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Shale gas outlook:

A U.S. perspective

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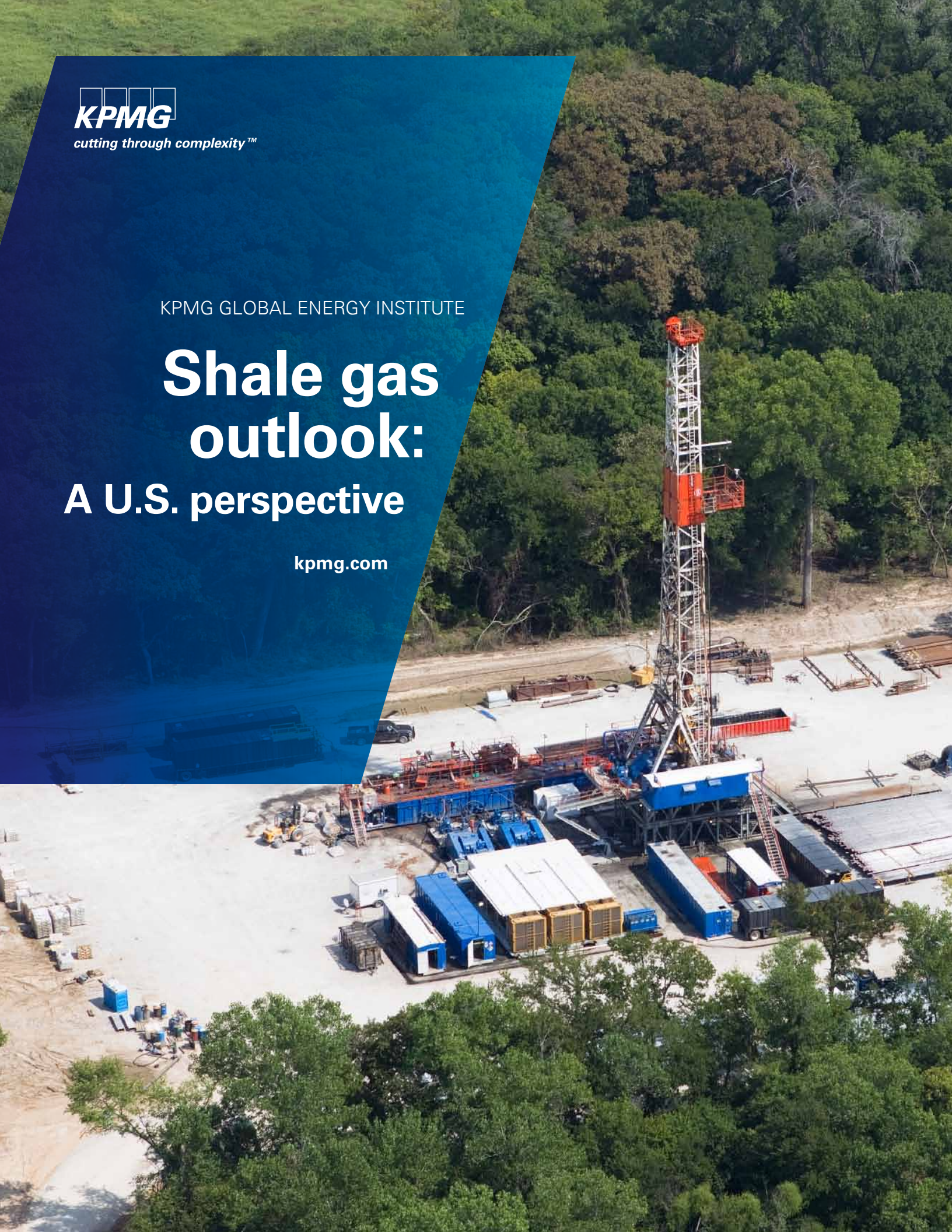


Contents

1. Introduction

As oil and gas production from conventional sources continues to decline, companies are concentrating on unconventional sources such as shale formations. Over the past few years, advancements in drilling technology have opened up huge shale gas reserves in the United States. From being a gas-deficient country a few years ago, the United States, at present is awash with gas supplies. The Barnett shale in North Texas and the Marcellus shale spread across Pennsylvania, New York, Ohio, West Virginia, and adjacent states are two of the most established and prolific shale gas-producing plays. Shale gas accounted for approximately 20 percent of total U.S. natural gas supplies in 2010, and is projected to increase to 45 percent by 2035. Shale gas extraction technology was pioneered by smaller companies, and the segment was mostly ignored by the international oil majors. However, with the end of easy oil and reserve restrictions in certain parts of the world, the majors recently started entering this segment.

Access to capital among smaller companies and the need for technology and resources among the larger cash-rich foreign companies are the key factors driving consolidation activities in this segment. After gaining experience in the United States, many of the larger companies will try to replicate their success in other parts of the world. In 2010, the total mergers and acquisitions (M&A) in the U.S. shale gas segment was US$39 billion—equivalent to 21 percent of the global upstream M&A value.[1] With the widening price differential between oil and natural gas prices, greater interest is being observed in liquids-rich shale plays.

The rising domestic shale gas production will have profound implications on the global energy sector. Imports into the United States are likely to drop 27 percent, over the period 2007–2011. Liquefied natural gas (LNG) import terminals that were initially planned in the United States may be converted to liquefaction terminals for exports. This will have far-reaching consequences on the global LNG markets. Midstream companies in the United States will need financing to build new infrastructure for additional gas processing and transportation.

The Marcellus play alone will need investments of US$100 billion over the next 20 to 25 years. Outside the United States, natural gas and LNG contracts are linked to prevailing crude oil prices. With the increasing disparity in gas and oil prices, major consumers in Europe and Asia are likely to push for contracts linked—at least partially—to natural gas prices. Additionally, consumers may demand a higher percentage of lower spot prices in existing and future gas contracts. Crude oil markets could suffer if gas is able to displace oil-based products in a significant way over a long period of time. Further, political relations between countries with huge conventional production and those with unconventional production may be impacted.

Although few doubt that shale gas will be a game-changer in the global energy markets, its extraction has many challenges. The most significant challenge is the environmental issues. Concerns have been raised that fluids used in the drilling process may contaminate the groundwater table. The huge quantity of water used in the extraction process is an issue in water-deficient areas. The geology of every shale play is unique and there is no guarantee that operational processes used in the United States will be successful in other parts of the world. Lack of adequate infrastructure may also be an impediment to the success of shale gas in the rest of the world.

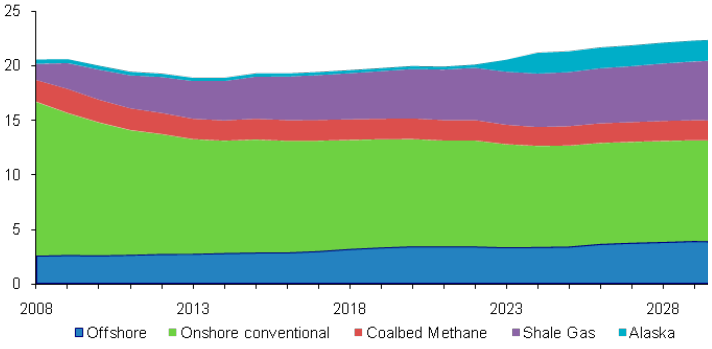
Energy professionals throughout the world are upbeat about the prospects of shale gas. "Shale gas makes the U.S. the Saudi Arabia of natural gas," according to Aubrey McClendon, chief executive officer of Chesapeake Energy.[2] Energy Secretary Steven Chu has called the increased development of shale natural gas a seismic shift in the energy landscape. Today, similar statements are increasingly being heard in the energy sector due to the success of shale gas. Although shale gas was first produced more than 100 years ago, it is now grabbing attention as advancements in drilling technology have lowered costs and increased production.

1. "Woodman: Strong upstream M&A activity forecast in 2011," *Oil and Gas Journal*, January 26, 2011
2. "Shale gas can meet US needs for 100 years – study," ICIS, July 30, 2008

According to the EIA Annual Energy Outlook (AEO) 2011, the United States possesses 2,552 trillion cubic feet (Tcf) of potential natural gas resources.[3] According to Energy Information Administration (EIA), supply of shale gas as a percentage of total gas production increased from 7.2 percent in 2008 to 23 percent in 2010, and is projected to grow further to 46 percent by 2035.[4]

Figure 1 shows natural gas production by source in the United States.

Figure 1: U.S. natural gas production by source, trillion cubic feet, 2008–30



Source: EIA Short Term Energy Outlook, October 2010

1.1 U.S. shale plays

In the United States, shale gas reserves are found across most of the lower 48 states. The major shale plays include the Barnett, Fayetteville, Haynesville, Marcellus, Woodford, and Eagle Ford. In 2009, the Barnett shale play was the most prolific play, accounting for almost 62 percent of the total shale gas production. The second largest production was from the Fayetteville play, accounting for 8 percent of the total production.[5]

Table 1 illustrates the key parameters of the measured shale gas plays in the United States.

Figure 2 shows a map of the U.S. and Canadian shale gas plays.

The rising shale gas production could be a game-changer in the global energy markets because, unlike conventional oil and gas reserves, abundant shale reserves are scattered all over the world. Additional overviews of the key shale plays in the United States in available in Section 2.

