Chapter 3

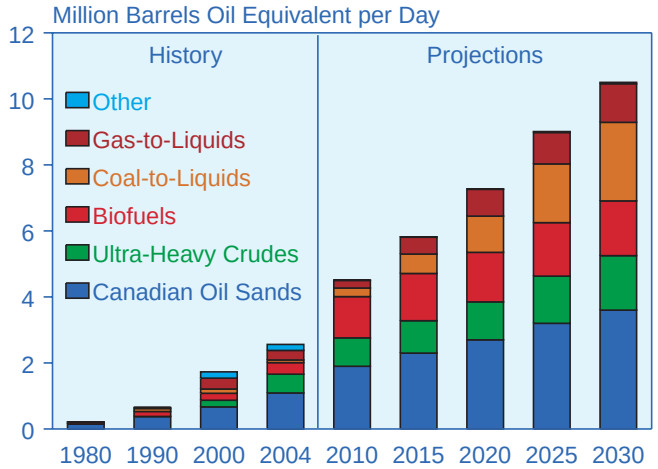
Petroleum and Other Liquid Fuels

World liquids consumption in the IEO2007 reference case increases from 83 million barrels per day in 2004 to 118 million barrels per day in 2030. Two-thirds of the increment is projected for use in the transportation sector.

In the *IEO2007* reference case, world consumption of petroleum and other liquid fuels[4] grows from 83 million barrels oil equivalent per day in 2004 to 97 million in 2015 and 118 million in 2030. The demand for liquids increases strongly in the projections, despite world oil prices that remain above $49 per barrel[5] throughout the period. Much of the overall increase in liquids consumption is projected for the nations of non-OECD Asia, where strong economic growth is expected.

To meet the increase in liquids consumption in the *IEO2007* reference case, liquids production is projected to increase by 14 million barrels per day from 2004 to 2015 and by an additional 20 million barrels per day from 2015 to 2030. OPEC producers[6] are expected to provide more than one-half of the additional production in 2015 (8 million barrels per day) and more than two-thirds in 2030 (23 million barrels per day).

Figure 32. World Unconventional Liquids Production in the Reference Case, 1980-2030



Note: "Other" includes shale oils and other unidentified sources of unconventional liquid fuels.

Sources: **1980-2004:** Energy Information Administration (EIA), *Short-Term Energy Outlook* (October 2006), and *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea.. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

In the reference case projections, sustained high world oil prices support a substantial increase in non-OPEC liquids production. Non-OPEC production in 2030 is projected to be 12 million barrels per day higher than in 2004, representing 35 percent of the increase in total world production over the 2004 total. The estimates of production increases are based on current proved reserves and a country-by-country assessment of ultimately recoverable petroleum, as well as the potential for unconventional liquids production.

The world oil prices in the *IEO2007* reference case—and in the high world oil price case—also are projected to make previously uneconomical, unconventional resources available. In 2004, world production of unconventional liquids totaled only 2.6 million barrels per day; in 2030, in the reference case, unconventional liquids production totals 10.5 million barrels per day (Figure 32) and accounts for nearly 9 percent of total world liquids production.

World Liquids Consumption

World liquids consumption in the *IEO2007* reference case increases to 118 million barrels per day (239 quadrillion Btu) in 2030, as the world continues to experience strong economic growth. Two-thirds of the increment in world liquids consumption in the reference case is projected for use in the transportation sector, where there are few competitive alternatives to petroleum (Figure 33). The industrial sector accounts for a 27-percent share of the projected increase, mostly for use in chemical and petrochemical processes.

The largest increases in consumption between 2004 and 2030 are projected for North America and non-OECD Asia, at 7 and 15 million barrels per day, respectively (Figure 34). Outside North America, liquids consumption in the OECD regions generally grows more slowly,

[4]"World Petroleum and Other Liquid Fuels" refers to all conventional crude oil and energy liquid substitutes (such as ethanol, coal-to-liquids, and gas-to-liquids), expressed in million barrels oil equivalent per day. Throughout this chapter, the term "liquids" is used to refer to petroleum and other liquid fuels.

[5]All prices are in real 2005 dollars, unless otherwise noted.

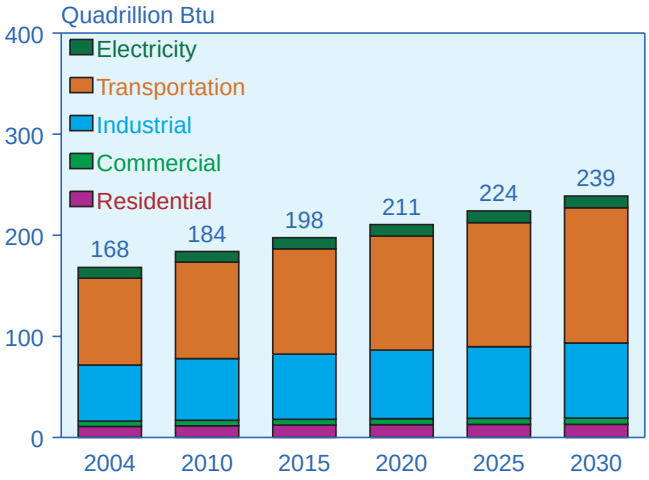
[6]Angola officially joined OPEC on February 1, 2007. In the remainder of this chapter, all references to OPEC include Angola. In addition, all time series have been updated to reflect country groupings as of March 1, 2007, so that Angola's liquids production is included in the OPEC totals for 1980 through 2030. Angola's production in 2030 is projected to be 3.1 million barrels per day.

reflecting expectations of slow growth or declines in population and slow economic growth in most of the OECD nations over the next two decades.

