Chapter Five

Macroeconomics

Abstract

This chapter is separated into four major sections to address four framing questions (discussed in the text box at the end of the Summary section). First, the Macroeconomic Impacts section addresses the natural gas and oil industry's significant impact on U.S. GDP, employment, and government revenues. Second, the Workforce Challenges section examines the aging workforce of natural gas and oil technical professionals and reviews enrollment trends in educational focus areas of importance to the industry. Third, the Volatility section addresses the historical drivers of natural gas and oil price variations, the impacts that price shocks can have on the economy, and the impacts of unconventional resource development on commodity price elasticity. Lastly, the Business Models section outlines the process that successful companies have used to identify and develop the U.S. natural gas and oil resources, and the government's role in domestic natural gas and oil resource development.

SUMMARY

The benefits of plentiful natural gas and crude oil reach far beyond their use as transportation, power generation, or direct home heating fuels. Manufacturers rely on petrochemical products as building blocks for the production of electronics (including computers and cell phones), plastics, medicines (and medical equipment), cleaning products, fertilizers, building materials, adhesives, clothing, and much more. The vital role natural gas and crude oil play in almost every aspect of our personal and professional lives underscores the importance of safely and efficiently producing our domestic resources, conserving their use through energy-efficient end-use products and practices, and developing technologies to reduce the environmental impact of producing and consuming them.

In addition to fueling vehicles, heating homes, generating electricity, and functioning as a necessary component of many of the products upon which people rely, natural gas and crude oil serve as a significant contributor to the U.S. economy. Companies that explore for, produce, refine, transport, and market natural gas and crude oil products employ millions of Americans directly and indirectly. These companies also pay taxes at the federal, state, and local levels. The natural gas and oil industry is the third largest payer of federal corporate income taxes after the manufacturing and finance industries.

The natural gas and oil industry, however, faces serious challenges to its productivity and growth. Compared to other industries, the average age of the workforce in the natural gas and oil industry is older. A large gap exists between the number of retiring technical professionals and the number of graduates coming out of junior college, college, and graduate school with the knowledge and skills required to work in the natural gas and oil industry. Part of this is pure demographics as the baby boomer generation has begun to retire from the workforce. Another part is not enough industry activity on university campuses and insufficient government study grants to undergraduate and graduate-level engineering and geosciences projects that relate to the natural gas and oil industry. Despite a recent uptick in enrollments in petroleum engineering and natural gas- and oil-focused geosciences programs, the student population will not have the raw numbers or experience to replace the number of retiring, experienced professionals.

Natural gas and crude oil price volatility, like the workforce demographics, poses a challenge for the natural gas and oil industry and the consumers of its products. Crude oil remains a global commodity, subject to global supply and demand fundamentals, and – as a dollar-denominated commodity – the impact of U.S. dollar currency movements. However, natural gas, with vast domestic supplies, is more insulated from global supply and demand shocks. The development of drilling, completion, and production technologies that enable producers to unlock natural gas resources from unconventional sources has created a unique opportunity for U.S. natural gas end users. Prior to this unconventional resource revolution, uncertainty regarding expectations of future natural gas price levels led many consumers, such as electricity producers or vehicle manufacturers, to avoid becoming more exposed to natural gas price volatility. However, our nation's unconventional natural gas resources now present end users with a more reliable source of natural gas that has the ability to be more responsive to price movements than conventional natural gas sources.

The business model employed by private-sector, for-profit companies in the United States to develop our domestic natural gas and oil resources relies on many of the same fundamentals as other industries, including free markets, rule of law, regulatory oversight, and appropriate taxation. Other countries have chosen different business models that vary from (1) somewhat similar to the U.S. model on one extreme to (2) significantly more government involvement in the development of their resources on the other extreme. The business model in the United States helps explain the success that U.S. companies (and many foreign companies operating in the United States) have had exploring for, developing, transporting, and selling natural gas and crude oil in the United States. This business model also fits well with the extensive amount of development required to produce our domestic unconventional natural gas and crude oil resources. Unconventional resources present the United States with a new opportunity to enhance its energy security, promote economic growth and environmental stewardship, and advance technological leadership in the natural gas and oil industry.

MACROECONOMIC IMPACTS OF THE NATURAL GAS AND OIL INDUSTRY ON THE DOMESTIC ECONOMY

The natural gas and oil industry is an important contributor to the U.S. economy, touching almost every aspect of the energy market, including transportation, power generation, home heating, and industrial processes. The industry is a major contributor to the United States' gross domestic

Framing Questions

The Macroeconomic Subgroup of the Coordinating Subcommittee was asked to address several specific framing questions:

1. What are the contributions to the domestic economy of the U.S. natural gas and oil industry?
   - Employment – direct, indirect, and induced
   - Economic activity
   - Federal, state, and local revenues
   - Regional composition and contributions.
2. What are the current age demographics in the workforce in the natural gas and oil industry (and its regulators)? What steps can the industry (and the government) take to address any workforce needs?
3. What are the primary causes of natural gas and oil price volatility? What impact does this have on natural gas and oil consumers? How does this influence capital investment in natural gas and oil production and consumption technologies?
4. Are current industry business models adequate for the successful deployment of new domestic natural gas and oil production and end-use consumption technologies? Are new business models needed, and if so, what might they look like?

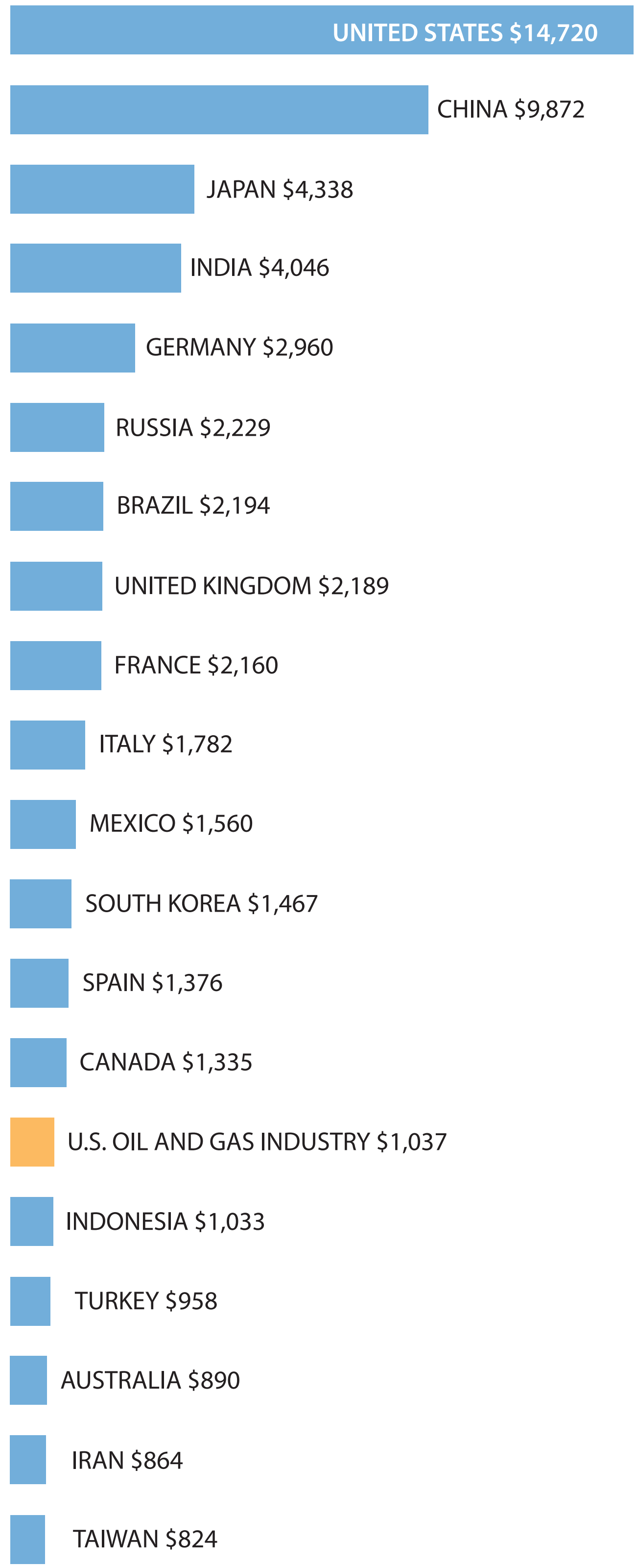
product (GDP), employment, labor income, and tax revenues to federal, state, and local governments.

In 2010, the U.S. GDP exceeded $14.5 trillion, approximately 50% larger than the next largest (but rapidly growing), the Chinese economy, as measured by purchasing power parity.[1] Estimates for the combined operational and capital investment impacts of the domestic natural gas and oil industry on the U.S. economy range as high as $1 trillion of "value added" to GDP.[2] Using this estimate, the domestic natural gas and oil industry is responsible for over 7% of the U.S. economy. To put this in perspective, Figure 5-1 illustrates where the natural gas and oil industry sits relative to the GDP of the 20 largest global economies.

The natural gas and oil industry's impact goes beyond the operations of the companies actively engaged in exploration and production (upstream), transportation (midstream), and refining and marketing (downstream) of crude oil, natural gas, and petroleum products. Through their operations and capital investment activities, natural gas and oil companies buy goods and services from suppliers and contractors, who in turn employ people and buy goods and services of their own.

In addition to finding, developing, processing, and delivering critical natural gas and oil resources that fuel our economy, the natural gas and oil industry employs millions of Americans. Estimates of the total direct, indirect, and induced[3] number of people in the United States employed as a result of the natural gas and oil industry range as high as 9.2 million jobs.[4] Using this figure, the natural gas and oil industry is directly and indirectly responsible for approximately 6.7% of non-farm payrolls. Of these 9.2 million total jobs, 2.2 million jobs are directly engaged in upstream, midstream, and downstream activities.[5]

Figure 5-1. Largest 2010 Global GDPs Compared to the U.S. Oil And Gas Industry (Billions of U.S. Dollars)



Sources: CIA World Factbook, 2010; PricewaterhouseCoopers, *The Economic Impacts of the Oil and Natural Gas Industry on the U.S. Economy in 2009*, May 2011.

1 A nation's GDP at purchasing power parity exchange rates is the sum value of all goods and services produced in the country valued at prices prevailing in the United States.

2 PricewaterhouseCoopers, *The Economic Impacts of the Oil and Natural Gas Industry on the U.S. Economy in 2009: Employment, Labor Income, and Value Added,* May 2011, page E-2.

3 The term "indirect" includes impacts from businesses that supply goods and services to the natural gas and oil industry. The term "induced" includes impacts from household spending of income generated either directly or indirectly from the natural gas and oil industry.

4 PricewaterhouseCoopers, *Economic Impacts*, page E-2.

5 PricewaterhouseCoopers, *Economic Impacts*, page 12.

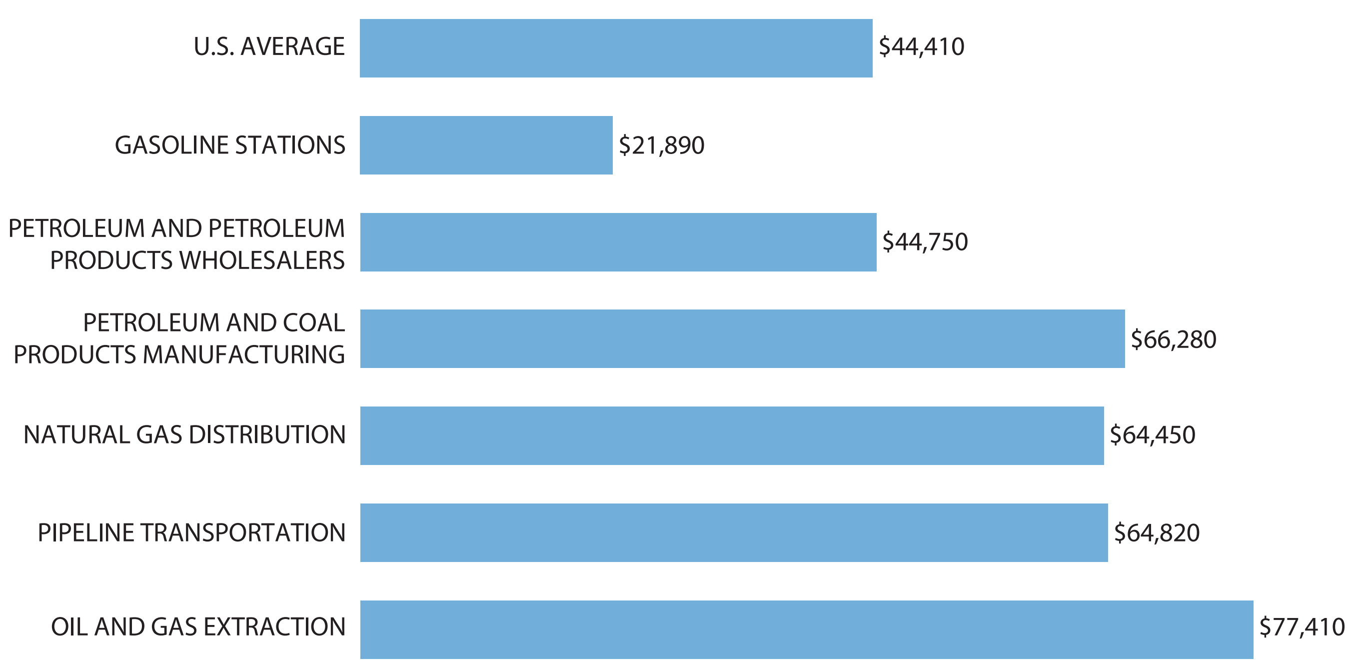
Jobs focused on the exploration and production of domestic natural gas and oil resources, by their nature, must be performed domestically with only a few limited exceptions. They cannot be performed in another country by lower-paid labor. Also, people employed in the natural gas and oil industry, particularly those involved in exploration and production, refining and distribution, earn above-average wages. Figure 5-2 illustrates average annual wages for several of the categories of natural gas and oil industry jobs as reported by the U.S. Bureau of Labor Statistics for the most recent available data (May 2010). Estimates of total labor income (defined as wages, salaries, and benefits) from the U.S. natural gas and oil industry range as high as $534 billion.[6]

Most of the studies on the North American industry's macroeconomic impact have used input-output analysis in one way or another. Input-output models relate a specific industry's or region's output value to the goods and services it purchases as inputs from other industries and/or regions. In practice, a single direct impact measure, such as employment, is usually used first to estimate other direct impacts, such as gross output, value added, income, and government revenue. Then, these direct measures are fed into the IMPLAN® system (a regional economic analysis system, short for "IM"pact on "PLAN"ning) to obtain the overall impacts on all variables. In addition to reporting the direct, indirect, and induced impacts in levels, researchers also use the input-output multipliers to describe the combined impacts. For example, an employment multiplier describes the ratio between the overall number of jobs gained in the economy versus one additional job in a particular industry and/or region. This standardized representation of the macroeconomic impact is particularly useful in comparing different studies' findings.

Input-output modeling is a powerful tool, but it does have some limitations. By its nature, input-output analysis relies on a static snapshot of the economy, based on fixed linear relationships between inputs and outputs that hold at a particular point in time. In reality, however, technological change modifies the technical relationships between inputs and outputs. A good example is improvements in drilling technology that require less of everything (steel,

6 PricewaterhouseCoopers, *Economic Impacts*, page E-2.

Figure 5-2. Oil and Gas Industry Average Annual Wages Compared to U.S. Average (U.S. Dollars)



Source: U.S. Department of Labor–Bureau of Labor Statistics, May 2010.

drilling services, labor) for any given amount of reserve additions. In addition, input-output modeling cannot analyze directly the effect of relative prices, which lead both producers and consumers to substitute, to the extent they can, less costly goods and services, or do with less. This effect works more powerfully in the longer run. For example, expensive gasoline induces people to either drive less or replace their cars with higher mileage cars.

Despite the differences in scope of analysis of various studies, industry definition, data source, and modeling treatments, the multiplier effects estimated by the studies are remarkably consistent for all three economic variables – employment, labor income, and value added. Many of the studies include impacts of operating expenses or capital expenditures, or both. The operational impact is felt mostly in services, finance/insurance/real estate/leasing, wholesale and retail trade, transportation, manufacturing, and construction. The capital investment impact goes mainly to services, manufacturing, trade, and transportation.

Table 5-1 summarizes the multipliers for several national and regional studies that analyzed impacts of both operational and capital expenditures on employment and value added. Employment multipliers ranged from 1.53 total jobs for each direct job in West Virginia (principally focuses on upstream activity in the Marcellus Shale) to 4.54 total jobs for each

Table 5-1. Summary of Multipliers Observed in Economic Impact Studies

Scope	State / Region	Year	Employment Multipliers (Jobs)	Value-Added Multipliers ($)
Marcellus Shale Gas*	West Virginia	2008	1.53	
Marcellus Shale Gas†	West Virginia	2009	1.57	1.48
Marcellus Shale Gas‡	Pennsylvania	2008	2.05	1.99
Marcellus Shale Gas§	Pennsylvania	2009	2.02	1.96
Marcellus Shale Gas¶	New York	2015	1.92	1.98
Oil and Gas#	Colorado	2008	2.67	
Offshore Oil and Gas**	Gulf of Mexico	2007	3.56	1.73
Eagle Ford Shale Oil and Gas††	Texas	2010	1.86	1.34
Oil and Gas‡‡	U.S. Total	2007	4.18	2.33
Natural Gas§§	U.S. Total	2007	4.54	2.24
			1.0X 3.5X 6.0X	1.0X 2.5X 4.0X

* National Energy Technology Laboratory, *Projecting the Economic Impact of Marcellus Shale Gas Development in West Virginia: A Preliminary Analysis Using Publicly Available Data*, U.S. Department of Energy, March 31, 2010, page IV.

