Chapter 4
Crude Oil

Introduction

We live in what has been called the Petroleum Age. This hydrocarbon-rich mixture of crude oil and gases runs our factories, our cars, heats some homes and has provided Americans with an unprecedented standard of living since its discovery in America in 1859.

Petroleum is an extremely versatile substance; refining it creates everything from asphalt and gasoline to lighter fluids and natural gas, along with a variety of essential elements such as sulphur and nitrogen. Petroleum products are also vital ingredients ("feedstocks") in the manufacture of medicines, chemicals and plastics.

Crude oil and other petroleum products found under Texas soil have been a major component of the Texas economy, in recent decades accounting for 10 to 25 percent of the Gross State Product. The combined oil and natural gas industry in 2006 employed 3.1 percent of the state's workforce and paid that workforce $30.6 billion — 6.9 percent of all wages.[1]

Texas consistently has led the nation in petroleum production since the early 20th century. Currently, Texas also leads the nation in the consumption of petroleum products for many reasons, including the state's reliance on electricity generated by natural gas, a petroleum product, for air conditioning and for its energy-intensive refineries and petrochemical plants.

History

People have used petroleum for thousands of years, for a variety of purposes. More than 4,000 years ago, natural seeps of a tar-like asphalt called bitumen were used to fortify walls and towers in ancient Babylon and Jericho. Ancient Persians used petroleum for medicine and light.

Fourth-century Chinese were the first to drill wells to collect oil and use it to fire boilers, evaporate brine and produce salt. In 1543, a Spanish expedition found oil floating on the surface of the water along the Texas coast and used it to caulk their boats.[2]

The Petroleum Age began with the 1854 discovery of a new process to make kerosene from heavy crude oil.[3] In August 1859 on Oil Creek near Titusville, Pennsylvania, Edwin L. Drake drilled down 69 feet and struck oil, creating the nation's first oil well.[4] Oil quickly proved to be a cheap, abundant and reliable feedstock for the manufacture of kerosene. Its use increased dramatically throughout the country, sparking an economic boom.

While coal continued to fuel industrial expansion in Europe and America, kerosene made from rock oil, the "new light," rapidly replaced kerosene made from coal as a source of home heating and light. By the time of the introduction of the internal combustion engine in the early 20th century, the petroleum economy was well established.

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Uses

Because of its chemical structure — long hydrocarbon molecules that can be "cracked" or recombined into shorter molecules with different characteristics — crude oil can be refined into everything from tar, gasoline, diesel and jet fuel to heating oil and natural gas. It is also an ingredient, or feedstock, for the manufacture of chemicals, fertilizer, plastic, synthetic fibers, rubber and even such everyday products such as petroleum jelly, ink, crayons, bubble gum, dishwashing liquids and deodorant.

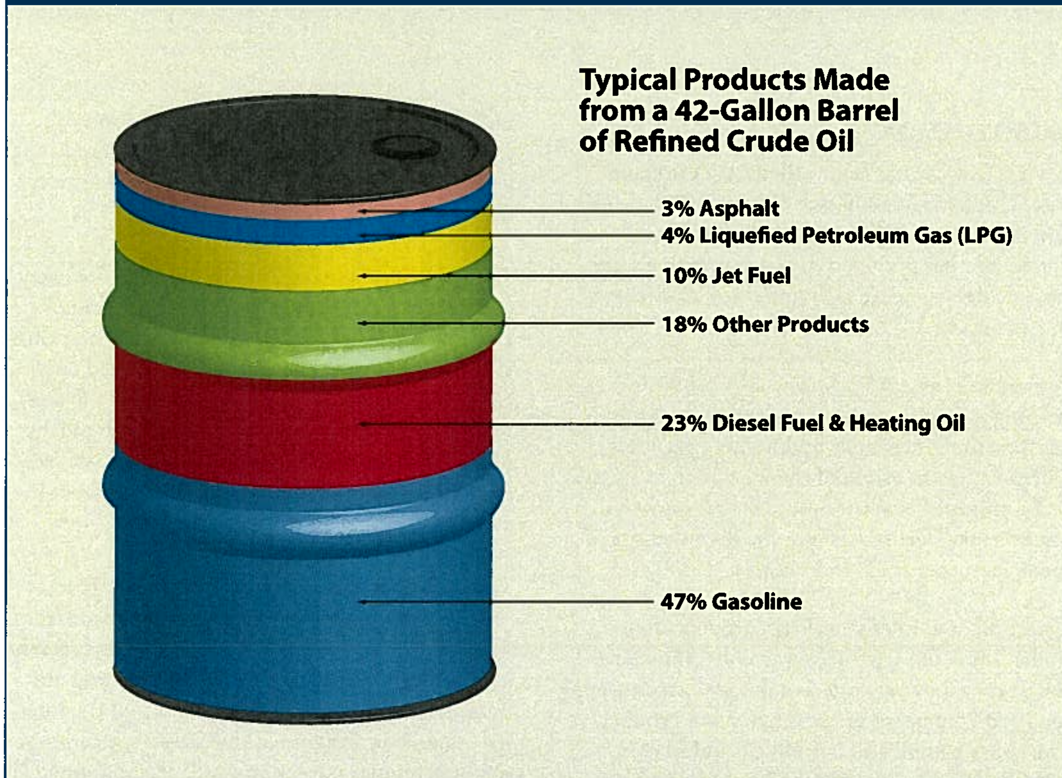
A 42-gallon barrel of crude oil will yield 44.6 gallons of refined products; the difference is what producers call "refinery gain." The greatest portion of a refined barrel of crude oil typically becomes fuel for transportation (**Exhibit 4-1**).

Depending on the season and oil quality, refiners adjust the proportion of fuels produced. For

Gasoline accounts for roughly 47 percent of all refinery products.

Exhibit 4-1

Products Made from a Barrel of Crude Oil



Source: U.S. Department of Energy.

instance, refiners generally make more heating oil in the fall to prepare for winter markets, which can mean a slight cutback in gasoline production. In the spring, refiners reverse this allocation to produce more gasoline for the summer driving season.

Common Refined Products

Gasoline accounts for roughly 44 percent of all refinery products. Gasoline is not a single hydrocarbon, but may be a blend of several. In areas with air quality problems, ethanol or other additives may be added to gasoline to reduce emissions. (Ethanol is a biofuel that adds oxygen to gasoline — making it an "oxygenate" — so that it burns with fewer emissions; see Chapter 13 of this volume.) Gasoline also can occur naturally within crude oil, although this product is more unstable and volatile than refined gasoline.[5]

Diesel fuel and heating oil are "distillates," fuels distilled in refineries and blended with light oils. They are similar, although diesel has a lower sulphur content. Both fuels are available in three grades depending on the intended use. The highest grade of diesel (with the lightest hydrocarbons) fuels buses; the middle grade fuels railroad locomotives, trucks and automobiles; and the lowest grade fuels off-road vehicles such as agricultural and construction equipment. Diesel and heating oil account for about 23 percent of refinery products. Diesel has more energy per gallon than gasoline and is less volatile, but it also produces more emissions than gasoline.

Heating oil accounts for about 5 percent of refinery products. High-grade heating oil is used in portable outdoor stoves and heaters. Mid-grade heating oil fires medium-capacity residential or commercial burners. Low-grade heating oil is used in industrial and commercial burners.[6]

Jet fuel, also called aviation gasoline, is kerosene blended to specifications for general and military aircraft. These specifications include a low freezing point (to keep fuel flowing at high altitudes), low combustibility (to help make handling safer and airplane crashes more survivable) and high energy content with low weight (to allow planes to gain and hold altitude).[7] Jet fuel accounts for 9 percent of refinery products.

Heavy fuel oil, also known as residual fuel oil or "resid," is used primarily for power, heat and electricity generation. The U.S. military uses resid to run steam-powered vessels. Resid accounts for 4 percent of refinery products.

Liquified petroleum gases (LPGs) are gases refined from crude oil or natural gas, liquefied under pressure for easy transportation. The term includes ethane, ethylene, propane, propylene, butane, butylenes, isobutane and isobutylene. LPGs account for 4 percent of refinery products (see Chapter 6 of this report).

The remaining 17 percent of crude oil products are a wide variety of gases, liquids and semi-solids. Among the more common products, *still gas*, also known as refinery gas, is a generic term for any gas produced by refining crude oil. Still gases include methane, ethane, butane and propane. Although containing the same constituent elements as LPGs, still gas is used to fuel refineries and as a chemical feedstock. *Road oil* is any heavy petroleum oil used to stabilize paved roads. *Asphalt* is a thick tar used to pave roads and to make roofing materials and floor coverings.

The heaviest product, *petroleum coke*, is almost pure carbon and is the product that remains after all other hydrocarbons have been removed. Coke with low sulphur content is used as fuel for industries and power plants. Coke with high sulphur content is used as a catalyst in refineries.[8]

Crude Oil in Texas

Texas' first oil well began producing in 1866, at Melrose in Nacogdoches County. The area became home to Texas' first commercial oil field, first pipeline and first effort to refine crude oil.

On January 10, 1901, an oil well on a small hill called Spindletop near Beaumont created a worldwide sensation when it came in with such explosive force that it blew six tons of drill pipe, mud, rocks and crude oil several hundred feet into the air. The geyser of oil continued for nine days, becoming the world's first "gusher."[9]

Within a few months, 214 wells on Spindletop hill owned by 100 different companies were producing up to 100,000 barrels of oil a day — more than all the rest of the world's oil production combined.[10] Within a year, Spindletop wells were producing 17.5 million barrels annually.

In October 1930, a vast oil field opened in East Texas. Overnight, Kilgore, Longview and Tyler became oil towns. The East Texas field was the largest and most prolific oil reservoir ever found onshore in the continental U.S. Spanning 140,000 acres of piney woods and sandy soil, the 30,340 wells drilled in the field so far have produced more than 5.4 billion barrels of oil.[11]

Along with Spindletop and the East Texas field, other prolific and well-known Texas oil fields were discovered: the Yates, McCamey, Kermit and Kelly-Snyder fields in the Permian Basin of West Texas; the Austin Chalk in Central and South Texas; and the Tomball and Anahuac fields on the Gulf Coast, to name only a few.[12]

Economic Impact

As mentioned throughout this report, both the federal and state governments consolidate economic data for oil and natural gas industries because of the high degree of overlap between the two. In 2006, more than 312,000 Texans, or 3.1 percent of the state work force, were employed in the oil and natural gas industry, which accounted for $159.3 billion or 14.9 percent of Texas' gross state product (GSP). For comparison, in 2003 the industry contributed $85.6 billion to GSP, 10.3 percent of the state GSP.

