2. U.S. EXPERIENCE

Between 2007 and 2013, U.S. annual shale gas production grew from roughly 3.5 bcf/day (36.5 bcm/year) to 31 bcf/day (323 bcm/year), reaching more than 46% of U.S. natural gas production.[1] Largely as a result of this boom, the United States is projected to become a natural gas exporter in the decade ahead. Energy historian Dan Yergin has called the U.S. shale gas boom "the biggest energy innovation so far in the 21st century."[2]

Factors that led to the growth of the U.S. shale gas sector include:

- a large and high-quality shale resource,
- a competitive market system,
- private property rights,
- federal government support for R&D,
- federal tax incentives,
- publicly available data,
- an extensive pipeline network, and
- an entrepreneurial culture.[3]

The United States has one of the world's largest shale resources. According to U.S. EIA, the United States has 665 trillion cubic feet of technically recoverable shale gas — a figure surpassed only by China, Argentine and Algeria.[4] The shale is located in different regions of the country and more than a dozen states, including Texas, Louisiana, Arkansas, Pennsylvania, Ohio, West Virginia and North Dakota. Much of the resource is relatively near the surface, with thickness, porosity and total organic content conducive to natural gas production. The shale resources are marine shales, with a favorable combination of silt, clay, organic material and fracture density. (There are also substantial tight liquid resources, which produce from siltstone layers.)

Perhaps the most fundamental factor behind the U.S. shale gas boom is the United States' competitive market system. With respect to natural gas, that system is relatively new.

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[1] U.S. EIA, Shale Gas Production, http://www.eia.gov/dnav/ng/ng_prod_shalegas_s1_a.htm (U.S. shale gas production in 2007 was 1293 bcf); US EIA, Issues and Trends: Natural Gas (Jan 16, 2014) http://www.eia.gov/naturalgas/issuesandtrends/production/2013/ (U.S. dry natural gas production in 2013 was 66.5 bcf/day); Adam Sieminski, http://www.eia.gov/pressroom/presentations/sieminski_01222014.pdf, p. 4 (U.S. shale gas production at end of 2013 was roughly 31 billion cubic feet per day)(confirmed in personal communication with author from EIA staff).

[2] Daniel Yergin, "Shale Gas Development: An Energy Game Changer," http://danielyergin.com/shale-gas-development.

[3] See generally Zhongmin Wang and Alan Krupnick, "US Shale Gas Development: What Led to the Boom?" (RFF 2013), http://www.rff.org/RFF/Documents/RFF-IB-13-04.pdf; Michael Shellenberger, Ted Nordhaus, Alex Trembath and Jesse Jenkins, "Where the Shale Gas Revolution Came From" (Breakthrough Institute), http://thebreakthrough.org/index.php/programs/energy-and-climate/where-the-shale-gas-revolution-came-from; Duke Suttikulpanich, Ying Wang and Akash Gupta, "China Shale Gas: Potential Unearthed" (Standard Chartered, September 30, 2013); Gregory Zuckerman, The Frackers (2013).

[4] US EIA, "Shale Oil and Shale Gas Resources are Globally Abundant" (January 2, 2014), http://www.eia.gov/todayinenergy/detail.cfm?id=14431

Natural gas prices were regulated in the United States until the 1980s, when those prices were gradually decontrolled. (Restrictions on the use of natural gas in the power sector were lifted at the same time.) The ability to sell natural gas at market prices, along with low barriers to entry in the U.S. natural gas industry, attracted a number of pioneering entrepreneurs who invested considerable risk capital in shale gas development in the 1990s and early 2000s. Foremost among these was George Mitchell of Mitchell Energy, whose relentless efforts during the 1990s played a central role in proving the potential for U.S. shale gas production.

The United States' system of private property rights also played an important role in the shale gas revolution. In the United States mineral rights are privately owned, often by the owner of the surface above where those minerals are located. Mineral rights may be transferred by contract, without approval by government agencies. Developers in the United States are able to gain access to shale resources by purchasing those rights from owners, greatly facilitating production of the resource.