† Considine, Timothy, *The Economic Impacts of the Marcellus Shale: Implications for New York, Pennsylvania, and West Virginia*, National Resource Economics, Inc., July 2010, page 24.

‡ Considine, Timothy and Robert Watson, *An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Shale Natural Gas Play*, The Pennsylvania State University, College of Earth and Mineral Sciences, July 24, 2009, pages 25-26.

§ Considine, Timothy, *Economic Impacts*, pages 20-21.

¶ Considine, Timothy, *Economic Impacts*, page 29.

McDonald, Lisa, Booz Allen Hamilton, and David Taylor, *Oil and Gas Economic Impact Analysis*, Colorado Energy Research Institute, Colorado School of Mines, June 2007, page XI.

** IHS Global Insight, *The Economic Impact of the Gulf of Mexico Offshore Oil and Natural Gas Industry and the Role of the Independents*, July 2010, pages 8-9.

†† America's Natural Gas Alliance, *Economic Impact of the Eagle Ford Shale*, Center for Community and Business Research, The University of Texas at San Antonio, February 2011, page 4.

‡‡ PricewaterhouseCoopers, *Economic Impacts*, page 17.

§§ IHS Global Insight, *The Contributions of the Natural Gas Industry to the U.S. National and State Economies*, September 2009, page 1.

direct natural gas industry job in the United States as a whole (based on a broader analysis of the entire value chain from extraction through delivery). Value-added multipliers ranged from $1.34 of total value added in the Eagle Ford Shale for every $1 of direct value added to $2.33 of total value added for every $1 of value added from the U.S. natural gas and oil industry as a whole. Most of the variance in multipliers for regional studies compared to broader, national studies is due to the fact that many of the domestic onshore unconventional developments are relatively new in their development (e.g., Marcellus and Eagle Ford) and the regional studies, in some cases, were published several years ago.

Many states rely heavily on natural gas and oil industry participants as critically important employers and economic contributors. Since many variables beyond the presence of natural gas and oil company activity (e.g., geographic issues, presence or absence of other industries, population distribution, etc.) contribute to a state's economic well-being, one cannot conclude that natural gas and oil industry activity alone causes a state to rank highly on employment, per capita income, or other economic comparisons. However, all of the states that rank in the top 10 in terms of natural gas and oil value added as a percent of state GDP have state unemployment rates below the U.S. national average. Six of those ten states have state GDP per capita in excess of the U.S. national average. Figure 5-3 shows the ten states with the greatest and least value-added contribution from the natural gas and oil industry as a percentage of total state GDP, and their corresponding state unemployment and state GDP per capita.

Related Industries

A healthy domestic natural gas and oil industry promotes economic growth as described above and the support of an increased use of natural gas as a transportation and/or power generation fuel promotes energy security and environmental benefits. However, the growth of the domestic natural gas and oil industry, particularly that of natural gas which displaces other energy sources, could negatively affect employment and value added from industries providing other fuel sources, such as coal, and businesses that are significantly supported by the coal industry, such as large freight railroads, also called Class I railroads.

Coal Industry

Studies that estimate the impacts of the coal industry on the domestic economy use a similar input-output model approach as studies on the impacts of the natural gas and oil industry on the domestic economy. Penn State's 2006 study used the IMPLAN model to estimate that the coal industry will contribute, directly and indirectly, $1.05 trillion (in 2005 dollars) of gross economic output, $362 billion of annual household incomes, and 6.8 million jobs in the year 2015.[7] However, the scope of the Penn State (2006) study included end users of coal (specifically, coal-fired electricity generators) in its model that generated these statistics, which complicates any comparison to PricewaterhouseCoopers' (2011) statistics related to the natural gas and oil industry. Moore Economics, in another study using input-output modeling methodology, estimates that each coal mining job creates 3.5 additional jobs and that each $1 of direct payroll in the coal mining industry generates an additional $1.98 of indirect payroll.[8] Moore Economics also estimates that the coal mining industry pays $8.1 billion in total payroll and income taxes.

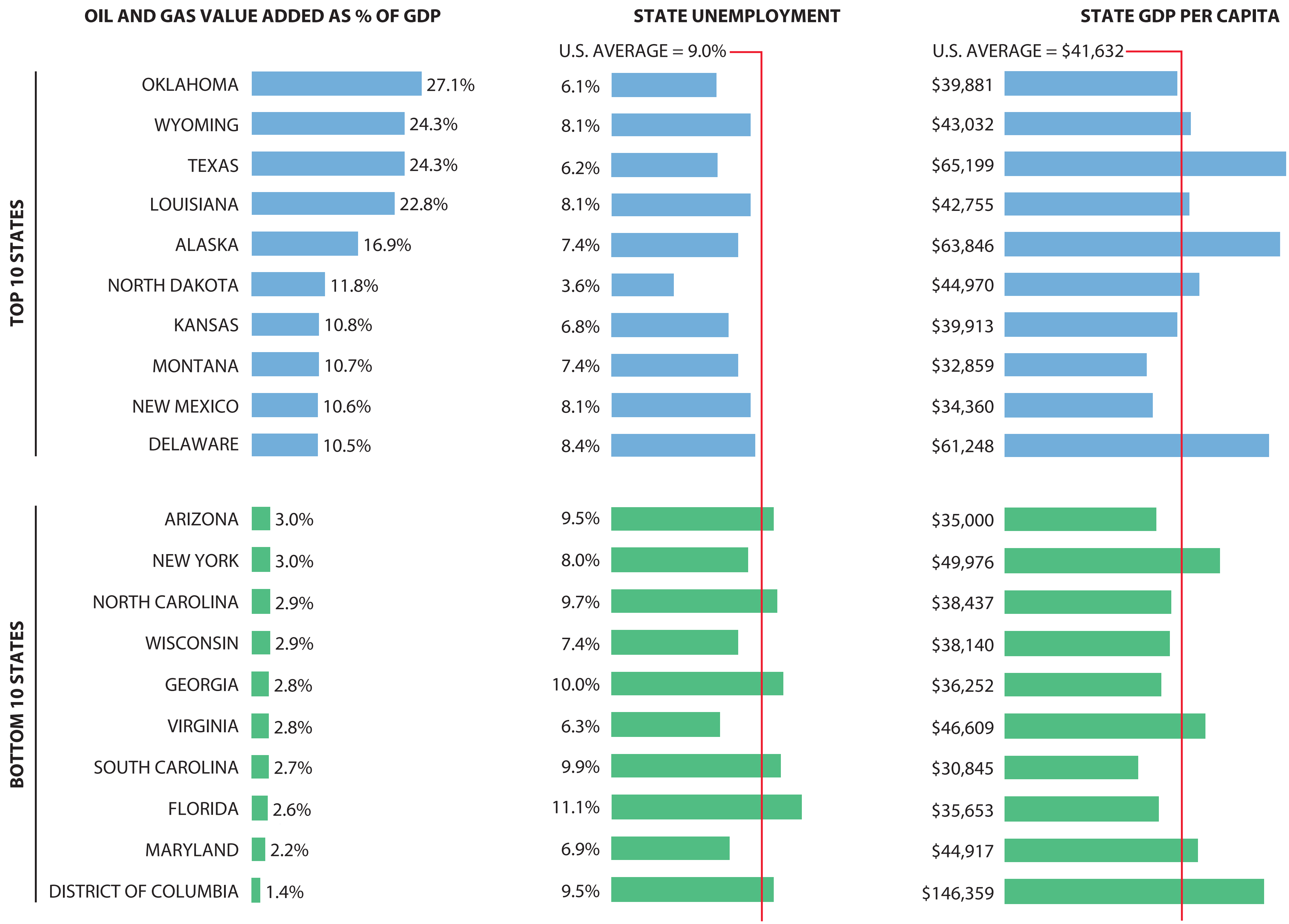
The electricity generation industry accounts for over 90% of the total U.S. coal consumption. As a result of this predominance, developments in the power sector directly affect the coal industry. From 2008 to 2009, domestic coal consumption decreased by 10.7% following an equivalent reduction in coal-fired generation. This was due to the recession's impact on electricity demand and, in some regions, the displacement of coal by natural gas, which benefitted from low prices.[9] The narrowing price differentials between coal and natural gas observed in 2008 were further exacerbated by a rapid increase in coal spot prices that followed a surge of Appalachian coal demand from overseas during that year. (See Figure 4-14 in Chapter Four for an illustration of the megawatt hour-weighted fuel costs and coal-gas generation cost spread.)

7 Rose, A. Z., & Wei, D., *The Economic Impacts of Coal Utilization and Displacement in the Continental United States, 2015,* 2006, page 4.

8 Moore Economics, *The Economic Contributions of U.S. Mining in 2007 – Providing Vital Resources for America,* February 2009, page 20.

9 National Mining Association, 2009 Coal Producer Survey, 2010, page 1.

Figure 5-3. Comparison of Unemployment and GDPs per Capita in States with and without a Significant Oil and Gas Presence



Sources: PricewaterhouseCoopers, 2009; U.S. Bureau of Labor Statistics, March 2011; and Bureau of Economic Analysis, 2009.

Furthermore, economic, regulatory and, more recently, environmental concerns have led to a shift in the supply of new power generation capacity. Although coal generated approximately 45% of the nation's electricity in 2009, approximately half of all new electric power generation capacity additions were natural gas-based. In general, coal remains the lowest cost fuel for electric power generation. That advantage is largely offset, however, by the much larger capital investments required for coal generation plants versus natural gas plants and the better efficiency rates and operational flexibility available with the latter.

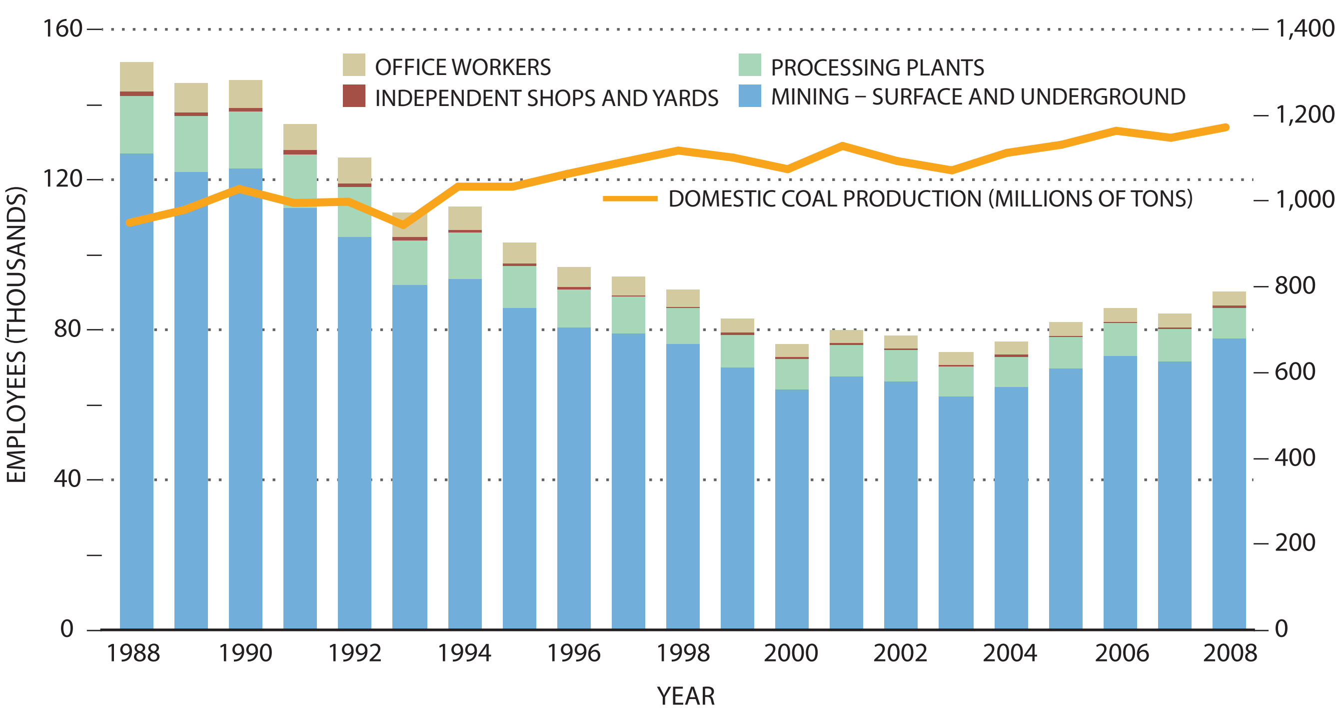
The cost of coal for electricity generation increased from $1.20 per million British thermal units (MMBtu) in 2000 to $2.21 per MMBtu in 2009, or 84.2%. By comparison, the cost of natural gas for electricity generation increased from $4.30 per MMBtu in 2000 to $4.74 per MMBtu, or 10.2%, although with much greater volatility than coal. That volatility was prominent in 2009, when the average delivered cost of natural gas fell by 47.5% to $4.74 per MMBtu.[10] The historical volatility in natural gas prices has been a disadvantage in comparison to coal as a fuel for electricity generation. The increase in the elasticity of supply of natural gas due to technological innovation has the ability to mitigate this historical disadvantage.

In 1996, natural gas-fired power generation capacity accounted for 23.5% of total installed capacity in the United States. In September 2010, that share had grown to 40.8%. In fact, while coal-fired installed capacity has remained largely unchanged over the last 20 years, natural gas-fired capabilities have almost tripled. Productivity improvements, efficiency measures, environmental concerns, regulatory challenges, and other factors have contributed to the 40.4% decrease in coal mining employment from 1988 to 2008. Figure 5-4 illustrates the significant decline in direct coal mining employment from 1988 to 2008.

According to the Bureau of Labor Statistics, the median earnings for people in the coal mining industry were $23.11 per hour for the May 2010 period, the latest for which data are available. This equates to approximately $48,069 per year.

10 U.S. Energy Information Administration, *Electric Power Annual*.

Figure 5-4. Direct Employment in the Coal Mining Industry



Source: Based on National Mining Association, "Mining Industry Employment in the United States by Sector, 1985–2008," January 2010; Energy Information Administration.

Railroad Industry

Domestic coal production is focused on a few key coal-rich areas like the Appalachian Mountain and the Rocky Mountain regions and several Midwestern states. However, coal is consumed widely across the country. The United States' extensive railroad system accounts for approximately 70% of coal deliveries and makes this wide distribution of coal logistically possible and cost-effective. In 2008, coal accounted for approximately 25% of carloads, 45% of tonnage, and 23% of the $60.5 billion of gross freight revenue for the Class I railroads.[11] Clearly, the performance of the railroad industry and the coal industry are linked. By comparison to the figures previously mentioned for the coal and the natural gas and oil industries, the U.S. freight railroad industry employed 183,743 people in 2008 who earned an average of $71,303 in 2008.[12]

Taxes and the Natural Gas and Oil Industry

Aside from the economic benefits the consuming public derives from the natural gas and oil industry in the forms of employment, value added, and resource availability, the industry also benefits the public by paying a significant amount of taxes. Literature on the topic of taxation refers to total "government take," or the total amount of revenues that the federal, state, and local governments collect in all forms of taxes or revenue receipts from the industry.

Much of the information available on total "government take" from the natural gas and oil industry focuses on the upstream exploration and production sector. These companies pay the standard federal and state corporate income taxes that firms in other industries pay. Upstream companies also pay severance and ad valorem taxes based on the amount of hydrocarbons they produce and pay bonuses and royalties to the owners of the mineral interests from whom they are leased. The largest of these mineral interest owners are federal and state governments. For 2007, direct payments by natural gas and oil corporations to the federal and state governments were approximately $50 billion: $29.8 billion in federal corporate income taxes, $10.7 billion in state severance taxes, and $9.4 billion in federal royalties.

In addition, natural gas and oil companies pay significant amounts in other forms of taxes, including excise fuel taxes, sales, property, and use taxes ($86 billion), and by generating employment income they indirectly support federal, state, and local governments ($140 billion).

Once all of these sources of government revenue are added together, they amount to approximately $276 billion for our 2007 reference year. This total does not include excise and other taxes levied by states and localities on piped natural gas, and several other industry products.

Federal Corporate Income Taxes

Corporate income taxes are a function of a company's taxable income, the rate at which that income is taxable and any tax credits available to the company. The natural gas and oil industry as a whole has been taxed at a steady rate of around 35%, with tax credits varying slightly over the years. Figure 5-5 illustrates the annual federal corporate income taxes paid by natural gas and oil corporations. The wide variations in federal corporate income taxes paid since 2001 are mostly due to changes in taxable income.

The industry represents a growing share of the federal government's tax revenue. In 2007, the natural gas and oil industry contributed to 9% of the U.S. government receipts from active corporations, up from 2% in 2002. The vast majority of those receipts come from refiners (65% in 2007). Extraction activities come in second at 16%. When compared to all other industry segments reported by the IRS, the natural gas and oil industry ranks third out of 20 broad industry segments. Figure 5-6 illustrates the contributions of each industry group to the total federal income taxes paid by corporations.

