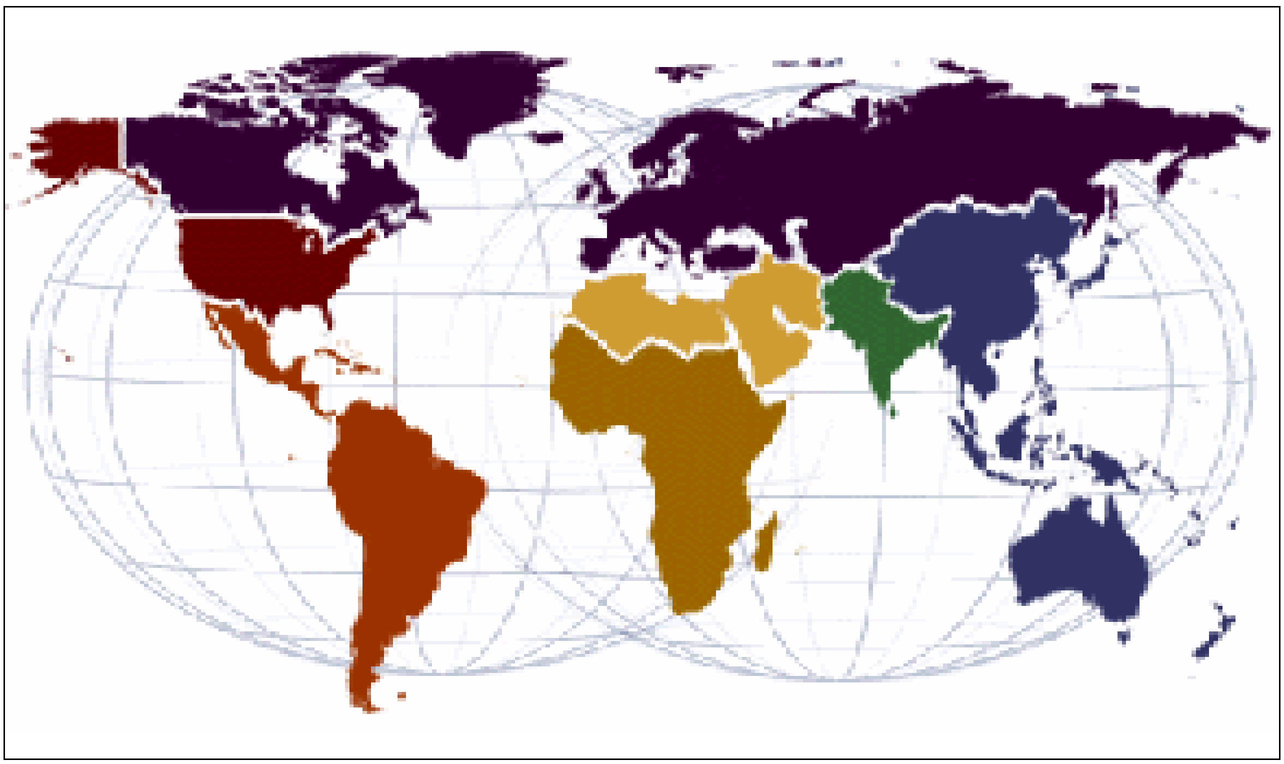
OCS Study
MMS 2003-004

Dynamics of the Oil and Gas Industry in the Gulf of Mexico: 1980-2000

Final Report



U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

OCS Study
MMS 2003-004

Dynamics of the Oil and Gas Industry in the Gulf of Mexico: 1980-2000

Final Report

Authors

Barbara Wallace
John Duberg
James Kirkley

Prepared under MMS Contract
1435-01-00-CT-31058
by
TechLaw, Inc.
4340 East West Highway
Bethesda, Maryland 20814

In cooperation with

Energy History Research
Midland, Texas

Published by

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

New Orleans
February 2003

OCS Study
MMS 2003-004

DISCLAIMER

REPORT AVAILABILITY

Extra copies of this report may be obtained from the Public Information Office (Mail Stop 5034) at the following address:

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region
Public Information Office (MS 5034)
1201 Elmwood Park Boulevard
New Orleans, Louisiana 70123-2394

Telephone: (504) 736-2519 or
1-800-200-GULF

CITATION

Suggested citation:

Wallace, B., J. Duberg, and J. Kirkley. 2003. Dynamics of the oil and gas industry in the Gulf of Mexico: 1980-2000; Final Report. Prepared by TechLaw, Inc. U.S. Dept. of the Interior, Minerals Mgmt. Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-004. 193 pp.

ACKNOWLEDGMENT

TechLaw, Inc. gratefully acknowledges the significant contributions of Diana Olien and Roger Olien from Energy History Research who conducted the personal communication with industry for the study.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (cont'd)

Page

LIST OF FIGURES

LIST OF TABLES

Table Page

LIST OF ABBREVIATIONS

ADL	Arthur D. Little
AGA	American Gas Association
ANWR	Alaskan National Wilderness Reserve
API	American Petroleum Institute
Bbl	Barrel
BPD	Barrels per day
BLM	Bureau of Land Management
BLS	Bureau of Labor Statistics
Btu	British thermal unit
CSR	Corporate social responsibility
CV	Coefficient of variation
DOE	Department of Energy
DOT	Department of Transportation
E&P	Exploration and production
EEC	European Economic Community
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FPC	Federal Power Commission
FPSO	Floating production, storage and offshore loading
FRS	Financial Reporting System
GDP	Gross Domestic Product
GOM	Gulf of Mexico
GSC	Gulf Safety Committee
IADC	International Association of Drilling Contractors
IEA	International Energy Administration
IPIECA	International Petroleum Industry Environmental Conservation Association
IRS	Internal Revenue Service
ISAC	Information sharing and analysis center
LDC	Local distribution companies
LNG	Liquid natural gas
LWD	Logging while drilling
Mcf	Thousand cubic feet
MMS	Minerals Management Service
MSA	Metropolitan Statistical Area

LIST OF ABBREVIATIONS (cont'd)

NASA	National Aeronautical and Space Administration
NGO	Non-governmental organization
NGPA	National Gas Policy Act
NIPC	National Information Protection Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPC	National Petroleum Council
NYMEX	New York Mercantile Exchange
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OOC	Offshore Operators Committee
OPEC	Organization of Petroleum Exporting Countries
PE	Petroleum engineer
PIFUA	Power Plant and Industrial Fuel Use Act
PIN	Personal identification number
PMSA	Primary Metropolitan Statistical Area
ROV	Remotely operated vehicle
SEG	Society of Exploration Geophysicists
SIC	Standard Industrial Code
SOEP	Sable Offshore Energy Project
Tcf	Trillion cubic feet
TLP	Tension leg platform
U.S. DOC	U.S. Department of Commerce
U.S. DOE	U.S. Department of Energy
U.S. DOE EIA	U.S. Department of Energy, Energy Information Administration
U.S. DOI	U.S. Department of the Interior
U.S. DOL BLS	U.S. Department of Labor, Bureau of Labor Statistics
USGS	U.S. Geological Survey
U.S. SEC	U.S. Securities and Exchange Commission
WBCSD	World Business Council for Sustainable Development
WEC	World Energy Council
WPC	World Petroleum Congress
WTI	West Texas intermediate
WWW	World wide web

1.0 EXECUTIVE SUMMARY

1.1 Background and Objectives

Sweeping changes have transformed the oil and gas industry in the United States. Perhaps the most obvious evidence of change is the disappearance of the “seven sisters,” the multi-national, multi-division corporations that were long dominant in national and international trade. Of the seven, Exxon, Chevron, Shell, British Petroleum, Mobil, Gulf, and Texaco, only the first-four named still exist as they did in 1980. Chevron acquired Gulf and Texaco, and Mobil merged with Exxon. Gulf succumbed because of poor performance and Texaco and Mobil were acquired or merged as giant corporations sought economies of consolidation and scale. John D. Rockefeller’s original Standard Oil of Ohio (SOHIO) and Amoco (Standard Oil of Indiana) were both acquired by British Petroleum, which had acquired Sinclair’s down stream assets, principally gasoline stations and refineries, when Arco bought Sinclair in 1968.

In 1980’s, the Gulf of Mexico (GOM) was considered a mature area for the offshore oil and gas industry and activity was waning. Within a few years, this situation was reversed. Leasing activity increased. Exploration followed. Production from deepwater began to make a significant contribution to total U.S. oil and gas production. When activity increased in the GOM, changes in the industry were evident. Some of these changes were unanticipated; others were slow to emerge as trends.

To gain a better understanding of the industry changes and their implications, this study examined the oil and gas industry in the GOM from 1980 to 2000 and synthesized the implications of those changes on industry, socioeconomic, and onshore and offshore impacts in the Gulf of Mexico. The study focused on two issue areas, oil and gas price changes and corporate organization and strategy, and four crosscutting topics, economics and finance, technology, labor, and the regulatory environment. Changes that occurred in the issue areas and crosscutting topics reflect changes in industry in general, the oil and gas industry specifically, or individual companies or projects. The study was conducted through a review of industry, government, and academic publications and personal communication with industry representatives.

1.2 Findings and Implications of Industry Changes

1.2.1 Oil and Natural Gas Price Changes

Major elements in the transformation of the oil and gas industry are price volatility and a general decline in the value of production, particularly of crude oil in the upstream sector. Oil prices declined from $31.77 per barrel (first purchase price) in 1981 to $12.51 (nominal) in 1986, followed by a run-up that reached $20.03 (nominal) in 1990 and a drop to $16.54 a year later. Thereafter, it rose to $18.46 in 1996 and fell again to $10.87 per barrel in 1998 before it shot up to $26.73 in 2000. Restated in 2000 dollars, the swings moved from $54.46 per barrel in 1981 to a low of $11.26 in 1998.

Natural gas prices similarly fluctuated in the last 20 years. In 2000 dollars, the swing of wellhead price moved from a high of $4.02 in 1984 to a low of $1.69 in 1995. There was a steady decline in price between 1985 and 1992.

1.2.2 Corporate Organization and Strategy

In the last 20 years, producers consolidated, restructured, implemented cost-saving technologies, and cost cutting programs. Companies sought economies through elimination of layers of management. They also re-examined properties, shedding some and acquiring others. Some companies reorganized to encourage effective adaptation to rapidly changing conditions and related opportunities. Sale of properties and company acquisitions created some large new independents. Large producers invested in foreign and offshore U.S. exploration and production. Foreign, nationally owned oil companies bought access to the U.S. market and took an interest in the GOM. After the introduction of areawide leasing, companies were able to acquire enough contiguous tracts to make billion dollar commitments in deepwater in the gulf. Improvements in 3D seismography and the more rapid processing of data have progressively supported exploration in ever-deeper water. The high costs of activity in deepwater have meant that seven companies (BP Amoco, Shell, ExxonMobil, Chevron, Total/Elf, Petrobas, and Texaco) have located most of the deepwater reserves. Exposure to risk was reduced through the use of joint ventures and alliances. The model of functional integration, from exploration to production, transportation, refining, and marketing, long the dominant model for large and medium sized oil companies, has undergone change. It has been replaced by asset management strategies, alliances, partnerships, and divestures.

1.2.3 Crosscutting Themes and Implications

The issues and topics examined, prices, corporate organization and strategy, economics, technology, labor, and regulation, are so interwoven in the dynamics of the industry that consideration of one soon involves most or all of the others.

Drivers of Change. The following factors stand out as major forces that created change in the oil and gas industry between 1980 and 2000:

- Increasing volatility of prices. By 2000, price volatility, uncertainty, and risk had become facts of life for industry companies.

- Rising costs of oil and gas projects. In the last 20 years, OCS as a share of total domestic natural gas production increased modestly, while the share of total domestic oil production from OCS sources almost tripled. Deepwater production grew even more dramatically. Offshore projects, in general, and deepwater projects, in particular, are expensive, involving billion dollar investments.

- Globalization of the industry. The oil industry is international in scope. In the last 20 years, the GOM has had to compete with other areas of the world for investment by companies involved in projects around the world. Even independent companies that have traditionally restricted their activities to the gulf began to operate internationally.

- Increased concern for shareholder value. In the last 20 years, the mission of oil companies shifted from extracting oil to providing shareholder value.

- Ascendance of technology. Like all industries, technology has enabled change. The flow of information and the speed of information have been drivers of change. Technology specific to the oil industry has enabled the industry to work in deeper water and more effectively exploit existing wells.

- Management of risk. Techniques used to manage risk represent changes in the industry. They include use of improved technology to increase the potential for successful exploration, multi-company partnering for individual projects, use of futures, options, and other hedging instruments to protect against drop in prices, and the shift of research and development to contractors or research consortia.

Resurgence of the GOM. A convergence of factors led to the resurgence of oil and gas activity in the GOM. The shift to areawide leasing allowed companies to assemble a sufficiently large number of contiguous tracts to increase the potential for finding oil and gas and to justify deepwater exploration. The Deep Water Royalty Relief Act allowed MMS to suspend royalty payments to increase interest in deepwater exploration. Seismic imaging reduced the probability that exploration would be unsuccessful and that additional oil and gas would be found in properties being reworked. Technology also made improvements in production. Prices were generally improving in the mid-1990's. Companies whose business focus is the GOM, with favorable technology, regulatory, and price factors, began a series of exploration and development activities, which resulted in the resurgence of the GOM.

Industry, Socioeconomic, and Onshore and Offshore Impacts. Changes in the industry between 1980 and 2000 led to industry and socioeconomic impacts onshore and offshore. The industry is now a high tech, new economy industry. Risk management, corporate strategy, technology, and other factors have pushed the oil and gas industry in the direction of increasingly complex arrangements and operations. In the 20-year period, the industry shifted from science-based to economic-based production. Technology generally allowed the industry to produce more oil and gas with less infrastructure and fewer personnel. The time required to do work has been reduced and the amount of information to do work has increased.

The industry responded to price volatility with a series of cost cutting programs that changed the way the industry uses personnel and how prospective workers respond to the industry. The cost cutting programs have left the industry with a shortage of personnel in all areas, reduced worker loyalty, dispelled the idea of job security, and made recruitment more difficult.

The basic steps to find, produce, and market petroleum remain unchanged and involve both onshore and offshore activities and result in onshore and offshore impacts. Changes in the industry are modifying these impacts. The rise of information technology is redefining where work is done. The ability to transmit electronically large amounts of information with ease and monitor physical activities remotely means that workers, in many cases, can be physically remote from where work is done. Technology advances has meant more can be done with fewer people. Corporate decision-making has led to the ascendancy of Houston as a concentrated center of oil and gas companies and employment, shifting activities from New Orleans, Denver, Tulsa, and other formerly prominent oil and gas cities.

2.0 INTRODUCTION

2.1 Background and Study Objectives

The Gulf of Mexico (GOM) has a large share of the country's known offshore oil and gas resources and dominates U.S. offshore oil and gas activity. Much of the technology needed to push farther into the Gulf of Mexico and other parts of the world in search of energy resources was initially developed by the offshore oil industry operating in the GOM. This included many of the support industries that service oil exploration, development, and production. The offshore oil and gas industry eventually expanded into other parts of the world making the local industry part of the global oil industry.

The GOM offshore oil and gas industry's role in the global oil industry has changed over time. Traditionally, the region supported the industry locally and as it expanded internationally. Personnel from the GOM went to the North Sea in the early stages of that area's development and trained the local workforce. Platforms were fabricated locally until competition from Korea and Japan developed. During the early years of large-scale offshore development in other parts of the world, the North Sea notably, technology developed offshore Louisiana and Venezuela was applied and adapted to local conditions. In more recent years, the flow has been from abroad to the GOM.

The GOM region is home to many companies operating in the region and overseas. A number of companies are either headquartered in or conduct GOM activities in the region. Many companies are located in Houston where they serve not only the deepwater of the Gulf of Mexico, but also the growth markets in Brazil and West Africa. Foreign oil companies maintain Houston offices and invest in GOM ventures. Contractors to the oil industry also operate locally and overseas.

The GOM was known as the "Dead Sea" in the mid-1980's mainly because the decline in oil and gas prices after 1981 made the higher cost of offshore exploration and operation unattractive. That changed with such things as the discovery of subsalt reservoirs in shallow water, the Deep Water Royalty Relief Act, production from new deepwater reservoirs, lower prices from service providers as a result of reduced activity, technological advances, and areawide leasing. When activity picked up again in the GOM, there were some changes in place. The surviving non-major companies (independents) emerged as more important players in the industry and in the GOM. Bottom line financial decisions led to a restructuring of the industry.

The Minerals Management Service (MMS) is responsible for the leasing and oversight of mineral operations on the Nation's Outer Continental Shelf (OCS). The dynamics of the industry have changed since the agency's formation in 1982. Some of the changes in the last 20 years were either unanticipated or slow to emerge as trends.

MMS is charged by the National Environmental Policy Act and the Outer Continental Shelf Lands Act to consider the effects of its decisions on the human environment. In support of that charge, this study seeks to increase the understanding of the sources and forces of impacts on the human environment from the offshore oil industry in the GOM and what those sources and forces mean for the future. To do this, the study objectives were to:

- Gather and review the knowledge of local, national, and international changes to the oil industry operating in the GOM between 1980 and 2000.

- Relate the significance and the implications of those changes to social, economic, and industry impacts in the GOM.

2.2 Study Issues, Organizing Framework, and Methodology

Given the range and complexity of issues related to offshore oil and gas development in the GOM, the first step of this study was to select and structure discrete research topics. The study began with the compilation of research issue areas organized around four headings – business trends and economics, corporate organization, labor and service needs, and regulatory environment. These issue areas were filtered through issue selection criteria and, in consultation with MMS, two issue areas were selected:

- Oil and gas price change. This issue is a driving force for the industry and is overarching. Oil price affects companies' business decisions on levels of activity in all areas – exploration, production, research and development, technology, and abandonment. Price volatility makes these decisions more difficult. Communities with economies tied directly to those activities prosper in good times and suffer during industry downturns. Impacts occur locally in response to industry activities that are tied to oil and gas prices.

  Economic impacts result from local industry expenditures (direct impacts), local expenditures by businesses that supply goods and services to the oil and gas industry (indirect impacts), and the wages and salaries that are dependent upon the initial industry expenditures that are spent in the local economy (induced impacts). Expenditures relate to onshore facilities that support offshore activities and offshore facilities and activities. Examples of onshore facilities supporting offshore activities include supply and crew bases, onshore oil and gas processing plants, and platform fabrication yards. Offshore facilities include platforms and the offshore portion of pipelines. Offshore activities are exploration, development, and production. Economic impacts can result in population changes, which in turn affect housing, public services (e.g., water) and facilities (e.g., schools). Industry offshore activities and related onshore facilities may also affect local social conditions such as social problems and social systems.

- Corporate organization and strategy. This issue addresses alternative and evolving approaches to business activities and how these approaches affect the companies and their contractors and where and how work is conducted. Impacts, social and economic, direct and indirect, and offshore and onshore, occur and shift in response to company decisions on their organization and strategy to find and produce oil and gas.

The two issue areas are examined in terms of four topics, finance, technology, labor, and regulatory environment. The material covered is listed in Table 1.

Table 1

Study Issue Areas and Topics

Topic	Issue Areas: Oil and Gas Price Change	Issue Areas: Corporate Organization and Strategy
Economics and Finance	• Factors affecting price • Price and the global market • Demand and supply • Ownership rights and U.S. prices • Oil prices and effects on finances/capital markets	• Financing methods • Leasing OCS tracts, exploration, and production
Technology	• Technology, costs, risk, and oil price changes • Changes in benchmark oil price versus market prices for oil • Oil price as a driver of technology • Prospects for future technology	• Approaches to R&D • Industry-specific technology • Digital technology • Technology and its effects on the oil industry
Labor	• Oil price volatility and employment • Gas price volatility and employment	• Reduction in force • Reorganization of work • Resulting personnel issues • Response to personnel issues
Regulatory Environment	• GOM versus the rest of the world • Areas of regulation	• Gulf of Mexico leasing • Deep Water Royalty Relief Act

The report is about the oil and gas industry and some of what is discussed relates specifically to that industry. The oil and gas industry has many sectors. Decisions in one of these sectors can have ramifications for other sectors. So, where appropriate the discussion separates the industry into sectors. The oil companies are the producers. They decide where and when to look for oil and gas and when to develop discoveries. Oil companies can be vertically integrated majors, meaning their operations encompass oil and natural gas production, transport, petroleum refining, and marketing of refined petroleum products. Nonmajors, often referred to as independents, are specialized oil and gas producers. The oil companies are supported by contractors -- drilling contractors and non-drilling or service contractors such as labor contractors, oil spill control companies, trucking and stocking companies, and fabrication, repair, and maintenance contractors.

Some of what is discussed relates to the broader category of industry, of which the oil and gas industry is one part, and some of what is discussed is narrower in focus looking at company or project specific factors. These three categories, all industry, the oil industry, and individual companies or projects, provide the organizing framework for thinking about changes that occurred in finance, technology, labor, and the regulatory environment between 1980 and 2000. That is, were these changes occurring across industry, within the oil and gas industry, or specific to a company or group of companies or individual projects? Table 2 summarizes this framework.

Table 2

Organizing Framework for Report Topics

Topic	All Industry	The Oil Industry	Individual Companies/Projects
Economics and Finance	X	X	
Technology	X	X	X
Labor	X	X	
Regulatory Environment	X	X	

The study was prepared through a review of industry, business, and government documents and personal communication (personal or telephone conversations, and e-mail exchanges) with primarily oil industry representatives. Personal communications with 24 industry representatives from 19 companies were conducted between August 2000 and May 2001:

Majors	Independents	Contractors
BP	Apache	Diamond Offshore
BP Exploration Company Ltd.	Devon Energy Corporation	Halliburton Energy Services Group
Conoco	Kerr McGee Oil and Gas Corporation	J. Ray McDermott
Exxon	Mitchell Energy	R&B Falcon, Inc.
ExxonMobil	San Jacinto Oil Company	Schlumberger
Shell Offshore Oil Company	Vastar Resources, Inc.	
Texaco	Unocal Spirit 76	

The remainder of this section provides background information which is used throughout the report. First, background on production activities and platform installation and removal is presented. Then the overall time line of significant events affecting the oil and gas industry is presented.

2.3 Offshore Statistics, 1980-1999

The following statistics set the stage for the description of changes in the oil and gas industry in the GOM in the last 20 years which follows in Sections 3.0 (Oil and Natural Gas Price Change), 4.0 (Corporate Organization and Strategy), and 5.0 (Crosscutting Themes and Impacts). Appendix A includes suggestions for additional research. While the period of interest is 1980 to 2000, a longer period of time is shown for these statistics (except the deepwater summary) in order to provide the context for the beginning of the study's timeframe.

- Federal offshore oil production, 1954-1999 (see Figure 1). Federal offshore oil is produced in the Gulf of Mexico and off California, but almost all of it comes from the GOM. In 1980, oil production on the OCS was at its lowest level since 1968 when the industry was in a growth mode. Offshore oil production peaked in 1971. Production declined between 1972 and 1980, with the exception of 1979. Production increased in the early 1980's (1981 to 1984), followed by a steady decline, except for 1986, between 1985 and 1990. Oil production has increased annually since 1991. In 1980, OCS oil production accounted for about 9 percent of total U.S. oil production. In 1999, it was about 25 percent of total U.S. oil production (U.S. DOI, MMS 2000). Petroleum from all sources accounted for an average 40.1 percent of total domestic energy consumption between 1949 and 1999 (U.S. DOE, EIA 2000a).

- Federal natural gas production, 1954-1999 (see Figure 2). Like oil, almost all natural gas produced on the OCS comes from the GOM. Offshore natural gas production first peaked in 1981. Natural gas production peaked again in 1990 and 1997. During the period between 1982 and 1986, production fluctuated. The trend since 1986 has basically been increased production, with declines in 1991, 1995, 1998 and 1999. OCS natural gas production accounted for almost 24 percent of total U.S. natural gas production in 1980 and about 26 percent of it in 1999 (U.S. DOI, MMS 2000). Natural gas from all sources accounted for 20.6 percent of total domestic energy consumption between 1949 and 1999 (U.S. DOE, EIA 2000a).

- Deepwater oil production in the GOM, 1985-1999 (see Figure 3). Deepwater is defined as water depths greater than 1,000 feet. Deepwater operations are significantly different from operations in shallower waters. More sophisticated technology and technical expertise are needed. Shell Offshore, Inc. installed the first deepwater production platform, Cognac, in 1978. Companies began to express greater interest in deepwater in 1983 when the largest number of deepwater tracts were leased (see Section 3.5). Deepwater oil production accounted for about 6 percent of total GOM OCS production in 1985 compared to about 45 percent in 1999 (U.S. DOI, MMS 2001b).

- Deepwater natural gas production, 1985-1999 (see Figure 4). Deepwater natural gas accounted for less than 1 percent of total GOM OCS production in 1985 compared to about 17 percent in 1999 (U.S. DOI, MMS 2001b).

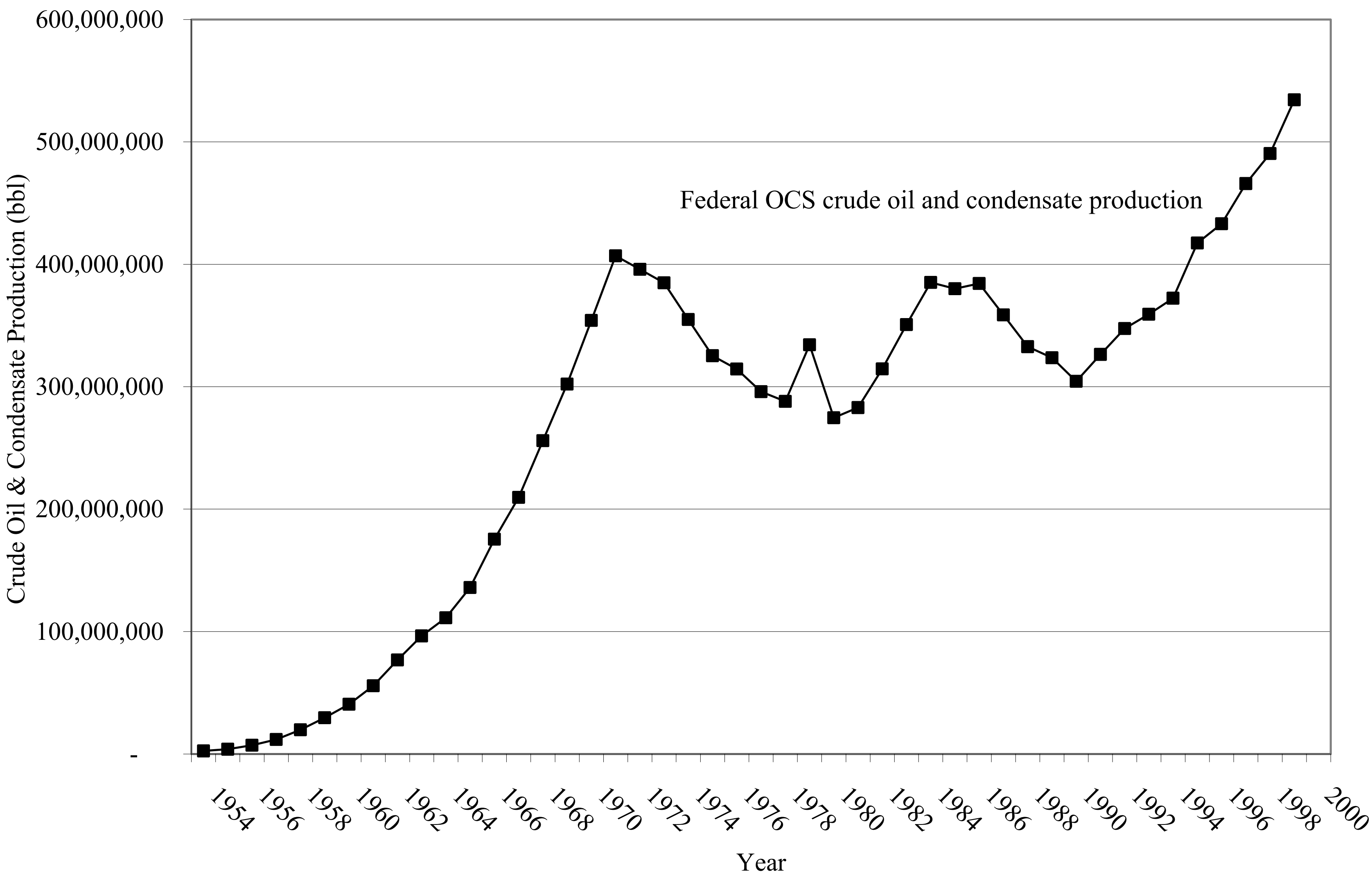


Figure 1. Federal offshore oil production, 1954-1999.

Source: U.S. DOI, MMS 2000.

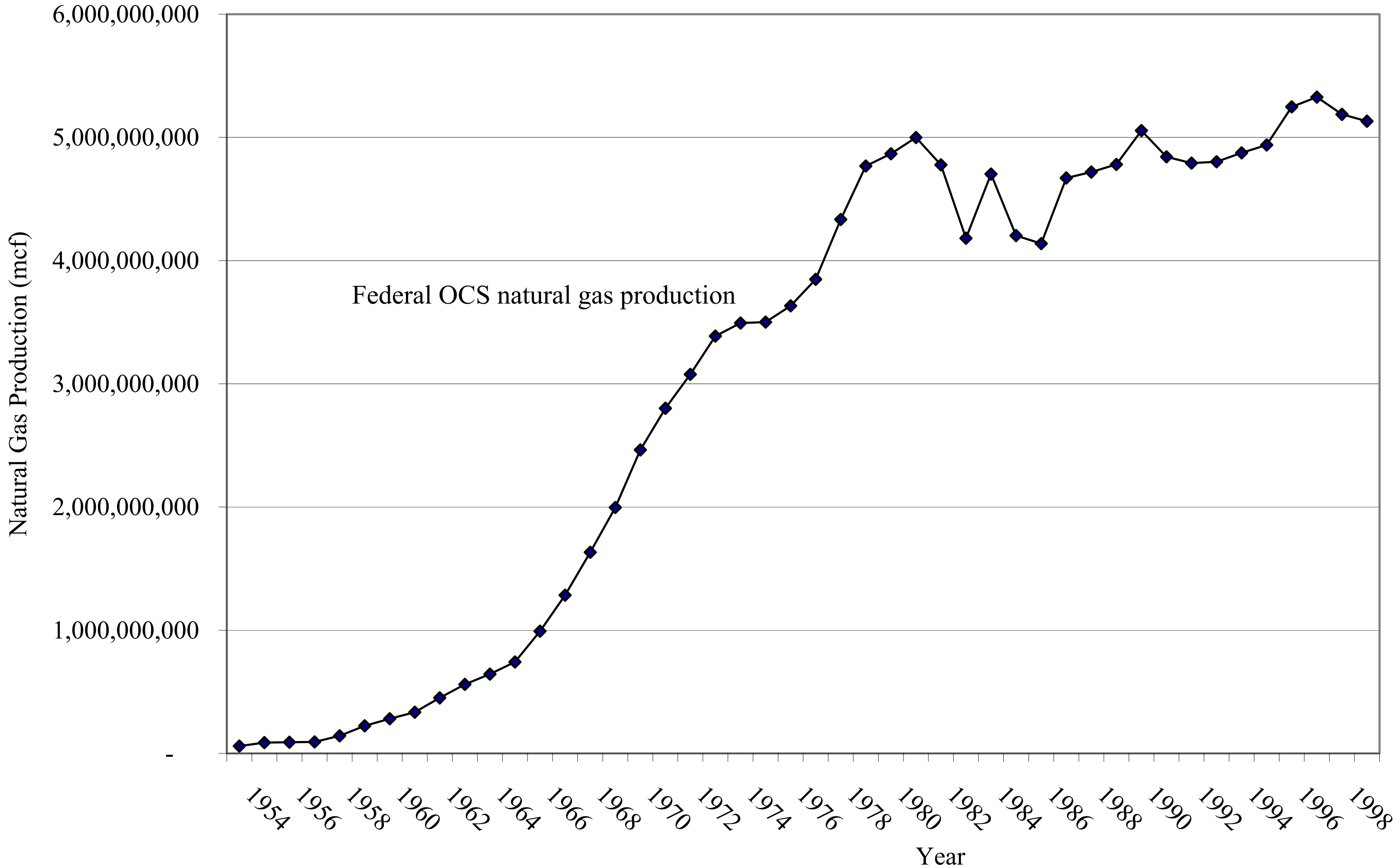


Figure 2. Federal offshore natural gas production, 1954-1999.

Source: U.S. DOI, MMS 2000.

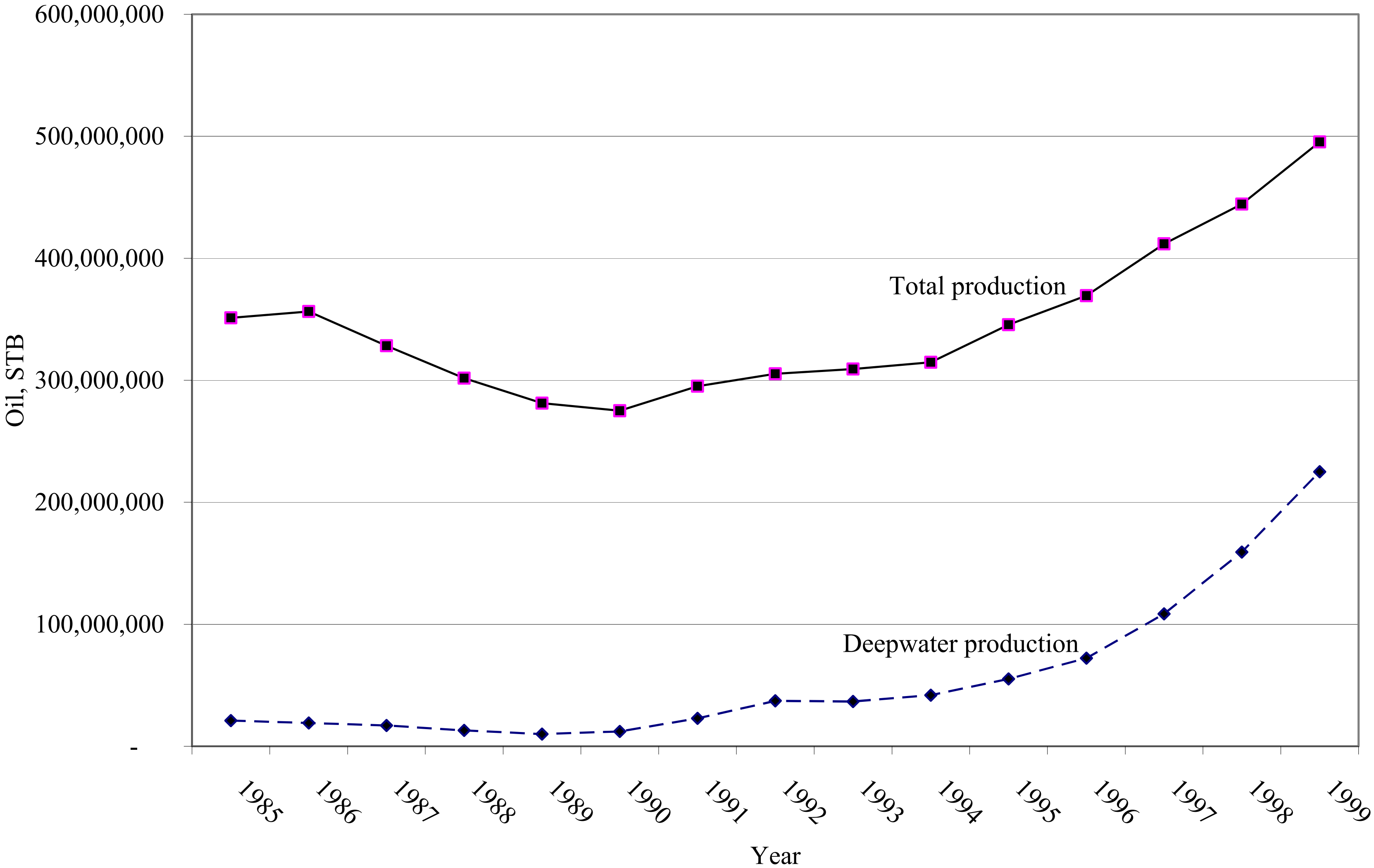


Figure 3. Deepwater oil production, 1985-1999.

Source: U.S. DOI, MMS 2001b.

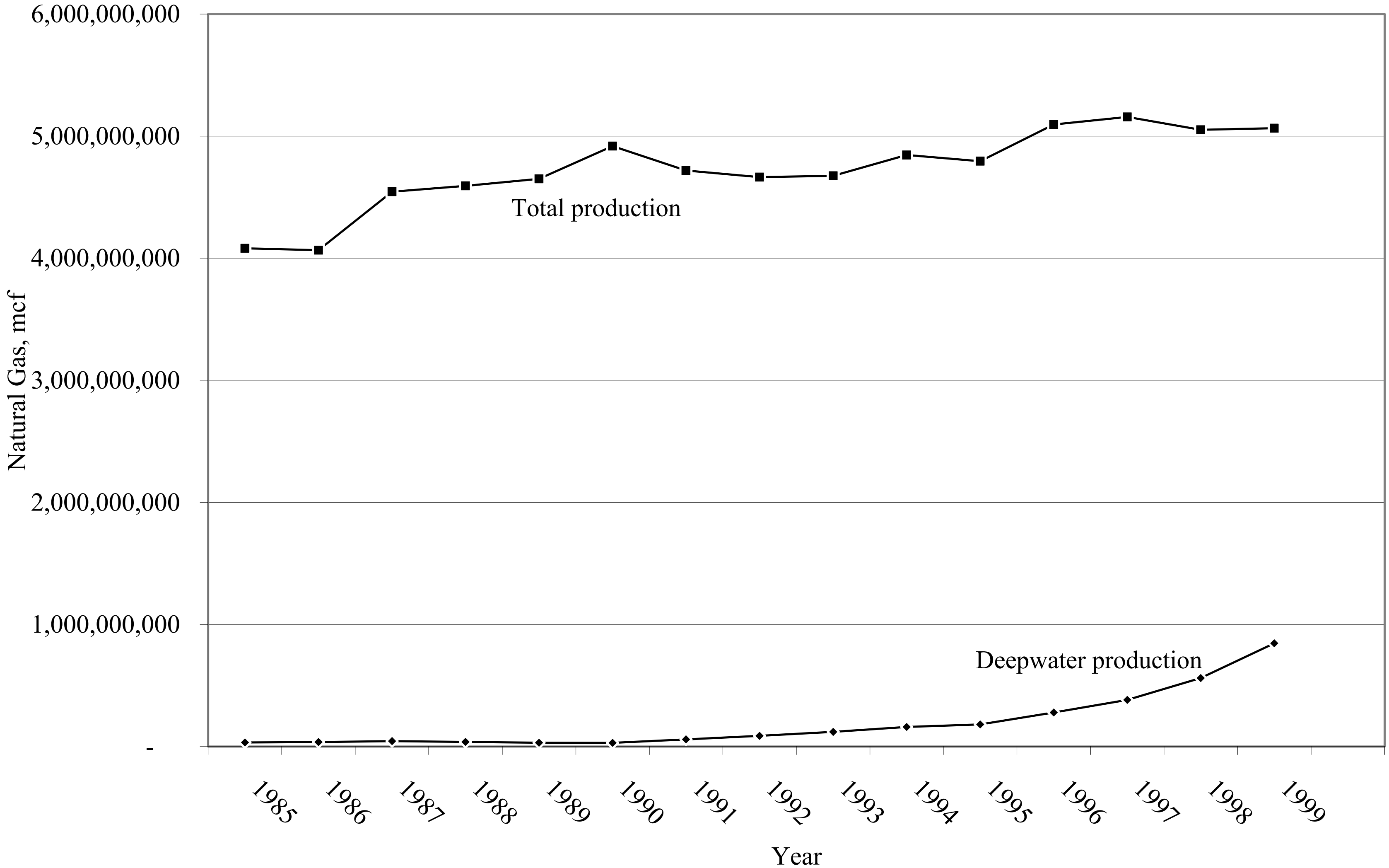


Figure 4. Deepwater natural gas production, 1985-1999.

Source: U.S. DOI, MMS, 2001b.

- Platforms installed and removed, 1942-1999 (see Figure 5). Platforms have been installed annually since 1942. The largest numbers of platforms were installed in 1984 (226) and 1985 (212). Platforms started being removed in 1973. More platforms were removed than installed in 1992, 1993, 1997, and 1999 (U.S. DOI, MMS 2000).[1] It should be noted that horizontal drilling (see Section 4.3.2.3) has made it possible to complete more wells with fewer platforms.

[1] A forecast of platforms in the GOM in 2023 predicts a 29 percent decline in operating structures between 1999 and 2023, from 3,687 to 2,612; 3,543 installations in the 1999 to 2023 timeframe or not quite 142 per year; and 4,645 removals or about 186 platforms per year. Many of the installed platforms are expected to be larger and in deepwater while many of those removed are forecast to be smaller platforms located in shallower waters (Pulsipher et al. 2001).

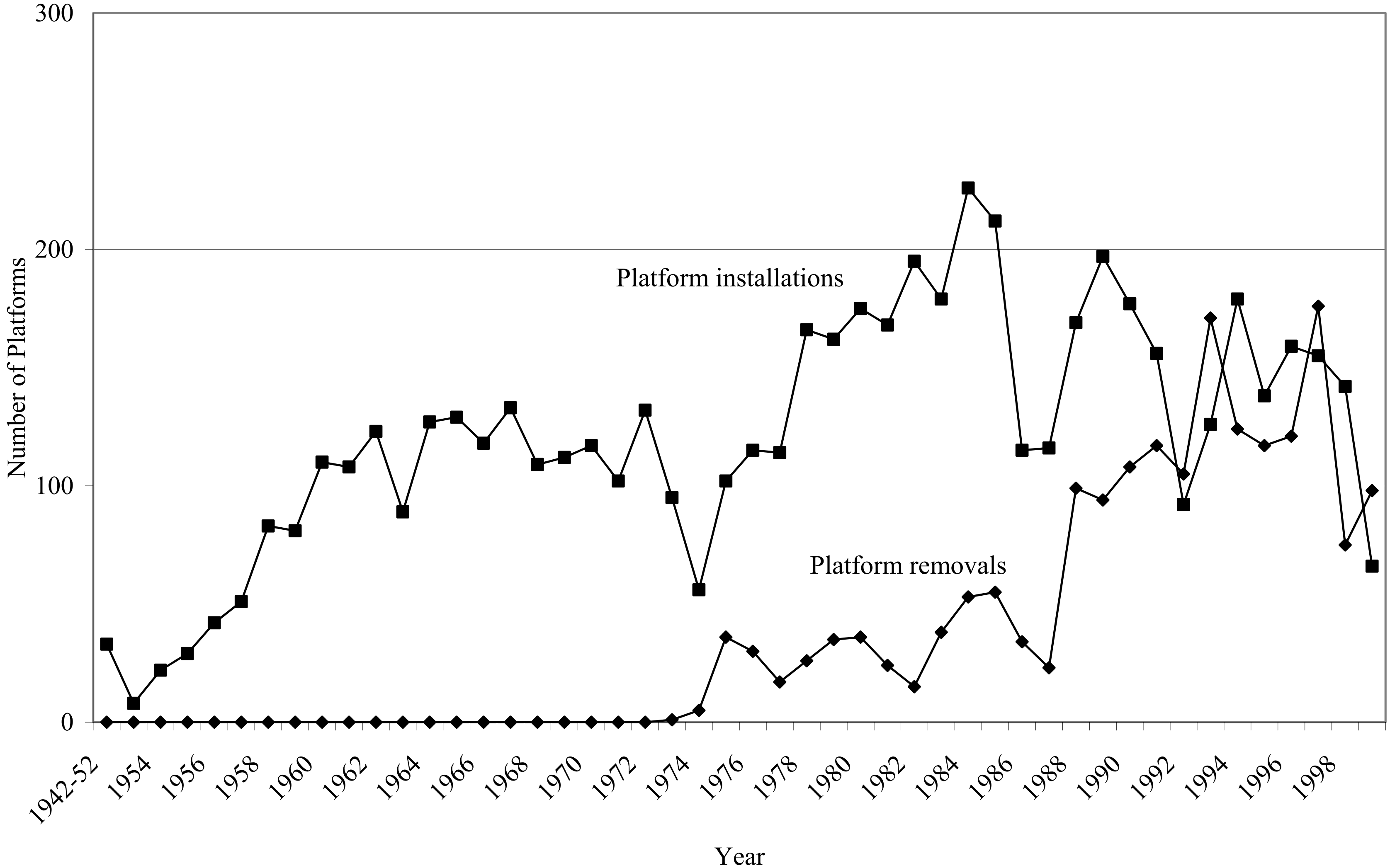


Figure 5. Platform installation and removal, 1942-1999.

Source: U.S. DOI, MMS 2000.

2.4 Time Line of Events Affecting the GOM Offshore Oil and Gas Industry, 1980-2000 and Beyond

Table 3 is an overall time line of events affecting the GOM offshore oil and gas industry from 1910-2000 and beyond. While the study period of interest focuses on 1980 to 2000, the time line begins in 1910. The events cover a range of topics including:

- Laws, directives, and regulations
- Technological advances
- Weather
- International events
- Financial markets
- Corporate decision making

Table 3

Time Line of Events Affecting the GOM Offshore Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1910-1952		
1910	First over-water drilling along the Gulf coast	On Caddo Lake near Shreveport
1938	Discovery of the Creole Field 1.5 miles offshore coastal Louisiana	Petroleum industry's first successful venture into open, unprotected waters
1945	Proclamation No. 2667, issued by President Truman, declared that the U.S. regarded the natural resources of the subsoil and seabed of the OCS as territory owned by the Nation	September. On the same day, President Truman also issued Executive Order No. 9633, reserving certain resources of the OCS under the jurisdiction of the Secretary of the Interior
1947	First offshore well drilled out of sight of land and first well drilled from a mobile platform	November 11. Discovery made by Kerr McGee Oil Company operating under state lease number 754, in the Ship Shoal Area, Block 32, 12 miles off Terrebonne Parish in 18 feet of water. The well produced 600 barrels per day, and marked the first commercial oil production in the GOM. The platform cost $230,000
1953-1979		
1953	Submerged Lands Act passed	May 22. Gives states jurisdiction over the lands and natural resources out to 3 miles seaward from the mean high tide line (3 marine leagues for Texas and the Gulf Coast of Florida) and also established federal jurisdiction over the offshore lands beyond those states waters
	Outer Continental Shelf Lands Act passed	August 7. Authorized the Secretary of the Interior to lease OCS lands for mineral exploration, development, and production. Also mandated development of OCS resources. Amended in 1978 and 1985
1954	Bureau of Land Management opened its New Orleans OCS office	The U.S. Geological Survey established its Gulf Coast regional office at about the same time
	First OCS lease sale offering blocks offshore Louisiana	October 13. Sale brought $116.4 million in bonuses into the federal treasury

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1956	First Nigerian discovery	In the delta of the Niger River; exploration began in 1937
1957	European Economic Community (EEC) formed	
1959	First North Sea discovery	Production began in the 1970's
	Eisenhower imposes import quotas on oil	
1960's	Key discovery off Angola	Offshore Cabunda
1960	Organization of Petroleum Exporting Countries (OPEC) formed	Consisted of Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela
1968-69	Discovery of North Slope oil and gas fields	
1969	National Environmental Policy Act passed	Requires a detailed environmental review and statement before any major or controversial federal action
1970's	International companies changed from owners to buyers of crude after the Libyan revolution and rise of OPEC	
	Diversification of some oil companies outside of the energy sector	For example, Mobil owned Montgomery Ward
1970	BP discovered the Forties field on the British side of the North Sea	Together with Phillip's discovery in the Ekofisk field drove the North Sea exploration in the 1970's
	Clean Air Act passed	Regulates the emission of air pollutants from industrial activities
1971	Peak oil production until 1995	
	Production started in Norwegian sector of the North Sea	
	Expansion of OPEC Nations	By end of 1971, OPEC adds Qatar, Indonesia, Libya, United Arab Emirates, Algeria, and Nigeria
1972	Texas Railroad Commission ends proratio to market demand and mandates production at 100 percent of well allowables	Shifts influence to establish world prices from U.S. to OPEC nations
	Clean Gulf Associates established by the offshore industry	A cooperative stockpiling of oil spill containment and clean-up equipment

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1973	First platform removed	
	Yom Kippur War	In retaliation against U.S. support of Israel, OPEC imposes embargo on export of oil supplies to the U.S.
1974	3D seismic data acquisition tested in GOM	
	Key discovery off Brazil	Guarroupa Field in the Campos Basin off Rio de Janero; went into production in 1981
1975	Production started in the United Kingdom sector of the North Sea	
	The Energy Policy and Conservation Act of 1975 passed	Mandated federal efficiency standards for 13 products
1976-78	Extremely cold weather in U.S.	Creates natural gas shortage relative to demand; prices increase
1977	Clean Water Act passed	Regulates discharge of pollutants into the surface waters of the U.S.
	Apple II released	Becomes the first mass produced computer
1978	Natural Gas Policy Act of 1978 passed	Began end of federal control over gas prices at the wellhead
	Power Plant and Industrial Fuel Use Act passed	Discourages use of gas and oil, particularly in boilers
	First deepwater production platform installed	Shell Offshore, Inc.'s Cognac
	Gas bubble emerged	Excess or surplus of natural gas on market—called gas bubble, a result of users switching to alternative fuels and the Fuel Use Act of 1978
Late 1970's – early 1980's	Capital expenditures primarily for buying leases and exploration and production (E&P) drilling	The enormous capital expenses of offshore oil and gas are largely in the future
	Financing largely through banks and based on assets in the ground	Senior term-debt and revolving credit are principal vehicles; revolving credit replaces term loans
	Anti-Shah demonstrations	Iranian oil worker strike
	Deepest offshore wells operate in 1,000 feet of water	Beginning of deepwater oil and gas activity
	Iranian Revolution	Start of second oil crisis

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1980 to 2000		
1980	Commercial 3D seismology begins in the early 1980's	
	Major integrated oil companies (e.g., Exxon, Mobil) account for 36 percent of the Fortune 500's net income	By 1990, this share dropped to 21 percent and then to less than 8 percent in 2000
	Oil and gas industry liquidity problems often related to bank debt (e.g., loans)	
	Oil industry planners forecast oil prices of $90 to $110 by 2000	Forecast largely based on extending trend lines from 1970's and 1980's
	Iran/Iraqi War	U.S. imports decrease and prices increase
1981	First offshore horizontal well	Rospo Mare field, offshore Italy
	Peak offshore natural gas production until 1990	
	Peak oil price	$54.46 per barrel (2000 dollars)
	Gasoline prices peak at $2.57 (2000 dollars) a gallon	Highest price ever through 2001
	First OCS leasing moratorium enacted (FY 1982)	California
1982	Federal Oil and Gas Royalty Management Act passed	Designed primarily to address issues, but also supports environmental protection and conserves federal resources
	U.S. DOI Secretarial Order No. 3071 establishes the Minerals Management Service	Functions previously carried out by the U.S. Geological Survey and the Bureau of Land Management
	OPEC imposes first quota	Attempt to restore petroleum prices, but non-OPEC production continues to rise
	First 5-Year Oil and Gas Leasing Schedule approved which included areawide lease offerings	July. Approved by Secretary of the Interior James Watts
1983	Horizontal well drilled from vertical shaft	Kern River, CA
	GOM Sale 69 first sale which set minimum bid for OCS acres at $150 per acre	Had been $25 per acre since 1968

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1983 (cont'd)	Presidential Proclamation established an Exclusive Economic Zone (EEZ) extending seaward 200 nautical miles from the "baseline" (the legal coastline) of the territorial sea of the U.S., the Commonwealth of Puerto Rico, and Northern Mariana Islands, and other U.S. overseas territories and possessions	March 10
	First areawide lease sale	May 25. Central GOM Lease Sale 72; largest number of deepwater tracts leased up to that point; new records set for bonus bids offered, high bids, and bids accepted
	New York Mercantile Exchange (NYMEX) begins to trade crude oil contracts	Oil seen as "commodity;" crude oil contracts help to "curtail" price increases of 1973 and 1979, free market trade in oil undermines OPEC influence on oil prices
	OPEC cuts benchmark price to $29.00	
	Spot market for natural gas developed	Allows prices for spot market to be below those for the contract market
	First preleasing moratorium enacted (FY 1984)	North Atlantic is closed to leasing
1984	National Fishing Enhancement Act passed	Encourages the use of offshore platforms as artificial reefs
	Federal Energy Regulatory Commission (FERC) issues orders to remove gas costs from minimum bills for consumers	
	Peak wellhead natural gas price	$4.02 per mcf (2000 dollars); a spot market fluke, not the average prevailing wellhead price
1984-88	Federal government sold hundreds of failed savings and loan banks	
1985	3D vertical seismic profiling developed	

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1985 (cont'd)	FERC Order 436	Encourages gas pipelines to become open access carriers of natural gas; permits treatment of natural gas as a commodity
1981-85	Merger cluster	Examples: Dupont bought Conoco, U.S. Steel bought Marathon, Mobil acquired Superior Oil, Chevron acquired Gulf Oil, Texaco bought Getty
1984-85	Largest number of platforms installed	226 in 1984; 212 in 1985
	Saudi Arabia increases oil output by 44 percent to make up for shortfall caused by Iran/Iraqi War	Petroleum prices tumble between 1985 and 1986
1986	Oil price crash	Price drops to $17.76 (2000 dollars)
	Major cost cutting efforts and layoffs begin	Continues to present
	FERC Order 436 implemented	
1986-89	Gas bubble	Producers try to enforce take or pay contracts in natural gas, while buyers try to evade them; helps lead to FERC Order 436
Late 1980's	Successful horizontal wells in Austin Chalk lead to general use of this technology; horizontal and multilateral wells are substantial part of drilling activity for the first time	First modern horizontal well completed in 1953 by Russian drilling engineer; despite excellent production, industry takes 35 years to adopt technology fully
1987	Mergers continue	For example, BP acquired Standard Oil (Ohio)
	Patent obtained for deepwater spar technology	
	First logging while drilling (LWD) tool	
	Minimum bid for OCS acres set at $25 per acre	Had been $150 per acre since 1983
	MMS institutes the Conservation Award for Respecting the Environment	Special recognition given to offshore operators that go beyond regulatory requirements in protecting and enhancing the coastal and marine environment

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1987 (cont'd)	FERC issues Order 500	Issued to address acute take-or-pay problems relative to natural gas
1988	First horizontal well drilled from semisubmersible drill rig	
	Capital dries up in late 1980's and early 1990's	Banks consolidate; oil and gas industry loses traditional sources of capital; price crash of 1986 wiped out many industry participants who bought into each other's deals
	First OCS drilling ban enacted (FY 89)	Affected 73 existing leases in the Eastern GOM; later expanded to North Aluetian Basin and leases offshore North Carolina
	Amendments to Power Plant and Industrial Fuel Use Act passed	Creates potential for additional use of natural gas
	National Appliance and Energy Conservation Act passed	Establishes minimum efficiencies for 12 types of residential appliances sold in U.S.
	End of Iran/Iraqi War	Oil price is $16.77 (2000 dollars) in 1988 and $20.36 (2000 dollars) in 1989
	FERC Order 490	Allowed abandonment of first sales contracts and allowed pipeline bypass
	FERC Order 491	Interpreted Section 5 of the Outer Continental Shelf (OCS) Lands Act to require that OCS pipeline companies offer both firm and interruptible transportation on a nondiscriminatory open-access basis
	FERC Order 493	Natural Gas Data Collection System—inquiry into alleged anti-competitive practices related to marketing affiliates of interstate pipeline companies
1989	5 percent of GOM wells based on 3D seismic data	
	Exxon Valdez oil spill in Alaska	
	November 1989: Sabine selected by NYMEX as the official delivery mechanism for the world's first natural gas futures contract	Changes the way that spot and future prices affect wellhead prices; Sabine owns and operates the Henry Hub

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1989 (cont'd)	Natural Gas Wellhead Decontrol Act passed	Eliminates all remaining wellhead price controls
	FERC Order 512	Removal of contract duration and right of first refusal regulations for certain OCS natural gas
1990	Clean Air Act amendments passed	Gives EPA jurisdiction for OCS facilities outside Central and Western GOM
	Oil Pollution Act of 1990 (OPA-90) passed	Includes provisions for oil spill prevention, contingency planning, and financial responsibility for offshore facilities in, on, or under navigable waterways
	Presidential decision withdraws areas for lease until 2000	Areas offshore California, Oregon Washington, North Atlantic and Eastern GOM (south of 26 degrees N latitude and East of 86 degrees W longitude) withdrawn
	Significance of oil and gas industry to U.S. economy diminishes over the 1980's	Changes from 1980 to 1990 show reduced role for oil industry • Sales as percent of total Fortune 500 sales: 1980--31.6 percent, 1990--18.5 percent • Income as percent of total Fortune 500 income: 1980—36.4 percent, 1990—21.1 percent • Employees as percent of total Fortune 500 employees: 1980—8.4 percent, 1990—4.9 percent • Sales per employee: 1980--$390,918, 1990--$699,377
	Houston emerges as a dominant American center in the oil and gas industry	Houston also becomes a key center for research, technology and operation of downstream oil
	Shell does not consider GOM deepwater discoveries (e.g., Auger, Mensa, Ursa) economically viable because of low flow rates	By 2000 all are producing profitably

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1990 (cont'd)	World's 10 leading oil and gas companies narrowed their focus to the core areas of oil, gas and chemicals in early 1990's	Refocusing and an emphasis on improving near-term financial performance dramatically improve financial results
	Americans consumed 6 percent less oil than in 1978	
	Futures trading for natural gas begins April 3, 1990	Allows trading at 18 months into the future
	Gulf War begins	Imports decrease and prices rise
1990-91	FERC Orders 528/528A	Caps recovery of take or pay costs through volumetric surcharges charged by pipeline companies
1991	First Colloquium on Petroleum Engineering Education	First of five meetings, 1991 to 2000 of the Society of Petroleum Engineers, U.S. Department of Energy (U.S. DOE), and the Association of Heads of U.S. Petroleum Engineering Schools to discuss issues
	Petroleum engineer (PE) undergraduates fall to about 200	Stayed between 200 and 300 in the 1990's
	Breakup of the former Soviet Union	
	Iraq defeated in the Gulf War	Oil price declines to $19.72 (2000 dollars) from $24.76 (2000 dollars) in 1990
	World Wide Web released	
	Natural gas price hits low of $1.96 per mcf (2000 dollars)	
1987-92	Independents expanded role in GOM, majors invested overseas	
1992	OPA-90 authority delegated by Secretary of the Interior to MMS	Expanded MMS authority for oil spill contingency planning to all offshore facilities platforms and pipelines in state waters and on the OCS
	Fast track approach to bringing a field onstream used to compress development timetable	

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1992 (cont'd)	Natural gas production exceeded crude oil production for first time in history (all, not just OCS)	Natural gas increasingly a driver in North American strategies of U.S. petroleum companies
	First winter of operations under FERC Order 636	Reduced government oversight and introduced competition to the industry; interstate natural gas pipeline companies required to unbundled
	PE departments considered diversifying programs to train outside the petroleum industry	About this time University of Texas petroleum engineering department changed name to the Department of Petroleum & Geosystems Engineering
`	First time more platforms removed than installed	Also occurred in 1993, 1997, and 1999
	New mission of Chevron: "…to achieve superior financial results for our stockholders, the owners of our business"	Reflected major oil company interest in shareholder value and growing importance of the stock market in corporate strategy for all industries
	New sources of capital emerge—high yield bonds, private placement of subordinated debt	Money is more plentiful, but more expensive
	Energy Policy Act passed	Promoted alternative sources of energy and conservation; passed to promote fuel diversity; diversified fuel supplies by promoting the use of alternative fuels in the U.S.
1993	Texaco left the petrochemical industry	The first international major to do so
	Second Colloquium of Petroleum Engineering Education	Discussed skills needed for future petroleum engineers
1994	Continued internationalization of the oil and gas industry encourages exploration and development activity around the globe	
	Natural gas price hits new low of $1.69 per mcf	Mild winter 1994/95 led to layoffs, restructuring, and mergers in gas sector in 1995
	Firms still restructuring, cutting costs under oil price uncertainty	

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1994 (cont'd)	Human resources is on major oil industry conference agenda for the first time	Offshore Northern Seas Conference
	North American Free Trade Agreement goes into effect	Opens trade between the U.S., Canada, and Mexico
1995	Deepwater Royalty Relief Act passed	Royalty payment relief on deepwater production and reduced operator environmental liability created better business climate for operations within U.S.
	Federal Energy Regulatory Commission Order 888	Initiated restructuring in the electric power industry
	4D seismic emerges	Offshore exploratory success rate for large producers including Exxon, Shell, Mobil and Texaco more than doubled between 1978 and 1995
`	Drilling and development technologies begin to emerge in 1995 and 1996	Examples included easier re-entries, multilateral completions, extended reach drilling, reliable subsea completions, floating production facilities
	Cost cutting efforts have helped major oil companies, but placed financial pressures on contractors	Return on equity in 1995: Global oil companies (11 percent), US oil companies (5 percent), service companies (8 percent), drilling contractors (-6 percent)
	Third Colloquium on Petroleum Engineering Education	Explored ways to increase value of petroleum engineering education to those with the degree
	High-yield bond market became a significant source of capital for the oil industry	1995 to 1998, E&P and service companies issued $20.5 billion in high-yield debt [i.e., debt rated lower than BBB by Standard & Poor's Corp. (S&P) or Baa3 by Moody's Investors Service]
	Choice programs are implemented for natural gas residential customers	Allowed consumers to select their own gas provider

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1996	OPA-90 amendments passed	Applied to financial responsibility for offshore facilities and to spill prevention in state waters
	World's first production SPAR installed in the Central GOM	Neptune SPAR (Oryx Energy) installed in 1,851 ft of water in Viosca Knoll
	80 percent of GOM wells based on 3D seismic data	
	4D seismic characterization methodology applied to previously recorded seismic surveys	
	Satellite transmitted seismic data from ship in GOM to shore-based supercomputer	Public-private collaboration demonstrated viability of remote analysis of seismic data
	Time from offshore discovery in 1996 to initial production is reduced to 2 years	For offshore discoveries in 1984, 10 years elapsed before initial production
	Cambridge Energy Research Associates issues "The Quiet Revolution: Information Technology and the Reshaping of the Oil and Gas Business"	Report estimated $6 billion annual spending on seismic technology, horizontal drilling, computers, graphics and futuristic visualization, advanced applications software, databases and networks, and similar technology.
	New discoveries confirm the value of deepwater GOM	
	MMS opens the Eastern Gulf Information Office in Pensacola, FL	Opened in response to demand for information from Florida constituents concerning OCS activities in the GOM
1997	Helicopter pilots consider unionizing	Offshore Logistics' pilots vote to join the Office and Professional Employees International Union; Petroleum Helicopters Inc. pilots vote not to
	Consolidation in drilling contractors	Reading Bates Corporation (offshore drilling) and Falcon Drilling, Inc. (onshore drilling) merged to become the R&B Falcon Corporation (acquired Cliffs Drilling Company in 1998)

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1997 (cont'd)	Fourth Colloquium on Petroleum Engineering Education	
	Employee retention program started at BP	
	Discovery rate almost six times the rate of early 1980's	Result of better imaging technology
	Capital for exploration and production provided through banks' syndicated loans rises to $55 billion	Figures for 1995 and 1996 were $22 billion and $36 billion, respectively
	OPEC increases export quota on oil	Underestimates impact of Asian financial crisis on demand for energy; oil prices plummet
1998	Falling oil profits, prices, and mergers result in oil industry layoffs	Oil price drops to $11.26 per barrel (2000 dollars)
	Spar technology proves successful in increasingly deep waters	Genesis: 2,590 feet Diana: 4,800 feet
	"Truss" spar designed for use in 5,500 feet of water	
	The world's longest well with a horizontal reach of 6. 2 miles completed by BP Exploration Operating Co. Ltd	
	The Baldpate deepwater production platform in GOM, the world's tallest freestanding structure	
	Oil and gas industry bond prices dropped from high 90-cent range to a much lower range—some trade at 50 or 60 cents on the dollar, others at 20 to 30 cents.	Initial industry experience with volatility of public debt market
	Personnel shortages in many sectors	Broadly experienced engineers, highly experienced engineers, and a cross section of drilling personnel in limited supply
	OPEC pledged to cut production	Purpose was to increase petroleum prices

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
1999	Major consolidation of drilling contractors	Transocean Offshore and Schlumberger's Sedco Forex combined to create the largest drilling company in the world, called Transocean Sedco Forex
	Mergers continue	Examples: Mobil merged with Exxon, Oryx merged with Kerr McGee, ARCO merged with BP Amoco, (announced)
	Average real cost of finding and producing oil dropped by an estimated 60 percent over past 10 years	Cumulative effect of incremental changes in technologies
	Proven reserves increased 60 percent over past 10 years	
	OPEC and non-OPEC nations cut production April 1	Petroleum price dramatically increases in 1999
2000	Helicopter pilots unionized	Petroleum Helicopters, Inc, pilots voted for union representation from the Office and Professional Employees International Union
	American Association of Petroleum Geologist initiated a Mentor Program	
	U.S. Geological Survey (USGS) released 5-year study of world oil reserves	USGS raised previous estimate by 20 percent to total of 649 billion barrels, based on geological data, changes in drilling and other technologies
	Fifth Colloquium on Petroleum Engineering Education	Focused on the partnership among industry, education, and government
	Personnel shortages cited as number one issue in a survey of drilling and well service companies	
	Further consolidation of drilling contractors	Transocean Sedco Forex bought R&B Falcon Corp.

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
2000 (cont'd)	University consortium model for R&D no longer used; its absence has major impact on training the next generation of geophysicists in the U.S.	Consortia—sponsored through oil or service companies' research or technology centers—had been the mainstay of exploration geophysics research at universities for 25 years
	Major integrated oil companies (e.g., ExxonMobil, Texaco) account for less than 8 percent of the Fortune 500's net income	Sign of waning significance of oil and gas to U.S. economy
	Offshore well located in over 9,000 feet of water	
	At start of the 21st century, oil and its related products made up a much smaller part of the Texas economy	Texas economy becomes considerably less sensitive to changing oil prices
	Overall success rate for new wells is 50 percent	In 1990, success rate was 10 percent
	Exxon Mobil's average cost for finding oil was $0.65 per barrel	Cost is lower than the company's long-term target of $1 per barrel
1998-2001	Mega merger cluster	Examples: Exxon acquired Mobil, Amoco merged with BP, ARCO acquired Union Texas, BP acquires ARCO, Chevron acquires Texaco, Anadarko and Union Pacific Resources Between 1996 and 2000, more than $500 billion in global oil industry merger transactions occurred
Beyond 2000		
Trends	• Mergers continue • Personnel shortages • Cost management • Knowledge management	There are legal (anti-trust) and practical (fewer companies) limits on future mergers, however
2001	Offshore well cost projected to drop by $5 to $12 million through use of subsea mudlift (riserless) drilling	Technology set off a series of cost saving opportunities and allowed for drilling in deeper water with greater production flow rates; lower costs open up more opportunities for profitable operations when oil price drops

Table 3 (cont'd)

Time Line of Events Affecting the GOM Offshore
Oil and Gas Industry, 1910-2000 and Beyond

Year	Action	Comment
2001 (cont'd)	Theory estimated 70 percent of oil in average reservoir is recoverable	Typical recovery rate was about half of this estimate
	ExxonMobil could process as much seismic data in 10 days as would have taken 11 years in 1990	
	Majors renewed interest in shallow water; large independents invested overseas	Reversal of trends from late 1980's and early 1990's
2005	Offshore costs projected to drop by as much as 50 percent relative to costs in 2000	
	BP Amoco hopes to reduce liquid natural gas production costs by 25 percent relative to costs in 2000	
2015	Projected date when all the world's seabed will be accessible to offshore drilling	Advances in platform, drilling, related technology will eliminate water depth as barrier to development
Future	Knowledge will surpass oil and gas reserves as companies number 1 asset	Computers, telecommunications, and information technology seen by some as radically transforming the industry. According to one expert, 40 percent of oil companies will be "virtual" by 2010

3.0 OIL AND NATURAL GAS PRICES AND INDUSTRY RAMIFICATIONS

3.1 Time Line

Examination of oil and natural gas prices and their ramifications for the oil and gas industry begins with the time line of prices. Although the project's period of interest is 1980-2000, a longer time period on prices is given in order to put the period of interest in context.

3.1.1 Oil Prices

The 1970's marked a major turning point in the level of oil prices. Prior to the large shock in 1974, which was induced by the Organization of Petroleum Exporting Countries 1973 embargo of oil supplies to the United States, the real price (actual price adjusted for inflation) of oil (measured in terms of crude oil domestic first purchase price) was declining at a relatively modest rate (Brown and Yucel 1995) (see Figure 6). In 1949, the real price (price adjusted for inflation and expressed in terms of year 2000 dollars) was $15.73 per barrel; in 1973, the real price was $12.38. Between 1973 and 1974, however, the real price increased 62.0 percent (from $12.38 to $20.06 per barrel). From 1974 through 1981, oil prices increased at an increasing rate (from $20.06 to $54.46 per barrel); prices for crude peaked in 1981. Following the 1981 peak price, however, prices began to plummet and reached a low of $17.76 in 1986. Oil prices between 1986 and 1999 exhibited considerable annual variation but an overall generally declining trend. In 2000, however, oil prices reached $26.73 per barrel (an increase of 68.3 percent over 1999 prices).

There appear to be between four and six basic patterns in the price of crude petroleum. Between 1949 and 1972, prices were relative stable and slightly decreasing. In 1973, prices increased by nearly 9.0 percent over the 1972 level. The largest annual price increase between 1949 and 1999 occurred between 1973 and 1974—the price of crude increased by 62.4 percent. Prices were relative stable, however, between 1974 and 1978 because of price control under the Nixon, Ford, and Carter administrations. From 1978 to 1981, prices steadily increased, with the largest annual rate of increase occurring between 1979 and 1980. Oil price decontrol was phased in over a 28-month period beginning in 1979. In 1982, prices began to drop, and they continued to decline until 1987. Between 1981 and 1986, prices declined by 67.4 percent. After 1986 and on through 1997, crude prices generally varied from year to year, but the level of variation was not as large as it had been in proceeding periods. In 1998, the price of crude declined by nearly 38.0 percent. The 1999 price was 41.0 percent higher than it was in 1998. Between 1999 and 2000, the price of crude jumped by 68.3 percent; the largest annual rate of increase observed between 1949 and 2000.

