World Oil Markets

In the IEO2004 forecast, OPEC export volumes are expected to more than double while non-OPEC suppliers maintain their edge over OPEC in overall production. Prices are projected to rise gradually through 2025 as the oil resource base is further developed.

Throughout most of 2003, crude oil prices remained near the top of the range preferred by producers in the Organization of Petroleum Exporting Countries (OPEC), $22 to $28 per barrel for the OPEC "basket price." OPEC producers continued to demonstrate disciplined adherence to announced cutbacks in production. Throughout 2003, the upward turn in crude oil prices was brought about by a combination of three factors. First, a general strike against the Chavez regime resulted in a sudden loss of much of Venezuela's oil exports. Although the other OPEC producers agreed to increase their production capacities to make up for the lost Venezuelan output, the obvious strain on worldwide spare capacity kept prices high. Second, price volatility was exacerbated by internal conflict in Nigeria. Third, prospects for a return to normalcy in the Iraqi oil sector remained uncertain as residual post-war turmoil continued in Iraq.

Although the labor turmoil in Venezuela has ended and the Nigerian situation has stabilized, world oil prices are expected to remain above $30 per barrel (for West Texas Intermediate crude oil, in nominal dollars) throughout most of 2004, mainly because of low oil inventories, a surge in oil consumption in developing Asia, and the instability in Iraq. A slight softening of oil prices is anticipated in 2005 but is not expected to endure given OPEC's recent successes in market management behavior through production cutbacks. However, OPEC producers might find it more challenging to firm up oil prices over the next few years, given the expected increase in non-OPEC supply. They not only will have to demonstrate discipline within their own ranks but also must convince selected non-OPEC producers of the merits of production restraint. It remains to be seen whether such a coalition of OPEC and non-OPEC producers can demonstrate the restraint necessary to manage the market. Despite evidence that OPEC has achieved some of its price goals in recent years, production cutback strategies have historically had only limited success.

World oil consumption rose in 2003 by about 1.4 million barrels per day, with the industrialized nations accounting for about 55 percent of the increase. Demand in the developing nations rose by 0.7 million barrels per day, and developing Asia accounted for 81 percent of the increase. With the developing Asian economies no longer in recession, their current growth is beginning to show signs of a return to the rapid economic expansion of the early and mid-1990s. Latin America's oil demand continued to show only modest growth. In the former Soviet Union (FSU), where oil demand grew in 2000 for the first time in more than a decade, there was no increase in demand in 2003. In 2004, world oil demand is expected to grow by about 1.7 million barrels per day [***1***].

Historically, OPEC's market management strategies have often ended in failure. A string of successes over the past 5 years have been the result of tight market conditions characterized by low inventory levels and disciplined participation by OPEC members. Currently, spare production capacity worldwide—with the exception of two or three Persian Gulf members of OPEC—is negligible, and OPEC's consensus building is easier as a result. Non-OPEC production is expected to show significant increases in the near future, however, and several OPEC members have announced plans to expand production capacity over the next several years. In an oil market environment with substantial spare production capacity, it may be more difficult for OPEC to achieve unanimity among its members.

Although non-OPEC producers have been somewhat slow in reacting to higher oil prices, there remains significant untapped production potential worldwide, especially in deepwater areas. The lag between higher prices and increases in drilling activity seems to have increased in the aftermath of the low price environment of 1998 and 1999; nevertheless, non-OPEC production increased by 1 million barrels per day in 2002 and by an additional 900 thousand barrels per day in 2003, and it is expected to increase by an impressive 1.4 million barrels per day in 2004. More than one-half of the total increase in non-OPEC production over the next 2 years is expected to come from Russia and Kazakhstan, and most of the remainder is expected to come from the developing economies of the Atlantic Basin (Latin America and West Africa).

Incorporating the recent price turbulence into the construction of an intermediate- to long-term oil market outlook is difficult and raises the following questions: Will prices remain in OPEC's preferred range in response to production cutback strategies, or will the anticipated increase in non-OPEC production temper the price rise? Will the promising indications of robust economic growth be sustained in the developing

countries of Asia, or will there be a return to the severe recessions of 1997-1999? Will technology advances guarantee that oil supply development will move forward even if a low world oil price environment returns?

Although oil prices rose by almost $10 per barrel over the course of 2002 and remained high in 2003, with little promise of downward movement in 2004 because of low inventory levels, surging demand in developing Asia, and the situation in Iraq, such developments are not indicative of the trend in the *International Energy Outlook 2004* (*IEO2004*) reference case. In the short term, oil prices are expected to reflect the market uneasiness brought about by the continuing strife in Iraq. From anticipated high levels throughout 2004, oil prices are projected to decline briefly (through 2006), then rise by about 0.7 percent per year to $27 per barrel in 2025 (all prices in 2002 dollars unless otherwise noted). The economic recovery in Asia is almost complete, and demand growth in developing countries throughout the world is expected to be sustained at robust levels. Worldwide oil demand is projected to reach 121 million barrels per day by 2025, requiring an increment to world production capacity of about 44 million barrels per day over current levels. OPEC producers are expected to be the major suppliers of increased production, but non-OPEC supply is expected to remain highly competitive, with major increments to supply coming from offshore resources, especially in the Caspian Basin, Latin America, and deepwater West Africa.

Over the past 25 years, oil prices have been highly volatile. In the future, one can expect volatile behavior to recur principally because of unforeseen natural, political, and economic circumstances. It is well recognized that tensions in the Middle East, for example, could give rise to serious disruptions of normal oil production and trading patterns. On the other hand, significant excursions from the reference price trajectory are not likely to be sustained for long. High real prices deter consumption and encourage the emergence of significant competition from marginal but large sources of oil and other energy supplies. Persistently low prices have the opposite effects.

Limits to long-term oil price escalation include substitution of other fuels (such as natural gas) for oil; marginal sources of conventional oil that become reserves (i.e., economically viable) when prices rise; and nonconventional sources of oil that become reserves at still higher prices. Advances in exploration and production technologies are likely to bring down prices when such additional oil resources become part of the reserve base. The *IEO2004* low and high world oil price cases suggest that the projected trends in growth for oil production are sustainable without severe oil price escalation; however, some oil market analysts find this viewpoint overly optimistic, based on what they consider to be a significant overestimation of both proved reserves and ultimately recoverable resources.

Highlights of the *IEO2004* projections for the world oil market are as follows:

- The reference case oil price projection shows high prices persisting from 2003 into 2004 as a result of OPEC's market management strategies, low oil inventories, surging demand in developing Asia, and the post-war strife in Iraq, a brief decline through 2006, and a modest 0.7-percent average annual increase out to 2025.
- Deepwater exploration and development initiatives generally are expected to be sustained worldwide, with the offshore Atlantic Basin emerging as a major future source of oil production in both Latin America and Africa. Technology and resource availability can sustain large increments in oil production capability at reference case prices. The low price environment of 1998 and early 1999 did slow the pace of development in some prospective areas, especially the Caspian Basin region.
- Economic development in Asia is crucial to the long-term growth of oil markets. The projected evolution of Asian oil demand in the reference case would strengthen economic ties between Middle East suppliers and Asian markets.
- Although OPEC's share of world oil supply is projected to increase significantly over the next two decades, competitive forces are expected to remain strong enough to forestall efforts to escalate real oil prices significantly. Competitive forces (especially, production from nonconventional sources) operate within OPEC, between OPEC and non-OPEC sources of supply, and between oil and other sources of energy (particularly natural gas).
- The uncertainties associated with the *IEO2004* reference case projections are significant. The post-war strife in Iraq, the international war on terrorism, uncertain economic recovery in developing Asia and Japan, the success of China's economic reforms and its political situation, the potential for continued social unrest in Venezuela, Brazil's impact on other Latin American economies, and economic recovery prospects for the FSU all increase the risk of near-term political and policy discontinuities that could lead to oil market behavior quite different from that portrayed in the projections.
- Total world oil consumption is expected to increase by 1.9 percent per year over the projection period, from 77 million barrels per day in 2001 to nearly 121 million barrels per day in 2025. The transportation sector is the largest component of worldwide oil use today, and it is expected to account for an increasing share of total oil consumption in the future. Oil's

importance in other end-use sectors is likely to decline where other fuels are competitive, such as natural gas, coal, and nuclear, in the electric power sector, but currently there are no alternative energy sources that compete economically with oil for transportation uses. A review of developments in regional transportation sectors is included in this chapter to underscore the increments in oil production required to meet the projected growth in demand for transportation fuels.

World Oil Prices

The world oil price is defined as the annual average U.S. refiner's acquisition cost of imported crude oil. Three distinct world oil price scenarios are represented in *IEO2004*. The reference case represents EIA's current judgment regarding the expected behavior of OPEC producers in the mid-term, adjusting production to keep world oil prices in the $22 to $28 per barrel range. OPEC (particularly, the Persian Gulf nations) is expected to be the dominant supplier of oil in the international market in the mid-term, and its production choices will significantly affect world oil prices. The low world oil price case represents a future market in which all oil production becomes more competitive and plentiful. The high world oil price case represents a more cohesive and market-assertive OPEC, with lower production goals and other nonfinancial (geopolitical) considerations.

