

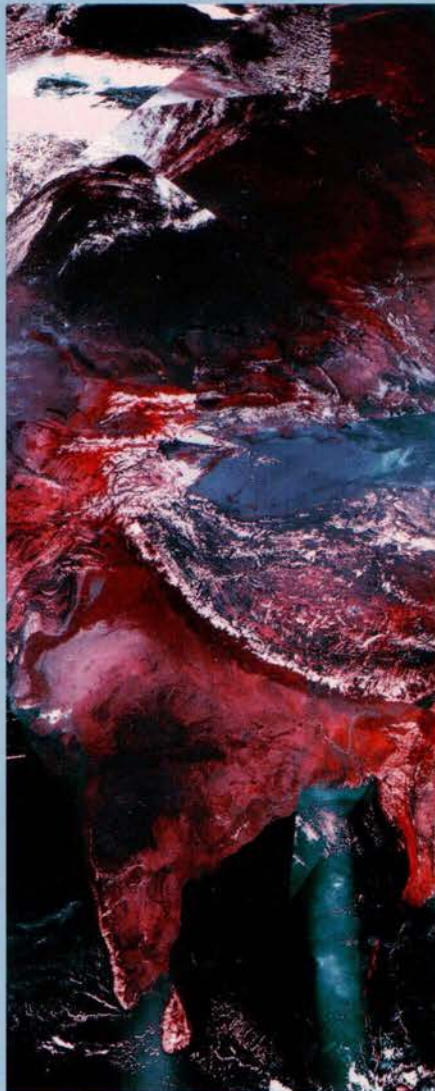
# International Energy Outlook

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## 1993



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*Cover Photo: The three panels are taken from a montage of infrared Landsat satellite pictures showing the Earth's vegetation. Clearly shown are the Red Sea and the Persian Gulf in the small panel, India in the center panel, and the countries of the South China Sea and China itself in the large panel.*

# International Energy Outlook 1993

**April 1993**

**Energy Information Administration**  
Office of Integrated Analysis and Forecasting  
U.S. Department of Energy  
Washington, DC 20585

This report was prepared by the Energy Information Administration, the independent statistical and analytical agency within the Department of Energy. The information contained herein should not be construed as advocating or reflecting any policy position of the Department of Energy or any other organization.

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## Preface

This report presents the current Energy Information Administration (EIA) assessment of the long-term outlook for international energy markets. This and other EIA reports are provided as a statistical service for use by managers and international energy analysts, not as a Government energy plan. Current U.S. Government policies and foreign government policies are assumed to hold over the projection interval, which extends to the year 2010.

The projections of world oil prices presented here are the same as those used as assumptions for analyses of the U.S. domestic energy market provided in EIA's *Annual Energy Outlook 1993*. In turn, the domestic projections shown here are the same as those contained in the *Annual Energy Outlook 1993*.

Several major EIA assumptions determine, in large part, the resulting energy projections presented. Key assumptions concern the energy intensity of economic activity; oil and natural gas production capacities; nuclear and hydroelectric generation capacities; international coal trade; and the rate of incremental energy requirements met by alternatives to oil. Uncertainties associated with the assumptions used to produce a base case projection are conveyed here through presentation of a set of ranges around a base case. Projected uncertainty ranges for world oil prices and energy consumption are derived by altering baseline assumptions concerning economic growth, energy demands, and energy supplies, as follows:

- First, the impacts of the variations are estimated individually; and

- Second, a procedure is used that generates a combined range of uncertainty that is greater than any single impact but less than the impact of all changes taken simultaneously (see the Appendix). The result is a base case and a corresponding set of uncertainty ranges, rather than a set of alternative scenarios.

The projections for the United States presented in this report and in the *Annual Energy Outlook 1993* were prepared using the Intermediate Future Forecasting System (IFFS). Projections of foreign oil production and consumption, and prices of world oil, were prepared using the Oil Market Simulation (OMS) Model. Assumptions about total energy requirements of projected economic growth (energy/gross domestic product (GDP) ratios) and about marginal changes in the makeup of that total (fuel shares) are incorporated in the World Energy Projection System (WEPS) spreadsheet. Assumptions concerning primary electricity requirements (nuclear and hydroelectric), including generating capacity, capacity utilization factors, and export adjustments, are also included in WEPS. Projections of foreign nuclear power consumption are based on capacity figures in EIA's *World Nuclear Capacity and Fuel Cycle Requirements 1992*. Projections of foreign GDP are from Wharton Econometric Forecasting Associates' *World Economic Outlook* (Bala Cynwyd, PA, February and October 1992).

Inquiries concerning the availability of EIA reports and models should be directed to EIA's National Energy Information Center (202/586-8800).

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# Highlights

*Although energy conservation trends should continue, total energy use should grow during these next two decades, as pressure from the world's increasing population and economic activity outweigh conservation efforts.*

*The mature economies of North America and Western Europe should experience relatively slow growth in overall energy use.*

*Much of the world's growth in energy demand will come from the developing countries of the Pacific Rim and Middle East.*

*Oil's market share should continue to decrease, even with world oil prices ranging between \$14 and \$29 per barrel in 2000 and between \$18 and \$38 per barrel in 2010 (1991 dollars).*

Energy use per dollar of gross domestic product (GDP) is expected to decline by 1.1 percent per year on a worldwide basis between the years 1990 and 2010 as older, less-efficient equipment is replaced in almost all sectors. However, the world economy is expected to grow by 2.7 percent per year; thus, total energy demand should increase from about 346 quadrillion British thermal units (Btu) in 1990 to between 454 and 500 quadrillion Btu in 2010. The regional composition of this increase will vary greatly depending on the relative maturity of the regional economies and differential population growth. The fuel mix will also vary in response to relative prices and resource availability.

As both population growth and energy-intensive industrial growth slow, economic growth in the Organization for Economic Cooperation and Development (OECD) countries is expected to average 2.5 percent per year between 1990 and 2010. These factors, when combined with further improvements in energy using technologies, should slow overall growth in energy use by OECD countries to 1.3 percent per year. One major exception to this trend is Japan, where economic growth is expected to average 3.7 percent per year and energy use is expected to continue to grow by 1.7 percent per year.

In China, the combination of population growth, urbanization, and industrialization is expected to result in a 3.3 percent annual increase in energy consumption between 1990 and 2010. Thus, China's energy consumption will have nearly doubled by the year 2010. Energy use in the other developing countries, including many Pacific Rim countries, is expected to grow by 2.5 percent per year for the same reasons. Members of the Organization of Petroleum Exporting Countries (OPEC) should reach an energy growth rate of 2.4 percent per year as they continue their efforts to add value to their energy resource base by developing energy-intensive industries. Energy use in current and former Centrally Planned Economies is expected to grow at a slower 1.6 percent average rate because of lower expectations for economic growth. In the former Soviet Union, continued inflation and under-investment are expected to lead to a decline in economic growth for the next several years, before market reforms can turn these economies around.

Even with relatively moderate world oil price increases, continued conservation and shifts to relatively abundant natural gas contribute to a continued decline in oil's market share from 39 percent of all energy in 1990 to 37 percent in 2010. However, even with this decline, oil will remain the leading source of energy, worldwide, during this period.



***Unless current policies are revised, OPEC should capture an increasing share of the world's oil market.***

Large, relatively inexpensive oil reserves in the Middle East will likely provide a larger share of the world's oil supplies. These reserves, concentrated in Saudi Arabia, Iran, Iraq, Kuwait, and the United Arab Emirates, are among the world's least costly to develop. Declining production in the United States and in Russia could be offset by increases in the Middle East. OPEC's market share of world oil supplies (38 percent in 1990) is expected to grow to 50 percent in 2010, a figure still below its 1973 share of 55 percent.

***Natural gas should be one of the world's fastest growing sources of energy.***

Large reserves of natural gas in Russia and the Middle East should ensure the continued growth in the use of this fuel. Russian supplies could be used to replace internal oil use as well as to serve the energy needs of Western and Eastern Europe. Middle East supplies of natural gas can be used in the Far East (especially if liquefying and transportation costs can be reduced) and in Southern Europe. The clean burning characteristics of natural gas make it an ideal heating fuel. Natural gas could become an important fuel for use in transportation vehicles if changes in government policy were achieved.

***Coal will continue to be an important source of energy in the United States and China.***

The United States, one of the world's largest sources of coal, is expected to continue to use this fuel as a major source of energy. China also has large coal reserves, and continued economic growth there will provide the impetus for increasing coal use. These projections assume that current policy with regard to global warming will not change. Should a substantial change in policy occur, coal use patterns could change dramatically.

***Carbon emissions should continue to increase during these next two decades, unless policy is changed.***

Carbon emissions should increase by 1.5 percent per year as energy use rises. Although natural gas, which emits less carbon than oil or coal, gains market share, this gain is not sufficient to offset the carbon emissions from increased energy use. Oil is responsible for the largest share of carbon emissions, followed by coal.

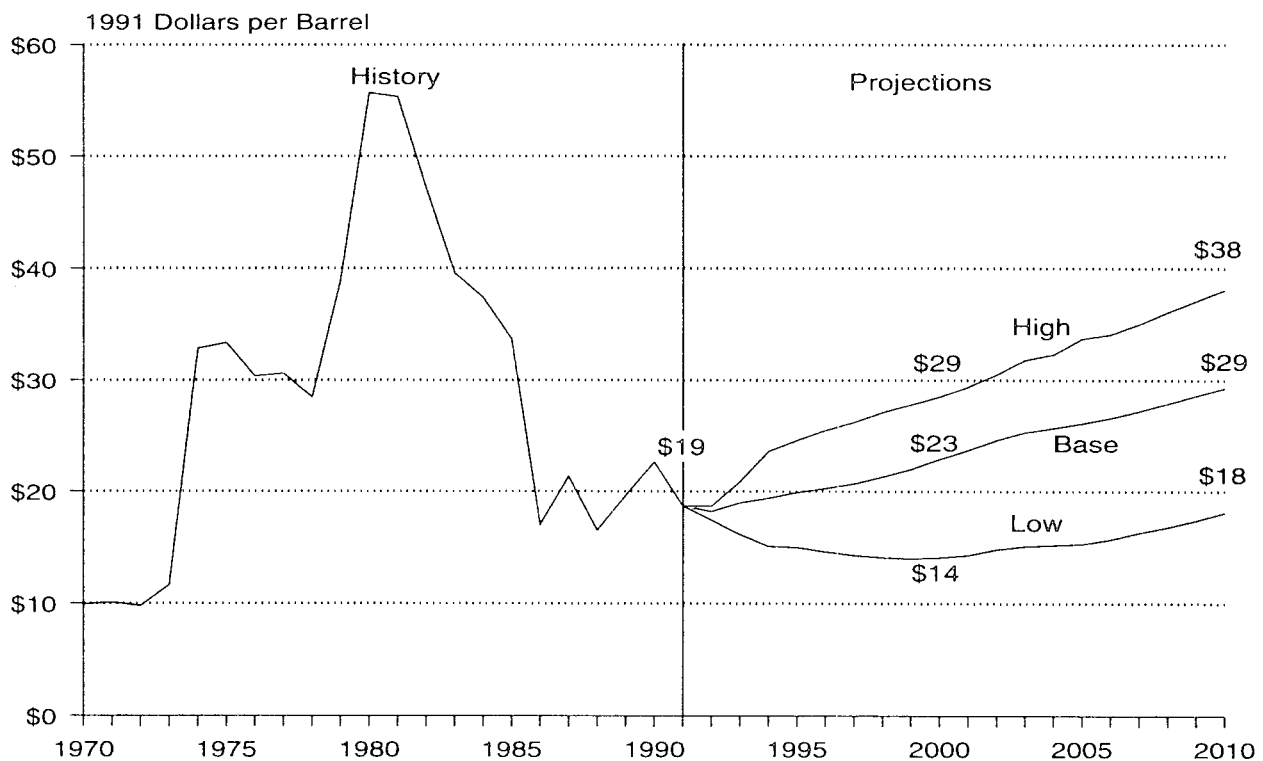
# World Oil Market

## Long-Term Price Trends

World oil prices are expected to rise slowly after the mid 1990's but to remain well below the record highs of 1980 and 1981 through 2010 (Figure 1). The \$23 per barrel base case price for the year 2000—in constant 1991 dollars—is about the same as the price in 1990, when prices rose because of concerns over the conflict

in the Persian Gulf. Prices are expected to range between \$14 and \$29 per barrel in 2000 and between \$18 and \$38 per barrel in 2010 (Table 1). These ranges reflect uncertainties about future prospects for supply and demand, but exclude potential impacts from a politically motivated supply disruption. Barring major political events, price movements outside the projected range should trigger market forces, which would then move prices back inside the range.

**Figure 1. World Oil Price Ranges, 1970-2010**



Note: Prices represent the U.S. refiner acquisition cost of imported crude oil.

Sources: **History:** Energy Information Administration, *Annual Energy Review 1991*, DOE/EIA-0384(91), Table 71; and U.S. gross domestic product (GDP) deflators from Data Resources Inc., USCENTRAL Database, November 16, 1992. **Projections:** Table 1.

## Country Groupings

The *International Energy Outlook 1993* uses a number of country groupings both in analyzing the current energy picture and in projecting future energy requirements and supply throughout the world. The country groupings used in this report are defined as follows:

**Centrally Planned Economies (CPEs).** The former, evolving, and current Centrally Planned Economies of Albania, Bulgaria, Cambodia, China, Cuba, Czechoslovakia (now two separate republics), Hungary, Laos, Mongolia, North Korea, Poland, Romania, the former Soviet Union (FSU), Vietnam, and Yugoslavia.

**Former Soviet Union (FSU).** The Baltic States of Estonia, Latvia, and Lithuania, as well as Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

**Commonwealth of Independent States (CIS).** The FSU, excluding Georgia, Azerbaijan, and the three Baltic States of Estonia, Latvia, and Lithuania.

**Organization for Economic Cooperation and Development (OECD).** Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

**Organization of Petroleum Exporting Countries (OPEC).** Algeria, Ecuador (no longer a member of OPEC but included here to preserve historical comparisons), Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.

**Market Economies.** All countries other than the CPE countries.

**Developing Countries.** All Market Economy countries other than the OECD countries.

**Pacific Rim Developing Countries.** Hong Kong, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

**Middle East.** Bahrain, Cyprus, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, and Yemen.

**Persian Gulf.** Bahrain, Iran, Iraq, Kuwait, Qatar, Saudi Arabia, and United Arab Emirates.

Market forces will determine whether future prices are closer to the high or low end of the range. Steadily increasing worldwide demand for oil, especially in developing countries, will exert an upward pressure on prices (Tables 2 and 3). It is assumed that demand for oil will continue to grow along with economic growth, especially in the developing and newly industrialized countries. Particularly high rates of economic growth are expected in countries in the Pacific Rim region where low-cost,

labor-intensive production has spurred economic growth. Changes in demand will also result from conservation, fuel substitution, and energy and environmental policies. The high end of the price range shown in Figure 1 is associated with sustained periods of high economic growth and resultant high growth in oil demand, less energy conservation, and greater reliance on oil relative to other energy sources. The opposite set of circumstances would produce a low price path.

**Table 1. World Oil Prices, 1979-2010**  
(1991 Dollars per Barrel)

Year	Price Cases		
	Low	Base	High
1979		\$38.97	
1980		55.68	
1981		55.32	
1982		47.16	
1983		39.58	
1984		37.39	
1985		33.68	
1986		17.02	
1987		21.36	
1988		16.51	
1989		19.63	
1990		22.64	
1991		18.70	
1992	\$17.42	18.19	\$18.67
1993	16.14	18.98	20.88
1994	15.10	19.40	23.60
1995	15.00	19.90	24.60
1996	14.60	20.30	25.50
1997	14.30	20.70	26.20
1998	14.10	21.30	27.10
1999	14.00	22.00	27.80
2000	14.10	22.90	28.50
2001	14.30	23.70	29.40
2002	14.80	24.60	30.50
2003	15.10	25.30	31.80
2004	15.20	25.70	32.30
2005	15.30	26.10	33.70
2006	15.70	26.60	34.10
2007	16.30	27.20	35.00
2008	16.80	27.90	36.10
2009	17.40	28.60	37.10
2010	18.10	29.30	38.10

Note: Prices represent the U.S. refiner acquisition cost of imported crude oil.

Sources: **History:** Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(92/12), Table 9.1, and U.S. gross domestic product (GDP) deflators from Data Resources, Inc., USCENTRAL Database, November 16, 1992. **Projections:** Energy Information Administration, Oil Market Simulation Model Spreadsheet, 1993.