Table 1: Key parameters of U.S. shale gas plays

Gas shale basin	Barnett	Fayetteville	Haynesville	Marcellus	Woodford	Eagle Ford
Estimated basin area, square miles	5,000	9,000	9,000	95,000	11,000	20,000[6]
Depth, feet	6,500–8,500	1,000–7,000	10,500–13,500	4,000–8,500	6,000–11,000	4,000–12,000[7]
Net thickness, feet	100–600	20–200	200–300	50–200	120–220	500
Well spacing, acres	60–160	80–160	40–560	40–160	640	NA
Original gas in place, Tcf	327	52	717	1,500	23	11[8]
Technically recoverable resources, Tcf	44	41.6	251	262	11.4	NA
Breakeven cost, US$ per mmbtu[9]	3.7	4.0	3.6	3.3	6.2	4.3

Source: EIA Short Term Energy Outlook, October 2010

3. "Annual Energy Outlook 2011, Early Release," EIA, December 16, 2010
4. "Shale gas is a global phenomena, April 2011," EIA, April 5, 2011 http://www.eia.doe.gov/todayinenergy/detail.cfm?id=811
5. "A Game Changer for U.S. and Global Gas Markets?," EIA, March 2, 2010
6. Eagle Ford Information, Web site of Railroad Commission of Texas, accessed on November 30, 2010
7. Ibid
8. "Pioneer Natural Resources announces Eagle Ford drilling results," *E&P Magazine*, April 14, 2010
9. "Shale gas: Small footprint…big impression!," *Edelweiss*, June 2010
10. "A Primer for Understanding Canadian Shale Gas," National Energy Board, November 2009
11. Ibid
12. "Talisman, Sasol in $1B shale gas deal," Business News Network, March 8, 2011
13. "PetroChina buys stake in Encana shale gas project," BBC News, February 10, 2011

Figure 2: U.S. and Canadian shale gas plays

Source: "North American Shale Plays" EIA, May 9, 2011

Table 2: Key parameters of Canadian shale gas plays

Gas shale basin	Horn River	Montney	Colorado	Utica	Horton Bluff
Depth, feet	8,200–9,850	5,580–13,120	980	1,640–10,830	3,670–6,560+
Net thickness, feet	490	<980	55–1,150	230–980	490+
Published estimate of natural gas, Tcf	144–600+	80–700	>100	>120	262

Source: "A Primer for Understanding Canadian Shale Gas," National Energy Board, November 2009

1.2 Canada

Canada has traditionally been known to possess significant conventional gas reserves and was a key supplier of natural gas to the United States for decades until the recent shale boom in the country. Canada is now trailing the United States in developing its nascent shale gas resources to counter gradual decline in its natural gas production. While still in the initial stages of evaluation, shale gas will likely help the country meet its domestic requirements for natural gas "far into the 21st Century," according to Canada's National Energy Board.[10] Canada potentially holds 1,000 Tcf of shale gas, of which almost 20 percent is considered recoverable. The primary shale plays include the Horn River and the Montney shale plays in northeast British Columbia, the Colorado in Alberta and Saskatchewan, the Utica in Quebec, and the Horton Bluff in New Brunswick and Nova Scotia.[11] The shale gas plays are attracting significant investment from domestic as well as international oil and gas companies. State-owned companies in particular, including Sasol from Africa and Petrochina from Asia, are acquiring stakes in shale gas assets from regional players, such as Encana and Talisman.[12] [13]

Table 2 illustrates the key parameters of the measured shale gas plays in Canada.

Table 3: Key parameters of European shale gas plays

Country	Basin	Play	Top depth range (ft)	Gross thickness range (ft)
Austria	Vienna	Mikulov Fm	16,000	–
Denmark	Norwegian-Danish	Alum	–	525
Germany	Northwest German	Wealden	–	–
		Posidonia Shale	–	115 (avg)
Netherlands	West Netherlands (Anglo-Dutch)	Epen	10,000–13,000	30–6,700; 1,475 (avg)
	Anglo-Dutch	Posidonia Shale	12,500 (max)	25–350; 100 (avg);
Poland	Baltic Depression	Graptolitic Shale	7,000–12,500	500–2,500
	Danish-Polish Marginal Trough	Silurian	13,000	–
	Fore-Sudetic Monocline	Wielkopolska Kulm	3,000–13,000	100–1,000
Sweden	Fennoscandian Border Zone	Alum	–	320 (max)
United Kingdom	Cheshire	Bowland	4,300	4,000
	Weald	Kimmeridge Clay	–	–
		Oxford Clay	–	–
		Lias	–	2,000

Source: "The shale frenzy comes to Europe," March 2010, *E&P Magazine*

1.3 Europe

Unlike the US, Europe has not completely leveraged the potential of its shale gas reserves estimated at 1200 Tcf, with Western Europe accounting for shale gas resources of nearly 510 Tcf. Germany, Poland, Sweden, France, Austria, Hungary, and the UK are presumed to have shale gas reserves.[14] Poland is estimated to have 48 Tcf of unconventional gas, which could increase the EU's proven natural gas reserves by 47 percent, to 101 Tcf, according to Wood Mackenzie estimates.[15]

According to IHS CERA, to assess the commercial viability of the five large plays in Europe, a minimum of 12 exploratory wells will have to be drilled. However, European regulations dictate that even after spending for these wells, there is no guarantee that companies will be granted access to reserves. As a result, there is little incentive for companies to drill further wells.[16]

Table 3 illustrates the key parameters of the measured shale gas plays in Europe.

1.4 China

Largely untapped shale gas reserves in China[17] are expected to become considerable sources of energy. Chinese shale gas reserves are spread across four big provinces including South China, North China, Northeastern China, and Northwestern China. The total shale gas resource estimates range from 21.5 to 45 trillion m^3, with an average estimate of 30.7 trillion m^3.

1.5 India

The shale gas reserves in India[18] are concentrated in the Cambay Basin in Gujarat, the Damodar Basin in Assam, and Gondwana in Madhya Pradesh, Rajasthan, and Jharkhand. According to India's Association of Petroleum Geologists, the country has conventional gas reserves of 39.4 Tcf and preliminary indications are that shale reserves may be larger than these conventional reserves.[19] In the ninth round of New Exploration Licensing Policy bidding (scheduled for March 2011), India is expected to offer 34 oil and gas exploration blocks up for auction.

14. "The Hunt for Shale Gas in Europe," *Economist*, December 3, 2009
15. "Dash for Poland's gas could end Russian stranglehold," *The Sunday Times*, April 5, 2010
16. "Europe may be setting for next shale revolution," *Oil and Gas Financial Journal*, November 1, 2010
17. "Shale Gas in China New Important Role of Energy in 21st Century," Lexis Nexis, November 5, 2009
18. "India Emerges as Shale Gas Hub," *Hindustan Times,* September 1, 2010
19. "India Plans First Shale-Gas Auction to Boost Reserves," *Businessweek*, June 30, 2010

1.6 South Africa

Heavily plagued with power shortages, South Africa realizes the need to turn to alternative energy sources. Its Karoo Basin's (which spans nearly two-thirds of the entire country) shale gas reserves are expected to be significant. Shell has been granted exploration rights in the South Western Karoo Basin by Petroleum Agency South Africa to assess the viable unconventional gas resources. In addition, firms such as BHP Billiton and Sasol have shown interest in gas exploration in the country.[20]

1.7 Colombia

A preliminary estimation of shale gas potential of Colombia reveals a gas reserve of 37 Tcf, calculated based on organic-rich shales, vitrinite reflectance, formation thickness and size of the large structures in the Cordillera. The main shale gas reservoirs are the Turonian-Coniacian sequence, that correspond to the Luna, and Chipaque Formations.[21]

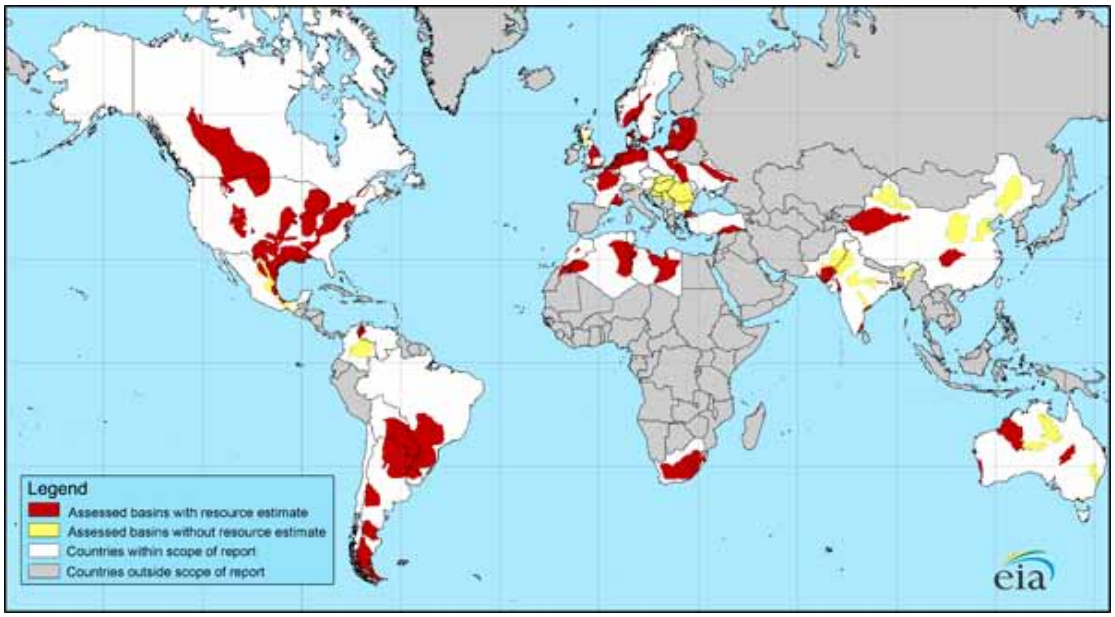
1.8 Argentina

In Argentina, Repsol-YPF recently discovered 4.5 Tcf of shale gas reserves in its Loma de la Lata conventional natural gas field in the Neuquen basin. The total estimated unproved natural gas reserve potential of the newly found play is estimated at 257 Tcf, and is expected to play a vital role in meeting the country's domestic demand for natural gas for decades.[22] The reserve potential is also drawing attention of foreign players including Apache. Steve Farris, CEO of Apache said, "We have significant acreage in the area. All the ingredients are there for a robust unconventional resource."[23]

Industry experts also expect Brazil to start developing its shale gas resources located northeast to support ongoing rapid industrialization in the region.[24]

Figure 3 shows the global distribution of shale gas reserves.

Figure 3: Distribution of global shale gas resources



Source: "Shale gas is a global phenomena, April 2011" EIA, April 5, 2011

20. "Shell awarded permit to study natural gas potential in central South Africa," Shell press release, December 16, 2009
21. "Shale Gas Potential in the Eastern Cordillera of Colombia," Search and Discovery, January 9, 2010
22. "UPDATE 3-Argentina's YPF makes massive natural gas find," Reuters, December 7, 2010
23. "Apache upbeat on Neuquén shale gas potential," *Business News Americas*, February 18, 2011
24. "Argentina gas: Brazil could join shale game," Economist Intelligence Unit, February 25, 2011

2. Overview of U.S. shale plays

2.1 Barnett

The Barnett shale (Figure 4) is located in north-central Texas within the Fort Worth Basin. The play, discovered in the 1950s, was not viable for commercial extraction until the 1980s. The development of drilling technologies and hydraulic fracturing techniques—many of which were perfected in the Barnett shale—has intensified drilling in the play. The commercial success and technology development in the Barnett shale play has established the economic potential of U.S. shale gas production and set the foundation for subsequent developments in other areas.[25] Recently, almost two-thirds of U.S. shale gas production came from the Barnett shale. However, despite the increase in total production in the Barnett shale—as productions in other plays increased over the years—its share of the total has declined.