3.1.2 Wellhead Natural Gas Prices

The trend in natural gas prices has closely tracked the trend in oil prices. Up through the early 1970's, the wellhead prices received for natural gas (in year 2000 constant dollar values, henceforth, real prices) very modestly increased. In 1949, the real price equaled $0.37 per thousand cubic feet (henceforth, mcf). In contrast to petroleum whose real price in 1999 was nearly the same as it was in 1949, natural gas prices increased to $2.11 per mcf in 1999—an increase of 470.3 percent. Between 1972 and 1973, the real price of natural gas increased by 9.66 percent. In 1974, the real price increased by 25.1 percent relative to 1973

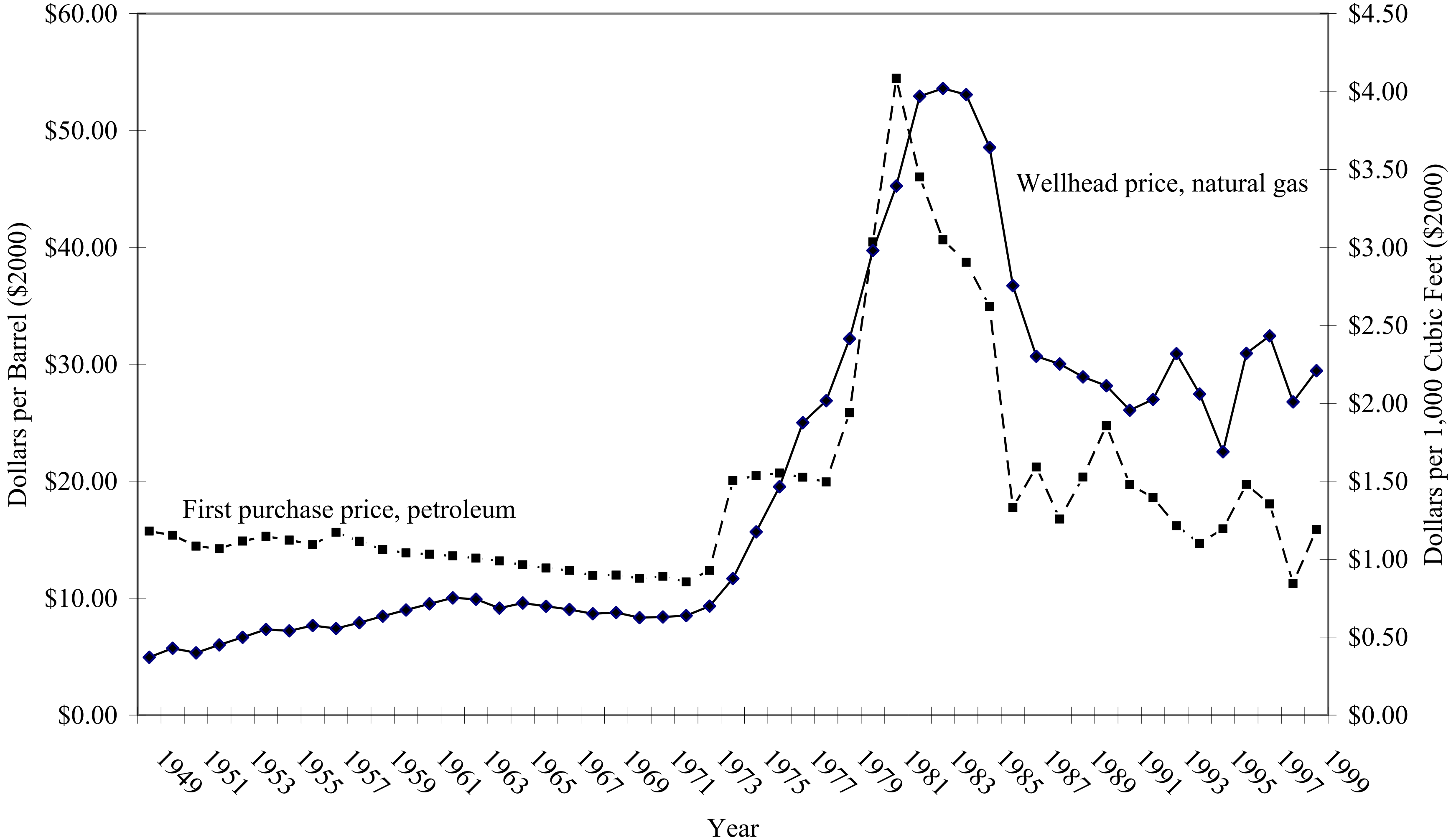


Figure 6. First purchase price of petroleum and wellhead natural gas price, 1949-2000.

Source: U.S. DOE, EIA 2001a.

levels. The real price continued to increase by double-digit percentages through 1977. Between 1973 and 1983, the real price increased by 474.3 percent. The price rises in the 1970's reflect higher prices one the intrastate market and gradual regulation after 1978. After the peak high price of 1983, the price of natural gas declined to $1.96 per mcf in 1991—a decrease of 51.2 percent. Since 1991, prices have widely varied but also exhibited a generally, but very modest, increasing trend. In 2000, the average wellhead price of natural gas was $3.60 per mcf; the average price for January and February of 2001 equaled $6.95 per mcf.

Natural gas prices between 1949 and 2000 had patterns similar to those that characterized petroleum. From 1949 through 1972, the price of natural gas remained relatively stable. The price did, however, increase between 10 and nearly 13 percent a year between 1951 and 1954. The first large percentage increase occurred between 1972 and 1974, when prices increased by nearly 10.0 percent. In 1974, the price of natural gas increased by 25.1 percent relative to the 1973 price level. Unlike oil prices, which dramatically increased between 1973 and 1974, but remained relatively constant between 1974 and 1978, natural gas prices consistently increased through 1983, when the price reached $4.02 per mcf of natural gas. Prices plummeted to a low of $1.96 per mcf in 1991. From 1991 through 1999, prices generally increased but also varied from year to year. Between 1999 and 2000, however, the price of natural gas increased 62.9 percent.

3.2 Economics and Finance: Oil and Natural Gas Prices

3.2.1 Factors Affecting Domestic Prices

Although it seems trivial to state, oil and gas prices are determined by demand and supply conditions. Demand represents the quantities demanded given different prices, incomes, and other factors. Supply represents the schedule of quantities supplied given different oil and gas prices. The intersection of demand and supply determines the market equilibrium price. The seemingly simple concept that price is determined by the equilibrium between demand and supply, however, is actually quite complicated.

The complications arise because of the dynamics of adjustments to economic, political, and other changes, and the factors affecting demand and supply at all market levels. America needs oil and natural gas or fossil energy. Consumers demand energy, such as oil or gas for heating homes and hot water and gasoline. Oil and natural gas are also used for producing electricity. Oil and gas prices are formed as a result of thousands of daily transactions occurring around the world. The price of each is even formed in relation to factors influencing the price of the other [e.g., oil (natural gas) prices may affect natural gas (oil) prices)]. These transactions occur at all levels of the distribution chain from producer to individual consumer.

To gain a better understanding of the factors which determine oil and gas prices, consider the following simple example. We have a consumer demand (D) function for energy; this is an aggregate demand, which represents the demand for energy by all individuals in an economy. This demand depicts the total demand for energy given the price of energy. It is derived, however, from an aggregation of individual consumer demand. The individual demand for energy is the result of an individual determining what quantities of goods and services he/she should purchase given prices and incomes, such that his/her overall level of satisfaction is maximized. On the other side, we have an aggregate supply curve (S) that depicts the total quantity of energy supplied for distribution to final consumers given prices offered for energy. The aggregate or market-wide supply curve for energy is derived as the aggregation of individual firm level supply functions.

The equilibrium or intersection of demand and supply determines the equilibrium market price (Pe) and quantity for energy (Qe) (see Figure 7). The equilibrium price is the price at which the market clears or demand equals supply. For points below the equilibrium, demand exceeds supply and prices will generally be driven upwards. For points above the equilibrium level, supply generally exceeds demand and prices will be driven downward.

The determination of price, as suggested by Figure 7, is seemingly simple. Yet, thousands of daily decisions are made, which may affect the price of oil and natural gas. Crude oil prices are affected by such factors as political instability, refinery/pipeline disruptions, changing weather patterns, economic prosperity, clean air laws, futures and commodity markets, rumors, crude oil and product stocks, and numerous other factors (U.S. DOE, EIA 2001b).

Consider two simple illustrations of how oil or gas prices might change. There is an unusually mild winter in the Northeastern United States. As a result, consumers do not demand as much energy; they experience a downward shift in demand (e.g., D_1 to D_2 in Figure 7). The downward shift in demand causes demand to decline to Q_2 and the equilibrium price to fall to P_2. Now consider a new technology, which lowers final consumer distribution costs. With the lower costs, distributors can now make the same supply available at a lower cost per unit, assuming they had no increase in other production costs. The new equilibrium price and quantity is P_3 and Q_3. In essence, any event or factor, which can shift or rotate demand and/or supply, can affect the market price and quantity.

The market for oil and natural gas is highly complex. Consider the domestic supply for oil (i.e., we ignore imports). We start from the raw material sector, exploration and production. We then proceed to transporting crude to the manufacturing sector, which includes refining. Next, there are the primary storage and throughput activities. Subsequently, refined products make their way to wholesale downstream markets, which require secondary transportation. Prior to the end user—the consumer, there is a secondary storage and final distribution sector.

Any event affecting supply or demand in any of the sectors can have ramifications for the domestic price. For example, an increase in the cost of labor for the exploration and production sector shifts that sector's supply schedule up and prices, for a given quantity, will increase. It costs more to explore and produce crude or natural gas, and producers likely establish production levels consistent with marginal cost pricing.

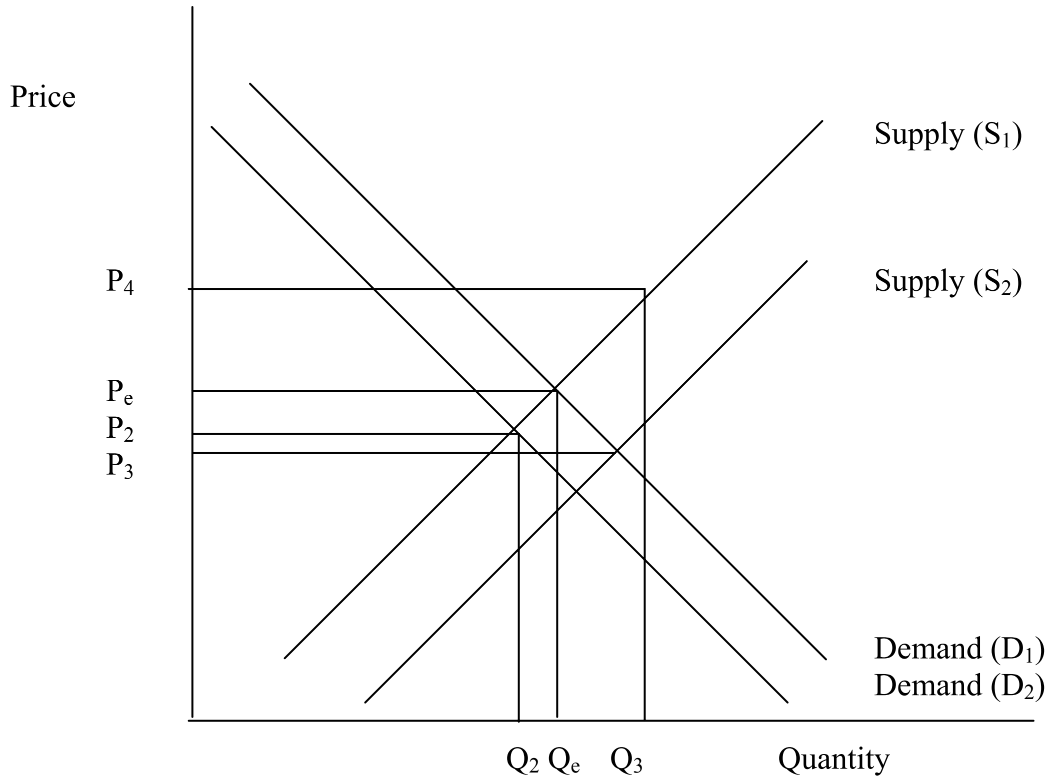


Figure 7. Simple Illustration of Market Price Determination.

What about something as innocuous as an increase in the California State excise tax on gasoline? Gasoline, one of the main products refined from crude, accounts for nearly 20 percent of the energy consumed in the U.S. (U.S. DOE, EIA 2001a). Gasoline is produced year-round, but there are seasonal production schedules to accommodate seasonal demands (e.g., high use during summer). Gasoline is delivered from oil refineries mainly through pipelines to a distribution chain serving approximately 180,000 retail stations in the U.S. What happens with the excise tax? Initially, it causes the supply schedule (S_2) to consumers to increase (S_1) (Figure 7). Retailers will supply the same quantity of gasoline (Q_3) as before the excise tax but only at a higher price (P_4); the price prior to the excise tax equaled P_3. Consumers, however, may not be willing to pay the higher price for the same quantity; the actual response by consumers will depend upon their demand elasticity, or how they change demand in response to a change in price. The final price and quantity levels will be determined by the equilibrium between the new supply schedule (S_1) and the old demand schedule (D_1). If demand is highly elastic, small changes in price induce large changes in the quantity demanded. If demand is inelastic, as has often been believed to characterize the demand for energy, small or large changes in price induce minimal zero changes in the quantity demanded. If we assume that demand is somewhat elastic, or at least it is not inelastic, the higher supply price by retailers will induce a reduction in the quantity demanded for gasoline (Qe) and a new equilibrium price (Pe) ((i.e., price level determined for the situation when quantity demanded equals quantity supplied). If retailers desired to increase their supply of gasoline to make up for the effects of the excise tax, they might have to obtain additional supplies from other geographic areas. They could subsequently bid up the domestic crude price and possibly even the world market price.

To better depict how prices are formed, consider that there are many consumers around the world and many different sectors associated with the energy industry. If we make the very simple assumptions that producers maximize profits conditional on their technology (the way in which inputs are used to produce, refine, store, or transport oil and gas products) and prices, we can envision some underlying profit function for each producer:

(1) Profit = $\Pi(P,W,Z)$

where Π represents some profit function, P represents the prices of all outputs for each producer, W represents the prices of all variable inputs for all producers, and Z represents all fixed inputs or variables believed to influence production of the firm, but which are generally beyond the control of the producer in the short-run (e.g., political structure). From a profit function (i.e., a function relating profits to input and output prices and other factors), we can deduce factor demands (e.g., the demand for labor) and output supplies (e.g., the supply of crude for a given producer):

(2) $X = F(P,W,Z)$

(3) $Y = G(P,W,Z)$

where X represents the producer demand for each factor, Y represents the supply schedule of each product produced by a producer, and F and G are input demand and output supply functions. There are N factors and M outputs, and thus, there are N factor demands and M output supplies.

We next consider the consumer. In theory, the consumer maximizes his/her personal utility subject to prices (PR) of all goods and services and income constraints (IN). This yields a demand schedule for the consumer, which expresses the demand for a given commodity (e.g., gasoline), Y, as function of prices and income

(4) $Y = H(Po,PR,IN)$

where Po is the price of the commodity demanded by the consumer, PR represents the prices of all other commodities purchased or desired by the consumer, and IN is the income level of the individual consumer. Demand could be modified to reflect additional factors influencing demand such as family constraints.

The price of oil or natural gas is unlikely to be affected by actions of any single producer or consumer. In the aggregate, however, small changes in consumer preferences, input prices, or events affecting large-scale production or consumption may drastically change the market price of crude and natural gas.

When OPEC nations or any other group of oil/gas producing nations act as one entity, they can influence crude oil prices and the price for natural gas; their influence on natural gas prices, however, is considerably less than is their influence on crude prices. More than 58 nations export crude and petroleum products to the United States (U.S. DOE, EIA 1999a); OPEC nations accounted for approximately 48 percent of all imports in 1999, and non-OPEC nations accounted for the remainder.

In terms of total exports of crude oil and petroleum products to the United States in 1999, Canada exported the largest quantity (561.8 million barrels); Venezuela was next with 544.8 million barrels; Saudi Arabia was third with 539.6 million barrels; and fourth was Mexico with 483.4 million barrels. The ranks of nations relative to exports of just crude oil to the United States is slightly different: (1) Saudi Arabia (506.3 million barrels); (2) Mexico (457.7 million barrels); (3) Canada (429.9 million barrels); and (4) Venezuela (419.9 million barrels). U.S. consumption has increasingly depended on imports. In 1980, net imports accounted for 37.3 percent of total consumption, and in 1999, net imports accounted for 49.6 percent of total domestic consumption (U.S. DOE, EIA 2001d). Events affecting supply or demand in any of the four nations, as well as Iraq, Nigeria, Angola, Colombia, and the United Kingdom could influence the domestic price of crude.

Since 1980, total imports of natural gas have increased from 984.8 to 3,585.5 billion cubic feet—an increase of 264.1 percent (U.S. DOE, EIA 2000b). Net imports (total imports minus exports) increased from 936.0 to 3,380.7 billion cubic feet or by 261.2 percent. In 1980, net imports accounted for 4.7 percent of the total U.S. consumption of natural gas; in 1999, they accounted for 15.8 percent. The United States imports natural gas from Canada, Mexico, Algeria, Australia, Malaysia, Qatar, Trinidad, and the United Arab Emirates. Canada has traditionally been the leading exporter of natural gas to the U.S. Events affecting the foreign supply or demand for imports or U.S. production and distribution could affect the domestic price of natural gas or crude.

3.2.2 Price and the Global Market

The price of crude oil is primarily established by the supply and demand conditions in the global market. The North American price of natural gas, however, is predominantly determined by demand and supply conditions in the United States. The U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA) in its report "Oil Market Basics" (1999e) indicates that the price of crude is primarily established by activities in the main refining centers of Singapore, Northwest Europe, and the U.S. Gulf Coast. There remains, however, considerable confusion about how prices of natural gas and crude are actually established.

A review of publications from the U.S. DOE, EIA, International Petroleum, and other sources suggests differences in opinion about which factors affect prices. The U.S. DOE, EIA (2000c), "A Primer on Gasoline Prices," states that crude oil prices are determined by worldwide supply and demand, and that OPEC has a major influence on crude prices. The Energy Economics Newsletter (WTRG 1998) states that prices are determined much like any other commodity relative to demand and supply conditions. They also state, however, that the U.S. industry's price has been heavily regulated through production or price controls throughout much of the 20th century. The Texas Railroad Commission in 1972 eliminated production quotas on the amount of oil that could be produced in Texas; the elimination of production quotas is believed to have shifted the dominant influence to control crude oil prices from the U.S. to OPEC. Hornsnell (2001) "Oil Markets and Prices" generalizes the notion that the Brent market generates a price for crude that is widely used by OPEC and other oil exporting countries. Then the oil markets for west Texas intermediate (WTI) crude in New York, Dubai in the Gulf (Middle East), and petroleum products in Rotterdam interact and determine a world price of oil. An article by two petroleum industry executives, "World Facing $50 Crude Oil," states that world and domestic price of oil is largely determined by the "spot" (i.e., cargo-by-cargo, transaction-by-transaction arrangements) market for oil (Anonymous 2000). The "spot price" is, by definition, the price for a one-time open market transaction for immediate delivery of a specific quantity of product at a specific location where the commodity is purchased "on the spot" at current market rates. The spot market best indicates the balance or imbalance between demand and supply. A rising spot price indicates excess demand and a declining spot price indicates excess supply.

The price of natural gas is determined by supply and demand. Natural gas, like oil, is injected into pipelines every day and makes its way to millions of U.S. consumers (U.S. DOE, EIA 1999b). The gas comes from domestic production, imports, or withdrawals from storage facilities. The price of natural gas, however, is considerably more seasonal than is the price of oil. During the summer months, supplies typically exceed demand and the excess is placed into storage facilities, which can be drawn against to supply the higher winter demand. During the winter, prices typically rise because of increased demand for heating and relatively tighter supplies. During the early 1980's, the well price of natural gas was generally viewed as being relatively stable. As a result of deregulation, it quickly went, however, from relative stability to highly volatile.[1] In 1979, price ceilings on natural gas began to be removed, and by 1993, natural gas was fully deregulated. As a consequence of the elimination of the price ceiling and deregulation, there has been more competition in the supply market. Many long-term contracts were replaced by more flexible arrangements. The enhanced competition generated a more dynamic system that can more quickly respond to changes in natural gas consumption or supplies.

It is also believed that the wellhead price is closely linked to the spot price at the market center in Henry, Louisiana (referred to as the Henry Hub) (U.S. DOE, EIA 1999b). Natural gas prices, however, are also affected by storage capability. If demand becomes sufficiently high so that domestic storage reserves or inventories are insufficient, supplies must be obtained through imports, and at usually higher prices. Alternatively, if demand is very low, which often occurs during years of very mild winters, inventories of natural gas accumulate and exert downward pressure on the wellhead price of natural gas.

There are, however, considerable differences in how oil and gas prices are determined. The price of crude appears to be mostly determined by worldwide activities, particularly OPEC. In contrast, natural gas prices are mostly determined by North American activities (IEA

[1] Price volatility describes the temporal rate of price fluctuations, and is measured by the day-to-day percentage difference in prices.

1999a). The United States has the largest gas market in the world. Prices and availability of substitute fuels, however, do affect the demand and price of natural gas, and therefore, global events affecting the demand or supply of petroleum can affect U.S. prices of natural gas. The U.S. produces approximately 84 percent of the natural gas consumed in the United States. In 1999, net imports (quantity imported less quantity exported) from Canada accounted for 15.4 percent of total U.S. consumption.

Market structure is the thing that makes the determination of gas prices different than that of oil. In the gas market, there is often more control or monopoly-like practices controlling the distribution or transportation of natural gas to the end user (IEA 1999a). Under this situation, it is easier for companies to establish prices that affect the final demand quantity. Moreover, the demand for natural gas is likely to be highly inelastic because it is difficult for many consumers to easily substitute other forms of energy. Natural gas suppliers may then affect prices by controlling supplies.

In considering how prices of natural gas are determined, it is important to distinguish between short- and long-run price determinations. At any given time, demand and supply determine the market price for natural gas, regardless of whether one is considering the base price in a long-term contract or the spot price. For the short run, there are several factors, which influence the wellhead demand and supply. Pipeline capacity is believed to have a significant influence because when the pipeline network is fully utilized, the market becomes disconnected and demand may not equal supply in some markets (e.g., pipeline capacity constraints between the East, West, and South have led to considerable differences in spot prices during periods of high winter demand). This imbalance may lead to changing spot prices and subsequently the wellhead price of natural gas.

In general, the short-run demand for natural gas at the wellhead is a function of the demand curve for gas in a given market. The short-run demand for natural gas in a given market is determined by the following factors (IEA 1999a): (1) seasonal heating load, which is related to weather; (2) seasonality of demand for gas in power generation, and the degree to which seasonal gas and electricity demand peaks coincide; (3) shipper demand for gas to place in storage, prevailing storage levels, and actual and expected price levels; and (4) capability of final users to switch to an alternative in a short amount of time.

The production policy of producers and the willingness of holders of gas in storage to release it to the market at different price levels determine the short-run supply curve. It is thought that the supply curve is very steep, or highly inelastic (i.e., a 1 percent change in quantity supplied requires more than a 1 percent change in price) because supply cannot be increased, regardless of the price level, as output reaches the maximum sustainable level. At very low levels of output, it is thought that the supply curve is relatively flat (highly elastic in which small changes in price induce larger percentage changes in supply) because producers will shut down wells rather than sell gas at very low prices. The willingness of producers to sell at different prices is believed to be largely a function of expected price movements and storage levels. In addition, interfuel competition (e.g., the use of oil, coal, or nuclear power rather than natural gas to generate electricity) substantially affects the price of natural gas, and subsequently, the supply of natural gas.

In the long run, wellhead (also referred to as border gas) prices should converge to the marginal cost of production at the wellhead for a given level of demand. This is regardless of the cost of competing fuels. Prices should be nearly equivalent to long-run marginal production costs. If productivity capacity is developed more rapidly than demand growth, however, natural gas prices at the wellhead will likely be lower than the long-run marginal production costs. Alternatively, a lack of investment in production capacity leads to prices that are higher than the long-run marginal costs; this occurred in the U.S. at the end of the 1970's. In turn, the long-run marginal production costs, which includes exploration, development, operation, and maintenance, are dependent upon four major factors: (1) the resource base [i.e., indigenous (domestic) or external (imports)]; (2) whether or not gas is jointly produced with oil and how revenues from one cover the various costs; (3) technology and technical progress; and (4) organizational efficiency and productivity. For example, advances in exploration, development, and offshore production technology, combined with organizational efficiencies increased the average reserve additions per exploratory well from about 9 billion cubic feet (bcf) in the mid-1980's to nearly 20 bcf by the mid-1990's, mostly associated with deepwater drilling in the Gulf of Mexico.

Economic growth, prices of substitute fuels, end-use technology, environmental constraints, and other factors determine the long-run demand, the other component that determines the long-run price. If we consider the various demand components for natural gas, it is possible to understand how the final user demand helps determine price. The final user signals a demand for natural gas. The medium or low-pressure distributor provides the gas by demanding gas from downstream storage, which in turn demands gas from the transmission system storage. The transmission system storage sector demands gas from the high-pressure transmission sector, which demands from the upstream storage. The upstream storage places demands on the producer of natural gas—the raw material producer at the well.

In a very simplistic framework, it is possible to illustrate how domestic and world prices of crude or natural gas are determined. With a world market, there is a corresponding world demand and a world supply (see Figure 8a). The world demand consists of domestic demand plus rest of world demand for oil; the world supply is determined by the domestic supply plus the supply of oil from the rest of the world. With trade, an equilibrium price of oil is established by the intersection of world demand and world supply (i.e., world price in Figure 8a). This international price is the world price of oil. In our simple example, we do not consider transport costs, which is a major reason why crude prices in the U.S. are different than crude prices in other nations.

To better understand the concept of exports, imports, and domestic prices, consider the demand and supply situation depicted in Figure 8b. On the right side of Figure 8b, the U.S. market for oil is depicted; the concept would be the same for natural gas. On the left side, demand and supply for the rest of the world is depicted (remember that the demand and supply curves for the rest of the world are reversed because increasing quantities are from right to left). The rest of the world can more cheaply produce oil; they produce a-x and demand b-x barrels of oil. Initially, the price of oil is higher in the United States than it is for the rest of the world (the price in the U.S. and the rest of the world is determined by the intersection of the world demand supply curves—Figure 8a). The rest of the world has a

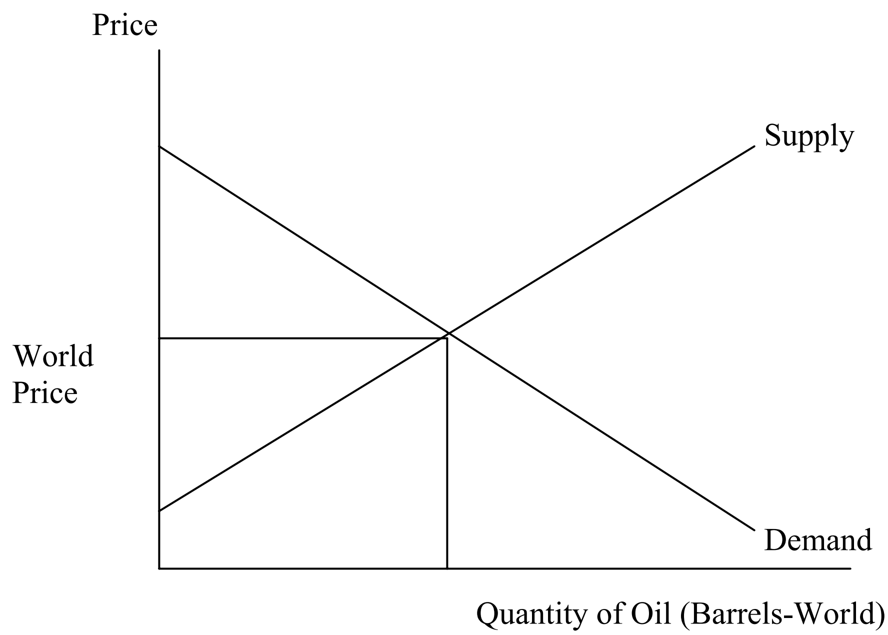


Figure 8a. World Demand, Supply, and Price.

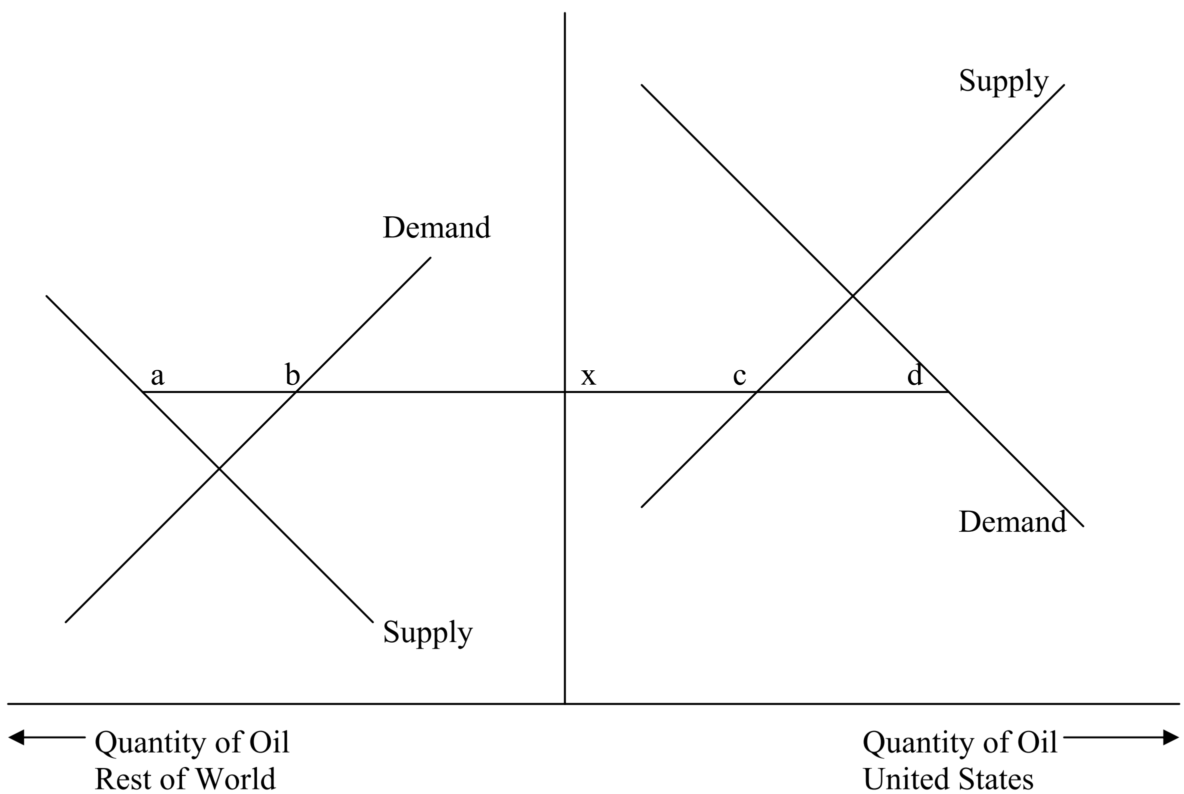


Figure 8b. Domestic and Foreign Demand for Oil.

surplus of a-b barrels of oil. The U.S. has excess demand equal to c-d. At some given price-quantity combination, the excess supply of the rest of the world will equal the excess demand by the United States (i.e., a-b will equal c-d). This equality determines the terms of trade and domestic and rest of world prices. Under the situation in Figure 8b, the initial price of oil in the U.S., prior to trade was higher than the price of oil after trade. For the rest of the world, exports of oil raised the price higher than it would have been in the absence of any trade or exports.

Figures 8a and 8b are, of course, extreme simplifications of how the domestic and world prices and quantities of oil, or natural gas, are established. Alternatively, events that affect the level of demand or supply response to changes in prices of major consuming or producing nations can also change the world and domestic prices. Changes in the level of demand or supply response to changes in price may be caused by shifts in demand; in this case, the demand curve shifts either out or in relative to its current position. If the demand shifts out, consumers demand the same quantity as originally demanded but at a higher price. A shifting out of demand can happen when the price of substitute forms of energy increase or consumers experience an increase in disposable income. An increase in consumer preferences may also shift the demand curve out and to the right. An inward shift in demand equates to demanding the same quantity at lower prices or a lower quantity at the same price. A reduction in disposable income can also shift the demand curve down and to the left of the original demand. Similarly, inward (up and to the left of the original supply curve) and outward (down and to the right of the original supply curve) shifts in supply may be caused by factors or events that affect costs. For example, the adoption of a new low cost technology could cause suppliers to offer a higher supply of petroleum products at lower prices. Consider, for example, the supply situation depicted in Figure 7. The original supply curve is S_2. Because of the excise tax, however, supply shifts up and to the left (S_1) of the original supply curve. The supply shift in Figure 7 represents a parallel shift. Shifts in either demand or supply, however, need not be parallel. There could be changes in the slope or price responsiveness of demand and supply. In this case, shifts in supply or demand would not be parallel to the original supply or demand curve. Events that typically affect the slope of the demand curve include changes in preferences, changes in habit, changes in uncertainty of income, and possibly changes in the price of substitute commodities. A major reason for a change the supply response to price (slope) is non-neutral technical change (i.e., technical change induces more or less use of one production factor, such as labor, than it does of other factors of production).

Concerned by the limited ability to explain changes in the domestic price of crude oil, the U.S. DOE, EIA initiated a 2001 Analysis Agenda to examine the relationship between crude oil prices and petroleum market fundamentals under the analysis theme “Energy Supply, Consumption and Price Developments” (U.S. DOE, EIA 2001b). Given the complexity of precisely determining how the prices of petroleum and natural gas are determined, the next two sections describe events believed to have affected or been partly responsible for changes in the domestic prices of crude and natural gas.

3.2.2.1 Major Factors Affecting Crude Prices

Understanding how events taking place between 1980 and 2000 affected oil prices requires knowledge of how some events prior to 1980 affected world-wide demand and supply conditions. Although many events in the 1950's and 1960's affected U.S. oil prices, the more significant events were the Korean War (1951-1953), the formation of the European Economic Community (EEC) in 1957, the 1958 U.S. recession, the imposition of import quotas by President Eisenhower in 1959, the formation of OPEC in 1960, discovery of oil in the North Slope in 1968 and 1969, and the ending of U.S. market control in March 1972, when the Texas Railroad Commission set proration at 100 percent for the first time. The setting of proration at 100 percent allowed Texas producers to produce the maximum of their well allowables. Relative to prices between 1980 and 2000, the formation of OPEC in 1960, the ending of U.S. market controls in 1971, and the various Middle East wars are thought to have had the largest impacts on U.S. and world oil prices (WTRG, 1998).

As stated earlier, OPEC was formed in 1960 with five member nations—Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela and by the end of 1971, had six new members—Qatar, Indonesia, Libya, United Arab Emirates, Algeria, and Nigeria. In the early 1970's, OPEC nations produced approximately 50 percent of the total world production of oil. In the mid-1980's, production by the OPEC nations dropped to slightly less than 30 percent. By 1995, their share of world production had increased to slightly more than 40 percent. In the 1960's, in terms of U.S. consumption of crude oil, OPEC nations accounted for a significant and generally growing share of U.S. oil supplies (Figure 9 and discussion in Section 3.2.3).

While the Texas Railroad Commission's action allowed Texas producers to produce to maximum well allowable levels, it also shifted the dominant influence to control crude oil prices from the United States (Texas, Oklahoma, and Louisiana) to OPEC (see Figure 10). This was particularly evident between 1973 and 1974 or the period of the Yom Kippur War, which started with an attack on Israel by Syria and Egypt on October 5, 1973. The U.S. and several other western world nations strongly supported Israel. The Arab exporting nations, however, imposed an embargo on the nations supporting Israel. In just 6 months, nominal crude prices increased 400 percent; by the end of 1974, however, they had declined. In 1979, the Iranian Revolution began after the 1978 Anti-Shah demonstrations and oil workers strike, and prices increased. The Iranian/Iraqi War began in 1980 and U.S. imports decreased and domestic prices increased. Between 1981 and 1988, OPEC or OPEC nations took several actions which either reduced prices (e.g., cutting the benchmark to $29 in 1982) or increased supplies (e.g., Saudi Arabia increased production by 44 percent in 1985). The Iranian/Iraqi War ended in 1988, and prices declined. (It should be noted that average world oil prices fell by over 50 percent in 1986.) In 1990, the Gulf War started and prices again increased. Two major OPEC and non-OPEC nations' actions appear to have serious ramifications for the current price of crude: (1) in 1998, OPEC pledged to cut production; and (2) in 1999, both OPEC and non-OPEC nations cut production; between 1999 and 2000, the nominal price increased 71.8 percent, and the real price increased 68.3 percent. Another event, which likely had significant ramifications for oil prices, was the windfall profits tax of 1980.

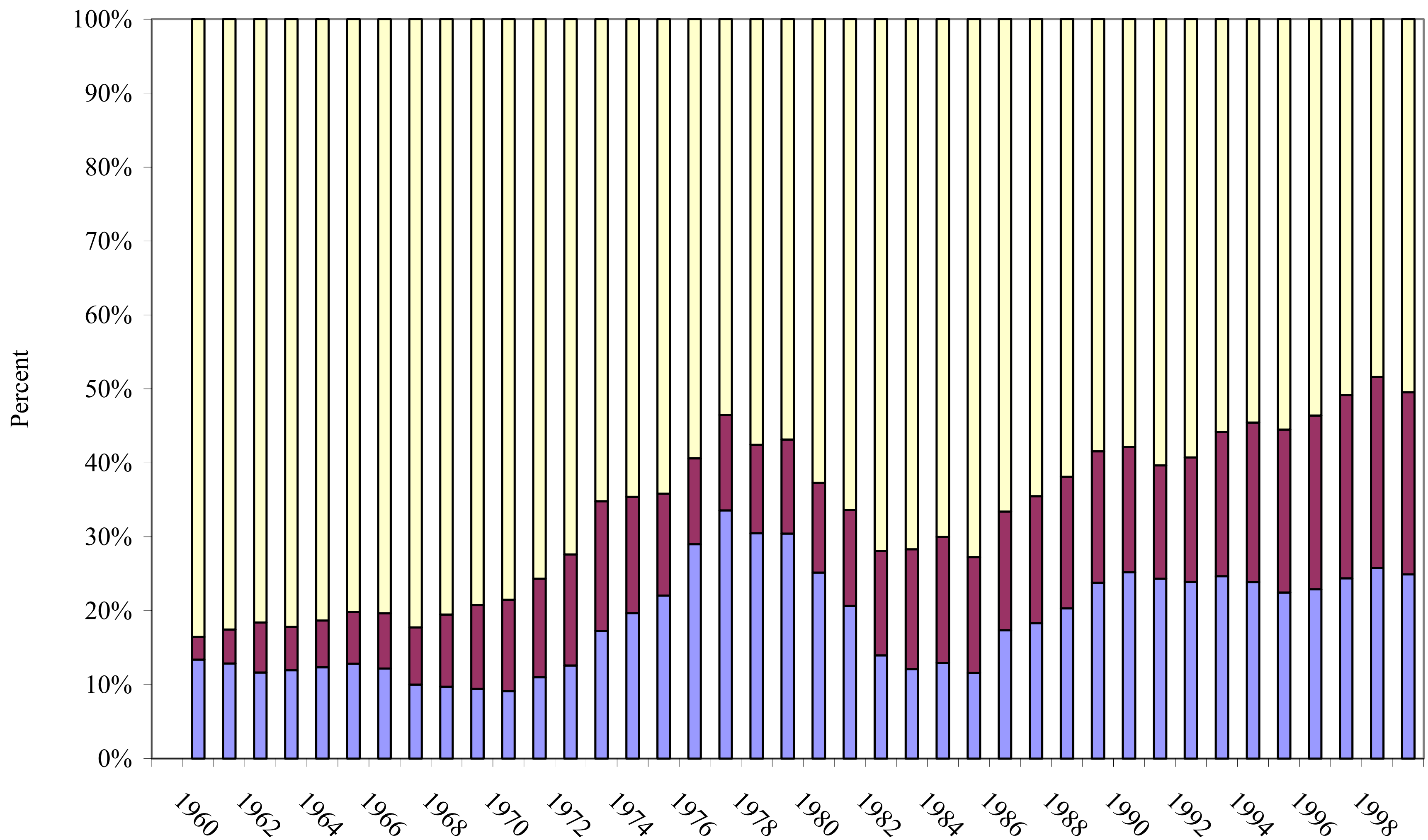


Figure 9. Percent of U.S. consumption supplied by OPEC and non-OPEC nations, 1960-1999.
Source: U.S. DOE, EIA 2000a.

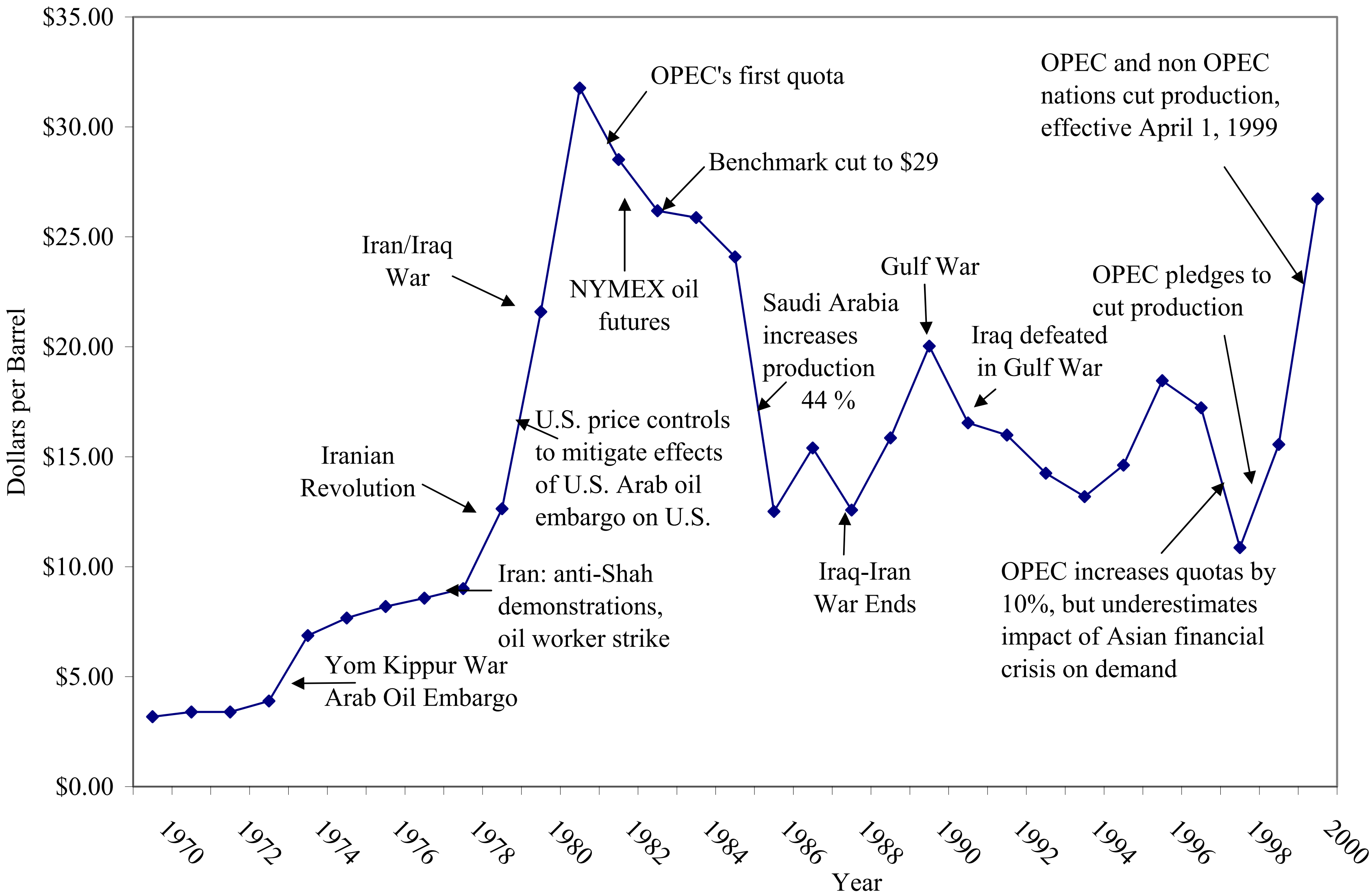


Figure 10. Nominal first purchase price, crude, 1970-2000.

Source: WTRG 1998.

3.2.2.2 Major Factors Affecting Natural Gas Prices

The price of natural gas is primarily influenced by factors affecting demand and supply in North America. Natural gas is the second major source of energy in the United States. It presently accounts for approximately 24.0 percent of all energy consumed in the United States, and equals 27.0 percent of all energy produced in the United States (U.S. DOE, EIA 2001c). The major user of natural gas is the industrial sector, which uses gas for plant operations, cogeneration of electric power, and as an industrial feedstock. Natural gas is also the largest source of energy for the residential sector. It is the fastest growing energy source for electricity.

In the past 20 years, numerous events have affected the domestic price of natural gas. Mariner-Volpe (2000) stated that the major drivers of the short-term prices of natural gas include weather, economic and business conditions, stock levels, pipeline capacity, operation difficulties, and lack of time and reliable information. There have been two other major factors--regulation and deregulation, particularly the various regulations either in place or subsequently imposed or removed between 1980 and 2000.

Prior to 1978, gas producers explored for and produced natural gas. These producers sold gas to pipeline companies. The pipeline companies transported gas across the nation, and then sold the gas to local distribution companies (LDCs). The LDCs (e.g., gas utilities) were responsible for selling gas to the end user. The federal government regulated the price at which producers could sell their gas to interstate pipeline companies. The price at which the pipelines could sell their gas to the LDCs was also regulated. State or local government agencies typically regulated end user prices.

In 1978, Congress passed the Power Plant and Industrial Fuel Use Act (PIFUA). This Act discouraged the use of natural gas in large industrial boilers and established pricing categories for wellhead gas production, which prevented the sending of competitive price signals to the marketplace. Prior to 1978, however, prices had been consistently rising; between 1973 and 1974, the wellhead price (in year 2000 constant dollars) increased by 25.1 percent. The rising price of natural gas, particularly between 1973 and 1978, was primarily in response to a growing demand for natural gas, which was spawned by fears of diminished supplies of petroleum (Hutzler 2000). Between 1976 and 1978, extremely cold weather is believed to have been responsible for a shortage of natural gas and, subsequently, rising gas prices. In the late 1970's, there was considerable concern by government that the shortages of 1976 through 1978 would continue into the future. In response, the Natural Gas Policy Act (NGPA) of 1978 was passed; the objective was to decontrol the wellhead price of natural gas. The NGPA placed wellhead price caps on several categories of natural gas. The NGPA, however, had escalation clauses to allow prices to rise to a level competitive with other fuels. The escalation clauses were developed believing that oil prices would continue to steeply increase in the future. As a consequence, price caps for the various categories of natural gas subject to the escalation clauses became considerably higher than the prevailing market price. As would be expected, the higher prices encouraged more exploration and development, and later, higher reserves of natural gas. Concurrently, the higher prices were decreasing the demand for natural gas. By the early 1980's, there was an excess of supply of natural gas—now often referred to as the gas bubble (IEA 1999b).

Examination of prices in Figure 11 suggests that changes in gas prices between the late 1970's and early 1980's closely followed regulatory change. Following the NGPA of 1978, the wellhead price increased nearly 20.0 percent. It continued to follow double-digit increases through 1982. In 1983, a spot market for natural gas developed, which allowed prices for the spot market to be below those for the contract market; between 1982 and 1983, the price of natural gas increased by only 1.26 percent. In 1984, the Federal Energy Regulatory Commission (FERC), the successor to the Federal Power Commission (FPC), issued orders that removed gas costs from minimum bills for consumers. The FERC in 1985 issued orders requiring that pipelines provide open access to transportation services; Order 436 was implemented in 1986. Between 1984 and 1985, the price declined 8.52 percent. From 1984 through 1986, the consumption of natural gas declined, particularly for the industrial sector, the largest domestic user of natural gas. Consumption by both the residential and commercial sectors also declined. From 1985 to 1986, the wellhead price (inflation adjusted) declined by 24.4 percent, which was the largest decline in price between 1949 and 2000. Order 500 in 1987 was implemented to address acute take-or-pay problems. In 1989, the FERC issued the Wellhead Decontrol Act, which specified the staged removal of all remaining controls on wellhead prices by the end of 1992. In 1992, the FERC issued Order 636 requiring interstate natural gas pipelines to unbundle products and services; the goal was to promote a competitive market for natural gas suppliers. In 1995, choice programs for residential customers were implemented.

Since 1978, the numbers of regulatory changes, which have affected wellhead prices and the market, have been quite substantial (see Table 4). The initial purpose of regulation during the late 1970's was to decrease reliance on natural gas and petroleum by promoting alternative sources of energy. At the same time, legislation, such as the Natural Gas Policy Act of 1978, was passed to deregulate the natural gas industry or to make it more competitive. From 1978 through 1983, the real wellhead price for natural gas steadily increased. After 1983, however, the wellhead price for natural gas began to decline. This was in part because of two factors: (1) there was a dramatic drop in world oil prices; and (2) FERC issued and implemented Order 436, respectively, in 1985 and 1986. Order 436 was the first of many actions to deregulate the natural gas industry. From 1987 through 1991, the real price of natural gas remained relatively constant. Following the Natural Gas Wellhead Decontrol Act of 1989, the Energy Policy Act (1992), Restructuring Act of 1992, which unbundled gas and related services, and other legislation and/or FERC Orders were implemented. Finally on January 1, 1993, all natural gas price controls were removed. Subsequent to these events, the wellhead price of natural gas has generally increased, but has also demonstrated great volatility.

From 1988 through 1994, the market for natural gas dramatically changed. The changes were the result of both economic pressures and governmental initiatives. Gas production increased by 10.0 percent, while the real wellhead price declined by 8.4 percent. Proven reserves declined by only 2.0 percent (Natural Gas Council 2001). The gas supplied to consumers increased by 16.0 percent and equaled the highest level of consumption since 1974. Most of the increase was driven by the increased use of natural gas for electricity generation by nonutility generators.

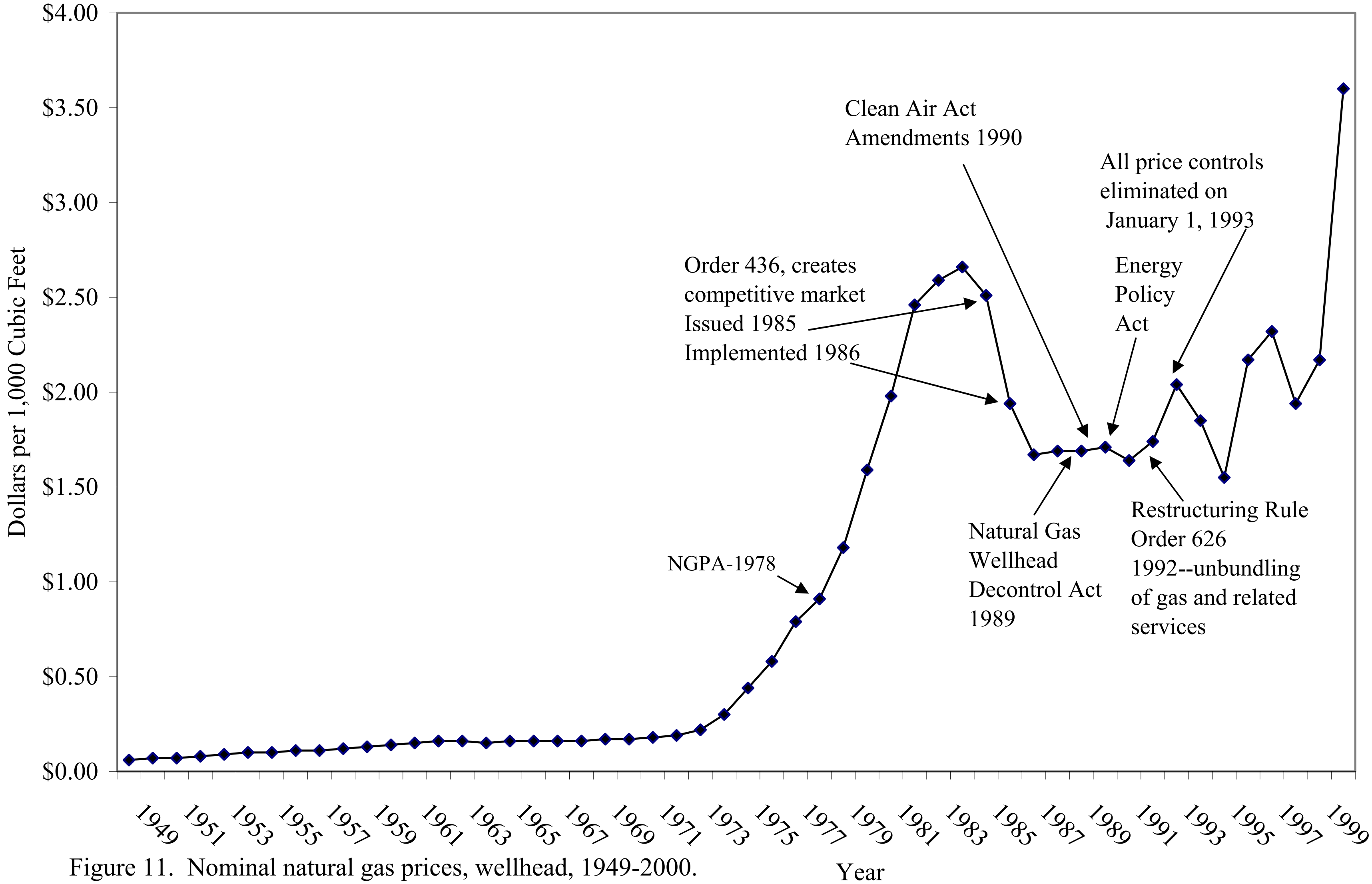


Figure 11. Nominal natural gas prices, wellhead, 1949-2000.

Source: U.S. DOE, EIA 2000b.

Table 4

FERC Orders and Other Legislation
Affecting the Wellhead Price of Natural Gas, 1980-2000

Year	**Order/Legislation**	**Action**
1978	Natural Gas Policy Act	Ends control over wellhead price of new gas
1978	Power Plant and Industrial Fuel Use Act	Discourages use of gas and oil, particularly in boilers
1985	FERC Order 436	Voluntary program to encourage gas pipelines to become open access carriers of natural gas
1987	Amendments to Fuel Use Act	Creates potential for additional use of gas
1987	National Appliance and Energy Conservation Act	
1987	FERC Order 500	Modified Order 426 to address pipeline companies' take or pay issues
1988	FERC Order 490	Allowed abandonment of first sales contracts and allowed pipeline bypass
1988	FERC Order 491	Interpreted Section 5 of the Outer Continental Shelf Lands Act to require that OCS pipeline companies offer both firm and interruptible transportation on a nondiscriminatory open-access basis
1988	FERC Order 493	Natural Gas Data Collection System—inquiry into alleged anticompetitive practices related to marketing affiliates of interstate pipeline companies
1988	FERC Order 493	Natural Gas Data Collection System—inquiry into alleged anticompetitive practices related to marketing affiliates of interstate pipeline companies
1989	Natural Gas Wellhead Decontrol Act	Eliminates all remaining wellhead price controls
1990's	Repeal of Power Plant/Fuel Use Act	
1990	Clean Air Act Amendments	
	Ozone Transport Rule	
1990/91	FERC Orders 528/528A	Caps recovery of take or pay costs through volumetric surcharges charged by pipeline companies
1992	FERC Order 636	Requires interstate gas pipelines to unbundle
1993	Omnibus Budget Reconciliation Act	
1994	North American Free Trade Agreement	
1995	First choice programs implemented	
1995	Outer Continental Shelf Deep Water Royalty Relief Act	
1997	Taxpayer Relief Act	
1997	Climate Change Action Plan	

Sources: AGA 1997a, IEA 1999a, Mariner-Volpe 2000, U.S. DOE, EIA 2000d.

Since 1995, the wellhead price for natural gas has generally increased, but dropped sharply from 1997 to 1998. Between 1999 and 2000, the wellhead price increased by 62.9 percent, the highest observed rate of increase between 1949 and 2000. To a great extent, the large increase, particularly between 1999 and 2000, was associated with lower storage levels of natural gas. Goldsmith (2001) suggests that industrial customers, rather than gas companies, were largely responsible for inadequate storage of natural gas, and the subsequent large increase in price. In 1998 and into early 1999, the price of natural gas collapsed. In response, producers of natural gas cut back production. By early 2000, inadequate supplies caused prices to escalate.

Other major factors, which influence the wellhead price of natural gas, include weather, storage and processing capacity, transportation, extraction and exploration costs, trading level on the spot market, overall demand, prices of competing fuels (primarily oil and coal), and competition between gas companies for supplies. The spot market developed in the early and mid-1980's, when many purchasers no longer desired long-term contracts, and natural gas supplies were quite high. On April 3, 1990 on the New York Mercantile Exchange (NYMEX), trading began for natural gas futures. The futures prices and natural gas spot market prices jointly influence each other, and subsequently, influence the wellhead price of natural gas.

In summary, the wellhead price of natural gas is predominantly determined by domestic demand and supply factors. In an evolutionary mode, the price has gone from being greatly influenced or actually established by federal and state regulations to being mostly influenced or determined in a relatively competitive market—demand and supply fully determine price. External factors that influence gas prices have mostly consisted of increasing oil prices, coupled with greater demand relative to supply of natural gas. It is too early to determine how the residential customer choice programs have affected the wellhead price of natural gas. By allowing customers to choose from whom they buy their natural gas, much like individuals select their long-distance telephone company, competition should increase; increased competition should reduce prices consumers pay to providers of natural gas, which in turn, should reduce wellhead prices. If consumers select non-utility suppliers of natural gas, however, it is possible that residential and wellhead prices will rise (AGA 1997b). Presently, the most important factor that determines the natural gas wellhead price is the competitive marketplace.

3.2.3 Demand and Supply

The fact that price is determined by demand and supply was discussed in previous sections. In this section, changes in demand and supply are described for years between 1980 and 2000. Although the focus of the report is on the extraction and related service industries, it is necessary to also discuss general patterns in consumption and supply. Changes in any given market level activity may influence production activities, the demand for petroleum and natural gas, and related prices.

3.2.3.1 Demand and Supply: Petroleum

During the 1960's, the United States produced 81.4 percent of its total petroleum need (see Table 5). OPEC provided 11.6 percent of the domestic need. Non-OPEC nations provided 7.0 percent. During the 1970's, the percent of consumption supplied by domestic production declined to 64.8 percent; the percent of consumption supplied by imports increased to 35.2 percent. U.S. share of consumption first fell below 70.0 percent in 1973. It was also in 1973, the year of the Arab Oil Embargo, that U.S. dependency on foreign oil increased to over 30.0 percent of total consumption. During the 1990's, U.S. producers of petroleum provided just over 50.0 percent (54.7 percent) of U.S. consumer needs. Starting in 1997, U.S. producers were supplying only about 50.0 percent of U.S. petroleum needs.

Table 5

Average Annual Percent of Domestic Consumption
Supplied by Domestic Production and Imports, 1960-1999

Period	Domestic	OPEC	Non-OPEC	All Imports
1960-1969	81.4	11.6	7.0	18.6
1970-1979	64.8	21.5	13.7	35.2
1980-1989	66.7	17.6	15.7	33.3
1990-1999	54.7	24.2	21.1	45.3

Source: U.S. DOE, EIA 2000a.

In the past 40 years, the United States has become increasingly dependent upon imports for petroleum. Up until 1981, OPEC nations routinely accounted for about 60.0 percent of all imports. In terms of petroleum products supplied to U.S. consumers, imports accounted for approximately 21.8 percent between 1949 and 1981; between 1982 and 1999, imports accounted for 39.8 percent of total petroleum products supplied to U.S. consumers. Between 1982 and 1988 and since 1993, non-OPEC nations accounted for more than 50.0 percent of total imports. Since 1996, Canada has become the leading non-OPEC exporter of petroleum to the United States. Although Saudi Arabia had traditionally been a major source of foreign supplies for petroleum and an OPEC nation, the United States presently imports more petroleum from Venezuela.

In 1980, the United States imported 6.91 million barrels of oil a day (see Figure 12). Approximately 4.3 million barrels were obtained from OPEC nations and 2.61 million barrels were obtained from non-OPEC nations. Saudi Arabia accounted for 1.3 million barrels of imports per day. Between 1981 and 1986, imports from Saudi Arabia and OPEC nations substantially declined. In 1985, OPEC nations provided 36.1 percent of total imports, and Saudi Arabia accounted for only 3.3 percent of total imports. Imports from the non-OPEC nations accounted for 63.9 percent of total imports. In 1999, petroleum products from foreign sources accounted for 49.6 percent of total domestic petroleum products supplied.

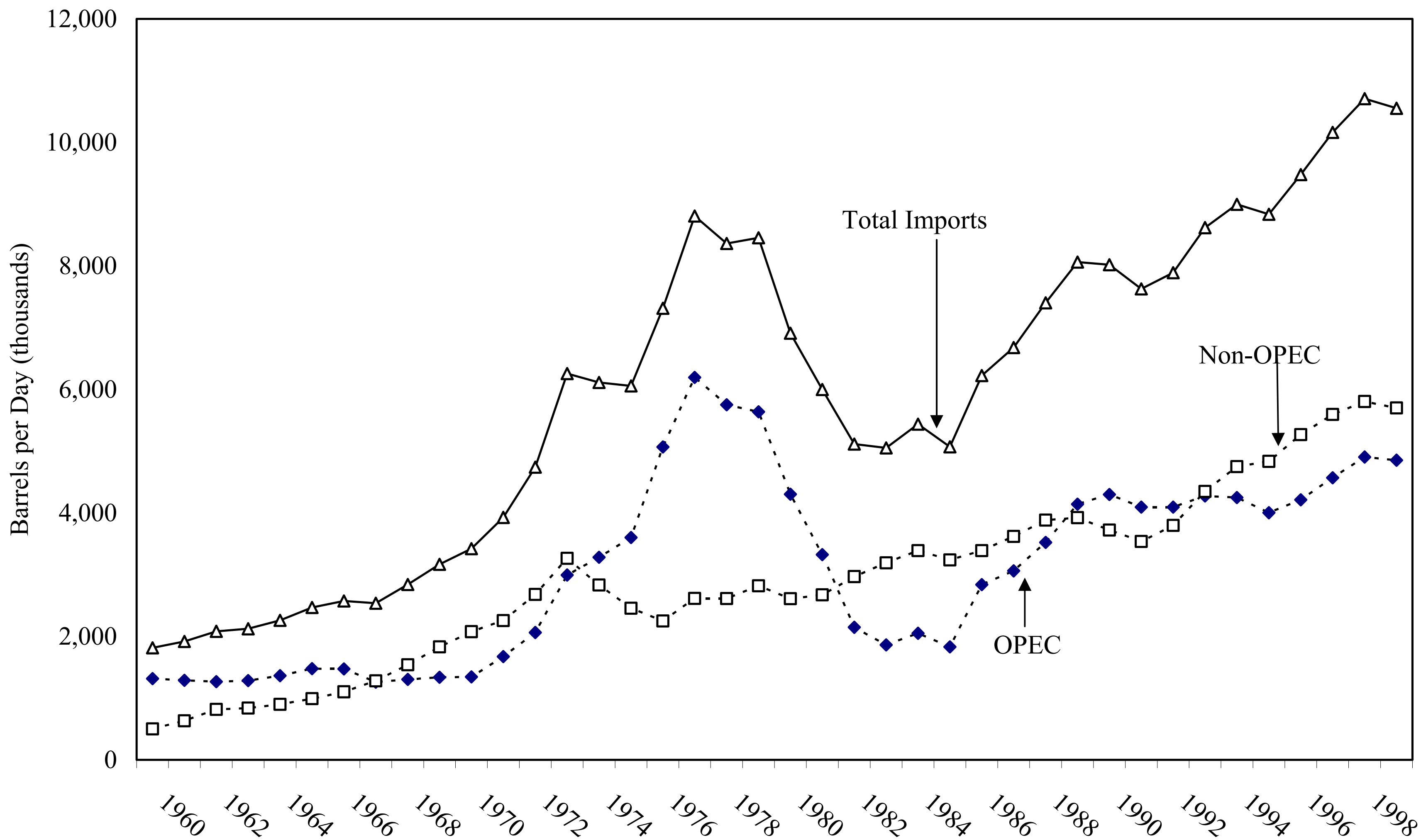


Figure 12. Petroleum imports, OPEC and non-OPEC, 1960-1999.

Source: U.S. DOE, EIA 2000a.

The U.S. DOE, EIA in its annual report (2000a) provides information indicating the percent of total domestic production from the OCS areas has steadily increased since 1954 (see Figure 13). In 1954, OCS production accounted for only 2.1 percent of total domestic production of crude. From 1967 on, OCS production accounted for double-digit shares of total production, and in 1997, accounted for as much as 25.5 percent of total production. Generally, onshore production has tended to decrease since 1985, while offshore production has increased (see Figure 14).

Examination of the potential relationship between OCS offshore production and wellhead prices does not indicate the expected economic relationship between output prices and commodity production (see Figure 15). As prices increase, production would normally be expected to increase. There is often, however, a long time between price signals and actual production. Even considering lags in how producers respond to prices, there is no apparent relationship between offshore OCS production and output prices. For example, prices were increasing between 1978 and 1981 and OCS production was decreasing. Between 1981 and 1984, the real wellhead price decreased by 28.9 percent; OCS production increased by 24.1 percent.[2] From 1990 through 1999, the wellhead price generally decreased, and OCS production dramatically increased in part because of the opening of deepwater production and the impact of technology. There is, however, a more pronounced relationship between total domestic production and wellhead prices between 1985 and 1999[3]. In general, as wellhead prices decline, so does the total domestic production.

The United States is the largest oil consuming and oil importing country in the world; it ranks second, after Saudi Arabia, in the production of oil (IEA 1999a). Between 1949 and 1999, total U.S. energy consumption, from all sources, increased from 32 quadrillion British thermal units (Btu) to nearly 97 quadrillion Btu. Petroleum has accounted for an average 40.1 percent of total domestic consumption of energy. Natural gas has accounted for 20.6 percent of total consumption. Electricity generated from oil, gas, coal, non hydro-renewables, nuclear, and hydroelectric sources has accounted for an average of 7.7 percent of total energy needs (U.S. DOE, EIA 2000a).

Petroleum’s share of total domestic energy needs was nearly the same in 1999 as it was in 1949 (38.0 percent in 1999 vs. 35.8 percent in 1949). From 1954 to 1980, however, petroleum’s share of domestic energy consumption regulatory exceeded 40.0 percent each year; the annual share varied between 40.3 in 1980 and 43.3 in 1958. Since 1980, petroleum’s share of total annual domestic energy needs has been less than 40.0 percent.

Of the four major sources of energy (i.e., coal, natural gas, petroleum, and electricity) only per capita consumption of coal has declined. Between 1949 and 1999, the average annual per capita consumption of natural gas, petroleum, and electricity increased, respectively, 1.7, 1.5, and 12.3 percent. Petroleum consumption exhibited the lowest rate of increase in per capita utilization. Relative to the years between 1950 and 1979, the per capita consumption of petroleum has been declining. Per capita consumption declined from 1980 through 1995;

---

[2] Areawide leasing, which relies on oil company geological assessments for tracts offered, began in May 1983.
[3] This period was post areawide leasing.

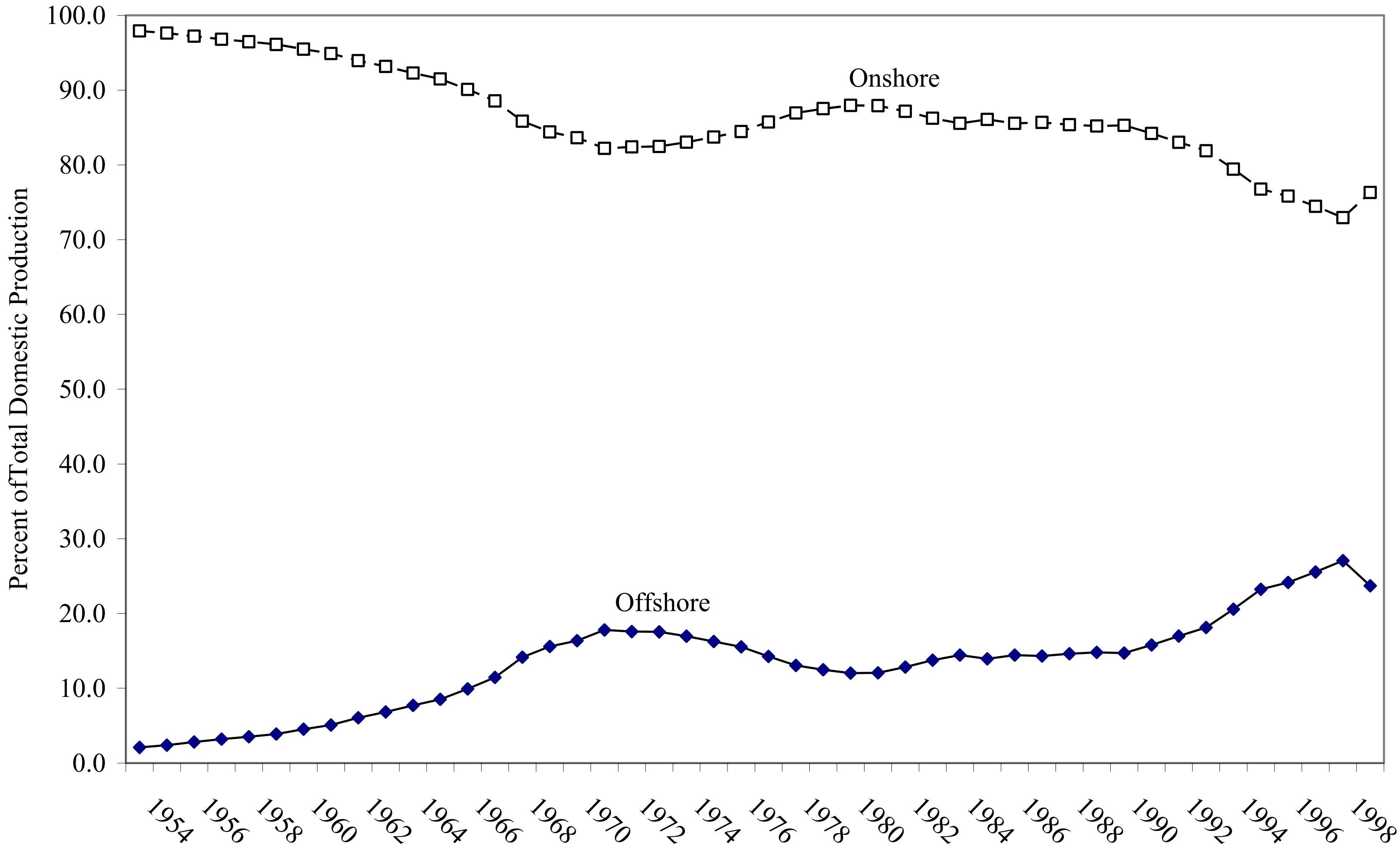


Figure 13. Percent of crude oil production by onshore and offshore operations, 1954-1999.

Source: U.S. DOE, EIA 2000a.

