World Oil Markets

In the IEO2002 forecast, periodic production adjustments by OPEC members are not expected to have a significant long-term impact on world oil markets. Prices are projected to rise gradually through 2020 as the oil resource base is expanded.

Throughout the last quarter of 2001, crude oil prices were below the range preferred by Organization of Petroleum Exporting Countries (OPEC) producers ($22 to $28 per barrel for the OPEC basket price). Three factors contributed to the softening of prices late in 2001. First, there was only a loose adherence by some OPEC producers to announced cutbacks in production. Second, the long-anticipated increase in non-OPEC production brought about by the high price environment of 2000 and 2001 began to materialize. Third, world demand growth continued to be extremely sluggish.

World oil prices are expected to show some recovery in 2002, assuming disciplined adherence by OPEC producers to their stated cutback intentions as well as additional supply reductions by several key non-OPEC producers. Russia, Norway, Mexico, Oman, and Angola all have committed to production cutbacks in order to firm up prices. It remains to be seen, however, 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 traditionally had only sporadic success.

World oil consumption in 2001 rose by less than 100 thousand barrels per day, scattered evenly among the industrialized nations (mainly Western Europe) and developing nations (mainly Latin America). Although the developing Asian economies are no longer in recession, their current growth is modest by comparison with their rapid economic expansion during the early and mid-1990s. Latin American oil demand has also experienced only modest growth since 1999. In the former Soviet Union (FSU), where oil demand grew in 2000 for the first time in more than a decade, there was a slight decline in demand in 2001. Global oil demand in 2002 is expected to grow by about 600,000 barrels per day [***1***].

OPEC members (not including Iraq) have agreed to cutbacks that will reduce current production levels by about 1.7 million barrels per day, in response to indications of price weakness in the near-term market. It is anticipated that the cutbacks will keep the world oil price (U.S. refiner acquisition cost for imports) commensurate with the lower end of the OPEC target range for the basket price of $22 to $28 per barrel throughout 2002, although additional production corrections are certainly possible. Iraq's oil production and export volumes have been continuing at the sanction levels dictated by the United Nations Security Council. Those levels are assumed to remain in effect throughout all of 2002.

Historically, OPEC's market management strategies have often ended in failure. OPEC's recent successes have been the result of tight market conditions 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, making OPEC's consensus building easier as a result. Non-OPEC production is expected to show significant increases in the near future, however, and several members of OPEC have announced plans to expand production capacity over the next several years. In an oil market environment with substantial spare production capacity, it will 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. Although 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, non-OPEC production increased by 1.1 million barrels per day in 2000 and by an additional estimated 700 thousand barrels per day in 2001, and it is expected to increase by another 1 million barrels per day in 2002. Almost one-half of the worldwide non-OPEC production increase over the next 2 years is expected to come from the FSU. The remainder of the expected increase is evenly divided between producers in industrialized nations and those in developing economies.

Incorporating the recent price turbulence into the construction of an intermediate- and long-term oil market outlook is difficult and raises the following questions: Will prices return to OPEC's preferred range in response to production cutback strategies, or will the anticipated increase in non-OPEC production temper the price rise? Will sustained and robust economic growth in developing countries return in the aftermath of the severe setback to the Asian economies in 1997-1999? Will

technology guarantee that oil supply development will move forward even if a low world oil price environment returns?

Although oil prices more than doubled in real terms from 1998 to 1999 and have softened considerably since then, such developments are not indicative of the trend in the *International Energy Outlook 2002* (*IEO2002*) reference case. In the short term, oil prices are expected to decline slightly until agreed-upon OPEC production cutbacks are put into place along with some non-OPEC cooperation early in 2002. From their anticipated level in 2002, oil prices are expected to increase gradually to 2020. When the economic recovery in Asia is complete, demand growth in developing countries throughout the world is expected to be sustained at robust levels. Worldwide oil demand is projected to reach almost 119 million barrels per day by 2020, requiring an increment to world production capability of almost 44 million barrels per day relative to current capacity. OPEC producers are expected to be the major suppliers of increased production requirements, 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 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 long sustained. 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 *IEO2002* low and high world oil price cases suggest that the projected trends in growth for oil production are sustainable without severe oil price escalation. There are oil market analysts, however, who find this viewpoint to be overly optimistic, based on what they consider to be a significant overestimation of both proven reserves and ultimately recoverable resources (see box on page 25).

Highlights of the *IEO2002* projections for the world oil market are as follows:

- The reference case oil price projection shows an increase of more than $4 per barrel over current prices out to 2003, followed by a modest 0.6-percent average annual increase from 2003 to 2020.
- Deepwater exploration and development initiatives are generally 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 long-term growth in 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 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 *IEO2002* reference case projections are significant. The international war on terrorism, uncertain economic recovery in developing Asia and Japan, the success of China's economic reforms and its political situation, 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.

World Oil Prices

The near-term price trajectory in the *IEO2002* reference case is somewhat different from that in *IEO2001*. In last year's reference case price path, only modest relief was expected in 2001 from the high oil prices of late 1999 and 2000, primarily because of OPEC's demonstrated ability to adhere to announced production cutbacks. This year's reference case price path shows prices falling to $21.55 per barrel in 2001, based on weak demand, less-than-anticipated non-OPEC supply, some cheating by OPEC members in their market management strategies, and

Oil Resources in the 21st Century: What Shortage?

In the late 1990s it became fashionable to warn the world of a looming shortage in worldwide oil supplies. Much of the pessimistic speculation was related to a disbelief in the estimates of oil reserves, especially those claimed by OPEC nations throughout the 1980s. Although the controversy regarding oil reserves has dissipated somewhat, there has been much evidence that the long-term production potential of oil resources is healthy. This is true for both conventional oil and nonconventional resources.

The U.S. Geological Survey, in its most recent assessment of oil's long-term production potential, identified at least 3 trillion barrels (mean estimate) of ultimately recoverable conventional oil worldwide.[a] Because history has shown that only about one-fourth of the oil estimated to be "ultimately recoverable" has actually been produced, rough calculations would place the likely peak in worldwide conventional oil production at some point beyond 2020.

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 technology. With higher prices, the gap between conventional oil and nonconventional resources narrows. Ultimately, a combination of escalating prices and technological enhancements will transform the nonconventional into the conventional. Much of the pessimism about oil resources has been focused entirely on conventional resources. However, the decade of the 1990s saw technological advances that helped bring down the cost of producing liquid fuels from several nonconventional sources, including heavy oils, tar sands, and natural gas.

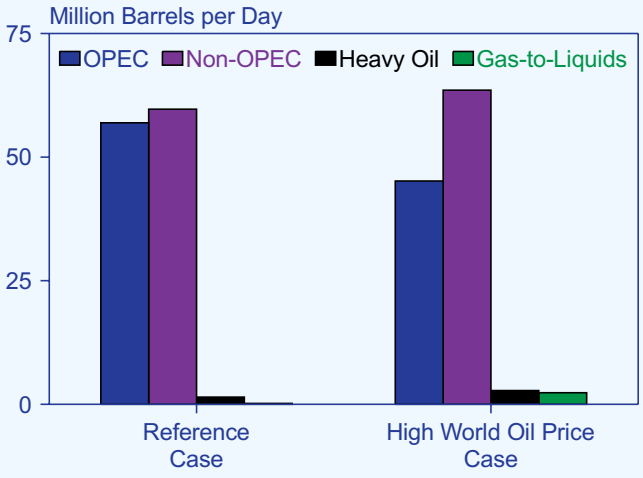
Heavy oils typically have an API gravity of less than 24 degrees and will not flow on their own at standard reservoir temperatures. Tar sands are similar, but with more viscous oil and located closer to the surface. More than 3.3 trillion barrels (oil in place) of heavy oil and tar sands is estimated worldwide, with Canada and Venezuela having the most significant deposits. There are two distinct methodologies for recovering these resources from the ground. For deposits close enough to the surface, mining is feasible. For deeper deposits, steam injection can be used to heat the oil, allowing it to flow more like conventional oil. Once the oil has been retrieved, it still must be cleaned and upgraded before it will behave more like conventional refinery feedstocks.[b] The reference case in *IEO2002* shows development of almost 900 thousand barrels per day in heavy oils and tar sands production capacity over the forecast period. The high world oil price case shows an increase of almost 2.2 million barrels per day of production capacity by 2020. All of the new capacity is expected to be built in Canada and Venezuela. It is assumed that this production capacity could be economically developed and produced at prices in the range of $23 to $25 per barrel.

Significant portions of the world's natural gas resources lie in remote locations or are found in small accumulations. Development of such projects usually is discouraged, because delivery via pipeline or LNG tanker is often uneconomical. Using an updated version of a technology that has existed since World War II (Fischer-Tropsch), natural gas molecules can be recombined as liquid synthetic petroleum products. Gas-to-liquids (GTL) technology is an attractive marketing option, because the infrastructure for petroleum products is already in place. The GTL technology also has enough versatility to accommodate smaller gas deposits economically. In addition, GTL offers a number of environmental advantages that may enhance its economic attractiveness.[c]

A few GTL projects are expected to be built in the *IEO2002* reference case because of convenient access to

(continued on page 26)

Projected OPEC, Non-OPEC, and Nonconventional Oil Supply in 2020



Source: Energy Information Administration, World Energy Projection System (2002).