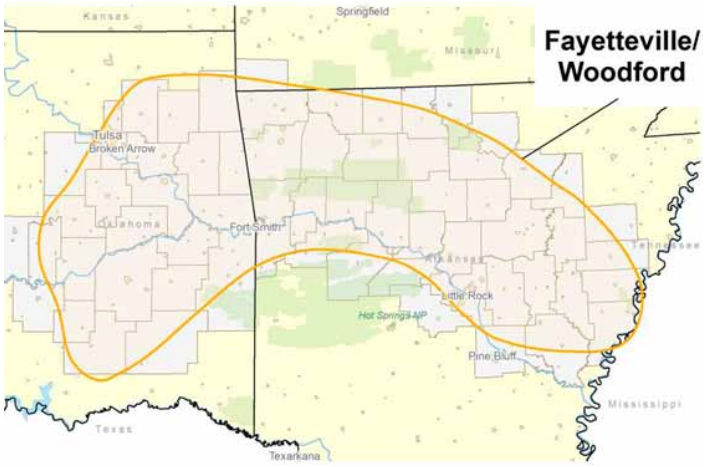
2.2 Fayetteville

The Fayetteville shale (Figure 5) is situated on the Arkansas side of the Arkoma Basin and extends across northern Arkansas from the state's western edge through north central Arkansas. The play, under development for almost a decade, is estimated to hold 52 Tcf of original gas in place. Fayetteville, still far from finished, is attracting significant investments.

Figure 4: Map of the Barnett shale

Source: "Modern Shale Gas Development in the United States: A Primer," U.S. Department of Energy, April 2009

Figure 5: Map of Fayetteville shale



Source: "Modern Shale Gas Development in the United States: A Primer," U.S. Department of Energy, April 2009

25. "US Shale Gas," Halliburton, September 2008

2.3 Haynesville

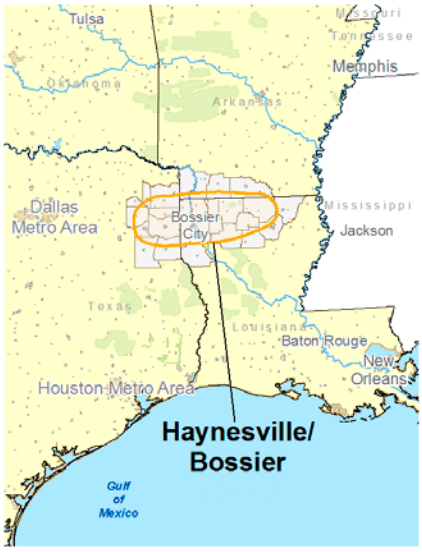
The Haynesville shale (Figure 6) is spread across North Louisiana, North Texas, and South Arkansas. The Bossier shale, also referred to as the Upper Haynesville, lies across East Texas and Louisiana, above the Haynesville shale, and is part of the same formation. Together these plays are referred to as the Haynesville shale.[26] The shale formation is unusually thick—and thicker at higher reservoir pressure. Despite the higher costs of drilling owing to depth and higher pressure, the plays are considered attractive due to the thickness of the shale. Experts believe the Haynesville shale will outproduce the more mature and developed Barnett shale in the future.

Of the two regions of the formation, the Haynesville is more developed, and companies are investing heavily in exploration and production in this region. The Bossier region, where the exploration activity is more recent, is also showing great potential, and early results appear to be as good as Haynesville wells, according to EOG Resources.[27]

2.4 Marcellus

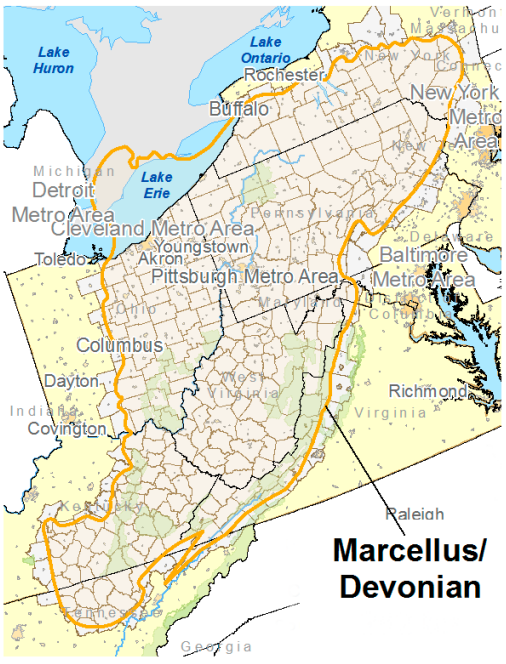
The Marcellus shale (Figure 7) is the most expansive play in the United States, spreading across six northeastern states. The formation covers 95,000 square miles, at an average thickness of 50–200 feet. Despite relatively lower gas contents, the size of its formation makes it the play with highest gas in place. Further, its proximity to population centers in the eastern United States, a major source of demand, makes it one of the most attractive shale plays in the United States.[28]

Figure 6: Map of the Haynesville shale



Source: "Modern Shale Gas Development in the United States: A Primer," U.S. Department of Energy, April 2009

Figure 7: Map of the Marcellus shale



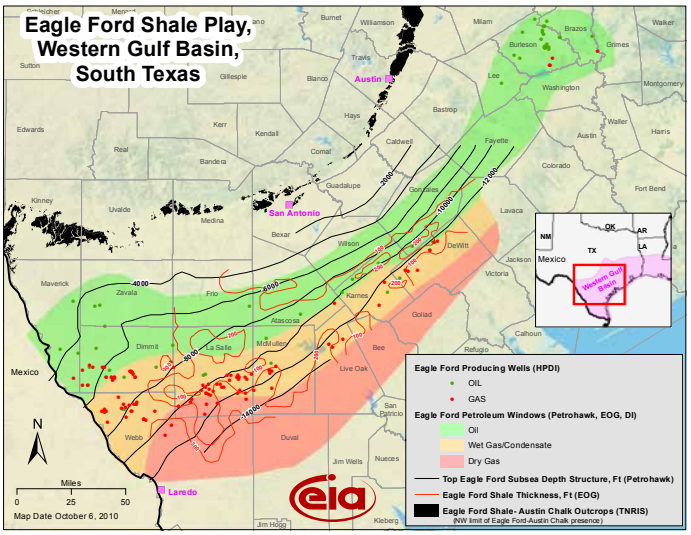
Source: "Modern Shale Gas Development in the United States: A Primer," U.S. Department of Energy, April 2009

26. "Watch For The Bossier Shale In 2010," Investopedia, December 30, 2009
27. "Bossier Shale: The Natural Gas Source the Market Doesn't Need," Investopedia, December 30, 2009
28. "A Review of Shale Gas Plays In North America," Gerson Lehrman Group, August 24, 2010
29. "Woodford Shale," *Oil & Gas Financial Journal*, Accessed on November 23, 2010

Figure 8: Map of the Woodford shale

Source: "Modern Shale Gas Development in the United States: A Primer," U.S. Department of Energy, April 2009

Figure 9: Map of Eagle Ford shale



Source: "Eagle Ford Shale," Energy Information Association

2.5 Woodford

The Woodford shale (Figure 8), under development for the past 10 years, is in southeast Oklahoma. Since 2005—when Devon Energy drilled the first well in the play—a large number of companies have acquired acreage and launched drilling programs in the Woodford shale play. After the Barnett, the Woodford is the oldest shale play in terms of production.[29]

2.6 Eagle Ford

The Eagle Ford shale (Figure 9) is located directly below the Austin Chalk in South Texas and runs from Houston to Laredo. The play, with average thickness of approximately 500 feet, produces both natural gas and oil. However, only the oil-producing and gas condensate areas are currently active.[30]

Explorations in the Eagle Ford are in earlier stages, compared with those in the other major U.S. shale plays such as Barnett, Haynesville, and Fayetteville. In addition to smaller energy ventures that paved the way, major producers are increasingly moving in to the Eagle Ford.[31]

30. "A Review of Shale Gas Plays In North America," Gerson Lehrman Group, August 24, 2010
31. "Shell raises natural gas stake with S. Texas lease," Chron Energy, March 27, 2010
32. "WoodMac: Strong upstream M&A activity forecast in 2011," *Oil and Gas Financial Journal*, January 2011

2.7 Other shale plays in the United States

Other shale gas plays (Table 4) being developed in the United States include Cody, Mancos, Lewis, Pierre, Antrim, New Albany, Granite Wash, and Collingwood.

Table 4: List of other oil plays in the United States

Shale play	Region
Cody	Montana
Mancos	Colorado, Utah, and New Mexico, the Piceance, Uinta, and San Juan Basins
Lewis	Greater Green River Basin
Pierre	South Dakota, Colorado, Minnesota, New Mexico, Wyoming, and Nebraska
Antrim	Michigan Basin
New Albany	Illinois, Indiana, and Kentucky
Granite Wash	Texas and Oklahoma
Collingwood	Michigan

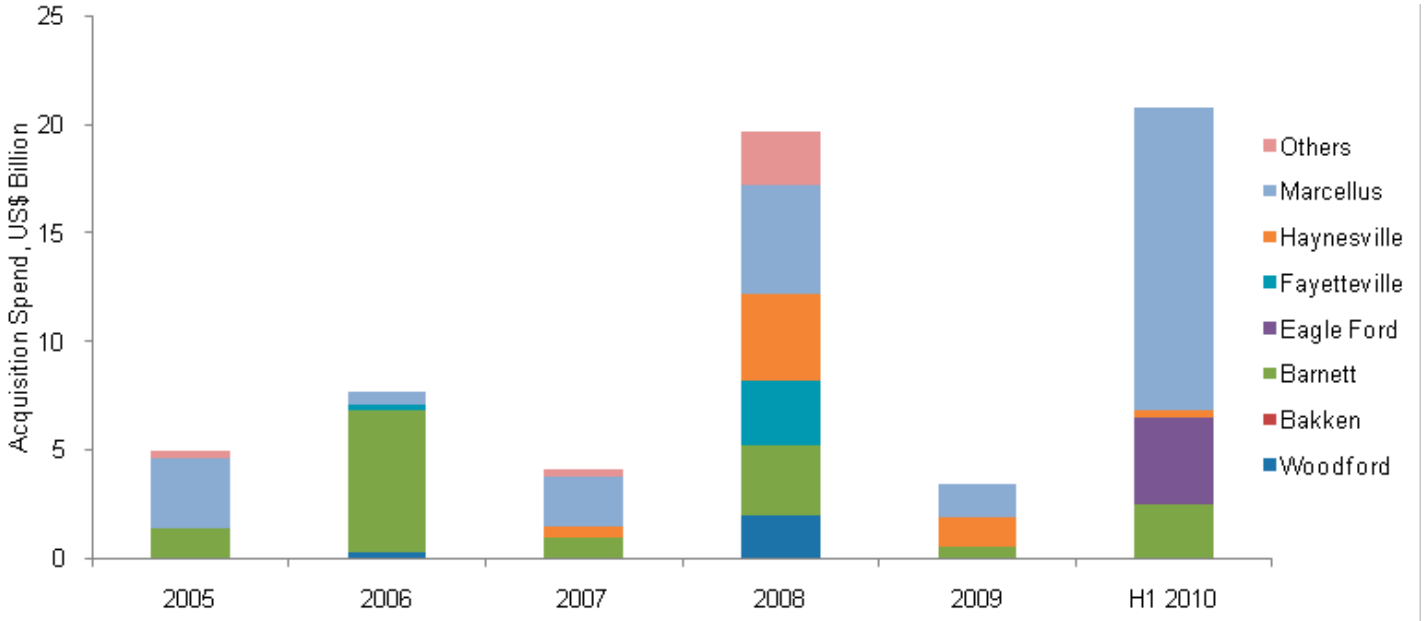
Source: "US Shale Gas Brief" Phasis, September 2008