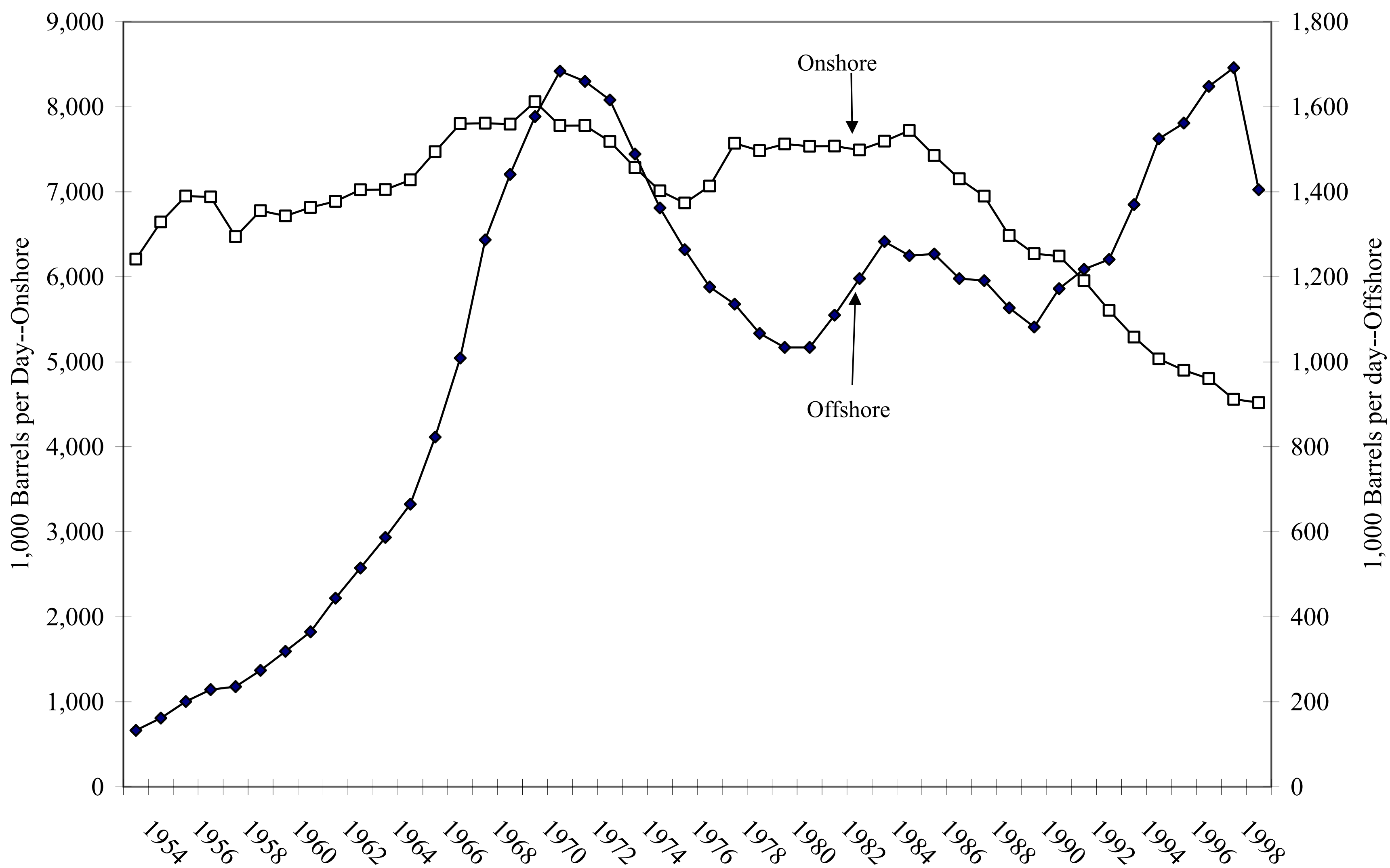


Figure 14. Onshore and federal offshore petroleum production, 1954-1999.

Source: U.S. DOE, EIA 2000a.

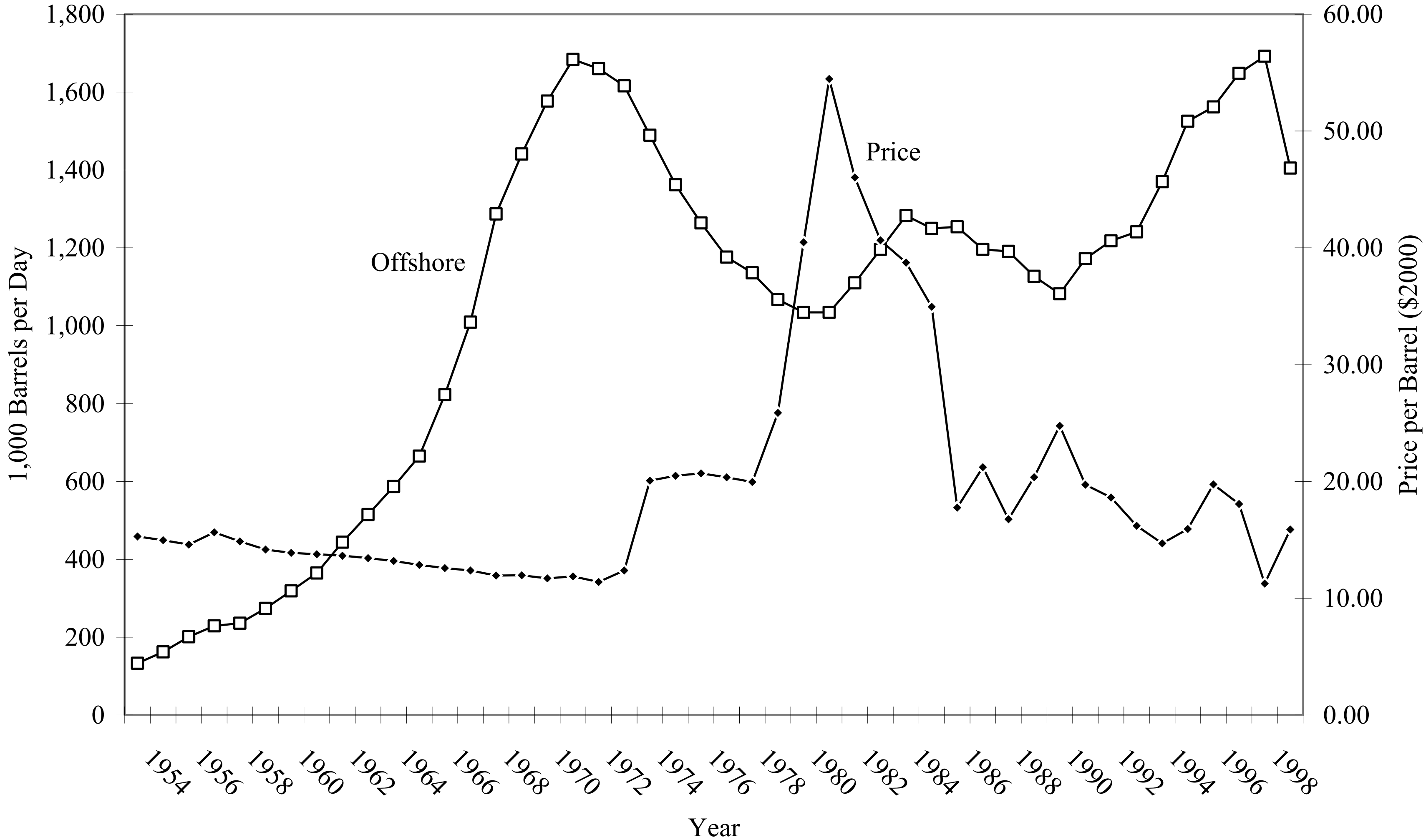


Figure 15. Offshore (OCS) production and wellhead prices, 1954-1999.

Source: U.S. DOE, EIA 2000a.

from 1996 forward in time, however, the annual per capita consumption has marginally increased—from 132.1 million Btu's to 134.7 million Btu's.

In general, there are three major energy-using sectors: (1) residential and commercial, (2) industrial, and (3) transportation. In terms of total energy consumed in America, the industrial sector has traditionally had the highest consumption; residential and commercial users ranked second in consumption; and the transportation sector ranks third. Relative to petroleum, the transportation sector is the largest consumer; the industrial sector is second; residential and commercial users rank third in terms of consumption (see Figure 16). While total petroleum usage has dramatically increased since 1949, its use in the residential and commercial and industrial sectors has generally declined since 1980. Between 1980 and 1999, petroleum usage by the residential and commercial sector declined from 3.04 quadrillion Btu's to 2.08 quadrillion Btu's. In the industrial sector, usage declined from 9.53 to 9.46 quadrillion Btu's, but usage was also well below 9.0 quadrillion Btu's between 1981 and 1995. Usage of petroleum by the transportation sector, however, has continued to increase. Between 1980 and 1999, usage of petroleum by the transportation sector increased by 31.6 percent.

The major petroleum-based commodity is, of course, gasoline (see Table 6). Motor gasoline accounts for approximately 40.0 percent of total domestic petroleum use. Distillate fuel oil and jet fuel account for approximately 25.0 percent of total domestic petroleum use. Residential fuel oil, which historically accounted for 14.0 or more percent of total petroleum usage, substantially declined in usage between the late 1960's and the 1990's. Between 1969 and 1982, residual fuel oil typically accounted for between 11.0 and 17.0 percent of total petroleum usage. During the 1980's, the residential fuel oil share of total petroleum usage declined to between 7.0 and 9.0 percent; by the late 1990's, residential fuel oil accounted for less than 5.0 percent of total petroleum usage. Between 1980 and 1999, each product's share of total petroleum usage changed as follows: (1) asphalt and road oil—21.4 percent; (2) distillate fuel oil—8.9 percent; (3) jet fuel—37.3 percent; (4) liquefied petroleum gas—30.4 percent; (5) motor gasoline—12.1 percent; (6) residential fuel oil—(-70.9 percent); and (7) other products—(-9.2 percent).

3.2.3.2 Demand and Supply: Natural Gas

Between 1949 and 1999, America's consumption of energy tripled, increasing from 32.0 to 96.6 quadrillion BTUs or by approximately 4.0 percent per year. Between 1949 and 1999, domestic consumption of petroleum energy increased 220.3 percent or at an annual rate of 4.4 percent. In contrast, domestic consumption of natural gas-based energy increased 298.5 percent or at an annual rate of nearly 6.0 percent per year. Since 1980, consumption of energy increased by 23.2 percent or by only 1.2 percent per year. Since 1980, the consumption of petroleum-based energy has increased 16.3 percent, while the consumption of natural gas-based energy increased 14.6 percent. When examined together, the overall trend in consumption is quite similar for the two sources of energy (see Figure 17).

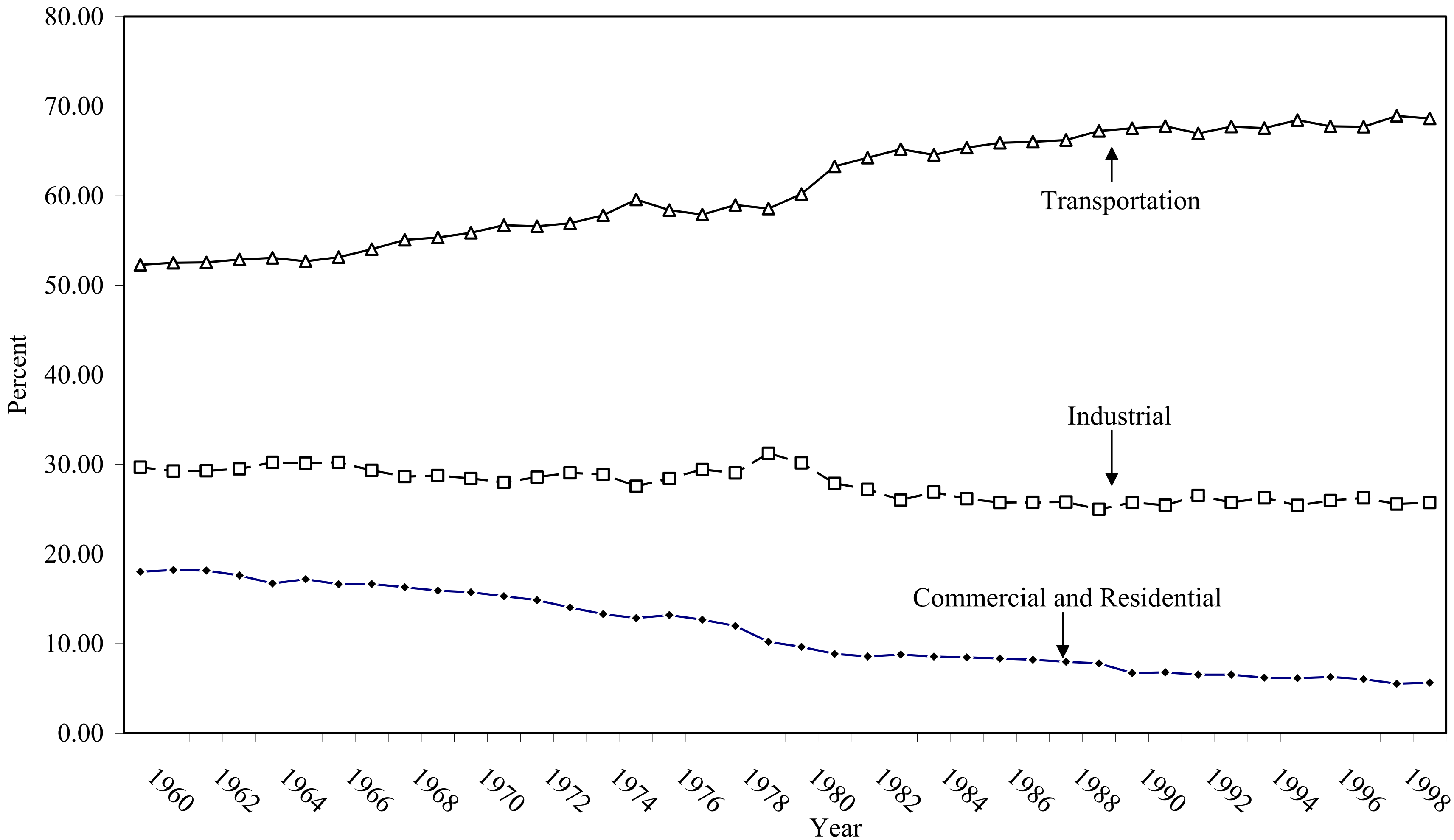


Figure 16. Share of petroleum consumption by end-use sector, 1960-1999.

Source: U.S. DOE, EIA 2000a.

Table 6

Share of Total Petroleum Usage by Products Used in America, 1969-1999

Year	Asphalt and Road Oil	Distillate Fuel Oil	Jet Fuel	Liquefied Petroleum Gases		Motor Gasoline	Residual Fuel Oil	Other Products	Total Products
				Propane	Total				
1969	2.97	17.47	7.00	5.52	8.63	39.11	14.00	10.89	100.00
1970	3.06	17.28	6.60	5.31	8.30	39.32	14.97	10.41	100.00
1971	3.02	17.49	6.64	5.19	8.22	39.51	15.12	9.99	100.00
1972	2.87	17.78	6.41	5.44	8.67	38.97	15.46	9.90	100.00
1973	3.00	17.85	6.12	5.03	8.38	38.53	16.29	9.76	100.00
1974	2.88	17.72	5.95	4.98	8.47	39.28	15.86	9.91	100.00
1975	2.57	17.46	6.13	4.78	8.15	40.87	15.07	9.68	100.00
1976	2.35	17.93	5.67	4.75	8.02	39.98	16.04	10.02	100.00
1977	2.39	18.18	5.64	4.45	7.70	38.96	16.66	10.53	100.00
1978	2.55	18.20	5.62	4.14	7.48	39.31	16.02	10.77	100.00
1979	2.59	17.88	5.83	4.59	8.59	37.98	15.29	11.89	100.00
1980	2.34	16.82	6.27	4.40	8.62	38.57	14.71	12.72	100.00
1981	2.12	17.62	6.29	4.79	9.15	41.03	13.01	10.83	100.00
1982	2.22	17.45	6.60	5.23	9.80	42.75	11.24	9.87	100.00
1983	2.43	17.66	6.89	4.92	9.91	43.47	9.32	10.31	100.00
1984	2.61	18.05	7.50	5.28	9.98	42.53	8.71	10.55	100.00
1985	2.73	18.25	7.76	5.59	10.17	43.42	7.63	10.04	100.00
1986	2.76	17.87	8.05	5.10	9.28	43.18	8.72	10.14	100.00
1987	2.82	17.88	8.28	5.52	9.66	43.25	7.56	10.56	100.00
1988	2.72	18.06	8.39	5.32	9.61	42.48	7.99	10.82	100.00
1989	2.60	18.23	8.60	5.71	9.64	42.30	7.91	10.73	100.00
1990	2.83	17.78	8.95	5.41	9.18	42.55	7.24	11.42	100.00
1991	2.63	17.47	8.80	5.86	10.11	43.03	6.94	11.01	100.00
1992	2.64	17.50	8.51	6.05	10.33	42.69	6.40	11.92	100.00
1993	2.73	17.63	8.53	5.86	10.03	43.39	6.26	11.37	100.00
1994	2.71	17.83	8.63	6.09	10.61	42.89	5.76	11.51	100.00
1995	2.77	18.12	8.52	6.21	10.72	43.96	4.80	11.17	100.00
1996	2.62	18.41	8.63	6.23	10.98	43.09	4.64	11.63	100.00
1997	2.74	18.47	8.59	6.28	10.96	43.07	4.30	11.98	100.00
1998	2.75	18.29	8.56	5.92	10.31	43.60	4.70	11.73	100.00
1999	2.84	18.31	8.61	6.45	11.24	43.22	4.28	11.55	100.00

Source: U.S. DOE, EIA 2000a.

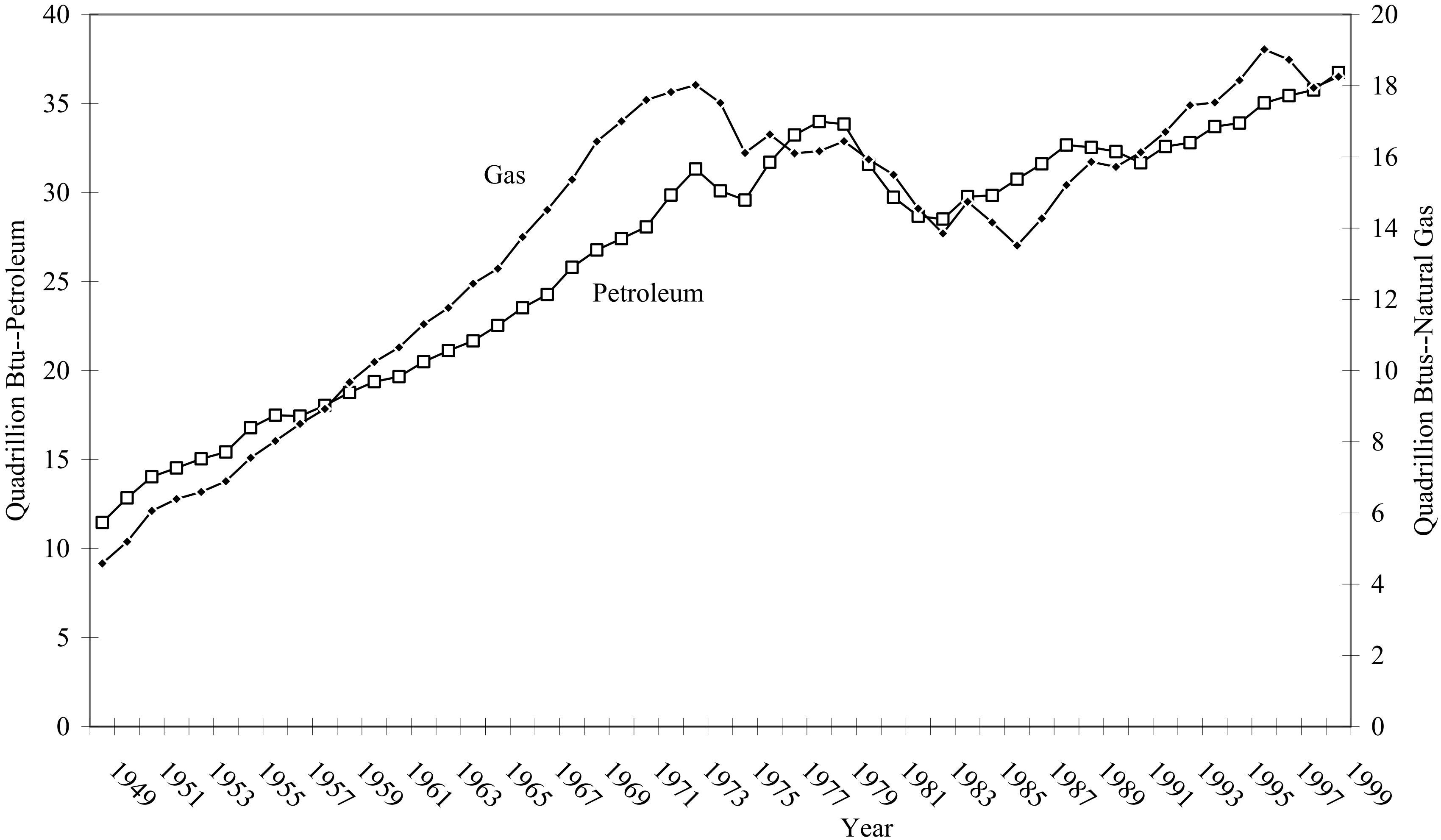


Figure 17. Consumption of petroleum and natural gas, 1949-1999.

Source: U.S. DOE, EIA 2000a.

Prior to 1952, America produced enough natural gas to satisfy all of the domestic demand (see Table 7). Starting in 1952, the United States began to import natural gas. Initially, the quantities of natural gas imported into the U.S. were extremely small, typically less than 0.01 trillion cubic feet (tcf). Between 1952 and 1957, the U.S. had a positive balance of trade in the quantity of natural gas; the U.S. exported more than it imported. It was not until 1972 that the U.S. started importing more than 1.0 trillion cubic feet of natural gas. Since 1949, the supply of natural gas available for domestic consumption has generally increased. There have been periods, however, when the supply of natural gas decreased; this was most notable between 1979 and 1988 when the supply of natural gas available for domestic consumption decreased by 18.3 percent.

To date, the largest exporting nation of natural gas to the United States has been Canada (see Table 8). Imports from Canada dramatically increased in the late 1980's, and remained relatively high through 1999. Moreover, it was in 1999 that Canada completed the Maritimes and Northeast Pipeline. This pipeline established a direct link between the Sable Offshore Energy Project (SOEP) and New England markets (U.S. DOE, EIA 2000b). The Energy Information Administration reports imports from Algeria, Australia, Canada, Indonesia, Mexico, and the United Arab Emirates. Starting in 1999, the EIA also reports imports from Malaysia, Qatar, and Trinidad and Tobago. Although the U.S. has imported natural gas since 1952, the U.S. dependency on foreign suppliers did not exceed 5.0 percent until 1983. From 1983 through 1999, the percent of U.S. consumption provided by imports increased from 5.1 percent to 15.8 percent. In quantity terms, imports increased by 293.2 percent between 1983 and 1999.

Natural gas supplies provided from federal offshore (OCS) withdrawals have traditionally been dwarfed by onshore production. From 1960 through 1965, less than 1.0 trillion cubic feet of natural gas came from offshore production (see Figure 18). Between 1960 and 1999, however, OCS offshore withdrawals increased 1,848.1 percent or at an annual rate of 47.4 percent. Prior to 1970, withdrawals from offshore areas were less than 10.0 percent a year. In 1970, withdrawals from the OCS areas equaled slightly more than 10.0 percent of total U.S. withdrawals. In 1978, OCS withdrawals equaled 20.5 percent of total withdrawals. Since 1978, the percentage of total withdrawals from both onshore and offshore sources has remained relative constant–approximately 78.0 and 21.0 percent, respectively. Concurrently, while the percent of withdrawal has remained relatively constant from both sources, the quantity withdrawn has not (see Figure 19). Between 1960 and 1970, the level of withdrawal from both sources increased. After 1970, however, the level of withdrawal from the onshore sources substantially declined; at the same time, however, the withdrawal rate from offshore sources continued to increase, and did so until 1981. Between 1981 and 1983, there was a very moderate decrease in the quantity withdrawn from offshore sources. Since 1985, there has been a small, but generally increasing, trend in the annual rate of withdrawal from both onshore and offshore sources.

There are some emerging concerns, however, about natural gas, as well as petroleum, production on the U.S. Gulf of Mexico shelf (Dodson 2001). Natural gas production in the OCS areas of the U.S. Gulf of Mexico is in a state of decline. Annual gas production on the shelf and in less than 1,000 feet of water reached its highest level in 1981 (4.75 tcf). After

Percent of Consumption Supplied by Imports, 1952-1999

Year	Algeria	Australia	Canada	Indonesia	Mexico	United Arab Emirates	Percent of U.S. Consumption
1952	0.00	0.00	0.11	0.00	0.00	0.00	-0.27
1953	0.00	0.00	0.12	0.00	0.00	0.00	-0.25
1954	0.00	0.00	0.09	0.00	0.00	0.00	-0.27
1955	0.00	0.00	0.13	0.00	0.00	0.00	-0.23
1956	0.00	0.00	0.11	0.00	0.00	0.00	-0.28
1957	0.00	0.00	0.21	0.00	0.17	0.00	-0.04
1958	0.00	0.00	0.87	0.00	0.45	0.00	0.94
1959	0.00	0.00	0.73	0.00	0.45	0.00	1.02
1960	0.00	0.00	0.91	0.00	0.39	0.00	1.20
1961	0.00	0.00	1.34	0.00	0.42	0.00	1.67
1962	0.00	0.00	2.64	0.00	0.38	0.00	2.91
1963	0.00	0.00	2.55	0.00	0.36	0.00	2.78
1964	0.00	0.00	2.64	0.00	0.36	0.00	2.86
1965	0.00	0.00	2.65	0.00	0.34	0.00	2.81
1966	0.00	0.00	2.61	0.00	0.30	0.00	2.77
1967	0.00	0.00	2.95	0.00	0.29	0.00	2.78
1968	0.00	0.00	3.24	0.00	0.25	0.00	3.00
1969	0.00	0.00	3.39	0.00	0.23	0.00	3.37
1970	0.00	0.00	3.68	0.00	0.19	0.00	3.55
1971	0.00	0.00	4.19	0.00	0.10	0.00	3.92
1972	0.01	0.00	4.57	0.00	0.04	0.00	4.26
1973	0.01	0.00	4.66	0.00	0.01	0.00	4.34
1974	0.00	0.00	4.52	0.00	0.00	0.00	4.16
1975	0.03	0.00	4.85	0.00	0.00	0.00	4.50
1976	0.05	0.00	4.78	0.00	0.00	0.00	4.51
1977	0.06	0.00	5.11	0.00	0.01	0.00	4.89
1978	0.43	0.00	4.49	0.00	0.00	0.00	4.65
1979	1.25	0.00	4.95	0.00	0.00	0.00	5.92
1980	0.43	0.00	4.01	0.00	0.51	0.00	4.71
1981	0.19	0.00	3.93	0.00	0.54	0.00	4.36
1982	0.31	0.00	4.35	0.00	0.53	0.00	4.90
1983	0.78	0.00	4.23	0.00	0.45	0.00	5.13
1984	0.20	0.00	4.21	0.00	0.29	0.00	4.39
1985	0.14	0.00	5.36	0.00	0.00	0.00	5.17
1986	0.00	0.00	4.62	0.01	0.00	0.00	4.25
1987	0.00	0.00	5.77	0.00	0.00	0.00	5.46
1988	0.09	0.00	7.08	0.00	0.00	0.00	6.77
1989	0.22	0.00	7.12	0.00	0.00	0.00	6.78
1990	0.45	0.00	7.74	0.00	0.00	0.00	7.73
1991	0.34	0.00	8.98	0.00	0.00	0.00	8.63
1992	0.22	0.00	10.72	0.00	0.00	0.00	9.83
1993	0.40	0.00	11.18	0.00	0.01	0.00	10.90
1994	0.25	0.00	12.39	0.00	0.03	0.00	11.89
1995	0.08	0.00	13.05	0.00	0.03	0.00	12.45
1996	0.16	0.00	13.12	0.00	0.06	0.02	12.67
1997	0.30	0.05	13.20	0.00	0.08	0.01	12.92
1998	0.32	0.06	14.36	0.00	0.07	0.02	14.08
1999	0.35	0.06	15.59	0.00	0.26	0.01	15.85

Source: U.S. DOE, EIA 2000a.

Table 8

Imports of Natural Gas, by Nation and Year, 1952-1999 (billion cubic feet)

Year	Algeria	Australia	Canada	Indonesia	Mexico	United Arab Emirates
1952	0	0	8	0	0	0
1953	0	0	9	0	0	0
1954	0	0	7	0	0	0
1955	0	0	11	0	0	0
1956	0	0	10	0	0	0
1957	0	0	21	0	17	0
1958	0	0	90	0	46	0
1959	0	0	83	0	51	0
1960	0	0	109	0	47	0
1961	0	0	167	0	52	0
1962	0	0	350	0	51	0
1963	0	0	356	0	50	0
1964	0	0	391	0	53	0
1965	0	0	405	0	52	0
1966	0	0	430	0	50	0
1967	0	0	513	0	51	0
1968	0	0	604	0	47	0
1969	0	0	680	0	47	0
1970	1	0	779	0	41	0
1971	1	0	912	0	21	0
1972	2	0	1,009	0	8	0
1973	3	0	1,028	0	2	0
1974	0	0	959	0	0	0
1975	5	0	948	0	0	0
1976	10	0	954	0	0	0
1977	11	0	997	0	2	0
1978	84	0	881	0	0	0
1979	253	0	1,001	0	0	0
1980	86	0	797	0	102	0
1981	37	0	762	0	105	0
1982	55	0	783	0	95	0
1983	131	0	712	0	75	0
1984	36	0	755	0	52	0
1985	24	0	926	0	0	0
1986	0	0	749	2	0	0
1987	0	0	993	0	0	0
1988	17	0	1,276	0	0	0
1989	42	0	1,339	0	0	0
1990	84	0	1,448	0	0	0
1991	64	0	1,710	0	0	0
1992	43	0	2,094	0	0	0
1993	82	0	2,267	0	2	0
1994	51	0	2,566	0	7	0
1995	18	0	2,816	0	7	0
1996	35	0	2,883	0	14	5
1997	66	10	2,899	0	17	2
1998	69	12	3,052	0	15	5
1999	75	12	3,340	0	55	3

Source: U.S. DOE, EIA 2000a.

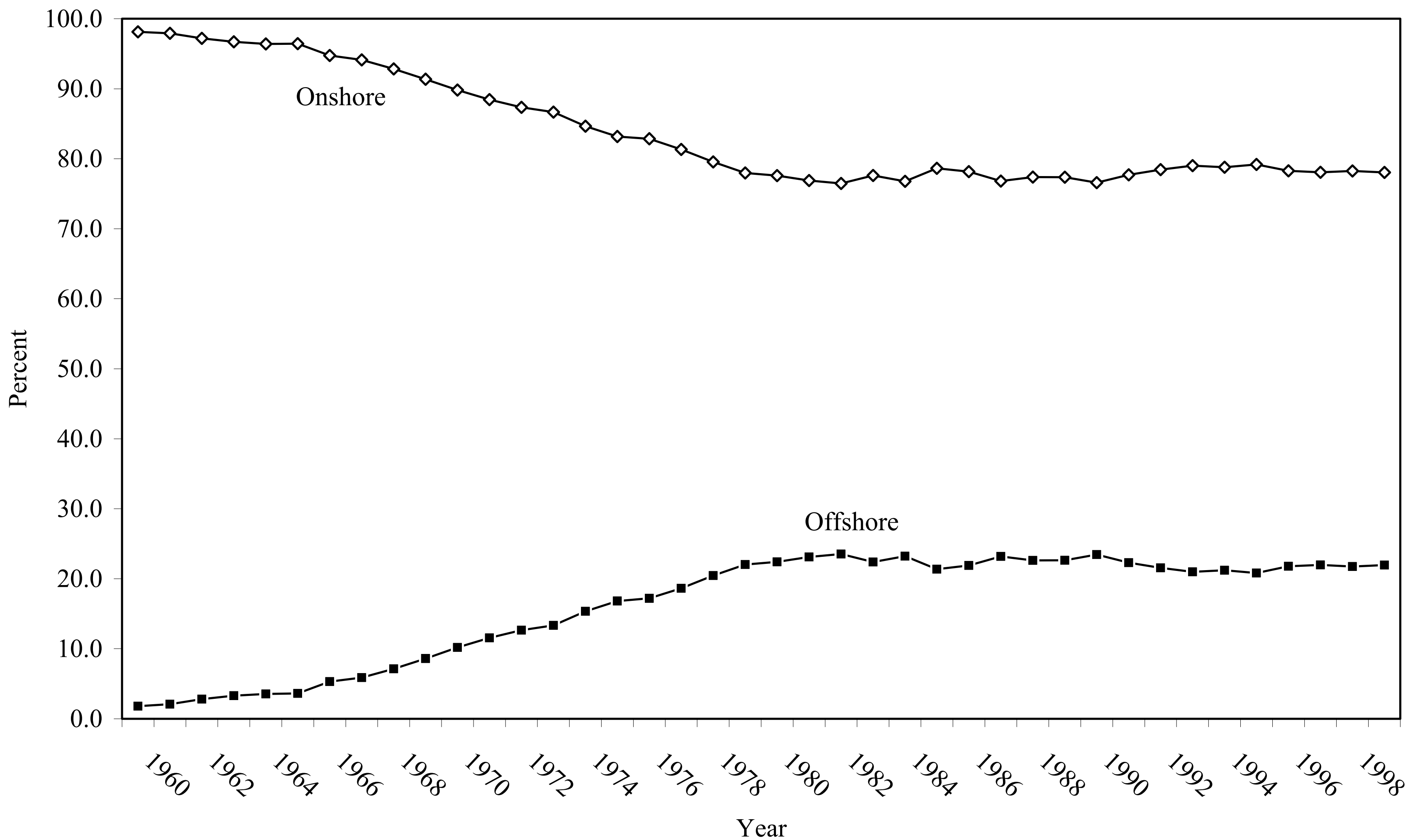


Figure 18. Percent of total natural gas withdrawals by location, 1960-1999.

Source: U.S. DOE, EIA 2000a.

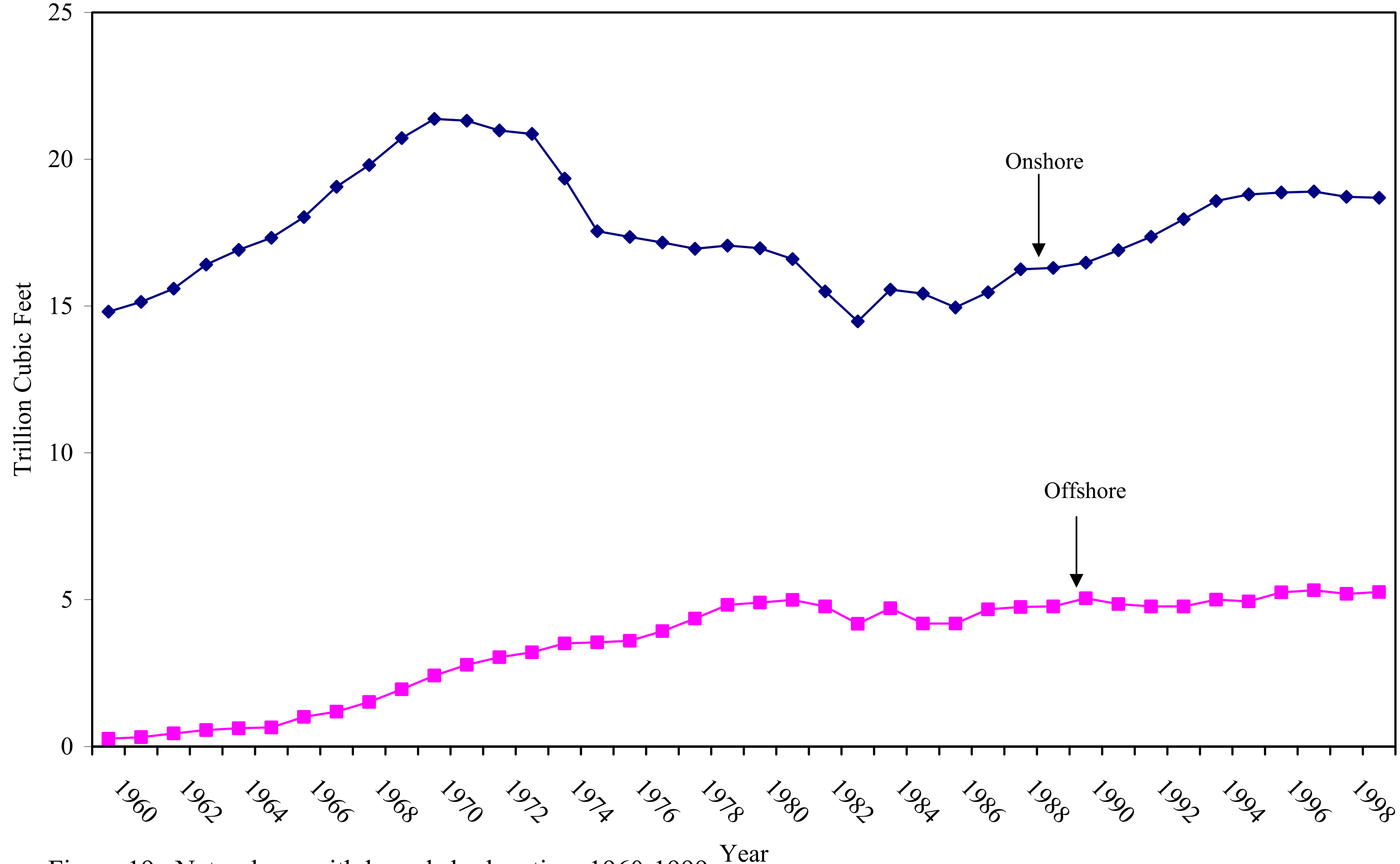


Figure 19. Natural gas withdrawals by location, 1960-1999.

Source: U.S. DOE, EIA 2000a.

1981, gas production declined, but varied between 3.8 and 4.6 tcf. In 1999, sub 1,000-foot gas production was 3.8 tcf. Following a low and stable level of production between 1986 and 1990, gas production escalated rapidly in deepwater (i.e., greater than 1,000 foot depth). Production increased from 45 billion cubic feet (bcf) in 1990 and grew by nearly 80.0 percent per year until 1996. Much of the gas produced was derived from wells on the slope, which are close to the shelf and where pipelines are available. Between 1997 and 1999, deepwater gas production increased by more than 125.0 percent. In general, it has been production from other sources that has maintained supplies for natural gas.

In terms of natural gas consumption or demand by sector, the EIA provides information on the following sectors: (1) residential, (2) commercial, (3) industrial, (4) transportation, and (5) electric utilities. The primary user of natural gas has historically been, and is also currently, the industrial sector (see Figure 20). The residential sector has been, and is, the second leading user of natural gas. The transportation sector accounts for the smallest share of natural gas consumption. Until 1988, the electric utility industry was the third highest user of natural gas. Since 1988, however, the commercial sector has used about the same level of natural gas as has the electric utility sector.

Important determinants of the demand for natural gas are weather and prices of substitute fuels. The price of substitute fuels, however, plays a lesser role than does weather in determining price; equipment purchased to operate on natural gas is quite expensive and usually cannot be converted to run on other fuels (U.S. DOE, EIA 2000a). Examination of the recent situation in weather in relation to gas use indicates just how significant weather is in determining demand. Temperatures were relatively mild between 1999 and 2000 (3,351 heating degree-days or 457 fewer heating degree-days than normal). For the 2000-2001 period, which was a particularly cold period, there were 4,048 heating degree-days or 270 more heating degree-days than normal. In 2000, the consumption of natural gas reached the all time high of 22.8 tcf, 4.8 percent higher than in 1999.

The U.S. DOE, EIA (2000c) in its report "U.S. Natural Gas Markets: Recent Trends and Prospects for the Future" predicts that natural gas will be the key fuel required for economic growth for the next several years. The industry, in order to meet supply, however, will have to replenish natural gas storage to normal levels. Projections for demand by the industrial, residential, commercial, and electricity generating sectors suggest a very strong short-run future demand (through 2004). Industrial sector demand for natural gas is expected to increase by about 2.5 percent. Residential demand is expected to decline by about 0.8 percent over the next few years, primarily because of high natural gas prices. The commercial sector will likely increase demand by about 1.1 percent. Growth in demand for natural gas by the electricity generation sector is expected to be low.

Most of the current imbalance between demand and supply for natural gas is believed to have been caused by limited capacity and low storage levels. The capacity problem has been caused mostly by inadequate productive capacity, but also by inadequate interstate and intrastate pipeline systems. Most notable, these bottlenecks occurred in California and other western market areas. Prior to the 1990's, production plus drawdowns from storage and imports were generally sufficient to satisfy domestic demand. Because of low profits and returns, however, in the late 1990's, gas companies decreased drilling activities. As a

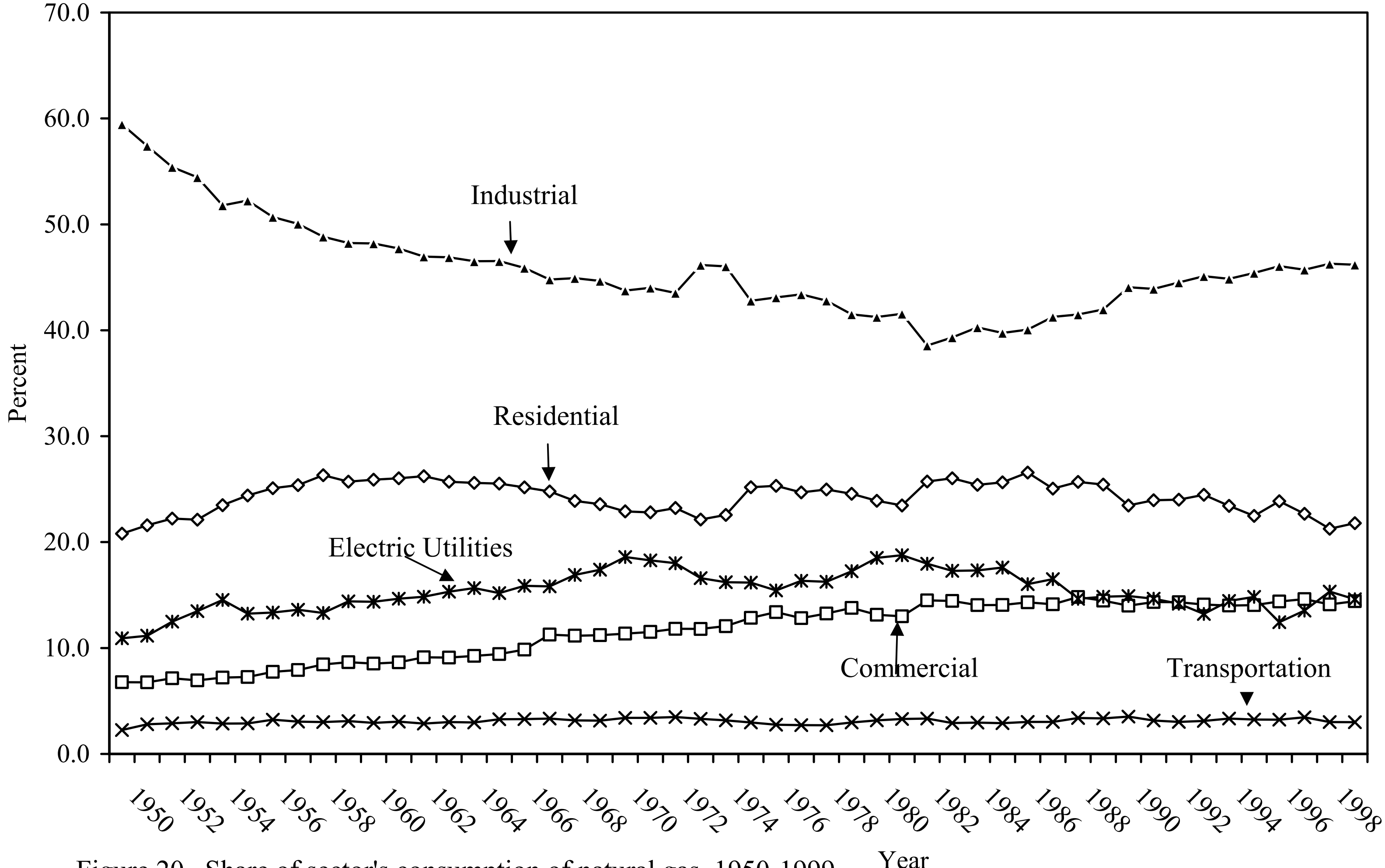


Figure 20. Share of sector's consumption of natural gas, 1950-1999.

Source: U.S. DOE, EIA 2000a.

consequence, drilling was insufficient to convert proven natural gas reserves into increased productive capacity. In 1994, domestic production increased by 0.74 tcf. In every other year of the 1990's, however, production increased by less than 0.3 tcf per year. In 2000, domestic production increased by 0.7 tcf, which was sufficient to meet the major portion of demand growth experienced in 2000. Meeting this growth, however, required a large net drawdown of gas in storage and an increase in imports.

3.2.4 Ownership Rights and U.S. Prices

The U.S. upstream energy sector is quite different from the rest of the world's main producing areas. An International Energy Agency report "Energy Policies of IEA Countries – The United States 1998 Review" classifies the upstream sector as being highly "atomistic," in which there is a large number of parties making independent decisions across a wide array of geological and economic situations. There are highly dispersed holdings of land and associated mineral rights, and therefore, exploitation of U.S. oil and gas resources has followed a patchwork pattern throughout history (IEA 1999a). In more recent periods, new gas and petroleum provinces have moved into federal lands in the west, Alaska, and federal offshore waters.

In stark contrast to many nations, the U.S. exploration and extraction sector is an open-market system. Free-market incentives and disincentives drive domestic oil and gas exploration activities. Private investors either own the rights to drill and produce oil and gas or they have been granted the rights to do so on federal lands, as well as in the federal OCS areas. In contrast, much of Canada's energy sector is at least partly government owned. Canada, however, does appear to be increasingly moving in the direction of privatization. The state-owned oil company in Mexico (Petróleos Mexicanos, referred to as Pemex) also still dominates domestic energy resources at all Mexican market levels. Ecuador and Peru have a monopoly energy policy; both nations, however, are examining options for privatization.

Prior to 1978, the U.S. oil and gas producing sectors were heavily regulated, but they were open-access segments of the energy industry. That is, if investors had sufficient capital and satisfied regulatory requirements, they could explore for and produce oil and natural gas. The fact that industry was open-access, however, did not mean that producers could do whatever they wanted. They were subject to price and production limits and regulations, usually at the state level. After 1978, major initiatives were introduced to restructure the oil and gas segments. The industry, however, remained open-access. Price and quota or output limits were subsequently removed, but the federal government retained regulatory authority for interstate activities, while the states retained authority for intrastate activities.

Oil and natural gas can be bought and sold like most other goods, but in some cases, particularly natural gas, the transportation component may be a natural monopoly. This is because it is generally inefficient to build competing pipeline networks, particularly for local distribution. The supply of, at least, natural gas to end users will in most cases always involves some element of monopoly—even in a competitive market.

With a competitive market system, there tends to be more variability in the wellhead prices of natural gas and oil. In fact, this has been the case for the U.S. Not long after the Texas Railroad Commission initiated a total pro-allocation of oil in 1972, which basically eliminated production constraints, prices of crude and gas became highly variable or volatile. Price determination shifted mostly from the U.S. to OPEC. Even OPEC, however, does not have the complete power to set prices. Between 1986 and 1996, OPEC's attempts to set prices and coordinate volumes failed. OPEC's mission of controlling prices became a mission of crisis management. Between 1949 and 1973, the coefficient of variation (cv) for the real price of oil was only 0.09; from 1974 though 1999, the cv for the wellhead price of oil was 0.44. In contrast, the cv for natural gas declined—from 1.50 for the 1949-1973 period to 0.34 for the 1974 to 1999 period. The cv for natural gas prior to the 1978 FERC Order 436, which initiated the unbundling of services and products of natural gas, equaled 0.43; after Order 436, the cv for the wellhead price of natural gas declined to 0.28. What is so odd about the cv patterns for the wellhead prices of natural gas is that the wellhead price was heavily regulated during the early period; regulating prices, however, apparently led to supply shortages and gross market distortions (IEA 1999a).

The history of the structure and organization of the oil and gas industry has dramatically changed over time. It has gone from near monopoly in the 1800's to open markets and mega majors (e.g., BP/Amoco/ARCO and ExxonMobil). Yet, the United States is unique in several respects. In contrast to most major producing nations, producers have private ownership of resource rights—a requirement for technical and economic efficiency. Under a full-open access regime, with no private rights, technical and economic inefficiency typically occur. In the U.S. the decision to explore for and produce oil is between the landowner and the producing company. The producing company subsequently pays the landowner a royalty on each barrel of oil produced. Presently, there are no restrictions to production by any government agency (U.S. DOE, EIA 1999e).

The private ownership of resource rights permits the active participation of thousands of independent producers and the prevalence of the stripper well, or one producing less than 10 barrels of oil a day. At the same time, the fact that there are many producers of oil and natural gas results in producers being mostly price-takers. That is, they have little influence over the wellhead price of either petroleum or natural gas. Even with the mega mergers and the fact that many domestic companies have become active in energy production in other nations, they still lack the ability to establish wellhead prices for oil and natural gas. Consider that the two mergers—BP/Amoco/ARCO and Exxon/Mobil—will produce only 7.5 percent of the world's petroleum.

Currently, the U.S. permits the production of natural gas and petroleum within a private or quasi-private property rights regime. That is, the United States, as a nation, does not specify the quantities that may be produced or the prices that producers may receive, nor does the United States own the resource rights, except for offshore deposits. This production arrangement differs from many other nations, which control the ownership, access, and production of petroleum or natural gas. For most major petroleum producing nations, the government owns the rights to develop resources. For privately owned property in the United States, decisions about exploration and production are between the landowner and the producing company. The private ownership rights in the U.S. also contribute to the existence of independent producers and production by "stripper" wells, those that typically produce less than 10 barrels a day (U.S. DOE, EIA 1999e).

Under this private property regime and given the size of the world petroleum market, U.S. producers are primarily price-takers (i.e., they cannot influence the price of petroleum). They have little or no ability to influence the wellhead prices of either petroleum or natural gas. In many of the major oil producing nations, however, prices may be established for petroleum or natural gas. In addition, U.S. deregulation and unbundling of products and services have created a competitive market in the United States for oil and gas. Deregulation and an increasing global market, however, have forced producers to substantially alter their production strategies. Producers, who in the past might have attempted to produce as much as possible in as short amount of time as possible, now develop production strategies based on the dynamic aspects of economics. Producers focus more on developing long-run strategies to maximize expected net returns (revenues less costs) over time subject to technological (the underlying method of production) and other constraints. Under such a strategy, oil producers attempt to develop decision rules about exploration, production, and related activities based on long-run expectations about prices, demand, costs, and technology. Alternatively, producers have changed their planning horizon and production activities from maximizing production over a short time to maximizing net returns over a longer time horizon.

Consider a producer that attempts to maximize output or the level of crude over as short amount of time as is possible given the existing technology. In this case, the production technology (i.e., the way inputs are used to produce outputs) may be represented by $Q=f(X,R)$ where Q is output in barrels of oil, X is a vector of the factors of production, R indicates the initial reserves, and f characterizes the production technology or how output is related to X and R. Under the case of maximizing output, the producer does not consider the costs of production. Instead, the producer determines a path of extraction over time that exhausts the initial reserves. Demand or the price of petroleum and the technology determine the time path of extraction such that the rate of extraction maximizes output for each production period. Next, introduce costs and uncertainties about demand and output prices, and consider that the producer is now concerned with maximizing net returns over time or a longer time horizon. To realize this objective, the producer must consider what prices and costs will be in the future (expectations). The producer now produces up to the level that the price net of marginal cost equals the private rate of interest (i.e., the level at which the producer values $1.00 in the future vs. $1.00 in the present time period).

3.2.5 Energy Prices and Effects on Finances and Capital Markets

Data necessary for examining the potential relationships between oil and natural gas wellhead prices and their potential influences on corporate/company finances and capital markets are extremely limited. The Energy Information Administration maintains a Financial Reporting System (FRS), which requires companies that are either U.S.-based publicly-owned companies or U.S.-based subsidiaries of publicly-owned foreign companies that had at least 1.0 percent of either production or reserves of oil or gas in the United States, or 1.0 percent of either refining capacity or petroleum product sales in the United States to routinely report their financial performance to the EIA. The program began in 1977 and the criteria and format for reporting has changed numerous times since 1977. In 1999, EIA identified 48 companies as FRS companies. Thirty-two companies filed the necessary financial statements with EIA in 1999. Total sales of these companies equaled approximately 9.0 percent of the $6.3 trillion in sales of the largest Fortune 500 corporations. In addition, the EIA examines the financial performance of the independent producers, companies that are not part of FRS. Data are provided to EIA from Arthur Andersen and Co., Oil and Gas Reserve Disclosures Database (Arthur Andersen 1999).

In general, investor willingness to provide funds to oil and gas companies, like any other company, is reflected in the market's evaluation of the financial performance of the company. The perceptions of performance by investors are based on the financial performance, and financial performance reflects cash flow, profitability, and cost. Changing oil prices can have significant influences on cash flow, profitability, and cost. For example, the U.S. DOE, EIA (1995) states that "the oil price collapse of 1986 was the defining event in shaping the financial factors."

Although detailed data on source of funds for each major energy-producing sector are unavailable, EIA does provide aggregate summary statistics on source of operating funds for three energy-producing sectors and one nonenergy sector. The three energy-producing sectors are petroleum, which includes oil and gas, coal, and other energy. The nonenergy sector includes chemicals.

Historically, the energy producing FRS companies have relied mostly on funds provided by operations, with income earned being the largest single contributor to funds. Over time, however, there has been a general trend for these energy companies to increasingly rely on long-term debt for corporate funds (U.S. DOE, EIA 2000e). For example, the FRS companies in 1998 increased their long-term debt to help close the gap between capital expenditures and cash flow—a record $27 billion. They also resorted to issuing more stock; sold a record amount of assets; reduced cash payouts to shareholders; and drew down their cash balances by $4 billion (U.S. DOE, EIA 2000e). Oil prices were up nearly 50.0 percent in 1999 relative to 1998 wellhead prices. Cash flow realized from oil and gas production also increased by 50.0 percent. Yet, the FRS companies decreased their worldwide expenditures on oil and gas exploration and development by $19 billion—a 38.0 percent reduction relative to 1998. In 1999, the FRS oil and gas companies increased their cash outlays for debt reduction, and reduced dividends and share purchases. They also reduced capital expenditures. In the context of volatile economics, corporate budgets necessarily reflect conditions that existed at the time of allocations. Thus, capital expenditures for a year can be down, even when market conditions improve.

Prior to the collapse of world oil prices in 1986 and the bottoming out of domestic gas prices in 1991, many companies engaged in exploring, drilling, and production mostly financed their own operations. They had a relatively low dependence on long-term debt, particularly from financial lending institutions. Independents, who accounted for 85.0 percent of the country's drilling activity, however, borrowed heavily in what was viewed as a "no-lose" future (Niering 1987). During the period preceding the collapse of prices, prices and revenues of the majors and independents were soaring. Between 1978 and 1985, lending by the oil-state banks, mainly in Texas and Oklahoma, increased by as much as 20.0 percent each year. With the price collapse, however, independents experienced large losses (e.g., a survey by the Oil and Gas Journal of 170 independent producers revealed that they had a combined loss of $3.45 billion in the first half of 1986). The downgrading of the value of the petroleum reserves caused consolidations and bankruptcies, which rendered many outstanding loans unserviceable.

Loans during this period, and prior to 1978, were typically structured on the basis of 50.0-60.0 percent of the value of proven oil and/or gas in the ground; it also was typically assumed that oil prices would not drop much below $20 a barrel. Moreover, loan portfolios applying directly to energy projects usually did not exceed 20 percent of the total loan amount. After the crash, the oil-state banks began looking for new business from non-oil sectors. The banks also developed alternative procedures for granting loans and determining loan amounts; they particularly focused on strategies that would protect them from downward price swings.

There are several aspects to consider when determining the possible relationships between finance, capital markets, and oil prices. Both investment decisions and financial aspects of exploration and production activities are based on expectations about rates of return on investment, profits, and reserve values. Revenues and costs define profits, in turn. Oil prices and demand drive revenues. The reserve value equals the amount of reserves (i.e., quantity of oil or gas that can be extracted) by year-end crude prices (Perkins 1999). In fact, the reserve values of oil and gas may be the most important financial aspect relative to investment and financing decisions. A low reserve value affects the producers' stock value and financing opportunities. Both publicly owned major and nonmajor oil and gas companies (mostly independents) annually report reserve values to the shareholders and the U.S. Securities and Exchange Commission. A low reserve value makes it difficult for majors and nonmajors to obtain loans. Moreover, if the reserve value falls below a certain level, a lending institution, which issued existing loans, may call the loans due immediately.

There are substantial differences between the independent oil and gas producers and the majors relative to financing and expenditures. In general, the independents have tended to rely more on external funds (e.g., issues of long-term debt and equity securities) to fund operations. Between 1986 and 1990, the independents realized approximately 43.0 percent of their funds from long-term debt; the majors received approximately 25.0 percent from long-term debt (see Figure 21). Between 1991 and 1993, the independents increased their dependence of long-term debt; nearly 50.0 percent of their operating funds was financed via long-term debt; the majors also followed suit by increasingly relying on long-term debt. Between 1991 and 1993, the majors received 27.1 percent of their total cash from long-term debt arrangements.

Profitability or expected profitability is an important determinant of investors' perceptions of a company. Profitability in previous years is typically regarded as a useful indicator of future profitability. Profitability is closely related to oil and gas prices (Perkins 1999). One widely

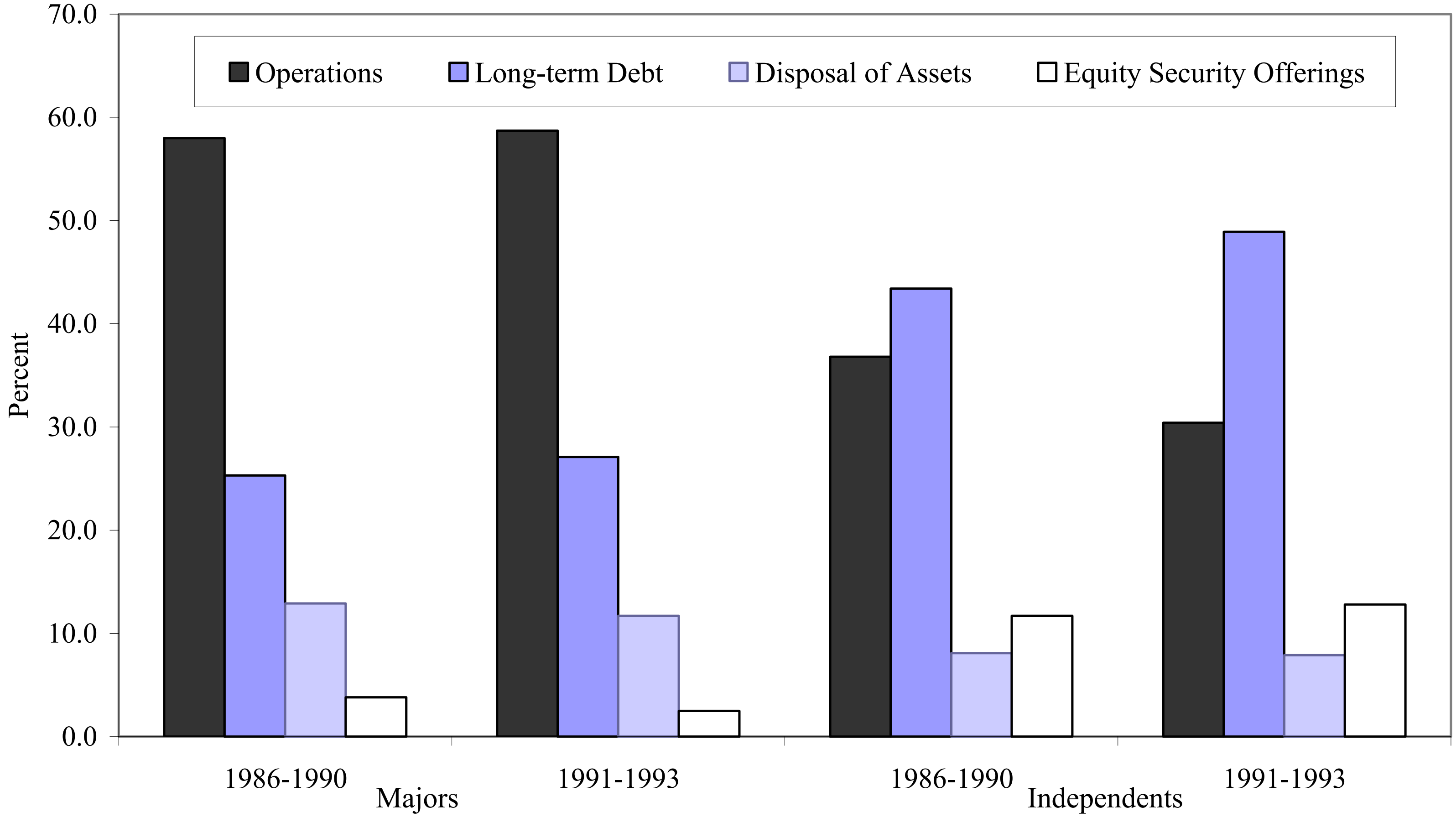


Figure 21. Percent distribution of source of cash, majors and independents.

Source: U.S. DOE, EIA 1995.

used measure of profitability is net income as a percent of stockholders' equity—the rate of return, expressed in percentage terms, on equity. Examination of profitability for investment decisions, however, can be misleading when examining independents vs. the majors. The major oil and gas companies engage in both upstream (exploration and production) and downstream activities (refining and marketing). During low oil price years, the majors may have poor profitability in the upstream sectors, but use earnings from the downstream sector to offset the low upstream earnings. The independents primarily engage in exploration, drilling, and production. They do not have downstream earnings to offset upstream losses. The lack of vertical integration is a major reason why the independents were more devastated by the oil price collapse of in the mid-1980's.

Although wellhead prices for petroleum and the profit rate followed nearly identical patterns between 1981 and 1998 (Perkins 1999), investors also consider the ratio of market value of a company's shares to the book value of a company's net assets (i.e., stock-holders' equity) (U.S. DOE, EIA 1995). An oil or gas company's current share price is an indication of investors' expectations of profitability at the time the shares are purchased; the book value indicates the future expected profitability of productive assets when the assets were purchased.

The cost of capital for oil and gas producing companies is directly related to risk. If the risk of loss is high, investors require a higher rate of return in order to induce them to purchase stock or assume debt. A risky firm must offer greater returns to attract capital. During the 1990's, however, an interesting pattern emerged relative to risk and the cost of capital and whether or not an oil/gas firm was an independent or one of the majors. During the 1980's, independents had a higher risk of loss and lower returns relative to the majors. It would be expected that the independents would have to pay higher rates of interest on debt. This was not the case in the 1990's. In fact, the rate of interest paid by independents for loans was often lower than the rate paid by the majors (U.S. DOE, EIA 1995).

One method often used to measure systematic risk, defined as the probability of loss, is to assess a company's "beta." Beta is the mathematical value of the regression coefficient obtained from a regression of stock value of a company against the value of the market. A value of beta equal to one implies that the stock value of company and the value of the market move together. If the market goes up 1.0 percent, the stock will increase by 1.0 percent. A stock with a value of beta less than one is less volatile than the market. For example, a beta of 0.8 implies that as the market decreases (or increases) by 1.0 percent, the value of the stock will decrease (or increase) by 0.8 percent. A stock with a value of beta less than 1.0 is regarded as a valuable defense against a declining market (U.S. DOE, EIA 1995).

The beta values for the independents have tended to be lower than the values for the majors. This was the case until 1992. In the latter part of the 1980's, the beta values for the majors were typically less than one, but ranged between 0.51 and 0.97. In contrast, the beta values for the independents ranged from 0.39 to 0.80 between 1986 and 1991. The finding of the low beta values for the independents relative to the majors indicates that investors have been able to diversify away a substantial portion of the risk of investing in the independent companies.

The fact that the beta values for the independents have been somewhat lower than the beta values for the majors can be explained by several factors. Although the independents are generally more debt-dependent than the majors, the independents have been quite conscientious in reducing their dependence upon debt. In turn, the independents have become lower leveraged producers or firms (i.e., a firm with less debt than its peers). A low leverage firm would likely be able to better cover its interest payments with its operating cash flow, and thus, be less prone to default on debt. Since 1986, the independents have allocated about 44 percent per year of their cash for debt reduction; the majors have allocated only 27 percent of funds to reduce debt. The independents are, thus, viewed as less likely than the majors to default on loans. The independents also devote the bulk of their cash to reinvestment in their own operations, which is also viewed as lowering the probability of a loss. Profitability by the independents has also increased, particularly since 1986. Reductions in debt and improved profitability have reduced the cost of capital to the independents, and both the majors and independents have approached the yield on low risk corporate bonds. These factors have further reduced the probability of loss by the independents.

In summary, wellhead prices affect profitability of oil and gas production activities. In turn, price changes affect revenues and profits. Price changes also affect investor expectations. The major source of cash for the majors is the cash flow from operations; the primary source of cash for the independents is long-term debt or loans. Over the 1980 to present period, the manner in which investors and lending institutions invested or made loans to producers has changed. Investment and lending decisions have increasingly emphasized risk in more recent years, particularly with respect to the value of reserves. The major oil and gas companies have disproportionately relied on cash received from the disposal of assets for funds. Both segments have increasingly used long-term debt to finance operations.

3.3 Technology

Technology has made a significant contribution to the relationship between the oil and gas industry and the market price for oil and gas. Over the 20-year period 1980 to 2000, the prices of oil and gas have gone through several cycles and have shown an increasing tendency towards volatility. While oil and gas prices have always moved up and down, the frequency of these changes and the extent of changes has increased dramatically over the past two decades. (See Section 3.1 for discussion of oil and natural gas price changes.) 1981, gas production declined, but varied between 3.8 and 4.6 tcf. In 1999, sub 1,000-foot gas production was 3.8 tcf. Following a low and stable level of production between 1986 and 1990, gas production escalated rapidly in deepwater (i.e., greater than 1,000 foot depth).

Technology's role in the relationship between the oil and gas industry and changes in oil and gas prices might be characterized as being a buffer or shock absorber. Over the past 20 years, technology has lowered costs for the oil and gas industry significantly. Thus, in the broadest terms, the steady lowering of costs resulting from the application of various technologies has allowed companies to operate profitably at progressively lower prices. This ability to continue profitable operations has given the industry more flexibility to absorb more easily the inevitable shocks of dramatic drops in prices.

As has been noted earlier, the oil and natural gas industry is complex, comprises many segments, and covers a wide array of activities. The industry's activities range from the initial efforts to discover significant volumes of hydrocarbons through the extraction of those resources to their final delivery as numerous different products to a variety of customers. Necessarily, the industry uses a vast number of technologies to accomplish these activities.

Over the last two decades, the kinds of technology that have had the greatest impact on the oil and natural gas industry can be grouped either as industry-specific technology or other, more generic technology. Industry-specific technology of principal interest to this study includes the following.

- Seismic imaging. This group of technologies provides information on the location of hydrocarbons within the earth. Through the application of increasingly refined techniques, seismic imaging can generate the equivalent of three-dimensional pictures of geological formations which include the identification and location of oil and natural gas reservoirs. This so-called 3D imaging can also be produced over time to create so-called 4D images.

- Platforms. The structures that house drilling, production, and/or storage equipment and facilities have been transformed by the requirements of offshore oil and natural gas. As the industry moves into increasingly deeper waters, platforms have had to solve fundamental problems of supporting these functions in depths that preclude rigid connections to the seabed.

- Drilling. The creation of wells has become more sophisticated as the ability to drill in virtually any direction has evolved. Standard vertical drilling was first changed by the addition of horizontal drilling, and has since evolved by the use of increasingly flexible drilling techniques that allow bits to be steered through geological formations.

  Drilling technology includes a host of other applications of which the most important are termed measurement while drilling. These technologies provide a real-time stream of information on the progress of drilling and conditions downhole and have replaced earlier techniques that required the cessation of drilling in order to send instruments down the well hole to collect data. Detailed production monitoring has tended to produce sharp cuts in both drilling and production down time, improving the economics of production.

- Deepwater technologies. The increasing depths at which offshore activities occur create a set of problems that industry must solve. In several thousand feet of water, it is no longer feasible to attach a platform to the seabed with rigid legs. Water temperatures at the seabed are cold enough (about 32 degrees) to inhibit the flow of oil in pipelines. At more remote deepwater locations, pipelines and other infrastructure are not available, making the handling of natural gas particularly difficult. Technologies, such as subfloor/subsea completions and robotics, have been created or are evolving to deal with many, but not all of these problems.

The second broad category of technology for the oil and natural gas industry is not industry specific. Within this generic category are two related groups of technologies: information technology and telecommunications/the internet.

- Information technology. The continuing evolution of computers and software has transformed the oil and gas industry as it has transformed most U.S. industries. This technology is intertwined with much of the industry-specific technology listed above. Seismic imaging, for example, is dependent upon the processing of enormous amounts of data using complex software and the display of that data on highly sophisticated computer monitors.

- Telecommunications/the Internet. In tandem with the development of computers, telecommunications and the internet have also had fundamental impacts on all industries including the oil and natural gas industry. These technologies include e-mail, intranet, and internet capabilities and have created opportunities that range from simpler transmission of electronic data and documents to what is often termed e-commerce.

The total impact of technological change on the oil industry has been dramatic, particularly in more recent years. Moreover, it is possible to identify a relatively small number of technologies that most observers credit with the majority of these impacts—seismic imaging, drilling technologies, deepwater platforms, for example. Closer examination of these technological breakthroughs, however, tends to disclose a pattern of relatively small incremental changes. Frequently these changes have been bundled together or have accumulated over a period of years or even decades. Horizontal drilling, for example, was successfully accomplished in 1939; and the first modern horizontal well was completed in 1953. This technology did not gain wide acceptance by the industry, however, until the late 1980's (Chambers 1998).

Rather than benefit from a few dramatic changes, the oil and gas industry has typically implemented many improvements affecting virtually every part of the industry. The results of this embody the concept of synergy—the total impact of these small and diverse changes is greater than sum of each individual impact.

Being incremental, technological change often does not demonstrate dramatic effects at specific points in time. Nevertheless, there have been many milestones that mark important progress in the application of technology in the oil and gas industry. These are summarized in Table 9.