Severance Taxes

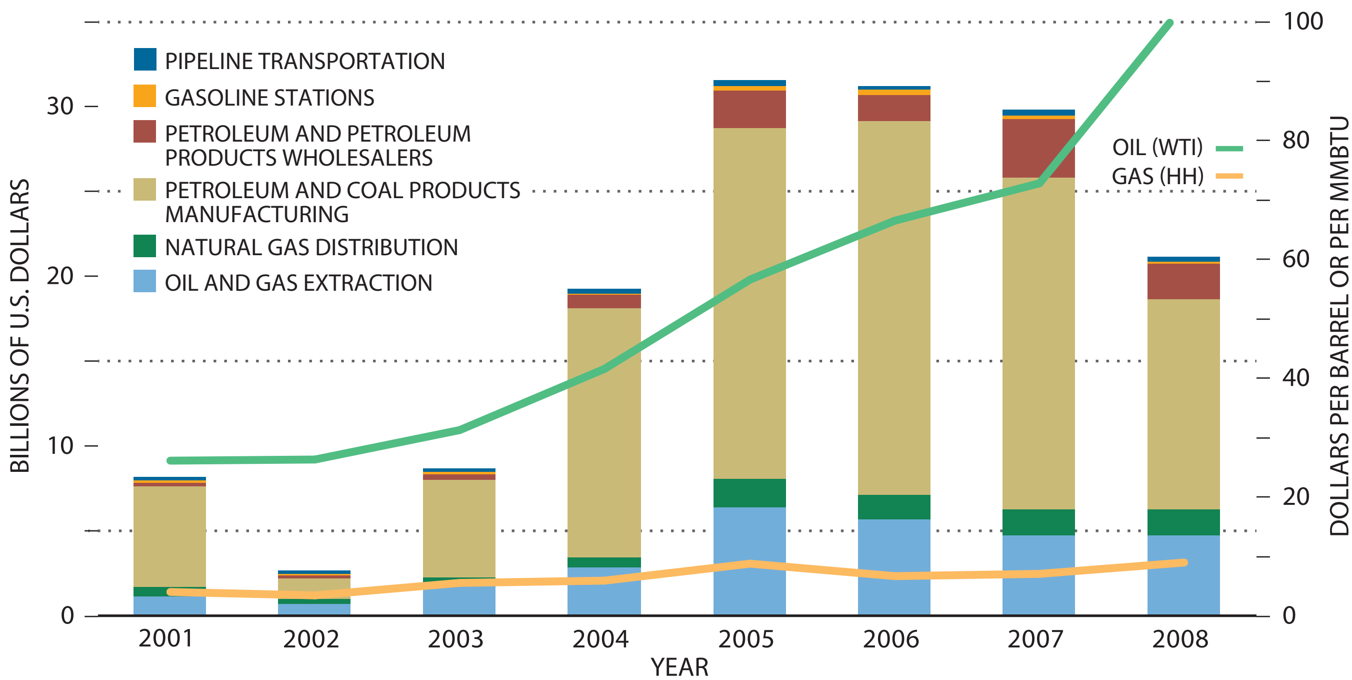
Twenty-seven states collect severance taxes from natural gas and oil producers. Table 5-2 highlights the 16 states that receive over 1% of their state tax collections from severance taxes. The remaining states either do not collect severance taxes or their severance tax collections account for less than 1% of their total state tax collections.

The increased drilling activity targeting the Marcellus Shale in the New York, Pennsylvania, and West Virginia region has prompted Pennsylvania to review

11 Association of American Railroads, "Railroads and Coal," 2010, page 1.

12 Association of American Railroads, "Class I Railroad Statistics," 2010, page 4.

Figure 5-5. Federal Income Taxes Paid by Corporations



Notes: HH = Henry Hub, used as the point of delivery for the natural gas futures contract of the New York Mercantile Exchange (NYMEX). WTI = West Texas Intermediate.

Source: U.S. Department of the Treasury.

its alternatives for balancing priorities of supporting communities in which extraction activities take place and of enabling natural gas and oil companies to operate competitively within the state. Pennsylvania Governor Corbett assembled an advisory commission to recommend a solution to address these priorities. In July 2011, this commission recommended that Pennsylvania institute a drilling impact fee in lieu of a severance tax.

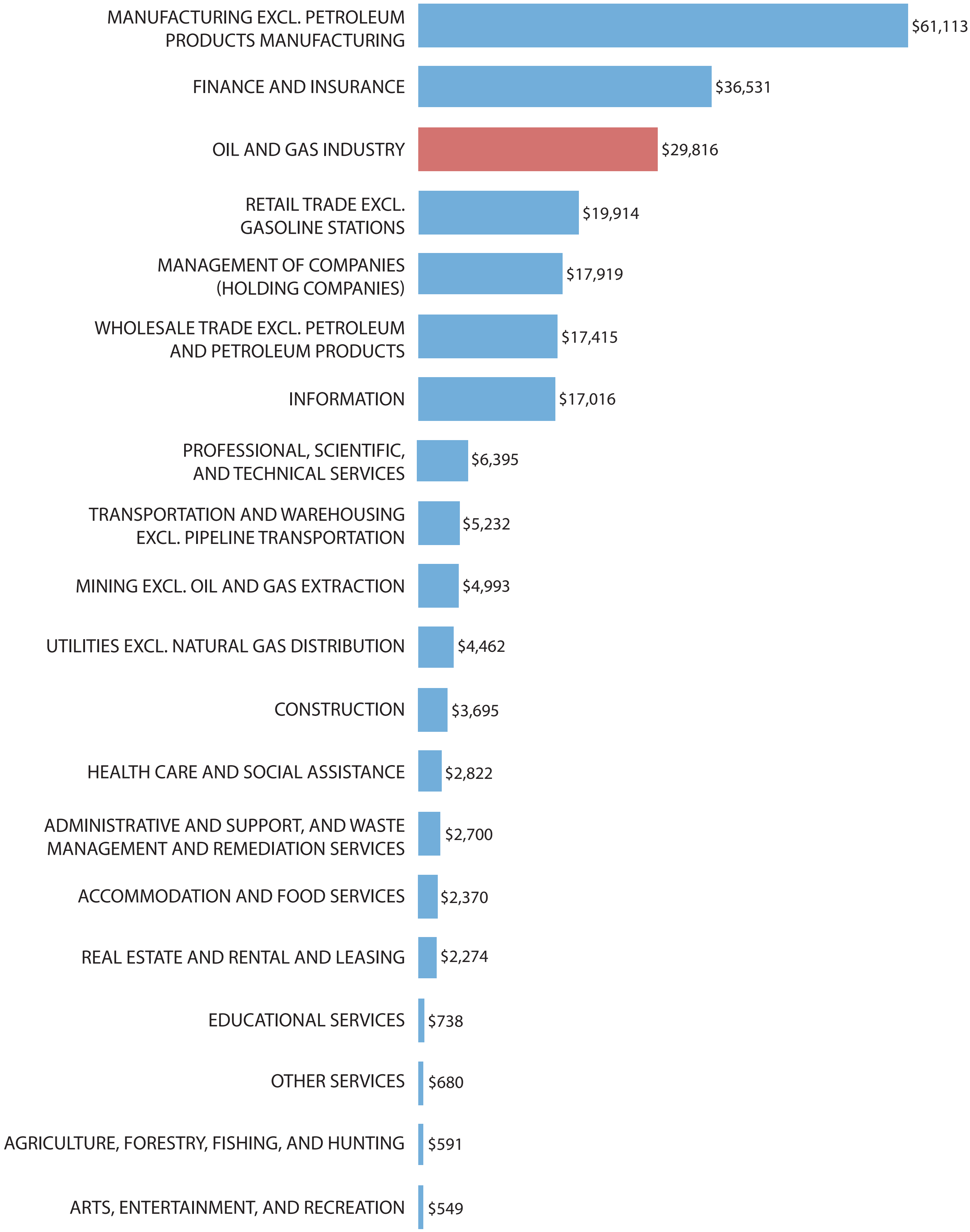
Royalties

Producers of natural gas and crude oil pay royalties to the owners of the mineral rights for the privilege of extracting the resources. Royalty rates vary by commodity and by jurisdiction and are applied to gross revenues from the sale of natural gas and oil. Onshore, the federal government charges a statutory minimum of 12.5% royalty, and offshore, the royalty rate ranges from 12.5% to 18.75%.

Under the Mineral Revenue Management program, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE, formerly known as the Minerals Management Service) collects, accounts for, and distributes revenues associated with offshore and onshore oil, gas, and mineral production from leased federal and American Indian lands. Figure 5-7 shows the reported royalty revenues collected by the BOEMRE for crude oil, natural gas, and NGLs from 2001 to 2009. The 45% decrease in royalty revenue in 2009, compared to 2008, resulted from the decrease in crude oil and natural gas prices, which averaged $61.99 per barrel and $4.94 per thousand cubic feet (Mcf) in 2009, respectively, compared to $99.92 per barrel and $8.89/Mcf, respectively, in 2008.

The BOEMRE collected over $72 billion from 2001 to 2009. Each year, the BOEMRE disburses its revenue to states, counties, parishes, the U.S. Treasury, American Indian Tribes, individual American Indian mineral owners, the Reclamation Fund for water projects, the Land and Water Conservation Fund, and the Historic Preservation Fund. In fiscal year 2009, the BOEMRE disbursed approximately $10.7 billion from revenues collected from energy and mineral production on federal and American Indian lands. Thirty-five states received a total of almost $2.0 billion directly from the BOEMRE as part of this disbursement.

Figure 5-6. 2007 Federal Taxes Paid by Corporations
(Millions of U.S. Dollars)



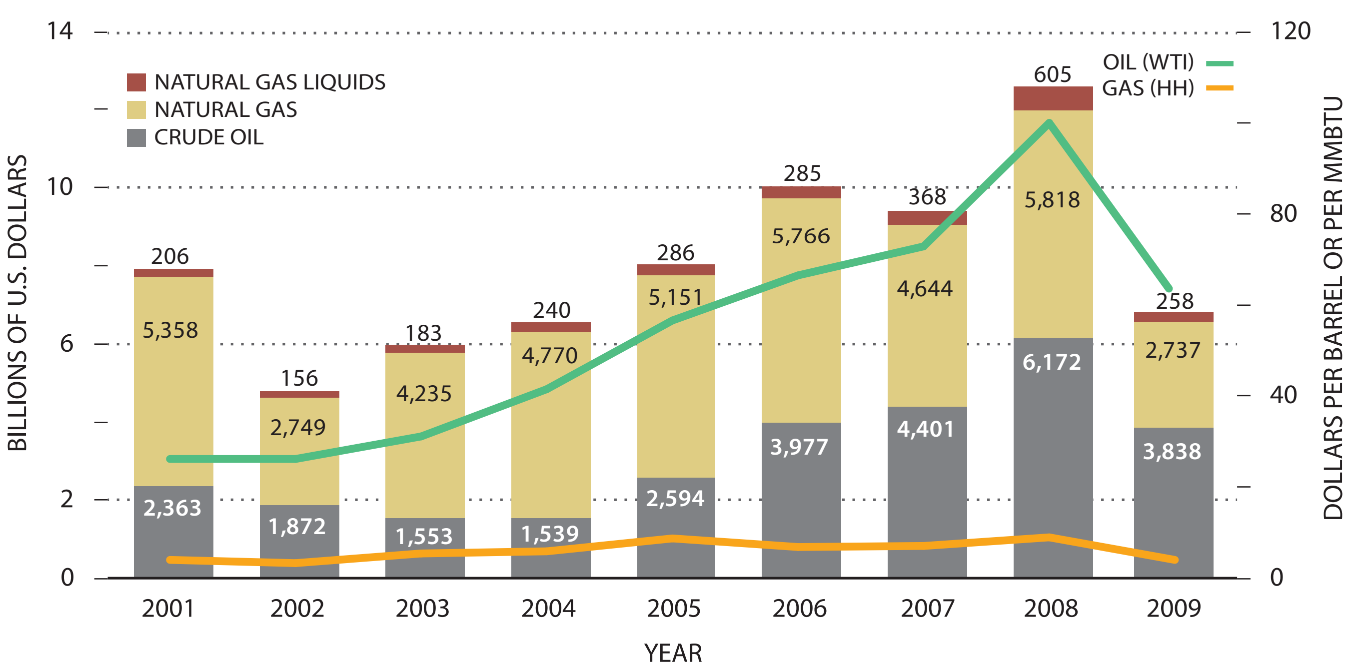
Source: U.S. Department of the Treasury.

Table 5-2. 2007 State Severance Taxes

	Collections (U.S. $ Millions)	As a % of State Tax Collections	Rank
United States	10,728.9	1.4%	
Alabama	144.2	1.6%	13
Alaska	2,216.0	64.4%	1
Colorado	136.9	1.5%	14
Kansas	132.3	1.9%	11
Kentucky	275.3	2.8%	10
Louisiana	904.2	8.3%	7
Mississippi	81.8	1.3%	15
Montana	264.7	11.4%	5
Nevada	62.2	1.0%	16
New Mexico	843.9	16.2%	4
North Dakota	391.3	21.9%	3
Oklahoma	942.1	10.6%	6
Texas	2,762.9	6.9%	9
Utah	101.5	1.7%	12
West Virginia	328.3	7.1%	8
Wyoming	803.6	39.7%	2

Source: National Conference of State Legislatures.

Figure 5-7. Reported Royalty Revenues



Notes: HH = Henry Hub, used as the point of delivery for the natural gas futures contract of the New York Mercantile Exchange (NYMEX). WTI = West Texas Intermediate.

Sources: Bureau of Ocean Energy Management; John S. Herold, Inc.

Other Taxes Generated Directly by the Industry

The natural gas and oil industry pays significant federal and state excise taxes on fuels. The combined weighted average tax rates per gallon were 38.6 cents for gasoline and 45.2 cents for diesel in 2007.[13] Applied to the 139 billion gallons of gasoline and 40 billion gallons of diesel sold in 2007, these tax rates generated approximately $72 billion, which is the largest tax item paid by the industry and, ultimately, by gasoline and diesel consumers.

Natural gas and oil companies also pay significant amounts of sales, use, and property taxes, which were estimated at $3.2 billion in 2007.[14] However, this is not the full story. Most gasoline stations are not directly owned by natural gas and oil companies, and convenience stores associated with gas stations sell approximately $180 billion of non-fuel merchandise.[15] Applying the national sales tax average rate of 7.3% to that amount provides an estimate of $13 billion in sales taxes generated by the broader natural gas and oil retail industry.

Tax Deductions for the Natural Gas and Oil Industry

A review of the tax burden on the natural gas and oil industry would be incomplete without referencing the tax deductions used solely by the industry or directed towards multiple industries, including the natural gas and oil industry. President Obama's 2012 budget includes proposals to eliminate eight of these tax deductions and one natural gas and oil research and development (R&D) program. Several of these tax deductions proposed for elimination are specific to the natural gas and oil industry (e.g., the ability to expense rather than capitalize intangible drilling costs). Other tax provisions targeted for elimination, such as the domestic manufacturing deduction, are available to multiple industries, but the president proposes targeting the natural gas and oil industry (and the coal industry) to end their use of the deduction. According to President Obama's 2012 budget, eliminating these eight tax deductions and one R&D program will generate over $43 billion in additional tax revenue over the next 10 years. Eliminating these tax provisions will reduce investment in domestic production across the industry by reducing company cash flow available for investment and making some domestic projects uneconomic. These provisions are particularly important for independent exploration and production companies that, on average, outspend their cash flow from operations by drilling new wells or acquiring new properties. Without these tax provisions, these companies would have less capital available to invest in their businesses. Table 5-3 summarizes the tax deductions and the R&D programs that are proposed for elimination.

Supporters of the elimination of these tax deductions argue that they primarily benefit multibillion-dollar oil companies that would remain profitable without these tax deductions.[16] Opponents of the elimination of these tax deductions maintain that this system has evolved over time to direct capital to critical industries to develop our domestic resources and mitigate our dependence on foreign sources of fossil fuels.[17]

Wood Mackenzie analyzed the impacts of the elimination of two of the tax deductions: the expensing of intangible drilling costs and the domestic manufacturing tax deduction for natural gas and oil companies. This analysis included the evaluation of the economic viability of 230 discrete domestic natural gas and oil plays under current commodity price conditions. Assuming that natural gas and oil companies lose both the manufacturing tax deduction and the ability to expense intangible drilling costs, Wood Mackenzie estimates that the average natural gas price needed to achieve a 15% internal rate of return would increase by $0.60/Mcf to $6.00/Mcf. Using this 15% internal rate of return as the breakeven threshold puts approximately 3 billion cubic feet per day of incremental natural gas production at risk in 2011 and 27 trillion cubic feet of natural gas resources at risk through 2020.[18]

Another provision proposed by the Senate to be repealed would further limit foreign tax credits and subject only U.S.-based natural gas and oil companies

13 Federal Highway Administration, *February 2008 Monthly Motor Fuel Reported by States*, 2007.

14 American Petroleum Institute, "America's Oil and Gas Industry: Paying Their Share," 2010.

15 National Association of Convenience Stores.

16 Gandhi, S. J., *Eliminating Tax Subsidies for Oil Companies*, Center for American Progress, 2010.

17 Hodge, S. A., *Who Benefits Most from Targeted Corporate Tax Incentives?* Tax Foundation, 2010.

18 Wood Mackenzie, *Evaluation of Proposed Tax Changes on the US Oil & Gas Industry*, commissioned by the American Petroleum Institute, 2010, page 4.

