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International Energy Outlook

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Preface

This International Energy Outlook presents historical data from 1970 to 1993 and EIA's projections of energy consumption and carbon emissions through 2015 for six country groups. Prospects for individual fuels are discussed.

The *International Energy Outlook 1996 (IEO96)* presents an assessment by the Energy Information Administration (EIA) of the outlook for international energy markets through 2015. The report is an extension of the EIA's *Annual Energy Outlook 1996* (*AEO96*), which was prepared using the National Energy Modeling System (NEMS). U.S. projections appearing in the *IEO96* are consistent with those published in the *AEO96*. *IEO96* is provided as a statistical service to energy managers and analysts, both in government and in the private sector. The projections are used by international agencies, Federal and State governments, trade associations, and other planners and decisionmakers. They are published pursuant to the Department of Energy Organization Act of 1977 (Public Law 95-91), Section 205(c). The *IEO96* projections are based on U.S. and foreign government policies in effect on October 1, 1995.

Projections in *IEO96* are displayed according to six basic country groupings (Figure 1). In addition, the Organization for Economic Cooperation and Development (OECD) includes projections for four individual countries—the United States, Canada, Mexico, and Japan—along with the subgroups OECD Europe and Other OECD (defined as Australia, New Zealand, and the U.S. Territories). The non-OECD countries are represented by five separate regional subgroups: Eastern Europe and the former Soviet Union (EE/FSU), non-OECD Asia, Africa, Middle East, and Central and South America. China and India are represented in non-OECD Asia. The detailed projections for India are new to this year's report.

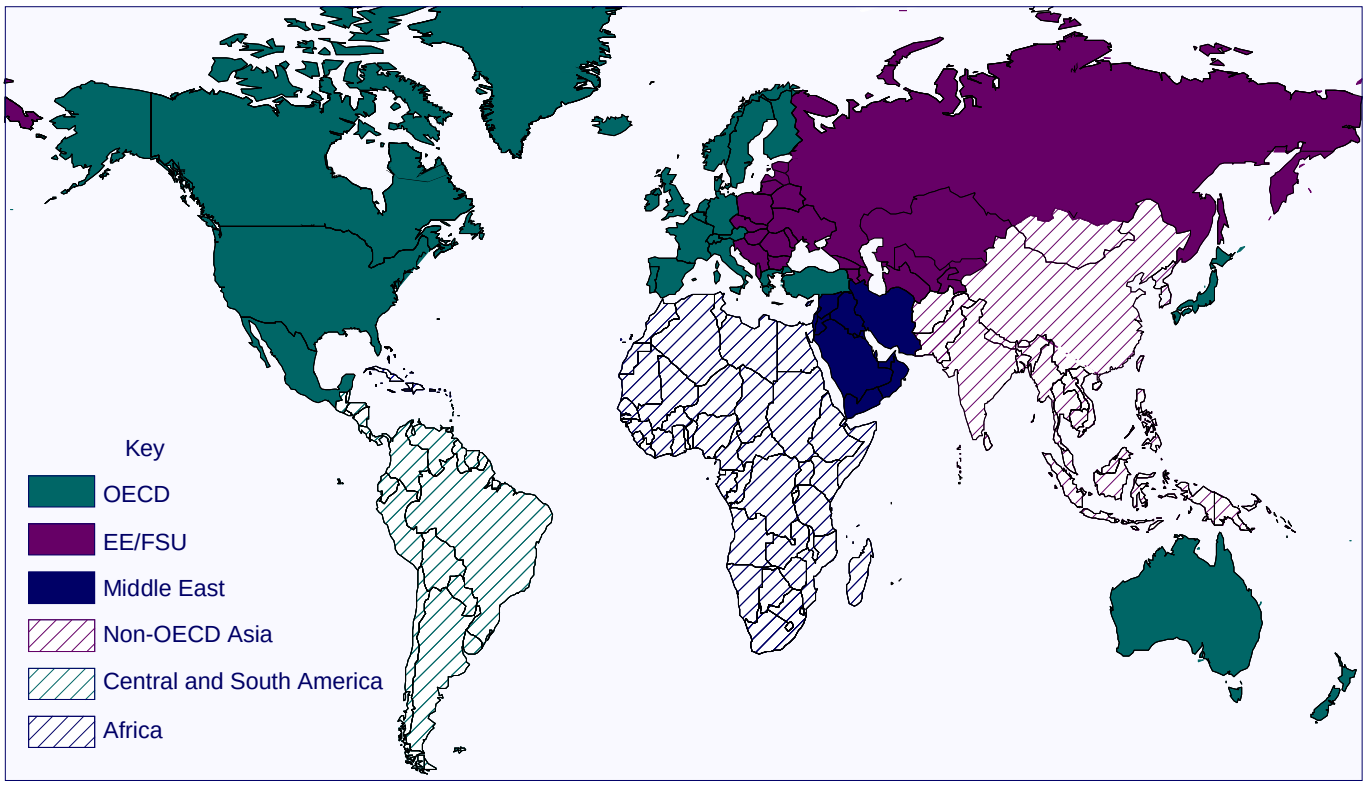
The report begins with a review of world trends in energy demand. The historical time frame begins with data from 1970, and—for the first time—*IEO96* projections extend to 2015. This provides readers with a 23-year historical view of energy demand and a 22-year forecast. New to this year's report is a set of scenarios developed for use in depicting a set of alternative growth paths. The scenarios consider alternative growth paths of regional gross domestic product (GDP). The resulting projections and the uncertainty associated with making international energy projections in general are discussed in the first chapter of the report. The status of environmental issues, including global carbon emissions, is reviewed. Comparisons of the *IEO96* projections with other available international energy forecasts are included in the first chapter.

The next part of the report is organized by energy source. Regional consumption projections for oil, natural gas, coal, nuclear power, and renewable energy (hydroelectricity, geothermal, wind, solar, and other renewables) are presented in the five fuel chapters, along with a review of the current status of each fuel on a worldwide basis.

The last part of the report contains a discussion of energy consumed by electricity producers. The electricity demand model used for previous international energy forecasts has been replaced by a module that fits electricity consumption to logistic curves on a regional basis.

Summary tables of the *IEO96* world energy consumption, oil production, and carbon emissions projections are provided in Appendix A. The reference case projections of total foreign energy consumption and of natural gas, coal, and renewable energy were prepared using EIA's World Energy Projection System (WEPS) model. Reference case projections of foreign oil production and consumption were prepared using the International Energy Module of the National Energy Modeling System (NEMS). Nuclear *consumption* projections were derived from the International Nuclear Model, PC Version (PC-INM). Alternatively, nuclear *capacity* projections were developed using two methods: the lower reference case projections were based on analysts' knowledge of the nuclear programs in different countries; the upper reference case was generated by the World Integrated Nuclear Evaluation System (WINES)—a demand-driven model. In addition, the NEMS Coal Export Submodule (CES) was used to derive flows in international coal trade. As noted above, foreign projections of electricity demand are now projected as part of the WEPS.

Figure 1. Map of the Six Basic Country Groupings



Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

The six basic country groupings used in this report (Figure 1) are defined as follows:

- **Organization for Economic Cooperation and Development (OECD):** Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. (The OECD countries contain 18 percent of the 1995 world population.) Note: Although not reflected in the projections, the Czech Republic joined the OECD on December 21, 1995.

- **Eastern Europe and the former Soviet Union (EE/FSU)** (7 percent of the 1995 world population):
  - **Eastern Europe:** Albania, Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, and former 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.

- **Non-OECD Asia** (53 percent of the 1995 world population): Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia (Kampuchea), China, Fiji, French Polynesia, Hong Kong, India, Indonesia, Kiribatia, Laos, Malaysia, Macau, Maldives, Mongolia, Myanmar (Burma), Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Philippines, Singapore, Solomon Islands, South Korea, Sri Lanka, Taiwan, Thailand, Tonga, Vanuatu, Vietnam, and Western Samoa.

- **Middle East** (3 percent of the 1995 world population): Bahrain, Cyprus, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, the United Arab Emirates, and Yemen.

- **Africa** (12 percent of the 1995 world population): Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Djibouti, Egypt, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra

Leone, Somalia, South Africa, St. Helena, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Western Sahara, Zaire, Zambia, and Zimbabwe.

- **Central and South America** (7 percent of the 1995 world population): Antarctic Fisheries, Antigua and Barbuda, Argentina, Aruba, Bahama Islands, Barbados, Belize, Bolivia, Brazil, British Virgin Islands, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Falkland Islands, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Montserrat, Netherlands Antilles, Nicaragua, Panama Republic, Paraguay, Peru, St. Kitts-Nevis, St. Lucia, St. Vincent/Grenadines, Suriname, Trinidad and Tobago, Uruguay, and Venezuela.

In addition, the following commonly used country groupings are referenced in this report:

- **G-7 Countries:** United States, Japan, Canada, United Kingdom, France, Germany, and Italy.
- **Organization of Petroleum Exporting Countries (OPEC):** Algeria, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.
- **Pacific Rim Developing Countries:** Hong Kong, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.
- **Persian Gulf:** Bahrain, Iran, Iraq, Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates.

The projections in *IEO96* are not statements of what will happen, but what might happen given the specific assumptions and methodologies used. These projections provide an objective, policy-neutral reference case that can be used to analyze international energy markets. As a policy-neutral data and analysis organization, EIA does not propose, advocate, or speculate on future legislative and regulatory changes. The projections are based on current U.S. and foreign government policies. Assuming current policies, even knowing that changes will occur, will naturally result in projections that differ from the final data.

Models are abstractions of energy production and consumption activities, regulatory activities, and producer and consumer behavior. The forecasts are highly dependent on the data, analytical methodologies, model structures, and specific assumptions used in their development. Trends depicted in the analysis are indicative of tendencies in the real world rather than representations of specific real-world outcomes. Even where trends are stable and well understood, the projections are subject to uncertainty. Many events that shape energy markets are random and cannot be anticipated, and assumptions concerning future technology characteristics, demographics, and resource availability cannot be known with any degree of certainty.

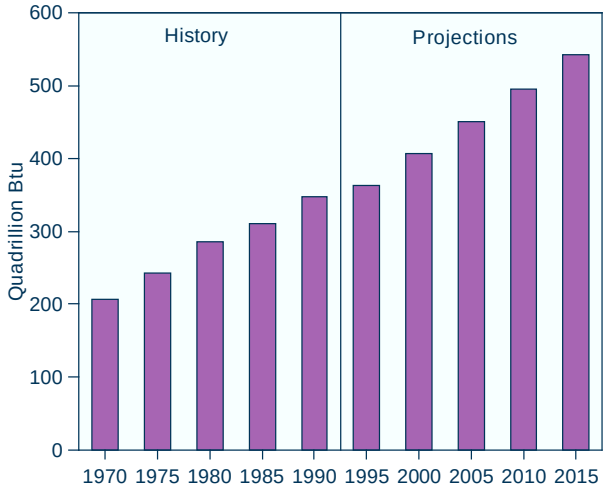
Highlights

The outlook for world energy demand is higher than projected in previous years, as developing nations grow rapidly and use more energy. Energy supplies are expected to be plentiful, at stable prices.

Strong economic growth is expected to substantially boost world energy demand over the next two decades. By 2015 world energy consumption increases to 542 quadrillion British thermal units (Btu), 1.6 times the current level (Figure 2). New discoveries of oil and natural gas reserves, technological developments that allow more energy sources to be recovered, and increased efficiency of generating plants will make it possible to obtain enough energy to accommodate great increases in energy demand.

Energy demand projections in this report have been increased relative to last year's. In this year's forecast for 2010, world energy demand is projected to reach 495 quadrillion Btu, 23 quadrillion Btu more than last year's projection for 2010. Higher standards of living in emerging economies are propelling increased use of energy for electric power generation and for personal automobile transportation. Gains in demand are offset, in some measure, by improving efficiency in the industrial sector of developing countries; however, the rate of such improvement is uncertain and has been scaled back for this projection.

Figure 2. World Energy Consumption, 1970-2015

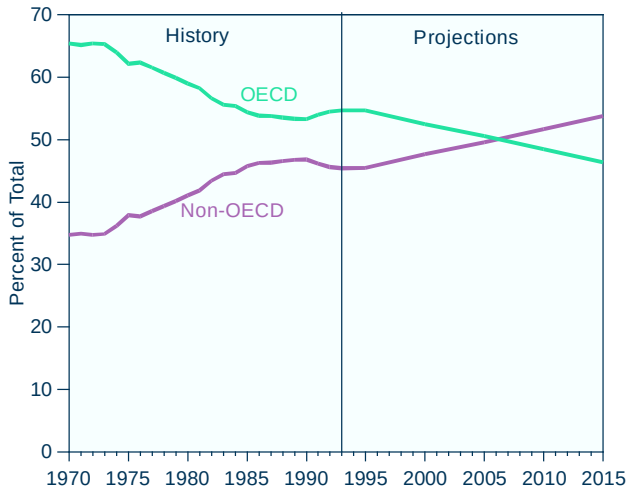


Sources: **History:** 1970-1975: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1990: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

The emerging economies of nations outside the Organization for Economic Cooperation and Development (OECD) account for almost 69 percent of the projected increase in world energy demand over the projection period. The increase is a result of rapid economic development, particularly in non-OECD Asia. By 2015, advanced economies within the OECD account for less than one-half of world energy consumption, whereas in 1970 they consumed 65 percent (Figure 3).

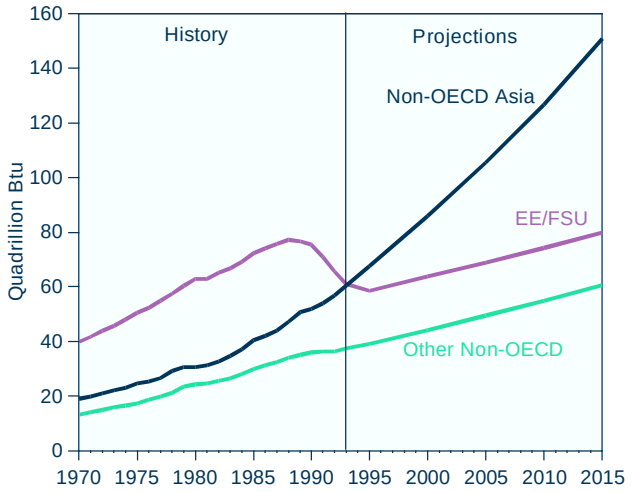
The largest gains in energy use occur in the non-OECD Asia region (Figure 4), where energy demand increases by 150 percent between 1993 and 2015, led by the economies of China and India. In comparison, a 32-percent increase is projected for the OECD. Whereas OECD consumption grows by 1.3 percent annually between 1993 and 2015, non-OECD consumption grows by more than twice that rate, 2.8 percent annually, and non-OECD Asia consumption expands by 4.3 percent annually. While the future rate of penetration of new energy-intensive consumption patterns is difficult to determine, both China and India seem to be capable of

Figure 3. OECD and Non-OECD Energy Consumption, 1970-2015



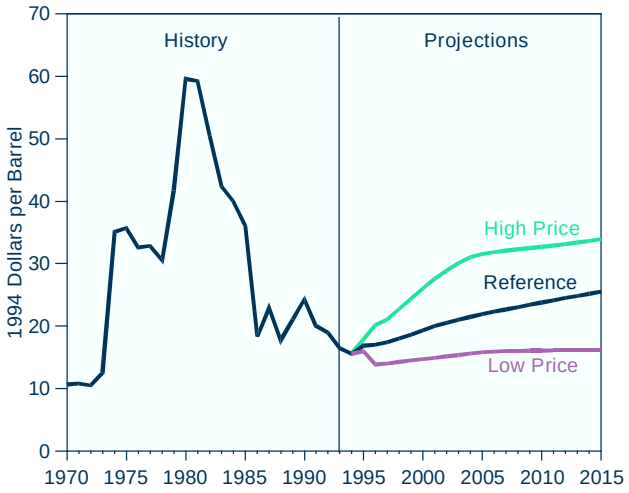
Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 4. Non-OECD Energy Consumption by Region, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 5. World Oil Prices, 1970-2015



Source: Energy Information Administration, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996).

sustaining substantial improvements in economic wealth which will increase personal demand for energy. Both countries have large, energy-intensive industrial sectors, which present many opportunities for energy efficiency improvements, but growth in residential and commercial energy use will probably more than offset any prospective energy savings associated with improved industrial efficiency.

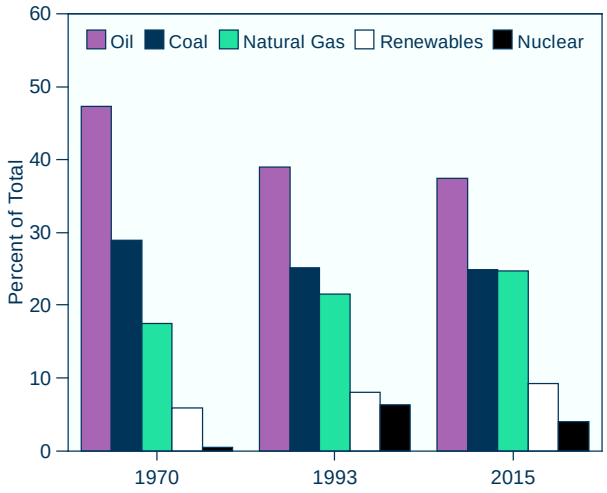
In contrast to the rapid energy growth in non-OECD Asia, little net growth is projected over 1990 levels in the region of Eastern Europe and the former Soviet Union (EE/FSU). In fact, by 2015 the region gains only 4 quadrillion Btu over its 1990 consumption level in the reference case projections. The dramatic economic declines witnessed in the 1990s are projected to stop in the FSU only by 2000. On the other hand, economic recovery has already begun in Eastern Europe. The projections in this report assume that efforts at institutional reform will eventually be successful, and that more normal economic growth and energy consumption will resume by the end of the projection period throughout the EE/FSU region.

Despite one-half growth in total world oil consumption—attributed to rapidly increasing non-OECD demand for transportation, as well as expanded demand for a wide range of industrial, commercial, and residential sector uses—no significant escalation in world oil prices is expected. For the current reference case, oil prices rise from about $16 to $25 between 1995 and 2015 (Figure 5). The oil price projections in this year's report have been scaled back from past years. As recently as 1992, the reference case oil price forecast was around $40 (1994 dollars) per barrel for 2010. Even in an environment that appears to present limited opportunity for improved prices, profit expectations grow. Such optimism is based, in part, on growing demand; but even more important are the prospects for technological advances that will allow for expanded oil production, along with modified government policies (e.g., in terms of taxes, royalties, or profit sharing) that encourage oil production in such areas as South America, the North Sea, Nigeria, Indonesia, and Australia.

The outlook for the international oil market over the next 20 years is one of sufficient sources of supply to meet anticipated growth in demand with only moderately increasing (or potentially stable) world oil prices. New technology and additional discoveries have led to stable or slightly increased levels of production in non-OPEC areas in recent years, which are expected to continue through 2015. It is now generally accepted that the potential for further expansion of non-OPEC oil production is substantial enough to offset declines from old producing areas. Moreover, Persian Gulf nations have sufficient reserves to meet expected increases in oil demand through 2015, although they must contend with a substantial range of potential competition if they are to achieve such growth.

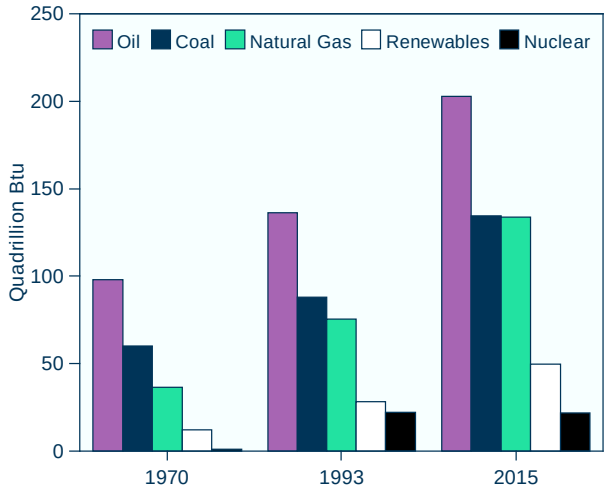
Oil's share of world energy consumption actually drops slightly over the projection period, from 39 percent in 1993 to 37 percent in 2015 (Figure 6). Slow growth is projected for oil demand in the OECD—with increases of less than 1 percent annually between 1993 and 2015—mainly because of the implementation of more

Figure 6. World Energy Consumption Shares by Fuel Type, 1970, 1993, and 2015



Sources: **1970:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. **1993:** EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **2015:** EIA, World Energy Projection System (1996).

Figure 7. World Energy Consumption by Fuel Type, 1970, 1993, and 2015



Sources: **1970:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. **1993:** EIA, *International Energy Annual 1993*, DOE/ EIA-0219(93) (Washington, DC, May 1995). **2015:** EIA, World Energy Projection System (1996).

efficient energy-using technologies and because natural gas is replacing oil for many uses. Conversely, non-OECD oil demand is projected to grow by almost 3 percent annually over the projection period. Strong economic growth, rapidly increasing transportation demand, and an expansion of oil demand for industrial, residential, and commercial uses all contribute to the expectation of strong growth in the demand for oil by non-OECD nations.

Natural gas is projected to gain a larger share of world energy consumption over the projection period, rising from 22 percent in 1993 to almost 25 percent in 2015. The fastest growth in natural gas consumption is projected for OECD Europe and developing countries in non-OECD Asia and Central and South America. Natural gas is an attractive alternative to other fossil fuels for industrialized countries concerned about reducing greenhouse gas emissions. Further, technological developments, particularly in terms of increasing the efficiency of natural-gas-fired electricity generating plants, encourage the penetration of natural gas in the electric utility sector. Natural gas is expected to fuel the vigorous electric power development needed by non-OECD countries to sustain economic growth. In fact, by 2015, world gas use is expected to equal coal consumption (Figure 7).

Coal consumption is projected to increase by almost 2.6 billion short tons over the projection period. Nevertheless, coal's share of world energy consumption remains virtually unchanged between 1993 and 2015 (Figure 6). Increasing concerns about air pollutants released in the combustion of coal, coupled with the growing availability of natural gas in countries of OECD Europe and North America, have slowed the growth of coal use, as has the collapse of the EE/FSU economies. However, coal consumption in the countries of Asia—especially China and India, but also including Japan—is expected to offset those declines. Much of the projected coal growth will be used to fuel electricity generation throughout the world.

Fewer than half of the countries with nuclear power programs are projected to expand capacity over the projection period, and the nuclear share of world energy consumption declines by nearly 2 percent between 1993 and 2015. Growth is expected mainly in developing countries—especially those in non-OECD Asia that are just beginning their nuclear programs (including China, India, South Korea, and Taiwan)—and in Japan. Nuclear energy is seen as necessary to supply much-needed electricity in China, where there are increasing concerns about the adverse environmental impacts resulting from high levels of coal consumption, poor transportation infrastructure that makes it difficult to transport coal resources to areas of need, and limited potential for developing hydroelectric resources.

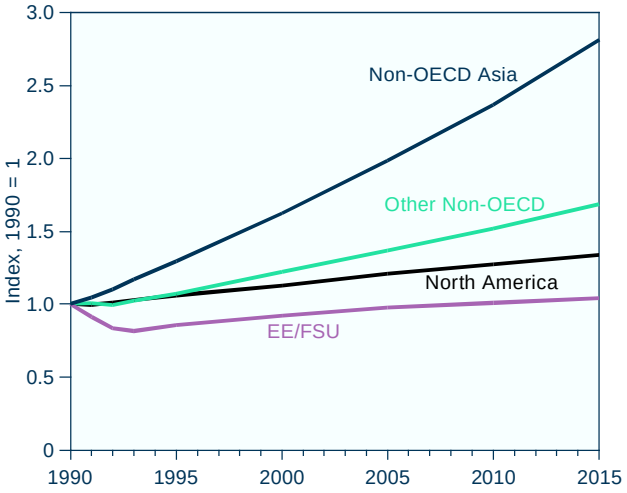
Hydroelectricity and other renewable resources make only small gains in their share of total energy consumption, exceeding current levels by only 1 percent in 2015.

While environmental concerns are expected to create appropriate market conditions for growth in renewable energy demand, competitive fossil fuel prices may hinder the expansion of renewables, especially in the OECD countries. Consumption of renewables grows slightly faster in the non-OECD, as a result of aggressive development of hydroelectric resources in countries of non-OECD Asia (such as Indonesia, Malaysia, and Vietnam).

Electric power is projected to be the fastest-growing source of end-use energy supply worldwide over the next two decades. Growing world dependence on electricity should result in dramatic changes in the electric power industry; many countries are currently working to create more competitive environments for electricity markets in order to promote greater efficiency. The changes affect ownership, regulation, and industrial structure (i.e., unbundling of electricity generation, transmission, and distribution).

Assuming that world energy consumption reaches the levels forecast in the reference case, world carbon emissions are expected to rise by 3.4 billion metric tons between 1993 and 2015. By the end of the forecast period, world carbon emissions are projected to exceed 1990 levels by 54 percent. In 1992, more than 100 countries signed the United Nations Framework Convention on Climate Change to encourage worldwide efforts to achieve stabilization of greenhouse gas concentrations. Industrialized countries within the OECD have pledged to pursue efforts that would stabilize greenhouse gas emissions at their 1990 levels. Indeed, in the forecast, OECD countries substitute natural gas for coal in an effort to stabilize emissions; but petroleum products used in the transportation sector have few substitutes, and petroleum accounts for nearly half the increase in emissions. In the present forecast, only the EE/FSU countries are projected to attain emissions below their 1990 levels, as a result of the drop in energy consumption that accompanied the region's economic woes in the early and mid-1990s (Figure 8). By 2015, carbon emissions for non-OECD Asia almost triple over 1990 levels, as coal use in the region grows substantially.

Figure 8. Growth in Carbon Emissions for Selected Regions, 1990-2015



Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

World Energy Consumption

The world will require, and can produce, large increments of energy supply over the next two decades. As energy use grows—especially in the developing nations of Asia—carbon emissions will keep pace.

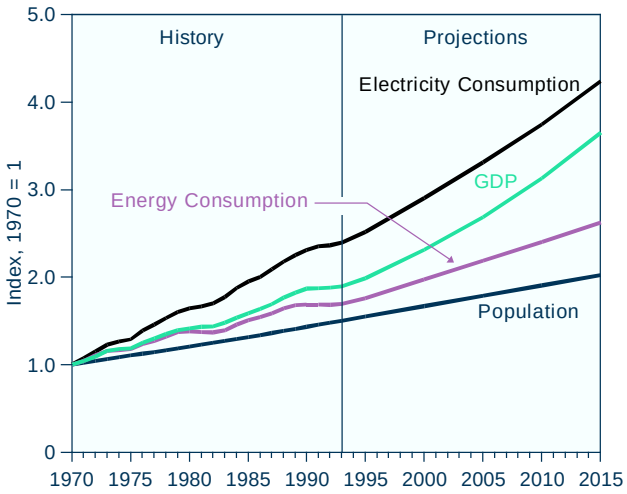
Introduction

The central message of the *International Energy Outlook 1996* (*IEO96*) is that the world will require, and can produce, large increments of energy supply over the next two decades. The normal course of economic development is likely to spread the energy use patterns currently prevalent in advanced economies of the OECD to newly developing nations, such as non-OECD Asia, where half the world's population resides. New demands for energy can be satisfied from available resources with known technologies. Thus, the real cost of energy need not escalate significantly over the projection period. Were these developments actually to transpire, worldwide carbon emissions in 2015 would be 50 percent higher than the current level.

World energy use is projected to grow by about 2 percent per year through 2015, resulting in total consumption in excess of 542 quadrillion British thermal units (Btu). Between 1993 and 2015 energy consumption is expected to increase by 193 quadrillion Btu—an amount nearly equal to the world's total energy consumption in 1970. All forms of energy supply except nuclear power are expected to grow over the projection period. By 2015 oil use will total about 99 million barrels per day, up more than 32 million barrels per day relative to 1993. On a worldwide basis, coal use equaled 4.9 billion short tons in 1993; by 2015, it is projected to reach 7.5 billion tons. In aggregate, fossil fuel use is expected to grow at the same rate as world energy use over the next 20 years, with natural gas gaining share relative to oil and coal.

Economic growth is the main factor driving growth in energy demand. Between 1970 and 1993 world gross domestic product (GDP) rose from $12 trillion (1990 U.S. dollars) to $23 trillion. By 2015 world GDP is expected to almost double again, rising to $45 trillion. On average, demand for energy does not rise in direct proportion to increases in income (Figure 9). Between 1970 and 1993 energy consumption grew by 2.3 percent per year, while income rose at an annual rate of 2.8 percent. The *IEO96* projections assume that world economic growth will average about 3.0 percent per year, but that growth in energy use will slow to 2 percent.

Figure 9. World Energy, GDP, and Population Trends, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996). **Gross Domestic Product (GDP):** The WEFA Group, *World Economic Service Historical Data* (Bala Cynwyd, PA, July 1993); and *World Economic Outlook*, Vol. 1 (Bala Cynwyd, PA, November 1995). **Population:** United Nations, *World Population Prospects: The 1994 Revision Annex Tables* (New York, NY, 1994), Tables A.1 and A.2.

Population is also expected to grow substantially over the forecast period, but at less than one-half the rate of income growth. The slow growth in population relative to growth in GDP permits substantial improvements in per capita income over the projection period. World population currently is estimated to equal 5.7 billion; by 2015 it is expected to total 7.5 billion (Figure 9). Both the level and composition of energy demand are affected by gains in per capita income. In general, the more advanced an economy and the higher personal income, the greater the demand for energy-using equipment.

Electricity demand is especially sensitive to growth in income. Economic development leads to increased reliance on electricity for machine drive in industrial processes and increased use for heating, lighting, cooking, and other appliances in residential and commercial

activities. The trend evident over the past 20 years—higher growth for electricity use relative to energy use in general—is expected to continue throughout the projection period (Figure 9).

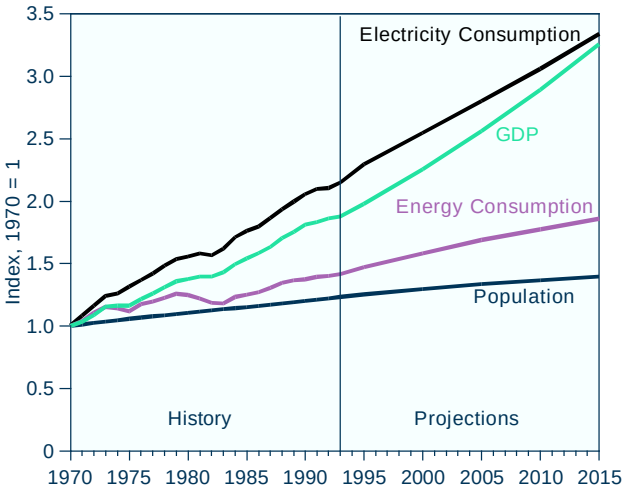
The geographic composition of energy demand will change substantially over the projection period. Two-thirds of all energy growth will occur in newly industrializing economies. Most of that growth will be concentrated in the developing countries of Asia, where half the world's population resides. Energy growth in Asia is expected to reach 4.3 percent per year on average (Table 1), compared with 1.3 percent for the industrialized economies in the Organization for Economic Cooperation and Development (OECD). The U.S. growth rate is expected to average about 1 percent per year. As recently as 1990, U.S. consumption exceeded total non-OECD Asia consumption by 33 quadrillion Btu. By 2015, non-OECD Asia is expected to exceed U.S. consumption by almost 43 quadrillion Btu (Table 1).

The link between energy growth and economic growth is relatively weak in industrialized economies. While substantial economic expansion is expected over the next two decades, growth in energy demand within the OECD will be modest (Figure 10). In contrast, for much of recent history and through much of the projection period, energy use and economic growth closely track each other in developing countries in non-OECD areas (Figure 11).

The relatively higher energy growth in developing countries is a result not only of rapid economic and population expansion but also of changing lifestyles. Many areas of the world are now gaining access to electricity for the first time. Those that have electricity are expanding the range of appliances they use. At the same time, personal automobile ownership is becoming an important component of consumer demand in newly industrializing areas. Double-digit growth rates in automobile ownership are evident in many countries, including South Korea, Thailand, India, and China.

In developed countries, high levels of per capita energy use have already been achieved. Most of the new demand for energy-using equipment relates to maintaining existing capital stock. Additions to personal

Figure 10. OECD Energy, GDP, and Population Trends, 1970-2015



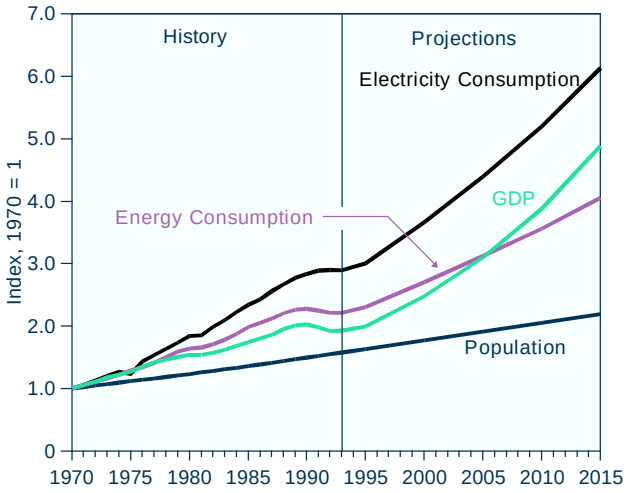
Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996). **Gross Domestic Product (GDP):** The WEFA Group, *World Economic Service Historical Data* (Bala Cynwyd, PA, July 1993); and *World Economic Outlook*, Vol. 1 (Bala Cynwyd, PA, November 1995). **Population:** United Nations, *World Population Prospects: The 1994 Revision Annex Tables* (New York, NY, 1994), Tables A.1 and A.2.

Table 1. World Energy Consumption by Region, 1970-2015
(Quadrillion Btu)

Region	1970	1993	2010	2015	Annual Percent Change 1970-1993	Annual Percent Change 1993-2015
OECD	**135.1**	**190.7**	**239.8**	**251.4**	**1.5**	**1.3**
United States	67.6	87.3	104.7	108.0	1.1	1.0
Non-OECD	**71.7**	**158.3**	**255.3**	**291.0**	**3.5**	**2.8**
Non-OECD Asia	18.9	60.3	126.6	150.8	5.2	4.3
EE/FSU	39.7	60.9	74.0	79.7	1.9	1.2
Total World	**206.7**	**349.1**	**495.1**	**542.3**	**2.3**	**2.0**

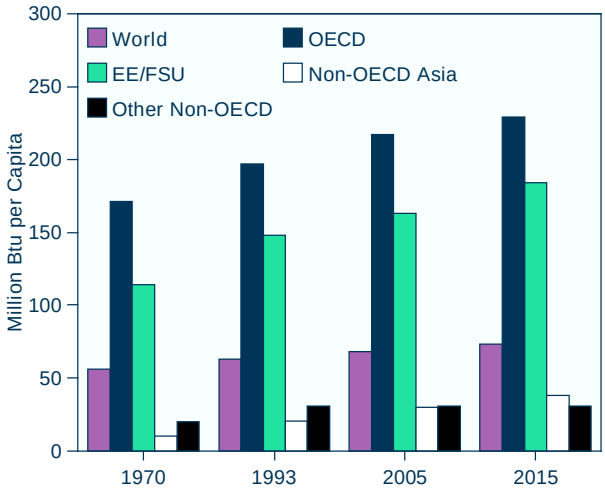
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database; and *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 11. Non-OECD Energy, GDP, and Population Trends, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996). **Gross Domestic Product (GDP):** The WEFA Group, *World Economic Service Historical Data* (Bala Cynwyd, PA, July 1993); and *World Economic Outlook*, Vol. 1 (Bala Cynwyd, PA, November 1995). **Population:** United Nations, *World Population Prospects: The 1994 Revision Annex Tables* (New York, NY, 1994), Tables A.1 and A.2.