The near-term price trajectory in the *IEO2004* reference case is considerably different from that in *IEO2003*. Last year's reference case price path did not fully reflect the upward price pressure in 2003 brought about by the situations in Venezuela, Nigeria, and Iraq. In the longer term, oil prices in both the *IEO2004* and *IEO2003* reference cases are projected to rise gradually from 2005 through 2025, at an average annual rate of 0.7 percent. The price growth projected in both the *IEO2004* and *IEO2003* reference cases reflects the recognition that OPEC has been able to adhere to a production restraint strategy for the purpose of firming up prices. Three possible long-term price paths are shown in Figure 26. In the reference case, projected prices in 2002 dollars reach $27 per barrel in 2025. (In nominal dollars, the reference case price is expected to be around $51 per barrel in 2025.) In the low price case, prices are projected to be $17 per barrel in 2005 and to remain at about that level out to 2025. In the high price case, prices are projected to reach $34 per barrel in 2013 and to be around $35 per barrel in 2025. The leveling off in the high price case results from projected market penetration of alternative energy supplies that could become economically viable at that price (such as liquids from oil sands, natural gas, coal, biofuels, and oil shale).

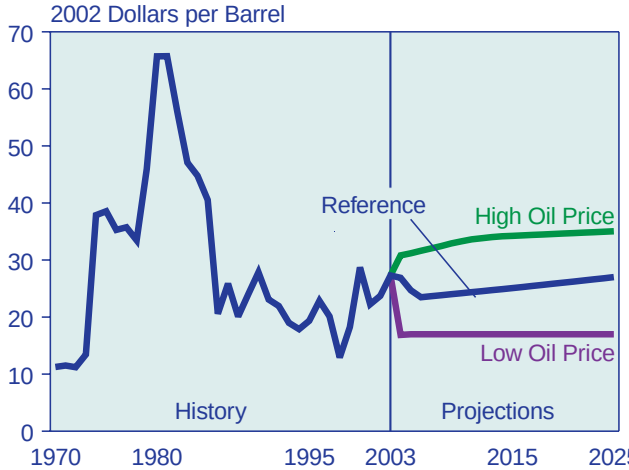
In all the *IEO2004* oil price cases, oil demand is expected to rise significantly over the projection period. The projected increase in oil consumption ranges from a low of 36 million barrels per day in the high price case to a high of 56 million barrels per day in the low price case. There is widespread agreement that resources are not a key constraint on world demand to 2025 (see box on page 37). Rather more important are the political, economic, and environmental circumstances that could shape developments in oil supply and demand.

World Outlook for Oil Use in the Transportation Sector

Energy use in the transportation sector is dominated by petroleum product fuels; and barring any increase in the penetration of new technologies, such as hydrogen-fueled vehicles, alternative fuels are not expected to become competitive with oil before 2025. Thus, the *IEO2004* reference case projection of 2.1-percent average annual growth in the world's total energy use for transportation from 2001 to 2025 (Figure 27) is paralleled by the forecast for transportation oil use.

Energy use for the transportation sector is poised for its strongest growth in developing Asia. China is the key market that will drive regional consumption growth. India is also on a rapid growth path, and the region's mid-sized markets, such as Thailand and Indonesia are projected to post strong growth. In China the number of cars has been growing by 20 percent per year, and the potential growth is almost unlimited. If the present patterns persist, China's car ownership would exceed the U.S. by 2030 [**2**].

Figure 26. World Oil Prices in Three Cases, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www. eia.doe.gov/iea/. **Projections:** 2003-2004—EIA, *Short-Term Energy Outlook*, on-line version (April 2004), web site www.eia.doe.gov/emeu/steo/pub/contents.html. 2004-2025—EIA, *Annual Energy Outlook 2004*, DOE/EIA-0383 (2004) (Washington, DC, January 2004).

United States

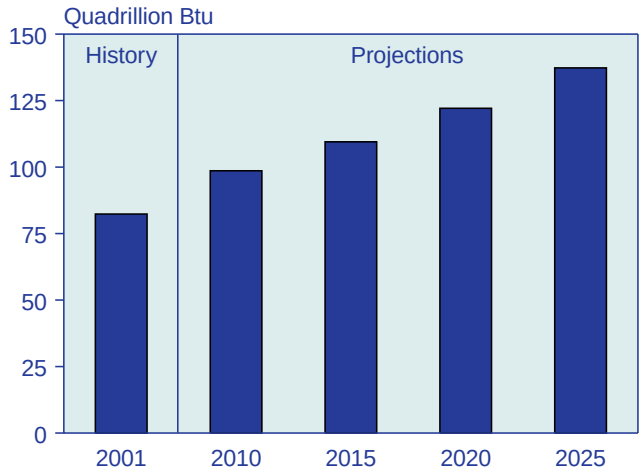
Demand for oil in the United States is projected to increase at an average rate of 1.5 percent per year from 2001 to the end of the forecast, reaching 28.3 million barrels per day in 2025. Demand for energy in the transportation sector is expected to grow rapidly as the result of a projected increase in per capita travel, along with a slower increase in fuel efficiency than was achieved over the past two decades due to projected stable fuel prices and the absence of new efficiency standards. Growth in U.S. energy demand for transportation averaged 2.0 percent per year in the 1970s but was slowed in the 1980s by rising fuel prices and new Federal efficiency standards that led to a slight increase in average vehicle fuel economy. In the *IEO2004* reference case, transportation energy demand in the United States is projected to grow from 26.6 quadrillion Btu in 2001 to 41.2 quadrillion Btu in 2025, and the transportation share of total energy use is projected to increase from 28 percent in 2001 to 30 percent in 2025 (Figure 28).

Fuel economy for the light-duty vehicle stock is projected to improve by 6 percent over the forecast period. Projected low fuel prices and higher personal incomes are expected to increase the demand for larger, more powerful vehicles; however, advanced technologies and materials are expected to provide increased performance and size while improving new vehicle fuel economy. Fuel economy standards for cars are assumed to stay at current levels, and light truck standards are expected to increase from 20.7 miles per gallon in 2001 to 22.2 miles per gallon by 2007 [***3***]. For the stock of freight trucks, fuel economy is projected to increase from 6.0 miles per gallon in 2002 to 6.5 miles per gallon in 2025. A larger gain (22.2 percent) is expected for aircraft.

Non-highway transportation modes accounted for about 20 percent of total U.S. transportation energy use in 2001, and their share is projected to be only 1 percentage point higher in 2025. Fuel consumption by U.S. domestic and international air carriers is projected to increase at an average rate of 1.8 percent per year, from 2.97 quadrillion Btu in 2001 to 4.3 quadrillion Btu in 2025. Energy use by railroad freight carriers is projected to increase by 0.9 percent per year, from 0.50 quadrillion Btu in 2001 to 0.57 quadrillion Btu in 2025, and energy use railroad passenger carriers is projected to increase by 1.8 percent per year, to 0.17 quadrillion Btu in 2025. Energy use by transit buses is projected to increase by 0.4 percent per year, to 0.26 quadrillion Btu in 2025 [***4***].

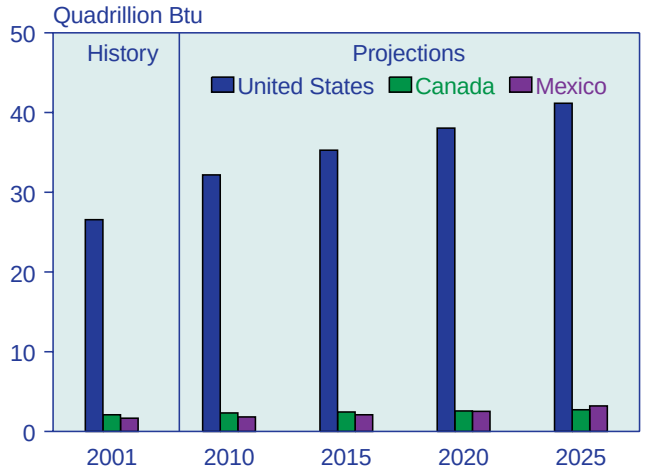
Alternative fuels are projected to displace some light-duty vehicle fuel consumption in 2025, in response to current environmental and State energy legislation intended to reduce oil use, such as the California Low Emission Vehicle Program, which sets sales mandates for low-emission, ultra-low-emission, and zero-emission vehicles [***5***]. Advanced technology vehicles, representing automotive technologies that use alternative fuels or require advanced engine technology, are projected to reach 3.9 million vehicle sales per year in the United States and make up 19 percent of total light-duty vehicle sales in 2025. Alcohol flexible-fueled vehicles are projected to continue to lead advanced technology vehicle sales, at 1.4 million vehicles in 2025. Hybrid electric vehicles, introduced into the U.S. market by Honda and Toyota in 2000, are expected to sell well: 750,000 units

Figure 27. World Transportation Energy Use, 2001-2025



Sources: **2001:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219 (2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2010-2025:** EIA, System for the Analysis of Global Energy Markets (2004).

Figure 28. Transportation Energy Use in North America, 2001-2025



Sources: **2001:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219 (2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2010-2025:** EIA, System for the Analysis of Global Energy Markets (2004).

are projected to be sold in 2010, increasing to 1.1 million units in 2025. Sales of turbo direct injection diesel vehicles are projected to increase to 716,000 units in 2010 and 1 million units in 2025 [*6*].

Eighty percent of the advanced technology sales in the forecast are expected to result from Federal and State mandates for fuel economy standards, emissions programs, or other energy regulations. Currently, manufacturers selling alcohol flexible-fueled vehicles receive fuel economy credits that count toward compliance with corporate average fuel economy regulations. In the forecast, the majority of projected gasoline hybrid, fuel cell, and electric vehicle sales result from compliance with low-emission vehicle programs in California, New York, Maine, Vermont, and Massachusetts.

Canada

With the lowest population growth among North American countries, estimated at 0.6 percent per year between 2001 and 2025, Canada's energy demand for transportation is projected to grow relatively slowly, from 2.1 quadrillion Btu in 2001 to 2.7 quadrillion Btu in 2025, and the transportation share of total energy use is projected to fall from 17 percent in 2001 to 15 percent in 2025. Canada's total refinery capacity has declined in the past decade as a result of reduced demand for refined products. The number of retail outlets in Canada has decreased steadily since 1990 [*7*].