In 2006, more than 312,000 Texans, or 3.1 percent of the state work force, were employed in the oil and natural gas industry.

Likewise, oil and gas industry wages have risen substantially in recent years. In 2006, wages totaled $30.6 billion, or about 6.9 percent of all wages in Texas. In Texas in 2003, oil and gas industry wages were $20.9 billion or 5.8 percent of all wages.

Historically, the oil and natural gas industry have accounted for approximately 10 percent to 25 percent of the state's GSP, a trend that roughly tracks the price of oil (**Exhibit 4-2**). (The price indicated in the exhibit is based on the taxable value of oil from in-state production, in dollars adjusted for inflation.)

Historically, the oil and natural gas industry have accounted for approximately 10 percent to 25 percent of the state's GSP, a trend that roughly tracks the price of oil.

Refining and petrochemical industries combined represented 31 percent of all oil and gas employment in 2006, or about 1 percent of all nonfarm employment in Texas. Likewise, refining and petrochemical industries accounted for 28.5 percent of all oil and gas wages and 27.5 percent of oil and gas GSP. When compared to the state, these two industries accounted for 2 percent of all state wages and 4.1 percent of GSP.[13]

The federal and Texas state governments impose several major taxes on oil and gas production and consumption, in addition to receiving royalties, rentals and bonuses from the leasing of federally- or state-owned mineral ownership. The federal and state gasoline taxes support transportation initiatives such as highway infrastructure and mass transit.

Texas imposes severance taxes on the value of oil and gas produced in the state, which has been a major and relatively stable source of revenue until the last two decades. Portions of these tax revenues are rebated back to producers under economic incentive programs. (For more information on oil and gas taxes, incentives and subsidies, see Chapter 28 of this report.)

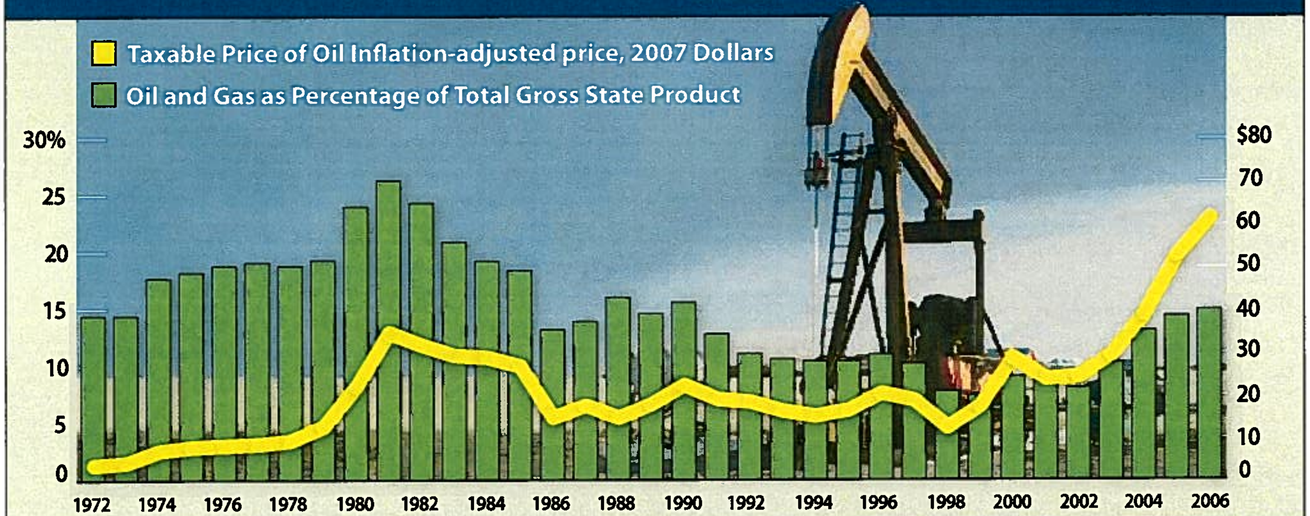
Consumption

Demand for petroleum products in the U.S. remains strong, but it can be mitigated by conservation and efficiency improvements. For example, in 2005, each of the estimated 296 million people in the U.S. used an average of almost three gallons of petroleum every day. In 1978, the average American used 3.5 gallons per day.[14]

In 2006, crude oil imports totaled 10.1 million barrels per day (MBD), two-thirds of the

EXHIBIT 4-2

Texas Oil and Gas Industry Percentage of Gross State Product and Taxable Price of Oil (2007 dollars)



Sources: U.S. Bureau of Economic Analysis and Texas Comptroller of Public Accounts.

total U.S. supply of 15.2 MBD, according to the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE). After several additions of other petroleum products by refiners and fuel blenders, total petroleum consumption came to 20.6 MBD for 2006.

The transportation sector used almost 14 MBD, or 68 percent, of all petroleum resources, mainly for fuels. Industry used 25 percent or 5.1 MBD. Residential, commercial and electric power use of petroleum products accounted for a combined 1.5 MBD or 7 percent (**Exhibit 4-3**).[15]

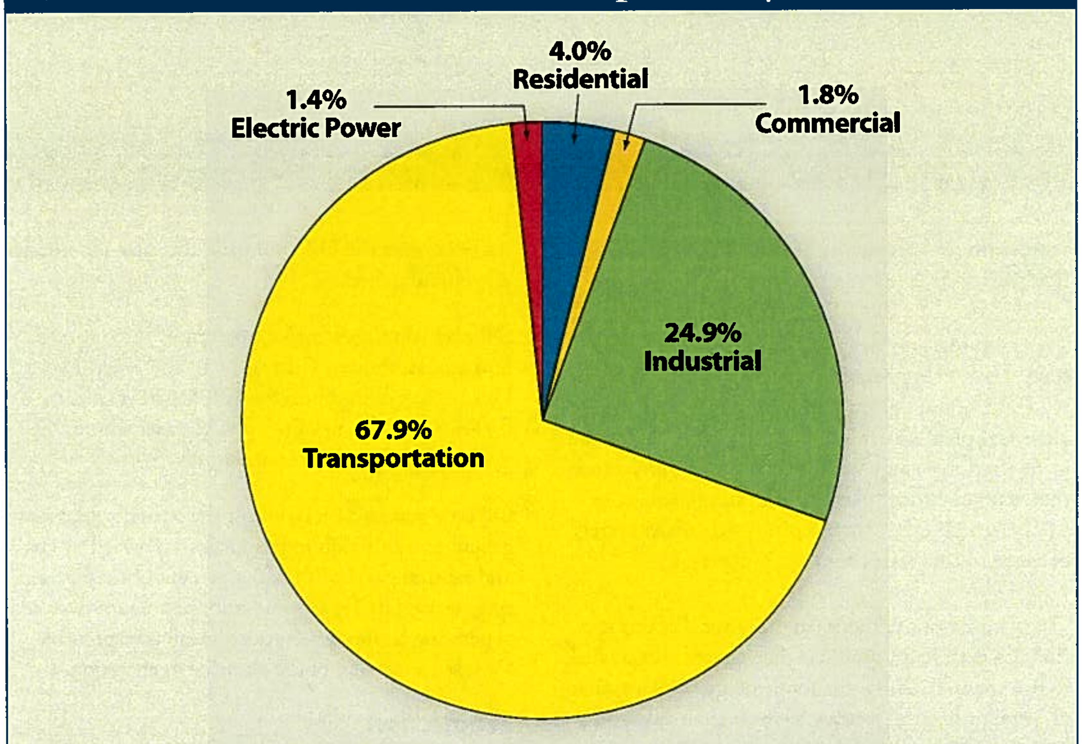
In 2006, motor gasoline accounted for 45 percent of all fuels consumed in the U.S. Distillate fuel oils, used primarily for heating, represented 20 percent; LPGs, 10 percent; jet fuel, 8 percent; and residual fuel oil, used to run refineries, accounted for 3 percent (**Exhibit 4-4**).

To compare the energy value of different fuels, EIA reports each fuel's use in British thermal units (Btu), the amount of heat each fuel produces, whether it is sold by weight, volume or quality. In 2005, petroleum products (including oils, gasoline and other liquid fuels, but not natural gas) provided 41 percent of the 100.4 quadrillion Btu consumed in the U.S.

In the same year in Texas, petroleum products alone accounted for 49 percent of the state's almost 12 quadrillion Btu (or "quads") of energy consumption, an amount almost half as much as the consumption of the second-ranked state, California.[16] Texas led all states in both

Exhibit 4-3

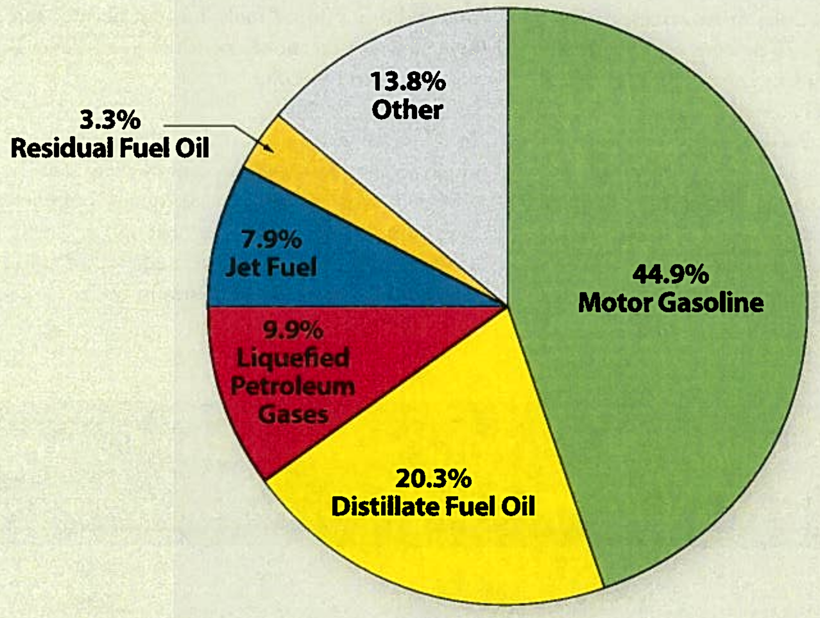
U.S. Petroleum Consumption by Sector, 2006 (Total 20.6 Million Barrels per Day)



Sources: U.S. Energy Information Administration and Texas Comptroller of Public Accounts.

