhead Price ($/Thousand Cubic Feet)

Recovering forecaster

Real price →

$y = -6E-05x^3 + 0.3775x^2 - 747.37x + 493159$
$R^2 = 0.6439$

$y = 0.0791x - 153.99$
$R^2 = 0.6053$