



California Energy Commission

Natural Gas Supply

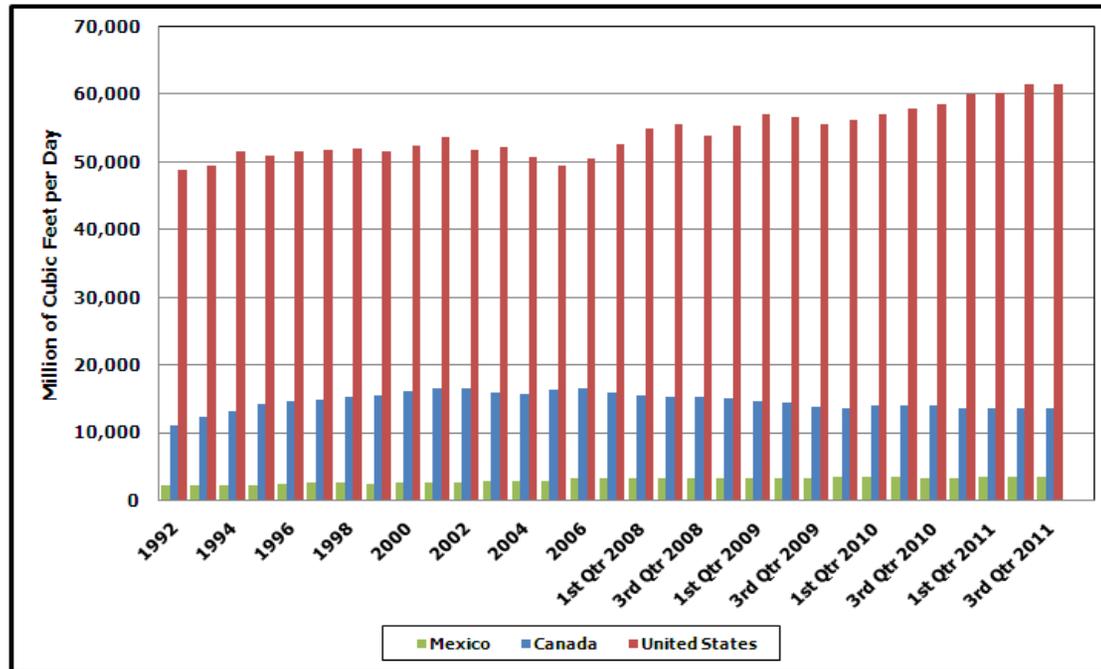
California Natural Gas Stakeholders Working Group Meeting
California Energy Commission

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North America Natural Gas Production