EXHIBIT 4-4

U.S. Petroleum Consumption, 2006 (Total 20.6 Million Barrels per Day)



Note: Numbers may not total due to rounding.

Sources: U.S. Energy Information Administration and Texas Comptroller of Public Accounts.

Texas is the largest chemical producer in the country, with 14 percent of the nation's chemical output and more than 200 chemical plants.

petroleum and all energy consumption in 2005 (**Exhibit 4-5**).

Texas' lead in consumption is largely due to the state's vast, energy-intensive petrochemical industry and the state's hot climate. Texas is the largest chemical producer in the country, with 14 percent of the nation's value of chemical output and more than 200 chemical plants.[17] The state uses more LPG than all other states combined, again largely because of the petrochemical industry.

Texas' numerous refineries and chemical plants use the very petroleum products they are refining as fuel to run them. In 2005, the total energy consumption of Texas' industrial sector was more than two and a half times higher than that of second-place Louisiana's — 5.8 quads, compared to 2.3 quads.[18]

In Texas and the U.S., oil products provide nearly all vehicular fuel.[19]

Oil also supplies a major portion of the nation's home heating fuel. Currently, in the Northeastern U.S., 6.2 million households (78 percent) burn fuel oils for heating. For the U.S. as a whole, the number is 8.0 million households.[20]

Oil products also fuel some of the nation's electricity generators, although in proportions dwarfed by coal and natural gas. In 2006, 0.4 percent of the electricity generated in Texas came from petroleum-powered generating facilities.[21] Nationally, oil is responsible for just 1.7 percent of the electricity generation.

Production

Texas produced 397.2 million barrels of crude oil in 2006, 21.3 percent of total U.S. production.[22]

Exhibit 4-5

Top Ten Petroleum-Consuming States, 2005 (Trillion Btu)

State	Petroleum Only Total	Percent of U.S. Total	All Energy Sources Total	Percent of U.S. Total
Texas	5,671.1	13.9%	11,558.3	11.5%
California	3,869.6	9.5	8,359.8	8.3
Florida	2,163.2	5.3	4,563.3	4.5
New York	1,849.4	4.5	4,179.5	4.2
Louisiana	1,587.4	3.9	3,613.0	3.6
Pennsylvania	1,535.4	3.8	4,050.2	4.0
Illinois	1,486.1	3.6	4,121.5	4.1
Ohio	1,366.5	3.4	4,081.6	4.1
New Jersey	1,331.7	3.3	2,728.6	2.7
Georgia	1,159.1	2.8	3,173.0	3.2

Source: U.S. Energy Information Administration.

Texas is currently the world leader in CO_2 enhanced oil recovery, with more than 50 projects under way in West Texas.

Crude oil most commonly is found in underground reservoirs and is obtained by drilling. Some alternative sources of oil, however, like the tar sands of Alberta, Canada, are mined near the surface. Other alternative sources, now feasible because of improved but expensive drilling methods, are found in certain rock formations previously thought to be too difficult from which to produce, such as oil shales and coalbeds.

Drilling the Well

To retrieve oil and gas, a rig with a rotating bit drills a hole six to 10 inches wide into the earth. Steel pipe called "casing" is cemented in the hole to line it. As the drill bit slowly grinds downward, drilling fluid called "mud" is pumped down the inside of the drill pipe to help break up the rock, maintain downward pressure and clean, cool and lubricate the bit. To complete the well, the casing in the production zone is perforated with small holes, allowing oil and gas to flow from the surrounding rock up into the pipe.

Exhibit 4-6 provides a schematic of a typical oil rig. **Exhibit 4-7** provides more detail on the underground portion of the well.

In all oil and gas fields, the hydrocarbons are found in small (microscopic to less than BB-sized) holes distributed though the reservoir-rock interval. Fracturing that rock and applying downward pressure are two of the most common retrieval methods. Typically, even the best production methods have produced only one-third of the oil in place.[23]

Producers routinely use "enhanced oil recovery," or EOR to retrieve the remaining oil or gas in place. EOR involves injecting fluids or gases into the reservoir to make the oil more mobile and more likely to flow to producing wells. Water, carbon dioxide (CO_2), soap-like substances and steam are the most common EOR fluids.[24]

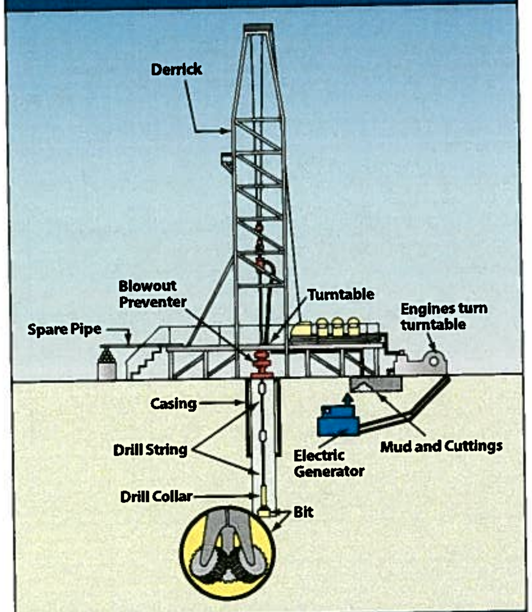
Carbon Dioxide EOR

Texas is currently the world leader in CO_2 EOR, with more than 50 projects under way in West Texas. An extensive CO_2 pipeline network in the western U.S. carries the gas from natural sources in Colorado and New Mexico to West Texas. This system is capable of carrying one to four billion cubic feet (Bcf) of CO_2 daily.

West Texas fields now produce more than 100,000 barrels of oil per day via carbon dioxide EOR. Further expansion is limited by a lack of available CO_2 supplies. The most likely candidate for these

EXHIBIT 4-6

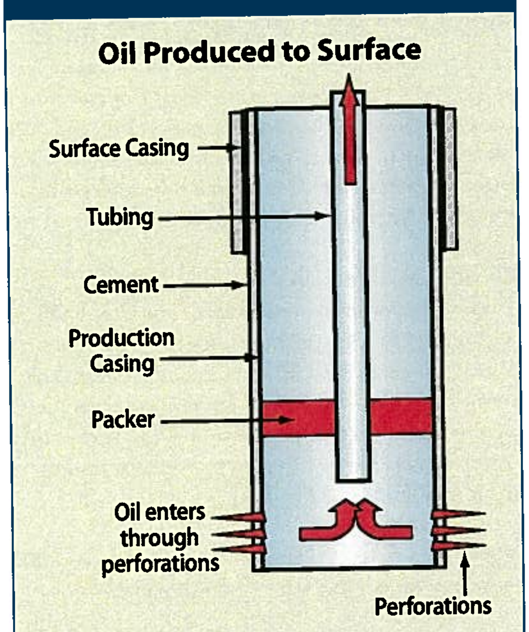
A Typical Oil Rig



Source: Dukes Wood Oil Museum.

EXHIBIT 4-7

The Well



Source: Oil and Gas Blog.

supplies is from industrial carbon-capture efforts such as FutureGen.[25] (See Chapter 7 for more information on FutureGen.)

Post-Production

When the well is complete and producing, it is topped off with a pumpjack or a cluster of valves known as a "Christmas tree." These valves regulate pressure and control flows. An outlet valve from the Christmas tree is connected to a distribution network of storage tanks and pipelines that supply the crude oil to refineries.

According to Baker Hughes, a Texas corporation specializing in oil drilling equipment, Texas had an average of 377 rotary rigs — the standard drilling rig in use today — operating between 1987 and 2007. The rig count fluctuated significantly during that period, however, from an average low of 227 in 1999 to 748 in 2007, the latter figure representing 45.4 percent of all oil rigs operating in the U.S. in that year (**Exhibit 4-8**).[26]

In 2007, Baker Hughes reported that U.S. drilling activity had reached a 21-year high, with 1,798 rigs in operation. Onshore rigs and rigs in Texas accounted for most of the increase.[27]

Exhibit 4-9 shows the locations of Texas' highest-producing oil and gas fields and oil wells, respectively. Today, about 79 percent of the state's oil wells are classified as marginal or "stripper" wells, which produce fewer than 10 barrels per day.[28] This low recovery rate per well is one indication of the advanced maturity of Texas oil production.

Offshore Production

Texas oil also is produced offshore in the Gulf of Mexico. As of 2006, offshore oil reserves in Texas' portion of the Gulf totaled 158 million barrels, from both state and federal areas.[29] Much of the Gulf's proven reserves lie beneath federal waters off the Louisiana shore. About 3.7 billion barrels of oil now exist in federal offshore reserves in the Gulf (**Exhibit 4-10**).