Strong expansion of liquids use is projected for the non-OECD countries, fueled by robust economic growth, burgeoning industrial activity, and rapidly expanding transportation use. The fastest growth in oil consumption is projected for the economies of non-OECD Asia, averaging 2.7 percent per year from 2004 to 2030. For the other non-OECD regions, annual consumption growth averages 1.0 percent in non-OECD Europe and Eurasia, 2.1 percent in the Middle East, 2.3 percent in Central and South America, and 2.2 percent in Africa.

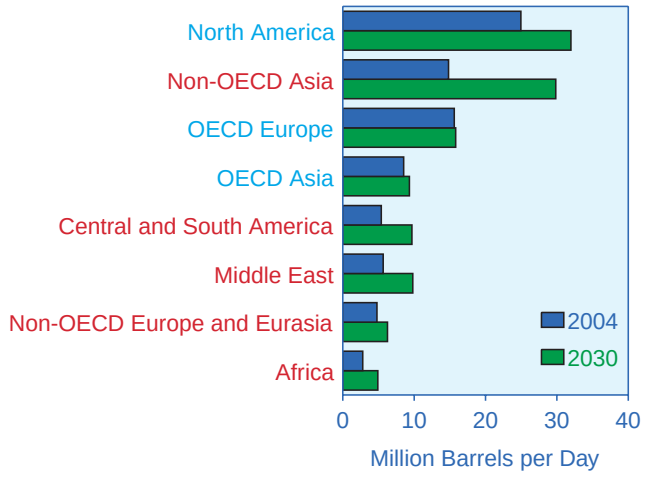
Non-OECD Asia accounts for 43 percent of the overall increase in world liquids consumption, with projected increases of 6.5 million barrels per day from 2004 to 2015 and another 8.5 million barrels per day from 2015 to 2030. China, India, and the other nations of non-OECD Asia are expected to experience combined economic growth of 5.8 percent per year from 2004 to 2030, the highest rate among all the world regions. The robust expansion of GDP projected for non-OECD Asia contributes to a 2.7-percent average annual increase in the region's liquids use.

Figure 33. World Liquids Consumption by Sector, 2004-2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

Figure 34. World Liquids Consumption by Region and Country Group, 2004 and 2030

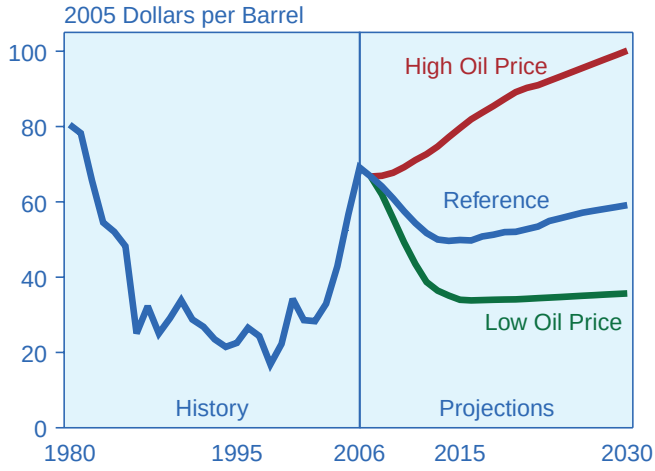


Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

World Oil Prices

The world oil price cases in this report are the same as those in EIA's *Annual Energy Outlook* 2007. In the reference case, world oil prices decline from $68 per barrel in 2006 to $49 per barrel in 2014, then rise to $59 per barrel in 2030 ($95 per barrel on a nominal basis). Total world liquids consumption rises to 118 million barrels per day in 2030 in the reference case. The low and high price cases are included to illustrate uncertainties in the reference case projections (Figure 35). In the low price case, world oil prices are projected to be $36 per barrel in 2030 ($58 per barrel on a nominal basis). In the high price case, oil prices are projected to be $100 per barrel in 2030 ($157 per barrel on a nominal basis). The projections for total liquids consumption in 2030 range from 103 million barrels per day in the high price case to 134 million barrels per day in the low price case, indicating the substantial range of uncertainty in the world's future oil markets.

Figure 35. World Oil Prices in Three Cases, 1980-2030



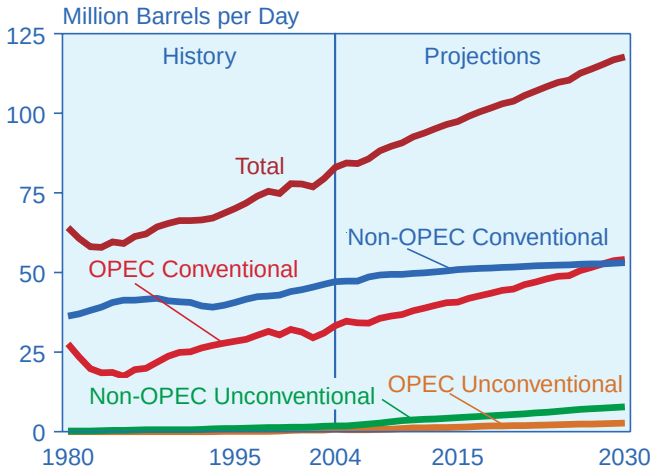
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, *Annual Energy Outlook 2007*, DOE/EIA-0383(2007) (Washington, DC, February 2007).