Table 9

Major Technology Milestones for Oil and Gas Industry

Year	Action	Comment
1974	3D seismic data acquisition tested in GOM	
1978	First deepwater production platform installed	Shell Offshore Inc.'s Cognac
1979	Deepest offshore wells operate in 1,000 feet of water	
1980	Commercial 3D seismology begins in the early 1980s	
	Oil industry planners forecast oil prices of $90 to $110 by the year 2000	Forecast is largely based on extending trend lines from 1970's to 1980's
1981	First offshore horizontal well	Rospo Mare field, offshore Italy
1983	Horizontal well drilled from vertical shaft	Kern River, CA
	New York Mercantile Exchange begins to trade crude oil contracts	Oil seen as "commodity;" crude oil contracts help to "curtail" price increases of 1973 and 1979
1985	3D vertical seismic profiling developed	
Late 1980's	Successful application of horizontal wells in Austin Chalk leads to general use of this technology; horizontal and multinational operations substantial part of drilling activity for the first time	First modern horizontal well completed in 1953; despite excellent production, industry takes 35 years to adopt technology fully
1987	Patent obtained for deepwater spar technology	
	First logging while drilling (LWD) tool	
1988	First horizontal well drilled from semisubmersile drill rig	
1989	5 percent of GOM wells based on 3D seismic data	
1987-1992	Independents expand role in GOM; majors invest overseas	
1992	First time more platforms removed than installed	Also occurred in 1993, 1997, and 1999
1995	4D seismic emerges	Offshore exploratory success rate for large producers more than doubled between 1978 and 1995
	Drilling, development technologies begin to emerge in 1995 and 1996	Examples: easier re-entries, multilateral completions, extended reach drilling, reliable subsea completions, floating production facilities

Table 9 (cont'd)

Major Technology Milestones for Oil and Gas Industry

Year	Action	Comment
1996	World's first production SPAR installed in the Central GOM	Neptune SPAR (Oryx Energy) installed in 1,851 feet of water in Viosca Knoll
	80 percent of GOM wells based on 3D seismic data	Up from 5 percent in 1989
	4D seismic characterization methodology applied to previously recorded seismic surveys	
	Satellite used to transmit seismic data from ship in GOM to shore-based supercomputer	Public-private collaboration demonstrates viability of remote analysis of seismic data
	Time from offshore discovery (in 1996) to initial production reduced to 2 years	For offshore discoveries in 1984, 10 years elapsed before initial production
	Cambridge Energy Research Associates issues "The Quiet Revolution: Information Technology and the Reshaping of the Oil and Gas Business	Report estimates $6 billion annual spending on seismic technology, horizontal drilling, computers, graphics and futuristic visualization, advanced application software, databases and networks, and similar technology
1997	Discovery rate almost six times the rate of early 1980's	Result of better imaging technology
1998	Spar technology proves successful in increasingly deep waters	Genesis: 2,590 feet Diana: 4,800 feet
	"Truss" spar designed for use in 5,500 feet of water	
	World's longest well with a horizontal reach of 6.2 miles completed by BP Exploration Operating Co. Ltd	
	Baldplate deepwater production platform in the GOM, world's tallest freestanding structure	
1999	Average cost of finding, producing oil drops by an estimated 60 percent in real terms over past 10 years	Cumulative effect of incremental changes in many technologies
	Proven reserves increase 60 percent over past 10 years	Better seismic imaging, drilling, and recovery technologies critical to this increase

Table 9 (cont'd)

Major Technology Milestones for Oil and Gas Industry

Year	Action	Comment
2000	U.S. Geological Survey (USGS) releases 5-year study of world oil reserves	USGS raises previous estimate by 20 percent to total of 649 billion barrels, based on geological data and changes in drilling, other technologies
	Offshore well located in over 9,000 feet of water	
	50 percent overall success rate for new wells	In 1990, success rate was 10 percent
	Exxon Mobil's average cost for finding oil - $0.65 per barrel in 2000	Cost even lower than the company's long-term target cost of $1 per barrel
2001	Offshore well cost projected to drop by $5 to $12 million through use of subsea mudlift (riserless) drilling	Technology eliminates mud from drilling riser which sets off a series of cost saving opportunities and allows for drilling in deeper water with greater production flow rates; lower costs open up more opportunities for profitable operations when oil price drops
	Theory estimates 70 percent of oil in average reservoir recoverable	Typical recovery rate about half of this estimate
	Exxon Mobil processes as much seismic data in 10 days as would have taken 11 years to process in 1990	
2005	Offshore costs projected to drop by as much as 50 percent relative to costs in 2000	
	BP Amoco hopes to reduce liquid natural gas production costs by 25 percent relative to costs in 2000	
2015	Projected date when all the world's seabed will be accessible to offshore drilling	Advances in platform, drilling, related technology will eliminate water depth as barrier to development
Future	Knowledge surpasses oil and gas reserves as number one asset of companies	Computers, telecommunications, and information technology seen by some as radically transforming the industry

Sources: Bohi 1998, Chambers 1998, Huber and Mills 1998, Kennedy 1999, Le Blanc 1997b, Porubon 2001, Skaug 1998, Staff 2000h, Taylor 2001.

3.3.1 Technology, Costs, Risk, and Oil Price Changes

The discussion of technology and oil price changes should begin with a brief acknowledgement of the stakes. Oil and natural gas companies are capital-intensive businesses, which routinely undertake projects of enormous expense. While this is true across the industry, high cost is more true when projects are undertaken offshore, and, by the time projects occur in deepwater, the costs involved are spectacular. Commitments of $400 million to $500 million are not uncommon (Van Wie 2000). And commitments at such levels do not necessarily encompass an entire project or, of course, assure production. Shell invested $3 billion in deepwater GOM before this investment began to generate income (Pattarozzi 2001).

If money is a challenge, so also is time. The planning horizon for projects is measured in years. Early deepwater GOM projects required 8 or 9 years of effort to move from searching for oil and natural gas to being able to start production (Pattarozzi 2001). Currently, time requirements have been substantially reduced, but project phases are still measured in years. Thus, a new deepwater project may require 2 years for appraisal, then 3 years to construct the necessary equipment and infrastructure (Bell 2000). As a result, companies have to think ahead. Any major decision for a given project would have to have been made at least 2 to 3 years prior to undertaking action (Van Wie 2000). With these long time periods for developing oil and natural gas resources, it is difficult to make reliable and accurate economic forecasts given the price volatility experienced over the last 20 years. No company or government agency has accurate tools for economic forecasts in this area. Consequently price volatility is an important problem (Bell 2000).

Against this background of great expenses committed years in advance and incurred over long periods of time, the industry has had to respond to changes in oil and natural gas prices that have become more volatile over time, particularly in the case of oil prices. Because prices are set by markets operating nationally or globally and are outside the control of any given company, the industry does not have the option of influencing prices. The principal response of the industry has been to control costs.

The control of costs is a fundamental strategy of the oil and gas industry. Since the collapse of oil prices in the mid-1980’s, companies have used various strategies to manage and reduce the costs of finding, producing, and marketing oil and natural gas. (See Section 4.4 for discussion of cost cutting as part of corporate organization and strategy.)

In controlling costs, a major weapon available to the oil and gas industry has been improved technology and the changes that this technology has made in the process of finding, producing, and marketing oil and natural gas. Business goals for change usually fall under the headings of better, cheaper, or faster. As an important driver of change, technology has often been able to achieve each of these goals. Each of these goals ultimately has the effect of reducing industry’s costs for doing any of the almost countless individual tasks required to bring oil and natural gas out of the ground and to consumers.

For a decade or more prior to the mid-1980's collapse of oil price, cost reduction through the application of technology was not a critical industry strategy. With record high prices and an expectation that prices would steadily climb even higher, there was little incentive to manage costs. Indeed, in the early 1980's, platform production costs increased 85 percent and still fabrication yards were backlogged with demand (Le Blanc 1997b). In the North Sea and elsewhere in the early 1980's, the focus was on getting oil to market as fast as possible, rather than on costs (Bishop 2000). One estimate of the cost of finding new oil in the 1970's and 1980's was $12 to $16 per barrel (in 2000 dollars). Today that figure is $4 to $8 per barrel (Rauch 2001). The most efficient companies today find oil at even lower prices. Exxon Mobil spent only 65 cents to find a barrel of oil in 2000 (Taylor 2001).

In the early 1980's, much of the technology that would later have major impacts on the industry's costs was in place, but was not making a substantial difference to operations. Seismic imaging with three-dimensional capabilities was tested in the GOM as early as 1974 and was considered commercial by the early 1980's. By 1989, however, 3D seismic imaging could claim to have been used to locate only about 5 percent of the GOM's wells. Horizontal drilling, which can trace its modern history to 1953, was first used offshore in 1981 and did not gain widespread acceptance until the late 1980's. Deepwater production platforms were first installed in the GOM in 1974 and were operating in 1,000 feet of water by 1979, but deepwater production remained a modest, even declining part of overall production in the 1980's. In the 1980's, deepwater oil contributed no more than 6 percent to total U.S. production and deepwater gas no more than 1 percent (U.S. DOI, MMS 2001b).

The sense that technology failed to make a significant difference in the early 1980's is supported by a U.S. Department of Energy analysis. This study examined the impact of technology on the oil and gas industry success rate and estimated the effects of the major variables thought to affect the offshore success rate. The analysis estimated that the offshore success rate is positively impacted by price, drilling depth, and gas intensity. The results also suggested that the impact of technological change was somewhat negligible over the 1978-1985 period. Alternatively, technological progress increased the success rate at an estimated average annual rate of 8.3 percent over the period 1986-1995 (Forber and Zampelli 2000).

The oil price crash of 1986 was a wake-up call for the oil and gas industry. Projections of $100 per barrel oil evaporated in the face of the precipitous fall in oil and natural gas prices. To survive, companies turned their focus to reducing costs. (See Section 4.4 for discussion of cost cutting programs.)

In the late 1980's, more technology began to emerge. A patent for spar technology permitting platforms in heretofore-unknown depths was issued in 1987. That same year, the first spar platform was installed in almost 2,000 feet of water in the GOM. Also in 1987, the first logging while drilling tool was used, allowing real-time transmission of data from the well bore. The following year the first horizontal well was drilled from a semi-submersible drill rig.

While this technology opened up new options in the GOM, it was not the salvation of the industry. Costs were still high, particularly in deepwater GOM, where major reservoirs had been found. Moreover, many of the major oil companies had an international perspective and found opportunities overseas more appealing. In the GOM, the independents became the dominant players in near-in production over a period stretching from the late 1980's to the early 1990's. By some accounts, the industry had concluded that high prices, large discoveries, and even tax relief would not offset increased costs experienced in the late 1980's. For some in the industry, the questions were whether oil was still undervalued and whether it was still considered a strategic commodity (Le Blanc 1997b).

By the mid-1990's, several factors helped to turn technology into a major driving force in the oil and gas industry, in the GOM, and around the world. With time, technologies that had been in place for years began to mature; other complementary technologies came online. Thus, 3D imaging was augmented by using time series data for the same location to create 4D images. A host of drilling and production technologies were commercialized. (See Table 9 for examples.) Independents, by then the dominant players in the GOM, had greater incentives to operate there successfully. These companies were often not comparing GOM opportunities to those in other areas of the world. Capital, constrained by the real estate and savings and loan crisis that hit banking in the late 1980's and early 1990's, became more available from newer financial instruments (Brown et al. 1998). Some in the oil and gas industry also worried that the reserves of the more shallow water GOM were declining or those obscured by salt formations were too hard to find. Without breaking into the new frontiers of deepwater or subsalt, the GOM would no longer be an actively developed area (Staff 1996).

The impacts of technology since the mid-1990's have been remarkable. In 1996, the world's first production spar platform was in place in the GOM. By that year, 80 percent of GOM wells were developed using 3D imaging. Using old seismic data, 4D imaging was finding recoverable oil and natural gas in old reservoirs. One result of this was that the U.S. Department of Energy estimated that 89 percent of the "new oil" being produced in the U.S. was from existing fields that had been re-explored and exploited with improved technology. Current theory now estimates that 70 percent of the oil in an average reservoir is recoverable—about twice what is typically recovered (Rauch 2001). By 1998, the discovery success rate was six times better than it had been in the early 1980's; platforms were operating in almost 5,000 feet of water; extended reach drilling had completed a horizontal well over 6 miles in length. By the year 2000, an offshore well was operating in over 9,000 feet of water; overall success for new wells was 50 percent versus 10 percent in 1990.

This industry-specific technology has been supported and complemented by the increasing application of more generic technology—computers, software, telecommunications, and the internet. These technologies have driven certain other technologies, particularly seismic imaging, and have also been applied in the oil and gas industry as they have by almost every other industry.

The overall result of the application of this array of technology has been to lower the cost of finding, producing, and marketing oil and natural gas while increasing the quality of work done and increasing the rate at which work is accomplished. The oil and gas industry has been singularly successful in executing its strategy to respond to oil and gas price changes by controlling costs with technology. For some observers, the oil and gas industry has in fact evolved from the epitome of the old economy—extractive, low-tech, heavy industry—to a model of the new economy—high-tech, knowledge-based, and increasingly "virtual." And, the future is likely to bring more of these cost reductions as new technologies continue to emerge (see Section 4.3.4.).

The lowering of costs, increase in quality, and reduction in time also represent a leap forward in risk management for the oil and gas industry. The industry's concern with lowering risk is a direct result of the huge investments and long time frames required for most major projects—particularly in deepwater—and the inevitable price volatility of oil and gas. Risk for the industry and for individual companies is essentially the probability that the money spent to bring oil and gas to market will fail to produce an adequate return. In a world where most companies are highly attuned to the concept of shareholder value and the need to satisfy Wall Street's expectations, oil and gas companies want to maximize the return they receive for the investment and effort they make.

Because the industry cannot control prices, they have turned to controlling costs. Because the history of oil and gas prices is one of sudden and dramatic increases and decreases, companies look for ways to mitigate the financial damage of sudden drops in prices and revenues. This volatility required the refinement of risk analysis and the development of additional strategies for resource optimization because of the likelihood that narrow margins will always be a part of the reality of oil and gas (Cunningham 2000). By allowing companies to operate profitably when prices fall, technology has been a major tool in allowing the oil and gas industry to manage risk and respond to price changes.

The success of technology as a risk management strategy can be seen in the lack of sensitivity of major projects to what are considered short-term price swings. Companies, particularly the majors, do not stop and start activities as quickly as they did in the past. In 2000 when prices shot up, there was no great surge in investments, as there might have been in response to high prices back in the 1980's (Bishop 2000). BP, for example, is not likely to write-off its deepwater plays, even in the presence of price volatility, although sharp declines in the price of oil will slow the pace of project development (Farnsworth 2000). Price volatility did lead companies to seek more economical means to undertake and complete projects; but has not affected their basic commitment to such projects (Pattarozzi 2001).

Technology, however, is maturing for deepwater and other frontier areas. As a result, time horizons are shrinking. The technology, which has allowed companies to be less sensitive to price shocks, increasingly also makes these projects like other less risky efforts. Thus, there are signs that the buffering quality of technology-driven cost reductions is waning. More recently, deepwater has grown more sensitive to price shifts as this part of the industry matures and production cycle times decrease (Bell 2000, Bishop 2000, Farnsworth 2000, Jeppesen 2000, Cunningham 2000, Plaisance 2000).

There are several kinds of risk that oil and gas companies must manage. In the GOM, these are largely technical, relating to the ability of companies to find and develop oil and gas reservoirs within the set budget. In other areas of the world, the technical issues are compounded by what might be considered political risks. Technology can play a role in helping oil and gas companies manage these kinds of risks as well. Thus, given the long-term decline in costs and in technical risks (e.g., finding oil, recovering most of a deposit), these other risks may be more acceptable. This can be seen in the recent interest that companies based in the U.S. and other Western countries have in oil in high-risk areas like the Russian Arctic, one of the last unexplored areas of the world with the potential for yielding substantial quantities of oil and gas. There the risks include significant technical challenges, but the more important risks are legal, financial, and political. The technical risks of working in extreme cold are compounded by the general difficulties that Western companies have had in working in Russia because of its history of political instability, shifting tax laws, reneging on debt, and canceling contracts. Past efforts of a consortium of Russian and Western firms to develop the Russian Arctic have also ended in failure. The surge in oil and gas prices in 2000 began to offset these risks. The incentives can be explained by the estimate that the Timan Pechora area within the Russian Arctic has reserves of 126 billion barrels of oil, valued at over $4 trillion at 2000 prices (Varoli 2000).

Given the volatility of oil and gas prices since 1980, it not surprising that what industry would prefer is stable and predictable prices (Van Wie 2000, Bishop 2000, Bell 2000). In the absence of such a perfect world, technology has proven to be a critical tool for industry to manage risks and maintain operations in the face of inevitable and even increasing price volatility.

3.3.2 Changes in Benchmark Oil Price Versus Market Prices for Oil

Given the magnitude of investment and the long planning horizons for oil and natural gas projects, planning is crucial. As noted in Section 3.3.1, oil companies are making decisions about billions of dollars when they are deciding where to put new deepwater platforms and related infrastructure. Successful projects will produce oil for 20 to 30 years (Bell 2000). Thus, it is only reasonable that major oil companies have planning horizons of 20 years (Taylor 2001).

When trying to make investment decisions, industry planners are faced with a major dilemma. Given the volatility of oil and natural gas prices, what assumptions should planners make for the future price of oil and natural gas?

These assumed prices, typically called benchmark prices, can serve at least two purposes. One, benchmark prices can be used to predict the most likely prices that will prevail over the planning period. Two, benchmark prices can be used to determine the lowest prices that will still allow companies to make an acceptable return on investment. The two purposes are distinct. The benchmarks based on most likely prices constitute what amounts to a best guess as to what the future holds. Alternatively, benchmarks based on lowest prices that allow acceptable profits can be used to decide when a company has to make strategic decisions on resource allocation or other risk management issues.

Current thinking about price benchmarks and planning is done in the context of fundamentally flawed planning in the not too distant past. Twenty years ago, the industry's planners looked to the future after a decade of unprecedented increases in prices that had enormous impacts on economies around the world. In the early 1980's, industry planners were projecting oil prices of $90 to $110 a barrel oil by the year 2000 (Le Blanc 1997b). Based on a simple extrapolation of the price increases of the 1970's and early 1980's, the oil and natural gas industry was able to justify many business decisions that only worked with oil at very high prices. As noted in Section 3.3.1, given the high prices of the early 1980's and the expectation that these prices would continue to rise over many years, cost control was not an issue. In effect, planning for the longer-term future was not even an issue. Getting oil to market as soon as possible was the motivating force for the industry.

The oil price collapse of the mid-1980's rewrote the assumptions about the future price of oil and the basic assumptions that the industry needed to make in order to plan for the future. It has been easy in hindsight to see that decisions based on $100 per barrel oil were poor ones that opened companies to major risks. The lessons of the mid-1980's have not been forgotten. In fact, they are routinely cited by industry representatives and observers as the reason that oil and gas planners are much more conservative when setting benchmark prices and planning for the future (Bell 2000, Cunningham 2000, Knight 2000, Von Flatern 1997a, Van Wie 2000).

The problems of planning for the future can be seen in the costs of deepwater development in 1993, a few years before production from this frontier began to increase dramatically. At that time, oil prices were in the $14 to $16 range (unadjusted), barely above deepwater costs. Because costs were barely covered and deepwater was very much a frontier (i.e., relatively high risk) area in the early 1990's, deepwater development could not proceed. The benchmark price for planning was essentially the same as the market price (Le Blanc 1997b).

By the end of the 1990's, the benchmark prices used by industry planners had begun to come down in real terms. There is, however, no consensus on planning benchmark prices. Most companies use a range of prices. For BP Amoco, the mid-point of this range from 1994 to 1998 was $16 (unadjusted). By 1999, this mid-point was down to $14. Even more interesting, in 1999, the company was basing its financial planning on the "challenging" assumption of oil at $11 a barrel (Gibson-Smith 1999). These benchmarks probably represent the low end of the spectrum for the industry. Another perspective on mid-1990's benchmarks found them above BP Amoco's figures. In 1997, industry executives were reported to have used price scenarios in their planning for projects of $2 and $18 (unadjusted), for gas and oil respectively. Although the figures were considered conservative (i.e., low), technology and a low cost structure was allowing operators to gain profits at these price levels (Von Flatern 1997a).

In trying to determine the benchmark related to the most likely future price of oil and natural gas, the industry's conservatism has now pushed most planners to an oil price somewhere in the mid to high teens. In the year 2000, this price seems to average $18 per barrel, and was only recently raised to that level. It would probably take relatively high prices for a few years to nudge the benchmark higher (Cunningham 2000). For Conoco, planning is done on the basis of long-term prices between $16 and $18 per barrel (Bishop 2000). In remarking that all companies operate with benchmarks, an industry official noted that perhaps the most current (i.e., in 2001) was $18 per barrel in constant dollars (Griffith 2001). A major investment bank had a somewhat different perspective seeing the planning benchmark for oil continuing to be in the mid-teens (Staff 2000f).

Technology plays an important role in establishing benchmarks of future prices, at least those concerned with the lowest prices that allow companies to make an acceptable return on investment. By lowering costs with technology, companies also lower the threshold at which adequate financial returns can be realized.

This other type of benchmark price—the lowest price at which companies can continue to operate projects profitably—has undergone change in the last two decades. Thus by 1997 lower costs were allowing companies to make profits at prices of $15 a barrel or lower (Coy and McWilliams 1997). As noted above, BP Amoco has set a goal of being profitable with oil at $11 (Gibson-Smith 1999).

Anything significantly below $10 per barrel is not sustainable, however, as the fundamentals of supply and demand are disrupted by lack of investment. Somewhere around $8 to $9 per barrel, disinvestment by the industry begins, leading to tighter supplies and higher prices (Gibson-Smith 1999). The Federal Reserve Bank shares this view. If oil prices fall below $10 and remain in those levels, Texas producers will have difficulty covering costs, and would have to cede production to lower cost areas of the world (Gunther et al. 1999).

Changes have not only been reflected in lowering this "worst case" benchmark price, but also in how companies respond to changes in oil prices. The use of conservative benchmarks allows companies to survive periods of lower prices that would have been disastrous in the past although it also tempers new activity when prices increase dramatically (Coy and McWilliams 1997). Conservative benchmarks used by operators have kept oil price increases from translating into a rush of drilling contracts (Plaisance 2000). Despite the surge upward in prices for oil and gas in 2000, people in the industry are expected to remain cautious. Especially for deepwater projects, companies are not expected to reap significant economic advantage from reacting precipitously to near term price rises (Bell 2000).

It is useful to note that different segments of the oil and natural gas industry view benchmarks differently. Most of the material above applies best to the major oil companies. Independents that rework properties already exploited by the majors will need higher benchmarks. An official at such a firm noted that a workable benchmark price range for crude oil would be $20 to $26 and for gas about $3. This would permit effective planning and allow projects to go forward. Lower prices—perhaps $18 for oil and $2 for gas—make it hard to complete projects and discourage capital expenditure (Jeppesen 2000).

If the benchmark prices used by oil industry planners are compared to the actual world price over time, what may emerge is a general tendency for the gap between the benchmark price and the actual world price to increase over time. That is, because costs are dropping at a rate faster than any long-term decline in prices, the benchmark price tends to be increasingly lower than the actual world price. While this pattern holds over longer periods of time, it is clear that during shorter periods, this gap may grow dramatically when actual prices spike or may disappear completely when world oil prices collapse as happened in 1998 and 1999.

Ultimately much of what allows industry to plan for the future using lower benchmark prices is technology. By increasing productivity, technology tends to lower the costs of finding and producing oil and natural gas.

3.3.3 Oil Price Changes as a Driver of Technology

In the simplest terms, there is no direct, immediate link between oil price changes and technology. Interest in technology does not rise or fall with changes in the prices of oil and natural gas. If this were the case, investment in technology, application of technology, and creation of technology-based companies would show a stop-and-start pattern. If price were a driver of technology, one would expect to see a volatile interest in technological development that tracked oil or gas prices. This does not appear to be the case. Indeed, it is difficult to imagine the requisite continuous application of research and development effort that is the hallmark of the recent success of technology in the context of a volatile and unpredictable driving force (i.e., oil or gas prices).

Since 1980, technological development and its application in the oil and gas industry has shown three broad trends. The first is a period of high prices and little impact from technology. This period ended around 1985. For the next 10 years or so, technology began to have a more distinct effect on overall industry success with annual increases at an estimated average rate of 8.3 percent over the period 1986-1995 (Forber and Zampelli 2000). Prices were relatively low in this period although there were sharp increases and decreases. Finally, since 1995, technology seems to have had a sharply increased effect on the oil and gas industry. Over the past 5 to 6 years, prices have both collapsed and sharply risen.

These three broad trends and the behavior of prices may suggest an inverse correlation between oil prices and the effects of technology. That is, lower prices may tend to encourage technological development as a way to lower costs. In periods of higher prices, technology-driven cost cutting may seem less important.

This relationship, however, does not seem to comport with industry's own view of its responses to oil and gas price changes and the role of technology. That view, discussed in the previous two sections, suggests that the experience of collapsing oil prices in the mid-1980's was a turning point for the industry overall, leading to a permanent concern with cost reduction, efficiency, and productivity.

Thus, instead of a more dynamic relationship between oil and gas price changes and technology, there is a more static relationship. Changes in oil prices—particularly the increased volatility in prices that has marked the last 20 years—have been instrumental in the oil and natural gas industry's embrace of technology because of its ability to lower costs and help to manage risks. As noted earlier, the oil and gas industry is well aware of its inability to influence the course of prices, especially when oil and gas prices are low. With the revenue side under the control of national or world markets, industry did what it could and chose to control costs. One way has been through implementation of technology (Le Blanc 1997b).

This concern with cost reduction and risk management is insufficient to explain the application of technology. Another necessary driver is the nature of technology itself. Technology seems to be largely driven by its own internal momentum that seeks greater effectiveness, efficiency, productivity, or speed. For generic technology such as information technology or telecommunications, advances are created by technology companies—large and small—that are always interested in new product development. The ongoing competition between Intel and Advanced Micro Devices for ever-faster computer chips is an example of product driven technological improvement.

The development of more industry-specific technology such as seismic imaging is also largely driven by the desire to increase effectiveness, efficiency, productivity, or speed. In many of these cases, the driver of technological development can be defined as specific problems the industry faces. These include the need to identify hydrocarbon reservoirs, to operate in deep water, or to increase the portion of hydrocarbons extracted from known reservoirs. Many of these advances are incremental, known as next-step technologies, that are focused on whatever is the most immediate barrier to success in the field. Most technological advances either reduce costs directly or lead to other advances that reduce costs. Better seismic imaging reduces the chances that a new well will produce nothing and increases the production from known reservoirs. Both consequences reduce the costs of finding and producing a barrel of oil.

From an economic perspective, cost management is then a more direct driver than price. The ability of technology to reduce costs is clearly proven and relatively predictable. This is a benefit to oil and gas companies regardless of oil prices. When prices are high, profits are greater. When prices drop, the window of opportunity for profitable operations is greater. A fuller explanation of what drives technology combines the advantages of lower costs with technology's long track record of always striving for the next new (and improved) product.

3.3.4 Prospects for Future Technology and Likely Relation to Oil Price

As has been true of technology development over the past 20 years, the relationship between future technology and the price of oil and gas will be strong, but indirect. Given the industry's inability to control prices and the well-established history of price changes and volatility, the desire to control and lower costs will remain a major force behind the introduction of new technology.

Closely linked to cost reduction is the idea of next-step technology. The industry is constantly facing technical challenges that constitute the next incremental step in improving any number of processes involved in finding, producing, and bringing to market oil and natural gas. Solving these kinds of problems is in fact the principal goal of most industry research and development.

A third factor driving future technology is the desire of individual companies to create new products. This is particularly true for the newer, still evolving technologies such as computers and telecommunications where the rush to market the next, even more powerful, service or machine has been the overriding motivation for the past two decades.

With these factors in play, the oil and natural gas industry fully expects technology to continue to lower costs (Loth et al. 1999, Van Wie 2000). BP Amoco, for example, looks to technology to reduce liquid natural gas (LNG) production costs by 25 percent within 5 years, and to reduce onshore pipeline costs by a similar amount over 5 to 10 years (MacKenzie 2000). An article looking at future technology found some experts estimating that offshore technology could be 50 percent cheaper by 2005 and that by 2002 offshore well costs could drop $5 million to $12 million (Staff 2000h).

Despite this optimism, others are concerned that the oil and natural gas industry's ability to lower costs will be thwarted by the major technical challenges posed by deepwater and other frontier areas. As the more easily developed areas are exploited, the industry has always searched in more difficult areas. Whether cost saving technologies can keep pace with these challenges or fulfill their expectations are major uncertainties. Thus, some observers have estimated that, relative to the mid –1990's, finding and development costs have not decreased. This reflects in part the greater costs of development in deepwater where there may be a trend to higher capital costs early in projects' lives because of greater initial drilling activities. Deepwater projects could reverse the trend of lower costs, and will also lead to more cost management challenges. Companies may struggle to maintain profits in the future as more projects take place in deepwater or are related to stranded gas (Traynor 2000). For a more specific view, one expert noted that dual rig drill ships are expected to become efficient and economical, although major problems in managing two strings of pipe below a ship remain. The 40 percent savings forecast when dual-ships were introduced has not yet been realized (Ellis 2001).

While most industry experts and observers anticipate change in industry-specific technologies, a few look to information technology and related technologies as the sources of future changes. The ability to complete business transactions on the internet, for example, has radically reduced the time and effort required to complete sales of energy contracts for companies like Enron (Porubon 2001). This same technology opens up the possibility of electronically buying and selling oil and gas assets. This would allow companies to manage their portfolios of oil and gas producing properties in a fundamentally new manner by reducing the time required to complete transactions and by opening the market to any company with access to the internet. One ultimate outcome of this technology may be a "virtual" company that delivers energy to customers, but never actually finds, produces, or owns the energy. These e-commerce changes may provide another level of protection from the vagaries of oil and gas price changes, allowing companies to adjust to such changes almost instantaneously.

The range of technological improvements and challenges that industry experts and observers anticipate is vast and relates to seemingly every activity that industry undertakes. The following is a brief list of these areas of or opportunities for future technological development.

Exploration

- Increased computing power and speed will reduce the time required to interpret seismic data, thereby further lowering costs and risks significantly (Cunningham 2000).

- Opportunities exist for improvement in using seismic data to assess sub-salt formations. Salt deflects seismic energy in irregular patterns, making less accurate images. Longer seismic cables have helped capture more of the deflected seismic energy, getting more data that can eventually go to make up a 3D picture (Van Wie 2000, Knight 2000).

- Improved interpretation and additional experience with seismic imaging technology will help to identify next-step solutions and responses. Interpretation of the older formations, for example, could advance and support fresh approaches to even deeper exploration (Griffith 2001).

Drilling

- The loop current and eddy phenomena in the GOM deepwater are not well understood. The difference between pore pressure and fracture gradients is very narrow in GOM compared to other areas; there is also a lack of overburden to give formations strength. At present, these problems drive up costs for drillers (Plaisance 2000).

- Expandable casing, not now available, will permit much faster drilling (Knight 2000).

- Improvements in drilling technologies will be important because the major capital expenditure item is still drilling. Lower drilling costs will encourage the development of smaller prospects (Cunningham 2000).

- Companies are still learning a great deal about drilling deep wells in deepwater. The next year or so should be important learning time in this area (Farnsworth 2000, Van Wie 2000).

- Logging technology will continue to improve, cutting drilling time and making it possible for drillers to avoid potentially costly errors and accidents (Mitchell 2000).

- A focus for change is drilling technology resulting in higher efficiencies and improved reservoir drainage. Cost-reducing technology could make offshore technology 50 percent cheaper by 2005. By 2002 well costs could drop $5 to $12 million (Staff 2000h).

- A major challenge is the ability to drill horizontally in soft offshore formations, while keeping the hole open and free of sand. It is hard to gravel pack such horizontal wells and eliminate void spaces where sand will come through and rapidly stop flow. The industry is still experimenting with gravel packing on horizontal wells (Utsler 2001).

- Increasing experience with deepwater formations and characteristic low fracture gradients is improving flow rates, making projects more economical for operators. Expandable casing has made fracturing more efficient. Dual rig drill ships will probably become efficient and economical (Ellis 2001).

Production

- The same kind of technology surge that pushed North Sea development to develop will likely occur in deepwater GOM. The major unresolved production problem in deepwater GOM is storage of natural gas (Taylor 2000).

- Another bottleneck area is gas-to-liquids technology. To avoid flaring gas, and in the absence of pipelines, some sort of compact gas-to-liquids plant that one could install on a floating facility is needed. Improvements in gas-to-liquids technology would allow deepwater to take off (Plaisance 2000, Van Wie 2000).

- With respect to deepwater activity, the big area in which there could be breakthrough is in handling gas. The rough topography of parts of the deepwater GOM sea floor presents special problems to pipelines, and there are problems with respect to size of lines and high pressures encountered. The bottleneck in handling gas is a challenging one, and the breakthrough would be in the area of gas-to-liquids conversion (Bishop 2000).

- Current technological bottlenecks in deepwater GOM are largely related to flow assurance and storage. Incremental improvements in production technologies will probably continue to cut costs in the future (Cunningham 2000, Farnsworth 2000).

- Further development of “intelligent wells,” with onshore monitoring and control through fiber optical connection has important possibilities (Farnsworth 2000).

- Water depth limitations still need to be overcome. Petrobras has made some advances in this area. In approximately 15 years (i.e., by 2015), the oil industry will be capable of reaching all of the world's seabed (Bell 2000, Staff 2000h).

- Tension Leg Platform and drill ship technology will advance incrementally to facilitate operation in progressively deep water (Pattarozzi 2001).

- The future of the industry will include floating and subsea production as the industry moves into deeper waters. Floating production systems will be interchangeable, units will act as drilling and production vessels, and mobile production systems will demand more flexibility. Success resulting from these advances, however, may lead to new technology challenges related to transporting oil long distances in deepwater pipelines (Staff 2000h, Loth et al. 1999).

Other

- One industry expert believes breakthroughs will chiefly come in applied computer technology. Improvements are expected in automation systems or in tracking data and capturing gas flow measurement, but there are other areas where applied computer technology may create substantial breakthroughs (Kappmeyer 2001).

- Speakers at an offshore technology conference believed that e-commerce technology had the promise to revolutionize the oil and gas business (Wetuski 2000).

Finally, much of the focus for future technological change may shift from oil to natural gas. Upstream capital spending should rise in the 2001-2005 period compared to 1990-1999. Much of this spending will be aimed at gas, not oil (Traynor 2000). BP Amoco thinks gas will be the fuel choice of the 21st century and customers are seeking cleaner transport fuels and petrochemicals. One response to this is to synthesize more hydrogen-rich clean fuels from natural gas. BP Amoco is currently focused on gas-to-liquids technologies. BP Amoco looks to technology to reduce LNG production costs by 25 percent within 5 years, and to reduce onshore pipeline costs by 25 percent over 5 to 10 years. The next step is gas for chemicals in 5 to 10 years time followed by gas for transport fuels in 10 to 15 years (MacKenzie 2000).

3.4 Labor

People with many different skills work in the oil and gas industry – geophysicists, petroleum geologists, petroleum engineers, rotary drilling crews, general laborers called roustabouts, welders, pipe fitters, electricians, and machinists, to name a few. Offshore work also requires cooks, radio operators, and helicopter and marine transportation support. No single source provides employment estimates in the oil and gas industry. Not only are there many different skill sets involved but the workers in the oil and gas industry are employed by oil companies, and drilling contractors, transportation companies, and service companies and other vendors, depending on the nature of their work. Those working for the oil companies are direct labor. Those working for companies providing a service to the oil companies are indirect labor.

For purposes of this discussion three categories of oil and gas workers will be used.
The first is oil and gas extraction (SIC 13) which includes oil and gas exploration, drilling, well operation and maintenance activities, and the operation of natural gasoline and cycle plants. The second is crude petroleum and natural gas (SIC 131) which includes establishments engage in activities such as petroleum and natural gas exploration, drilling, completing, and equipping wells, and activities in preparation of oil and gas up to the shipment from the producing property. The third is oil and gas field service (SIC 138) which includes establishments that primarily drill wells for oil or gas field operations for others on a contract or fee basis. The crude petroleum and natural gas and oil and gas field service

sectors are subsets of the oil and gas extraction category. All three sectors include workers in the entire oil and gas industry, that is, they are not limited to the offshore portion. Employment in these three sectors between 1980 and 2000 is shown in Figure 22. The trends seen in employment in these sectors are compared below to oil and natural gas prices between 1980 and 1999 for gas and 2000 for oil.

3.4.1 Oil Price Variability and Employment

Employment in oil and gas extraction peaked in 1982 at 708,300, a year after the peak in oil price during the period 1980 to 2000. Between 1970 and 1981, the sector created 438,000 jobs (U.S. DOL, BLS, 2001d). In 1982, larger volumes of oil became available from oil-producing countries around the world causing oil prices to collapse by 1985. Oil prices declined between 1982 and 1986, rose in 1987, declined in 1988, rose in 1989 and 1990, then declined annually between 1991 and 1995, rose in 1996, declined annually between 1997 and 1999, and then rose again in 2000. Oil prices between 1982 and 2000 never came close to the high of $54.46 (2000 dollars) per barrel in 1981, and reached a low for the period under discussion of $11.26 (2000 dollars) in 1998. Employment in oil and gas extraction declined beginning in 1983, a year after the peak employment and 2 years after the peak oil price and, expect for 1984 and 1990, declined every year between 1983 and 1995. Employment rose between 1996 and 1998, declined in 1999 and then rose again in 2000. Employment in 2000 was estimated at 304,400 compared to 559,700 in 1980 (U.S. DOL, BLS, 2001a). So, while oil prices rose and declined between 1981 and 2000, employment essentially fell. Figure 23 shows oil prices and oil and gas extraction employment between 1980 and 2000.

Figure 24 shows oil prices and crude oil and natural gas production employment between 1980 and 2000. Like oil and gas extraction employment, crude petroleum and natural gas employment peaked in 1982, the year following the peak oil price. Employment in the sector then declined annually, except for 1991, through 2000. Employment in 2000 was estimated at 127,400 compared to 219,600 in 1980 (U.S. DOL, BLS, 2001b).

Employment in oil and gas field services and oil prices between 1980 and 2000 are shown in Figure 25. In general, employment in this sector closely follows the increases and decreases of oil price. Price tends to affect upstream oil and gas industry jobs through effects on drilling and production, that is the jobs in this sector. There tends to be an immediate effect on exploration activities. Higher prices result in increased drilling. However, the impact of price on production is smaller. Employment increases when oil prices increase, but not as much as oil prices (Kendall, 1999). Oil and gas field service employment was estimated at 172,200 in 2000 compared to 333,800 in 1980. Employment in the sector peaked in 1982, the year following the peak oil price (U.S. DOL, BLS 2001c).

A number of factors contribute to overall employment declines in oil and gas industry sectors between 1980 and 2000, a time when oil prices experienced some volatility. The factors included corporate strategies to reduce costs and technological advances which reduced the need for oil and gas platforms on the one hand and created jobs in data processing and interpretation on the other. See Section 4.3 for a discussion of technology and labor needs and location and Section 4.4 for a discussion of labor and corporate strategy.

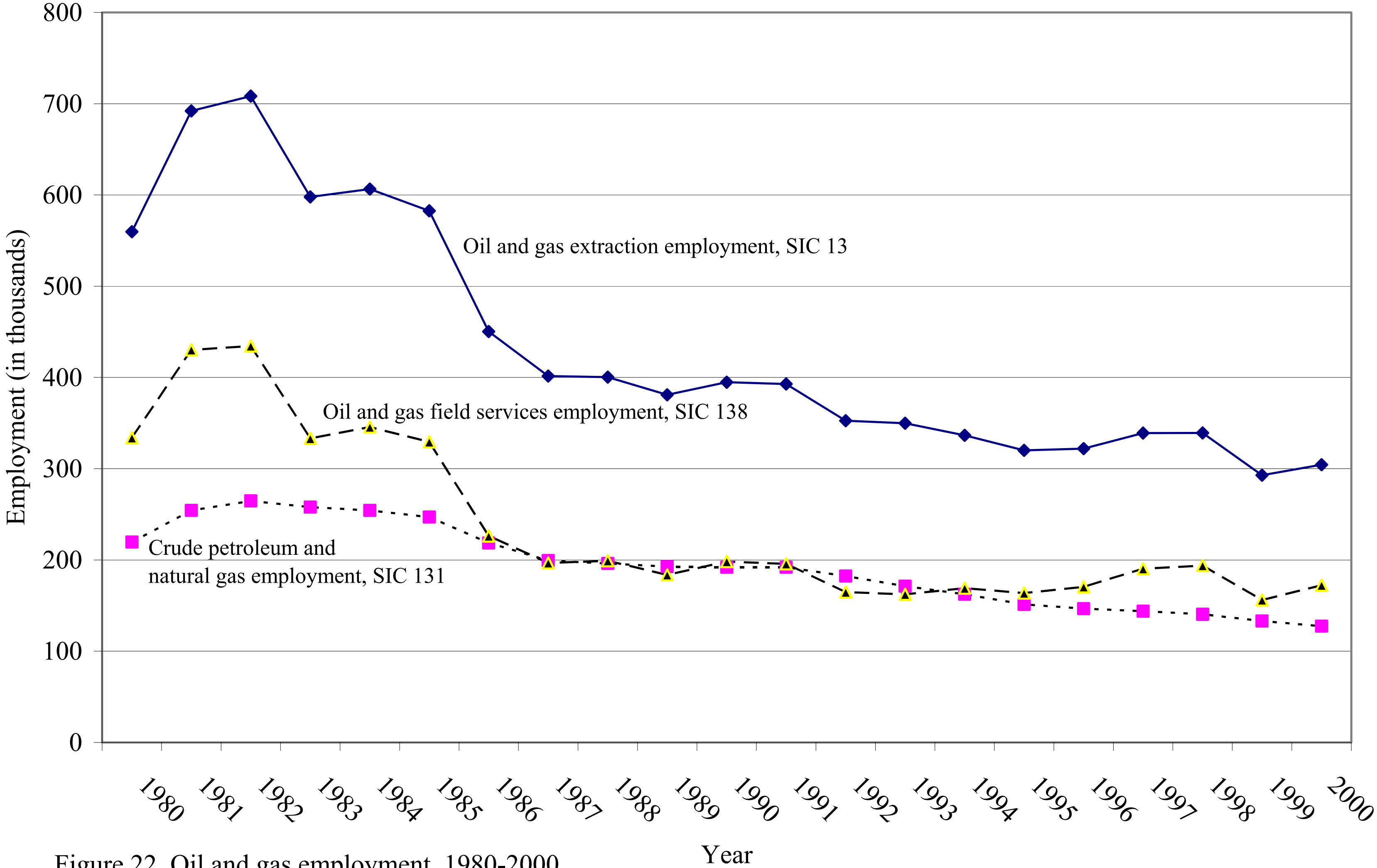


Figure 22. Oil and gas employment, 1980-2000.

Sources: U.S. DOL, BLS 2001a, b, and c.

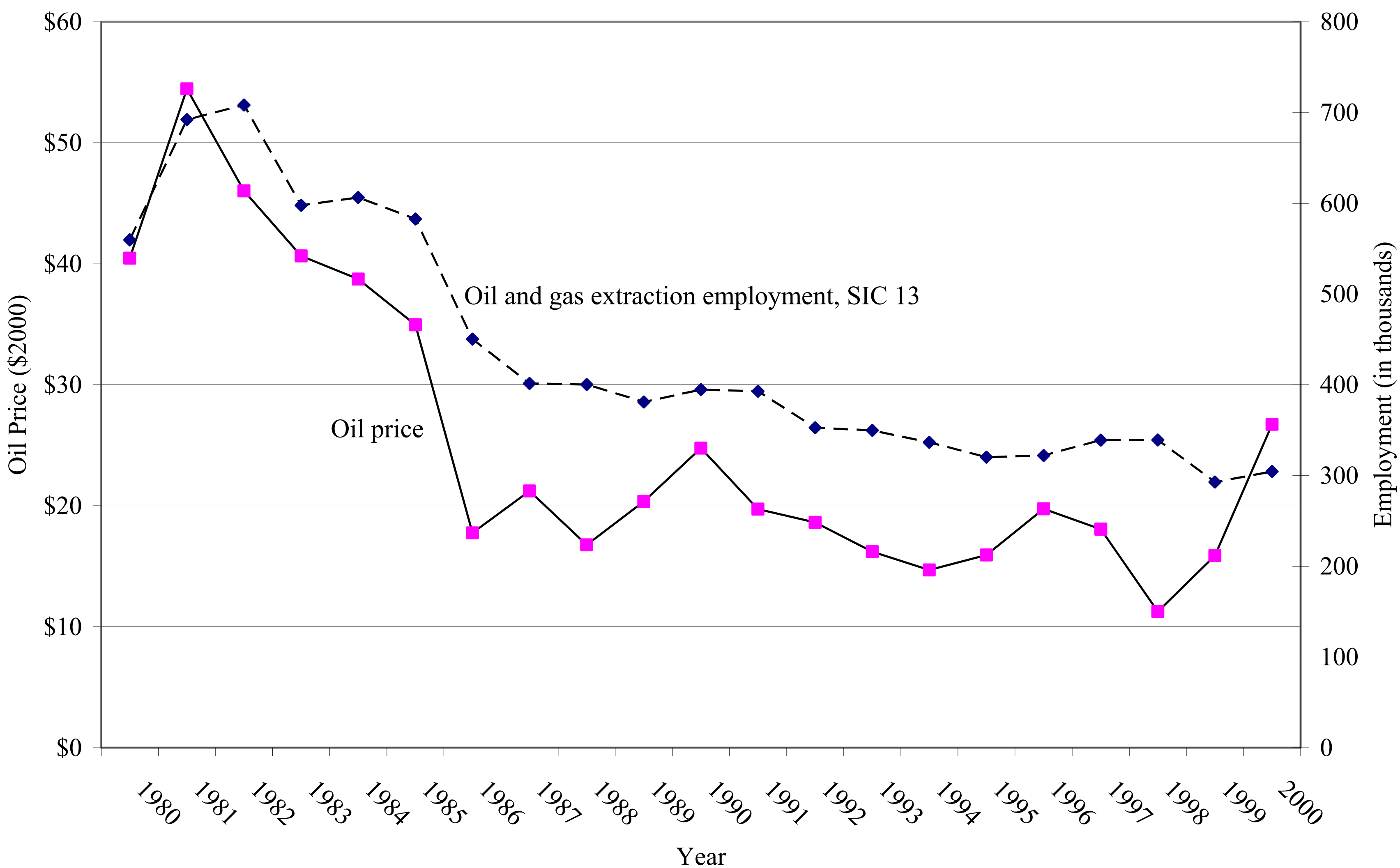


Figure 23. Oil price and oil and gas extraction employment, 1980-2000.

Sources: U.S. DOE, EIA 2001a, U.S. DOL, BLS 2001a.

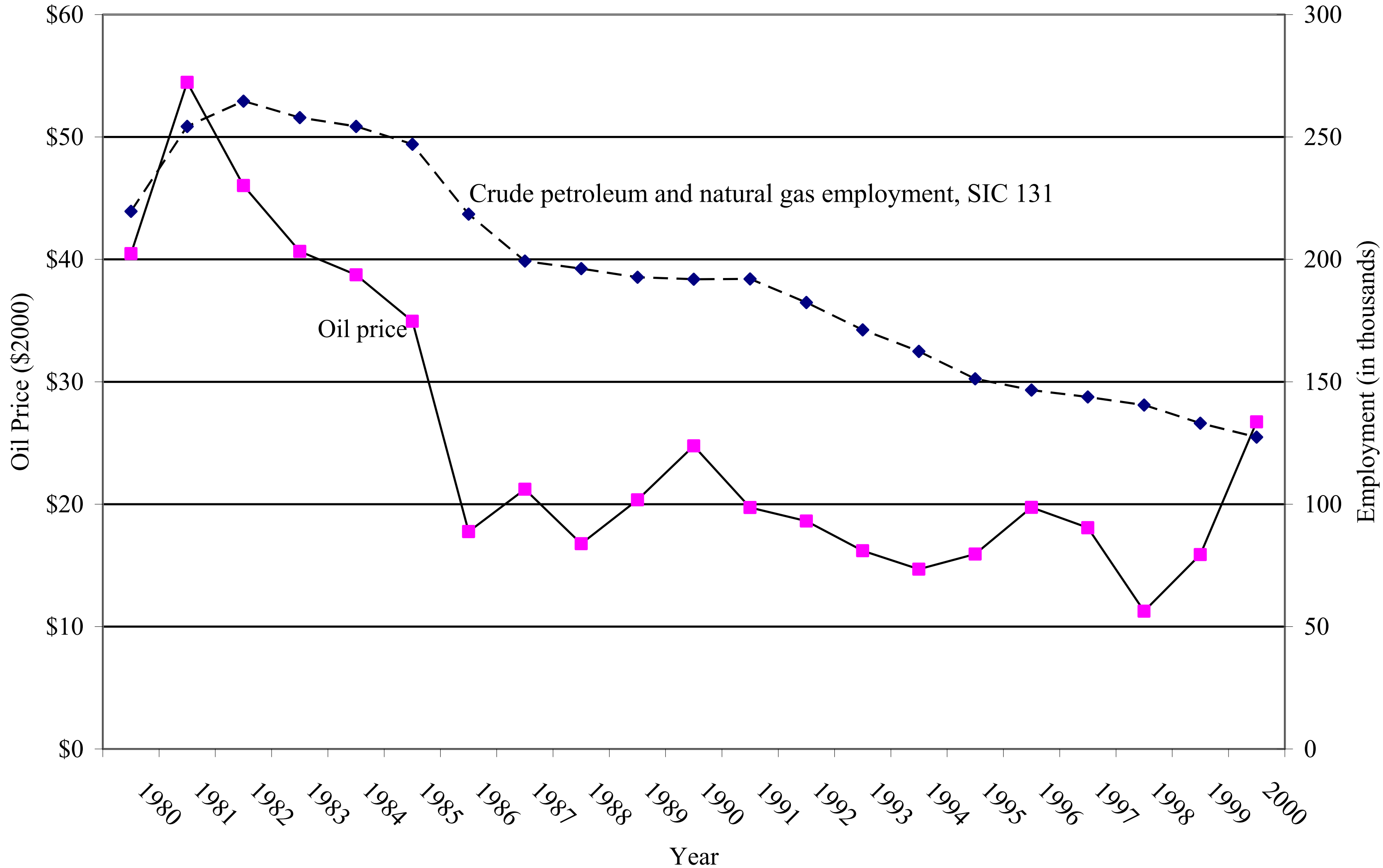


Figure 24. Oil price and crude petroleum and natural gas employment, 1980-2000.

Sources: U.S. DOE, EIA 2001a, U.S. DOL, BLS 2001c.

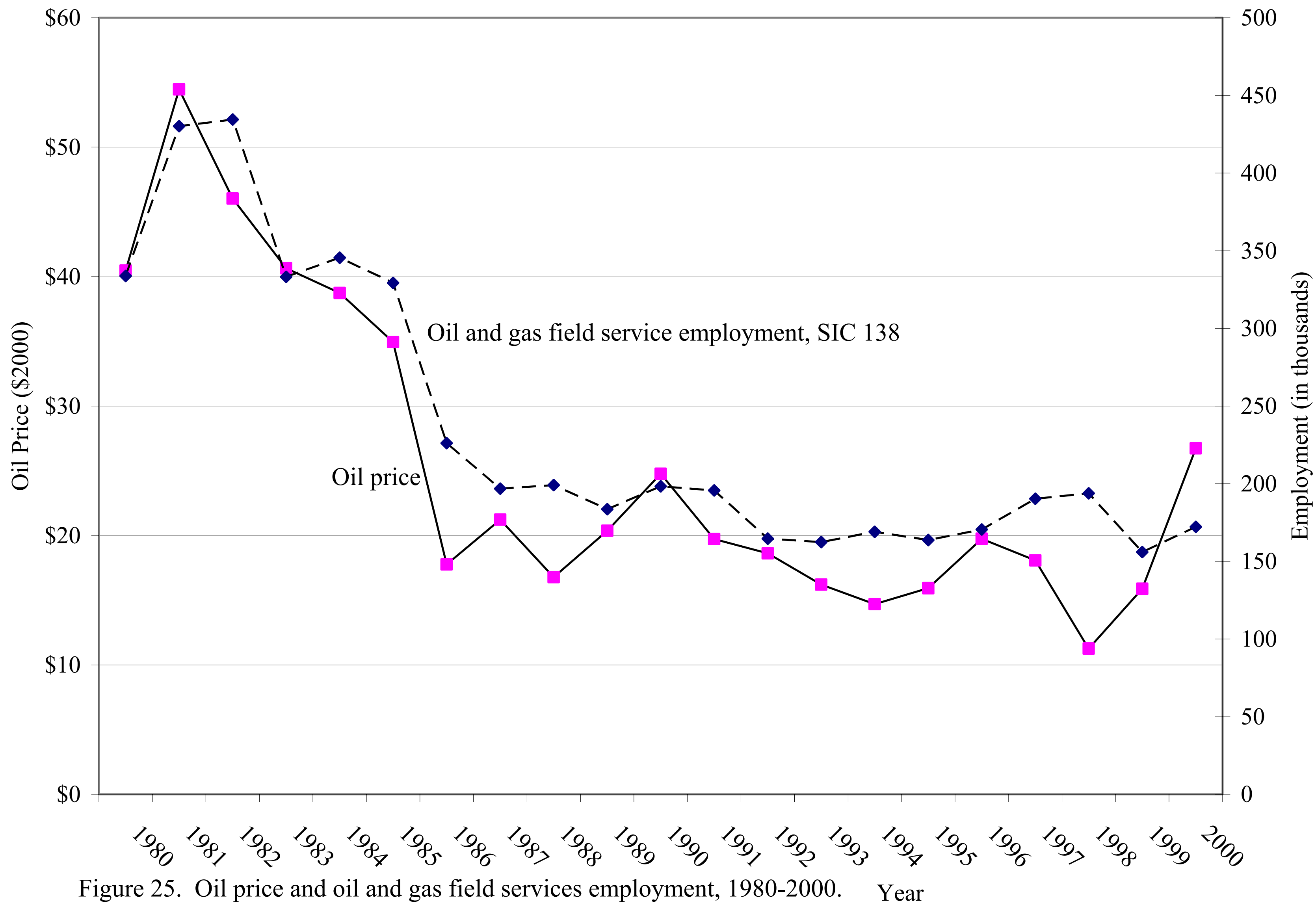


Figure 25. Oil price and oil and gas field services employment, 1980-2000.

Sources: U.S. DOE, EIA 2001a, U.S. DOL, BLS 2001b.

3.4.2 Natural Gas Price Variability and Employment

Natural gas wellhead prices (real prices) between 1980 and 2000 peaked in 1983, a year after the peak oil price during the period. Between 1984 and 1991, natural gas prices declined as did oil and gas industry employment. The price then increased between 1992 and 1994 before falling to the low for the period in 1995. It then increased in 1996 and 1997, decreased in 1998, and increased in 1999. The price in 1999 was the same as it was in 1990 and below the price in 1980. As show in Figure 26, employment in the oil and gas extraction sector declined over the period. Between 1980 and 1990 employment and natural gas prices fell. In the 1990's, natural gas prices rose and fell while oil and gas extraction employment did not experience the same increases and decreases.

Figure 27 compares the trends in natural gas wellhead price to employment in the crude petroleum and natural gas sector. The employment in this sector declined fairly steadily over the period and did not experience increases in the 1990's at the time that natural gas prices experienced volatility.

As show in Figure 28, employment in the oil and gas field services sector tracks fairly closely with natural gas wellhead prices. Employment, however, did not experience the same volatility as price in 1990's. In 1999, the price of natural gas went up while oil and gas field service employment went down.

3.5 Regulatory Environment

The regulatory environment of offshore oil and gas activity as it related to oil and gas price change is addressed in two ways. First, the work environment of the gulf is compared to that of the rest of the world. Some companies have the option to work outside the gulf, so that when conditions change they can shift their investments geographically. Other companies focus their activity on the gulf or North America. Second, the major regulators and the major environmental regulations affecting offshore oil and gas activities are discussed. Cost of compliance with regulations adds to the costs of doing business and, therefore, is a component in oil and gas prices. The regulators also affect access to search for oil and gas and, therefore, affect access to potential supplies of oil and gas. (Also see Section 3.2.1.2 for a discussion of legislation and FERC orders affecting the wellhead price of natural gas.)

3.5.1 Gulf of Mexico Versus the Rest of the World

The offshore oil and gas industry grew from the Gulf of Mexico. The first well drilled from a fixed platform almost out of sight of land in federal waters occurred in 1947 south of Terrebonne Parish, La. Since then, the industry has expanded to the North Sea, West Africa, South America, Asia Pacific, the former Soviet Union, Australia, and Canada. The Gulf of Mexico competes with basins around the world for development capital. After the collapse of oil price in 1986, exploration budgets increasingly shifted to overseas so in 1988 more investment was made outside the U.S. than within it (Staff 1992a).

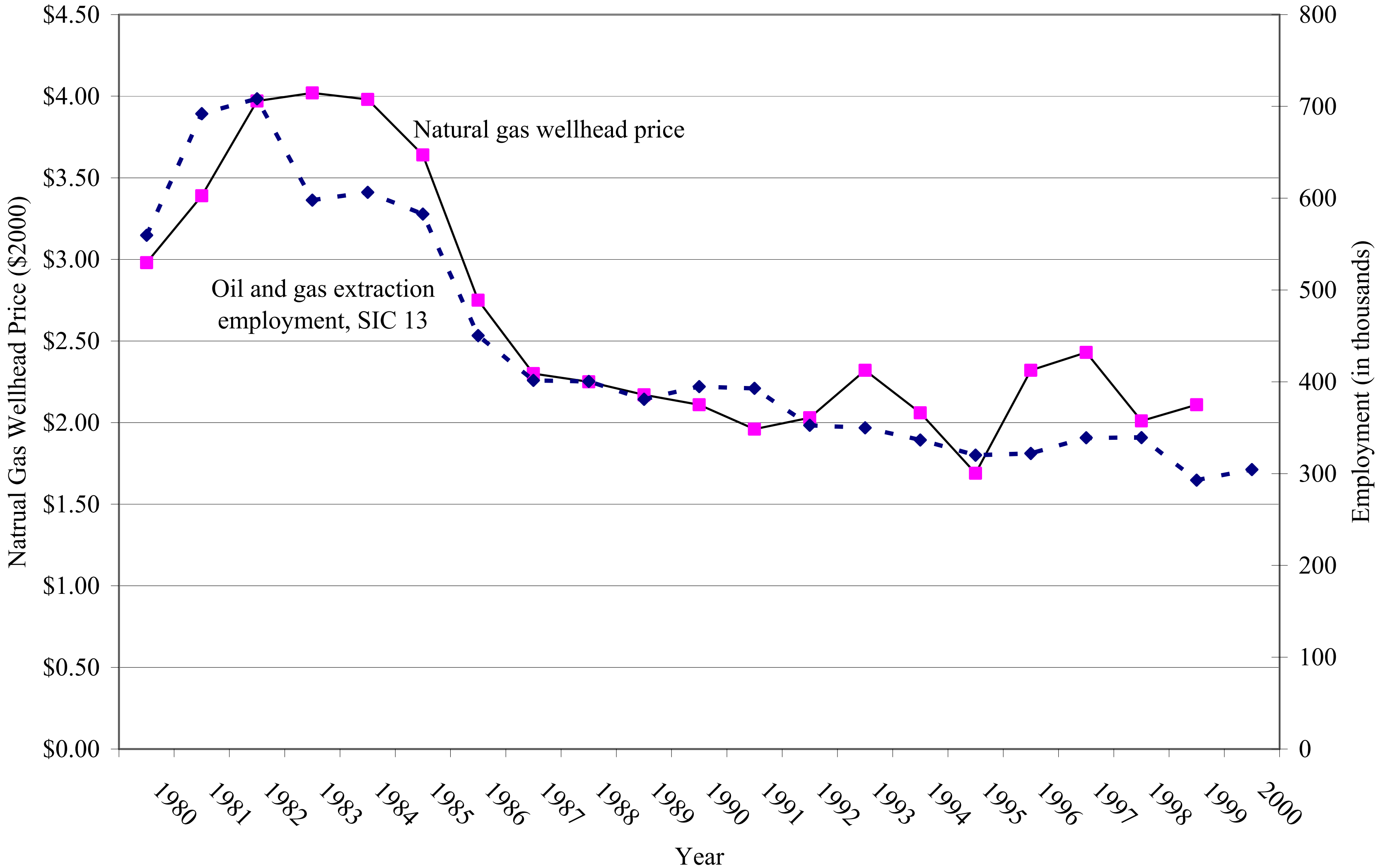


Figure 26. Natural gas wellhead price and oil and gas extraction employment, 1980-1999.

Sources: U.S. DOE, EIA 2000b, U.S. DOL, BLS 2001a.

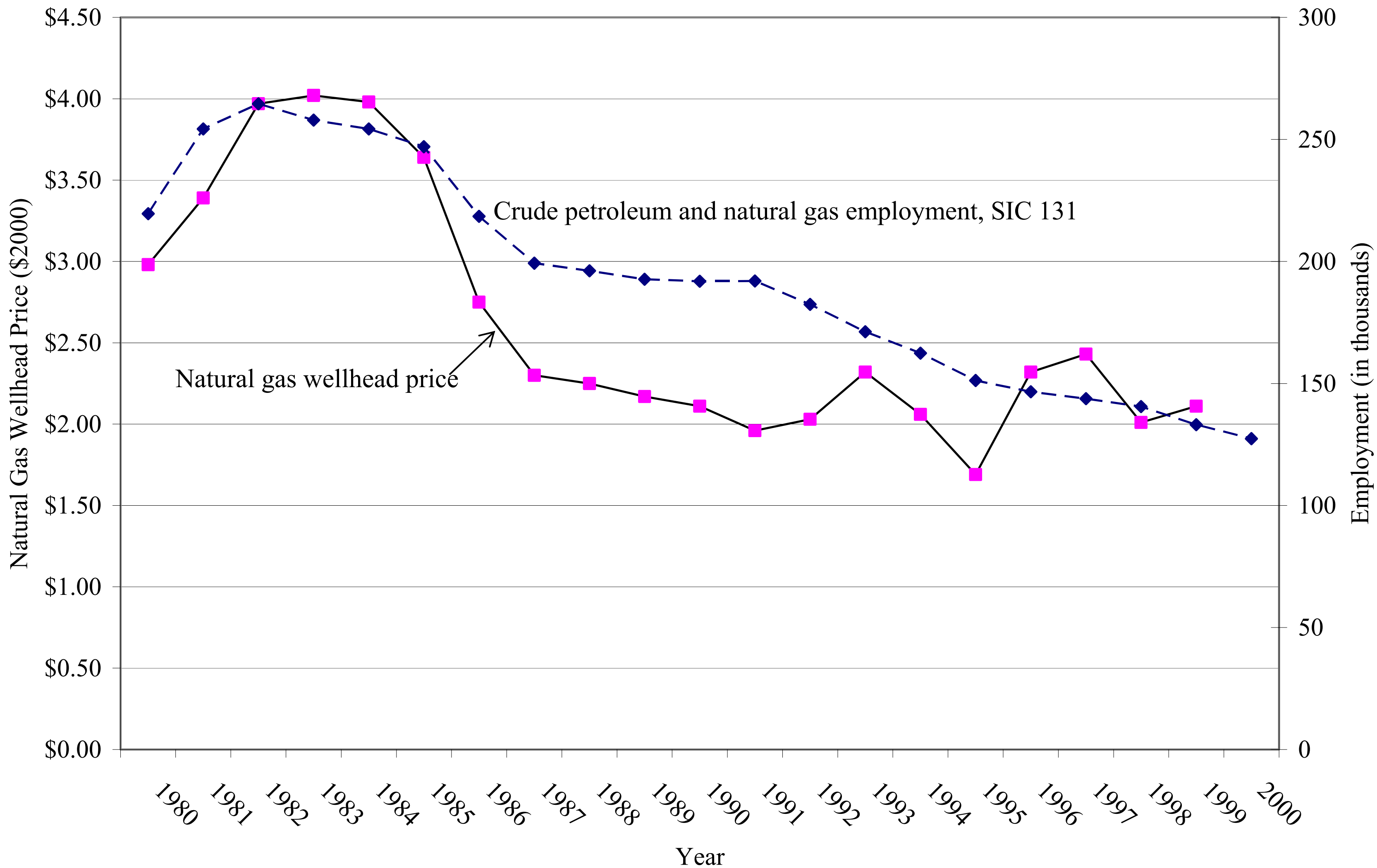


Figure 27. Natural gas price and crude petroleum and natural gas employment, 1980-1999.

Sources: U.S. DOE, EIA 2000b, U.S. DOL, BLS 2001c.

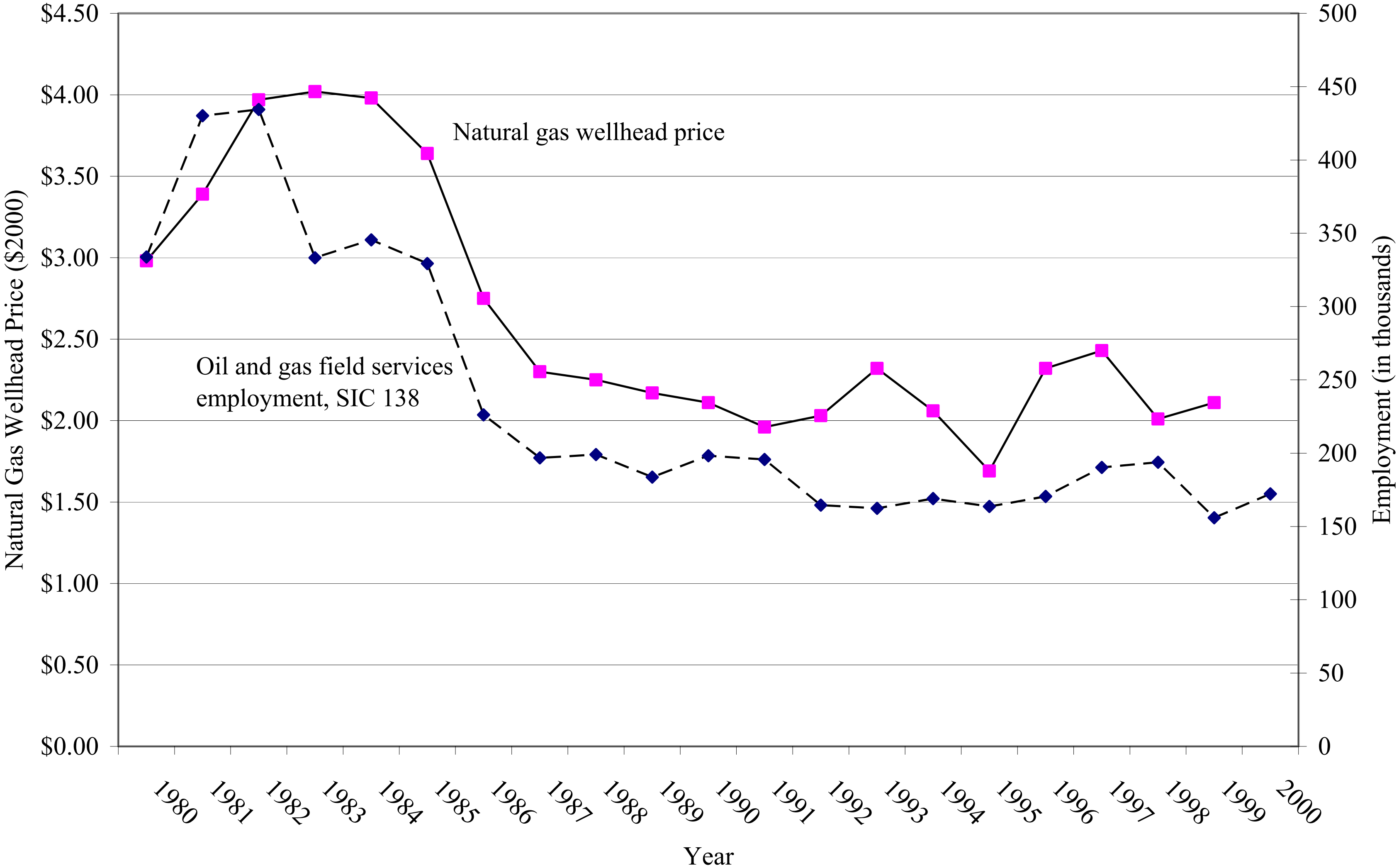


Figure 28. Natural gas wellhead price and oil and gas field services employment, 1980-1999.

Sources: U.S. DOE, EIA 2000b, U.S. DOL, BLS 2001b.

Table 10 highlights some of the advantages and problems of working in the GOM articulated in discussions with industry representatives for this study. The advantages tend to focus on the existing infrastructure and the low political risk. The regulations and the regulators are known and viewed as fair. The disadvantages range from natural characteristics which make drilling challenging to unresolved technology problems in deepwater.

The alternatives to the GOM for companies that work outside the gulf, that is overseas locations, offer challenges that are not captured in Table 10. The North Sea, for example, has harsher environmental conditions than the gulf, which affects platform design and safety systems. Portions of the North Sea have a unionized labor force which add to project costs. Political instability and terrorism is a fact of life in some areas. For example, more than 200 employees and contractors of Chevron Nigeria Ltd, a subsidiary of Chevron Corporation, were taken hostage by youths armed with machetes, knives, and clubs on an offshore platform in 1998. Nigerian law enforcement lacked helicopter transportation and expertise to land on an offshore platform so Chevron had to supply transportation for law enforcement (Staff 1998a). Another problem sometimes encountered in lesser-developed areas of the world is unstable local banking institutions. Logistical challenges can also be present. Remote areas without medical infrastructure offer special challenges in providing health care. Shifting tax laws, cancelled contracts, and a history of reneging on debt has made business in post-Soviet Russia unacceptably risky in the absence of very high oil and gas prices (Varoli 2000).

For some companies, the rest of the world is limited to the gulf or North America because the companies are structured to only work in those areas. These companies do not have the option of shifting their exploration budgets overseas if price conditions change. Limitations on leasing areas in the gulf restrict the options of these companies more than those that work internationally or globally. Beginning in 1983, Congress imposed a series of annual leasing moratoria in the Eastern Gulf of Mexico Planning area, south of 26 degrees north latitude and east of 86 degrees west longitude (Gachter 1994). President George Bush, in 1990, imposed an administrative moratorium on leasing in several areas through 2002 (Owen, 1993). In 1998, President Bill Clinton extended these for 10 years to 2012 (Staff 1998b).

For foreign companies, the gulf is part of the rest of the world. Non-U.S. companies are attracted to the gulf for many of the same reasons that U.S. companies are. They have expertise amassed in producing basins around the world that is being applied in GOM deepwater. Paris-based Elf Aquitaine through various oil and gas subsidiaries has had a presence in the U.S. for over 30 years, working initially in Alaska and the Lower 48 before refocusing on the gulf in the early 1990’s. It has followed a dual track approach in the gulf -- selective leasing of high quality prospects in OCS lease sales and aggressively seeking partnering and alliance opportunities. Elf maintains a Houston office. Australia’s BHP Petroleum Americas, Inc. started in the gulf in 1994 with a few blocks and through a lease sale and strategic alliances increased its inventory. The gulf is expected to continue to be attractive to non-U.S. companies because of growth opportunities through application of technology and the many opportunities for partnerships and alliances (Staff 1997b).

Table 10

Advantages/Problems of Working in the GOM

Advantages	Problems
Proximity to supplies, staging areas, and market; skilled labor force; access to major contractors and services; concentration of technology development	Federal government opened an area via lease sale, permitted bidding and then closed it to exploration (e.g., North Carolina)
Regulatory compliance costs, except for environmental regulations, slightly less than North Sea, which along with the GOM are the highest in the world	Floating Production Storage Offloading vessels not permitted (but under consideration)
Accessibility of service and supply companies; long term experience working with same companies cuts delivery time; easiest place in world for drilling contractors	Loop currents and eddies in deepwater cause difficulties for drilling contractors
Easier processes to show regulatory compliance compared to other parts of the world	Personnel and equipment, including those needed for deepwater, drawn from GOM when other areas are active
Low political risk	High entry costs of leases
Systematic development of infrastructure	Storage of deepwater natural gas is an unresolved production problem
Proximity and completeness of infrastructure for operations	Potential for increased pressure on support services if deepwater exploration is successful
Can use accumulated experience	
Stable, consistent lease terms	
Reasonably competitive based on fiscal considerations	
Ease of forming alliances in Houston because of the concentration of firms in the area	

Sources: Bell, 2000, Cunningham 2000, Ellis 2001, Farnsworth 2000, Griffith 2001, Hasan 2001, Holleck 2000, Jeppeson 2000, Taylor 2000, Verrett 2001.