Mexico

Oil consumption in Mexico is projected to rise by 2.5 percent per year in the forecast, to 3.5 million barrel per day in 2025. Over the same period, energy for transportation is projected to nearly double, from 1.7 quadrillion Btu in 2001 to 3.2 quadrillion Btu in 2025, and the transportation share of total energy consumption is projected to be 28 percent in 2025. Gasoline used in private cars is expected to account for most of the increase, in addition to some growth in consumption of liquefied petroleum gas (LPG), assuming that LPG will continue to be taxed at a lower rate than gasoline for environmental reasons [*8*].

Western Europe

Energy demand for transportation in Western Europe is projected to grow at a comparatively slow pace, from 15.5 quadrillion Btu in 2001 to 16.7 quadrillion Btu in 2025, and the transportation sector's share of total energy use is projected to decline from 23 percent in 2001 to 21 percent in 2025. Low population growth, high taxes on transportation fuels, and environmental policies are expected to slow the rate of energy demand growth in Western Europe to an average rate of 0.3 percent per year.

Oil is projected to remain Western Europe's largest energy source, with demand increasing by 0.5 percent per year on average from 2001 to 2025. Almost all of the projected increase in demand for oil is expected to be for transportation. Demand for aviation fuel shows the fastest growth among transportation fuels in the forecast, and demand for diesel fuel is projected to increase more rapidly than demand for gasoline, because most countries in the region are expected to keep diesel taxes lower than those for gasoline.

The European Commission has been pushing for deregulation of mass transit systems in the European Union. Some recent European Court of Justice rulings will force hundreds of cities to open their local bus, tram, and subway systems to private competition over the next few years. Deregulation would offer cities across the European Union an opportunity to create more efficient public transit systems [*9*].

Japan

Energy demand for transportation in Japan is projected to grow at an average rate of 0.6 percent per year, from 4.2 quadrillion Btu in 2001 to 4.8 quadrillion Btu in 2025, based primarily on Japan's aging population and low birth rate. The *IEO2004* reference case projects that the Japanese population will shrink by 0.1 percent per year, from 127 million in 2001 to 123 million in 2025.

There were about 53.5 million cars and 19.8 million commercial vehicles in use in Japan in 2001, with an estimated ownership rate of 2.3 persons per car [*10*]. Passenger cars in Japan are subject to nine taxes, imposed on acquisition, ownership, and operation. The taxes are aimed at reducing oil imports and securing government funds for infrastructure projects, such as road maintenance and construction. The taxes amount to $73.6 billion per year, accounting for one-tenth of total government revenues. For environmental reasons, mini-cars are offered a preferential tax rate. In addition to annual registration fees, Japan assesses an annual tax on mini-cars, which in 2000 was equivalent to $58, compared with $278 for large vehicles.

Japan has a mature air transportation infrastructure, with more than 65 commercial airports, 14 of which handle international traffic; however, its airports generally are congested, expensive, and in many cases inefficient. The largest and most important airport is New Japan Narita International, located 41 miles from Tokyo. Although it handles more cargo than any other airport in Asia, it is overcrowded, and efforts to expand it have been opposed by residents and lobbying groups.

Japan also has more than 1,000 ports and harbors, 19 of which are designated as major ports for foreign trade. Kobe, Japan's main port, is the second largest container port in the world.

The physical infrastructure of roads, highways, and railroads in Japan is fully developed. Because of high land

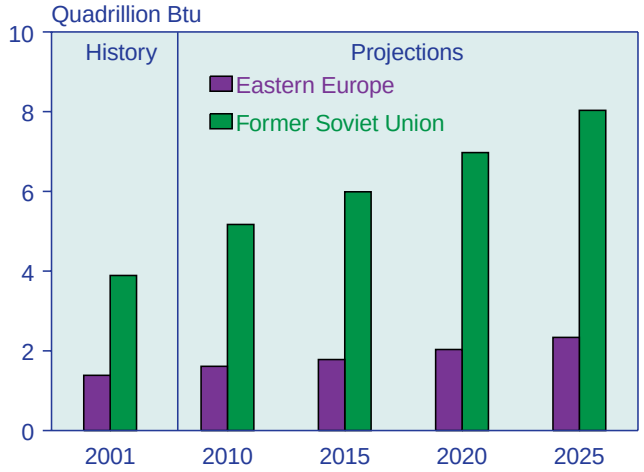
prices and regulations restricting large stores, Japan's retail stores are generally small, lacking adequate shelf space. As a result, they require frequent stocking by wholesalers using small trucks that can navigate the narrow streets, and there are huge numbers of trucks on urban roads and highways during daytime business hours, causing major traffic jams in urban centers.

Japan leads the global field in alternative fuel technologies, with more than 2,500 electric vehicles currently in use. Japan was also the first market to develop mass-produced hybrid vehicles with gasoline engines and electric motors. Many trucks and city buses use the technology. In addition, there are more than 300,000 LPG-fueled vehicles currently in use, including trucks and city taxis, as well as a number of compressed natural gas (CNG) vehicles. Toyota became the first automaker to debut a hybrid vehicle in 1997 with its Prius model, and it introduced the world's first hybrid minivan, the Estima, in June 2001. Toyota plans to sell 300,000 hybrids per year worldwide by 2005 [***11***].

Australia and New Zealand

Energy demand for transportation in Australia and New Zealand combined is projected to grow at an average rate of 2.0 percent per year, from 1.5 quadrillion Btu in 2001 to 2.4 quadrillion Btu in 2025, and the transportation share of total energy consumption for the two countries is projected to grow from 25 percent in 2001 to 27 percent in 2025. Although road transport is expected to continue to dominate energy use in the transportation sector, led by passenger vehicles in both Australia and New Zealand, continued strong growth is expected for both domestic and international air travel. Oil use for rail transport is projected to grow only slightly, consistent with increased electrification of the rail system and the continued dominance of trucks as the main mode of domestic freight transport [***12***]. In the Australian Northern Territory, the completion of the Alice Springs to Darwin rail link between 2003 and 2005 is expected to increase energy consumption in the rail sector.

Figure 29. Transportation Energy Use in Eastern Europe and the Former Soviet Union, 2001-2025



Sources: **2001:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219 (2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2010-2025:** EIA, System for the Analysis of Global Energy Markets (2004).

Eastern Europe and the Former Soviet Union

Energy demand in the EE/FSU transportation sector as a whole is projected to grow at an average annual rate of 3.1 percent, from 3.9 quadrillion Btu in 2001 to 8.0 quadrillion Btu in 2025 (Figure 29), led by expanding ownership of private automobiles and an increasing role of trucking in freight transportation. The economies of the EE/FSU countries traditionally have depended heavily on rail transport, an inheritance from the centrally planned system. Slower growth in transportation energy use is projected for Eastern Europe, averaging 2.2 percent per year (from 1.4 quadrillion Btu in 2001 to 2.3 quadrillion Btu in 2025) Nearly all the projected growth in oil consumption for Eastern Europe results from an expected increase in private car ownership.

Developing Asia

China

Energy use for transportation in China is projected to grow by 5.3 percent per year, from 4.1 quadrillion Btu in 2001 to 14.0 quadrillion Btu in 2025 (Figure 30). Virtually all the of the projected increase is for petroleum products, and about two-thirds of the total projected increment in China's oil demand over the forecast period is expected to be for transportation use.

Road transport is expected to be the primary factor in China's growing demand for transportation fuels. China had 4.3 million registered automobiles and 10.2 million registered trucks and buses at the end of 2001 (as compared with 128.7 million registered automobiles and 88.0 million trucks and buses in the United States) [***13***]. Personal travel in China has soared in the past two decades, with passenger miles traveled increasing fivefold [***14***].

The Chinese passenger car market grew tenfold between 1990 and 2000. In addition, demand for cars exploded in 2002, when a price war was launched by local automakers in expectation of increased import competition after tariffs were lowered by the government following China's entry into the World Trade Organization in December 2001. However, the road system still is failing to keep up with the growth in car use, and major cities are already facing gridlock. The *Beijing Evening News* has reported that fuel consumption per kilometer for cars in China is 10 to 20 percent higher than in developed countries [***15***], and Chinese vehicle emission standards

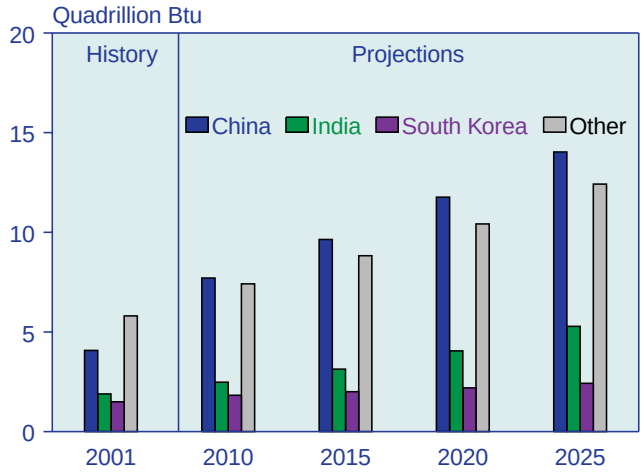
allow cars to emit almost twice as much carbon monoxide and three times as much hydrocarbons and nitrogen oxides as do the U.S. emission standards. Air pollution has been estimated to cost China roughly 5 percent of GDP annually [***16***].