**Table 2. World Oil Consumption and Production: Base Case**  
(Million Barrels per Day)

Supply and Disposition	History			Projections		
	1989	1990	1991	1995	2000	2010
<b>Market Economies</b>						
<b>Production</b>						
United States <sup>a</sup> .....	9.88	9.68	9.88	9.0	8.3	8.6
Canada .....	2.03	2.02	2.04	2.1	2.1	2.2
OECD Europe .....	4.38	4.54	4.78	6.2	6.2	4.6
OPEC .....	23.81	25.10	25.41	28.4	33.1	42.7
Other Countries <sup>b</sup> .....	10.43	10.80	11.05	13.1	13.6	12.2
Net CPE Exports .....	2.09	1.88	1.27	0.9	0.7	0.0
<b>Total</b> .....	<b>52.62</b>	<b>54.02</b>	<b>54.43</b>	<b>59.5</b>	<b>64.0</b>	<b>70.3</b>
<b>Consumption</b>						
United States <sup>a</sup> .....	17.33	16.99	16.71	18.2	19.3	21.0
U.S. Territories .....	0.21	0.21	0.24	0.2	0.3	0.3
Canada .....	1.73	1.69	1.61	1.7	1.8	1.8
Japan .....	4.98	5.14	5.29	5.7	6.1	6.5
Australia and New Zealand .....	0.79	0.82	0.80	0.8	0.9	1.0
OECD Europe .....	12.83	12.91	13.33	13.9	14.5	15.0
Other Market Economies .....	14.92	15.69	16.30	19.4	21.5	25.0
<b>Total</b> .....	<b>52.79</b>	<b>53.45</b>	<b>54.28</b>	<b>59.8</b>	<b>64.3</b>	<b>70.6</b>
Discrepancy <sup>c</sup> .....	0.22	-0.07	-0.22	0.3	0.3	0.3
<b>Centrally Planned Economies<sup>d</sup></b>						
<b>Production</b>						
China .....	2.76	2.77	2.80	2.9	3.1	3.5
Former Soviet Union .....	12.14	11.40	10.41	8.4	9.3	11.2
Other .....	0.43	0.41	0.39	0.4	0.5	0.6
<b>Total</b> .....	<b>15.33</b>	<b>14.58</b>	<b>13.60</b>	<b>11.7</b>	<b>12.9</b>	<b>15.3</b>
<b>Consumption</b>						
China .....	2.38	2.30	2.46	2.9	3.2	4.0
Former Soviet Union .....	8.74	8.39	8.20	6.3	7.2	8.9
Other .....	2.12	2.01	1.67	1.6	1.8	2.4
<b>Total</b> .....	<b>13.24</b>	<b>12.70</b>	<b>12.33</b>	<b>10.8</b>	<b>12.2</b>	<b>15.3</b>
<b>World Oil Consumption</b> .....	<b>66.03</b>	<b>66.15</b>	<b>66.60</b>	<b>70.6</b>	<b>76.5</b>	<b>85.9</b>

<sup>a</sup>Includes the 50 States and the District of Columbia.

<sup>b</sup>Includes Australia, New Zealand, and the U.S. Territories.

<sup>c</sup>Includes net stock withdrawals.

<sup>d</sup>Includes former, evolving, and current Centrally Planned Economies.

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

Notes: Production includes crude oil, natural gas liquids, refinery gains, hydrogen, and other hydrocarbons. Totals may not equal sum of components because of independent rounding.

Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Tables 7, 8, and 13; and *International Petroleum Statistics Report*, DOE/EIA-0520(92/11), Tables 2.1 and 2.2. **Projections:** Energy Information Administration, Oil Market Simulation Model Spreadsheet, 1993; World Energy Projection System Spreadsheet, 1993; and *Annual Energy Outlook 1993* DOE/EIA-0383(93), Table A8.

**Table 3. World Oil Consumption**  
(Million Barrels per Day)

Region/Country	Projection Ranges										
	History		1995			2000			2010		
	1990	1991	Base	Low	High	Base	Low	High	Base	Low	High
<b>Market Economies</b>											
<b>OECD</b>											
United States <sup>a</sup> .....	17.0	16.7	18.2	17.8	18.7	19.3	18.6	20.7	21.0	19.7	23.5
Canada .....	1.7	1.6	1.7	1.5	1.9	1.8	1.3	2.1	1.8	1.2	2.3
Japan .....	5.1	5.3	5.7	5.0	6.1	6.1	5.0	6.9	6.5	4.9	7.9
Europe .....	12.9	13.3	13.9	13.1	14.5	14.5	13.1	15.6	15.0	13.1	16.9
United Kingdom .....	1.8	1.8	1.8	1.6	2.1	1.9	1.5	2.4	2.0	1.6	2.7
France .....	1.8	1.9	2.0	1.8	2.2	2.1	1.6	2.3	2.1	1.5	2.6
Germany .....	2.7	2.8	3.0	2.6	3.3	3.1	2.5	3.7	3.2	2.4	4.3
Italy .....	1.9	1.9	2.0	1.8	2.2	2.1	1.8	2.4	2.2	1.6	2.6
Netherlands .....	0.7	0.8	0.8	0.7	0.8	0.8	0.7	1.0	0.8	0.7	1.1
Other Europe .....	4.1	4.2	4.3	3.8	4.7	4.5	3.5	5.3	4.7	3.3	5.8
Other OECD .....	1.0	1.0	1.1	1.0	1.3	1.1	0.9	1.4	1.3	0.9	1.7
<b>Total</b> .....	37.8	38.0	40.5	39.4	41.4	42.8	40.8	44.9	45.6	42.7	49.1
OPEC .....	4.6	4.7	5.5	5.2	5.9	6.0	5.3	6.8	7.1	6.0	8.5
Other Developing Countries ...	11.1	11.6	13.9	12.6	15.0	15.5	13.0	17.7	17.9	14.1	21.4
<b>Total Market Economies</b> .....	53.5	54.3	59.8	58.1	61.4	64.3	61.0	67.4	70.6	65.7	75.7
<b>Centrally Planned Economies<sup>b</sup></b>											
China .....	2.3	2.5	2.9	2.7	3.1	3.2	2.8	3.6	4.0	3.2	4.8
Former Soviet Union. ....	8.4	8.2	6.3	4.8	7.8	7.2	5.8	8.6	8.9	6.3	11.4
Other .....	2.0	1.7	1.6	1.4	1.7	1.8	1.6	2.0	2.4	1.9	2.9
<b>Total</b> .....	12.7	12.3	10.8	9.3	12.3	12.2	10.7	13.7	15.3	12.5	18.0
<b>World Total</b> .....	66.2	66.6	70.6	68.4	72.8	76.5	72.9	80.0	85.9	80.3	91.7

<sup>a</sup>Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

<sup>b</sup>Includes former, evolving, and current Centrally Planned Economies.

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

Notes: High and low range values for Europe and the four regional totals are not equal to the sum of the component countries or country groups but consist of the base value adjusted by the quantity: the square root of the sum of the squared deviations of the respective component countries or country groups from their base value. Other totals may not equal sum of components because of independent rounding.

Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Tables 8 and 13. **Projections:** Energy Information Administration, *Annual Energy Outlook 1993*, DOE/EIA-0383(93), Tables A8, C8, D8, and E8; Oil Market Simulation Model Spreadsheet, 1993; and World Energy Projection System Spreadsheet, 1993.

Supply will be affected by production decisions of the Organization of Petroleum Exporting Countries (OPEC), changes in non-OPEC production, political events (particularly in the former Soviet Union (FSU) and the Middle East), and other events in OPEC countries. OPEC production should continue to grow over the

projection period; however, non-OPEC production should peak toward the end of the 1990's. Production losses from mature fields in non-OPEC regions should exceed gains from new fields by the turn of the century. Higher oil prices would be associated with less success in expanding production in non-OPEC countries and

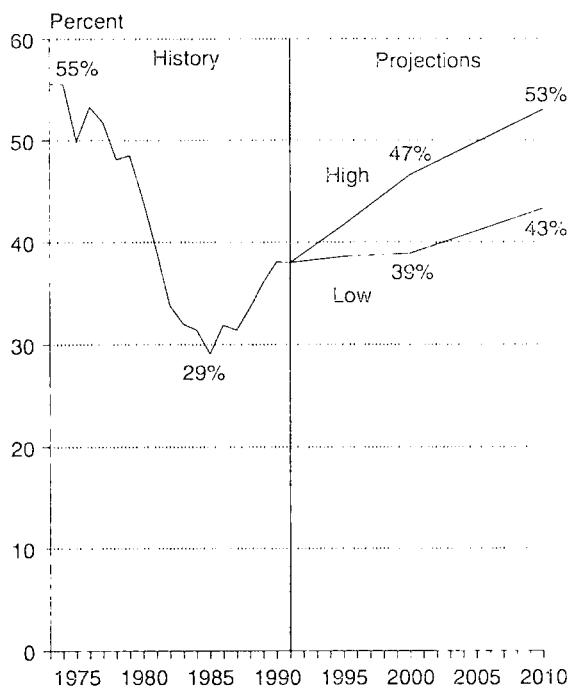
the desire and ability of OPEC to implement aggressive policies to achieve higher prices.

The dependence on oil from OPEC, particularly from the Persian Gulf, should increase despite record levels of non-OPEC production (Figures 2 and 3). Because little surplus production capacity exists outside of OPEC, prices are likely to rise to balance supply and demand in response to declines in surplus OPEC capacity during the next 5 to 20 years. Absent a major change in current energy policies by consuming countries, dependence on OPEC oil is expected to continue, because OPEC countries, particularly Persian Gulf members, control the world's largest and least expensive known oil reserves. For example, 1991 lifting

costs—the direct operating costs required to extract oil—to major American energy companies averaged \$4.72 per barrel in the United States. These costs to American companies ranged from \$6.46 per barrel in Western Europe to \$2.39 per barrel in the Middle East. {5, p. 34}

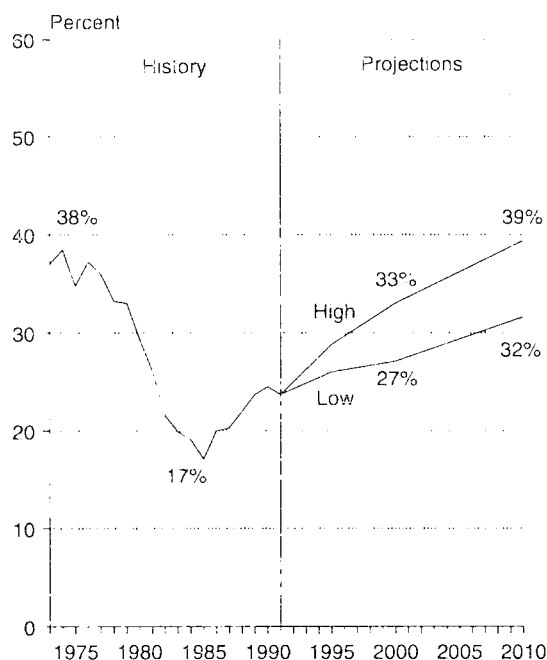
The degree by which oil prices will rise depends largely on OPEC decisions concerning the expansion of production capacity. Only OPEC countries, particularly the Persian Gulf members, can add enough capacity to meet anticipated increases in demand (Table 4). About two-thirds of the world's known petroleum reserves are located in the Middle East. Currently, OPEC produces more than one-third of all the oil consumed in the

**Figure 2. OPEC Oil Production as a Percentage of World Oil Consumption, 1973-2010**



Sources: **History:** Energy Information Administration, *International Petroleum Statistics Report*, DOE/EIA-0520(93/01), Table 4.3; *International Energy Annual 1991*, DOE/EIA-0219(91), Table 8; and *Annual Energy Review 1991*, DOE/EIA-0384(91), Table 123. **Projections:** Assumed utilization rates applied to production capacities in Table 4, divided by world consumption from Table 2.

**Figure 3. Persian Gulf Oil Production as a Percentage of World Oil Consumption, 1973-2010**



Sources: **History:** Energy Information Administration, *International Petroleum Statistics Report*, DOE/EIA-0520(93/01), Table 4.3; *International Energy Annual 1991*, DOE/EIA-0219(91), Table 8; and *Annual Energy Review 1991*, DOE/EIA-0384(91), Table 123. **Projections:** Assumed utilization rates applied to production capacities in Table 4, divided by world consumption from Table 2.

**Table 4. World Oil Production Capacity Assumptions**  
(Million Barrels per Day)

Region/Country	Assumptions								
	Estimates			1995		2000		2010	
	1990	1991	1992	Low	High	Low	High	Low	High
<b>Market Economies</b>									
<b>Non-OPEC</b>									
United States <sup>a</sup>	9.7	9.9	9.7	8.5	9.3	7.1	9.3	6.4	9.8
Canada	2.0	2.1	2.1	2.0	2.3	2.0	2.5	2.0	2.6
Mexico	3.1	3.2	3.2	3.2	3.7	2.9	3.8	3.0	3.8
North Sea	4.0	4.0	4.2	4.9	5.6	4.5	5.6	3.3	4.1
Other Non-OPEC	8.9	9.0	9.2	9.3	10.6	9.1	11.3	7.7	9.5
<b>Total</b>	<b>27.7</b>	<b>28.1</b>	<b>28.3</b>	<b>28.9</b>	<b>30.8</b>	<b>27.7</b>	<b>31.3</b>	<b>24.5</b>	<b>29.0</b>
<b>OPEC</b>									
Algeria	1.4	1.4	1.3	1.1	1.4	1.1	1.4	1.4	1.7
Ecuador	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.1	0.1
Gabon	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.1	0.1
Indonesia	1.5	1.7	1.7	1.3	1.6	1.3	1.6	0.6	0.9
Iran	3.2	3.4	3.6	3.1	4.0	3.5	4.3	4.0	4.8
Iraq <sup>b</sup>	2.2	0.3	0.4	2.7	3.3	3.7	4.5	5.5	6.9
Kuwait <sup>b,c</sup>	1.7	0.2	1.1	2.0	2.4	2.4	2.8	3.0	3.5
Libya	1.6	1.6	1.6	1.5	1.8	1.5	2.0	1.6	2.2
Nigeria	1.8	2.0	2.0	1.8	2.4	1.9	2.5	1.5	2.5
Qatar	0.5	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.6
Saudi Arabia <sup>c</sup>	8.5	9.1	9.6	9.1	11.0	10.4	12.1	13.0	16.1
United Arab Emirates	2.5	2.7	2.6	2.5	2.9	2.5	3.1	3.5	4.5
Venezuela	2.6	2.6	2.6	2.6	3.2	3.0	3.7	4.5	5.8
Persian Gulf	18.6	16.2	17.7	21.6	23.9	24.4	26.6	31.9	35.6
<b>Total</b>	<b>28.1</b>	<b>26.0</b>	<b>27.7</b>	<b>32.1</b>	<b>34.6</b>	<b>35.0</b>	<b>37.5</b>	<b>43.8</b>	<b>47.9</b>
<b>Net CPE<sup>d</sup> Exports</b>	<b>1.9</b>	<b>1.2</b>	<b>1.0</b>	<b>-0.2</b>	<b>2.0</b>	<b>-0.5</b>	<b>1.9</b>	<b>-1.8</b>	<b>1.9</b>
<b>Total Market Economies</b>	<b>57.6</b>	<b>55.3</b>	<b>57.0</b>	<b>60.8</b>	<b>67.4</b>	<b>62.2</b>	<b>70.7</b>	<b>66.5</b>	<b>78.8</b>
<b>Centrally Planned Economies<sup>d</sup></b>									
China	2.8	2.8	2.8	2.8	3.0	2.8	3.4	3.0	4.0
Former Soviet Union	11.5	10.3	9.1	6.9	9.9	7.8	10.8	8.7	12.7
Other	0.4	0.4	0.4	0.3	0.5	0.4	0.6	0.5	0.7
<b>Total</b>	<b>14.7</b>	<b>13.5</b>	<b>12.3</b>	<b>10.2</b>	<b>13.2</b>	<b>11.4</b>	<b>14.4</b>	<b>12.7</b>	<b>16.9</b>
<b>World Total</b>	<b>70.4</b>	<b>67.6</b>	<b>68.3</b>	<b>71.3</b>	<b>79.0</b>	<b>74.1</b>	<b>83.4</b>	<b>80.9</b>	<b>94.4</b>

<sup>a</sup>Includes the 50 States and the District of Columbia.