3. Summary of key deals

Consolidation in the industry is on the rise as the global economy recovers from the recession and tight liquidity conditions. In 2010, total M&A activity in the U.S. shale gas segment was US$39 billion—equivalent to around one-fifth of global upstream M&A value in 2010.[32] This is well above the deal value of US$2 billion (2009) and US$19.7 billion (2008) in this segment.[33]

Most of the deals over the past few years share a similar pattern. Smaller companies enter shale plays early and acquire significant acreage positions. Once the plays become commercially attractive, they sell off their stakes to bigger players to minimize their capital commitments. Another strategy being adopted, mostly by the majors, is to gain technology through an outright acquisition. Smaller companies undertaking M&A for acreage and technology are often backed by financial buyers and independents that provide the necessary finance.

Figure 10: Shale gas acquisition spending by play, 2005–H1 2010



Source: "WoodMac: Majors Buying into Shale Gas Plays," *Oil & Gas Journal,* October 2010

3.1 Acquisitions

A summary of the largest announced shale M&A deals by a strategic acquirer since 2009 is as follows:

Table 5: Summary of M&A deals

Companies involved	Date	Deal size (US$million)	Summary
BHP Billiton (Australia) buys Fayetteville assets from Chesapeake (U.S.)	February 2011	4,750	BHP will gain entry into the U.S. shale gas market and secure significant production position, expanding its net reserve and resource base by 45 percent. The acquisition supports the company's strategy of geographic diversification and inorganic investment in long-life, low-cost assets.[34]
Chevron (U.S.) buys Atlas Energy (U.S.)	November 2010	3,200	Chevron will gain access to Atlas' 850 billion cubic feet of proved natural gas reserves with approximately 80 million cubic feet of daily natural gas production, mostly in the Marcellus and other fields in the East and Midwest United States. Atlas' shale gas assets include 486,000 net acres of Marcellus shale and 623,000 net acres of Utica shale.[35]
Acquisition of East Resources (U.S.) by Royal Dutch Shell (The Netherlands)	May 2010	4,700	East Resources has 650,000 net acres in the Marcellus Shale and 1.05 million net acres overall. This acquisition will help Shell to increase its daily natural gas production by 7.5 percent.[36] All together in 2010, Shell has added some 1.3 million acres (5,250 square kilometers) of North America tight gas acreage. Shell estimates that these new positions could yield over 16 trillion cubic feet of gas equivalent (tcfe) of resources.[37]
Consol Energy acquired Dominion Resources Inc.'s natural-gas business	March 2010	4,700	Consol Energy will gain exposure to Marcellus shale formation and increase its proved gas reserves by around 50 percent to about 3 Tcf. This will allow the company to reduce coal leverage and the impact of potential carbon regulation.[38]
Acquisition of XTO Energy (US) by Exxon Mobil (US)	December 2009	30,000	XTO has gas reserves of 45 Tcf, including shale gas, tight gas, coal bed methane, and shale oil. The XTO acquisition will boost Exxon's resource base by about 10 percent. If the deal is approved by regulators, Exxon will become the top natural gas producer in the United States.[39]

33. "M&A expenditures total $21B for US Shale gas in first half of 2010," Penn Energy, September 30, 2010
34. "HP Billiton Announces Acquisition Of Chesapeake Energy Corporation's Fayetteville USA, Shale Assets," BHP Billiton press release, February 2011
35. "Chevron to Buy Atlas Energy in $4.3 Billion Deal," *Industry Week*, November 10, 2010
36. "Shell pays $4.7 billion for shale gas company," Reuters, May 28, 2010
37. "Royal Dutch Shell plc acquires new positions in US tight gas," Shell, May 28, 2010
38. "Consol to buy Dominion gas assets for $3.48 billion," Reuters, March 2010
39. "Exxon Mobil to buy XTO Energy in $41 billion deal," MarketWatch, December 14, 2009

3.2 Joint ventures

Table 6 gives a summary of the most significant joint ventures formed since 2009.

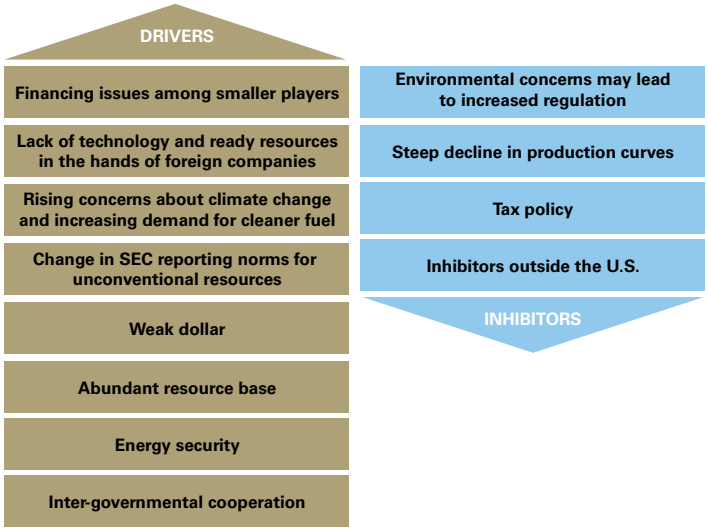
Table 6: List of major joint ventures

Companies involved	Date	Deal size (US$million)	Summary
Chesapeake Energy (U.S.) and CNOOC (China)	October 2010	1,100	CNOOC will provide funds to Chesapeake for drilling and completion in the liquid-rich Eagle Ford shale play. CNOOC will benefit by gaining exposure to complicated shale gas extraction technology that it lacks.[40]
Statoil (Norway) and Talisman Energy (Canada)	October 2010	1,325	The 50/50 JV will develop assets in the Eagle Ford shale, comprising 97,000 net acres. In addition, Statoil will acquire half of Talisman's existing 37,000 acres of Eagle Ford properties, leaving the Norwegian group with total net control over 67,000 acres.[43] The companies have an option to jointly acquire further 22,000 net acres.[44]
Sumitomo (Japan) and Rex Energy (U.S.)	September 2010	140	Sumitomo bought a 30 percent stake in the Marcellus shale region. It also agreed to fund 80 percent of Rex Energy's remaining share of drilling and completion costs until the US$52 million drilling carry is fully utilized. This deal is in alignment with Sumitomo's plan to have 150 billion yen of energy assets by 2015.[45]
Reliance (India) and Carrizo Oil & Gas (U.S.)	September 2010	392	The JV agreement covers approximately 104,400 gross acres in northern and central Pennsylvania. Carrizo retains a 40 percent working interest in the acreage and Reliance owns the rest. Reliance will fund 75 percent of Carrizo's portion of these costs over the next two years or until the earlier full utilization of the US$52 million development carry, subject to certain conditions and extensions. Carrizo will continue as operator with Reliance having the right to assume operations in certain parts of central Pennsylvania after one year.[46]
Reliance (India) and Pioneer Natural Resources (U.S.)	June 2010	1,360	The deal gives Reliance a 45 percent stake in the venture's Eagle Ford shale play. Reliance will provide US$266 million in cash, and $879 million to carry Pioneer's share of future drilling costs. The drilling plan will enable Pioneer to meet its lease commitments by the end of 2012.[47]

40. "China's CNOOC tests U.S. with Chesapeake shale deal," Reuters, October 11, 2010
41. "Total in $2 bln shale gas tie-up with Chesapeake," Reuters, January 4, 2010
42. "Statoil Buys Additional Shale Acres From Chesapeake," Bloomberg, March 26, 2010
43. "Statoil in $1.3bn shale deal with Talisman," FT, October 10, 2010
44. "Statoil, Talisman Team Up in Eagle Ford JV," Rigzone, October 11, 2010
45. "Sumitomo Plans to Boost Energy Assets by 50 Percent," *Businessweek*, September 3, 2010
46. "Carrizo Oil & Gas Announces Closing of Marcellus Shale Joint Venture With a Subsidiary of Reliance Industries," Moneycontrol, September 10, 2010
47. "Reliance buys 45 percent in U.S. shale gas JV," Reuters, June 24, 2010
48. "BG pays $950m in latest US shale gas deal with Exco," *The Telegraph*, May 10, 2010
49. "BG Group announces US Appalachian Basin joint venture," BG Group, May 10, 2010
50. "Eni moves on Barnett Shale play," Upstream Online, May 18, 2009
51. "Eni signs with Quicksilver Resources a strategic alliance in US onshore unconventional gas," ENI, May 18, 2009

Companies involved	Date	Deal size (US$million)	Summary
BG Group (U.K.) and Exco Resources (U.S.)	May 2010	950	BG will provide US$800 million in cash and the rest toward drilling costs for a 50 percent share in a total of 654,000 net acres in the Appalachian basin. The transaction increases BG's net gas resources by 2.4 Tcf.[48] This JV agreement provides critical mass to BG Group's U.S. upstream gas business, with total resources estimated at more than 7 Tcf, equivalent to more than 1.2 billion BOE.[49]
Chesapeake Energy (U.S.) and Statoil (Norway)	March 2010	253	Statoil added 59,000 net acres at Marcellus shale to the 600,000 acres that it acquired in 2008.[42]
Chesapeake Energy (U.S.) and Total (France)	January 2010	2,250	Total will purchase a 25 percent stake in the Barnett shale gas fields. It will fund 60 percent of Chesapeake's share of drilling and completion costs until 2010. The joint venture (JV) includes about 270,000 net acres of leaseholds in the Barnett, 700 million cubic feet of daily gas output, and gas reserves of 3 Tcf. Total estimated the expanse at about 300,000 net acres. The deal will increase Total's daily production by 30,000 barrels of oil equivalent (BOE) of gas.[41]
Eni S.p.A. (Italy) and Quicksilver Resources (U.S.)	May 2009	280	Eni acquired 27.5 percent stake in 270,000 acres in Barnett shale from Quicksilver Resources. The deal includes the sale of 131 billion cubic feet of proved reserves. Eni's share is likely to be around 4,000 barrels of oil equivalent per day (BOED), increasing to 10,000 BOED in 2011.[50] The deal will give Eni recoverable net reserves of 40 million BOE, of which 23 million BOE are proved and 17 million BOE are probable and possible reserves, at an implied cost per barrel of US$7. [51]

4. Investment drivers and inhibitors



4.1 Drivers

Financing issues among smaller players

Although costs have dropped in the past few years, the high initial testing costs and subsequent development costs of shale reserves are daunting. Smaller companies, especially those having high levels of debt, are unable to fulfill their drilling commitments and are entering into JVs with larger, cash-rich companies that are ready to share some of the drilling costs. The need for capital is often the most important driver of JVs in the shale gas segment.