World Liquids Production

In the *IEO2007* reference case, world liquids production in 2030 exceeds the 2004 level by 35 million barrels per day (Figure 36). Increases in production are expected for both OPEC and non-OPEC producers; however, 65 percent of the total increase is expected to come from OPEC areas. In 2030, OPEC is expected to produce 57 million barrels per day and non-OPEC producers 61 million barrels per day in the reference case. Over the past two decades, the growth in non-OPEC liquids production has resulted in an OPEC market share substantially below its high of 52 percent in 1973. In 2004, OPEC produced 41 percent of the world's liquids supply. High oil prices, new exploration and production technologies, aggressive cost-reduction programs by industry, and the emergence of unconventional resources contribute to the outlook for continued growth in non-OPEC liquids production.

The reference case outlook for liquids production was formulated in a two-stage approach. The mid-term projections (through 2015) are based primarily on the current activities of the oil industry and national governments, including: current production volumes; recent rates of decline in output from producing fields; planned exploration, development, and enhanced oil recovery activities; country-specific policies and fiscal regimes; and current conflicts and social unrest that could interrupt production and make incremental investments more risky. After 2015, the reference case assumes that production decisions are made primarily on economic grounds, based on assessments of the resource base, with less weight placed on current political conditions.

Figure 36. OPEC and Non-OPEC Conventional and Unconventional Liquids Production, 1980-2030



Sources: **1980-2004:** Energy Information Administration (EIA), *Short-Term Energy Outlook* (October 2006), and *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea.. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

The *IEO2007* reference case projects greater reliance on OPEC oil supplies than was anticipated in last year's outlook. In *IEO2006*, OPEC's total liquids production (excluding Angola) was projected to increase by nearly 15 million barrels per day from 2003 to 2030; in *IEO2007*, the projected increase in OPEC production (excluding Angola) is about 22 million barrels per day over the same period. An extensive review of anticipated investment in exploration and production through 2015 was conducted for *IEO2007*. As a result, the projections of non-OPEC supply from several key producers were lowered. However, the investment that several OPEC members (notably, Saudi Arabia and Angola) currently are making to expand their oil production capacity is expected to more than offset the slower expansion of non-OPEC supply projected in this year's outlook.

There are several regions where production is restrained through 2015 in the reference case. For instance, in the key resource-rich countries of Mexico and Venezuela, expected investment levels are lower than those assumed in the *IEO2006* reference case. In both countries, liquids production is projected not to expand (and, in Mexico, to decline) until after 2015, when economic decisions on investment allow production to improve. Also, North Sea production is projected to decline more rapidly than in last year's outlook. The rate of decline in North Sea production over recent years has been higher than observed in earlier years, and economics do not support a reversal of the declining trend in the *IEO2007* reference case. In Iran and Iraq, political developments are assumed to keep production levels fairly flat until after 2015, when investment and production are projected to grow strongly through 2030.

IEO2007 includes supply estimates for the low and high world oil price cases, based on the availability of world crude oil resources. In the high price case, worldwide crude oil resources are assumed to be 15 percent smaller and therefore more expensive to produce than in the reference case, and the preferred production levels of OPEC producers are reduced. In the low price case, worldwide crude oil resources are assumed to be 15 percent larger and therefore less expensive therefore to produce than in the reference case, and the preferred production levels of OPEC producers are increased. In each of three oil price cases, a business-as-usual oil market environment is assumed. The *IEO2007* cases do not consider disruptions in oil production for any reason (war, terrorist activity, weather, geopolitics).

Non-OPEC Production

The world oil prices projected in the *IEO2007* reference case allow non-OPEC suppliers to expand their production through 2030. Non-OPEC production increases

steadily in the projections, from 49 million barrels per day in 2004 to 61 million barrels per day in 2030, as high prices attract investment in areas previously considered uneconomical. The non-OPEC market share in 2030, however, at 52 percent of the world's liquids production, is lower than its 2004 share of 59 percent.

Non-OPEC conventional liquids production in the reference case increases from 47 million barrels per day in 2004 to 51 million barrels per day in 2015 and 53 million barrels per day in 2030, and unconventional liquids production from non-OPEC suppliers rises to 4 million barrels per day in 2015 and 8 million barrels per day in 2030. In the high world oil price case, non-OPEC unconventional liquids production rises to 11 million barrels per day in 2030, as compared with 4 million barrels per day in 2030 in the low price case, where most unconventional liquids are not economically competitive.

North Sea production is projected to decline more rapidly in the *IEO2007* reference case than was projected in *IEO2006*. Production from Norway, OECD Europe's largest producer, appears to have peaked at about 3.4 million barrels per day in 2001, and it is projected to continue declining to about 1.4 million barrels per day in 2030 as the larger and older fields mature. Production from the United Kingdom, which peaked in 1999 at 3.0 million barrels per day, is projected to fall to 0.5 million barrels per day in 2030.