Proven oil and gas reserves are an important indicator of the nation's energy future. These reserves are estimates of oil or gas in the ground deemed to be both economically and operationally recoverable.[30] Since 1996, proven reserves from water deeper than 200 meters (656 feet, or 0.12

miles) have exceeded those in shallower water and now account for more than 81 percent of all Gulf of Mexico reserves.[31] Recent large discoveries in ultra-deep (greater than 5,000 feet) water offshore Texas are not yet included in these data.[32]

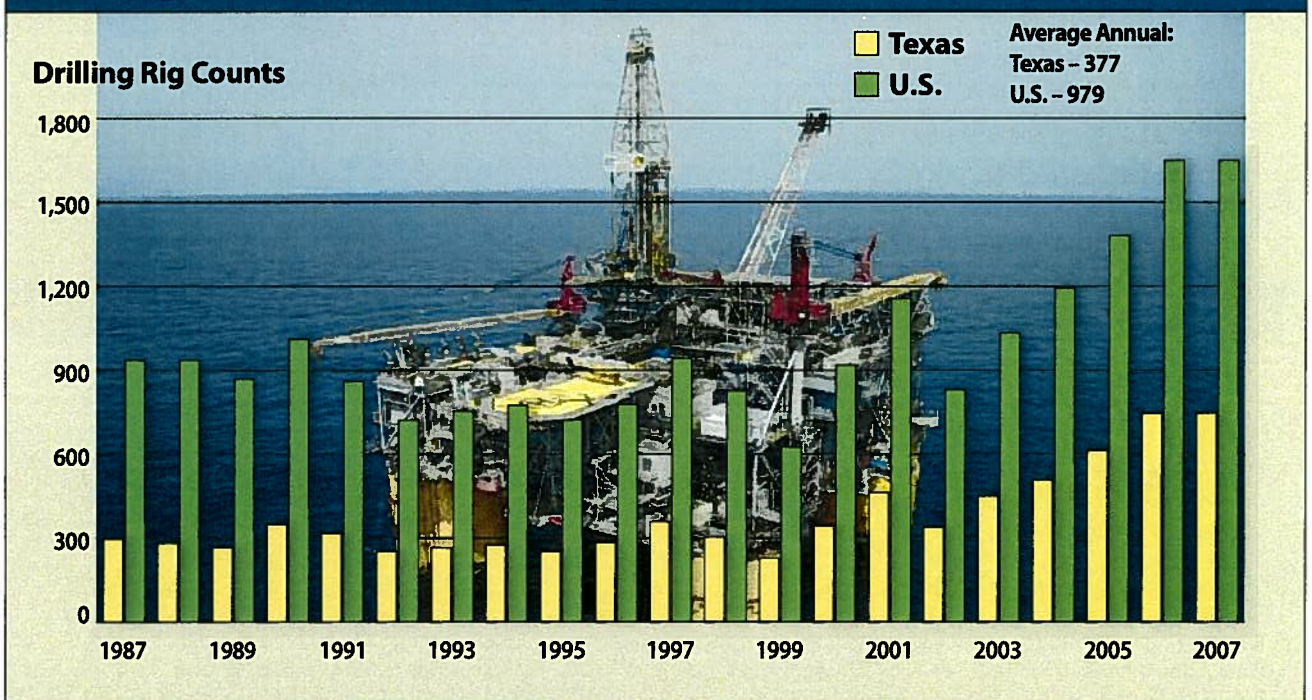
Texas has an unusual relationship with the federal government concerning its offshore lands. When Texas entered the Union in 1845 by treaty, it retained ownership of more than 4 million acres of offshore lands out to the "three marine league" line — about 10.3 statute miles, or 9 nautical miles.[33] Only Texas and Florida (along its Gulf coast only) own these "submerged lands" out to 10.3 miles; all other states retain ownership only as far as three nautical miles. (A nautical mile is a measure of latitude equivalent to 1.15 miles.)[34]

In the 1970s, a dispute arose between Texas and the federal government over how to divide the bonuses, rents, royalties and other revenues of wells in areas of the Gulf where state and federal ownership appeared to overlap. In 1984, a federal district court determined that these tracts were co-owned, resulting in a 50/50 split over the revenues in dispute.[36] Federal law passed in 1986 in response to the decision awarded Texas $382 million in past bonuses, rents, royalties and other revenues and allowed a 27 percent share of future income.[37] In fiscal 2006, Texas collected $13.4 million in these revenues; in fiscal 2007, Texas collected $15.9 million.[38]

> One ton of carbon dioxide or CO_2 at normal atmospheric pressure and 77 degrees Fahrenheit occupies 556.2 cubic meters or 19,642 cubic feet. Twenty tons would fit inside the Senate chamber in the Texas Capitol. Each gallon of conventional gasoline, when combusted, produces almost 172 cubic feet of CO_2, an area with a height, width and depth of 5.6 feet.[35]

EXHIBIT 4-8

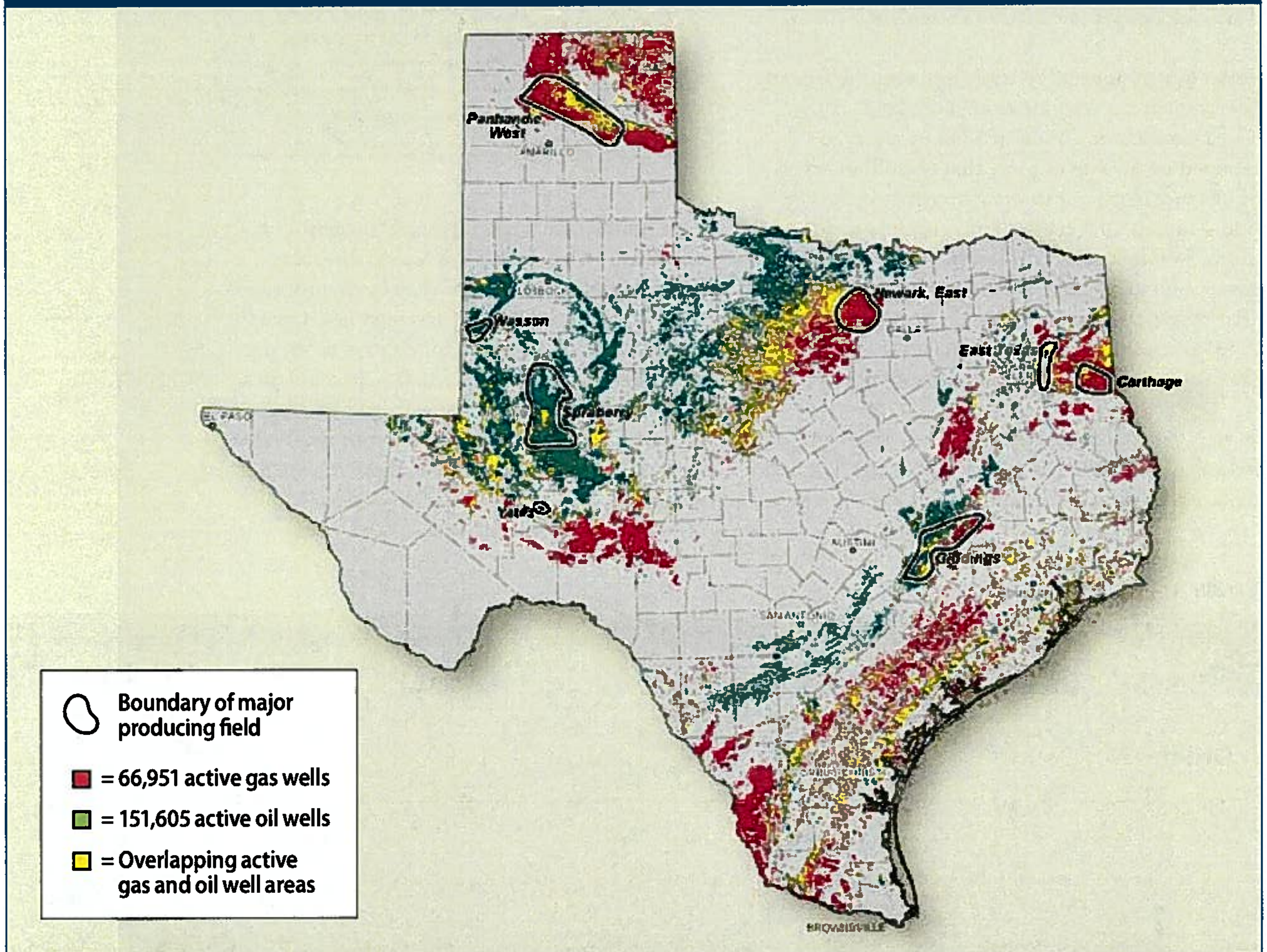
Average Annual Drilling Rig Counts for Texas and the U.S.



Sources: Baker Hughes Inc and Texas Comptroller of Public Accounts.

EXHIBIT 4-9

Oil and Gas Map of Texas



Source: University of Texas at Austin.

The first CO_2-flood project in the world began in West Texas in the 1970s, in the Kelly-Snyder field in Scurry County. Kelly-Snyder, one of the largest fields in the U.S., has produced to date 1.3 billion barrels of oil from the Canyon Reef formation since its discovery in 1948.[39]

In the 1970s, many operators and producers in the Kelly-Snyder field realized that EOR was becoming necessary, but knew it would be expensive and possibly fruitless if each approached it alone. The operators formed SACROC, the Scurry Area Canyon Reef Operating Committee, to oversee reservoir-wide EOR operations, and began injecting CO_2. As a result, anticipated total production increased by 5 to 12 percent.[40] More than 13 million tons of CO_2 is injected into SACROC wells annually, with about half of that withdrawn and recycled. Since CO_2 injections began in 1972, SACROC has stored more than 55 million tons of CO_2. By comparison, a 500 megawatt coal-fired power plant produces three to four million tons of CO_2 annually.[41]

Exhibit 4-10

Federal Proven Crude Oil Reserves in Gulf of Mexico (Million Barrels)

Year	Total Proven Reserves	Percentage of Crude Oil Proven Reserves from Waters More than 200 Meters Deep
1992	1,835	30.4%
1993	2,072	39.8
1994	2,127	41.2
1995	2,518	49.3
1996	2,567	51.1
1997	2,949	57.0
1998	2,793	57.7
1999	2,744	59.3
2000	3,174	63.7
2001	4,288	74.8
2002	4,444	75.9
2003	4,554	79.6
2004	4,144	79.2
2005	4,042	81.0
2006	3,655	81.6

Source: U.S. Energy Information Administration.

Texas is home to 23 petroleum refineries, including half of the 12 most productive refineries in the U.S.

Reserve estimates for Texas' state-owned offshore reserves are very small compared to reserves further offshore, in federal waters (**Exhibit 4-11**). The relatively shallow state offshore fields are considered to be "mature" by experts; that is, their production is declining, and new discoveries are smaller and more quickly depleted. But the industry is seeking deeper production, primarily of natural gas in state waters based on new three-dimensional (3-D) seismic survey results.[42]

Refining

Texas is home to 23 petroleum refineries, including half of the 12 most productive refineries in the U.S.[43] Texas has more than a fourth of all U.S. oil refining capacity, more than any other state.[44] The nation's largest refinery, owned by ExxonMobil, is located in Baytown, Texas. This refinery, originally built in 1919, has a distillation capacity of 562,500 barrels per day (b/d).[45] Texas as a whole has a daily refining capacity of 4.7 million barrels (**Exhibit 4-12**).[46]

In addition to leading the U.S. in refining capacity, Texas also leads the U.S. in daily refinery production (**Exhibit 4-13**).