[a]U.S. Geological Survey, *World Petroleum Assessment 2000,* web site http://greenwood.cr.usgs.gov/energy/WorldEnergy/DDS-60.
[b]National Energy Board, *Canada's Oil Sands: A Supply and Market Outlook to 2015* (Calgary, Alberta, October 2000), p. 22.
[c]Energy Information Administration, *International Energy Outlook 2000,* DOE/EIA-0484(2000) (Washington, DC, March 2000), p. 59.

Oil Resources in the 21st Century: What Shortage? (Continued)

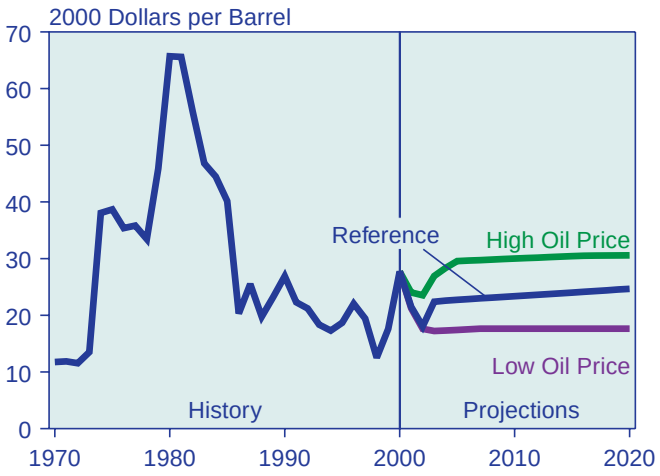
distribution infrastructure. In the high world oil price case, an increase of more than 2.3 million barrels per day is projected over the forecast period, including projects in Latin America, the Pacific Rim, the Middle East, the former Soviet Union, and the United States. It is assumed that this production capacity could be economically developed and produced at prices in the range of $26 to $28 per barrel. The figure below compares the supply-side response in the *IEO2002* high world oil price case with that in the reference case.

In the *IEO2002* high world oil price case, heavy oil, tar sands, and GTL are the only nonconventional oil supplies that are economically viable. It is conceivable, however, that oil prices could be substantially higher. For example, if the OPEC producers adopt a conservative capacity expansion strategy, prices could more than double in real terms over the forecast period. Such a steady diet of high oil prices would further alter the supply side of the market in ways even beyond those suggested by heavy oil, tar sands, and GTL. For example, other nonconventional liquids might begin to make inroads into such a market. Coal-to-liquids technologies and even shale oil (with enormous worldwide reserves that dwarf those of conventional oil) might be introduced into the supply mix.

Any long-term strategy that has as an objective the achievement of sustained high prices is unlikely to be successful, given the feasibility of making nonconventional supplies economical at those prices. The inability to predict accurately the diminishing costs of current technologies or the enhanced capabilities of new technologies could make a long-term high price strategy a risky one for OPEC. Reasonable arguments can be made that any artificial (non-market) means of production management might achieve short-term objectives but are unlikely to optimize revenues or stabilize market share in the long run. 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.

Saudi Arabia's decision to postpone production cutbacks in the aftermath of the September 11, 2001, terrorist attacks on the United States. In both outlooks, the price trajectory in the reference case beyond 2005 shows a gradual increase of about 0.5 percent per year to 2020. Three possible long-term price paths are shown in Figure 23. In the reference case, projected prices reach $24.68 in 2020 (all prices in 2000 dollars unless otherwise noted). In nominal dollars, the reference case price is expected to exceed $42 in 2020. In the low price case, prices are projected to reach $17.41 by 2005 and to remain at about that level out to 2020. In the high price case, prices are projected to reach $30.50 by 2015 and to remain at about that level out to 2020. The projected leveling off in the high price case is due to the market penetration of alternative energy supplies that could become economically viable at that price.

Figure 23. World Oil Prices in Three Cases, 1970-2020



Sources: **History:** Energy Information Administration (EIA), *Annual Energy Review 2000*, DOE/EIA-0384(2000) (Washington, DC, July 2001). **Projections:** 2000-2002—EIA, *Short-Term Energy Outlook*, on-line version (January 8, 2002), web site www.eia.doe.gov/emeu/steo/pub/contents.html. 2003-2020—EIA, *Annual Energy Outlook 2002*, DOE/EIA-0383 (2002) (Washington, DC, December 2001).

In all the *IEO2002* oil price cases, oil demand is expected to rise significantly over the projection period. In the high and low world oil price cases, the projected rise in oil consumption ranges from a low of 39 million barrels per day to a high of 50 million barrels per day, respectively. There is widespread agreement that resources are not a key constraint on world demand to 2020. Rather more important are the political, economic, and environmental circumstances that could shape developments in oil supply and demand.

World Oil Demand

Over the next two decades, oil is projected to remain the dominant fuel in the world energy mix, accounting for 40 percent of total energy consumption worldwide throughout the forecast period. Total world oil demand is expected to grow by 2.2 percent annually, rising from 74.9 million barrels per day in 1999 to 118.6 million barrels per day in 2020 (Figure 24). In the industrialized world, oil use grows much more slowly than the world average, at 1.3 percent per year, as oil markets reach saturation levels in all end use sectors except electric

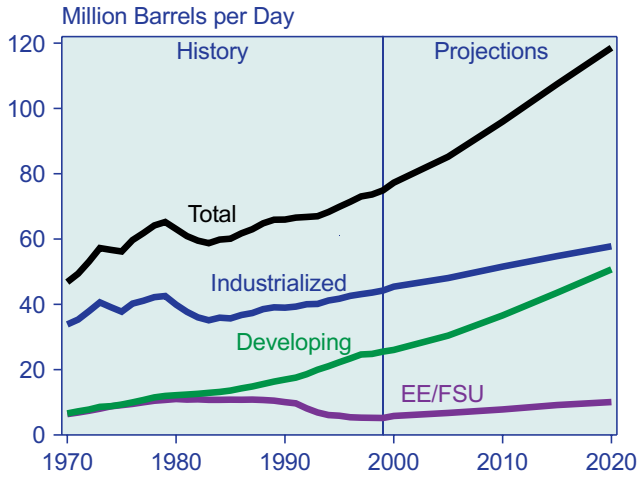
power. Oil use in the industrialized world is expected to decline as natural gas becomes the fuel of choice for new electricity generation capacity.

The highest growth in oil demand is projected for developing Asia, at 3.7 percent per year and accounting for 35 percent of the increment in oil consumption in the forecast period (Figure 25). Oil intensity is projected to remain high in developing countries relative to that in the industrial world (Figure 26). Industrial processes continue to require large amounts of fuel relative to output. Even in the transportation sector, the motor vehicle fleets in developing countries burn large amounts of gasoline or diesel fuel relative to their size, power, and capacity, as is the case in China. Relatively high levels of oil intensity are expected to contribute to the fast-paced growth of oil use in the region as a whole [***2***].

World oil demand increased modestly in 2001, by 100 thousand barrels per day [***3***]. Early in 2001 the world oil market was extremely tight. Prices were high and there was concern that there might be shortages in supply. In the last quarter of 2001, however, prices eased considerably as a result of the economic slowdown in the United States and a sharp decrease in jet fuel demand after the September terrorist attacks. The current global economic slowdown is expected to have only short-term effects on oil demand. As the world economy recovers, oil demand is expected to resume an upward trend in the *IEO2002* reference case projection. In general, disruptions in oil demand have historically been short-lived. For instance, in 1990 and 1991 many economies were in recession, and air travel fell sharply in reaction to the Gulf War. As the global economy recovered, however, oil demand returned to its upward trend.

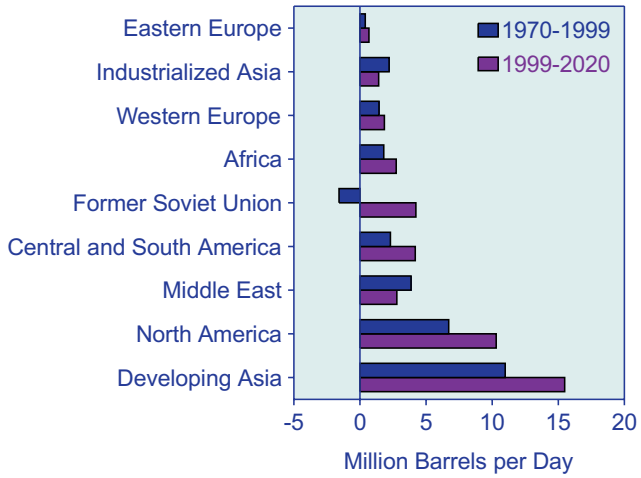
The transportation sector is expected to account for much of the worldwide increase in oil use over the projection period. By 2020, transport is projected to account for 55 percent of world oil demand, based on expectations that there will be no economically viable substitutes for oil as a transportation fuel, and that private ownership of motor vehicles will continue to expand in most of the developing countries.