Oil production in the non-OECD Europe and Eurasia region is projected to reach nearly 15.0 million barrels per day in 2015, based in large part on the potential investment outlook for the Caspian Basin region, where long-term production potential still is regarded with considerable optimism. Caspian output more than doubles from the 2004 level to 4.3 million barrels per day in 2015 in the reference case and increases steadily thereafter. Current uncertainty about export routes from the Caspian Basin region is assumed to be resolved.

North African producers Egypt and Tunisia produce mainly from mature fields, and the *IEO2007* reference case assumes few additions to resources in the future. As a result, their production volumes decline gradually in the projections. In East Africa, Sudan is expected to produce significant volumes by the end of this decade, with the potential to exceed 700,000 barrels per day in 2010. Eritrea, Somalia, and South Africa also have some resource potential, but they are not expected to produce significant volumes until late in the projections.

Several West African producers—Cameroon, Chad, Congo (Brazzaville), Equatorial Guinea, Gabon, Mauritania, Niger, Sao Tome and Principe, and Ivory Coast—are expected to reap the benefits of substantial exploration activity, especially if current high oil prices persist. West African producers with offshore tracts are expected to increase output by up to 1.1 million barrels per day by the end of the projection period.

Oil producers in the Pacific Rim are expected to increase their production volumes as a result of enhanced exploration and extraction technologies. India's deepwater prospects are expected to show some encouraging production increases in this decade, with the potential for significant increases near the end of the projection period. China's conventional oil production is projected to decline slightly, to about 3.3 million barrels per day in 2030. Vietnam's long-term production potential is viewed with considerable optimism, although exploration activity has been slower than originally anticipated. Output from Vietnamese fields is projected to reach 504,000 barrels per day in 2015.

Malaysia is not expected to find significant new reserves; its output has already peaked and is expected to decline gradually through the end of the projection period, to less than 500,000 barrels per day in 2030. Papua New Guinea continues to add to its proved reserves and is expected to achieve production volumes approaching 110,000 barrels per day in 2015, followed by only a modest decline over the remainder of the projection period. Exploration and test-well activity have pointed to some production potential for Bangladesh and Myanmar (formerly Burma), but significant output is not expected until after 2010.

In North America, U.S. output that rises to 10.1 million barrels per day in 2020 and remains fairly flat through the end of the projection period is expected to be supplemented by significant production increases in Canada. Canada's conventional oil output contracts steadily in the reference case, by about 0.5 million barrels per day over the next 25 years, but an additional 2.5 million barrels per day of unconventional output from oil sands projects more than offsets the decline in conventional supplies. Since the publication of *IEO2006*, Mexico's state oil company, Petróleos Mexicanos (Pemex), has announced annual production decline rates of 14 percent in its largest oil field at Cantarell [***1***]. The *IEO2007* reference case does not anticipate adequate investments through 2015, and as a result, production in Mexico is projected to fall to 3.0 million barrels per day in 2015 (see box on page 33). *IEO2007* assumes that declining revenue from oil production in Mexico ultimately will encourage government action to increase investment and technology access in the petroleum sector after 2015. Given the country's available resource base, such action eventually should reverse the decline in production.

Liquids producers in South America have potential for increasing output over the next decade. Brazil became a million barrel per day producer of crude oil in 1999, with considerable production potential waiting to be tapped. Brazil's production rises throughout the projection

Reassessing the Potential for Oil Production in Mexico

Projections for Mexico's crude oil production in *IEO2007* are much lower than those in *IEO2006*. In last year's outlook, oil production in Mexico was projected to increase steadily, to 5.0 million barrels per day in 2030, despite an anticipated decline in production from the country's largest oil field, Cantarell (see map on page 34).[a] *IEO2007*, instead, projects a decline to 3.0 million barrels per day in 2012, followed by a gradual recovery to 3.5 million barrels per day in 2030. The new assessment reflects the anticipated decline in Cantarell production, assumptions about announced projects and recent discoveries, and long-term assumptions about economic motivations and national oil industry policy that better reflect the country's production potential.

Cantarell is, by far, Mexico's most important oil field today. In 2004, Cantarell held more than 26 percent of Mexico's total remaining oil reserves and produced 2.1 million barrels per day, accounting for more than 61 percent of the country's total crude oil output.[b] Since its peak production in 2004, Cantarell has been in decline. According to Lui Ramirez Corzo, the former president of Pemex, the Cantarell decline rate is likely to average 14 percent per year from 2007 to 2015, implying that Pemex will have to develop other fields if it is to offset the decline.[c]

Crude oil production from the KMZ complex—consisting of the Ku, Maloob, and Zaap fields—has been discussed as a possible new source of liquids production. There have been reports that the complex could produce enough crude oil to compensate for the yearly reduction in production from Cantarell.[d] In 2005, the combined production of the KMZ fields was just 316 thousand barrels per day, or about 16 percent of Cantarell's production in the same year; however, Pemex has estimated that KMZ could produce 800 thousand barrels per day by 2008. Achieving that goal would require 35-percent annual increases in production from KMZ from 2006 to 2008.

Although increasing crude oil production at KMZ would lessen the degree to which the Cantarell decline affects Mexico's total output of crude oil over the next few years, total proved ultimately recoverable reserves at the complex are only 21 percent as large as those at Cantarell. Consequently, KMZ production cannot be sustained at the levels necessary to counteract Cantarell's decline in the long run. If Cantarell does decline at the expected rate, production at the KMZ complex would have to increase by about 17 percent per year to offset the lost production. Since 1993, when the three major fields at KMZ came on line, annual production increases have averaged 4 percent—significantly less than would be necessary to maintain Mexico's current level of output. The *IEO2007* reference case projects modest growth for KMZ production as a result of nitrogen injection.