Figure 12. World Energy Consumption per Capita by Region, 1970-2015



Sources: **History:** 1970: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996). **Population:** United Nations, *World Population Prospects: The 1994 Revision Annex Tables* (New York, NY, 1994), Tables A.1 and A.2.

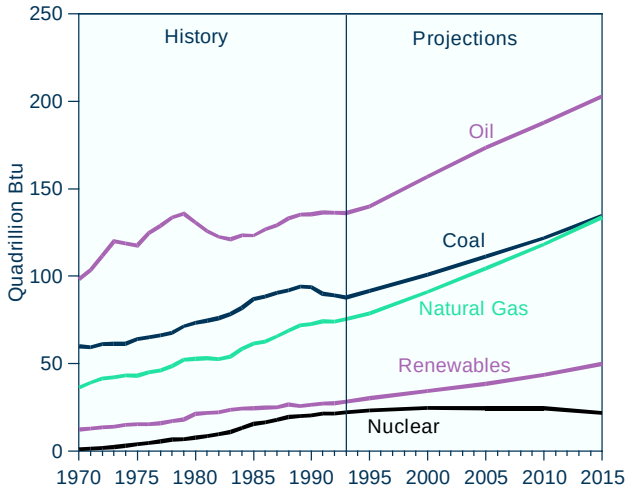
consumption associated with higher income in advanced economies tend to be directed toward less energy-intensive consumer goods and services. Because of prior development, per capita energy use in industrialized economies far exceeds the levels in newly emerging economies (Figure 12), and it is expected to change only moderately in the next two decades. In emerging economies, per capita energy use may double or triple. Even with such growth, however, average per capita energy use in non-OECD countries—excluding Eastern Europe and the former Soviet Union (EE/FSU)—will still be less than one-fifth of the average for OECD countries in 2015.

This issue of the *International Energy Outlook* reflects an upward revision in energy use projections relative to last year. For 2010, the *IEO96* anticipates nearly 5 percent (24 quadrillion Btu) more energy demand than did *IEO95*. For the most part, the change reflects an upward revision of the prospects for energy demand in non-OECD Asia, and particularly in China and India. Although the future rate of penetration of new energy-intensive consumption patterns is difficult to determine, both countries appear to be capable of sustaining substantial improvements in economic wealth, which will increase personal demand for energy. On the other hand, both countries have large, energy-intensive industrial sectors, which present significant opportunities for improvements in energy efficiency. Recent studies by the World Bank, however, suggest that there is a potential for substantial growth in demand for energy for personal use in these countries. Rapid growth in residential and commercial energy use would offset some of the prospective energy savings associated with improved industrial efficiency [**1**, **2**].

Sources of Energy Supply

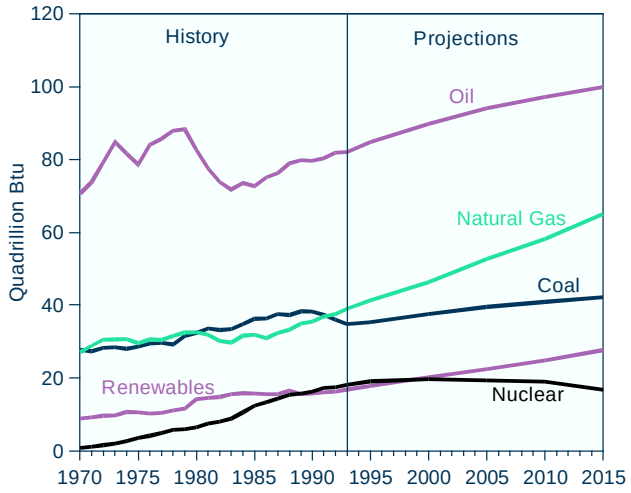
Oil, which has been the dominant energy source historically, is projected to continue its dominance during the projection period (Figure 13 and Table 2). By 2015, oil consumption throughout the world is projected to total about 99 million barrels per day. On the other hand, growth in oil consumption is expected to trail growth in total energy use over the next two decades, primarily because oil demand in OECD regions is projected to increase by only about 1 percent per year (Figure 14 and Table 3). Much of the projected growth in oil use in the OECD region occurs in the transportation sector, where petroleum fuels continue to have limited competition from other energy sources. In non-OECD areas, oil demand is expected to increase by almost 3 percent per year on average, with growth occurring in all economic sectors (Figure 15 and Table 3). By 2015, the non-OECD area is projected to consume as much oil as does the OECD, and world oil requirements are expected to exceed current levels by more than 32 million barrels per day. This increment is

Figure 13. World Energy Consumption by Fuel Type, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 14. OECD Energy Consumption by Fuel Type, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

greater than the current level of oil production from all of OPEC.

With such substantial growth in demand, the reference case projection for oil prices rises over the next two decades. Still, oil prices in the reference case are only about $25 a barrel in 2015. The high and low world oil price cases included in the *IEO96* forecast cover a range between $16 and $34 per barrel in 2015, as detailed in the following chapter.

It should be noted that, while the *IEO96* projections of oil demand are somewhat higher than the *IEO95* projections were, the oil price trajectories have been scaled down. In 2010, the *IEO96* reference case projects the world oil price at $24 per barrel, compared with $25 in the *IEO95* reference case. In fact, the downward revision in price expectations in this forecast is only the latest in a series: as recently as 1992, the *IEO* had a base case oil price of nearly $40 per barrel in 2010 [**3**].

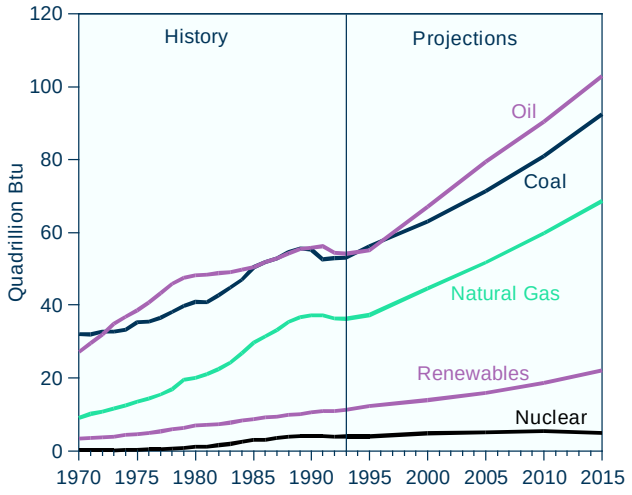
Oil market forecasters have been persistently surprised by real oil market developments. The key development that has made it possible to have higher oil demand and lower prices is the marked improvement in technology applied to oil exploration, development, and production. The increasingly widespread use of three-dimensional seismic imaging, horizontal drilling, and

Table 2. World Energy Consumption by Fuel, 1970-2015
(Quadrillion Btu)

Energy Source	1970	1993	2010	2015	Annual Percent Change 1970-1993	Annual Percent Change 1993-2015
Oil	97.8	136.2	187.7	202.8	1.4	1.8
Natural Gas	36.1	75.1	117.9	133.7	3.2	2.7
Coal	59.7	87.6	121.8	134.6	1.7	2.0
Nuclear	0.9	22.1	24.3	21.6	14.9	-0.1
Renewables	12.2	28.1	43.4	49.7	3.7	2.6
Total	**206.7**	**349.1**	**495.1**	**542.3**	**2.3**	**2.0**

Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database; and *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 15. Non-OECD Energy Consumption by Fuel Type, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

subsea well completion technology has helped to revive production from mature oil provinces and to reduce development and production costs from new provinces. As a consequence, the size and geographic diversity of economical sources of oil supply have grown. While the vast reserves of the Middle East still hold the most promise for assuring large-scale availability of reasonably priced oil, the reserve and production potentials of other areas of the world have expanded substantially. Thus, future growth in oil demand may be served by a wider array of supply areas than was hitherto thought possible.

Among all fossil fuels, natural gas use is expected to increase at the most rapid rate over the next two decades. By 2015 the energy value of natural gas consumption worldwide is expected to be approximately equal to that of coal (Table 2). In 1970, coal consumption exceeded natural gas use (in energy value) by 50 percent. As the level of gas use has risen, the geographical dispersion of consumption has broadened greatly. In 1970 the major portion of natural gas consumption was in the United States; since 1970, growth in natural gas consumption has occurred in all major areas of the world. By 1990 the U.S. share of world gas consumption had dropped to just over 26 percent, and Europe and the FSU had become major users. Over the next two decades, the use of natural gas in established markets is expected to rise, while in Asia and Central and South America major increments will be added to demand (Table 3).

Factors boosting natural gas use include widespread availability of recoverable reserves, rapid expansion of systems for gas gathering and distribution, and the favorable emissions characteristics of natural gas combustion. Use of natural gas helps to moderate local air pollution problems, especially when gas is substituted for coal in electric power generation.

Table 3. World Energy Consumption by Region and Fuel, 1970-2015
(Quadrillion Btu)

Region and Energy Source	1970	1993	2010	2015	Annual Percent Change 1970-1993	Annual Percent Change 1993-2015
OECD	**135.1**	**190.7**	**239.8**	**251.4**	**1.5**	**1.3**
Oil	70.6	82.1	97.2	100.0	0.7	0.9
Natural Gas	27.1	38.9	58.1	65.0	1.6	2.4
Coal	27.7	34.7	40.8	42.1	1.0	0.9
Nuclear	0.8	18.1	18.9	16.7	14.5	-0.4
Renewables	8.8	16.8	24.8	27.6	2.9	2.3
Non-OECD	**71.7**	**158.3**	**255.3**	**291.0**	**3.5**	**2.8**
Oil	27.2	54.1	90.5	102.8	3.0	3.0
Natural Gas	9.1	36.2	59.9	68.7	6.2	3.0
Coal	32.0	52.9	81.0	92.5	2.2	2.6
Nuclear	0.1	4.0	5.4	4.9	17.4	1.0
Renewables	3.3	11.2	18.6	22.0	5.5	3.1

Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database; and *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

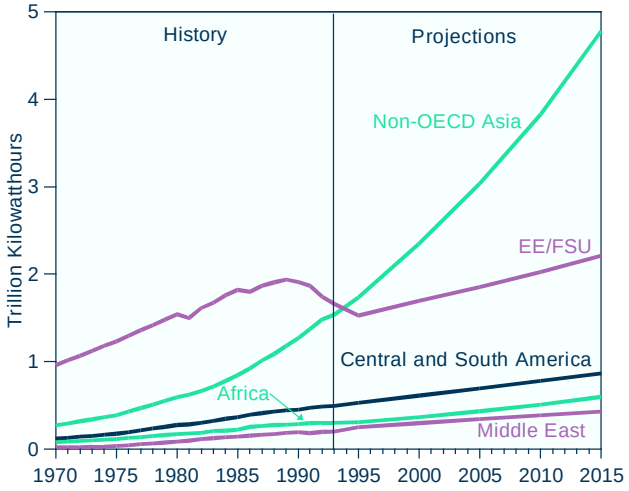
Coal is expected to supply about 25 percent of all energy consumption over the next two decades. On a worldwide basis coal consumption is expected to rise at about the rate of growth for all energy. However, most growth in demand will be centered in non-OECD Asia countries, especially China and India, both of which have large reserves and are undertaking rapid expansion of electric power generation capacity based on coal.

Over the next two decades the share of renewables (hydroelectricity, geothermal, wind, solar, and biomass) is projected to rise somewhat. Most of the rise is attributable to increased use of hydropower. Major projects to expand hydroelectric power generation in China and other Asia/Pacific nations are underway or are planned. While the use of other renewable energy sources is growing, the outlook for their use is less optimistic in *IEO96* than it was in *IEO95*. Although the costs of many renewable fuels technologies have declined in recent years—a trend that should contribute to an expansion of their use—fossil fuel prices are expected to remain relatively low, making it more difficult for renewable technologies to compete with conventional energy sources.

Among all energy supply sources, only nuclear power is expected to decline both relatively and absolutely over the projection horizon. Some areas will increase reliance on nuclear power: new plants will be commissioned in China, Japan, and South Korea. However, plants in the United States and in other countries with mature programs are expected to be retired more rapidly than new plants are activated in other areas. Substantial capacity reduction is expected in the FSU and in the United States, where plants are expected to be retired after 2010 as they reach the end of their designed operating lives.

Electricity is the most rapidly growing component of energy demand throughout the world (Figures 9, 10, and 11). In the OECD, electricity showed strong growth between 1970 and 1993, at 2.6 percent per year, in contrast to 2.3-percent annual growth in total energy use. Between 1993 and 2015 the growth rate for electricity demand in the OECD is projected to slow to 2.0 percent per year. Electricity consumption in non-OECD countries grew by 4.7 percent per year between 1970 and 1993 and is expected to grow by 3.5 percent per year between 1993 and 2015 (Table A8). Electricity growth has been particularly strong in non-OECD Asia, where the 1993 level of electricity consumption was more than 5.5 times its 1970 level (Figure 16). In that region, electricity consumption is expected to more than triple again by 2015, as aggressive industrialization and urbanization plans correspond to aggressive development of electricity supplies.

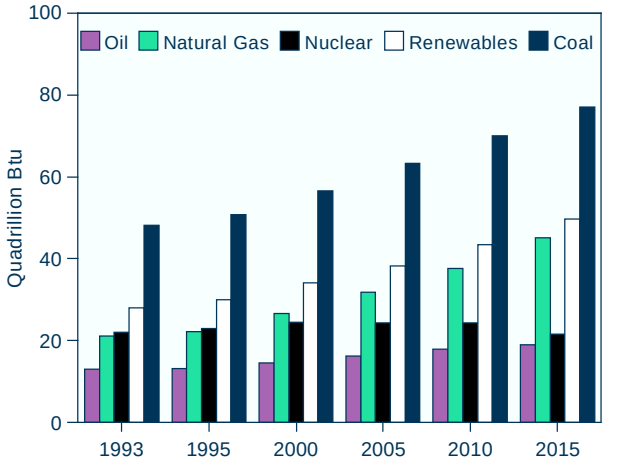
Figure 16. Non-OECD Electricity Consumption by Region, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

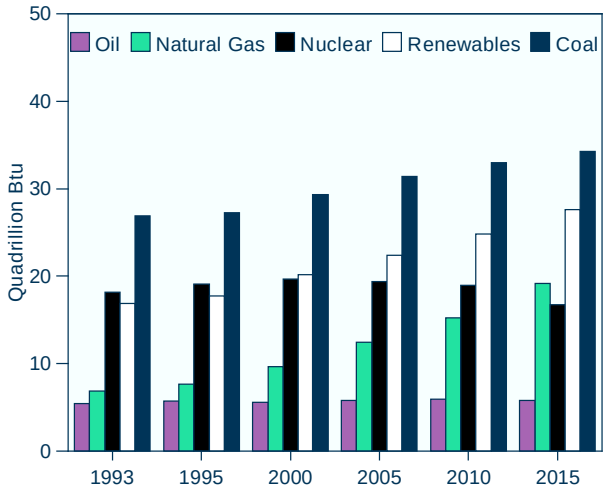
Throughout the forecast, coal is expected to remain the dominant fuel used for electricity generation worldwide (Figure 17). Slow growth in coal-fired generating capacity in the OECD (Figure 18) is expected to be offset by

Figure 17. World Energy Use for Electricity Generation by Fuel Type, 1993-2015



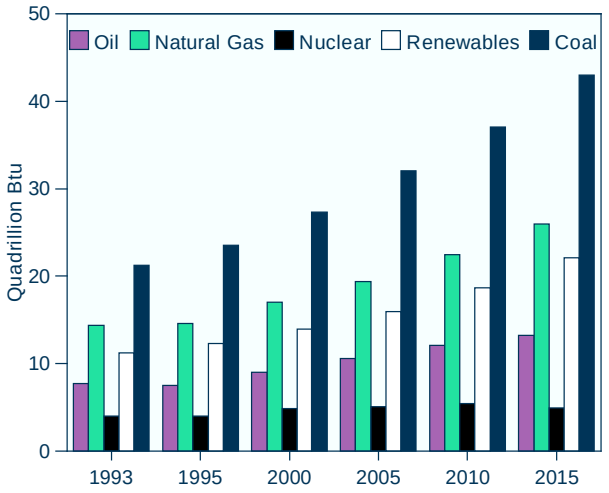
Sources: **History (1993):** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 18. OECD Energy Use for Electricity Generation by Fuel Type, 1993-2015



Sources: **History (1993):** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 19. Non-OECD Energy Use for Electricity Generation by Fuel Type, 1993-2015



Sources: **History (1993):** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

rapid expansion in non-OECD regions (Figure 19). The large increase in electricity consumption in non-OECD Asia—particularly, China and India—accounts for a major portion of the overall rise in coal-fired generation. Both countries are rich in coal reserves and have well-developed infrastructures for coal mining and distribution, and because their oil and natural gas infrastructures are relatively less developed, coal is their most economical fuel.

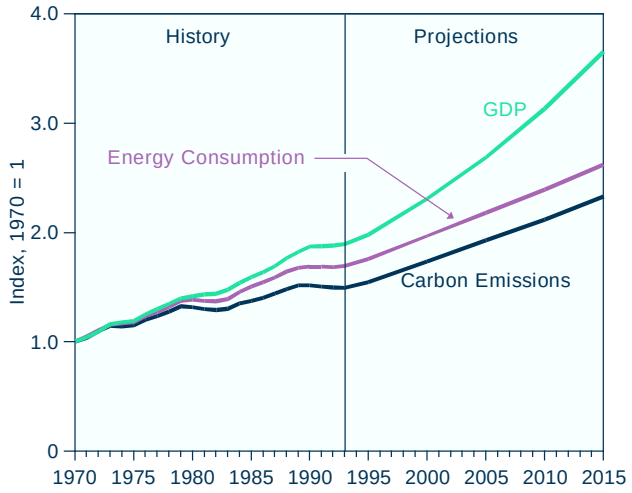
Renewables (primarily hydropower) are currently the second largest source of electricity, followed closely by nuclear power and natural gas. Both renewables and natural gas continue to grow as energy sources for electricity generation throughout the forecast. China contributes substantially to the growth in renewables through an expansion of hydropower, and a number of countries in non-OECD Asia and other parts of the world are turning to gas as their first choice for expansion of generation capacity. Oil use for electricity generation changes little. Nuclear, after a slight rise through the end of the century, begins to decline, and by the end of the forecast its share is only slightly larger than oil's. Nuclear's share of electricity generation rises slightly in Japan, France, and non-OECD Asia, but for many parts of the world, unsolved problems with plant safety, waste disposal, and public acceptance have become barriers to the growth of commercial nuclear power.

Energy Use and Carbon Emissions

If world energy consumption reaches the projected levels in the *IEO96* reference case, world carbon emissions are expected to increase by 3.4 billion metric tons—or at a rate just over 2 percent per year—through 2015 (Table A9 and Figure 20). In that case, world carbon emissions in 2015 would exceed 1990 levels by 54 percent. Oil and coal will contribute about 1.3 and 1.2 billion metric tons, respectively, to the increase, and natural gas will provide the remainder (Tables A10, A11, and A12 and Figure 21). Carbon emissions will grow at a slower rate than energy consumption, reflecting more rapid growth in the use of natural gas than other fossil fuels.

Carbon emissions from energy use in OECD countries are expected to increase by 902 million metric tons to about 3.9 billion metric tons by 2015 (Figure 22), or by about 1 percent a year. Petroleum products, used principally in the transportation sector and having few substitutes, will account for nearly half the increase in emissions. Natural gas will become a relatively more important source of emissions as it replaces coal, which is "dirtier" with respect to carbon dioxide (as well as sulfur dioxide and nitrogen oxide). Nonetheless, coal will remain an important source of emissions, primarily because of its role as an economical fuel for baseload electric power generation.

Figure 20. World Carbon Emissions Trends, 1970-2015



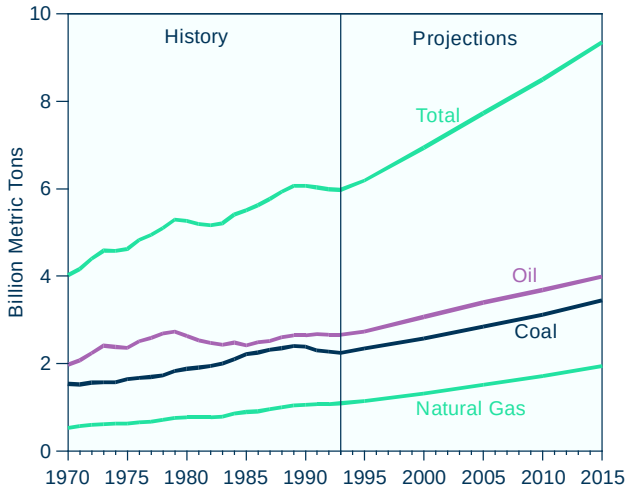
Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections: Gross Domestic Product (GDP):** The WEFA Group, *World Economic Outlook*, Vol. 1 (Bala Cynwyd, PA, November 1995). **Energy Consumption and Carbon Emissions:** EIA, World Energy Projection System (1996).

By 2000, carbon emissions in non-OECD countries are expected to surpass those in the OECD, even though developing countries will use less energy than industrialized countries at that time. Non-OECD emissions are expected to increase by 2.3 billion metric tons to a total of almost 5.5 billion metric tons in 2015 (Figure 22). Their growth represents about two-thirds of the projected increase worldwide. The sizeable rise in emissions from non-OECD countries is a result of their heavy dependence on coal, the most carbon-intensive of the fossil fuels, especially in the non-OECD Asia region, which has the highest expected rate of economic growth. Carbon emissions in non-OECD Asia are projected to increase from 1.3 billion metric tons in 1993 to 3.1 billion metric tons in 2015.

While coal use grows at the slowest rate among the three fossil fuels worldwide, coal's relatively high level of carbon emissions per Btu lead to higher growth in emissions from coal than from oil or natural gas. A high rate of natural gas penetration is the principal factor curtailing the growth of emissions relative to the growth rate for energy in the projection period. Non-carbon energy sources are not expected to grow in relative importance to mitigate carbon emissions. Although the share of renewables in the overall energy supply is projected to increase, that trend is offset by a reduction in the use of nuclear power.

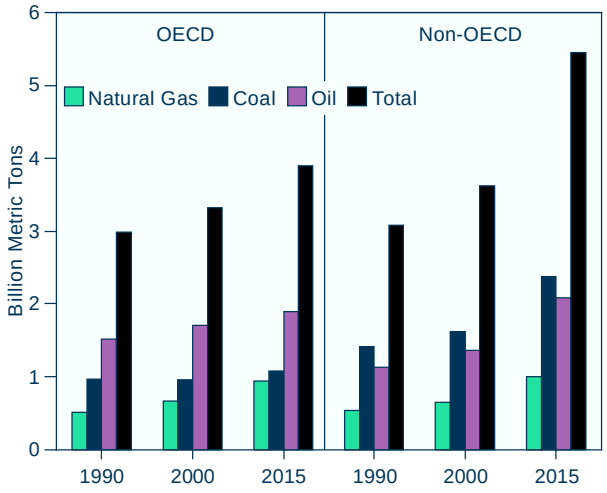
More than 100 countries are signatories to the United Nations Framework Convention on Climate Change. The ultimate concern of the Convention is to encourage worldwide efforts to achieve stabilization of greenhouse gas concentrations at levels which would forestall the threat of global warming. Industrialized countries within the OECD have pledged to pursue efforts that could

Figure 21. World Carbon Emissions by Fuel, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 22. World Carbon Emissions by Region and Fuel, 1990, 2000, and 2015



Sources: **History (1990):** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

stabilize greenhouse gas emissions at their 1990 levels. Negotiations are currently underway to clarify commitments regarding projected stabilization targets.

Energy combustion accounts for 85 percent of all greenhouse gas emissions. Thus, what happens to international energy use is of fundamental importance to the concerns identified in the Convention agreement. Although developed countries are projected to increase their energy use relatively slowly, at this point, taken as a whole, they are not on a path to stabilizing greenhouse gas emissions from energy use. Were such stabilization achieved by the industrialized nations, annual carbon emissions in 2015 would be about 900 million metric tons less than projected in this report; nonetheless, worldwide emissions would still rise by one-third from their 1990 levels—to about 8 billion metric tons in 2015—because of the rapid rate of growth in energy use in other parts of the world.

Alternative Growth Cases

Long-term projections of energy consumption are subject to substantial uncertainties. The sources of uncertainty include economic growth rates, energy prices, and the intensity of energy use in growing economic systems. The *IEO96* forecasts include a baseline set of assumptions for these variables to provide a reference case. A measure of the uncertainty in the reference case projections of future energy consumption is represented by two additional cases, which assume future economic growth rates that are higher and lower, respectively, than for the reference case.

In the reference case, total economic activity worldwide is expected to grow at an average rate of 3.0 percent a year from 1993 to 2015 (Table 4). The economies of the OECD nations are assumed to average 2.5-percent annual growth, compared with an average of 4.3 percent a year for the non-OECD nations. Growth rates within non-OECD areas are expected to vary widely: China's growth is projected at 7.7 percent per year; Africa and Central and South America are expected to grow at less than half that rate; and the EE/FSU region is expected to average 2.8 percent annual growth in GDP between 1993 and 2015.

There have been substantial differences in economic growth rates both within and between regions over time. For developing nations, in particular, unexpected

Table 4. Annual Growth Rates in Gross Domestic Product by Region and for Selected Countries, 1970-2015
(Percent per Year)

Region/Country	History		Projections		
	1970-1980	1980-1990	1990-2000	2000-2015	1993-2015
OECD	**3.2**	**2.8**	**2.2**	**2.5**	**2.5**
North America	3.0	2.6	2.1	2.3	2.3
Europe	3.0	2.6	2.1	2.6	2.6
Pacific	4.3	4.0	2.6	2.7	2.8
Non-OECD	**4.4**	**2.8**	**2.0**	**4.7**	**4.3**
EE/FSU	3.2	2.1	-4.0	3.8	2.8
Former Soviet Union	3.2	2.1	-4.4	3.7	2.6
Eastern Europe	3.5	1.8	-1.1	4.2	3.9
Non-OECD Asia	6.3	6.9	6.4	6.0	6.0
China	5.8	8.9	9.2	7.6	7.7
Other Asia	6.4	6.3	5.4	5.2	5.2
Middle East	4.8	1.5	3.3	3.4	3.4
Africa	4.2	1.4	2.3	3.5	3.2
Central and South America	5.8	1.1	3.9	3.8	3.7
Total World	**3.5**	**2.8**	**2.2**	**3.1**	**3.0**

Note: India is included in Non-OECD Other Asia.

Sources: **History:** Derived from The WEFA Group, *World Economic Service Historical Data* (July 1993). **Projections:** The WEFA Group, *World Economic Outlook*, Vol. 1 (Bala Cynwyd, PA, November 1995); U.S. data from Energy Information Administration (EIA), *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996); and EIA, World Energy Projection System (1996).

developments have played a major role in national or regional development. Similarly, unanticipated events are likely to play a major role in the future. The economic turmoil in the FSU over the past 5 years serves as an example: it was not anticipated in energy forecasts much before the region's economic fortunes began to decline. Likewise, the double-digit rates of economic growth seen in China in the past few years were not anticipated in many forecasts. The more mature economies of OECD nations grow more slowly and show less variation than those of developing nations, but their economic growth is also subject to uncertainty.

For the high and low economic growth cases, different assumptions were made about the range of possible economic growth rates for developing and developed nations, reflecting the greater uncertainty inherent in attempts to forecast economic growth in developing economies. The same pattern of change in energy intensity relative to change in GDP (discussed below) was assumed for the high and low growth cases as for the reference case. For OECD countries, increments of +0.5 and -0.5 percentage points, respectively, were added to the reference case growth rates to generate the high and low growth cases. For developing countries and/or regions, apart from China and EE/FSU, increments of +1.5 and -1.5 percentage points were used to generate the high and low growth cases.

China and the EE/FSU countries are special cases with regard to prospects for future economic growth. China has had quite high economic growth in the past few years, and the EE/FSU region has suffered a severe economic downturn. For both regions, the opportunity for a substantial change in growth exists: China has the potential for a larger decline in growth rate given its currently high rate, and there are prospects for a substantial increase in the rate of growth for EE/FSU nations should their current political and institutional problems be moderated sufficiently for the recovery of a considerable industrial base. Reflecting these uncertainties, -3 percentage points have been added to China's growth rate for the low economic growth case and +1.5 added for the high; and +3.0 percentage points have been added to the EE/FSU growth rate for the high economic growth case and -1.5 added for the low.

In the reference case, total world energy consumption is expected to reach 542 quadrillion Btu in 2015, with OECD countries consuming 251 quadrillion Btu and non-OECD countries 291 quadrillion Btu (Table 5 and Figure 23). Under the assumptions of the high economic growth case, total world energy consumption would be 622 quadrillion Btu in 2015, 80 quadrillion Btu higher than the reference case projection. In the low economic growth case, worldwide consumption would be 473 quadrillion Btu, down 70 quadrillion Btu from

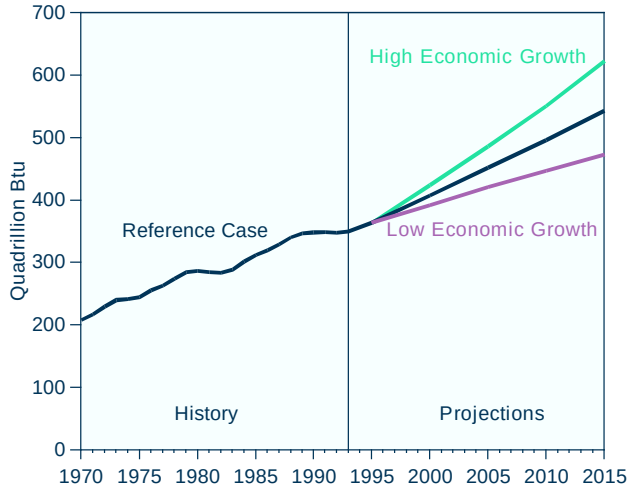
Table 5. Annual World Energy Consumption by Region in Three Economic Growth Cases, 1970, 1993, 2005, and 2015
(Quadrillion Btu)

Region	History		Projections					
			2005			2015		
	1970	1993	Low	Reference	High	Low	Reference	High
OECD	**135.1**	**190.7**	**220.2**	**227.7**	**235.2**	**237.6**	**251.4**	**265.6**
Non-OECD	**71.7**	**158.3**	**199.6**	**223.4**	**250.1**	**235.1**	**291.0**	**356.6**
EE/FSU	39.7	60.9	64.0	68.7	78.9	70.2	79.7	102.5
China	11.6	31.6	45.8	54.2	58.9	58.8	81.8	96.2
Other Asia	7.2	28.7	45.2	51.2	57.9	55.8	69.1	85.3
Total World	**206.7**	**349.1**	**419.8**	**451.1**	**485.4**	**472.7**	**542.3**	**622.2**

Note: India is included in Non-OECD Other Asia.

Sources: **History:** Derived from The WEFA Group, *World Economic Service Historical Data* (July 1993). **Projections:** The WEFA Group, *World Economic Outlook*, Vol. 1 (Bala Cynwyd, PA, November 1995); U.S. data from Energy Information Administration (EIA), *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996); and EIA, World Energy Projection System (1996).

Figure 23. World Energy Consumption in Three Cases, 1970-2015



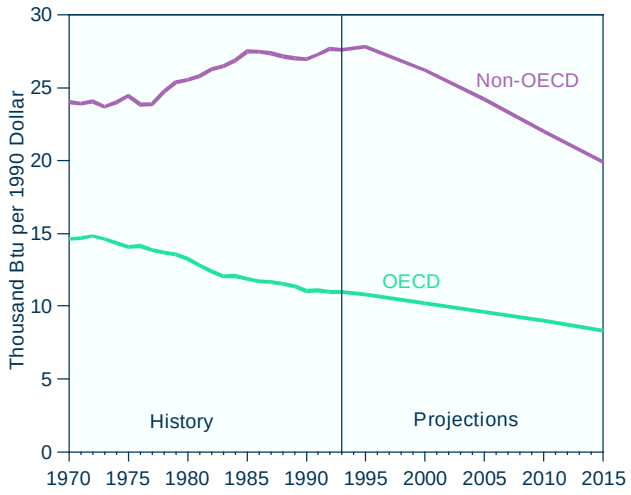
Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

the reference case. Thus, for the range of growth rates used in the high and low cases, the associated spread in total international energy consumption is 150 quadrillion Btu, or one-third of the total consumption projected for 2015 in the reference case. Non-OECD nations contribute 122 quadrillion Btu to the spread, reflecting the higher potential variability in economic growth rates associated with their economic development.

Changes in energy intensity (the ratio of total energy consumption to GDP) could also have a significant impact on the projections presented in this report. As economies grow, the energy intensity of the additional economic activity will influence the course of energy consumption. In industrialized countries, the expansion of economic activity has tended to be in areas that are less energy intensive. Further, more energy-efficient technology has been adopted in many areas. As a result, energy consumption in the OECD has grown more slowly than GDP since the mid-1970s (Figure 10). The divergence, which developed after the Arab oil embargo of 1973-1974, has persisted even as oil and other energy prices have fallen to pre-embargo levels in real terms. Thus, by 2015, GDP is expected to be three times its 1970 level but energy use only twice its 1970 level.

In contrast, energy demand has risen at a more rapid rate than GDP in non-OECD areas (Figure 11). This pattern is expected to persist during the early years of the projection period. Between 2000 and 2015, however, a relationship between energy and economic growth similar to that achieved in OECD countries is expected to emerge. The future path of energy intensity for the non-OECD nations is subject to much uncertainty and is therefore more difficult to project than that for OECD nations. Figure 24 depicts the historical and projected energy intensities used in this report. Particularly for the economies that are expanding rapidly, the expansion rates of key sectors—such as electricity generation (associated with expanding electricity consumption), transportation, and energy-intensive manufacturing industries—will be key determinants of trends in energy intensity. Equally important is the type of capital equipment used in these sectors, as energy intensity will vary considerably, depending on the energy-use characteristics of new equipment.

Figure 24. OECD and Non-OECD Energy Intensities, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

The dynamics of growth in energy consumption are demonstrated by considering an approximate measure of the elasticity of change in energy consumption relative to change in GDP. To smooth the year-to-year differences, an average annual elasticity is calculated for a 5-year period. The elasticity is the percentage change in energy consumption divided by the percentage change in GDP. When the elasticity is greater than 1, each percentage point increase in GDP results in more than 1 percentage point increase in consumption. Consequently, when the average elasticity is greater than 1, energy intensity is increasing; and when it is less than 1, energy intensity is decreasing.