Figure 24. World Oil Consumption by Region, 1970-2020



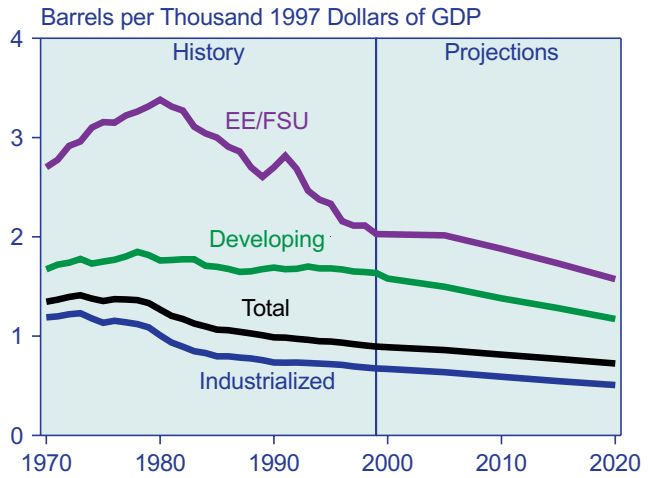
Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

Figure 25. Increments in Oil Consumption by Region, 1970-1999 and 1999-2020



Sources: **1970 and 1999:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **2020:** EIA, World Energy Projection System (2002).

Figure 26. Oil Intensity by Region, 1970-2020



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

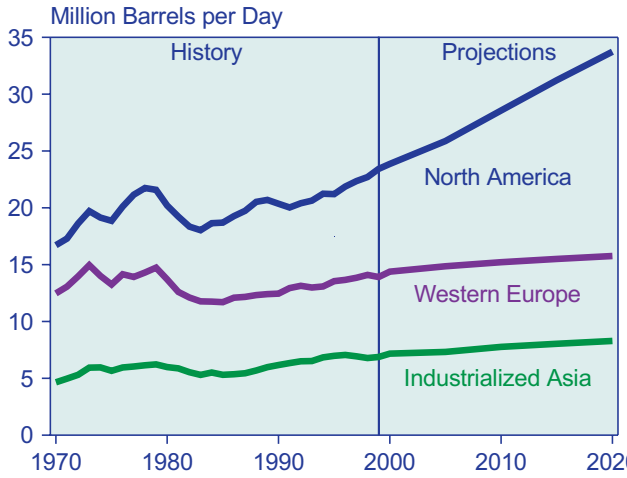
North America

Petroleum product consumption in North America is projected to increase by 10.3 million barrels per day from 1999 to 2020, at an average annual growth rate of 1.8 percent. This is by far the largest expected increase among the industrialized regions (Figure 27).

The effects of the slowing global economy and the recession in the United States are expected to affect demand for all petroleum products in North America. In the short term, the largest expected reduction in oil demand is in the jet fuel market. U.S. jet fuel demand declined by almost 4 percent in 2001 and is expected to be down by 10 percent in the first half of 2002 [***4***]. Over the past year, high jet fuel prices, the largest component of airline costs, contributed to the slowdown of air passenger travel and air cargo shipments [***5***]. The slowdown became steeper after the September 11 terrorist attacks. Most airlines in North America announced significant reductions in flight schedules, averaging 20 to 25 percent from normal levels [***6***]. There is considerable uncertainty in the short term about the pace of recovery of North American airline travel and jet fuel demand.

The United States is the largest consumer of oil in the world, accounting for more than one-fourth of total world demand. The *IEO2002* reference case projects that primary consumption of oil in the United States will increase by 1.5 percent annually from 1999 to 2020, and that oil's share in the U.S. energy mix will increase slightly, from 39.4 percent in 1999 to 39.7 percent in 2020, totaling 26.7 million barrels per day.

Figure 27. Oil Consumption in the Industrialized World by Region, 1970-2020



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

The economic slowdown that started in late 2000 and the terrorist attack on the United States in September 2001 have worsened the short-term demand outlook not only for jet fuel but for all other petroleum products. Distillate fuel use in the United States fell between April and June 2001, when lower natural gas prices led most industrial sector consumers and electric utilities to switch back to natural gas from distillates. Faltering consumer spending and business investment also slowed the growth in demand for petrochemicals and for liquefied petroleum gas (LPG) and naphtha feedstocks as well.

Over the next 20 years, the expected trend of moderate oil prices should facilitate growth in U.S. oil demand, centering on the transportation fuels. The growing penetration of relatively high-consumption sports utility vehicles will support higher oil demand in this sector. It is not expected that diesel will surpass or substitute for gasoline as the primary passenger fuel, as it has in Western Europe. Oil use in the electric power sector is expected to continue its long-term decline as natural-gas-fired generating capacity gains market share. Industrial oil demand is also expected to rise at a modest rate of 1.1 percent per year, reflecting slower growth in industrial output and a continuing structural shift toward less energy-intensive manufacturing and services [***7***].

In Canada, virtually all the increase in oil consumption expected from 1999 to 2020, estimated at 0.5 million barrels per day, is expected to occur in the transportation sector. Canada's extensive hydroelectric and natural gas resources are widely used for power generation and for industrial and commercial uses. The trend in transport fuel demand is similar to that in the United States. Gasoline is the preferred vehicle fuel in the Canadian market, and sales of sport utility vehicles are rising.

In Mexico, total demand for oil is expected to rise by 4.1 percent per year from 1999 to 2020, sustained by an upsurge in the consumption of oil products in all economic sectors, except for power generation. Transportation is expected to remain the largest consumer of oil products, accounting for 50 percent of total petroleum demand in 2020. Total demand for oil is expected to more than double over the forecast period, rising from 2.0 million barrels per day in 1999 to 4.6 million barrels per day in 2020, due mainly to economic growth and a rapidly expanding population.

Western Europe

Oil is the largest energy source in Western Europe; however, the growth in demand projected for the region is the lowest in the *IEO2002* forecast. Oil use in Western Europe is projected to increase by about 0.6 percent per year, from 13.9 million barrels per day in 1999 to 15.8

million barrels per day in 2020. Most of the incremental demand is expected in the transportation sector.

The oil share of the electricity generation market is expected to continue to decline with the rapid penetration of natural gas in the power sector. At current oil prices, heavy fuel oil is too expensive for normal baseload generation, and its main use is in delivering power at peak periods from existing oil-fired boilers. Because cheaper natural gas has become available in the Southern part of Europe through the Trans-Mediterranean pipeline from North Africa (completed in 1983) and the Algerian Bazoduc Maghreb-Europe pipeline to Spain (completed in 1996) [***8***], oil's share of the power generation market is expected to continue to decline [***9***].

Jet fuel demand in Western Europe has increased by 40 percent since 1990, and demand for diesel fuel has risen by more than one-third. Over the same period, gasoline demand has barely changed, mainly because it continues to be more highly taxed than are other fuels, and tax differentials have encouraged consumers to purchase diesel-fueled cars. In addition, the steady growth in road freight is expected to boost diesel demand, assuming that diesel fuel continues to be taxed less heavily than gasoline.

Industrialized Asia

All the countries of industrialized Asia (Japan, Australia, and New Zealand) are net importers of oil. Japan, which imports all the oil it uses, accounts for 81 percent of the total demand in the region. Oil demand in industrialized Asia is projected to increase by an average of 0.9 percent per year, from 6.9 million barrels per day in 1999 to more than 8.3 million barrels per day in 2020. Relative to other fuels, oil use is expected to grow slowly. Oil's share in the region's energy mix is declining steadily with a continuing shift toward other fuels, particularly to natural gas in the power sector. Oil use produces 18 percent of Japan's electricity, and its share has been declining. Australia's use of oil for electricity generation is marginal, and New Zealand uses none [***10***].

Most of the demand for oil in industrialized Asia is for transportation. In Japan, demand for gasoline continues to rise, in large part because of deregulation of the market. Retail gasoline prices in 2001, on average, remained below the levels of 1996, when the Japanese market was liberalized and competition intensified [***11***].

Eastern Europe and the Former Soviet Union

After the collapse of the Soviet Union in 1991 oil demand fell steadily, from 8.3 million barrels per day to approximately 3.7 million barrels per day in 1999. However, economic prospects in the region have improved since 2000, and economic growth is expected for the countries of the FSU in the near future. FSU oil consumption is expected to increase at an annual average rate of 3.7 percent from 1999 to 2020, reaching 8.0 million barrels per day at the end of the forecast period—still well below the region's peak use of 9.0 million barrels per day in 1987.

All the FSU economies began to show positive economic growth in 2000, many of them at high rates. Economic growth in the region is expected to average 4.7 percent per year from 1999 to 2020, but improved industrial efficiencies and fuel switching in favor of natural gas for power generation are projected to result in somewhat slower increases in oil demand, averaging 3.7 percent per year over the forecast.