For instance, the US$2.2 billion JV deal between Chesapeake Energy and Total gives the latter a 25 percent stake in the Barnett shale gas fields. In return, Total will fund 60 percent of Chesapeake's share of drilling and completion costs until 2010.

Lack of technology and ready resources in the hands of foreign companies

Until now, only a few U.S.-based companies have developed expertise in horizontal drilling and hydraulic fracturing—critical technology in shale gas production, positioning the United States to lead shale gas development activity. Foreign companies, particularly from resource-seeking countries, such as Reliance (India) and CNOOC (China) are signing JV deals with U.S. companies to gain experience and replicate the shale gas success in their home countries as a move toward energy self-sufficiency. India will launch its first ever auction of shale gas blocks in 2011 and Reliance is likely to bid, with technical assistance from a foreign partner.[52] Additionally, the majors are extending their partnerships and exploring shale reserves in other parts of the world. For instance, the deal between Statoil and Chesapeake Energy provides for the global exploration of shale gas. The two companies, along with Sasol (South Africa), have submitted a joint application to explore for shale gas in the Karoo Basin in South Africa.[53] Meanwhile, Shell and PetroChina have begun work on developing shale resources in China's Sichuan province.[54]

Rising concerns about climate change and increasing demand for cleaner fuel

Although renewable energy sources such as wind and solar will play important roles in the long term, technological and economic constraints as well as the lack of commercial scalability will prevent them from being a significant part of the energy supply mix in the immediate future. In the intermediate period, abundant natural gas could well be the holy grail of clean energy, as it is the cleanest burning fossil fuel containing the lowest carbon content. Many power utilities, the largest consumers of coal, may shift to gas-fired plants if prices remain under US$7 per mmbtu and gas producers agree to long-term contracts. According to Shell CEO, Peter Voser, "In the short term, we should focus on areas where we can get the cheapest and quickest carbon dioxide reductions." Referring to the shale reserves in the United States and China, he further added, "So there is ample gas available, and it is cheaper than nuclear power, so it is clearly something in which we can invest." Gas prices are currently around US$4 per mmbtu and are likely to remain weak over the short term. Hence, the increasing preference for clean fuel such as natural gas is driving interest in this segment.

Change in SEC reporting norms for unconventional resources

According to the new Securities and Exchange Commission (SEC) reserves reporting standards, companies can now include unconventional resources such as shale gas in their reserve base. As reserves represent the growth potential of a company to an investor, these new provisions are extremely

52. "RIL turns focus on domestic shale gas, awaits govt nod," *Financial Chronicle*, June 30, 2010
53. "Sasol-Chesapeake-Statoil apply to explore for shale gas in Karoo," *Mining Weekly*, March 19, 2010
54. "Shell, PetroChina to Develop Shale Gas in Sichuan," Rigzone, November 27, 2009

favorable to oil and gas companies. It will help investors to calculate future cash flows and lead to better valuation of a company. Those companies having large unproved reserve bases are attractive targets for cash-rich international majors.

Weak dollar

Over the past few years, except for a brief period during the peak of the economic crisis in early 2009, the U.S. dollar has been depreciating against currencies such as the Japanese yen and the Indian rupee. For instance, the yen has appreciated 10 percent against the dollar this year. With the recent quantitative easing by the Federal Reserve, it is likely that the dollar may further weaken against major global currencies. Cash-rich foreign companies benefit as appreciation of domestic currencies helps to reduce the cost of purchasing assets in the United States.

Abundant resource base

The United States has abundant shale reserves. There are various estimates about the size of possible reserves; however, most agree that they are sufficient to satisfy natural gas demand for many decades. Although the valuation of many plays has increased, the huge resource base provides sufficient opportunities for consolidation. Even when natural gas prices are weak, liquids-rich plays such as the Eagle Ford are expected to command premium valuations due to higher realized prices of natural gas liquids (NGLs). Moreover, with advancements in drilling and improved productivity, the economics of shale gas are improving. For instance, a pure natural gas play such as Haynesville is attractive because of low production costs and huge production value.

Energy security

Tapping domestic shale gas reserves and greater use of natural gas is an important step to achieve energy security. Currently, in the United States, natural gas accounts for 28 percent of the total primary energy production.[55] Given the increased supply of gas over the next few years, it has the potential to displace traditional oil-based fuels, provided it is priced competitively. Laws promoting natural gas vehicles have been passed in the United States and if the supporting infrastructure is put in place and more gas-based vehicles are purchased by consumers, oil imports could decline.

Meanwhile in Europe, nearly 25 percent of the natural gas flowing into the region via Ukraine is transported by Gazprom, the Russian national gas transmission company.[56] In the past, Europe has often been held hostage to decreased gas supplies due to differences between Russia and Ukraine.[57] If Poland, Germany, Hungary, and other countries are able to commercially extract shale gas, Gazprom's and thereby Russia's influence on Europe could reduce.[58]

Inter-governmental cooperation

The U.S. State Department—through the Global Shale Gas Initiative—is collaborating with many foreign governments to analyze local shale gas potential.[59] As a part of this program, in November 2009, the United States and China formed a shale gas initiative to promote the development of shale gas resources in China. The U.S. Geological Survey has also offered to study the shale basins in India and train Indian geologists in exploiting shale reserves. Further cooperation in this sector was also a part of President Obama's agenda when he visited India in November 2010.

4.2 Inhibitors

Environmental concerns may lead to increased regulation

Shale gas production has increased due to new drilling techniques called hydraulic fracturing or "fracking." The process involves blasting of the reservoir rock with a combination of sand, water, and chemicals at high pressure. The drilling and fracturing of wells requires millions of gallons of water, which presents a challenge in water-deficient areas. Moreover, there is concern over water contamination resulting from the improper disposal of fluids. Concerns have also been raised that chemicals may migrate into drinking water sources, posing threats to human health and the environment. Politicians and environmentalists wanted the companies to disclose the chemicals used for fracking. Many companies refused to do so, insisting that the formulations were trade secrets and any disclosure would lead to loss of competitive advantage. However, as public pressure mounted, companies such as Halliburton, Chesapeake Energy, and Range Resources recently started to reveal the ingredients of hydraulic fracturing fluids.[60]

55. "Annual Energy Outlook 2010 with Projections to 2035," EIA, May 11, 2010
56. "Russia's Medvedev Visits Algeria to Discuss European Gas Exports," Bloomberg, October 5, 2010
57. "Behind the Russia-Ukraine Gas Conflict," *Businessweek*, January 3, 2009
58. "Shale Gas Could Alter Balance between Russia, Europe," Rigzone, September 24, 2010
59. Web site of U.S. Department of State, accessed on October 20, 2010
60. "Halliburton to disclose frac chemicals," Upstream Online, October 22, 2010

The environmental risks associated with shale gas production have led to increased government and regulatory oversight. In June 2009, Democrat members in the Congress introduced the Fracturing Responsibility and Awareness of Chemicals Act. The act amended the federal Safe Water Drinking Act by bringing hydraulic fracturing under federal purview.[61] Additionally, in March 2010, the Environmental Protection Agency (EPA) decided to undertake a study to understand the consequences of shale gas drilling on the environment and human health.[62] A board called the Hydraulic Fracturing Study Plan Review Panel, comprising geologists, engineers, toxicologists, and doctors, will peer-review the analysis and techniques used in the study, which may be released in 2012.[63] The states of Texas and New York recently proposed to monitor shale gas drilling. The Texas Commission on Environmental Quality has proposed to strengthen drilling regulations in the Barnett shale region.[64] Meanwhile, the New York Senate voted for a temporary moratorium until May 2011, to review concerns over the extraction of shale gas.[65]

Steep decline in production curves

Unlike production from conventional oil and gas fields, production from shale plays is characterized by high initial rates followed by a rapid decline. Higher production in the initial years improves economics of the shale gas fields. The results from the Haynesville play indicate that production peaked in 2008 and that it has now started to stabilize.[66] Moreover, the increasing number of fracture treatments has failed to increase output. So far, most of the gas has been produced from the most prolific area of the play and it is doubtful if gas from outer areas would be economically viable at current low prices. It seems that production from newer plays such as Haynesville is maturing at a faster rate than older plays such as Barnett. Although it is too early to draw conclusions, high valuations of some of the recent deals may be questioned.[67]

Tax policy

The US tax policy, implemented in 2004, has favored oil and gas development over the years and helped draw investments to the high-risk sector. Nevertheless, debates continue to surround federal support to the industry and surfaced yet again in early 2011 with Obama's proposal to withdraw US$4 billion-a-year tax breaks for oil and gas companies.[68] The proposal seeks to withdraw the intangible drilling cost (IDC) expensing provision that presently allows independent producers to expense drilling costs in the year they are spent. According to Independent Petroleum Association of America (IPAA), withdrawal of the provision is likely to reduce investments made by independent producers in the sector by one-third, which may pressure production from higher-cost shale operations.[69] Also, under the U.S. taxation system, all mineral resources may use the percentage depletion method to reflect the decreasing value of the resource as it is produced; however, in the oil and gas industry, usage is restricted only to independent producers and royalty owners, and that too only on U.S. production. "The US offers little in the way of fossil fuel subsidies, compared to other nations, as the IEA reports… The Administration should focus on making the US more competitive for corporate activities instead of targeting energy firms for punitive tax treatment."[70]

Each of President Obama's three budget proposals have included the repeal of a number of tax incentives for domestic oil and gas production which, if enacted, would result in significant tax increases on oil and gas companies with production in the United States. The net effect of the proposals would be to increase the cost of capital for domestic production (including shale gas and oil) causing a reduction in domestic production and a greater reliance on imports from increasingly volatile foreign markets. Further, this could also cause significant revenue reductions in federal and state mineral lease bonus payments and royalties.