<sup>b</sup>1990 estimate is pre-Iraqi invasion capacity.

<sup>c</sup>Includes 50 percent of Neutral Zone capacity.

<sup>d</sup>Includes former, evolving, and current Centrally Planned Economies.

OPEC = Organization of Petroleum Exporting Countries.

Notes: Capacity is defined as maximum sustainable production capacity adjusted to reflect current operable capacity in selected countries. Production includes crude oil, natural gas liquids, refinery gains, hydrogen, and other hydrocarbons. All uncertainty ranges are derived independently and do not necessarily add to totals.

Sources: **Estimates:** Energy Information Administration, Energy Markets and Contingency Information Division. **Projections:** Energy Information Administration, Oil Market Simulation Model Spreadsheet, 1993.



world and could easily produce half of all oil consumed by 2010. Market share and revenue goals, as well as political and security considerations, will influence OPEC's production and capacity decisions. Political uncertainty in the Middle East remains high, even after the Persian Gulf war.

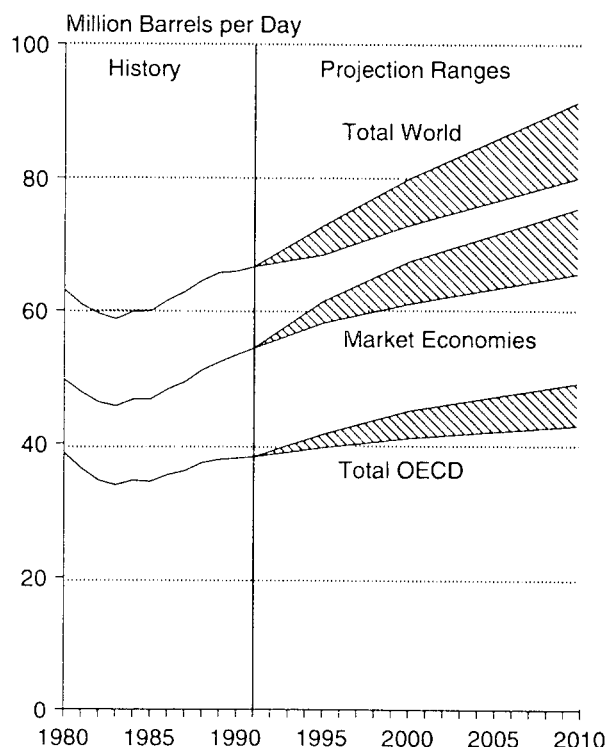
The outcome of the profound changes taking place in the FSU and other Eastern European countries making a transition to independent market economies may also have a significant impact on oil markets. Consumption in the Republics constituting the FSU is likely to continue to fall in the near term because of poor economic performance, as well as falling production of oil caused by the use of antiquated technology and under-investment. It is assumed, however, that the current cycle of massive Central Bank deficit financing, rapid inflation, and rising unemployment will eventually moderate. {10, pp. 2.2-2.4} The relatively strong resource base of many of the FSU Republics should permit positive economic growth after a near-term period of decline. The outlook for production in the long term is for a turnaround from the current declines, as Western investment has a noticeable impact over the next 5 to 10 years.

The base case price path does not represent a most-likely case. Rather, it is a representative mid-level case. It is a smooth path for analytical convenience. The future oil price path will probably show fluctuations as it has in the past, but the trajectory is expected to remain within the range of the low and high price paths. Prices could fluctuate either below or above this range for short periods—exhibiting a pattern similar to what was experienced between 1970 and 1991 when prices fluctuated between \$10 per barrel and \$55 per barrel in 1991 dollars, but the extremes could not be sustained. For the majority of the 1970 to 1991 timeframe, prices ranged between \$15 and \$30 per barrel. For the next 20 years, therefore, prices are expected to remain predominately within the range in *IEO93*, although temporary movements outside this range should be expected.

## World Oil Consumption

World oil demand should continue to grow in response to economic growth (Figure 4). Total world oil consumption is expected to grow by 1.3 percent per year between 1990 and 2010—a rate of growth that is less than the projected annual growth rate in gross domestic product (GDP) of 2.7 percent (Table 5). This consumption growth rate is considerably less than that

**Figure 4. World Oil Consumption, 1980-2010**



Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Table 8 and other selected issues. **Projections:** Table 3.

of the past few years when total world oil consumption grew by 1.9 percent per year from 1985 to 1990, or 61 percent as fast as GDP growth. {2, p. 24}

Oil should remain the dominant fuel for many uses, especially transportation, where neither natural gas nor alternative fuels are expected to displace oil's dominant position. Growth in world oil demand will be moderated, however, by increases in energy efficiency, conservation, and increased use of other fuels for some applications, such as natural gas for electric generation. Increases in world oil prices are expected to spur many of these oil-saving activities.

Growth in demand for oil is expected to continue and to be most rapid in the developing nations of Asia and the Middle East. The growth in economic activity is expected to be the highest in developing countries taken as a group, with particularly high growth rates in

**Table 5. Annual Growth Rates of Real Gross Domestic Product (GDP): Base Case**  
(Percent)

Country/Region	Average Annual GDP Growth Rates					
	History			Assumptions		
	1970-1980	1980-1985	1985-1990	1990-2000	2000-2010	1990-2010
<b>World</b> .....	3.5	2.3	3.1	2.5	2.9	2.7
<b>Market Economies</b> .....	3.5	2.3	3.2	2.9	2.9	2.9
<b>Total OECD</b> .....	3.1	2.4	3.1	2.5	2.5	2.5
United States .....	2.8	2.5	2.7	2.2	1.9	2.0
Canada .....	4.6	2.9	3.0	2.7	2.5	2.6
Japan .....	4.5	3.7	4.6	3.9	3.6	3.7
OECD Europe .....	3.0	1.5	3.1	2.3	2.6	2.5
<b>Developing Countries</b> .....	5.2	1.9	3.4	4.2	4.2	4.2
OPEC .....	5.1	0.2	1.6	3.7	4.0	3.8
Other .....	5.3	2.6	4.2	4.4	4.3	4.4
<b>Centrally Planned Economies<sup>a</sup></b> .....	3.4	2.7	0.5	0.6	3.1	1.9
Former Soviet Union .....	NA	2.2	1.7	-1.9	2.0	0.0
China .....	NA	10.1	7.8	7.3	6.0	6.7

<sup>a</sup>Includes former, evolving, and current Centrally Planned Economies.

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

NA = Not available.

Note: Projected growth rates are calculated from aggregate real gross domestic product in 1985 dollars at 1985 exchange rates.

Sources: **History:** Wharton Econometric Forecasting Associates, World Economic Service and *World Economic Service Historical Data* (June 1992). **Projections:** Energy Information Administration, *Annual Energy Outlook 1993*, DOE/EIA-0383(93), Table A7; assumptions and derived from Wharton Econometric Forecasting Associates, World Economic Service, and *World Economic Outlook* (February and October 1992).

the Pacific Rim region. The GDP growth rate for developing nations is 4.2 percent between 1990 and 2010 (Table 5), and is expected to fuel a rapid growth in demand for oil. Oil consumption rose by 5.0 percent in the Asia/Pacific region from 1985 to 1990, placing growth in these regions well above that for the rest of the world. [2, p. 24] In particular, China, India, Indonesia, Malaysia, South Korea, Taiwan, and Thailand showed rapid increases in consumption during that timeframe, as did the industrialized nation of Japan. The rates of increase in consumption for developing nations are expected to slow considerably, but should still be significantly higher than those in the rest of the world. There are, however, some constraints on oil demand growth in developing nations. Increases

in traffic congestion and related air pollution problems could, for example, limit growth in automobile transportation in certain metropolitan areas.

## OPEC Production

Most oil-producing countries, both in and outside of OPEC, expanded production to offset the loss of oil that followed the invasion of Kuwait by Iraq and the subsequent economic embargo of Iraq. Saudi Arabia, in particular, expanded production by 60 percent as the result of the Gulf War and, thereby, increased substantially its influence over OPEC decisionmaking (Table 4). Saudi Arabia now accounts for roughly 35

percent of OPEC production. (Saudi Arabia accounted for about 23 percent of production just before the Gulf war.)<sup>3</sup>, p. 4) This expansion is motivated in part by political and security reasons, as Saudi Arabia seeks to exert its influence and continue its current role as the dominant producing force in OPEC. Kuwait is restoring its production capabilities and is expected to reach prewar output levels in 1993. (See box on "Kuwaiti and Iraqi Production.") Although Iraq exports are still prohibited under the United Nation's embargo, the increase in production by other countries has fully compensated for the loss of Iraqi oil.

Countries with the largest reserves, principally OPEC members in the Persian Gulf, should play the major role in determining supply conditions in future oil market developments. OPEC has more than 75 percent of the world's proved oil reserves (almost 1 trillion barrels), with a high probability of much more still to be discovered (Table 6, Figure 5). Five Persian Gulf countries alone account for about 84 percent of OPEC reserves (Figure 6). Saudi Arabian reserves equal 260 billion barrels, followed by Iraq, the United Arab Emirates,<sup>1</sup> Kuwait, and Iran, each near 100 billion barrels. Venezuela has about 63 billion barrels. OPEC reserve levels at the end of 1992 were the equivalent of more than 80 years of crude oil production at 1991 production rates, compared with 7 years for the United States, and 15 for the FSU.

Within OPEC, the disparity between countries with large reserves and those with smaller reserves is growing. Each group faces different future prospects for production and revenues. Several OPEC countries (Algeria, Libya, Nigeria) are expected to invest in enhanced oil recovery methods, and some (Gabon and Indonesia) may even become net oil importers. For the future, the interests of these groups of countries are likely to diverge:

- Countries with small reserves will likely prefer a future with relatively lower production and higher prices to gain the maximum possible revenue from their dwindling resource; however,
- Countries with larger reserves are likely to favor a future with sufficient production to keep prices stable or growing slowly so that consumers have little incentive to switch to other fuels and competition from non-OPEC producers is minimized because the financial incentive to invest in new productive capacity is reduced.

The price projections in *IEO93* assume that countries with large reserves will control the future and will expand their production sufficiently to keep price growth moderate.

## Energy Vulnerability

The vulnerability of the U.S. economy and the energy sector to changes in world markets is a complex subject. Vulnerability is not simply a matter of dependence on a particular supply source, as is frequently stated. Oil supply vulnerability is a world concept because the oil market is an integrated market where disruptions in any part are almost immediately reflected in changes in every part of the world. Vulnerability, therefore, can be thought of as a combination of global dependence on a concentrated supply source and the availability of oil supply-disruption offsets such as excess oil production capacity and petroleum stocks. Other factors, such as political and even economic stability, and the ability quickly to substitute other fuels or factors of production in the face of a shortage, are not only inherently difficult to quantify but can also influence the security of supplies. Although these complexities make it difficult to quantify vulnerability, the index in Figure 7 attempts to present an indication of how vulnerable the Market Economies are to potential oil supply disruptions. The index is constructed to show only relative measures of vulnerability. A higher index indicates that Market Economies are relatively more vulnerable to large increases in prices as a result of a disruption than when the index is lower. That is, relatively large index values indicate that the probability of experiencing large price increases (and hence greater impact on the economy) is higher than when the index values are relatively low. The projections detailed in this report show an increase in dependence on Persian Gulf oil, which, in turn, reinforces concerns about energy vulnerability. The index characterizes past and future vulnerability, taking into account:

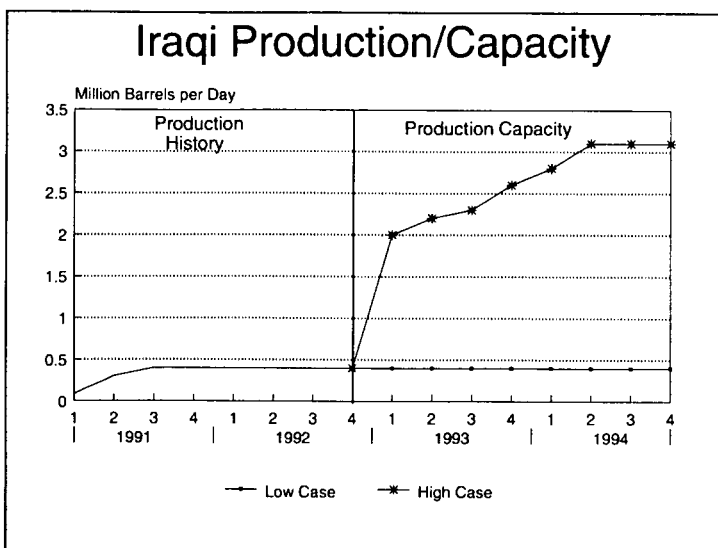
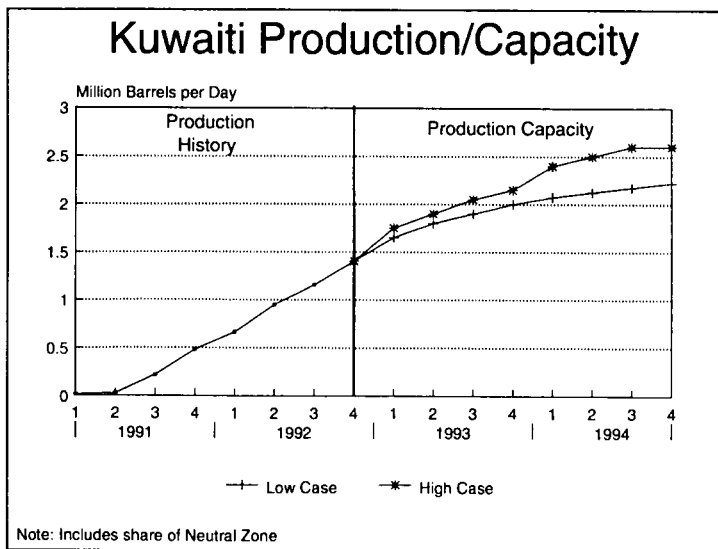
- Dependence on Persian Gulf oil—in this case, the percent of Market Economy demand supplied by Persian Gulf countries;
- Oil stock levels—in this case, the level of stocks at the end of the year in OECD countries, including strategic stocks expressed in terms of days of supply; and

<sup>1</sup>The United Arab Emirates includes Ajman, Abu Dhabi, Dubai, Fujairah, Ras al-Khaimah, Sharjah, and Umm al Qaiwain.

## Kuwaiti and Iraqi Production

At the end of 1992, Kuwait (including its share of the Neutral Zone) produced about 1.5 million barrels of oil per day. During the same time period, Iraq had the capacity to produce about 2.0 million barrels and export about 1.4 million barrels per day. Iraq produced only about 400,000 barrels per day, however, primarily for its own use with a limited amount of oil exported to Jordan despite the United Nations embargo on exports.

The low case for Iraq assumes that the United Nations embargo will continue. The high case provides levels of maximum production once the embargo is removed. The low and high cases for Kuwait show two possible paths for Kuwaiti production. In the high case, Kuwait produces at capacity, as it did in 1992. In the low case, Kuwait is pressured by the other member nations of OPEC to hold production below capacity as part of the OPEC's efforts to avoid downward pressures on oil prices.



Source: **History:** Energy Information Administration, *International Petroleum Statistics Report*, DOE/EIA-0520(93/01), Table 1.1.