3.5.2 Areas of Regulations Governing the Offshore Oil and Gas Industry

OCS oil and gas operations and related onshore facilities are subject to stringent oversight by many federal regulations, and in the case of onshore facilities, by state and local regulations. The cost of compliance with regulations adds to the cost of finding and producing oil and gas. A survey of oil companies doing business in the gulf in the mid 1990's identified the federal agencies having the greatest impact on oil and gas exploration and production activities in the gulf as (Seydlitz et al. 1995):

1. U.S. Department of the Interior, Minerals Management Service
2. U.S. Environmental Protection Agency
3. U.S. Coast Guard
4. U.S. Department of Transportation
5. U.S. Department of Labor, Occupational Safety and Health Administration

MMS was cited as the federal agency with the most effect on their operations most often and by all types of companies (i.e., majors, large integrated, small integrated, large non-integrated, and small non-integrated). Other agencies mentioned, but much less frequently than the top five were: Coastal Zone Management, U.S. Army Corps of Engineers, U.S. Department of Commerce, Federal Communication Commission, Federal Energy Regulatory Commission, Internal Revenue Service (IRS), National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Department of Labor, Office of Central Compliance. (It should be noted that organizationally NMFS is part of NOAA, and both are part of the U.S. Department of Commerce.) This array of federal agencies includes those that regulate more than the oil and gas industry (IRS), those with oil and gas industry-specific regulations (e.g., the U.S. Coast Guard), and those which regulate at least in part on a project specific basis (e.g., MMS).

Another way to slice the examination of the regulatory environment is by the area of concern. Table 11 summarizes major environmental actions affecting OCS oil and gas activities.

The list of legislation and Presidential directives in Table 11 makes several points about the regulatory environment of offshore oil and gas exploration and development. First, there is legislation in place and amended over the years that provides for the procedural steps to finding and production offshore oil and gas, although these caused compliance costs. Second, there are a number of environmental concerns that are addressed in specific legislation (e.g., clean air, clean water, wildlife). Third, beginning in the early 1980's and carrying forward to 1998 a series of restrictions were placed on where offshore oil and gas activities could take place. These limit access to the potential supplies of offshore oil and gas. Since 1990, most of the coastal waters have been off limits to oil and gas activity. Therefore, the supply of uncontracted drillable GOM leases is relatively low.

Table 11

Major Environmental Actions Affecting OCS Oil and Gas Activities

Year	Action	Comment
1953	Outer Continental Shelf Lands Act passed	Provides for federal jurisdiction over the OCS and authorizes the Secretary of the Interior to lease those lands for mineral development
1969	National Environmental Policy Act passed	Requires a detailed environmental review and statement before any major or controversial federal action
1970	Clean Air Act passed	Regulates the emission of air pollutants from industrial activities
1972	Coastal Zone Management Act passed	Requires state review of federal action that affects the land and water use of the coastal zone
	Marine Mammal Protection Act passed	Provides for the protection and conservation of all marine mammals and their habitats
1973	Endangered Species Act	Requires a permit to take an endangered species and that all federal agencies must ensure that federal actions will not significantly impair or jeopardize protected species or their habitats
1977	Clean Water Act passed	Regulates discharge of pollutants into the surface waters of the United States
1981	First OCS leasing moratorium enacted (FY1982)	In central and northern California OCS. Later extended to six other OCS planning areas
1982	Federal Oil and Gas Royalty Management Act passed	Designed primarily to assure proper and timely revenue accountability from production and leasing of federal lands
1983	First preleasing moratorium enacted (FY 1984)	North Atlantic
1984	National Fishing Enhancement Act passed	Encourages using offshore platforms as artificial reefs
1988	First OCS drilling ban enacted (FY1989)	73 existing leases in the Eastern GOM, south of 26 degrees N Latitude. Drilling moratoria later expanded to include North Aleutian Basin and leases offshore North Carolina
1990	Amendments to the Clean Air Act passed	Give EPA jurisdiction for OCS facilities outside Central and Western GOM

Table 11 (cont'd)

Major Environmental Actions Affecting OCS Oil and Gas Activities

Year	Action	Comment
1990 (cont'd)	Oil Pollution Act of 1990 passed	Among other provisions, addresses areas of oil-spill prevention, contingency planning, and financial responsibility for all offshore facilities in, on, or under navigable waterways
	North Carolina Outer Banks Protection Act passed	Includes moratorium language for areas offshore North Carolina
	Presidential decision to withdraw areas from leasing until after the year 2000	Areas offshore California, Washington, Oregon, North Atlantic, and Eastern GOM (south of 26 degrees N Latitude) affected
1994	Presidential Executive Order No. 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations signed	February 11. Requires each federal agency, to the extent practicable and permitted by law, to make achieving environmental justice part of its mission
1995	Deep Water Royalty Relief Act passed	Expands MMS' discretionary authority to grant royalty relief and mandates royalty relief (under certain conditions) for GOM leases in 658 ft or greater water depth
1996	OPA-90 Amendments passed	Applied to financial responsibility for offshore facilities and to spill prevention within state waters
	Section 6003 of OPA-90 repealed	Resulted in repeal of North Carolina leasing and drilling moratorium
1998	Presidential directive under OCS Lands Act to prevent leasing any area under moratorium before 2012	Extended by 10 years the protection provided by DOI's leasing plan

Sources: U.S. DOI, MMS 2001c, U.S. DOE, EIA, 1999c.

3.6 Sidebars

Changes in the dynamics of the oil and gas industry over the past 20 years are reflected in phenomenon not directly related to this study's main concerns. These side issues, however, provide some worthwhile insights into the changes the industry has undergone since 1980.

3.6.1 Results of Oil and Gas as a Reduced Share of Gross Domestic Product

Oil and gas as reduced share of Gross Domestic Product (GDP) leads to diminution of impact of price changes on overall economy and greater willingness of consumers to pay high prices or buy SUVs. As the U.S. economy becomes more service-oriented, the volatility of oil and gas prices becomes less important economically.

In the 1970's and 1980's the oil crises were a major disruption to the U.S. economy and to the everyday lives of Americans. Long lines at gas stations and a sense of panic among consumers were emblematic of the impacts of sharply higher energy prices. Prices also had the effect of restructuring the U.S. automobile industry, national energy policies, and practices of virtually every sector of the economy. Thus, compact, fuel-efficient cars—many from Japan—became a major share of the total U.S. vehicle fleet. The federal government was able to create an increasingly stringent set of fuel efficiency standards for passenger vehicles. Industry invested billions in energy efficiency improvements—from retrofitting fluorescent lighting to installing more efficient electrical motors.

A simple indicator of the importance of oil and gas to the overall economy is a comparison of U.S. energy expenditures and gross domestic product. In 1980 at the height of oil prices, total U.S. energy expenditures were equal to roughly one-seventh of the nation's economic output. By 1990, this ratio had dropped to about one-twelfth of the gross domestic product, roughly the same as in 1970, well before the first oil crisis. By 1997, the latest year for which data are available, total energy expenditures were about one-fifteenth of the gross domestic product, less than half the proportion of 1980. Current energy expenditures now constitute a smaller share of our economy than in the years before gas lines first became a part of the energy history of the country (see Table 12).

Table 12

U.S. Energy Expenditures as Share of Gross Domestic Product, 1970-1997
(in billions of current dollars)

Year	Energy Expenditures	Gross Domestic Product	Energy Expenditures as Share of GDP
1970	83	1011	8.2%
1975	172	1635	10.5%
1980	374	2708	13.8%
1990	469	5546	8.5%
1997	567	8318	6.8%

Sources: U.S. DOE, EIA 1997, U.S. DOC 2000.

The declining role of oil can also be seen in the prominence that major oil companies have among the nation's leading companies. In 1980 after two major increases in oil prices in the previous decade, the Fortune 500 petroleum-refining group, which includes the major integrated oil companies like Exxon and Mobil, accounted for 36 percent of the Fortune 500's net income. By 1990, this share had declined to 21 percent; and by the year 2000, major oil companies accounted for less than 8 percent of the Fortune 500's net income (Nulty 1991, Staff 2001c).

This sense that oil is less important to the economy is part of mainline thinking. The Federal Reserve Bank of Dallas estimated that by 2000 the U.S. economy was about one-third less sensitive to oil-price fluctuations than it was in the early 1980's. Even Texas, the ultimate oil and gas state, now depends much less on the oil and gas industry which comprises a smaller part of the Texas economy, making it considerably less sensitive to changing oil prices than it was in previous decades. Although Texas is not immune to oil price shocks, the Federal Reserve Bank's economists estimate that prices would have to fall below $10 and remain at those levels to disrupt the Texas economy. Even then, unless sustained low oil prices were accompanied by other negative shocks, the Texas economy should continue to grow (Gunther et al. 1999).

This reduced significance of energy to the nation's economy and to the average consumer's pocketbook has various implications.

- It helps to explain why consumers for the most part shrugged off recent high gasoline and fuel prices. Few people sharply cut back on their driving or considered more fuel-efficient cars (Leonhardt and Whitaker 2000).

- The one exception to this indifference is the impact of higher oil prices on the poor who heat with oil (Anderson 2000).

- There has been little indication that overall oil demand in the U.S. has decreased in response to high prices (Leonhardt and Whitaker 2000).

- High oil prices in 2000 have raised global inflation rates, but only moderately slowed economic growth. This results in part from the reduced dependence of the global economy on oil and the global rise of the service sector (Staff 2000f).

3.6.2 Oil as a Commodity

The term commodity has come to mean any good that is produced in large quantities by a relatively large number of companies and that has become a staple or common item in the economy. Historically, commodities referred to agricultural or mining products. More recently, the term has been applied to a broader range of products including computers and other types of manufacturing goods.

One general trend for commodities is that they become less expensive over time. Mass production whether of agricultural, mining, or manufactured products tends to lower the costs of producing items and thus leads to lower prices.

This trend may apply to oil as it has to other products. This is in contrast to other models that see oil as a finite natural resource that will become increasing costly as that resource is depleted. (See limits to growth discussion in Section 3.6.4 below.) According to one analysis, oil prices showed real declines in price from the 1860's to the 1970's except for two periods of rapid price increases followed by rapid price decreases (Wardt 1996). From the late 1940's to the early 1970's, real oil prices gradually declined despite a number of modest increases. This quarter century of gradual decline was overturned by the oil crises of the 1970's and 1980's that radically raised prices and led to sharply increased volatility of world oil prices (Brown and Yucel 2000).

The trend over the past quarter century is difficult to discern. Since 1973 prices have been highly volatile, but without sustained direction. In inflation-adjusted 2000 dollars, peak prices were $67 a barrel for crude in 1980 and $2.57 a gallon for gasoline in 1981. Prices have come down sharply from those levels, but have remained volatile (Anderson 2000). While the period since 1986 has seen real prices approach or even drop below pre-1973 levels, it is not possible to predict whether prices will return to what is considered the long-term trend to lower prices in evidence prior to 1973.

Even with the increased volatility and reduced predictability of the last 20 to 25 years, technology has consistently proven wrong predictions of oil scarcity and extraordinarily high oil prices. Despite repeated forecasts of these events, the total effect of technology has been to find and produce oil in excess of world demand at relatively consistent prices. Although prices have fluctuated over time and supplies have not always matched demand, technology's impact on oil and gas has been similar to its effects on other commodities. In the long run, through the application of small and large technological change, costs and prices may indeed tend to decline while supplies tend to increase (Huber and Mills 1998). That is, in the future, oil and natural gas may behave the way commodities typically do—growing cheaper and more plentiful over time.

3.6.3 Rise of Alternative Energy Sources

In the 1970's, many assumed that the demand for oil and other natural resources would soon outstrip the supply. Only a few years ago, the scarcity of oil was considered an important limit to growth of the economy and society as a whole. The increase in productivity of the oil and gas industry has now changed conventional wisdom so that some believe the demand for oil will wither away before this resource is depleted. In this view, the advent of new power technologies (e.g., hydrogen-based fuel cells) will overtake oil and natural gas-based technologies reducing and finally eliminating demand for these hydrocarbons.

In the oil and gas industry, however, this is a minority view. The leadership of Exxon Mobil, for example, sees no market demand over the next 20 years for the range of possible alternatives to current oil and gas-based technologies including cars powered by battery or fuel cells or the general use of photovoltaics, wind, solar, and biomass. While Exxon Mobil supports R&D related to global warming, cleaner cars, and similar efforts and monitors alternative energy development, the company is not convinced that any of these alternative energy sources have any real prospects of replacing oil and natural gas (Raymond 2000). An alternative to this is the idea that the major oil and gas companies will evolve into companies providing energy from a variety of sources in addition to oil and gas. Even in this case, where there is more acceptance of alternative energy, there is a core belief in the long-term viability and necessity of oil and gas (Davies 1999).

Thus, there seems little support in the oil and gas industry for the basic premise that oil and gas supplies will be unavailable in the foreseeable future. With this view, it follows that the industry does not foresee the replacement of oil and gas-based technologies with alternative technologies.

3.6.4 Change in "Limits to Growth" Mentality of the 1960's and 1970's

In the 1960's and 1970's a general theory that oil and natural gas, as finite resources, would pose severe limits to economic growth was proposed and widely accepted. One aspect of this theory held that the price of oil would rise inexorably as supplies shrank (Meadows 1972).

The general notion of limits to growth and the particular idea that prices would soar was reinforced by the price increases associated with the oil crises of the 1970's and 1980's. As has been noted several times, the oil and gas industry was sufficiently convinced of the inexorable rise in prices that projections of oil rising to $100 a barrel by the year 2000 became conventional wisdom. This view has continued to have some adherents who predict that economic growth is outstripping oil supplies (Helyar 2001).

Nonetheless, the history of the last 15 to 20 years has tended to overturn this view. While oil and natural gas remain finite resources, our capacity to identify and extract these resources has usually outpaced our increased demands. Technology has reduced costs of delivering these products to customers[4]. As a result, oil and gas have become more like traditional commodities, which become less expensive over time as production becomes more efficient and effective. While prices have changed precipitously in the past two decades, there is no evident long-term trend towards higher prices. In real terms, the world price for oil reached its lowest level over the last 30 years in 1998. Even after tripling between early 1999 and the fall of 2000, real oil prices were not much higher than they were in 1970. (See Figure 6 in Section 3.1.1).

For the present, there appears to be little evidence that the "limits to growth" view of oil and natural gas will hold. More likely from the perspective of the last 20 years, is the idea that oil and natural gas will tend to act like many commodities where, over the long-term, prices will remain at levels in the low to mid $20 range (in 2000 dollars) or decline. Short-term

[4] It should be noted that Catton in his 1982 work, *Overshoot: The Ecological Basis of Revolutionary Change*, argues that it is a delusion to think that new technologies will always allow us to either avoid depleting natural resources or to wholly replace them.

factors (e.g., war, recessions) will always drive prices up or down, but this will not change the long-term pattern of level to declining prices.

Reserves are no longer an estimated fixed number of barrels, currently, they are seen as a dynamic estimate that grows as a function of technology. This estimate grows as new sources of oil are found, and more oil is extracted from existing fields (Coy and McWilliams 1997). In the year 2000, estimates of reserves issued by the U.S. Geological Survey were 20 percent higher than the previous 1995 estimate. This latest estimate includes reserves in areas such as Greenland that have never been developed (Niiler 2000). By one estimate, by the year 2015, technology will allow oil production from the seabed anywhere in the world. Thus, at least for the medium term, there should continue to be opportunities to add reserves from previously undeveloped areas as technology allows development in progressively deeper waters.

4.0 CORPORATE ORGANIZATION AND STRATEGY

4.1 Time Line

The time line of events affecting corporate organization and strategy is made of milestones in a variety of areas: factors affecting price, management techniques, technology advances, legislation and regulations, and industry restructuring. See Table 3 in Section 2.4 for the time line of events affecting the GOM offshore oil and gas industry from 1980-2000 and beyond. As seen in the table some of the events affecting the industry in the last 20 years occurred prior to 1980.

Trends or changes in corporate organization and strategy in the last 20 years overlay on the periods of oil prices identified in Section 3.1. The general patterns are:

- 1971-1981: expanding
- 1982-1986: downturn
- 1987-1992: downsizing and restructuring
- 1993-1997: increasing price volatility I
- 1998-2000 and beyond: increasing price volatility II

In response to changes in oil and gas prices, changes in philosophy on oil and gas extraction, technological needs and advances, and a host of other factors, the oil and gas industry in the last 20 years adjusted how, when, and where it does business. Key events related to economics and finance, technology, labor, and the regulatory environment are described in the remainder of this section.

4.2 Economics and Finance

It would be difficult to overstate the significance of finance and access to capital to the overall strategy of the oil and gas industry as a whole or to individual companies. While the availability of investment funds has always been critical, as the industry has moved progressively farther from shore and into deeper waters, the costs involved in individual projects have grown enormously. Hundreds of millions of dollars or even billions of dollars are necessary to move from the identification of deepwater resources with commercial potential to the beginning of production when investments will finally create income.

These projects are also developed over a span of at least a few years and then may produce oil and gas for decades. Money is thus committed for exceedingly long periods of time.

Given these conditions, it is not surprising that when drilling prospects are attractive and oil and gas prices are favorable, the availability of capital and access to financing are critical (Arthur Andersen 1999). When companies are ready to make capital spending decisions, they need ready access to substantial amounts of money.

For larger and more successful companies, retained earnings and cash flow are the first and most common source of capital (see discussion in Section 3.2.5). For the most successful firms, like ExxonMobil, retained earnings may run to tens of billions of dollars (Taylor

2001). The majority of oil and gas companies, however, will also need outside sources of capital. These outside sources have included wealthy private investors.

In finding the necessary capital to support new projects, acquisitions and divestitures, or other major expenses, the oil and gas industry has become increasingly creative. Traditional sources of funds have been supplemented by an array of financing options. Some of these have been created by the oil and gas industry itself; but the majority began in other industries. Oil and gas has thus tended to be a laggard in adopting these financial strategies for access to capital.

In addition to finding diverse routes to capital funds, the oil and gas industry over the past 20 years has plunged into the market for future contracts of oil and natural gas. These contracts are the foundation of hedging strategies which have become increasingly common and complex as the industry tries to manage risk in the face of inevitable swings in price and other factors that influence the course of the business.

Another trend underscoring the significance of financing has been the redefinition of the basic mission of the major oil companies. Throughout the long economic expansion of the 1990's and the bull market that has defined Wall Street for most of the past 20 years, the sensitivity of major oil companies to shareholders has grown sharply. Investors began to voice demands for better returns for their investments by the late 1980's (Le Blanc 1997b). In the more distant past, oil and gas companies may have seen their jobs as finding these resources and selling them to customers. That is no longer true. Thus, Chevron in 1992 made public its new corporate mission: "… to achieve superior financial results for our stockholders, the owners of our business" (Crain 1993).

This trend of shareholder value driving corporations is a reflection of changes in almost all industries and among seemingly all publicly traded companies. We have become a nation where the state of the stock market is front-page news and the so-called wealth effect of individuals' stock portfolios is considered a fundamental force in helping or hurting the national economy. In this climate, the oil and gas industry is unlikely to diminish the significance of financing as a strategy for corporate success.

4.2.1 Traditional and Innovative Financial Methods

In addition to cash flow and retained earnings, the oil and gas industry relies on an array of financial instruments and financial strategies to generate the capital required by investments in oil and gas assets, equipment, and other high-cost items and activities. It appears that over the past two decades the number of financial instruments and options has increased significantly. Moreover, the industry may be adopting fundamentally new financial strategies and shedding or at least downgrading some of the financial instruments, which it has traditionally used.

The use of new financial instruments and strategies stems both from the industry's internal efforts as well as through changes that have affected many industries. In some cases, the oil and gas industry has adopted financing methods (e.g., high-yield bonds) that were initially employed by other industries. In others, the oil and gas industry has been among the first to utilize some of the more innovative instruments such as syndicated loans and hedging instruments.

Discussing the oil and gas industry as a monolith entity is misleading. As with other aspects of the industry, the distinctions between the major companies, independents, and smaller industry segments (e.g., the oil service companies) can be important. Similarly the size of companies within segments can also be important.

For example, as companies have grown larger through merger and acquisition, internal growth, or other means, they have tended to increase their financial resources. When these reach a certain threshold, a company may be able to enter financial markets that were previously closed. As a result these large companies (e.g., majors and super independents) may be able to issue and sell high-yield bonds or may be of interest to institutions interested in private equity placements. Larger companies may also benefit from the stock market's perception that they are more diversified and have greater liquidity. Conversely the market may "punish" smaller companies that are seen as too narrowly focused or lacking in liquidity (Hackett 1999).

The prospects for continued success in the natural gas business in the GOM are largely dependent on proper management of financing and capital expenditures. The GOM is seen as the backbone of U.S. oil and gas supplies, but in the 1990's initial project costs often rose dramatically as production entered the frontiers of deepwater and subsalt formations.

The financial stakes for the oil and gas industry can be seen in a recent assessment of the global industry's capital spending in the mid-1990's in comparison to projected needs for the 10-year period starting in 1997. From 1992 to 1996, publicly traded oil companies spent an estimated $279 billion (unadjusted) on exploration and production to increase production by 3.2 million barrels per day, while national oil companies spent an estimated $500 billion (unadjusted) to increase production by 5.1 million barrels per day. Over the period 1997 through 2006, demand was projected to increase 42 million barrels per day. If the 1992-1996 relationships hold, the required investment to achieve that increase in production has been estimated at $2.5 trillion (Staff 1998d).

4.2.1.1 Reserves-based Financing

In the 1930's, banks first began lending to the oil and gas industry. Initially, lending capacity was determined through a multiple of a company's monthly oil and/or gas revenues from existing wells. Over time, banks developed their own expertise in evaluating oil and gas properties and the future income they could produce. This allowed banks and companies to develop a financial relationship based on the value of assets owned by companies. This was the basis for reserve-based lending.

For roughly 40 years, reserve-based loans were the industry's financial instruments of choice. Some changes slowly evolved. Term loans were eventually replaced by revolving credit agreements. These allowed a company a line of credit that could be used as needed and then repaid. The limits for these agreements were typically reviewed at 6-month intervals and adjusted as the value of owned reserves changed.

4.2.1.2 Limits of Traditional Methods

While reserve-based financing worked reasonably well for decades, the soaring of oil prices in the 1970's began to unravel this arrangement. As prices soared, so did demands for capital to buy new properties and to support new drilling. Favorable tax policies further increased the level of oil and gas activity.

Banks that specialized in the oil and gas industry generally thrived in the 1970's and into the 1980's, carried along by high prices and thus highly valued reserves. The demands for capital, however, began to tax the lending limits of banks. Simply put, the banks could not keep up with the industry's need for new capital as new projects were developed.

These good times attracted other sources of capital (e.g., limited partnerships, private drilling funds). Unlike the financial instruments of banks, these new financial mechanisms tended to rely on equity stakes in projects or companies, not loans (Helm 1998).

The disadvantages of traditional banking financing of the industry first manifested themselves through the limits on the lending capacity of the banks themselves. Other limits became clear when the good times of the 1970's and early 1980's came to an end. Reserve values plunged as prices collapsed; revolving credit lines were progressively lowered; access to banks was reduced.

Coincidentally with the collapse of oil prices, the U.S. banking industry was undergoing a crisis generated by poor real estate lending practices. By 1988, due in part to the collapse of oil prices, half of all Texas banks were rated as "problem banks" and the government was restructuring the banking and savings and loan industry. From 1985 to 1991, the volume of loans made by Texas banks shrank by 50 percent. The number of banks also declined, including many that specialized in lending to the oil and gas industry, as problem banks were absorbed by stronger institutions.

The limits to this traditional source of capital had become clear by the late 1980's:

- Asset-based financing is restricted by the value of the assets themselves. When these values decrease so does credit. As prices become more volatile, the underlying security of bank loans also becomes less predictable and thus less secure.

- This credit is limited by the requirement that the assets be owned. Companies not owning such assets have no basis for financing capital needs.

- The health of banks is crucial to the availability of credit. "Sick banks" cannot be reliable sources of capital.

4.2.1.3 Equity Instruments

In contrast to standard bank loans, equity instruments cover a broad range of arrangements which involve ownership of the enterprise. Shares of stock in publicly traded companies are a common example. Such shares need not be publicly traded, but can also be sold privately usually to investors with especially favorable standing. Partnerships constitute another form of ownership that typically involves a smaller number of owners in comparison to owners of shares of stock.

An equity interest (i.e., ownership) provides the investor with an opportunity to share in the earnings of a company. It creates no requirement, however, that the company provide a return on that investment. Thus, unlike a loan, with equity investments, there is no requirement that a company make a specified payment to the source of capital.

Selling shares of stock to the public or to other owners is a long-standing means of raising capital for the major U.S.-based oil companies. Exxon Mobil, Texaco, and other well-known oil companies were formed as publicly owned companies decades ago.

For smaller companies, however, including some independents and more oil service firms, "going public" has been a more recent strategy to raise capital through the sale of stock. Thus, Burlington Resources—the second largest independent U.S. oil and gas company—was spun off of the railroad, Burlington Northern Incorporated, in 1988 and raised over $500 million (unadjusted) with an initial public offering of stock. Global Industries, Limited, began providing diving services to the oil and gas industry about 1980. By 1993, it had grown internally and through acquisitions to a size that warranted conversion to a publicly traded company. In that year, Global Industries raised about $30 million in an initial public offering of stock (Value Line 2001a).

The case of Global Industries illustrates the financial benefits of size. In 1993, the company had sales of $81 million. While this is trivial relative to the $32 billion of sales made by Chevron in that year, Global Industries was large enough to attract the interest of investors and successfully raise funds in the public capital market (Value Line 2001b).

The public offering of stock continues to be important to the industry, particularly independents. The usefulness of this strategy can be directly tied to investor sentiment and to the price of oil and gas. In the early 1990's, rising prices created new value for independent production companies, which drove energy industry activity in U.S. equity markets. In 1993 energy industry companies raised $4.2 billion (unadjusted) of equity from investors outside the industry through initial public offerings; this was a 258 percent increase from 1992 (Koen 1994a). In the several years prior to 1997, oil and gas stocks outperformed the S&P 500. In 1997, oil service stocks continued to outperform, although exploration and production companies lagged the market. Consequently, at that time, there was a dramatic increase in oil and gas stock public offerings, driven largely by the perception that the industry's prospects were quite favorable (Staff 1998d).

As noted above, the 1970's huge increases in oil prices and demands for capital attracted sources of capital other than traditional bank loans. In the 1970's and early 1980's, limited partnerships first became an important source of capital to invest in specific projects or in companies. These partnerships tend to involve a relatively limited number of individuals able to invest large sums of money (Helm 1998).

In this same time period, private drilling funds also became significant capital sources (Helm 1998). These funds were harbingers of other pooled investment vehicles that focused on the oil and gas industry. By 1984, major mutual fund companies were creating funds that specialized in investments in the oil and gas industry (T. Rowe Price 2001, Vanguard 2001).

Mutual funds are considered institutional investors. That is, they are investors with assets well in excess of those available to almost all private individuals. By virtue of their size, institutional investors (e.g., endowments, foundations, and pension funds) are often able to gain access to investment opportunities unavailable to the general public on terms that may be more favorable than those available to the general public. For companies, the advantages of institutional investors include the large amounts of capital they may be able to invest, the long-term perspective (e.g., up to 10 years) they have on their investment, and in some cases other benefits they will bring to the table. These investors support new ventures or projects as well as divestitures of noncore business units. In the mid-to-late 1990's, this was one of the fastest growing sources of capital for the industry and was expected to continue to grow rapidly (Staff 1998d). As these investments are typically made directly with the relevant company, not through the public stock markets, they are also considered private equity.

A specialized type of private equity is venture capital. Of particular note in support of high-technology companies, venture capital generally provides early stage investments when companies are relatively new and their products or services are not fully developed and tested. In return for favorable terms, venture capitalists provide funds well before many other investors are willing to commit. Because these investments are frequently made for start-up or relatively new firms, venture capitalists may also provide management and other expertise to support the firm and protect their investment. As with other private equity sources, venture capital became prominent in the 1990's and is expected to continue to be a significant and growing of investment in the industry (Staff 1998d).

4.2.1.4 Debt Instruments

Loans and bonds are the main types of debt-based instruments used by the oil and gas industry. These instruments operate in different manners, but both create debt and interest charges that companies are obliged to pay.

Unlike equity instruments, debt-based financing does not provide the lender an ownership stake in the earnings or stock performance of the company. By the same token, debt-based financing is a higher financial priority than providing returns to equity. As a consequence, loans and debt tend to be a lower-risk, lower-cost source of capital, than equity investments.

Banks loans, as discussed in Section 4.2.1.1, are the most traditional source of capital for the oil and gas industry. These are debt instruments, traditionally created by a single bank.

With the unraveling of this traditional capital source in the 1980's and the upheaval in the banking industry, banks sought ways to continue to service the oil and gas industry while distributing risk. One response to this need was syndicated loans, a significant and growing source of capital to the industry. Loans are originated by approximately 200 major banks and are sold to approximately 500 institutions, mostly banks, but also investment companies, mutual funds, and insurance companies. While they are similar in their origination to traditional bank loans, by selling portions of each loan to other financial institutions, the originating bank spreads the risk among all participants in the syndication. By tapping the financial resources of other institutions, the originating bank is also available to overcome any obstacles posed by its own lending limits (Staff 1998d).

Syndicated loans are intermediate term (5 to 7 years) instruments generally providing more flexibility and significantly lower costs than notes or bond issues. They have frequently been used to support exploration and production activities. Syndications totaling $22 billion (unadjusted) were used for these purposes in 1995; this figure grew to $55 billion (unadjusted) by 1997 (Helm 1998).

Despite this growth, syndicated loans are not a universal source of funds within the industry. Oil service firms reportedly receive little capital in this manner and are served by only a fraction of the universe of major banks involved in originating syndicated loans. (Staff 1998d).

Bonds are another debt instrument that have proven increasingly valuable as a source of capital. Like stocks, bonds have been a source of capital for the larger companies in oil and gas industry for decades. Also like stocks, bonds are sold in public markets or private markets. The significance of bonds as a capital source began in the early 1980's as the capital requirements of the oil and gas industry outstripped the capacity of banks to meet those needs. Bonds were one means of meeting those needs (Helm 1998).

In the mid-to-late 1980's, the issuance of high-yield bonds (so-called junk bonds) expanded dramatically. These instruments allow companies with less than investment-grade bond ratings to issue bonds by paying higher yields than those paid by more financially sound firms (T. Rowe Price 2001). Although the interest rates on these bonds are relatively high, they still are frequently attractive to companies.

By the early 1990's, bonds including high-yield bonds and other debt instruments were instrumental in filling the void left by the banking industry's inability to meet the oil and gas industry capital needs. This source of capital continues to help to fuel the consolidation of different segments of the industry and supports a range of oil and gas projects.

In the 1990's, the industry found access to funds greatly improved, but the cost of capital rose sharply. The higher cost did not discourage use, however. In the 1970's and 1980's, the oil service industry raised an annual average of almost $240 million through bonds. From 1991 to 1997, the annual average capital raised by oil service companies through issuing bonds of all grades increased to roughly $1.2 billion, a fivefold increase (Staff 1998d). From 1995 to 1998, the period in which the high-yield debt market first became a significant source of cash for the industry as a whole, oil and gas exploration and production companies issued $20.5 billion in high-yield debt (Haines 2000).

While high-yield bonds have been of great benefit, they also pose risks if conditions influencing the public debt markets change[1]. In early 1998, oil and gas-related bond prices started to drop from the high 90-cent range. By 1999, some were trading at 50 or 60 cents on the dollar, others at 20 to 30 cents. This collapse in bond prices was attributed to deteriorating industry conditions and a negative near-term forecast for U.S. gas prices. As a result, companies issuing these bonds experienced eroded financial flexibility, difficulty in selling assets, adverse loan redeterminations, and reduced access to capital in general. Some companies took drastic steps to reduce their debt and live within their vastly reduced means. These factors all but temporarily closed public debt markets for the oil and gas industry. Companies that needed capital turned to the private markets and became more creative in their financial arrangements (Haines 2000).

4.2.1.5 Hedging Instruments

In addition to accessing capital through various equity and debt instruments, the oil and gas industry also routinely employs hedging instruments as a financial strategy. Typically, hedging is an attempt to provide the equivalent of financial insurance against the risk that prices will fall precipitously or rise sharply from current levels.

In 1983, the New York Mercantile Exchange began selling crude oil contracts and created the first opportunities for sellers and buyers of crude oil to hedge. Today light, sweet (i.e., sulfur-free) crude is the most actively traded commodity in the world and the light, sweet crude oil futures contract is considered the easiest way to trade crude in the world. Contracts of 1,000 barrels of crude are agreements by sellers to deliver that volume of crude to the buyer for a specific price at a specified future date. That future date typically is 1 to 30 months in the future, but may be as long as 84 months into the future (New York Mercantile Exchange 2001).

---

[1] High-yield bonds (also known as junk bonds) offer investors relatively higher interest payments to offset the presumed risk of default (i.e., not paying the interest or principal of the bonds) associated with the company issuing the bonds at the time the bonds are issued. Risk may be associated, for example, with a new company with a limited financial track record or with an established company that is in financial difficulties. Bonds are issued by a specific company at a specific interest rate (e.g., 10 percent) on the quoted face value of $1.00 and are then traded on the bond market. Interest rates will vary over time as various factors affect the financial conditions of industries (e.g., a drop or rise in the price of oil or natural gas) or individual companies (e.g., Company A fails or succeeds in discovering new reserves). Once bonds have been issued, their interest rates are fixed; their prices, on the other hand, will vary to accommodate market-based changes in interest rates. If Company A issues bonds at an interest rate of 10 percent and then suffers from a loss of reserves and a decline in prices, investors may perceive a higher risk in buying Company A’s bonds. The price of Company A’s bonds could drop to $0.50. As a result, because Company A will continue to pay 10 percent interest on the face value of the bonds, the actual interest paid on these bonds rises from 10 percent to 20 percent. That is, a bond which originally cost $1.00 and paid $0.10 in annual interest (10 percent), now costs only $0.50, but still pays $0.10 in annual interest (20 percent). If Company A then wants to issue new bonds, it will be forced to pay much higher interest costs (i.e., 20 percent) on those new bonds. Company A’s cost of money has then increased dramatically and its ability to raise money has been reduced. As risk declines this process is reversed and bond prices rise, lowering interest rates, and making it easier for Company A to borrow money.

The major advantage of these contracts is that they provide a fixed future price for oil, natural gas, or other oil and gas products. Thus, instead of using the daily market price, buyers and sellers can agree on prices for large quantities of oil or gas.

For the producers of energy, futures contracts provide an opportunity to manage their revenues, locking in prices that will provide an acceptable profit and reducing the uncertainty associated with the unpredictable swings in market prices. For some energy producers, futures are seen as a way to avoid being passive in the face of the inevitable volatility of the market. The major disadvantage of futures contracts for sellers is that the future market price may be higher than the contract price. In such cases, sellers would have lost the opportunity for even more revenues and profits (Hackett 1999).

For buyers, the advantage of futures contracts is securing a known supply of oil or gas at a known price. The possibility that the buyer will need to pay sharply higher prices or will be unable to find adequate supplies of oil or gas is eliminated. As with sellers, this certainty allows buyers to plan financially with the knowledge of what future costs will be.

Hedging began with the selling of relatively straightforward contracts. Over time these have multiplied as different types of risks are identified and the imagination of financial markets has been sparked. Options may be sold or purchased that give the owner the right (but not obligation) to buy (i.e., a call option) or sell (i.e., a put option) an asset such as oil contracts at an agreed upon price on or before a specified future date. Other variations on hedging include instruments known as straddles, where the investor buys a call or a put with the same strike price and expiration date, and strangles, where the strike price for the call is higher than the strike price for the put (Hughes and Negus 1999).

Among the most recent of these hedging instruments are weather derivatives, financial instruments used to manage risk associated with change in weather. They cover against a drop in profits caused by weather, thus reducing earnings volatility. Exceptionally warm or cold winters can push natural gas prices up or down significantly. Trading of weather derivatives began in 1997 and sales exceeded $2 billion (unadjusted) in the first 2 years of trading (Hughes and Chen 1999). The payout is often based on exceeding either heating or cooling degree days, that is, the deviation of a day's average temperature from 65°. They can also be embedded in physical delivery contracts. In this situation, suppliers structure delivery contracts so that prices are adjusted if certain temperatures or other weather conditions occur. Weather derivatives might be purchased by utilities and would provide benefits, for example, if winter weather were warmer than usual, thereby reducing a utility's sales of natural gas. The creators of weather derivatives include some major integrated oil and gas companies (e.g., Enron) that sell energy to the utility industry and are seeking new ways of generating business ultimately based on the sale of oil and natural gas products (Hughes and Chen 1999).

The proliferation of hedging instruments is a measure of the interest that the oil and gas industry and the financial services industry have in trying to manage financial risk in the face of inevitable price swings of oil and gas. While most hedging involves contracts for future delivery of oil and gas at fixed prices, this area of financial strategy has been among the most creative in the past 20 years, generating new products to cope with the range of risks oil and gas companies face.

4.2.2 Economics and Corporate Objectives: Leasing OCS Tracts, Exploration, and Production

Oil and natural gas extraction once emphasized removing the maximum level of the resource in as short amount of time as possible (U.S. DOE, EIA 2000e). In essence, oil production companies attempted to maximize output conditional on the existing technology. This strategy generally characterized production activities prior to the elimination of production quotas by the Texas Railroad Commission in 1972. Prices were relatively constant and predictable from year to year. Although not apparently ever empirically assessed, it appears that many production decisions made prior to 1971 were based mostly on static expectations (i.e., production decisions affecting current production are made without respect to the future). Alternatively, the private rate of time preference or the discount rate (the rate at which an individual or producer values the future today) for oil production was approximately equal to infinity, which implies that the producer has a zero value on future returns. This also suggests that the producer should maximize production in the current period. Pesaran (1990) suggested, however, that the discount rate between 1978 and 1986 for producers was between 0.0 and 1.0 percent. Hendricks and Porter (1996) estimated the discount rate for drilling activities on offshore OCS tracts to be approximately 5 percent between 1980 and 1995.

In the 1970's and 1980's, the decision-making framework for exploration and production activities, particularly relative to offshore OCS entities, changed (Bolton and Harris 1993, Epple 1985, Reiss 1990). Decisions became based more on long-run concerns rather than mostly short-run. The bidding process for OCS tracts also changed in the 1980's. Companies began to increasingly bid on tracts with high expectations of petroleum and natural gas; they became less interested in the wildcat tracts (i.e., those areas where there has not been prior exploratory drilling). Offshore OCS exploration and production firms developed delay strategies, or delaying the drilling decision to avoid circulation of information about the potential production of the tract. The majors also changed corporate strategies. They increasingly focused on optimizing earnings of the corporation rather than earnings from individual enterprises (e.g., petroleum and natural gas production, gasoline sales, and other product sales). In this latter case, firms increasingly recognized the joint product nature of production (i.e., decisions about one product affect production about other products) rather than viewing their production activities as non-joint inputs (i.e., decisions about production of one product are independent of the decisions about production of other products).

4.2.2.1 Profits, Costs, and Other Financial Aspects: Leases and Joint Ventures

Of the many changes affecting profits and costs of OCS activities during the past 20 or so years, changes in the bidding process for OCS leases are thought to have had substantial affects on profits and overall financial health of the oil and gas industry (Paddock et al. 1988). Prior to 1978, firms offered sealed bids on OCS tracts. A tract is typically a block of 5,000 or 5,760 acres (Porter 1995). The bid is a dollar figure and referred to as a bonus. The firm reimburses the government on the sale date if it is awarded the tract. The government, however, may reject a bid, even if it is the highest bid. Once production begins, the firm must reimburse the government a fixed proportion of the revenues—one sixth, which is a royalty payment.

In 1978, the OCS Lands Act Amendments specified that the Secretary of the Interior offer at least 20.0 percent of the offshore oil and gas leases through alternative bidding systems to the cash-bonus method. This requirement was implemented with the belief that it would better enable independent firms to participate in OCS lease sales; it was thought that capital markets were incapable of efficiently supplying funds for oil and gas exploration (Rockwood 1983). The alternative bidding system was eliminated in 1984 and replaced with the bidding system used prior to 1978.

Under the current bidding system (the system used between 1954 and 1978 and 1984 to date), a participating bidder submits a separate bid on each tract it has an interest in acquiring. The bid may be for a wildcat site, a drainage site, or a development site. For a wildcat site, firms are permitted to gather only seismic information prior to the sale; no on-site drilling is permitted. Drainage and development sites consist of tracts in areas where deposits have been discovered. On-site drilling is not permitted but firms owning adjacent tracts can conduct off-site drilling. Development leases are often re-offerings of previously sold tracts with leases, which were relinquished because no exploratory drilling was ever conducted, or they are re-offerings of areas where previous bids were rejected, as inadequate. Once a firm acquires a tract, the firm usually has 5 years to explore it. If exploration and production activities are not conducted within 5 years, the lease reverts to the government. A nominal rental fee per acre is typically paid to the government; the fee varies by type of tract, with wildcat tracts having the lowest rental fees. If oil or gas is discovered and extracted, the lease is automatically renewed, and the firm pays a royalty rate of approximately one sixth of the revenues for each tract.

Bid prices offered for tracts are based on expected net returns (i.e., expected revenues less expected costs) (Hendricks and Porter 1996). Costs expectations are highly related to water depth, the depth of the formation, and uncertainty of information about the tract. Although drilling costs have substantially declined in the past 20 years, the potential losses from dry holes are quite expensive. Given the potential for large losses, it is only natural that bidding and exploration activities would increasingly involve joint ventures.

A joint venture provides an arrangement for sharing the financial burden and risks of leasing tracts and exploring for oil and natural gas. In 1980, Superior Oil Company, Pennzoil Oil Company, and Standard of Ohio submitted a record bid of $52,457.81 (unadjusted) per acre. As demonstrated by Hendricks and Porter (1996), however, joint ventures seldom involve several firms actively engaged in exploratory drilling. Instead, it is common for firms actively engaged in exploratory drilling to turn to outside partners to raise capital. Firms engaged in joint ventures have unitization agreements, which allocate revenues from a common pool according to a pre-specified rule.

The increasing use of joint ventures is believed to have affected the timing and incidence of exploratory drilling. In the past when there were fewer joint ventures, there was a tendency, and there still is, for firms not involved in joint ventures, to delay exploratory drilling until other firms had drilled and obtained more information. For those firms involved in joint ventures or collaborating with other firms (cooperative behavior), drilling occurs earlier after obtaining the lease.

Even though joint ventures reduce risk for individual firms, the quarterly hazard rate (i.e., the fraction of tracts that had not previously been drilled but where exploratory drilling began in that quarter) for joint ventures is U-shaped or the same as it is for activities not involving joint ventures. Even though there appears to be little difference in the time it takes to explore or drill a lease between joint and non-joint venture firms, joint ventures have helped reduce the time it takes to discover oil in the OCS areas of the Gulf of Mexico (Westwood 2001). In the early 1980's, development times for deepwater prospects were about 10 years for a discovery; by 1996, the development time was about 2 years.

4.2.2.2 Profits, Costs, and Other Financial Aspects: Technology and Business Practices

After the 1986 oil price slump, oil and natural gas companies began to adopt a wide range of cost-cutting strategies. Concurrently, there were several major technological advances which helped reduced capital and operating expenditures in deepwater areas. Companies also adopted new approaches in project management. There are now more partnerships and strategic alliances between key players. These changes all contributed to reducing project timescales. (Also see Section 4.4.2.)

A major business-practice change by the exploration and production companies is the undertaking of major reviews of their business practices. Companies now examine every facet of company operations looking for new ways of conducting business. There has been a tendency to eliminate many in-house services such as accounting and field operations, and contract these activities out to third parties. Field development methods have changed to single product alliances formed between oil companies and major contractors to reduce risk and share return.

The number of changes in corporate strategy by exploration and production companies, particularly since the oil price crash of 1986, is substantial (Baxter 1993). Major restructuring led to new standards to evaluate assets and investment opportunities with the desired objective of improving short-term profitability and reducing risk. The majors intensified their long-term planning process and increased headquarters control of capital outlays. Companies have increasingly focused on the underlying economic aspects of exploration, development, and production rather than science. Adelman (1986) offers that a Marxian perspective explains industry restructuring as the concentration and centralization of capital as a response to excess production problems associated with competition among firms and nation-states. Managerial control has changed from an emphasis on operations to an emphasis on finance.

In contrast to many nations, which control the exploration and production of oil and natural gas, exploration and production decisions in the United States are made by the private sector. The private sector may be divided into integrated multinational oil companies and non-integrated domestic oil companies. The large integrated companies have their own reserves, but they are experiencing difficulty replacing them. They have increasingly relied on the purchase of existing reserves, improved recovery methods, and exploration for high cost reserves, particularly deepwater Gulf of Mexico. These large firms have also increasingly explored for reserves overseas rather than exploring for less promising domestic reserved.

The non-integrated companies may be divided into those that concentrate on exploration and production and those that focus on refining and marketing. The non-integrated companies have generally consolidated since 1986, which has reduced the number of independent oil firms. At the same time, the independent firms drill a larger percentage of wells in the Gulf of Mexico. The large integrated companies tend to subcontract more leases to the independent operators for drilling and exploration.

Other major changes in business practices, particularly for the integrated multinational oil companies, include mergers, stock repurchase strategies, asset purchases, and internal reorganization. Mergers are used to accomplish a number of goals, including improving reserve position, reducing overhead, diversifying geographically, sharing risk and technical expertise, and for speculation in oil reserves. Speculation is the purchasing of existing reserves at a price less expensive then drilling for new reserves. Many of the major oil companies engaged in a stock repurchase strategy to defend themselves against unfriendly mergers. A stock repurchase increases stock prices and improves a company's balance sheet, and it removes stock from the market to protect from a takeover by other firms. The purchase and sale of assets has also increased as one way to affect the overall financial performance of a company.

4.3 Technology

By the year 2000, technology had become a driver, in some ways, the key driver in the ongoing development of the oil and gas industry. As a corporate strategy, technology had shown an ability to solve a wide array of technical problems while delivering increasing volumes of oil and gas at lower costs in shorter time frames. Technology was meeting the goals of better, cheaper, and faster that industry frequently sets for any change or the introduction of new processes.

As discussed in Section 3.3, the ascendance of technology as a major force in the oil and gas industry is a relatively recent phenomenon. Although technology has always been an important part of the industry, the period starting from the mid-1990's has seen the maturation or emergence of technologies that have had substantial effects on the overall industry. The simplest demonstration of this impact may be the steep rise in deepwater production of oil in the U.S. starting roughly in 1995 (see Figure 4 in Section 2.3).

With such dependence on technology, the role of research and development (R&D) is crucial to long-term industry success. Investing in R&D, however, presents industry with a classic dilemma. Not putting funds into R&D, the industry compromises its future; yet, with an increasingly competitive marketplace that demands financial performance on a quarter-by-quarter basis, funding R&D detracts from present profitability.

This dilemma is complicated by the shifting strategies the oil and gas industry has employed in the organization of work. The increasing use of multi-employer teams, alliances, partnerships, and other forms of cooperation and collaboration means that ideas circulate within the industry rapidly. (See Section 4.4.3 for a discussion of the reorganization of work.) Thus, many firms choose to save the R&D costs of developing new technology and plan instead to be "fast followers" that will quickly capitalize on the efforts of others (Knight 2000).

While technology touches a broad range of processes, technology can also be grouped into a handful of categories that follow the basic steps in finding, reaching, producing, and finally delivering oil and natural gas to customers. Moreover, the enormous strides that have been made in the past few years are typically attributed to a relatively short list of technologies—seismic imaging, drilling, and platforms are at the top of most lists. Given the increasing importance of deepwater deposits, the technologies that have opened this frontier are also critical.

In some ways, the greatest technological strides have been made with entirely different clusters of technology. Computers, software, telecommunications, the Internet, and other facets of digital technology suffuse virtually every activity undertaken by the oil and gas industry. These technologies support, enable, or enhance almost all industry-specific technologies. As with all other parts of the economy, these technologies have also transformed the most basic work tasks undertaken by the industry's workers.

The impacts of technology can be felt from the boardroom to the drilling rig. The effects can be seen in what, how, and where work is done. While the effects have sometimes been remarkable, some observers feel the changes in the future will dwarf those seen in past 20 years.

4.3.1 Approaches to Research and Development

For the oil and gas industry, as for many industries, there are three traditional sources of R&D—the industry itself, academia, and government. Each of these has had a role in generating new technology for the oil and gas industry although the role of government has been relatively small.

Within industry the range of models for R&D is relatively broad. This range is influenced by the segment of the industry, the time horizon of research, the price of oil and gas, and the status and strategies of individual companies. Certain segments of the industry, especially the major international oil companies, have tended to have a substantial role while smaller service companies have tended to conduct no R&D. Most, but not all, industry research is targeted to immediate short-term issues.

While R&D might be reasonably considered an "investment" in the future, R&D expenses are paid out of cash flow. Thus, when prices drop and revenues are curtailed; R&D can suffer. Some companies are more committed to R&D than others. This is true within the oil and gas industry as well as within industries that provide technology to the oil and gas industry. The computer and software industries are famous for devoting time and effort to R&D; their products are also increasingly important to the oil and gas industry.[2]

Academia and government have also played a role in oil and gas industry R&D. For academia, the most prominent model is the research consortium. Government has been a funder of research by the oil and gas industry and has conducted some independent research.

---

[2] It should be noted that this discussion of R&D is restricted to the oil and gas industry. The efforts of high-tech industries that heavily influence the oil and gas industry (e.g., information technology, telecommunications) are not considered.

The approach to R&D has changed over the period 1980 to 2000. The basic change has been from simpler to more varied models. As technology has grown more important through this 20-year period, commitment to R&D has in many ways grown more uncertain.

4.3.1.1 Industry-based R&D: In-house Versus Outsource

In 1980, R&D was largely a function of the major oil companies. These firms had internal R&D staffs responsible for the development of research and the refinement of technology.

About 1990, as financial performance was becoming a more critical issue for publicly traded companies, a basic shift in research and technology development occurred. The major oil and gas companies began to downgrade their internal R&D efforts, reducing spending in this area by about one-fourth in the mid-to-late 1990's. At the same time, the oil service companies began to increase technology development spending and increased funding in this area by 50 percent in the late 1990's (Staff 2000a).

This shift in emphasis resulted in a number of changes at the major companies. Lower spending meant fewer R&D facilities and the delegation of more testing to manufacturers and service companies, which may not have fully equipped facilities. For manufacturers and service companies, the concern is typically next-step technology or product refinement, rather than more fundamental and far-reaching change (Loth et al. 1999). While many majors tended to keep some R&D functions, these were often downsized, rightsized, and restructured. Thus Chevron in 1992 reduced five R&D centers to one and cut R&D staff by about one-third (Staff 1992d). While this strategy may have reduced short-term costs for the major oil and gas companies, it may also have come at the cost of a less coherent approach to overall R&D (DeGuzman 1999).

The increasing use of contractors for R&D tended to place this effort on more uncertain footing. Cash flow for contractors tends to be more uncertain and any downturns resulting from lower oil and gas prices tend to reduce R&D funding disproportionately. This funding uncertainty also tends to put an emphasis on short-term, incremental improvements, rather than longer-term, more basic changes (Taylor 2000). Other concerns that have arisen from this trend to outsourcing focus on reduced quality control and a general slowing of new technology development (Wetuski 2000, Ellis 2001). Nonetheless, the major oil companies may feel that these disadvantages are more than offset by the improvements made by contractors and services companies and by the savings derived from not funding their own R&D shops (Knight 2000).

Critics also point to the limited scope of much industry R&D, particularly that effort done by cash-strapped contractors and service companies. In this view, a distinction should be made between technology development and more basic research. The former is the typical strategy of most oil and gas industry effort. The latter, however, is seen as crucial to understanding how to operate in the increasingly complex or hostile environments that the industry will face in the longer run (Staff 2000a).

Despite the general trend away from basic research and participation by the majors, some large oil companies are still committed to this kind of research. Shell is continuing with more basic research, believing that its success in the deepwater GOM has relied on just this kind of effort (Hasan 2001). Similarly, Exxon Mobil is focusing substantial resources on 11 areas of breakthrough technologies (e.g., less expensive ways to deliver natural gas from remote areas and new ways to detect oil and gas in the earth from the surface), rather than the incremental, next-step changes characteristic of much of the industry's R&D (Taylor 2001). Exxon Mobil, a company with a 20-year planning horizon, not surprisingly continues to see R&D as a core function of oil companies (Raymond 2000).

The shift out of R&D by the major oil and gas companies was also supposed to have shunted a greater share of the research effort to academia. Research consortia, sponsored by the oil and gas industry, would be housed and conducted at university-based research centers. Such consortia have in fact been created at a number of leading universities with ties to the industry (Van Wie 2000). Participants in these consortia run from the major oil companies to independents to some of the larger service companies (Verrett 2001, Van Wie 2000).

While these consortia have continued to generate new technologies, they have not been universally successful. For the last quarter of the 20th century, consortia were the mainstay of exploration geophysics research at universities. Currently, this consortium model no longer exists; and its demise has reportedly had a major negative impact on training the next generation of geophysicists in the United States (Marfurt et al. 2000).

Other R&D alternatives have also recently emerged. The Gas Research Institute (GRI), which has always had a role in the development and commercialization of new technologies, has decided to transform itself from an industry-funded research and development management firm to a self-sustaining service-based enterprise providing technology to the E&P industry (Gavin 2000).

By the year 2000, substantial R&D was still being conducted by some of the major oil and gas companies. Yet, much of the R&D effort had been pushed out to contractors, service companies, and university-based, industry-sponsored consortia. This trend has also transformed other industry groups. Overall, R&D models have proliferated while the focus of this R&D has seemed more concentrated on incremental, next-step technology rather than more basic or more long-term concerns.

These trends for R&D are set within a context that would appear to encourage greater R&D efforts—more difficult problems faced in deepwater and other extreme conditions, recent dramatic improvements in productivity attributable to technology, and the continuing pace of development of technology in general. This context, however, also includes more pressure for financial results for shareholders, competitive pressures on the profits of contractors and service companies, and other disincentives to fund R&D. While technology seems to be an increasingly important part of the oil and gas industry, the R&D effort to sustain technological excellence seems a less certain part of the industry.

4.3.1.2 Role of Government

Historically, government has tended to support research (as opposed to R&D) in areas that were not well supported by industry. These would include more basic, longer-term research without good promise of commercialization or more risky technologies.

Government's role in oil and natural gas R&D has been relatively limited. Typically the federal government has provided funding to test very new technologies or the use of existing technologies in new applications. For example, the development of light sand fracturing technology by Halliburton and Mitchell was underwritten in part by funding from the U.S. Department of Energy (U.S. DOE) (Mitchell 2000). Another common area of interest that is supported by the federal government is technology that can help compliance with environmental or other types of regulation (Utsler 2001).

A review of U.S. DOE-sponsored research supports the idea that the federal role in R&D focuses on long-term issues and regulatory concerns. Federal support of measurement-while-drilling technology dates back to the 1970's. In the 1990's, work on high-technology drilling, innovative fracturing, and various "smart well" technologies has been supported. The U.S. DOE has also funded any number of small, highly focussed projects that have applied existing technologies to novel situations. This work has involved support not only to individual oil and gas companies, but also research at the national laboratories and at universities (BDM-Oklahoma, Inc. 1998, U.S. DOE 2001).

4.3.2 Industry-specific Technology

A handful of technologies specific to the oil and gas industry have made remarkable improvements in the productivity and effectiveness of the industry. While technologies related to seismic imaging, drilling, platforms, completion and production, and deepwater activities can be seen as separate and distinct, they are intimately linked. It is in fact the synergy among these technologies that has produced some of the more dramatic improvements in finding and producing oil and gas.

The objectives of the technology that has come on line since 1980 are little different from the challenges seen for technology today (Watts 2000). These include the following.

- Recovering more from mature reservoirs
- Accessing more difficult resources
- Achieving higher operating standards
- Profiting in highly competitive environments
- Finding new cost reduction opportunities
- Coping with volatile prices

For a chronology of the most significant technological milestones of the past 20 years, see Table 9 in Section 3.3. As noted there, many of the technological advances since 1980 have been incremental and the milestones in Table 9 represent a selected group of general markers for technological change.

4.3.2.1 Seismic Imaging

By most accounts, 3D seismic imaging is the most important technology of the last 20 years. It has revolutionized the identification of oil and gas deposits. By more precisely locating oil and gas within geological formations, 3D seismic imaging is also used to assess reservoir characteristics, guide drilling, and then monitor reservoir depletion for better management of oil recovery. By adding 3D images of the same formation over time, so-called 4D imaging results. This is particularly useful in managing production activities and determining the best strategies for optimal depletion.

Seismic imaging began in the 1920's with so-called 2D images. Although initial experience with 3D imaging can be traced to the mid-1970's, this technology did not begin to become important in the GOM until the mid-1980's (Bohi 1998, Van Wie 2000).

The development of seismic imaging has been particularly dependent on the development of computing power and software. As these technologies have become more powerful, they have enabled seismic imaging to be based on the analysis of increasingly large volumes of data, creating increasingly information-rich images of subsurface rock formations and the oil and gas deposits within those formations. Thus, in 1993, an industry veteran estimated that a computer could process 100 times the volume of seismic data that could be processed in 1957 when he started in the industry (Crain 1993). The volumes of data that can be processed have only gone up since that comparison was made in 1993. In 2001, Exxon Mobil processes as much seismic data in 10 days as would have taken 11 years to process in 1990 (Taylor 2001).

The application of 3D imaging has had three fundamental applications. One, it can be used to rework existing reservoirs either using existing data or using newly created data. This was in fact the first application of 3D images and it has continued to be an important tool for independents and others interested in reworking previously found deposits (Bishop 2000, Bohi 1998, Jeppesen 2000). This application has been found to be the overwhelming choice for explaining success in getting more natural gas from existing deposits onshore and offshore in Louisiana, where other reserves growth activities had proved fruitless (Staff 1997a).

Two, as an exploratory tool, 3D imaging has transformed the discovery process for oil and gas companies. Information from these kinds of images was, for example, a precondition to the development of deepwater leases by Shell in the mid-1980's (Pattarozzi 2001). This kind of information has also been credited with the increase in GOM activity from the mid-1990's to the present (Jeppesen 2000).

Three, 3D and 4D imaging can greatly improve ongoing production from reservoirs. Thus, 3D helps guide drilling activities to both large and small deposits and facilitates so-called smart wells (Watts 2000). This has led to both higher discovery rates and reduced costs for well development (Huber and Mills 1998, Bishop 2000).

4.3.2.2 Platforms

In the GOM, the story of oil and gas development and production is basically a story of going into deeper and deeper waters. This posed a basic problem for the industry in creating structures that could house the necessary drilling and other production equipment and facilities. Platforms to support all these activities successfully had been devised for the shallower waters of the near shore Continental Shelf. The challenges of these waters requiring operations in several hundred feet of water could be met by platforms rigidly connected to the seabed. As water depths grew progressively deeper, new solutions were required.

At the end of the 1970's and very early 1980's, platforms in the GOM were operating in 1,000 feet. This was beginning to draw close to the limit of what steel jacket platforms can accommodate. These platforms connect steel to the seabed and can work in water up to about 1,500 feet in depth (Bohi 1998).

Beginning in the 1970's, technology for tension leg platforms (TLPs) began to emerge. These platforms are anchored to the seabed with hollow steel tubes and can be used in waters several thousand feet deep. This capability was essential to the strategies of Shell and others desiring to develop deepwater projects. Bullwinkle was an early TLP platform operating in 1,300 feet. Progressive improvements pushed applications of this technology to near 3,000 feet with Auger and are moving toward capacity for about 10,000 feet (Pattarozzi 2001).

As an alternative to TLP technology, spar technology applies to deepwater drilling and production platforms. In 1987, spar technology for deepwater operations was patented; and the first spar was installed at 1,930 ft. of water in the Gulf of Mexico. In 1998 two others were installed at 2,590 and 4,800 ft. This demonstrated the extension of the spar concept into deeper waters. By 1998, advances in spar technology included a platform designed specifically for drilling in waters over 8,000 ft. (Skaug 1998). By 2000, spar designs for operations in waters to 10,000 feet were being published. These designs were modular, lighter in weight than previous, re-usable from site to site, and cheaper (Staff 2000e).

The rapid pace of change can be seen in the conventional wisdom of 2000 and 2001 that sees capacity for operating in 10,000 feet of water developing in the near term. Only two years earlier, in 1998, Exxon set a new depth record at less than half that depth with an 83-story floating platform in 4,800 feet of water in the GOM. This platform was scheduled to start operating in the year 2000 (Huber and Mills 1998).

Platform design seems to be rising to the challenge of progressively deeper waters. Not all deepwater platforms are successful, however. In March of 2001, a Brazilian floating platform sank in waters 120 miles off the coast (Muello 2001). Nonetheless, industry optimists have predicted that by 2015, platforms and other technology will permit operations offshore anywhere in the world. The world's entire seabed will then be accessible to the oil and gas industry (Staff 2000h).

4.3.2.3 Drilling and Smart Wells

Advances in drilling technology have focused on two capabilities: control of the direction of the drill bit and gathering information about conditions as the drill bit is operating. The former is variously termed horizontal, multilateral, or directional drilling while the latter generally falls under the heading of measurement while drilling or logging while drilling.

Drilling exemplifies the type of technology that develops over very long periods of time and then suddenly becomes a dramatically successful technology. Horizontal drilling was tried unsuccessfully in the 1920's, was successfully applied in the 1930,s, and then in a modern version was again demonstrated successfully in the 1950,s. More recently, the early 1980's saw the first horizontal wells drilled offshore, in waters off the coasts of Italy and California. Despite this history, only the success achieved with horizontal drilling in the Austin Chalk formation in the late 1980's produced industry-wide acceptance of this technology (Chambers 1998).

Since its overnight success in the late 1980's, horizontal drilling has gained progressively more capabilities that allow even greater remote control over the direction of the drill bit. By 2000, drilling could be "steered" in virtually any direction. With 3D imaging available to show where oil and gas can be found, directional drilling can more easily access these deposits. The result has been improved efficiency in drilling and greater effectiveness in recovering oil and gas from subsurface rock formations (Moritis 1996, Coy and McWilliams 1997). This has been true for existing projects as well as new discoveries (Caldwell and Heather 1992). Speed has also been a benefit as drilling technologies have reduced well completion times by as much as 75 percent compared to the 1950's (Mitchell 2000).

The impact of horizontal and directional drilling can be seen in the increasing areas that are accessible from one drilling site. In 1970, a 5-acre drill site could access a subsurface area 2 miles in diameter. By 1999 the drill site had increased 160 percent to 13 acres, but the accessible subsurface area that could be drilled had increased 1,500 percent to an area 8 miles in diameter (Revkin 2001). This drilling reach will likely continue to increase. In 1998, a horizontal well just over 6.2 miles was completed (Kennedy 1999). Such a well would allow for access to an area almost 13 miles in diameter from a single drilling site.

Parallel with the improvements in controlling the direction of drilling operations have been advances in the collection of data during the drilling operations. Sensors are now located near the drill bit and these transmit data in real time. These technologies allow drill operators to monitor such essential information as bottom hole temperature and pressure, drill rotation speed, and physical characteristics of the surrounding rock. The first logging-while-drilling tool was used in 1987 about the time that industry realized that horizontal drilling was valuable. Since then, numerous incremental improvements have advanced this cluster of technology adding more types of data and greater volumes of data to the technology (Bohi 1998).

The data available from measurement-while-drilling systems is coupled with computer capability to provide additional analytical power. This information can then be used to guide the drilling operation, avoid difficult conditions in formations, better manage drilling muds, compare the well under development with other nearby wells, and other activities (Knight 2000).

In addition to these major drilling technologies, other more incremental improvements have improved drilling over the past 20 years. Drilling fluid and mud systems, which are used to cool the drill bit, maintain pressure on the bit, remove cuttings from the well bore, and other essential functions have improved over time. Drill bits have also improved with the use of harder abrasives and better adhesives to keep the abrasives on the bit face. Other systems result in faster drill speeds (Kappmeyer 2001, Jeppesen 2000).

All of these and other related improvements are sometimes termed “smart wells.” This bundle of technologies has resulted in improved effectiveness and efficiency, cutting costs and the time required to accomplish work (Watts 2000, Staff 2000h, Verrett 2001).

4.3.2.4 Completion and Production Technologies

Once wells are drilled and deposits of oil and natural gas have been reached various technologies are employed to complete the well structure and to initiate and maintain production. Unlike the use of seismic imaging or drilling technologies, these technologies do not stand out as breakthrough or even remarkable advances for the oil and gas industry. Nonetheless, they have often made substantial differences in the effectiveness of operations.

Most of these technologies advance incrementally. So, for example, Shell developed a second-generation underwater manifold center in 1982 that was modeled on submerged production technology developed by Exxon. This technology was progressively improved and simplified, reducing its cost, and modified on a case-by-vase basis. This is a demonstration of next-step technology repeatedly applied. When the technology was sufficiently defined, the American Petroleum Institute (API) worked with various manufacturers to standardize the equipment, thereby lowering costs again.

Technology to control the intrusion of sand into the well bore is another example of steady incremental progress. Sand can clog wells, stopping production, and forcing time consuming and expensive work to reopen wells. In 1980, plasticized resins were used to try to keep sand from the well bore. The next step was screens with prepacked resins. Gravel packs were the next advance. By the mid-1990’s, the technology had moved to frac packs, which do an even better job of keeping sand from the well bore. The results of this progression of sand control technologies can be dramatic. Without any control system, flow from a gas well might be 2 mcf/day. With gravel packs, the flow might increase to 14 mcf/day. Using frac packs, flow could increase to 80 mcf/day—40 times higher than a well without any control system (Utsler 2001, Jeppesen 2000).

Another production technology that has improved production results is the manner in which the formation is fractured to encourage flow into wells. Recently, foam-fracturing materials have been replaced in many cases by water-soluble gels. Older formations have been reworked with the new fracturing technology and consequent production has exceeded the production achieved when the formation was first developed (Kappmeyer 2001).

While "smart wells" technology often refers to the technology in use during drilling, other "smart well" technology helps manage and increase the effectiveness of production. Thus, in the mid-1990's, technology was coming on line that allowed operators to monitor the pressure and temperature of oil coming from two different pools in a single well. The "smart valve" device permits monitoring multiple oil reservoirs from one shaft, allowing operators to control the pressure and production from different pockets of oil simultaneously, and thus obtain a vast increase in economically recoverable oil (McWilliams 1996).

4.3.2.5 Deep-water Technologies and Strategies

Much of the technology discussed above applies to deepwater and other locations. Deepwater, however, provides particular challenges: the weight of fluid columns on unstable formations, remote intervention, subsea flowlines and assuring flow in extremely cold environments, and ultra deep platform design. Costs and risks rise as water depth increases, as does the potential for damage to equipment from rough seas. Distance from shore can also mean distance from pipelines and other infrastructure (Skaug 1998, Watts 2000).

The response to these issues has been to look at deepwater requirements as an integrated system of technologies, developed within a broad framework. Thus, the Auger discovery in the mid-1980's was followed by the identification of perhaps 10 other large prospects. Collectively, the potential of these deepwater deposits could justify Shell's development of deepwater facilities. The basic Shell strategy begun in the 1990's was to create a hub and satellite system, first developing the larger hub properties then developing smaller fields that could be tied into the larger hub. By sharing infrastructure, the total system would lower costs and optimize the use of technology. Experience of the late 1990's has borne out Shell's expectations of this strategy (Pattarozzi 2001).

The systems that are employed in deepwater depend on the utilization of 3D and 4D seismic imaging, platforms capable of operating in increasing deepwater, new drilling systems, horizontal and directional drilling, and the host of completion and production technologies discussed immediately above. In addition, deepwater relies on other technologies for its success.

- Drill ships are necessary for extreme deepwater locations. These ships house the drilling systems used to find oil and gas. Advances in telemetry and ship control have made significant improvements in this technology in recent years (Bell 2000, Ellis 2001).

- Remotely operated vehicles (ROV) have been developed from early models resembling flying basketball-sized eyeballs to single-arm vehicles, then two-arm vehicles, and finally grabbers and more sophisticated manipulator arms. ROV technology eliminates the need for human divers in waters deeper than 300 feet and greatly facilitates deepwater activities while lowering costs (Rickey 2000, Taylor 2000, Plaisance 2000).

- As projects move into deeper waters, the pressure on equipment increases making certain technologies (e.g., hydraulic systems) that work in less hostile conditions ineffective. New electronic controls and fiber-optic based technologies have been developed to address these concerns (Von Flatern 1997b).

- Much of the production equipment that traditionally was located on platforms has in recent years been modified so that it can be located on the seabed. This subsea technology is evolving rapidly and will likely incorporate subsea processing of produced oil and gas sometime in the near future (Loth et al. 1999).

- Of particular concern in extreme deepwater is assuring that oil will flow in pipelines. The technology to assure flow is also recently emerging and includes insulated pipe and vacuum-packed tubing. Here the issue is mostly cost and the expectation is that either costs will declince or other more cost-effective technologies will emerge (Utsler 2001).

4.3.3 Digital Technology

Computers, software, telecommunications, and the Internet—sometimes called digital technologies—have had a remarkable effect on the oil and gas industry as they have had on all industries. A selective listing of major events related to these technologies is presented in Table 13. This table begins with the introduction of the first commercially successful personal computer in 1977 just before the period of interest to this study.

The change that has occurred in the 20 years from 1980 to 2000 is astonishing. In 1980, the predecessor to the Internet in popular use today comprised a network of about 200 host computers with registered addresses. By the end of 2000, approximately 100 million host computers were connected to the Internet. In 1980, IBM was still a year away from introducing its first personal computer, a machine that set the standard for the computers that have transformed working and personal life.

Rather than discuss the particular aspects of digital technology and its evolution in the 1980-2000 period, the following sections introduce the major applications of this technology and the resulting benefits for the oil and gas industry.

4.3.3.1 Information and Computer Technology

The adoption of computers, software, and other information and computer technology by the oil and gas industry has had two broad categories of effects. The first is a generally acknowledged impact on overall productivity as the computer became a commonplace tool for oil and gas industry workers. The ability of the average worker to use a computer has allowed that individual to produce more output over time than would be otherwise possible. “Teamware” software has allowed, for example, locationally and technically diverse groups to work together (Barton and Ritter 2000). In this way, the effects of computers and related technology mirrors those in virtually every U.S. industry. For some observers, this broadly distributed benefit has in fact been the major change brought by this technology (Cunningham 2000, Verrett 2001).

The other area where these technologies have been applied is in the enhancement or enabling of more industry-specific and focused technologies. The capacity of computers to store, manage, and analyze ever larger quantities of data at ever greater speeds has made many technologies better and allowed some to exist that otherwise could not.