61. "Water Contamination Concerns Linger For Shale Gas," NPR, September 23, 2009
62. "EPA begins study on shale gas drilling," Reuters, March 18, 2010
63. "Peer-review panel for EPA fracking study includes six Pa. scientists," *The Times Tribune*, January 18, 2011
64. "Devon and Chesapeake are top ranked companies in Barnett Shale production," *Oil and Gas Financial Journal*, August 1, 2010
65. "Shale gas extraction: Investors aim to profit from US experience," *Financial Times*, October 29, 2010
66. "Shale Economics: Watch the Curve," Oil and Gas Evaluation report, March 17, 2010
67. "New Research Questions Haynesville Shale Economics," *Energy Tribune*, February 19, 2010
68. "Obama's Bid to End Oil Subsidies Revives Debate," *New York Times*, January 2011
69. "Tax Discussion for Independent Oil and Natural Gas Producers, 112th Congress," IPAA, February 2011
70. "IEA Study Ranks Nations' Subsidies to Fossil Fuel Consumption," The Tax Foundation, November 2011

Two other oil and gas provisions that are identified by the President's budget for repeal are the section 43 enhanced oil recovery credit and the section 451 credit for producing oil and gas from marginal wells.

Table 7: Summary of tax provisions

Name of deduction	Current deduction	Budget proposal	Potential impact on industry
1. Section 199 manufacturing deduction with regard to oil and gas produced and sold in the United States	Six percent of qualified income from oil and gas production is deductible. The deduction for all other industries is scheduled to increase to 9 percent of qualified income beginning in 2010.	Repeal the deduction for oil and gas producers in its entirety.	• The proposal may reduce capital available for drilling wells in the United States. • Oil and gas drilling and producing jobs may be lost. • Over time, domestic production could decrease as drilling moves overseas. • Independent producers may be affected the most because these producers count on the deduction as a means to increase cash flow for domestic drilling.
2. Section 167(h) amortization of costs incurred for geological and geophysical exploration work on mineral properties	In 2005, Congress enacted section 167(h), which provided that all geological and geophysical costs not otherwise deductible as IDC were to be capitalized and amortized over a 24-month period. Since 2005, the amortization period has been extended to seven years for major integrated oil companies.	Extend the seven-year amortization period to independent producers.	• The proposal may increase the cost of this exploration work to independent producers. • The proposal may reduce cash flow available for exploration and development in the United States.
3. Section 193 deduction for qualified tertiary injectant expenses on enhanced oil recovery projects	The deduction was enacted in 1980 as an incentive for producers to initiate tertiary recovery projects principally in mature oil fields otherwise experiencing production decline. These projects are capital intensive and typically involve injecting carbon dioxide or other qualified substances into the oil reservoir.	Repeal the deduction.	• Tertiary recovery projects would become more expensive to initiate and maintain. • As these projects decline over time, domestic reserves that otherwise could be produced may be left in the ground. • Domestic oil production could decline, possibly leading to increased dependence on foreign oil and higher prices for oil.
4. Working interest exception to the section 469 passive activity loss disallowance rules	Individuals, trusts, estates, and closely held C corporations owning working interests in oil and gas properties directly or through entities that do not limit the liability of the taxpayer with respect to such interests need not meet the material participation rules in order to deduct losses incurred from producing those interests.	Repeal the working interest exception.	• The proposal may reduce the incentive for certain taxpayers to invest in oil and gas exploration and production operations. • Reduced investment and availability of capital could lead to reduced domestic production, increased dependence on foreign oil, and higher prices for oil and gas.

Source: Shale Gas Outlook, KPMG Internationl, 2011

Congress has not enacted any of these proposals and does not appear likely to do so in the near future. However, these proposals are likely to remain in any of President Obama's future budgets as they will provide projected revenue increases to reduce the projected deficit impacts in those budgets.

4.3 Inhibitors outside the United States

The geology of every shale play is unique and there is no guarantee that operational processes used in the US will be successful in other parts of the world. EIA has estimated that Europe potentially has 639 million cubic feet of shale gas reserves, however, the depth of the resources is belived to be 1.5 times greater than the depth of U.S. shale gas. The Oxford Institute for Energy Studies estimated the cost in Europe could reach $16.20 per thousand cubic feet, far above the current cost of gas imports from Russia and Africa.[71]

Exploiting shale reserves needs abundant water supply and while this may not be a problem in the United States, this is an issue in countries such as India and parts of the EU where population density is greater. Also, infrastructure such as rigs and gas pipeline network in other parts of the world is not adequate and as well developed as in the United States. For instance, India has just 10,800 kilometers of natural gas pipelines, while the United States has nearly 491,050 kilometers of interstate and intrastate pipelines.[72, 73] Additionally, tighter environmental standards in the EU may increase costs or result in fracking being banned. For example, the French Senate will start debating a proposed law to ban the use of hydraulic fracturing except for scientific projects. This bill is different than the bill passed by the National Assembly in May which would impose fines, jail time, and cancellation of permits if explorers used the fracking technique.[74]

71. "Formidable Obstacles Noted to Possible European Shale Gas Boom," *Wall Street Journal*, June 1, 2011
72. "India to add 7,450 km to gas pipeline network in 3 yrs," *Economic Times*, March 22, 2010
73. About U.S. Natural Gas Pipelines, Web site of EIA, accessed on November 24, 2010
74. "French Senate to Debate Shale Law Allowing 'Scientific' Fracturing," Bloomberg, May 30, 2011

5. Implications

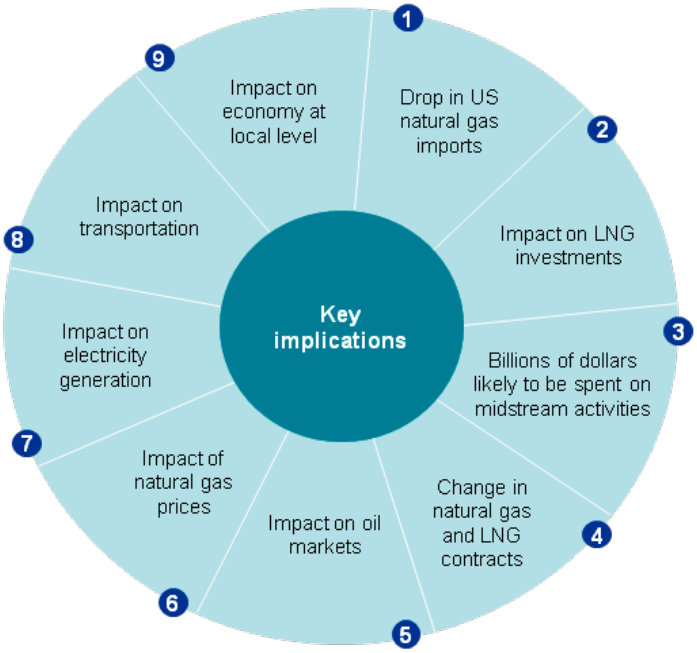
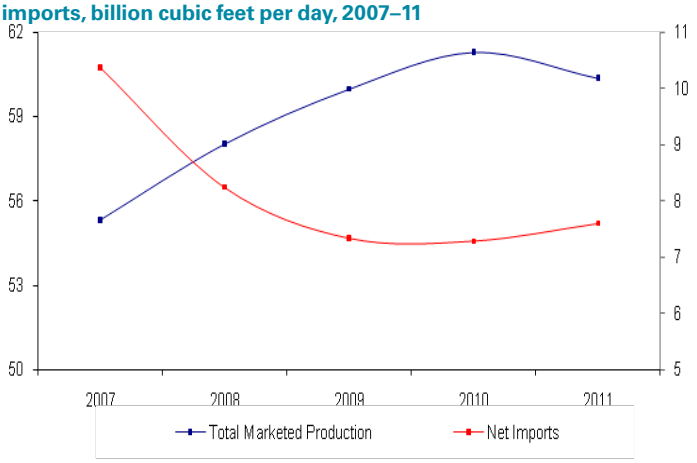


Figure 11: Domestic natural gas production and net imports, billion cubic feet per day, 2007–11



Source: EIA Short Term Energy Outlook, October 2010

The rising shale gas production—currently in the United States and expected to follow in other parts of the world—can have profound implications on the global energy sector. Some of these are discussed below.

5.1 Drop in US natural gas imports

For years, the United States has faced a scarcity of natural gas. In 2003, the National Petroleum Council warned that "North America is moving to a period in its history in which it will no longer be self-reliant in meeting its growing natural gas needs; production from traditional US and Canadian basins has plateaued."[75] Many analysts predicted that the country would have to import natural gas to satisfy its needs. Even as recently as 2006, many analysts forecasted that the United States would be dependent on LNG imports to meet its demand.[76] However, rising domestic natural gas production turned this prediction on its head. Imports are likely to fall from 10.4 billion cubic feet per day (bcfd) in 2007 to 7.6 bcfd in 2011—a decline of nearly 27 percent.

Figure 11 shows the drop in natural gas imports.