The Tabasco state, containing the Jujo and Tecominoacan fields, is also frequently mentioned as an oil-producing region with the potential to compensate for some of Cantarell's decline; however, the two fields have combined proven ultimate recoverable reserves of only 1,690 million barrels, or 11 percent the size of Cantarell. In addition, their production levels have been declining for almost two decades, and in 2005 they produced a combined total of only 72 thousand barrels per day. Pemex has announced plans to increase production from the Jujo and Tecominoacan fields significantly by using nitrogen injection, but even with enhanced recovery, it is unlikely that their output will be sufficient to slow the rate of decline in Mexico's total crude oil output beyond the short term.

The most promising possibility for offsetting the impact of Cantarell's decline on the rest of Mexico's crude oil production is deepwater production in the Gulf of Mexico, where recent discoveries include Chuktah-201, Nab-1, Noxal-1, and Lacach-1 (still under construction). Production levels from the deepwater fields will depend on Pemex's financial ability to implement the technology needed to access them. To date, the deepest production achieved by Pemex has been 3,068 feet. Lacach-1 is planned to reach 3,241 feet.[e] In the U.S. Gulf of Mexico, however, drilling depths routinely exceed 6,500 feet and can be more than 9,800 feet.

Pemex has been discussing the possibility of service contracts with foreign oil companies that have experience in exploring deepwater reserves, but agreements have yet to be reached. So far, the service agreements

(continued on page 34)

[a]The Cantarell complex comprises the Akal, Nohoch, Chac, Akal, Kutz, Ixtoc, and Sihil fields. The largest, Akal, produced 2,079 thousand barrels per day or 90 percent of Cantarell's crude production in 2004.

[b]I.H.S. Energy database. Unless otherwise noted, all data cited in this text box were obtained or derived from the I.H.S. Energy database.

[c]A. Harrup, "Pemex CEO Says Cantarell Decline by Average of 14 Percent per Year," Dow Jones Newswires (November 16, 2006).

[d]Pemex Online, Investor Relations, "Issues Related to the Cantarell Complex," (August 12, 2005), web site http://www.pemex.com/index.cfm?action=content&sectionID=8&catID=428&subcatID=3679.

[e]Pemex Online, web site www.pemex.com/files/content/dcf_ccw_0609_i_061105.pdf.

Reassessing the Potential for Oil Production in Mexico (Continued)

Mexico's Major Southern Offshore Oil Fields

Source: I.H.S. Energy Database, web site http://energy.ihs.com.

offered by Pemex would return set fees to foreign companies rather than allowing them to own shares of the oil produced or discovered, because a clause in the Mexican constitution bars foreign investment in the oil industry. Although the clause has allowed Pemex to maintain ownership of all its oil reserves, it also has prevented it from benefiting from technological advances that have allowed other national and major independent oil companies to improve their production opportunities.

Promising deepwater discoveries in the Gulf are taken into consideration in this year's assessment of Mexico's oil production potential; however, the *IEO2007* reference case assumes a considerable time lag between the discoveries and the date when Pemex will have the technology necessary to develop the fields effectively, based on assumptions both about the technology and about the financial resources available to exploit the deepwater resources. Pemex spent about $4.5 billion on deepwater exploration from 2000 to 2004, and it estimates that an additional $15 billion will be needed over the next 15 years to continue their development. Other estimates of the necessary capital investment are as high as $10 billion annually.

Financial resource estimates affect not only the *IEO-2007* assumptions about Mexico's deepwater resource development but also the assumptions about Pemex's general exploration and development programs. Although Pemex increased the amount of funding allocated to exploration and development programs in 2005, it spent only $10.3 billion in 2004 and $10.5 billion in 2005.[f] By some estimates, Pemex may need to invest as much as $32 billion annually in exploration and development to prevent a sharp decline in oil production.[g,h] The lack of available funds is largely

(continued on page 35)

[f]Pemex Online, Investor Relations, "Annual Report 2005: Business Highlights," web site www.pemex.com/files/dcf/Businesshighlights2005.pdf. Assumed conversion rate is $0.09147 per peso.

[g]A. Harrup, "Pemex CEO Says Cantarell Decline by Average of 14 Percent per Year," Dow Jones Newswires (November 16, 2006).

[h]C. Bremer, "Analysis—Mexico Seen Struggling To Stem Oil Output Decline," *World Oil Market Update* (January 18, 2007).

Reassessing the Potential for Oil Production in Mexico (Continued)

attributed to the redirection of company profits by the Mexican Congress to support government programs.

Mexico's Congress annually approves the funding for and taxation of Pemex, incorporating the expenses and revenues into the national budget. Although Pemex typically has shown a net profit before taxes in recent years, the government has not returned sufficient revenues to the company for it to book a net profit after taxes. Between 2001 and 2005, taxes on Pemex operations averaged $3.8 billion more than its pre-tax income. As a result, Pemex has been unable independently to increase investment in exploration.

