California Energy Commission

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Current Trends: Natural Gas Supply

Staff Workshop

2011 Integrated Energy Policy Report

California Energy Commission

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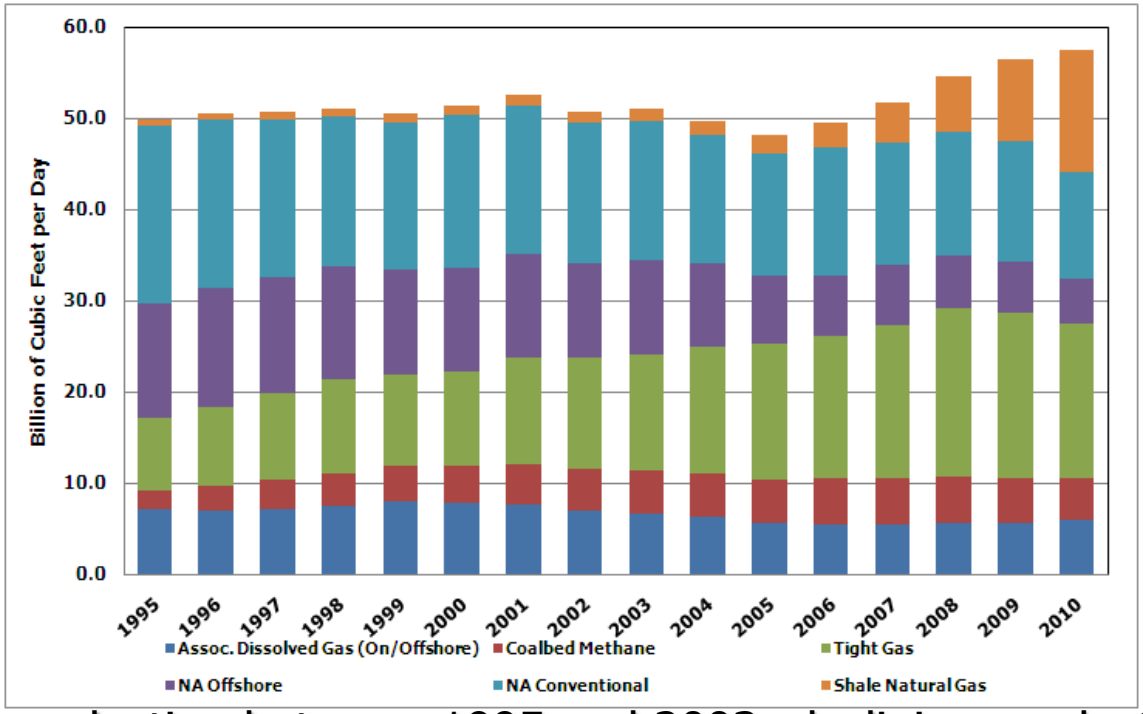
Current Trend:

Total Lower 48 natural gas production is rising



Sub-Trends

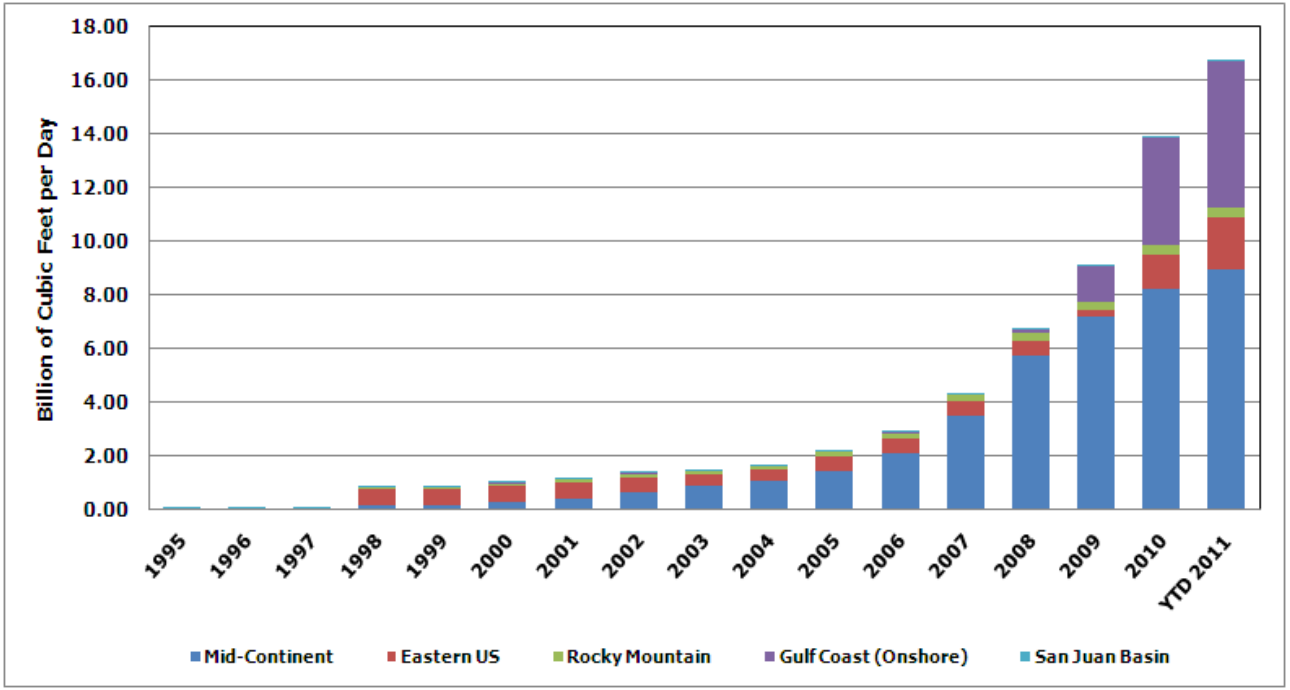
- Shale natural gas is rising;
- Non-associated conventional natural gas is declining;
- Coalbed Methane is declining;
- Tight gas is rising.

- Flat production between 1995 and 2003; declining production between 2003 and 2005; increasing production since 2005
- Without the development of shale formations, overall production would be declining

Source: Lippman Consulting

Current Trend:

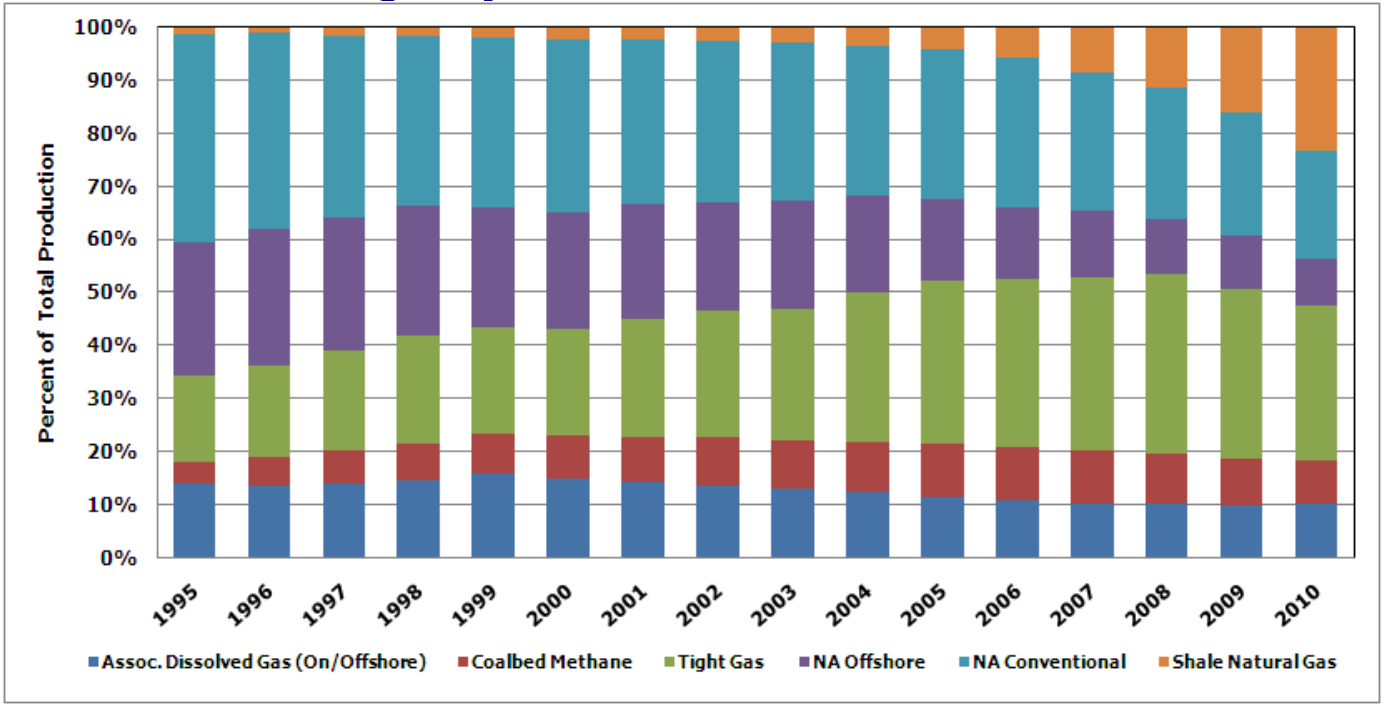
Total production from shale formations is surging