Table 5-3. Summary of Proposed Federal Budget Elimination Impacting the Natural Gas and Oil Industry (Millions of U.S. Dollars)

	2012	2013	2014	2015	2016	2012–2016	2012–2021
Total proposed changes from current law	(3,492)	(5,400)	(4,908)	(4,631)	(4,586)	(23,017)	(43,762)
Repeal enhanced oil recovery credit	0	0	0	0	0	0	0
Repeal credit for oil and gas produced from marginal wells	0	0	0	0	0	0	0
Repeal expensing of intangible drilling costs	(1,875)	(2,512)	(1,762)	(1,403)	(1,331)	(8,883)	(12,447)
Repeal deduction for tertiary injectants	(6)	(10)	(10)	(10)	(10)	(46)	(92)
Repeal exception to passive loss limitations for working interests in oil and natural gas properties	(23)	(27)	(24)	(22)	(21)	(117)	(203)
Repeal percentage depletion for oil and natural gas wells	(607)	(1,038)	(1,079)	(1,111)	(1,142)	(4,977)	(11,202)
Repeal domestic manufacturing tax deduction for oil and natural gas companies	(902)	(1,558)	(1,653)	(1,749)	(1,842)	(7,704)	(18,260)
Increase geological and geophysical amortization period for independent producers to seven years	(59)	(215)	(330)	(306)	(230)	(1,140)	(1,408)
Terminate oil and gas research and development program	(20)	(40)	(50)	(30)	(10)	(150)	(150)

Source: Office of Management and Budget, *Fiscal Year 2012 – Terminations, Reductions, and Savings: Budget of the U.S. Government*, pages 52–53.

to double taxation of foreign earnings. This would make domestic companies less competitive than their foreign-based counterparts in the United States and abroad.

The natural gas and oil industry is not the only energy-related industry to benefit from federal tax deductions. In fact, as a percentage of total U.S. consumer spending by energy source, the natural gas and oil industry is among the lowest recipients of federal tax deductions or subsidies compared to other energy sources. Table 5-4 summarizes the estimated federal government taxpayer incentives by energy source as a percentage of total U.S. consumer spending on each energy source in 2006.

NATURAL GAS AND OIL WORKFORCE CHALLENGES

Like most industries, the natural gas and oil industry is experiencing the initial stages of a large wave of retirements as the oldest members of the baby boomer generation (those born between 1946

Table 5-4. Estimated Federal Government Financial Incentives by Energy Source in 2006*
(Millions of U.S. Dollars)

Energy Source	Government Financial Incentives	Total Spending on Energy Source	Government Financial Incentives as a Percent of Total Spending	Government Financial Incentives per Million Btu of Consumption
Ethanol	$4,708	$17,791	26.5%	$10.13
Nuclear	$1,187	$5,694	20.9%	$0.14
Solar	$383	$3,114	12.3%	$5.32
Wind	$458	$3,960	11.6%	$1.73
Biodiesel	$92	$933	9.9%	$2.80
Coal	$2,755	$39,984	6.9%	$0.12
Hydroelectric Power	$295	$56,419	0.5%	$0.10
Geothermal	$29	$5,854	0.5%	$0.09
Natural Gas and Oil†	$3,503	$775,907	0.5%	$0.06
Biomass	$210	$50,631	0.4%	$0.06

* Federal fiscal years run from October 1 to September 30.

† Natural gas and oil includes natural gas, crude oil, and natural gas liquids plant production.

Source: Energy Information Administration and Texas Comptroller of Public Accounts.

and 1964) reach age 65 this year. Similar to most industry sectors dependent on a robust technical workforce, the natural gas and oil industry faces crucial challenges in replacing that talent, particularly highly skilled technical positions such as petroleum engineers and geoscientists. University-level programs that directly feed into natural gas and oil careers have contracted over the past several decades, resulting in a supply of new employees that will be unable to replace the talent vacated by baby boomer retirements.

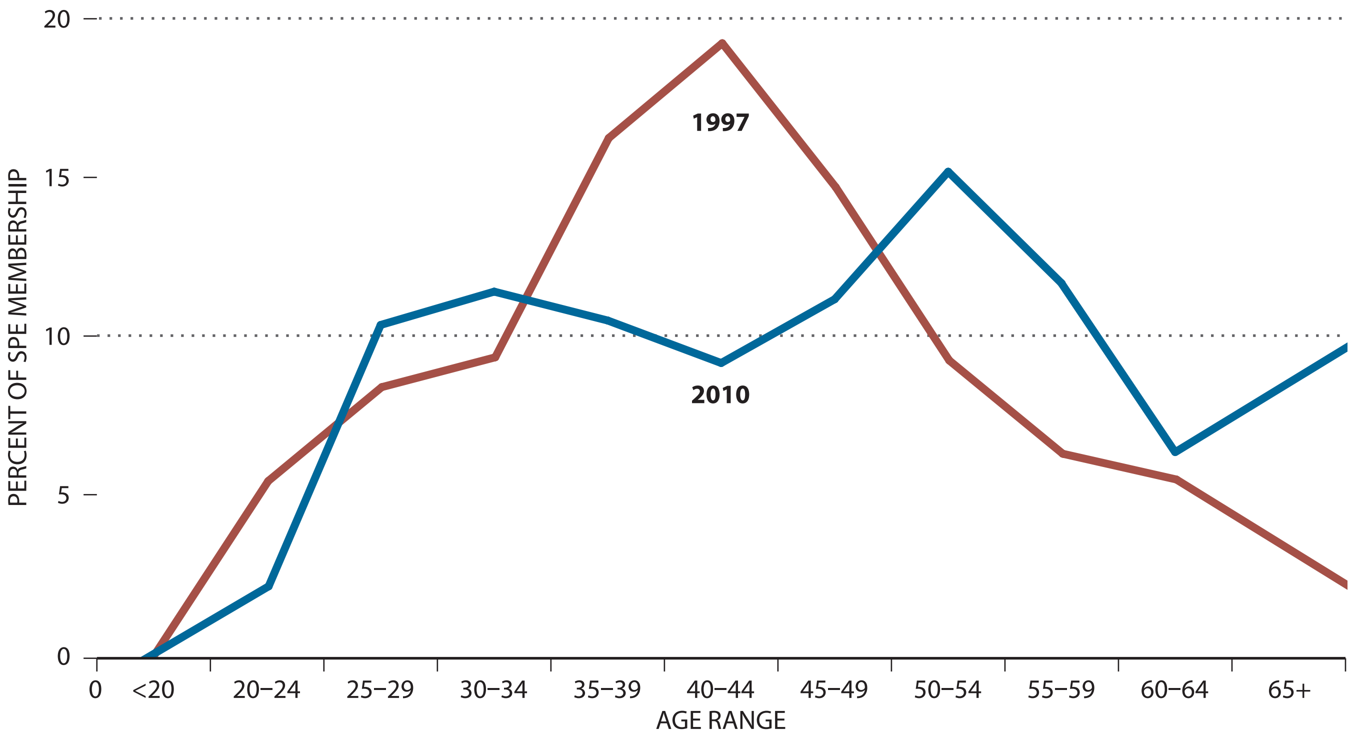
The recession that ended in June 2009 (according to the U.S. National Bureau of Economic Research) negatively impacted retirement savings for many baby boomers and thus delayed their ability and/or willingness to retire. This recession thus may have deferred the onset of critical shortages of talent and provided a narrow window to enable appropriate knowledge transfer and development for younger workers.

However, the recession, combined with weak natural gas prices in the United States, also led to a decrease in recruiting efforts by natural gas and oil companies and limited the rate at which companies took on new hires that would have allowed them to leverage the delayed retirements. As seen in the student response to contraction in the 1980s, and in student attitude surveys taken of geosciences majors, when the industry limits its hiring, that trend is quickly communicated within the student community. This, plus existing prejudices against natural gas and oil careers by students, further dissuades them from degrees that map to the needs of the industry. This process can often limit the potential new hires market for nearly a decade, as impacted high school and college students enter the workforce six to ten years later.

Challenge #1 – Aging Natural Gas and Oil Workforce

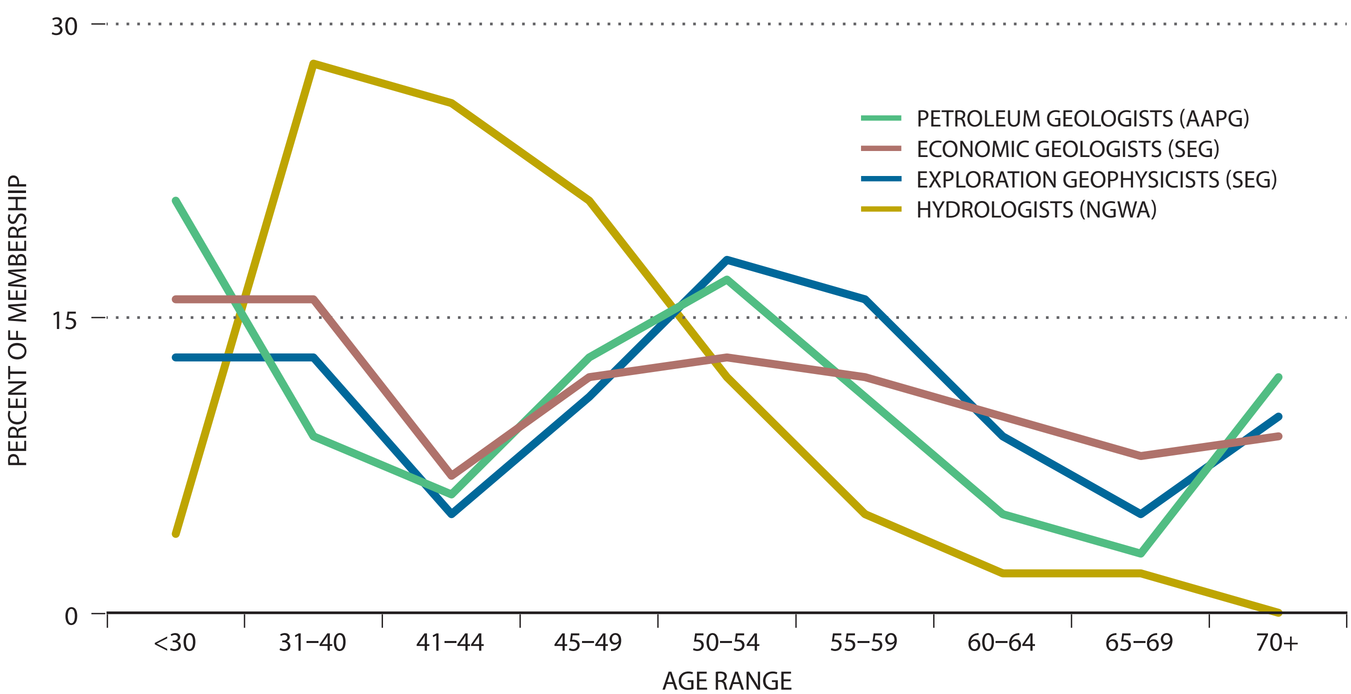
The natural gas and oil industry relies heavily on petroleum engineers and geoscientists to explore for, evaluate, and quantify subsurface natural gas and oil resources. As Figures 5-8 and 5-9 illustrate, a significant percentage of the petroleum engineer and geologist population is within 10 years of retirement. Also of note, approximately 52% of Society of Petroleum Engineers (SPE) members are in the baby boomer

Figure 5-8. Age Distribution of Society of Petroleum Engineers (SPE) Membership



Source: Society of Petroleum Engineers.

Figure 5-9. Geoscientist Age Distribution by Membership Society (2008)



Sources: AGI Geoscience Workforce Program; data provided by the Society of Exploration Geophysicists (SEG), American Association of Petroleum Geologists (AAPG), Society of Economic Geologists (SEG), and the National Ground Water Association (NGWA).

generation or older, the segment of the population that has begun to reach retirement age. This compares to 38% for the U.S. population as a whole.

Figure 5-9 illustrates the relative age distribution imbalance of exploration geophysicists and petroleum geologists compared to disciplines such as hydrology that have attracted more young talent over the past decades. Hydrologists in the National Ground Water Association aged 45 and older represent only 42% of that group's membership. By comparison, 61% and 69% of American Association of Petroleum Geologists and Society of Economic Geologists members, respectively, are over age 45. Similarly, Figure 5-10 highlights the spike in the population of geoscientists in the natural gas and oil industry that are in the 50 to 54 age range.

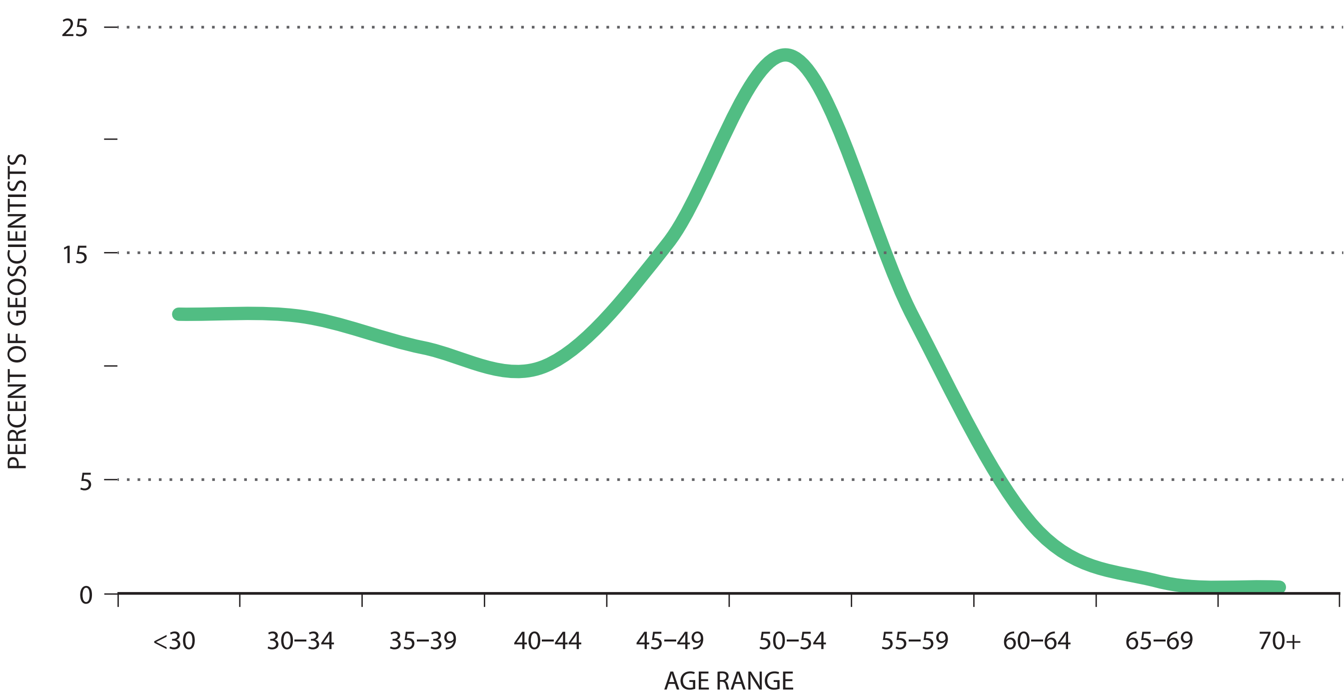
The private sector will not face the challenge of an aging workforce alone. The public sector demographic looks even worse, with 75% of petroleum engineers and 72% of geologists in U.S. government jobs aged 45 or older. Figures 5-11 and 5-12 illustrate the migration of the age demographics of petroleum engineers and geologists in the U.S. government over the time period from 2003 through 2010.

Figures 5-11 and 5-12 illustrate that the natural gas and oil industry, and the federal government institutions responsible for regulation, face an aging and shrinking experienced workforce over the next 10 years; and in the case of geoscientists in federal agencies, the so-called "Great Crew Change" is already underway.