Table 13

Milestones in Digital Technology, 1977-2000

Year	Milestone
1977	• Apple II released and becomes first mass produced personal computer
1980	• About 200 computers are connected to predecessor of the World Wide Web
1981	• IBM PC is released
1982	• Compaq introduces its first computer, stimulating the production of PC-compatible machines by companies large and small
1983	• Lotus 123 becomes standard for spreadsheet software • IBM XT computer, first with hard drive, is introduced
1984	• Hewlett-Packard ships first laser printer • National Science Foundation joins the Internet and creates standards followed over the next several years by NASA, National Institutes of Health, other federal agencies
1985	• Intel introduces first 32-bit processor (80386) • Microsoft introduces first version of Windows
1987	• Internet computers exceed 10,000
1990	• Vastly improved version of Windows is released • Internet computers exceed 350,000
1991	• World wide web (www) first released
1992	• Internet host computers exceed 1 million
1993	• Intel manufactures first Pentium chip containing 3 million transistors • Internet growing 20 percent a month • White House comes online
1994	• Early version of Netscape, Internet browser, created
1995	• Microsoft releases Windows 95 and Internet Explorer
1996	• First commercial successful Personal Digital Assistant introduced
1998	• Two million domain names have been issued for the WWW
2000	• Intel introduces Pentium chip with processing speed of 1.5 GHz • Roughly 100 million computers are linked to WWW • Wireless access to internet becomes more common

Sources: pcbiography 2001a, pcbiography 2001b.

- Design processes have been speeded up by standardization and the application of computer technologies and can be completed in less time, improving economics and the competitive advantage of those at the leading edge of development. Modeling and preliminary testing have benefited vastly from increasing capacities of computers and sophistication of software (Taylor 2000).

- Computer applications have speeded up imaging and visualization work, reducing time required for analysis and coordination from months to hours. Real-time drilling monitoring enables rapid mid-course adjustments on projects, saving time and money (Farnsworth 2000).

- Computers are the crucial component of subsalt exploration. What might have taken 6 months in the 1980's, now may be done overnight (Van Wie 2000).

- The technology to control sand is not new, but what has made application feasible is the ability to use computer technology to process data. This is an almost universal problem with GOM; thus, managing sand is a vital step in optimizing production (Utsler 2001).

- The greatest reduction in cycle time for moving from idea to execution is data management and data quality control driven by ever increasing computer processing speed. An estimated 60 percent of the pursuit of hydrocarbons is driven by data acquisition and quality control of that data, all enabled by computer and software technology (Utsler 2001).

- The fundamental breakthroughs of 3D and 4D seismic in the last 20 years rest on enormous improvements in applied computer technology. Computers have also made a great difference in production technology (Kappmeyer 2001).

While computers have had an enormous effect on the industry in the past 20 years, some consider these changes modest in comparison to what the future holds. Moreover, these future changes are felt to be most likely in the general application of this kind of information technology, not in industry-specific technologies (Barton and Ritter 2000, Perdue 2000).

4.3.3.2 Telecommunications, the Internet

Like computers and software improvements, the changes that have been made in telecommunications technology and the extraordinary changes in the Internet have had both general and particular applications and benefits for the oil and gas industry. E-mail and the Internet have fundamentally changed how many employees work each day. In particular applications, these technologies have begun to transform the oil and gas industry, according to some observers.

Communication over the Internet tends to increase the volume and speed of information flow among workers. Using the Internet to communicate Royal Dutch Shell teams were credited with a "light touch" discovery method that successively found significant quantities of oil (Reingold et al. 2000). Internet-based communications has helped create "virtual" teams that are not constrained by the physical location of team members (Barton and Ritter 2000). By eliminating the need to meet in a single location, the Internet allows these virtual teams to operate less expensively and with greater time efficiency (Staff 2000c).

By combining the Internet, and telecommunications, computer and other technologies, the oil and gas industry has been able to engage in commercial transactions and activities in ways that represent a fundamentally different approach to business (Salomon Smith Barney 2000).

- Web sites dating no farther back than 1999 have begun to offer procurement of well drilling services, auctions of oil service goods and services, and the buying and selling of oil and gas properties. These sales activities are supported by online access to economic and interpretation data (Greenberg 2000).

- Such web-based business is credited with offering alternatives to fragmented procurement methods (Staff 2000c).

- E&P companies are just beginning to realize the enormous potential for managing their portfolios of assets through the capabilities of online technology (Fockens and Warren 2001).

- The Internet allows companies to plan and monitor exploration, drilling, and production in real time from remote locations (Staff 2000c).

- Cycle times for procurement using internet-based systems can be reduced by 50 percent (Beyster and Glancy 1999).

- Even more drastic reductions in time have been claimed for assembling large sales of natural gas. Where before internet-based sales were available, such transactions would have taken 9 months; using the Internet, these transactions can now be completed in 20 minutes (Reingold et al. 2000). Others assert even faster transaction completion times for standardized deals—1 second (Porubon 2001).

Much of the application of the Internet has been to traditional business processes. The reduction in completion times for these transactions when the Internet is used seems a harbinger of more fundamental change for some. In 2000, an estimated $650 billion of business of all kinds was transacted over the Internet. By 2004, the Chief Executive Officer of Enron predicted $6.5 trillion will be transacted over the Internet (Porubon 2001).

The capability to use the Internet and information technology to transact business may overturn basic business models for certain kinds of oil and gas companies. Whereas in the past, companies were asset-based and vertically integrated; some see the future as one of "virtual companies" that concentrate on marketing the delivery of energy products and rely on virtual integration to deliver the goods (Porubon 2001).

4.3.4 Technology and Its Effects on the Industry

The effects of technology on the strategies and organization of the oil and gas industry and its companies have been identified throughout the discussion of technology. The following sections primarily serve to highlight and summarize this material.

4.3.4.1 Risk and Corporate Decision Making

In the context of the oil and gas industry, risk is the probability that companies will either lose money or fail to receive an adequate return on investment of time, funds, and effort. This risk, focused on technical issues, can be translated into a few major issues along the industry's value chain.

- How can commercially viable deposits of oil and gas be found?
- Having located such deposits, can the necessary resources be brought to bear to access and extract them?
- What portion of such deposits can be recovered?

As has been noted throughout the earlier discussions of technology, each of these technical issues can be more easily solved today because of advances in technology over the 20-year period ending in 2000. Seismic imaging is, by most accounts, the greatest technical advance in that period. Seismic 3D and 4D images provide much more informative estimations of where oil and gas are located. In conjunction with advanced drilling techniques, this imaging helps create wells that access all significant deposits of hydrocarbons in these reservoirs. When this activity is in deepwater, advances in drilling ships, platforms, and floating production systems assure companies that exploration and production activities can be successfully undertaken. Once production is initiated, 3D and 4D images in conjunction with completion and production technologies can monitor and manage reservoir depletion so as to optimize oil and gas recovery.

The total effect of these and related technologies on risk is to lower the probabilities that basic oil and gas activities will be unsuccessful, that is, to lower risk. These technologies in fact provide the industry with basic tools that allow the industry to manage that risk and to balance risks against likely outcomes or against competing projects.

The improved success resulting from technological advances permits companies to enter complex and more hostile environments with greater confidence that the problems of deepwater exploration and production, for example, can be solved. As the costs of development climb in these more difficult environments, the ability to reduce and manage risks becomes increasingly important. Thus, the reduction in risk allows companies to make affirmative decisions in frontier areas that would not have been possible 20 years ago.

4.3.4.2 Information Technology and Corporate Decision Making

The general effects of information technology on corporate decision making are to make it faster, cheaper, flatter, more complex, and usually better. Faster decisions are a direct result of the speed of computers and the interactive qualities of the Internet. As noted above, transactions that would have taken months in the past are now completed within hours or even less time. This reduced time almost always drives down costs.

Information technology also has the effect of reducing layers of decision making in many organizations. This is often due to its ability to facilitate the kinds of corporate restructuring that have overtaken the oil and gas and most other industries in the past 10 years. (See discussion in Section 4.4.2 for the effects of restructuring.) By easing the flow of information between layers of management, information technology has essentially helped to eliminate the need for much middle management.

Through the ability to manage and process large volumes of information, information technology makes possible decisions based on more complex, more information rich analyses. When properly handled, this capability leads to better decision making. Thus, models that monitor production from wells can guide decisions that will recover an optimal amount of oil and gas from subsurface formations. Resource allocation decisions among competing projects can be made on the basis of real-time data streams generated by numerous projects.

Such information does not guarantee good decisions, however. At least one industry expert believes that information requirements of top management are often not met. While companies are capable of producing large volumes of data for operations, they are not as good at providing enterprise-wide information that can help top management make decisions that are best for the entire company (Chevriere 2000). Thus, the value of information technology is ultimately dependent upon the ability of decision-makers to have the right kinds of information in a form they can use at the proper time.

4.3.4.3 Change in Labor Requirements

As the sophistication of technology has increased and that technology has diffused throughout the oil and gas industry, the need for workers to have appropriate technical skills has grown. The necessity of having technical skills no longer applies just to petroleum engineers, geologists, and similar workers. As computers have enhanced drilling, production, and other core processes, the need for technological literacy has become virtually universal.

This basic upgrading of the technical skill requirements of the industry's workforce creates a number of issues. Workers need to remain on the leading edge of an increasing number of technologies, but a leaner industry is less interested in on-the-job training. The needs of other industries for similarly skilled workers have increased overall competition in hiring. (These and other issues related to technology and labor are discussed in Section 4.4.1 below.)

4.3.4.4 Location of Activities and Personnel

The communications revolution brought about by computers and the Internet has begun to make geography irrelevant. As noted above, "Teamware" software can greatly ease communications among workers regardless of their locations. An increasing number of activities (e.g., drilling, monitoring production) can be accomplished remotely because data are transmitted virtually anywhere in real time and controls can be activated from distant locations.

These developments are distinct from the more general changes in the workplace resulting from computing and telecommunications technologies. Collectively they are freeing workers from the need to work at the specific location where the physical activities occur. For the GOM, this tends to reduce the need for offshore workers and increases the potential for work to be conducted onshore. (See also discussion in Section 4.4.1 on the location of work.)

4.4 Labor

Traditionally, the goal of oil companies was to find oil and gas and sell it. Success was measured in production volumes. When prices outpaced costs, increased production meant increased profits (Crain 1993). Following the collapse of oil prices in the mid-1980's, the goal shifted to measuring business success in terms of shareholder value. That meant revenues needed to go up and costs needed to go down. Cost cutting became a corporate strategy to achieve that goal. Oil and natural gas prices are outside of management's control. But, costs are not. So, management began to focus on costs it could control, like labor and capital expenditures. Cost cutting strategies were prominent in the mid-1980's to the mid-1990's and beyond. They were used in industry in general, and as discussed here in the oil industry. Companies focused on reducing organizational costs through reduction in force, improved performance, and introduction of technology. Other efforts to lower operating costs included selling noncore properties and business units. Cost cutting led to flatter management structures, smaller staffs, altered ways of doing work, shifts in skill needs, and personnel issues that could potentially hinder the growth of the industry in the coming years.

In the decade between 1985 and 1995, low oil prices often offset company savings through cost cutting programs. This situation led to further cost cutting activities. Oil and gas companies selected a mix of cost cutting approaches according to individual needs. Cost cutting boosts cash flow and supports capital spending and shareholder value, but affects the industry's work force. Labor-related strategies and their impacts on personnel and personnel issues are described in this section.

4.4.1 Reduction in Force

As first discussed in Section 3.4, employment in the oil and gas industry declined between 1982 and 2000. Oil and natural gas price variability was one of the factors that contributed to the decline. But, employment kept on declining even when prices rose. Other factors that contributed to the employment decline in the industry include corporate strategies involving mergers and acquisitions, downsizing/rightsizing, freezes on salaries and benefits, and technological advances. These are discussed below.

4.4.1.1 Mergers and Acquisitions

Mergers and acquisitions are corporate strategies to accomplish one or more of the following:

- Improve reserve position
- Reduce overhead and create synergies
- Diversify geographically and functionally
- Grow by acquisition as opposed to exploration (i.e., by the drill bit)
- Enhance position of core areas and entry into new core areas
- Change direction of the firm
- Share risk and technical expertise

Table 14 shows some of the mergers and acquisitions in the oil industry that occurred between 1980 and 2000. Oil companies, drilling contractors, and service companies used the merger and acquisition strategy during this time. Between 1996 and 2000, more than $500 billion (unadjusted) in global merger transactions occurred, more than the cumulative total of oil and gas merger and acquisition activity over the previous 95 years (Cassidy et al. 2001). In 2000, the total value of upstream and downstream mergers and acquisitions in the global oil and gas industry was reported as $79.2 billion, down from $85 billion in 1999, and the record $122.1 billion in 1998 (Staff 2001d). The merger and acquisition strategy is expected to continue, resulting in further consolidation within the industry. However, the number of companies available for merger or acquisition has decreased and the potential anti-trust issues has increased which may slow this trend.

One of the most obvious changes in the oil industry in the last 20 years is the disappearance of the "seven sisters," the multi-national, multi-division corporations that were long dominant in national and international trade. Of the seven, Exxon, Chevron, Shell, British Petroleum, Mobil, Gulf, and Texaco, only the first four named still exist as they did in 1980. Chevron acquired Gulf and Texaco, and Mobil merged with Texaco. Gulf succumbed because of poor performance. Texaco and Mobil were acquired/merged as giant corporations sought economies of consolidation and scale. John D. Rockefeller's original Standard Oil Company of Ohio (SOHIO) and Amoco (Standard Oil of Indiana) were both acquired by British Petroleum, which had acquired Sinclair's downstream assets, principally gas stations and two refineries, when Arco bought Sinclair in 1968.

Second-rank companies, such as Phillips, Conoco, and Kerr McGee, also went through major transformations, launching aggressive acquisition campaigns. After Conoco was spun off from DuPont Company in 1999, it made extensive buys in the Permian Basin and Canada, making it the 10th largest investor-owned oil and gas company in the U.S. Kerr McGee increased its presence in offshore U.S. areas and in foreign regions, as did Phillips.

The consolidations in exploration and production were mirrored by changes in the industry's service sector. During the 1980's, the downturn led to failure of even large companies, such as Western Geophysical. Other diversified companies sold petroleum industry-related assets. Thus, Fluor sold its oil and gas operations to Houston Industries, which was later acquired by Schlumberger, which also bought Western Geophysical in 2000. By the end of 2000,

Table 14

Examples of Mergers and Acquisitions, 1980-2001

Year	Merger/Acquisition
1981	Dupont bought Conoco
1982	U.S. Steel bought Marathon
1982	Occidental Petroleum acquired Cities Service
1983	Sun Oil bought Exeter
1984	Mobil acquired Superior Oil
1984	Chevron acquired Gulf Oil
1984	Schlumberger bought Sedco
1985	Royal Dutch Shell purchased Shell U.S.
1985	Texaco bought Getty
1987	BP America acquired Standard Oil
1988	Chevron acquired Tenneco Oil Gulf of Mexico operations
1997	Falcon Drilling and Reading & Bates Corp. merged to form R&B Falcon
1998	BP acquired Amoco
1998	Halliburton Co. acquired Dresser Inc.
1998	Schlumberger Ltd acquired Camco International Inc.
1999	Mobil merged with Exxon
1999	Kerr McGee acquired Oryx
1999	Schlumberger spun off Sedco Forex Offshore which then merged with Transocean Offshore, Inc.
2000	BP Amoco bought ARCO
2000	Transocean Sedco Forex bought R&B Falcon Corp.
2000	Anadarko Petroleum acquired Union Pacific Resources
2001	Texaco merged with Chevron

Sources: Meister and Cady 1986, Staff 1995a, Flanagan 2000.

Halliburton, the other giant among service companies, had acquired M.W. Kellogg, the dominant engineering firm, and Dresser, the leader in production services, among other companies (Staff 1985, Fisher 2000).

Consolidations were massive in the drilling and equipment sectors. Baker International merged with Hughes Tool in 1986 to become Baker/Hughes. The most recent price downturn placed Reading & Bates Corporation in a weak debt position and it was acquired by Falcon Drilling, which also bought Cliff's Drilling Company. The relative lag in day rates, in turn, undermined the position of R&B Falcon, which was acquired by another product of recent mergers, Transocean Sedco Forex, Inc., in early 2001.

The merger and acquisition strategy as a means to growth or improve cash flow is not unique to the oil and gas industry. In FY 2000, for example, more than 4,900 merger-related filings were made with the Federal Trade Commission, the agency that oversees antitrust enforcement in mergers and non-merger areas (Staff 2000b). This was a record number of filings. The number of filings more than tripled between 1991 and 2000. Consolidation through mergers and acquisitions has reduced the number of firms in some industries. In the 1980's, for example, meat-packing firms in the U.S. consolidated to the point that four firms account for the slaughter of about 84 percent of the nation's cattle. And, after acquisition or elimination of smaller firms, three companies produce about 80 percent of the U.S. frozen french fry market (Schlosser 2001).

One of the consequences of merger and acquisition activity has been a reduction in labor force. The loss of employment results from redundancies of jobs once the companies are merged, early retirement programs offered to reduce employees, and employees who resign rather than take job reassignments or transfers to other cities. Companies commonly sought economies through elimination of layers of management. Companies quickly save on the salaries and benefits that are no longer paid to these former employees.

In 1984, for example, Gulf Oil merged with Chevron. By 1989 following their merger, the combined work force of the two companies had been reduced from 79,000 to 61,000. The remaining company, Chevron, was reported to have "emerged as a much stronger company, more diverse geographically and functionally and with worldwide reserves of oil and gas about doubled" (Staff 1989a). Chevron further eliminated more than 800 jobs in 1990 and more than 2,000 jobs in 1992 (Staff 1992c, e). When the Chevron Texaco merger was announced in 2000, workforce reductions of 4,500 worldwide, or 7 percent of the combined workforce were expected. Following the merger, workforce cuts increased by another 500 as the merged corporation set higher financial and operational targets (Staff 2001b).

In another example, a reduction of about 9,000 workers was initially anticipated in the 1999 ExxonMobil merger. That figure was later revised to upward of 16,000 or about 15 percent of the combined company's workforce. Retirements, including early retirements, were to account for about 6,000 of the cuts, while layoffs were to account for the other 10,000 jobs. The reduction of workers was to be completed by the end of 2002 (Smith and Fan, 2000).

4.4.1.2 Corporate Restructuring

Company restructuring resulted from cost cutting programs. Restructuring usually involves elimination of duplication and reduction in labor force. Approaches to corporate restructuring include downsizing, rightsizing, and reengineering.

Downsizing is "using fewer people to do the same or less work in the same way" (Hammer and Champy 1993). This may be achieved in a number of ways, including mandated cuts across all departments. While mandated cuts may be perceived as an equitable approach to achieve desired results, it ignores differences in the requirements or competitive cost positions of various business units and it rewards managers who have been spenders and punishes managers who have consistently run lean operations. Other downsizing strategies include eliminating positions that would unlikely be filled any way and to not fill positions that are vacated through attrition or retirement. Contract labor is sometimes substituted for full-time employees in specialized areas as another way to eliminate company positions. It is not uncommon for employees to be laid off, only to be hired as contractors. The advantage to the company is retaining the expertise without incurring costs associated with benefits paid to company employees.

Rightsizing is "the process of eliminating nonstrategic, financially marginal, or other undesirable properties from the portfolio, along with a parallel restructuring of the organization in order to reach such optimum" (Langley 1992). Divestiture programs to sell noncore properties, common in cost cutting programs and following mergers, are part of rightsizing activities. Divestiture of noncore properties by the major oil companies in the late 1980's led to an increased role for independent companies in the early 1990's (U.S. DOE, EIA 1995). The majors also divested domestic properties in the early 1990's when they refocused exploration and development activities overseas (Koen 1994b). Sale of noncore properties or business units resulted in employment losses and company restructuring. Employees whose jobs are eliminated in restructuring are sometimes reassigned to other parts of the company so that the number of employees laid off does not always equal the number of jobs eliminated.

Reengineering is "the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed" (Hammer and Champy 1993). In contrast to downsizing, it is designed to do more with less and results in changes to work processes.

Restructuring techniques, particularly downsizing or rightsizing, are sometimes used following mergers/acquisitions when redundancies are eliminated. Rightsizing and reengineering often start with the goal to improve performance. All three approaches can result in layoffs. These strategies are not unique to the oil and gas industry. Rather, they are commonly used corporate strategies to improve the company's bottom line, regardless of the company's line of business. While still in use, these strategies were common in the early 1990's. Hammer and Champy's book, *Reengineering the Corporation: A Manifesto for Business Revolution*, was published in 1993. These strategies were in use throughout all types of industry in the early 1990's and began being used to reinvent government in the mid-1990's.

Companies not achieving desired results with one of the techniques tried more than one. Many oil companies used a series of cost cutting programs from the mid-1980's to the mid-1990's and sometimes beyond. Examples of activities within restructuring programs are shown in Table 15.

The sale of properties and company acquisitions created some large new independents, including Parker and Parsley (acquired by Pioneer in 1999), and Apache Corporation. Apache, on the scene in a relatively small way since the 1950's, moved to acquire properties from Hadson Energy Resources in Australia and other companies, then worked to offset mounting production costs by acquiring additional holdings, buying offshore U.S. leases from Shell Offshore, Occidental, and Petsec, along with Canadian assets purchased from Phillips, Shell Canada, and Fletcher Challenge Energy. As part of its growth, the enlarged company bought holdings in Egypt along with sizable assets in the Permian Basin. By the end of 2000, opportunistic buying had made Apache one of the world's largest independent oil and gas exploration and production companies, with nearly $7.5 billion in assets (Staff 1993, U.S. SEC 2000, Apache Corporation 2000).

4.4.1.3 Salary Freeze and Benefit Cuts and Shifts

Salary freezes and cuts in benefits are another cost saving technique used to improve cash flow. This technique is used throughout business and industry when economic conditions warrant it. It was used by the oil industry in conjunction with techniques to cut costs and improve cash flow. For example, Occidental Petroleum began a broad restructuring program in 1991. The program included a pay freeze for all salaried employees earning more than $40,000 (unadjusted) per year from late 1992 through 1993. Salaried employees earning less than $40,000 per year received a 3 percent pay increase in April 1992 to offset inflation. Savings from the salary freeze and some adjustments to benefits were expected to be about $55 million per year (Staff 1992g).

More recent economic conditions have warranted use of this approach. A survey of 222 energy firms taken in January 1999 found that about 94 percent had taken compensation actions in the preceding 6 months in response to the decline in oil and gas prices. Of those surveyed, 62 percent of the drilling contractors and 37 percent of E&P companies had placed a freeze on salaries. Other actions taken by those surveyed included reducing salary increases, lengthening the interval between salary reviews and increases; terminating incentives/bonuses, offering smaller incentives/bonuses, adjusting stock options, offering early retirement, instituting a hiring freeze, layoffs, and not replacing terminated employees (Staff 1999b).

The volatility of the industry during the 1990's led some companies that still offered fixed benefits to shift to fixed-contribution pension programs. Some companies also offer more stock options than they did previously when personnel were less mobile (Bender 2001).

Table 15

Examples of Oil Company Restructuring Programs

Year	Company	Announced Activities
Late 1980's	British Petroleum Co. plc (currently BP Amoco)	• Sold assets worth $7 billion and cut 12,000 jobs following a series of reorganization and rationalization efforts
1989	Occidental Oil and Gas	• Reduced staff by 900
1989	Mobil	• Reduced staff by 400
1990	Chevron (To become ChevronTexaco Corp. in 2001)	• Sold assets, streamlined the organization, and eliminate more than 800 jobs
1992	Chevron	• Reduced work force by about 2,000 • Initiated cost cutting program and shifted spending outside the U.S. • Sold nonstrategic producing leases • Consolidated production department to three business units from five • Consolidated exploration department business units in Houston
1992	Unocal	• Consolidated regional offices in Houston • Sold assets • Reduced staff • Sold emulsion polymers and chemical distribution businesses
1992	Phillips	• Sold assets and reduced work force by 1,100
1992	Amoco	• Eliminated 8,500 jobs
1992	BP	• Cut spending and reduced staff
1994	Amoco (Merged with BP in 1998)	• Replaced three operating divisions with 17 business groups • Cut corporate staff
1995	Oxy	• Consolidated work • Redesigned systems • Redeployed assets • Transferred and laid off employees • Sold agricultural business
1998	Shell	• Reduced staff by 4,000 • Sold a portion of its chemical portfolio
1998	ARCO	• Reduced staff by 450 • Divested noncore properties
1998	Mobil	• Sold 25 fields
1999	Phillips	• Sold 22 properties and laid off 1,400 positions

Sources: Vielvoye, 1990, Staff, 1989b, Staff 1992a, 1992b, 1992c, Staff 1992f, Staff 1992i, Staff 1994a, Staff 1995b, Staff 1998c, Staff 1999a, Solis 1998, Staff 2000g.

Note: Examples based on selected announcements in industry publications. Actual reductions in staff and sale of properties per year are likely to have been higher.

4.4.1.4 Response to Technology

The oil industry is a now a high technology business. Technology, such as computers and 3D seismic exploration, have increased productivity, made it possible to undertake more work with fewer people, and share information rapidly (Hasan 2001; Knight 2000). Technology has affected workers in terms of how they do their work and the required skill levels and corporate strategies to staff positions.

Technology has increased the skill level needed for geoscientists entering the industry. These professionals need to be able be productive immediately. The cost cutting programs begun in the 1980's mean there are fewer people doing the work and there are fewer people to develop new employees. Since orientation and training are overhead expenses and, take away from the bottom line, these programs have been scaled back. In 1985, the average training staff with a major multinational firm was over 100. Each geoscientist was expected to accumulate a minimum of 100 hours of training each year. In 1999, training staffs had shrunk to about 15 to 20 and expected training time had been cut to 20 hours (Pohlman 1999). While on-the-job training for geoscientists has decreased in response to leaner operations, the number of software packages they are expected to know increased from six in 1985 to 37 in 1999 (Pohlman 1999).

Technology has changed where some work is done as well. Table 16 summarizes the evolution of the geophysicist's workplace since the 1950's. Technology has changed where and how this work gets done.

Companies such as Shell and ExxonMobil have large imaging theaters in which geologists and engineers see the projected data at the same time as geophysicists and provide their own reactions and interpretations on the spot. Formerly, the geophysicists processed and interpreted data, sometimes in collaboration with the geologists. The engineers were brought in at the end of the evaluation process. The results of bringing all the three disciplines in at about the same time as has been saved time and money and transfer of learning and perspective.

From the drilling perspective, operations became more sophisticated in the 1990's. The need is for technically competent workers in the areas of electronics, hydraulics, and subsea systems. Rural areas of the South have traditionally supplied labor to the drilling industry. The mechanical skills needed for drilling have declined as the areas from which the labor is drawn become increasingly suburbanized. Much of the operating knowledge in the drilling part of the business is learned on the job. Relatively little of it is written, despite the increasing number of manuals. This is potentially serious because technological improvements in drilling require a larger number of trained technicians (Plaisance 2000).

From the companies' perspective, recruiting personnel with proper computer expertise has been a struggle. The oil industry competes with other industries for the some of the same skill sets -- computer science and information technology personnel, engineers, and administrative support staff, for example. Price swings have worked against recruitment. The layoffs that have accompanied low prices do not encourage promising candidates to go into the industry. (See Section 3.4.2, for a discussion on petroleum engineers and their education.) Also, the price swings led many people to leave the industry (Van Wie 2000).

Table 16

Evolution of the Geophysicist's Workplace

Year	Workplace	Comments
1950	Worked in field using analog methods	• Sent results determined in the field to the central office
1960's	Worked in central office using paper sections and colored pencils	• Sent data to the central office for processing and interpretation
1975	Worked in central office using mainframe computers and paper sections	• All aspects of geophysics done in-house • Most petroleum geophysicists worked for integrated major oil companies
1980's	Introduction of interactive workstations and development of 3D seismic acquisition	• Led to decrease in support staff and increase in productivity of seismic interpreter
2000	Work in central office using workstations	• All acquisition and most processing outsourced • Most geophysicists work for contractors • In transition on where work is done because of the World Wide Web (1990), fiber optical networks, satellite technology, and wide-area networks
Future	Work anywhere with instantaneous interaction	• Real time exchange of information

Source: Russell et al. 1995.

The oil industry now competes for graduates of traditional oil industry disciplines with companies that a decade ago did not exist (Lucent Technologies) or traditionally were not interested in the same graduates. In 1999, for example, Chevron recruited 144 new employees, mostly engineers while IBM hired 6,000, Schlumberger hired 371, and Lucent Technologies hired 408, many from traditional oil industry disciplines (Staff 2001a). As part of their corporate strategy in 2000, Chevron developed a more strategic approach to hiring. For example, Chevron North America Exploration and Production plans to add 30 new professionals per year regardless of oil prices (Staff 2001a).

Companies also hire laid off workers with needed skills. Previously, there was not much movement of personnel among companies so there was not much sharing of proprietary technologies. Personnel take their accumulated knowledge, skill, and experience when changing jobs. That includes the transfer of technology.

4.4.1.5 Globalization of the Industry

Globalization, a term that came into use in the 1980's, refers to the ongoing process and complex forces that are increasing the integration of ideas, people, and economies worldwide. Trade, capital movement, movement of people (labor), and spread of knowledge and technology play key roles in globalization.

Globalization affects the oil industry's labor in a number of ways. Oil company investment affects the level of activity in a region and, therefore, the need for labor in a region. Offshore oil and gas development expanded from the Gulf of Mexico. By 1992, the GOM was viewed as a mature area and there was declining interest in the gulf from the majors oil companies. Field sizes tend to be smaller in North America than in other parts of the world. Smaller fields tend to have higher per barrel finding and production costs making them less attractive economically. An accommodating policy toward investment from western corporations by many oil-producing nations also attracted investment. Many areas in the U.S. had been placed off limits to offshore oil and gas exploration and development (see Section 3.5.2). So as opportunities opened up overseas, the major companies shifted their focus away from the GOM. Divestiture programs shifted properties to independents, who in turn, replaced the majors as the gulf's predominant players. Between 1987 and 1992, they had acquired more leases in the GOM than major companies and had drilled about 64 percent of the shallow water wells on the federal OCS (Staff 1992h). The industry expanded into more parts of the world in the 1990's. Exploration and development spending started shifting to outside the U.S. in late 1970's, and by the late 1980's more than half of E&P budgets were being spent overseas, meaning oil industry employment opportunities also shifted away from the U.S (U.S. DOE, EIA 1999d, Staff 1992a.)

As major oil companies moved overseas, petroleum engineers (PEs) in the United States relied on independents and service companies for employment or worked as independent consultants rather than work for the integrated majors, a traditional source of employment (Koen 1994b). Membership roles of the Society of Petroleum Engineers in the mid-1990's showed job opportunities for PEs shrinking in the U.S., but growing overseas (Koen 1994b). At the same time rapidly expanding technology was forcing PEs to acquire new skills. Some PEs, who lost their jobs with major companies, were hired by independents that had acquired leases from the majors' divestiture programs. But, there were not enough jobs with the smaller companies to absorb all those who lost jobs with the majors.

As oil companies spent more of their investment funds overseas, service companies followed. Halliburton, for example, was a U.S. company that did business overseas. Now it is a U.S. company that receives about 70 percent of its revenues from outside the U.S. This switch in perspective has meant recruiting a diverse management team from all parts of the world (Lyle 2000).

Globalization also involves the spread of knowledge. When oil is discovered and developed in areas for the first time, labor needs to be trained or imported until there is a sufficient qualified workforce to hire locally. Labor from the GOM played a role in developing the offshore oil industry in the North Sea. For example, when oil was first discovered and developed in the North Sea, several tugboat companies from south Lafourche Parish, Louisiana took boats and crew to live on the coasts of England and Scotland to teach the local populations about the marine transportation aspects of the offshore oil industry.

For workers with specialized skills such as divers, globalization has meant that labor markets are defined internationally. Employment opportunities increase for those with these skill sets as more regions of the world are opened to outside investment in oil and gas projects. However, given the nature of the work (e.g., only at specific times during the project) these workers live where they choose to and commute to work sites globally. Workers with rotational work schedules (e.g., 7, 14, 21 days on followed by 7, 14, 21 days off) also often have different place of residence patterns from their place of work. The commuter employment nature of the industry has implications for local communities. On the one hand, they may avoid boom and bust cycles of employment if there is a commuter workforce. On the other hand, they lose opportunities for economic development.

Globalization of the industry also strengthens the problem-solving skills and deepens the experience of the workforce of oil industry firms working globally. Oil and gas properties, water conditions, and other factors present challenges that must be overcome in order to successfully find, develop, and produce oil and gas in an offshore environment. The challenges vary by region. For example, water temperatures are much colder in North Atlantic Canada than in the GOM. Companies working in many regions of the world have in-house experience overcoming a variety of challenges that can be applied to challenges in new regions or new challenges. Technology is often a key to overcoming these challenges.

Technology is an integral part of globalization. Computerization, fiber optics, digitization, satellite communications, and the Internet facilitate information exchange. They permit more work to be completed with fewer workers, information to be shared rapidly and simultaneously among different and sometimes remote work places, and some work to be conducted at vast distances from the well site. While technology requires fewer people, it requires people with higher skill levels.

4.4.1.6 Outsourcing

Not all oil industry companies are large enough or choose to have all needed expertise in house. What is not available in house is outsourced. Outsourcing noncore activities reduces costs and staff, or enables more to be done without adding staff. It requires a company to (1) determine its core business, (2) find firms whose core business is performing one or more of the company's noncore activities, and (3) then hire them to do the noncore activities. Company personnel are used to oversee outsourced work to maintain quality control over the work (Knight 2000; Jeppesen 2000). Outsourcing was a cost savings business strategy of the 1990's.

4.4.2 Reorganization of Work

Reinventing the organization for the good of business customers, partners, and stockholders is part of recognizing the need to change. The structure of companies was modified from top down hierarchical structures to models that are flexible, fast, and coordinated. Layers of middle management were reduced. This is sometimes called delayering and often results from downsizing, rightsizing, reengineering, introduction of technology, or other techniques which reduced the labor force. In the reshuffling, authority was delegated to business units where work is done. In the jargon of the times, this is called empowerment. In addition, companies turned to other firms to form strategic partnerships or alliances to cut costs, and sometimes opportunities beyond cost cutting. Reorganization of work occurred with external partners and within the firm, as discussed below.

4.4.2.1 With External Partners

Another response to low commodity prices was to forge new cooperative working relationships; that is to change from being ruggedly independent to being collaborative through interdependent alliances and tighter integration between oil companies and service companies. These changes were typical in the period 1985 to 1995 (Le Blanc 1997a). Some alliances transferred jobs, including petroleum engineers, from operators to service companies, provided efficiencies, provided opportunities for cross training experiences, and created value through cooperation.

Alliances take many forms – for example, informal cooperation, simple contracts, and contracts with long-term explicit commitments. They have significant benefits initially, with the right mix of people. Team members with people skills are needed for successful alliances (Bruce and Shermer 1993). Alliances require periodic reassessments to determine if they are still beneficial. Over the longer term, as people change, the benefits tend to disappear. Long-term relationships tend to stagnate over time. After 4 or 5 years, there is little benefit from an alliance in comparison to when it was initiated (Kappmeyer 2001; Hasan 2001).

Long-term relationships with contractors allow oil companies to proceed with project development with less elaborate, detailed planning, and in the presence of some uncertainties or ambiguities. Changes can then be negotiated as they become necessary. When contractors are brought in early and work with the company for relatively long periods of time, the learning curve accelerates and costs are cut (Hasan 2001).

The downside to alliances is the limitations placed on getting work done. No one company has the edge in terms of technology over all the others. Alliances with service providers limit options for oil companies (Knight 2000). The pace of technological innovation on the part of contractors tends to lag over time which is a major disincentive to long-term relationships with non-drilling contractors. Operators can lose out on new technologies if they are locked into tight arrangements with contractors. In turn this may raise costs relative to other producers (Pattarozzi 2001). Depending on operator needs, there may be an advantage to working with smaller service providers. Operators need the best people for what they are doing, and those skills may well be with smaller providers. Many highly skilled personnel have left the larger service providers to work for "Mom and Pop" type companies. These smaller companies may provide the best service. Also, some contractors are more proactive about applying the newest technology than others. Operators with complicated projects may want to try to find contractors who are ready to use the newest technology (Kappmeyer 2001).

Another strategy started in the early 1990's was in the integration or bundling of services. Halliburton started Integrated Solutions in 1993 right after Shell's Drilling in the '90's. It began by examining processes. It then moved to integrate processes, which resulted in some costs savings. Finally, technology was integrated into the processes, which took out more costs. Once the processes and technology were integrated, service companies took over from production companies to construct wells.

The alternative to integrated services is best of breed service. Some companies prefer integrated services, while others prefer best of breed. Flexibility allows the large service companies to serve either customer (Lyle 2000).

4.4.2.2 Within the Firm

Within the oil companies, work moved from a sequential or linear approach to work teams. Under the linear approach, the responsible person completed each piece of a project and the results passed to the person responsible for the next step. Once a person's work was completed, he or she was assigned to the next project. With this approach it was unlikely an intermediate part of a project would be reworked if new information became available. Under the work team approach, the team is multidisciplinary and all members complete their portion of the project with the help of other team members. New ideas are developed and assumptions tested as the project progresses. The work team approach encourages information sharing, creativity, and innovative problem solving. Workers refine their work based on intermediate results. Team members are responsible for the whole project not just their portion. The project reflects the combined knowledge of all team members. A major obstacle to implementing the work team approach was computer systems and software that did not work together well enough to allow updates or changes to previous work. By the early 1990's this issue had been resolved. Project teams have enhanced productivity and are a better way to handle decision making (Van Wie 2000).

There is some disagreement on whether they save costs. The interviewee from Conoco said they do (Bishop 2000). The interviewee from Vastar disagrees (Knight 2000). Teams were used in large and medium size companies in the 1950's through 1970's for large projects like lease sales. They became common in the mid-1980's when cost cutting efforts meant that it was necessary to do more work with fewer people (Sneider 1999). Cost cutting led to flatter organizational structures and fewer managers. The work team approach requires fewer managers.

Work teams are part of fast track management designed to cut the time from prospect to production. Fast track, started in the cost cutting era, was used to maintain income flow and productivity. The approach includes letting the platform tenders shortly after field discovery, one team performing parallel work instead of a sequence of teams conducting sequential work, concurrent engineering, building equipment of same basic design, and use of portable, reusable equipment. Components are usually comparable wellhead platforms, not staffed if possible, or subsea equipment tied to existing infrastructure, floating production systems, topside process equipment and production offloading systems (George 1997). Fast track management has cut costs in all exploration and production operations. It became a management approach in the early 1990's.

For 10 years, BP has been working with interdisciplinary teams and three business units: exploration, development, and production. The organization by business units has kept operations flexible. Employment by activity is: about 150 in exploration, 300-400 in development, and 300-400 in production. Exploration, includes geologists and geophysicists, reservoir engineers, seismic processors, and commercial analysts who have been added relatively recently. The trend is to overlap more, by bringing development engineers into the exploration process as it advances. Team organization speeds up operations within each group and the overlap shortens the time from exploration to production, producing shorter and more economical cycles (Farnsworth 2000).

Work teams are formed in a variety of ways. For example, ExxonMobil has a geoproject management system, whereby after identification of a specific problem or situation, the company uses inventories of experience-relevant skills to assemble task groups, which are assembled on a project basis (Griffith 2001). Both companies were working with multidisciplinary teams prior to their merger. Apache uses teams of geologists and engineers on projects. As needed, geoprofessionals from other firms participating in a project will be included on the project team (Jeppesen 2000). Some companies combine specialists from different countries so teams become multicultural as well as multidisciplinary.

Contractors or partners are often brought in at the beginning of a project. Vastar includes personnel from its partners on work teams. A recent work team on a Grand Isle project, for example, included members from Occidental, Conoco, and Texaco. Usually this management strategy works well, although there can be problems. For example, partners value properties differently because of differences in business objectives (Knight 2000). At Conoco, teams have evolved to become much more inclusive, and in joint ventures, representatives from all firms involved are included (Bishop 2000).

Some work teams have been together for awhile which brings synergies to the group. For example, interdisciplinary work teams became the mode of operation nearly 20 years ago at Shell Offshore. Many staff have worked together in this system for decades given their continuity of employment. This working relationship has tended to increase the flow of information and make them more efficient in project design, implementation, and problem-solving (Hasan 2001).

At the beginning of deepwater GOM development, Shell was working with interdisciplinary work teams, whose members commonly served more than one project at a time. As a result, productivity increased as individuals became highly expert with some problems and conditions and took this intellectual capital with them to other teams. Information flows became increasingly efficient and rapid. The same teams who developed Auger, Mars, Ursa, and are now completing Brutus. The internationalization of Shell has expanded information flows. The learning curve produced by extended team experience accelerated projects, led to cost-saving changes in implementations, and sustained the economics of work in the deepwater GOM even in the context of price volatility. The advantage Shell had in this regard over other large companies was the concentration of effort in deepwater GOM, which focused attention and assets (Pattarozzi 2001).

Work teams, like downsizing, created a lot of efficiency in the industry. Companies who downsized, took the best and brightest people, who were the most creative and had the greatest breadth of experience, and put them together to determine how to do everything faster, cheaper, better. They created "A Teams." With rising prices, companies try to expand again, but in order to do so, they must break up their "A Teams"—half on one project, half on another. In effect, that means there is no longer an "A Team" but two "A-Teams." This means lost efficiency (Patterson 2000).

Work teams, however, pose special problems for drilling contractors. The older workers in the producing firms, who before the late 1980's had been authorized to make decisions, were often forced into early retirement in the cost cutting programs because they were expensive to employ. With the upturn of the late 1990's, contractors found that they were often working with young and relatively inexperienced engineers and that it was time consuming to get answers from operators' work teams when unavoidable questions arose while drilling was underway. It is hard to get the oil company to assemble a 16-person group for a teleconference at 4 a.m. so they can respond to the drillers' questions or problems. The result has been that downtime has increased sharply. Operator work teams have also tended to overwhelm drilling personnel with questions that are often redundant. One anecdote indicated a drilling superintendent could not be reached when needed because all the phone lines were tied up by members of a single operator project team (Ellis 2001).

4.4.3 Resulting Personnel Issues

The various activities described above to cut costs, improve cash flow, and support shareholder value resulted in a number of personnel issues that now may limit future growth of the industry. Human resources became an agenda item at a major oil industry conference, the Offshore Northern Seas Conference, for what is thought to be the first time in 1994 (Staff 1994b). By then some companies were on their third or fourth round of lay offs in an effort to boost profits. In 1997, worker shortages were not thought to be driving the speed of offshore expansion (Von Flatern 1997c). In 1999, shortage of skilled personnel was listed as the sixth most significant problem facing the U.S. exploration and production industry by all respondents to the Arthur Andersen 1999-2000 survey of 89 oil and gas company executives (Arthur Andersen 1999). Majors ranked it sixth, large independents ranked it fourth, and other independents ranked it seventh. By 2000, following layoffs in 1998 and 1999, personnel shortages were cited as the top concern of a 2000 survey of drilling and well service companies (Neal 2000). The following are personnel issues facing the oil industry:

- Age cohort distortion. The layoffs and retirements following the oil price collapse in 1986 have left a large age gap in management and technical ranks in oil companies and drilling companies. Veteran workers, who also had the highest salaries, took early retirement and the layoffs affected those under 30. Now, essentially there are few employees between the ages of 25 and 45 (Cunningham, 2000, Sunwall 2000, Ellis 2001). The average age at ExxonMobil Explorations is reported to be about 45 (Griffith 2001), about 47 at Chevron (Staff 2001a), and 45 or older at BP (Kappmeyer 2001). The average age of members of the Society of Exploration Geophysicists (SEG) is 45; 75 percent of the membership are age 40 or older; and more than 51 percent of SEG members will reach retirement age (55) within 10 years (Wyatt 2000). A concern expressed by some is where experienced and knowledgeable staff will come from in 5 to 10 or 15 years given the lack of current personnel in the late 20's to mid-40's age bracket (Knight 2000; Holleck 2000). Others note the gap and comment there does not seem to be evidence of company concern (Rickey 2000). The difference in point of view may well be the vantage point of different companies. Those that have acquired companies have had additional employees to incorporate (or release if unneeded), whereas companies that have not taken that path have had to recruit or purchase the missing skill sets through contract labor or contracts.

- Some personnel in short supply. Personnel shortages range from geoprofessionals to drilling crews to those with computer science and information technology expertise. There are a number of reasons for this.
  - Some of the personnel laid off after 1986 did not return to the industry. All segments of the industry permanently lost experienced and knowledgeable personnel through the massive lay offs of the 1980's and 1990's. Many qualified people found jobs in other industries and have not returned.
  - Some companies are short-handed because they laid off many of their staff. Contractors, for example, are reported to be short handed because of consolidations and past layoffs. Contractors are now quite conservative in responding to increased demand because of their cut backs during the 1980's and 1990's (Griffith 2001). There is a reluctance on the part of some oil companies to staff up in an improved price environment because of uncertainties that an expanded staff will be needed in a year or two (Kappmeyer 2000). Shortages of personnel constrain the ability to manage projects when expansion is warranted (Kappmeyer 2001; Bishop 2000).
  - During and after the lay offs in the mid-1980's to early 1990's, the next generation of some needed personnel were not trained (see discussion of lay offs and university programs below).
  - Some personnel (like IT personnel, for example) needed in the oil industry work in other industries. So, the oil industry must compete with other industries for these skills.
  - There is reportedly a critical shortage of personnel in some entry-level technical drilling jobs. New roustabouts have fewer mechanical skills than those with farming and shrimping experience who used to work on the offshore rigs. Extensive training is needed (Plaisance 2000). Turnover is reportedly high with roustabouts and higher than roughnecks (Von Flatern 1997c).
  - It is reportedly getting more difficult to find people willing to work offshore (Bishop 2000, Plaisance 2000). The long hours and weeks-on/weeks-off work schedule are

impediments to recruitment. One view holds that part of the problem is many young workers have never been away from home for extended periods. The military has downsized and many young people do not go away from home to go to technical or university. So, the isolation and communal living of offshore oil industry life require a difficult adjustment which many do not make (Plaisance 2000). It should be noted that a 1980 article in Work Boat Magazine cites the same problem. “There has always been a high degree of turnover in new workers going offshore. The hours are long, the work is hard, and even though the pay is high, the weak and faint-hearted are quickly weeded out.” (Staff 1980).

- Layoffs and university programs. The massive lay offs in the oil industry had a dramatic and almost immediate affect on university petroleum engineering programs. Figure 29 shows total undergraduate engineering degrees and degrees in petroleum engineering from 1980 to 1997. Total undergraduate engineering degrees during this period peaked at 80,000 in 1982. There was an annual decline in the number of undergraduate engineering degrees between 1986 and 1992, followed by slight increases in 1993, 1994, and 1995 and decreases in 1996 and 1997. Undergraduate degrees in petroleum engineering were on the rise from 1980 to1985 when there were about 1,700 graduates. The number of graduates then fell off dramatically to about 200 in 1991. Since 1990 the number of graduating petroleum engineers has been between 200 and 300 per year. Many of these graduates are thought to be foreign students. While they may be part of the global oil industry workforce, many will not be part of the U.S oil industry work force. The number of schools offering PE degrees decreased from 27 in 1991 to 20 in 1998 (Gaddy 1998).

  Efforts have been made to encourage students to study petroleum engineering. The Society of Petroleum Engineers and operators are taking steps to increase enrollment in PE programs including recruiting at high schools (Gaddy 1998). Previously, Texas A&M had a recruiting program for its PE program that included scholarships averaging $1,200 (unadjusted) for 200 incoming freshmen (Staff 1990).

- Colloquia on petroleum engineering education. The lay off and cost cutting programs had ramifications beyond the companies initiating those strategies. As seen above, the number of graduates of petroleum engineering programs declined after 1986. Declining enrollments in a particular discipline affects the number of facility needed, the amount and type of research that can be done, and in some cases, whether the department will survive or be phased out. The University of Texas petroleum engineering department, for example, changed its name in the early 1990’s to the Department of Petroleum and Geosystems Engineering as a way to broaden and diversify its programs to train students for employment outside the petroleum industry (Koen 1994a). In response to the changes taking place in the industry after 1986, petroleum educators and representatives from industry and government began meeting to discuss petroleum engineering education. There were five Colloquias on Petroleum Engineering Education between 1991 and 2000.

  The issues discussed at these meetings reflect the evolving nature of the industry. The second colloquium held in 1993, for example, looked at skills needed for the future and concluded that problem solving, petroleum engineering skills, and computer literacy were already part of PE training. However, desirable attributes such as cultural awareness,

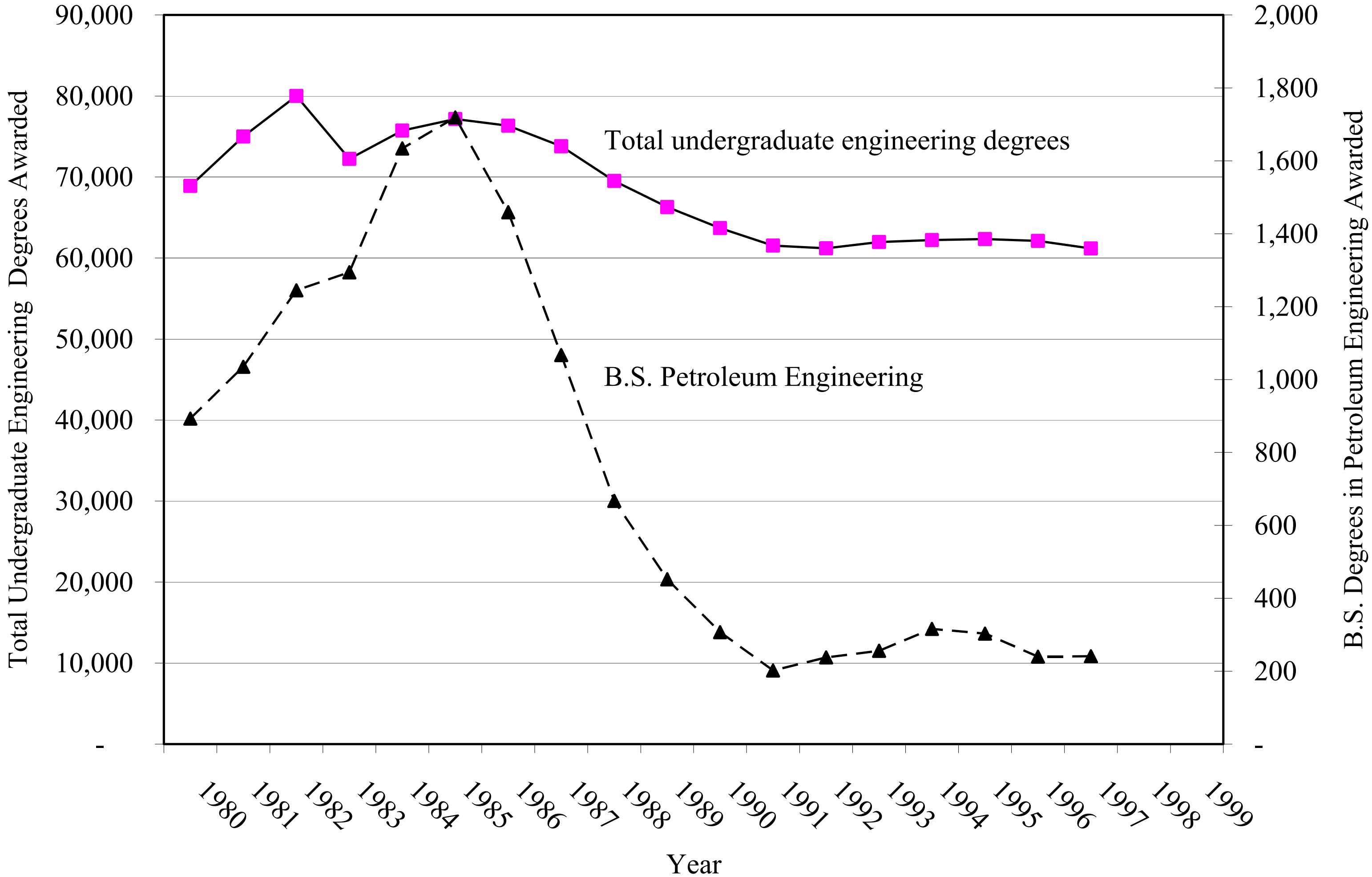


Figure 29. Undergraduate engineering degrees awarded, 1980-1997.

Source: U.S. Department of Education annual 1981-1998.

adaptability to new situations, and team skills had not been integrated into most PE curricula (Koen 1994a). This was at a time when work teams were replacing the traditional sequential or linear approach to work and spending was shifting E&P expenditures outside the U.S. The third colloquium held in 1995 explored ways of increasing the value of PE education to those with the degree (Russell et al. 1995). By the fifth colloquium in 2000, the focus was on the partnership among industry, education and government and how each partner can develop the people and technology needed for the 21st century (Lee et al. 2000).

- Salaries. Offshore salaries for drilling did not keep pace with onshore salaries. In an era when a more highly skilled worker is needed, salaries are no longer an incentive to endure what are difficult working conditions. The drilling sector as well as the overall oil industry competes for labor with other industries. Previously, people with little formal education beyond high school eagerly took jobs on a rig. The oil industry paid more than other industries so the industry could be selective in personnel hired. Now, wages on rigs are not competitive for the caliber of worker required (Ellis 2001, Plaisance 2001).

  Industry publications indicate that wages for offshore workers are not as high in comparison to other jobs as they were previously. However, no specifics are given. Table 17 provides a recent snapshot of three offshore jobs, rotary drill operator, derrick operator, and roustabout, and petroleum engineer in comparison to two service industry jobs – cashier and retail sales. The service industry jobs In the Houston Primary Metropolitan Statistical Area (PMSA) are $3.57 to $6.15 per hour below that of roustabout, the lowest paying of the jobs in Table 17, making the offshore jobs higher paying than the service industry jobs. Examples of jobs similar in hourly wage to a roustabout in Houston are: first line supervisors/managers of landscaping services ($12.14), pesticide handler ($12.70), fitness trainer ($11.54), travel agent ($12.72), billing and posting clerks ($12.08) (U.S. DOL, BLS 1999). No wage data for roustabouts in the Houma, La. Metropolitan Statistical Area are provided. However, examples of jobs with similar hourly wages to a roustabout in Louisiana are: emergency medical technician and paramedics ($10.92), parts salesperson ($10.05), bill and account collectors ($9.61), carpenters ($10.16), and general maintenance and repair workers ($10.70).

- Tarnished image of the industry. The mass lay offs in the mid-to late-1980's destroyed the myth there was job security in oil industry jobs and reduced worker loyalty. At the beginning of the period of interest people thought they would be able to work for the same company to retirement. For companies able to maintain staff throughout the last 20 years that could be true. For the remainder, the oil industry no longer offers job security. In 2000 at the Offshore Technology Conference, the public image of the oil industry was referred to as "just awful" by an industry analyst (Staff 2000g). The industry has demonstrated in the last 15 years that it does not, as a whole, offer stable employment. This is a factor in the industry's difficulties attracting workers.

Table 17

Comparison of Wages

Location	Mean Hourly Wage (1999 dollars)					
	Petroleum Engineer	Rotary Drill Operator	Derrick Operator	Roustabout	Cashier	Retail Service
United States	$34.99	$17.81		$11.18		
Texas	$37.19	$18.38	$13.23	$10.95	$6.96	$9.26
Houston, TX PMSA	$39.36	$20.75	$13.56	$12.99	$6.84	$9.42
Louisiana	$33.96	$18.43	$18.21	$9.94	$6.32	$8.50

Source: U.S. DOL, BLS 1999.

- Impacts on professional associations. Professional associations exist to service their membership. The massive lay offs meant that fewer geoprofessionals were employed and that fewer had the means to pay membership fees or had the need for membership services of professional associations. The Society of Petroleum Engineers, Society of Exploration Geologists, and American Association of Petroleum Geologists are the major professional associations for the oil industry. In 1999, a member of the oil industry community writing in the *Oil and Gas Journal* proposed a merger of the three societies. Companies would save money with an annual mega society meeting/exhibition by not having to send personnel to multiple events. Integrated work flow demonstrations and technologies could be presented to the benefit of cross functional teams. Under the three society system, integrated work flow demonstrations are limited to the portion that fits the specific meeting (Peebler 1999).

- Needed attributes of personnel. Oil companies rate networking skills, relationships with colleagues, and communication skills higher than technical skills on the list of requirements for new employees. Since much of the technical work is done by service companies, being able to work as an effective team member is essential. New hires in service companies need strong technical skills and a good foundation in geology and reservoir engineering. Other skills needed in service companies include communication and marketing skills, computer programming, project management, and strong writing skills. Internships with oil companies are valued by service companies. Computer programming, written and oral communication skills, and project management are skills that can be transported to other industries when there is a down cycle in the oil industry (Marfurt et al. 2000).

- Recruiting from colleges and universities. On-campus recruiting was common in the 1970's. Students were hired prior to graduation and enrolled in company training programs upon joining the firm. The concepts of company loyalty and working for a single company for an entire career were still in place. From 1985 to 1992, there was no college recruiting (Preng 1998). Students left geoprofessional programs or never entered them. As a result, the pool of qualified entry-level personnel from colleges and universities has shrunk and on-campus recruiting has returned. University-based recruiting is being used more now than in the 1990's (Cunningham 2000).

Much of on-campus recruiting is based on networks with professors, who facilitate contact between students and recruiting companies. The professors invite company representatives to be guest lecturers, introduce them to students, and keep students up to date on technologies and industry developments. Companies that have been away from college recruiting for a number of years may have difficulty getting it restarted because they have lost their college and university contacts (Preng 1998).

Some companies, however, were never heavily involved in recruiting from universities. Traditionally, independent firms have not done much college recruiting because they did not have training programs for new graduates. However, because of the difficulty finding personnel some have turned to college recruiting (Jeppesen 2000). Competition for the few graduates is fierce (Hollek 2000). Companies do not want to recruit graduates only to lay them off in 18 months.

- Shift of jobs from oil companies to contractors and manufacturers. The shift in staffing between operators and contractors has reduced accessibility of professionals to one another. Company personnel are generally more accessible than outside expertise since there is a reluctance to go outside the firm for short term consultations (Loth et al. 1999).

- Globalization of industry requires a diversified workforce. It is easier to stabilize a work force since workers can be transferred from slack areas to active ones and keep experience and knowledge within the company (Pattarozzi 2001). The geoscientist of the future will need to be career proactive, a generalist, computer literate, with a solid foundation in oil and gas fundamentals (Staff 2000d).

- Doing more with fewer people. Blue collar workers who survived the personnel cuts are now very knowledgeable and experienced. They operate facilities with far fewer people than 20 years ago. Replacing them is going to be a serious problem (Holleck 2000, Patterson 2000).

- Not much learning curve time for geoprofessionals. New geoprofessionals get assigned to deepwater projects with little practical experience. What experience they have is narrow. At one firm, for example, new graduates would be assigned to relatively inexpensive onshore projects to drill lots of well, encounter lots of problems and learn the industry from the ground up. Now new personnel are immediately assigned to work on wells costing $25-30 million. This could prove to be very costly since they are working on expensive projects with minimal amounts of experience (Holleck 2000). Interdisciplinary teams and overlapping project teams tend to bring more experienced staff into projects from the beginning.

4.4.4 Response to Personnel Issues

A number of approaches have been and are being used to address the personnel issues in the industry. The following examples highlight personnel training and development and retention programs.

- In-house training programs. The answer to personnel shortages is to hire skilled personnel or train them. The U.S. military has been a source of labor for offshore segments of the industry. Drilling crews require more formal education or in-house training than before. Those with computer and electronic skills are often recruited away by other industries for better pay and working conditions after they have had some on the job training in the offshore oil industry. Downsizing in the military has reduced the number of maritime workers coming from the U.S. Navy and Coast Guard, traditional sources of these personnel. Contractors are increasingly relying on the maritime academies in California, New York, and Maine for personnel needed for deepwater activities or dynamic positioned vessels. There are no schools that teach drilling skills. They are learned through experience and in-house training programs. It can take many years to develop a good driller or tool pusher and they almost always work their way up the ranks. Companies that offer training for drilling and offshore work frequently lose their personnel to smaller companies or other industries (Ellis 2001).

- Mentoring. The American Association of Petroleum Geologists initiated a mentoring program in the fall of 1999 for young professionals. The program was launched because the industry no longer promotes mentoring and there are few corporate programs. It was also a way to use the resources of members after their retirement and a way to encourage retired members to retain their membership (Freeman 2000).

- Company programs. Schlumberger initiated two personnel programs during the downturn in the mid-1980's that were viewed as successful by both the company and the individuals who participated. One program was the Advanced Degree Program which provided for an educational leave of absence for one year for selected field personnel to pursue an advance degree or gain additional course work in the petroleum field. The second program was the Summer Petroleum Engineering Seminar, administered with the University of Texas, a 12-week program of instruction for field engineers in petroleum engineering (Gadomski 1988).

  One way to broaden the based of experience is to cross-train personnel. BP, for example, has a program called "Petroleum Challenger" which is designed to broaden an engineer's experience quickly. In this program, a BP engineer receives assignments of approximately a year in different areas, so that at the end of 3 years he/she has received solid training and understands operations that might otherwise take 6 to 9 years to achieve. This training program provides the foundation for an engineer's career as much as his/her college education. However, from a project manager's point of view, as soon as the engineer gains knowledge and experience he or she is gone (Kappmeyer 2001).

- Retention program. The rules for retaining good personnel differ now from 20 years ago. When oil engineers changed jobs in the 1970's and 1980's, it was usually from a major company to an independent. Banks such as Texas Commerce (now Chase Texas) and First City as well as service companies hired oil engineers as well. Higher salaries and sometimes cutting commute time in Houston were the reasons for the switch. Employees look at factors beyond salary now (Preng 1998).

  Some companies now offer retention programs and make an effort to address the personal and professional needs of their employees. For example, in 1997 BP established an employee retention program whereby the company donated to an account which the employee could redeem in 2000, if still employed by the company (Von Flatern 1997c). Other programs include payment of a percentage of an employee's base salary each quarter and stock options (Preng 1998). Hiring, orientation, and training new employees is expensive and those costs can be avoided if employee turnover is low.

4.5 Regulatory Environment

The regulatory environment from the perspective of corporate organization and strategy is discussed in terms of Gulf of Mexico leasing and the Deep Water Royalty Relief Act. Leasing starts the process by which offshore oil and gas are found, developed, and produced. The placement of infrastructure, existing and future, plays a role in determining approaches to where, how, and when exploration and development proceeds. Technology allows the industry to work in deeper and deeper water and deepwater is viewed as the future.

4.5.1 Gulf of Mexico Leasing

The Outer Continental Shelf Lands Act (OCSLA) in 1953, and subsequent amendments in 1978 and 1985, establish federal jurisdiction over the submerged lands of the OCS and, as amended, authorizes the Secretary of the Interior to lease OCS lands for mineral development (U.S. DOI MMS 2000). A lease is a contract authorizing the right to explore, develop, and produce minerals covered by such a contract. It usually contains 9 square miles. A tract is the geographic and legal extent of a single lease area (Havran and Collins 1980). Since offshore oil and gas exploration and development starts with a lease, the rate of leasing drives other activities. Through August 2000 in the GOM, over 91 million acres on 17,754 tracts had been leased through 86 sales. About 53 percent of the lease sales occurred between 1980 and 2000 (U.S. DOI, MMS 2001a). There were two lease sales per year between 1980 and 2000, except for 1983, 1985, and 1988 when there were three lease sales.

Prior to Lease Sale 72 in May 1983, tracts were offered on a tract-selection basis, which was designed to offer for lease by competitive bidding a limited number of blocks determined to have the greatest interest from a broad spectrum of industry. Under this system, tracts were "nominated" by the oil and gas industry for inclusion in a lease sale. The U.S. Department of the Interior would then study the tracts geologically to determine which were offered in the lease sale. This system resulted in piecemeal geological work for the oil companies (Staff 1983).

Beginning with Lease Sale 72 in the Central GOM OCS, tracts in the GOM are offered on an areawide basis. The new system relies totally on the geological assessments. Lease Sale 72 set new records for bonus bids offered, high bids, and bids accepted. This sale also indicated industry's interest in the application of deepwater technology, since 85 (about 13 percent of the blocks receiving bids) tracts were in water over 1,000 feet (Weise et al. 1983). Areawide leasing has enabled operators to assemble sufficiently large tracts to justify the risks associated with deepwater exploration (Pattarozzi 2001).

In 1994, companies that had participated in leases sales were asked about the change in leasing policy on business practices. Most of the responses were positive with common responses citing (Seydlitz et al. 1995):

- Stimulated activity
- Reduced risk
- Justified the purchase of new technology for extraction
- Increased the potential for finding oil and gas
- Ease and increased fairness in the leasing procedure
- Reduced costs
- Increased exploration
- Increased the number of leases
- Enabled some companies to become active in Gulf extraction

A second policy change in leasing occurred in 1987 when the minimum bid was set at $25 per acre. Respondents to a survey of oil companies that had bid on GOM leases were asked about the effect of the policy change. No impact was seen by 19 percent of the respondents. The following were cited as positive effects of the policy change (Seydlitz et al. 1995):

- More activity
- Increased bids, leases, and acres
- Greater exploration
- Reduced costs
- Enabled entry into extraction in the Gulf
- Allowed funds to be used for extraction activities rather then acquiring lands

Bidding on leases is a risky business as demonstrated in Conoco's lease simulation game, "Oil is Where You Find It," that models leasing and drilling risks. The primary objective of the game is profits, not leases gained, discoveries made, or money saved. The second priority is to win the most desirable leases. The third priority is laying off risk through deal making and partnering among producers and suppliers. Other simulated realities include (Staff 1998b):

- Producers winning too many leases must deal with budgets without enough money to explore them

- Producers that do not win enough leases have leftover cash

- Producers that have drilling contractors under contract and not enough tracts to drill are attractive to producers that have tracts to explore but no drilling contractors

- Diversification is not a goal of leasing. Concentration and focus are needed

- Only the government values the bidder who leaves too much bid money on the table, that is, the difference between the winning bid and the second bid

4.5.2 Deep Water Royalty Relief Act

While deepwater blocks were acquired in lease sales, initial exploratory activity was slow. With the oil price collapse, as described above, cost cutting measures and movement of capital overseas adversely affected GOM activity. In 1987, Shell discovered the Auger field with reserves of approximately 220 million barrels of oil equivalent. This discovery altered the view of the Gulf of Mexico as a declining offshore oil area to one with deepwater promise. Oil prices were low and the U.S. was increasingly competing for exploration and development investment dollars with other parts of the world. Economic incentives needed to encourage exploration of GOM deepwater were provided in the Deep Water Royalty Relief Act, signed in November 1995. The law affects oil companies and specific deepwater projects. It allowed MMS to suspend royalties on existing leases in order to promote development, increase production, and encourage production of marginal resources on producing or nonproducing leases. The mandatory provision for offering leases with royalty suspension volumes under the Deep Water Royalty Relief Act expired in 2000.

By all accounts the Deep Water Royalty Relief Act stimulated GOM deepwater activity. Quantitatively, this can be seen in Table 18 which shows OCS by water depth between 1994 and 1998, that is before and after the Act.

Table 18

Gulf of Mexico OCS Bids, 1994-1998

Water Depth[1]	1994	1995	1996	1997	1998	5-Year Total
<200 m	490	516	637	542	280	2,465
200-400 m	18	50	69	52	38	227
400-800 m	28	83	113	104	61	389
>800 m	49	214	722	1,138	817	2,940

[1]Water depth categories defined by the Deep Water Royalty Relief Act.

Source: U.S. DOI, MMS 1999.

Qualitatively, the significance of the Act is revealed in the personal communication with oil company representatives conducted for this study. The Act was highly important, it kicked off major plays in the GOM, and it had a positive effect on deepwater projects (Cunningham 2000, Griffith 2001, and Knight 2000). The Act could affect the order in which projects are developed, particularly satellite fields. The potential for royalty relief figures into a project's economic analysis but does not make or break a project (Pattarozzi 2001).

The Act enabled an increasing number of participants to take the risk to get into deepwater. Some huge finds have resulted from increased exploration. The improved economics may have encouraged more independents to try deepwater (Van Wie 2000).

The Act brought new players into deepwater. It is significant in marginal fields. The absence of deepwater relief might make it more difficult to develop subsea tiebacks with infrastructure in relatively close fields. The cumulative effect would be to slow deepwater GOM development (Farnsworth 2000). The Act did spur activity and it is a factor people consider in comparing the GOM to other areas in the world. It has influenced the pace of activity (Bishop 2000). Areawide leasing is essential to deepwater development because without it, operators could not assemble sufficiently large tracts to justify the risks in frontier exploration (Pattarozzi 2001).

Deepwater activity has resulted in increased oil and gas production (see Figures 3 and 4.) GOM deepwater oil production exceeded production from shallower water in 1999. Deepwater gas production in the GOM is expected to exceed conventional gas operations in the gulf within the next 9 to 10 years (Fletcher 2000). The high costs of activity in deepwater GOM has meant that seven companies, BP Amoco, Shell, ExxonMobil, Chevron, Total/Elf, Petrobas, and Texaco, have located more than three-quarters of the deepwater reserves.

4.6 Sidebars

The following are examples of information gathered or observations made in the course of the research for this report which are important, but not directly on target with the thrust of this chapter. They are presented briefly so as to not lose sight of the information.

4.6.1 Organizations Preoccupied with Consolidation

Organizations preoccupied with consolidation have little time for day-to-day operations. Merger integration redirects resources away from operations. It is estimated that executives and managers in firms involved with merger integration are internally focused for 1 to 2 years (Cassidy et al. 2001). There are internal audiences, investors, government regulators, and customers which must be attended to during the consolidation process. This means that day to day activities are not priorities. New drilling programs are put on hold while details of the merger are sorted out. Reductions in staff that accompany mergers also upset the contractor/operator relationship. The same people are unlikely to be in the same position after a merger than prior to it, meaning that new working relationship between contractors and operators need to be developed. This may help explain price surge in 1996 did not produce a recovery in drilling activity. Employee morale usually falls during the integration because of anxiety and uncertainty. Growth initiatives are stalled while the executives and managers focus on integration and realizing synergy cost savings.

4.6.2 Oil Industry and the Energy Industry

Oil and gas represent a majority of the fuel used by the economy. According to one industry expert, 80 percent of the fuel consumed globally is either oil or gas (Gibson-Smith 1999).

Given the dominance of these fuels and the success the industry has had in maintaining production, it is not difficult to understand the widely held belief that oil and gas will continue to dominate the world's energy markets for the next several decades (Raymond 2000, Gibson-Smith 1999). While all of the major oil companies monitor the development of alternative sources and some of these companies have actively considered development of these options, there is skepticism over the ability of solar, wind, or other alternatives to play any significant role in the energy picture for many years. In this view, the oil and gas industry will continue to be just that—devoted to the delivery of oil and gas products to customers (Raymond 2000).

Despite this skepticism, there is a minority view among the major companies that their core business is the creation and marketing of energy. BP Amoco may be the leader in this thinking. Part of this thinking derives from a very long-term view of the industry—looking at world energy markets in 2050 and beyond. Another factor supporting a somewhat broader view is the belief that the economy of the 21st century will be much more reliant on gas than oil. This gas-based economy will succeed in developing technologies (e.g., fuel cells) that will radically change basic industries (MacKenzie 2000).