**Table 6. World Crude Oil Reserves**  
(Billion Barrels)

Region/Selected Countries	Crude Oil Reserves	
	<i>Oil and Gas Journal</i> (1/1/93)	<i>World Oil</i> (1/1/92)
<b>North America</b> .....	81.3	81.7
Canada .....	5.3	6.1
Mexico .....	51.3	50.9
United States .....	24.7	24.7
<b>Central and South America</b> .....	72.5	73.1
Ecuador .....	1.6	1.7
Venezuela .....	62.7	62.7
<b>Western Europe</b> .....	15.8	22.2
United Kingdom .....	4.1	4.1
Norway .....	8.8	15.3
Denmark .....	0.7	0.7
<b>Eastern Europe and Former Soviet Union</b> .....	59.2	61.8
Former Soviet Union .....	57.0	59.9
<b>Middle East</b> .....	661.8	596.6
Iran .....	92.9	62.5
Iraq .....	100.0	100.0
Kuwait <sup>a</sup> .....	96.5	95.2
Qatar .....	3.7	2.9
Saudi Arabia <sup>a</sup> .....	260.3	261.9
United Arab Emirates .....	98.1	65.8
<b>Africa</b> .....	61.9	75.5
Algeria .....	9.2	9.9
Egypt .....	6.2	3.5
Gabon .....	0.7	0.9
Libya .....	22.8	38.4
Nigeria .....	17.9	17.9
Tunisia .....	1.7	1.8
<b>Far East/Oceania</b> .....	44.6	56.4
Australia/New Zealand .....	1.9	2.3
China .....	24.0	30.0
Indonesia .....	5.8	11.8
<b>Total OPEC</b> .....	772.2	731.6
<b>World Total</b> .....	997.0	967.1

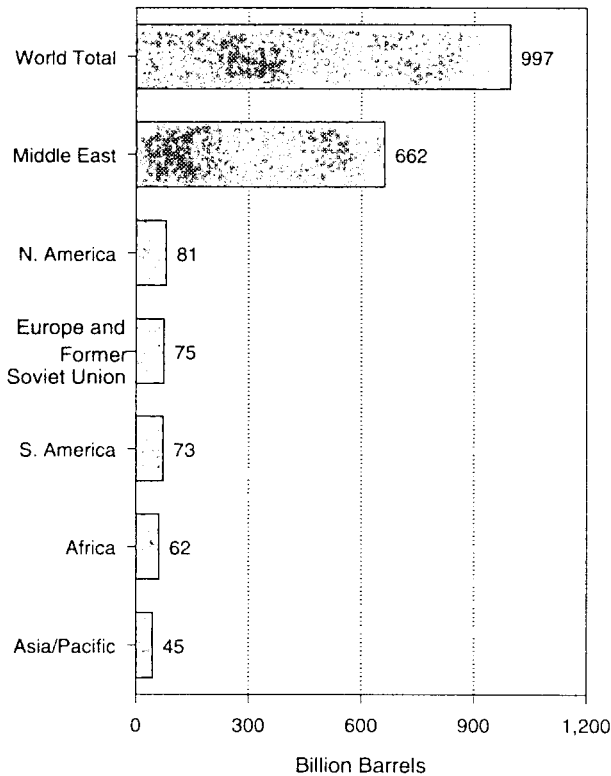
<sup>a</sup>Includes 50 percent of the Neutral Zone.

OPEC = Organization of Petroleum Exporting Countries.

Note: Totals may not equal sum of components due to independent rounding.

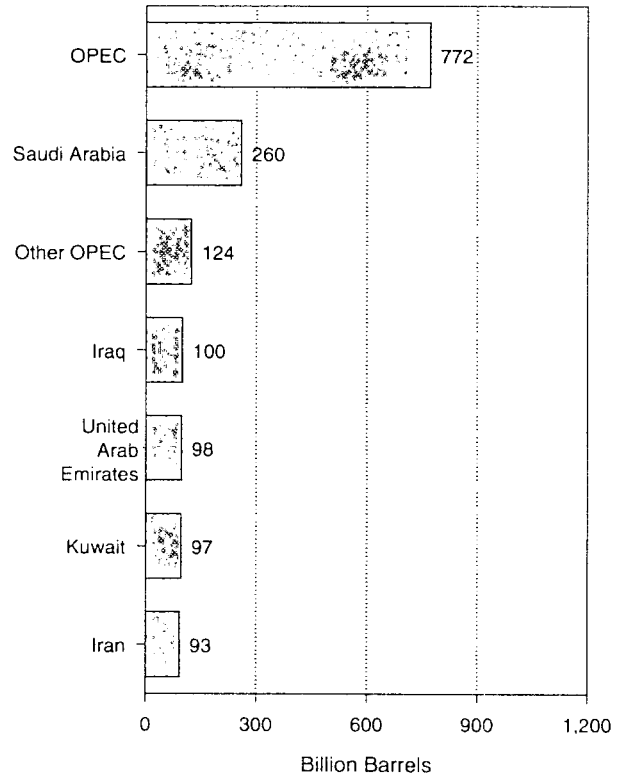
Sources: *Oil and Gas Journal* (December 28, 1992), pp. 44-45; *World Oil* (August 1992), p. 28.

**Figure 5. World Oil Reserves, January 1, 1993**



Source: *Oil and Gas Journal* (December 28, 1992), pp. 44-45.

**Figure 6. OPEC Proved Oil Reserves, January 1, 1993**



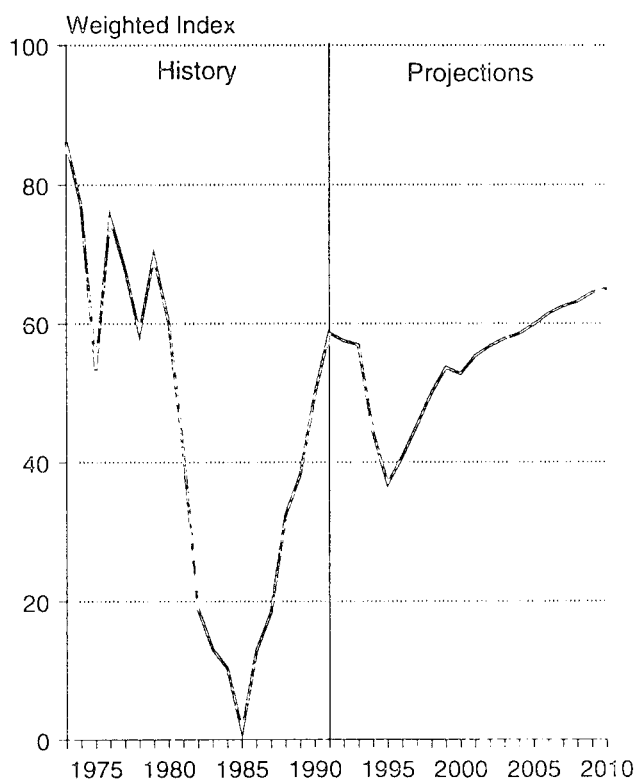
Source: *Oil and Gas Journal* (December 28, 1992), pp. 44-45.

- Excess crude oil production capacity—in this case, production capacity in OPEC minus actual production.

The more dependent that Market Economies are on Persian Gulf oil, the more likely that a disruption of supplies from this region would affect world markets. Conversely, high levels of oil stocks, including strategic reserves held by the United States, Japan, and Germany, can be used to counter or limit the impact of a disruption and may even make such an event less likely. The availability of excess crude oil production capacity to counter the effect of a disruption is critical. During the Persian Gulf War, for example, excess capacity and strategic reserves were used to help counter the impact of the disruption and greatly reduced the economic damage that could have occurred.

Figure 7 summarizes the index of vulnerability for the period 1973 through 2010. The three measures of vulnerability were combined using a weighted average of 50 percent for excess capacity, 30 percent for Persian Gulf dependence, and 20 percent for available stocks. It is important to note that, because these variables generally follow similar patterns, the use of another weighting scheme would make very little difference (see the Appendix). Low vulnerability was experienced in the late 1980's—because of high excess production capacity levels and high stock levels. Vulnerability jumped in the early 1990's when Iraqi and Kuwaiti supplies were disrupted. After a short period of decline, vulnerability should again start to increase after 1995 and by 2010 would be much closer to the level experienced in the early 1970's. Vulnerability rises as non-OPEC production peaks and Persian Gulf dependence rises.

**Figure 7. Vulnerability of Market Economies to Oil Supply Disruption, 1973-2010**



Sources: **History:** Energy Information Administration, *Annual Energy Review 1991*, DOE/EIA-0384(91), Tables 118, 123, and 124; *International Petroleum Statistics Report*, DOE/EIA-0520(93/01), Table 4.3; and capacity estimates from the Energy Markets and Contingency Information Division. **Projections:** See discussion and Table A1 in the Appendix.

## Non-OPEC Production Potential

Production in non-OPEC countries—excluding former and current Centrally Planned Economies (CPEs)—is expected to increase steadily until the end of this decade (Table 2). This increase continues a long-term trend interrupted only in the mid- to late-1980's, when production plateaued largely because of a series of accidents in the North Sea and a decline in U.S. production that offset production increases elsewhere. Non-OPEC production has historically been underpredicted—additional oil has been found when it was believed that production was ready to peak and decline. Recent advances in extraction technology, such as improved deepwater drilling techniques and increasingly accurate horizontal drilling methods, allow more production from existing fields. The *IEO93*

assumes higher non-OPEC production levels than the *IEO92*, primarily after 2000 when prices increase in real terms throughout the remainder of the projection period. In the *IEO93* base case, production by the end of the decade increases over 1990 levels by more than 3 million barrels per day, then levels off and slowly declines thereafter.

Expected record production levels in the North Sea is the major reason for predicting a continued rise in non-OPEC production. Production in the North Sea by the United Kingdom is recovering from the large decline that followed the 1988 accident, and is expected to rise by another 0.5 million barrels per day by 1995. Capacity increases from Norway and, to a lesser extent, the United Kingdom could total about 1 million barrels per day. As a result, North Sea production should not peak until the end of the decade, in contrast to expectations of a few years ago that these fields would mature and decline by 1995. The primary reasons for the change in expectations are {8}:

- Larger-than-anticipated discoveries in the 1980's;
- Discoveries of small fields near existing infrastructure, which will allow for easier development;
- Improved oil reservoir management techniques, which reduced declines in mature fields; and
- Increased North Sea natural gas production, which resulted in the production of additional natural gas liquids and condensate.

Production increases are also expected in the Middle East and Far East. Oman and Yemen together are expected to add several hundred thousand barrels per day of production during the next decade, with Syria holding steady or perhaps declining slightly. Oil companies have also increased their efforts in the Far East, and production from Australia, India, Malaysia, New Zealand, Pakistan, the Philippines, and Thailand of, perhaps, 0.75 million barrels per day is anticipated by the end of the decade. New Far Eastern producers, including Bangladesh and Mongolia, are expected to come online by 2000. Additional Far Eastern production in excess of 0.5 million barrels per day is expected to come from China and Vietnam.{8}

In Latin America, Brazil and Colombia together could add another 1 million barrels per day within the decade. In addition, modest increases are expected from Argentina, Bolivia, and Peru. Brazilian increases are not expected to peak until after 2000, and are contingent on development of the country's deepwater fields.{8}

Mexican increases are relatively modest when weighed against that country's enormous potential for further exploration and development. If the Mexican government were to make significant investments in the development of Mexican oil discoveries, or if foreign companies were allowed to participate in the country's oil projects, Mexican production could easily more than double during the forecast period. Mexico has proven reserves of more than 50 billion barrels—compared to 57 billion barrels in the FSU—yet Mexican production remains at around 2.7 million barrels per day while the FSU produces more than three times that amount.{3, p. 3}

African non-OPEC production is expected to increase slightly by the end of the decade. Although production from Cameroon, Egypt, and Zaire is expected to decline, production gains in Angola, the Congo, and Tunisia will more than offset that decline. New African producers (Chad, Equatorial Guinea, the Somali Republic, South Africa, and Sudan) are expected to come online by the year 2000.{8}

North American production is expected to continue its decline. Canada should increase production slightly because of increased oil from tar sands and bitumen, as well as from natural gas liquids and condensates.{8} However, these small increases should not offset the continued decline expected in the United States. This decline was briefly interrupted during the latter part of 1990 when a rise in Alaskan production played an important role in the U.S. response to events in the Middle East. However, the decline in Alaskan production is expected to resume as the fields age.{1, p. 90}

Another factor contributing to the decline in U.S. production is the shifting of oil company investments from drilling in the United States to drilling in foreign areas. For the first time, major American oil companies are spending more in foreign countries than in the United States.{9} Three basic reasons account for this shift in investment:

- The United States has been well explored and the chances of finding another large field, outside of a few environmentally sensitive areas, are not as great as overseas;
- Environmental restrictions that now affect leases of U.S. offshore areas and areas in Alaska are expected to reduce potential production; and
- The size and age of U.S. fields make production costs in the United States higher than elsewhere.

These negative factors are expected to result in production declines that more than offset increased offshore production projected in the Pacific and from recent large deepwater discoveries in the Gulf of Mexico.

## Comparison of International Oil Projections

Projections of world oil markets involve considerable uncertainty. This uncertainty is generated by political events, such as the recent Persian Gulf war or the demise of communism in Eastern Europe and the FSU. Uncertainty also arises from the difficulty of knowing key determinants of supply and demand, such as future world oil prices, economic growth rates, exchange rates, changes in efficiency and conservation, and environmental factors.

Recent and anticipated developments in world oil markets are reflected in *IEO93* price paths projection for world oil—which are lower than those published in *IEO92* (Table 7). The world oil price, defined as the average cost of imported crude oil to U.S. refiners, is about \$4 per barrel lower in 2000 and about \$5 per barrel lower in 2010 than those in the *IEO92* base case. The base case projection still shows a gradual increasing trend in prices, however, with the greater part of the increase occurring after 1995.

The main reason for lower prices compared with *IEO92* projections is raised expectations about the expansion of oil production capacity among OPEC members, particularly during the next few years. Major increases in production capacity are expected from Saudi Arabia, which may become the world's largest oil producer, as production from the FSU, the largest producer in recent years, declines. Capacity is also expected to expand in Kuwait and other Persian Gulf countries, and eventually in Iraq when United Nations sanctions are lifted.

Expectations about demand behavior among the developing countries have been modified relative to the *IEO92*. This adjustment also contributes to the lower price projections. As the economies in these countries mature, it is expected that they will use more energy-efficient technology to produce higher value-added products.{11, p. 9} Thus, the overall energy intensity of economic activity in these countries will be reduced, just as it has been in OECD countries. To account for this changing economic base in many developing countries, the oil intensity (the ratio of oil consumption per unit of GDP) of prospective economic activity for the developing-countries group was reduced slightly.



**Table 7. Comparison of World Oil Projections**  
(Million Barrels per Day)

Projections	Oil Consumption				Oil Production				Price <sup>a</sup>
	World	OECD	CPE	Other	World	OPEC	CPE	Other	
<b>Year 2000</b>									
IEO93	76.5	42.8	12.2	21.5	76.2	33.1	12.9	30.2	\$22.90
IEO92	75.0	41.6	12.9	20.5	74.7	30.9	13.2	30.6	27.36
DRI	76.2	42.2	13.3	20.7	76.4	33.3	14.0	29.1	22.75
GRI	72.5	39.7	15.0	17.8	72.5	32.5	15.9	24.1	23.75
PEL <sup>b</sup>	75.7	40.5	12.4	22.8	75.9	29.7	13.2	33.0	Stable
WEFA <sup>c</sup>	75.6	40.1	7.4	28.1	75.8	33.3	9.2	33.3	19.70
<b>Year 2010</b>									
IEO93	85.9	45.6	15.3	25.0	85.6	42.7	15.3	27.6	\$29.30
IEO92	84.3	43.6	15.6	25.1	84.0	41.9	15.6	26.5	34.61
DRI	85.1	45.5	14.3	25.3	85.4	38.8	16.3	30.3	29.67
GRI	80.0	41.2	17.1	21.7	80.0	38.9	17.0	24.1	36.84
PEL	87.3	41.8	17.7	27.8	87.1	38.8	17.4	30.9	Stable
WEFA	82.1	40.5	7.9	33.7	82.3	37.8	10.0	34.5	25.21

<sup>a</sup>1991 dollars per barrel.

<sup>b</sup>The base case in this study is based on the assumption of no significant change in real crude prices throughout the forecast period.

<sup>c</sup>CPE amounts include only the former Soviet Union. All other CPE amounts included in "Other."

OECD = Organization for Economic Cooperation and Development.

Note: CPE includes former, evolving, and current Centrally Planned Economies.

Sources: **IEO93**: *International Energy Outlook 1993*, DOE/EIA-0484(93), Tables 1, 2, and 3. **IEO92**: *International Energy Outlook 1992*, DOE/EIA-0484(92), Tables 1, 2, and 3. **DRI**: DRI/McGraw-Hill, *International Oil Bulletin*, Third Quarter 1992. **GRI**: Gas Research Institute, *1992 Edition of the GRI Baseline Projection of U.S. Energy Supply and Demand to 2010*, April 1992. **PEL**: Petroleum Economics Ltd., London, *World—Long Term Oil and Energy Outlook to 2010*, December 1992. **WEFA**: WEFA Group, *Energy Analysis Quarterly*, Fall 1992.

*IEO93* also assumes that developing countries will be more responsive to changes in oil prices than in the past, moving in the direction of the responsiveness in OECD countries. This change results from technological advances and more optimistic prospects for other energy supplies. Although these changes in oil intensity and price responsiveness assumptions are small, they result in the developing-countries group consuming less oil at a given price in *IEO93* than they would have with *IEO92* assumptions. Nonetheless, by 2010, developing countries should account for almost half of all the growth in oil consumption worldwide.