Challenge #2 – Long Decline in University-Level Population Seeking Natural Gas and Oil Careers

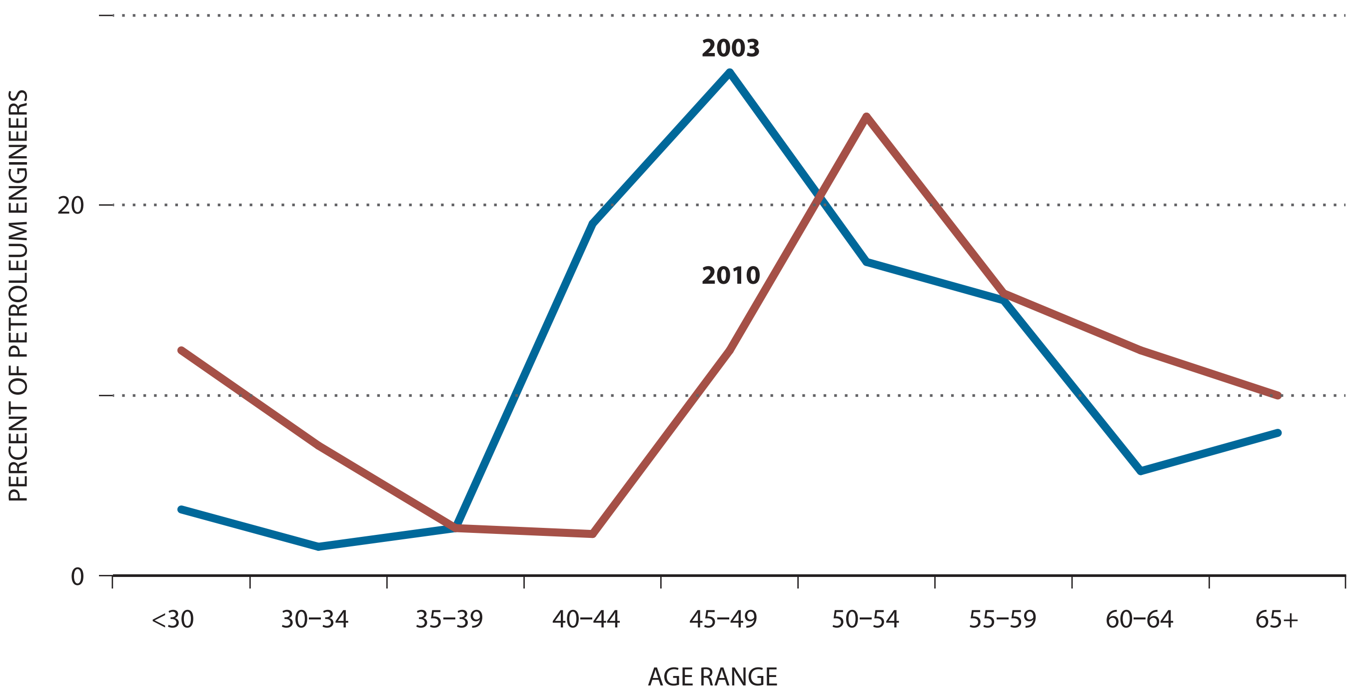
Compounding the aging workforce issue is the inability of our current pipeline of university graduates to fill the natural gas and oil industry's hiring needs. As illustrated in Figure 5-13, university-level petroleum engineering enrollment in the United States peaked in 1983 with over 12,000 students working on petroleum engineering degrees. Enrollment in petroleum

Figure 5-10. Age Distribution of Geoscientists in the Oil and Gas Industry



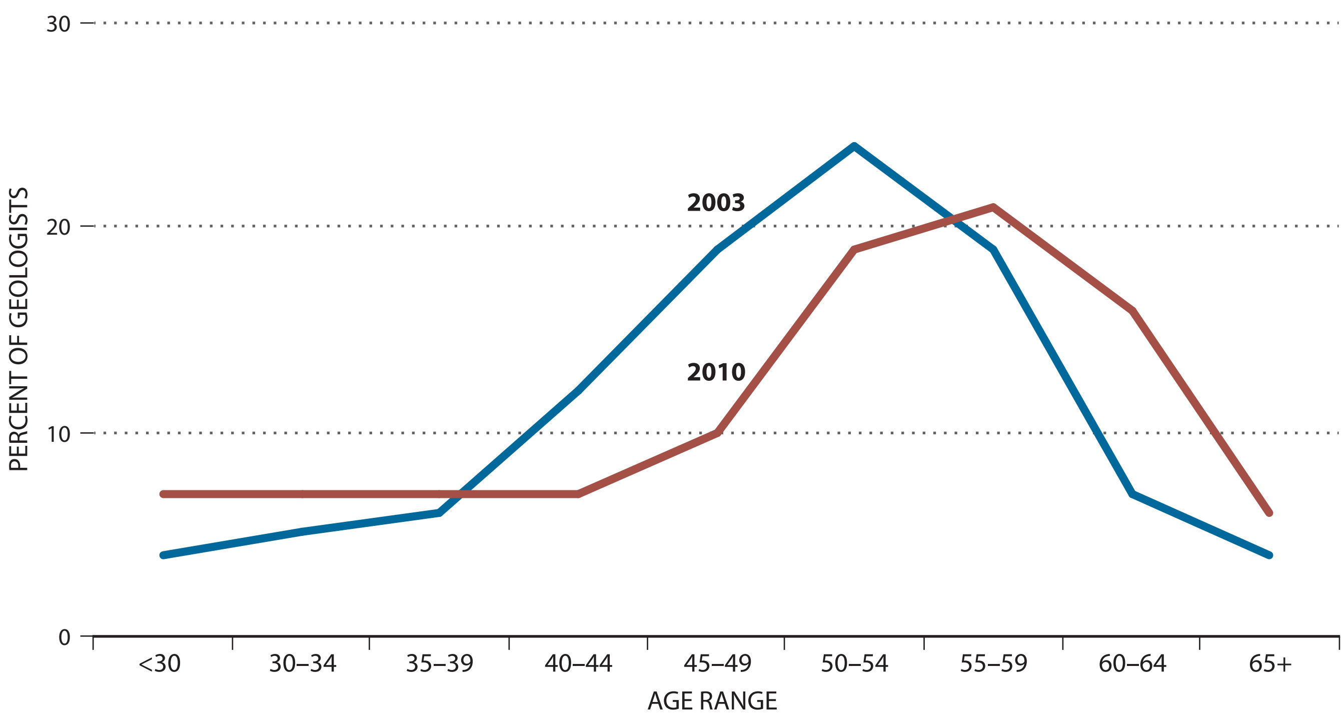
Source: AGI Geoscience Workforce Program.

Figure 5-11. Age Distribution of Petroleum Engineers in the U.S. Government



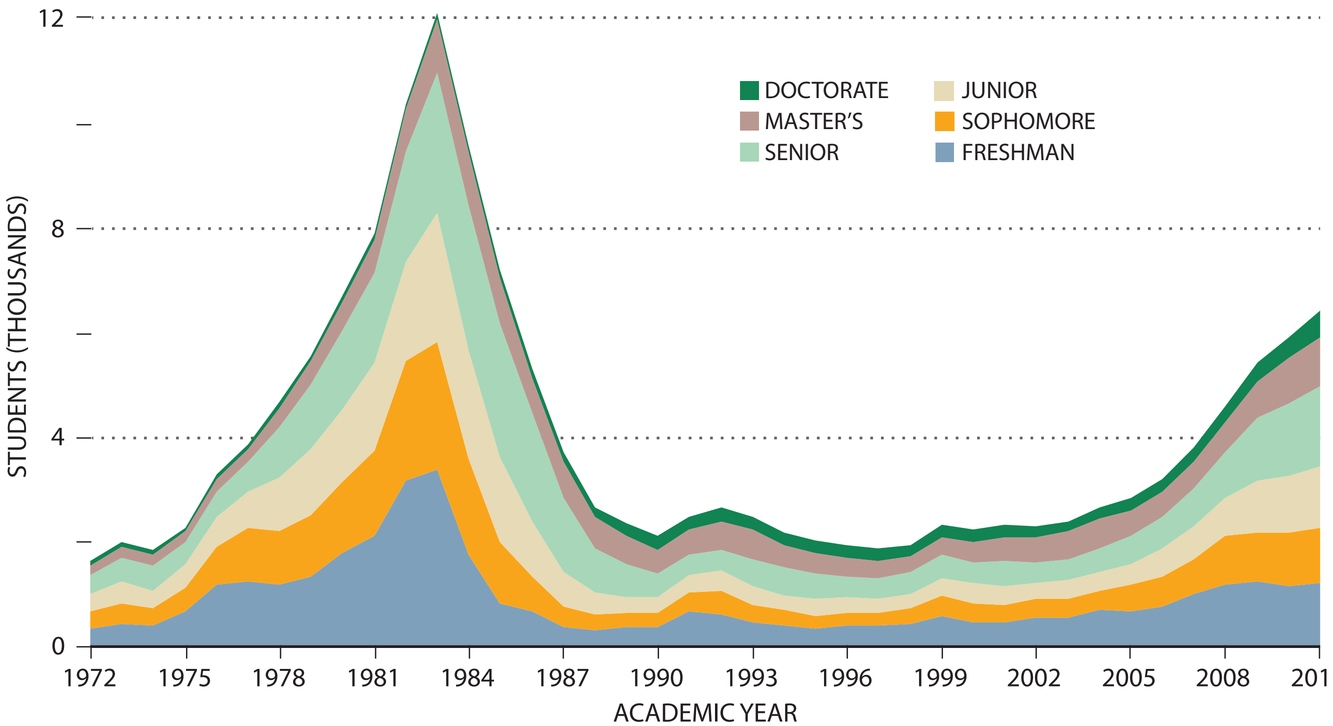
Sources: AGI Geoscience Workforce Program; data derived from the Office of Personnel Management FedScope database.

Figure 5-12. Age Distribution of Geologists in the U.S. Government



Sources: AGI Geoscience Workforce Program; data derived from the Office of Personnel Management FedScope database.

Figure 5-13. U.S. Petroleum Engineer Enrollment (1972–2011)



Source: Dr. Lloyd Heinze, Texas Tech University.

engineering programs dropped sharply to just under 1,900 students by 1997, an 84% decline. However, petroleum engineering enrollments have been on an upward trend since 2004 and now stand at approximately 6,400 students.

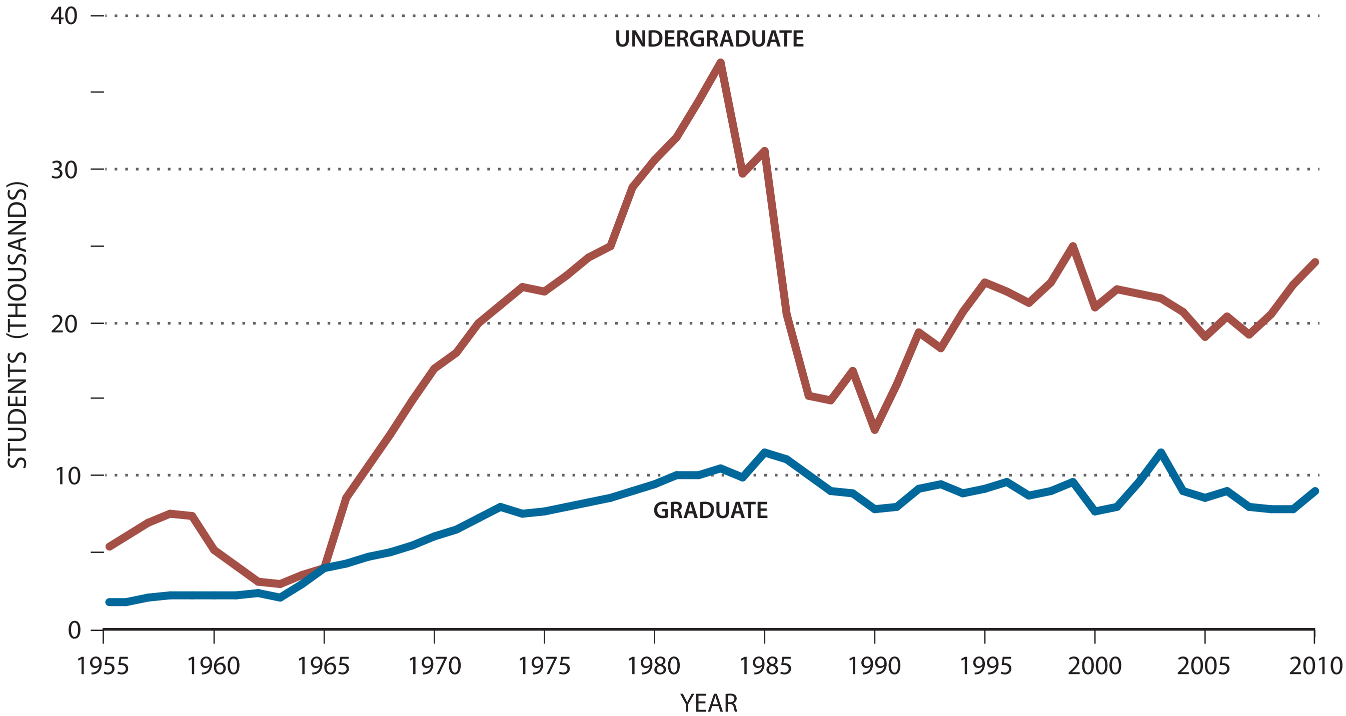
Similarly, undergraduate-level geosciences enrollment peaked in 1983 with almost 37,000 undergraduate students working on geosciences degrees. Since that year, U.S. undergraduate geosciences enrollment decreased to a low in 1990 and then began a slow recovery. Enrollment, however, is still down by 35% compared to 1983. Figure 5-14 illustrates the trends in U.S. undergraduate and graduate geosciences programs from 1955 through 2010.

Enrollment in both petroleum engineering and geosciences programs faced a steep decline through the late 1980s as commodity prices, rig counts, and industry hiring activity all dramatically decreased and the U.S. economy swung into the 1990-1991 recession (see Figure 5-15).

As seen in the enrollment numbers, the petroleum engineering and geosciences academic situation responded dramatically to the changes in fortune in the energy sector. Students left the geosciences for other fields as natural gas and oil opportunities decreased. Perhaps more importantly, the faculty within the geosciences departments shifted to fields that distinctly do not lead towards the targeted skill sets needed by the natural gas and oil industry. This shift led to the current situation where there is insufficient university staff available to teach the courses and support the majors needed to produce sufficient numbers of graduates that would meet the needs of the natural gas and oil industry.

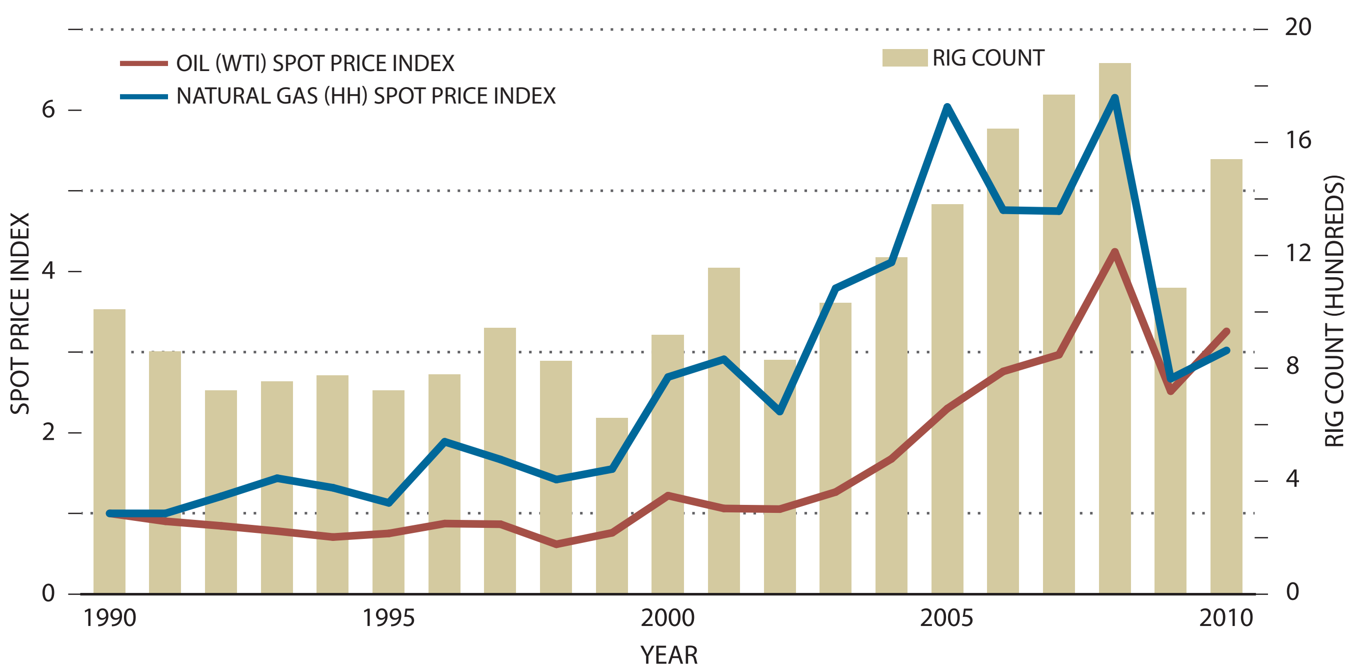
The divergence of geosciences programs from some of the technical areas desired by the natural gas and oil industry was further institutionalized by several key actions: (1) in times of rapid expansion, companies hired away key university faculty that were needed to maintain sufficient educational capacity in those departments; (2) companies cut university recruiting and training programs in times of business contraction; and (3) students sought careers in less-cyclical industries. Other drivers included the increased popularity of alternate careers, such

Figure 5-14. U.S. Geosciences Enrollments (1955–2010)



Source: American Geological Institute.

Figure 5-15. Average Annual U.S. Rig Count Compared to Average Annual Crude Oil and Natural Gas Prices



Notes: HH = Henry Hub, used as the point of delivery for the natural gas futures contract of the New York Mercantile Exchange (NYMEX). WTI = West Texas Intermediate.

Sources: Baker Hughes; Bloomberg.

as technology and environmental sciences, and the elimination of most upstream research centers in the domestic industry. The latter led faculty and students to solely focus on federal research grants for monetary support, and the vast majority of the funded research has little application towards topics and skills of interest in the natural gas and oil industry.