The railway system is the backbone of China's transport network, and the Chinese government plans to spend more than $42 billion to build 4,375 miles of new track from 2001 to 2006 [***17***]. Aviation is the second fastest growing passenger-transport mode. Passenger-miles traveled by air quadrupled in the 1990s, and rising household incomes and commercial activity are expected to result in continued strong growth in air travel. Demand for buses is expected to increase rapidly in China with the extension of expressways in the south and west, and demand for heavy trucks is expected to increase as a result of infrastructure development in preparation for the 2008 Beijing Olympics.

India

India's energy demand for transportation is projected to grow at an average rate of 4.4 percent a year, from 1.9 quadrillion Btu in 2001 to 5.3 quadrillion Btu in 2025, and the transportation sector is expected to account for 20 percent of the country's total energy consumption in 2025. Some of India's transportation infrastructure is well developed by Asian standards, especially the railways (although many rural areas still are largely inaccessible by rail). India has the most extensive railway system in the world, dating back to colonial times. An estimated 1.6 million people are employed by the railway system, making it the world's largest employer [***18***].

Figure 30. Transportation Energy Use in Developing Asia, 2001-2025



Sources: **2001:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219 (2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2010-2025:** EIA, System for the Analysis of Global Energy Markets (2004).

The Indian automotive industry is also well established, dating back more than 50 years. There were about 4.9 million cars and 6.9 million commercial vehicles in use in India in 2001, with an estimated vehicle ownership rate of 195 persons per car [***19***]. With increased attention on India's polluted cities, the trend in passenger cars and commercial vehicles is becoming more environmentally conscious, with greater emissions restrictions and a surge in CNG-fueled vehicles. In April 2002, the Delhi government pulled 6,000 diesel buses off the roads and purchased 1,000 new CNG-fueled buses.

India's road transport continues to be held back by poverty, urban overcrowding, and the absence of decent roads in many rural areas. The quality of roads, and even highways, is poor by international standards; they are badly maintained, narrow, and highly congested. There are nearly 60,000 fatalities a year in traffic crashes, compared with just over 40,000 in the United States. Recognizing the problem, the Indian government is spending about $12.5 billion to upgrade existing roads and construct new highways [***20***].

South Korea

In South Korea, energy demand for transportation is projected to grow by 2.0 percent per year, from 1.5 quadrillion Btu in 2001 to 2.4 quadrillion Btu in 2025. Its total demand for oil is projected to grow at an average annual rate of growth of 1.3 percent, from 2.1 million barrel per day in 2001 to 2.9 million barrel per day in 2025, much slower than the average of 8.0 percent per year over the past three decades, an indication of the maturity of the South Korean transportation sector. Just over one-half of the projected increase in oil demand is expected in the transportation sector, with much of the remainder in the industrial sector.

The South Korean government plans to allow the sale of diesel-powered cars beginning in January 2005 [***21***]. Under current government policy, diesel fuel is priced at 60 percent of the gasoline price, and thus it is expected that diesel-powered cars will grow in popularity over the forecast period. There were about 9 million cars and 4 million commercial vehicles in use in 2001 in Korea, with an estimated vehicle ownership rate of 5.3 persons per car [**22**].

South Korea has three international airports, including Kimpo, 16 miles from the capital Seoul, which is the largest and the tenth busiest cargo airport in the world and the third busiest in Asia. Air travel is an important component of South Korea's transportation sector, trains and buses are well established, and the Seoul subway system is considered one of the best in the world.

Other Developing Asia

Energy demand for transportation in the other nations of developing Asia is projected to grow from 5.8

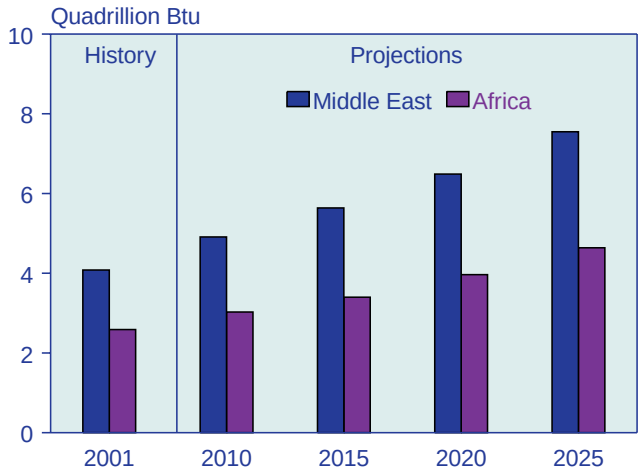
quadrillion Btu in 2001 to 12.4 quadrillion Btu in 2025. The transportation share of total energy use in the region is projected to increase from 24 percent in 2001 to 30 percent in 2025, as national economies continue to mature and rising standards of living result in increased motor transport.

The largest economies in the region are Thailand, Indonesia, Malaysia, Singapore, Taiwan, and Hong Kong. Air traffic within and to the region was hit especially hard during the severe acute respiratory syndrome (SARS) outbreak in 2003, which contributed to a drop in the consumption of jet fuel. SARS weakened Hong Kong's economy, reducing GDP growth in 2003 by an estimated 1.4 percent as consumer spending and tourism declined [***23***]. The impact of the SARS epidemic was temporary, however, and by early 2004 air travel had rebounded. In 2004, Hong Kong's economy is expected to grow by 4.5 percent [***24***].

In Thailand, strong economic growth has increased energy demand for transportation. Diesel fuel consumption is growing quickly, indicating a strong recovery in industrial activity. Jet fuel and kerosene consumption fell during the SARS outbreak but have since recovered. Automobile sales have increased by 30 to 40 percent in each of the past 2 years [***25***].

In Indonesia, weak economic growth, along with a series of price increases for refined products, slowed the growth in demand for transportation fuels in 2003. Malaysia continues to register strong industrial production that is stimulating demand for refined products, although jet fuel demand has yet to recover from a decline during the 2003 SARS scare in the region.

Figure 31. Transportation Energy Use in the Middle East and Africa, 2001-2025



Sources: **2001:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219 (2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2010-2025:** EIA, System for the Analysis of Global Energy Markets (2004).

In Singapore, bunker fuel oil consumption makes up more than one-half of total oil demand. During 2003, before and during the Iraq war, consumption surged as some tankers preferred to fuel in Singapore and avoid fueling in the Middle East as much as possible.

Middle East

The Middle East region has a relatively small population and is not a major energy consumer but rather an exporter; however, rapid population growth is expected to result in greater demand for transportation energy use in the future. Energy demand for transportation is projected to grow from 4.1 quadrillion Btu in 2001 to 7.5 quadrillion Btu in 2025 (Figure 31).

In percentage terms, the "Asian boom" in oil demand and refinery expansion in the early 1990s has been eclipsed by growth in the Middle East since the late 1990s. From 1973 to 2003, annual growth in demand for oil in the Middle East quadrupled (from 1 percent to 4.3 percent), while the U.S. market remained stagnant at just over 1 percent per year, and Asian markets average 2.5 percent per year [***26***]. Demand for transportation fuels in traditional exporting countries such as Saudi Arabia, Kuwait, Iraq, Oman, the United Arab Emirates, Yemen, and, most notably, Iran made the region a net importer of gasoline in 2003; however, that trend is expected to be reversed by 2010, when planned expansions of refinery capacity come on stream.

Africa

Energy demand for transportation in Africa is projected to grow from 2.6 quadrillion Btu in 2001 to 4.6 quadrillion Btu in 2025. South Africa's economy, the largest in the continent, has been growing strongly for the past few years, helping to sustain total economic growth in the region. The average life expectancy is less than 50 years in most of Africa, and less than 40 years in some of the countries that have been ravaged by AIDS [***27***]. The *IEO2004* reference case assumes that Africa's population will increase by 59 percent from 2001 to 2025 (to 1,292 million), and that economic growth will average 4.0 percent per year, leading to higher demand for energy in the transportation sector.

Central and South America

Economic growth in Central and South America has begun to recover from the downturns in several or the region's major economies from 2000 to 2002, but lingering economic problems are expected to limit growth in transportation energy use for several more years. Brazil, Argentina, and Venezuela, which together account for more than 50 percent of the region's oil demand, had negative growth in oil consumption as result of weak economic performance in 2002, and price decontrols are affecting consumption of transportation fuels in Brazil and Colombia, as liberalized prices float higher with

strong crude oil prices. Brazil's gasoline prices rose by 30 percent in local currency terms in 2003, and demand declined by nearly 7 percent. Colombia is also cutting back government subsidies for gasoline and diesel fuel, with full elimination expected by the end of 2006 [**28**].

In the *IEO2004* forecast, energy demand for transportation in the region is projected to grow at an average annual rate of 2.1 percent, from 5.7 quadrillion Btu in 2001 to 9.5 quadrillion Btu in 2025, as a result of rising demand for personal mobility and for transport of commercial goods.

The Composition of World Oil Supply

In the *IEO2004* reference case, world oil supply in 2025 is projected to exceed the 2001 level by about 44 million barrels per day. Increases in production are expected for both OPEC and non-OPEC producers; however, only about 40 percent of the total increase is expected to come from non-OPEC areas. Over the past two decades, the growth in non-OPEC oil supply has resulted in an OPEC market share substantially under its historic high of 52 percent in 1973. New exploration and production technologies, aggressive cost-reduction programs by industry, and attractive fiscal terms to producers by governments all contribute to the outlook for continued growth in non-OPEC oil production.

The reference case projects that 60 percent of the increase in petroleum demand over the next two decades will be met by an increase in production by members of OPEC rather than by non-OPEC suppliers. OPEC production in 2025 is projected to be more than 25 million barrels per day higher than it was in 2001 (Figure 32). The *IEO2004* estimates of OPEC production capacity to 2010 are slightly less than those projected in *IEO2003*, reflecting a shift toward non-OPEC supply projects in the recent high price environment. Some analysts suggest that OPEC might pursue significant price escalation through conservative capacity expansion decisions rather than undertake ambitious production expansion programs; however, the projections in this outlook do not assume such views.