Refineries require extensive federal and state environmental review, which may explain in part why no new refineries have been built from the ground up in the U.S. since 1976. One proposed refinery near Yuma, Arizona recently received final approval from state and federal authorities after a seven-year process.[47] Cost is another factor. The International Energy Agency estimated in 2003 that refineries cost $10,000 per barrel of daily capacity.[48] The new Yuma refinery will cost an estimated $2 billion to build.[49]

While new refineries have not been built, expansions of existing refineries are a common occurrence. Just recently, on December 10, 2007, in Port Arthur, Texas, a partnership of Royal Dutch Shell and Saudi Aramco broke ground on a 325,000 b/d refinery expansion that will increase the existing refinery's throughput capacity to 600,000 b/d by 2010, replacing Exxon's Baytown refinery as the largest refinery in the world.[50] In February 2008, Total S.A. of France announced a 50,000 b/d expansion of its Port Arthur refinery. At the same time, Valero Energy of San Antonio announced plans to expand its Port Arthur refinery.

Exhibit 4-11

Texas Proven Crude Oil Reserves (Million Barrels)

Year	Texas Onshore Reserves	Texas Gulf of Mexico FEDERAL Offshore Lands	Texas Gulf of Mexico STATE Offshore Lands
1986	7,152	101	2
1987	7,112	88	8
1988	7,043	78	7
1989	6,966	69	6
1990	7,106	71	6
1991	6,797	60	7
1992	6,441	192	5
1993	6,171	192	4
1994	5,847	205	4
1995	5,743	249	8
1996	5,736	210	8
1997	5,687	362	4
1998	4,927	310	1
1999	5,339	302	3
2000	5,273	423	5
2001	4,944	411	6
2002	5,015	356	6
2003	4,583	303	7
2004	4,613	225	9
2005	4,919	190	5
2006	4,871	155	3

Sources: U.S. Energy Information Administration and Texas Comptroller of Public Accounts.

Exhibit 4-12

Top 15 U.S. States and Territories, Total Refining Capacity, 2006 (Barrels per Day)

State	Total Operable Refining Capacity	Percent of U.S. Capacity
Texas	4,685,526	26.0%
Louisiana	2,971,183	16.5
California	2,037,188	11.3
Illinois	903,600	5.0
Pennsylvania	773,000	4.3
New Jersey	655,000	3.6
Washington	623,850	3.5
Ohio	510,120	2.8
Virgin Islands	500,000	2.8
Oklahoma	490,700	2.7
Indiana	433,000	2.4
Alaska	375,000	2.1
Mississippi	364,000	2.0
Minnesota	349,300	1.9
Kansas	300,700	1.7
U.S. Total	18,021,392	

Sources: U.S. Energy Information Administration and Texas Comptroller of Public Accounts.

Preparing Petroleum Products for Market

Oil is refined in three basic steps: separation, conversion and treatment. Refineries remove impurities in crude oil such as sulphur, nitrogen and metals. Refined and distilled oil yields three major types of products: fuels, finished non-fuel products and chemical industry feedstocks.

After crude oil is removed from the ground, it is sent to refineries by pipeline, ship or barge. According to EIA data for 2006, U.S. refineries and blenders produced more than 6.5 billion barrels of petroleum products from 6.2 billion barrels of crude oil, natural gas and other hydrocarbons and gases.[51] (Blenders are companies that do not refine oil products but prepare them for the marketplace by, for instance, adding oxygenates to gasoline.) Crude oil accounted for 90 percent or 5.6 billion barrels of the hydrocarbons used by refineries and blenders.

Gasoline accounted for more than 46 percent, or 3 billion gallons, of the products made by refiners and blenders in 2006; distillate fuel oil amounted to less than half of that share, at 22.6 percent or 1.5 billion gallons. **Exhibit 4-14** illustrates a refinery's typical processes.

Once refined, the products make their way from onshore "tank farms" to pipelines, storage terminals near urban areas and finally to trucks for

Exhibit 4-13

U.S. Crude Oil and Petroleum Products Refinery Net Production (Thousand Barrels per Day)

	2005 Production	2005 Percent of U.S.	2006 Production	2006 Percent of U.S.	2007 Production	2007 Percent of U.S.
U.S.	15,579	100.0%	14,996	100.0%	14,731	100.0%
East Coast	1,711	11.0	1,482	9.9	1,434	9.7
Midwest	3,140	20.2	3,150	21.0	3,032	20.6
Gulf Coast	8,120	52.1	7,818	52.1	7,812	53.0
Texas Inland	620	4.0	629	4.2	578	3.9
Texas Gulf Coast	4,113	26.4	3,674	24.5	3,610	24.5
Louisiana Gulf Coast	3,110	20.0	3,228	21.5	3,335	22.6
North Louisiana, Arkansas	189	1.2	199	1.3	188	1.3
New Mexico	89	0.6	87	0.6	101	0.7
Rocky Mountain	590	3.8	585	3.9	567	3.8
West Coast	2,018	13.0	1,961	13.1	1,885	12.8

Sources: U.S. Energy Information Administration and Texas Comptroller of Public Accounts.

delivery to individual consumers, which could be residential homes, gasoline stations, electric power generation facilities or petrochemical plants.

Availability

Texas' crude oil reserves represent almost one-fourth of total U.S. reserves. Alaska, other Gulf states, Oklahoma, Wyoming, New Mexico, California and federal offshore areas provide most of the remainder.[52] Although Texas' oil reserves are found throughout the state, its largest remaining reserves are concentrated in the Permian Basin of West Texas, which contains 21 of the nation's 100 most productive oil fields.[53]

Texas oil production peaked in 1972, at more than 3.4 million barrels per day. Since then, production has declined steadily and now represents less than a third of its 1972 peak. **Exhibit 4-15** shows Texas' oil production from 1981 through 2006.

While Texas' crude oil reserves and production have declined, the state still leads the nation in its average daily crude oil production (**Exhibit 4-16**).

Both the U.S. and Texas depend on foreign countries for petroleum. U.S. net imports of foreign oil represented 59.9 percent of the petroleum it consumed in 2006.[54] The U.S. leads the world in petroleum imports (**Exhibit 4-17**).

Costs and Benefits

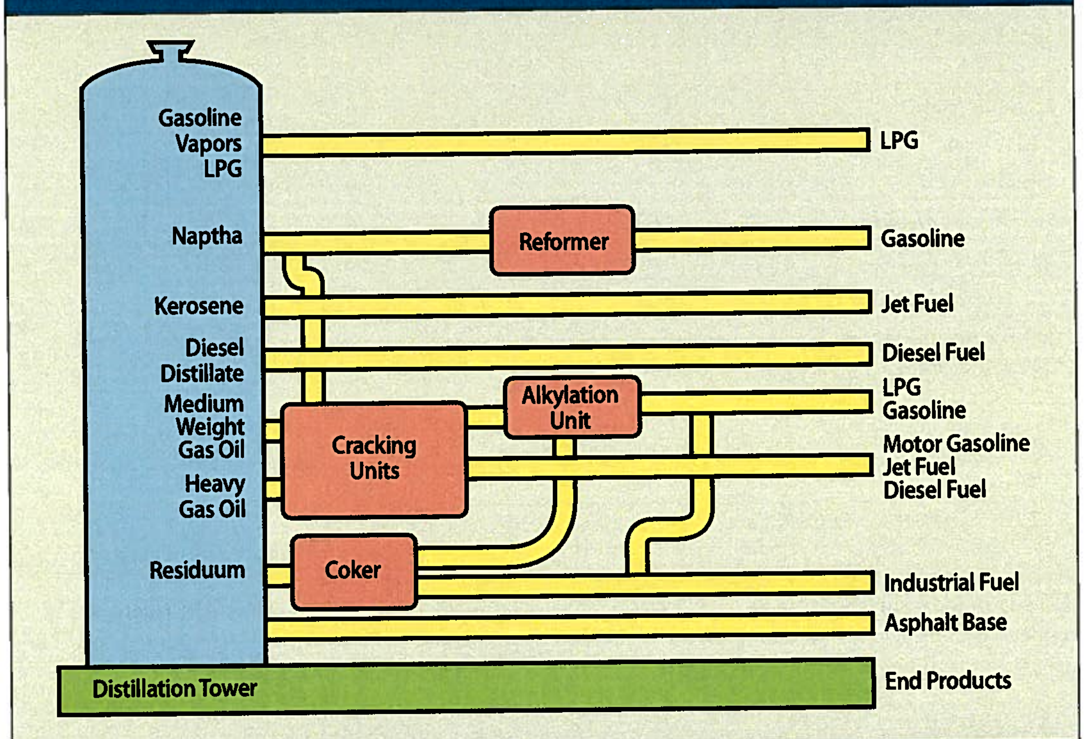
The cost of finding and producing petroleum depends on many factors, particularly the type and complexity of the geological surveys needed to locate it; the location of the target reservoir (and particularly, whether it is onshore or offshore); and the depth of the well. According to EIA, in 2004 the U.S. average oil and gas well drilling depth for all exploratory and development wells was 5,838 feet; the average nominal cost of drilling those wells was about $1.7 million, or $292.57 per foot.[55]

Deep-water drilling is considerably more expensive than drilling the average well on land. Houston-based Transocean, the world's largest offshore drilling contractor, has 19 ultra-deepwater rigs capable of drilling in water depths of at least 7,500 feet. The current contract rate to lease one of these rigs ranges between $183,000 and $600,000 per day.[56]

While company drilling cost data are highly proprietary, some information gleaned from

EXHIBIT 4-14

Petroleum Refining: Basic Processes and Products



Source: U.S. Department of Energy.

public sources confirms that record oil prices and finite supplies of drilling equipment are driving up costs. A July 2007 article in *The Wall Street Journal* stated that "Renting a state-of-the-art floating drilling rig in 2001 cost about $200,000 a day; the same rig now fetches more than $500,000 a day."[57] EIA reports that offshore operating costs increased by a third in 2006.[58]

But similar price increases have affected onshore drilling in West and South Texas. In 2006, drilling equipment costs for typical 4,000 foot and 8,000 foot oil wells in West Texas were $1.4 million and $2.3 million, respectively, representing 41.2 percent and 33 percent increases since 2000. The additional cost of EOR on holes of these depths was $8.8 million and $17.9 million, respectively, representing price increases of 39.8 percent and 36.7 percent since 2000 (**Exhibit 4-18**).[59]