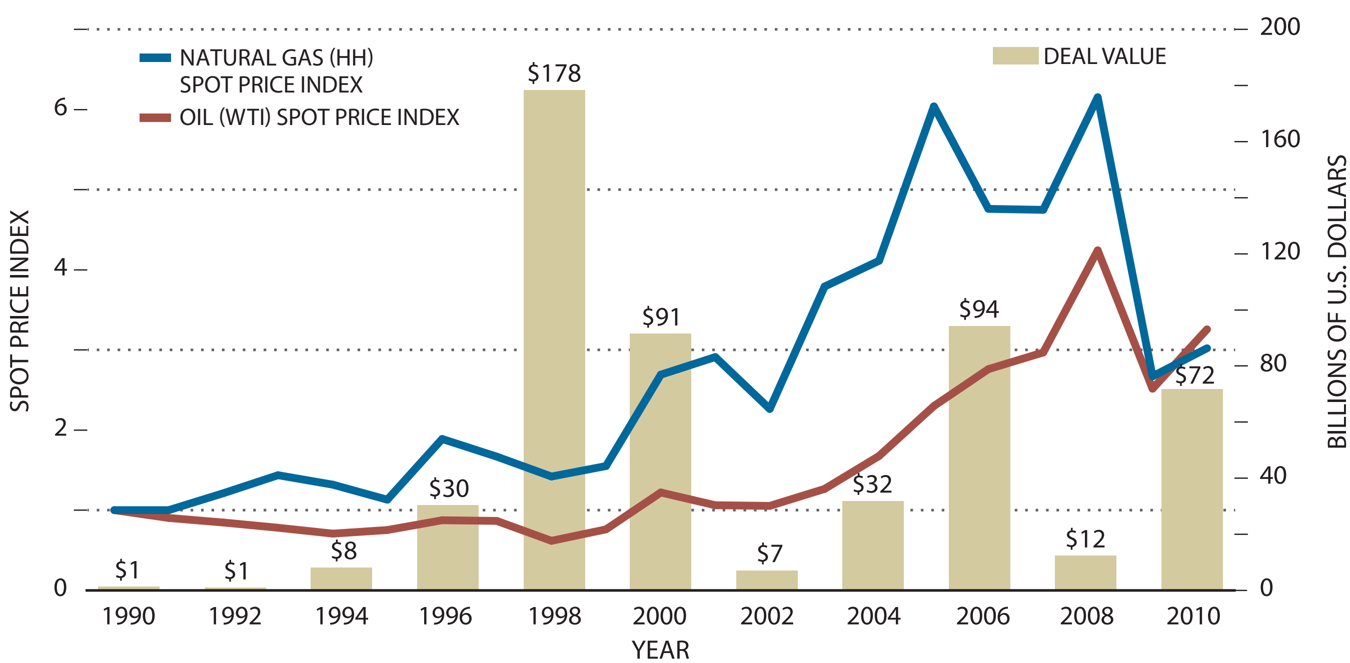
The cyclical nature of the natural gas and oil industry has resulted in a series of large-scale workforce early retirements or layoffs in times of weak commodity prices and declining capital investment, followed by periods of rapid hiring in times of stronger commodity prices and expanding capital investment. During these cycles, a portion of the workforce elects to leave the industry to work in an entirely different market, or to retire, and does not return. In addition, the industry must contend with an annual attrition rate of 10% for petroleum engineers with 10 to 15 years of experience.[19] The result is a shrinking population of experienced technical professionals necessary to meet the needs of industry and government and to train the next generation of technical professionals.

Also, the natural gas and oil industry has transformed itself over the decades through waves of corporate mergers and acquisitions. Since 1990, the volume of annual corporate natural gas and oil mergers and acquisitions activity has ranged from less than $1 billion in 1992 to almost $180 billion in 1998, averaging $45 billion per year (see Figure 5-16). Companies often cite opportunities for greater scale, access to additional resources, improved growth outlooks, and competitive positioning as drivers for consolidation. Companies also benefit from cost savings in the form of improved efficiencies and headcount reductions.

The combination of the aging workforce and constrained pipeline of new, well-educated talent leads to images like that in Figure 5-17. Even in a low-demand scenario, the quantity of students enrolled in geosciences programs today will be insufficient

19 University of Houston – Boyden, *The Workforce Crisis in the Upstream Oil and Gas Sector,* 2007, page 15.

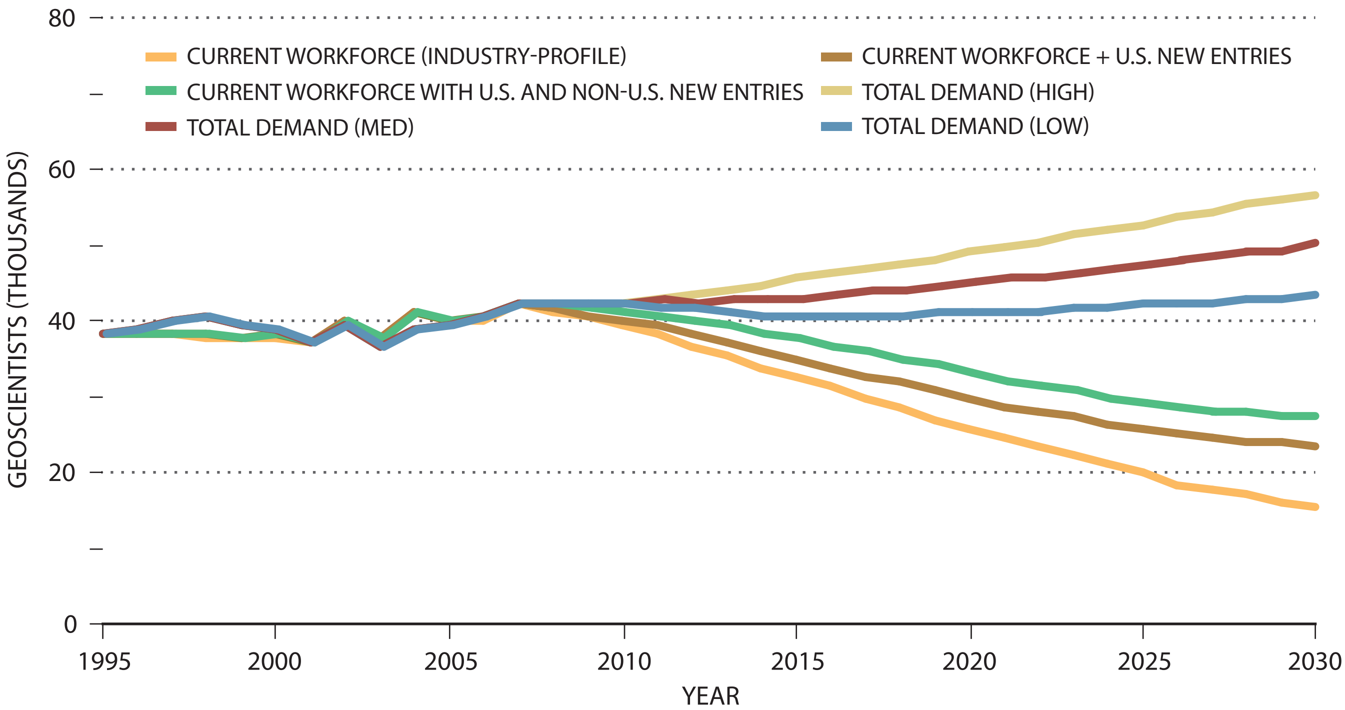
Figure 5-16. Total Annual U.S. Oil and Gas Industry Corporate Mergers and Acquisitions' Volume Compared to Average Annual Crude Oil and Natural Gas Prices



Notes: HH = Henry Hub, used as the point of delivery for the natural gas futures contract of the New York Mercantile Exchange (NYMEX). WTI = West Texas Intermediate.

Sources: John S. Herold Inc.; Bloomberg.

Figure 5-17. Oil and Gas Industry Demand for Geoscientists



Source: AGI Geoscience Workforce Program.

to meet the domestic natural gas and oil industry's needs later this decade and beyond. Also, new university graduate hires, by definition, will not have the experience and, therefore, the ability to replace retiring 30+ year veterans of the natural gas and oil industry.

Challenge #3 – The U.S. Need for Increased Investment in K-12 Mathematics and Science Education

The discussion above focused on university and postgraduate level education; but the natural gas and oil industry, and the United States as a whole, needs an improved kindergarten through high school (K-12) education system. The need for improvement is particularly acute in the mathematics and science disciplines, which provide the foundation for university-level engineering and geosciences studies. In 2005, the National Academies conducted a study of America's competitiveness and released a report referred to as "Gathering Storm." The highest priority recommendation and actions in this report involved K-12 education, where the United States, on average, lags other industrial economies. In 2010, the National Academies reviewed the U.S. progress since 2005 in *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*. The participants unanimously agreed that the nation's outlook has worsened since 2005 and, despite some bright spots, the 14,000 public school systems have shown little sign of improvement, particularly in mathematics and science. These results lead the participants to assert that the recommendations made five years ago, of which the highest priority was strengthening the public school system and investing in basic scientific research, appear to be as appropriate today as they were in 2005.

The 2010 National Academies study listed three specific implementing actions in support of the recommendation to move the U.S. K-12 education system in science and mathematics to a leading position by global standards:

- Funding four-year scholarships for 10,000 U.S. citizens annually to obtain degrees in mathematics, science, or engineering with a requirement that they teach in a public school for five years thereafter

- Strengthening skills of 250,000 current teachers by subsidizing advanced training and workshops, and also create a new mathematics and science curriculum for voluntary adoption across the country
- Increasing the number of teachers qualified to teach Advanced Placement courses and the students taking such courses by offering financial bonuses both to high-performing teachers and to students who excel.

Responding to the Workforce Challenges

In the short-term, companies have several unattractive options to mitigate their workforce challenges, including: abandoning projects, taking a non-operator role in projects, delaying projects, and/or operating projects with less staffing than needed for efficient operations. The long-term solution to the emerging talent gap is increased engagement by natural gas and oil companies with campus communities in meaningful ways. Expansion of recruitment efforts by broadening the range of institutions that are visited allows the industry to show itself as an attractive alternative to competing technical careers. Firms can showcase the high-tech nature of the industry and the potential for long and rewarding careers for technical professionals.

Even more importantly, natural gas and oil companies need to change the nature of their relationship with the appropriate departments on a broad range of campuses. This will require direct investment in these programs through research partnerships and funding, scholarships, sabbatical exchanges, and other activities that can impact academic culture and focus on a campus. Yet, even with increased recruiting efforts and improved relationships with academic programs, natural gas and oil companies will be forced to promote people faster than they have done historically, which will require additional investments in training programs. The shortage of technical professionals will likely result in higher personnel costs across the industry. Other short-term solutions include retaining retirees as consultants and hiring experienced professionals from abroad.

The federal government has potential solutions it can contribute to this workforce dilemma. As part of a broader national energy policy, government research grants can be directed towards disciplines and topics designed to address those natural gas and oil energy policy goals. Also, an easier and less costly contribution the government can make would be to acknowledge the importance of the natural gas and oil industry. If students and young professionals view the industry as critical to the nation's economic, environmental, and energy security goals, the industry will have a better chance of attracting new technical professionals. Lastly, the petroleum engineering and geosciences student enrollment numbers mentioned above only tell part of the story. A significant percentage (greater than 25%) of students in these programs are not U.S. nationals. Under a modified immigration program for these types of professionals, the domestic natural gas and oil industry would have a larger pool of potential talent to recruit.

NATURAL GAS AND CRUDE OIL VOLATILITY IMPACTS ON PRODUCERS AND CONSUMERS

Commodity Price Volatility

Natural gas and oil producers and consumers, capital providers to these companies, governments, and other stakeholders each have individual views on volatility. The main differences lie in how each party defines volatility and responds to volatility as observed in its markets.

Traditionally defined commodity price "volatility" is a healthy signaling mechanism for market participants about supply and demand information.[20] If price changes rapidly over short periods of time, then price is said to have high volatility. If price changes slowly over time, then price is said to have low volatility.

Regular variation in price, provided there is a means of mitigating price risks through well-functioning financial markets, need not be disruptive. It is incorrect to argue that prices that have high, routine variability are more problematic than prices that are very stable for a period of time but which suddenly change. In fact, investment planning is much more difficult in the latter case, and it has been shown in various studies that unexpected changes in price have a much larger negative impact.

20 Price volatility is estimated by calculating the annualized standard deviation of the periodic (usually daily or weekly) changes in price.

When discussing energy security, we often discuss either the level of price or the volatility of price, yet neither of these metrics is sufficient. Rather, unexpected changes in the supply-demand balance (and hence price) are what generate difficulties at the macroeconomic level.

Background: Commodity Prices

Oil Prices

Energy sources derived from oil and natural gas make up the majority of consumer energy expenditures and a significant share of expenditures by the production sectors. According to the Energy Information Administration (EIA), during the 60-year period from 1950 through 2009, 37% to 48% of total annual U.S. energy consumption was fueled by petroleum products, with petroleum always being the dominant energy source (averaging 41% of total consumption over that time frame), followed by natural gas (25%) and coal (22%). The share of petroleum-based products has followed a somewhat parabolic trajectory during that time frame: rising during most of the first three decades until peaking at 48% in 1977 and falling gradually since.

Due to the volatility of petroleum prices as well as their dominant share as an energy source, economists have primarily focused on oil price shocks in their analyses of the effects of energy prices on the economy. In fact, no published research has empirically examined the relationship between natural gas prices and aggregate economic activity.

Natural Gas Prices

Seasonality, variations in normal weather patterns, deviations of natural gas in storage from seasonal norms, and disruptions in natural gas production (for example, hurricanes in the Gulf of Mexico) directly affect natural gas supply and demand and exert an important influence on natural gas prices. In particular, natural gas prices show: (1) a pronounced seasonal rise in the winter months; (2) an increase in response to colder than normal winter weather due to increased heating demand; (3) an increase in response to warmer than normal summer weather due to increased demand to generate electricity; (4) a rise when hurricanes disrupt production in the Gulf of Mexico; and (5) a rise when natural gas storage is below seasonal norms. Conversely, prices decrease in the winter when it is warmer than normal, in the summer when it is colder than normal, when production initially lost to hurricane damage is regained, and when natural gas storage is above seasonal norms. Industry experts also observe that industrial activity has a powerful influence on natural gas demand and affects natural gas prices. These price movements show the influence of variations in supply and demand.

Natural gas supply and demand can be extremely inelastic in the short run, which means that small variations in either the supply or demand would lead to sharp movements in natural gas prices. These significant movements, as well as seasonal variation in the natural gas price, are reduced considerably by natural gas in storage. It follows that when storage is low, a shock to supply or demand can lead to extreme price movements. Such an incident occurred in 2000-2001, when there was strong demand for natural gas to generate electric power in California during that state's power crisis.

Macroeconomic Impacts of Changing Commodity Prices

Consumption

Changing energy prices have a tangible impact on consumption as households modify spending patterns to accommodate energy prices that may suddenly increase or decrease the energy share of their budgets. The magnitude of this effect upon direct energy purchases is inversely proportional to the consumer price elasticity of energy. A price rise causes a direct reduction in energy expenditures, as well as a shift in spending patterns away from energy-intensive goods to more energy-efficient appliances, and also a general reduction in consumption of goods that consume energy. Consumer expectations about the duration of energy price changes weigh heavily on larger consumer decisions regarding energy consumption such as purchasing a more fuel-efficient vehicle or more energy-efficient appliance. Reductions in energy expenditures also affect complementary goods and services. For example, reduced driving might result in a collateral reduction in fast food sales.

Indirect effects on general consumption activity also stem from changing energy prices. Uncertainty about future price movements may lead to a general conservatism in spending as consumers engage in precautionary saving and postpone purchases of durable goods. Reduced earnings expectations lead to falling stock prices and, ultimately, a perceived decline in wealth, which further spurs saving. When commodity price inflation leads to economy-wide inflation, increasing interest rates meant to suppress economy-wide inflation further stifle general consumption patterns. The shifts in spending patterns described above may create a need for the reallocation of resources across or within sectors of the economy, which in turn may lead to at least a transitional rise in unemployment and a consequent further decline in consumption. However, if there is a strong expectation that a price increase is temporary, then consumers may actually tap into their savings and/or borrow more. A shift to more liquid asset portfolios and increase in the demand for money will cause interest rates to rise, a macroeconomic mechanism which also leads to economy-wide price inflation.

Manufacturing

The manufacturing sector is also affected by energy price shocks through a number of channels. As described above for households, industrial sales decline as a result of the drop in consumption. Another direct effect of an increased price is through the higher cost of manufacturing inputs as prices rise for materials that have energy as a significant input. A rise in the general level of prices may either cause real wages to fall, which will result in a decline of the labor supply, or an increase in labor costs as employees demand higher wages to contend with their own higher energy costs. A drop in energy prices, of course, causes the reverse of these processes.

Uncertainty – about both the future of sales and the future of production costs – induces manufacturers to curtail or postpone investment expenditures, particularly expenditures that are irreversible. This phenomenon persists particularly in periods of volatility, which only reinforces the sense of uncertainty about future price movements. As such, the persistent uncertainty effect may counteract the positive effects of an energy price drop, leading to asymmetric impacts of energy price changes. If, however, a rise in commodity prices is expected to persist, then manufacturers will tend to shift purchases to more energy-efficient factors of production (or to other countries), similar to the shift in consumer purchasing choices described earlier.

Summary

Some studies have attempted to draw general conclusions about the effects of commodity price changes on the macroeconomy. For example, one study estimated that the first-year impact of a $10/barrel increase in crude oil prices caused a decrease in GDP ranging from -0.15% to 0.80%, with an average estimate of -0.23%, rising in the second year to a range of 0.24% to -1.61%, with an average estimate of -0.49%.[21] However, other experts have concluded that one cannot interpret time series data outside of the context of expectations regarding changing prices and sources of the changing prices.