The base case price path presented in *IEO93* is generally consistent with similar projections presented in other recent studies of world oil markets (Table 7). Similarly, there is reasonable agreement among the studies cited with respect to the outlook for world oil consumption and production. The variations between the projections in the *IEO93* and the other studies presented in

Table 7 reflect uncertainties in factors affecting oil supply and demand prospects.

The greatest area of uncertainty through the year 2010 concerns prospects for the developing countries and for the CPEs. There are major uncertainties concerning oil market prospects in the CPEs. The rapid political and economic changes occurring in these countries and the lack of economic and energy data comparable to that available for the Market Economies, particularly the OECD countries, make it particularly difficult to analyze oil markets in these countries.

With respect to the developing countries, oil production prospects for these countries taken together will be influenced in large part by the actions of OPEC. Economic and political objectives sought by the respective OPEC countries have been and will likely continue to be highly volatile, particularly in the Middle East. This volatility and the fact that a large

portion of the world's oil reserves are controlled by OPEC are reflected in oil market projections.

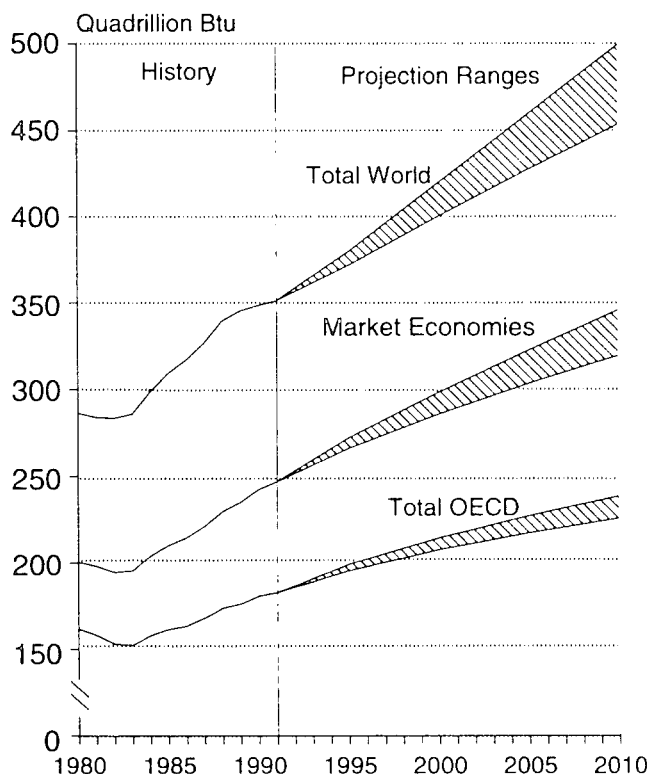
Important political and economic changes are occurring in the other developing countries as well. As a result, much of the growth in oil consumption through 2010 is expected to occur in these countries. However, there is considerable uncertainty as to whether or not many of these countries will be able to finance or otherwise meet growth objectives.[11, pp. 9-12] On the supply side, there is uncertainty concerning

the magnitude of oil reserves in many of the less explored regions. Indeed, reserve estimates have been increased substantially for many developing countries in recent years. These more optimistic prospects were reflected in the *IEO92* projections. Production levels in that report for the developing countries were about 2 million barrels per day higher in 2000 and about 1 million barrels per day higher in 2010 than they were in the *IEO91*. Production prospects for the developing countries are increased further for 2010 in the *IEO93*.

# World Energy Consumption

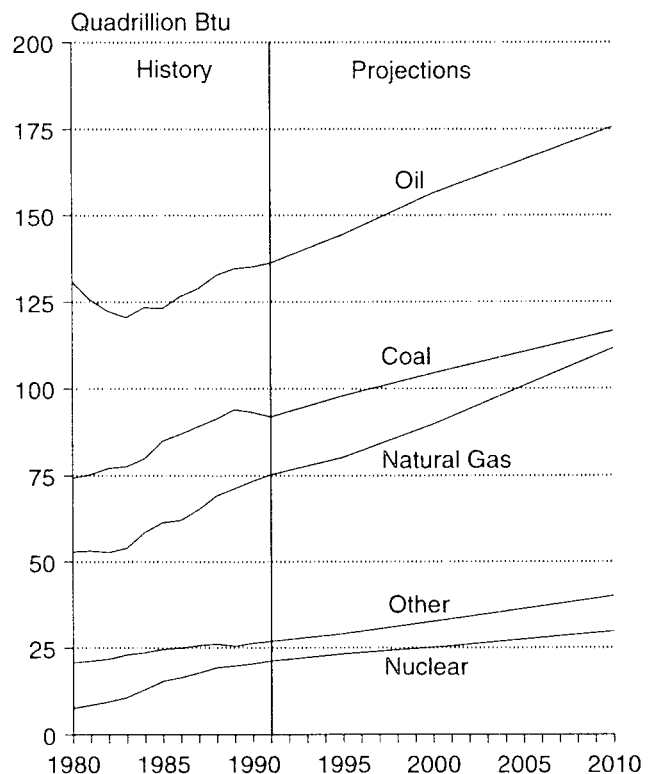
World consumption of total primary energy is projected to grow at an average annual rate of 1.6 percent per year between 1990 and the year 2010 (Figure 8), compared to an average rate of 2.7 percent per year for world economic growth as measured by gross domestic product (GDP) (Table 5). Oil remains the most important source of energy through 2010 (Figure 9). Among the major energy sources, oil and coal consumption grow more slowly than total energy consumption during the next two decades, while

**Figure 8. World Energy Consumption by Region, 1980-2010**



Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Table A9 and other selected issues. **Projections:** Table 9.

**Figure 9. World Energy Consumption by Type, 1980-2010**



Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Tables A10 through A14 and other selected issues. **Projections:** Table 8.

natural gas, nuclear, and other energy consumption grow faster.<sup>2</sup> World consumption of natural gas and other energy grow at an annual rate of 2.2 percent and 2.1 percent between 1990 and 2010 (Table 8). Reflecting a faster rate of economic growth, energy consumption in the developing countries grows about twice as fast as that in the industrial countries that make up the Organization for Economic Cooperation and Development (OECD) (Table 9).

<sup>2</sup>Other energy consists of hydropower and geothermal. The U.S. amounts also include energy from solar, wind, and biofuels.

**Table 8. World Total Energy Consumption by Type**  
(Quadrillion Btu)

Energy Source	Projection Ranges										
	History		1995			2000			2010		
	1990	1991	Base	Low	High	Base	Low	High	Base	Low	High
<b>Market Economies</b>											
Oil .....	108.8	110.4	122	118	125	131	124	137	143	134	154
Gas .....	45.2	48.3	54	52	56	61	57	65	74	67	81
Coal .....	48.6	48.1	50	49	51	52	50	54	56	54	59
Nuclear .....	17.3	18.3	20	19	20	21	21	21	25	23	25
Other .....	21.6	21.7	24	23	25	27	25	29	32	30	35
<b>Total</b> .....	<b>241.4</b>	<b>246.8</b>	<b>269</b>	<b>266</b>	<b>272</b>	<b>292</b>	<b>286</b>	<b>298</b>	<b>333</b>	<b>320</b>	<b>346</b>
<b>Centrally Planned Economies<sup>a</sup></b>											
Oil .....	26.6	25.8	23	20	26	26	22	29	32	26	38
Gas .....	27.2	27.0	27	24	29	29	26	32	38	31	45
Coal .....	43.5	43.8	48	47	49	52	51	54	60	57	64
Nuclear .....	3.0	2.9	3	3	4	4	4	4	5	5	5
Other .....	4.7	4.6	5	5	5	6	6	6	8	7	8
<b>Total</b> .....	<b>105.0</b>	<b>104.1</b>	<b>106</b>	<b>105</b>	<b>107</b>	<b>118</b>	<b>114</b>	<b>121</b>	<b>144</b>	<b>134</b>	<b>154</b>
<b>World Total</b>											
Oil .....	135.4	136.2	144	140	149	156	149	163	176	164	187
Gas .....	72.4	75.3	80	77	83	90	85	95	112	102	122
Coal .....	92.0	91.9	98	97	99	104	102	107	117	112	121
Nuclear .....	20.3	21.2	23	23	23	25	25	25	30	28	31
Other .....	26.3	26.4	29	28	30	33	31	34	40	38	43
<b>Total</b> .....	<b>346.4</b>	<b>351.0</b>	<b>375</b>	<b>371</b>	<b>379</b>	<b>410</b>	<b>400</b>	<b>420</b>	<b>476</b>	<b>454</b>	<b>500</b>

<sup>a</sup>Includes former, evolving, and current Centrally Planned Economies.

Notes: Energy totals include consumption of biofuels in the United States. All uncertainty ranges are derived independently and do not necessarily add to totals. Other totals may not equal sum of components because of independent rounding.

Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Tables A9 through A15 and database related to Table 30. **Projections:** Energy Information Administration, *Annual Energy Outlook 1993*, DOE/EIA-0383(93), Tables A1, B1, C1, and related Forecasting System runs for U.S. renewables; and World Energy Projection System Spreadsheet, 1993.

IEO93 projects that, by 2010, the largest consumers of energy will be the United States, the former Soviet Union (FSU), and China (Table 9). Taken together, OECD Europe is currently second only to the United States in total energy consumption and will remain second through 2010. Energy consumption in the FSU, which has experienced internal economic disruptions, declines in absolute terms through 1995 and does not return to current levels until 2000, or later. In contrast, energy consumption in China grows twice as fast, on average, between 1990 and 2010, as does energy consumption worldwide.

After the United States, Japan consumes the most energy among the industrialized countries of the

OECD, close to a quarter of the U.S. amount by 2010. A major difference exists, however, in the energy makeup of these two industrial giants. The United States produces more than four-fifths as much energy as it consumes, while Japan produces less than one-fifth as much energy as it consumes. (2, pp. 104, 112) To meet growing energy demands, the United States is expected to import a larger share of the total energy consumed—primarily oil—between now and 2010. Japan is planning to more than double its production of nuclear power by 2010. Japan must also expand oil and natural gas imports substantially over this period to meet the demands of economic growth, which is expected to be the fastest among the OECD countries. OECD Europe, which consumes almost three-quarters

**Table 9. World Total Energy Consumption by Region**  
(Quadrillion Btu)

Region/Country	Projection Ranges										
	History		1995			2000			2010		
	1990	1991	Base	Low	High	Base	Low	High	Base	Low	High
<b>Market Economies</b>											
<b>OECD</b>											
United States <sup>a</sup> . . . . .	84.6	84.8	91.4	90.5	92.3	97.5	95.1	99.6	106.7	101.7	111.5
Canada . . . . .	10.7	10.7	11.7	11.5	11.9	13.2	12.7	13.7	15.1	14.1	16.2
Japan . . . . .	18.2	18.8	21.0	20.6	21.3	22.4	21.7	23.0	25.5	24.2	26.8
Europe . . . . .	61.3	63.3	67.9	66.7	69.2	72.2	70.1	74.4	78.6	74.8	82.5
United Kingdom . . . . .	9.0	9.4	10.4	10.1	10.8	11.0	10.6	11.6	12.3	11.5	13.1
France . . . . .	8.9	9.4	10.5	10.3	10.8	11.5	11.0	12.0	12.9	12.0	13.8
Germany . . . . .	14.8	15.1	15.6	15.5	15.8	16.3	16.1	16.6	17.2	16.7	17.7
Italy . . . . .	6.8	7.2	7.9	7.7	8.1	8.5	8.2	8.9	9.3	8.7	9.8
Netherlands . . . . .	3.3	3.4	3.6	3.5	3.6	3.8	3.7	3.9	4.3	4.1	4.5
Other Europe . . . . .	18.6	18.9	19.8	19.6	20.0	21.0	20.5	21.5	22.7	21.8	23.6
Other OECD . . . . .	4.9	4.9	5.3	5.2	5.3	5.7	5.5	5.8	6.2	5.9	6.5
<b>Total</b> . . . . .	179.8	182.5	197.3	195.4	199.1	210.9	207.5	214.4	232.1	225.8	238.7
OPEC . . . . .	16.4	17.3	19.0	18.7	19.3	21.4	20.7	22.1	26.6	24.8	28.4
Other Developing Countries . . . .	45.2	47.1	52.8	51.9	53.7	59.7	57.6	61.8	73.8	69.0	78.9
<b>Total Market Economies</b> . . . . .	241.4	246.8	269.0	266.0	272.1	291.9	285.7	298.3	332.5	319.6	346.0
<b>Centrally Planned Economies<sup>b</sup></b>											
China . . . . .	27.9	29.2	35.5	34.7	36.3	41.7	40.0	43.5	53.6	49.7	57.7
Former Soviet Union . . . . .	58.0	57.2	53.1	52.4	53.8	57.0	55.1	59.0	68.8	63.3	74.7
Other . . . . .	19.1	17.8	17.7	17.6	17.7	19.2	18.9	19.4	21.2	20.4	22.0
<b>Total</b> . . . . .	105.0	104.1	106.3	105.3	107.3	117.9	114.4	121.5	143.6	134.0	153.8
<b>World Total</b> . . . . .	346.4	351.0	375.4	371.4	379.4	409.8	400.1	419.7	476.1	453.7	499.7

<sup>a</sup>Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

<sup>b</sup>Includes former, evolving, and current Centrally Planned Economies.

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

Notes: All uncertainty ranges are derived independently and do not necessarily add to totals. Other totals may not equal sum of components because of independent rounding.

Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Tables A9 and A15 and database related to Table 30. **Projections:** Energy Information Administration, *Annual Energy Outlook 1993*, DOE/EIA-0383(93), Tables A1, B1, C1, and related Forecasting System runs for U.S. renewables; Oil Market Simulation Model Spreadsheet, 1993; and World Energy Projection System Spreadsheet, 1993.

as much energy as does the United States through 2010, should also increase natural gas imports substantially to meet growing demands. Natural gas imports would help reduce Europe's reliance on oil imports and would provide a relatively clean-burning alternative to coal. Gas would flow to Europe from the Middle East and from the FSU.

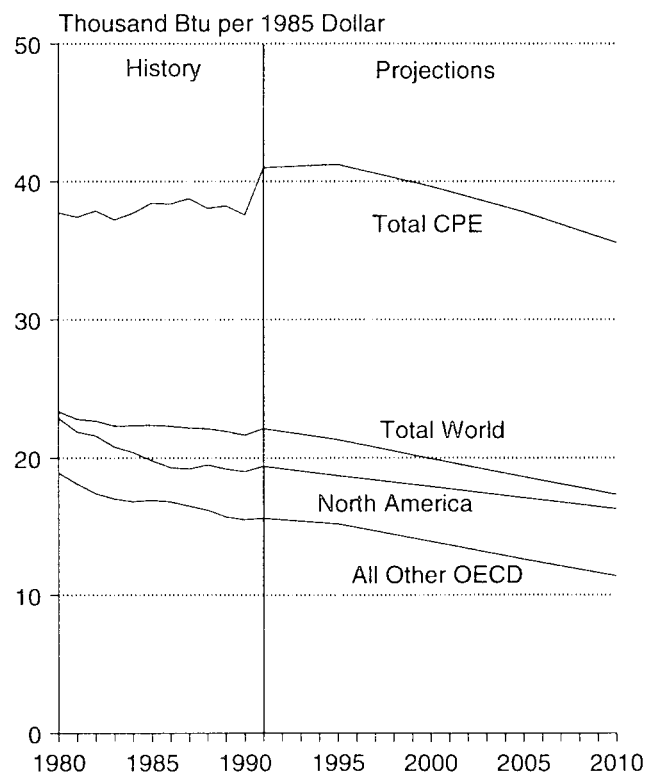
The developing countries of the world, taken as a group and excluding the former, evolving, and current Centrally Planned Economies (henceforth called simply the CPEs), are expected to experience the fastest growth in economic activity, growing at a rate of about 4.2 percent per year between 1990 and 2010. As a result, energy consumption should also grow faster—almost twice as fast—among these countries than among the industrialized OECD countries. In particular, the Pacific Rim countries are expected to demonstrate relatively rapid economic growth over this period, 6.3 percent per year compared to 2.7 percent for the world as a whole. [11, p. 17] In general, the ongoing growth of urban areas and industrial activities in many of the developing countries should be accompanied by increased demands for transportation, electrification, and the other energy-using amenities associated with economic development.