For OECD nations, the energy-to-GDP elasticity has typically been less than 1 (Table 6). The economic troubles of the EE/FSU countries have distorted the

picture for non-OECD nations in the 1990 to 1995 period: while GDP and energy consumption have both been declining in the EE/FSU, GDP has fallen more rapidly, leading to a rise in energy intensity and a positive energy-to-GDP elasticity. However, adding the declines for the EE/FSU to the rest of the non-OECD results in a misleading negative energy-to-GDP elasticity. To correct for this distortion, average elasticities were also computed for the non-OECD nations excluding EE/FSU. For those nations, the average elasticity hovered around 1 for the 1970 to 1980 period, corresponding to relatively flat energy intensity values (Table 6). From 1980 to 1985 the average elasticity was almost 2, and it has since declined through 1995.

The decline in energy-to-GDP elasticity for non-OECD nations is projected to continue through 2015 in the *IEO96* forecasts, but at a slower rate than that for OECD nations. The projected reduction in energy intensity is based on the assumption that energy-efficient technologies used in OECD nations will increasingly be adopted in the developing nations. The widespread use of efficient technology could come about through pressures for economic efficiency as the economies in non-OECD nations become more market driven and more integrated into a world market. Environmental considerations could be another factor contributing to the adoption of more efficient technologies around the world.

The reference case projections of energy intensity assume a substantial rate of decline in energy intensity. Several recent reports on China illustrate different views on this subject. In one report, *China: Issues and Options in Greenhouse Gas Emissions Control* [**1**], which provides a forecast to the year 2020, the baseline forecast has an energy-to-GDP elasticity of 0.56, comparable to that assumed for *IEO96*. In contrast, a World Bank discussion paper, "Energy Demand in Five Major Asian Developing Countries" [**2**], assumes an elasticity of 0.78 through 2005, citing an International Energy Agency finding that there may not be sufficient funds for China to build plants using highly efficient, and therefore more expensive, technology. Using this larger energy-to-GDP elasticity with the GDP growth assumptions in *IEO96* to 2015 (well beyond the intended range of the World Bank study) would give a total energy consumption for China in 2015 that is about 30 quadrillion Btu larger than the reference case forecast of 82 quadrillion Btu.

Still another report, *Pacific Energy Outlook* by the East-West Center [**4**], has a more optimistic view of the decline in China's future energy intensity, with an implicit energy-to-GDP elasticity of about 0.47 for the 1995 to 2010 period. This elasticity applied to the *IEO96* GDP growth rates would place total energy consumption for China at about 71 quadrillion Btu in 2015. Thus, the range of estimates for China's energy consumption, using this range of estimates for energy-to-GDP elasticities, is about 41 quadrillion Btu, or 50 percent of the *IEO96* reference case forecast for China's total consumption.

Because assumptions about energy intensity have such a strong influence on energy consumption projections,

Table 6. Average Energy Elasticity (Change in Consumption Versus Change in Gross Domestic Product), 1970-2015: World, OECD, Non-OECD, and Non-OECD Asia

Region/Country	History				Projections				
	1975	1980	1985	1990	1995	2000	2005	2010	2015
Total World	**0.95**	**0.92**	**0.74**	**0.68**	**0.71**	**0.74**	**0.67**	**0.61**	**0.59**
OECD	**0.74**	**0.65**	**0.03**	**0.56**	**0.79**	**0.56**	**0.51**	**0.42**	**0.39**
Non-OECD	**1.08**	**1.23**	**1.63**	**0.85**	**-0.51**	**0.74**	**0.67**	**0.61**	**0.59**
Non-OECD without EE/FSU	0.97	1.07	2.05	1.07	0.87	0.85	0.74	0.66	0.63
EE/FSU	1.27	1.70	1.24	0.49	0.46	0.54	0.42	0.40	0.39
Non-OECD Asia	**1.03**	**0.61**	**0.86**	**0.72**	**0.82**	**0.81**	**0.68**	**0.62**	**0.61**
China	0.88	0.53	0.57	0.44	0.51	0.59	0.57	0.56	0.55
Other Asia	1.21	0.83	0.98	1.03	1.04	0.98	0.74	0.62	0.59

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. The elasticity was calculated for each 5-year period by dividing the percentage change in energy consumption by the percentage change in GDP.

Sources: **History:** Derived using gross domestic product data from The WEFA Group, *World Economic Service Historical Data* (July 1993), and energy consumption data from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

it is useful to consider the effects of alternative assumptions for the non-OECD nations as a whole. Under the possibly pessimistic view that development in the non-OECD nations will not result in changes in energy intensity (an energy-to-GDP elasticity of 1.0), total energy consumption in 2015 by non-OECD nations would be 441 quadrillion Btu, an increase of 150 quadrillion Btu over the reference case projection (Table 7). On the optimistic side, if it is assumed that the average energy intensity for non-OECD nations will decline on average at the same rate as that for OECD nations, total non-OECD energy consumption in 2015 would be 31 quadrillion Btu less than in the reference case (Table 7).

Comparisons with Other Projections

Another way to assess uncertainty is to compare different forecasts. Three forecasts that are comparable in scope to *IEO96* have been developed by the International Energy Agency (IEA), Petroleum Economics Limited (PEL), and Petroleum Industry Research Associates (PIRA). Two of the forecasts (IEA and PIRA) expect higher levels of growth in energy demand over the next two decades than those presented here, and the PEL forecast projects roughly the same level of growth (Table 8).

A core difference across the forecasts lies in assumptions about regional economic growth rates (Table 9). Although the four forecasts have similar expectations with respect to economic growth in OECD countries—differing by only one-tenth of a percentage point—there are sizeable differences in the assumptions about prospects for developing countries. The *IEO96* projection assumes the slowest rate of growth for non-OECD areas: 3.3 percent a year for the 1990 to 2010 period. The range for the other forecasts is from 4.6 percent a year for PEL, to 4.8 percent for IEA, to 5.0 percent for the PIRA forecast (which extends only to 2005).

The forecasts are generally pessimistic regarding the outlook for recovery in the EE/FSU, where GDP has declined by as much as one-third since 1990.[1] The IEA appears to be more optimistic, projecting an average growth rate for the region of 2.1 percent per year; however, that estimate is for the period 1992 to 2010 rather than 1990 to 2010. The time difference is significant, because there was a substantial loss of GDP between 1990 and 1992 for the EE/FSU region. Indeed, *IEO96* projects average growth of 1.6 percent a year between 1992 and 2010 for the region. Even though the forecasts generally expect some economic recovery in the EE/FSU economies, GDP levels in 2015 are expected to be only about at 1990 levels; and even to achieve that result, growth rates in excess of 2 percent would be needed after 2000.

All four of the forecasts agree that non-OECD Asia will be the area of largest growth over the two decades. Further, all the forecasts agree that China, with GDP growth assumptions ranging from 7.9 to 8.4 percent a year, will have the strongest economic growth. The *IEO96* assumptions are at the high end of the range.

In large part, differences in projected world energy requirements flow directly from different assumptions about economic growth. As seen for the comparison of economic growth rates (Table 9), the *IEO96* projection of 1.8-percent annual growth in total world energy use (Table 8) is slightly lower than the other forecasts, which range from 1.9 percent (PEL), to 2.1 percent (IEA), to 2.4 percent (PIRA). The crucial role of energy demand growth in determining world energy needs is underscored when one notes that a difference of 0.6 percentage point between the PIRA and *IEO96* reference case growth rates for world energy consumption translates into 66 quadrillion Btu more energy use in 2010 in the PIRA forecast.

Table 7. Variation in Non-OECD Energy Consumption in 2015, Given Alternative Assumptions About Energy Intensity
(Quadrillion Btu)

Alternative Assumptions	Non-OECD Energy Consumption, 2015	Change from Reference Case
Non-OECD energy intensities remain constant at 1995 levels	441	+150
IEO96 reference case	291	—
Non-OECD energy intensities decline at OECD rate	260	-31

Source: Energy Information Administration, World Energy Projection System (1996).

[1]It is useful to bear in mind in comparing different forecasts for the EE/FSU that statistical data from these regions are not reliable, particularly for the period of the economic collapse. Differences among forecasts could result in part from the use of different historical data for GDP and energy consumption.

Table 8. Comparison of Energy Consumption Growth Rates, 1990-2010, by Fuel Type
(Average Annual Percent Growth)

Fuel Type	*IEO96* Low Growth	*IEO96* Reference	*IEO96* High Growth	*IEO95*	IEA[a]	PEL	PIRA[b]
Oil	1.1	1.6	2.2	1.5	1.9	1.8	1.9
Natural Gas	2.0	2.5	3.1	2.0	2.5	2.5	2.9
Coal	0.6	1.3	1.9	1.3	2.0	1.4	2.6
Nuclear	0.7	0.9	1.2	0.9	1.4	1.4	1.5
Other Energy	2.1	2.5	3.0	2.3	3.3	2.6	3.1
Total Energy	**1.3**	**1.8**	**2.3**	**1.6**	**2.1**	**1.9**	**2.4**

[a]IEA growth rates are for the period 1992-2010.
[b]PIRA growth rates are for the period 1990-2005.

Sources: ***IEO96*:** Energy Information Administration (EIA), World Energy Projection System (1996). ***IEO95*:** EIA, *International Energy Outlook 1995*, DOE/EIA-0484(95) (Washington, DC, June 1995), Table 9, p. 22. **IEA:** International Energy Agency, *World Energy Outlook 1995* (Paris, France, April 1995), Capacity Constraints Case, p. 301. **PEL:** Petroleum Economics, Ltd., *Oil and Energy Outlook to 2010* (London, United Kingdom, December 1995), Table 1. **PIRA:** Petroleum Industry Research Associates, Inc., *Annual Retainer Client Seminar—World and U.S. Oil* (New York, NY, October 1995), Table II-5.

Table 9. Comparison of Economic Growth Rate Assumptions, 1990-2010, by Region
(Average Annual Percent Growth)

Region	*IEO96* Low Growth	*IEO96* Reference	*IEO96* High Growth	*IEO95*	IEA[a]	PEL	PIRA[b]
OECD	**2.0**	**2.4**	**2.7**	**2.3**	**2.5**	**2.4**	**2.3**
North America	1.8	2.2	2.6	2.2	2.5	2.4	2.4
Europe	1.9	2.3	2.7	2.3	2.3	2.1	2.2
Pacific	2.3	2.7	3.1	2.8	2.7	2.2	2.2
Non-OECD	**2.0**	**3.3**	**4.6**	**3.4**	**4.8**	**4.6**	**5.0**
EE/FSU	-1.3	-0.2	1.9	0.6	2.1	—	0.1
Former Soviet Union	-1.5	-0.5	1.7	0.1	1.3	-0.1	—
Eastern Europe	0.4	1.5	3.7	2.2	3.6	1.8	—
Non-OECD Asia	4.6	6.2	7.4	6.1	6.6	—	6.8
China	6.1	8.4	9.5	7.4	7.9	8.3	8.2
Other Asia	4.2	5.4	6.5	5.4	6.0	6.1	5.0
Middle East	2.3	3.3	4.5	3.9	3.4	3.5	3.6
Africa	1.7	2.8	4.0	2.8	3.7	3.2	2.8
Central and South America	2.5	3.8	4.8	3.7	3.7	2.8	3.6
Total World	**2.0**	**2.6**	**3.3**	**2.7**	**3.1**	**2.8**	**3.7**

[a]IEA growth rates are for the period 1992-2010.
[b]PIRA growth rates are for the period 1990-2005.

Notes: ***IEO96*, *IEO95***: India is included in Non-OECD Other Asia. Mexico is included in North America. **PEL**: North America includes only the United States. OECD Pacific includes only Japan. Mexico is included in Central and South America. **PIRA**: North America includes only the United States and Canada. Mexico is included in Central and South America. OECD Pacific includes only Japan. Asia is defined as South Asia and Southeast Asia and Pacific.

Sources: ***IEO96*:** Energy Information Administration (EIA), World Energy Projection System (1996). ***IEO95*:** EIA, *International Energy Outlook 1995*, DOE/EIA-0484(95) (Washington, DC, June 1995), Table 8, p. 21. **IEA:** International Energy Agency, *World Energy Outlook* (Paris, France, April 1995), Table A2, p. 298. **PEL:** Petroleum Economics, Ltd., *Oil and Energy Outlook to 2010* (London, United Kingdom, December 1995), Table 4. **PIRA:** Petroleum Industry Research Associates, Inc., *Annual Retainer Client Seminar—World and U.S. Oil* (New York, NY, October 1995), Table II-1.

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3. Energy Information Administration. *International Energy Outlook 1992*. DOE/EIA-0484(92). Washington, DC, April 1992. p. 15.
4. East-West Center. *Pacific Energy Outlook: Strategies and Policy Imperatives to 2010*. Edited by F. Fesharaki, A.L. Clark, and D. Intarapravich. Honolulu, Hawaii, March 1995.

The World Oil Market

Oil is the major source of energy worldwide and is expected to remain so over the next two decades. Oil use is projected to grow by 2 percent a year, but oil prices are not expected to rise beyond $25 per barrel before 2015.

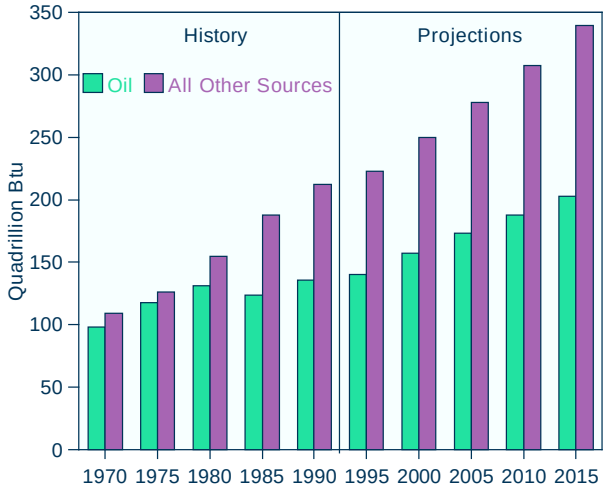
Since the oil price collapse of 1986, petroleum has re-emerged as a premier growth industry in world energy markets. Current oil consumption exceeds 68 million barrels per day and is rising at an annual rate in excess of 1.5 million barrels per day. By 2015, the world's daily consumption of oil is expected to reach about 99 million barrels, as compared with an average of 57 barrels per day in 1973, when the world was first racked by an oil price crisis. Despite continued demand growth of nearly 2 percent per year over the next two decades, oil prices are not expected to rise beyond $25 per barrel. The existence of vast quantities of producible oil reserves, along with actual and potential competition from nonpetroleum fuels, is expected to moderate many tendencies for sustained oil price escalation over the projection period.

Oil is the major source of energy worldwide and is expected to remain so over the next two decades (Figure 25 and Table 2). While natural gas and renewables are making inroads into energy markets in OECD nations, leading to a decline in oil's share in those markets, its share is rising in the developing nations as transportation, industrial, and other uses for oil expand.

Growth in Oil Demand

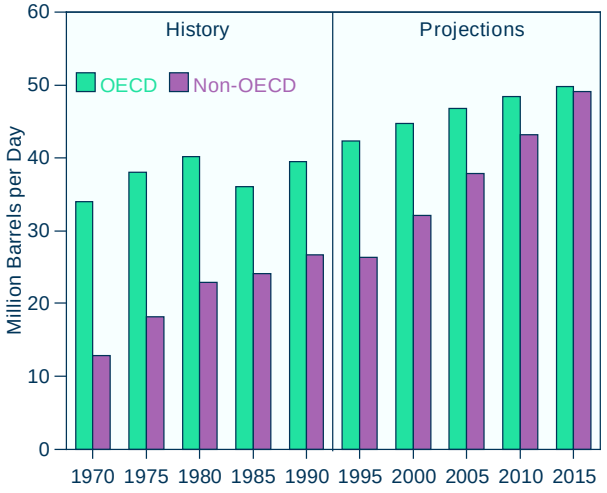
Oil consumption by OECD countries is expected to grow at about 0.9 percent per year, rising from 41 million barrels per day in 1993 to about 50 million barrels per day in 2015 (Figure 26). Oil remains the most important energy source in the majority of OECD countries, although its share of energy consumption for all OECD nations is expected to drop by 3 percentage points (from 43 to 40 percent) over the 1993 to 2015 period. This drop reflects the continuation of trends in Europe, Japan, and other countries in which newer technologies use oil more efficiently and where natural gas and other energy sources are replacing oil for many uses, constraining the bulk of oil's growth to its principal market—transportation fuels—where it has no substantial competition.

Figure 25. World Consumption of Oil Relative to All Other Energy Sources, 1970-2015



Sources: **History:** 1970-1975: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1990: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 26. OECD and Non-OECD Oil Consumption, 1970-2015



Sources: **History:** 1970-1975: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1990: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Growth in oil use by non-OECD countries of 3 percent per year is projected to cause oil consumption to rise from 26 to about 49 million barrels per day in the 1993 to 2015 time period. In 2015, the OECD and non-OECD nations approach parity in their levels of oil consumption. Strong economic growth, the rapidly increasing demand for transportation, and an expansion of demand for oil in a wide range of industrial and residential/commercial uses all contribute to the projected growth in oil demand in the non-OECD countries. Many of the non-OECD countries where rapid economic growth is taking place do not have transmission and distribution infrastructures in place for natural gas to compete with oil in all areas where energy demand is increasing. Consequently, more incremental energy demand is met by oil in developing nations than in the OECD, where gas infrastructure has become widespread in most nations.

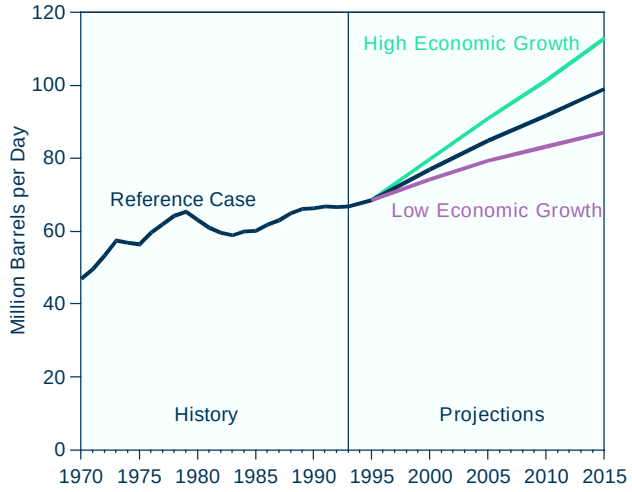
In the *IEO96* high and low economic growth cases, oil consumption worldwide could reach 113 million barrels per day or be as low as 87 million barrels per day (Figure 27). At present, there appears to be greater potential for oil demand growth to exceed the reference case projection than the reverse. Oil demand is highly income-elastic, especially in countries with underdeveloped personal transportation usage—including China and India, with 38 percent of the world's population. Although high growth rates in oil use are projected in the reference case, the rates are much lower than those experienced in the recent past by Asian countries that first emerged as rapidly growing economies (Taiwan, Thailand, and South Korea). If China and India were to match the oil demand growth rates seen recently in smaller Asian economies, the increment in oil demand over reference case levels could be 1.2 million barrels per day in 2005 and more than 20 million barrels per day in 2015.

Regional Variations in Demand Growth

For non-OECD Asia, in the reference case, oil consumption is expected to grow at an average rate of 4.4 percent per year from 1993 to 2015 (Figure 28). In the regions with less dramatic projections for economic growth (Middle East, Africa, and Central and South America), the growth rate for oil consumption is closer to 2 percent per year. Oil consumption in the EE/FSU nations is expected to resume positive growth by 1996, but the severe economic downturn this region has suffered, coupled with opportunities for significant technical advances leading to more efficient use, dampens net growth over the forecast period. The projected EE/FSU consumption level of 9 million barrels per day in 2015 is expected to exceed consumption in 1993 by about 2 million barrels per day, but it is still slightly below the 1990 level.

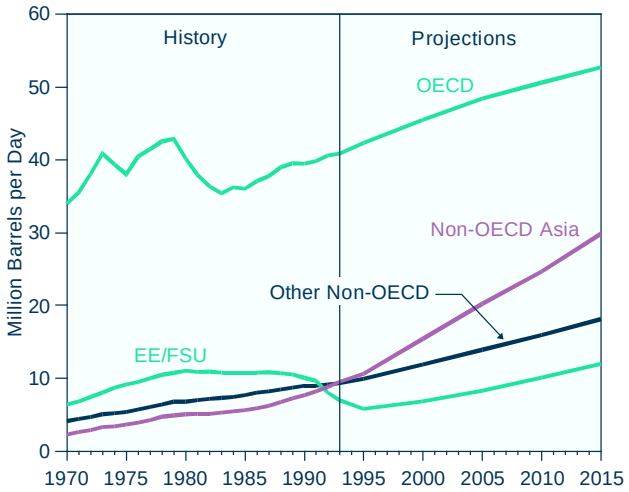
The projected increase in oil consumption by the OECD as a whole from 1993 to 2015 is 8.9 million barrels per day. Oil's share of total energy use is projected to increase in Australia and New Zealand, with oil consumption growing by 1.6 percent a year (Figure 29). In

Figure 27. World Oil Consumption, 1970-2015



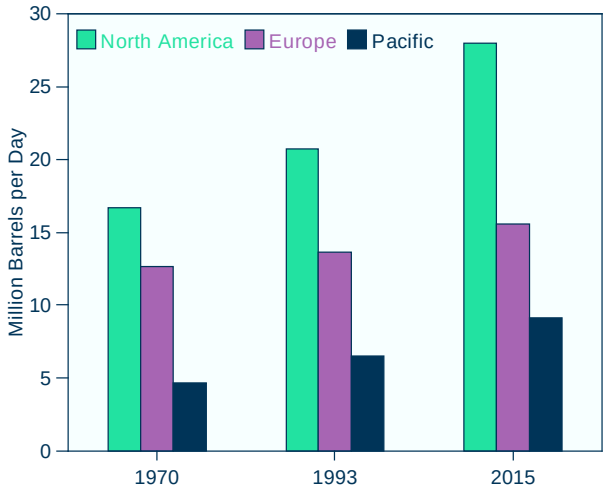
Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 28. World Oil Consumption by Region, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 29. OECD Oil Demand by Region, 1970, 1993, and 2015



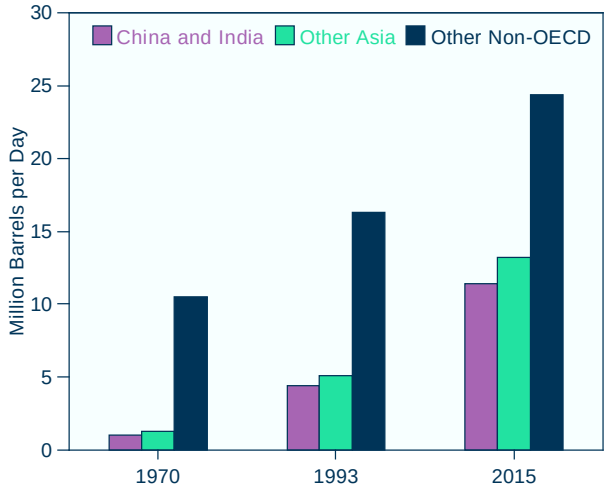
Sources: **1970:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. **1993:** EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **2015:** EIA, World Energy Projection System (1996).

the United States, oil's share remains unchanged at 39 percent between 1993 and 2015. And in the remainder of the OECD countries, oil's share falls substantially, dropping by 5 to 10 percentage points in most countries. Next to Australia and New Zealand, Mexico has the highest projected rate of growth for oil demand at 2.0 percent a year; however, other energy use is expected to grow even more rapidly, so that oil's share of Mexico's total energy consumption declines from 72 percent in 1993 to 58 percent in 2015. Japan also has a higher growth rate for oil consumption than most OECD nations, averaging 1.3 percent a year, but oil's share of total energy consumption also decreases there, from 57 percent in 1993 to 52 percent in 2015. Lacking indigenous energy resources, Japan remains dependent on imports to meet its oil needs and is expected to continue diversifying its energy resource base to reduce its dependence on a particular fuel or supplier.

In the rest of the OECD, oil consumption grows at a much slower rate. Growth in OECD Europe averages only 0.4 percent per year, growing from 13.6 to 14.9 million barrels per day over the projection period. In this region oil continues to be displaced in space heating and power generation and to lose market share to natural gas and electricity in many industrial energy uses. This trend is further accentuated by the decline in energy-intensive industries and the growth in service industries, which are more likely to use natural gas and electricity than oil.

Over the projection period, non-OECD Asia will become a dominant force on the demand side of the world oil market (Figure 30). By the year 2000, the region's oil demand is expected to average nearly 0.3 million barrels per day more than average daily consumption in OECD Europe. By 2010 the region's demand of 21 million barrels per day is expected to surpass consumption in the United States. In 2015, non-OECD Asia's share of world oil consumption is expected to be nearly twice what it was in 1993.

Figure 30. Non-OECD Oil Demand by Region, 1970, 1993, and 2015



Sources: **1970:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. **1993:** EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **2015:** EIA, World Energy Projection System (1996).

There is a sizeable difference between China and India and the other non-OECD Asia countries in their dependence upon oil. In 1993, oil accounted for 21 percent of China's total energy consumption and 30 percent of India's. Those shares are not projected to change much over the projection period. On the other hand, the remaining non-OECD Asian countries (of which Indonesia, Malaysia, South Korea, and Thailand are the major energy consumers) are much more dependent on oil, which claimed a 55-percent share of their total energy consumption in 1993 and is expected to reach 60 percent in 2015. A significant factor contributing to higher reliance on oil use in these countries is the rapid growth in road transportation, especially for personal transportation.

The transportation sector in both China and India is currently dominated by rail, using coal-fired engines [**1**]. Both countries are switching to diesel or electric

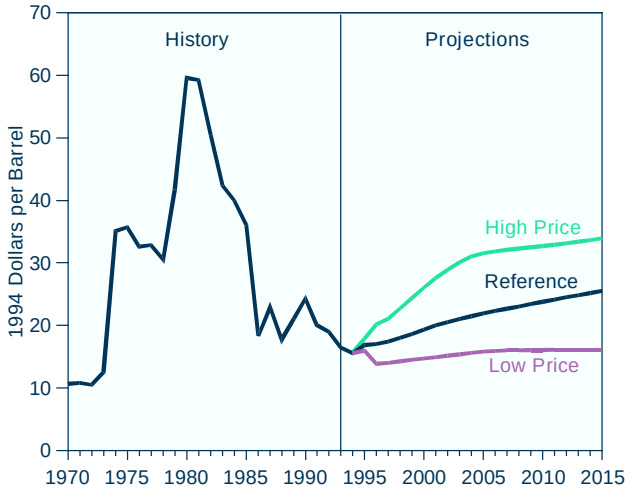
engines, which will lead to some increase in the demand for oil. More importantly, road transportation in both countries is limited, both for freight hauling and for personal travel, and is likely to develop rapidly in the future. The increase in demand for motor fuels will lead to an increase in the use of lighter petroleum products in both countries. China's economy over the projection period is assumed to grow at an average rate of 7.7 percent a year, and its oil consumption is expected to grow by 4.5 percent a year, with oil consumption nearly tripling. In 2015, China's oil consumption is expected to approach 40 percent of U.S. consumption and 55 percent of OECD Europe's.

World Oil Price Projections

As noted earlier, the oil price projections included in the *IEO96* reference case indicate a rise in oil prices over the projection period from about $16 to $25 per barrel between 1995 and 2015 (Figure 31). In the low and high oil price cases, the price in 2015 could be as low as $16 or as high as $34 per barrel. Despite a 40-percent increase in total world daily consumption over the forecast period, no significant escalation in world oil prices is expected. Moreover, this *IEO* projects lower prices for oil through 2010 than did *IEO95*, despite higher consumption projections for 2010 and for most of the preceding years.

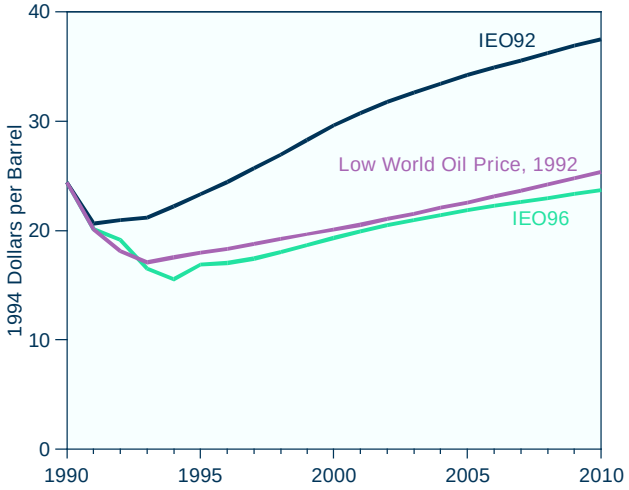
Over the past several years, oil price expectations have been scaled back drastically. As recently as 1992, the reference case oil price forecast for the *IEO*—and for most other forecasts—was in the neighborhood of $40 per barrel for 2010. The current reference case projections track what was presented as the low price case for typical forecasts in 1992 (Figure 32). The low price case for *IEO96*—around $16 per barrel through the forecast period—is the current base case for some other forecasts.

Figure 31. World Oil Prices in Three Oil Price Cases, 1970-2015



Sources: **History:** Energy Information Administration (EIA), *Annual Energy Review 1994*, DOE/EIA-0384(94) (Washington, DC, July 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996).

Figure 32. Comparison of Oil Price Projections, 1990-2010



Sources: ***IEO92*:** Energy Information Administration (EIA), *International Energy Outlook 1992*, DOE/EIA-0484(92) (Washington, DC, April 1992). ***IEO96*:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996).

Typical investment decisions by petroleum companies currently engaged in oil exploration and development are undertaken with the assumption that oil prices will not rise in real terms in the foreseeable future. Despite this price outlook, investment is rising and oil production capabilities are expanding in many parts of the world, including the United States. Even in an environment which appears to present limited prospects for improved prices, profit expectations are growing, fueled in part by growing demand, but fueled even more importantly by opportunities for economical expansion of output.

The potential for expanded oil production has been vastly enlarged by the development of new technologies to identify and develop producible oil reserves, even in geologically and operationally hostile areas. This potential also applies to difficult horizons and to producing areas formerly considered to be near depletion. In addition, government policies in many areas of the world have been modified to encourage investment in oil production. Taxes, royalties, or profit-sharing arrangements have been changed to profit margins for investment in areas such as South America, the North

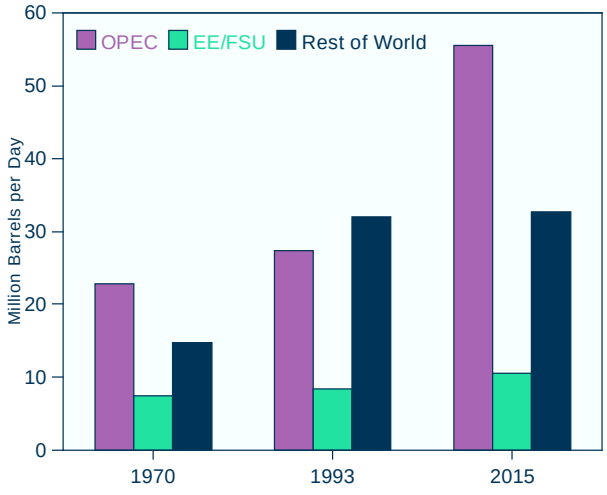
Sea, Nigeria, Indonesia, and Australia. Moreover, investment opportunities now exist in parts of the former Soviet Union and in some OPEC member countries where for decades private investment was excluded.

As a consequence, while oil demand has risen in recent years, new technology and additional discoveries have led to a stable or slightly increasing level of production in non-OPEC areas (Figure 33). This trend is expected to continue through 2015, as the range of application of new technologies is extended to old producing areas and to new areas which, through discovery or through the modification of host countries' oil investment policies, now offer new opportunities for private investment. It is now generally agreed that there is substantial potential for further expansion of non-OPEC production that is at least sufficient to offset declines from old producing areas. Although Persian Gulf nations alone have sufficient reserves to meet the expected increases in demand through 2015, to gain that market they must compete with a substantial range of potential competition. Consequently, the outlook for the international oil market over the next 20 years is one with sufficient sources of supply to meet anticipated growth in demand with only moderate growth in—or potentially stable—world oil prices.

Production Assumptions for the World Oil Price Cases

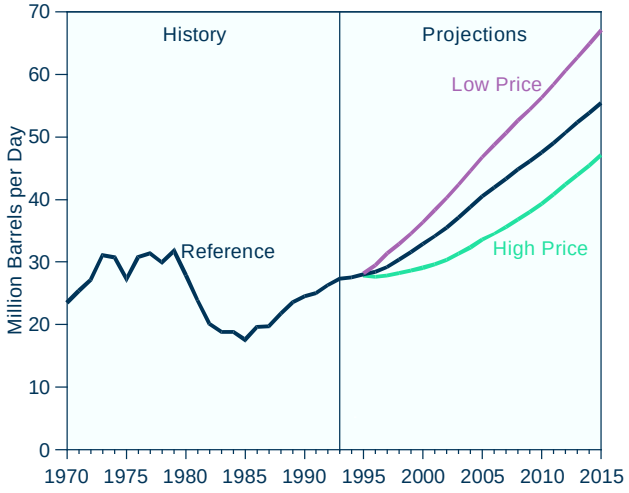
Three alternative paths for world oil prices are considered in this report. The three price paths result from three different sets of assumptions about production rates for OPEC and for EE/FSU producers (Figure 34 and Table 10). The *low oil price case* uses optimistic production rates from OPEC and the FSU, while the *high oil price case* uses pessimistic production rates. These are the only assumptions made in generating the three price paths. Non-OPEC production and oil consumption vary across the three cases as a result of the different prices, but the changes are a consequence of the different prices and are not part of the assumptions made to generate the three price cases.

Figure 33. World Oil Production by Region, 1970, 1993, and 2015



Sources: **1970:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. **1993:** EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **2015:** EIA, World Energy Projection System (1996).

Figure 34. OPEC Oil Production in Three Oil Price Cases, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Table 10. OPEC Oil Production, 1990-2015
(Million Barrels per Day)

Year	Reference Case	High Oil Price	Low Oil Price
History			
1990	24.8	—	—
Projections			
1995	28.0	27.8	28.1
2000	32.8	29.0	36.4
2005	40.5	33.5	46.8
2010	47.5	39.3	56.3
2015	55.5	47.1	67.1

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

Sources: **History:** Energy Information Administration (EIA), *International Petroleum Statistics Report*, DOE/EIA-0520(96/02) (Washington, DC, February 1996), Table 4.4. **Projections:** EIA, World Energy Projection System (1996).

OPEC oil production is expected to grow significantly in the future, and all three *IEO96* price cases assume that Persian Gulf producers will substantially expand their production (Table 10). In the reference case, OPEC production in 2015 is assumed to be 56 million barrels per day, more than twice its 1990 level. The assumed OPEC production levels in 2015 are about 8 million barrels per day lower in the high price case (47.1 million barrels per day) and about 12 million barrels per day higher in the low price case (67.1 million barrels per day).

The low price case assumes that OPEC production will be near the maximum feasible, as a result of competition among producers for market share and aggressive development to bring additional reserves into production. The high price case assumes lower production levels, which could be brought about by a combination of slower development of production capabilities and production further below capacity than is assumed in the reference case. The variations in non-OPEC production between the high and low price cases result from the responses of non-OPEC producers to the different price levels, as well as variations in such assumptions as the number of exploration wells, finding rates, reserve-to-production ratios, and advances in extraction technology (Table 11).