Reserves and Resources

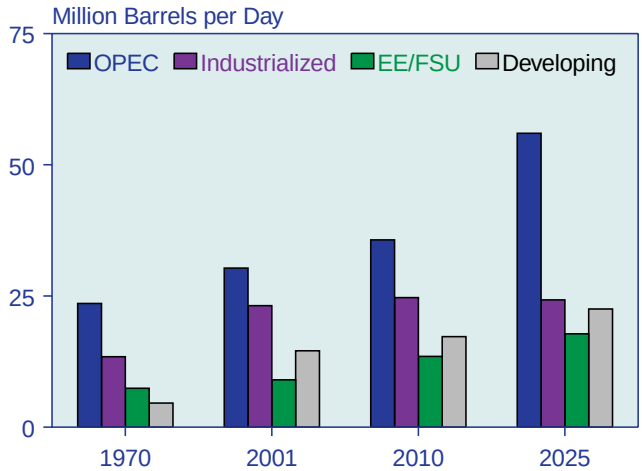
Table 5 shows estimates of the conventional oil resource base by region over the period 1995 to 2025. Proved reserves are taken from the annual assessment of worldwide reserves published by *Oil & Gas Journal* [**29**]. Reserve growth and undiscovered estimates are based on the *World Petroleum Assessment 2000* by the U.S. Geological Survey (USGS). The oil resource base is defined by three categories: proved reserves (oil that has been discovered but not produced); reserve growth (increases in reserves resulting mainly from technological factors that enhance a field's recovery rate); and undiscovered (oil that remains to be found through exploration). The information in Table 5 is derived from current estimates of proved reserves and the USGS mean estimate, an average assessment over a wide range of uncertainty for reserve growth and undiscovered resources. The *IEO2004* oil production forecast is based on the information in Table 5.

Expansion of OPEC Production Capacity

It is generally acknowledged that OPEC members with large reserves and relatively low costs for expanding production capacity can accommodate sizable increases in petroleum demand. In the *IEO2004* reference case, the production call on OPEC suppliers is projected to grow at a robust annual rate of 2.6 percent through 2025 (Table 6 and Figure 33). OPEC capacity utilization is expected to increase sharply after 2001, reaching 90 percent by 2015 and remaining there through 2025.

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 slightly more than $5.2 billion in oil exports allowed by United Nations Security Council resolutions. The expansion was required because of the low price environment of early 1999. In the *IEO2004* reference case, Iraq is assumed to maintain its current oil production capacity of 3.1 million barrels per day into 2004, and its exports are assumed to generate revenues no greater than those allowed by the United Nations Security Council sanctions. Iraq has indicated a desire to expand its

Figure 32. World Oil Production in the Reference Case by Region, 1970, 2001, 2010, and 2025



Sources: **1970 and 2001:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219 (2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2010 and 2025:** EIA, System for the Analysis of Global Energy Markets (2004).

Table 5. Estimated World Oil Resources, 1995-2025
(Billion Barrels)

Region and Country	Proved Reserves	Reserve Growth	Undiscovered	Total
Industrialized				
United States	22.7	76.0	83.0	**181.7**
Canada	178.9	12.5	32.6	**224.0**
Mexico	15.7	25.6	45.8	**87.1**
Japan	0.1	0.1	0.3	**0.5**
Australia/New Zealand	3.6	2.7	5.9	**12.1**
Western Europe	18.2	19.3	34.6	**72.1**
Eurasia				
Former Soviet Union	78.0	137.7	170.8	**386.5**
Eastern Europe	1.4	1.5	1.4	**4.2**
China	18.3	19.6	14.6	**52.5**
Developing Countries				
Central and South America	98.8	90.8	125.3	**314.9**
India	5.4	3.8	6.8	**16.0**
Other Developing Asia	11.0	14.6	23.9	**49.5**
Africa	87.0	73.5	124.7	**285.2**
Middle East	726.8	252.5	269.2	**1,248.5**
Total	**1,265.8**	**730.1**	**938.9**	**2,934.8**
OPEC	**869.5**	**395.6**	**400.5**	**1,665.6**
Non-OPEC	**396.3**	**334.5**	**538.4**	**1,269.2**

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

Sources: **Proved Reserves as of January 1, 2004:** *Oil & Gas Journal*, Vol. 101, No. 49 (December 22, 2003), pp. 46-47. **Reserve Growth Total and Undiscovered, 1995-2025:** U.S. Geological Survey, *World Petroleum Assessment 2000*, web site http://greenwood. cr.usgs. gov/energy/WorldEnergy/DDS-60. **Estimates of Regional Reserve Growth:** Energy Information Administration, *International Energy Outlook 2002*, DOE/EIA-0484(2002) (Washington, DC, March 2002), p. 32.

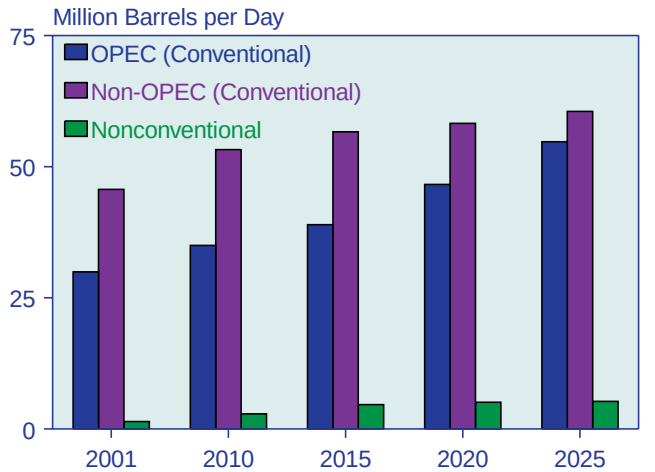
Table 6. OPEC Oil Production, 1990-2025
(Million Barrels per Day)

Year	Reference Case	High Oil Price	Low Oil Price
History			
1990	24.5	—	—
2001	30.3	—	—
Projections			
2010	35.7	28.2	42.1
2015	40.0	29.5	49.3
2020	47.8	35.4	60.1
2025	56.0	42.2	71.2

Note: Includes the production of crude oil, natural gas plant liquids, refinery gain, and other liquid fuels.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www. eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2004).

Figure 33. OPEC, Non-OPEC, and Nonconventional Oil Production in the Reference Case, 2001 and 2010-2025



Sources: **2001:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219 (2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2010-2025:** EIA, System for the Analysis of Global Energy Markets (2004).

Oil Resources in the 21st Century

Early in 2004, two oil market issues captured the attention of market observers. First, Royal Dutch Shell announced that it was revising its reporting of reserves, moving 3.9 billion barrels of oil equivalent from the proved to the probable category. Second, an article in the *New York Times* on February 24 implied that Saudi Arabia's oil fields were in decline, and that the kingdom probably would be unable to expand oil production capacity to meet increasing oil demand. Both of these supply-side issues had a somewhat negative effect on the stock market. The reserve revision by Shell turned out to be a reinterpretation of reporting conventions and had more to do with natural gas than oil; and in an emphatic rebuttal to the *New York Times* article, Saudi Arabia maintained that its oil producers are confident in their ability to sustain significantly higher levels of production capacity well into the middle of this century.[a]

As the above examples demonstrate, whenever the sustainability of the oil resource base comes into question, there are always those eager to warn the world of a looming shortage in oil supplies. Inevitably, the question becomes, "Are we running out of oil?" In April 2000, the U.S. Geological Survey (USGS) released the results of its thorough and methodologically sound assessment of worldwide petroleum resources.[b] The USGS identified at least 3 trillion barrels (mean estimate) of ultimately recoverable conventional oil resources worldwide. The assessment prompted EIA to analyze the long-term world conventional oil supply potential, using alternative assumptions about the levels of ultimately recoverable resources and demand growth.[c] Based on the EIA analysis, all three of the *IEO2004* oil price cases would expect conventional oil to peak closer to the middle than to the beginning of the 21st century.

No one doubts that fossil fuels are subject to depletion, and that depletion leads to scarcity, which in turn leads to higher prices. Resources are defined as "nonconventional" when they cannot be produced economically at today's prices and with today's technology. With higher prices, however, the gap between conventional and nonconventional oil resources narrows. Ultimately, a combination of escalating prices and technological enhancements can transform the nonconventional into the conventional. Much of the pessimism about oil resources has been focused entirely on conventional resources. In the *IEO2004* forecast, nonconventional liquids include production from oil sands, ultra-heavy oils, gas-to-liquids technologies, coal-to-liquids technologies, biofuel technologies, and shale oil. Total nonconventional liquids production in 2025 is projected at 4.1, 5.2, and 8.0 million barrels per day in the low price, reference, and high price cases, respectively. It is anticipated that nonconventional oil resources will act as a buffer against prolonged periods of high oil prices well into the middle of this century, and perhaps well beyond.

[a]M. Abdul Baqi and N. Saleri, *Fifty-Year Crude Oil Supply Scenarios: Saudi Aramco's Perspective* (Washington, DC, February 2004).
[b]U.S. Geological Survey, *World Petroleum Assessment 2000*, web site http://greenwood.cr.usgs.gov/energy/WorldEnergy/DDS-60.
[c]"World Conventional Oil Supply Expected To Peak in 21st Century," *Offshore* (April 2003), p. 90.

production capacity aggressively, to more than 6 million barrels per day, once the sanctions are lifted and the oil sector is deemed safe from terrorist activities. Preliminary discussions of exploration projects have already been held with potential outside investors, including companies from France, Russia, and China. Such a large increase in Iraqi oil exports would offset a significant portion of the price stimulus associated with current OPEC production cutbacks.