- Shale production exhibited steady, but slow, growth between 1995 and 2005
- After 2005, rapid development has pushed production pass 16 billion cubic feet per day

Source: Lippman Consulting

Current Trend:
Shale formations are contributing an increasing share of Lower 48 natural gas production

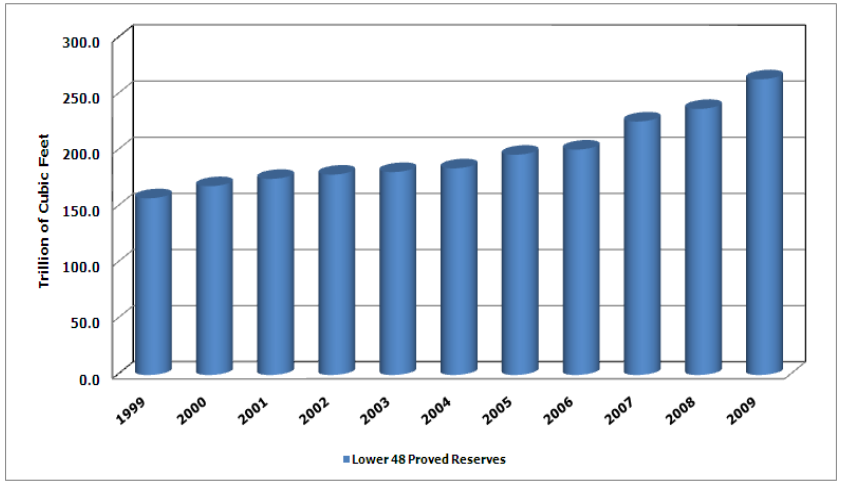


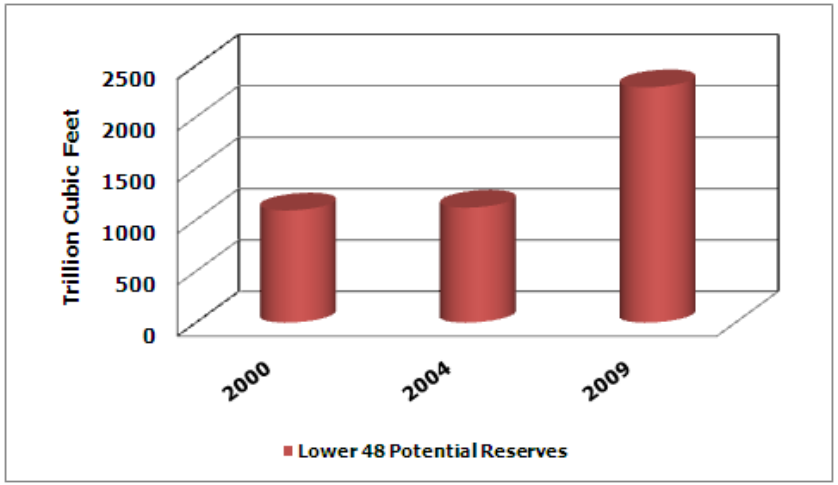
- In 2000, shale formations contributed about 2% to total natural gas production in the Lower 48
- By 2010, the contribution exceeded 23%