Table 11. Non-OPEC Oil Production, 1990-2015
(Million Barrels per Day)

Year	Reference Case	Low Oil Price	High Oil Price
History			
1990	41.9	—	—
Projections			
1995	41.7	41.7	41.8
2000	43.7	42.5	45.0
2005	43.9	41.8	46.5
2010	43.8	40.9	46.7
2015	43.1	39.6	45.9

Note: Includes the production of crude oil, natural gas plant liquids, refinery gain, and other liquid fuels.
Sources: **History:** Energy Information Administration (EIA), *International Petroleum Statistics Report*, DOE/EIA-0520(96/02) (Washington, DC, February 1996), Table 4.4. **Projections:** EIA, World Energy Projection System (1996).

With the wide disparity between OPEC and non-OPEC reserve-to-production ratios, it is logical to assume that most production capacity expansion in the mid- to long term will be in the OPEC member nations, especially those in the Persian Gulf region. In fact, a compilation of official plans and announcements by OPEC member nations indicates additions to OPEC crude oil production capacity of at least 10 million barrels per day by the turn of the century [**2**]. Such plans are consistent with the anticipated vigorous growth in oil demand, especially in the newly industrialized countries of the Pacific Rim region.

Other Views of Prices and Production

Table 12 presents price projections alternate to *IEO96* prepared by other oil market analysts. Among these forecasts, the *IEO96* price expectations are toward the high side of a very broad range. The 2005 price estimates range from $14.64 per barrel (PEL) to $28.59 (IEA), with *IEO96* at $21.86. For 2010, the range is $12.32 (PEL) to $28.59 (IEA), with *IEO96* at $23.70. For 2015, *IEO96* is slightly above $25, DRI is just below, and GRI, which has assumed constant prices in real terms, is at $16.17.

A major factor conditioning alternate views on oil prices is the expected composition of world oil production. At issue in particular is the expected strength of production expansion within OPEC areas. Also of concern is the timing of production recovery in the former Soviet Union. There is general agreement among the forecasts that production from the EE/FSU will remain in the neighborhood of 10 percent of world production (Table 13). The expectations regarding the split between OPEC producers and the rest of the world excluding EE/FSU vary much more. *IEO96* has the highest estimate for the OPEC share, growing from 48 percent in 2005 to 56 percent in 2015. Forecasts that are more bullish for non-OPEC producers include NERA and PIRA, which have the OPEC share at 35 and 36 percent, respectively, in 2005. For 2010 and beyond, the other forecasts have the OPEC share remaining just below 50 percent. In general, the more bullish analysts are with regard to non-OPEC supply development, the lower their price expectations are.

Worldwide Reserves and Ultimately Recoverable Oil

In the late 1980s, more than 350 billion barrels of crude oil reserves were added worldwide. The additions were made predominantly by the OPEC nations (almost 94 percent of the total). It might be natural to assume that such dramatic increases in OPEC crude oil reserves would be accompanied by commensurate increases in OPEC crude oil production. Such has not been the case. Although OPEC crude oil production has been increasing steadily since the mid-1980s, crude oil production from non-OPEC suppliers has shown surprising resilience over the past two decades, increasing by more than two-thirds. In fact, the long-term outlook for non-

Table 12. Comparison of World Oil Price Projections, 1995-2015
(1994 Dollars per Barrel)

Year	IEO96	IEA	PEL	PIRA	DRI	GRI	WEFA	NWS	NERA
1995	16.81	—	16.41	17.73	16.46	—	17.22	18.03	16.89
2000	19.27	23.48	14.66	14.66	16.82	16.17	19.61	19.52	21.60
2005	21.86	28.59	14.64	15.37	20.83	16.17	21.30	—	27.10
2010	23.70	28.59	12.32	—	23.22	16.17	22.06	—	21.49
2015	25.43	—	—	—	24.79	16.17	—	—	18.53

Notes: PEL projections are for Brent crude oil. NWS projections are for West Texas Intermediate crude oil spot prices. PIRA projections are for West Texas Intermediate crude oil at Cushing. *IEO96* projections are for average landed imports to the United States. DRI, GRI, and WEFA projections are for composite prices. NERA projections are for U.S. refiners' acquisition cost.

Sources: ***IEO96*:** Energy Information Administration, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table 3. **IEA:** International Energy Agency, *World Energy Outlook* (Paris, France, April 1995), Capacity Constraints Case, p. 295. **PEL:** Petroleum Economics, Ltd., *Oil and Energy Outlook to 2010* (London, United Kingdom, December 1995). **PIRA:** Petroleum Industry Research Associates, Inc., *Annual Retainer Client Seminar—World and U.S. Oil* (New York, NY, October 1995). **DRI:** DRI/McGraw Hill, *Oil Market Outlook: Special Issue* (Lexington, MA, October 1995), p. 40. **GRI:** Gas Research Institute, *Draft of the GRI Baseline Projection of the U.S. Energy Supply and Demand*, 1995 Edition (Washington, DC, October 1995). **WEFA:** The WEFA Group, *U.S. Long-Term Economic Outlook*, Volume 1 (Bala Cynwyd, PA, Fourth Quarter 1995), pp. 5.92-5.93. **NWS:** NatWest Securities, Ltd., *Strategic Assessment, Major Oils Identifying Value from a Global Perspective* (London, United Kingdom, September 1995). **NERA:** National Economic Research Associates, Inc., *NERA Energy Outlook* (White Plains, NY, February 1996), Table 2.

OPEC supply has become increasingly optimistic even in the face of lower world oil prices. Figure 35 shows the estimates for non-OPEC production for the year 2010 from six consecutive editions of the *International Energy Outlook*. After adjusting for differences in the world oil price forecast (all production paths were normalized to the *IEO96* reference case price path), there is a difference of almost 10 million barrels per day between the *IEO90* forecast for non-OPEC production (33.7 million barrels per day) and the *IEO96* projection (43.6 million barrels per day).

What accounts for this evolving optimism regarding non-OPEC supply potential? New exploration and production technologies, aggressive cost-reduction programs by industry, and attractive fiscal terms to producers by governments all have contributed to the steady increase in non-OPEC oil production. Although forecasters have long been predicting a precipitous decline of non-OPEC oil supplies, there is reason to be optimistic that such production will continue to be vigorous well into the next century. Table 14 shows estimates of worldwide proven crude oil reserves and a forecast range of undiscovered conventional crude oil. Also shown is an estimate of ultimately recoverable resources, which is derived from the sum of cumulative production, undiscovered conventional crude oil (modal value), and identified reserves (assuming current technology and prices). Cumulative production is also included, to give a sense of that portion of ultimately recoverable resources that has already been produced. OPEC producers, led by those in the Persian Gulf region, obviously enjoy an enormous advantage in proven reserves over non-OPEC producers. However, the U.S. Geological Survey estimates that of the more than 450 billion barrels of undiscovered conventional crude oil that would most likely be recoverable assuming current economic and technological conditions, about two-thirds of that oil would come from non-OPEC producers [**3**]. In this context one may conclude that OPEC could potentially remain at less than a 50-percent share of worldwide production even in the face of strong demand growth for at least the first two decades of the next century.

OPEC Production Capacity Expansion

The *IEO96* price projections assume that the OPEC countries with large reserves that can be exploited at relatively low cost will have the greatest influence on future oil market conditions. It is assumed that OPEC nations will pursue policies—and that investment capital will be available—to expand production capacity as necessary to meet growing demand.

In the *IEO96* reference case, the production call on OPEC producers grows at a robust annual rate of 3.5 percent. When compared with the estimates in last year's *International Energy Outlook*, OPEC production in *IEO96* is 1.1 million barrels per day lower than *IEO95* in the year 2000, equivalent in 2005, and 900,000 barrels

Table 13. Comparison of World Oil Production Forecasts

(Percent of World Total)

Forecast	OPEC	EE/FSU	Other
History			
1993	40	12	48
Projections			
1995			
IEO96	40	10	49
PEL	42	9	50
PIRA	36	11	53
DRI	39	10	51
NERA	42	9	51
2005			
IEO96	48	10	42
PEL	45	11	43
PIRA	36	13	51
DRI	48	11	41
NERA	35	11	54
2010			
IEO96	52	11	37
IEA	49	11	40
PEL	48	12	40
DRI	49	11	41
2015			
IEO96	56	11	33
DRI	49	10	41

Note: Percentages may not add to 100 due to independent rounding.

Sources: ***IEO96***: Energy Information Administration, World Energy Projection System (1996). **IEA:** International Energy Agency, *World Energy Outlook* (Paris, France, April 1995), Capacity Constraints Case, p. 295. **PEL:** Petroleum Economics, Ltd., *Oil and Energy Outlook to 2010* (London, United Kingdom, December 1995). **PIRA:** Petroleum Industry Research Associates, Inc., *Annual Retainer Client Seminar—World and U.S. Oil* (New York, NY, October 1995). **DRI:** DRI/McGraw Hill, *Oil Market Outlook: Special Issue* (Lexington, MA, October 1995), p. 40. **NERA:** National Economic Research Associates, Inc., *NERA Energy Outlook* (White Plains, NY, February 1996), Table 2.

per day higher in 2010. By 2015, the *IEO96* production estimate for OPEC exceeds 55 million barrels per day. This outlook assumes that Iraq will resume exports in 1997 and will gradually build up its output to almost 3 million barrels per day by the year 2000.

The return of Iraq's production to the international oil supply market marks a period—out to the end of this decade—in which OPEC capacity utilization will not exceed 85 percent. In the aftermath of the Persian Gulf War, OPEC capacity utilization remained above 85 percent through 1995, with rates above 91 percent in 1991 and 1992. With the expected growth in demand, especially in the developing countries of Asia, OPEC capacity utilization is expected to exceed 85 percent after 2000

Figure 35. Comparison of Non-OPEC Oil Production Projections, 2010

Sources: ***IEO90, 91, 92, 94, 95***: Energy Information Administration (EIA), *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years). ***IEO96***: EIA, World Energy Projection System (1996).

and remain there for the duration of the forecast period. Official plans and announcements by OPEC producers indicate that their total liquids capacity by the year 2000 could exceed 38 million barrels per day.

Given the production capacity expansion requirements for OPEC inherent in the *IEO96* estimates, much attention has been focused on the oil development, production, and operating costs of individual OPEC producers. The reserve-to-production ratio of Persian Gulf OPEC producers currently exceeds 80 years, implying that the adequacy of the reserves base to support significant capacity expansion should not be an issue. But what can be said regarding the economies of production capacity expansion estimates, given the alternative world oil price projections included in *IEO96*?

The cost to produce a barrel of oil in Persian Gulf OPEC nations ranges between $0.99 and $1.49 per barrel, depending on field size [**4**]. The capital investment required to increase production capacity by 1 barrel per day in Persian Gulf OPEC nations ranges between $2,515 and $4,866, depending on field size. Assuming a world oil price of $16 per barrel and mid-size fields only, total development and operating costs over the entire forecast period expressed as a percentage of gross revenues range only between 10 and 15 percent. At least for the Persian Gulf OPEC producers, the total cost of the projected capacity expansion is a relatively small percentage of the gross revenue even in the low price case. The production capacity estimates in *IEO96* assume that investment funds exist and will be borrowed, or that foreign companies will be allowed to acquire an equity position.

Table 14. Estimated Undiscovered and Ultimately Recoverable Conventional Oil Resources as of January 1, 1993
(Billion Barrels)

Region	Undiscovered Oil			Cumulative Production	Identified Reserves	Ultimate Resources
	Low Estimate	Most Likely	High Estimate			
OPEC	**95.3**	**152.0**	**319.8**	**282.9**	**706.4**	**1,141.3**
Persian Gulf	74.2	116.4	232.0	177.0	583.0	876.4
Other	21.1	35.6	87.8	105.9	123.4	264.9
Non-OPEC	**196.9**	**318.7**	**685.4**	**415.7**	**396.8**	**1,131.2**
OECD	68.4	108.3	223.9	225.4	156.4	490.1
Eurasia	77.5	132.1	330.6	142.3	163.7	438.1
Rest of World	51.0	78.3	130.9	48.0	76.7	203.0
Total World	**292.2**	**470.7**	**1,005.2**	**698.6**	**1,103.2**	**2,272.5**

Notes: Identified reserves are the nominal sum of proved, probable, and possible reserves, or some major part thereof. Ultimate resources = cumulative production + identified reserves + undiscovered oil (most likely).

Source: C. Masters, E. Attanasi, and D. Root (U.S. Geological Survey), "World Petroleum Assessment and Analysis," *Proceedings of the Fourteenth World Petroleum Congress* (John Wiley and Sons, New York, 1994).

For OPEC producers outside the Persian Gulf, the cost to expand production capacity by 1 barrel per day is considerably greater, ranging from $7,610 (Indonesia) to $10,240 (Venezuela) [**5**]. Yet even this group of producers in the low price case can expect margins in excess of 50 percent on investments to expand production capacity over the long term. Of the non-Persian Gulf OPEC producers, Venezuela has the greatest capacity expansion potential and has already announced plans to expand capacity to nearly 4 million barrels per day by 2005. Tables A34-A37 in Appendix A present the ranges of production potential for both OPEC and non-OPEC producers.

Non-OPEC Oil Production in the Reference Case

The growth in non-OPEC oil supply has played a significant role in the erosion of OPEC's market share over the past two decades. Moreover, the non-OPEC oil supply has become increasingly diverse. North America dominated non-OPEC supply in the early 1970s, the North Sea and Mexico evolved as major producers into the 1980s, and much of the new production in the 1990s has come from the developing countries.

In the *IEO96* reference case, world petroleum demand rises at an annual average rate of 1.5 million barrels per day over the forecast period. Although OPEC is expected to benefit most from the projected growth in oil demand, there will be significant competition from a diverse range of non-OPEC suppliers that have shown surprising resilience even in the current low price environment. While U.S. exploration and development activity has dropped dramatically over the past decade, its production and its reserve availability have not fallen proportionately. For example, EIA's *Annual Energy Outlook* for 1996, published in January of this year, projects U.S. oil output in 2010 that is 1.5 million barrels per day higher, with 40 percent lower prices, than those projected in the 1992 *Annual Energy Outlook* [**6**]. At the same time, even with lower prices, exploration activity in some of the developing countries has actually expanded. In the *IEO96* reference case, non-OPEC supply is expected to remain virtually flat (ranging between 41.0 and 41.5 million barrels per day) out to 2010, with a decline of only 1 million barrels per day coming near the end of the projection period.

When the *IEO96* production profiles are compared with those in the *International Energy Outlook 1995*, several important differences emerge:

- U.S. production does not decline as severely in the *IEO96* projections, and the production recovery near the end of the forecast period is more robust, actually returning to about current production levels as a result of technological progress that has expanded the economically recoverable resource base.
- North Sea production peaks later in *IEO96* and does not decline as rapidly, due to a combination of several large new fields, enhanced subsea technology, and improved fiscal management.
- Oil production in the former Soviet Union does not rebound as quickly in *IEO96*, as a result of both physical problems (declining flow rates and under-

utilized or outmoded technology) and institutional factors (bureaucratic impediments to joint ventures, law and taxation constraints on investing, and idle production resulting from lack of capital).

- The production outlook for the developing countries, particularly those of Latin America and Asia, is more optimistic in *IEO96*, due to a combination of increased drilling, technology dissemination, and improved fiscal environments.

The net effect of these differences is that the *IEO96* non-OPEC production estimates are equivalent to the comparable *IEO95* estimates, even though the expected prices are somewhat lower. The reference case estimate for the year 2010 is 1.3 million barrels per day lower in *IEO96* than it was in *IEO95*, but the difference is largely attributable to the *IEO96* assumption that the production turnaround for the former Soviet Union will be delayed: resource availability in the area is great, but the politics to support economic investment remain highly uncertain.

In the *IEO96* forecast, North Sea production peaks in 1997 at almost 6.4 million barrels per day. Production from Norway, Western Europe's largest producer, is expected to peak at about 3.3 million barrels per day in 1997 and then gradually decline to about 2.2 million barrels per day by the end of the forecast period, as some of its larger and older fields mature. The United Kingdom sector of the North Sea is expected to produce about 2.8 million barrels per day for the remainder of this decade, followed by a decline of about 1 million barrels per day by the end of the forecast period. Recent discoveries, however, especially in the United Kingdom sector, indicate the possible availability of significant untapped potential.

Two non-OPEC Persian Gulf producers are expected to show production increases at least to the end of this decade. In Oman, enhanced recovery techniques are expected to increase current output by almost 150,000 barrels per day. And assuming that the recent civil strife in Yemen remains dormant, current oil production could increase by more than 200,000 barrels per day early in the next century. Syria is expected to hold output at its current level for the remainder of this decade, with production declining thereafter.

Far Eastern producers are beginning to explore and develop what appears to be a promising potential for oil production, which could reap benefits well into the next century. Assuming no barriers for foreign investment, India is expected to increase its current output steadily to about 900,000 barrels per day by 2015. Deepwater fields offshore from the Philippines could produce about 250,000 barrels per day by the turn of the century. There appears to be enough long-term production potential in Vietnam for output to reach 500,000 barrels per day by the end of the forecast period. Australia will have a near-term increase that peaks at

Former Soviet Union Oil Production and Export Potential

During the 1980s, oil production in the former Soviet Union (FSU) consistently averaged around 12 million barrels per day. In each year of this decade, however, there have been severe declines in FSU oil production, largely because of the economic problems of the post-Communist era. Data for 1995 suggest that the downward trend may have ended at a low point of about 7 million barrels per day. A gradual recovery is expected over the remainder of the decade, but no significant production gains are anticipated before the turn of the century.

Currently, in the upstream segment of the FSU oil industry, flow rates at producing wells are down, and many idle wells are flooded. Rig technology is often outmoded, and fairly common extraction techniques such as gas injection are underutilized. According to World Bank estimates [**7**], an investment of about $8 billion per year would be needed to return FSU oil production to its 1991 volume of just over 10 million barrels per day by the year 2000. Given the current political and economic uncertainty in the FSU, it is unlikely that such investment levels can be achieved.

The energy sector in the FSU now operates on a viable economic basis, but profit levels are low. There is still a widespread perception among consumers that the energy utilities are state-subsidized monopolies obligated to maintain supply, and many customers, both corporate and individual, do not pay their oil bills. As a result, the oil industry suffers a chronic shortage of capital for investment.

The export market is currently the most profitable arena for the FSU oil industry. Three new export facilities now under active consideration would make the promising fields in the northeast sector of European Russia available to the world market, and full deregulation of oil exports appears to be imminent. These developments would contribute substantially to renewed confidence—and investment—in the FSU oil sector. In the past, the region's inconsistent regulatory

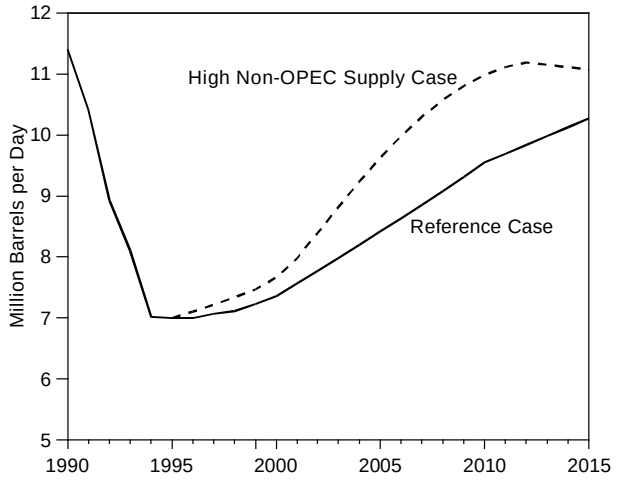
and legislative environment has constrained the development of joint ventures.

The long-term outlook for FSU oil production is more optimistic. Proven reserves exceed 125 billion barrels, and a recent assessment of world petroleum by the U.S. Geological Survey [**3**] postulates an additional 100 billion barrels of undiscovered oil in the FSU whose discovery and development are considered likely under current economic and technological conditions. Thus, ultimately recoverable oil resources in the FSU region could total at least 340 billion barrels. Only Saudi Arabia, with estimates in excess of 374 billion barrels, can boast a greater potential for ultimately recoverable oil.

As described on pages 32 and 33, the *IEO96* projections include a high non-OPEC oil supply case, based on assumptions that are somewhat more optimistic than the reference case with regard to technology gains, economically recoverable resources, and institutional constraints on oil production throughout the world. The two figures below show projected FSU oil production and export potential in the reference case and the high non-OPEC supply case.

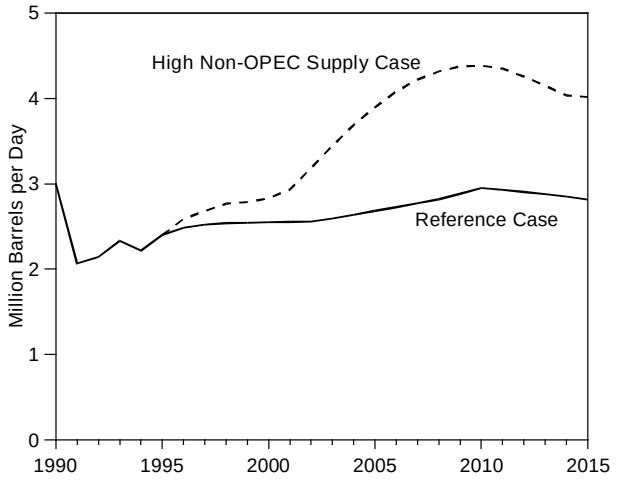
In the reference case, oil production in the FSU is projected to exceed 8.4 million barrels per day in 2005 and to reach 10.4 million barrels per day by 2015. In the high non-OPEC supply case, FSU production levels reach 10 million barrels per day in 2006 and 11 million barrels per day in 2010. In the reference case, net exports of oil from the FSU remain between 2 and 3 million barrels per day throughout the forecast. In the high non-OPEC supply case, they surpass 3 million barrels per day in 2002 and rise above 4 million barrels per day in 2006.

FSU Oil Production Potential in Two Cases, 1990-2015



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

FSU Oil Export Potential in Two Cases, 1990-2015



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

more than 650,000 barrels per day by 1997, but production declines are expected to be rather severe beyond the year 2000 unless current offshore exploration pays some dividends. Malaysia's production activity comes mostly from mature fields that are in decline. Preliminary seismic exploration and test wells indicate some production potential for Bangladesh and Mongolia, but it is unlikely that output would be realized until the turn of the century.

In Central and South America, Colombia—which continues to encourage significant multinational investment—is expected to at least double its current output by 2000. By the turn of the century, both Brazil and Colombia are expected to join the relatively short list of producers whose output exceeds 1 million barrels per day. Brazil has vast untapped production potential; and given no government impediments to foreign investment, it could approach 2 million barrels per day of

output by the end of the forecast period. Argentina is expected to raise current production levels by up to 150,000 barrels per day by the end of this decade. Former OPEC member Ecuador is expected to increase its production capacity to allow an additional 200,000 barrels per day in output.

A few non-OPEC producers in Africa are expected to show modest increases out to the end of the decade. Angola, Congo, and Tunisia, combined, will account for about 200,000 barrels per day of additional output by the year 2000. The absence of significant discoveries, coupled with normal declines from mature fields, has Egypt's production falling by almost 150,000 barrels per day by the end of the decade. Two new African producers, Chad and the Sudan, are expected to bring a combined 500,000 barrels per day of output on line by the turn of the century. The Ivory Coast, Equatorial Guinea, Somalia, and South Africa have some production potential, but they are unlikely to begin production before 2000.

Due mainly to the decline in U.S. production, North American output will show steady decline into the early years of the next century. Canada's output should increase modestly over current levels, declining only slightly by the end of the forecast period. Offshore discoveries in the Gulf of Mexico, incremental Alaskan production from Cook Inlet, and technological advances in extraction methods reverse the downward trend in U.S. production for the remainder of the forecast period. By 2015, U.S. production is expected to return to current production levels. Mexico is expected increasingly to make concessions that will encourage foreign investment in its oil sector, resulting in a much-needed infusion of capital and leading to more efficient use of its vast resource base. Production volumes in Mexico are expected to reach 3.5 million barrels per day by 2005 and could increase by another 300,000 barrels per day by 2015.

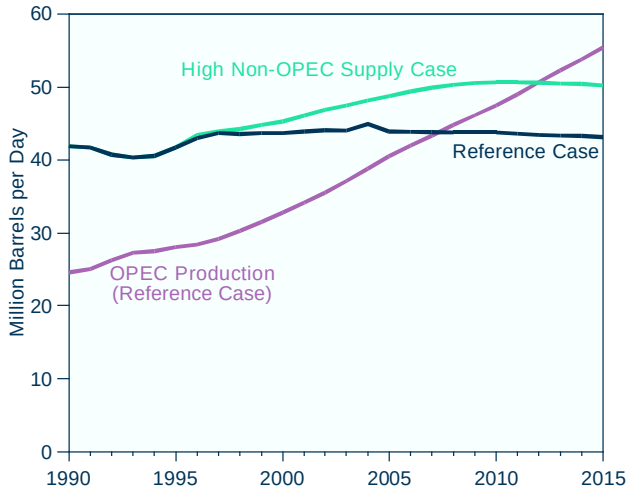
The estimates for non-OPEC production potential presented in this outlook are based on such parameters as the number of exploration wells, finding rates, reserve-to-production ratios, advances in extraction technology, and the world oil price. By the end of the projection period, the range of non-OPEC supply varies between 38.5 million barrels per day and 47.2 million barrels per day. Tables A34-A36 in Appendix A present the ranges of production potential for both OPEC and non-OPEC producers.

The High Non-OPEC Supply Case

As noted above, world oil market forecasts in the past have been notable for their persistent underestimation of oil production by non-OPEC nations. The three world oil price cases considered here present three alternative paths for non-OPEC production resulting from the three different price paths. A range of estimates for non-OPEC production potential is presented in Tables A34-A37 in Appendix A, reflecting different assumptions about the number of exploration wells, finding rates, and so on. The range shown for non-OPEC production potential probably is conservative, in that it does not incorporate incremental production that could result from the development of currently undiscovered oil that is thought to exist (Table 14). A fourth view of future non-OPEC production is provided by assuming that a portion of the undiscovered oil in non-OPEC nations will be developed and produced over the forecast period.

Figure 36 compares OPEC and non-OPEC production estimates over the forecast period for the reference case and for a *high non-OPEC supply case*. The high non-OPEC supply case was developed from the following assumptions:

Figure 36. Non-OPEC Oil Production in Two Cases, 1990-2015

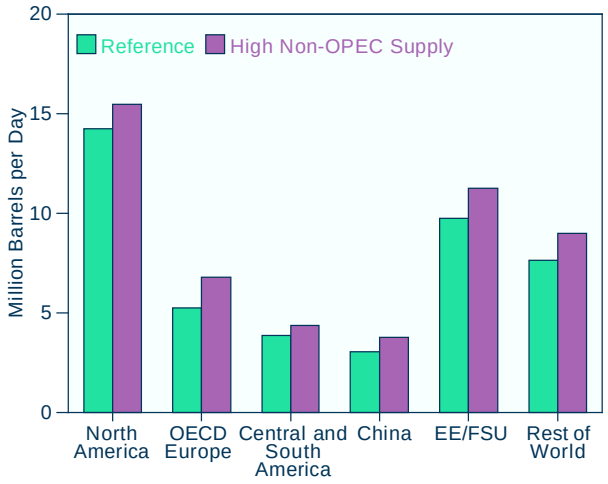


Sources: **History:** 1970-1979: Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

- World oil prices were the same as those in the reference case.
- U.S. production was the same as in the reference case.
- One-third of the world's undiscovered oil was considered economical to develop over the forecast period.
- Technology improvements over the forecast period were assumed to be transferrable worldwide.
- It was assumed that no institutional barriers would constrain production.
- A reserve-to-production ratio of 15 years (slightly less than the current non-OPEC ratio) was used as a lower bound for production estimates.

These assumptions result in 0.7-percent annual growth of non-OPEC production over the forecast period, compared with slightly declining growth in the reference case. Non-OPEC production reaches a peak of 47.4 million barrels per day in the high case, compared with a high of only 41.5 million barrels per day in the reference case. Figure 37 compares peak production levels for the six non-OPEC nations whose volumes increased the most in the high case with the corresponding peak levels in the reference case.

Figure 37. Non-OPEC Oil Production in Two Cases by Region, 2010



Source: Energy Information Administration, World Energy Projection System (1996).

In the reference case, OPEC production peaks at 57.5 million barrels per day, and the OPEC share of worldwide production begins to exceed that of non-OPEC suppliers in 2005. In the high non-OPEC supply case, OPEC production peaks at 50.6 million barrels per day, and OPEC is delayed from regaining the majority market share until 2013. A somewhat conservative estimate of ultimate recoverable resources was used in the high non-OPEC supply case; on the other hand, if *more* than one-third of the undiscovered oil in non-OPEC countries were economically recoverable, it is conceivable that OPEC might never again produce more than one-half of the world's oil.

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3. C. Masters, E. Attanasi, and D. Root (U.S. Geological Survey). "World Petroleum Assessment and Analysis" *Proceedings of the Fourteenth World Petroleum Congress* (New York, NY: John Wiley and Sons, 1994).
4. Energy Information Administration. *Oil Production Capacity Expansion Costs for the Persian Gulf*. DOE/EIA-TR/0606. Washington, DC, February 1996.
5. DRI/McGraw-Hill. *Oil Market Outlook*. Lexington, MA, July 1995. Table 1, p. 10.
6. Energy Information Administration. *Annual Energy Outlook 1996*. DOE/EIA-0383(96) (Washington, DC, January 1996). Table 14, p. 41.
7. R. Gränzer. "Energy in Russia." *The OECD Observer*. No. 192. February/March 1995. p. 28.

Natural Gas

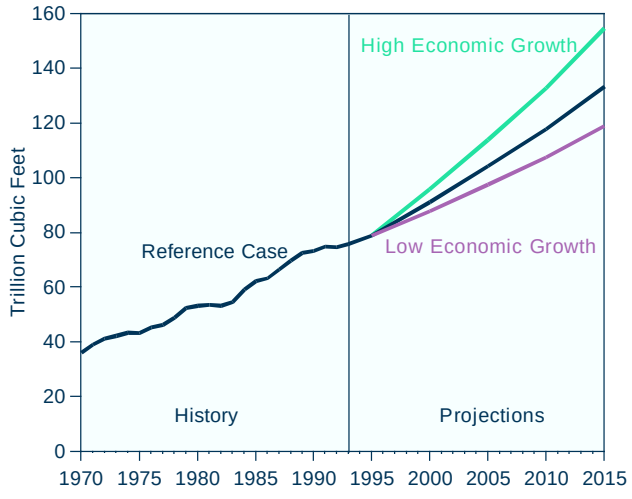
Natural gas is the cleanest of the fossil fuels, and reserves are abundant. Environmental considerations and technological advances in gas-fired electricity generation are making it the fastest-growing fossil fuel worldwide.

Natural gas remains the fastest-growing fossil fuel worldwide, and strong growth in gas demand is projected through the end of the forecast period. There are several reasons for this optimism. Natural gas is the cleanest of the fossil fuels, and many countries are increasing their use of natural gas resources because of environmental concerns. It is an attractive alternative fuel for industrialized OECD countries concerned about reducing greenhouse gas emissions. It is also an increasingly popular choice for countries building new electric generating facilities. Natural-gas-fired plants often require lower capital costs and shorter construction leadtimes than solid fuel plants, and technological advances are lowering operating costs [**1**, p. 21]. In addition, natural gas prices are expected to be increasingly competitive with oil prices, and gas reserves are abundant [**2**, p. 60].

Worldwide, natural gas demand is expected to grow by more than 76 percent by 2015 over current levels. In the *IEO96* reference case, consumption grows to 133 trillion cubic feet in 2015 from 76 trillion cubic feet in 1993 (Figure 38). The fastest growth is projected for Europe (both OECD and Eastern Europe), Asia, and Central and South America (Figure 39). Each of these regions makes gains in its share of world natural gas demand (Table 15), with OECD Europe increasing its share by 3 percentage points between 1993 and 2015. In Asia and Central and South America, natural gas resources have not been developed to the same extent that they have in regions with more mature natural gas markets, such as North America. Natural gas demand is expected to grow by 6.5 percent annually in Asia, 4.8 percent in Eastern Europe, and 4.4 percent in Central and South America, compared with the 1.7 percent projected for North America. Natural gas is expected to play a key role in the vigorous electric power development that is needed—particularly in the non-OECD countries—to sustain economic growth.

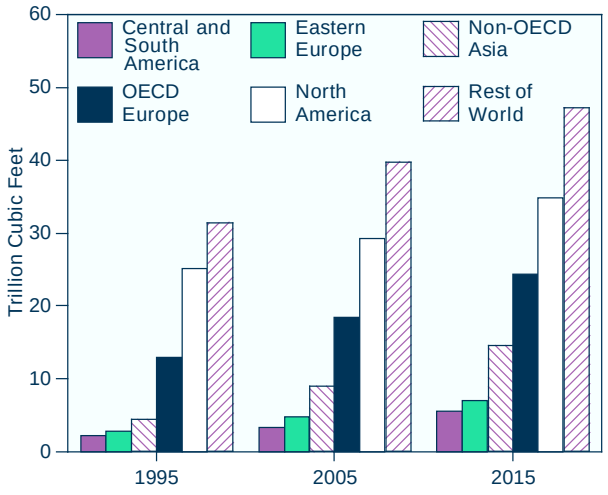
Changes in the natural gas industry and technological advances are also facilitating the growth of natural gas demand in the OECD countries. While the U.S. natural gas market is almost completely a competitive market, many countries of OECD Europe are in various stages of privatization. For most of the non-OECD nations,

Figure 38. World Consumption of Natural Gas, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Figure 39. Natural Gas Consumption by Region, 1995, 2005, and 2015



Source: Energy Information Administration, World Energy Projection System (1996).

Table 15. Shares of World Natural Gas Consumption by Region, 1993-2015
(Percent of Total)

Region	History	Projections			
	1993	2000	2005	2010	2015
OECD	**51.0**	**50.2**	**49.8**	**48.7**	**48.2**
OECD North America	31.9	29.2	28.1	26.8	26.2
OECD Europe	15.3	17.1	17.7	18.0	18.2
OECD Pacific	3.8	3.9	4.1	3.9	3.7
Non-OECD	**49.0**	**49.8**	**50.2**	**51.3**	**51.8**
EE/FSU	33.6	32.4	31.0	30.3	29.8
Former Soviet Union	30.3	28.1	26.4	25.3	24.6
Eastern Europe	3.3	4.4	4.6	5.0	5.2
Non-OECD Asia	4.9	7.0	8.6	10.1	10.9
Middle East	5.7	5.7	5.5	5.2	4.9
Africa	2.0	1.8	2.0	2.1	2.1
Central and South America	2.8	2.8	3.2	3.7	4.1

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995), Table 1.3. **Projections:** EIA, World Energy Projection System (1996).

natural gas utilities remain under state control, although many non-OECD countries have also begun to explore privatization. In addition, there are efforts in OECD Europe and North America to increase storage to ensure secure gas supplies. Finally, technological developments, particularly in terms of increasing the efficiency of natural-gas-fired electric power plants, favor the penetration of natural gas in the electric utility sector, especially in OECD Europe.