Sub-Trends

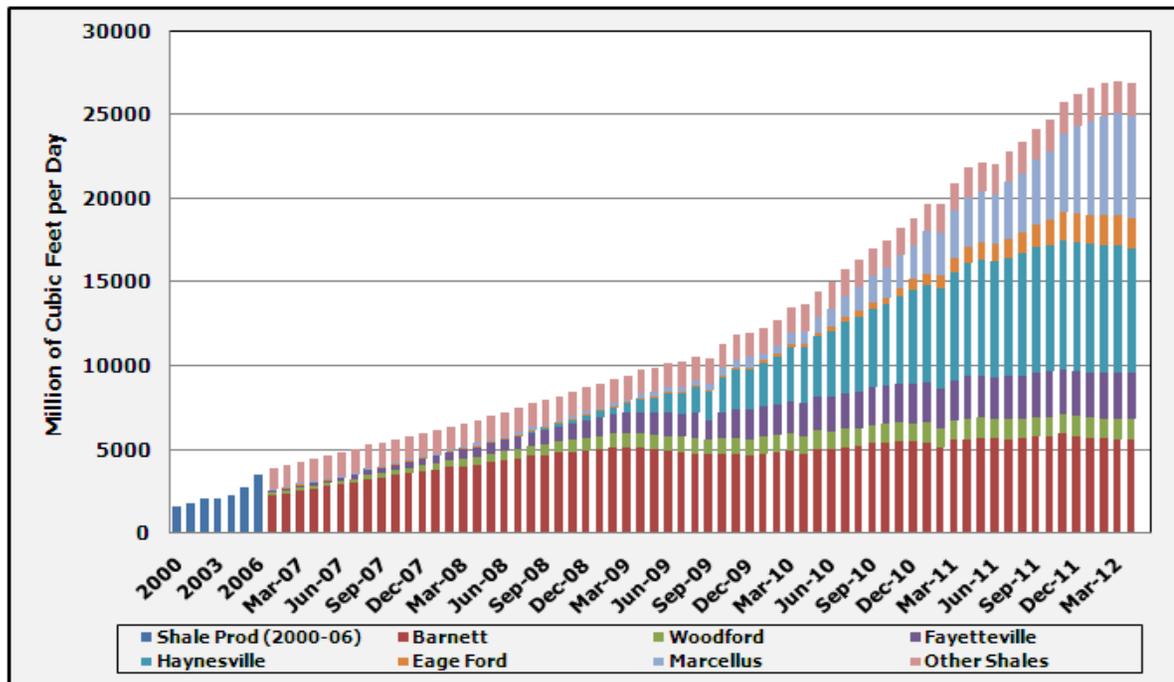
- Shale natural gas production is rising;
- Non-Shale production is declining.
- Sub-trends are a manifestation of the movement of capital dollars

- **Flat US 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



Lower 48 Shale Production



- Shale formations stretch through at least 25 states
- These formations contain vast quantities of natural gas, natural gas liquids, and crude oil
- Technological innovations are providing access to shale formations

- Shale production exhibited steady, but slow, growth between 2000 and 2005
- After 2005, rapid development has pushed production pass 25,000 million cubic feet per day
- Is shale natural gas production beginning to level out?

