

RFF's Center for Energy Economics and Policy

A Retrospective Review of Shale Gas Development in the U.S.: What Led to the Boom?



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U.S. Shale Gas Annual Production from Five Classic Plays to 2007



Over the last decade, U.S. shale gas production has increased 12-fold and now comprises about 25 percent of total U.S. production

annual shale gas production trillion cubic feet



Sources: EIA and Lippman Consulting

Shale gas plays, Lower 48 States



Source: Energy Information Administration based on data from various published studies. Updated: May 9, 2011

The production of tight gas and coalbed methane increased significantly as well





Key Factors Leading to the Boom:

- Government policies on R&D and tax credit on unconventional gas
- Private entrepreneurship
- High natural gas prices in the first 10 years of this century
- Favorable resource base and infrastructure



Energy crisis before government policies

Energy Crisis in the 1970s

- Severe natural gas shortage in many areas of the U.S.
- Low proved natural gas reserve

(Main reason: gas price was set too low by the government)

• Oil embargo in 1973-74









Government policies

As a response, U.S. federal government decided to

- Support R & D programs on unconventional natural gas
- Offer tax credit for unconventional natural gas production
- Deregulate wellhead prices of natural gas, and later, mandate open access to natural gas pipelines

Relatedly,

- Merge several governmental organizations to form Department of Energy (DOE) in 1977 to coordinate energy research and development
- Increase budget for energy research in general



Government policies: R&D

DOE's Unconventional Gas Research Program, which includes three major research-demonstration-pilot programs

- Eastern Gas Shales Program (1976-1992)
 - Devonian-age shales of the eastern U.S.
- Western Gas Sands Program
 - Low permeability gas sandstone reservoirs of the western U.S.
- Methane Recovery from Coalbeds Program

Research and demonstration were done by DOE's technology centers, national labs, universities, and private firms



Eastern Gas Shales Program

- Total budget in its 16 year history: slightly over \$92 million
- Overall goals:
 - To develop technologies for locating and producing natural gas from Devonian shales
 - To get a better estimate of reserve sizes so that the private sector would be encouraged to develop the resource on a large scale



Eastern Gas Shales Program

The first five years (1976-1981) focused on:

- characterizing the Eastern gas shales (geological, geochemical, geophysical, and reservoir properties)
- conducting cost-shared stimulation research experiments together with oil and gas operators

Starting in the early 1980s, research emphasized:

• detailed reservoir performance analysis, among other things

The later stages emphasized:

drilling directional\horizontal well together with industry partners, among other things



Eastern Gas Shales Program

Major Results:

- Produced large quantity of geologic and production data about Eastern gas shales, improved understanding of shale gas reservoirs
- A number of technologies later became commercially viable, including
 - First use of nitrogen foam fracture in 1975
 - Large-scale massive hydraulic fracturing
 - First use of directional drilling in shales



Government policy: R&D

Gas Research Institute

- Founded by industry in 1976, but funded by a surcharge on natural gas sales until 1998
- Manage and finance natural gas R&D programs, with a focus on unconventional natural gas until 1994
- Focused more on application and technology transfer; DOE programs more on basic research
- Annual Budget: average \$120M in the 1980s



Government policy: tax credit

Tax credit for unconventional natural gas

- Took effect in 1980
- Applied to new unconventional wells drilled before the end of 1992, and to gas produced from these wells until the end of 2002
- \$1/Mcf for shale gas and coalbed methane; \$0.5 per Mcf for tight gas
 - national average wellhead price was between \$1.5 and \$2.5



Impact of R&D programs and tax credit

Over 17,000 shale gas wells were drilled from 1978 to 1999



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How did the boom in Barnett get started?

Entrepreneur George Mitchell

- In the 1980s, Mitchell Energy needs new sources of natural gas to fulfill its contractual obligation to deliver natural gas to feed a pipeline
- Drilled the first Barnett shale well in 1981, and continued to drill despite losing money; spent \$250M by 1997
- Drilled 187 of the first 207 Barnett wells (by 1994)
- Breakthrough in 1997-1998: light sand/slick water fracking
- Sold to Devon Energy in 2002 for \$3.5 billion; Devon good at horizontal drilling



Long gestation period in Barnett before boom

Total Producing Barnett Shale Wells by Year as of June 1, 2012 All RRC Fields in the Fort Worth Basin



Source: Railroad Commission of Texas

Powell Shale Digest, Aug. 13, 2012

Horizontal wells did not take off in Barnett until 2003



Source: EIA

What explains the recent shale gas boom? Economics!

- High natural gas price in the first decade of this century
- In most basins, to achieve an IRR of 15%, gas price needs to be about \$5/Mcf or higher; \$5/Mcf = ¥1.1/cubic meter

U.S. Natural Gas Wellhead Price



Shale gas development pioneered by major gas firms

Not by major oil companies:

- Chevron was the only oil major present in Barnett, but closed its Barnett operation in 1997; In 2003, no oil majors were active in Barnett
- No major oil companies were active in Marcellus until they bought some independent gas firms

Not by really small firms either:

- Mitchell Energy was the largest gas producer in North Texas when it started to explore Barnett
- In 2008, nearly 200 companies were active in Barnett, but 80% of the production came from the 6 largest operators
- Range Resources was the first to develop Marcellus; already the 15th largest publicly traded independent oil & gas company in U.S. in 1998
- In the first half of 2012, nearly 40 companies were active in Marcellus, and 66.7% of the production came from the 6 largest operators

(Yes, some firms started from scratch and made billions by selling themselves)



Gas boom was facilitated by Wall Street

Wall Street facilitated financing the recent boom:

- Large amount of capital needed to lease land and drill wells
- Independent gas firms relied on Wall Street for financing
 - Natural gas deals were a major profit area for investment banks after the financial crisis
- Major investors: overseas oil companies, including CNOOC & Sinopec
- Boom has turned into a bust!



Other key contributing factors

- Large resource base
- Favorable geology
- Good infrastructure (pipeline, storage, roads)
- Water generally available for fracking
- Private land ownership and 'use or lose' lease clause
- Well-established oil & gas service industry
- Environmental concerns have not stopped development except in some states (e.g., New York)



Compare China with U.S.:

Similarities

- Huge market
- Very large gas reserves
- Energy security and environmental concerns
- Government support (?)

Differences

- Geology
- Water resource
- Access to technology
- Gas industry structure (size and service industry)
- Natural gas pricing
- Pipeline network and access
- Land ownership
- Environmental regulation



Thank You!