Reserves

As of January 1, 1996, proven world gas reserves[2] (Table 16) were estimated at nearly 5 quadrillion cubic feet [**3**, p. 43], 46 trillion cubic feet less than the estimate for 1995. Over the past two decades, however, estimated reserves have increased by 94 percent, mostly because of increases in domestic reserve estimates in the Middle East and EE/FSU. While reserves in the OECD have remained fairly stable between 1975 and 1996 (Figure 40), estimated reserves in the non-OECD have more than doubled, from 1,990 trillion cubic feet to 4,442 trillion cubic feet [**3**, p. 43; **4**, pp. 237-238].

More than 70 percent of the world's gas reserves are located in the former Soviet Union and the Middle East. Remaining reserves are distributed fairly evenly throughout the other regions of the world (Figure 41), except for the OECD Pacific. Natural gas reserves in the OECD Pacific region amounted to only 24 trillion cubic feet in 1996, about one-seventh the size of those in OECD Europe.

Despite rapid growth in natural gas use, reserves-to-production ratios are high by standards seen in developed gas markets in North America and Europe. On a worldwide basis, known reserves would be sufficient to maintain production at current rates for more than 60 years. In many countries with emerging economies, the reserves-to-production ratio is twice the world average. In developed areas, the ratio is nearly 16 years for the OECD, compared with 79 years for the former Soviet Union and over 100 years for the Middle East [**5**, p. 18].

Infrastructure To Support Natural Gas Usage

Delivery and storage systems are key to making natural gas an economical source of fuel for energy consumption. In the United States, major developments in infrastructure occurred especially in the 1950s and 1960s. In Europe and Japan the energy crises of the 1970s drove

[2]Proven reserves are the estimated quantities that analysis of geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. However, significant reserves in the probable category are included in "reserves" estimates for various countries, including those in the former Soviet Union.

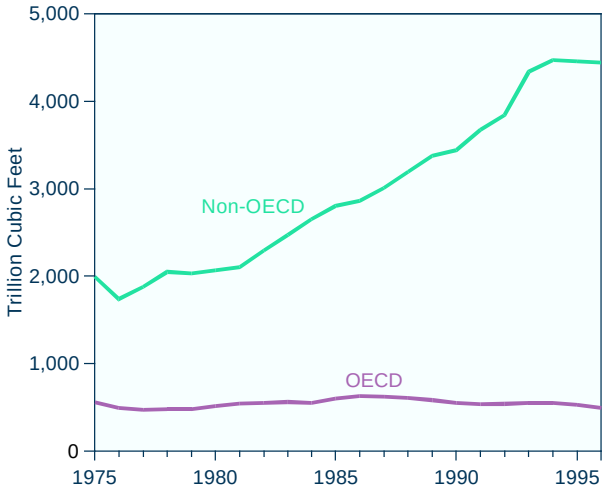
Table 16. World Natural Gas Reserves by Country as of January 1, 1996

Country	Reserves (Trillion Cubic Feet)	Percent of World Total
World Total	**4,933.6**	**100.0**
Top 20 Countries	**4,579.7**	**92.8**
Former Soviet Union	1,977.0	40.1
Iran	741.6	15.0
Qatar	250.0	5.1
United Arab Emirates	205.5	4.2
Saudi Arabia	185.4	3.8
United States	163.8	3.3
Venezuela	139.9	2.8
Algeria	128.0	2.6
Nigeria	109.7	2.2
Iraq	109.5	2.2
Indonesia	68.9	1.4
Mexico	68.4	1.4
Malaysia	68.0	1.4
Canada	67.0	1.4
Netherlands	65.2	1.3
China	59.0	1.2
Kuwait	52.4	1.1
Norway	47.5	1.0
Libya	45.8	0.9
Pakistan	27.0	0.5
Rest of World	**353.9**	**7.2**

Note: The sum of the shares for the top 20 countries may not equal their total share due to independent rounding.

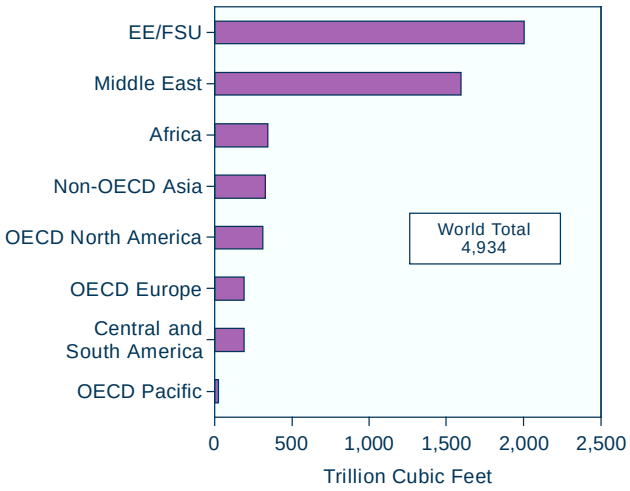
Source: "Worldwide Look at Reserves and Production," *Oil and Gas Journal*, Vol. 93, No. 52 (December 25, 1995), pp. 44-45.

Figure 40. OECD and Non-OECD Natural Gas Reserves, 1975-1996



Sources: **1975-1995:** *International Petroleum Encyclopedia: Worldwide Oil and Gas at a Glance* (Tulsa, OK: PennWell Publishing Co.), various issues. **1996:** "Worldwide Look at Reserves and Production," *Oil and Gas Journal*, Vol. 93, No. 52 (December 25, 1995), pp. 44-45.

Figure 41. World Natural Gas Reserves by Region, as of January 1, 1996

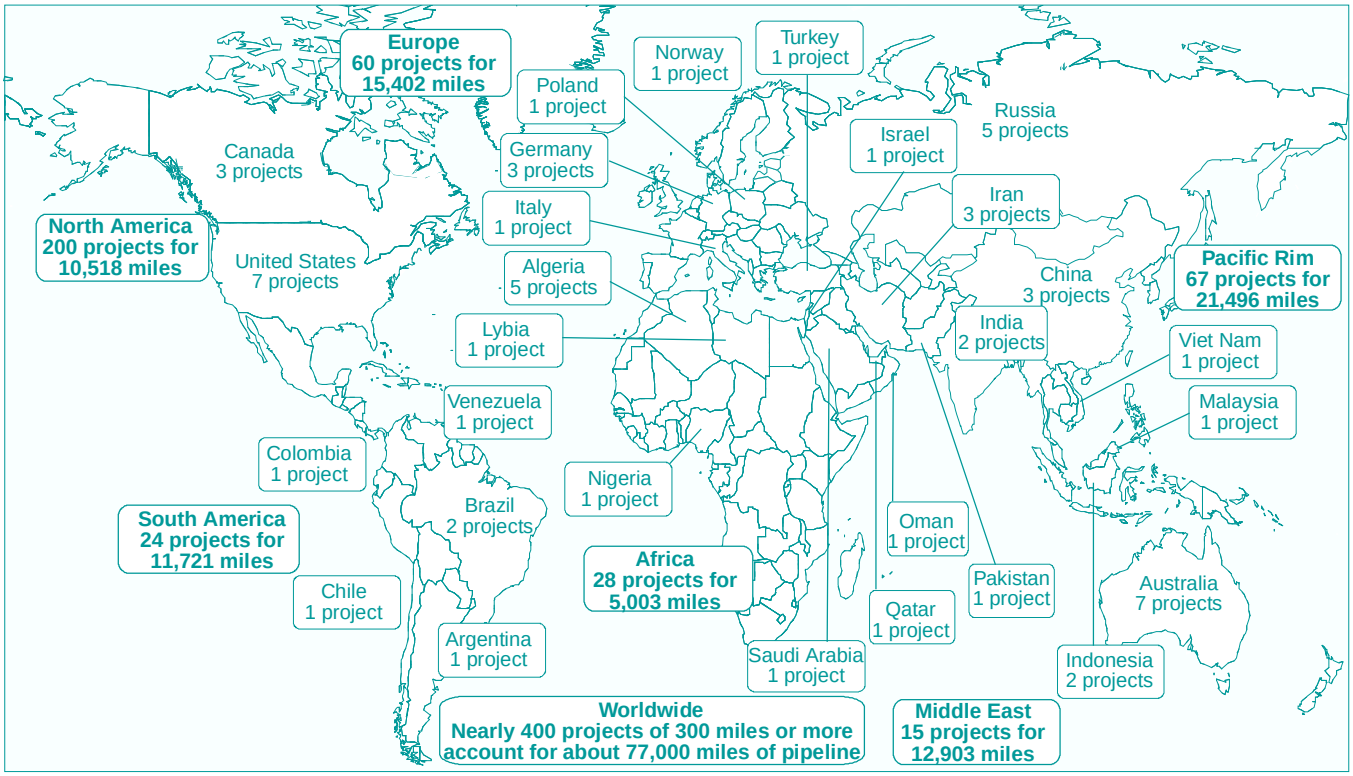


Source: "Worldwide Look at Reserves and Production," *Oil and Gas Journal*, Vol. 93, No. 52 (December 25, 1995), pp. 44-45.

rapid development of pipeline and liquid natural gas (LNG) processing facilities. In these established markets, substantial expansion of natural gas handling facilities continues. Although infrastructure development is less advanced in other areas of the world, widespread development is underway, featuring not only major LNG projects (see box on page 38) but also extended pipeline connections (Figure 42).

In addition, the increasingly competitive global natural gas market has resulted in a need for countries to increase natural gas storage capacity, both to ensure secure supplies of the fuel and to increase market efficiency and, subsequently, market growth. This is particularly evident in countries in North America, OECD Europe, and Eastern Europe, where growing gas imports, deregulation, and competition have increased the demand for flexible mechanisms to transmit gas to customers. The need for more storage is particularly strong in those European countries that are import-dependent and are unable to dramatically increase domestic production.

Figure 42. Proposed Natural Gas Pipeline Construction Projects Worldwide



Source: Enron Corporation, *The 1995 Enron Outlook* (Houston, TX, 1995), p. 22.

Liquefied Natural Gas

Liquefied natural gas (LNG) is natural gas that has been converted to a liquid state. When natural gas suppliers are not able to connect with customers through pipelines, the gas must be converted to LNG before shipment. The converted gas is loaded into specially designed refrigerated ships and delivered to ports equipped with special receiving facilities. It is then regasified and distributed to consumers by pipeline, just as natural gas is usually distributed. The considerable costs associated with processing and transporting LNG reduce its economic viability, especially in today's oil market. Nevertheless, LNG production is showing some signs of increasing.

Most LNG is produced in Asia, Africa, and the Middle East. In 1994, Indonesia and Algeria accounted for 40 percent and 21 percent of the world's LNG exports, respectively [**5**, p. 24]. Australia, Brunei, and Malaysia together account for 31 percent. Algeria exports the vast majority of its LNG to OECD Europe and the United States and a small amount (less than 2 million cubic feet) to Japan. LNG from Asian suppliers is exported mainly to Asian markets in Japan, South Korea, and Taiwan. A small amount of Australian LNG is exported to Spain (see map on page 39).

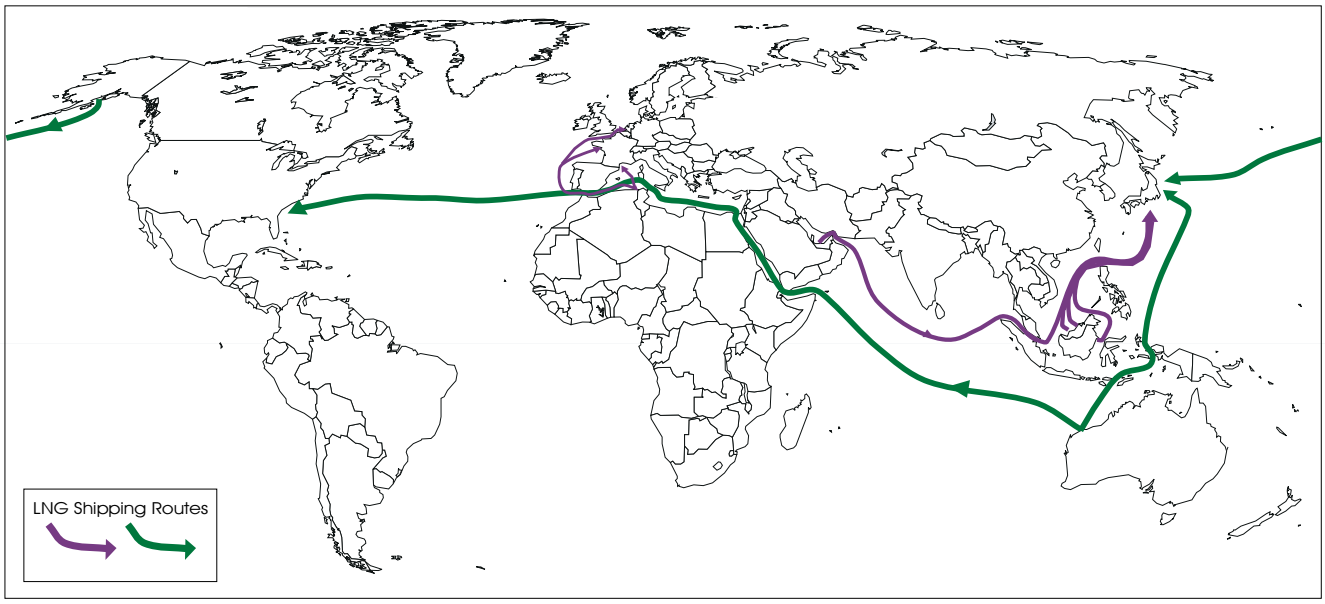
New LNG projects currently planned or under construction in Abu Dhabi, Indonesia, and Malaysia are expected to produce about 1.2 trillion cubic feet of LNG per year by 1998. In addition, Qatar and Nigeria have plans for two projects that would produce 1 trillion cubic feet per year by 2000. Qatar expects to be able to produce about 195 billion cubic feet of LNG per year, all for export to Japan [**6**, p. 52].

Existing LNG production and transportation capacities are estimated to be about 10 percent higher than market demand [**7**, p. 10]; but by 2010, demand may exceed supply [**7**, p. 10]. South Korea and Taiwan have the largest potential markets for LNG, depending on the extent to which their nuclear power programs grow to meet electricity demand. Thailand and China are also potential future LNG consumers [**8**, p. 3].

In Taiwan, the Kaosiung regasification plant is being expanded, and a planned trans-island pipeline will increase capacity to 438 billion cubic feet a year. The completion date for these projects is 1997 [**9**, p. 7]. South Korea was scheduled to increase LNG imports by 14 percent in 1995 (to 330 billion cubic feet), with imports from Indonesia, Malaysia, and Brunei [**10**, p. 12]. The state-owned Korea Gas Corporation is also negotiating for supplies from Australia and Qatar.

Demand for LNG is also expanding in Europe. France accounted for almost 9 percent of the world's LNG imports in 1994, all of it from Algeria [**5**, p. 24]. Belgium, Italy, Spain, and Turkey also import LNG from Algeria [**5**, p. 24; **11**, p. 22.6]. Growth in the electric power sector in Turkey is projected to result in growing LNG imports [**7**, p. 10]. By some estimates, imports may grow fivefold over current levels [**12**]. In August 1995, Turkey purchased five LNG cargoes on the spot market with some 14 billion cubic feet of LNG from Australia [**12**]. Algeria is Turkey's other major supplier, but the country has signed memoranda of intent with Qatar and Nigeria, and has in the past purchased spot cargoes from Abu Dhabi, which is also a supplier to France, Spain, and Belgium.

Worldwide Trade Flows for Liquefied Natural Gas, 1995



Source: British Petroleum Company, *BP Review of World Gas* (London, UK, 1995), p. 5.

Regional Activity

North America

The North American natural gas market is becoming increasingly integrated and competitive. The United States has an estimated economically recoverable resource base[3] of over 1 quadrillion cubic feet, compared with 740 trillion cubic feet in Canada and 250 trillion cubic feet in Mexico [**13**, p. 43; **14**, p. 6.6; **15**, p. 180]. North America contains roughly 7 percent of the world's total natural gas reserves but accounts for more than 31 percent of world production—the second largest source of natural gas production in the world. The vast majority of North American production is consumed domestically: less than 1 percent is currently exported. Because of its relatively abundant supply and low environmental emissions, natural gas is expected to continue to play a key role in North American energy markets.

Underground storage has become increasingly important in North America, especially in the United States, where regulatory changes over the past decade have

[3]Economically recoverable resources are those volumes considered to be of sufficient size and quality for their production to be commercially profitable by current conventional technologies, under specified economic assumptions. They include proven reserves, inferred reserves, and undiscovered and other unproven reserves. These resources may be recoverable by techniques considered either conventional or unconventional.

resulted in the higher usage of storage facilities throughout the year. The industry currently has the capability to store approximately 8 trillion cubic feet of natural gas in 375 storage sites across the United States. Of this capacity, about 46 percent (3.7 trillion cubic feet) is considered working gas storage that can be withdrawn as necessary to meet demand requirements.[4] On a peak day, the industry has the capability to deliver more than 120 billion cubic feet of natural gas to consumers, and underground storage can supply as much as half of that capacity. Proposed capacity additions through the end of the decade could increase the ability of the U.S. storage industry to deliver gas from storage on a peak day by almost 31 percent from the 1993 level [**16**, p. vii].

Natural gas consumption in Canada is expected to grow at a modest rate (1.2 percent annually) between 1993 and 2015. Canadian production has been increasing since 1986 and is expected to continue to rise as known fields are more intensely developed, due in part to technological improvements. Historically, Canada has exported substantial volumes of gas to the United States, increasing from 28 percent of its domestic production a decade ago to 50 percent in 1994. Canada has the productive capacity and the resource potential to remain a significant supplier of natural gas to the United States. Currently, however, the flow of gas between the two countries is near the upper limit of existing pipeline capacity (Figure 43). Several projects currently are either planned or underway. If all the projects announced through the end of 1994 were completed as proposed, pipeline capacity on the U.S.-Canadian border would expand by more than 500 billion cubic feet per year by 1997 [**17**, p. 23]. Canada has a current total underground storage capacity of 682 billion cubic feet in 11 storage sites, with a peak delivery capability of about 8 billion cubic feet per day, and some 66 billion cubic feet of new storage capacity is in the planning stage [**18**].

The United States currently accounts for more than 80 percent of natural gas consumption in North America, and its consumption is expected to increase at an average annual rate of 1.6 percent through the forecast period. The highest growth in U.S. consumption is expected in the electricity generation sector, where projected consumption approximately doubles between 1994 and 2015. The United States currently is the second largest producer of natural gas in the world and accounts for roughly 76 percent of total North America production [**19**, p. 26]. Despite high levels of domestic production, the United States is still expected to increase imports from 11 percent of total supply in 1994 to 14 percent in 2015.

Of the three countries in North America, the strongest growth in natural gas consumption is expected in Mexico (at 4.5 percent annually over the projection period), in part because of new environmental standards. Relatively clean-burning natural gas is an attractive alternative to the use of high-sulfur heavy fuel oil for power generation and other industrial applications. Mexico also has the greatest potential for growth in production, with a reserve-to-production ratio greater than 30 years, compared with 8.5 for the United States and 17.0 for Canada [**17**, p. 21].

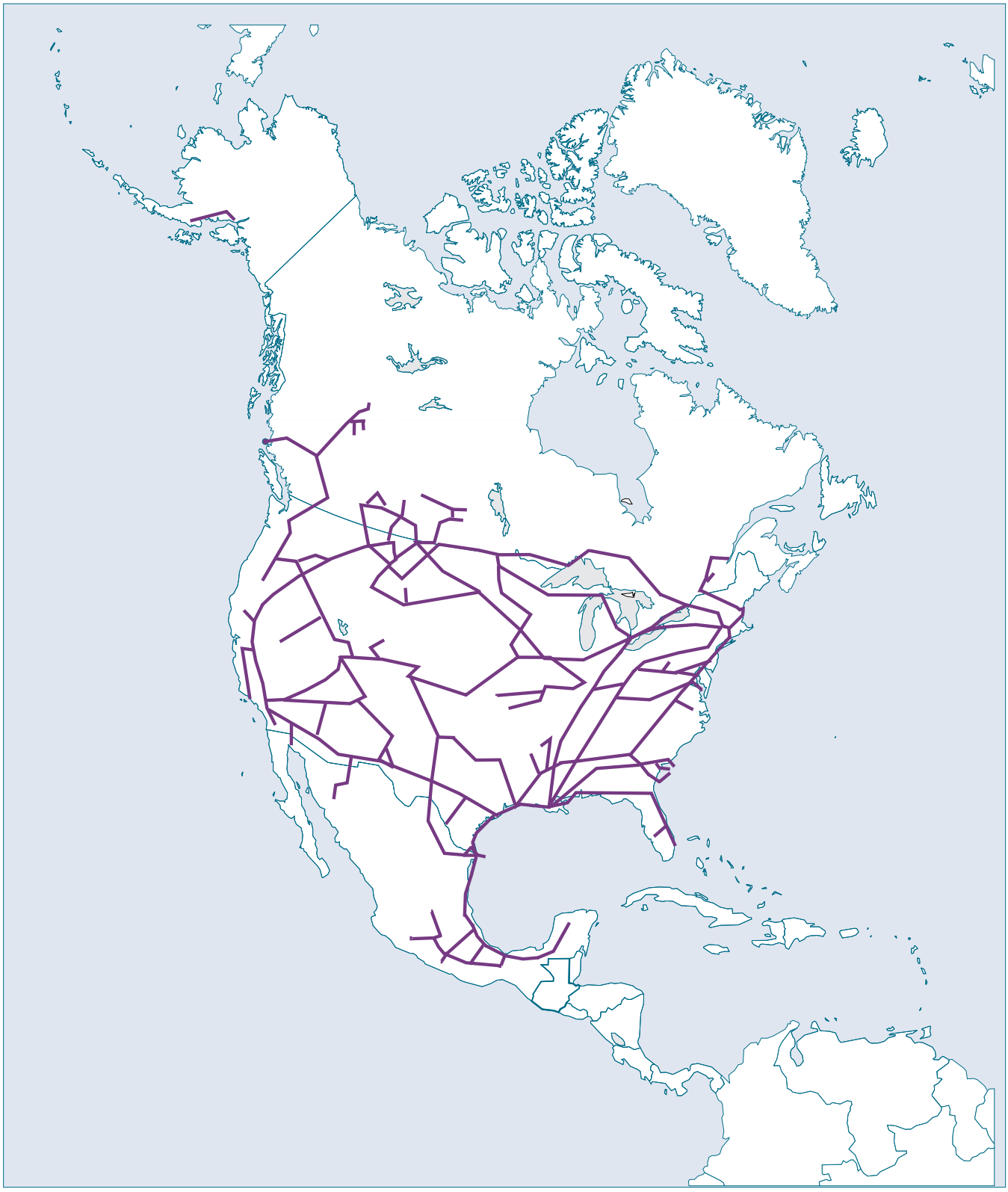
Although Mexico currently does not have the infrastructure (nor the capital) needed to exploit its natural gas reserves, the Mexican government has demonstrated an interest in attracting the capital needed for infrastructure development from domestic and foreign investors. Legislation recently passed by the Mexican congress partially privatizes the transmission, storage, and distribution of natural gas [**20**, **21**]. Proposed projects to expand pipeline capacity on the U.S.-Mexican border also reflect the growing interest of U.S. firms in expanding their trade with Mexico. Currently, there are six proposed projects to facilitate increased trade with the United States: two will increase pipeline capacity at the California-Mexico border, three target the New Mexico-Northwest Texas area, and one connects a pipeline originating in Hidalgo County, Texas, with a PEMEX pipeline near Reynosa, Tamaulipas, Mexico. If all the projects announced were completed as proposed, annual cross-border capacity would increase by more than 600 billion cubic feet [**22**, p. v]. It is unlikely, however, that all the projects will actually be built, because construction of some pipelines may eliminate the need for others.

OECD Europe

Particularly strong growth is expected for natural gas in the electric utility sector of OECD Europe. Until recently, in many countries of OECD Europe (exceptions are the Netherlands, Ireland, and Austria) natural gas was considered a premium fuel. Gas utilities—under pressure from their respective governments—were reluctant to promote its use for electricity generation [**2**, p. 60]. In recent years, however, several developments have brought about a more favorable climate for natural gas in the electric power sector: heightened environmental concerns (especially in terms of tighter emission restrictions for carbon dioxide,

[4]Workable gas capacity is defined as the maximum amount of natural gas that can be injected and withdrawn from a site, excluding minimum operating levels.

Figure 43. Major North American Natural Gas Pipelines



Source: British Petroleum Company, *BP Review of World Gas* (London, UK, 1995), p. 9.

sulfur dioxide, and nitrous oxide); the 1991 repeal of a 1975 directive that limited natural gas use for power generation; and improved combined-cycle technology that increases the efficiency of natural-gas-fired plants to over 50 percent, compared with 35 to 40 percent for oil- or coal-fired plants [**2**, p. 60]. In addition, the deregulation and widespread development of independent power plants has favored the construction of gas-fired plants, which have lower capital costs and shorter construction periods than coal-fired or nuclear power plants. In the United Kingdom, in particular, gas usage restrictions have been lifted as part of the privatization of the electric utility sector [**23**, p. 7.9]. In addition, phase-downs of coal production in the United Kingdom, Germany, and Spain are creating opportunities for natural gas use in electric power generation [**2**, p. 60].

Some of the most vigorous pipe-laying activity in 1994 was focused around plans to expand the international gas grid serving the OECD European markets (Figure 44). Much of this effort involved installing large-diameter international pipeline systems to transport natural gas from the North Sea, North Africa, and Russia [**24**, p. 24]. Five large gas pipelines (over 1,600 miles of pipe) are planned to transport gas from the Norwegian North Sea to markets in Europe: 184 miles of pipe from Norway's Kollses terminal to a North Sea transmission hub on Block 16/11 (Zeepipe IIB); 415 miles of pipe linking Block 16/11 to an onshore terminal at Emden Germany (Europipe II); 535 to 560 miles of pipe from Norway's Sleipner field to Zeebrugge, Belgium, or Dunkirk, France (Zeepipe IV); 95 miles of pipe around Norway's Ekofisk field; and 375 miles of pipe from the Haltenbanken area (Norwegian Sea, offshore mid-Norway) to the North Sea gas grid. Construction on Zeepipe IIB is scheduled to begin in October 1997; construction on the four other projects should begin at least by 1999.

The main gas suppliers to France are currently Algeria and Russia [**23**, p. 2.22]. Concerns in France about dependence on these two suppliers have led the French public gas utility, Gaz de France, to maintain storage to accommodate disruptions for up to a year from either major supplier, as well as to secure more diverse supplies. In 1995, Gaz de France signed a 26-year contract with the Norwegian Gas Negotiating Committee to purchase more than 1.4 trillion cubic feet of gas beginning in 2001 [**24**, p. 24]. The gas will be delivered through a pipeline at Dunkirk, which is currently under construction, with an estimated completion date of October 1998. Deliveries through the pipeline are expected to peak in 2005 at 70 billion cubic feet. With this contract, Norwegian gas deliveries to France in 2005 should reach almost 530 billion cubic feet, around 35 percent of the total French gas demand.

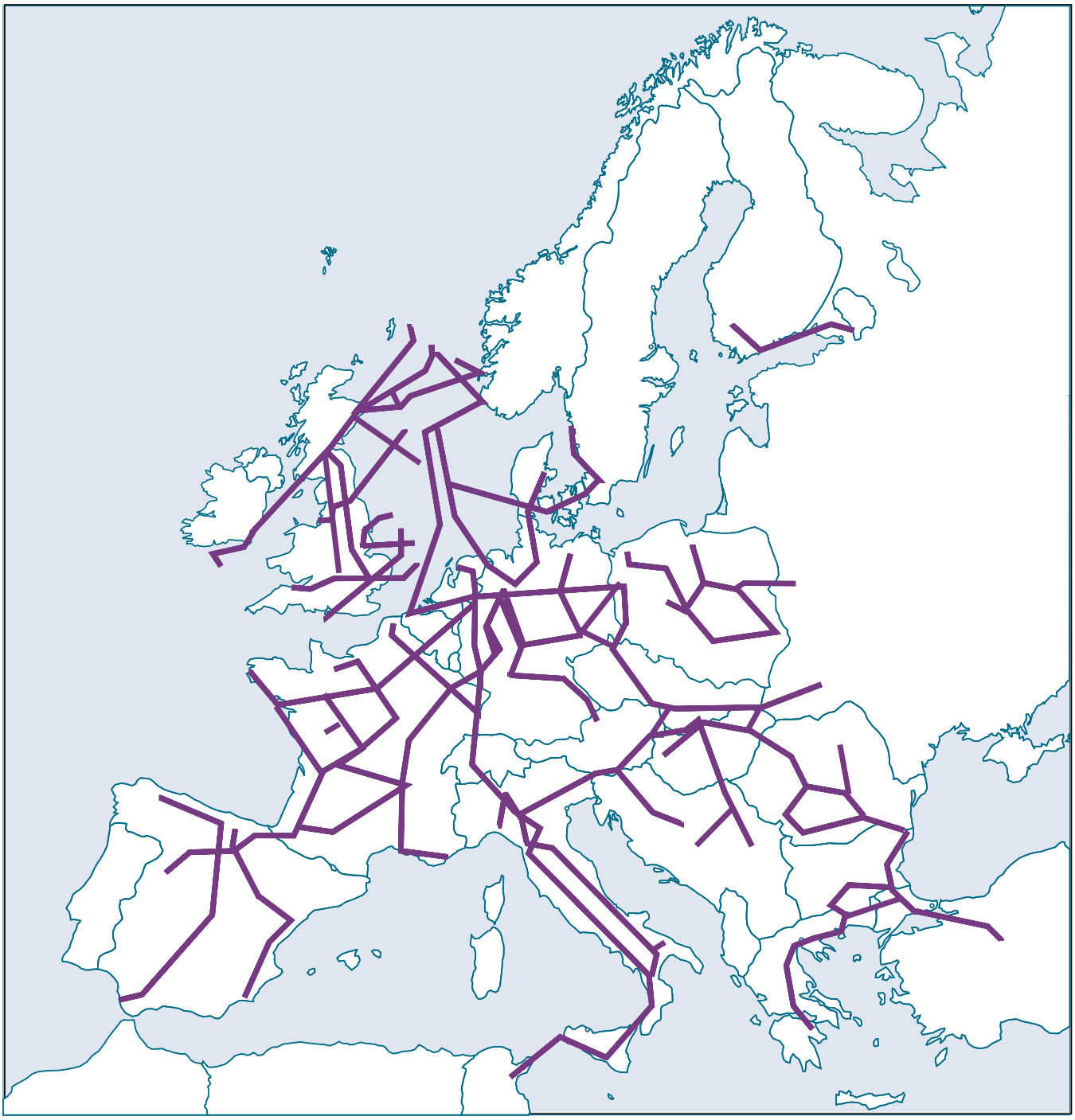
In Germany, natural gas is expected to make big gains as its use increases in the residential sector in the eastern part of the country, and as the entire country reduces its dependence on coal. Substantial gains have been made in the effort to upgrade residential use in eastern Germany from town gas[5]—which has low energy content and high manufacturing costs—to natural gas [**23**, p. 3.7]. By 1994, 80 percent of the homes using town gas had converted to natural gas.

The Norwegian companies Statoil and Norsk Hydro announced at the end of 1994 that they would participate in gas pipeline expansions in Germany, through the newly-formed company, Norddeutsche Erdgas-Transversale (Netra) [**24**, p. 25]. The $720 million, 181-mile Etzel-Salzwedel pipeline project, completed at the end of 1995, will transport between 560 and 630 billion cubic feet of Norwegian gas per year to eastern German markets [**25**, p. 29]. In addition, the Etzel-Salzwedel line should connect with an existing 112-mile segment between Salzwedel (at the former East-West German border) and Bernau (north of Berlin). Existing contracts call for Norway to triple its gas supplies to Germany to more than 1,050 billion cubic feet per year by 2005, from 385 billion cubic feet in 1994. By 2005, Norway is expected to supply almost one-third of Germany's natural gas demand.

The United Kingdom is estimated to have the third-largest reserves of natural gas in OECD Europe, after Norway and the Netherlands [**19**, p. 99]. Currently, 89 percent of British households use natural gas [**23**, p. 7.1]. With its large reserves, the United Kingdom is not expected to import any natural gas in the foreseeable future. In 1994, a consortium of companies led by British Gas agreed to lay a 150-mile pipeline—the Interconnector—between England and continental Europe, with a capacity of 1.9 billion cubic feet per day [**24**, p. 25]. The Interconnector, which is expected to connect into the Belgium gas grid at Zeebrugge, will be the first pipeline link between Britain and the continent. Plans are to begin construction in 1996, with a projected completion date of October 1998. Other pipelines serving the United Kingdom market include a 25-mile subsea pipeline to transport gas from Twynholm, Scotland (Bord Gais Eireann interconnect) to Larne, Northern Ireland (Ballylumford power station), which is scheduled for completion in late 1996.

[5]"Town gas" (or "coal gas"), a substitute for natural gas, is produced synthetically by the chemical reduction of coal at a coal gasification facility.

Figure 44. Major European Natural Gas Pipelines



Source: British Petroleum Company, *BP Review of World Gas* (London, UK, 1995), p. 19.

Pipeline construction is expected to continue in regions interested in feeding the healthy gas markets of OECD Europe. Many European countries are depending on the completion of the proposed 2,500-mile pipeline that will connect Russia with the European markets through Poland and Belarus. Current estimates for its completion are for 2010, although the first gas might begin to flow from already-producing fields in western Siberia at the end of 1996, at a rate of around 483 million cubic feet per day [**26**, p. 5]. Construction also continues on pipelines between Africa and Europe. The first phase of the 865-mile Maghreb-Europe pipeline between Algeria

and Spain is expected to be completed by the end of 1996 [**24**, p. 25]. This line would also provide a route for Algerian gas into Portugal, France, and Germany. Spain alone has plans to expand its pipeline system by more than 20,000 miles by 2004, as well as plans to connect with the gas grids of Portugal and France [**24**, p. 26].

Italy is expected to increase its capacity on the trans-Mediterranean pipeline from Algeria to about 2.5 billion cubic feet per day [**24**, p. 26]. The trans-Mediterranean pipeline is being expanded by more than 1,366 miles of new pipe, running from the Algeria-Tunisia border to Minerbio, Italy. Construction has also continued on pipelines connecting Tunisia and Sicily, where adding one to three compression units could increase capacity to as much as 2.9 billion cubic feet per day. Within Italy, a 900-mile expansion to the trans-Mediterranean system is expected to begin by the end of 1995. In September 1995, Edison SpA, an Italian energy producer, agreed to set up a joint venture with Russia's Gazprom to transport natural gas to Italy. The proposed 620-mile pipeline is expected to begin operation in 1998, and it is slated to be used mainly to supply electricity generators [**27**].

Increased gas storage capacity is needed in Europe to deal with the increasingly competitive nature of the natural gas market, as well as to ensure supplies in periods of peak demand [**28**, p. 2]. The Netherlands utility, Gasunie, considered one of the largest and most flexible suppliers in Europe, announced at the beginning of 1995 that it was losing the ability to provide swing capacity during peak winter demand periods as a result of the growth in gas demand, deregulation, and competition throughout Europe [**28**, p. 1]. Other important European exporters, such as Norway, Russia, and Algeria, are not considered flexible enough to accommodate seasonal demand swings. Moreover, these suppliers and numerous LNG suppliers depend upon high-load, inflexible deliveries to make the gas trade economically viable.