Source: Lippman Consulting



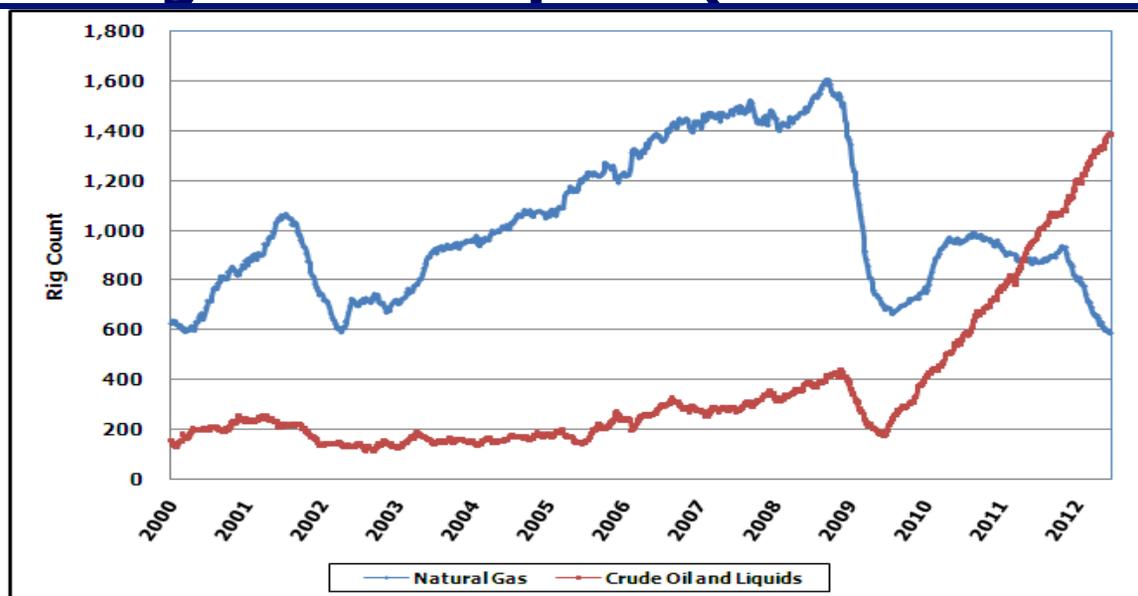
Shale Formations in North America

- **Lower 48 (United States)**
 - In 2000, shale formations contributed about 2% to total natural gas production
 - By 2010, the contribution exceeded 23%
 - In 2011, shale production contributed about 31%
 - Now, the contribution hovers around 40%
- **Canada is developing several shale formations:**
 - Production from the Horn River, Bakken, and Montney shales is nearing 2000 MMcf/d
- **Mexico's state-owned petroleum company tested its first shale gas well:**
 - Tested the Mexican portion of the Eagle Ford shale. First well produced about 3.0 MMcf/d



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Emergence of Liquids (NGLs and Crude Oil)

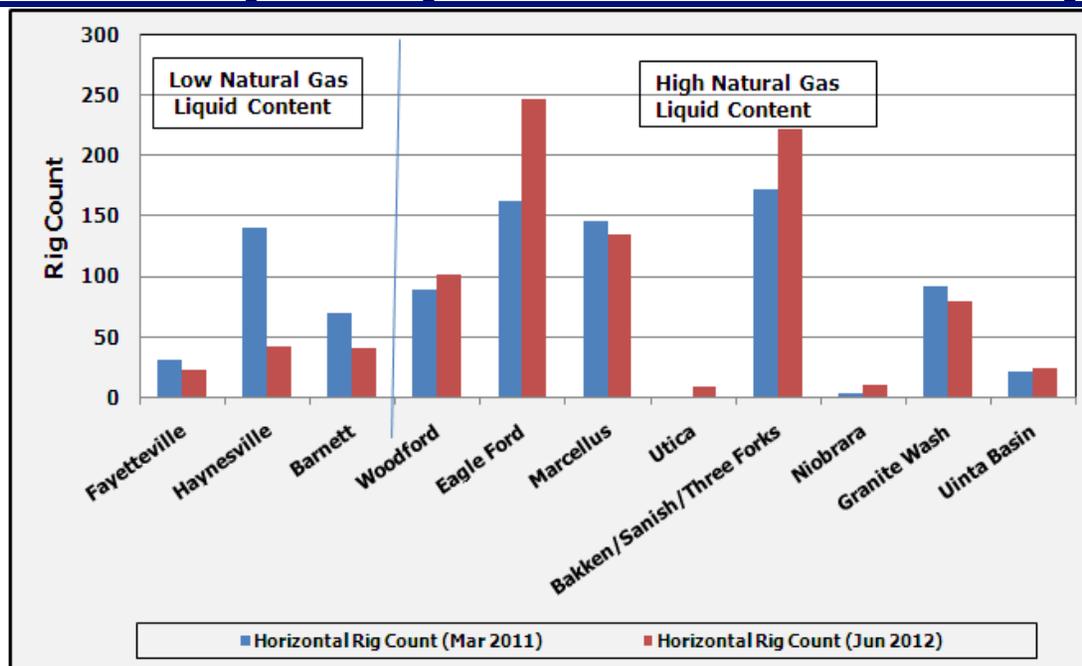


United States Geological Survey says the Green River Formation (Colorado, Utah, and Wyoming), a kerogen-rich deposit, may contain as much three trillion barrels of crude oil and other liquids. Producers have not yet reached commercial viability in the development of this formation .

- Liquid-rich formations such as the Eagle Ford, the Niobrara, and the Bakken/Three Forks produce about 5 – 6 barrels of NGLs per Mcf.
- Other liquid plays include the Tuscaloosa Marine Shale, the Avalon/Bone Springs Shale, Smackover Brown Dense Shale, and the Granite Wash sandstone.