IEO2007 assumes that the trend of heavy taxation and minimal government financial support for expanding exploration activities will continue in the near term. Thus, over the period from 2006 to 2015, the reference case projects an annual decline in Mexico's oil production. After 2015, it is assumed that changes in current oil industry regulations, whether they concern taxation rates or rules about foreign investment in the sector, will be made when the country suffers a significant loss of profits from declining oil production. The current assumptions incorporate several different time lags for the implementation of new investment policies and the impact of increased funding for exploration and development. A 4-year delay, based on the world average, is incorporated into the long-term outlook for production increases after a significant increase in funding for exploration and development funding.

period, to 3.9 million barrels per day of conventional production and 0.5 million barrels per day of unconventional production in 2030. Colombia's current economic downturn and civil unrest have delayed development of its oil production infrastructure, but its output is expected to reach 700,000 barrels per day in 2015, with continued modest increases over the remainder of the projection period. Although the current political situation in Ecuador is in transition, there is still optimism that Ecuador will increase production volumes over the projection period.

OPEC Production

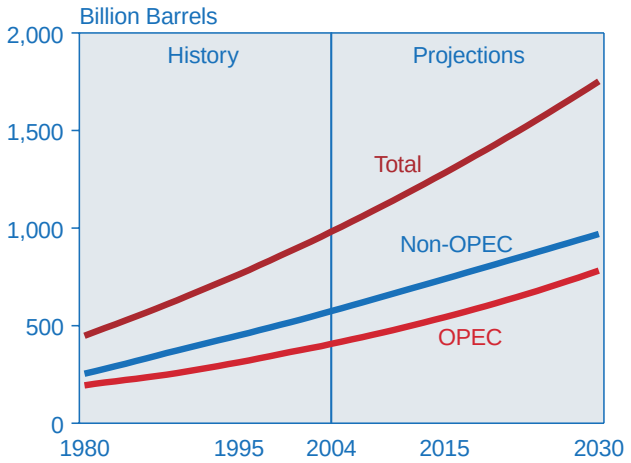
It is generally acknowledged that OPEC members with large reserves and relatively low costs for expanding production capacity can accommodate sizable increases in the world's petroleum consumption. In the *IEO2007* reference case, the production call on OPEC suppliers grows at an annual rate of 2.0 percent through 2030 (Figure 37).

Amidst enormous uncertainty, Iraq's role in OPEC in the next several years will be of particular interest. In 1999, Iraq expanded its production capacity to 2.8 million barrels per day in order to reach the maximum export revenue (slightly more than $5.2 billion) allowed under United Nations Security Council resolutions. Iraq's oil production capacity in 2007 is assumed to be 2.0 million barrels per day [2]. Iraq has indicated a desire to expand production aggressively, to more than 6 million barrels per day, once the security and political situation in the country has stabilized. Preliminary discussions of exploration projects have already been held with a number of potential outside investors. In the *IEO2007* reference case, Iraq's oil production is projected to reach 3.3 million barrels per day in 2015 and 5.3 million barrels per day in 2030.

Oil production in Iran is projected to increase only slightly in the early years of the reference case, from 4.1 million barrels per day in 2004 to 4.3 million barrels per day in 2015, despite the country's sizable resource base. In the long run, Iran's oil production is projected to reach 5.0 million barrels per day in 2030.

Kuwait and the United Arab Emirates (UAE) are expected to follow similar growth paths in their oil production sectors. In 2004, levels of production from the two countries were 2.5 and 2.8 million barrels per day, respectively; in 2015, they are projected to be 3.2 and 3.8 million barrels per day, respectively; and in 2030 they

Figure 37. Cumulative World Production of Crude Oil and Lease Condensates in the Reference Case, 1980-2030



Sources: **1980-2004:** Energy Information Administration (EIA), *Short-Term Energy Outlook* (October 2006), and *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

are projected to be 4.1 and 4.9 million barrels per day, respectively. Qatar's production is projected to grow from 1.0 million barrels per day in 2004 to 2.9 million barrels per day in 2030, with liquids other than crude oil expected to provide more than half the increase.

In the past, Saudi Arabia—with its very low development and production costs per barrel of output—has maintained 1 to 5 million barrels per day of spare production capacity, which has given it considerable market power. It is expected to maintain average spare capacity of 1 to 2 million barrels per day in the future. In the reference case, Saudi Arabia's production is projected to be 9.4 million barrels per day in 2015 and 16.4 million barrels per day in 2030.

Angola became a 1.1 million barrel per day producer in 2004, and the results of deepwater exploration indicate that its production could increase to as much as 4.0 million barrels per day by 2030. The rapid increase in Angola's production demonstrates the importance of political stability, international investment, and technology advances. Angola's oil production languished for the most part during a 20-year civil war, which ended in 2003. It was not until the late 1990s, when prospects for a peaceful resolution were taking shape, that the foreign investment needed to support offshore production began to materialize. Angola's decision to join OPEC in January 2007 is not expected to slow the increase in its oil production, given that other OPEC members were granted some flexibility while they were rapidly expanding their production.

In the *IEO2007* reference case, OPEC members outside the Persian Gulf (excluding Angola) are projected to increase their production capacity only moderately, in part because of the relatively high cost of capacity expansion in most of the member countries. There is some optimism surrounding Nigeria's potential for offshore production. For Algeria and Libya, the reference case projects an increase of 1.2 million barrels per day in their combined liquids production from 2004 to 2015, but after 2015 it is projected to remain fairly flat. Indonesia's production is expected to decline over the projection period, and Venezuela is expected to see some increase in production after 2015. Tables G1-G9 in Appendix G show the ranges of production potential for both OPEC and non-OPEC producers.