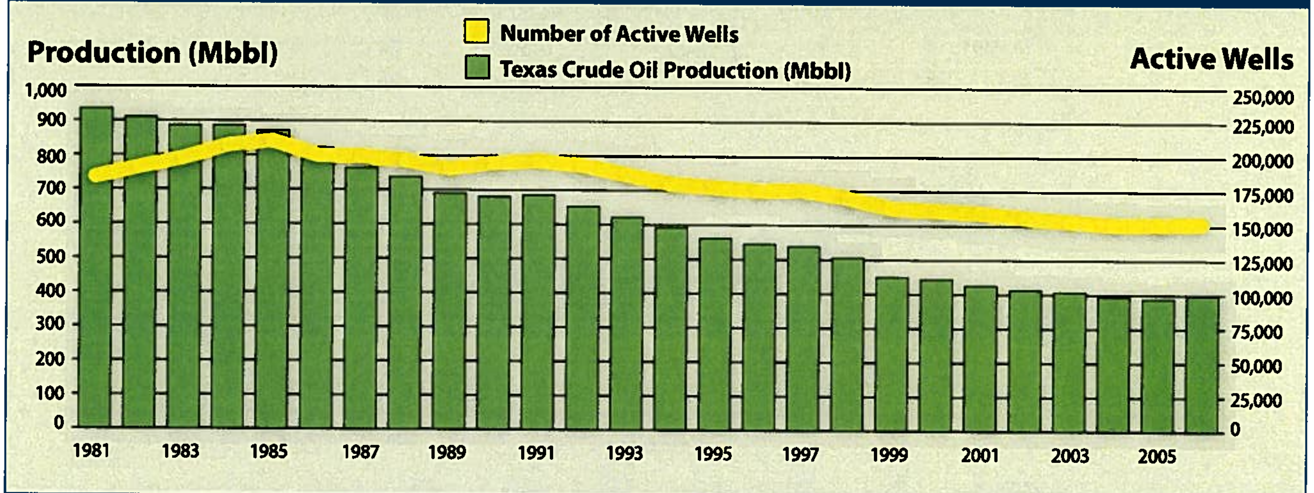
As **Exhibit 4-18** indicates, the story in South Texas is similar. Typical 4,000-foot oil wells now cost nearly $1.5 million for equipment and $332,700 in annual operating costs, 47 percent and 53.4 percent more than in 2000, respectively. Typical 8,000-foot oil wells cost almost $1.9 million in equipment and $416,300 in annual operating costs, 49.4 percent and 54.2 percent more than in 2000. EIA data do not include EOR costs in South Texas.

Cost to Consumers

Sharp increases in the price of a barrel of oil and a gallon of gasoline have dominated recent headlines. Crude oil futures topped $100 per barrel in early 2008 for the first time, eventually exceeding the

EXHIBIT 4-15

Texas Crude Oil Production and Active Wells, 1981-2006



Sources: U.S. Energy Information Administration and Texas Railroad Commission.

all-time inflation-adjusted high price of $103.76 set in April 1980.[60]

In June 2005, the national average retail price of gasoline was $2.16 per gallon. By June 2007, it had risen to $3.05, dropped to $2.80 in September 2007 and was up to $3.24 by March 2008.[61] EIA gives many reasons for these increases, including: strong world economic growth, usually indicating increasing consumption of petroleum products, especially in China and India; the declining value of the dollar, which is used to price oil on the world markets; geopolitical risks; production and refining bottlenecks; and OPEC decisions.[62]

The market price of oil is determined at a few producing areas in the country where pipelines converge before setting off for distant markets. One of those places is Cushing, Oklahoma, where the U.S. benchmark crude oil, West Texas Intermediate (WTI), is priced for futures contracts at the New York Mercantile Exchange. WTI is a "light, sweet" crude because of its low density (making it "light") and low sulphur content (making it "sweet").[63]

WTI developed as a benchmark commodity because it dominates U.S. production. WTI can be refined into high-value products such as gasoline, diesel and jet fuel more easily and less expensively than can heavy, "sour" crudes such as some from the Middle East and Venezuela.[64]

The cost structure of gasoline includes distributing and marketing costs, refining costs and profits, federal and state taxes and the cost of crude oil. In March 2008, the cost of crude oil accounted for 72 percent of the cost of a gallon of gasoline; federal and state taxes accounted for 13 percent; refining costs and profits accounted for 8 percent; and distribution and marketing accounted for 8 percent of the cost (**Exhibit 4-19**).[65]

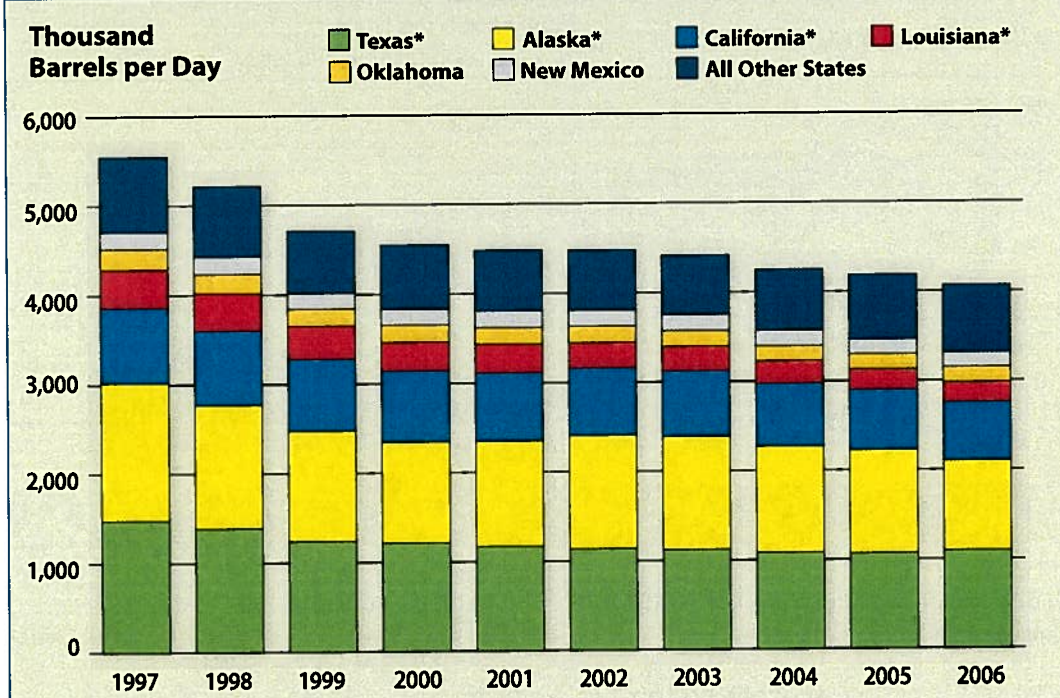
Environmental Impact

The production, refining, transportation, storage and consumption of petroleum and its byproducts, if not expertly handled, entail some environmental risk. The most toxic compounds found in crude oil and many refined products are aromatic hydrocarbons, also known as volatile organic compounds or VOCs. These hydrocarbons mix with the lower levels of the atmosphere and, when heated by the sun, create ground-level ozone, a major component of smog and a greenhouse gas.[66]

While oil spills from tankers can be dramatic and deadly to wildlife, the fact is that more oil seeps out

EXHIBIT 4-16

U.S. Crude Oil Production by State



*Includes state offshore production.

Source: U.S. Energy Information Administration.

EXHIBIT 4-17

Top Oil-Importing Countries (Thousand Barrels per Day)

2006 Rank	Country	2006 Net Imports	2005 Rank	2004 Rank	2000 Rank	Net Change 2000-2006
1	United States	12,357	1	1	1	16.1%
2	Japan	5,031	2	2	2	-6.5
3	China	3,356	3	3	7	136.7
4	Germany	2,514	4	4	3	-4.2
5	Korea, South	2,156	5	5	4	1.7
6	France	1,890	6	6	5	-1.3
7	India	1,718	7	8	9	26.6
8	Italy	1,568	8	7	6	-8.9
9	Spain	1,562	9	9	8	10.7
10	Taiwan	940	10	10	10	7.8

These data include crude oil, lease condensates, natural gas liquids, other liquids and refinery gain.
Sources: U.S. Energy Information Administration and Texas Comptroller of Public Accounts.

EXHIBIT 4-18

Equipment Lease Costs and Annual Operating Costs in South and West Texas

South Texas 4,000-Foot Wells

	2000	2001	2002	2003	2004	2005	2006	Percent Change Since 2000
Lease Equipment Costs	$994,400	$1,014,600	$1,025,800	$1,051,100	$1,269,400	$1,361,700	$1,461,800	47.0%
Annual Operating Costs	$216,900	$224,500	$226,300	$262,800	$281,300	$308,900	$332,700	53.4%

South Texas 8,000-Foot Wells

	2000	2001	2002	2003	2004	2005	2006	Percent Change Since 2000
Lease Equipment Costs	$1,250,300	$1,268,400	$1,277,300	$1,307,300	$1,635,500	$1,749,500	$1,867,900	49.4%
Annual Operating Costs	$269,900	$281,100	$279,000	$328,400	$351,900	$391,600	$416,300	54.2%

West Texas 4,000-Foot Wells

	2000	2001	2002	2003	2004	2005	2006	Percent Change Since 2000
Lease Equipment Costs	$1,018,700	$1,059,300	$1,055,000	$1,065,700	$1,259,800	$1,351,900	$1,438,800	41.2%
Annual Operating Costs	$160,800	$168,400	$154,600	$178,100	$186,900	$214,400	$223,500	39.0%
Enhanced Oil Recovery	$424,700	$447,200	$439,700	$470,900	$472,200	$516,300	$593,700	39.8%

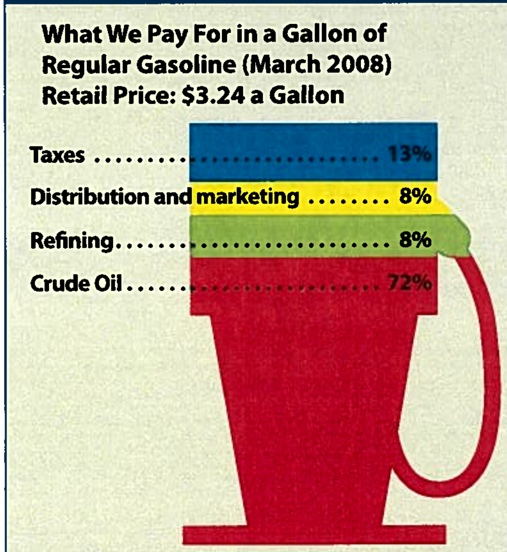
West Texas 8,000-Foot Wells

	2000	2001	2002	2003	2004	2005	2006	Percent Change Since 2000
Lease Equipment Costs	$1,765,500	$1,775,000	$1,771,900	$1,781,400	$2,087,100	$2,221,300	$2,348,700	33.0%
Annual Operating Costs	$220,700	$232,700	$213,400	$248,300	$262,700	$309,700	$326,200	47.8%
Enhanced Oil Recovery	$605,800	$635,600	$615,500	$665,700	$662,000	$723,100	$827,900	36.7%

Sources: U.S. Energy Information Administration and Texas Comptroller of Public Accounts.