In either of the two scenarios described above in the Consumption section (sticky commodity price inflation or commodity price volatility characterized by inflation followed by a return to pre-inflation levels), the economy faces price inflation. However, while sticky commodity price inflation results in the somewhat paradoxical outcome of a decline in consumption coupled with rising prices, or "stagflation," temporary commodity price volatility can be expected to only have temporary effects. Stagflation is also a likely outcome in a third scenario, long-term commodity price volatility, as uncertainty around energy costs would cause consumers to save more for their uncertain future spending needs and suppliers to maintain prices at levels that would cover any increases in energy costs.

The cause of energy price shocks is a critical determinant of both the magnitude and timing of their effect on the economy. For example, a sudden restriction of supply leads to a sudden but relatively moderate decline in GDP that peaks after about seven quarters from the incidence of the event. On the other hand, an increase in aggregate global demand has the immediate effect of a rise in GDP over the first three quarters, followed by a protracted and more significant decline. A third type of price shock, termed an "oil-market specific shock," often occurs as the result of a surge in "precautionary oil demand" in response to a perceived threat to supply. It may result in a simultaneous shift of both the supply and demand curves for oil, with a resulting compounding of the effects of either.

21 Huntington, H., *The Economic Consequences of Higher Crude Oil Prices*, prepared for the U.S. Department of Energy, October 3, 2005, pages 1–53.

An oil-market specific demand shock will result in a persistent and relatively significant decline in GDP that will not reach a maximum until after an estimated three years. This framework provides a possible explanation for why the run-up in oil prices during the past 10 years did not produce an immediate recession in the United States and other economies, as the cause of these was clearly due to strong global economic growth and a concomitant general surge in demand for all industrial commodities. Conversely, each of the supply-driven energy price shocks in the 1970s almost certainly included an oil-specific demand shock as at least a contributing factor to its occurrence.

Energy Sector-Specific Impacts of Changing Commodity Prices

Commodity prices and commodity price fluctuations also impact investment by companies in the natural gas and oil industry. When examined as an isolated variable, analysis indicates that "[investment in] mining structures and mining and oil field machinery is large and statistically significant," with elasticities of 1.39 and 2.13, respectively.[22] These results indicate that increasing commodity prices have a strong, positive effect on the investment decisions made by oil, gas, and mining companies while decreasing commodity prices have the opposite effect.

A study of the effects of short-term and long-term crude oil price changes on oil rig activity found that an increase in commodity price that is expected to be short-lived will not influence investment decision-makers to take on a new field development project because it is costly to develop an oilfield and the investment is spread over a long period of time. For price changes that are expected to be longer term, there exists "a clear positive relationship between oil rig activity in non-OPEC regions and crude oil prices in the long-run" in North America.[23] When price increases are expected to be long-term, the long-term elasticity observed is 1.28, and typically "about half of the long-run response is obtained after five months."[24] Also, when compared to drilling activity in other countries, drilling activity in the United States reacts relatively quickly to long-term commodity price changes. This short reaction time may be due to the flexible rig market, more established regulations in the United States, and the fact that oil drilling in the United States is a mature industry so any new drilling activity is done at the margin and is highly sensitive to commodity prices.

An additional factor that may influence company spending decisions during periods of increased commodity price volatility is the practice of hedging. Companies that run hedging programs typically secure their hedges 6 to 18 months in advance. As such, these companies are better protected in the short- and medium-term against commodity price fluctuations. Because hedged companies have better visibility of their future cash flows, they are less likely than unhedged companies to significantly alter their capital spending programs due to changing commodity prices. Unhedged companies are better able to capture upside in rising commodity price environments and may also be more likely to decrease their capital spending plans if commodity prices, and thus cash flows, drop significantly in the near term.

Impacts on Volatility

Commodity price expectations have experienced a great deal of variability, and this plays an important role in the types of investments that market participants (e.g., utilities and utility rate-payers) are willing to make.

Factors that can mitigate volatility (both in the traditional definition of the term and in the sense of accuracy of price expectations) include:

- Increased elasticity of supply – A higher elasticity of supply means that a given change in price will result in a larger increase in supply, so that the supply curve is relatively flat. Examples include increased shale gas production, increased storage capacity and flexibility, and the ability to import/export supplies from/to external sellers/buyers.
- Increased elasticity of demand – A higher elasticity of demand means that a given change in price will result in a larger change in demand; for example, transparency of pricing to allow greater consumer responsiveness to prices.

The emergence of unconventional gas is making the supply curve of natural gas in the United States

22 Killian, L., "The Economic Effects of Energy Price Shocks," *Energy Journal*, 2008.

23 Ringlund, G. B., Rosendahl, K. E., and Skjerpen, T., "Does Oilrig Activity React to Oil Price Changes? An Empirical Investigation." *Energy Economics*, 2008, page 373.

24 Ringlund et al., "Does Oilrig Activity React to Oil Price Changes?" page 381.

more elastic. Prices are lower because technology and operational advances have led to increased supply availability at lower development and production costs. As consumption grows, the potential for development of unconventional natural gas resources in many small increments that can be brought online relatively quickly will tend to reduce upside price volatility. Excess liquefied natural gas (LNG) import capacity adds incremental flexibility for supply to respond to increased demand. This dramatic increase in physical liquidity has enhanced the diversity of potential supplies in the natural gas market and will serve as a key vehicle for achieving overall market flexibility. As a matter of policy, promoting flexibility within markets is an important step to ensuring secure delivery of energy supplies.

Greater unconventional gas production, combined with declines in offshore Gulf of Mexico production as a result of basin maturity and slower post-Macondo development of new offshore fields, has led to a shift in the proportion of U.S. natural gas production that comes from onshore sources. As onshore, unconventional gas production grows, it continues to reduce weather-related volatility caused by hurricanes or severe weather in the Gulf of Mexico.

Only storage or excess capacity in wells, the natural gas collection system, and pipelines can provide a nearly flat supply curve that would dampen price volatility originating from short-term fluctuations in demand, because supply would be better able to respond to short-term price fluctuations. The ability of natural gas system to meet short-term fluctuations in demand has not been tested in the shale-gas era because natural gas use experienced a cyclical downturn in 2009 that, combined with robust natural gas production growth, led to substantial excess capacity.

ASSESSING THE BUSINESS MODEL OF THE NATURAL GAS AND OIL INDUSTRY

The competitive business model for natural gas and oil companies in the United States has worked well to identify, develop, produce, process, and deliver significant volumes of crude oil, natural gas, and petroleum products. Private-sector, for-profit natural gas and oil (and other) industry business models in the United States rely on many common, fundamental needs: free markets, established legal systems, and appropriate and reasonable government oversight, taxation, and regulation. This differs materially from business models employed in many other natural gas and oil producing countries and defines why companies in the United States (and private-sector companies in other countries with market-based economies) have succeeded at developing new technologies, finding new natural gas and oil resources, and creating value for stakeholders.

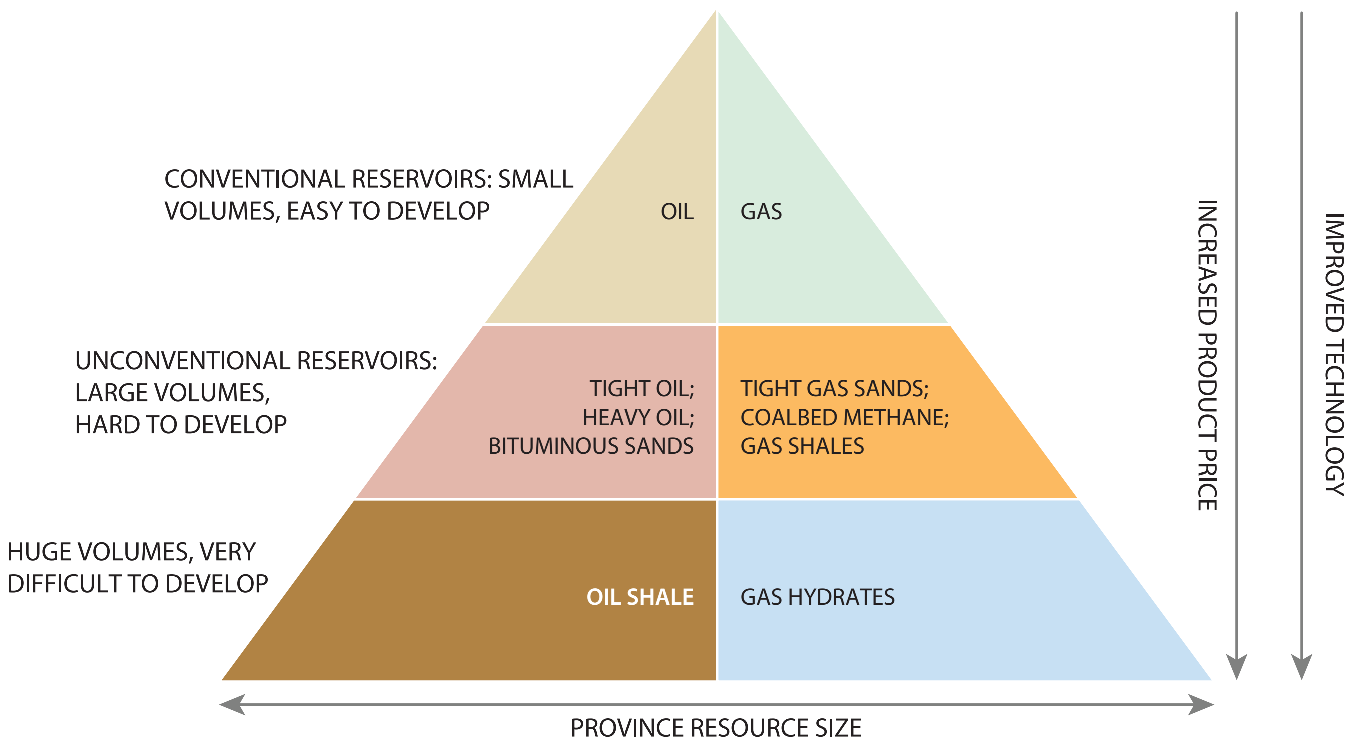
As illustrated in Figure 5-18, the domestic unconventional natural gas and oil resource base dwarfs the conventional resource base. Historically, the conventional resource base was the source of most of our domestic natural gas supplies and a large percentage of our domestic oil supplies. Unconventional natural gas resources have the potential to meet all of our domestic demand needs for decades (see Chapter One, Oil and Gas Resources and Supply). The keys to developing these unconventional resources are also the strengths of the domestic natural gas and oil business model.

Realizing the full potential of the vast unconventional natural gas and oil resources will require a market transformation resulting from structural changes (some of which have already begun), such as:

- More complete integration of the physical delivery system in the North American market
- Increases in high deliverability storage capacity
- Massive reallocation of capital and human resources
- Huge influx of nontraditional operators and investors
- Increased emphasis on repeatability within unconventional resource plays driving the industry towards larger scale activities and specialization
- Continued delinkage of oil and natural gas prices from each other.

These will change the market dynamics by having the ability to rapidly increase supply when market needs require, coupled with storage additions in line with growth in market demand. This presents a unique opportunity for the United States to make progress towards its economic, environmental, and energy security goals through new industry and government initiatives.

Figure 5-18. The Resource Pyramid



Source: Steve Sonnenberg, Colorado School of Mines.

Company Roles within the Unconventional Natural Gas Business

The unconventional onshore natural gas business was pioneered by the independent exploration and production companies in North America. As a rule, the major (integrated) natural gas and oil companies slowly exited the U.S. onshore over the past two decades in order to find resources of the scale necessary to allow them to sustain and grow their business. Medium- and small-sized independents, often lacking the skills and financial resources necessary to compete internationally, focused on trying to more fully exploit or rejuvenate U.S. basins and reduce costs to create profitable projects. Large independents often sought out niche positions internationally, but in most cases derived the bulk of their production and reserves from North America (both Canada and the United States, which are highly integrated both in terms of infrastructure and corporations).

As natural gas prices began to rise in the middle of the last decade, it was the independents that began to perfect the technologies to unlock shale gas. The process of successfully discovering and developing a new unconventional play requires companies to be very nimble, make rapid decisions, and strive for growth. The independents exemplify these qualities and were therefore uniquely able to develop this technology and deploy it rapidly.

As the development of shale and other unconventional plays has progressed, the sector has seen the entry of the large integrated and international firms. While they may not have been pivotal in the inception of the key unconventional plays in North America, these firms have the ability to take unconventional natural gas even further. These giant companies bring strong technical skills, immense financial resources, the ability to manage world-scale projects, and disciplined processes.

It is also essential to understand the critical role played by the oilfield service companies. These firms provide the technology, logistics, knowledge, equipment, and manpower that have driven the gas revolution. Simply put, unconventional natural gas cannot survive – much less flourish – without a vibrant service sector.

The continued presence of these three sets of players – independents, large integrated/international companies, and the oilfield service providers (along with governments) – will provide the tools and resources necessary to meet the challenges of tapping unconventional natural gas (and unconventional oil) to produce abundant, clean, safe affordable energy for consumers. They will also create jobs and have a positive economic impact on the country at large through both direct and indirect means.

How the Business Model Works: Process of Unconventional Development

Each unconventional play is different in its pace, scale, and exact path of development. However, as detailed in Table 5-5, it is possible to generalize somewhat about the various stages that individual plays pass through and the characteristics of each.

Stage 1: Prove It

The earliest stages of the life of a play involve companies' efforts to demonstrate geologic and reservoir potential and secure a leasehold position. It should be noted that cash flows during this period are negative or meager. Funding must come from other assets or from equity investments.

Stage 2: Optimize It by Trial and Error

If the industry establishes potential, the next stage involves an attempt by individual companies to raise the productivity and economics of the wells to an optimal level. In this regard, each company will experiment with a number of drilling and completion techniques. At this point, play development benefits from the participation of more firms since it leads to a greater variety of techniques, quantity of data, and experience. Many wells drilled in this phase will be relatively high cost and potentially uneconomic.

In general, companies seek to hold data and information proprietary. However, if most of the acreage in a particular play has been leased, then participants may be willing to share information (such as drilling techniques, frac spacing, number of frac stages, etc.), since each will benefit. Thus, consortia for technical collaboration may develop. Moreover, even if companies sought to protect their proprietary information, the structure of operations largely prevents this. While there are exceptions, exploration and production companies do not drill and complete wells themselves. Rather, they outsource this to the service sector companies, who not only provide equipment and crews, but also often have deep knowledge and technical capabilities. Thus, the experience accrues to these entities, who then seek to leverage the success of a given exploration and production company onto others. In this way, the stream of lessons learned and improvements in technology migrate to all the players, which allows for optimization of the entire play.

Stage 3: Standardize It

In the third stage of a play's life, companies have "cracked the code" and the goal is to bring down unit costs by creating large programs focused on aboveground efficiencies. This involves reducing idle time for equipment and raising utilization. It also plays to the strengths of companies that can adequately fund activities across the commodity price cycle and avoid the inefficiencies of stop and start programs. By this time, the core area(s) of the play are well known and the bulk of activity will take place in these high-productivity regions.

The bulk of the spending and activity for the play development takes place in this third phase. At this stage, the development of unconventional plays has been compared to an industrial assembly line process, and many observers call the development of these resources "gas manufacturing." The developer attempts to repeat a particular set of tasks hundreds or even thousands of times in an identical way and in doing so, reduces costs and gains efficiencies. Also, companies have the ability in this phase to bring in numerous concepts, lessons, and best practices from unrelated industries. These include supply chain analysis, inventory management, coordination of multiple parties, etc. Many of these concepts have historically had very limited application in conventional upstream natural gas and oil efforts, since geologic risk was the overriding determinant of success and because these fields require vastly fewer wells to fully develop. For unconventional plays, geologic risk is reduced and the emphasis is on gaining above-ground efficiencies.

While these manufacturing concepts have great potential, it is worth noting one difference between manufacturing of industrial goods and "gas manufacturing": a factory aims for precision and efficient inputs to achieve identical, high-quality products as the output. In the upstream business, companies also aim to optimize the chain of inputs; however,

Table 5-5. General Stages of Unconventional Resource Development

Stage	Major Activities	Keys to Success
Prove	• Perform geosciences and other analyses to determine technical properties and suitability for exploration • Acquire leases • Drill pilot and test wells for information	• Amount of relevant geotechnical and engineering information gathered per dollar spent • 1–3 technical "champions" with financial capabilities • Presence of service sector partners with science/experience
Optimize	• Try everything • Interpret mass amounts of data • Ramp drilling/create local operational and service sector hubs	• Constantly raise well productivity • Constantly decrease costs • Rapidly integrate diverse data streams • Draw correct conclusions and apply learning to current and future drilling programs • Engage in heavy scouting or form partnerships with other operators • Presence of multiple service sector partners with science/experience
Standardize	• Large, steady programs • Focus on above-ground efficiencies	• Standardization – grinds down unit costs • Effective coordination of chain of input • Efficiency gains • Adequate and timely ancillary infrastructure such as midstream and transport • Economies of scale and volume discounts • Low cost of capital and adequate free cash flow at bottom of cycle • Sequential unit cost reduction (opex and capex)
Rethink	• Transfer of ownership • Downspace further • Rework and refracture • Expansion	• Strong cost control • Leveraging of existing wellbores, infrastructure, and field personnel • Discovery of new zones • Application of new technologies

the quality of the outputs (i.e., the production of gas from a well) will still be controlled by the unique characteristics of the well and producing reservoir. Unfortunately, no matter how well companies "manufacture" the gas, the difference in economics and price thresholds within and between plays will still be significant.