Given the requirements for OPEC production capacity expansion implied by the *IEO2004* estimates, much attention has been focused on the oil development, production, and operating costs of individual OPEC producers. With Persian Gulf producers enjoying a reserve-to-production ratio that exceeds 115 years, substantial capacity expansion clearly is feasible.

The average production cost in Persian Gulf OPEC nations is less than $2 per barrel, and the capital investment required to increase production capacity by 1 barrel per day is less than $5,750 [***30***]. Assuming the *IEO2004* low price trajectory, total development and operating costs over the entire projection period, expressed as a percentage of gross oil revenues, would be about 28 percent. Thus, Persian Gulf OPEC producers can expand capacity at a cost that is a relatively small percentage of projected gross revenues.

For OPEC producers outside the Persian Gulf, the cost to expand production capacity by 1 barrel per day is considerably greater, exceeding $12,870 in some member nations; yet those producers can expect cost to revenue ratios of about 46 percent on investments to expand production capacity over the long term, even in the low price case [***31***]. Venezuela has the greatest potential for capacity expansion and could aggressively increase its production capacity by more than 1.0 million barrels per day, to 4.2 million barrels per day by 2005. It is unclear, however, whether the current political climate will support the outside investment required for any substantial expansion of production capacity. Tables D1-D6 in

Appendix D show the ranges of production potential for both OPEC and non-OPEC producers.

The reference case projection implies aggressive efforts by OPEC member nations to apply or attract investment capital to implement a wide range of production capacity expansion projects. If those projects were not undertaken, world oil prices could escalate; however, the combination of potential profitability and the threat of competition from non-OPEC suppliers argue for the pursuit of a relatively aggressive expansion strategy.

In the *IEO2004* forecast, OPEC members outside the Persian Gulf are expected to increase their production potential substantially, despite their higher capacity expansion costs. There is much optimism regarding Nigeria's offshore production potential, although it is unlikely to be developed until the middle to late part of this decade. In addition, increased optimism about the production potential of Algeria, Libya, and Venezuela supports the possibility of reducing the world's dependence on Persian Gulf oil.

Non-OPEC Supply

The growth in non-OPEC oil supplies played a significant role in the erosion of OPEC's market share over the past three decades, as non-OPEC supply became increasingly diverse. North America dominated non-OPEC supply in the early 1970s, the North Sea and Mexico evolved as major producers in the 1980s, and much of the new production in the 1990s has come from the developing countries of Latin America, West Africa, the non-OPEC Middle East, and China. In the *IEO2004* reference case, non-OPEC supply from proved reserves is expected to increase steadily, from 46.7 million barrels per day in 2001 to 64.6 million barrels per day in 2025 (Table 7).

There are several important differences between the *IEO2004* production profiles and those published in *IEO2003*:

- The U.S. production decline is somewhat more severe in the *IEO2004* projections as a result of higher exploration and production costs, coupled with lower expected finding rates in the National Petroleum Reserve-Alaska.
- The growth in Russian oil production is more optimistic in the *IEO2004* forecast, as Russian companies in alliance with Western service companies continue to surprise industry experts with productivity increases in West Siberia.
- Production of nonconventional liquids (especially those from oil sands and ultra-heavy oils) is considerably more optimistic in *IEO2004* as production costs decline and markets evolve.
- In the *IEO2004* projections, Caspian output is expected to exceed 3.1 million barrels per day in 2010 and increase steadily thereafter. However, there still remains a great deal of uncertainty about export routes from the Caspian Basin region.

In the *IEO2004* forecast, the decline in North Sea production is slowed as a result of the implementation of strategies for redeveloping mature fields. Production from Norway, Western Europe's largest producer, is expected to peak at about 3.6 million barrels per day in 2006 and then gradually decline to about 2.5 million barrels per day by the end of the forecast period with the maturing of some of its larger and older fields. The United Kingdom sector is expected to produce about 2.2 million barrels per day through 2010, followed by a decline to 1.4 million barrels per day in 2025.

Two non-OPEC Persian Gulf producers are expected to increase output gradually over the first half of this decade. Enhanced recovery techniques are expected to increase current output in Oman by more than 190,000 barrels per day, with only a gradual production decline anticipated after 2010. Current oil production in Yemen is expected to increase by at least 50,000 barrels per day in the next several years, and those levels could show a slight increase throughout the forecast period. Syria is expected to hold its production flat throughout this decade, but little in the way of new resource potential will allow anything except declining production volumes out to 2025.

Oil producers in the Pacific Rim are expected to increase their production volumes significantly as a result of enhanced exploration and extraction technologies. India is expected to show some modest production increase

Table 7. Non-OPEC Oil Production, 1990-2025
(Million Barrels per Day)

Year	Reference Case	High Oil Price	Low Oil Price
History			
1990	42.2	—	—
2001	46.7	—	—
Projections			
2010	55.4	58.4	54.0
2015	60.2	64.1	58.1
2020	62.1	67.6	59.4
2025	64.6	70.5	61.3

Note: Includes the production of crude oil, natural gas plant liquids, refinery gain, and other liquid fuels.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www. eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2004).

early in this decade and only a modest decline in output thereafter. Deepwater fields offshore from the Philippines have resulted in an improved reserve picture; by the end of the forecast period, production is expected to exceed 60,000 barrels per day. Vietnam is still viewed with considerable optimism regarding long-term production potential, although exploration activity has been slower than originally hoped. Output levels from Vietnamese fields are expected to exceed 375,000 barrels per day by 2015.

Australia has continued to make additions to its proved reserves, and it is possible that Australia could exceed 800 thousand barrels per day in oil production by the end of this decade. Malaysia shows little potential for any significant new finds, and its output is expected to peak at around 750,000 barrels per day in this decade and then gradually decline to less than 700,000 barrels per day by 2025. Papua New Guinea continues to add to its reserve posture and is expected to achieve production volumes approaching 120,000 barrels per day by the end of this decade, followed by only a modest decline over the remainder of the forecast period. Exploration and test-well activity have pointed to some production potential for Bangladesh and Myanmar, but significant output is not expected until after 2010.

Oil producers in Central and South America have significant potential for increasing output over the next decade. Brazil became a million barrel per day producer in 1999, with considerable production potential waiting to be tapped. Brazil's production is expected to rise throughout the forecast period and to top 3.9 million barrels per day by 2025. Colombia's current economic downturn and civil unrest have delayed development of its upstream sector, but its output is expected to top 640,000 barrels per day within the decade and continue to show modest increases for the remainder of the forecast period. In both countries, the oil sector would benefit significantly from the creation of a favorable climate for foreign investment.

Argentina is expected to increase its production volumes by at least 60,000 barrels per day over the next 3 years, and by the end of the decade it could possibly to become a million barrel per day producer. Although the current political situation in Ecuador is in transition, there is still optimism that Ecuador will increase production by more than 450,000 barrels per day over the forecast period.

Several West African producers (Angola, Cameroon, Chad, Congo, Equatorial Guinea, Gabon, and Ivory Coast) are expected to reap the benefits of substantial exploration activity, especially if current price levels persist. Angola is expected to become a million barrel per day producer sometime over the next several years. Given recent excellent exploration results, Angola could produce volumes of up to 3.4 million barrels per day well into the later years of the forecast period. The other West African producers with offshore tracts are expected to increase output by up to 750,000 thousand barrels per day for the duration of the forecast.

North African producers Egypt and Tunisia produce mainly from mature fields and show little promise of adding to their reserve posture. As a result, their production volumes are expected to decline gradually throughout the forecast. In East Africa, Sudan is expected to produce significant volumes by the end of this decade and could exceed 500,000 barrels per day by the end of the forecast period. Eritrea, Mauritania, Sao Tome and Principe, Somalia, and South Africa also have some resource potential, but they are not expected to produce significant amounts until after 2010.

In North America, moderately declining U.S. output is expected to be balanced by significant production increases in Canada and Mexico. Canada's conventional oil output is expected to decrease by about 500,000 barrels per day over the next 20 years, but an additional 2.5 million barrels per day is expected in nonconventional output from oil sands projects. Mexico is expected to adopt energy policies that will encourage the efficient development of its vast resource base. Expected production volumes in Mexico exceed 4.2 million barrels per day by the end of the decade and continue to increase by another 500,000 barrels per day by the end of the forecast period.

With higher oil prices projected, oil production in the FSU is expected to exceed 11.0 million barrels per day by 2005, due in large part to the more optimistic outlook for investment in Russia. The long-term production potential for the FSU is still regarded with considerable optimism, especially for the resource-rich Caspian Basin region. The *IEO2004* reference case shows FSU output exceeding 17.2 million barrels per day in 2025, implying export volumes exceeding 10 million barrels per day. In China, oil production is expected to decline slightly, to about 3.4 million barrels per day in 2025. China's import requirements are expected to be as large as its domestic production by 2011 and to continue growing as its petroleum consumption increases.

The estimates for non-OPEC production potential presented in this outlook are based on such parameters as numbers of exploration wells, finding rates, reserve-to-production ratios, advances in both exploration and extraction technologies, and sensitivity to changes in the world oil price. A critical component of the forecasting methodology is the constraint placed on the exploration and development of non-OPEC undiscovered resources. For the purpose of the three *IEO2004* price cases, no more than 15, 30, and 45 percent of the mean United States Geological Survey estimate of non-OPEC

undiscovered oil is assumed to be developed over the forecast period in the low price, reference, and high price cases, respectively. In all the oil price cases, OPEC producers are assumed to be the source of the required residual supply. Tables D1-D6 in Appendix D show the ranges of production potential for both OPEC and non-OPEC producers.