The increasing domestic natural gas production is largely due to growth in unconventional sources such as shale and coal bed methane. The combined share of coal bed methane and shale gas in the total gas supply may increase from 16.8 percent in 2008 to 32.8 percent in 2030, according to the Energy Information Administration (EIA). Between the two, shale gas production is projected to increase the most—contributing 25 percent of the total gas supply by 2030.[77]

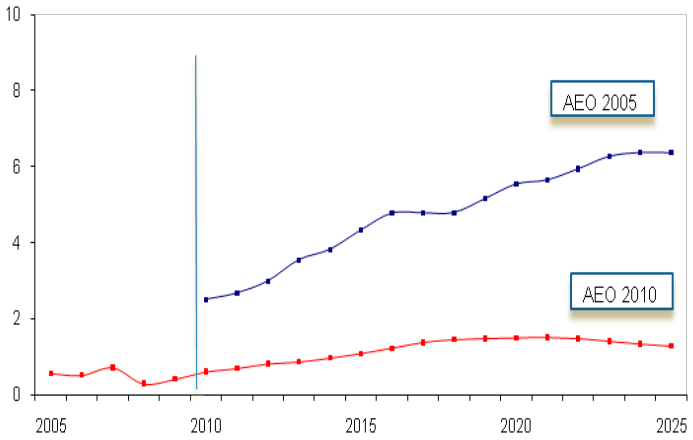
75. "Meeting future natural gas demand requires a balanced energy policy," National Petroleum Council, September 25, 2003
76. "North American LNG Outlook," Corporation for Public Access to Science and Technology, September 15, 2006
77. "Annual Energy Outlook 2010 with Projections to 2035," EIA, May 11, 2010

5.2 Impact on LNG investments

In the United States, increased natural gas supplies may jeopardize billions of dollars of investment in new LNG terminals, at least in the short term. The United States has always been a market of last resort, and LNG operators depended on the United States to off-take any excess gas in the global LNG market. Due to excess domestic gas in the United States, LNG cargoes originally intended to be shipped to the United States are now being directed to markets in Asia and Europe, which may further depress LNG prices in these regions. This impact is already being felt, as the Russian gas company Gazprom recently indicated that it would delay LNG production from its Shtokman field by another three years.[78] While Gazprom originally planned to ship around 90 percent of the LNG to the United States, it has now been forced to explore other markets. Moreover, market conditions have forced many U.S. companies to put their LNG re-gasification projects on hold, despite having received regulatory approval. In fact, the originally planned LNG import terminals may be converted to liquefaction terminals for exports. Additionally, over the past five years, the EIA has lowered its forecasts for U.S. LNG imports.

Figure 12 shows the drop in LNG import forecasts made in the Annual Energy Outlook (AEO) 2010 compared to that made in 2005.

Figure 12: U.S. LNG imports forecasts, trillion cubic feet, 2005–25



Source: EIA AEO 2005 and AEO 2010

5.3 Billions of dollars likely to be spent on midstream activities

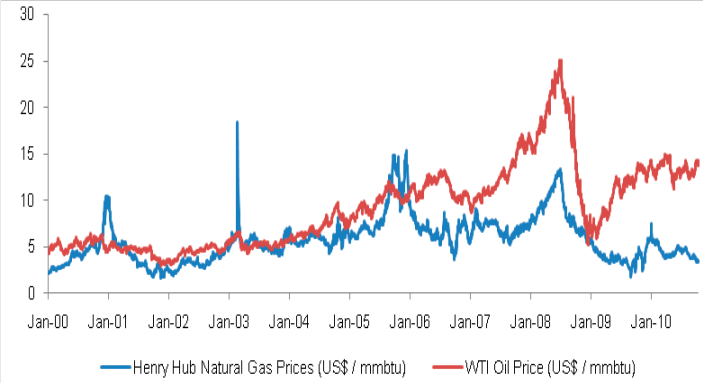
The increasing shale gas supply has provided opportunities to midstream companies to build new infrastructure for additional processing and transportation. The Haynesville and Eagle Ford regions may require investments of US$10 billion. However, the largest investments are likely to be made in the Marcellus play; investments up to US$100 billion are forecast over the next 20 to 25 years.[79] This has led to a rush among companies to raise capital for their midstream activities. The largest Initial Public Offering (IPO) in 2010 was by Chesapeake Energy when it launched Chesapeake Midstream Partners by raising US$513 million.[80] Kinder Morgan filed an IPO in early 2011, with proceeds reaching US$2.3 million.[81]

5.4 Change in natural gas and LNG contracts

A structural shift in the framework and duration of natural gas and LNG contracts can occur due to the changing supply equations of oil and natural gas. Traditionally, prices of crude oil and natural gas have exhibited some correlation on an energy equivalency basis, despite differences in the global markets for the commodities. However, an analysis of the Nymex crude and Henry Hub gas prices, particularly over the past couple of years, reveals that prices are gradually being delinked due to changes in global consumption patterns and supply factors.

78. "Gazprom delays giant Shtokman gas field by 3 years," Reuters, February 5, 2010
79. "Caiman Energy Looks East for Natural Gas," *D Magazine*, October 13, 2010
80. "Shale-gas opens golden opportunities for midstream players," *Pipeline and Gas Technology*, October 1, 2010
81. "Kinder Morgan Inc Announces Gearing Up For $2.3 Billion IPO," Reuters, January 2011

Figure 13: Widening price differential between natural gas and crude oil , January 2000–October 2010



Source: EIA; Thomson 3000

Figure 13 shows the widening price difference between natural gas and crude oil over the last two years.

While natural gas contracts in the United States are linked to Henry Hub gas prices, those in other parts of the world (transnational pipeline gas and LNG) are linked to crude oil prices. Over the past year, natural gas prices in the United States have been declining due to the increase in supply, while natural gas prices in other parts of the world remain high due to the rise in oil prices. However, producers argue that even now, natural gas is far cheaper than oil, on an energy equivalent basis. In spite of this argument, major consumers in Europe and Asia are likely to push for contracts linked, at least partially, to natural gas prices. They would do so with the hope that gas prices would better reflect gas market fundamentals.

Producers and consumers in the United States are also sparring over the duration of contracts. Previously, producers preferred short-term contracts, as they could benefit when gas prices rose in winter and other occasions, while consumers preferred long-term contracts. Now, however, the roles have reversed, and producers such as Chesapeake Energy and Devon Energy—fearing that prices may fall over the next few years—are trying to lock consumers into long-term contracts.[82] Such long-term contracts—some for over 20 years—are already commonplace in Europe and Asia. However, consumers in those regions may demand a higher percentage of lower spot prices in existing and future gas contracts.

5.5 Impact on oil markets

In 2009, the United States consumed 18.6 million barrels of oil per day, which constitutes nearly 22 percent of the global oil consumption. Road-transportation fuels accounted for around 65 percent of the total consumption of liquid fuels.[83] While crude oil costs about US$15 per mmbtu, gas costs around US$4 per mmbtu. Consequently, if only 10 percent of vehicles shifted to natural gas, the United States could reduce its dependence on foreign oil, and oil prices would drop. Today, Pakistan, the number one country in terms of usage of natural gas for transportation, has over 2.4 million vehicles powered by gas and more than 3,000 fueling stations, while the United States has just 100,000 similar vehicles and 1,300 fueling stations.[84]

Shale gas can also displace other crude oil-based products such as naphtha and gas oil. In 2009, the United States and Western Europe accounted for nearly half of the global naphtha and gas oil consumption.[85] If shale gas displaces these petroleum products, oil refiners can be affected, and at a macrolevel, oil demand can also be affected. Already, countries such as India are enacting policies encouraging the use of natural gas for fertilizer production.[86]

5.6 Impact of natural gas prices

During the past two years, production has exceeded the demand for natural gas. The imbalance in demand and supply conditions has increased gas in storage and driven natural gas prices lower. Henry Hub natural-gas spot prices had fallen by around 27 percent on a year-over-year basis to US$4.22 per mmbtu, as on December 31, 2010.[87] The natural gas price drop began to impact development plans as operators started shifting investments in late 2009 toward the development of shale gas plays, in areas with a higher yield of NGLs and crude oil.[88] Further, the rising price of oil has made the exploration of oil shale and NGLs much more attractive. This has led to the development of both oil rich shale fields, namely the Bakken and wet gas shale plays such as the Eagle Ford, which have a higher content of NGLs such as propane. The production of higher priced crude oil and NGLs helps improve project economics. Meanwhile, growth in the rig count has slowed due to the continued shift away from dry gas toward more oil-directed drilling, natural gas formations rich in associated oil or NGLs.[89]

82. "Natural-Gas Producers Seek Long-Term Contracts," Rigzone, December 30, 2009
83. Web site of EIA, accessed on October 19, 2010
84. "Surprises, accidents and the world energy scenario," *Live Mint*, July 18, 2010
85. "Petroleum Liquid Feedstocks - Naphtha and Gas Oil," SRI Consulting, June 2010
86. "Fertilizer industry set for wave of investments of up to $10 bn," *Live Mint*, August 31, 2010
87. Natural Gas Spot and Futures Prices (NYMEX), December 2010
88. "Shale Gas Development Drives U.S. Reserves to New High," Rigzone, December 1, 2010
89. "Schork Oil Outlook: $100 Crude Bearish for Natural Gas?," CNBC, January 14, 2011

5.7 Impact on electricity generation

The rising production of shale gas has brought down natural gas prices in the past two years. This makes natural gas a more cost effective source of power generation in comparison to coal. Shale gas accounts for around 20–25 percent of the U.S. natural gas output.[90] Improved drilling techniques may lead to increased exploration of shale gas, which is expected to stabilize and even lower the prices of natural gas. Lower prices are expected to increase the use of natural gas as a fuel for electricity generation, at the expense of coal and renewable sources such as wind turbines.

Meanwhile, environmental regulations require coal-fired electricity generation companies to install expensive pollution-control equipment thereby increasing their production cost. Natural gas is being preferred over coal as it is more economical to build gas-fired plants than it is to outfit the coal units with the necessary pollution-control equipment.[91] According to the EIA, coal-powered plants are expected to be just 10 percent of total new generating capacity in the United States by 2013, while gas is expected to account for 82 percent of new capacity. Furthermore, the shale gas boom and the lower forecasted gas prices (the annual average natural gas wellhead price is expected to be US$5 per thousand cubic feet through 2022, as per EIA[92]) are driving the shift towards natural gas generation. Jim Rogers, CEO of Duke Energy, said recently, "You will see more and more utilities in the US build gas plants assuming gas prices stay in the range of US$4–7 per million BTUs." Gas prices were hovering at around US$4.39 per million BTU in December 2010.[93] According to Exxon Mobil's long-term energy outlook, the global demand for natural gas for electricity generation may increase by 85 percent from 2005 to 2030.[94]

5.8 Impact on transportation

Natural gas is regarded as the cleanest fossil fuel as it emits less than 50 percent carbon as compared to coal and up to 25 percent less than oil. Also, natural gas contains less carbon than any other fossil fuel, per unit of fuel consumed. Furthermore, natural gas as a fuel has the potential of reducing greenhouse gas emissions by 20–29 percent as compared to diesel and gasoline-fueled vehicles.[95] Recent technological advancements in drilling techniques have made a number of shale gas reserves accessible leading to increased production of natural gas. Domestic production is expected to increase by 24.5 percent during the period 2009–2035, as per EIA. Consequently, the U.S. reliance on natural gas imports is expected to drop from 11.2 percent in 2009 to 1.2 percent in 2035.[96] This self-reliance in natural gas creates an unprecedented opportunity to use gas in developing a clean energy transportation system that relies on enhanced fuel economy; lightweight, electric vehicles; advanced bio-fuels; and low-carbon fossil fuels such as natural gas.[97]