Geopolitical issues in a number of the OPEC countries, including Iraq, Iran, Venezuela, and Nigeria, make it difficult to estimate future production levels. As a result, there is a high level of uncertainty associated with the reference case assumptions and projections for OPEC production through 2030.

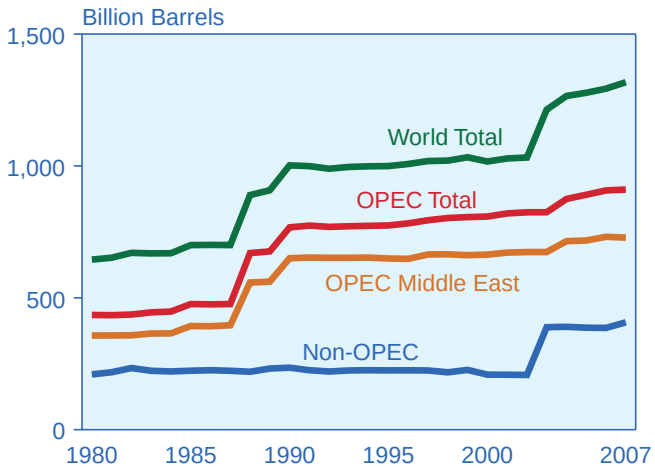
The *IEO2007* high price case provides one scenario in which OPEC limits production. Assuming lower availability of non-OPEC conventional resources, OPEC would be able to exercise greater influence on oil prices. Production of both OPEC and non-OPEC conventional liquids is projected to increase in the high price case, but at a slower rate than projected in the reference case. Because higher prices would make more unconventional liquids production economically competitive, non-OPEC liquids production is projected to be nearly the same in the reference and high price cases, with unconventional liquids replacing most of the reduction in conventional production that is projected in the high world oil price case.

The *IEO2007* low price case assumes greater availability of non-OPEC conventional resources than in the reference case. Oil prices fall as non-OPEC production expands, and OPEC producers must increase production to meet their revenue requirements. As a result, OPEC's options for influencing the market are limited. In the low price case, OPEC production is projected to be about the same as in the reference case, but with lower total revenues.

Oil Reserves and Resources

Historically, estimates of world oil reserves have generally trended upward (Figure 38) [3]. As of January 1, 2007, proved world oil reserves, as reported by *Oil & Gas Journal*,[7] were estimated at 1,317 billion barrels—24 billion barrels (about 2 percent) higher than the estimate

Figure 38. World Crude Oil Reserves, 1980-2007



Note: Reserves include crude oil (including lease condensates) and natural gas plant liquids.

Sources: **1980-1993:** "Worldwide Oil and Gas at a Glance," *International Petroleum Encyclopedia* (Tulsa, OK: PennWell Publishing, various issues). **1994-2007:** *Oil & Gas Journal* (various issues).

[7]Proved reserves, as reported by the *Oil & Gas Journal*, are estimated quantities that can be recovered under present technology and prices. Oil reserves reported by the *Oil & Gas Journal* are compiled from voluntary survey responses and do not always reflect the most recent changes. Changes made to individual countries' reserves during 2006 are not likely to be reflected in the reserves reported here.

for 2006 [*4*] (Table 3). In addition to growth in remaining oil reserves, production from conventional crude oil and condensate reserves, natural gas plant liquids, Canadian oil sands, and Venezuelan ultra-heavy oil during 2006 were estimated to be 30 billion barrels. Taken together, the reserve increases and production imply that 54 billion barrels of reserve discoveries and growth occurred during 2006, or an increase of about 4 percent.

Reserve estimates for oil, natural gas, and coal are difficult to develop. EIA develops estimates of reserves for the United States but not for foreign countries. As a convenience to the public, EIA makes available global reserve estimates from the *Oil & Gas Journal*, *World Oil*, and BP's *Statistical Review of World Energy*, and uses the data in its analyses.

Proved reserves of crude oil are the estimated quantities that geological and engineering data demonstrate with reasonable certainty can be recovered in future years from known reservoirs, assuming existing economic and operating conditions. Companies whose stocks are publicly traded on U.S. stock markets are required by the Securities and Exchange Commission (SEC) to report their holdings of domestic and international proved reserves, following specific guidelines. Country-level estimates of proved reserves are developed from the data reported to the SEC, from foreign government reports, and from international geologic assessments. Estimates are not always updated annually, and some countries invest in exploration only to maintain a target level of proved reserves. Thus, historical data series may be relatively flat over some periods, with sudden jumps in others.

Since 2000, the largest net increase in estimated proved oil reserves has been made in Canada, with the addition of 174 billion barrels of Canadian oil sands as a conventional reserve.[8] Iranian oil reserves have increased by 46.6 billion barrels, or 52 percent, since 2000. Kazakhstan has had the third-largest increase, 24.6 billion barrels, since 2000. The 10 countries with the largest net increases in reserves between 2000 and 2007 are listed in Table 4. According to *Oil & Gas Journal*, 56 percent of the world's total proved oil reserves are located in the Middle East (Figure 39). Among the top 20 reserve holders in 2007, 11 are OPEC member countries that, together, account for 65 percent of the world's total reserves

Table 3. World Oil Reserves by Country as of January 1, 2007
(Billion Barrels)

Country	Oil Reserves
Saudi Arabia	262.3
Canada	179.2
Iran	136.3
Iraq	115.0
Kuwait	101.5
United Arab Emirates	97.8
Venezuela	80.0
Russia	60.0
Libya	41.5
Nigeria	36.2
Kazakhstan	30.0
United States	21.8
China	16.0
Qatar	15.2
Mexico	12.4
Algeria	12.3
Brazil	11.8
Angola	8.0
Norway	7.8
Azerbaijan	7.0
Rest of World	65.5
World Total	**1,317.4**

"Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 104, No. 47 (December 18, 2006), pp. 24-25.