Another issue in the mix of the oil and gas industry's future is sustainability. Here the predominance of oil and gas begins to make way for a broader definition of the role of the major oil and gas companies. Sustainability raises a number of fundamental issues related to oil and gas including global warming, the environmental impacts of energy use, and the ultimately finite nature of fossil fuels. Thus, on the basis of sustainability, there is some oil and gas industry interest in active pursuit of renewable energy sources. For those with an eye on the more distant, sustainable future, the "ultimate objective" of the oil and gas industry is to "provide the energy the world needs without negative social environmental impact" (Davies 1999).

5.0 CROSSCUTTING THEMES AND IMPACTS

It is difficult to look at the events and trends of the past 20 years in the oil and gas industry in isolation. Prices, corporate organization and strategy, economics, technology, labor, and regulation are so interwoven in the dynamics of the industry that, as has been shown in the previous sections of this report, the discussion of one issue soon involves most or all of the others.

This should not be surprising in an industry as complex or extensive as oil and gas. Nevertheless, this interconnectedness does not lead to an analytical Gordian knot. Rather, there are a relatively small number of phenomena that have driven most of the changes and dynamics experienced by the industry from 1980 through 2000. These can be seen as a small number of fundamental forces that drive change and a similarly small number of industry responses that also drive change.

Most of these drivers converged in the mid-1990's to revive the once moribund prospects of the GOM. Over the past 5 to 7 years, the result has been a remarkable turnaround for this area as a locus of oil and gas activity.

These forces and dynamics create a number of impacts that affect the industry, the economy, the communities, and the people that support and sustain oil and gas activities in the GOM. The impacts vary widely, but some are of particular interest to government and specifically MMS.

5.1 Major Drivers of Change

Determining the causes of change as opposed to its consequences can be problematic. This is particularly true in an industry as multifaceted as the oil and gas industry. Nevertheless the following factors stand out as major forces that have created change within the oil and gas industry in the 1980-2000 period.

The increasing volatility of prices. As the most casual of glances at Figure 6 shows, the behavior of prices of oil and natural gas was radically transformed by the oil crises that began in 1973 and carried out their havoc through the early 1980's. Price changes had always been experienced by the industry and were associated with national recessions in the period between World War II and 1973. These earlier examples of volatility seem innocuous in retrospect compared to the sea change in price behavior since 1973. By 2000, price volatility, uncertainty, and risk had become facts of life for every company in the industry and had changed the industry in fundamental ways.

The rising costs of oil and gas projects. Less dramatic, but also fundamental to change in the industry, has been the increasing role of offshore and especially deepwater oil and gas. In the period 1980-2000, OCS as a share of total domestic natural gas increased a modest but significant amount, while the share of total domestic oil production from OCS sources almost tripled. The role of deepwater in the GOM has grown even more dramatically from 1985 to 1999, from 6 percent to 45 percent of OCS oil production and from less than 1 percent to 17 percent of OCS gas production. (See discussion in Section 2.3.) Compared to onshore

It is likely the case that technology is ahead of corporate culture. Certain actions that could be conducted remotely are not because the physical presence of relevant workers during, for example, drilling operations is still considered necessary. Nonetheless, the need to be at the site of physical activities is declining and will likely continue to do so. This has reduced and will continue to reduce the need for personnel to be offshore or in a central onshore location. In turn, this will tend to reduce the effects—both positive and negative—of moving and keeping people offshore or gathering them in a single onshore location.

Capital replaces labor. As capital and machines have replaced labor, there has been a diminution of impacts associated with staffing projects or companies. The industry has become a much smaller source of employment compared to its status in 1980. This is similar to the impact of technology on where work is done—fewer people generate fewer impacts, good or bad, onshore or offshore.

Houston is the center. One of the more noticeable onshore impacts is the agglomeration of oil and gas businesses in Houston. Companies have chosen to relocate staff to this city or establish a presence there, if only because all other companies are there. This shifting has benefited Houston and transferred activities from New Orleans, Denver, Tulsa, and other formerly more prominent oil and gas cities.

activities, developing projects offshore is more expensive and deepwater is a quantum leap in expense beyond shallow water activities.

Thus, in the past 20 years, the industry has been increasingly engaged in exploration and production in locations where expenses are substantially higher than the onshore locations that sustained the industry for decades. While these higher costs are more than compensated by the income that offshore and deepwater projects generate, the cost of getting into the offshore, and particularly the deepwater, game is very high.

The globalization of the industry. Oil has always been an international industry. Still, the consolidation of the industry since 1980 and the advances in communications and other technology have created an industry led by corporate giants that think and act internationally. Even the so-called independents that historically focused on the U.S. and often on specific regions within U.S. have shown an increasing tendency to operate internationally. As a result, the interests of these companies in the GOM or any other area are increasingly seen in comparison to opportunities in other areas of the world. More and more, the GOM is in competition with West Africa, Brazil, the Caspian Sea, and other locations where the industry is active.

The triumph of the marketplace and competition. Along with globalization, there has been a marked trend towards a marketplace mentality and an emphasis on competition in the industry. These parallel trends have washed over the oil and gas industry as they have over almost all major industries. Part of this trend has been the increasing interest in many companies in financial performance and the perceptions of Wall Street, encompassed under the heading of concern with shareholder value. Closely allied to this is heightened level of competition within the industry (as well as among oil and gas and other industries).

The ascendance of technology. One of the most critical enablers of price volatility, deepwater exploitation, globalization, and marketplace is technology. Principally by increasing the flow of information and the speed at which information is processed and distributed, technology itself has become a major driver of change in the oil and gas industry (and all other industries).

The management of risk. In reaction to many of the drivers listed above, the oil and gas industry has been increasingly concerned with the management of risk. This focus on risk management has in turn driven a wide array of changes in the industry. The increasing importance of technology reflects in part its ability to reduce the chance that drilling will produce a dry hole or that less than the optimal amount of oil and gas will be extracted from a formation. In order to spread risk, individual projects are increasingly collaborative, multi-company efforts. To protect themselves against precipitous drops in price, companies have moved to futures, options, and other hedging instruments. To reduce costs of R&D major companies have pushed many these efforts onto contractors and many companies have relied on research consortia.

5.2 The Resurgence of the GOM

In the late 1980's and the early 1990's, the GOM was considered such an unpromising area for oil and gas, it was known as the "Dead Sea." Within a few years, this situation was reversed as leasing activity surged, explorations followed, and soon thereafter, production from deepwater began to make significant contributions to the total production of petroleum in this country.

This remarkable turnaround illustrates the array of factors that drive oil and gas activity. Indeed, the complexity of variables that influence the industry is one of its more salient characteristics. This confounds attempts to predict demand and prices and creates the uncertainty that is the context for all industry decision-making.

When these factors converge, they can focus the industry's attention and result in major shifts in activities as was seen in the GOM in the mid-1990's. The factors in the GOM's resurgence that contributed were diverse. Among the most important of these were the following.

Areawide leasing. This shift in MMS leasing policy allowed companies to assemble GOM tracts sufficiently large enough to increase the potential for finding oil and gas and to justify deepwater exploration. These and other benefits contributed to a significant increase in industry bidding for OCS tracts (see Table 18).

Deepwater royalty relief. In late 1995, the federal government allowed MMS to suspend royalty payments to increase interest in OCS deepwater. The clear increase in deepwater bids shown in Table 18 is evidence of the success of this regulatory strategy.

Exploratory technology. Seismic imaging as a technology began to make remarkable strides in the early to middle 1990's, reducing the probability that attempts to find oil and gas would be unsuccessful from 90 percent in 1990 to 50 percent in the year 2000—a fivefold increase in the industry's exploratory success rate. The utility of this technology to the industry can be seen in the fact that only 5 percent of GOM wells resulted from 3D imaging in 1989, but that by 1996, this technology was used to find 80 percent of GOM wells. (See Table 3.) At the same time, improved imaging technology allowed independents and other companies to find additional oil and gas in properties that were being reworked. While these new technologies were instrumental in deepwater locations, they also have continued to improved success with subsalt reservoirs throughout the GOM.

Production technology. As in exploration, technology made substantial improvements in production. Drilling technologies, including steerable drills, horizontal and multilateral wells, improved fracturing methods, and real-time monitoring of drilling and production, were among the technologies that sharply increased the recovery rates for the industry.

Favorable prices. In the mid-1990's oil and gas prices were generally improving or at least they were not clearly unfavorable. Moreover, the level of volatility was lower than it had been in the 1980's.

Corporate necessity. Despite the increasingly global nature of the oil and gas industry, certain companies continued to focus on the GOM as their only business location. For global companies, some major business units by definition were essentially restricted to the GOM. Thus, for these companies, particularly the U.S.-based units of the majors, deepwater GOM was their last, best hope of being successful. By necessity, if they were going to succeed, that success would have to be in the deepwater GOM.

With technology, regulatory, and price factors in their favor, these companies began a series of exploratory and production steps that effectively turned the "Dead Sea" into a hub of new, renewed, and successful activity. That renewal continues to the present (i.e., in 2001) and shows little sign of subsiding as new deepwater finds are followed by massive projects that promise more production for years to come.

5.3 Impacts of Change and Industry Dynamics: 1980-2000

Change and the ever more dynamic nature of oil and gas have affected the way industry operates. Impacts from these forces also extend to the socioeconomic realm and how they occur onshore and offshore.

5.3.1 Industry

Old economy to new economy. The oil industry is now as good an example of a high-tech, new economy industry as can be found. While in many ways oil and gas as an extractive industry that dominated much of the 20th century typifies the so-called old economy, the industry is now highly dependent upon a very broad range of digital technologies. It is also constantly refining these through its concern with next-step technology. While much of this technological change has been incremental, the industry today is radically different from the industry that operated in 1980.

Simple to complex. Risk management, corporate strategy, technology, and other factors have pushed the oil and gas industry in the direction of increasingly complex arrangements and operations. The decline of the vertically integrated oil company has meant that a network of outsourcing arrangements supplants activities what were once internal to a given company. To spread risk, major projects are undertaken collaboratively with alliances or partnerships. Once the province of the major companies, R&D is now parceled out among contractors, university-based consortia, and other parties. Work that was once done sequentially is now done in parallel by multi-disciplinary, sometimes multi-national and multi-cultural, teams. Companies that once looked for oil and gas within a fairly narrowly defined area are increasingly weighing the value of the GOM versus other, far flung parts of the world.

Science-based production to economic-based production. Decades ago companies operated under the assumption that getting oil from ground to market as fast as possible was the best course of action. Thus, the best strategy was to use science and engineering to accelerate that process. Stimulated by the nationalization of oil assets in the early 1970's, the increasingly volatile nature of prices, and other factors, companies began to reconsider how best they could maximize long-term returns. In an environment of price uncertainty, the economics of production are no longer straightforward. Thus, hedging instruments, strategies to retain or release products, and other considerations became part of a production strategy that may not find the quickest route to market to be in the best economic or financial interests of the company. Increasingly sophisticated understandings of oil recovery from formations have also added complexities to this trend as optimal rates of flow from deposits may be significantly less than the quickest rates of flow.

Uncertain status of R&D. Demands for better financial performance may argue against using cash flow and earnings to support R&D, particularly those efforts without short-term and almost certain "returns on investment" in R&D. As a result, the oil and gas industry is in a position where it may limit its future success or delay the onset of that success for the sake of present-day financial success. Technology has transformed the industry particularly in the past 5 to 10 years. Whether the industry will continue to exploit technology as it faces more complex challenges will depend in part on its ability to finesse the competing, sometimes conflicting, demands of shareholders and R&D.

Less is more. Technology has generally allowed the industry to produce more oil and gas with less infrastructure and fewer people. The most visible example of reduced infrastructure is the declining number of platforms or drilling sites needed to reach and produce oil and gas. As drilling technology has advanced, the horizontal reach of any given drilling location has expanded dramatically. The hub system used in the GOM has allowed new production to reach shore by tapping into existing infrastructure. The classic substitution of capital for labor has also reduced the number of people needed to produce this country's oil and gas. This increased efficiency and effectiveness has contributed to the financial success of the industry and has also reduced the environmental impacts of oil and gas production.

Everything is faster. The hallmark of the information age is speed. As information has become more important and information technology has become more intertwined in the industry, the time required to do work has collapsed. Parallel processing in computers has been echoed in the parallel activities of multi-disciplinary teams that are now standard in the industry. A few examples from the timeline in Table 3 illustrate the remarkable reductions in time needed to complete major activities.

- By 1996, the time from initial offshore discovery to initial production was about 2 years. In 1984, the elapsed time from initial discovery to initial production was a decade.

- By 2001, Exxon could process the same volume of seismic data in 10 days that would have taken 11 years in 1990.

- Before internet-based transactions were available, large sales of natural gas took approximately 9 months. Using the Internet, these transactions can now be completed in 20 minutes according to one report and only 1 second according to another. (See Section 3.3.3).

Information is essential. Whether the issue is finding oil, drilling, maximizing the recovery rate from a formation, or understanding world prices, information is increasingly critical to the industry. Real-time monitoring capabilities allow companies to adjust drilling and production activities to avoid problems and increase success rates. Information systems can allocate resources across widely dispersed projects. Software can enable the creation of virtual teams focusing on a single project from locations almost anywhere in the world. The Internet and e-commerce are making portfolio management an increasingly powerful tool for companies ever more active in shedding or acquiring assets. All of these impacts are derived from the increasing availability, quantity, and quality of information.

5.3.2 Socioeconomic Impacts

Socioeconomic impacts center on the industry's human resources. The repeated cycles of hiring and firing over the 1980-2000 period have changed the way the industry uses people and how prospective workers respond to the industry.

Different, more sophisticated skills. Given the increasing significance of information and information technology, the skills that almost all oil and gas workers must bring to their jobs are different and much more sophisticated. As with other basic industry, the opportunities for unskilled or semi-skilled workers to find jobs and advance have largely gone away. As the newly important skills are often transferable from oil and gas to other industries, the competition among industries for those with the right skills is also greater.

Shortage of PEs. Perhaps the most acute impact of industry dynamics is the shortage of PE talent. This is true of young people just starting their careers as well as mid-career professionals. Petroleum engineering schools produce a fraction of the undergraduate PEs that they did in 1980.

Personnel issues. A host of other personnel issues have also emerged in response to the dynamics of the industry and other trends over the past 20 years. The layoffs following the oil price collapse of 1986 have left a hole in the middle of the industry's age distribution with relatively few workers in mid-career status and a high average age for the overall workforce. Workers no longer view the industry as a stable place to work throughout one's career. The downsizing of the military has reduced the supply of technical workers comfortable with the work environment offshore. The industry no longer enjoys the high salary and wage differential that was a major attraction for labor.

5.3.3 Onshore and Offshore Impacts

Despite the many changes that have affected oil and gas, the basic steps involved in finding, producing, and marketing petroleum are unchanged. These steps generate a series of impacts onshore and offshore. The forces changing the industry have begun to modify the quality and extent, if not the basic nature of, these impacts.

Where work is done. The rise of information technology is beginning to redefine where work is done. The ability to transmit electronically large volumes of data with ease, to monitor physical activities from remote locations, and other consequences of digital and related technology have given rise to workers physically remote from where the work is conducted. In other cases "virtual teams" of workers have been assembled that operate on projects without regard to the physical locations of individual team members.

LITERATURE CITED

Adelman, M. A. 1986. Scarcity and world oil prices. *Review of Economics and Statistics* 68(3):387-397.

American Gas Association (AGA). 1997a. The dynamics of competition in the natural gas industry. April.

American Gas Association (AGA). 1997b. Natural gas customer choice: a matter for state and local policy-makers. www.aga.org.

Anderson, J. 2000. The surge in oil prices: anatomy of a non-crisis, Discussion Paper 00-17, Resources for the Future, April, 7 pp.

Anonymous. 2000. World facing $50 crude oil. Gold Eagle Editorials. www.gold-eagle.com/editorials_00/aoe062800.html.

Apache Corporation. 2000. Annual report.

Arthur Andersen. 1999. 1999-2000 U.S. Oil and gas outlook survey results. December.

Barton, C. and D. Ritter. 2000. Software to teamware: leveraging knowledge in real time through the Internet. *Journal of Petroleum Technology* (April). www.spe.org/jpt.

Baxter, V. 1993. The effects of oil industry restructuring in Louisiana. In: Laska, S. ed. *Impact of offshore oil exploration and production on the social institutions of coastal Louisiana*. MMS Contract # 14-35-0001-30479. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. Pp. 43-76.

BDM-Oklahoma, Inc. 1998. Petroleum technology advances through applied research by independent oil producers. Report to U.S. Department of Energy, September. 51 pp.

Bell, M. S. 2000. Vice President, Deepwater Business Unit, Unocal Spirit Energy 76. Personal communication, August 16.

Bender, J. M. 2001. Vice President, Human Resources, Apache Corporation. Personal communication, May 18.

Beyster, J. and J. Glancy. 1999. The impact of next-generation network technologies. *World Energy*. www.worldenergysource.com/articles.

Bishop, G. 2000. General Manager, Gulf of Mexico Deepwater, Conoco. Personal communication, August 16.

Bohi, D. 1998. Changing productivity in U.S. petroleum exploration and development. Resources for the Future, June. 90 pp. www.rff.org.

Bolton, P. and C. Harris. 1993. Strategic experimentation. Working Paper No. TE/93/261, London School of Economics.

Brown S. and M. Yucel. 1995. Energy prices and state economics performance. *Federal Reserve Bank of Dallas Economic Review* (Second Quarter):13-23.

Brown, S. and M. Yucel. 2000. Oil prices and the economy. *Southwest Economy* (July/August): 1-6. www.dallasfed.org.

Brown, S. and M. Yucel, and L. Taylor. 1998. Changing Texas economy: dynamics of the free market, December 10. 9 pp. www.dallasfed.org.

Bruce, G. and R. Shermer. 1993. Strategic partnerships, alliances used to find ways to cut costs. *Oil and Gas Journal* (November 8). www.ogj.pennet.com.

Caldwell, R. and D. Heather. 1992. Dismantling the dinosaurs: look at U.S. M&A trends. *Oil and Gas Journal* 90 (45, November 9). www.ogj.pennet.com.

Cassidy, D., A. Lohman, and P. Weissgarber. 2001. Focus on growth vs. costs key to oil company merger success. *Oil and Gas Journal* (March 5). www.ogj.pennet.com.

Chambers, M. 1998. Multilateral technology gains broader acceptance. *Oil and Gas Journal* (November 23).

Chevriere, J. 2000. Global economics, the dollar, and financial stability. *Offshore (*August). www.FindArticles.com.

Coy, P. and G. McWilliams. 1997. The new economics of oil. *Business Week* (November 3):140-144.

Crain, W. 1993. Management perspective: Managing for change in today's oil industry. *Oil and Gas Journal* 91(47, November 22). www.ogj.pennet.com.

Cunningham, S. M. 2000. Vice President, World Exploration, Texaco. Personal communication, August 18.

Davies, P. A. 1999. Oil demand: the current world economic downturn and future prospects. Paper presented at the Centre for Global Energy Studies Conference, April 22. 7 pp. www.bp.com.

De Guzman, N. 1999. Capturing outside technology. *Offshore* 59 (July). www.os.pennet.com.

Dodson, J. 2001. Gulf of Mexico: will royalty relief, gas prices, bail out US Gulf shelf production in rapid decline? *Offshore* (January). www.os.pennet.com.

Ellis, W. L. 2001. Regional Operations Manager, R&B Falcon (International & Deepwater), Inc. Personal communication, January 11 and April 25.

Epple, D. 1985. The econometrics of exhaustible resource supply: a theory and an application. In: Sargent, T., ed. *Energy, foresight, and strategy*. Washington, D.C: Resources for the Future. Pp. 143-200.

Farnsworth, J. W. 2000. Vice President, Gulf of Mexico Deepwater Exploration, BP Exploration Company, Ltd. Personal communication, August 16.

Fisher, P. A. 2000. Western and Geco merge. *World Oil* (25, July).

Flanagan, T. 2000. Offshore driller to buy rival. *The Washington Post* (August 22). P. E3.

Fletcher, S. 2000. Deepwater GOM production topping shallow-water output. *Oil and Gas Journal* (May 22). www.ogj.pennet.com.

Fockens, P. and W. Warren. 2001. Online E&P asset management. *Oil and Gas Journal* (April 23):18-22.

Forber, K. F. and E. M. Zampelli. 2000. Technology and the exploratory success rate in the U.S. Offshore. *The Energy Journal* 21(1):109-120.

Freeman, D. 2000. AAPG mentors are lending a hand. *Explorer* (November). www.aapg.org.

Gachter, R. 1994. Gulf of Mexico update: July 1992-June 1994: Outer Continental Shelf oil & gas activities. U.S. Department of the Interior, Minerals Management Service, Information and Training Branch. 29 pp.

Gaddy, D. E. 1998. Salaries rising for new petroleum engineers. *Oil and Gas Journal* (May 4).

Gadomski, C. R. 1988. Educational opportunity in depressed economic times. Paper presented at the Society of Petroleum Engineers Annual Technical Conference and Exhibition, Houston, TX. Oct. 2-5. SPE 18101.

Gavin, J. 2000. Using past strengths to build a bright future. *GRID Magazine* (January). www.gri.org.

George, D. 1997. Major offshore provinces, deepwater, & frontiers all enjoying resurgence of exploration and production. *Offshore* 57(5 May 1). www.os.pennet.com.

Gibson-Smith, C. 1999. Living with $10 oil, World Bank Energy Conference. April 7. www.bp.com.

Goldsmith, M. 2001. California's effect on deregulation. *American Gas Magazine* (March).

Greenberg, J. 2000. IADC, oilfield firms go live with e-commerce, *Drilling Contractor* (May/June):24-33.

Griffith, E. C. 2001. Vice President, North American Region, ExxonMobil Exploration. Personal communication, March 2.

Gunther, J., K. Klemme, and K. Robinson. 1999. Can low oil prices cripple the Texas banking system?, *Southwest Economy* (May/June). www.dallasfed.org.

Hackett, J. 1999. Creating value in exploration & production. *World Energy*. www.worldenergysource.com/articles.

Haines, L. 2000. 'Til debt do us part. *Oil and Gas Investor*. www.oilandgasinvestor.com.

Hammer, M. and J. Champy. 1993. Reengineering the corporation: A manifesto for business revolution. New York: HarperCollins Publishers, Inc. 233 pp.

Hasan, M. 2001. Vice President, Project Implementation, Shell Oil Company. Personal communication, January 19.

Havran, K. J. and K. M. Collins. 1980. Outer Continental Shelf oil and gas activities in the Gulf of Mexico and their onshore impacts: a summary report, September. Prepared for the U.S. Department of the Interior, Geological Survey in cooperation with the Bureau of Land Management by Rogers, Golden & Halpern, Inc. 102 pp.

Helm, L. 1998. Through thick and thin: energy-focused banks have an over 60-year tradition of serving the needs of the independent oil and gas industry. *World Energy*. www.worldenergysource.com/articles.

Helyar, J. 2001. Sittin' pretty. *Fortune* (June 11). www.fortune.com.

Hendricks, K. and R. H. Porter. 1996. The timing and incidence of exploratory drilling on offshore wildcat tracts. *The American Economic Review* 86(3):388-407.

Hollek, D. E. 2000. Director, Gulf of Mexico Operations and Shelf Assets, Kerr McGee Oil and Gas Corporation. Personal communication, August 17.

Hornsnell, J. 2001. Oil markets and prices. Houston, TX: Brown Technical Bookshop.

Huber, P. and M. Mills. 1998. King Faisal and the tide of technology. *Forbes* (November 23):235-238.

Hughes, K. and F. Chen. 1999. Weather derivatives – know your options. *Energy Houston*. www.worldenergysource.com/articles.

Hughes, K. and J. Negus. 1999. To hedge or not to hedge. *World Energy*. www.worldenergysource.com/articles.

Hutzler, M. J. 2000. Statement of Mary J. Hutzler, Director, Office of Integrated Analysis and Forecasting, Energy Information Administration, Department of Energy before the Committee on Energy and Natural Resources, U.S. Senate, July 26, 2000.

International Energy Agency (IEA). 1999a. Energy policies of IEA countries—The United States 1998 Review. 152 pp.

International Energy Agency (IEA). 1999b. Natural gas pricing in competitive markets. 178 pp.

Jeppesen, J. A. 2000. Regional Vice President, Offshore Region, Apache Corporation. Personal communication, August 18.

Kappemeyer, L. W. 2001. Operations Manager, Central East, Gulf of Mexico Shelf Business Unit, BP. Personal communication, March 2.

Kendall, J. 1999. Employment trends in oil and gas extraction In: *Issues in midterm analysis and forecasting 1999*. Prepared by the U.S. Department of Energy, Energy Information Administration. Report # EIA/DOE 0607(99). www.eia.doe.gov.oiaf/issues/oil_gas.html.

Kennedy, J. 1999. How oil and gas companies fought 1998 and won. *Oil and Gas Journal* (January 4):18-23.

Knight, D. 2000. Manager, Offshore Shelf Exploration/Exploitation, Vastar Resources, Inc. Personal communication, August 17.

Koen, A. D. 1994a. Economics, technology rule petroleum engineers' future. *Oil and Gas Journal* (March 28). www.ojg.pennet.com.

Koen, A. D. 1994b. U.S. firms still restructuring, cutting costs under oil price uncertainty. *Oil and Gas Journal* 92(20 May16). www.ogj.pennet.com.

Langley, J. O. 1992. Management perspective: a guide to "rightsizing" oil and gas companies. *Oil and Gas Journal* (April 20). www.ogj.pennet.com.

Le Blanc, L. 1997a. Alliancing and integration. *Offshore* 57(8 August). www.os.pennet.com.

Le Blanc, L. 1997b. 1947 shaking the bounds of land, 1997 probing 10,000 foot depths *Offshore* (May):82.

Lee, W. J., H. Kazemi, T. Blasingame, R. Allman III, Z. Bassiouni, C. H. Bowman, A. W. Eustes III, D. W. Green, L. R. Heinze, R. N. Horne, J. Judah, M. A. Miller, and D. T. Numbere. 2000. The fifth SPE colloquium on petroleum engineering education – an industry perspective. Paper presented at the 2000 SPE Annual Technical Conference and Exhibition, Dallas, TX, October 1-4. SPE 64307.

Leonhardt, D. and B. Whitaker. 2000. Higher fuel prices do little to alter motorists' habits. *The New York Times* (October 10). www.nytimes.com.

Loth, B., N. P. Brown, and G. Glass. 1999. Reorganization impacts upstream technology. *Oil and Gas Journal* (January 18). www.ogj.pennet.com.

Lyle, D. 2000. Halliburton bets on technology, flexibility. Hart's E&Pnet. January. www.eandpnet.com.

MacKenzie, A. 2000. The global gas industry in the 21ST century: the technology requirements. Paper presented at the Gas & Power Conference, June. www.bp.com.

Marfurt, K. J., H. Zhou, K. K. Sekharan, R. E. Sheriff, S. Hall, S. Nagihara, and H. Hou. 2000. Future need for geophysicists and geophysical research in the oil business? Conclusions of a 'listening tour.' *The Leading Edge* (September):974-978.

Mariner-Volpe, B. 2000. The evolution of gas markets in the United States. Bangladesh Ministry of Energy and Mineral Resources. Energy Information Administration. USAID. May.

McWilliams, G. 1996. Making oil wells good to the last drop. *Business Week* (October 7). P. 142H.

Meadows, D. L. 1972. The limits to growth: a report for the Club of Rome's project on the predicament of mankind. New York: Universe Books.

Meister, P. M. and G. V. Cady. 1986. Corporate takeovers and petroleum industry restructuring. Paper presented at the Rocky Mountain Regional Meeting of the Society of Petroleum Engineers, Billing, MT, May 19-21. 8 pp.

Mitchell, G. P. 2000. CEO, Mitchell Energy and Development Company. Personal communication, September 14.

Moritis, G. 1996. New technology, concepts aim at lower costs. *Oil and Gas Journal* (October 7):49-54. www.ogj.pennet.com.

Muello, P. 2001. Brazil tries to save oil rig. *Los Angeles Times* (March 16). www.latimes.com.

Natural Gas Council. 2001. Supply of natural gas. www.naturalgas.com.

Neal, P. 2000. 48th annual Reed-Hycalog rig. *World Oil Magazine* 221(October). www.worldoil.com/magazine.

New York Mercantile Exchange. 2001. Markets. www.nymex.com..

Niering, F.E., Jr. 1987. Oil-state banks in trouble. *Petroleum Economist* (February).

Niiler, E. 2000. Awash in oil. *Scientific American* (September):21.

Nulty, P. 1991. Oil's prospects: a better decade. *Fortune* (April 22):139-148.

Owen, D. 1993. It's a new ball game; U.S. energy policy. *World Oil* 214(2):31-33.

Paddock, J. L., D. R. Siegel, and J. L. Smith. 1988. Option valuation of claims on real assets: the case of offshore petroleum leases. *Quarterly Journal of Economics* 103(3):479-508.

Pattarozzi, R. A. 2001. Shell Oil Company. Personal communication, January 18.

Patterson, F. J. 2000. Director, Gulf of Mexico Exploration, Kerr McGee Oil and Gas Corporation. Personal communication, August 17.

Pcbiography. 2001a. Short history of the micro computer, pcmuseum. www.furtunecity.

Pcbiography. 2001b. Short history of the internet, pcmuseum. www.furtunecity.com/pcmusuem/.

Peebler, R. P. 1999. Time ripe for E&P professional societies to start integrating. *Oil and Gas Journal* (January 4).

Perdue, J. 2000. IT to revolutionize oil industry. *Hart's E&P* (January):67-69.

Perkins, J. M. 1999. Economic state of the U.S. oil and natural gas exploration and production industry: long-term trends and recent events. American Petroleum Institute, Policy Analysis and Strategic Planning Department.

Pesaran, M. H. 1990. An econometric analysis of exploration and extraction of oil in the U.K. continental shelf. *The Economic Journal* 100(401):367-390.

Plaisance, M. R. 2000 and 2001. Vice President and General Manager, Diamond Offshore Team Solutions, August 16 and April 27.

Pohlman, J. 1999. Geoscientists coping with more work, less training, more software, less help. *Offshore* 59(10, October 1).

Porter, R. H. 1995. The role of information in U.S. offshore oil and gas lease auction. *Econometrica* 63(1):1-27.

Porubon, S. 2001. Enron's Lay sees more e-commerce changes for industry. *Oil and Gas Journal* (April 16):32, 33.

Preng, D. E. 1998. Making a living in the oil patch. *World Oil*. April.

Pulsipher, A. G., O. O. Iledare, D. V. Mesyanzhinov, A. Dupont, and Q. L. Zhu. 2001. Forecasting the number of offshore platforms on the Gulf of Mexico OCS to the Year 2023. Prepared by the Center for Energy Studies, Louisiana State University for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-013. 52 pp.

Rauch, J. 2001. The new old economy: oil, computers, and the reinvention of the earth. *The Atlantic Monthly* (January):35-49.

Raymond, L. 2000. Technology in a barrel. Institute of Petroleum—London, United Kingdom. Remarks by the Chairman, Exxon Mobil Corporation. www.exxon.mobil.com/public_policy/presentations.

Reingold, J., M. Stepanek, and D. Brady. 2000. Why the productivity revolution will spread. *Business Week* (February 14):112-118.

Reiss, P. C. 1990. Economic and financial determinants of oil and gas exploration activity. In: Hubbard, G. R., ed. *Asymmetric information, corporate finance, and investment.* Chicago: University of Chicago Press. 181-206 pp.

Revkin, A. 2001. Hunting for oil: new precision, less pollution. *The New York Times.* (January 30):D1, D2.

Rickey, W. P. 2000. Retired Vice President, Production, Exxon. Personal communication, August 17.

Rockwood, A. 1983. The impact of joint ventures on the market for OCS oil and gas leases. *Journal of Industrial Economics* 31(4):453-468.

Russell, J. E., N. J. Brousssard, and H. A. Tiedemann. 1995. Colloquium on petroleum engineering education: a summary. Paper presented at the 1995 SPE Annual Technical Conference and Exhibition, Dallas, TX, October 22-25. SPE 30653. 6 pp.

Salomon Smith Barney. 2000. Bubba 2 bubba- an update: changing landscape of oilpatch e-commerce. September 26. 16 pp.

Schlosser, E. 2001. Fast food nation. New York: Houghton, Mifflin Co. 356 pp.

Seydlitz, R., J. Sutherlin, and S. Smith. 1995. Characteristics and possible impacts of a restructured OCS oil and gas industry in the Gulf of Mexico. Prepared by the Coastal Marine Institute, Louisiana State University for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0055. 188 pp.

Skaug, L. 1998. New designs advance spar technology into deeper water. *Oil and Gas Journal* (November 2):47-52.

Smith, A. and A. C. Fan. 2000. Downsizing's downside: energy industry facing severe personnel crunch. Prepared by John S. Herold, Inc. 19 pp.

Sneider R. 1999. Geo-teams prove their E&P value. *Explorer* (November). www.aapg.org.

Solis, D. 1998. Lowering the boom: falling oil profits prompt companies to slash jobs. *The Dallas Morning News* (October 28. Home Edition):1D.

Staff. 1980. Offshore rig school- Harvard grads, dropouts learn how. *The Work Boat* (March):60.

Staff. 1983. Gulf lease bonanza. *The Work Boat* (July):20-21.

Staff. 1985. Untitled. *Petroleum Economist* (November).

Staff. 1989a. Company information, Chevron. *Petroleum Economist* (November):362.

Staff. 1989b. United States: Staff cutbacks at Oxy and Mobil. *Petroleum Economist* (December):384.

Staff. 1990. Job offers, salaries up for petroleum engineering grads. *Oil and Gas Journal* (September 24). www.ogj.pennet.com.

Staff. 1992a. Anatomy of top 100 upstream players. *Petroleum Economist* (December):18.

Staff. 1992b. BP plans further cost cutting moves. *Oil and Gas Journal* (February 10). www.ogj.pennet.com.

Staff. 1992c. Chevron schedules big changes. *Oil and Gas Journal* (January 20). www.ogj.pennet.com.

Staff. 1992d. Chevron to combine R&D groups. *Oil and Gas Journal* (June 8). www.ogj.pennet.com.

Staff. 1992e. Chevron, Unocol detail plans for restructuring. *Oil and Gas Journal* (May 11). www.ogj.pennet.com.

Staff. 1992f. Restructuring continues to roll. *Oil and Gas Journal* (April 20). www.ogj.pennet.com.

Staff. 1992g. Oxy outlines more cost cutting measures. *Oil and Gas Journal* (December 7). www.ogj.pennet.com.

Staff. 1992h. U.S. companies keep tight rein on 1993 capital budgets. *Oil and Gas Journal* (December 21). www.ogj.pennet.com.

Staff. 1992i. Unocol details employee reduction programs. *Oil and Gas Journal* (May 25). www.ogj.pennet.com.

Staff. 1993. Untitled. *Petroleum Economist* (December).

Staff. 1994a. Amoco slates restructuring start July 1. *Oil and Gas Journal* (June 20). www.ogj.pennet.com.

Staff. 1994b. Watching the world layoffs not always the answer. *Oil and Gas Journal* 92(36, September 5).

Staff. 1995a. The big players in oil and gas transactions. *Petroleum Economist* (December):15.

Staff. 1995b. U.S. companies map plans to reorganize and refocus. *Oil and Gas Journal* (November 6). www.ogj.pennet.com.

Staff. 1996. Frontiers of the Gulf of Mexico, white paper, National Ocean Industries Association, April 2, unpaginated.

Staff. 1997a. Measuring the impact of technology advances in the Gulf coast. www.gri.org.

Staff. 1997b. Non-U.S. firms making their marks in sizzling Gulf of Mexico plays. *Oil and Gas Journal* (September 1). www.ogj.pennet.com.

Staff. 1998a. Chevron's statement regarding seizure of Nigerian Parabe Offshore Platform. www.chevron.com/newsvs/currentissues/nigeria.

Staff. 1998b. No lease-no grease. *Offshore* (May).

Staff. 1998c. Shell reorganizes for speed and profit. *Oil and Gas Journal* (December 21). www.ogj.pennet.com.

Staff. 1998d. Where will oil industry financing come from? (1997 Meeting of the National Ocean Industries Association: A 25-Year Tradition of Service). *Offshore* (May). www.findarticles.com.

Staff. 1999a. Atlantic Richfield – 4th quarter & final results. *The Regulatory News Service* (January 26).

Staff. 1999b. U.S. energy firm compensation squeezed by oil price slump. *Oil and Gas Journal* (March 22).

Staff. 2000a. Business models for future E&P technology. *The Leading Edge* (June):620-629.

Staff. 2000b. FTC wraps up record year in antitrust enforcement with new mix of litigation and guidance. October 13. www.ftc.gov/opa2000/10/antitrustfy2000.htm.

Staff. 2000c. JPT forum: what are the likely effects of Internet technology on the oil and gas industry. *Journal of Petroleum Technology* (May). www.spe.org/jpt.

Staff. 2000d. The millennial geoscientist. *Offshore* 60(4, April). www.os.pennet.com.

Staff. 2000e. New designs for deepwater Spar and FPSO. *World Oil* (July):56.

Staff. 2000f. Oil & gas: Comfortably numb. Deutsche Bank, October. Report in two sections: 69 pp. and 18 pp.

Staff. 2000g. OTC panel discusses improving industry's image. *Oil and Gas Journal* (May 3). www.ogj.pennet.com.

Staff. 2000h. 20/20 Offshore Vision. *Hart's E&P* (January):64-65.

Staff. 2001a. The talent wars. *Chevron Now*. www.chevron.com.

Staff. 2001b. ChevronTexaco raises goals for post-merger improvements. Oil and Gas Journal (November 19). www.ojg.pennet.com.

Staff. 2001c. Fortune 500 list. *Fortune* (April 16). www.fortune.com.

Staff. 2001d. Gas fuels merger and acquisition pace in 2000. Energy Intelligence Group. www.energyintel.com.

Sunwall, M. T. 2000. Area Manager, Western Gulf of Mexico Exploration, Texaco. Personal communication, August 18.

T. Rowe Price. 2001. T. Rowe Price New Era Fund, T. Rowe Price High Yield Fund. www.troweprice.com.

Taylor, A. 2001. Oil, oil everywhere. *Fortune* (April 16). www.fortune.com.

Taylor, L. H. 2000. J. Ray McDermott. Personal communication, August 17.

Traynor, J. 2000. Exploration and production benchmarking, Deutsche Bank, October, 55 pp.

U.S. Department of Commerce (U.S. DOC). 2000. Survey of current business. August. www.bea.doc.gov.

U.S. Department of Education. Annual 1981-1998. Digest of educational statistics. Washington, D.C.

U.S. Department of Energy (U.S. DOE). 2001. Advanced drilling, completion & simulation. www.fe.doe.gov.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 1995. Oil and gas development in the United States in the early 1990's: an expanded role for independent producers. U.S. Department of Energy, Washington, D.C. 28 pp.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 1997. State energy price and expenditure report. 441 pp. www.eia.doe.gov.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 1999a. Annual energy review. U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 1999b. Washington, D.C. Market trends-oil & natural gas. U.S. Department of Energy, Washington, D.C. DOE/EIA-0383 (1999).

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 1999c. Natural gas 1998: Issues and trends. DOE/EIA-0560(98). 167 pp.

U.S. Department of Energy, Energy Information Administration (U.S. DOE EIA). 1999d. Performance profiles of major energy producers, 1997. DOE/EIA-0206(97). January. 149 pp.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 1999e. Washington, D.C. Oil market basics. a primer on oil markets combined with hotlinks to oil price and volume data available on the Internet. www.eia.doe.gov.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 2000a. Annual Energy Review. Washington, D.C. www.eia.doe.gov.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 2000b. Natural gas monthly. Washington, D.C. www.eia.doe.gov.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 2000c. A primer on gasoline prices. Washington, D.C. www.eia.doe.gov.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 2000d. U.S. natural gas markets: recent trends and prospects for the future. U.S. Department of Energy, Washington, D.C. www.eia.doe.gov.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 2000e. Performance profiles of major energy producers. U.S. Department of Energy, Washington, D.C. www.eia.doe.gov.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 2001a. Petroleum supply monthly, May. Washington, D.C. www.eia.doe.gov.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 2001b. The relationship between crude oil prices and petroleum market fundamentals, analysis report. U.S. Department of Energy, Office of Oil and Gas, Washington, D.C. www.eia.doe.gov.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 2001c. U.S. natural gas markets: recent trends and prospects for the future. Office of Integrated Analysis and Forecasting, Washington, D.C. www.eia.doe.gov.

U.S. Department of Energy, Energy Information Administration (U.S. DOE, EIA). 2001d. Monthly Import Report, Form EIA 824. www.eia.doe.gov.

U.S. Department of Labor, Bureau of Labor Statistics (U.S. DOL, BLS). 1999. Occupational Employment and Wage Estimates. http://stats.bls.gov/oes/1999.

U.S. Department of Labor, Bureau of Labor Statistics (U.S. DOL, BLS). 2001a. National employment, hours, and earnings. Series ID: eeu10130001 (SIC Code 13, Oil and gas extraction). http://146.142.4.2.24/cgi-bin/srgate.

U.S. Department of Labor, Bureau of Labor Statistics (U.S. DOL, BLS). 2001b. National employment, hours, and earnings. Series ID: eeu10138001 (SIC Code 138, Oil and gas field services). http://146.142.4.24/cgi-bin/srgate.

U.S. Department of Labor, Bureau of Labor Statistics (U.S. DOL, BLS). 2001c. National employment, hours, and earnings. Series ID: eeu10131001 (SIC Code 131, Crude petroleum and natural gas). http://146.142.4.24/cgi-bin/srgate.

U.S. Department of Labor, Bureau of Labor Statistics U.S. DOL, BLS). 2001d. Occupational outlook handbook. Pgs. 33-37. http://stats.bls.gov.

U.S. Department of the Interior, Minerals Management Service (U.S. DOI, MMS). 1999. Deepwater development facts. January.

U.S. Department of the Interior, Minerals Management Service (U.S. DOI, MMS). 2000. Federal offshore lands through 1999.

U.S. Department of the Interior, Minerals Management Service (U.S. DOI, MMS). 2001a. OCS lease sale statistics. January 24.

U.S. Department of Interior, Minerals Management Service (U.S. DOI, MMS). 2001b. Gulf of Mexico offshore information. www.gomr.mms.homepg/offshore/deepwatr/summary.asp.

U.S. Department of the Interior, Minerals Management Service. 2001c. U.S. Offshore milestones. www.mms.gov/stats/pdfs/milestones.pdf.

U.S. Securities and Exchange Commission (U.S. SEC). Form 10-K: Apache Corporation, for the fiscal year ending December 31, 2000, 24-5.

Utsler, M. 2001. Asset manager, BP Americas. Personal communication, March 2.

Value Line. 2001a. The Value Line investment survey, February 23.

Value Line. 2001b. The Value Line investment survey, March 23.

Vanguard. 2001. Vanguard Energy Fund. www.vanguard.com.

Van Wie, W. A. 2000. Vice President and General Manager, Southern Division, Devon Energy Corporation. Personal communication, August 18.

Varoli, J. 2000. Energy on ice. *The New York Times* (October 3):W1.

Verrett, R. 2001. Vice President, Halliburton Energy Services Group. Personal communication, May 17.

Vielvoye, R. 1990. BP's Robert Horton oversees broad change in firm's corporate culture. *Oil and Gas Journal* 88(50, December 10). www.ogj.pennet.com.

Von Flatern, R. 1997a. Gulf of Mexico shelf exploration, rejuvenation activity at full pace. *Offshore* 57(1, January). www.os.pennet.com.

Von Flatern, R. 1997b. Remote, subsea control technology grows with water depth. *Offshore* 57(10, October 1). www.os.pennet.com.

Von Flatern, R. 1997c. Work shortage becoming critical: demand outstripping supply at all worker levels. *Offshore* 57(2, February). www.os.pennet.com.

Wardt, J. 1996. Operational realities of the '90s; new production strategies for petroleum companies. *World Oil* (February).

Watts, P. 2000. Technology makes the difference—pursuing advances for business & society. Paper presented at the European Association of Geoscientists and Engineers Conference, Glasgow, May 29. 8 pp.

Weise, J. D., D. L. Slitor, and C. A. McCord. 1983. Gulf of Mexico summary report: Outer Continental Shelf oil and gas activities in the Gulf of Mexico and their onshore impacts. Prepared by Rogers, Golden & Halpern, Inc. for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. September. 108 pp.

Westwood, J. 2001. Offshore petroleum operations – worldwide offshore sector offers major challenges. *Oil and Gas Journal* (April 30).

Wetuski, J. 2000. "Execs predict a decade of change. *Hart's E&P* (July):8-9.

WTRG. 1998. Oil price history and analysis. *Energy Economics Newsletter*. Wtrg@wtrg.com.

Wyatt, K. D. 2000. Who will fill our shoes? *The Leading Edge* (September):972-973.

Appendix A

Future Study Issues

FUTURE STUDY ISSUES

During this project, the team identified a number of issues that merit further investigation. The more significant of these are described below.

- **GOM versus the rest of the world.**

Objective. Determine the competitive advantages and disadvantages of the GOM relative to the other important oil and gas areas in the world. Describe the resource allocation decision-making processes of companies that have the option of working in the GOM or other areas.

Description. Through literature review and interviews with industry and other experts, the project would examine how the GOM competes with other oil and gas areas such as Brazil, West Africa, and the Caspian Sea. It would examine and compare factors such as the leasing process, lease costs, lease terms, regulations, and taxes in the GOM and other oil regions of the world. The role of government agencies (e.g., MMS) would be highlighted as would other areas that could be influenced to support continued interest in the GOM.

Linkages. The study would likely address such issues as globalization, the role of regulation, risk management, technology, and the optimization of resource utilization.

- **The role of independents in developing the GOM.**

Objective. Describe the changing role of independent oil and gas producers in the development of the GOM and likely future prospects for these companies. Identify the forces that have influenced changes in those roles and the major trends that have emerged in the past 10 to 15 years.

Description. Through literature review and interviews with industry and other experts, the project would document the recent history of the activities of independents, which have played a more active role in the GOM in the past decade. It would document how independents enter the GOM through primary lease sales and through the secondary lease sale market. It would also explore the niche areas of the independents in shallow water and in deepwater. The study would distinguish between the forces that drive the behavior of these firms and those that motivate the major international oil companies. It would also examine the role of the independents in the GOM as compared to Alaska.

Linkages. The study would likely address the issues of differentiation within segments of the oil and gas industry, globalization, shallow water versus deepwater development, and access to capital and other barriers to action.

- **Foreign oil companies in the GOM.**

Objective. To determine the forces that have encouraged the increasing participation of foreign oil companies in the GOM.

Description. Through literature review and interviews with industry and other experts, the project would document the history of foreign oil company participation in the GOM. Distinctions between private foreign firms and national oil companies would be drawn. Distinctions would be made between new players, that is those who have not previously bought leases, and old players operating under new names. Examination of bid levels and win rates of new and old players would be made. Reasons why foreign oil companies decide to operate in the GOM would be explored. The opportunities to encourage additional investment by these companies would be described.

Linkages. The study would likely address the issues of globalization, privatization of foreign firms, and stakeholder agendas.

- **The role of OPEC in the development of GOM and U.S. oil and gas.**

Objective. To describe the changing nature of OPEC's role in influencing prices and production in the GOM. To identify those factors that have helped and hurt OPEC in its attempts to manage world oil markets.

Description. Through literature review and interviews with industry and other experts, the project would look at how OPEC has succeeded and failed as an organization trying to support the interests of its members.

Linkages. The study would likely address the issues of globalization, the role of foreign oil companies, the role of OPEC and non-OPEC countries.

- **Labor shortages in the oil and gas industry.**

Objective. To identify the range of labor shortages that have emerged within the industry in the past 10 to 15 years. To isolate the factors that have led to those shortages. To assess the opportunities for redressing these shortages.

Description. Through literature review and interviews with industry and other experts, the project would identify the range of labor requirements of the oil and gas industry and quantify the demand and supply conditions for each category of labor. The forces that have been instrumental in creating problems would be described. The potential for intervention by government or others to reduce these shortages would be assessed through the identification of successful efforts and by synthesizing findings from literature and interviews.

Linkages. The study would likely address the issues of downsizing and other labor-related corporate strategies, changing views of industry, loyalty of workers to companies and the industry, outsourcing, and the use of immigrants by the industry.

- **Oil and gas wages versus wages for competing industries.**

Objective. To document the wages of oil and gas labor versus competing industries. To examine the role of wages in securing and sustaining the industry's labor force.

Description. Through the analysis of standard secondary sources for the labor force and wages, literature review and interviews with industry and other experts, the project would define major labor categories and associated wages for the oil and gas industry. These categories and wages would be compared to competing work opportunities that may also be attractive to current or prospective oil and gas workers. The study would track these wages over time to determine trends and the underlying reasons for changes in these trends (e.g., any reduction in the wage premium paid to oil and gas workers for difficult or potentially unattractive work conditions).

Linkages. The study would likely address the issues of downsizing and other labor-related corporate strategies, short-term planning, demands of the financial marketplace on labor rates, changing views of industry, loyalty of workers to companies and the industry, outsourcing, and the use of immigrants by the industry.

- **Whither R&D?**

Objective. To document the changing nature of R&D within the oil and gas industry. To assess the potential for the industry to devote sufficient resources to this area in light of the prospective need for technological change and innovation.

Description. Through literature review and interviews with industry and other experts, the project would describe the changing role of major, independents, contractors, academia, government, and others in oil and gas R&D. The need for R&D, particularly in relation to the perceived need for technology to address prospective exploration and development problems, would be described. The opportunities for industry, academia, government or others to address any R&D shortfalls would be identified.

Linkages. The study would likely address the issues of technology, innovation, risk management, stakeholder agendas, and the conflict between funding R&D and other uses of cash flow and retained earnings.

- **Houston versus New Orleans as the center for U.S. offshore oil and gas.**

Objective. To examine the reasons for the concentration of oil and gas businesses and staff in Houston, particularly those related to offshore operations, as opposed to New Orleans. To assess the advantages and disadvantages of this trend.

Description. Through literature review and interviews with industry and other experts, the project would document the history of the movement and gradual accumulation of the offshore oil and gas industry in the Houston area as well as the primary forces that drove this trend. The business climate and locational advantages and disadvantages of the two regions for different types of oil industry operations (e.g., headquarters, R&D) would be examined. The positive impacts (e.g., easier deal making) and negative impacts (e.g., the isolation of the industry from the economy and society as a whole) would be identified and described.

Linkages. The study would likely address the issues of redistribution of personnel and businesses to Houston, globalization, corporate strategy, and stakeholder agendas.

Appendix B

Current Dynamics of the Oil and Gas Industry: After September 11, 2001

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (cont'd)

Page

1.0 INTRODUCTION[1]

1.1 Background and Objectives

The study, Current Dynamics of the Oil and Gas Industry, was undertaken to review changes in the oil and gas industry operating in the Gulf of Mexico (GOM) between 1980 and 2000. During those 20 years, the industry responded or adjusted to changes on many fronts. Some of the changes that occurred were unanticipated. Others were slow to emerge as trends. The oil and gas industry, like so many other industries and institutions, now faces the challenge to respond, change, and adapt in the aftermath of the terrorist attacks on the United States on September 11, 2001. The dynamics of the industry changed as a result of September 11, but, in what ways?

Some of the changes, responses, and adjustments in the oil and gas industry result from political actions taken by governments – the U.S. government and other governments. The political actions are redefining the nature of parties who affect international oil and gas operations and shifting the equation on when and where exploration and production activities can occur. Some of the changes are originating in the oil and gas industry. Others are from outside the industry. Some of the responses are strategic in nature. Others are operational. Some oil and gas industry responses are new. Others reflect a shift in priorities and a re-thinking of issues already facing a global industry.

This appendix was begins the examination of the changing forces in the oil and gas industry as a result of the events and fallout of September 11. The objectives are to:

- Frame the issues affecting the oil and gas industry's response to the events of September 11, and
- Summarize early indications of the industry's response to the issues and the implications for the industry in the Gulf of Mexico.

1.2 Appendix Issues, Organizing Framework, and Methodology

The appendix focuses on three issues:

- Stakeholder expectations. Stakeholders are individuals or groups who either influence (or can influence) or are affected by a particular decision, action, or activity. Changes in expectations of oil industry stakeholders can affect an array of factors including: investment, labor, goods and services, policy, regulations, and access to reserves, thereby potentially affecting all types of oil and gas activity (e.g., exploration, production, research and development, technology).

- Globalization. Globalization refers to the ongoing process and complex forces that are increasing worldwide integration of ideas, people, and economies. Since it is not a universally embraced phenomenon, it embodies opportunities, challenges, and added

[1] The draft report was completed prior to September 11, 2001. This appendix was prepared after the draft report was completed.

responsibilities. On the one hand, it offers the oil and gas industry increased access to known reserves. On the other, the industry must increasingly address such issues as diversity, sustainable development, transparency, corporate conduct and social responsibility.

- Risk management. Risk management encompasses strategies and techniques used to deal with the possibility that some future event will cause harm. It seeks to protect tangible assets – physical, financial, and human resources – and intangible assets such as corporate reputation or goodwill. For the oil and gas industry, this covers an array of factors affecting results such as infrastructure, reserves, geographical location, security of assets and people, project economics, market volatility, and technology.

While the issues are addressed separately in this appendix, they are actually intertwined. For example, diversifying holdings to include international assets can be a strategy that addresses risk and shareholder (as one type of stakeholder) expectations. At the same time, it contributes to globalization. The analysis of stakeholder expectations focuses on first identifying stakeholder groups and then on what has changed or is changing for the key groups. The discussion of globalization focuses on some of the changing geopolitics of oil and the challenges to companies operating outside their home country. The risk management discussion is organized into two parts – strategic and operational responses. Strategic responses are the long range, big picture implications of changes for the oil and gas industry. Operational responses address day to day issues facing the industry. Some of these responses are short term. Others are longer term.

The appendix was prepared through a review of industry, government, and general circulation publications and websites. The appendix uses the same organizing framework as the original report. That is, some of what is discussed relates to the broader category of industry, of which the oil and gas industry is one part, and some of what is discussed is narrower in focus looking at company or project specific factors. These three categories, all industry, the oil and gas industry, and individual companies or project specific factors, provide the organizing framework for thinking about the changes, response, and adaptations to the dynamics affecting the oil and gas industry following September 11. This framework is summarized below:

Issue Area	All Industry	The Oil and Gas Industry	Individual Companies/Projects
Stakeholder Expectations	X	X	X
Globalization	X	X	X
Risk Management	X	X	X

The oil and gas industry has many sectors. The companies that decide where and when to explore for oil and gas and when to develop discoveries are primarily the focus of the discussion which follows because their decisions affect when and where other sectors of the industry work. One way to look at these companies is to divide them into majors and independents. Major oil companies are vertically integrated, meaning their operations encompass oil and natural gas exploration, production, transport, petroleum refining, and marketing of refined petroleum products. Non-majors, often referred to as independents, are specialized oil and gas producers. Another way to slice exploration and production companies, and one that is more relevant here, is by their geographic focus. Some companies literally work wherever there are known oil and gas reserves. Others are more focused geographically. The following is a scheme for thinking about where oil companies work geographically:

- Global: anywhere known oil and gas reserves are found.

- International: in their home country and overseas, but not in every area of known reserves.

- Multi-nation region: within a continent or area comprising several countries such as the North Sea or West Africa.

- National: Limited to one country such as the United States.

- Sub-national: Limited to one area within a country such as the Gulf of Mexico.

Some of the issues discussed in the remainder of this appendix affect companies no matter where their geographic focus is. Others more directly affect those with a wider geographic focus.

2.0 STAKEHOLDER EXPECTATIONS

2.1 Defining Stakeholders

The word stakeholder refers to individuals or groups who either influence (or can influence) or are affected by a particular decision, action, or activity, that is, they have a stake in the future of, in this case, the oil and gas industry. Five broad categories of stakeholders, their changing expectations, and September 11-related issues are described in the remainder of this section. The stakeholder groups discussed are:

- The U.S. government as policymaker,
- The U.S. government as implementer of policy and law,
- Oil producing and net exporting countries,
- Shareholders and investors, and
- Other stakeholders (e.g., financial services, employees, and local communities).

2.2 The U.S. Government as Policymaker

Government is a major stakeholder in the oil industry. This is true around the world whether nations are generally seen as oil producing or oil consuming or, in the case of the U.S. and other countries, are both major producers and major consumers. While the U.S. government has many roles as a stakeholder, one of its most fundamental is the role of defining national policy with respect to the oil industry, in particular, and to energy in general. This involves a range of interests and the articulation of policies through which government attempts to balance these interests or attempts to find optimal solutions to competing or conflicting interests.

2.2.1 Stakeholders

In creating oil and energy policy in its broadest terms, the U.S. Congress is the principal formal decision-making body. Interacting with Congress are many organizations and individuals representing a broad swath of interests. What these disparate organizations and individuals have in common is a desire to influence the formal decision-makers. They constitute a set of policy stakeholders who may not directly work with the oil industry, but are clearly affecting the industry's fortunes.

The following is a brief identification of the most critical of these policy decision-makers and stakeholders. It should be noted that each category identified below encompasses many organizations that share a few key characteristics, but may have radically different perspectives on specific policy issues or methods of trying to influence policy issues.

- Legislatures and other formal policymaking bodies. The U.S. Congress is the principal source of policy in this country. Its fundamental purpose is to be a forum for the range of interests of policy stakeholders on oil and energy policy and to create legislation that reflects to varying degrees the concerns of stakeholders.

- Industry and allies. The oil industry directly and through such organizations as the American Petroleum Institute (API) advocates its policy positions with the U.S. Congress and other governmental policymaking bodies.

- Environmental community. This community comprises a spectrum of organizations that has an avowed interest in the environment. Concerns related to energy and the oil industry include exploitation of federally-owned land [e.g., Alaskan National Wilderness Reserve (ANWR)], energy conservation and efficiency, and renewable resources.

- Antiglobalist community. The rise of globalization as a force shaping economies and societies has sparked the creation of organizations that are opposed to the issues related to global economic development and trade and their potential impacts. As some of the most visible international corporations, major oil companies are closely associated with globalization, and are targets of concern for the antiglobalists.

2.2.2 Changing Expectations

The shock of the events of September 11 has revived several key energy issues that have been part of the energy and oil debate for decades. The change in expectations focuses on four issues:

- Increased interest in identifying and developing domestic (i.e., U.S.) sources of oil,

- Increased interest in securing oil and gas from foreign sources that are nearby and have friendlier ties to the U.S.,

- Greater concern with energy efficiency, particularly in cars and trucks, and

- Greater interest in developing renewable and innovative energy sources.

2.2.3 Issues

In the weeks and months following September 11, U.S. policy priorities have been reconsidered and to some extent reordered. The policy issues that have been raised are not new; however, they had in many cases receded into the background prior to the terrorist attacks. These terrorist attacks served as a wakeup call for a range of policy issues that have been part of the national energy debate at least since the energy crisis of the 1970's.

The broadest of these issues is the call for U.S. energy independence, which has been commonly linked to national security in the commentary following September 11 (Russell 2001, Russell 2002). A close corollary is the cry for reducing our dependence on imported oil, particularly from the Middle East (Appleyard 2001, Benditt 2002, Kates 2001). While this increased concern with reducing U.S. need for imported oil has been acknowledged even by the major oil companies, experts have pointed out that there is no alternative to Saudi Arabia as a major source of oil (Staff 2002c). Following these expressions of concern from the spectrum of interests with a stake in oil and energy policy, Congressional consideration of energy and oil policy became front-page news for the first time in years.

One dimension of this issue relates to the supply of energy available within the U.S. The Secretary of the Department of the Interior spoke for many when she called for increased U.S. oil production (Russell 2001). The development and exploitation of oil resources in the Alaskan National Wilderness Reserve is emblematic of the interests of those who feel that the energy benefit of this region outweighs the environmental costs of developing these resources (Staff 2001f). Similarly, others have advocated greater exploitation of energy resources on other federally-owned land. These issues have been the subject of debate for years, of course. It should be noted that while many advocate ANWR development, in particular, at least some oil companies have expressed reservations about working in this area. These companies assume that groups opposed to ANWR development could tie up any development for years in the courts, thereby delaying any oil development activities. These companies would prefer to pursue more achievable opportunities (Banerjee 2002). In addition to such hot button issues as ANWR, there have also been renewed calls for more traditional incentives for domestic production such as tax breaks for drilling and opening up more federal lands for exploration and production (Russell 2002).

Despite these longstanding disputes, some have called for a spirit of compromise and sacrifice including initiatives on the part of the environmental community to identify areas suitable for drilling, not solely identify areas like ANWR where drilling is unacceptable. This spirit of compromise is seen as an appropriate response to the "war" on terrorism (Kates 2001).

While dependence on foreign sources has long been a concern, the availability of oil and gas from our immediate neighbors—Mexico and Canada—is usually much less controversial. The role of these sources was elevated after September 11. By December 2001, Mexico had been the largest source of crude oil imports for three straight months. In that month, Canada was the largest source of imported crude oil and oil products combined. Conversely, Saudi Arabia was the third largest source of crude oil imports in December 2001 and the volume of imported Saudi crude had decreased 28 percent from December 2000 (Staff 2002c).

In the post-September 11 world, independent oil companies have been reported to be aggressively pursuing "hemispheric" sources of oil and gas. These include such frontier areas as western and eastern Canada, deepwater Gulf of Mexico, and coal-bed methane (Lawrence 2002).

The call for new sources of energy has extended not only to oil in controversial locations, but also to unconventional oil sources. Thus, commentary has drawn attention to Canadian oil sands and heavy oil in Canada and Venezuela. These sources are more expensive to develop than conventional oil deposits, but are receiving greater attention and investment from major oil companies (Staff 2002c).

Within the overall issue of energy supply is the potential for energy production from renewable resources. September 11 has raised the visibility of these interests as well, including wind energy and ethanol (Staff 2002c).

This broad concern with energy independence clearly supports energy activities in the GOM. Whether considering the "frontier" of deepwater GOM or other GOM areas, all provide sources of domestic energy, without the security concerns of imported oil and gas.

The other major dimension of the energy independence policy debate is reducing energy demand. Here the most salient issue is the efficiency of the U.S. vehicle fleet and the opportunity to raise that efficiency by requiring higher mileage in new cars and trucks, particularly the mileage of sport utility vehicles and light trucks that have claimed an increasing share of the U.S. market (Benditt 2002, Kates 2001). Unchanged since the 1980's, these standards are seen by many as a significant opportunity to use available technology to reduce the need for imported oil because the principal use of oil in the U.S. is for transportation.

In considering the U.S. reliance on Middle Eastern oil, the post-September 11 debate also called for a price for oil that considers what some see as the true price of this resource. Thus, there have been calls for the price of energy to reflect costs of securing oil from unstable areas of the world and of the long-term environmental effects such as global warming (Benditt 2002).

One of the advantages that oil and gas from the GOM has is a lack of substantial external costs that apply to oil from the Middle East or some other areas of the world. Thus, the costs of military intervention or foreign aid that some economists would consider an externality attributable to some imported oil are absent.

2.3 The U.S. Government as Implementer of Policy and Law

Once public policy related to the oil industry is established, the government is the agency by which that policy is implemented. As U.S. policy is a function of the legislative branch, implementation is the function of the executive branch.

2.3.1 Stakeholders

In the U.S. several cabinet level departments are stakeholders with respect to the oil industry. There is a federal stakeholder related to virtually every activity undertaken by the oil industry, including principally the following.

- Department of the Interior. Through the Minerals Management Service (MMS) and the Bureau of Land Management, the Department of the Interior controls and manages industry access to federal lands, both onshore and offshore, and the oil and gas resources that lie beneath them.

- Department of Transportation (DOT). The transportation of industry workers and oil and natural gas products is regulated by agencies with U.S. DOT.

- U.S. Coast Guard. The Coast Guard has maritime safety, mobility, and security responsibilities.

- Department of Labor. The safety and health of onshore industry workers is regulated by Labor's Occupational Safety and Health Administration.

- Department of Energy (DOE). Research and development activities related to oil and gas are funded in part by U.S. DOE, which also sponsors research and development of renewable resources and alternative energy technology (e.g., fuel cells).

- Environmental Protection Agency (EPA). EPA regulates the industry relative to air, water, solid waste, and hazardous waste emissions. It also has a substantial stake in industry-relevant issues such as for the administration of federal vehicle mileage standards, global warming, and greenhouse gases.

2.3.2 Changing Expectations

Since September 11, the change in expectations focuses on the following:

- Increased regulation related to safety and security.
- Seeking the proper balance between safety and security and company operations.
- Heightened interest in government as the promoter of innovative energy technology.

2.3.3 Issues

In the days immediately following September 11, perhaps the most widely discussed concern relative to the oil industry was security. This concern focused on the safety of the industry's workers around the world, especially in locations considered vulnerable to terrorism. Almost equally important was the security of the industry's facilities and operations. In response to concerns about industry facilities and operations, government began to tighten certain regulations that govern helicopter flights, pipeline operations, and marine vessels. The thrust of these changes was to increase government oversight and increase security and surveillance. While security was increased with the implementation of many of these measures, some also interfered significantly with oil and gas company operations. The filing of helicopter flight plans with the Federal Aviation Administration rather than internally within oil companies soon created major bottlenecks and the initial regulatory response was modified (Fletcher and Lorenzetti 2001).

Increased security precautions directly bear on the GOM. For example, the reliance on helicopters for transportation to offshore platforms means that greater security becomes an added burden on the efficiency of operations.

Government security concerns were by no means the exclusive province of the U.S. In an extreme case, the Nigerian navy initiated 24-hour surveillance of that nation's oil facilities shortly after September 11 to respond to concerns about internal terror threats (Staff 2001h).

The concerns for government action did not stop with operational security. There were also calls for greater federal investment in energy-related research and development. The desire is to advance the state of energy technology (e.g., fuel cells) so that U.S. dependence on Middle Eastern oil is reduced and the environmental effects of oil and gas (e.g., greenhouse gases) are minimized (Benditt 2002).

Energy–related research and development is pivotal to the long-range health of deepwater GOM. This frontier has been developed largely because of the industry's ability to refine and advance exploration, drilling, platform, and other critical technologies. While industry and its private sector allies have generally been the leaders in technology development, the federal government has also played a role.

2.4 Oil Producing and Net Exporting Countries

The discussion here concerns those countries that are net exporters of oil, natural gas, and petroleum products. These countries are critical players in the world economy. Substantively, the focus is on broad policy concerns, rather than issues of regulation. For the oil industry, these countries are obvious stakeholders as they manage access to the oil and natural gas resources that oil companies seek to develop. While regulation by these countries clearly affects oil companies, in the post-September 11 world the basic issues are at the policy level.

2.4.1 Stakeholders

The net exporters of oil can be grouped into three principal categories. The most visible category is the countries in the Organization of the Petroleum Exporting Countries (OPEC). In recent decades, OPEC has increasingly shared the world market with others.

- OPEC. OPEC comprises 11 developing countries, mostly Arab nations in the Middle East that are reliant on oil revenues as their main source of income. Current members are Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates and Venezuela (OPEC n.d.). Of these, 6 are among the 10 largest oil exporters worldwide: Saudi Arabia (#1), Iran (#4), Venezuela (#5), Iraq (#6), Nigeria (#8), and the United Arab Emirates (#9). The leading power in OPEC is commonly considered to be Saudi Arabia, which produces 12 percent of the world's oil and accounts for more than one-sixth of total world crude oil exports (IEA n.d.a).

  OPEC includes all important producers and exporters of oil in the Middle East. From 1973 to 2000, the Middle East share of crude oil production declined from 37 percent to 31 percent (IEA n.d.a).

  The export market for natural gas is not dominated by OPEC as is crude oil. Although natural gas is less significant to OPEC than oil, OPEC has substantially increased its share of world natural gas production from 1973 to 2000. Over that period, OPEC's share of global production rose from 2 percent to 9 percent. In the year 2000 global export market for natural gas, Algeria ranked second, Indonesia was fifth, and Qatar was tenth (IEA n.d.b).

- Established non-OPEC. In addition to OPEC, several other countries have been major players in the global oil market for decades. These countries tend to have strong ties to the developed world and include Norway, the United Kingdom, and Mexico, which ranked second, seventh, and tenth in oil exports in 2000. As noted, OPEC does not dominate world natural gas exports; Norway, however, is the fourth largest natural gas exporter; Canada is the second largest (IEA n.d.a, IEA n.d.b).

- Emerging sources. The third category of oil exporting countries constitutes most of the frontier areas for oil and natural gas exploration and development today. Within this category are Russia, various countries that were part of the Soviet Union, West Africa, and Brazil. Russia's oil and natural gas industry has become a major world player following the collapse of the Soviet Union, ranking third in global oil exports and dominating natural gas exports. Most of the other areas have not entered the top ten ranks for oil or natural gas exports, although Turkmenistan was ninth in natural gas exports in 2000 (IEA n.d.a, IEA n.d.b) Nevertheless, these countries have been the source of attention from oil companies in recent years and in some cases have gained substantial visibility since September 11. Indeed, the countries that were formerly part of the Soviet Union are seen by some as the locus of the biggest attempt to create a "new U.S. sphere of influence" since the U.S. entered the Middle East 50 years ago (Starobin 2002).

While clearly different in type from oil producing and exporting nations, Muslim fundamentalists constitute a type of stakeholder in the oil industry in countries where much of the population is Muslim. These include key OPEC members as well as some of the emerging sources of oil in former parts of the Soviet Union.

2.4.2 Changing Expectations

As in many other areas of concern following the terrorist attacks, the changes in expectations for oil exporting nations are more a matter of priority and emphasis than of new expectations. They include the following:

- Increased sensitivity of oil exporting nations, particularly OPEC members, to the role of oil and oil price in the world economy and the potential for higher oil prices to undermine global economic growth and the demand for oil.

- Increased concern by oil companies, developed countries, and others, with political stability in oil exporting countries and the tension between those countries' governments and the general populace.

- Increased awareness of longstanding conflicts between the Arab world and the West and the Arab world and the symbols of globalization, including international agencies such as the United Nations and major oil companies (Staff 2001i).

- Increased interest by oil companies in emerging nations (e.g., former parts of the Soviet Union in Central Asia) and a reciprocal interest by those nations in becoming alternatives to traditional oil sources.

- Increased awareness of the role oil and gas companies can play in economic development plans of oil exporting countries.

2.4.3 Issues

In at least some quarters of the oil-exporting world, the events of September 11 are considered tumultuous, capable of overturning the established order. This view sees major struggles in the Middle East, stretching from the "Stans"[2] in the east to the Mediterranean Sea in the west and down to Somalia and Sudan in Africa. Disparities between global supply and demand will create substantial tensions between growth areas that need oil and the Middle East where most of the world's reserves are located. In this extreme view, the attacks of September 11 are a harbinger of the strife to come (Bakhtiari 2002).

For most of the oil producing areas, the issues after the terrorist attacks have been characterized in less catastrophic terms. While much of the policy debate in the U.S. revolved around energy independence, the policy issues for many oil producing nations focused on the balance between maximizing oil revenues (thereby providing many benefits to citizens) and maintaining a viable global economy. For those nations largely dependent on oil as a source of gross domestic product and of revenues from exports, this debate was particularly important.