In Europe there are plans to expand underground storage by 730 billion cubic feet over the next 10 years [**28**, p. 1]. Overall, gas from existing underground storage sites in Europe can, at a maximum, supply about 2 months of peak winter demand. Currently, European workable underground storage capacity is estimated at 1.5 trillion cubic feet, divided among 76 sites in 12 net importing countries. Most of the sites and storage capacity (61 sites storing 1.2 trillion cubic feet) are located in OECD Europe. Germany, with an expected 300 billion cubic feet of storage capacity expansion between 1995 and 2000, has the most ambitious plans for increased storage capacity in OECD Europe, followed by Italy and Austria, which expect to add 151 and 53 billion cubic feet, respectively, over the same time period [**28**, p. 2].

Eastern Europe and Former Soviet Union

As of the end of 1995, Eastern (non-OECD) Europe and the former Soviet Union combined accounted for approximately 41 percent of the world's natural gas reserves, and exploratory efforts continue to uncover reserves. The vast majority of the reserves (34 of the 41 percent) are located in the Russian Federation, with the rest mainly in Turkmenistan (2 percent), Uzbekistan (1.3 percent), and Ukraine (0.8 percent). While the natural gas industry is currently experiencing a decline in those countries, there is significant potential for long-term growth if the political environment favors Western investment.

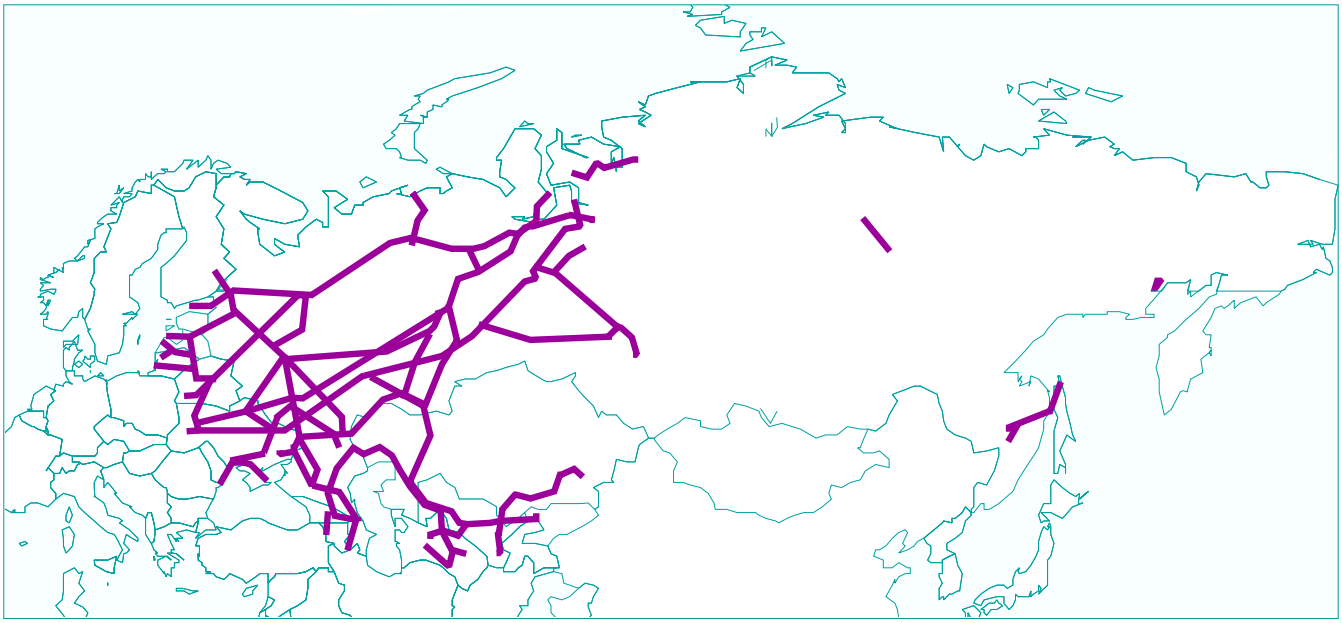
About 34.5 percent of the world's total natural gas production in 1994 came from the EE/FSU region—33.0 percent from the FSU alone. While a large portion of the gas produced in the FSU is also consumed there, 17.5 percent of its 1994 production was exported. Key export markets were Austria, Finland, France, Germany, Italy, Turkey, and most of Eastern Europe [**5**, p. 20].

Natural gas consumption in EE/FSU countries nearly doubled between 1980 and 1990, from 16.0 to 28.1 trillion cubic feet. Although consumption has dropped yearly since 1990 as a result of the economic and political upheaval in the region, the *IEO96* reference case projects renewed growth in total EE/FSU consumption, reaching 39.7 trillion cubic feet in 2015. Both historically and in the forecast, the FSU accounts for more than 80 percent of the region's total consumption.

The economic and political transitions occurring in Eastern Europe and the FSU continue to hamper growth in natural gas production and consumption in most countries, continuing the decline that began in 1990. The highest consumption drops were seen in Ukraine and the Russian Federation, where consumption fell by 12.4 and 7.1 percent, respectively. The highest production drop was seen in Turkmenistan, where production fell by 45.5 percent between 1993 and 1994. Partially offsetting the drastic decline in Turkmenistan production was a 4.9-percent increase in production in Uzbekistan. Due to increased storage and exports from the FSU, overall production fell less (5.6 percent) than consumption (7.2 percent) [**5**, pp. 20-22].

With the relaxation of the political environment in Eastern Bloc countries over the past few years, some foreign investors are being attracted, and prospects for increased development of their natural resources are

Figure 45. Major Eastern Europe/Former Soviet Union Natural Gas Pipelines



Source: British Petroleum Company, *BP Review of World Gas* (London, UK, 1995), p. 23.

becoming more favorable. Substantial natural gas resources over and above already proven reserves appear to exist, and foreign capital continues to flow in for projects to discover and develop resources in several countries. Until an investor-friendly petroleum law is passed in the Russian Federation, however, plans for large expenditures by Western firms are on hold. Kazakhstan, which has huge oil and gas reserves, has made a deal with Chevron to develop the huge Tengiz oil field, but lack of adequate export facilities impairs this effort. The government of the FSU republic of Moldova is negotiating with U.S. investors, who are planning to initiate drilling for the country's limited oil and gas resources. The legislated willingness of EE/FSU countries to allow foreign investment is key to resource development.

Foreign investment may also play a role in developing Eastern Bloc natural gas transmission and distribution systems (Figure 45). The Japanese firm Mitsubishi is looking into a much longer term development possibility—building an oil and gas pipeline from Turkmenistan and Kazakhstan through China and Korea to Japan. The distance requires a higher real cost of energy than at present, and the project probably will not be feasible in this century. However, a very large resource base is available to serve such a development.

Other key developments in the expansion of gas transmission systems are the signing of an agreement in August 1994 between Turkmenistan and Iran to build a pipeline from Turkmenistan through northern Iran to Turkey, and the February 1995 agreement signed by Russian Prime Minister Chernomyrdin to build the Yamal-Poland-Germany gas pipeline across Poland. The Yamal pipeline will deliver cheap gas to Poland beginning in 1996 and has a large potential for delivery to Western Europe by 2010.

While the natural gas market is controlled by the government in most EE/FSU countries, some are moving toward privatization. The Russian state gas company Gazprom is currently a monopoly controlling all aspects of the natural gas market. The government owns a major stake in Gazprom but has plans for its eventual privatization. As Gazprom is a major source of income for the Russian government, the move toward full privatization is not imminent; but it is expected to occur over the longer term. The government is currently divesting itself of Gazprom shares via voucher auctions, and there are rumors that it is about to sell 15 percent of its 40-percent stake in Gazprom to Gazprom itself. The company would then be free to resell those shares to the highest bidder, at a huge profit [**29**, p. x].

Asia

Strong growth in natural gas use is expected for Asia, where developing countries face increasing demand for energy. Natural gas is expected to be particularly important in the region's fast-paced expansion of electricity supply. The demand for natural gas throughout Asia is projected to increase by 6.5 percent annually over the forecast period, reaching 14.5 trillion cubic feet

in 2015. In addition, some of the most vigorous activity in the liquefied natural gas market is occurring in this region (see box on page 38).

Pipeline construction plans necessary to meet India's growing gas demand have not materialized as hoped. A proposed pipeline connecting Oman to India was tabled at the end of 1995, as a consequence of the death of Oman's Finance Minister, Qais al-Zawawi [**30**]. India's Gas Authority of India Limited (GAIL) is working to secure needed gas supplies by developing domestic reserves and securing import sources that will allow gas demand to double by 2000 [**31**].

In Southeast Asia, there are some 39 current or probable natural gas development projects [**32**]. An estimated 51 trillion cubic feet of gas may be produced by these projects. Growing domestic demand for natural gas, as well as an increasing market for LNG, have resulted in gas projects in Indonesia, where some 14 gas development projects have startup dates between 1996 and 1999. Thailand, Myanmar, and the Philippines also have a number of gas development projects. Gas production in the region may increase by as much at 54 percent by 2002 over current average production of 12.4 billion cubic feet per day [**32**; **19**, p. 27].

Natural gas is not expected to displace coal as China's dominant fuel source over the projection period: in the reference case forecast, coal supplies more than 65 percent of the energy consumed in China through 2015. However, gas demand in China is growing rapidly. China has four offshore natural gas projects expected to be operational between 1995 and 1999, with estimated reserves of more than 6.2 trillion cubic feet [**32**]. In January 1996, Asia's longest large-diameter subsea pipeline began operating. The 480-mile system links China's Yacheng gas field (South China Sea) and Hong Kong [**33**]. There are notable efforts to expand the gas transportation system in the Xinjiang Uygur region in remote Northwest China, including a 56-mile pipeline from Lunnan to Korla, a 192-mile pipeline from Shanshan to Urumqu with a capacity of 153 million cubic feet per day, and a 195-mile pipeline from Tazhong 4 field to Lunnan with a capacity of 38 million cubic feet per day [**34**, p. 32].

Myanmar is expected to begin gas production in the Yadana gas field in the Gulf of Martaban by July 1998 [**35**]. The field has estimated reserves of as much as 5.8 trillion cubic feet. Plans are to supply the gas to Thailand, as well as for domestic consumption. A 260-mile pipeline is planned to transport the gas from Yadana to Thailand, and construction is expected to begin by the end of 1995; however, anti-government minorities have threatened to sabotage the pipeline, which is routed through densely forested areas. The Yetagun gas field, discovered in Myanmar's Gulf of Martaban in 1992, should provide Thailand with gas deliveries of about 200 million cubic feet per day by 2000. Plans are to construct a pipeline from Yetagun to Thailand.

Indonesia may be another potential gas supplier for Thailand. In 1994 the U.S. company Exxon signed an agreement with Indonesia's utility, Pertamina, to build an LNG facility at Natuna Sea to tap some of Natuna's estimated 210 trillion cubic feet of gas reserves [**36**, p. 30]. To date, however, Exxon has not been able to obtain financing for the proposed $40-billion project. Instead, Pertamina and the Petroleum Authority of Thailand began discussions in 1996 to consider building a 620-mile pipeline to Thailand [**37**].

South Korea is expected to become a major consumer of LNG within the next two decades [**7**, p. 10]. The country's new natural gas transmission system is scheduled for completion by the end of 1996, and extensions to the system have already been planned and are scheduled for completion in 1998 [**38**]. LNG imports are correspondingly scheduled to increase by 14.3 percent by the end of 1995 over 1994 levels. Indonesia should remain South Korea's largest natural gas supplier, with about 90 percent of the Korean market. Malaysia and Brunei currently supply the remaining 10 percent. South Korea has recently added Qatar as a supplier and has also entered negotiations with Australia for gas supplies.

Much of the natural gas pipeline development in the OECD Pacific is projected to occur in Japan and Australia. Japan began construction in 1994 on a 155-mile pipeline running from the west coast city, Niigata, to Sendai City in Niyagi Prefecture on the Pacific Ocean [**24**, p. 28]. This is the first part of a 2,050-mile gas distribution system that could transport as much as 82.6 million metric tons of regasified LNG per year by 2005. In 1994, Japan imported almost 65 percent of the world's LNG [**4**, p. 24]. In mid-1995, work began on the 470-mile Australian pipeline, which is to link Queensland with Brisbane and Gladstone [**24**, pp. 27-28]. The project is expected to begin operation in late 1996.

Central and South America

Development of natural gas resources is expected to be strong in some countries of Central and South America, in order to meet increasing demand for electricity in a region where natural gas is considered a relatively immature industry. Natural gas and hydropower are the two major energy sources for electricity generation in the region [**2**, p. 61].

Construction of several large pipeline projects was scheduled in 1995 [**24**, p. 28]. When completed, the pipelines will transport gas from Argentina to markets in Brazil and Chile. A 750-mile system planned for the Argentina-Chile line is expected to be completed in 1997. A 2,000-mile pipeline system is being developed to deliver gas from Argentina and Bolivia to Brazil, and a 685-mile project is currently under consideration to link Bolivia and Chile.

In 1994, construction began on Colombia's first large natural gas pipeline, a 357-mile system running from Ballena, Colombia, into the Barrancabermeja area [**25**, p. 28]. The system should begin operating by the end of the first quarter of 1996 [**25**, p. 28]. For the first 15 years of operation, the gas will be used to supply the domestic market. The pipeline is expected to supply about 150 million cubic feet per day.

Africa

Algeria, by far, has the most highly developed natural gas resources in Africa. The pipelines linking Algeria with markets in OECD Europe, combined with growing LNG exports, provide the country with a particularly strong commodity. Pipelines are currently under construction to link both Algeria and Tunisia with Italy and Spain, and through them to markets in Belgium, Portugal, and France.

Natural gas resources in North Africa (primarily, Algeria, Egypt, and Libya) are considerably more developed than those in the rest of Africa. There is, however, growing interest in pursuing gas resources outside the north, particularly in terms of fueling electric power. Nigeria, for example, is the site of a $569-million gas utilization project in Escravos, which is expected to be operational in 1997 [**39**, p. 36]. A Nigerian LNG project has also been proposed [**39**, p. 36]. The country is estimated to have some 120 trillion cubic feet of natural gas reserves, the most of any west African country. Long-term hopes are to expand the Escravos gas project into the West African Pipeline, which would allow gas in eastern Nigeria to reach potential customers in Benin, Togo, and Ghana, as well as other parts of Nigeria's domestic market.

Another African country anxious to develop its natural gas resources is Tanzania. Although Tanzania's reserves are markedly smaller than those of Nigeria, at 4 trillion cubic feet, financing is being sought to construct two small natural-gas-fired electricity plants (one at Songo-Songo and one at Mnazi Bay) [**39**, p. 38]. Tanzania is interested in increasing the amount of electricity generated by natural gas to counter losses in hydroelectricity—caused by low rainfall and aging facilities—and to replace some of the 90 percent of its energy consumption that is now provided by wood burning.

Middle East

More than 30 percent of the world's natural gas reserves are located in the Middle East [**6**, p. 51], and about 93 percent of the Middle Eastern reserves are located in Iran, Iraq, Qatar, Saudi Arabia, and the United Arab Emirates (mostly Abu Dhabi) [**6**, p. 51]. Natural gas is an increasingly important fuel in this region, both in terms of utilization and as an export commodity. Electricity demand is increasing rapidly in the Middle East, and much of it is expected to be accommodated by natural-gas-fired plants. At present, more than 50 percent of the region's marketed natural gas production is consumed in electric power generation and for seawater desalination [**6**, p. 52]. Most of the thermal power plants in countries that border the Arabian Gulf are fueled by natural gas.

There is also evidence of increased development of natural gas for export in the Middle East. The region accounted for almost 5 percent of the world's LNG exports in 1994, all of it exported to Japan [**5**, p. 24]. There are plans to develop Qatar's North field gas reserves for export to Japan, and initially the project will be designed to produce 195 billion cubic feet per year.

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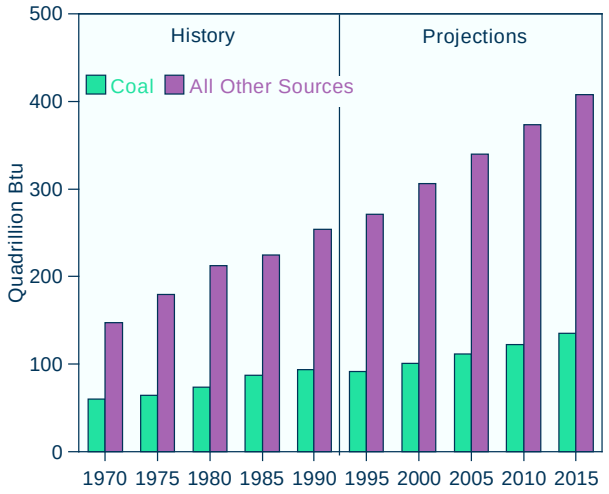
Coal

World coal use is projected to increase by more than 50 percent between 1993 and 2015, primarily for electricity generation. Environmental regulation and competition from other fuels are increasing, but the demand for coal remains strong.

Coal is an abundant and relatively low-cost energy resource. It has been used extensively worldwide in the past, and it is expected to be an important part of the world's energy supply in the future. In the 1970s, coal consumption grew steadily in both absolute and relative terms (Figure 46), as oil embargoes and price shocks caused consumers to substitute more economical and secure supplies of coal for petroleum products, especially for power generation. Since the mid-1980s, however, coal has lost out in relative terms as a source of incremental energy supply. Coal's share of total energy consumption has decreased from 28 percent in 1985 to 25 percent in 1993. The collapse of oil prices, the growing availability of natural gas in Europe and North America, and the adoption of new, highly competitive technologies for natural-gas-fired electricity generation have been major factors in coal's decline.

Figure 46. World Consumption of Coal Relative to All Other Energy Sources, 1970-2015



Sources: **History:** 1970, 1975: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1990: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

In some regions, coal consumption has decreased in both absolute and relative terms. For example, while consumption has continued to rise in the United States and Japan (on a Btu basis) over the past decade, coal use in other OECD countries has declined by more than 20 percent as a result of interfuel competition. And in the EE/FSU countries, substantial declines in economic growth have led to a 27-percent decline in coal use between 1989 and 1993.

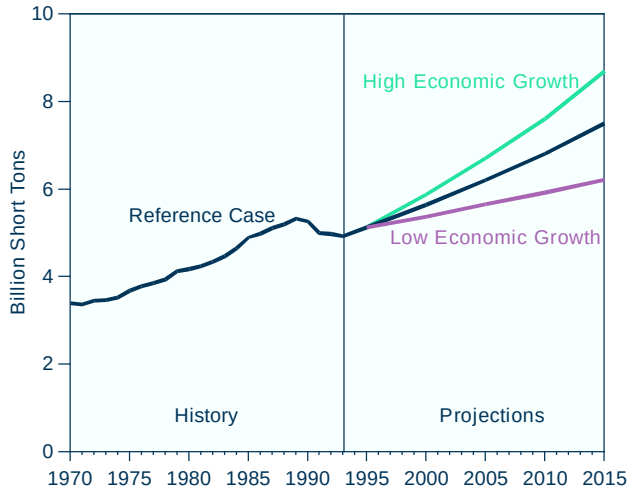
Declines in usage in OECD countries and in the former Soviet Union have been offset by strong growth in coal usage elsewhere, particularly in China and other Asian countries. In 1980, China accounted for 17 percent of world coal use (on a Btu basis); in 1993, its share exceeded 26 percent. As a group, the Asian countries, including Japan, accounted for more than 40 percent of world coal consumption in 1993, whereas in 1980 their share was about 26 percent.

Increased concern about the adverse environmental impacts associated with coal use has taken a toll on coal demand throughout OECD areas. Coal combustion produces several air pollutants that adversely affect ground-level air quality. One of the most significant pollutants from coal is sulfur dioxide, which has been linked to acid rain. Many countries have implemented policies or regulations to limit sulfur dioxide emissions, which typically require electricity producers to switch to lower sulfur fuels or invest in technologies that reduce the amount of sulfur dioxide emitted. In addition, coal has the highest carbon content of all the fossil fuels. Carbon dioxide emissions per unit of energy obtained from coal are nearly double those from natural gas and approximately 20 percent higher than from residual fuel oil—the petroleum product most widely used for electricity generation [**1**, p. 76].

The first binding international legal agreement dealing directly with climate change—the United Nations Framework Convention on Climate Change—became effective in March 1994. The Convention's primary objective is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." It was initially presented at the Earth Summit in Rio de Janeiro in June 1992, where it was signed by representatives from more than 160 countries, including the United States and the countries of the European Union. Carbon dioxide is generally viewed as the most significant of the greenhouse gases.

In terms of physical units, coal usage increased from 4.2 billion tons[6] in 1980 to a peak of 5.3 billion tons in 1989 (Figure 47) but has since declined to 4.9 billion tons in 1993. In the forecast, world coal consumption rises by 53 percent between 1993 and 2015, reaching almost 7.5 billion tons in 2015. Based on alternative assumptions about economic growth rates and trends in energy intensity, however, world coal consumption in 2015 could be as high as 8.7 billion tons or as low as 6.2 billion tons.

Figure 47. World Coal Consumption, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1992: EIA, *International Energy Annual 1992*, DOE/EIA-0219(92) (Washington, DC, January 1994). **Projections:** EIA, World Energy Projection System (1995).

Burning coal to generate electricity will account for most of the projected growth in coal consumption worldwide. In contrast, the outlook for non-electricity coal consumption is relatively flat. In the industrial sector, other fuels—primarily, natural gas and electricity—are expected to gain market share, except in China, where coal continues to be the fuel of choice. Consumption of coking coal should decline slightly as a result of technological advances in steelmaking, increasing output from electric arc furnaces, and continuing substitution of other materials for steel.

Overall, the changes in regional coal market activities over the past decade have been significant. World coal consumption was substantially higher in 1993 than in 1980, primarily because steady growth in the Asian market has overshadowed the recent setbacks in European markets. In the future, environmental regulation will represent a major challenge for coal markets. In addition, competitive pressure from other fuels, particularly oil and natural gas, has intensified, in part because of low oil and gas prices, and in part because of new technologies that favor the use of natural gas for electricity generation. Nevertheless, coal use is still projected to grow by 2.6 billion tons (more than 50 percent) worldwide between 1993 and 2015.

Reserves

Total recoverable reserves of coal are estimated at 1,145 billion tons—enough to last another 230 years at current production levels (Figure 48).[7] Although coal deposits are widely distributed, 57 percent of the world's reserves are located in three regions: FSU (23 percent); United States (23 percent); and China (11 percent). Another four countries—Australia, Germany, India, and South Africa—account for an additional 28 percent. In 1993, these seven regions accounted for 80 percent of total world coal production.

Figure 48. World Coal Reserves

Note: Data shown for the United States represent recoverable reserves as of December 31, 1991. Data for all other countries are as of December 31, 1990.

Source: Energy Information Administration, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995), Table 8.2.

Quality and geological characteristics of coal deposits are other important parameters for coal reserves. Coal is a much more heterogeneous source of energy than is oil or natural gas, with quality varying significantly from one region to the next and even within an individual coal seam. For example, both Australia and the

[6]Throughout this chapter, tons refers to short tons (2,000 pounds).

[7]Recoverable reserves are those quantities of coal which geological and engineering information indicates with reasonable certainty can be extracted in the future from known deposits under existing economic and operating conditions.

United States are endowed with substantial reserves of superior coals that can be used to manufacture coke, and together they supplied 71 percent of the metallurgical coal traded worldwide in 1993 (Table 17). Coal deposits in South Africa, the number three exporter in the world, are high in ash content and require much more preparation to produce a marketable product than do coals from other regions [**2**, p. 16]. South Africa's

Table 17. World Coal Flows by Importing and Exporting Regions, Reference Case, 1993, 2000, and 2015
(Million Short Tons)

Exporters	Importers											
	Steam				Metallurgical				Total			
	Europe	Asia	Other	Total	Europe	Asia	Other	Total	Europe	Asia	Other	Total
	1993											
Australia	10	51	1	**62**	16	51	14	**81**	25	102	15	**142**
United States	14	8	5	**26**	27	12	12	**51**	41	20	17	**78**
South Africa	33	17	2	**52**	0	4	1	**5**	34	21	3	**57**
Former Soviet Union	14	2	0	**16**	2	3	0	**5**	16	5	0	**21**
Poland	16	0	0	**16**	6	0	2	**7**	21	0	2	**23**
Canada	1	3	1	**5**	2	22	2	**26**	3	25	4	**31**
China	1	15	0	**17**	0	4	0	**5**	2	20	1	**22**
South America	13	0	6	**19**	1	0	0	**1**	14	1	6	**20**
Other[a]	9	16	1	**26**	3	2	0	**6**	12	18	1	**31**
Total	**111**	**112**	**17**	**240**	**57**	**99**	**31**	**187**	**168**	**211**	**48**	**426**
	2000											
Australia	19	87	2	**109**	13	51	5	**69**	33	138	7	**178**
United States	21	4	7	**31**	28	14	15	**57**	49	18	22	**89**
South Africa	25	28	2	**56**	1	4	0	**5**	26	32	2	**61**
Former Soviet Union	6	5	0	**11**	3	4	0	**7**	9	9	0	**18**
Poland	13	0	0	**13**	7	0	0	**7**	20	0	0	**20**
Canada	3	5	1	**10**	4	18	0	**22**	7	23	1	**31**
China	0	17	0	**17**	0	3	0	**3**	0	20	0	**20**
South America	29	0	12	**41**	0	0	0	**0**	29	0	12	**41**
Other[b]	0	26	0	**26**	0	0	0	**0**	0	26	0	**26**
Total	**117**	**172**	**25**	**314**	**56**	**93**	**20**	**169**	**172**	**266**	**45**	**483**
	2015											
Australia	35	150	7	**192**	15	48	5	**69**	50	198	12	**260**
United States	37	12	19	**68**	32	13	17	**62**	69	24	36	**130**
South Africa	41	53	7	**101**	1	3	0	**4**	42	56	7	**105**
Former Soviet Union	9	6	0	**15**	3	4	0	**7**	11	10	0	**21**
Poland	10	0	0	**10**	9	0	0	**9**	19	0	0	**19**
Canada	7	4	1	**13**	4	23	1	**28**	11	28	2	**40**
China	0	32	0	**32**	0	4	0	**4**	0	36	0	**36**
South America	63	0	27	**90**	0	0	0	**0**	63	0	27	**90**
Other[b]	0	42	0	**42**	0	0	0	**0**	0	42	0	**42**
Total	**202**	**299**	**61**	**562**	**64**	**95**	**22**	**181**	**265**	**394**	**83**	**743**

[a]Includes principally Indonesia's trade within Asia, as well as the United Kingdom and Germany's trade within Europe.
[b]Does not include the United Kingdom and Germany's trade within Europe.

Note: Totals may not equal sum of components due to independent rounding. The sum of the columns may not equal the total, because the total includes a balancing item between importers' and exporters' data.

Sources: **1993**—International Energy Agency, *Coal Information 1993* (Paris France, 1994). **Projections**—Energy Information Administration, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), National Energy Modeling System run AEO96B.D101995C.

coal seams lie relatively close to the surface, however, and they are both flat and thick. As a result, low production costs—along with relatively low sulfur content—compensate for the higher preparation costs. Germany, on the other hand, has substantial amounts of bituminous or hard coal reserves (26 billion tons), but its production costs are high because much of the coal is in deep-lying, discontinuous seams [**3**]. Consequently, Germany's hard coal production requires large government subsidies to ensure its competitiveness with other fuels [**4**, p. 21].

Several new low-cost producers, including Indonesia, Colombia, and Venezuela, have entered the coal supply picture in recent years and are rapidly penetrating the market for world coal trade. Indonesia currently ranks ninth in the world, with an estimated 35 billion tons of recoverable coal reserves. As late as 1989, Indonesia's recoverable reserves were estimated at only 3 billion tons [**5**]. Indonesian coal production has increased rapidly, rising from less than 1 million tons in 1980 to 30 million tons in 1993 [**6**, p. I.109]. Some of its coal reserves have unique characteristics that have made them sought after in the world marketplace. Some have extremely low sulfur content (0.08 percent average by weight). Other high-quality Indonesian reserves are finding acceptance as soft coking coals and in the newly evolving market for pulverized coal injection at blast furnaces [**7**].

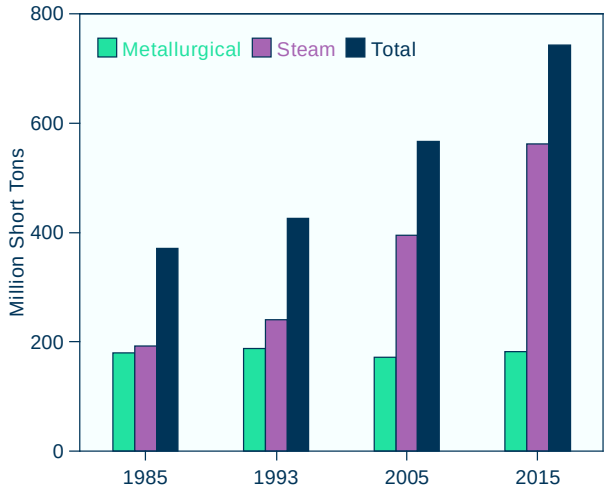
Trade

The amount of coal traded in international markets is relatively small in comparison with world coal consumption. In 1993, world imports of coal amounted to 426 million tons (Table 17 and Figure 49), representing 9 percent of total consumption. By 2015, coal imports are projected to rise to 743 million tons, or 10 percent of total world coal consumption.

The current market for international coal trade has been characterized by relatively stable coal import demand in Europe and expanding demand in Asia. Although rationalization of the indigenous coal industry has led to substantial declines in European production in recent years, other factors, which include the continuing process of economic reform in EE/FSU countries, a weak economy in Western Europe, and increased electricity generation from natural gas, nuclear, and hydropower, have kept European coal imports from rising. Conversely, growth in coal demand in Japan, South Korea, and Taiwan in recent years has contributed to a substantial rise in Asian coal imports.

Asian coal import demand is poised for exceptional growth over the forecast period due to strong economic

Figure 49. World Coal Trade, 1985-2015



Sources: **History:** International Energy Agency, *Coal Information 1993* (Paris, France, 1994). **Projections:** Energy Information Administration, *Annual Energy Outlook 1996*, DOE/EIA-3838(96) (Washington, DC, January 1996), National Energy Modeling System run AEO96B.D101995C.

growth, particularly in China and India, and plans to construct many new coal-fired generating plants. Japan, South Korea, and Taiwan are projected to account for most of the additional imports (Table 17). Imports to China and India are projected to rise by a slightly smaller amount, as domestic coal supplies are expected to be given first priority in meeting the large projected increase (2.0 billion tons) in coal demand. China and Indonesia—Asia's internal coal suppliers—are projected to meet 20 percent of the region's import demand by 2015, up from 16 percent in 1993. Australia, however, should continue as the major exporter to Asia, meeting 50 percent of that region's total coal import demand in 2015, compared with 48 percent in 1993.

During the 1980s, Australia became the leading coal exporter in the world, primarily by meeting increased demand for steam coal in Asia. Some growth in exports of metallurgical coal also occurred, however, as countries such as Japan began substituting some of Australia's semi-soft or weak coking coals in their coke oven blends [**6**, I.78]. As a result, imports of hard coking coals from other countries, including the United States, were displaced. Australia's share of total world coal trade, which increased from 17 percent in 1980 to 33 percent in 1993, is projected to rise to 35 percent in 2015 [**8**].

European coal imports also are projected to rise, although the expected increase is less than half that projected for Asia. The forecast for Europe, however, is less certain than that for Asia. Uncertainties surrounding the prospects for European imports include the

extent and pace of the decline in indigenous coal production (primarily in Germany and the United Kingdom) and the extent to which natural gas and other sources of energy will substitute for coal in electricity generation.

Coal production in Germany and the United Kingdom, taken together, has declined by almost 50 percent since 1989. This substantial decline is attributable in part to some decline in total energy demand in Germany. More importantly, however, other fuels—particularly, natural gas—have substituted for domestic coal in the energy mix of the two countries. Growth in coal imports has been small, rising by 7 million tons in Germany between 1989 and 1994 and by 4 million tons in the United Kingdom.

In the United Kingdom, coal production declined from 111 million tons in 1989 to 53 million tons in 1994 [**6**, p. I.109]. Most of the decline was due to privatization efforts in the electricity sector, which led to a rapid increase in gas-fired generation at the expense of coal [**6**, p. I.63]. In Germany, coal production declined from 540 million tons in 1989 to 292 million tons in 1994 [**6**, pp. I.109 and I.114]. More than 90 percent of the decline was in the production of lignite, which has approximately one-third the heat content of German hard coal. The large decline in lignite production is mostly attributable to the conversion from lignite-based town gas to natural gas that occurred in the eastern states of Germany following reunification in 1990 [**6**, p. II.163; **9**]. A second key factor was the collapse in industrial output in the eastern states that resulted from the loss of markets in Eastern Europe and increased competition from the West [**6**, p. II.163; **10**].

In the *IEO96* forecast, further declines in lignite production are expected to be small. This outlook is based on the competitiveness of German lignite with other imported fuels, as well as planned investments to refurbish or replace existing lignite-fired plants using best available combustion and pollution control technologies [**4**]. On the other hand, some observers in Germany contend that alternative investments in energy-saving technologies, renewable energy, and natural-gas- and hard-coal-fired power stations represent a wiser investment from an environmental perspective [**11**]. Germany's hard coal production, which is highly subsidized, declined from 85 million tons in 1989 to 63 million tons in 1994. Current plans call for some reductions in subsidies over time, which are expected to result in subsequent declines in domestic production and some increases in imports. German imports are also projected to rise as a result of increasing coal demand.

In the forecast, the United States, Australia, and South Africa continue to supply approximately 60 percent of Europe's coal import demand. Low-cost producers in South America are projected to increase their share of European imports from 8 percent in 1993 to 24 percent in 2015, primarily at the expense of the FSU and Poland, whose combined share is projected to decline from 22 percent in 1993 to 11 percent in 2015.

Compared with European and Asian coal markets, imports of coal by North and South America are relatively small, amounting to only 34 million tons in 1993. Brazil imported 41 percent of the 1993 total, followed by Canada (27 percent) and the United States (21 percent) [**12**]. Almost all (95 percent) of the imports to Brazil were metallurgical coal. In the forecast, coal imports to these regions increase by 44 million tons, with most of the additional amounts going to South America and Mexico. Over the next few years, Mexico plans to convert many of its oil-fired power plants to natural gas and coal and to construct additional generating capacity, including a number of coal-fired units [**13**, **14**]. On the basis of expectations that Mexico's economy will recover and that sufficient coal import facilities will be built, steam coal imports of 17 million tons are projected by 2015, originating from mines in South America and the United States. The North American Free Trade Agreement (NAFTA) provides some economic incentive for imports, as it removes the current tariff and value-added tax on U.S. coal shipments to Mexico [**15**].