Oil demand in Eastern Europe is expected to grow by an average of 1.8 percent per year, from 1.5 million barrels per day in 1999 to 2.1 million barrels per day in 2020. Given the expectations for continued economic growth and the accompanying rise in personal income levels, most of the growth in East European oil use is expected to occur in the transportation sector, particularly in the region's largest economies—Poland, Hungary, and the Czech Republic—which are close to Western European markets and are members of the Organization for Economic Cooperation and Development (OECD).

Motorization levels in Eastern Europe (the number of vehicles per thousand persons) are expected to rise from 217 in 1999 to 284 in 2020. Growth in demand for transportation fuels is expected to be led by diesel, as is also expected for the neighboring countries of the European Union. In fact, as part of their drive to join the European Union and meet its fuels standards, major Eastern European refiners such as Poland's PKN Orlen and the Czech Republic's Czeska Rafinerska are continuing to invest heavily in improvements aimed at achieving fuel standards required by the European Union. PKN Orlen, for example, is planning to invest $250 million at its Plock refinery to improve gasoline and diesel quality to meet 50 parts per million sulfur specifications before 2005. This investment is on top of the $2 billion spent on a major refinery upgrade project in 2000 [***12***].

Developing Asia

China

Developing Asia remains the focus of expectations for future growth in world oil demand. In less than 10 years, China is expected to become the largest oil consumer in Asia, surpassing Japan as the world's second largest oil consumer after the United States. With the transportation sector accounting for most of the increase, oil use in China is expected to grow by 4.3 percent per year, from 4.3 million barrels per day in 1999 to 10.5 million barrels per day in 2020 (as compared with 6.4 million barrels per day projected for Japan in 2020).

Currently, the transportation sector is the smallest final energy consumer in China among the major economic sectors, accounting for 14 percent of total energy use. Within the transportation sector, motor fuels consumption accounts for around 70 percent [***13***]. Vehicle ownership, still relatively low in China at less than 12 cars per thousand persons in 1999, is projected to reach 52 per thousand by 2020. As per capita income rises, the demand for cars, and therefore for transport fuel, is expected to increase dramatically. The Chinese government has allocated more resources to expand and upgrade the highway network in anticipation of this growth. By 2020, demand for transportation fuels is projected to make up 56 percent of total oil demand in China. Increasing personal wealth and higher average incomes in China are expected to outweigh high retail prices for transportation fuels, which still are set by the Chinese government but increasingly have reflected global market prices.

Outside the transportation sector, oil demand in China is projected to increase by an average of 2.4 percent per year, as compared with the average growth rate of 0.5 percent per year projected for nontransportation oil use in the industrialized countries. In the 1970s, China consumed a large volume of crude oil directly in various industries, especially for power generation. In the late 1970s, when crude oil production became stagnant, the government moved to restrict the use of oil in the electric power sector and to convert as many oil-fired power plants to coal firing as possible [***14***]. Consumption of petroleum products in China grew by 3.2 percent per year on average during the 1980s and by 6.5 percent per year from 1990 to 1999.

India

India is projected to be among the world's fastest growing economies over the forecast period, and its oil consumption is projected to grow by 4.6 percent per year on average from 1999 to 2020, to nearly 4.9 million barrels per day. The country depends on oil for about 33 percent of its total energy needs and imports about 1.3 million barrels per day or two-thirds of its crude oil requirement.

The transportation sector is expected to be the main source of the increase in India's oil demand over the next two decades. Fuel use for road travel is heavily weighted toward diesel fuel, and approximately 80 percent of motor vehicles in India run on diesel (compared to 15 percent in China). Despite substantial increases in crude oil prices from 2000 through early 2001, diesel remains less than half as expensive as gasoline. India's domestic price deregulation will likely support growth in gasoline demand if it proceeds as scheduled in 2002, with prices expected to fall to import parity levels.

India's agricultural sector is a large consumer of oil products, mainly distillate, although droughts like the one experienced in 1999 have tended to dampen oil demand. Assuming normal precipitation in India, agricultural activity is expected to increase, leading to faster growth in demand for oil in this sector.

Other Developing Asia

Although demand for oil products in developing Asia recovered more rapidly than many analysts expected after the economic crisis of 1997-1999, it is anticipated that, over the long term, oil demand will increase at a slower and more sustainable rate than the high growth rates recorded during the 1990s. The short-term economic outlook and oil demand growth remain mixed, given the current weakness of the export-oriented economies such as South Korea, Taiwan, Singapore, Malaysia, Thailand, Indonesia, and the Philippines. Recovery is expected to be in line with the U.S. economy in the next few quarters.

In 2001, naphtha demand increased rapidly as sizable expansions in naphtha-cracking ethylene production capacities took place in Taiwan and Singapore. To meet this growing demand, ExxonMobil constructed an 800,000 metric ton per year ethylene production unit in Singapore, which became fully operational at the end of 2001. In addition, a combined increment of 280,000 metric tons per year in capacity was scheduled for completion in Singapore and Thailand by the end of 2001 [***15***].

Demand for residual fuel is expected to remain sluggish among the countries of other developing Asia. Power generation and industrial plants are likely to continue shifting away from residual fuel in favor of natural gas. The shutdown of Indonesia's natural gas fields in North Aceh in response to domestic insurgency, however, increased concerns over the stability of the natural gas supply to industries that have switched from oil and have become highly dependent on liquefied natural gas (LNG). South Korea, which currently imports about 42 percent of its LNG from Indonesia [***16***], would be particularly vulnerable to a disruption of LNG supplies.

Total oil demand in South Korea is projected to grow from 2.0 million barrels per day in 1999 to 3.0 million barrels per day in 2020—an average annual rate of 1.9 percent—led by growth in the transportation and industrial sectors. The rate of increase in oil demand is expected to be much slower than it was over the past two decades. Oil demand grew by more than 8 percent per year between 1980 and 1999, as transportation energy use increased rapidly. The main factors that are expected to slow the growth of oil use in the future are moderating economic growth, industrial restructuring, and energy demand saturation in some sectors, particularly transportation. As the Korean economy moves from

energy-intensive industrial activities to service industries, energy intensity is also projected to decline [***17***].

Central and South America

Oil consumption in Central and South America is projected to increase from 4.7 million barrels per day in 1999 to 8.8 million barrels per day in 2020. At present, oil consumption in Central and South America accounts for about 48 percent of total primary energy demand. However, oil's share of the energy mix has been steadily declining, mainly in the power generation and industrial sectors due to substitution of hydroelectricity, natural gas, and coal. Continued declines in oil's share in these sectors are expected to be offset by growth in the transportation sector.

Oil consumption for transportation in Central and South America is expected to increase at an average rate of 3.1 percent per year, from 2.6 million barrels per day in 1999 to 4.9 million barrels per day in 2020. The number of vehicles per thousand people is projected to increase from 100 in 1999 to 236 by 2020.

Brazil is the largest economy in Central and South America, accounting for 42 percent of the region's total oil demand. Brazil's oil consumption in 1999 is estimated to have been 2.0 million barrels per day, the same as India's, and it is projected to grow at an annual average rate of 3.3 percent to 3.9 million barrels per day in 2020.

Brazil's electricity capacity shortage in 2000—caused by a persistent drought that reduced hydroelectric reservoir levels substantially—led to rationing in June 2001. In response to the lack of hydroelectric capacity available, some industrial consumers began to use backup diesel generation to avoid shutting down plants. Brazil's state-owned oil company, Petrobras, announced that it would increase oil imports by 20 percent, from 115,000 barrels per day to 140,000 barrels per day, in order to keep up with the new power-related demand [***18***].

Middle East

Oil dominates the energy mix because of its abundance in the Middle East. After the collapse of oil prices in 1998, economic activities and energy demand in the region were constrained. Low oil prices reduced economic growth in most of the region, particularly Iran and the United Arab Emirates. Saudi Arabia's economy managed to expand but at a slow pace. The impact of lower world oil prices in mid- to late 2001, combined with the economic slowdown led by the United States, kept oil use from expanding in 2001, and demand in the region is expected to be flat in 2002. However, as the world's economies recover and oil demand returns in the industrialized world, so too should growth in Middle East oil use. Oil consumption in the Middle East is projected to grow by 2.1 percent per year, from 5.0 million barrels per day in 1999 to 7.8 million barrels per day in 2020.

Oil demand growth in the Middle East is driven by the transportation sector, particularly in countries with large populations, such as Turkey and Iran. The growing petrochemical sectors of Saudi Arabia and the United Arab Emirates are another explanation for the increase in oil use in the region.

Africa

Oil currently supplies 44 percent of Africa's total energy needs. Demand for oil in the region is projected to grow by 3.6 percent per year, from 2.5 million barrels per day in 1999 to 5.3 million barrels per day in 2020. The transportation and electric power sectors, and to a lesser degree the residential sector, account for most of the region's oil consumption. About 47 percent of Africa's total oil use in 1999 was for transportation, and oil demand in the region's transportation sector is expected to grow by an average of 3.1 percent per year, to 2.2 million barrels per day in 2020.