Emergence of Liquids (NGLs and Crude Oil)

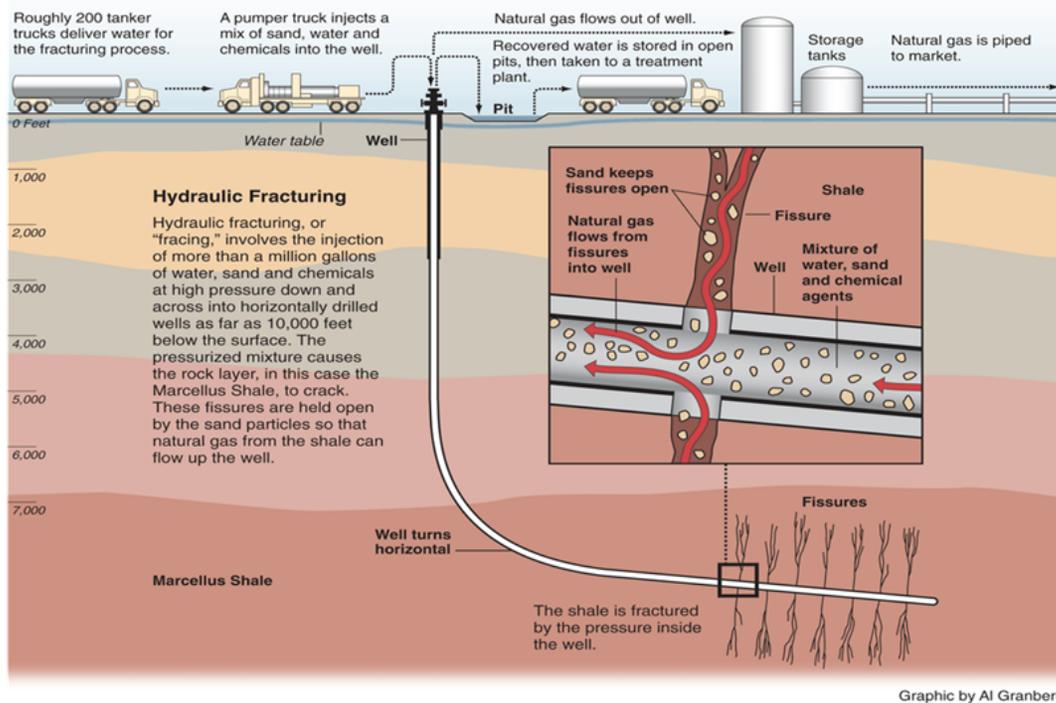


Using Rig Count as a proxy for capital expenditures:

- Operators are shifting to more "oily" shales and sandstones (liquid-rich properties)
- Driven by the gas-oil price differential
- Natural gas at about \$2.50/Mmbtu; NGLs (ethane, propane, iso-butane, and butane) between \$15 - \$25/ Mmbtu.



Environmental Challenges



- Technological innovations:
 - i. Hydraulic fracturing creates network of artificial sand-packed fractures
 - ii. Multiple-stage fracturing stimulations boost recovery rates

- **Development of natural gas has created several potential environmental challenges**

Source: Energy Information Agency



Environmental Challenges

- Greenhouse gas emissions
- Surface disturbance
- Freshwater usage
 - Hydraulic fracturing requires between two and five 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
- 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



Environmental Challenges

- **Groundwater Contamination (case study)**
 - In Dec 2011, a US Environmental Protection Agency report concluded that “[t]he groundwater in Pavillion, WY, contains chemicals that are normally used in natural gas production practices, such as hydraulic fracturing (fracking).”
 - Many in the industry, including the Energy Institute of the University of Texas, disagree with the finding. EPA has agreed to do further sampling.
- **Many jurisdictions are now requiring disclosure of chemicals used in hydraulic fracturing**
 - In California: An Assembly Bill (AB 591) now under consideration will require such disclosure.
- **In May 2012, United States Bureau of Land Management and Environmental Protection Agency proposed rules and guidelines for the regulation of hydraulic fracturing.**



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Questions & Comments