Historically, metallurgical coal has dominated world coal trade, but its share has steadily declined, falling from 54 percent in 1980 to 44 percent in 1993 (Figure 49). In the forecast, its share of world coal trade continues to shrink, falling to 24 percent by 2015. In absolute terms, metallurgical coal trade is projected to decline by only a small amount over the forecast. Factors that contribute to the decline are additional penetration of steel production from electric arc furnaces (which do not use coal coke as an input) and technological improvements at blast furnaces, including greater use of pulverized coal injection (PCI) equipment as well as higher average injection rates per ton of hot metal produced. One ton of pulverized coal (categorized as steam coal) displaces approximately 1.4 tons of coking coal [**16**]. In 1993, an estimated 15 million tons of coal for PCI were traded worldwide [**6**, p. I.81], representing 8 percent of total coal imports for consumption at coke plants and blast furnaces. Partly offsetting the downward pressure on metallurgical coal trade is an expected rise in imports to Europe, attributable to projected declines in indigenous coking coal production, and some growth in world steel production.

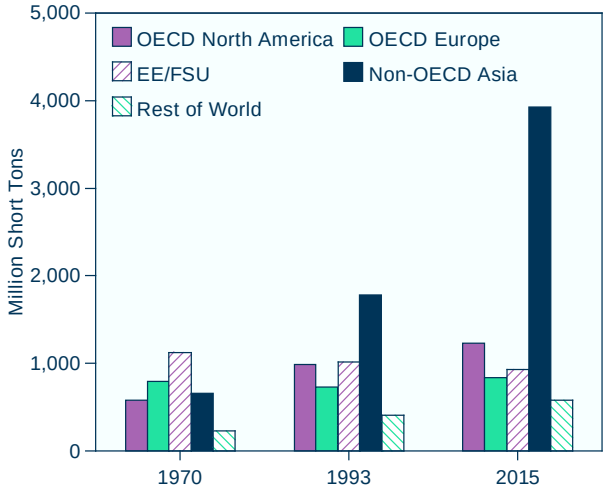
Regional Overview

Worldwide, the consumption of coal relative to other fuels is projected to remain stable, accounting for 25 percent of total energy consumption through 2015. The approximate stability masks strongly divergent trends.

Asia

As a result of fast-paced economic growth, coal consumption is expected to grow most rapidly in non-OECD Asia. In the *IEO96* forecast, this region's share of total world coal consumption increases from 36 percent in 1993 to 52 percent in 2015. Coal consumption in the region is projected to more than double, rising from 1,777 million tons in 1993 to 3,931 million tons in 2015 (Figure 50). China, alone, is expected to increase its coal consumption by 1,725 million tons. India, too, is poised for a substantial increase in coal usage, with consumption projected to rise by 320 million tons.

Figure 50. World Coal Consumption by Region, 1970, 1993, and 2015



Sources: **1970:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. **1993:** EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **2015:** EIA, World Energy Projection System (1996).

The large projected increases in coal consumption in China and India are based on an outlook for strong economic growth (7.7 percent per year in China and 5.1 percent per year in India) and the expectation that much of the increased demand for energy will be met by coal, particularly in the industrial and electricity sectors. By 2015, coal is projected to meet 66 percent of the total demand for primary energy in China and 47 percent in India. The *IEO96* forecast assumes no significant change in environmental policies in the two countries. It also assumes that necessary investments in the countries' mines, transportation, industrial facilities, and power plants will be made.

Strong growth (26 percent) in coal usage in Japan is also anticipated. Japan imports more coal than any other country in the world. In 1993, Japanese coal imports amounted to 122 million tons, or 29 percent of total world imports. Although imports to Japan are expected to expand to meet increases in electricity coal demand, its share of total world imports is projected to decline to 21 percent by 2015.

Europe

As noted earlier, coal consumption in OECD Europe has declined in recent years. Increased coal consumption is projected for the region, but it is not expected to reach the levels of the late 1980s. Environmental concerns in OECD Europe play an important role in the competition among coal, natural gas, and nuclear power, and they have favored increased use of fuels other than coal in recent years. The countries of OECD Europe are committed to the stabilization of greenhouse gas concentrations in the atmosphere as established by the Framework Convention on Climate Change.

In the countries of Eastern Europe and the former Soviet Union, the process of economic reform continues, as the transition to a market-oriented economy replaces centrally planned economic systems. The dislocations associated with these institutional changes have contributed substantially to the declines in both coal production and consumption. Coal consumption in the EE/FSU region has fallen from 1,441 millions tons in 1988 to about 1 billion tons in 1993. In the future, total energy consumption in the EE/FSU is expected to rise, driven primarily by increasing production and consumption of natural gas. In the forecast, coal's share of total EE/FSU energy consumption declines from 27 percent in 1993 to 19 percent in 2015, while the portion of consumption met by natural gas increases from 40 percent in 1993 to 48 percent in 2015.

North America

In North America, coal consumption is concentrated in the United States, which, at 926 million tons, accounted for 94 percent of the regional total in 1993. By 2015, U.S. coal consumption is projected to rise to 1,120 million tons. With its substantial supplies of coal reserves, the United States has come to rely heavily on coal for electricity generation and will continue to do so over the forecast. Coal provided 52 percent of total U.S. electricity generation in 1993 and is projected to provide 49 percent in 2015 [**17**]. Coal consumption in Canada and Mexico, taken together, is projected to rise from 59 million tons in 1993 to 109 million tons in 2015.

Africa

In Africa, coal production and consumption are concentrated almost entirely in South Africa. In 1993, South Africa produced 201 million tons of coal, with 71 percent routed to domestic markets and the remainder to exports [**6**, p. I.109]. South Africa ranks third in the world in exports, behind Australia and the United States, and is projected to maintain that position over the forecast. On the domestic front, South Africa holds the distinction of being the world's largest producer of coal-based synthetic liquid fuels. In 1993, almost one-fourth of the coal consumed in South Africa (on a Btu basis) was used to produce coal-based synthetic fuels [**6**, p. III.42], which in turn accounted for approximately one-third of all liquid fuels consumed in South Africa for the year. For Africa as a whole, coal consumption is projected to increase by 36 million tons between 1993 and 2015, primarily to meet increased demand for electricity. There are substantial opportunities for trade in electricity and natural gas between South Africa and neighboring countries. Such trades may occur, given government reform in South Africa and the subsequent removal of trade sanctions.

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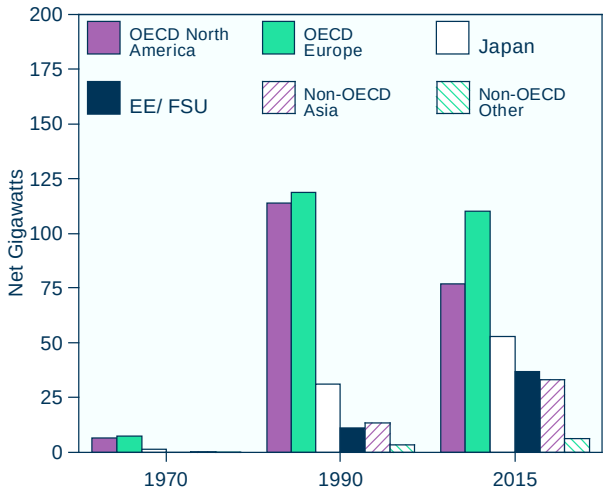
Nuclear Power

Growth in nuclear capacity is expected in France, in Japan, and in developing nations just beginning their nuclear power programs. In other nations with nuclear capacity, declines are anticipated.

Nuclear power plants have been generating electricity since the 1960s. In recent years, countries with nuclear power programs have derived an average of more than 20 percent of total electricity generation from nuclear fuels; however, fewer than half of those countries are projected to experience net growth in nuclear capacity between 1994 and 2015 in the lower reference case (as defined below). Growth is expected mainly in developing countries just beginning their nuclear programs, and in France and Japan (Figure 51). In the United States, nuclear power capacity is projected to decline by one-third, given the assumption that existing plants will be retired at the end of their licensed operating lives. In Europe, only France is expected to achieve further growth in nuclear generating capacity. Despite rapid growth in nuclear capacity in Asia, overall reliance on nuclear energy is projected to decline by 2015.

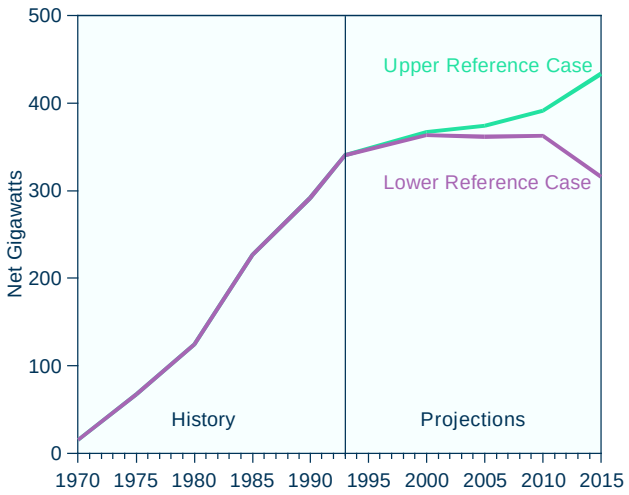
Figure 51. World Nuclear Capacity by Region, 1970, 1990, and 2015



Sources: **History:** International Atomic Energy Agency, *Nuclear Power Reactors in the World* (Vienna, Austria, April 1993). **Projections:** Energy Information Administration, *World Nuclear Outlook 1995*, DOE/EIA-0436(95) (Washington, DC, October 1995), p. 8.

Two scenarios were developed for projections of nuclear capacity in this report (Figure 52). The *lower reference case* reflects a continuation of the present trends in the nuclear power industry, resulting in minimal growth through 2010 and a decline by 2015, as discussed above. The *upper reference case* reflects a moderate revival in nuclear orders, with net capacity growth of 1.1 percent per year over the forecast period. In the upper reference case, net increases in nuclear capacity are projected for all but 7 of the 39 countries with nuclear programs (Table 18).

Figure 52. World Nuclear Capacity, 1970-2015



Sources: **History:** International Atomic Energy Agency, *Nuclear Power Reactors in the World* (Vienna, Austria, April 1993). **Projections:** Energy Information Administration, *World Nuclear Outlook 1995*, DOE/EIA-0436(95) (Washington, DC, October 1995), p. 8.

World Trends

The performance of nuclear reactors has been improving worldwide. A review of 1994 performance, as measured by reactor load factors,[8] indicates that 55 percent of all reactors achieved load factors above 75 percent, whereas only 48 percent were above the 75-percent level in 1993 [**1**]. Moreover, 54 reactors in various countries achieved load factors above 90 percent for the year. The highest national averages—all above 80 percent—were reported by Switzerland, Argentina, Finland, Hungary, South Korea, Netherlands, Czech

[8]The annual load factor is calculated as the gross generation of a reactor in a 1-year period, divided by the gross capacity of the reactor, as originally designed, multiplied by the number of hours in the calendar year.

Table 18. Historical and Projected Operable Nuclear Capacities, 1994-2015

(Net Gigawatts)

Country	1994[a]	2000		2005		2010		2015	
		Lower Reference Case	Upper Reference Case	Lower Reference Case	Upper Reference Case	Lower Reference Case	Upper Reference Case	Lower Reference Case	Upper Reference Case
OECD	**276.4**	**285.7**	**285.9**	**281.8**	**283.9**	**277.1**	**288.3**	**239.7**	**317.4**
United States	99.1	100.3	100.3	99.7	100.3	93.3	100.3	63.6	99.6
Canada	15.8	14.1	14.1	14.1	14.1	12.0	12.0	12.0	15.3
Mexico	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.9
Japan	38.9	43.7	43.7	45.8	46.1	51.1	52.3	52.6	57.7
Western Europe									
Belgium	5.5	5.5	5.5	4.7	4.7	3.9	3.9	3.9	4.8
Finland	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.7
France	58.5	64.3	64.3	62.9	62.9	62.9	64.3	60.5	72.8
Germany	22.7	22.0	22.0	21.4	21.4	21.4	21.4	20.2	23.6
Italy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Netherlands	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0	1.4
Spain	7.1	7.0	7.1	7.0	7.0	6.5	7.0	6.5	9.4
Sweden	10.0	10.0	10.0	10.0	10.0	10.0	10.0	6.7	10.5
Switzerland	3.0	3.0	3.0	2.3	2.3	1.9	1.9	1.9	2.6
Turkey	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	2.0
United Kingdom	11.7	11.8	11.8	10.5	10.5	9.5	10.7	7.2	12.4
EE/FSU	**44.1**	**51.8**	**52.8**	**47.6**	**61.8**	**45.9**	**59.2**	**36.8**	**62.7**
Eastern Europe									
Bulgaria	3.5	2.7	2.7	1.9	2.9	1.9	3.8	1.9	3.8
Czech Republic	1.6	2.6	3.5	3.5	3.5	3.5	3.5	3.1	5.1
Hungary	1.7	1.7	1.7	1.7	1.7	1.7	2.3	2.1	3.3
Romania	0.0	0.6	1.3	1.3	1.9	1.9	2.5	2.5	3.2
Slovak Republic	1.6	1.6	2.0	1.6	1.6	1.6	1.6	0.8	1.4
Slovenia	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Former Soviet Union									
Armenia	0.0	0.4	0.7	0.4	0.7	0.4	0.7	0.4	0.7
Kazakhstan	0.1	0.1	0.1	0.0	0.6	0.1	0.6	0.0	1.2
Lithuania	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Russia	19.8	23.6	23.6	20.1	20.9	17.5	24.5	12.9	27.1
Ukraine	12.7	15.5	14.1	14.1	15.1	15.6	16.6	11.4	15.2
Non-OECD	**20.2**	**26.0**	**28.4**	**32.1**	**38.5**	**39.7**	**43.8**	**39.6**	**53.4**
Asia									
China	2.1	2.1	2.1	3.3	5.3	5.3	5.3	5.3	8.2
India	1.5	2.3	2.5	2.2	3.6	3.3	3.5	3.3	5.1
Korea, North	0.0	0.2	0.2	0.2	1.9	0.2	1.9	0.2	1.9
Korea, South	8.2	13.0	13.0	13.9	14.9	17.4	17.4	17.4	19.3
Pakistan	0.1	0.1	0.4	0.4	0.4	0.4	0.7	0.3	0.6
Philippines	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.6
Taiwan	4.9	4.9	4.9	6.7	6.7	6.7	6.7	6.7	8.5
Central and South America									
Argentina	0.9	0.9	1.6	1.6	1.6	1.3	1.3	1.3	1.5
Brazil	0.6	0.6	1.9	1.9	1.9	1.9	3.1	1.9	3.1
Cuba	0.0	0.0	0.0	0.0	0.4	0.4	0.4	0.4	0.8
Middle East									
Iran	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.3
Israel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
South Africa	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Total World	**340.7**	**363.5**	**367.1**	**361.5**	**374.2**	**362.8**	**391.2**	**316.1**	**433.5**

[a]Status as of December 31, 1994.

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The lower and upper reference cases reflect varying degrees of optimism regarding nuclear power.

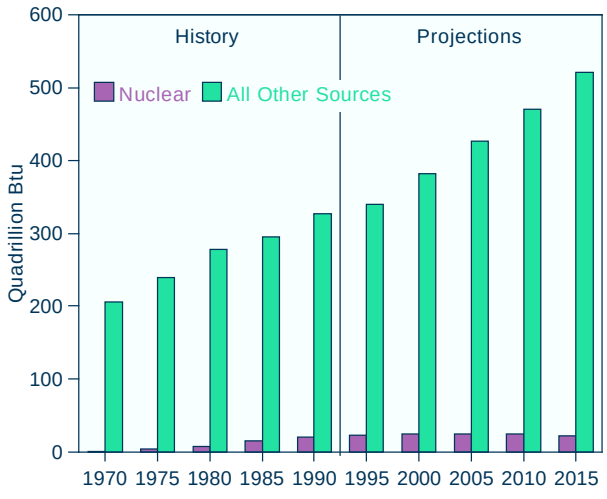
Sources: **United States:** Energy Information Administration, *Annual Energy Outlook 1996,* DOE/EIA-0383(96) (Washington, DC, January 1996). **Foreign:** Energy Information Administration, *World Nuclear Outlook 1995*, DOE/EIA-0436(95) (Washington, DC, October 1995).

Republic, and Belgium. All of these countries, except Argentina and the Netherlands, operate four or more reactors.

Improvements in reactor performance have been made possible, in large part, by longer operating cycles and shorter refueling times. For example, the longest continuous run ever achieved for a light-water reactor—616 days at Indian Point 2 in the United States—was completed in 1994, and two impressively short refueling outages were recorded during the year—35.5 days at Peach Bottom 2 and 31 days at North Anna 1, both in the United States.

The world's net operable nuclear capacity at the end of 1994 was 341 gigawatts for 432 reactors [**2**]. Total electricity generation from nuclear power increased slightly in 1994, with production of 2,131 net terawatthours worldwide. The United States, France, Germany, Russia, Ukraine, and Japan accounted for more than 70 percent of the total. Total nuclear generation, which grew substantially between 1980 and 1990, is projected to remain nearly level through 2015 (Figure 53). As increased emphasis on competition in electricity markets causes providers to turn to generating sources with short construction leadtimes and low capital costs, nuclear power will be at a severe disadvantage because of the higher construction costs and longer leadtimes for new nuclear capacity. In most areas of the world, currently operating nuclear plants will have to demonstrate improved performance and lower operating costs to prove that investments in nuclear power can be competitive.

Figure 53. World Consumption of Electricity From Nuclear Power Relative to All Other Fuels, 1970-2015



Sources: **History:** 1970-1975: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1990: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Regional Overview

Non-OECD Asia

Countries in non-OECD Asia currently operating nuclear power plants include China, South Korea, Taiwan, India, and Pakistan. With the exception of South Korea, these programs are small, but all expect growth in the future. At the end of 1994, these five countries had 16.8 gigawatts of nuclear capacity on line. By 2015, additional programs are expected to be operating in the Philippines and North Korea, and nuclear capacity for the region is projected to be between 33.2 and 44.2 gigawatts. South Korea, currently the largest operator of nuclear power in the region, with 10 operable units totaling 8.2 gigawatts, projects a doubling of capacity to between 17.4 and 19.3 gigawatts by 2015.

During 1994 two new units became operable in the region: Guangdong 2, a 906-megawatt pressurized-water reactor (PWR) in China, and Yonggwang 3, a 950-megawatt PWR in South Korea. At the end of 1994, 27 units were under construction or on order in non-OECD Asian countries, including 11 in South Korea [**2**, p. 6]. South Korea has experienced rapid growth in energy demand over the past 20 years but still lags behind Japan and Taiwan in per capita electricity consumption. Therefore, its potential for continued growth is high. The latest power development plan for South Korea calls for 35 percent of new generating capacity over the next 10 years to come from nuclear power. China has also announced aggressive plans to build additional nuclear power plants to meet rapid growth in electricity demand. It is pursuing several different options to purchase new nuclear reactors and technology (see box on page 60). India and Pakistan are also expecting continued growth in electricity consumption, and both countries will need new capacity to meet the demand.

OECD Pacific

In the OECD Pacific region, only Japan has a well-established nuclear program, with 49 units totaling 38.9 gigawatts of operable capacity at the end of 1994. Japan's nuclear share of electricity in 1994 was 31 percent. Japan has ambitious plans for further nuclear expansion, mainly to help achieve energy independence. Japan's nuclear capacity is projected to increase by 13.7 gigawatts—to a total of 52.6 gigawatts—by 2015 in the lower reference case. The upper reference case projects an increase in capacity to 57.7 gigawatts by 2015. In 1994, one new unit was connected to the grid—

China's Nuclear Expansion

China began considering nuclear energy in the late 1970s as an alternative source of much-needed electricity. Current electricity production is not sufficient to satisfy demand, especially in the heavily populated and industrialized southeastern region of the country [**3**]. Several factors drive China's efforts to expand its electricity supply with new nuclear capacity:

- *Environmental considerations.* China uses large amounts of coal to generate electricity. The country already ranks among the world's largest emitters of carbon dioxide from its coal-fired generation.* In 1989, China emitted 6.01 million metric tons of carbon dioxide per $1,000 of GNP—more than any other nation, according to the National Academy of Sciences' Commission on Policy Options for Global Warming [**4**].
- *Poor transportation infrastructure.* Even if China were willing to increase coal use, its underdeveloped rail system would not be adequate to transport enough coal to areas of need. Most of the country's coal resources are located in the north—away from its most needy areas [**5**]. In fact, half of the present railway capacity and one-fourth of the trucking fleet are already committed to hauling coal and oil.
- *Limited potential for hydroelectric development.* Another alternative source to coal-generated electricity in China is hydroelectricity. This year construction began on the Three Gorges Dam on the Yangtze River, which may be fully operational by 2015, with a capacity of 18 gigawatts. Unfortunately, the need to preserve valuable arable land to feed the nation's population constrains extensive hydroelectric development on the scale of Three Gorges.

In 1980, China announced to the world that it intended to build 12 nuclear power plants over the next 20 years, and that the country would open its doors to foreign contractors to help in the billion dollar construction process. However, China's refusal to sign the Nuclear Non-Proliferation Act, which is designed to prevent the spread of nuclear weapons, forced the country to announce in 1987 that it would revert to self-reliance.

Today China's nuclear infrastructure consists of three plants (see map on page 61) with a total capacity of 2.1 gigawatts, which provided 1.5 percent of the country's total electrical output in 1994 (see table on page 62) [**2**, p. 4]. The first reactor, Qinshan 1, a 288 net megawatt-electric (MWe) PWR, went on line in 1991, making China the 26th nation in the world to generate commercial electricity from nuclear power. The plant is seen by the Chinese as a victory in its fight for national self-reliance, although some 30 percent of the components were provided by Japan and Western Europe. The plant is located by the Hangzhou Bay at the foot of Qinshan Mountain in Zhejiang province and feeds electricity to the grid serving Shanghai and three eastern Chinese provinces.

Two other 906-MWe PWRs, Guangdong 1 and 2 at Daya Bay in the Guangdong province, are modeled after reactors used by Electricité de France and jointly owned by the Chinese government and China Light and Power of Hong Kong. The units were connected to the grid in 1993 and 1994, respectively [**2**, p. 89]. The completion of the Guangdong station helps increase the generating capacity of the country's fastest growing province. The station is less than 50 kilometers northeast of Hong Kong and provides over 70 percent of its output to the city; the remainder is dispersed to relieve the area's energy shortage.

China's 2.1 gigawatts-electric (GWe) of capacity is far short of its original projection. The main reason for the slow start of the country's nuclear program is lack of capital. While central planners in Beijing set overall objectives for nuclear power, budgeting by individual provinces has made it difficult to force the pace for implementation. China's National Nuclear Corporation (CNNC), which is responsible for promoting nuclear power, currently projects a goal of 15 to 17 GWe of nuclear generating capacity by 2010 and 30 to 50 GWe by 2020 [**5**]. If China is able to connect 50 GWe to the grid by 2020, it will provide about 10 percent of the country's expected electricity demand. To reach that ambitious goal, foreign capital will be essential.

Four nuclear power units, totaling 3.2 GWe capacity, are currently in the construction pipeline in China (see table): Qinshan 2 and 3 and Lingao 1 and 2 (also known as Guangdong 3 and 4). Qinshan 2 and 3 are 600-MWe PWRs. CNNC hopes that they will be the model for a standardized Chinese design for those provinces whose systems and finances are not yet

*Carbon dioxide emissions per unit of energy obtained from coal are nearly double those from natural gas and approximately 20 percent higher than from residual fuel oil.

suitable for large imported nuclear power plants. Concrete pouring for Qinshan 2 and 3 began in late 1995 [**6**, pp. 26-27], and the Chinese government estimates completion by 2000 and 2001, respectively. The purchase of Lingao 1 and 2, both 985-MWe PWRs, was agreed on in January 1995 between China and French vendor Framatome. The reactors are to be built at Lingao in the Guangdong province, only a few kilometers from Guangdong 1 and 2. Construction of the units was scheduled to begin before the end of 1995, and they are due to enter service in 2002 and 2003, respectively.

Nuclear Power Units in China

Source: S. Rippon, "China Ready for More Nuclear Power," *Nuclear News* (June 1995), pp. 32-33.

China's Nuclear Expansion (Continued)

Three countries have recently concluded agreements that could lead to the supply of nuclear power plants for the eastern provinces of China. In May 1995, Chinese authorities in Beijing approved the construction of two 1,000-MWe PWRs from Russia at Wufangdian in the northeastern province of Liaoning, at an estimated cost of $3.2 billion. The project is slated for operation by 2002. Financing will be provided from Russia and from CNNC and the Liaoning provincial government.

At the end of 1994, Atomic Energy of Canada Limited (AECL) and CNNC signed a memorandum of understanding (MOU) regarding the purchase of two 700-MWe reactors, possibly at the Qinshan site. The MOU is an agreement to start detailed technical and commercial discussions, including options for financing. The reactors are expected to be based on the CANDU-6 design currently in use at Point Lepreau and Gentilly in Canada, and their cost is estimated at about $3.5 billion.

Also at the end of 1994, South Korea concluded an MOU for the supply of two units based on its Korean standardized nuclear power plant design. The South Koreans are working with CNNC on assessment of prospective sites in Shandong or Fujian provinces. In 1992, a site known as Dongping in the Guangdong province was selected for a nuclear power station, where four 950-MWe units will be built at an estimated cost of $11 billion.

Nuclear Power Units in China

Unit Name	Type	Location	Capacity (Net Megawatts-Electric)	Published Date[a]
Units in Operation				
Guangdong 1	Pressurized-water reactor	Guangdong	906	1993
Guangdong 2	Pressurized-water reactor	Guangdong	906	1994
Qinshan 1	Pressurized-water reactor	Zhejiang	288	1991
Total			**2,100**	
Units in Construction Pipeline				
Lingao 1	Pressurized-water reactor	Guangdong	985	2002
Lingao 2	Pressurized-water reactor	Guangdong	985	2003
Qinshan 2	Pressurized-water reactor	Zhejiang	600	2000
Qinshan 3	Pressurized-water reactor	Zhejiang	600	2001
Total			**3,170**	
Planned Units				
Dongping 1	Pressurized-water reactor	Guangdong	950	Unknown
Dongping 2	Pressurized-water reactor	Guangdong	950	Unknown
Dongping 3	Pressurized-water reactor	Guangdong	950	Unknown
Dongping 4	Pressurized-water reactor	Guangdong	950	Unknown
Liaoning 1	Pressurized-water reactor	Liaoning	1,000	2002
Liaoning 2	Pressurized-water reactor	Liaoning	1,000	2002
Qinshan 4	Pressurized heavy-water reactor	Zhejiang	700	Unknown
Qinshan 5	Pressurized heavy-water reactor	Zhejiang	700	Unknown
Fujian/Shandong 1	Pressurized-water reactor	Fujian/Shandong	960	Unknown
Fujian/Shandong 2	Pressurized-water reactor	Fujian/Shandong	960	Unknown
Total			**9,120**	

Sources: **Units in Operation:** Energy Information Administration (EIA), *World Nuclear Outlook 1995*, DOE/EIA-0436(95) (Washington, DC, October 1995), p. 89. **Units in Construction Pipeline:** Eia, *World Nuclear Outlook 1995*, p. 108; and *Nuclear Engineering International* (February 1995), p. 15. **Planned Units:** *NUEXCO Review* (1993), pp. 26-29; S. Rippon, "China: Ready for More Nuclear Power," *Nuclear News* (June 1995), pp. 32-33; and "Four Projects in China's 5 Year Plan," *Nuclear News* (December 1995).

Ikata 3, an 846-megawatt PWR [**2**, p. 3]. The aggressive expansion plan includes 18 units, totaling 19.3 gigawatts, in the construction pipeline at the end of 1994 [**2**, p. 5]. Japan's expansion plans include the construction of reprocessing and recycling facilities to handle nuclear waste domestically.

OECD Europe

Western Europe relies heavily on nuclear power to satisfy its electricity demand. In 1994, OECD Europe generated 43 percent of its electricity with nuclear power. In France and Belgium, 75 and 56 percent, respectively, of the national demand for electricity was supplied from nuclear power plants [**2**, p. 4]. However, the overall trend in OECD Europe is away from nuclear power builds. In the lower reference case, only France and Turkey (building its first unit) are projected to have net increases in nuclear capacity between 1994 and 2015. Seven other West European countries are projected to have decreases in total nuclear capacity due to plant retirements.

No new units were brought on line in the region during 1994, but two units were retired. In France, Bugey 1, a 540-megawatt gas-cooled, graphite-moderated reactor (GCR) was retired after 22 years of operation; and in the United Kingdom, Dounreay PFR, a 234-megawatt fast breeder reactor (FBR), was permanently shut down. In early 1995 Sizewell B, a 1,188-megawatt PWR, was brought on line in the United Kingdom, after just under 7 years of construction time.

The bleak outlook for nuclear power in Western Europe can be explained by several factors. France's 56 units provided 75 percent of the country's electricity needs, and the country will continue to depend on nuclear power for the majority of its electricity. Demand is not growing substantially, however, and the French are considering extending the operating lifetimes of current plants. Therefore, orders for new capacity are not expected until after 2000. Political opposition is limiting new nuclear construction in Finland, Sweden, and Germany. In the United Kingdom it has been determined that privatization of the advanced gas-cooled and PWR nuclear stations is possible, and will take place during 1996. As a result, Nuclear Electric, the only utility building new nuclear units, will not receive government assistance for new nuclear construction, as it would represent intervention in the electricity market.

North America

The nuclear program in the United States is much larger than those of Canada and Mexico, the two other countries in the region. However, reliance on nuclear power is very similar in the United States and in Canada. In 1994, the nuclear share of electricity in the United States was 20 percent; in Canada it was 19 percent. Mexico brought on line its second nuclear unit in 1994, and 3 percent of the country's electricity was generated from nuclear power during 1994. Little to no growth is expected in this region. In the United States, one unit under construction is projected to come on line in 1996. By 2015, however, U.S. nuclear capacity is projected to decrease by 36 percent from the 1994 level in the lower reference case, due to retirements and the lack of new orders. In Canada, with no new orders projected in the lower reference case, capacity decreases by 3.8 gigawatts by 2015 as a result of retirements. In the upper reference case, nuclear capacity is projected to remain relatively stable through 2015; this could be achieved if plants currently scheduled for retirement were life-extended.

During 1994 one new nuclear unit was connected to the grid in North America. In Mexico, Laguna Verde, a 654-megawatt boiling-water reactor (BWR), was brought on line. At the end of 1994, the construction pipeline included seven units under construction or planned in the United States; however, all but one are indefinitely deferred or have since been canceled. Canada and Mexico have no new units under construction [**2**, p. 5].

Although the national average performance of nuclear reactors in the United States is lower than in other countries, probably because of the large number of plants operating and the variability in operations, it is still steadily improving relative to past performance. A study of U.S. capacity factors[9] for the 3-year period 1992-1994, showed improved performance for all categories of plants, grouped either by size or by age [**7**]. Three-year averages were used to eliminate any dramatic changes from one year to the next based on refueling cycles. Almost three-quarters of U.S. plants had average capacity factors above 70 percent for 1992-1994, and only nine plants performed below 50 percent. The median capacity factor was 77 percent, up from 70 percent in 1989-1991. Improvements in nuclear reactor performance in the United States should improve the competitive potential for nuclear power, but further

[9]The capacity factor differs from the load factor in that net rather than gross generation and capacity are used. Otherwise, the calculation is the same.

reductions in operating and maintenance costs must also be achieved.

Eastern Europe/Former Soviet Union

In the EE/FSU region, the nuclear share of total electricity generation was 18 percent in 1994; 75 percent of the electricity in the region from nuclear plants was generated in the FSU [**2**, p. 4]. Reliance on nuclear power varies in this region, with Lithuania supplying 76 percent of the electricity from nuclear power and Russia only 11 percent. Several countries in the region have ambitious plans for additional nuclear capacity, but there are many challenges that will likely limit new nuclear builds. Due to the uncertain potential for future projects, the region's projected nuclear capacity in 2015 ranges from a net loss of 7.3 gigawatts in the lower reference case to a gain of 18.6 gigawatts in the upper reference case. These forecasts, particularly the upper reference case, assume that either financing will be available to the Eastern European countries through international lending institutions, or the respective economies will recover sufficiently to make nuclear construction a viable option.

The ability of EE/FSU countries to complete their aggressive plans to build new capacity (some 30 new units are under consideration) will depend on obtaining financial support and on improving safety at existing units. While the region is in transition to a market economy, investments in capital-intensive nuclear power projects are difficult. Many Western nations are tying financing agreements to improved safeguards at current plants, or requiring that unsafe plants be shut down. In many cases, the power generated by such plants cannot be supplied by any currently available alternatives. In Lithuania, two RBMK reactors (Soviet-designed light-water-cooled, graphite-moderated reactors) provide 76 percent of the country's electricity as well as a portion for export. The Ukrainian parliament originally voted to shut down permanently the two remaining reactors at the Chernobyl site by the end of 1993, but the units are still operating to alleviate electricity shortages in the area. The government has tentatively agreed to close the plants by the year 2000, given that replacement power would come from upgraded VVERs (Soviet-designed light-water reactors) [**8**]. Both the European Union and the G7 countries have pledged funds for the closure of the Chernobyl units.

Other Non-OECD Countries

Other non-OECD countries that currently operate nuclear power include Argentina, Brazil, and South Africa. Cuba is projected to bring its first unit on line by 2010. Argentina's two nuclear units provided 14 percent of the country's electricity in 1994. In March 1993, Brazil shut down the one unit it had in operation; however, the 657-megawatt PWR, Angra 1, came back on line in early 1995. South Africa has two nuclear units currently operable, which provided 6 percent of the country's electricity generation in 1994. No new nuclear units are planned in South Africa.

In the Middle East, Iran and Israel are projected to complete their first nuclear power projects by 2015. Development in these countries is not supported by many Western nations, which are concerned that the countries will also develop nuclear weapons capability. Nevertheless, Iran is pursuing several options for obtaining nuclear power. China has tentatively agreed to sell one or more reactors to Iran, but it is unclear whether any progress has actually been made [**8**]. Russia has also signed a contract to build nuclear reactors for Iran, and according to Russia's Atomic Energy Minister, work on the first has already begun [**9**]. Russia will also complete the Bushehr power plant in Iran, which was worked on for 5 years in the 1970s. Israel's plans are less defined, and only one small plant is projected to be on line by 2015 in the upper reference case.

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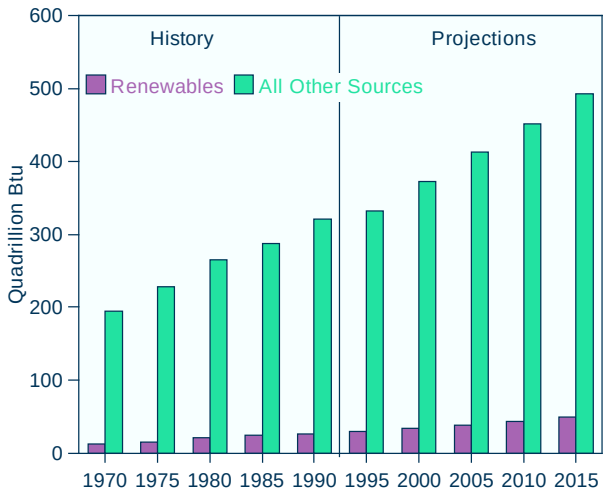
Hydroelectric and Other Renewable Energy

Hydroelectric resources are being developed aggressively in the emerging nations. In many developed nations, where few new hydropower sites are available, attention has shifted to wind as a renewable energy source.