Oil is widely used for electricity generation in Africa, with the exception of South Africa which has huge domestic coal deposits. In the second half of the forecast period, natural gas is expected to start to make some inroads in the electricity sector as African countries develop natural gas infrastructures [***19***]. In addition, oil is still important for agricultural activities in many African economies.

The impact of the high oil price environment in 2000 and at the beginning of 2001 was lower demand in South Africa, the largest economy in the region, as well as in many small, oil-importing countries. However, most of the continent's key economies, including Egypt, Nigeria, Algeria, and Libya, export oil and continue to boost their revenues and consequently economic growth and oil use [***20***].

The Composition of World Oil Supply

In the *IEO2002* reference case, world oil supply in 2020 is projected to exceed the 2000 level by 41 million barrels per day. Increases in production are expected for both OPEC and non-OPEC producers; however, only about one-third 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.

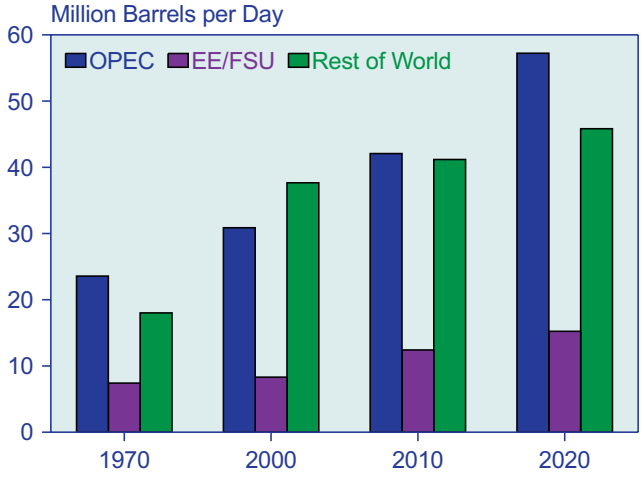
While the long-term outlook for non-OPEC supply remains optimistic, the low oil price environment of 1998 and early 1999 had a definite impact on exploration and development activity. By the end of 1998, drilling activity in North America had fallen by more than 25 percent from its level a year earlier. Worldwide, only the Middle East region registered no decline in drilling activity during 1998. In general, onshore drilling fell more sharply than offshore drilling. Worldwide, offshore rig utilization rates were generally sustained at levels better than 80 percent of capacity [***21***].

The reference case projects that about two-thirds 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 2020 is projected to be more than 26 million barrels per day higher than it was in 2000 (Figure 28). The *IEO2002* estimates of OPEC production capacity to 2005 are slightly less than those projected in *IEO2001*, 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 low and high world oil price forecasts in this outlook do not assume such suggestions.

Reserves and Resources

Table 8 shows estimates of the conventional oil resource base by region out to the year 2025, based on the *World Petroleum Assessment 2000* by the U.S. Geological Survey (USGS). The oil resource base is defined by three categories: remaining 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 8 is derived from the USGS mean estimate, an average assessment over a wide range of uncertainty for reserve growth and undiscovered resources. The *IEO2002* oil production forecast is based on the USGS mean assessment.

Figure 28. World Oil Production in the Reference Case by Region, 1970, 2000, 2010 and 2020



Sources: **History:** Energy Information Administration (EIA), *International Petroleum Monthly*, DOE/EIA-0520(2001/11) (Washington, DC, November 2001). **Projections:** EIA, World Energy Projection System (2002).

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 *IEO2002* reference case, the production call on OPEC suppliers is projected to grow at a robust annual rate of 3.3 percent through 2020 (Table 9 and Figure 29). OPEC capacity utilization is expected to increase sharply after 2000, reaching 95 percent by 2015 and remaining there for the duration of the projection period.

Table 8. Estimated World Oil Resources, 2000-2025
(Billion Barrels)

Region and Country	Proved Reserves	Reserve Growth	Undiscovered
Industrialized			
United States	30.48	76.03	83.03
Canada	15.46	12.48	32.59
Mexico	35.48	25.63	45.77
Japan	0.15	0.09	0.31
Australia/New Zealand	4.34	2.65	5.93
Western Europe	23.77	19.32	34.58
Eurasia			
Former Soviet Union	63.56	137.70	170.79
Eastern Europe	2.40	1.46	1.38
China	24.00	19.59	14.62
Developing Countries			
Central and South America	99.86	90.75	125.31
India	6.24	3.81	6.78
Other Developing Asia	16.51	14.57	23.90
Africa	80.46	73.46	124.72
Middle East	702.69	252.51	269.19
Total	**1,105.41**	**730.05**	**938.90**
OPEC	**863.29**	**395.57**	**400.51**
Non-OPEC	**242.12**	**334.48**	**538.39**

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

Source: U.S. Geological Survey, *World Petroleum Assessment 2000*, web site http://greenwood.cr.usgs.gov/energy/WorldEnergy/DDS-60.

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 *IEO2002* reference case, Iraq is assumed to maintain its current oil production capacity of 3.1 million barrels per day into 2002, 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 production capacity aggressively, to about 6 million barrels per day, once the sanctions are lifted. Preliminary discussions of exploration projects have already been held with potential outside investors, including France, Russia, and China. Such a significant 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 *IEO2002* 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 86 years, substantial capacity expansion clearly is feasible.

Production costs in Persian Gulf OPEC nations are less than $2 per barrel, and the capital investment required to increase production capacity by 1 barrel per day is less than $5,500 [***22***]. Assuming the *IEO2002* low price trajectory, total development and operating costs over the entire projection period, expressed as a percentage of gross oil revenues, would be less than 23 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 $12,000 in some member nations; yet those producers can expect margins in excess of 32 percent on investments to expand production capacity over the long term, even in the low price case [***23***]. Venezuela has the greatest potential for capacity expansion and could aggressively increase its production capacity by more than 1.1 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 *IEO2002* 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

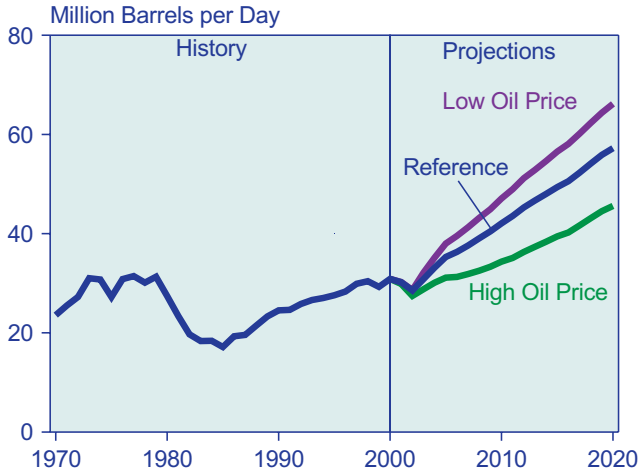
Table 9. OPEC Oil Production, 1990-2020
(Million Barrels per Day)

Year	Reference Case	High Oil Price	Low Oil Price
History			
1990	24.5	—	—
2000	30.9	—	—
Projections			
2005	35.3	31.1	38.0
2010	42.1	34.3	47.1
2015	49.4	39.4	56.5
2020	57.2	45.6	66.2

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

Sources: **History:** Energy Information Administration (EIA), *International Petroleum Monthly*, DOE/EIA-0520(2001/11) (Washington, DC, November 2001), Table 1.4. **Projections:** EIA, World Energy Projection System (2002).

Figure 29. OPEC Oil Production in Three Oil Price Cases, 1970-2020



Sources: **History:** Energy Information Administration (EIA), *International Petroleum Monthly*, DOE/EIA-0520(2001/11) (Washington, DC, November 2001). **Projections:** EIA, World Energy Projection System (2002).

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 two 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 *IEO2002* reference case, non-OPEC supply from proven reserves is expected to increase steadily, from 46.0 million barrels per day in 2000 to 61.1 million barrels per day in 2020 (Table 10).

There are several important differences between the *IEO2002* production profiles and those published in *IEO2001*:

- The U.S. production decline is considerably less severe in the *IEO2002* projections as a result of higher oil price paths, technological advances yielding higher recovery rates, and lower costs for deep exploration and production in the Gulf of Mexico.
- The estimated peak for North Sea production is delayed by a year to 2006 in the *IEO2002* forecast, and the expected decline in production to 2020 is slightly tempered, due to higher oil price paths coupled with enhanced subsea and recovery technologies.
- Resource development in the Caspian Basin region was expected to be delayed significantly in the *IEO2001* forecast due to significant geopolitical challenges and an expected lower price environment. In the *IEO2002* projections, Caspian output is expected to rise to almost 3 million barrels per day by 2005 and to increase steadily thereafter. There still remains a great deal of uncertainty about export routes from the Caspian Basin region.
- *IEO2001* anticipated moderate delays in the exploration and development of deepwater projects worldwide. Significant output from such projects was not anticipated until oil prices returned to and remained in the range of $22 to $28 per barrel for a significant period of time. With higher world oil price assumptions, output from deepwater projects in the U.S. Texas Gulf, the North Sea, West Africa, the South China Sea, Brazil, Colombia, and the Caspian Basin is accelerated in the *IEO2002* forecast by 2 to 3 years (see box on page 35).