The U.S. federal government played a central role in the shale gas revolution.[5] Federal funding for research and development began in the 1970s, when the U.S. Energy Research and Development Administration and later U.S. Department of Energy supported resource assessments and technology demonstrations in the Appalachian Basin. DOE shared the cost of the first multifracture horizontal drilling play (in West Virginia in 1986) and of Mitchell Energy's first horizontal well (in Texas in 1991). Describing the role of the U.S. Department of Energy in the U.S. shale gas revolution, former Mitchell Energy Vice President Dan Steward said: "DOE started it, and other people took the ball and ran with it. You cannot diminish DOE's involvement."[6]

Federal tax incentives also played a key role. During the 1980s and 1990s, U.S. shale gas producers were entitled to tax credits between $0.52/Mcf and $0.94/Mcf. Average wellhead prices for natural gas during those decades were mostly between $1.5/Mcf and $2.5/Mcf.[7] For two decades, the federal government therefore supplemented the revenues of many shale gas producers by amounts that ranged from roughly 20% to 60% of market prices.[8] Federal tax credits for shale gas production were phased out in 2002.

Many experts cite publicly available data as a key factor in the U.S. shale gas revolution. State laws throughout the United States require public disclosure of well logs and

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[5] See Shellenberger et al., "Where the Shale Gas Revolution Came From" at note 30; Zhongmin Wang and Alan Krupnick, "US Shale Gas Development: What Led to the Boom?" (RFF 2013) – http://www.rff.org/RFF/Documents/RFF-IB-13-04.pdf; Shellenberger et al., at note 30; Suttikulpanich et al., "China Shale Gas: Potential Unearthed" at note 30.

[6] Michael Shellenberger, "Interview with Dan Steward, Former Mitchell Energy Vice President" (The Breakthrough, December 12, 2011) – http://thebreakthrough.org/archive/interview_with_dan_steward_for,

[7] Lei Tian et al., Stimulating Shale Gas Development, p. 6, at note 1.

[8] A comparison with wind and solar tax credits is instructive. Starting in 1992, the United States adopted a wind production tax credit (PTC), set initially at US$ 0.015/kWh of wind energy produced, indexed to inflation (now equal to about US$ 0.022/kWh). Solar photovoltaics benefited from an investment tax credit of 15% of total cost beginning in 1978, falling to 10% from 1988 to 2005, when Congress raised the credit to 30% to the end of 2007. Average retail electricity prices between 1992 and 2000 ranged from 6.64 to 6.93 cents/kWh (nominal prices)(EIA Annual Energy Review, September2012). http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0810).

production data for oil and gas development. Time periods vary, but in general that data must be disclosed within 30 to 90 days of the time it is obtained. That data has played an important role in helping shale gas producers target the best opportunities and deploy their limited capital. In addition, the U.S. Geologic Survey maintains maps that can assist with initial decision-making and the Securities and Exchange Commission requires public companies to disclose material information about their business, including information on shale gas reserves and production. In combination, these data sources have provided shale gas producers information critical to their success.

The United States' vast natural gas pipeline network also played an important role in the shale gas revolution. The U.S. has more than 305,000 miles of natural gas pipelines, connecting producers to consumers in almost every region of the country.[9] In addition, federal policies require open access to interstate natural gas pipelines and natural gas storage facilities. These regulations helped provide shale gas producers with confidence that gas produced could reach markets.

Other factors important to the shale gas revolution include the United States' entrepreneurial culture. Small entrepreneurs — not large companies — started the U.S. shale gas revolution. (Some of George Mitchel's early shale gas wells were famously within a few miles of Exxon Mobil's headquarters in Irving, Texas. However the world's largest independent oil company wasn't looking for oil and gas in its own backyard.)[10]

[9] About U.S. Natural Gas Pipelines," U.S. Department of Energy, Energy Information Administration, 2008. The region of the United States most poorly served by natural gas pipelines is New England. Partly for that reason, natural gas prices in New England spiked to US$ 50–100/MMBtu during the cold winter of 2014, see Northeast Gas Association, Gas & Power Generation (2014), http://www.northeastgas.org/gas_power_generation.php.

[10] Zuckerman, The Frackers, p. 45, at note 30.