The expectation in the late 1980s and early 1990s was that non-OPEC production in the longer term would stagnate or decline gradually in response to resource constraints. The relatively insignificant cost of developing oil resources in OPEC countries (especially those in the Persian Gulf region) was considered such an overwhelming advantage that non-OPEC production potential was viewed with considerable pessimism. In actuality, however, despite several periods of relatively low prices, non-OPEC production has risen every year since 1993, adding more than 5.8 million barrels per day between 1993 and 2001.

It is expected that non-OPEC producers will continue to increase output, producing an additional 8.7 million barrels per day by 2010. Three factors are generally given credit for the impressive resiliency of non-OPEC production: development of new exploration and production technologies, efforts by the oil industry to reduce costs, and efforts by producer governments to promote exploration and development by encouraging outside investors with attractive fiscal terms.

Worldwide Petroleum Trade in the Reference Case

In 2001, industrialized countries imported 16.1 million barrels of oil per day from OPEC producers (Table 8). Of

Table 8. Worldwide Petroleum Trade in the Reference Case, 2001 and 2025
(Million Barrels per Day)

Exporting Region	Importing Region: Industrialized: North America	Industrialized: Western Europe	Industrialized: Asia	Industrialized: Total	Nonindustrialized: Pacific Rim	Nonindustrialized: China	Nonindustrialized: Rest of World	Nonindustrialized: Total	Total Exports
				2001					
OPEC									
Persian Gulf	2.9	2.7	4.1	**9.7**	4.8	0.9	1.5	**7.2**	**16.9**
North Africa	0.4	2.0	0.0	**2.3**	0.2	0.0	0.0	**0.2**	**2.6**
West Africa	0.9	0.6	0.0	**1.5**	0.7	0.0	0.1	**0.8**	**2.2**
South America	1.8	0.2	0.2	**2.2**	0.1	0.0	0.3	**0.4**	**2.6**
Asia	0.1	0.0	0.3	**0.4**	0.2	0.0	0.0	**0.2**	**0.7**
Total OPEC	**6.1**	**5.5**	**4.6**	**16.1**	**6.0**	**0.9**	**1.9**	**8.8**	**24.9**
Non-OPEC									
North Sea	0.6	4.5	0.0	**5.2**	0.0	0.0	0.0	**0.0**	**5.2**
Caribbean Basin	0.6	0.1	0.0	**0.7**	0.1	0.0	0.1	**0.1**	**0.8**
Former Soviet Union	0.2	3.6	0.3	**4.2**	0.2	0.0	0.1	**0.3**	**4.5**
Other Non-OPEC	5.5	3.6	1.2	**10.3**	3.7	1.1	5.7	**10.5**	**20.8**
Total Non-OPEC	**6.9**	**11.8**	**1.6**	**20.4**	**4.0**	**1.1**	**5.8**	**11.0**	**31.4**
Total Petroleum Imports	**13.0**	**17.3**	**6.2**	**36.5**	**10.0**	**2.0**	**7.8**	**19.7**	**56.3**
				2025					
OPEC									
Persian Gulf	5.8	4.5	5.9	16.3	9.4	5.7	4.9	20.1	36.4
North Africa	0.5	3.1	0.1	3.6	0.8	0.3	0.5	1.6	5.3
West Africa	1.6	1.1	0.3	2.9	1.9	0.5	0.2	2.6	5.6
South America	3.9	0.1	0.4	4.3	0.1	0.0	0.4	0.6	4.9
Asia	0.1	0.0	0.3	0.4	1.5	0.1	0.2	1.9	2.3
Total OPEC	**11.9**	**8.8**	**6.9**	**27.6**	**13.8**	**6.6**	**6.3**	**26.8**	**54.4**
Non-OPEC									
North Sea	0.7	3.4	0.0	4.2	0.3	0.0	0.2	0.5	4.7
Caribbean Basin	1.6	0.5	0.2	2.3	0.6	0.0	0.8	1.4	3.7
Former Soviet Union	0.5	4.7	0.6	5.7	0.7	1.7	1.5	3.8	9.6
Other Non-OPEC	6.8	3.0	0.4	10.1	4.2	0.3	2.5	6.9	17.1
Total Non-OPEC	**9.5**	**11.6**	**1.2**	**22.3**	**5.7**	**2.0**	**5.0**	**12.7**	**35.0**
Total Petroleum Imports	**21.4**	**20.4**	**8.1**	**49.9**	**19.5**	**8.6**	**11.4**	**39.5**	**89.4**

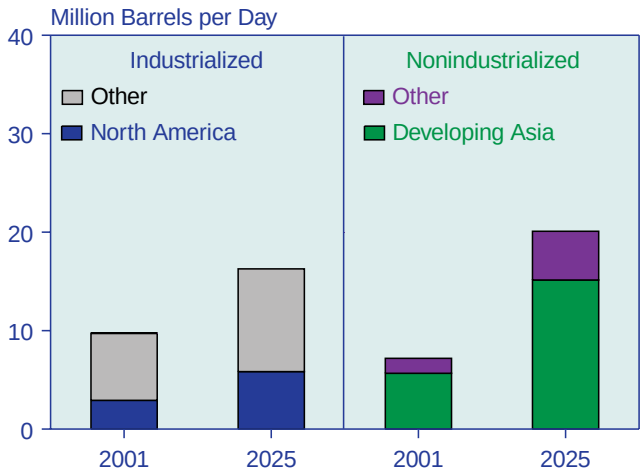
Notes: Totals may not equal sum of components due to independent rounding.
Sources: **2001:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **2025:** EIA, Office of Integrated Analysis and Forecasting, IEO2004 WORLD Model run IEO2004.B25 (2004).

that total, 9.7 million barrels per day came from the Persian Gulf region. Oil movements to industrialized countries represented almost 65 percent of the total petroleum exported by OPEC member nations and almost 58 percent of all Persian Gulf exports. By the end of the forecast period, OPEC exports to industrialized countries are estimated to be about 11.5 million barrels per day higher than their 2001 level, and more than half the increase is expected to come from the Persian Gulf region.

Despite such a substantial increase, the share of total petroleum exports that goes to the industrialized nations in 2025 is projected to be almost 9 percent below their 2001 share, and the share of Persian Gulf exports going to the industrialized nations is projected to fall by about 13 percent. The significant shift expected in the balance of OPEC export shares between the industrialized and developing nations is a direct result of the economic growth anticipated for the developing nations of the world, especially those of Asia. OPEC petroleum exports to developing countries are expected to increase by more than 18.0 million barrels per day over the forecast period, with three-fourths of the increase going to the developing countries of Asia. China, alone, is likely to import about 6.6 million barrels per day from OPEC by 2025, virtually all of which is expected to come from Persian Gulf producers.

North America's petroleum imports from the Persian Gulf are expected to double over the forecast period (Figure 34). At the same time, more than one-half of total North American imports in 2025 are expected to be from Atlantic Basin producers and refiners, with significant increases expected in crude oil imports anticipated from Latin American producers, including Venezuela, Brazil, Colombia, and Mexico. West African producers, including Nigeria and Angola, are also expected to increase their export volumes to North America. Caribbean Basin refiners are expected to account for most of the increase in North American imports of refined products.

Figure 34. Imports of Persian Gulf Oil by Importing Region, 2001 and 2025



Sources: **2001:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2025:** EIA, Office of Integrated Analysis and Forecasting, IEO2004 WORLD Model run IEO2004.B25 (2004).

With a moderate decline in North Sea production, Western Europe is expected to import increasing amounts from Persian Gulf producers and from OPEC member nations in both northern and western Africa. Substantial imports from the Caspian Basin are also expected. Industrialized Asian nations are expected to increase their already heavy dependence on Persian Gulf oil. The developing countries of the Pacific Rim are expected to almost double their total petroleum imports between 2001 and 2025.

Worldwide crude oil distillation refining capacity was about 81.9 million barrels per day at the beginning of 2002. To meet the projected growth in international oil demand in the reference case, worldwide refining capacity would have to increase by more than 40 million barrels per day by 2025. Substantial growth in distillation capacity is expected in the Middle East, Central and South America, and especially in the Asia Pacific region. Refiners in North America and Europe, while making only modest additions to their distillation capacity, are expected to continue improving product quality and enhancing the usefulness of the heavier portion of the barrel through investment in downstream capacity. Likewise, future investments by developing countries are also expected to include more advanced configurations designed to meet the anticipated increase in demand for lighter products, especially transportation fuels.

Other Views of Prices and Production

Several oil market analysis groups produce world oil price and production forecasts. Table 9 compares the *IEO2004* world oil price projections with similar forecasts from the International Energy Agency (IEA), Petroleum Economics, Ltd. (PEL), Petroleum Industry Research Associates (PIRA), Energy and Environmental Analysis, Inc. (EEA), Natural Resources Canada (NRCan), Global Insight, Inc. (GII), Deutsche Bank AG (DB), National Petroleum Council (NPC), Strategic Energy & Economic Research (SEER), and the Centre for Global Energy Studies (CGES).

The collection of forecasts includes a wide range of price projections, based on the volatility of the world oil markets. In particular, oil prices have fluctuated widely since the late 1990s, first tumbling as a result of the Asian economic recession of 1997-1998, then climbing with the

region's subsequent recovery (see Figure 26). High oil prices followed the ability of OPEC to maintain production quotas in 2000, which supported sustained high prices throughout the year. Oil prices collapsed in mid- to late 2001 as a result of decreases in demand that accompanied the global economic slowdown and the aftermath of the September 11 terrorist attacks but recovered during 2002 as a result of unrest in the Middle East, oil supply disruptions in Venezuela and Nigeria, and low storage levels in the United States. By the first quarter of 2003 oil prices had neared $35 per barrel (nominal dollars), and they remained near or above the $30 per barrel level throughout the year and into the first part of 2004.