EXHIBIT 4-19

Cost Structure of Gasoline



Note: Numbers may not total due to rounding.

Source: U.S. Energy Information Administration.

of the earth naturally, generally from subsea sources, than from manmade ("anthropogenic") spills. The National Academy of Sciences reported in 2003 that more than 60 percent — some 47 million gallons — of crude oil released in North American waters every year comes from natural seepage.[67]

Exploring and drilling for crude oil can disturb the surrounding land and ecosystems, although the impact is generally temporary. Most of the nation's untapped reserves are located offshore; these wells pose a unique set of environmental risks because of the risk of spillage or leakage into surrounding waters.

Many hazardous materials used in drilling must be disposed of after a well is complete. Given that oil and gas reservoirs are found in strata representing the remnants of ancient salt seas, salt water is a frequent drilling byproduct. The Railroad Commission of Texas (RRC) requires producers to use injection wells to force this salt water into deep formations to keep it from mixing with fresh water.

Pipelines used to transport crude oil can leak and pollute the environment. Old, unplugged wells also pose a threat to groundwater, as do the above- and below-ground tanks generally used to store oil and refined oil products. New technologies can reduce but not eliminate these environmental risks.

Refineries face particularly difficult disposal problems because of the number and volume of hazardous substances and chemical byproducts involved in their operations. Petroleum refineries are a major source of toxic air pollutants such as benzene, toluene, ethyl benzene and xylene (the so-called BTEX compounds.) They also are major sources of federal Clean Air Act (CAA) "criteria" air pollutants — that is, those subject to federal regulation — including particulate matter, nitrogen oxides (NO_X), carbon monoxide (CO), hydrogen sulfide (H_2S) and sulfur dioxide (SO_2). Refineries also release hydrocarbons such as methane and light volatile fuels and oils.[68]

In addition, oil refining produces wastewater sludge and solid waste that can contain metals such as arsenic, mercury and other toxic compounds, all of which require special handling, treatment and disposal. Treatment of these wastes includes burning, treatment both on- and off-site, land filling, chemical fixation and neutralization.

The combustion of hydrocarbons creates carbon dioxide, a greenhouse gas. Methane, the lightest hydrocarbon that can be produced by the decay or decomposition of any biological material, is another common greenhouse gas.

Crude oil production and refining also can result in some water consumption, requiring up to 2,500 gallons per million Btu of energy produced, depending on production methods.

Other Risks

The highly flammable nature of petroleum products, particularly when dispersed in the air, carries a risk of fire or explosion. Furthermore, as Hurricanes Katrina and Rita in 2005 showed, extreme weather poses a serious risk for the entire petroleum industry along the Gulf of Mexico, with potential environmental and economic effects.

Other hurdles for the Texas oil and gas sector include an insufficient number of technically educated workers to meet demand. Nationally, employment in this sector dropped by 55 percent between 1982 and 2003. In Texas, oil and gas extraction employment fell by 12.9 percent between 1990 and 2007, a loss of 11,260 jobs.[69] Those who remained in the workforce — the older, most experienced geologists, engineers and drilling crews — have few younger, educated workers to replace them, thus introducing the risk of a labor shortage that could extend supply outages and lead to higher maintenance costs. One producers' trade association estimates that less than 15 percent of the oil and gas work force is under 35 years of age; 10 percent is aged 65 or older. By comparison, 60 percent of a typical technology company's workforce is under 35 years of age with few employees over the age of 60.[70]

Furthermore, the CAA makes it difficult for refiners in areas such as Houston, which is not in compliance with CAA air quality standards, to build new refining capacity. In 2005, industry representatives identified state and local tax structures that rely on property and capital-intensive businesses as placing a limit on new development and expansion.[71] For these reasons and many others, no new refinery has been built in the U.S. since 1976.[72]

Energy and National Security Debate

Despite the fact that the U.S. is still its own largest supplier of total energy, the current policy dialogue has linked the idea of energy independence from foreign suppliers with our national security interests.

Many experts, however, including those with the National Petroleum Council (NPC) and the Center for Strategic and International Studies (CSIS), caution against making this connection absolute. A 2007 NPC study said:

> "Energy independence" should not be confused with strengthening energy security. The concept of energy independence is not realistic in the foreseeable future, whereas U.S. energy security can be enhanced by moderating demand, expanding and diversifying domestic energy supplies, and strengthening global energy trade and investment. There can be no U.S. energy security without global energy security.[73]

An oil expert with CSIS testified before Congress in March 2006 that:

> The oil market is a truly global market. Reducing America's oil consumption can potentially have a dampening effect on prices, but it will not completely insulate us from supply or price volatility. We frequently speak about "politically unstable" sources of oil supplies around the globe, but the largest protracted losses of global oil and gas output in both 2004 and 2005 were the result of hurricanes in the U.S. Gulf of Mexico.[74]

The security of Middle Eastern oil supplies often is expressed as the nation's greatest concern, but it is worth noting that in 2007, the U.S. imported more oil from Canada alone (2,337,000 barrels per day) than it did from Persian Gulf countries (2,305,000 barrels per day).[75]

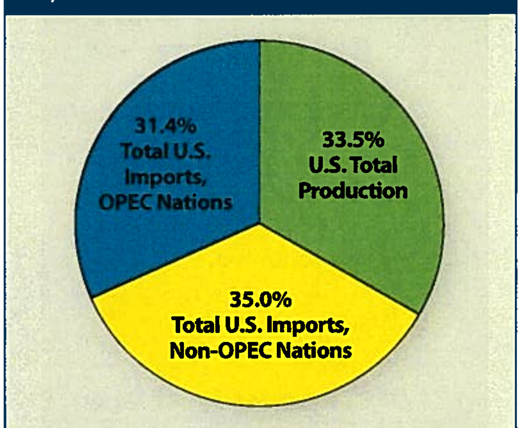
In addition, domestic production supplies one-third of all the oil consumed in the U.S. (**Exhibit 4-20**).

Exhibit 4-21 depicts the U.S.' 10 largest sources of foreign crude oil imports in 2007 by nation and what the U.S. imports from the rest of the world. Total imports that year were 4,394,600,000 barrels.

In fact, U.S. imports from OPEC nations as a share of all imports have declined since 1997. The share of U.S. imports attributable to OPEC was highest in the cartel's founding year, 1960, at 72.4 percent. (It should be noted that overall U.S. oil imports were only a small portion of total oil sup-

EXHIBIT 4-20

U.S. Crude Oil Supply by Source, 2006



Source: U.S. Energy Information Administration.

In 2007, the U.S. imported more oil from Canada alone than it did from Persian Gulf countries.

ply until the mid-1970s.) In 2007, with imports providing two-thirds of the U.S. oil supply, OPEC accounted for 44.5 percent of all U.S. imports and 28.9 percent of all U.S. supplies.[76]

State and Federal Oversight

Most federal agencies have some oversight over aspects of the oil exploration, production, refining and transportation industries, which generally comes with the enforcement of a wide spectrum of federal environmental, health, safety, emergency response and homeland security laws. Likewise, most states and some local jurisdictions either regulate the industries directly under authority delegated by a federal agency or by statute, or have a site-specific interest, such as the siting of a tank farm.

In addition to governmental oversight, some areas have organizations to help industries cope with disasters. For example, in the 1950s, petrochemical companies and local governments located along the Houston Ship Channel formed a non-profit mutual aid organization, agreeing to help each other fight fires, provide rescue and emergency medical assistance and handle hazardous material spills. The organization has also provided training.[77]

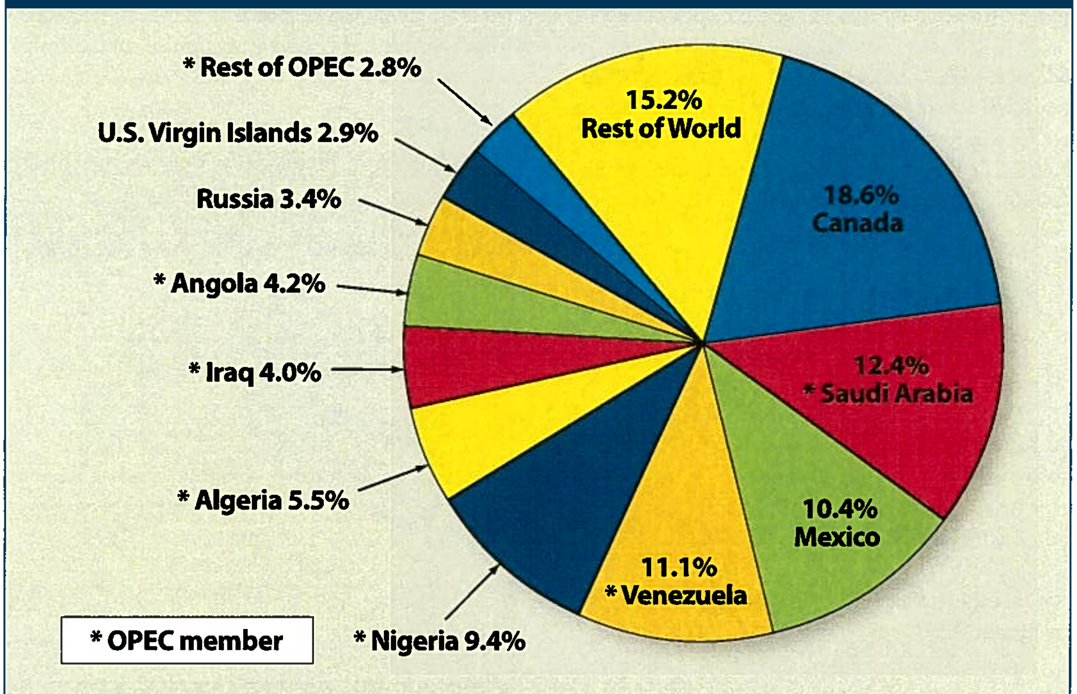
The U.S. Environmental Protection Agency (EPA) is entrusted with protecting human health and safeguarding the natural environment. In addition to enforcing the CAA, EPA specifically enforces the federal Clean Water Act, the Oil Pollution Act, the Comprehensive Environmental Response, Compensation & Liability Act and the Superfund Amendments and Reauthorization Act, which focus on cleaning up hazardous waste sites.