## Energy Intensity

Defined as the ratio of total energy consumption to GDP, the energy intensity of economic activity in the world as a whole declines steadily over the projection period (Figure 10). An exception to this general trend occurs in the CPEs, where the energy intensity of economic activity rises through 1995. This exception results from the disruptions caused by the political and economic changes occurring in the FSU. Although energy consumption in the FSU is projected to decline through 1995, economic activity there declines even faster. Thus, energy intensity (defined as total energy consumption divided by GDP) rises in the FSU and, consequently, in the CPEs between 1990 and 1995. Beyond 1995, both energy consumption and economic activity increase in the FSU. The severity of the economic downturn in the FSU is illustrated by the fact that its GDP is not expected to be much higher by 2010 than it was in 1990. Currently, the CPEs are expected to continue to be the world's most inefficient users of energy. Considerable room for improvement exists among these countries, and improvement should occur as general economic reforms take hold.

Continued improvements in energy efficiency and energy conservation are expected to be at least—if not

**Figure 10. Energy Consumption per Dollar of Real Gross Domestic Product, 1980-2010**



Note: CPE includes former, evolving, and current Centrally Planned Economies. North America consists of OECD members Canada and the United States.

Sources: **History:** Wharton Econometric Forecasting Associates, *World Economic Services* and *World Economic Service Historical Data 1992*; and Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Tables A9 and A15. **Projections:** See Appendix Table A2.

more—difficult to achieve in the future than they have been in the past. Many of the easy conservation measures have already been undertaken. Technological innovation is expected to be an important factor in reducing the overall energy intensity of economic activity around the world. Technology will be a key factor in determining the rate of structural change among the world's economies away from energy-intensive heavy manufacturing, toward less energy-intensive services and high-technology industries.

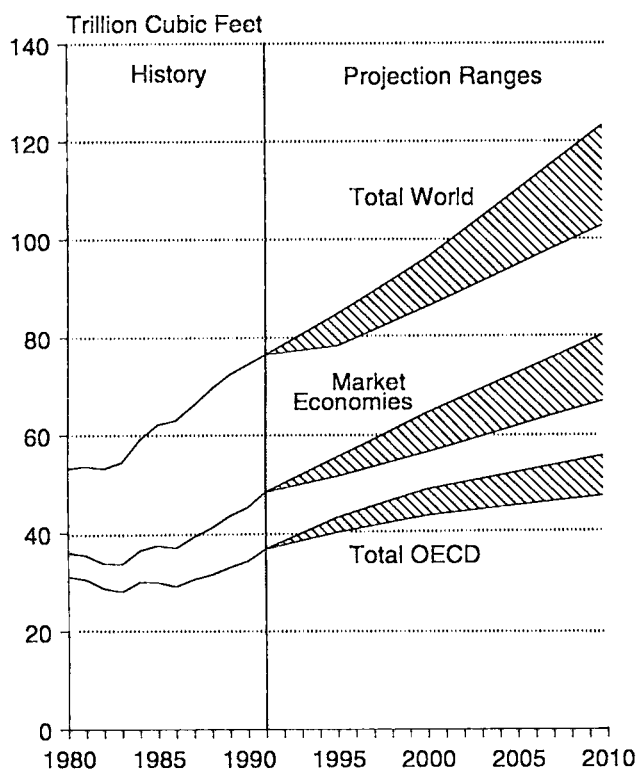
Other activities, particularly among the developing countries, will add to the general energy intensity of overall economic activity. Certain newly industrialized countries are expected to continue to expand their manufacturing base. Other countries should continue to

rely heavily on the development of natural resources, both activities being relatively energy intensive. Certain OPEC nations, rich in energy resources, are expected to use those resources more intensively as they strive to achieve greater economic growth. Petrochemical activities, in particular, require large inputs of oil and natural gas. General growth in motor transportation and in electrification would contribute further to the overall intensity of daily activity. Nevertheless, the general trend in the intensity of economic activity among the developing countries, and in the world as a whole, is down.

## Prospects for Natural Gas

Although the intensity of economic activity declines between 1990 and 2010, the absolute amount of energy

**Figure 11. World Natural Gas Consumption, 1980-2010**

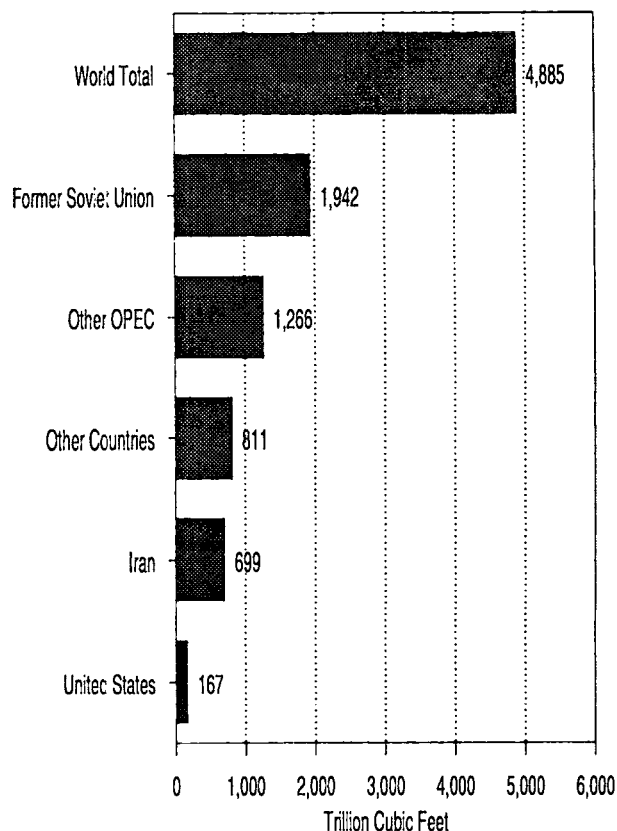


Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Table 9 and other selected issues. **Projections:** Table 10.

consumed increases worldwide in order to fuel the rates of economic growth anticipated during this period (Table 5). Natural gas provides an increasing share of total energy consumed—rising from 21 percent in 1990 to 24 percent by 2010. Natural gas and other energy are the fastest growing energy sources in the world, growing at a rate of 2.2 percent and 2.1 percent per year on average during this period (Table 10 and Figure 11).

Expectations for natural gas consumption have risen considerably in recent years, as estimates of world natural gas resources and reserves continue to grow (Figure 12). Technological advancements have added further to expectations for natural gas consumption. For example, electric utilities are more likely to use natural gas as a baseload fuel because of the increased efficiency of gas-fired technology. The use of high-

**Figure 12. World Natural Gas Reserves, January 1, 1993**



Source: *Oil and Gas Journal* (December 28, 1992), pp. 44-45.

**Table 10. World Natural Gas Consumption**  
(Trillion Cubic Feet)

Region/Country	Projection Ranges										
	History		1995			2000			2010		
	1990	1991	Base	Low	High	Base	Low	High	Base	Low	High
<b>Market Economies</b>											
<b>OECD</b>											
United States <sup>a</sup> .....	18.7	19.2	21.0	20.7	21.3	22.8	22.0	23.4	24.2	22.8	25.4
Canada .....	2.4	2.5	2.5	2.5	2.5	2.7	2.6	2.8	3.0	2.8	3.2
Japan .....	1.8	1.9	2.4	1.8	3.1	2.4	1.5	3.7	3.0	1.2	5.1
Europe .....	10.6	12.5	14.9	13.7	16.2	17.2	14.9	19.6	20.7	17.1	24.1
United Kingdom .....	2.0	2.2	3.0	2.5	3.5	3.5	2.5	4.3	4.7	3.1	5.8
France .....	1.1	1.3	2.1	1.6	2.6	2.7	1.8	4.0	3.5	1.9	5.5
Germany .....	3.0	4.2	4.5	3.7	5.4	4.8	3.3	6.2	5.1	2.8	6.8
Italy .....	1.7	1.8	2.0	1.9	2.2	2.3	1.9	2.7	2.7	2.1	3.4
Netherlands .....	1.4	1.5	1.6	1.5	1.7	1.7	1.5	2.0	1.9	1.5	2.2
Other Europe .....	1.4	1.5	1.7	1.4	2.3	2.2	1.2	3.3	2.8	1.3	4.6
Other OECD .....	0.7	0.6	0.8	0.6	0.8	0.9	0.7	1.1	0.9	0.6	1.2
<b>Total</b> .....	34.2	36.8	41.5	40.1	43.0	46.0	43.4	48.8	51.8	47.5	56.0
OPEC .....	5.6	6.1	6.2	5.6	6.7	7.4	5.9	8.7	9.6	7.0	12.0
Other Developing Countries . . .	4.8	5.3	5.7	4.5	7.1	7.0	4.8	9.6	12.6	7.8	17.5
<b>Total Market Economies</b> . . . . .	44.6	48.2	53.4	51.5	55.6	60.3	56.6	64.4	73.9	67.0	80.9
<b>Centrally Planned Economies<sup>b</sup></b>											
China .....	0.5	0.5	0.7	0.6	0.7	1.0	0.9	1.1	1.3	1.2	1.5
Former Soviet Union .....	25.0	25.1	24.7	22.2	27.2	26.3	23.2	29.4	34.3	27.0	42.0
Other .....	3.1	2.8	2.7	2.5	3.2	3.5	3.1	4.1	3.9	2.6	5.1
<b>Total</b> .....	28.6	28.3	28.0	25.5	30.6	30.8	27.7	33.9	39.5	32.1	47.3
<b>World Total</b> .....	73.2	76.5	81.4	78.3	84.8	91.1	86.3	96.3	113.4	103.3	123.9

<sup>a</sup>Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

<sup>b</sup>Includes former, evolving, and current Centrally Planned Economies.

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

Notes: High and low range values for Europe and the four regional totals are not equal to the sum of the component countries or country groups but consist of the base value adjusted by the quantity: the square root of the sum of the squared deviations of the respective component countries or country groups from their base value. Other totals may not equal sum of components because of independent rounding.

Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Tables 9 and 13. **Projections:** Energy Information Administration, *Annual Energy Outlook 1993* DOE/EIA 0383(93), Tables A9, B9, C9, E9, F9, and G9; and World Energy Projection System Spreadsheet, 1993.



efficiency combined cycle systems is growing, not only in the utility sector but also in the industrial sector. Natural gas-fired plants have an additional advantage in that they can be built faster and cheaper than larger coal-fired or nuclear plants—a characteristic that is becoming increasingly important because of growing uncertainties concerning regulatory and environmental requirements. Additional markets for natural gas will be for combined heat and power production in industry and for district heating in certain European countries. Use of natural gas as a transportation fuel is also expected to grow, in competition with gasoline and diesel fuel. A major incentive for using natural gas is the concern over the environmental costs associated with energy use. Compared with other fossil fuels, natural gas is a relatively clean-burning fuel.

According to the International Energy Agency, natural gas resources have been discovered in more than 50 developing countries.<sup>{7, p. 18}</sup> It is particularly abundant in the FSU and the Middle East. These two regions account for 71 percent of the world's natural gas reserves. Natural gas currently accounts for about two-fifths of all primary energy consumed in the FSU, and should provide even a larger share of total consumption by 2010.

International trade of this important energy source is expected to expand considerably, given the location of major natural gas reserves relative to the locations of growing demand. Major importers would be Japan and countries in Eastern and Western Europe. These countries should use natural gas to diversify energy imports and to avoid environmental problems associated with other fossil fuels, particularly coal. Liquefied natural gas could also be used to diversify energy imports. Western Europe currently imports considerable amounts of natural gas, particularly from the FSU and Algeria.<sup>{2, p. 68}</sup> Norway's Troll and Sheipner fields are important sources of indigenous supplies for Europe. Among many developing countries, growth in natural gas consumption will depend on the ability to attract the capital needed to develop new fields and to construct required distribution systems.

In the United States, natural gas consumption grows through 2010, with natural gas maintaining a steady market share. Growth in U.S. natural gas consumption results from growth in new markets, particularly in electricity generation. Gas consumption in the utility sector should nearly double by 2010. Consumption in

the industrial sector should grow by more than a quarter; however, consumption in the residential and commercial sectors is expected to remain relatively stable. Growth in the utility sector is driven by greater use of existing plants along with a substantial increase in combined-cycle plants between now and 2010. New market areas for natural gas also include commercial cooling and the use of compressed natural gas vehicles in the transportation sector.

Natural gas production in the United States increases through 2005 and then levels off. Relatively stable levels of production result in large part from the increasing use of unconventional gas recovery technologies and new contributions from Alaska that will be delivered by pipeline through Canada. Natural gas imports would be needed to meet growing demands, however, with most imports coming from Canada.

Natural gas trade with Mexico should also increase substantially in the future, encouraged by the North American Free Trade Agreement (NAFTA), which must still be ratified by Canada, Mexico, and the United States. Although the largest producer of natural gas in Latin America, Mexico is a net importer of natural gas. Mexico has the potential to increase future production and should become a net exporter of natural gas to the United States around 2010.

Between 1990 and 2010, the developing-countries group is expected to experience the most rapid growth in natural gas consumption. Consumption growth in those countries averages 3.9 percent per year, compared with 2.2 percent per year worldwide and 1.3 percent per year for the United States. Demand growth should be strong in the utility and industrial sectors, particularly the petrochemical sector. Oil-producing countries could use natural gas to free up oil resources for export. As in the OECD countries, natural gas would also be favored for environmental reasons.

## Prospects for Coal

After oil, coal is the most important energy source in the world today, accounting for just over a quarter of all energy consumed. Coal accounts for more than two-fifths of all energy consumed among the CPEs. Between 1990 and 2010, growth in coal consumption is expected to be the slowest of all the major energy sources. Coal should still account for a quarter of all energy consumed in the world by 2010, however, and should

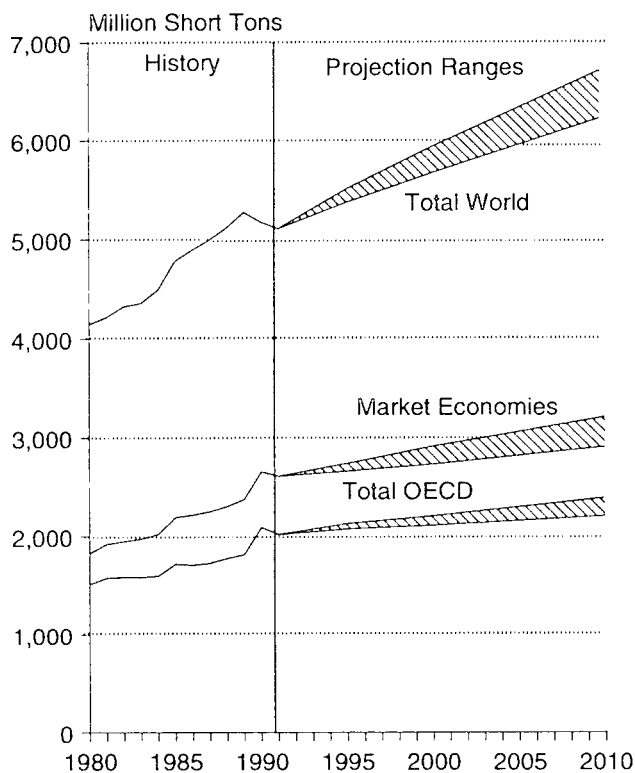
still account for two-fifths of all energy consumed among the CPEs. Coal consumption grows in most parts of the world, but consumption is expected to be lower in 2010 than it was in 1991 in Eastern and Western Europe, particularly in Germany (Table 11 and Figure 13). Production cutbacks are expected in Germany because of the elimination of production subsidies and the reduction of lignite production, a major pollutant, in former East Germany. Coal is expected to remain the primary energy source among the CPEs, except in the FSU, where natural gas dominates. Coal could actually increase its relative importance in the CPEs during the next decade, primarily because of the growth of coal consumption in China. Coal provides three-quarters of all energy consumed in China during the projection period.