The *IEO2004* price projections are generally at the high end of the spectrum of price forecasts across the 2010-2025 time period, with only two exceptions: PIRA's $26.70 price forecast for 2015 is higher than the *IEO2004* estimate of $25.07 (Table 9); and the IEA price estimate of $27.96 for 2025 is higher than the *IEO2004* reference case projection of $27.00. It should be noted that IEA did not publish a price projection for 2015 or 2025 in its *World Energy Outlook 2002*; however, it states that "prices are assumed to rise in a linear fashion after 2010," from $21.75 per barrel in 2010 to $30.03 per barrel in 2030. A simple interpolation results in oil prices in 2015 of about $23.82 per barrel and in 2025 of $27.96 per barrel, placing the IEA prices below the *IEO2004* estimate in 2015 but above the *IEO2004* estimate in 2025.

The PEL and CGES price forecasts for 2020 are the only two instances in which a price forecast falls below the *IEO2004* low world oil price scenario. Both forecasters expect world oil prices in the mid-term to stay at a flat, nominal $25 per barrel over the mid-term forecast, which translates to $15.60 per barrel in fixed 2002 dollars. If the PEL and CGES series are omitted, the range of prices among the remaining series for 2020 is $8.02, with *IEO2004* at the high end of the range ($26.02 per barrel) and NPC at the low end ($18.00 per barrel). At the end of the forecast period, in 2025, the uncertainty among the forecasters as measured by the difference between highest and lowest expected prices is $9.96 per barrel, with the range defined by the IEA ($27.96 per barrel) and NPC ($18.00 per barrel) forecasts.

The price forecasts are influenced by differing views of the projected composition of world oil production. Two factors are of particular importance: (1) expansion of

Table 9. Comparison of World Oil Price Projections, 2010-2025
(2002 Dollars per Barrel)

Forecast	2010	2015	2020	2025
IEO2004				
Reference Case	24.17	25.07	26.02	27.00
High Price Case	33.27	34.23	34.63	35.03
Low Price Case	16.98	16.98	16.98	16.98
IEO2003 Reference Case	24.28	25.01	25.77	26.89
GII	22.26	22.93	23.85	24.77
IEA	21.75	23.82	25.89	27.96
PEL	21.27	18.41	15.60	—
PIRA	23.90	26.70	—	—
NRCan	22.57	22.57	22.57	—
DB	18.43	18.41	18.16	18.26
EEA	20.33	19.84	19.36	—
NPC	18.00	18.00	18.00	18.00
SEER	19.86	20.88	22.49	24.53
CGES	21.27	18.41	15.60	—

Notes: *IEO2004* and *IEO2003* projections are for average landed imports to the United States. PIRA, NRCan, SEER, and NPC projections are for West Texas Intermediate crude oil at Cushing. GII, DB, and EEA projections are for composite refiner acquisition prices. IEA projections are for IEA crude oil import price. PEL projections are for Brent crude oil.

Sources: ***IEO2004*:** Energy Information Administration, *Annual Energy Outlook 2004*, DOE/EIA-0383(2004) (Washington, DC, January 2004). ***IEO2003*:** Energy Information Administration, *Annual Energy Outlook 2003*, DOE/EIA-0383(2003) (Washington, DC, January 2003). **GII:** Global Insight, Inc., *Global Petroleum Outlook, Winter 2003*-2004 (Lexington, MA, January 2004), p. 41. **IEA:** International Energy Agency, *World Energy Outlook 2002* (Paris, France, September 2002). **PEL:** Petroleum Economics, Ltd., *World Long Term Oil and Energy Outlook* (London, United Kingdom, April 2003), p. 71. **PIRA:** PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2003), Table II-3. **NRCan:** Natural Resources Canada, *Canada's Energy Outlook, 1996-2020*, Annex C2 (Ottawa, Ontario, Canada, April 1997) (reaffirmed in August 2003). **DB:** Deutsche Banc AG, "World Oil Supply and Demand Estimates," e-mail from Adam Sieminski (March 1, 2004). **EEA:** Energy and Environmental Analysis, Inc., EEA Compass Service: October 2003 Base Case. **NPC:** National Petroleum Council, *Assumptions for the NPC Natural Gas Study* (Washington, DC, October 2003). **SEER:** Strategic Energy & Economic Research, Inc., *2003 Energy Outlook* (Winchester, MA, 2003). **CGES:** Centre for Global Energy Studies, *Annual Oil Market Forecast and Review 2003* (London, UK, January 2003), p. 164.

OPEC oil production and (2) the timing of an expected increase in EE/FSU oil production. The views about the rate of supply increases to come from the former Soviet Union vary strongly among the forecasters and are key to explaining the differences between the series.

High world oil prices, in excess of $25 per barrel, that have been sustained since mid-2002 have helped sustain the economic recovery of Russia—currently the largest oil producer in the EE/FSU region. Higher investment in Russia's oil sector over the past several years and the interest of foreign companies in participating in the upstream projects in Russia and the other oil-rich former Soviet republics has no doubt influenced the thinking on how fast oil production may grow in the EE/FSU. In 2002, the EE/FSU region as a whole accounted for about 12 percent of total world oil supply. In the *IEO2004* reference case projection, the EE/FSU share of world supply rises to 15 percent in 2020 before declining to 14 percent by 2025 (Table 10). DB is much more bullish about the EE/FSU production potential in the early years of the forecast, expecting EE/FSU supply to rise quickly to account for 17 percent of world supply in 2010 and then drop to 15 percent in 2025. IEA is the least optimistic about growth potential in the region; its projected share for the EE/FSU grows to 14 percent in 2010 but falls to 13 percent in 2020.

The forecasts that provide projections through 2020 (*IEO2004*, DB, GII, IEA, and PEL) expect OPEC to

Table 10. Comparison of World Oil Production Forecasts

	Percent of World Total			Million Barrels per Day			
Forecast	OPEC	EE/FSU	Other Non-OPEC	OPEC	EE/FSU	Other Non-OPEC	Total
History							
2002	38	12	50	29.7	9.6	38.6	**77.9**
Projections							
2010							
IEO2004	39	14	46	35.7	13.1	42.3	**91.1**
GII	38	16	49	33.0	13.6	42.7	**88.4**
IEA[a]	40	14	39	35.9	12.7	35.1	**88.9**
PEL	38	15	45	33.5	12.8	39.5	**88.0**
PIRA	35	16	50	31.3	14.1	45.3	**90.7**
DB	39	17	42	34.7	15.1	37.6	**89.4**
2015							
IEO2004	40	15	45	40.0	15.1	45.1	**100.2**
GII	43	15	45	40.4	14.1	43.1	**94.9**
PEL	43	15	40	40.6	14	38.2	**95.2**
PIRA	38	16	46	37.2	15.4	45.6	**98.2**
DB	44	17	37	42.4	17.0	35.7	**97.3**
2020							
IEO2004	43	15	42	47.8	16.1	46.0	**110.0**
GII	47	15	42	48.4	15.1	43.2	**103.7**
IEA[a]	48	13	31	50.2	13.9	31.8	**104.1**
PEL	48	15	35	48.9	15.0	35.7	**102.2**
DB	47	17	34	48.8	17.7	35.7	**104.7**
2025							
IEO2004	46	14	39	56.0	17.3	47.2	**120.6**
GII	51	14	36	58.2	16.1	41.2	**116.9**
DB	49	15	34	56.0	17.3	38.9	**115.1**

[a]In the GII projections, EE/FSU includes only Russia.
[b]IEA total supply numbers include processing gains and unconventional oil. As a result, regional percentages do not add to 100.
Note: IEA, GII, PEL, and DB report processing gains separately from regional production numbers. As a result, the percentages attributed to OPEC, EE/FSU, and Other Non-OPEC do not add to 100.
Sources: ***IEO2004*:** Energy Information Administration, System for the Analysis of Global Energy Markets (2004). **GII:** Global Insight, Inc., *Global Petroleum Outlook, Winter 2003*-2004 (Lexington, MA, January 2004), p. 40. **IEA:** International Energy Agency, *World Energy Outlook 2002* (Paris, France, September 2002), p. 96. **PEL:** Petroleum Economics, Ltd., *World Long Term Oil and Energy Outlook* (London, United Kingdom, April 2003), Table 4. **PIRA:** PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2003). **DB:** Deutsche Banc AG, "World Oil Supply and Demand Estimates," e-mail from Adam Sieminski (March 1, 2004).

provide incremental production of between 18 and 20 million barrels per day between 2002 and 2020 (Table 10). There is more variation in expectations among these five forecasts for the "other" non-OPEC suppliers. GII expects other suppliers to provide increases of 5 million barrels per day and *IEO2004* expects an increase of 7 million barrels per day, whereas IEA expects declines of 7 million barrels per day—and PEL and DB expect declines of 3 million barrels per day—in production from other non-OPEC sources. IEA, DB, and PEL expect the "other" non-OPEC share of world oil supply to fall precipitously over the forecast period. The "other" share falls from 39 percent in 2010 to 31 percent in 2020 in the IEA forecast, from 45 percent in 2010 to 35 percent in 2020 in the PEL forecast, and from 42 percent in 2010 to 34 percent in 2020 in the DB forecast. Over the 2010-2020 period, *IEO2004* and GII foresee a much slower decline in the share of "other" supplies, on the order of 4 to 7 percentage points.

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