Source: Energy Information Administration

Current Trend:

Total reserves in the Lower 48 are increasing





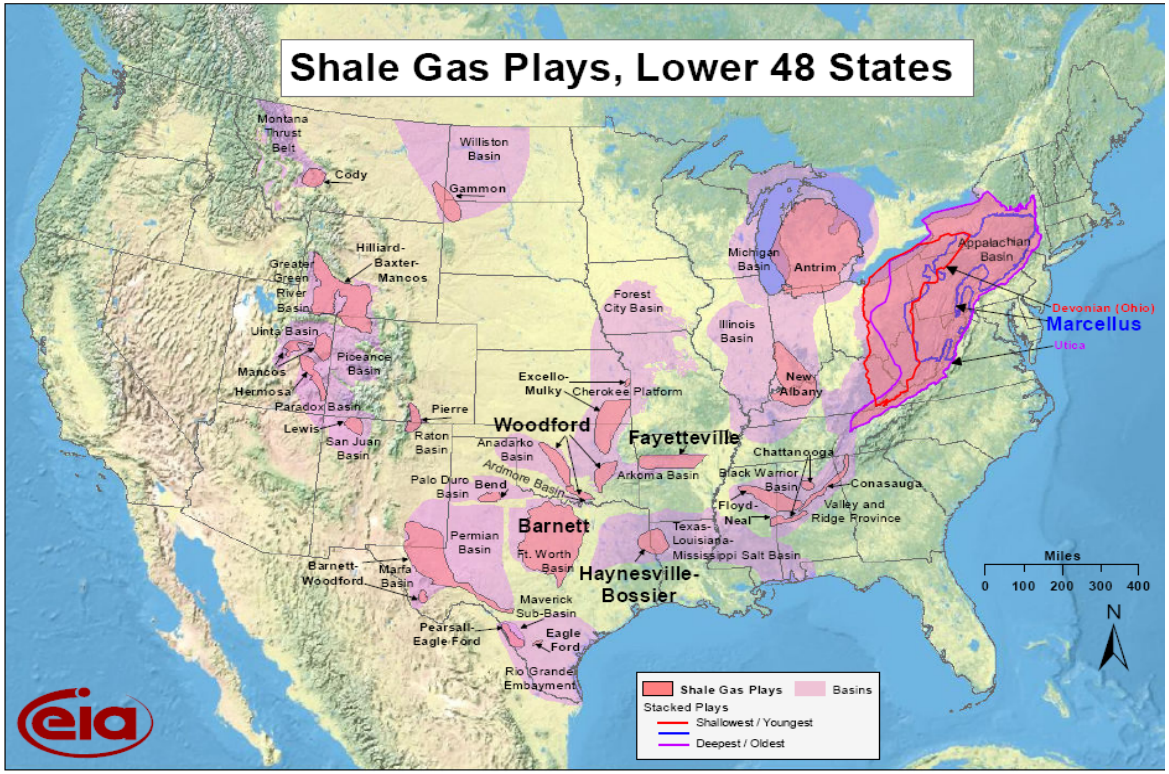
Proved Reserves: natural gas resources that are connected and ready for production (completed and behind-pipe). Resources are geologically-known, developed, and producible with current technology

Potential Reserves: natural gas resources that includes all probable, possible, and speculative reserves. Resources are geologically known with decreasing levels of certainty, undeveloped, and producible with current technology

- Shale formation development is pushing overall natural gas reserves to higher levels:
  - Proved Reserves rising from about 150 Tcf in 1999 to over 260 Tcf in 2009
  - Potential Reserves rising from about 950 Tcf in 2000 to over 2000 Tcf in 2009
- In AEO 2011, EIA reported technically recoverable reserves (proved plus potential) of 827 Tcf (shale) and 2552 Tcf (all natural gas sources)
- At current rates of consumption, reserve life index equals about 115 years

Current Trend:

Technology is transforming the natural gas industry



Source: Energy Information Administration based on data from various published studies.