China is the largest producer of coal in the world, producing about 1.2 billion short tons of coal in 1991. The United States was second at about 1.0 billion short

tons, and the FSU was third with about 0.8 billion short tons. Together, these three regions accounted for 58 percent of the world's coal production in 1991. They also accounted for 55 percent of total world coal consumption in 1991. Other major producers include, in rank order, Germany, India, Australia, Poland, and South Africa. [2, pp. 12, 28]

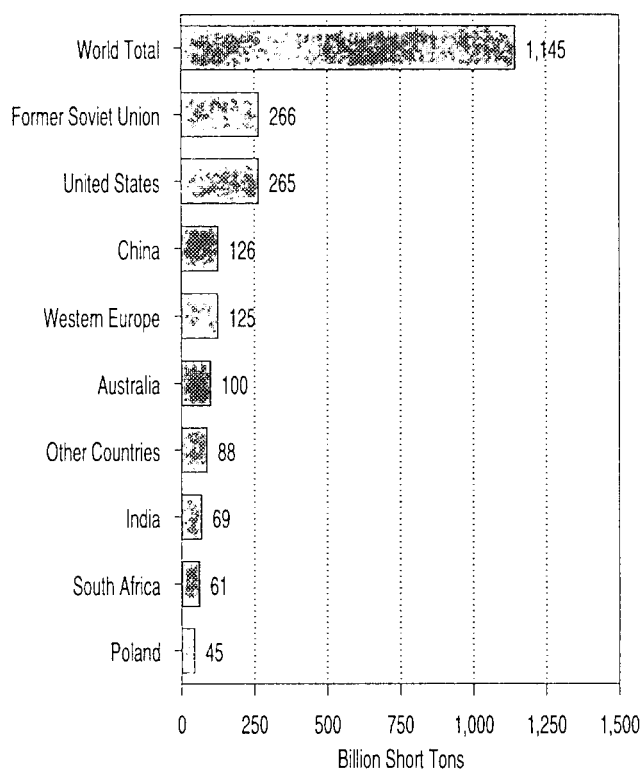
As with natural gas, the distribution of world coal reserves, when compared with areas of growing demand, should lead to expanded coal trade over the projection period (Figure 14). In 1990, Australia and the United States produced half of all internationally traded coal. These two countries, together with South Africa, account for close to two-thirds of all coal trade. Japan is by far the largest importer of coal, accounting for more than a quarter of total imports in 1990. [2, p. 80] Japan, South Korea, and Taiwan should continue to be large importers of coal, given their limited coal reserves and growing needs from expanding economies.

**Figure 13. World Coal Consumption, 1980-2010**



Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0129(91), Table 10 and other selected issues. **Projections:** Table 11.

**Figure 14. World Coal Reserves**



Source: Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Table 33.

**Table 11. World Coal Consumption**  
(Million Short Tons)

Region/Country	Projection Ranges										
	History		1995			2000			2010		
	1990	1991	Base	Low	High	Base	Low	High	Base	Low	High
<b>Market Economies</b>											
<b>OECD</b>											
United States <sup>a</sup> .....	895	888	947	941	948	987	983	996	1,135	1,084	1,210
Canada .....	58	56	68	61	77	83	72	99	90	76	108
Japan .....	125	127	134	125	145	134	123	150	136	121	156
Europe .....	930	832	825	806	853	821	783	866	795	735	857
United Kingdom .....	110	115	117	116	118	115	114	115	112	110	113
France .....	39	37	37	37	37	33	31	38	27	20	37
Germany .....	509	404	372	366	378	357	338	372	320	283	344
Italy .....	23	25	36	28	45	41	28	54	43	29	57
Netherlands .....	16	14	15	13	17	15	13	18	17	14	20
Other Europe .....	233	238	249	233	274	261	230	300	276	232	331
Other OECD .....	111	112	120	109	124	124	113	137	128	112	143
<b>Total</b> .....	2,119	2,015	2,094	2,069	2,125	2,150	2,106	2,202	2,285	2,202	2,387
OPEC .....	11	11	13	9	16	14	9	17	18	12	23
Other Developing Countries ...	557	575	585	559	615	646	573	731	744	628	870
<b>Total Market Economies</b> .....	2,687	2,601	2,692	2,656	2,735	2,810	2,725	2,910	3,047	2,904	3,209
<b>Centrally Planned Economies<sup>b</sup></b>											
China .....	1,144	1,192	1,441	1,398	1,484	1,685	1,596	1,776	2,113	1,927	2,305
Former Soviet Union .....	744	725	720	683	756	723	686	760	741	697	786
Other .....	601	585	586	584	592	580	577	587	578	573	591
<b>Total</b> .....	2,490	2,501	2,746	2,690	2,803	2,988	2,892	3,087	3,432	3,241	3,630
<b>World Total</b> .....	5,177	5,102	5,439	5,372	5,510	5,798	5,670	5,939	6,479	6,241	6,735

<sup>a</sup>Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

<sup>b</sup>Includes former, evolving, and current Centrally Planned Economies.

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

Notes: High and low range values for Europe and the four regional totals are not equal to the sum of the component countries or country groups but consist of the base value adjusted by the quantity: the square root of the sum of the squared deviations of the respective component countries or country groups from their base value. Other totals may not equal sum of the components because of independent rounding.

Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Tables 10 and 13. **Projections:** Energy Information Administration, *Annual Energy Outlook 1993*, DOE/EIA-0383(93), Tables A10, B10, C10, and G10; and World Energy Projection System Spreadsheet, 1993.

The United States exported about 109 million short tons of coal in 1991—an amount that is expected to more than double by 2010. [1, p. 62 and 4, p. 89] U.S. coal exports should grow as coal production in Europe declines and trade barriers fall, and as the ability of other coal producers to expand exports is reached—after 2000. Coal exports should consist primarily of steam coal, with the electric power sector providing by far the greatest growth in coal demand through 2010.

The electricity sector is also expected to account for most of the growth in coal consumption in the United States. The only other increase expected in consumption would be for steam coal for industrial cogeneration. Beyond 2005, coal-fired plants are expected to supplant gas-fired combined cycle and turbine power plants as the technology of choice for new generating capacity. Factors causing the shift include rising natural gas prices, greater need for baseload generating capacity, and advances in coal-burning technologies, such as integrated gasification combined-cycle and fluidized-bed combustors. Also affecting coal activity in the United States over the projection period will be the sulfur dioxide emission restrictions of the Clean Air Act Amendments of 1990, which will cause a shift in production from medium- and high-sulfur coal to low-sulfur coal in the amount of 110 million tons by 2010. [1, p. 65]

The outlook for coal in the CPEs is mixed. Coal consumption in China grows at a rapid 3.1 percent per year between 1990 and 2010, while coal consumption in the FSU and in Eastern Europe remains virtually unchanged. As elsewhere, much of the growth in Chinese coal consumption should come from the electricity sector. Unlike other areas, coal will also be important in the Chinese household sector, replacing traditional rural fuels. Constraints to growth in coal consumption are China's transportation and distribution networks, particularly because coal reserves are not located near the main load centers. Similarly, in Eastern Europe and the FSU, coal-burning facilities are located near declining production areas. Increased coal consumption in these areas would require improvements in the location of industry and in the transportation infrastructure.

Environmental considerations will influence coal consumption patterns in the United States and in the world. Concern over acid rain and possible climate change could stimulate various responses around the world, including efforts to improve coal-burning technology, conservation, and the enactment of measures to reduce carbon emissions. Prospects for the production of coal liquefaction and for other synthetic

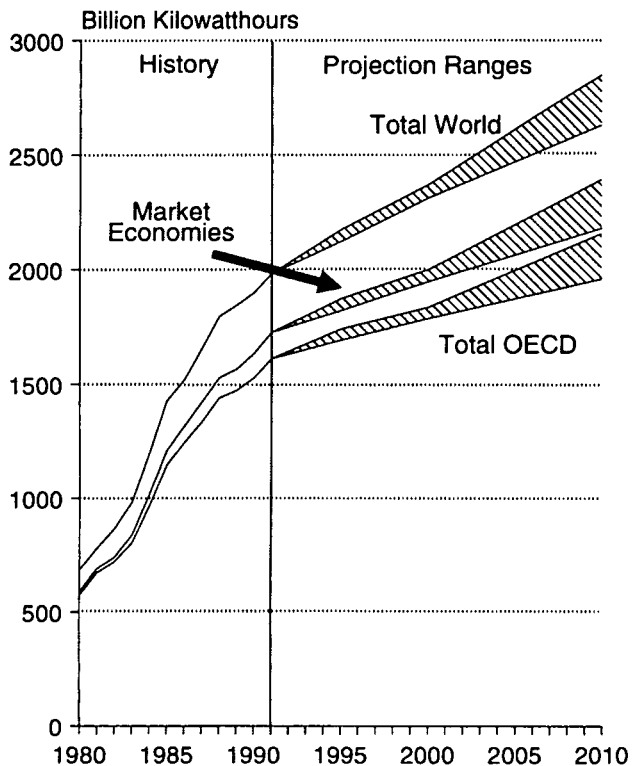
fuels will depend on their competitiveness with conventional fuels, particularly oil. World oil prices, as projected in this report, suggest a limited role for coal liquids through 2010.

## Nuclear and Other Energy Sources

The consumption of nuclear power grows at an annual rate of about 1.9 percent per year between 1990 and 2010 and maintains its relative share of total energy consumed at about 6 percent during the projection period (Figure 15). The United States is the largest consumer of nuclear power (which accounts for about 20 percent of total U.S. electric power production) and should continue to hold this position through 2010 (Table 12). [1, p. 86] A major issue facing the U.S. nuclear industry concerns the need to establish a permanent repository for spent nuclear fuel. Other issues, addressed recently by the Energy Policy Act of 1992, concern the standardization of nuclear reactor design and the combination of construction and operating licensing—the latter of which will help reduce the substantial financial risks associated with the construction of nuclear plants and the leadtime needed to bring reactors on line. In 1991, the United States, France, Japan, Germany, and the FSU accounted for more than 70 percent of the world's total nuclear-generated electricity production. Belgium, France, and Sweden produced more than 50 percent of their electricity from nuclear power. Hungary and South Korea produced slightly less than 50 percent of their electricity with nuclear power. [6, p. 19]

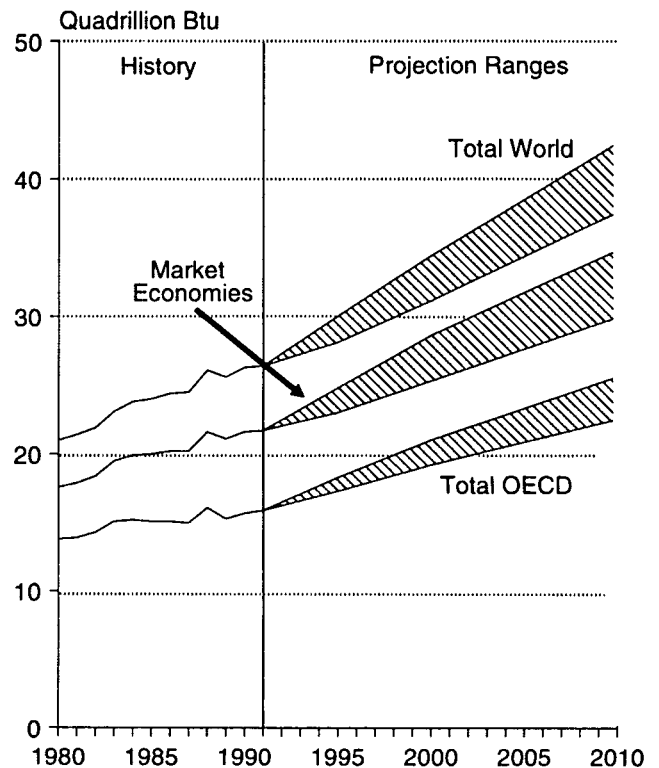
The consumption of nuclear power grows fastest in Japan during the projection period, averaging 4.3 percent per year between 1990 and 2010. Consumption grows at a rate of 3.9 percent per year in the other developing-countries group and 2.7 percent in the CPEs. Growth in nuclear consumption could be hindered by moratoriums, referendums, and public opinion in several countries, including the Netherlands, Spain, Sweden, Switzerland, and Yugoslavia. In contrast, France, the FSU, Japan, and other countries in the Far East plan major expansions in nuclear capacity between now and 2010. [6, p. 25] Early in 1993, the Russian government approved a program of nuclear power plant construction. This action ends the moratorium put in place after the 1986 Chernobyl accident. Concern over the safety of existing reactors in the FSU may, however, affect the acceptance and development of new reactors. Many existing units operate well below international safety standards, lack containment structures, and have inadequate emergency and fire protection systems.

**Figure 15. World Nuclear Energy Consumption, 1980-2010**



Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Table 12 and other selected issues. **Projections:** Table 12.

**Figure 16. World Hydropower and Geothermal Energy Consumption, 1980-2010**



Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Table A13 and other selected issues. **Projections:** Table 13.

Consumption of other energy sources, primarily hydropower and geothermal, grows at an annual rate of 2.1 percent per year between 1990 and 2010. These sources accounted for 7.6 percent of total energy consumption in 1990 and account for 8.4 percent of the total in 2010 (Figure 16). Both Canada and the United States are major consumers of hydropower (Table 13). In 1991, installed hydroelectric capacity was 90.9 million kilowatts in the United States and 59.4 million kilowatts in Canada. Capacity in the FSU and Brazil was 64.1 and 45.6 million kilowatts, respectively. Geothermal installed capacity accounts for less than 0.5 percent of the world's total electric installed capacity. [2, p. 93]

The potential for hydroelectric power is greatest in the developing-countries group and in China, which has the greatest potential. Development of small-scale local

power stations would play a major role in providing electricity to rural areas, but a number of very large- and medium-scale projects are anticipated as well. China is expected to rely on electricity to spur general economic development and to improve the quality of life in its vast rural areas. [7, pp. 115-116]

The fact that much of the unrealized potential among the developing countries is in remote areas that will be more difficult and expensive to develop is constraining future development. Many countries will also face financial constraints. Concern is also growing over the potential environmental impact associated with this energy source, especially from the larger projects. Problems associated with hydro development include the flooding of agricultural lands, dislocation of villages, and the potential degradation of surrounding lands and river deltas. [7, pp. 81-166]

**Table 12. World Net Nuclear Energy Consumption**  
(Billion Kilowatthours)

Region/Country	Projection Ranges										
	History		1995			2000			2010		
	1990	1991	Base	Low	High	Base	Low	High	Base	Low	High
<b>Market Economies</b>											
<b>OECD</b>											
United States <sup>a</sup> . . . . .	577	613	628	628	628	633	632	636	636	636	647
Canada . . . . .	69	82	97	94	100	105	101	110	130	108	152
Japan . . . . .	182	196	256	218	263	275	253	297	419	304	429
Europe . . . . .	692	721	749	741	756	796	787	805	907	843	970
United Kingdom . . . . .	63	71	71	70	71	64	62	66	54	50	59
France . . . . .	261	278	304	297	311	338	330	345	400	375	424
Germany . . . . .	147	142	141	139	143	151	149	154	181	153	210
Italy . . . . .	12	12	14	13	14	15	15	15	19	17	19
Netherlands . . . . .	6	6	7	7	7	7	7	7	10	4	10
Other Europe . . . . .	203	211	212	210	214	221	217	225	242	192	293
Other OECD . . . . .	0	0	0	0	0	0	0	0	0	0	0
<b>Total</b> . . . . .	<b>1,520</b>	<b>1,611</b>	<b>1,729</b>	<b>1,691</b>	<b>1,740</b>	<b>1,809</b>	<b>1,785</b>	<b>1,834</b>	<b>2,091</b>	<b>1,958</b>	<b>2,160</b>
OPEC . . . . .	0	0	0	0	0	0	0	0	0	0	0
Other Developing Countries . . . . .	107	115	130	123	136	163	154	172	229	194	264
<b>Total Market Economies</b> . . . . .	<b>1,628</b>	<b>1,725</b>	<b>1,859</b>	<b>1,820</b>	<b>1,872</b>	<b>1,972</b>	<b>1,946</b>	<b>1,999</b>	<b>2,320</b>	<b>2,182</b>	<b>2,397</b>
<b>Centrally Planned Economies<sup>b</sup></b>											
China . . . . .	0	0	12	7	12	18	16	20	25	24	25
Former Soviet Union . . . . .	197	188	217	215	219	261	250	272	298	275	320
Other . . . . .	69	68	74	72	77	91	87	96	126	116	136
<b>Total</b> . . . . .	<b>266</b>	<b>256</b>	<b>304</b>	<b>298</b>	<b>307</b>	<b>370</b>	<b>359</b>	<b>382</b>	<b>449</b>	<b>424</b>	<b>473</b>
<b>World Total</b> . . . . .	<b>1,894</b>	<b>1,982</b>	<b>2,163</b>	<b>2,124</b>	<b>2,176</b>	<b>2,343</b>	<b>2,314</b>	<b>2,372</b>	<b>2,769</b>	<b>2,629</b>	<b>2,850</b>

<sup>a</sup>Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

<sup>b</sup>Includes former, evolving, and current Centrally Planned Economies.