In the *IEO2002* forecast, North Sea production reaches a peak in 2006, at almost 6.7 million barrels per day. Production from Norway, Western Europe's largest producer, is expected to peak at about 3.4 million barrels per day in 2004 and then gradually decline to about 3.0 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 2.7 million barrels per day by the middle of this decade, followed by a decline to 2.5 million barrels per day by 2020.

Two non-OPEC Persian Gulf producers are expected to increase output gradually for the first half of this decade. Enhanced recovery techniques are expected to increase current output in Oman by more than 180,000 barrels per day, with only a gradual production decline anticipated after 2005. Current oil production in Yemen is expected to increase by at least 110,000 barrels per day within the next couple of years, and those levels should show little decline throughout the forecast period. Syria is expected to hold its production flat through the first half of this decade, but little in the way of new resource potential will allow anything except declining production volumes.

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 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 middle of this decade, production is expected to reach almost 240,000 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 425,000 barrels per day by 2020.

Table 10. Non-OPEC Oil Production, 1990-2020
(Million Barrels per Day)

Year	Reference Case	High Oil Price	Low Oil Price
History			
1990	42.2	—	—
2000	46.0	—	—
Projections			
2005	49.6	51.7	48.9
2010	53.6	58.1	52.2
2015	57.8	63.7	55.7
2020	61.1	68.2	58.7

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

Sources: **History:** Energy Information Administration (EIA), *International Petroleum Monthly*, DOE/EIA-0520(2000/11) (Washington, DC, November 2001), Table 1.4. **Projections:** EIA, World Energy Projection System (2002).

The 21st Century's First Non-OPEC Surprise: The Atlantic Basin

Non-OPEC oil production has always shown amazing resiliency in the face of overt pessimism. Words such as "decline" and "stagnation" have frequently been associated with forecasts of long-term non-OPEC supply potential. However, the year 2000 saw non-OPEC producers achieve output volumes of almost 46 million barrels per day after two decades of steady growth that averaged 1.1 percent annually.[a] Two factors are generally given credit for non-OPEC's dependable growth. First, the evolution of exploration and recovery technologies dramatically reduced costs and allowed the exploitation of more hostile environments. 3-D seismic, horizontal drilling, floating platforms, and sub-sea completion systems are just some of the technologies that have made important contributions. Second, a few non-OPEC surprises have always seemed to surface every decade. Over the past 25 years, the Alaskan North Slope, Mexico, the North Sea, and the Caspian Basin all have qualified as surprises, with oil production potential exceeding expectations.

A rebound in oil prices from the extremely low levels of 1998 and early 1999 ushered in the new century. The increased drilling activity brought about by higher prices produced an obvious candidate for the first non-OPEC surprise of the 21st century. The Atlantic Basin, featuring Brazil and Argentina along coastal Latin America and the countries from Mauritania to Namibia along coastal West Africa, was experiencing oil finds that were both frequent and sizable. As with many of the non-OPEC surprises of the past, most of this oil was being found in hostile environments. In this case, it was offshore fields in water depths that tested exploration and recovery technologies to their limits.

Most of the interest in the Latin American offshore sector is focused on Brazil. Many of the significant developments in deepwater exploration and production have evolved in Brazil. As early as the 1970s, Brazil recognized the need to concentrate its exploration efforts in offshore areas. The initial production from an offshore basin started in 1977. Its ventures into ultra-deep projects have claimed several world records. Brazil has also realized that two-thirds of the prospective global offshore basins lie in extremely deep water. It is estimated that 75 percent of Brazil's total reserves couldcome from ultra-deepwater projects, exceeding 3,000 feet. Industry experts expect that water depths exceeding 8,000 feet will most likely be feasible for production purposes within 5 years.

In 1997, Brazil enacted legislation that allowed private-sector participation in oil exploration, production, refining, and distribution. As a result of this decision and the resulting diversity and expertise of the investors in Brazil's oil sector,[b] the country's long-term oil exploration and production outlook is viewed with optimism. In the *IEO2002* forecast, Brazil's oil production is expected to increase to 2.8 million barrels per day by 2010, more than doubling current levels. By 2020, production is projected to reach 4.1 million barrels per day. It is expected that the entirety of Brazil's oil production will be consumed domestically, leaving only a modest requirement for imports.

Most of the non-OPEC interest in the West African offshore sector is centered on Angola. Over the past 3 years, the success rate of exploration wells in Angola's deepwater blocks has been stunning, and the field sizes are proving to be astonishing. More than a dozen fields, each with reserves totaling more than 500 million barrels, are being readied for near- to mid-term development. Capital investment in the Angolan oil sector has eclipsed even OPEC member Nigeria's investment draw. In 2000, the offshore sector provided 40 percent of Angola's gross domestic product.

The prolific nature of Angola's oil field discoveries has brought the region to the forefront as the cutting edge for new deepwater technologies. As with many of the West African states, Angola offers attractive terms and conditions with less costly operations than other offshore provinces.[c] *IEO2002* projects that Angola's oil production will increase to levels of 2.1 million barrels per day by 2010, almost tripling current levels, and to 3.3 million barrels per day by 2020. There is a long-term strategic value to Angolan crude oil supplies that should not be underestimated. Many West African streams are lighter, higher-valued crude oils that are tailor-made for U.S. East Coast markets and are able to offer an alternative to Middle Eastern supply sources.

While Brazil and Angola are the Atlantic Basin's predominant non-OPEC oil producers, other emerging economies are also positioned to capture a slice of the deepwater action. In Latin America, Argentina is projected to become a 1 million barrel per day producer by the end of this decade with the development of its offshore sector. In Africa, just about every West African country is either conducting its own search for hydrocarbons or attempting to attract outside investors for licensing agreements. Those countries displaying a

(continued on page 36)

[a]Energy Information Administration, *International Petroleum Monthly*, DOE / EIA-0520(2001 / 12) (Washington, DC, December 2001).

[b]"Deepwater at the Double," *Hart's E&P*, Vol. 73, No. 10 (October 2000), p. 40.

[c]"World Focus on West Africa," *Hart's E&P*, Vol. 74, No. 1, Supplement (January 2001), p. 3.

Australia has made significant recent additions to its proven reserves, and it is possible that Australia will become a million barrel per day producer by the middle of this decade. Malaysia shows little potential for any significant new finds, and its output is expected to peak at around 800,000 barrels per day early in this decade and then gradually decline to 650,000 barrels per day by 2020. Papua New Guinea continues to add to its reserve posture and is expected to achieve production volumes approaching 200,000 barrels per day by the middle 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 Mongolia, but significant output is not expected until late in this decade.

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 4.1 million barrels per day by 2020. Colombia's current economic downturn and civil unrest have delayed its bid to join the relatively short list of worldwide million barrel per day producers, but its output is expected to top a million barrels per day within the decade and show modest decline 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 150,000 barrels per day over the next 2 years, and by the middle of the decade it is likely 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 300,000 barrels per day within the next couple of years.

Several West African producers (Angola, Cameroon, Chad, Congo, Gabon, and Ivory Coast) are expected to reap the benefits of substantial exploration activity, especially considering the recent rebound in oil prices. Angola is expected to become a million barrel per day producer early in this decade. Given the excellent exploration results, Angola could produce volumes of up to 3.3 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 1 million barrels per day for the duration of the forecast.

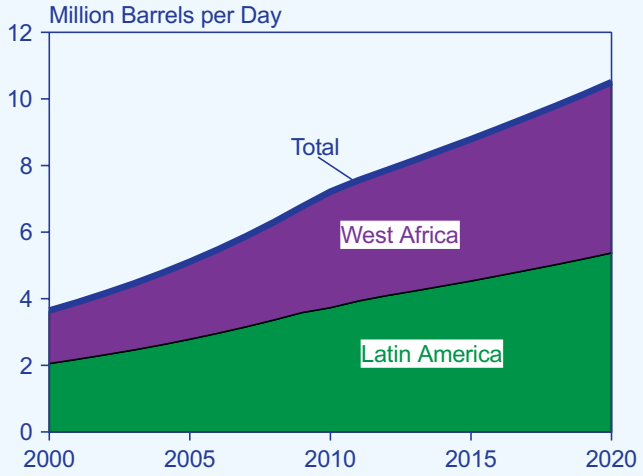
North African producers Egypt and Tunisia produce mainly from mature fields and show little promise of adding to their reserve posture. As a result, their production volumes are expected to decline gradually throughout the forecast. Sudan and Equatorial Guinea are expected to produce modest volumes early in this decade. Eritrea, Somalia, and South Africa also have some resource potential, but they are not expected to produce significant amounts until after 2005.