EPA has delegated the responsibility for issuing permits and monitoring and enforcing compliance to the states. Programs not delegated to the states are managed through EPA's 10 regional offices across the nation.

When national standards are not met, EPA can issue sanctions and take other steps to assist the states in reaching the desired levels of environmental quality.

EXHIBIT 4-21

Sources of U.S. Oil Imports, 2007



Source: U.S. Energy Information Administration.

Federal/Private Partnership for Enhanced Oil Recovery

The Wilmington field, running roughly southeast to northwest through the Los Angeles Basin, is the third-largest oilfield in the contiguous U.S. and has been in operation for 73 years.[78] This oilfield had seen a steady decline in oil production over the years, and many considered it to be depleted.

In 1995, DOE and a private company began a partnership to employ new EOR methods to revitalize the field. Specifically, the project has developed:

- new three-dimensional computer modeling to find better ways to inject steam, hot water and other treated water into the production zone, thus heating its thick crude and driving it toward production wells without causing surface subsidence, a common problem in the area;
- a new well completion technique using alkaline steam instead of sand to dissolve the oil-bearing rock, cutting capital costs by 25 percent;
- a new commercial technology to remove deadly hydrogen sulfide (H_2S) gases from steam emissions, reducing the cost of this process by 50 percent; and
- a new steam generator that can burn a variety of low-quality waste gases created by the operation.

The project formally ended on March 31, 2007. The new technologies developed in the project ultimately could add 525 million barrels of additional oil production at Wilmington field. The private company that implemented the DOE-supported technologies has experienced its most successful drilling in 25 years at the Wilmington oil field. In fact, its best wells were drilled in an area that had been abandoned as depleted.[79]

EPA also may seek the assistance of state agencies in its own efforts to protect the environment.

In Texas, EPA has delegated enforcement duties for many regulatory and environmental permits and standards to RRC and the Texas Commission on Environmental Quality (TCEQ). Generally, TCEQ has jurisdiction to enforce all major federal environmental laws except those applying to oil and gas production, which fall under RRC's authority.

The federal Occupational Safety and Health Administration (OSHA) oversees the working environment in nearly all phases of crude oil exploration and production. The U.S. Department of Transportation oversees not just overland petroleum transportation, but also pipeline safety. The Coast Guard enforces federal pollution and safety laws regulations on navigable waters. The U.S. Army Corps of Engineers issues permits for any construction in either federal waters or wetlands. The Federal Energy Regulatory Commission has rate-setting oversight for interstate oil pipelines and market oversight for interstate gas pipelines.

Subsidies and Taxes

Chapter 3 of this report discusses major taxes related to the oil and gas industries, including severance and motor fuels taxes, which together accounted for about 18 percent of state tax revenue in 2006. Chapter 28 contains information on subsidies for the oil and gas industries.

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Other States and Countries

Major initiatives and innovations in the oil industry concern developing and enhancing the cost-effectiveness of secondary or enhanced oil recovery. Such technologies have become a major concern because of the world's dwindling oil reserves.

One example of these initiatives is a recently completed, DOE-funded project in a small portion of the Wilmington oil field in the heart of Long Beach, California.

Many U.S. companies and the U.S. government are actively investigating alternative sources of oil and gas, which includes "tight" sands (those with low permeability for hydrocarbons), oil sands, coalbed methane and oil-bearing shale rock. For example, DOE's National Energy Technology Laboratory is actively researching the potential of oil shales in Utah, Colorado and Wyoming; tar and oil sands in Utah, Alaska, Alabama, Texas and California; coal-to-liquid technologies that create a synthetic gas or "syngas" from coal that ultimately forms ultra-clean diesel and jet fuels; "heavy oil" in California, Alaska and Wyoming that requires heat, solvents or both to move underground; and, as mentioned previously, carbon dioxide enhanced oil recovery.[80]

One concern regarding crude oil supplies is China's modernization and its increasing consumption of petroleum.

One concern regarding crude oil supplies is China's modernization and its increasing consumption of petroleum. **Exhibit 4-22** shows the top 15 petroleum-consuming countries in 2006.

In addition to increasing consumption in China, oil-producing countries such as Saudi Arabia and Iran are increasing their oil consumption rapidly while other Asian and European countries are reducing theirs.

Outlook for Texas

Texas has been a major producer and consumer of petroleum products and will continue to be for the foreseeable future. The outlook for Texas, however, is inextricably linked to national and global supply and demand for oil.

Companies throughout the industry are pushing technological limits to develop oil and gas fields offshore in ever-deepening waters. Most recently, in 2006, Chevron and its partners set a drilling depth record in the Gulf of Mexico, reaching strata 34,189 feet or 6.5 miles deep in 3,500 feet of water.[81] The federal Minerals Management Service reported in August 2007 that a record number of drilling ships — 15 — were work-

Exhibit 4-22

Top Petroleum-Consuming Countries, 2006 (Thousand Barrels per Day)

Rank	Country	Consumption	2005 Rank	2004 Rank	2000 Rank	Net Change in Consumption 2000-2006
1	United States	20,687	1	1	1	5.0%
2	China	7,273	2	2	3	51.7
3	Japan	5,159	3	3	2	-6.1
4	Russia	2,861	4	4	5	10.9
5	Germany	2,665	5	5	4	-3.9
6	India	2,587	6	6	8	21.6
7	Canada	2,264	7	7	10	11.7
8	Brazil	2,217	9	9	6	2.3
9	Korea, South	2,174	8	8	7	1.8
10	Saudi Arabia	2,139	11	12	14	39.2
11	Mexico	1,997	10	11	9	-1.9
12	France	1,961	12	10	11	-2.0
13	United Kingdom	1,830	13	13	13	4.0
14	Italy	1,732	14	14	12	-6.6
15	Iran	1,686	16	16	16	35.0

Sources: U.S. Energy Information Administration and Texas Comptroller of Public Accounts.

Has Oil Production Peaked?

Another current issue is the debate among academics, business leaders, economists and government officials as to whether the world has seen "peak oil" — that is, the absolute peak of oil production, followed by an irrevocable production decline. Daniel Yergin, author of the Pulitzer Prize-winning *The Prize: The Epic Quest for Oil, Money & Power*, has said that the more appropriate vision is that of an "undulating plateau," with the slope of decline much more gradual than that of the rapid increases of the 20th century, largely due to technological advances.[84] Others argue that economic models should begin reflecting a downturn in global oil production to better prepare for the future.[85]

A November 2007 article in the *Wall Street Journal* provides some insight into the debate.

> A growing number of oil-industry chieftains are endorsing an idea long deemed fringe: The world is approaching a practical limit to the number of barrels of crude oil that can be pumped every day. Some predict that, despite the world's fast-growing thirst for oil, producers could hit that ceiling as soon as 2012. This rough limit — which two senior industry officials recently pegged at about 100 million barrels a day — is well short of global demand projections over the next few decades. Current production is about 85 million barrels a day.... The new adherents — who range from senior Western oil-company executives to current and former officials of the major world exporting countries — ...share a belief that a global production ceiling is coming for other reasons: restricted access to oil fields, spiraling costs and increasingly complex oil-field geology.[86]

Today, the U.S. economy is as reliant on oil and gas as ever. Alternative fuel development has risen and fallen with the price of oil, but has yet to increase its relative share of U.S. consumption. Unconventional sources of hydrocarbons — such as tar sands, oil shale and coalbed methane — are neither cheap nor easy to produce. Clearly, however, the better we become at finding and using petroleum economically, the more likely we are to hold our petroleum consumption to sustainable levels and foster the development of alternatives.

ing in Gulf of Mexico waters deeper than 5,000 feet.[82]

Other challenges exist in producing more of the hydrocarbons we have already discovered using EOR technologies. For Texas, with its mature producing fields, more EOR is a significant opportunity. The Bureau of Economic Geology (BEG) at UT-Austin estimates that an additional three billion barrels of Texas oil could be produced if sources of CO_2 can be provided for EOR.[83]

BEG announced recently that it will be coordinating research by seven major oil-related companies over three years to determine if nanomaterials — cutting-edge materials created in a lab on an infinitesimally small scale — have the potential to improve EOR. One possible application under review is injecting nanomaterials into oil and gas reservoirs where they could link together and serve as sensors to help petroleum engineers monitor oil and gas reservoirs.[87]

The federal government is funding research to determine if pumping carbon dioxide into mature oil and gas fields will increase yield and at the same time sequester CO_2, a known greenhouse gas.[88] And other researchers are working to find better materials to use to find, recover and use petroleum products.[89]

Oil and natural gas built modern Texas. Although production rates for both reached their peaks in the early 1970s, the industry still remains a major factor in the state's economy.

Texas' oil and natural gas production is expected to continue declining for the foreseeable future, but employment numbers and wages should remain steady or increase slightly through 2014.[90]

Texas will be a preeminent oil and gas producer for as long as the world relies on them. The development of alternative energy sources such as wind, solar and biomass is not likely to challenge Texas' preeminence; in fact, it stands to enhance Texas' position as an energy producer.

Endnotes

1 Texas Comptroller of Public Accounts, "Oil&Gas EmplWages&GSPJAN2008," Austin, Texas, April 3,

2008. (Internal data with supplementary data from U.S. Bureau of Economic Analysis.)

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3 Daniel Yergin, *The Prize: The Epic Quest for Oil, Money & Power* (New York: Touchstone, 1991), p. 23.

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