Table 4. World Oil Reserves: Ten Largest Gains and Losses, 2000-2007, by Country
(Billion Barrels)

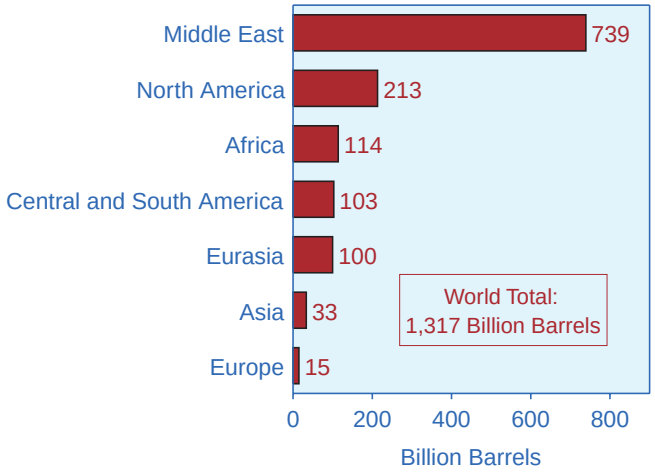
Country	Change in Oil Reserves
Canada	174.3
Iran	46.6
Kazakhstan	24.6
Nigeria	13.7
Libya	12.0
Qatar	11.5
Russia	11.4
Venezuela	7.4
Azerbaijan	5.8
Kuwait	5.0
Romania	-0.8
Malaysia	-0.9
Yemen	-1.0
Colombia	-1.1
Saudi Arabia	-1.2
United Kingdom	-1.3
Australia	-1.3
Norway	-2.9
China	-8.0
Mexico	-16.0

"Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 104, No. 47 (December 18, 2006), pp. 24-25.

[8] As reported by the Canadian Association of Petroleum Producers. BP's *Statistical Review of World Energy* classifies roughly 12 billion barrels of oil sands as reserves, based on the amount that is "under active development."

(Table 3). The largest declines in oil reserves between 2000 and 2007 were reported in Mexico (16.0 billion barrels), China (8.0 billion barrels), Norway (2.9 billion barrels), Australia (1.3 billion barrels), and the United Kingdom (1.3 billion barrels).

Figure 39. World Proved Oil Reserves by Geographic Region as of January 1, 2007



Source: "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 104, No. 47 (December 18, 2006), pp. 24-25.

The most common measure of the adequacy of proved reserves relative to annual production is the reserve-to-production (r/p) ratio, which describes the number of years of remaining production from current proved reserves at current production rates. For the past 25 years, the U.S. r/p ratio has been between 9 and 12 years, and the top 40 countries in conventional crude oil production rarely have reported r/p ratios below 8 years. The major oil-producing countries of OPEC have maintained r/p ratios of 20 to 100 years (Table 5).

References

1. T. Murray, "Pemex To Fund Increased Share of Capital Spending from Operating Cashflow," *The Oil Daily*, Vol. 56, No. 100 (May 25, 2006), p. 4.
2. International Energy Agency, *Oil Market Report* (Paris, France, May 2006), p. 14, web site http://omrpublic.iea.org.
3. Energy Information Administration, "International Petroleum (Oil) Reserves and Resources," web site www.eia.doe.gov/emeu/international/oilreserves.html.
4. "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 104, No. 47 (December 18, 2006), pp. 24-25.

Table 5. World Crude Oil and Lease Condensate Production and Reserve-To-Production Ratios by Country, 2005

Country	2005 Production (Million Barrels per Day)	2005 Share of World Production (Percent)	Reserve-to-Production Ratio (Years)
Saudi Arabia	9.55	13.3	75
Russia	9.04	12.6	18
United States	5.18	7.2	11
Iran	4.14	5.7	83
China	3.61	5.0	14
Mexico	3.33	4.6	12
Norway	2.70	3.7	9
Nigeria	2.63	3.6	37
United Arab Emirates	2.54	3.5	106
Kuwait	2.53	3.5	110
Venezuela	1.98	2.7	107
Iraq	1.88	2.6	168
Algeria	1.80	2.5	18
United Kingdom	1.65	2.3	7
Brazil	1.63	2.3	18
Libya	1.63	2.3	65
Canada	1.28	1.8	10
Angola	1.26	1.7	12
Indonesia	1.07	1.5	12
Kazakhstan	1.05	1.5	23
Qatar	0.84	1.2	50
Oman	0.77	1.1	19
Malaysia	0.75	1.0	11
Argentina	0.70	1.0	10
India	0.66	0.9	22

Sources: **2005 Production:** Energy Information Administration, *Short-Term Energy Outlook* (October 2006). **Reserves:** "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 104, No. 47 (December 18, 2006), pp. 24-25.