The most obvious illustration of this policymaking concern can be seen in the deliberations of the OPEC countries and its most important member, Saudi Arabia (Banerjee 2001). In the past quarter century, OPEC has become increasingly sophisticated in its understanding of the relationship between oil prices and global economic growth. In brief, when oil prices are too high, economic growth slows or stops and demand for oil declines. Alternatively when oil prices are low, growth is encouraged. At some point, however, lower prices fail to stimulate additional growth. The issue for OPEC and other oil producers is to determine the optimal price that stimulates global growth, and also provides for substantial oil revenues. While OPEC has shown greater or lesser skill in managing this balancing act, some observers felt it had been successful in the several years leading up to September 11 (Banerjee 2001, Staff 2001g).

The ability of OPEC and a few others to attempt to manage the global oil market (and sometimes to succeed) stands in sharp contrast to oil production in the GOM. For crude oil developed in the GOM, prices are established by the world markets. The GOM is not a part of the efforts of OPEC to move oil prices up or down, but must live with whatever prices are established by the world market.

September 11 occurred as the global economy was already weakening. Thus, the perennial question of the balance between the price for oil and global economic health had already been a matter of increased attention. The immediate economic concern following the terrorist attacks was then whether a weak global economy would be pushed into recession or depression (Banerjee 2001). These concerns were not unwarranted as the International Energy Agency (IEA) reported the sharpest drop in fuel consumption in almost two decades

[2] The "Stans" include Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. All were part of the Soviet Union until its demise in 1990.

following the terrorist attacks. Regardless of source, estimates for oil demand growth for 2001 were substantially below historical averages while expectations for 2002 were also showing much slower growth[3] (Staff 2002a).

For countries highly dependent on oil revenues, maintaining those revenues is often critical to maintaining government-funded social welfare systems and political stability. Social welfare systems help maintain the political allegiance of those who are served, but are particularly expensive. Economic growth in Russia and economic reform in Mexico are both considered highly dependent on oil export revenues. When stress on these systems is combined with high unemployment among young men, non-democratic governments, and Islamic fundamentalism, the political stakes can be high (Banerjee 2001, Lawrence 2002, Staff 2001e, Staff 2001g).

There have been long-term concerns with the viability of authoritarian governments in the Middle East. The events of September 11 underscore these concerns. Links between Islamic fundamentalism and the terrorists have created basic conflicts for Middle Eastern governments that want to participate in the global economy and reap the benefits of this participation, but are subject to internal criticism for doing so. Among the benefits from keeping the West supplied with oil is military protection for existing Middle Eastern governments. This protection has been sharply opposed by some groups that are at odds with current Middle Eastern governments (Snow 2001, Banerjee 2001).

For at least some Muslim fundamentalists, the West, including the U.S., is anathema on religious grounds; U.S. policy on Israel and the Palestinians and on Iraq is inextricably linked to this religious and ideological opposition. Often focused on the U.S., this antipathy also extends to international organizations like the United Nations. Accommodations with the West by the governments of major oil exporting countries and becoming a part of the global economy are accordingly opposed by many fundamentalists. The major oil companies are seen as extensions of the U.S. or the West and are opposed on that basis (MacFarquhar 2002, Snow 2001, Banerjee 2001).

For some analysts, this conflict between Middle Eastern governments and Islamic fundamentalists constitutes a “hidden” civil war and the attacks of September 11 were part of a larger effort to unseat rulers in Saudi Arabia and other oil exporting countries. The increased integration of these countries into the global economy is seen as an effort to generate the economic growth and diversity that will address critical problems of unemployment. If successful, these efforts are expected to defuse the concerns that support fundamentalist dissent. Investments by major oil companies in projects that will create this economic diversity are crucial to this strategy. As a result, the actions of major oil companies are interwoven with the economic and social policies of oil exporting nations (Caffentzis 2001).

---

[3] IEA estimated a 750,000-barrel per day (bpd) decrease in global oil demand for the third quarter of 2001. Estimates by several sources for oil demand growth for all of 2001 were below the 1 million to 2 million bpd average for the decade preceding 2001 and ranged from 640,000 bpd (OPEC) to 400,000 bpd (U.S. Department of Energy) to 120,000 bpd (IEA). Projected oil demand growth for 2002 was higher, but still below historic growth levels: 1 million bpd (OPEC), 800,000 bpd (U.S. Department of Energy), and 600,000 bpd (IEA). These projections for 2002 were revised downward following the terrorist attacks (Staff 2002a).

The issue of internal political stability that haunts the oil and gas industry in many key countries is simply not a factor in the GOM. Indeed, the ability of oil and gas companies to operate in the GOM confident that the basic political framework is sound is one of the key competitive advantages offered by the GOM. This does not mean that politics is unimportant; the issue of leases in the eastern GOM is evidence of that. Still, oil and gas activities in the U.S. are not subject to the kinds of fundamental political risk that can exist in some parts of the world.

2.5 Shareholders and Investors

2.5.1 Stakeholders

These stakeholders are vital sources of capital for the oil industry, always a capital-intensive enterprise. Among the stakeholders are those institutions and individuals who own shares in individual companies as well as partnerships and other financial interests in corporations within the industry. The common thread here is having an equity position in a company that is part of the oil and natural gas industry as opposed to being a creditor of such a company.

2.5.2 Changing Expectations

The change in expectations following September 11 focuses on:

- Long run investor optimism about the economy and the markets.
- Optimism towards companies in the oil and gas industry, which in some cases have already served as a sort of safe haven for investors.
- Lower expectations for returns on investment than before the general collapse of the stock markets.

2.5.3 Issues

The fundamental concern of investors has not changed. It is obtaining a desirable return on their investment. Investors, however, tend to value stability and predictability. Both were badly affected in the immediate aftermath of the terrorist attacks, resulting in some sharp downturns in the world's stock markets. Within weeks of the attacks, however, investors had begun to regain some confidence in markets and optimism for the future although that optimism is tempered by a general sense that future returns will not match the returns witnessed in the late 1990's, before the high-tech stock bubble burst.

As a key element of the global economy, the oil industry was integral to the concerns about that economy and the world's stock markets following September 11. Following a very short period of substantial volatility in the market, general investor sentiment in the oil industry rebounded. September 11, however, tended to underscore the sense that the high stock market returns of the late 1990's were history (Value Line 2001).

Despite general concerns about the market, investor faith in the oil and gas industry appears to have quickly recovered. Indeed, some investors tended to move into oil and gas industry stocks because they were considered less risky than the market in general. The companies in the industry are often considered more conservative investments, particularly the larger, integrated companies. The longer-term outlook for investors in these companies tends to be positive as analysts see oil and gas as critical to the global energy market for many years to come. As global growth returns to expansion, the prospect for major oil companies is considered to be positive (Value Line 2001).

2.6 Other Stakeholders

The stakeholders identified above are those that appear to be particularly and immediately affected by the events of September 11. Other important oil industry stakeholders, it appears, have not fundamentally changed their expectations of the industry and of their relationships with oil companies.

These other stakeholders include many components of the financial services industry, the employees of the oil industry, and the local communities where oil industry activities occur. In addition to facilitating equity investment in the oil industry, the financial services industry plays a critical role in supplying capital through bonds, loans, and other financial instruments. The insurance industry helps manage risk through the provision of insurance policies. From the insurance industry's perspective, the events of September 11 can be handled in a manner similar to other belligerent events. The risk of war and its effects on the oil industry have been a part of the relationship between insurers and the oil industry for decades. Thus, insuring the oil industry against terrorist attacks and their potential impacts on the industry are, if not standard operating procedures, then at least within the bounds of previously available protections (Ahmad 2001).

Employees of the oil industry are clearly stakeholders in the industry. Their security has been one of the most immediately raised concerns following the terrorist attacks. This issue was discussed above from the perspective of impacts on oil industry operations and related changing expectations. What is not clear yet, is whether heightened awareness of security issues in the oil and gas industry will have an effect on industry recruitment at a time when there is a labor shortage.

Local communities where the oil industry operates have important stakes in the industry. As a source of direct employment, an engine of economic development, or a generator of environmental impacts, the oil industry can play an important role in the life of local communities. The terrorist attacks have had operational impacts on the industry that affect local communities and were discussed above under the industry's response. As discussed below in Section 4, physical barriers have been added to some facilities, which serve to separate the facilities from the community. The terrorist attacks, however, have so far had little bearing on the basic economic, environmental, or social relationship between the oil industry and local communities where they already operate.

3.0 GLOBALIZATION

3.1 Globalization Defined

In *The Lexus and the Olive Tree*, Thomas Friedman argues that globalization is the phenomenon that succeeded and replaced the Cold War as the global organizing system at the end of the twentieth century. Unlike the Cold War, globalization is defined as a dynamic system that tends to integrate corporations, markets, nations, and technologies. Free-market capitalism is the fundamental driving force. The process of globalization tends to spread free-market capitalism into formerly closed economies, opening them to the private sector and reducing the role of government as regulator of national economies and individual companies (Friedman 1999).

The growing importance of globalization and the interdependence among countries that it encourages can be seen in what did not happen after September 11. One, oil prices experienced a very short-term volatility, but soon began to fall. They did not rise precipitously as a response to economic panic. Rather, they began to decrease as global economic activity slowed even further. Realizing the importance of global economic growth and health, OPEC tried to maintain adequate supplies and moderate prices. Two, international trade negotiations did not falter either as a response to terrorism or in the face of antiglobalist protests (Tippee 2002).

As a dynamic system, globalization is responsive to events such as the terrorist attacks of September 11. When particular events have sufficient force they can create repercussions that are felt throughout this globalization system.

Globalization tends to link the interests of the private sector and government. While this is by no means a new relationship, globalization tends to accelerate and accentuate this intertwining of interests. The lines between the roles of government and the private sector become more blurred.

Globalization is not a universally embraced phenomenon; witness the backlash of protests that accompany meetings of the World Trade Organization, the World Bank, and the International Monetary Fund and the attacks on September 11. Although the oil industry has a long history of working globally, globalization has altered oil industry behavior and the industry continues to adjust and respond to the dynamics of the globalization. The response is an evolutionary process that started before September 11. However, the events of September 11 underscore some of the challenges facing the industry related to globalization.

3.2 The World of Oil is Changing

The U.S. government's response to the September 11 attacks included a call for a global united front against terrorism[4]. This was followed by a major military campaign against Al Qaeda and Taliban forces in Afghanistan. These two actions had ramifications within and

[4] In other actions, in late 2001 the U.S. called for United Nations weapons inspectors to return to Iraq to determine whether it was building weapons of mass destruction. Iraq initially rejected the request.

among the oil producing countries of the world and their relationships with the U.S. As a result, the world of oil is changing in the following ways:

- Greater governmental and corporate interest in countries that represent emerging sources of oil.
- Increased capital flows to the Stans, West Africa, and other frontier areas.
- Loosening of established strictures on Iran and Libya.
- Continuing and increased emphasis on opening closed country economies to globalization.
- Reinforcing of the integration of public and private parties in the global economy.

The military effort against Al Qaeda and Taliban forces in Afghanistan sparked a much closer military relationship between the U.S. and several new nations along the northern Afghan border. There was also a general warming of relations between the U.S. and these and other new countries that were formerly a part of the Soviet Union. Among these countries are several with significant oil and natural gas resources.

These countries (often termed the "Stans") are not strangers to the global oil companies. Indeed, the break up of the Soviet Union created opportunities beginning in the early 1990's for western oil companies to seek oil and gas deals. Since September 11, however, Western interest (e.g., from the U.S. and other national governments and from international lending agencies like the World Bank) in these countries has intensified (Andrews 2002). Indeed, global oil companies reportedly are ready to invest up to $200 billion in Kazakhstan over the next 5 to 10 years (Brauer 2002). Since the terrorist attacks of September 11, U.S. government aid to these countries will reportedly increase by 50 percent to over $800 million annually (Starobin 2002).

Part of this interest is in the development of oil sources that are alternatives to the Middle East. In concert with this heightened interest, at least one of the Stans—Kazakhstan—has expressed an interest in becoming a major force in global oil trade. Kazakhstan sees oil as a means of generating income and wealth and pulling itself out of poverty[5] (Brauer 2002, Starobin 2002).

In Africa, the aftermath of September 11 and the war on terrorism has underscored the strategic value of that continent's oil resources. This is especially true for West Africa, closer to the U.S. than the Middle East and considered by some to be the most exciting oil frontier in the world. Investment in West African exploration and production is expected to increase sharply in the next few years, quintupling to $10 billion by 2005 from current levels. Within a decade capital flows to West Africa could exceed those to the Gulf of Mexico and the North Sea (Staff 2002a, Crawley 2002).

---

[5] Income levels in Central Asian countries range from about $200 in Tajikisatan to $600 in Uzbekistan to $1200 in Krygyzstan (Andrews 2002).

Even within the context of Middle Eastern oil, the events of September 11 may have reshuffled international relationships. For years, Iran has been on the outs with the U.S. and other governments and has been the focus of restrictive economic policies. As an alternative to other major Middle Eastern oil sources and a neighbor of Afghanistan, however, Iran has clear economic and political benefits that could lead to more engagement with the West and global oil companies (Banerjee 2001). Indeed, within a month of September 11, high level European Union and British officials visited Iran. This was the first visit to Iran by a British foreign secretary since 1979 (Staff 2001e). In response, Iran is reportedly eager for European and Asian investments that could modernize its oil and gas industry. Even Libya, long an outcast from U.S. and western economies, has benefited from the shifting political alliances of the post-September 11 world. Sanctions imposed years ago on trade with Libya have been suspended, reopening ties to that country's oil (Townsend 2002). These shifts in relations, however, have also been seen as the kind of exaggeration in geopolitics that is characteristic of a major crisis (Staff 2001e).

Also within the traditional sources of oil in the Middle East, shifting geopolitics have underscored interests in economic diversification that depend on investment by foreign oil companies and other parties. Longstanding prohibitions against foreign investment in Saudi Arabia and other countries had begun to crumble before September 11, but subsequent events appear to have increased the momentum for a number of economic diversification projects in Saudi Arabia, Kuwait, and Qatar that have been implemented only with outside investments. Consistent with these changes in investment opportunities, new fiscal, legal, and regulatory provisions in Saudi Arabia have significantly improved the investment climate. Overall, September 11 has helped to open up the Middle East for foreign investments, with Europe and Asia the most eager to pursue new opportunities while the interest of the U.S. may be waning. While the impact of September 11 appears to be measurable, long-term interest will depend on the success or failure of one or two key projects that have depended on foreign investment (Townsend 2002).

While September 11 and its aftermath have enhanced oil-based economic opportunities for some countries, they have also increased strains in some countries which have long been mainstays of the global oil market. The call for governments to announce their opposition to terrorism, particularly that sponsored by the Al Qaeda network, increased internal pressures in certain Muslim countries or at least gave substantially greater publicity to those internal pressures. The essence of these pressures is the array of political, social, and/or cultural conflicts between the rulers of a number of Muslim countries and the general populace. These countries are often plagued with high levels of unemployment for young men, little prospect of future employment, increasingly fundamental religious outlooks among the general populace which tends to have a strong anti-Western bias, and other contentious issues (Staff 2001i). The participation of these countries in the global economy can hold the promise of economic development and the mitigation of internal economic problems, but also further integrates these countries into globalization and its Western-oriented values (MacFarquhar 2002).

Despite the countervailing forces in the oil world, the impact of September 11 will likely be in the direction of increased globalization of the oil and gas industry. This would mean a further integration of traditional oil powers like Saudi Arabia into the global economy as well as the introduction of additional countries from the Stans to certain developing African nations to globalization. To the extent that this happens, the GOM will face competition for the investment dollars and other resources of the oil and gas industry from additional parts of the world.

Some oil and gas companies operate solely within the GOM and, to some extent, are not as directly affected by these global shifts. Nevertheless, many key players in the GOM operate in one or many other areas of the world. For these companies, the issue is whether to invest resources in the GOM or elsewhere. September 11 will in all likelihood create more "elsewheres" for these companies to consider, potentially increasing competition for the GOM.

3.3 Meeting the Triple Bottom Line

Social issues and corporate strategy, traditionally treated separately, are increasingly coming together as a result of globalization, because globalization creates the need for responsibility. The role of the foreign oil and gas industry in the economies of the less developed countries in which they operate and those countries' opportunities for economic development are under increasing scrutiny by the companies, shareholders, non-governmental organizations (NGOs), financial institutions such as the World Bank, and the host countries. In brief, the argument is that trade and globalization are critical to the reduction of poverty and the maintenance of general stability in such countries. Further, oil and gas are central to economic growth and the economic transformation of those parts of the Third World with significant oil and gas resources. Thus, it behooves oil companies to understand more clearly the role that oil and gas have played and could play in these countries' development (Tippee 2002). As discussed below, multinational oil companies led by the major companies are:

- Assuming greater responsibility (although sometimes reluctantly) and see opportunities to participate in economic development in less developed countries where they operate.

- More accepting of their global corporate citizenship including, within limits, responsibilities to clarify their relations with governments in the developing world.

Business success, in general, and for the oil industry specifically, is increasingly measured by the triple bottom line − performance in environmental protection and community affairs, as well as economic performance. This phenomenon is not a direct result of the events of September 11, but those events underscore the industry's struggle to address the economic growth, environmental protection, and social issues. Embodied in the triple bottom line are the concepts of sustainable development and corporate social responsibility, examples of other dynamics reshaping the oil industry.

3.3.1 Intertwined Concepts: Sustainable Development and Corporate Social Responsibility

Sustainable development was first defined in 1987 in the United Nations-published report *Our Common Future*, also known as the Brundtland Report, as "development which meets the needs of the present without compromising the ability of future generations to meet their needs" (Brundtland 1987). The report also highlights sustainable development's three fundamental components − environmental protection, economic growth, and social equity − and the need to work toward economic development that can be sustained without depleting natural resources or damaging the environment. The 1992 Earth Summit, during the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, stressed the global nature of the environment and that long term economic progress must be linked to environmental protection. The Rio Earth Summit resulted in the adoption of Agenda 21, a wide ranging action plan to achieve sustainable development worldwide. A progress report on Agenda 21 is expected at the United Nations-sponsored World Summit on Sustainable Development, Johannesburg Summit 2002 (August 26-September 4).

There is no single definition of Corporate Social Responsibility (CSR) but it is "about companies determining their social values, or what they stand for, and about integrating social concerns into their business strategy" (Staff 2001b). It is a dynamic concept that is evolving. CSR implies deeper and wider involvement of companies in the societies where they operate. This means companies can gain insights into host countries and become more politically and culturally sensitive and better equipped to manage the associated risks (Fjell 2000). Companies are increasingly incorporating social responsibility programs into their operations, both because they make for good community relations and because they make business sense. If CSR is not fully aligned with other components of business strategy, it becomes philanthropy. But, integrating CSR into business strategy is easier said than done (Fjell 2000). Companies are being encouraged to combine CSR and business strategy from multilateral lending organization such as the World Bank, NGOs, and shareholders.[6]

CSR is also one aspect of managing reputational risk. Companies, all types of companies not just oil companies, are acutely aware these days with the examples of Enron, Arthur Andersen, WorldCom and others, of how fragile company reputations can be and that consumer and shareholder trust and the company's favorable reputation can evaporate overnight. Gaps between what companies say about CSR and what they do are quickly noticed in our interconnected world. Political and economic developments that once went largely unnoticed can now be flashed around the world immediately with the internet and influence public perceptions of international companies and industries, including the oil industry. Trust and reputation are created with results and help sustain commercial success (Brinded 2002, Fjell 2000, Cheney 2000). Many companies make a concerted effort to communicate their efforts beyond financial performance through their websites, in their annual reports, and in special reports. This move from simply doing to demonstrating what is done is also about trust and reputation. A good reputation can benefit a company – with investors and by attracting a good workforce with like values (Fjell 2000). The values tie the company together top to bottom and across geographic areas. One of the many challenges for oil companies operating in countries with different social and political systems is to respect

[6] There are organizations that monitor corporate governance and social responsibility issues for those interested in socially responsible investing. The Interfaith Center for Corporate Responsibility, for example, sponsors shareholder resolutions on major social and environmental issues such as human rights and emissions of greenhouse gases. Companies are targeted for specific issues. These resolutions, while not often successful in passing, gain media attention and send a strong message to management.

the local culture and appreciate its history while preserving the companies' core values (Browne 2001).

CSR programs are typically structured to meet the needs of the countries in which the companies are working. In developing countries, they may address basic infrastructure or health needs. In essence, these programs fund activities associated with government, and whether the companies like it or acknowledge it, the programs fund development and can act as catalysts of change. The programs are sometimes run by the companies or sometimes funded through international organization such as the World Health Organization or UNICEF. So between sustainable development and CSR, international oil companies are wrestling with a host of issues besides the technical challenges of extracting oil. There is increasing interest within the industry to standardize programs with the adoption of best practice standards (Alba 2001).

There is not general consensus yet on how to meet the triple bottom line, i.e., tie profits to the principles of sustainability and responsibility. Oil companies differ in their willingness to acknowledge responsibility for sustainability and community affairs and to act accordingly (Fjell 2000). The oil industry in general is addressing the intertwined issues of sustainable development and CSR in a number of forums. Given that meeting themes and agendas are set months in advance, the focus of some recent or planned forums on sustainable development and CSR illustrates the timeliness and evolving nature of the issues for the industry.

Some oil companies are members of the World Business Council for Sustainable Development (WBCSD), a coalition of international companies from 30 countries and 20 industrial sectors with the shared commitment to sustainable development through economic growth, ecological balance, and social progress. The current WBCSD Chair is Philip Watt, Chairman of the Committee of Managing Directors for the Royal Dutch/Shell Group.

The issues are also being addressed in oil industry-sponsored forums. The International Petroleum Industry Environmental Conservation Association's (IPIECA) Strategic Issues Assessment Forum sponsored a Workshop on Corporate Responsibility in 2000. The participants in this information sharing session acknowledged that the oil industry needs to further address the issues of corporate responsibility and is being pressured to do so by non-governmental organizations, government, and the media (IPIECA 2000).

The theme of the 18th World Energy Council (WEC) Congress held in October 2001 in Buenos Aires was the globalization of energy and its impacts on developing nations, "Energy Markets: The Challenges of the New Millennium." The Congress, held every 3 years, was the first in the new century and the first held in Latin America. The meeting message was "sound energy development is the key to global economic sustainability" (Williams 2001). A key sub-theme focused on the increasingly important role of social responsibility programs in energy industry operations. In keeping with the globalization theme, an official from the Philippines energy sector was named chairman of the WEC, the first from a developing nation.

The World Petroleum Congress (WPC) holds its meeting every 2 years. The theme for the 16th WPC held in Calgary in 2000 was "Petroleum for Global Development: Networking

People, Business, and Technology to Create Value." One session was devoted to the challenges of achieving international consensus on social responsibility in an international market economy.

The discussions of sustainable development and corporate social responsibility will continue at the 17th World Petroleum Congress in 2002 whose theme is "The Petroleum Industry: Excellence and Responsibility in Serving Society."

3.3.2 Components of Corporate Social Responsibility

There are a number of key themes within CSR, and four of these themes are discussed below:

- Human rights and security. By the nature of where oil and gas reserves are found, oil and gas companies must work in a variety of settings, including isolated and remote areas and in developing countries. Here two forces, human rights and security, interface. Some companies have been accused of complicity with security forces accused of human rights violations (Bray 1999). To help address this, the U.S. and United Kingdom governments along with seven oil and mining companies and several human rights NGOs conducted a year-long dialogue which resulted in the release in December 2000 of The Voluntary Principles on Security and Human Rights (U.S. Department of State 2001). The voluntary principles or best practices fall into three categories: risk assessment (i.e., risks within a company's operating environment), relations with public security, and relations with private security. Security arrangements with host governments are encouraged to promote the principles of the Universal Declaration of Human Rights and the International Labour Organization's Declaration of Fundamental Principles and Rights at Work. Private security arrangements should be consistent with law enforcement principles such as the U.N. Principles on the Use of Force and Firearms by Law Enforcement Officials and the U.N. Code of Conduct for Law Enforcement Officials.

- Economic development. Economic development attempts to reduce poverty and improve the quality of life through job creation, wages, investment opportunities, and training. Foreign investment for financing economic development in developing countries comes from official development assistance and private capital. The recent trend has been a decline in official aid and an increase in private investment (Staff 2001b). Direct foreign investment is part of globalization in which the world becomes more integrated. Oil revenues are a major source of income in many developing countries and should be a source of development funding and, through development, a way to reduce poverty.

- Business conduct. Business conduct ties CSR to the company's senior management and Board of Directors who are responsible for overall business strategy, and policies and procedures. The significance of corporate governance to some companies can be seen in the appointment of a director of business ethics in October 2001 at one major oil company. The company expects the highest ethical standards in areas such as business relations, human rights, and respect of the law (Browne 2001).

  One of the issues in business conduct is corruption, often referred to as transparency. Corruption began to be seen as a threat to the environment, sustainable development, and human rights and as an economic issue negatively affecting economic development efforts in the 1990's. It garners media and shareholder attention. Oil companies pay significantly to explore and produce oil and gas. In the United States, leasing and royalty payments are public record and the transactions are transparent.

In some other areas of the world, there is no public accounting of oil-related payments. These transactions are referred to as opaque. In oil producing countries with established track records of failed development, inadequate legal systems and deficient infrastructure, corruption is thought to have diverted oil revenues from supporting human and economic development. There is some thought that oil revenue spent in support of economic development would help temper the criticism of globalization. Greater transparency would, at a minimum, demonstrate what oil companies paid and would encourage governments to be more accountable for the management of these monies (Swarns 2002). The transparency issue raises a dilemma for oil companies: make their royalty and license payments public when host governments do not or respect the wishes of host governments when they do not choose to make oil payments public. In some cases, disclosures would violate contracts with host countries, break its laws, and cause a loss of concession (Aalund 2002). Whether payments are disclosed or not, the transparency issue is part of sustainable development and CSR.

A coalition of more than 30 NGOs has teamed with international financier George Soros to launch a "Publish What You Pay" appeal to transnational oil and mining companies. The NGOs include such diverse groups as Amnesty International, Friends of the Earth, Global Witness, OxFam, Save the Children, and Transparency International. Under their proposal, full disclosure of net taxes, fees, royalties, and other payments made to governments would be a precondition for oil, gas, and mining companies to be listed on international stock exchanges and financial markets. The information requested is the same basic information disclosed in many developed countries (Suri, 2002).

- Environment. Energy is essential to economic development and the eradication of poverty. One of the challenges is to develop energy in an environmentally responsible way. In the last 30 years, a number of high profile environmental events (e.g., Santa Barbara Channel oil spill, Three Mile Island, Exxon Valdez), the creation of environmental protection institutions (e.g., U.S. Environmental Protection Agency, and international meetings (e.g., U.N. Conference of Environment and Development) have shaped environmental issues. National and international mechanisms regulate environmental protection. The environmental challenge has changed in two ways for companies. First, the environment, which was once a bottom line concern, is now an aspect of corporate performance. Second, recently there has been recognition that poverty in developing countries and environmental degradation are linked. So, environmental issues are merging with issues of poverty alleviation and social equity.

One of the many challenges facing the oil and gas industry is how to meet the demand for affordable oil and gas, while protecting the environment and meeting societal needs. Business success in the developed and developing world is linked to strong performance in financial, markets, environmental stewardship, and community affairs (Gossen and Riemer 2001).

3.4 Other Globalization-Related Challenges

Globalization provides at least three other challenges to oil and gas companies working outside their home country.

- Diversity. Globalization brings oil and gas companies into different parts of the world and into different cultures and working environments. Companies are increasingly recognizing the benefits of diversity in the workforce and implementing strategies to achieve it. People are the backbone of companies. While technology is credited with many of the advances of the oil and gas industry, people develop the technology and make it work. So having a talented workforce is essential for a successful and sustained business (Moody-Stuart 2001). There is a competitive market for oil industry workers. People who have appropriate cross-cultural skills in addition to technical skills are critical to getting the job done in other parts of the world.

  Building a diverse workforce is a challenge that involves addressing cross cutting issues of gender, culture, and education, at a minimum. Historically the industry's workforce was predominantly male, white, and Anglo Saxen. The industry requires professionals with university degrees, and access to higher education is not universal throughout the world. The science and technology based disciplines used in the industry traditionally have not attracted large numbers of women. Industry management has been predominantly male and Anglo Saxen and has recruited and promoted like people (Browne 2002).

- Getting the deal done. Globalization underscores the need for companies working in multiple countries to understand the distinctive characteristics of the countries and communities in which they work. That understanding contributes to being able to get the deal done. Getting the deal done requires a host of skills, including the ability to: understand each part of the world in which a company works and to establish working relationships; listen and find terms for each party at the table; and develop and maintain trust (respect) (Guther 2002, Brinded 2002, Sprow 2002). Some companies partner with indigenous companies. Some companies staff with local personnel. It has been noted that the small size of independents gives them an advantage compared to the majors in the developing world. With the independents, the host government is working with the people who run the company, unlike the majors where the decision makers are less visible (Dittrick 2002a).

- Getting the Project Done. Globalization underscores operational issues related to getting a project completed. These include management, technology, security of people and assets, respect for local communities (Longwell 2001, Sprow 2002). These are issues that apply to projects no matter where they are located geographically. However, projects that are part of the globalization process may have special needs based on location, number and type of partners, personnel or other factors. Projects involve all types of management: teams, contracts, outcomes, and knowledge. Technology, which plays a key role in globalization, is used in projects in several different ways. It is needed to extract the oil or gas. It is also needed and used by the project staff, which can be geographically distant, to stay connected. Security issues are heightened in many of the environments in which oil and gas exploration and development are now taking place. (Also see Section 4.3.)

4.0 RISK MANAGEMENT

4.1 Risk Management Redefined and Priorities Reshuffled

If asked, most people would say that the goal of the oil and gas industry is to make profits, thus the overriding activity of oil and gas companies is financial management, assuring that revenues exceed costs. An equally strong argument could be made that the core activity of oil and gas companies is risk management. Risk involves not only finances, but a host of other factors from the ability of technology to increase well yield to the probability that a barrel of oil loaded onto a ship in the Persian Gulf will safely reach its destination.

For one oil company corporate economist, risk management has superceded economic forecasting. Economic conditions can be difficult to predict. Risks, on the other hand, can be defined and plans to manage risks can be developed. Risks here include not only financial conditions such as currency exchange rates, but also more qualitative variables such as political risk in developing countries. The assessment of these risks is not an academic exercise. Basic business decisions—credit limits on specific deals, go/no go decisions on investments in new exploration and production projects—are routinely based on country specific risk analysis (Painter 1999).

There is no consensus on the ultimate impact of September 11 on risk management in the oil and gas industry. One view is that nothing has changed; at the other extreme, some view September 11 as the beginning of a new and fundamentally different world for oil and gas.

The no change argument is based on the conflict faced throughout the 120-year history of the oil and gas industry (Dahan 2002). As a result, terrorism is nothing new to the industry (Staff 2001c). Indeed, the history of the Middle East is a long saga of local distrust of the West and all its agents, oil and gas companies being particularly salient examples of the latter (Staff 2001i). One indicator of this lack of change in the post-September 11 world is the fact that reportedly few oil companies have added significantly to their insurance coverage since that date—political risk is a basic fact of life for these companies (Ahmad 2001).

Others argue that September 11 has made and will continue to make a difference in the oil and gas industry. While analysts have pointed out that crises always exaggerate the geopolitics of oil (Staff 2001e), the head of Royal Dutch/Shell has asserted that the terrorist attacks will affect not only oil's geopolitics, but also the entire issue of energy security (Staff 2002c). While the industry has historically dealt with terrorism, the issues surrounding Islamic fundamentalism, including the political strife flowing from the tension between fundamentalists and more moderate reformers in many Muslim countries, will need to be added to the risks that oil companies manage (Staff 2001c).

This shift in risk assessment can be seen in analyses of the insurance industry which estimate that the events of September 11 created claims worth $10 billion that erased 8 to 10 percent of the insurance market's capital. As a result, insurance companies will be more restrictive in providing coverage in the future. There will likely be a "flight to quality" that penalizes greater risks and an increase in the cost of that coverage. Politically susceptible regions—the kinds of areas where oil and gas companies often operate—may lack coverage. One sign of insurance companies' reaction to this greater risk is the reported addition of a $0.20 per barrel war insurance premium to cargo loaded at Persian Gulf ports (Ahmad 2001).

This sense of reordered risks also includes oil exporting countries. For many OPEC countries, September 11 underscored the risks associated with faltering economies and high unemployment among young men—a combination ripe for exploitation by fundamentalists (Townsend 2002). For these countries maintaining domestic living standards is crucial to maintaining social stability (Staff 2001e). One response is the recent invitation to oil companies to invest in projects designed to diversify the economies of Persian Gulf countries and provide massive employment opportunities. This invitation represents an overturning of policies banning foreign investments in these countries that have stood for as long as 70 years (Townsend 2002).

Among the many responses to September 11 was a call for a better, more integrated approach to risk management and contingency planning. This was seen as a responsibility of both government and the private sector. As one commentator put it, in the past the concern was that a single house would burn down. Now the concern is that the whole street will be destroyed. Moreover, the ability of individuals to disrupt company operations or even national level systems will likely lead to a more uncertain and chaotic future (Aldred 2002).

On balance there seems to be a sense that risk management needs to be reassessed in light of the events of September 11. For oil companies, this reassessment is seen in part as a need to reconsider their effort to balance traditional issues in the Middle East (e.g., maintaining access to oil, coping with popular sentiment that opposes the West and global oil companies) with longstanding ties to Western democracies (Snow 2001). One upshot of this reassessment is a renewed sense of urgency for the task of understanding the proper role of oil and gas companies in the developing world. In countries where they operate, companies have even more reason to understand why development fails to occur or to flourish, the role of corruption in government, and the debilitating effects of inadequate legal systems and deficient infrastructure and to ponder how best to respond to these difficulties (Tippee 2002). This is all the more important as companies see their future sources of oil in countries that are less politically stable and, for that and other reasons, more challenging (Longwell 2001). For the U.S., September 11 has redefined energy security as a national priority (Russell 2001) and redefined energy supply as both an energy security and national security issue (Russell 2002). Realizing the limits on domestic sources, the U.S. sees emerging sources of supply such as Kazakhstan as strategically important means to reduce dependence on the volatile Middle East (Starobin 2002).

Thus, the events of September 11 appear to have reordered risk management priorities. For oil companies, the issues of geopolitics and energy security have increased significance. The particular threats posed by terrorism in the age of Al Qaeda are a new and important variation on the historic theme of terrorism. Whatever limits they face, leading global oil companies are also more aware that they have a responsibility to act as a force for change in developing countries. They cannot ignore those local concerns that give rise to unstable socioeconomic and political conditions. With the U.S. and other Western countries, oil companies have placed and will continue to place greater emphasis on diversifying sources of oil and gas, trying to reduce their dependence on any given area, particularly the Middle East, and thereby increase energy security. While some will argue that none of these issues are new, the preponderance of evidence to date indicates that since September 11 all have gained significance in the overall process of managing risk, taking greater priority over other ongoing risk factors.

4.2 Strategic Risk Management

While the risks receiving greatest attention in the immediate aftermath of the terrorist attacks were operational, the safety of employees and workers and the security of facilities, much of risk management tends to concentrate on long-term issues of demand and supply and the core mission of companies. As such it is concerned with the future and what fundamental forces drive that future. These drivers tend to be factors that affect a broad range of oil company business (or any other business) activities such as geopolitics and technology (Pratt 1999).

4.2.1 Thinking About the Future

How to sustain and grow a competitive and profitable enterprise is a challenge. For oil companies that challenge encompasses meeting people's energy needs as well as meeting customers, vendors, partners, and shareholder needs. The events of September 11 changed the geopolitics of oil and thinking on energy security (see Sections 3.2 and 4.1). These shifts, along with other uncertainties such as oil prices, the state of the economy, and globalization, affect corporate strategies which determine choices for the future; choices that affect investments, employees, customers, vendors, partners, shareholders, and the communities in which companies operate.

To develop corporate strategies, one must think about the future. Scenario planning is one approach to thinking about alternative futures. It is a management tool that relies on imagining the future rather than predicting it or extrapolating from the past. Scenarios are not projections; "rather, they are coherent and credible alternative stories about the future, incorporating a spectrum of ideas and focusing on issues that are important for our business decisions today" (Davis 2002). They focus "less on predicting outcomes and more on understanding the forces that would eventually compel an outcome; less on figures and more on insights" (Wack 1985b). They "effectively organize a variety of seemingly unrelated economic, technological, competitive, political, and societal information and translate it into a framework for judgment – in a way that no model could do" (Wack 1985a). Scenario planning has its roots in military planning, but was further developed by Royal Dutch/Shell in the late 1960's and early1970's, at a time when management became fixated with the next quarter as opposed to the next decade. It is sometimes referred to as the "Shell method" for thinking about the future. It was Shell's scenario planning in the 1970's that is credited with preparing the company to react quickly to the oil crisis and rise from last of the seven majors operating in the United States before the oil crisis to second within 10 years (Pratt 1999).

The following are two sets of current examples of oil and gas scenarios, neither of which address Islamic fundamentalism blocking the spread of western capitalism and democracy, but both of which are viewed as relevant by their developers in the post-September 11 environment. The first was prepared by Shell International; the second by the Global Energy Practice of Arthur D. Little (ADL).

4.2.1.1 Shell International: People and Connections

Shell International prepares scenarios every 3 years. The most recent, *People and Connections*, was completed in mid-2001. It considers how people with different perspectives, values, and motivations may react to the forces of globalization, liberalization, and technological advances. The scenarios focus on the interplay of four interconnected geographies of connection: the diverse circles of association, influence, and loyalty (local and global) with which people find identity, the changing role of nations, the interplay between deeply-rooted cultural values of the heartland of many regions with outward-oriented cities inhabited by people with often different lifestyles and values, and the growing appreciation of shared interdependence of all on the earth's systems (Shell International 2002). There are two scenarios in *People and Connections*: Business Class and Prism.

The Business Class scenario describes

> a world focused on efficiency and individual choice – driven by an interconnected global elite influenced by US values and ideas. Power diffuses from states and people pursue the 'politics of protest' – particularly against multinationals. Businesses have to satisfy many different interests – from governments to NGOs, local communities to international institutions.
>
> Integration brings economic volatility and companies require superior risk management – as well as relentless operational improvement and innovation. The key is to focus on the 'core' – what matters for value creation and competitive differentiation (Watts 2002).

The Prism scenario describes

> a future shaped not by what we have in common but by the interplay of our differences. People find their values in their roots. They are interested in economic well-being and growth – but also social cohesion, religious faith and national pride. Countries find their own development paths – to suit their individual economic, political, and social circumstances.
>
> For businesses being 'local' is what matters. Multinationals must compete in many different environments – each with their own values, rules, and requirements. Access depends on relationships and reputation – as well as the ability to deliver global best practice and cutting-edge technologies in a way that suits local conditions (Watts 2002).

The scenarios offer alternative energy futures in which the power of globalization, liberalization, and technology remains significant, but where the control by regulations, restraints, and rules differ.

> In 'The Great Game of Gas' traders manage risks in liberalized energy markets. Low prices limit oil investment while consumer priorities, business opportunities, fuel cells and emissions trading drive rapid gas growth.

> Companies prosper by acquiring strategic resources, developing infrastructure, supplying energy services and introducing disruptive technologies.
>
> 'The Long Oil Game' takes place in a security driven world – wary of liberalized markets and price volatility. Government promote efficiency, environmental standards and technological solutions. Security concerns limit cross-border gas infrastructure. Companies prosper by gaining access to attractive markets for long term investment. Renewables break through – but low-price oil remains the dominant fuel until 2040 (Watts 2002).

Although the scenarios were completed in mid-2001, the public summary published in 2002 includes a section that uses the scenarios to explain the implications of September 11 and how the U.S. response will further test the fragile networks of the globalized world.

> In Business Class, the US pulls together a global coalition against terrorism, allying itself with the interconnected global elites from other societies, who share its beliefs and empathize with its concerns. In a number of developing countries, however, this successful coalition-building widens the gap between the connected edges, instinctively drawn towards supporting the US, and their heartlands, whose people have other, more immediate concerns, or else even relish the sight of an overweening US hegemon being 'taken down a peg or two.' …The US continues as the only global superpower. Indeed, as has happened before in US history, crisis serves to strengthen American society and to involve it more constructively abroad. …Issues such as terrorism are really beyond the competence of individual nation-states to handle; and over the long run the US recognizes that it is in its own interests to respect the sensitivities of other states, and to pursue its anti-terrorism agenda through effective global institutions and regimes, which it seeks to reform…
>
> Prism is a story of modernization in which people look beyond efficiency and global homogeneity to their roots, their values, and their families. As the conventional view of globalization, including the growth of a universal cosmopolitan market, is shattered, old forces of religion, ethnicity, and territoriality revive. As Prism makes clear, these forces can act to strengthen modernization by grounding it within a world of 'multiple modernities,' characterized by diverse cultural values and practices. But there is equally a dark side, in which diversity feeds prejudice against 'the other,' giving rise to a nationalist backlash…The war against terrorism leads western governments to introduce new security measures and even tighter controls over the movement of people. These measures and controls, including surveillance by the state, are made easier and more pervasive by the technology of globalization… In a world of 'multiple modernities,' different countries will modernize successfully in different ways. In retrospect, the events of September 2001 will be seen to have triggered off a huge impetus leading to a more diverse pattern of governance around the world…The twentieth-century's obsession with US success is replaced by a twenty-first century awareness that many different forms of modernity are possible, and can co-exist … (Shell International 2002).

At the end of *People and Connections*, the reader is asked to consider what he/she or his/her organization *would* do differently in each of the scenarios and then to determine what *will* actually be done differently.

4.2.1.2 Recurrent Crises or Globalization

The Arthur D. Little oil industry scenarios were developed before September 11, but are still viewed by the company as being valid, although there have been shifts in the probabilities associated with each scenario. ADL identified the following as potential scenario drivers: geopolitics, sustainable development and environmentalism, energy technologies, other technologies, oil price formation, industry structure, and intellectual capital. They developed the following four scenarios by combining plausible outcomes for each of the drivers and using two key variables – economic potential (constrained to expansive) and degree of geopolitical cooperation (local optimization to global collaboration):

> Orchestrated World: This scenario portrays global collaboration combined with a belief in limits to economic growth. It echoes a widely held European view that a strong government and webs of treaties are needed to avoid recurrent crises, to address the inequalities created by rampant capitalism, and to promote sustainable development. Extremism is kept in check by more even distribution of wealth and economic opportunity through democratic processes and equitable treatment under stable laws. Global companies accept their share of responsibility for resolving long standing issues.
>
> Technology Solutions: This scenario combines global collaboration with an expansive view of economic potential. It describes a world in which leapfrog energy and communications technologies solve many problems. Poorer nations can achieve resource efficient accelerated development through technology, alternatives to conventional energy resources are rapidly developed, and opportunities in services and business innovation abound.
>
> Partial Globalization: A belief in unconstrained development combined with local optimization represents many aspects of the world we knew in the 1990's. This scenario reflects rampant capitalism enabled by a pro business agenda and rapid technology advances. Despite a rising tide of prosperity (including emerging economies), the uneven distribution of economic well-being in this scenario makes it unstable over extended periods of time.
>
> Recurrent Crises: Constrained economic potential combined with local optimization defines a gloomy world of growing conflict in which frequent geopolitical crises are likely to disrupt business. Wild oil price cycles result. This scenario reflects underlying demographic pressures, the uneven distribution of resources, and the failure of governments to address critical issues (Godley, n.d.).

According to ADL, prior to September 11 the oil industry had assumed the partial globalization scenario or something like it would continue. In the post September 11 world, the oil industry view appears to have shifted to the recurrent crises scenario. It is unclear if this is a temporary or permanent shift (Godley, n.d.).

4.2.2 Partners and Alliances

One of the changes in the industry that occurred after the dramatic decline in oil prices in the mid-1980's was the forging of new cooperative working relationships among firms. These strategic partnerships and alliances helped cut costs and share financial risk. In the post September 11 era, partners and alliances remain a risk management tool in which financial risk is shared. The opportunities for forming strategic partnerships and alliances are changing. For companies working in multiple countries, partnering and alliances, particularly with local firms, may make it possible to work in different environments. Access to oil and gas reserves depends on a variety of factors including relationships and reputation and trust, intangibles which have become part of the risk management equation (Watts 2002, Robertson 2002, Staff 2001d).

Foreign firms which partner with local firms in developing nations can claim to be making a contribution to sustainable development, through local investment, local employment, technology transfer, and by building long-term relationships that help protect their significant long term investment. It is viewed as good business sense and enlightened self-interest (Brinded 2002). (Also see Section 3.3, for a discussion of corporate social responsibility and sustainable development.)

4.3 Operational Risk Management

Operational risk management related to September 11 primarily addresses safety and security. On September 11 the immediate concern was the safety of company personnel and the security of facilities. In the Gulf of Mexico, helicopter service was shut down because of the nationwide federal emergency no-fly order, but vessel traffic was uninterrupted (Fletcher 2001). Flights resumed on September 13. Publicly available information on the oil industry's response to operational risk management issues in the aftermath of September 11 fall into the following categories discussed below:

- Overview of Security and Safety Issues Raised
- Information Sharing
- Offshore Platform Security and the Fishing and Diving Industries
- Information and Computer Security Technology

4.3.1 Overview of Security and Safety Issues Raised

Safety and security are not new issues for the oil industry and, like so many other industries, companies and industry organizations have undertaken and continue to undertake activities that reassess existing safeguards, fill safety and security gaps, try to anticipate unfulfilled needs, and share information. An overview of the types of issues that are being addressed is listed below. This is an evolving list.

- Plans and procedures
  - Hire security firms to conduct risk assessments and evaluate the security of specific facilities including offshore platforms (Dittrick 2002b).
  - Establish and follow procedures for verifying the identification and authorization of personnel (IADC 2002, Fletcher 2002c, GulfShare 2001).
  - Review, update, or prepare security measures and contingency plans (Dittrick 2002b, IADC 2002).
  - Consider preparing security impact reviews (similar to an environmental impact statement) to assess the security ramifications of key business decisions (Staff 2001a).
  - Establish security principles for U.S. offshore operations (IADC 2002).

- Information sharing
  - Update contact and notification lists (OOC 2001).
  - Discuss security-related topics at industry conferences (Fletcher 2002b, Staff 2001a)
  - Establish ENERGY/ISAC (see Section 4.3.2).
  - Use trade associations as clearinghouses of information for members and to coordinate with federal agencies on security issues (Lorenzetti 2001).
  - Form a Gulf Safety Committee to meet periodically to discuss security and anti-terrorism issues (Fletcher 2002a, OOC 2001).
  - Use internet for crisis management communication (Wiese and Rasch 2001).

- Physical security of facilities and equipment
  - Install gates and locks to control access (OOC 2001).
  - Require pre-flight manifests of passengers going offshore and verification by field for the need for personnel or cargo (OOC 2001).
  - Screen traffic and cargo entering shore facilities and going offshore (OOC 2001).
  - Hire security firms to conduct due diligence of vendors serving the oil industry (Dittrick 2002b).

- Personnel Identification
  - Deploy oil industry common personnel identification (GulfShare 2001).

4.3.2 Information Sharing

Two forms of new information sharing mechanisms are discussed below. The first, ENGERY ISAC, is industry specific. The second, the Gulf Safety Committee, is Gulf of Mexico specific.

4.3.2.1 ENERGY ISAC

The vulnerability of the energy sector had been recognized prior to September 11. The national effort to address the vulnerabilities of critical infrastructure, which includes oil and gas, began in July 1996 with the establishment of the President's Commission on Critical Infrastructure Protection. The Commission was tasked to develop a comprehensive national strategy to protect critical infrastructures from physical and cyber threats.[7] In October 1997, the Commission issued a report calling for a national effort to assure the security of the United States' critical infrastructure. In response to the Commission's recommendation, President Clinton issued Presidential Decision Directive 63 in May 1998, which among other things, authorized the formation of the National Information Protection Center (NIPC) located in the Federal Bureau of Investigation. It is the U.S. government's focal point for "threat assessment, warning, investigation, and response for threats or attacks against our critical infrastructures" (NIPC n.d.). It works with federal, state, and local agencies, the private sector, and international government agency partners. Presidential Decision Directive 63 also encourages the establishment by the private sector of Information Sharing and Analysis Centers (ISACs).

In response to the President's policy directive, the Secretary of Energy requested the National Petroleum Council's (NPC) "advice on cooperative approaches to protecting the critical infrastructure of the United States oil and gas industry" (NPC 2001). The NPC is a federally chartered, privately funded advisory committee that represents the oil and gas industry to the Department of Energy. The NPC issued its report, *Securing Oil and Natural Gas Infrastructures in the New Economy*, in June 2001. The study assessed vulnerabilities, consequences, and threats in the following categories: information technology and telecommunications, globalization, business restructuring, interdependencies among other critical infrastructures (e.g., information technology, transportation), political and regulatory issues, physical and human factors, and natural disasters. The report concluded that the creation of an oil and gas ISAC was "paramount to the protection of this infrastructure" (NPC 2001).

The ENERGY ISAC began operations November 1, 2001 with 11 U.S. oil and gas companies as the founding members. It is a limited liability company that operates and manages an information sharing and analysis center for oil and gas security. Membership has since expanded to all energy industry segments. ENERGY ISAC (n.d.) is a one stop clearinghouse of information and provides energy companies with:

- Information on threats and vulnerabilities
- Early notification of physical and cyber threats
- Potential responses to identified threats
- Alert conditions
- Best Practices
- A forum for members to communicate in a secure environment.

ENERGY ISAC provides for two-way sharing of information. It includes a secure data base, analytical tools, and information gathering and distribution mechanisms. Members share in an industry-wide database. They voluntarily report either anonymously or attributed information about cyber or physical security threats, vulnerabilities, and incidents. The

[7] Critical infrastructures are "systems whose incapacity or destruction would have a debilitating impact on the defense or economic security of the nation. They include: telecommunications, electrical power systems, gas and oil, banking and finance, transportation, water supply systems, government services, and emergency services" (President's Commission on Critical Infrastructure Protection n.d.).

information is analyzed for potential solutions, and, if warranted, is distributed to members (ENERGY ISAC n.d.) Data and analysis from non-ENERGY ISAC sources such as federal law enforcement, technology providers, and security associations are also available to members. While not a direct result of the events of September 11, the ENERGY ISAC provides for improved communication within the oil industry on threats, vulnerabilities, and best practices on security issues.

In the days following September 11, the oil and gas trade associations acted as clearinghouses for their members. They worked with the White House, Congress and federal agencies to improve and ensure the safety of the country's energy infrastructure. The American Petroleum Institute served as the temporary threat information sharing mechanism for the oil and gas industry until ENERGY ISAC came online. API developed a segment-based e-mail list for distributing threat and security information (Petty 2002).

4.3.3 Gulf Safety Committee

In early October 2001, several federal agencies led by the U.S. Coast Guard met with the Gulf of Mexico Offshore Operators Committee (OOC) to discuss security issues, mutual assistance measures, and identification procedures. This initial meeting led to several subsequent meetings and what is evolving into a Gulf Safety Committee (GSC) to serve as a forum for offshore GOM stakeholders (OOC 2001). The major stakeholder groups include the following industries: oil and gas, fishing industry (recreational and commercial), diving (commercial, recreational, spear), shipping, and passenger transportation (cruise ships and helicopters) (GSC 2002a). The groups are further segmented. For example, the oil and gas industry groups represent production, drilling, pipeline and geophysical/seismic. There is federal government participation through the Coast Guard and MMS and state government participation through several state agencies. Like the committee itself, representation of the stakeholders is evolving as well. The OOC is facilitating GSC-related activities such as logistics. See below for discussion of one of the GSC's activities.

4.3.4 Offshore Platform Security and the Fishing and Diving Industries

The security of offshore platforms is an obvious concern for the industry and the companies that own the platforms and has been the focus of a number of meetings of interested parties in the GOM since September 11. Unique to the GOM is the long standing tradition of commercial and recreational fishers and divers tying their boats to platforms because the structures act as fish aggregators. Access of fishers and divers to the platforms contributes to the economic well being of the coastal counties in the Gulf. A recent study estimated recreational fishing and diving activities near oil and gas structures contributed $324.6 million to the economies of Gulf coastal counties in 1999 (Hiett and Milon 2002). The study found about 22 percent of the estimated 4.5 million recreational fishing trips in the GOM and 94 percent of the diving trips were within 300 feet of an oil or gas structure. On average, more than two oil and gas structures were visited per trip. The analysis also showed that the typical angler who visited an oil or gas structure made more expenditures than those who did not (Hiett and Milon 2002). Any efforts to improve security of platforms in the GOM will need to address the interests of the fishing and diving community.

Prior to September 11 little attention was given to fishing and dive boats when they approached a platform. Since September 11, each boat approaching a platform garners attention. Scrutiny given approaching boats takes away from ongoing work tasks and can lead to safety issues related to the industrial processes on the platform. The GSC, a steering committee of cross industry groups in the GOM discussed above, is developing a voluntary GOM communications protocol for vessels approaching a fixed or floating platform intending to fish or sport dive around the platform (Fletcher 2002a). The protocol covers communication between commercial and recreational fishers, sport divers, and oil and gas contractors and operators. The communications protocol will establish an agreed upon format for the methods of notification, recommended radio frequencies, and generally accepted two-way marine VHF radio protocol. The protocol will be used in the GOM OCS and territorial waters adjacent to Alabama, Louisiana, Mississippi, Mississippi, and Texas (GSC 2002b).

4.3.5 Information and Computer Technology Security

Information and computer technology has changed how the oil and gas industry does business, as it has for other industries. It has increased overall worker productivity, allowed locationally and technically diverse groups to work together, and enhanced or enabled more industry-specific and focused technologies. Keeping the systems running is one challenge. Protecting intellectual property and network integrity and meeting internal, external, and system-induced threats are other challenges. Part of the security audits being done in the post September 11 environment include those related to information and computer technology (Dittrick 2002b).

Cyber security measures range from mandatory change of password at specified intervals to use of smart card technology. A smart card is superior to a password system in several ways. The user's digital credentials reside on the card, unlike password systems which store passwords on crash-prone hard drives. The smart card user must have it in his/her possession and use a personal identification number (PIN) to unlock the card which then presents the user's digital credentials. This is referred to as two-factor authentication. Three-factor authentication involves biometrics where biological data such as a thumbprint or iris scan are used to verify a person's identification.

Smart card technology can be used for more than employee identification and computer network and web access. Other needs for secure information which can be stored on a smart card include work area access, critical medical information, training records, competency certifications, and work history. It can also be tied to helicopter reservation systems related to transport to and from the platforms. An example of the smart card technology used in the oil industry is the DeXa.Badge developed by Schlumberger Network Solutions. A security badge developed by Schlumberger for Royal Dutch Shell was awarded a "Best Smart Card Application of the Year in 2001." The card is used to provide smart card log in and physical access security (SchlumbergerSema 2001).

5.0 CROSSCUTTING THEMES AND IMPLICATIONS

It may be difficult to argue with those who say that while the world has changed in the aftermath of September 11, 2001, the oil and gas industry remains the same. War in Afghanistan has not changed world oil flows; OPEC still faces its old dilemma of high prices versus global economic growth. Corporate realignments common in the late 1990's are still in the works. Even the market for jet fuel, which appeared to collapse as travelers abandoned airports in droves, may have been little affected if year-to-year inventories are considered (Staff 2002b).

In the long run, however, September 11 may be seen as a milestone marking changes that had been underway in the oil and gas industry. Terrorist attacks may not have created new problems, but they have underscored many issues that the industry faces. By bringing these issues into high relief, these events may accelerate certain changes and trends that will affect the oil and gas industry and its many stakeholders in fundamental ways.

5.1 Some Responses are New; Others, Re-Order the Priorities

- Energy security. Energy security is a concern shared by the oil companies, the U.S. government, and oil producing nations. Part of this security issue is derived from diversifying sources of oil, either by projects in emerging countries such as Kazakhstan or by developing unconventional oil sources (e.g., oil sands, heavy oil deposits). Another aspect of diversifying sources is to increase reliance on nearby sources such as Mexico, Canada, and Venezuela that pose fewer risks than other sources. Even for traditional sources such as OPEC, the terrorist attacks have spurred renewed commitments to providing oil to the world to insure stable economic conditions.

- Globalization. The events of September 11 have tended to strengthen the allegiance that countries and oil companies have to the principles of globalization. These include a common commitment to world trade and economic growth (e.g., the efforts by OPEC to stabilize oil prices after September 11) and close ties between the public and private sector in the achievement of economic and social goals (e.g., oil company investments in Saudi projects that will diversify that economy).

- Energy efficiency. While getting greater output from energy inputs is typically associated with the environmental community in the U.S. and those elected leaders sympathetic to environmental issues, energy efficiency as a response to September 11 cuts across a wide swath of stakeholders and commentators. This concern with efficiency is a long-term issue for at least some oil companies that see their futures as energy providers. For these companies greater fuel efficiency in transportation allows for a longer life in the oil business and greater flexibility to segue from oil to natural gas and emerging technologies such as fuel cells. Greater fuel efficiency in vehicles is also a concern for a broad range of stakeholders and others who see fuel inefficiency as creating a dangerous dependence on foreign oil, particularly from the Middle East.

5.2 The Role of the Oil Industry Continues to Evolve

- Oil companies and local development. In a case that can be seen as enlightened self-interest, the terrorist attacks have given further impetus to oil companies' concerns with local economic development. For some of the leading global oil companies, underdevelopment in countries where they operate had been an issue of concern well before the terrorist attacks. Nonetheless, September 11 has placed greater emphasis on the costs of failing to recognize the downside of local peoples who are shut out of the economic development opportunities that major investments by oil companies can create. While there are clear limits on what oil companies can accomplish, there are also more opportunities for engagement that have not been taken. This concern with local development has also spurred greater investment by the U.S. government in strategically located countries with major oil deposits.

- Oil companies and governmental reform. Closely connected with local economic development is the issue of governmental reform and effectiveness in some developing countries. As major foreign investors, oil companies have opportunities to address some of the issues that can facilitate governmental reform, particularly by making more transparent the process of delivering oil royalties and other payments to governments in developing countries. As with economic development, there are clear limits on what oil companies can do, but also unrealized opportunities to be a force for positive change.

5.3 Implications for the GOM

The challenges that arise from the events of September 11 do not change the basic advantages offered by the GOM nor do they alter the GOM's challenges. As in other areas addressed by this project, the effect of September 11 is to underscore what had been true before that date.

5.3.1 Competitive Advantages

- GOM as a model for public-private interaction. Oil companies operating in the GOM do not have to contend with many of the problems they face when operating in developing countries: inadequate legal systems, nonexistent infrastructure, corrupt government officials, disease, and inadequate health systems. Problems that may be routine in the developing world are simply not an issue when operating in the GOM. For business in general and oil and gas industry in particular, the U.S. and the GOM are a standard by which other areas can be measured.

- GOM deepwater as an oil frontier. The industry is constantly on the lookout for new, major sources of oil. Deepwater GOM is routinely listed among the important oil frontiers in the world.

5.3.2 Challenges

- New sources create more competition. One of the consequences of September 11 has been an apparent acceleration in the development of new sources of oil. The "Stans" may be the best example of this although others would argue that West Africa is the most exciting oil frontier in the world at this time. Regardless, the interest in developing important new sources outside of the Middle East will mean more competition for the GOM. Thus, global oil companies that have spearheaded GOM deepwater development will tend to have more non-U.S. opportunities in the post-September 11 world.

- Technology for deepwater. The success of deepwater has depended substantially on the constant improvements in technology that have allowed deepwater development to occur at all and then have progressively lowered risks and costs. In the even more competitive post-September 11 world, the continuing willingness of the oil industry or others to invest in deepwater technology as opposed to other opportunities will be critical to the continued success of the GOM.

- Labor. Technology has advanced the industry, but technology is developed and used by people. Technology has improved the efficiency and productivity of workers permitting more work to be done with fewer people. Nonetheless, there is an industry labor shortage in the GOM (Poruban 2001). Many of the dynamics affecting the industry in the last 20 years (e.g., mergers, cost cutting programs, efforts to support shareholder value) resulted in a number of personnel issues, including few employees between the ages of 25 and 45, a shortage of some skilled personnel, and a decrease in the number of universities offering petroleum engineering degrees and the number of students seeking and receiving that type of degree. The heightened awareness of the potential for industry facilities in the GOM to be targets for terrorist activities may further challenge the industry's ability to attract and retain the caliber of personnel needed in the GOM.

LITERATURE CITED

Aalund, L. 2002. Oil and corruption. *Oil and Gas Journal* (January 14).

Ahmad, T. 2001. Going under cover? *Project Finance* (November):21-24.

Alba, E. M. 2001. Mitigating the social impact of oil operations. Paper presented at the World Energy Council Congress. Buenos Aires, Argentina. October. 6 pp.

Aldred, C. 2002. Wider risk management urged. *Business Insurance* (January 7):19-20.

Andrews, E.L. 2002. New U.S. allies, the Uzbeks: mired in the past. *The New York Times* (May 31):A8.

Appleyard, D. 2001. Security dominates the agenda. *Power Economics* (October):3.

Bakhtiari, A. 2002. 2002 to see birth of new world energy order. *Oil and Gas Journal* (January 7):18-19.

Banerjee, N. 2001. Oil, politics and the new global fault lines. *The New York Times* (September 30):C1.

Banerjee, N. 2002. Oil industry hesitates over moving into Arctic refuge. *The New York Times* (March 10):A12.

Benditt, J. 2002. Energy futures. *Technology Review* (January/February):9.

Brauer, B. 2002. Oil field hopes to become world power. *The New York Times* (April 10):W1.

Bray, J. 1999. Petroleum and human rights: the new frontiers of debate. *Oil and Gas Journal* (November 1).

Brinded, M. 2002. Making our contribution count. Speech to the Institute of Directors Conference, London, England. April 24. 5 pp. www2.shell.com.

Browne, J. 2001. Warwick University Ramphal Lecture Series on Globalization. Paper presented at Warwick University, Coventry. October 31. 9 pp. www.bp.com/centres/press.

Browne, J. 2002. The strategic logic of diversity. Keynote address to the Women in Leadership Conference, Berlin, Germany. June. 7 pp. www.bp.com/centres/press.

Brundltand, G. H. (ed.). 1987. Our common future: The World Commission on Environment and Development (also referred to as the Brundtland Report). Oxford: Oxford University Press.

Caffentzis, G. 2001. Oil and the Islamists. *New Internationalist* (December):34-35.

Cheney, D. 2000. The challenge of achieving international consensus on social responsibility in an international market economy. Paper presented at the 16th World Petroleum Congress. June. 4 pp.

Crawley, M. 2002. With Mideast uncertainty, US turns to Africa for oil. *The Christian Science Monitor* (May 23):7.

Dahan, R. 2002. Business in a world of conflict. Remarks to Denver, Colorado International Chamber of Commerce. May 7. 3 pp. www2.exxonmobil.com/corporate/newsroom.

Davis. G. 2002. Questioning assumptions – exploring alternative business futures. Speech to the Swedbank Conference, Stockholm, Sweden. March 13. 9 pps. www2.shell.com.

Dittrick, P. 2002a. Independents, other companies find opportunity in basins off West Africa. *Oil and Gas Journal* (March 4):66-72.

Dittrick, P. 2002b. US oil, gas companies reassessing post-Sept. 11 security risks. *Oil and Gas Journal* (April 22):24-30.

ENERGY/ISAC. n.d. ENERGY frequently asked questions. 3 pp.

Fjell, O. 2000. The challenge of achieving international consensus on social responsibility in an international market economy. Paper presented at the 16th World Petroleum Congress. June. 5 pp.

Fletcher, S. 2001. Federal order shuts down helicopter services for the Gulf of Mexico. *Oil and Gas Journal* (September 11).

Fletcher, S. 2002a. US offshore operators, Coast Guard, fishermen to discuss security issues. *Oil and Gas Journal* (January 23).

Fletcher, S. 2002b. Energy companies warned to beef up security against terrorist attacks. *Oil and Gas Journal* (February 5).

Fletcher, S. 2002c. Gulf of Mexico oil and gas facilities open to attack, ex-SEAL warns. *Oil and Gas Journal* (February 5).

Fletcher, S. and M. Lorenzetti. 2001. Industry tries to cope with terrorism aftermath. *Oil and Gas Journal* (September 24):29-36.

Friedman, T.L. 1999. The Lexus and the olive tree. New York: Farrar Straus Giroux. 394 pp.

Godley, G. n.d. Oil industry scenarios. www.adlittle.com/management/services/energy. 3 pp.

Gossen, R. and P. Riemer. 2001. Corporate responsibility in the oil and gas industry. Paper presented at the World Energy Council Congress, Buenos Aires, Argentina. October. 6 pp.

Gulf Safety Committee (GSC). 2002a. GSC executive steering committee (list of stakeholder groups and representative).

Gulf Safety Committee (GSC). 2002b. Voluntary Gulf of Mexico marine communications protocol. Final draft. 1 p.

GulfShare. 2001. 2001 security forum. Presentation slides. November 13, 2001. www.gulfshare.com. 38 pp.

Guther, W. 2001. Terrorism, hostile intent problems continue around the globe. *Offshore* (April).

Hiett, R. and J. W. Milon. 2002. Economic impact of recreation fishing and diving associated with offshore oil and gas structures in the Gulf of Mexico. Prepared by QuanTech, Inc. for the Minerals Management Service. March. 98 pp.

International Association of Drilling Contractors (IADC). 2002. Security Principles for U.S. Offshore Operations. Draft. Prepared by the Offshore Security Task Force. January 14. 4 pp.

International Energy Agency (IEA). n.d.a. Crude oil production: evolution from 1971 to 2000 of crude oil production by region, 1973 and 2000 regional shares of crude oil production, and producers, exporters and importers of crude oil. www.iea.org.

International Energy Agency (IEA). n.d.b. Natural gas production: evolution from 1971 to 2000 of natural gas production by region, 1973 and 2000 regional shares of natural gas production, and producers, exporters and importers of natural gas. www.iea.org.

International Petroleum Industry Environmental Conservation Association (IPIECA). 2000. IPIEA workshop on corporate responsibility: summary report. April 12. 8 pps.

Kates, R. 2001. Responding to terror. *Environment* (December): preceding page 1.

Lawrence, F. 2002. Learning from the past--strategizing for the future. *Oil & Gas Investor* (January):9-11.

Longwell, H. 2001. The new wave in oil and gas projects. Remarks at the 2001 Annual Technical Conference and Exhibition. New Orleans. October 1. 3 pp. www2.exxonmobil.com/corporate/newsroom.

Lorenzetti, M. 2001. US energy infrastructure security now a key issue in Washington. *Oil and Gas Journal* (October 1).

MacFarquhar, N. 2002. Mideast turmoil: an anti-American boycott is growing in the Arab world. *The New York Times* (May 10):A1.

Moody-Stuart, M. 2001. Springboard for progress: building on the energy industry's record of responsiveness. Cadman Lecture, Institute of Petroleum, London. September 26. 6 pp. www2.shell.com

National Infrastructure Protection Center (NIPC). n.d. A message from Ron Dick, Director of the National Infrastructure Protection Center. 1 pp.

National Petroleum Council (NPC). 2001. Securing oil and natural gas infrastructures in the new economy. June. 81 pp.

Offshore Operators Committee (OOC). 2001. Minutes of the Offshore Oil and Gas Industry Security and Anti-Terrorism Issues meeting minutes. November 1. 4 pp.

The Organization of the Petroleum Exporting Countries (OPEC). n.d. About OPEC. www.opec.org.

Painter, D. 1999. The business economist at work: Mobil corporation. *Business Economics* (April):52-54.

Petty, B. 2002. Industry shares threat information. IDADC Government Affairs Committee. January. 1 p. http://idac.org/committees/governmentaffairs/industry.htlm.

Poruban, S. 2001. Oil and gas industry continues to grapple with technical personnel shortage. *Oil and Gas Journal* (September 24).

Pratt, C. 1999. Planning Noranda's future. *Research Technology Management* 42(1):15-18.

President's Commission on Critical Infrastructure Protection. n.d. Factsheet. 2 pp.

Robertson, P. 2002. The energy industry: catalyst for partnership and stability in times of change. Speech to the Cambridge Energy Research Associates Conference, Houston, Texas. February 12. 8 pp. www.chevrontexaco.com/news/speeches/2002.

Russell, B. 2001. Exploring the new frontier, post-September 11. *Oil & Gas Investor* (December):6.

Russell, B. 2002. Our message is clear: Domestic production hinges on independents. *Oil & Gas Investor* (March):7-8.

SchlumbergerSema. 2001. SchlumbergerSema wins two "best card application" SESAMES awards for state-of-the-art security. Press Release. November 1. 1 pp.

Shell International. 2002. People and connections, global scenarios to 2020, public summary. 95 pp.

Snow, N. 2001. In the wake of September 11. *Oil & Gas Investor* (November):60-64.

Sprow, F. B. 2002. Community involvement: essential to long term business success. Paper presented at the Society of Petroleum Engineers International Conference on Health, Safety and the Environment in Oil & Gas Exploration and Production. Kuala Lumpur. March 21. 5 pp. www2.exxonmobil.com/corporate/newsroom.

Staff. 2001a. Adopt "security impact review," law firm tells energy industry. *Oil and Gas Journal* (November 9).

Staff. 2001b. Building the business case for sustainable development. The quarterly newsletter of the World Council for Sustainable Development. *Sustain*. Issue 17. October. 20 pp.

Staff. 2001c. Business: the next big surprise; Scenario planning. *The Economist* (October 13):60.

Staff. 2001d. Corporate risk management needs grow, Rolls-Royce power exec says. *Oil and Gas Journal* (November 2).

Staff. 2001e. Fear and uncertainty. *Petroleum Economist* (October):2.

Staff. 2001f. How much would it really help? *Economist* (October 20):35.

Staff. 2001g. Market: demand hope fades. *Petroleum Economist* (November):35

Staff. 2001h. Nigeria launches 24-hour surveillance on oil facilities. Xinhua, available through Business Source Premier (database). (December 17).

Staff. 2001i. Same story, different century. *Petroleum Economist* (November):2.

Staff. 2002a. OPEC plays high risk poker. *African Business* (January):20.

Staff. 2002b. No change, really. *Petroleum Economist* (January):2.

Staff. 2002c. Supply security: Middle East instability puts US on edge. *Petroleum Economist* (March):37.

Starobin, P. 2002. The next oil frontier. *Business Week* (February 21). www.businessweek.com.

Suri, S. 2002. Oil firms asked to disclose payments to governments. OneWorld.net. June 17.

Swarns, R. 2002. Angola urged to trace its oil dollars. *The New York Times* (May 14):A9.

Tippee, R. 2002. Industry faces reorientation at start of 2002. *Oil and Gas Journal* (January 7):62-65.

Townsend, D. 2002. Slowly does it. *Petroleum Economist* (April).

Value Line. 2001. The Value Line investment survey. 2001. Selection and Opinion. (November 30):3903-3908.

U.S. Department of State. 2001. Voluntary principles on security and human rights: fact sheet. February 20. 5 pp.

Wack, P. 1985a. Scenarios: shooting the rapids. *Harvard Business Review* 85(4):139-150.

Wack, P. 1985b. Scenarios: uncharted waters ahead. *Harvard Business Review* 85(5):73-83.

Watts, P. 2002. Appreciating uncertainty – exploring the changing energy environment. Presentation to the Cambridge Energy Research Associates Conference, Houston, Texas, February 12. 4 pp. www2.shell.com.

Wiese, E. F., Jr. and M. Rasch. 2001. Crisis communications: beyond the basics. Presentation to the American Gas Association. October 29. 6 pp.

Williams, B. 2001. WEC: Sound energy development key to sustaining global economy. *Oil and Gas Journal* (November 5).

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.