The 21st Century's First Non-OPEC Surprise: The Atlantic Basin (Continued)

particular interest in deepwater projects include the Ivory Coast, Sierra Leone, Equatorial Guinea, Congo, Namibia, and Gabon. The figure at right presents the oil production forecast for Atlantic Basin non-OPEC producers out to 2020.

There is one particularly attractive aspect of the deepwater component of the oil industry: it is a sector that is still in its infancy. Of the deepwater oil that has been discovered, only 20 percent has been developed and produced. Excursions into water depths over 5,000 feet are still relatively rare and are considered on the edge of feasibility. However, such barriers are softening with the willingness and confidence of oil companies in tackling deepwater projects. Companies are beginning to realize that the deepwater sector is likely to mature over a substantial number of years, and it therefore represents an integral part of their future business for a long time to come. With the exception of Nigeria, most deepwater areas are outside OPEC boundaries. This can only be considered an unexpected but welcome bonus for the deepwater niche of the non-OPEC world oil market.

Projected Atlantic Basin Non-OPEC Oil Production, 2000-2020



Source: Energy Information Administration, World Energy Projection System (2002).

In North America, moderately rising U.S. output is expected to be complemented by significant production increases in Canada and Mexico. Canada's output is expected to increase by more than 200,000 barrels per day over the next 2 years, mainly from Newfoundland's Hibernia oil project, which could produce more than 155,000 barrels per day at its peak sometime in the next several years. Canada is projected to add an additional 700,000 barrels per day in output from a combination of frontier area offshore projects and oil from tar sands. Higher expected oil prices, technological advances, and lower costs for deepwater exploration and production in the Gulf of Mexico enhance the long-term U.S. production profile. Mexico is expected to adopt energy policies that encourage the efficient development of its vast resource base. Expected production volumes in Mexico exceed 4.1 million barrels per day by the end of the decade and remain near that level through 2020.

With assumed higher oil prices, oil production in the FSU is expected to reach 10.0 million barrels per day by 2005—a level that could be somewhat higher if the outlook for investment in Russia were not so pessimistic. The long-term production potential for the FSU is still regarded with considerable optimism, especially for the resource-rich Caspian Basin region. The *IEO2002* reference case shows FSU output exceeding 14.8 million barrels per day by 2020, implying export volumes exceeding 6.9 million barrels per day. In China, oil production is expected to decline by nearly 3.0 million barrels per day by 2020. China's import requirements are expected to be as large as its domestic production by 2010 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 the 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 *IEO2002* price cases, no more than 15, 25, and 35 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, reference, and high price cases, respectively. In all 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 within 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 a relatively low price environment, non-OPEC production has risen every year since 1993, adding more than 5.2 million barrels per day between 1993 and 2000.

It is expected that non-OPEC producers will continue to increase output, producing an additional 7.6 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 2000, industrialized countries imported 15.8 million barrels of oil per day from OPEC producers. Of that total, 9.9 million barrels per day came from the Persian Gulf region. Oil movements to industrialized countries represented more than 70 percent of the total petroleum exported by OPEC member nations and almost two-thirds of all Persian Gulf exports (Table 11). By the end of the forecast period, OPEC exports to industrialized countries are estimated to be about 6.2 million barrels per day higher than their 2000 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 2020 is projected to be almost 14 percent below their 2000 share, and the share of Persian Gulf exports going to the industrialized nations is projected to fall to about 40 percent. The significant shift expected in the balance of OPEC export shares between the industrialized and developing nations is a direct result of the robust 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 17.0 million barrels per day over the forecast period, with more than half of the increase going to the developing countries of Asia. China, alone, is likely to import about 7.2 million barrels per day from OPEC by 2020, virtually all of which is expected to come from Persian Gulf producers.

North America's petroleum imports from the Persian Gulf are expected to almost double over the forecast period (Figure 30). At the same time, more than one-half

of total North American imports in 2020 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.

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 more than double their total petroleum imports between 2000 and 2020.

Worldwide crude oil distillation refining capacity was about 81.5 million barrels per day at the beginning of 2000. To meet the projected growth in international oil demand in the reference case, worldwide refining capacity would have to increase by more than 50 million barrels per day by 2020. Substantial growth in distillation capacity is expected in the Middle East, Central and South America, and especially in the Asia Pacific region.

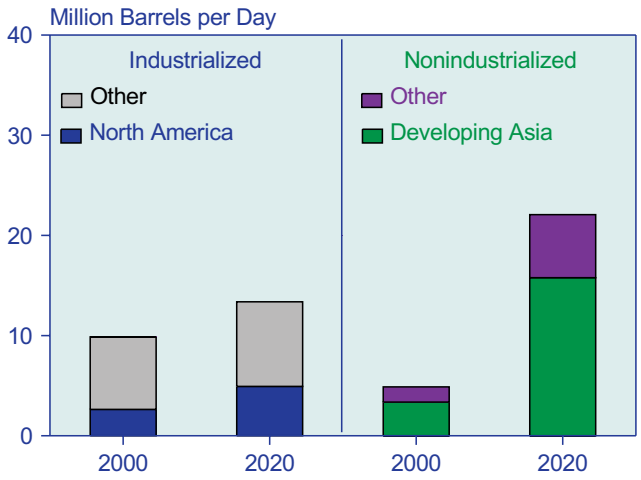
Table 11. Worldwide Petroleum Trade in the Reference Case, 2000 and 2020
(Million Barrels per Day)

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
				2000				
OPEC								
Persian Gulf	2.6	3.2	4.1	**9.9**	2.7	0.7	1.5	**4.9**
North Africa	0.3	2.0	0.0	**2.3**	0.0	0.0	0.1	**0.1**
West Africa	0.9	0.5	0.0	**1.4**	0.1	0.0	0.1	**0.2**
South America	1.6	0.2	0.0	**1.8**	0.1	0.0	0.8	**0.9**
Asia	0.1	0.0	0.3	**0.4**	0.2	0.0	0.0	**0.2**
Total OPEC	**5.4**	**5.9**	**4.5**	**15.8**	**3.2**	**0.7**	**2.5**	**6.4**
Non-OPEC								
North Sea	0.6	4.7	0.0	**5.3**	0.0	0.0	0.0	**0.0**
Caribbean Basin	1.8	0.2	0.0	**2.1**	0.3	0.0	2.2	**2.5**
Former Soviet Union	0.0	1.6	0.0	**1.7**	0.2	0.0	0.1	**0.3**
Other Non-OPEC	2.9	1.3	0.9	**5.1**	1.9	0.4	1.1	**3.4**
Total Non-OPEC	**5.3**	**7.8**	**1.0**	**14.1**	**2.4**	**0.4**	**3.4**	**6.2**
Total Petroleum Imports	**10.7**	**13.7**	**5.4**	**29.9**	**5.6**	**1.1**	**5.9**	**12.5**
				2020				
OPEC								
Persian Gulf	4.9	3.5	5.0	**13.4**	8.7	7.1	4.3	**20.1**
North Africa	0.5	2.3	0.0	**2.7**	0.1	0.0	0.4	**0.6**
West Africa	0.9	0.9	0.2	**2.0**	0.1	0.0	0.9	**1.0**
South America	3.3	0.3	0.1	**3.7**	0.1	0.0	1.4	**1.5**
Asia	0.1	0.0	0.1	**0.2**	0.2	0.1	0.0	**0.3**
Total OPEC	**9.7**	**6.9**	**5.5**	**22.0**	**9.3**	**7.2**	**7.0**	**23.4**
Non-OPEC								
North Sea	0.5	3.9	0.0	**4.4**	0.1	0.0	0.0	**0.1**
Caribbean Basin	3.4	0.4	0.1	**3.9**	0.2	0.0	1.5	**1.6**
Former Soviet Union	0.4	3.1	0.5	**4.0**	1.4	0.1	0.2	**1.7**
Other Non-OPEC	4.2	1.3	0.4	**5.9**	2.2	0.3	1.2	**3.7**
Total Non-OPEC	**8.4**	**8.8**	**1.0**	**18.2**	**3.9**	**0.4**	**2.9**	**7.2**
Total Petroleum Imports	**18.2**	**15.6**	**6.5**	**40.3**	**13.1**	**7.6**	**9.9**	**30.6**

Notes: Totals may not equal sum of components due to independent rounding.
Sources: **2000:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **2020:** EIA, Office of Integrated Analysis and Forecasting, IEO2002 WORLD Model run IEO2002.B20 (2002).

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.

Figure 30. Imports of Persian Gulf Oil by Importing Region, 2000 and 2020



Sources: **2000:** Energy Information Administration (EIA), *International Petroleum Monthly*, DOE/EIA-0520(2001/11) (Washington, DC, November 2001). **2020:** EIA, Office of Integrated Analysis and Forecasting, IEO2002 WORLD Model run IEO2002.B20 (2002).

Other Views of Prices and Production

Several oil market analysis groups produce world oil price and production forecasts. Table 12 compares the *IEO2002* world oil price projections with similar forecasts from the International Energy Agency (IEA), Petroleum Economics, Ltd. (PEL), Petroleum Industry Research Associates (PIRA), the Gas Research Institute (GRI), Natural Resources Canada (NRCan), DRI-WEFA, and Deutsche Banc Alex.Brown (DBAB).