Stage 4: Rethink It

The final phase is typically characterized by falling unit productivity and rising unit costs as the core acreage is saturated with wells and companies are forced to develop less desirable areas. At this point, a change in ownership is common since the asset often becomes non-core to the primary developer. The field almost always benefits from this renewal of focus.

The new operator typically pursues one or more of the following possibilities:

- Drill the field more densely, as economics and geology allow.
- Find overlooked upside – usually in the form of new zones or reservoirs.
- Spend capital and undertake operational measures to stem the decline of existing wells. In this regard, re-fracturing of wells may be a material source of new supply for certain fields.
- Reduce costs enough to make previously uneconomic wells economic.

All fields have a finite life, but that life can also occur in several cycles as technology progresses and/or price increases to create new ability and incentive to more fully exploit the resource. Table 5-6 describes the vital elements needed for an unconventional resource base to be prudently developed.

International Unconventional: Will It Work?

Shale gas, tight gas, and coalbed methane resources appear to be widespread around the globe. Many nations are keen to achieve the same results in their own countries as has been achieved in North America. To date, only Australia, with its large coalbed methane reserves, has made significant progress and is on track to produce meaningful volumes in the next five years. In many countries, governments own the entire natural gas and oil resource base and are seeking to prepare bid rounds.

While the long-term potential is real, a number of nations lack many of the characteristics listed above. In general, there are four large obstacles:

1. **Government dominance of the sector.** The fact that governments own the resource creates several problems for development of unconventional resources:
   - Governments lack the technical capabilities to unlock the plays.
   - The dominance of one or two state entities prevents the kind of competition that speeds learning.
   - Government ownership of land/minerals can result in slower development than private ownership. Countries with tax/royalty regimes (such as Canada or the U.K.) may have good experience, but in most places, it can take years simply to access land. In a private ownership regime, such as the United States, this can be accomplished in weeks or even days.
   - Governments tend to be reluctant to take the technical risk that is necessary.

   When the government owns the resource, surface rights owners and their communities can receive negligible benefits and compensation.

2. **Lack of infrastructure and service sector equipment.** North America drills the bulk of wells globally and, therefore, has the lion's share of trained personnel, technical expertise, and equipment. Accessing this infrastructure is relatively easy in the United States. This is not the case in most countries.

3. **Transparent and fair pricing.** Worldwide, natural gas prices are sometimes regulated at a very low level to subsidize industry or local consumers. Without fair pricing or a viable forward market to reduce risk, most U.S. companies have been hesitant to develop natural gas internationally except as liquefied natural gas, which can access international markets and is usually linked by contract to oil prices.

4. **Lack of experience in unconventional natural gas production.** The business of unconventional

Table 5-6. Necessary Ingredients to the Unconventional Business Model

Geologic quality	• Must have excellent basins
Geologic quantity	• Basins must be large enough to gain economies of scale and sustain many competitors • Must have multiple plays since many of the plays will fail
Property rights clarity	• Landowner and local cooperation is very important for effective development • Process is unavoidably busy • Risks are manageable, but they exist • Local communities must receive benefits since they bear real costs
Cooperative and capable local and national governments	• Governments are key stakeholders, both in terms of regulation and lease ownership • Agencies must have the funds, staff, experience, and resources to effectively and efficiently regulate and facilitate • Many public goods/common resources need to be developed (e.g., roads)
Abundant service sector capacity	• System needs to have large fleets of equipment • Site preparation • Drilling rigs • Pressure pumping equipment • Water hauling • Waste disposal • Efficiencies and critical mass of experience and data are not possible if services are difficult to access or too costly
Multiplicity of players	• Helps to speed learning and creates competition
Capital availability via private and public equity and debt markets	• Private markets are the best determinant of efficient flows of capital to produce the greatest returns and create prosperity
Willingness to spend money	• Reinvestment rates and the desire to grow are absolutely essential • Ability to retain gas price upside is an important incentive to the exploration and production companies to compensate for the substantial financial risks involved
Favorable commodity prices	• Inducement to drill – futures prices • Ability to fund – spot prices
Ease of processing and delivering gas	• Midstream facilities and gas pipelines must be in place or growth will stall
Voluntary (or not) technical collaboration	• The speed of dissemination of technical information determines the overall pace of learning

natural gas is intellectually, physically, and organizationally challenging. The wave of international players signing joint venture agreements with U.S. independents in order to gain exposure to and experience in this sector to transfer abroad is proof both of its complexity and the inexperience of the international players.

The difficulties of transferring the unconventional natural gas revolution abroad offer an excellent chance for U.S. companies to play a vital role in that process. While there are many issues that host governments must tackle on their own, partnerships between U.S. companies and international players offer a good opportunity for job creation and international clean energy goals attainment.

Implications of the Shift to an Unconventional Natural Gas Business Model

Unconventional natural gas development began with coalbed methane and tight gas, and has been an important contributor to U.S. supply for several decades. However, with the advent of shale gas development, unconventional drilling has come to dominate natural gas activity in almost every major onshore basin in the nation. When compared to historical activities and business models, this new prominence has a number of implications for industry, mineral owners, regulators, shippers, and consumers.

New geographic distribution: The "gas patch" has historically been comprised of the contiguous area formed by Texas, Louisiana, Oklahoma, New Mexico, and the shallow waters of the Gulf of Mexico. According to EIA data, this region accounted for 75% of lower-48 production in 2000. Over the course of the 1990s and 2000s, significant growth was seen in the Rockies states – Colorado, Utah, and especially Wyoming. The very large Appalachian Basin (the first basin to be produced in the country) remained a relatively minor, if steady, source of natural gas drilling and production. The advent of unconventional natural gas has led to a shift in the pattern of activity. While the "gas patch" has reestablished itself as the heart of the movement, there are important implications for other regions.

Gulf of Mexico: In light of the relatively high expense of drilling offshore, the geologic risk, and the maturity of the basin, new investment into the Gulf of Mexico shelf has been insufficient to maintain natural gas output, which has fallen by more than 50% since 2000. While certain companies continue to experience success in this area, many of the larger companies have preferred to focus on lower risk, less expensive onshore unconventional operations.

Rockies: The low natural gas prices prevailing in the market since mid-2008 have forced many companies to reduce their activity level and devote scarce resources to a smaller number of assets. While the Rockies contain a number of world-class plays and resources, most companies have reduced their focus on and spending level in the Rockies (though that activity remains quite substantial).

Northeast States (primarily Pennsylvania, New York, West Virginia): The advent of the Marcellus play has led to a rapid expansion of activity. This area has a very long history of natural gas and oil activity, of course, but in the modern era, these states have witnessed nothing like the tidal wave of investment and ensuing rush of activity they are now experiencing. The phenomenon may be long-lasting, as the Marcellus formation covers such an extensive area that full development will require decades of drilling. Also, the Northeast contains other shale plays besides the Marcellus that may prove beneficial to develop. This rapid migration of natural gas and oil activity to the Northeast is leading to challenges, as regulators, infrastructure, companies, workforces, and local populations seek to adapt to the scale of the opportunity and mitigate risks appropriately.

Greater areal extent: Since conventional fields represent a concentrated accumulation of oil or natural gas with a relatively high recovery factor, most conventional deposits cover a relatively small surface area. Unconventional plays are sometimes thought of as "blanket" resources. Sweet spots with more productive wells are important to find, but all the major shale plays cover vast areas by comparison, multiple counties – and sometimes multiple states. The natural result of this is to distribute the royalty lease and production benefits over a wider number of mineral rights holders.

More wellbore-intensive: Because unconventional wells tap into low-permeability reservoirs, they necessarily drain a small area around the wellbore (even after intensive fracturing) compared to conventional wells. As a result, effective and full development of a reservoir necessitates more intensive development than a conventional reservoir covering the same surface area. If a shale reservoir were developed using only vertical wells, then the surface land-use would be commensurate with the subsurface coverage. However, two developments are currently reducing the surface footprint materially: first, horizontal wells allow the subsurface drainage volume associated with one surface location to increase, with minimal impact on the size of that surface facility. Second, companies are increasingly drilling multiple horizontal wells in different directions from the same surface pad. Companies are adopting this "pad drilling" technique both to improve economics and to reduce the footprint of operations for environmental and/or regulatory reasons.

More service sector-intensive: Compared to onshore conventional wells, drilling and completing unconventional wells requires significantly more oilfield services (per unit of reserves or dollars expended). This is primarily due to the extent of equipment, expertise, and time associated with horizontal drilling and hydraulic fracturing, as well as a relatively small amount of reserves per well. During 2005–2007, natural gas production suffered from a shortage of rigs, qualified service sector employees, and fracturing equipment, and drilling and completion costs rose as a consequence. The service sector responded by building and employing new equipment. While the overall shortage is easing, services are still tight in a number of areas.

More people-intensive: The combination of the factors above leads to more job creation than either onshore conventional or offshore investment. The global natural gas and oil industry is one of the most capital-intensive in the world, with extremely high investment levels (to combat natural decline) and a relatively low ratio of employees-to-capital expenditures. While this is still true for unconventional resources compared to other industries, the migration of the industry towards a model dominated by unconventional resource development is likely to generate substantially more jobs than a model focused on conventional natural gas and oil.

The U.S. Government's Role in the Business Model for Unconventional Gas Development

Historically, the federal government has generally, as with most U.S. industries, treated the domestic natural gas exploration and production industry with an overall market approach.[25] This has allowed the North American private market to determine prices as a result of the dynamic interaction of supply and demand. The emergence of significant quantities of technically recoverable unconventional natural gas resources presents the government with the opportunity to redefine its business model for interacting with the domestic natural gas industry, its goals for the industry, and how it can facilitate achieving those goals.

The federal government has three primary objectives for the development of domestic supplies of natural gas and oil:

1. Enhance national energy security by becoming less reliant on foreign sources of oil.

2. Enhance the economic welfare of the country by promoting economic activity in the natural gas and oil industry. This creates high-pay, high-skill jobs for U.S. workers. It also increases the government's tax revenues (and royalty revenues from federal lands) with the increase in industry activity. This has particular value to the government because 29% of the estimated remaining technically recoverable U.S. natural gas resources and 45% of the estimated remaining technically recoverable U.S. oil resources are on federal lands (both on and offshore) – as these lands are developed, the U.S. Treasury receives considerable bonuses, rents, and royalties.[26]

3. To protect the environment by promoting the development of more efficient and environmentally sensitive exploration and production technologies and operating practices, and substituting clean natural gas for other fossil fuels where possible.

Governing Principles for the Government

While the government approaches the domestic natural gas and oil industry as a market-based and competitive industry where supply and demand

25 An exception to this is the period following the Supreme Court Phillips decision in 1954, which caused wellhead price regulation for sales into the interstate system. The Natural Gas Policy Act of 1978 changed the pricing mechanisms, but wellhead prices were still controlled. These price controls were not eliminated until the Natural Gas Wellhead Decontrol Act of 1989.

26 Energy Information Administration, *Annual Energy Outlook*, 2009.

conditions direct the industry's activities, the government does have important and distinct roles to play in conjunction with the industry:

1. In the area of R&D, the government does not want to duplicate the work of the industry, but it has an important role to play in addressing long-term, high-risk R&D that the industry cannot perform because the time horizon for commercial development is too long to warrant the research efforts required. The government's R&D also provides the government with expertise to effectively oversee the industry's operations, and also to understand and manage the risks associated with petroleum operations in complex and demanding geologic settings.

2. The government has, at times, provided financial incentives for the industry to develop new frontier resource areas or to develop new technologies needed to find and produce new resources. With financial incentives, the government's goal is to stimulate industry activity that would not otherwise occur, and to have the cost of these incentives be balanced by new revenues collected by the U.S. Treasury and/or balanced by benefits to the country in terms of enhanced energy security and more competitive petroleum prices.

3. The government's regulatory responsibilities have a wide-ranging effect on how and where the industry operates. The government oversees environmental regulations for the whole industry, as well as regulating leasing, development, and production standards for all natural gas and oil development on federal lands. In all these regulatory activities, the government's goals are to fully protect the environment and to promote development where it can be achieved safely.

The Government's Choice of Tools to Employ in the Natural Gas and Oil Industry Business Model

The tools the federal government has to promote the development of domestic natural gas and oil resources include:

- Conducting R&D to develop new technologies and operating practices for the industry
- Financial incentives
- Regulatory actions that promote development.

Conducting R&D to Develop New Technologies and Operating Practices for the Industry

This work should not duplicate what the industry is doing on its own, and should support new frontier area development or technologies that may be too risky or expensive for the private sector to pursue on its own.

The government (through the Department of Energy [DOE]) has traditionally conducted R&D that:

- Examines areas of technology that are ignored since companies find them difficult or impossible to monetize (e.g., basic research or multi-industry application)
- Takes advantage of government-owned assets (e.g., supercomputers or key personnel/skill sets) whose costs cannot be economically justified within the context of a single company
- Provides government regulators with the technical expertise to effectively oversee the industry's operations.

The 2010 Deepwater Horizon oil spill in the Gulf of Mexico also highlighted the need to understand and manage the risks associated with petroleum operations in complex and demanding geographic and geological settings. In response to this, the DOE has initiated R&D to help the government understand the risks associated with petroleum operations and the capabilities needed to respond to problems.

Historically, the federal government has conducted effective R&D programs that do not duplicate or compete with private industry R&D. This R&D has made significant contributions to many aspects of technology development benefiting the industry and the nation, including basic research, new drilling technologies, seismic mapping, and fracture technology.

With a long history of government R&D, the implications of continuing this work or taking it in new directions are clear:

- Basic and long-term, high-risk R&D that is not pursued by the industry is appropriate to be performed by the government because the private sector will not pursue these R&D efforts on which it cannot achieve an adequate risk-adjusted return on investment. The government's research in this area will benefit current technology development as well as helping to bring long-term, high-risk resources (e.g., methane hydrates) to commercial viability in a more timely manner.

- Studying the risks associated with petroleum operations and the capabilities needed to respond to any problems helps manage the risks associated with petroleum operations in complex and demanding geologic settings.

For the deepwater and ultra-deepwater, government R&D should collaborate with industry efforts and include:

- Development of technology to recognize previously unknown and changing downhole conditions that threaten overall safety of operations
- Researching effective strategies for remote intervention, including quantifying risks associated with deepwater exploration and production and determining appropriate safeguards to include blow out preventer standards.

For gas shale resources, government study and R&D could include:

- Water demand for use in fracturing
- Protection of drinking water aquifers during hydraulic fracturing; evaluation of the safety of chemicals used in hydraulic fracturing
- Air quality impacts resulting from increased drilling, natural gas production, and truck transportation activity
- Community safety issues surrounding hydraulic fracturing operations in populated areas
- Water treatment and management technologies to address water requirements, fracture fluid flowback, and produced water
- Potential mitigation steps should groundwater contamination occur
- The DOE could also conduct R&D to help bring the nation's long-term, high-risk natural gas resources (such as methane hydrates) to commercial viability.

Financial Incentives

Historically, the federal government (and many states) has used financial incentives to promote the development of domestic natural gas resources that might not be developed (or would be developed more slowly and to a lesser degree). These financial incentives have taken the form of tax incentives in the federal tax code or royalty incentives for development on federal lands.

These incentives have generally been used to promote the development of new frontier resource areas of the industry and the development of new technologies needed to develop these new resources. Examples of effective use of financial incentives to promote the development of new resources and technologies include:

- The Section 29 tax credit for the development of unconventional natural gas resources. This tax credit, which was instituted in 1979, provided a significant push to the development of the new technologies and practices needed to produce these unconventional resources. This tax credit was eventually eliminated in the 1990s when it was determined that the new technologies were in widespread use and that the industry no longer needed this incentive. Today, unconventional gas resources are a significant source of the nation's production of natural gas and are expected to be the major incremental source of supplies in the future.
- The deepwater royalty holiday to promote the development of new natural gas and oil resources in deep waters of the Gulf of Mexico. With this incentive, the industry has proceeded to create new technologies and operating practices to develop the vast petroleum resources found in the deep waters to the point where this region is among the largest sources of petroleum supplies in the country. The deepwater royalty relief program expired in 2000, as provided for in the Deepwater Royalty Relief Act of 1995, which instituted this program.
- Accelerated depreciation of new transportation infrastructure (pipelines). In 2005, as part of the Energy Policy Act, the term over which a pipeline company could write off new investment in natural gas pipelines was shortened from 20 to 15 years. This helped promote the development of new pipelines by allowing the pipeline companies to recapture their investment more quickly.

Regulatory Actions That Promote Development

An example of a regulatory action to promote development is the 2008 decision by then President Bush to remove the presidential moratorium on developing certain areas of the federal Outer Continental

Shelf. Regulatory action also includes the concept of removing or clarifying duplicative and/or confusing regulations that interfere with the market's ability to function properly (see Chapter Two, Operations and Environment).

As the federal government regulations and standards have developed and evolved over time, some of these regulations have not been coordinated or made clear. This has created situations where the industry is unsure about the regulations it needs to comply with and, as a result, responds with inefficient and more costly compliance strategies to ensure standards are met. Just as importantly, this regulatory uncertainty can inhibit investment and delay project schedules, which decrease supply, again raising costs to consumers and leaving resources undeveloped. This situation is further complicated by widely varying state regulatory standards that frequently govern the same issues as the federal regulations. It is, therefore, to the benefit of the government, natural gas and oil industry, and consumers if regulatory uncertainty is reduced.

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