In terms of cost per miles traveled, natural gas is 42 percent less expensive than diesel fuel (on an energy equivalent basis). With the prices of crude oil rising at a faster rate than natural gas prices, the gap is projected to widen to 50 percent in 2035 per the EIA.[98] Consequently, the payback period for incremental costs in retrofit vehicles as well as natural gas vehicles (NGVs), is expected to become shorter. The difference in fuel cost is also expected to drive the production of more NGVs, which stands at around 110,000 in 2009. However, the obstacle behind the rapid adoption of NGVs, particularly in the commercial segment, is the lack of adequate infrastructure: refuelling stations and pipelines. Creation of infrastructure combined with a favorable energy policy by the government will encourage use of natural gas by the transportation sector in the United States.[99]

5.9 Impact on economy at local level (city or county)

Shale gas brings direct and indirect economic benefits for a local economy. While the direct benefit comes from shale gas sales revenue, indirect benefits range from job creation to revenue from royalties and taxes. For example, the Marcellus gas industry in Pennsylvania contributed around US$3.77 billion dollars in gross sales to the local economy, as per a July 2010 study by the American Petroleum Institute (API).[100] Also, a recent Penn State study estimated that US$4.5 billion has been invested in Marcellus shale gas basin in 2009, generating nearly US$400 million in state and local tax revenue and creating 44,000 jobs.[101] These newly created jobs are in the areas of construction, trucking, engineering, and a variety of attendant services. Moreover, local economy benefits from royalties and leases paid to landowners for shale gas plays. Further, production in the Marcellus has the potential to provide US$15 billion in economic output and US$2 billion in state tax revenue over nine years, per the API study.[102]

90. "Shell pays $4.7 billion for shale gas company," Reuters, May 28, 2010
91. "How Cheap and Abundant Natural Gas Affects Renewables," The Energy Collective, January 3, 2011
92. "Annual Energy Outlook 2011- Early Release," EIA, December 20, 2010
93. "Natural Gas Price Analysis & Forecast," Forecastchart.com, December 2010
94. "Exxon chief: Gas to overtake coal as energy source," *Star Telegram,* January 27, 2011
95. "NGVs and the Environment," Web site of Natural Gas Vehicles for America, accessed on January 27, 2011
96. "Annual Energy Outlook 2011- Early Release," EIA, December 20, 2010
97. "Developing Natural Gas for Heavy Vehicles," Center for American Progress, April 14, 2010
98. "Issues in Focus," EIA, accessed on January 27, 2011
99. Web site of Natural Gas Vehicles for America, accessed on January 27, 2011
100. "The Economic Impacts of the Marcellus Shale: Implications for New York, Pennsylvania, and West Virginia," The American Petroleum Institute, July 22, 2010
101. "The Madness of New York: A tale of two states on exploiting the boom in shale natural gas," *Wall Street Journal*, December 16, 2010
102. Ibid

6. Outlook

Most energy analysts agree that shale gas has the potential to revolutionize the energy industry and be a game-changer in decades to come. The presence of huge shale reserves all over the world will provide a cheap, carbon-friendly solution to the energy requirements of many countries. During a meeting with the Energy Advisory Board, Energy Secretary Steven Chu suggested that the development of abundant natural gas from shale formations is a seismic shift in the energy landscape. He said it will "help the world transition to a cleaner fossil fuel supply." He further added, "It does change the geopolitics of energy in a significant way."

The development activity in the Haynesville and Eagle Ford shale plays is projected to drive upstream investment in the United States from US$3 billion in 2009 to more than US$11 billion in 2013, according to Iain Brown, manager with Wood Mackenzie.[103] Shale gas development will remain vital especially for the oil and gas majors as they face the threat of nationalization of assets and reserve restrictions in resource-holding nations. Moreover, deep-water drilling will become increasingly expensive, especially due to the tighter regulations following the Gulf of Mexico oil spill. As a result, despite near-term weakness in natural gas prices, majors will continue to invest in shale development to expand the share of natural gas in their production portfolio. For instance, Shell plans to produce more gas than oil by 2012 to meet growing worldwide demand with little environmental impact, according to Marvin Odum, president of Shell Oil Company.[104]

While the gas boom will reduce energy prices for consumers worldwide, it may decelerate growth and economic viability of renewable energy in the medium term. Dr. Fatih Birol, chief economist with IEA, commented, "It's cheaper than it was and the supply is more assured. And it's only half as polluting as coal. There will be strong debates between energy and climate supporters, as well as finance ministries round the world, about whether investment should continue to support renewables when the situation on gas has so radically changed."[105] Although renewable energy will be an important part of the energy mix over the long run, availability of cheap gas will reduce the urgency to invest and subsidize expensive renewable energy. Shale gas priced at less than US$5 per mmbtu is a serious challenge to the U.S. renewable energy industry, according to Michael Morris, chief executive of American Electric Power.

The biggest challenge to the U.S. shale gas industry is environmental hurdles and the imposition of additional regulations that may decrease production, and increase operational costs. According to a study by IHS Global Insight, federal regulations, when implemented, may lead to a decline of over 20 percent in the number of wells drilled in the next five years, and a reduction of 10 percent in the production levels compared with that in 2008. The recent moratorium on shale gas drilling in Quebec and France and EPA's renewed efforts to monitor gas well waste in the Marcellus shale play may force companies to improve the transparency of their drilling activities. Nevertheless, some analysts believe that federal legislations are unlikely to be imposed before the agency publishes its findings. The EPA study on the impact of hydraulic fracturing on drinking water resources, which was announced in March 2010, may take a minimum of two years to complete. Moreover, the energy industry is also closely monitoring the impacts of the natural disaster that struck Japan in March 2011. Several blasts at the nuclear plant in Japan that followed the tsunami are raising concerns over development of nuclear resource as an alternative for clean energy, not only in Japan but also in other countries including India and the US. "I think it calls on us here in the US, naturally, not to stop building nuclear power plants but to put the brakes on right now until we understand the ramifications of what's happened in Japan," said Senator Joseph I. Lieberman. According to Blakeslee, a U.S.-based geophysicist, "The devastating events in Japan underscore the importance of addressing the seismic uncertainty surrounding California's nuclear power plants." While the incident may make sanctioning and renewal of licenses for nuclear plants more challenging, it may make shale gas development vital to meet the additional energy demand. Consolidation will continue worldwide for shale gas assets over the next few years. Technological advancements in shale development will help larger players maintain sufficient returns amid depressed prices for the fuel. However, smaller, pure natural gas companies that are financially burdened by low gas

103. "Wood Mackenzie says Global Upstream Spending for 2010 has returned to growth," Wood Mackenzie press release, November 11, 2010
104. "Shell: We'll produce more gas than oil by 2012," CNN Money, December 15, 2010
105. "Harrabin's Notes: Mission impossible?," BBC News, January 19, 2011

prices, high operational costs, and tough drilling commitments will be susceptible to takeovers. Liquids-rich plays will attract majority investment from majors as well as larger independents amid widening price differential between natural gas and oil in the medium term.

North America will continue to attract global investments in the form of joint ventures and acquisitions by multinational majors and cash-rich private equity firms. Analysts expect higher private equity flow into the shale gas space as demand for funds to develop the plays and assured returns provide an investment window to PE firms in the absence of leveraged buyouts. A case in point, Kohlberg Kravis Roberts & Co. (KKR) divested East Resources in mid-2010, realizing three-fold returns over the price it paid to buy the assets in 2009.[106] Resource-seeking Asian companies, such as CNOOC, Mitsui, Sumitomo, Reliance Industries, and CNPC, will increase participation as they look to not only secure reserves but also to gain expertise and adopt the advanced techniques on domestic shale gas plays. For instance, PetroChina is planning to acquire 50 percent stake in a British Columbia shale gas project from Canada's Encana Corp for US$5.4 billion in 2011, the biggest Chinese overseas natural gas deal.[107] Shale resource holders, such as Nexen Inc., have sounded interest to partner with Asian NOCs to develop their resources. European firms (e.g., Total, BG Group) will increase investments to reduce reliance on Russian gas. The shale gas space may also witness new entrants eyeing long-term investments, as illustrated by BHP's first potential shale acquisition in the United States viewing an upturn in U.S. gas prices in the long term.[108]

Similar to North America, other parts of the world have huge shale reserves which guarantee assured supply of energy and give a boost to energy security. ONGC's recent shale gas discovery in India's Sarpi deposit is the first tapped shale gas reserve in Asia—widely recognized as a key demand center for the fuel. The country is said to possess vast shale gas reserves ranging from 600 to 2,000 Tcf of shale gas.[109] In addition, Argentina's newly discovered shale deposit in Patagonia is said to hold ~257 Tcf reserves, considered sufficient to meet the country's domestic demand for years to come.[110] However, significant environmental and operational challenges will have to be overcome for developing the resources. While the new discoveries will alter the global demand-supply dynamics, they will provide latent opportunities to the IOCs that possess the technological expertise and financial mettle to help develop the new resources. Argentina and Algeria are inviting participation from IOCs and large oil and gas multinationals to develop the newly found resource. "The potential is at least comparable to the major plays known in the US…The development of the unconventional hydrocarbons will be a new experience that we will be willing to share with companies that have demonstrated their know-how in this field," said Youcef Yousfi, Algeria's minister of energy and mines.[111]

There is little doubt about the importance of shale gas in today's global energy mix. Companies and consumers in the United States have benefited from the boom in gas production in recent times. However, mere possession of huge shale reserves does not guarantee success in other parts of the world. Shale gas development is a long process, and the rest of the world is still at the beginning of the learning curve.

106. "KKR Goes Prospecting for Energy Deals," Bloomberg *Businessweek*, July 9, 2010
107. "PetroChina to invest US$5.4b in Canada gas," *Business Times*, March 11, 2011
108. "BHP Billiton Announces Acquisition Of Chesapeake Energy Corporation's Fayetteville USA, Shale Assets," BHP Billiton press release, February 22, 2011
109. "India Announces Shale Gas Find," Natural Gas For Asia, March 11, 2011
110. "Argentina's YPF makes big shale gas find – reports," Reuters, December 6, 2010
111. "Algeria eyes huge domestic shale gas reserves," Reuters, March 11, 2010

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