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

Note: Totals may not equal sum of components because of independent rounding.

Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Tables 12 and 13. **Projections:** Energy Information Administration, *Annual Energy Outlook 1993*, DOE/EIA-0383(93), Tables A4, B4, and C4; and World Energy Projection System Spreadsheet, 1993.

**Table 13. World Hydropower and Geothermal Energy Consumption**  
(Quadrillion Btu)

Region/Country	Projection Ranges										
	History		1995			2000			2010		
	1990	1991	Base	Low	High	Base	Low	High	Base	Low	High
<b>Market Economies</b>											
<b>OECD</b>											
United States <sup>a</sup> . . . . .	6.5	6.8	7.7	7.5	7.8	8.9	8.7	9.1	10.7	10.4	11.0
Canada . . . . .	3.0	3.0	3.4	3.2	3.7	4.1	3.7	4.8	5.4	4.4	6.4
Japan . . . . .	1.0	1.0	1.2	1.0	1.5	1.3	0.8	1.9	1.5	0.6	2.5
Europe . . . . .	4.7	4.7	4.9	4.7	5.2	5.1	4.8	5.5	5.7	5.2	6.3
United Kingdom . . . . .	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2
France . . . . .	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7
Germany . . . . .	0.4	0.4	0.4	0.3	0.4	0.4	0.3	0.4	0.4	0.3	0.4
Italy . . . . .	0.5	0.6	0.7	0.6	0.8	0.7	0.6	0.8	0.8	0.6	1.0
Netherlands . . . . .	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.2	0.1	0.3
Other Europe . . . . .	3.2	3.1	3.2	3.0	3.4	3.3	3.0	3.6	3.4	3.0	4.0
Other OECD . . . . .	0.4	0.4	0.5	0.4	0.5	0.6	0.5	0.7	0.7	0.4	0.9
<b>Total</b> . . . . .	15.7	15.9	17.7	17.3	18.3	19.9	19.2	21.0	23.9	22.5	25.6
OPEC . . . . .	0.6	0.7	0.7	0.5	0.8	0.8	0.6	1.0	1.1	0.7	1.5
Other Developing Countries . . . . .	5.2	5.2	5.4	4.7	6.3	6.1	4.8	7.5	7.2	5.5	9.1
<b>Total Market Economies</b> . . . . .	21.6	21.7	23.8	23.0	24.8	26.8	25.3	28.6	32.3	29.9	34.8
<b>Centrally Planned Economies<sup>b</sup></b>											
China . . . . .	1.3	1.4	1.9	1.8	2.0	2.5	2.3	2.8	4.4	3.8	5.1
Former Soviet Union . . . . .	2.3	2.2	2.2	2.1	2.4	2.2	2.1	2.4	2.3	2.2	2.5
Other . . . . .	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	0.9	1.1
<b>Total</b> . . . . .	4.7	4.6	5.1	4.9	5.3	5.8	5.5	6.1	7.7	7.1	8.4
<b>World Total</b> . . . . .	26.3	26.4	29.0	28.1	30.0	32.6	31.1	34.4	40.0	37.6	42.6

<sup>a</sup>Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

<sup>b</sup>Includes former, evolving, and current Centrally Planned Economies.

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

Notes: U.S. amounts also include energy from solar, wind, and biofuels. High and low range values for Europe and the four regional totals are not equal to the sum of the component countries or country groups but consist of the base value adjusted by the quantity: the square root of the sum of the squared deviations of the respective component countries or country groups from their base value. Other totals may not equal sum of components because of independent rounding.

Sources: **History:** Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Tables A13 and database related to Table 30. **Projections:** Energy Information Administration, *Annual Energy Outlook 1993*, DOE/EIA-0383(93), Tables A1, B1, and C1 and related Forecasting System runs for U.S. renewables; and World Energy Projection System Spreadsheet, 1993.

## Environmental Considerations

The environmental implications of energy use continue to be cited as a major public policy concern. In the energy sector, the environmental impact of energy use ranges from altering a city's smog pattern to more regional or even global implications such as acid rain and the "greenhouse effect." The greatest attention continues to be directed towards this latter phenomenon, also popularly referred to as global warming. The International Energy Agency in Paris lists the following as major areas of energy related environmental concerns [7, p. 165]:

- Major environmental accidents;
- Water and maritime pollution;
- Land use and siting impact;
- Radiation and radioactivity;
- Solid waste disposal;
- Hazardous air pollutants;
- Ambient air quality;
- Acid deposition;
- Stratospheric ozone depletion; and
- Global climate change.

Total world carbon emissions from the burning of fossil fuels were approximately 6 billion metric tons in 1990, of which 44 percent were from the consumption of oil, 39 percent from coal, and 17 percent from relatively

clean-burning natural gas (Figure 17). Assuming no change in current regulations, carbon emissions are anticipated to grow to more than 8 billion metric tons in 2010, with 42 percent from oil, 38 percent from coal, and 20 percent from natural gas (Table 14). Most of this increase in carbon emissions is expected to come from the developing countries and the CPEs, particularly China (Figure 18).

International efforts to address energy-related and other environmental issues are in the early stages. A recent and important effort was the United Nations Conference on Environment and Development (UNCED) held June 3-14, 1992 in Rio de Janeiro and attended by 172 nations. Five agreements, with both binding and voluntary aspects, were reached at the Rio Conference. The Climactic Change Convention aims to stabilize toxic emissions in the earth's atmosphere at 1990 levels by the year 2000 in order to counteract potential greenhouse effects and subsequent global warming. The Twenty-First Century Agenda (Agenda 21) is a detailed 900-page action program that outlines specific directions concerning energy, recycling, and other activities that impact the environment. Two agreements concern Biodiversity and Forest Preservation. The final agreement, the Rio Declaration, emphasizes the need to prevent ecological destruction while at the same time insuring sustainable economic growth in developing countries. Although all agreements were not signed by all participants, the Conference did recommend that a United Nations Commission on Sustainable Development be established in order to carry on the work started in Rio.



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10. The WEFA Group, *Planned Economies in Transition: Outlook for Foreign Trade and Finance* (Bala Cynwyd, PA, January 1993).
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**Appendix**

**Analytical Methods**

# Analytical Methods

This appendix briefly describes the methods and sources used to construct the Index of Oil Vulnerability presented in Figure 7 of this *International Energy Outlook 1993 (IEO93)*, the Energy Intensity measures presented in Figure 10 of the *IEO93*, and the uncertainty ranges presented in several figures and tables of the *IEO93*. Additional sources of information about this index and the *IEO93* uncertainty ranges are also provided. Vulnerability Index values are shown in Table A1. Energy Intensity values are shown in Table A2.

## Index of Oil Vulnerability

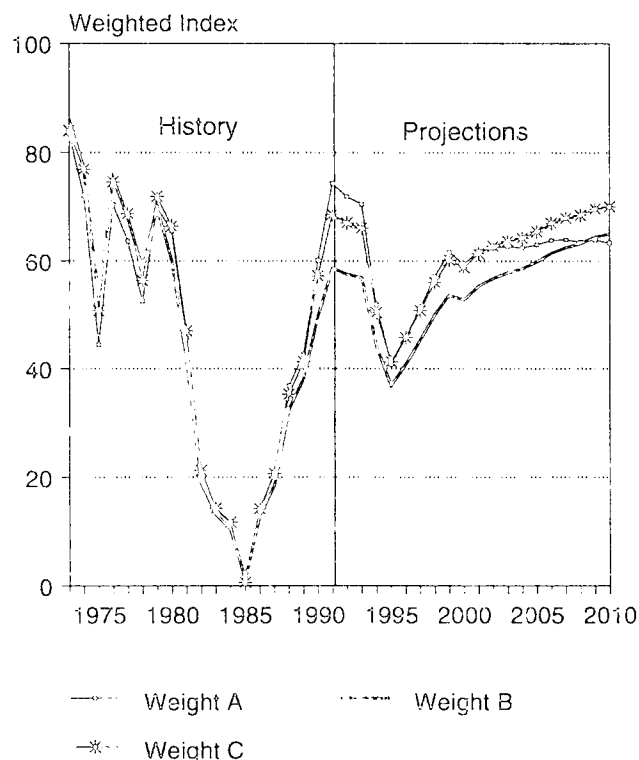
The Index of Oil Vulnerability consists of a weighted average of the indexed values of three variables. These are: (1) the percent of Market Economy consumption coming from the Persian Gulf, (2) the level of excess crude oil production capacity available in any given year, and (3) the level of petroleum stocks in the Market Economies. Each variable is indexed such that the highest value (greatest vulnerability) in that series equals 100 and the lowest value equals zero. The indexed values are then weighted to illustrate the index as shown in Figure 7 of the *IEO93*. Because the weights are judgmental, alternate weighting schemes are examined in this appendix.

Figure A1 shows the results of using alternate weighting schemes. The weights used are as follows:

	Series		
	A	B	C
<b>Excess Capacity</b> .....	70	50	60
<b>Persian Gulf Share</b> .....	15	30	30
<b>Stocks</b> .....	15	20	10

As can be seen in Figure A1, the basic pattern of the index does not vary significantly as different weighting schemes are used because the underlying series tend to move in the same direction over time. The values for Series B are presented in Figure 7 of the *IEO93*.

**Figure A1. Vulnerability Index**



Sources: **History:** Energy Information Administration, *Annual Energy Review 1991*, DOE/EIA-0384(91), Tables 118, 123, and 124; *International Petroleum Statistics Report*, DOE/EIA-0520(93/01), Table 4.3; and capacity estimates from the Energy Markets and Contingency Information Division. **Projections:** Table A1.

## Uncertainty Ranges

Uncertainty, an inevitable aspect of the projection process, is frequently conveyed through a set of scenarios or cases. Seven different scenarios are presented in the *Annual Energy Outlook 1993*: Reference, High Economic Growth, Low Economic Growth, High Oil Price, Low Oil Price, High Oil and Gas Recovery, and Low Oil and Gas Recovery. The scenario name indicates the change in assumption made from the Reference assumptions, and the scenario values reflect

**Table A1. Vulnerability Index, 1973-2010**  
(Weighted Index)

Year	Weight A	Weight B	Weight C
1973	83.5	86.2	84.0
1974	72.1	77.2	76.9
1975	44.4	53.3	50.7
1976	70.5	75.4	74.6
1977	63.7	68.1	68.8
1978	52.5	58.7	56.4
1979	70.0	69.8	72.0
1980	65.5	60.2	66.5
1981	45.7	41.6	47.0
1982	20.1	18.9	21.2
1983	13.9	13.2	14.3
1984	11.7	10.4	11.7
1985	0.9	1.2	0.6
1986	13.7	12.9	14.2
1987	21.0	18.4	20.7
1988	36.9	32.4	35.3
1989	42.6	38.1	41.3
1990	60.1	49.7	57.2
1991	74.4	58.7	68.6
1992	71.9	57.5	67.1
1993	70.6	56.9	66.1
1994	51.9	44.2	50.4
1995	40.8	36.8	41.3
1996	45.7	40.8	45.8
1997	51.3	45.3	50.7
1998	57.1	50.0	56.0
1999	61.6	53.7	60.2
2000	59.5	52.7	58.8
2001	61.8	55.3	61.4
2002	62.5	56.7	62.8
2003	62.7	57.8	63.7
2004	62.4	58.5	64.2
2005	63.0	59.8	65.5
2006	63.9	61.4	67.0
2007	63.9	62.5	68.0
2008	63.5	63.2	68.5
2009	63.9	64.5	70.0
2010	63.3	65.1	70.1

Sources: **History:** Energy Information Administration, *Annual Energy Review 1991*, DOE/EIA-0384(91), Tables 118, 123, and 124; *International Petroleum Statistics Report*, DOE/EIA-0520(93/01), Table 4.3; and the Energy Markets and Contingency Information Division for capacity estimates. **Projections:** Energy Information Administration, Oil Market Simulation Model and assumptions about Persian Gulf production and about planned additions to strategic stocks.

**Table A2. Energy Intensity: Total Energy Consumption per Dollar of Real Gross Domestic Product, 1980-2010**  
(Thousand Btu per 1985 Dollar)

Year	North America	Total CPE	All Other OECD	Total World
1980	22.9	37.7	18.9	23.4
1981	21.9	37.4	18.1	22.8
1982	21.6	37.9	17.4	22.7
1983	20.8	37.2	17.0	22.3
1984	20.4	37.7	16.8	22.4
1985	19.8	38.4	16.9	22.4
1986	19.3	38.4	16.8	22.3
1987	19.2	38.8	16.5	22.2
1988	19.5	38.0	16.2	22.1
1989	19.2	38.2	15.7	21.9
1990	19.0	37.6	15.5	21.7
1991	19.4	41.0	15.6	22.2
1995	18.7	41.2	15.2	21.3
2000	17.9	39.6	13.9	20.0
2005	17.1	37.8	12.6	18.6
2010	16.3	35.6	11.4	17.3

OECD = Organization for Economic Cooperation and Development.

Note: CPE includes former, evolving, and current Centrally Planned Economies. North America consists of the OECD members Canada and the United States.

Sources: **History:** Wharton Econometric Forecasting Associates, *World Economic Services and World Economic Service Historical Data* (June 1992); and Energy Information Administration, *International Energy Annual 1991*, DOE/EIA-0219(91), Tables A9 and A15. **Projections:** Derived from Wharton Econometric Forecasting Associates, *World Economic Outlook* (February and October 1992); Energy Information Administration, *Annual Energy Outlook 1993*, DOE/EIA-0308(93), Tables A1 and A7 and related Forecasting System runs for U.S. renewables; and World Energy Projection System Spreadsheet 1993.

this changed assumption. In *IEO93*, uncertainty is conveyed by a set of ranges surrounding a base case, rather than by a unique set of scenarios. For example, the high range for total energy consumption for each country or country group and for each projected year is determined by: (1) assuming higher rates of economic growth (0.5 percentage points above base-case rates), calculating the resulting differences in consumption from the base-case levels, and squaring these differences; (2) assuming a higher ratio of total energy consumed per dollar of gross domestic product (10 percent higher than base-case ratios), calculating resulting differences from base-case levels, and squaring these differences; (3) adding the squared differences from the first two steps and then taking the square root of that sum; and (4) adding the results from step 3 to

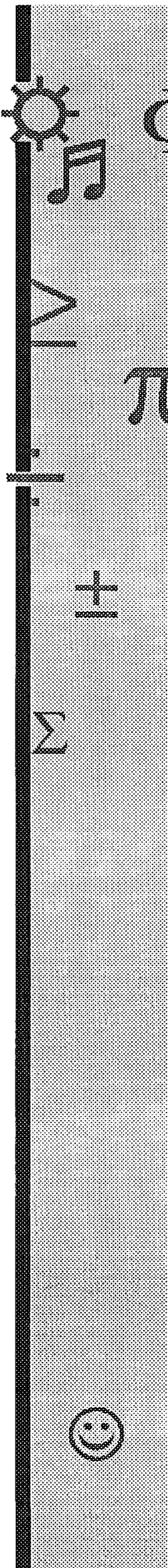
the base-case amounts. The result is a range value with a difference from base-case consumption that is greater than either of the two differences derived by changing a single assumption, but less than the difference had the two changed assumptions been considered simultaneously. The low range for total energy consumption is determined the same way, using minus 0.5 percentage points and minus 10 percent in the calculations.

The implied assumption underlying this approach is that it is less likely that the extreme of all possible specified events will occur simultaneously than it is that some set of events between the specified base-case and the extreme-case levels will occur. The ranges derived by this approach do not represent confidence intervals

or probability levels around the base-case projections. When considered appropriate, the high and low range values for regional totals are also determined using this approach, again under the assumption that individual country experiences will likely vary from the extremes.

To maintain consistency with projections presented in the *Annual Energy Outlook 1993*, range values for the United States are not derived using the approach described above. Rather, they are selected directly from the seven scenarios mentioned previously.

Determinations of range values for world oil prices and for consumption of specific energy sources also vary somewhat from the example presented here, primarily in terms of the number of assumptions altered. A detailed discussion of the determination of ranges is presented in *World Energy Projection System Model Documentation Report*. The base-case projections and associated ranges presented here can be replicated using archived personal computer diskettes entitled "World Energy Projection System Spreadsheet, 1993," available from EIA's National Energy Information Center (202/586-8800).



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