- Shale formations stretch through at least 23 states
- These formations contain vast quantities of natural gas
- Technological innovations are providing access to shale formations

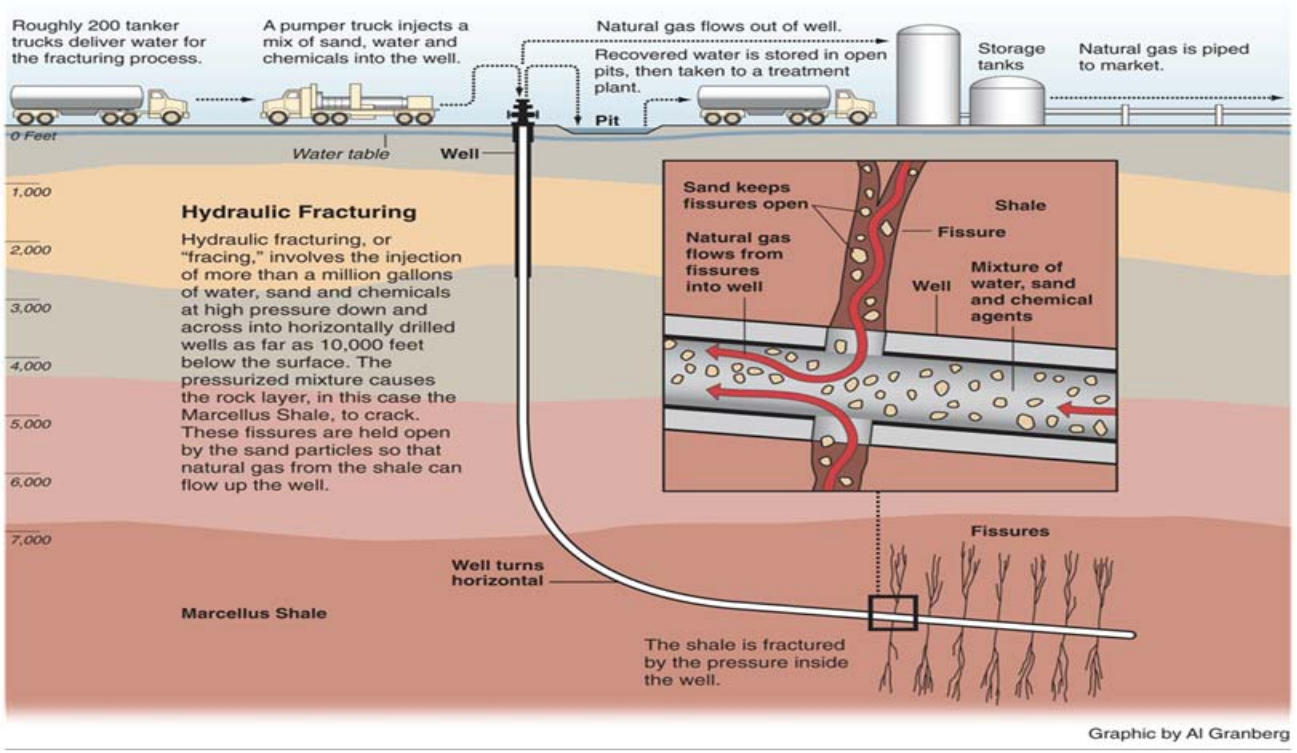
Current Trend:

Technology is transforming the natural gas industry (cont'd)

- Technology has impacted all stages of natural gas development:
  - Exploration
  - Drilling (including surface preparation and casing hole with pipe and cement)
  - Completion (including hydraulic fracturing)
  - Production
- Technological innovations in *exploration:*
  - Development of 3-D and 4-D seismic led to enhanced capability to delineate the limits of the deposits
  - Exploratory well success rate has climbed to about 65% in the late 2000s, up from about 30% in the late 1990s
- Technological innovations in *drilling:*
  - Overall, drilling success rate has reached 90%
  - Horizontal drilling increased wellbore exposure by a factor of five to twenty times

Current Trend:

Technology is transforming the natural gas industry (cont'd)