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 sent upward by the region's subsequent recovery. High oil prices followed the ability of OPEC to maintain production quotas in 2000, which supported sustained high prices throughout the year. Finally, 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.

Table 12. Comparison of World Oil Price Projections, 2005-2020
(2000 Dollars per Barrel)

Forecast	2005	2010	2015	2020
IEO2002				
Reference Case	22.73	23.36	24.00	24.68
High Price Case	29.56	30.01	30.44	30.58
Low Price Case	17.41	17.64	17.64	17.64
DRI-WEFA (October 2001)	19.39	20.32	21.81	23.12
IEA (November 2000)	20.41	20.41	—	27.83
PEL (June 2001)	13.53	14.77	13.38	—
PIRA (October 2001)	24.31	24.21	27.75	—
GRI (March 2001)	18.70	18.70	18.70	18.70
NRCan (April 1997)	21.79	21.79	21.79	21.79
DBAB (December 2001)	17.68	17.58	17.95	18.30

Notes: *IEO2002* projections are for average landed imports to the United States. S&P, GRI, WEFA, and DBAB projections are for composite refiner acquisition prices. PEL projections are for Brent crude oil. PIRA projections are for West Texas Intermediate crude oil at Cushing.

Sources: ***IEO2002*:** Energy Information Administration, *Annual Energy Outlook 2002*, DOE/EIA-0383(2002) (Washington, DC, December 2001). **DRI-WEFA:** DRI-WEFA, *U.S. Energy Outlook, Spring/Summer 2001* (Lexington, MA, October 2001), p. 49. **IEA:** International Energy Agency, *World Energy Outlook 2000* (Paris, France, November 2000), p. 39. **PEL:** Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, June 2001), p. 10. In the 2001 edition of this report, PEL declared two possible oil price projections in 2010 and 2015 (neither of which was identified as a "base case"). In 2010, either 13.53 or 18.06 and in 2015, either 13.38 or 16.35 depending on OPEC behavior. **PIRA:** PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2001), Table II-3. **GRI:** Gas Research Institute, *Baseline Projection Data Book 2001 Edition*, Volume I, p. SUM-21 (March 2001), crude oil (refiner acquisition). **NRCan:** Natural Resources Canada, *Canada's Energy Outlook, 1996-2020*, Annex C2 (Ottawa, Ontario, Canada, April 1997) (reaffirmed in January 2000). **DBAB:** Deutsche Banc Alex.Brown, Inc., "World Oil Supply and Demand Estimates," e-mail from Adam Sieminski (December 14, 2001).

Given the uncertainties of the current world situation, there is a spread of more than $10 per barrel among the forecasts for oil prices in 2005, as compared with the spread of only $6 per barrel among the forecasts available last year. The current oil price projections for 2005 range from PEL's $13.53 per barrel (constant 2000 U.S. dollars) to PIRA's $24.21 per barrel. The NRCan and IEA forecasts are the earliest: NRCan's projection was formulated in 1997 (but reaffirmed in 2000) and IEA's in November 2000. Nevertheless, those forecasts fall well within the range defined by the other forecasts. Two of the forecasts, PEL and DBAB, fall below the range defined by the *IEO2002* high and low world oil price scenarios in 2005, again demonstrating the wide range of projections in the early years of the forecast.

IEO2002 expects oil prices to rise to $23.15 in 2005. This projection leans somewhat toward the higher end of the forecasts: only PIRA projects higher world oil prices in 2005. Recent forecasts from DRI-WEFA, DBAB, and GRI all expect that prices will be in the range of $18 to just under $20 per barrel in 2005.

The entire PEL price forecast series may be considered an outlier relative to the rest of the forecasts. PEL's price projections fall consistently below those of the *IEO2002* low price path through 2015, when the PEL time series ends. If the PEL series is omitted, the range of prices among the remaining series is much smaller in 2015, $10 per barrel, with PIRA at the high end of the range ($27.75 per barrel) and DBAB at the low end ($17.95 per barrel). At the end of the forecast period, the uncertainty among forecasters as measured by the difference between highest and lowest expected prices remains about the same at $9.53 per barrel in 2020.

IEO2002 prices are the highest of any of the series across the 2005-2020 time period, with the exception of PIRA between 2005 and 2015 and IEA in 2020. It should be noted that IEA did not publish a price projection for 2015 in its *World Energy Outlook 2000*; however, it states that "between 2010 and 2020, the price increases steadily," from $20.41 per barrel to $27.83 per barrel. A simple interpolation results in an oil price in 2015 of about $24.12 per barrel, placing the IEA price very close to (but still below) the *IEO2002* estimate of $24.45 per barrel.

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 OPEC oil production and (2) the timing of a recovery in EE/FSU oil production. All the forecasts agree that the recovery of EE/FSU production will be fairly slow, although most are somewhat more optimistic about EE/FSU production development than they were last year.

Higher world oil prices in 2000 and the early part of 2001, along with accelerating economic recovery in Russia, currently the largest oil producer in the region, no doubt have influenced the production forecasts for the EE/FSU. Nevertheless, only DBAB projects that the share of EE/FSU production will rise above 13 percent over the course of the projection period. DBAB estimates that EE/FSU production will rise to 16 percent of the world total supply by 2020 (Table 13). DRI-WEFA is the least optimistic about recovery in the region, and its projected share for the EE/FSU remains at 9 percent throughout the 2005-2020 time period. *IEO2002* and PIRA are also optimistic about production in the region. Both forecasts expect the EE/FSU share of world oil production to climb from 12 percent in 2005 to 13 percent in 2010, where it remains for the remainder of the limits of the forecasts (that is, 2015 for PIRA and 2020 for *IEO2002*).

The forecasts that provide projections through 2020 (*IEO2002*, DRI-WEFA, DBAB, and IEA) all expect OPEC to provide incremental production of between 20 and 33 million barrels per day between 1999 and 2020 (Table 13). There is more variation in expectations among these four forecasts for the "other" non-OPEC suppliers. DRI-WEFA expects a substantial increase of 14.3 million barrels per day of supply from other suppliers, whereas IEA expects a decline of 3.4 million barrels per day in production from other non-OPEC sources. IEA projects that the "other" share of world oil production will fall to 29 percent by 2020 while the OPEC share increases to 54 percent. In contrast to DRI-WEFA, *IEO2002* expects more moderate growth in other non-OPEC supply, at 8.6 million barrels per day from 1999 to 2020; DBAB expects growth of 3.3 million barrels per day.

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Table 13. Comparison of World Oil Production Forecasts

Forecast	Percent of World Total			Million Barrels per Day			
	OPEC	EE/FSU	Other Non-OPEC	OPEC	EE/FSU	Other Non-OPEC	Total
History							
1999	39	10	50	29.1	7.6	37.2	**73.9**
Projections							
2005							
IEO2002	42	12	46	35.3	10.3	39.8	**84.9**
DRI-WEFA[a]	39	9	48	33.3	7.5	40.9	**85.4**
PEL	39	10	48	32.9	8.8	40.4	**84.0**
PIRA	36	12	52	30.3	10.0	43.4	**83.7**
DBAB	40	13	45	32.3	10.6	36.9	**81.1**
2010							
IEO2002	44	13	43	42.1	12.4	41.2	**95.7**
DRI-WEFA[a]	39	9	48	37.0	8.8	45.2	**90.3**
IEA[b]	46	11	38	44.1	10.3	36.6	**95.9**
PEL	43	10	44	40.2	9.4	41.1	**92.8**
PIRA	38	13	49	35.0	12.1	45.1	**92.2**
DBAB	42	15	41	38.0	13.2	36.9	**90.3**
2015							
IEO2002	46	13	41	49.4	14.0	43.8	**107.2**
DRI-WEFA[a]	41	9	47	42.7	9.8	49.1	**104.9**
PEL	51	10	37	52.4	9.8	37.7	**102.2**
PIRA	41	13	46	41.0	13.3	45.7	**100.0**
DBAB	44	15	39	43.4	15.3	38.4	**99.5**
2020							
IEO2002	48	13	39	57.2	15.3	45.8	**118.3**
DRI-WEFA[a]	43	9	44	50.6	10.8	51.5	**117.2**
IEA[b]	54	11	29	61.8	12.3	33.8	**114.7**
DBAB	45	16	37	49.4	17.7	40.5	**110.3**

[a]In the DRI-WEFA 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, DRI-WEFA, PEL, and DBAB 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: ***IEO2002*:** Energy Information Administration, World Energy Projection System (2002). **DRI-WEFA:** DRI-WEFA, *Oil Market Outlook: Long Term Focus, Second Quarter 2000* (Lexington, MA, 2000), p. 14. **IEA:** International Energy Agency, *World Energy Outlook 2000* (Paris, France, November 2000), p. 77. **PEL:** Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, June 2001). **PIRA:** PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2001). **DBAB:** Deutsche Banc Alex.Brown, fax from Adam Sieminski (December 14, 2001).

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