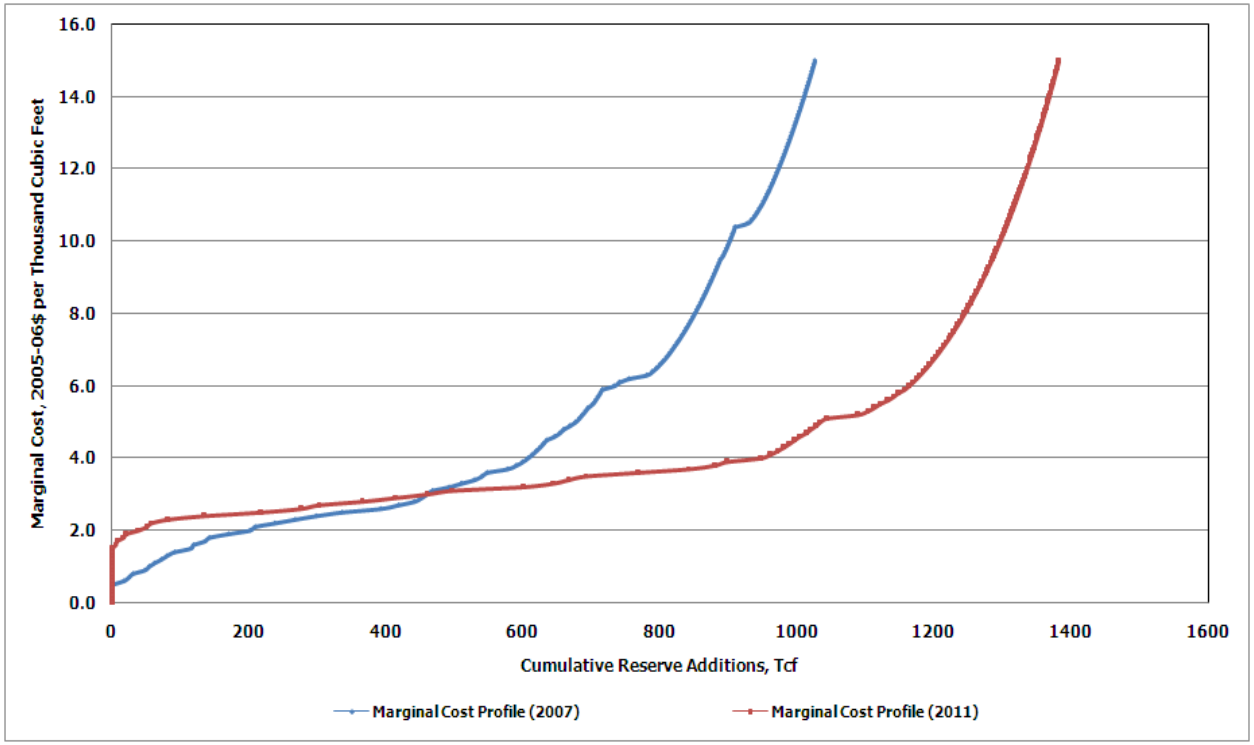


- Technological innovations in *well completions:*
  i. Hydraulic fracturing creates network of artificial sand-packed fractures
  ii. Multiple-stage fracturing stimulations boost *production* and recovery rates

Source: Energy Information Agency

Current Trend:

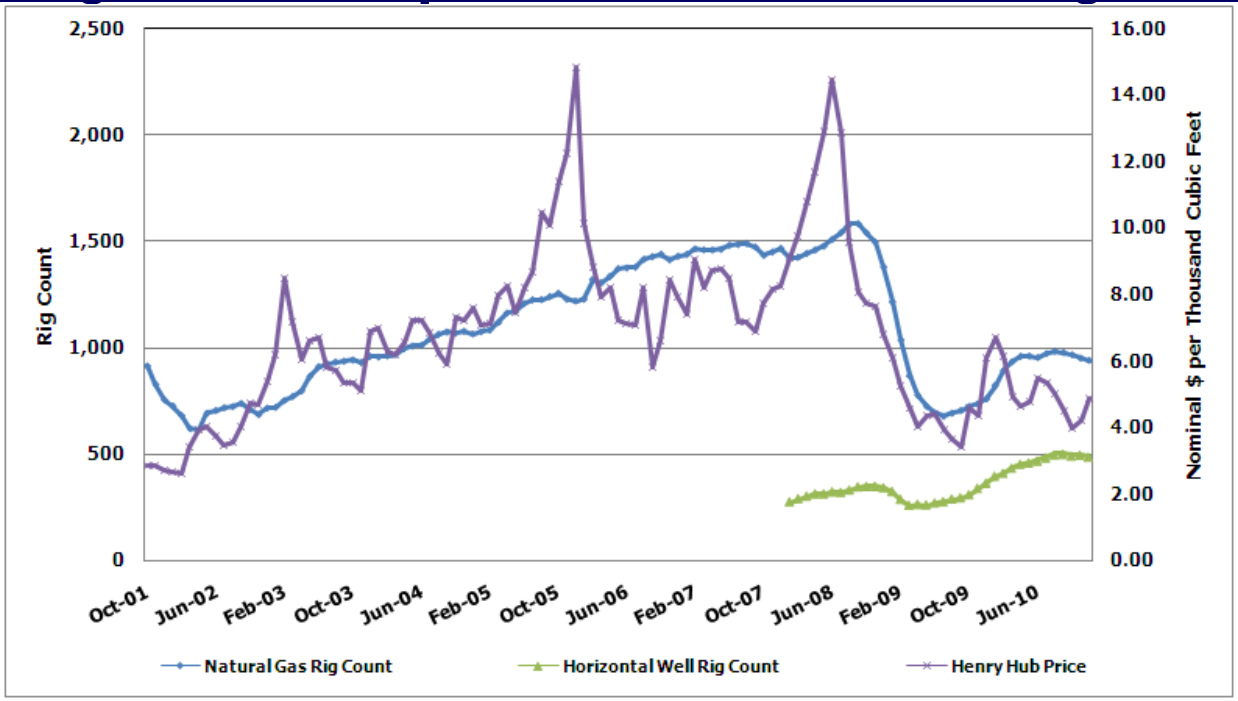
Technology is shifting the marginal cost profile



- Overall, the shifting marginal cost supply profile results in more resources available at lower cost

Sources: California Energy Commission; Altos Management Partners; Baker Institute; National Petroleum Council.

Current Trend:
Finding and development costs are declining



Rig Count: weekly census of the number of active drilling rigs exploring for natural gas in the United States

Horizontal well rig count remains strong despite price reduction

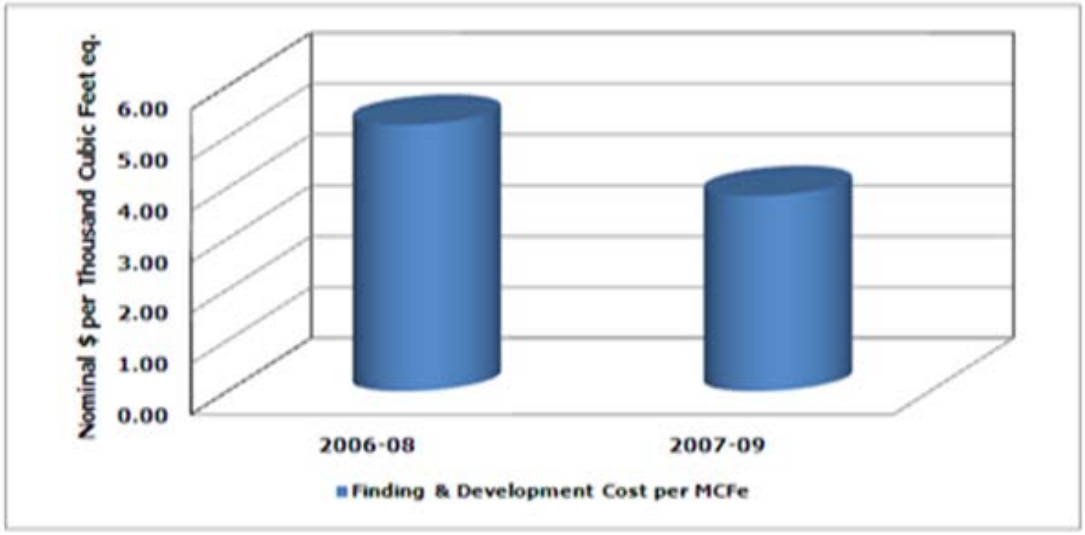
FERC reports:

- Shale gas development has turned the economics of drilling for gas on its head
  - New technology has pushed well productivity to new heights
  - In some markets, drill-time has plunged to just days from weeks
- Reduced drill-time has driven down breakeven costs to less than $4/MMBtu

Current Trend:

Natural gas liquids are boosting economic feasibility

- Cost of shale development is even lower in the presence of natural gas liquids:
  - Propane
  - Ethane
  - Butane



Source: Energy Information Administration

Current Trend:

Natural Gas Liquids are boosting economic feasibility (cont'd)

- Gas producers are shifting their exploration and development dollars to liquid-rich properties
- Joint ventures with foreign entities are increasing
- Liquid-rich shale formations include:
  - So-called "liquid corridor" of the Marcellus
  - Bakken in North Dakota and Montana
  - Niobara in Nebraska, Wyoming, and Colorado
  - Eagle Ford in South Texas (now producing over 40,000 b/d of oil and natural gas liquids)
  - Tuscaloosa Marine in Texas, Louisiana, and Mississippi

Current Trend:

Shale potential is changing the industry in other countries

- Canada is developing several shale formations:
  - Horton Bluff, Utica, and Lorraine in Eastern Canada
  - Muskwa shale of the Horn River in Northeast British Columbia
  - Montney and Bakken shales in the Western Canadian Sedimentary Basin
  - Production from the Horn River, Bakken, and Montney shales is nearing 1000 MMcf/d
  - Estimated Technically Recoverable Resources: 388 Tcf

- Mexico's state-owned petroleum company tested its first shale gas well:
  - Tested the Mexican portion of the Eagle Ford shale
  - Producing about 3.0 MMcf/d
  - Estimated Technically Recoverable Resources: 681 Tcf

Energy Information Administration's World Shale Gas Resources provided Estimated Technically Recoverable Resources

Current Trend:

Shale Potential is changing the industry in other countries (cont'd)

- Poland is beginning development, drilling its first well:
  - Estimated Technically Recoverable Shale Resources: 187 Tcf
- Sweden is exploring its identified shale formations:
  - Estimated Technically Recoverable Shale Resources: 41 Tcf
- China may have vast quantities of natural gas in shale formations and is beginning exploration:
  - Estimated Technically Recoverable Shale Resources: 1275 Tcf
- Total Estimated Worldwide Technically Recoverable Shale Resources: 6622 Tcf

Energy Information Administration's World Shale Gas Resources provided Estimated Technically Recoverable Resources

Current Trend:

Environmental Concerns are Creating Uncertainties

- Greenhouse gas emissions
  - Methane, the primary component of natural gas, contributes to GHG emissions
  - Produces about 117 lbs/MMBtu of carbon dioxide
- Surface disturbance
  - Development requires surface preparation and may create environmental stress in some sensitive areas
  - Led to drilling moratoriums in the Rocky Mountain and to moratoriums on the issuances of drilling permits in areas near or around New York's watershed areas, limiting development of the New York portion of the Marcellus Shale
- Freshwater usage
  - Hydraulic fracturing requires between two and four million gallons of freshwater per treatment
  - Diverts freshwater from other important and essential uses
- Disposal of retrieved water
  - After completion of a fracture treatment, operators retrieve about 30% to 70% of the injected fluid
  - Disposal of the retrieved water raises environmental concerns, such as spillage and groundwater contamination

Current Trend:

Environmental Concerns are Creating Uncertainties (cont'd)

- Increased Seismic Activity
  - On-going studies are examining possible link between oil and gas operations *and* increased seismic activity
- Groundwater Contamination
  - On-going studies are examining possible link between hydraulic fracturing and groundwater contamination
    - Attempting to quantify "…the potential risks associated with hydraulic fracturing"
  - Government entities include:
    - Environmental Protection Agency
    - Several state agencies
    - Secretary of Energy Advisory Board (Obama Administration)
  - All oil and gas operations pose some level of risk to groundwater aquifers
    - Unanswered question is: how much?

Current Trends:
Natural Gas Supply

Questions & Comments