Fast-paced growth in the use of renewable energy sources is expected to continue through 2015 around the world. Environmental concerns, in particular, are expected to create the appropriate market conditions for rapid growth in renewable energy demand. Despite competitive fossil fuel prices, which are expected to remain competitive throughout the projection period, the share of hydroelectricity and other renewable energy sources (primarily geothermal, wind, and solar) in the world's energy consumption mix increases from 8.0 percent in 1993 to about 9.2 percent in 2015 in the *IEO96* reference case (Figure 54).

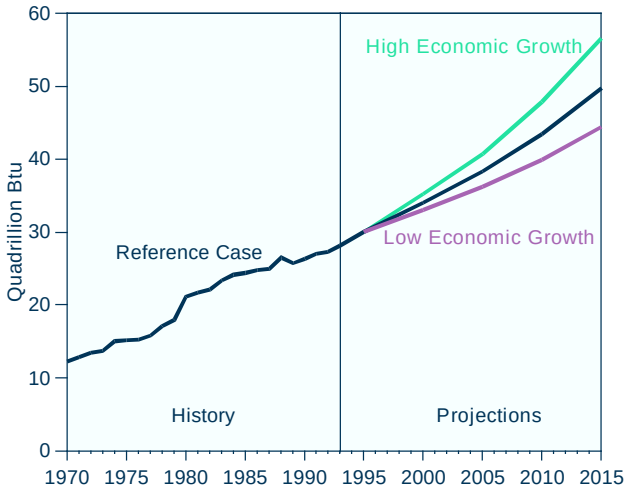
Figure 54. World Consumption of Hydroelectricity and Other Renewables Relative to All Other Fuels, 1970-2015



Sources: **History:** 1970-1975: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1990: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

World consumption of hydroelectricity and other renewables is projected to grow to 49.7 quadrillion Btu in 2015, an average annual increase of 2.6 percent between 1993 and 2015 (Figure 55). Slightly higher growth is expected in non-OECD countries, at 3.1 percent per year over the projection period, mainly as a result of aggressive development of hydroelectric resources in non-OECD Asia. Although slower growth is expected in the OECD countries, where most hydroelectric resources have already been developed, environmental concerns in Europe and North America are prompting the implementation of a variety of programs to promote the use of other renewables. In the industrialized nations of the world, further exploitation of hydropower resources for electricity generation is increasingly at odds with environmental protection. The adverse impacts of hydroelectric development, including displacement of population from flood plains and disruption of fisheries, have led to the suspension of a number of major projects in recent times, the most ambitious of which were located in Canada.

Figure 55. World Consumption of Hydroelectricity and Other Renewables, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Although wood waste, landfill methane, geothermal, wind, and solar energy still tend to be limited substitutes for hydropower, because of intermittent availability and relatively low power output with high cost per unit of operation, much progress has been made in improving the efficiency and performance of renewables technology. Efforts have been focused on making existing technology more cost-efficient and thereby more competitive with fossil fuels. In particular, substantial advances have been made toward

reducing the per-kilowatthour cost of producing electricity with wind power. In the United States, for example, the present cost of producing a kilowatthour of electricity with natural gas is estimated at about 3 cents; the cost of generating the same amount of energy with wind has dropped from a range of 7 to 10 cents per kilowatthour to as low as 5 cents per kilowatthour [**1**, p. D1].

Decreases in the cost of producing wind energy are attributed to intensive research programs in several OECD countries, most notably, the United States and Denmark. Turbines that can generate power in winds as low as 9 to 13 miles per hour are now being introduced in the United States [**2**, p. 9]. In 1994, the United States invested $30.5 million in research and development associated with wind power [**3**, p. 50]. By 2003, researchers expect to lower the cost of wind energy to 4 cents per kilowatthour. In contrast, solar-generated electricity presently costs more than 14 cents per kilowatthour.

Solar-generated electricity is being promoted by various government research and development programs. While its potential is large (Table 19), solar is currently dwarfed by such renewables as hydroelectricity, biomass, and geothermal, and only special circumstances allow it to be economical at this time. A principal issue in cost is the conversion rate of solar input to electricity output, which currently is only one-third of the theoretical maximum. Small quantities of solar power are installed on an economical basis where users are far removed from electricity grid networks.

Although the technology for generating electricity from tidal power may be considered mature (Table 19), it is also expensive to develop and is often accompanied by substantial environmental costs [**4**]. Efforts continue to develop tidal energy technologies that will be competitive with the costs of other energy sources and have minimal environmental impacts. A number of tidal energy projects have been proposed in India, including a 900-megawatt barrage in the Gulf of Kutch.

Table 19. Status of World Renewable Electric Power Generation Technologies, 1994

Technology		Technical Status	Commercial Status	Current Capacity (Megawatts)
Biomass	Agricultural residues	R-D	A	50,000
	Energy crops	R-D	A	500
	Urban wastes	R-D	A	1,000
	Biogas	D	A	1,000
Geothermal	Hydrothermal	M	E	10,000
	Geopressurized	R	U	0
	Hot dry rocks	R-D	U	0
	Magma	R	U	0
Hydroelectric	Small scale	M	A	19,500
	Large scale	M	A	627,000
Ocean	Tidal	M	A	263
	Tidal stream	R	U	0
	Shoreline wave	R-D	A	<1
	Offshore wave	R	U	<1
	Ocean thermal (OTEC)	R-D	A	0
	Salinity gradient	R	U	0
Solar	Solar thermal electric	R-D	U	>350
	Photovoltaics	D-M	A	380
Wind	Onshore	D-M	A	2,000
	Offshore	D	A	5

Notes: **Technical Status**—R = research, D = demonstrated, M = mature. **Commercial Status**—U = uneconomical, A = economical in certain areas or niche markets, E = economical.

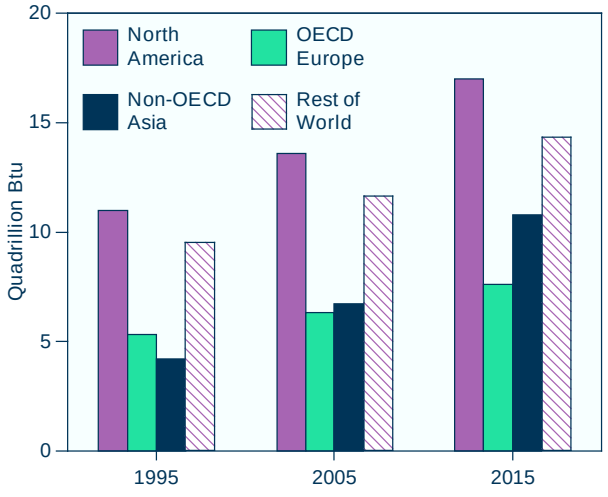
Source: International Energy Agency, *IEA/OECD Scoping Study: Energy and Environmental Technologies to Respond to Global Climate Change Concerns* (Paris, France, 1994), p. 93.

Noncommercial fuels from plant and animal sources are important energy sources, especially in the developing countries. Comprehensive data on the use of noncommercial fuels are not available, however, and they are not considered in the *IEO96* projections. Similarly, because there are few extensive sources of international data on their use, dispersed renewables (renewable energy consumed on the site of its production, such as solar panels used for hot water heating) also are not considered in the projections.

North America

In 1993 more than 10.3 quadrillion Btu of electricity generated by hydroelectric plants and other renewable resources was consumed in the three countries of OECD North America (Canada, Mexico, and the United States) [**5**, pp. 12-16]. Their consumption represented almost 37 percent of the world's use of renewable energy resources. Renewable energy in North America is projected to grow by 2.3 percent per year between 1993 and 2015, reaching nearly 17 quadrillion Btu at the end of the projection period (Figure 56).

Figure 56. World Consumption of Hydroelectricity and Other Renewables by Region, 1995, 2005, and 2015



Source: Energy Information Administration, World Energy Projection System (1996).

Hydroelectricity is well-established in the United States and, therefore, has limited potential for further development. In Mexico, hydroelectric capacity could double by 2010; however, a growing supply of electricity from independent power producers is expected to impede hydroelectric development somewhat [**6**, p. 115]. While there are numerous plans to expand the hydroelectric resources in Canada, grand schemes for large-scale hydroelectric projects—such as the three-phase James Bay project—have lost favor in light of decreasing estimates of electricity demand and increasing environmental concerns. In November 1994 work on the second phase of the James Bay project—the Grande Baleine (Grand Whale)—was suspended. Plans for the third phase, Nottaway-Broadback-Rupert, have been discarded.

By 2015, demand for renewable energy is projected to reach 8.9 quadrillion Btu in the United States, representing more than 8 percent of total U.S. energy consumption [**7**, p. 71]. Strong growth is projected for wind power, which could supply nearly 1 percent of U.S. electricity production by 2015. An annual growth rate of 11.5 percent is projected for wind-generated electricity between 1993 and 2015 [**7**, pp. 116-117].

At present, the total wind generating capacity in the United States is about 1.8 gigawatts, mostly located in California [**7**, p. 114; **2**, p. 8]. There is also extensive potential in other States, most notably, in North Dakota, South Dakota, Texas, Minnesota, and Montana. By one estimate, Texas and North Dakota alone could generate 46 percent of the electricity needed in the continental United States [**8**, p. 58]. Wind farms are currently under construction in Minnesota, Iowa, Hawaii, Texas, Wisconsin, and Washington, with demonstration projects planned in New England and Wyoming [**2**, p. 9].

In Canada, a shift from plans for nuclear power and large-scale hydroelectric schemes—most notable in Hydro Quebec's decision to terminate development of the Great Whale project in 1994—has resulted in renewed interest in alternative energy sources. The provincial utility, Ontario Hydro, has issued a request for proposals to acquire 100 megawatts of renewable energy capacity between 1995 and 1999 [**9**]. Plans include adding up to 200 megawatts of renewable sources—other than those generated at utility-owned large-scale hydroelectric stations—each year after 2000. The utility expects to develop wind power, solar power, combustion of wood and biomass, and burning of landfill gases. By 2020, Ontario Hydro would like to have long-term contracts for as much as 3.6 gigawatts of renewable nameplate capacity. The utility expects to fund wind power projects at $28 million annually through 1999.

Hydro Quebec has signed a power purchase agreement with the U.S. company, Kenetech, to install two on-grid wind farms with a combined capacity of 100 megawatts on the Gaspe peninsula, south of the St. Lawrence River in Quebec [**3**, p. 50]. Construction of the Gaspe Island project is slated to begin by summer 1997 [**10**, p. 7]. Currently, the Canadian company York-Vestas Energy is replacing old turbines at Cap Chat on the Gaspe peninsula with eight more efficient turbines [**11**, p. 56].

Work on Kenetech's 5-megawatt Magdalen Islands wind farm was scheduled to begin in 1995. In 1994, the company obtained a 25-year contract from Hydro Quebec to supply electricity at 5 U.S. cents per kilowatthour [**12**, p. 7]. The project was delayed in 1995, however, because of technical problems in connecting the wind farm with the existing diesel generator, and because the largest power consumer on the islands, a salt mining operation, was shut down in summer 1995 as a result of flooding.

Central and South America

Renewable energy, particularly hydropower, is an important source of electricity in Central and South America. In 1993, almost 400 billion kilowatthours of electricity from renewable sources was consumed in this region, most of it hydroelectricity [**5**, p. 12]. At present, 65 percent of the region's installed electricity capacity is hydroelectricity [**5**, p. 87]. Projected growth of renewables in this region is only 0.8 percent annually through 2015, because hydroelectric resources have already been developed to a large degree. Demand for renewables as a whole is expected to reach 5.0 quadrillion Btu by 2015. By 2010, there are plans to install over 30 gigawatts of additional hydroelectric capacity in Central and South America. Construction has already begun on much of the proposed capacity, or is at least in the final planning stages, including the large-scale, 20-gigawatt Guri project in Venezuela [**6**, p. 157].

Asia

Many countries in non-OECD Asia have an abundance of untapped hydroelectric resources. Indeed, in non-OECD Asia vigorous hydroelectric development continues, even though international financial support has declined. For example, Vietnam completed the 1.92-gigawatt Hoa Binh hydroelectric plant at the beginning of 1994 [**13**, p. 5]. A consortium of countries, including Vietnam, Thailand, Laos, and Cambodia, have agreed to begin building dams along the Mekong River [**14**, p. 29]. Hydroelectric projects are planned for the Borneo rain forest (Malaysia) and the Stung Nam River (jointly by Thailand and Cambodia) [**15**, p. 23].

Many large-scale hydroelectric projects continue to be difficult to finance because of high construction costs. Nepal is seeking a $175 million loan from the World Bank to support work on the 201-megawatt hydroelectric station on the Arun River, which is estimated to cost about $1 billion to construct [**16**]. While the Arun project has been the subject of protest from environmental groups, the Nepalese government argues that forests, their main energy source, are quickly being depleted and that utilizing the country's extensive hydroelectric potential is important to continued economic development.

In December 1994, construction began on China's controversial Three Gorges project at Sandouping. The 18-gigawatt project is expected to take between 15 and 20 years to complete with costs ranging from $12 billion to $70 billion, including interest charges and inflation [**14**, p. 25]. The Chinese government expects to provide much of the funding for the project and, toward that end, has already begun to levy a 2-percent tax on electricity. When completed, the Three Gorges project will provide power to an economic development program on the upper Yangtze River basin around the industrial city of Chongqing, as well as providing electric power to Shanghai, the fifth largest city in the world. In addition to the Three Gorges project, construction began on several smaller hydroelectric projects in 1995, including the Mianhuatan project (600 megawatts), Lingjintan (240 megawatts), Gaobazhou (240 megawatts), Bailongtan (192 megawatts), and Shiquankuo (90 megawatts) [**17**, p. 24]. Of the new electric capacity China plans to add between 1993 and 2010, 96.3 gigawatts are expected to be from hydropower [**18**, p. 2].

Government plans in India are to increase hydroelectric capacity to 71 gigawatts by 2007, an average increase of more than 3 gigawatts per year [**6**, p. 199]. However, the World Bank recently withdrew support for the large-scale Narmadu dam project on environmental grounds, and the future of the project is unknown. The Indian central government also devotes substantial resources to the development of other sources of renewable energy. Currently, other renewable capacity in India is on the order of 151 megawatts, including 3.3 megawatts from solar photovoltaic systems and 53.9 megawatts from wind power [**6**, p. 173].

Prospects for wind power development in India are very optimistic. Worldwide Institute estimated that, at the end of 1995, India was installing wind turbines at a faster rate than any other country [**19**, p. 66]. In 1989, tax incentives were introduced to encourage private-sector investment in wind resources [**20**, p. 62]. The policy allows companies to deduct the entire cost of equipment from pre-tax profits in the first year. India's Ministry for Non-Conventional Energy Sources projects that wind mills will contribute 500 megawatts of generating capacity to the national grid by 1997 [**20**, p. 62].

In Pakistan, hydroelectric resources are also abundant, but they are underdeveloped. Pakistan's hydroelectric capacity is about 3 gigawatts, one-third of its total electric utility capacity [**6**, pp. 199-200]. The potential for development of hydroelectric capacity is estimated

to be more than 30 gigawatts. As in India, environmental concerns have affected some hydroelectric projects. Recently, work ceased on the 2.4-gigawatt Kalabagh project because of environmental concerns.

In Indonesia, potential hydroelectric capacity has been estimated at 75 gigawatts, with less than 3 percent of this potential presently exploited. The state-owned electric utility, Perusahaan Listrik Negara (PLN), plans to add more than 5 gigawatts of hydroelectric capacity before 2004 by constructing more than 120 new hydroelectric plants [**21**, p. 9].

In OECD Asia, research and development on renewable energy sources continue to receive government sponsorship. The Japanese government supports development programs for such sources as waste-fired electricity, solar photovoltaics, and wind power [**22**, p. 5]. Australia also provides funds for research on renewable technologies. In 1995, a solar-thermal system designed to heat steam to drive turbine generators was installed in the Northern Australian community of Tennant Creek [**19**, p. 67].

Africa

There is abundant hydroelectric potential in Sub-Saharan Africa; however, the energy generated from existing hydroelectric facilities more than exceeds current electricity demand [**6**, p. 237]. For instance, the Inga site on the Zaire River has an installed capacity of 1.8 gigawatts, but only 550 megawatts is currently utilized. Inga alone could produce power far in excess of Zaire's current requirements. Zambia, Mozambique, and Egypt all have installed capacities of more than 2 gigawatts, and in Angola the 520-megawatt Capandu Dam on the Kwanza River is expected to be completed by 2000. Mozambique's civil war has substantially reduced generation from the 2.1-gigawatt Cahora Bassa dam on the Zambezi River to only 1.5 percent of capacity. When the civil war ends, Cahora Bassa could increase output to supply electricity to South Africa, for which that country has agreements in place to purchase 950 megawatts of capacity until 2004 and 1,500 megawatts beginning in 2005 [**6**, pp. 237-238].

OECD Europe

About 22 percent of the total world demand for hydroelectricity is attributed to OECD Europe. Most practical hydroelectric resources have already been exploited in this region, and little further development is expected. Currently, France, Norway, and Sweden account for more than half of the total hydroelectricity consumption in OECD Europe. In 1993, these countries together consumed 257 of the 479 billion kilowatthours generated in the region. Demand for renewable energy in OECD Europe is expected to grow to 7.6 quadrillion Btu by 2015 (Figure 56)—an increase of more than 1.8 percent per year.

As in the United States, wind power is expected to grow faster than any of the other renewable energy sources in OECD Europe. Most of the 3.4 gigawatts of installed worldwide wind capacity is split between the United States and Europe [**11**, p. 52], where OECD Europe has an installed wind capacity equivalent to about half that in the United States. There are plans to install 400 megawatts of wind power in Europe in 1995. Denmark remains Europe's biggest generator of wind-powered electricity, but aggressive development is also taking place in Germany, the United Kingdom, and other parts of OECD Europe. The European Wind Energy Association has predicted the creation of more than 11.5 gigawatts capacity of wind power in Denmark, Germany, the Netherlands, and the United Kingdom by 2005, and the U.S. company Kenetech is currently building wind turbine plants in Spain and the Netherlands [**1**, p. D8].

In Denmark, wind-powered electricity from utilities and independent power producers provided 2 percent of the country's power in 1990 [**23**, p. 33]. About 70 percent of Denmark's wind turbines are owned by local cooperatives, which provide free electricity to their stakeholders and are allowed to sell any excess electricity to the national grid [**24**, p. 14]. Government plans project that 10 percent of Denmark's electricity will be wind-generated by 2000 [**23**, p. 33].

In 1995, electricity generated by wind turbines in Germany was expected to exceed 1 billion kilowatthours, approaching the level of 1.1 billion kilowatthours generated at California's Altamont Pass in 1994. Germany's total installed wind capacity is expected to reach 750 megawatts by the end of the year. Most of the growth is planned for the northern states Schleswig-Holstein and Neidersachsen, but a small number of wind turbines are under construction in Rheinland-Pfalz, Nordrhein-Westfalen, and the former East German state, Mecklenburg-Vorpommeran.

Wind power development has also been aggressive in the United Kingdom. The first wind farm in Great Britain began operating in 1990 [**24**, p. 12], and the British government has pledged to generate 3 percent of all energy from renewable resources by 2000. The 25 existing clusters of wind turbines in England and Wales now provide 0.13 percent of the United Kingdom's electricity [**11**, p. 54]. The 103-turbine Llandinam site in central Wales is the largest wind farm in the United Kingdom, with a total installed capacity of almost 31 megawatts [**24**, p. 13], generating enough electricity for

Government Strategy for Increasing Renewable Energy Demand in the United Kingdom

The United Kingdom has employed two strategies to encourage the development of non-fossil fuel technologies. Since 1974, the government has supported a research, development, and demonstration program for non-fossil fuels [**26**, p. 1067]. More than $545 million (1993 U.S. dollars) was expended on renewable projects between 1974 and 1993. In addition, the Non-Fossil Fuel Obligation (NFFO) program was started in the United Kingdom as a result of the 1989 Electricity Act, to guarantee a market for electricity generated from renewable energy sources. Two NFFO calls for bids were made in 1990 for England and Wales, and a third round of bids was held in 1994 [**27**, pp. 234-235]. Money for the NFFO, which was envisioned as a way to stimulate the growth of the renewables market, comes from a tax on fossil fuel generation [**26**, p. 1067].

According to a 1988 paper from the United Kingdom's Department of Energy, public funding for non-fossil fuels should have been surpassed by private sector investment by 1994 [**26**, p. 1067]. However, declining prices for primary fuels, particularly oil and gas, have reduced the economic competitiveness of renewable energy. Most private funding has, in fact, been used to support "near market" projects rather than research projects [**26**, p. 1068]. The government reduced its own funding of research and development programs by 20 percent in its 1994-1995 budget, with plans for further reductions within the next few years. The cuts would mean that the NFFO would be the primary source of funding for the development of renewables, along with some funding from the European Commission.

The NFFO tax provided about $48 million for renewable energy projects in 1993 [**26**, p. 1067] and has been used to support almost 200 projects overall. About 80 percent of the capacity added as a result of NFFO funding involved waste combustion and landfill gas projects. A smaller portion of the funding has been directed toward wind power projects, including the 103-turbine project in Llandinam. Approximately 110 megawatts of wind capacity was added through the NFFO between 1990 and 1991 [**26**, p. 1067].

In 1994, the NFFO system was extended to Northern Ireland. Under the Irish NFFO, Northern Ireland Electricity (NIE), the region's electricity transmission and distribution company, would be required to supply 15 megawatts of energy from renewable sources [**27**, p. 235]. NIE has signed 20 contracts with 12 companies to produce renewable energy, 6 of which are for wind power development at proposed sites in Counties Antrim, Tyrone, Fermanagh, and Londonderry. Each wind farm is expected to have an installed generating capacity of more than 2 megawatts [**27**, p. 244]. Combined, they account for 12.6 of the 15.6 megawatts in total contracts. Nine small hydroelectric projects, with a combined installed capacity of 2.4 megawatts have also been accepted under the NFFO.

21,600 households [**25**]. Additional farms are planned for Northern Ireland and Scotland, subsidized by the Non-Fossil Fuel Obligation program (see box on page 70). The United Kingdom has set a goal of installing 1.5 gigawatts of declared net capacity by 2000.

Eastern Europe

Hydropower accounts for most of the projected improvements in renewable energy availability in Eastern Europe and the former Soviet Union. In the EE/FSU region, gains in production will derive principally from improved availability from existing producing sites. In 1995, a $50-million loan from the European Bank for Reconstruction and Development (EBRD) in cooperation with the World Bank, OECD, Switzerland, and Austria was designated for upgrading Albania's energy sector, including 3 small hydroelectric plants at Ulza, Shkopeti, and Selita [**28**, p. 5]. Bulgaria's National Electricity Company invited bids in 1995 for the completion of the 864-megawatt Chaira pumped-storage hydroelectric plant, the largest hydroelectric project in that country [**29**, p. 9]. In a joint venture between Romania and the former Yugoslavia, a station is being added to the Iron Gates Two hydroelectric site on the Danube River near Negotin [**30**]. The installed capacity of Iron Gates Two is expected to increase to 270 megawatts from its present 216 megawatts. The first unit of the new station was scheduled to be completed by the end of 1995, and the second is to be completed in 1996.

The Gabcikovo hydroelectric project in Slovakia has been a major cause of dispute between the Slovak and Hungarian governments since the October 1992 opening of the installation, which now provides 1,700 gigawatthours of electricity a year [**31**, p. 30]. In 1977, the Czechoslovakian and Hungarian governments agreed to construct the two dams on the Danube in an attempt

to link the Danube and Rhine rivers, so that a shipping lane could be formed between the North Sea and the Black Sea [**31**, p. 27]. In 1992, Hungary abandoned the 1977 treaty on environmental grounds; however, the Slovak government decided to continue work on Gabcikovo [**31**, p. 28]. In 1994, the two governments agreed to seek resolution of the disagreement at the International Court of Justice in The Hague. Hearings on the Slovak-Hungarian dispute over the Gabcikovo-Nagymoros project were held in May 1994 [**32**], but no ruling on the matter has been made to date.

In early 1995, the dispute between Hungary and Slovakia over Gabcikovo-Nagymoros diminished somewhat as the two countries began to consider their respective entries into the European Union. Gabcikovo-Nagymoros was considered one of two major disputes which had to be resolved before membership in the European Union could be seriously considered (the other was the treatment of the Hungarian minority in Slovakia). On April 18, 1995, Slovakia and Hungary signed a temporary agreement to divide the water of the Danube between the original river bed and the Moson branch of the Danube until the International Court rules on the pending case [**33**]. The increased water flow is expected to repair the ecological damage that occurred in the Hungarian Szigetkoz area. The temporary solution is expected to decrease electricity production at Gabcikovo by 150 gigawatthours per year [**34**].

Former Soviet Union

Countries of the former Soviet Union are similar to the countries of Eastern Europe, in that much of the development of hydroelectric power in the region is directed toward maintaining and improving performance at existing sites. For example, the World Bank announced in April 1995 that $114 million would be given to the Ukraine to upgrade eight hydroelectric power stations (Dnieper I and II, Kiev PSP, Kakhovka HPS, Kiev, Kanev, Kremenchug, and Dniprodzerzhinsk) located on the Dnieper River [**35**, p. 1]. The work is expected to extend the lives of the eight plants by as much as 20 years, as well as increase their electricity production.

In December 1994, the EBRD announced plans to loan Azerbaijan $53 million to complete construction of the Yenikend hydroelectric plant on the Kuru River [**36**, p. 174]. The EBRD is also providing loans to Georgia for the purpose of commissioning two 12-megawatt generating units at the Rioni hydroelectric power station [**36**, p. 175], which would help alleviate the country's chronic power shortages. For the most part, the buildings and industry sectors in Georgia have access to power only part of the day (less than 6 hours), and fines are levied against those who use more than their share.

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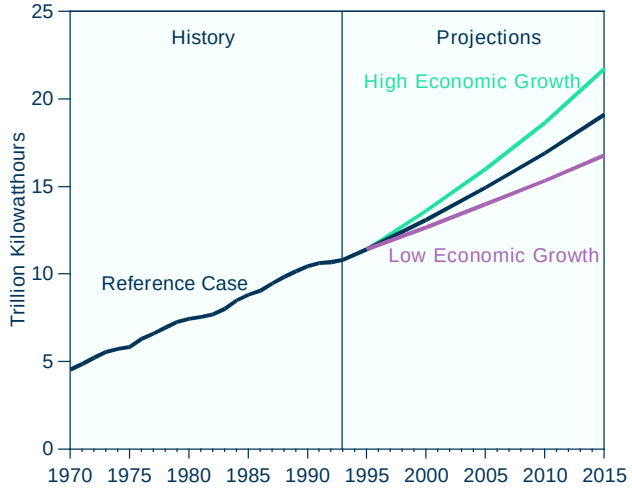
Electricity

Rapid growth in demand for electricity is expected throughout the world, and coal remains the primary fuel for generation. Many nations are restructuring their electric power industries to increase efficiency and hold down costs.

Electric power is expected to be the fastest-growing source of end-use energy supply throughout the world over the next two decades. Demand for electricity is projected to grow to 19 trillion kilowatthours in 2015 in the *IEO96* reference case, nearly doubling present electricity demand (Figure 57). While electricity markets continue to grow, dramatic changes are expected in the electric power industry. Many countries are currently working to create more competitive environments for electricity markets in order to promote greater efficiency. These efforts affect regulation, industrial structure, and ownership.

Figure 57. World Electricity Consumption, 1970-2015



Sources: **History:** 1970-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Regulatory changes can lead to the elimination of monopolies and reduction of governmental intervention in the electric power industry. Reforms include the reduction of price controls and tariff restrictions and the elimination of subsidies. Structural changes are characterized by the division of the industry into its three major functions—generation, transmission and distribution—and a commitment from governments to ensure that independent producers and other power-related enterprises will have full and fair participation in each of these functions. Ownership trends include an emphasis on privatization and commercialization to attract private capital from foreign and domestic sources.

Many non-OECD countries facing high electricity demand growth favor privatizing their electric power sectors and opening their markets to foreign firms. This approach can free up large amounts of public capital which can be used instead for social programs. In addition, private ownership allows managerial accountability, market efficiency, and better customer service while reducing government deficits and international debt.

Market reforms can also affect the environment, curbing the growth of greenhouse gas and related emissions. For example, reducing energy subsidies could increase the relative price of electricity, deterring its use; and the opening of market access could affect the mix of generating technologies, as private developers favor smaller gas-fired units, with lower capital costs and investment risks, over large coal-fired power plants. Technology is also expected to help curb the growth of emissions as generating units become more efficient and new, improved technologies for emissions control become available.

The choice of fuels for power generation has significant implications for the environment. As electricity demand continues to grow, coal will remain a primary fuel for power generation, especially in China and India. Coal is the most carbon-intensive of the fossil fuels, releasing nearly twice as much carbon per Btu to the atmosphere as natural gas does. Overall, throughout the world, fossil fuels are expected to be the primary energy source for electricity generation. The share of nuclear generation is expected to decline, raising the need for a substitute source of supply. Natural gas will grow in relative importance, but it will still supply a smaller share of total generation than either coal or renewables. Where natural gas is chosen over coal for new generating capacity, greenhouse gas emissions will be reduced; but where it replaces retiring nuclear capacity, emissions will increase.

Demand Growth

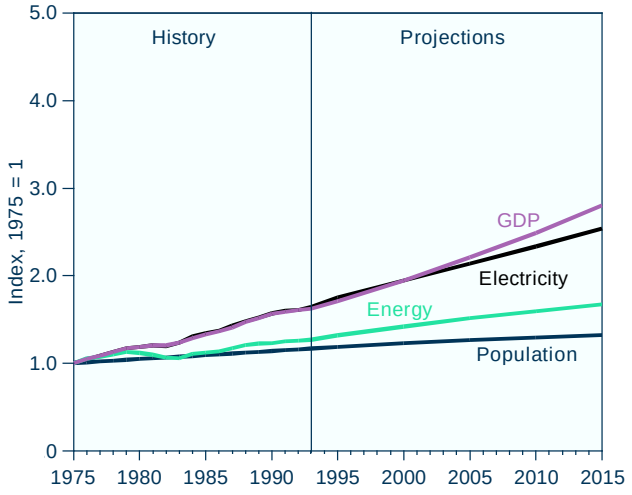
Over the past two decades, electricity consumption throughout the world has grown by 3.4 percent per year, as compared with 2-percent annual growth in total end-use energy consumption (Figures 58 and 59). Despite such strong growth, however, it is estimated that 2 billion of the world's 5.5 billion people still are not connected to electric power grids [**1**]. As efforts are made to reach unserved populations, and as electricity continues to penetrate end-use energy markets, electricity consumption worldwide is expected to grow at an annual average rate of over 2.6 percent (Figure 57). Stronger growth (2.8 percent per year) is expected from 1993 to 2000, largely due to strong economic growth in OECD Europe and non-OECD Asia, as well as increased electrification in developing regions. Somewhat slower annual growth (2.5 percent) is projected for the remainder of the forecast period.

Non-OECD countries constitute 80 percent of the world's population but consume less than 40 percent of the overall world's electricity output. On a per capita basis, the divergence between the OECD and non-OECD regions is significant (Figure 60): electricity generation per capita in the OECD is sevenfold that in the non-OECD. Average electricity generation per person is highest in Canada and the United States, at 15.4 and 11.1 megawatthours, respectively, in 1993 (Table 20). Africa has the lowest generation per person, at 0.4 megawatthours in 1993. Non-OECD Asia, where per capita electricity use has doubled since 1980 and is expected to continue to grow at an average annual rate of 2.0 percent, still had the second-lowest level of per capita consumption in 1993, at 0.5 megawatthours per person.

The overall trends for energy and electricity consumption are markedly different between developed and developing countries (Figures 58 and 59). In the OECD, growth in electricity demand is expected to keep pace with economic growth through early 2000; in non-OECD regions, overall electricity consumption growth between 1975 and 2015 is expected to continue to outpace economic growth. Between 1993 and 2015, economic growth and electricity growth are projected to average 2.5 and 2.0 percent per year in OECD areas, as compared with projected annual growth rates of 4.3 and 3.5 percent, respectively, in non-OECD areas. Although new uses for electricity are certain to appear in the future throughout the world, the penetration of electricity into energy markets overall is expected to slow relative to increases in economic growth.

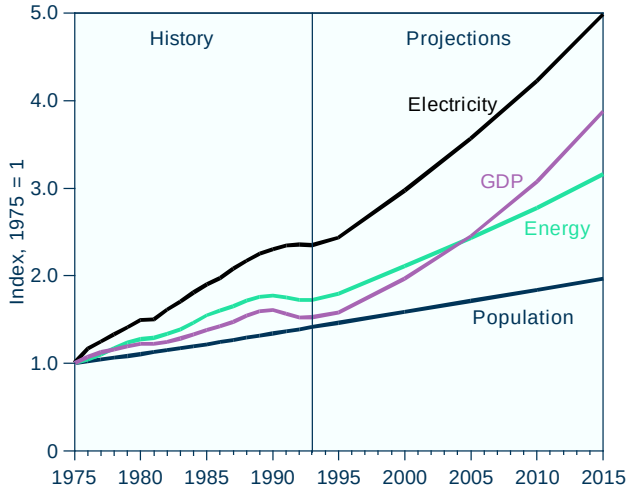
By 2015, non-OECD areas are expected to account for almost half of the world's consumption of electricity.

Figure 58. OECD Growth Trends, 1975-2015



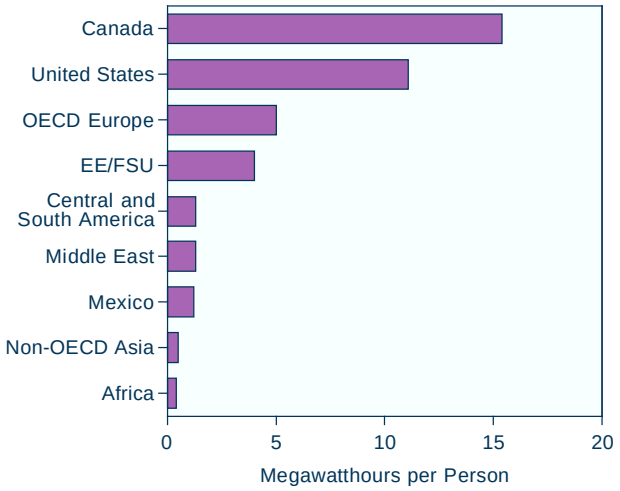
Sources: **History:** 1975-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996). **Gross Domestic Product (GDP):** The WEFA Group, *World Economic Service Historical Data* (Bala Cynwyd, PA, July 1993); and *World Economic Outlook*, Vol. 1 (Bala Cynwyd, PA, November 1995). **Population:** United Nations, *World Population Prospects: The 1994 Revision Annex Tables* (New York, NY, 1994), Tables A.1 and A.2.

Figure 59. Non-OECD Growth Trends, 1975-2015



Sources: **History:** 1975-1979: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database. 1980-1993: EIA, *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996). **Gross Domestic Product (GDP):** The WEFA Group, *World Economic Service Historical Data* (Bala Cynwyd, PA, July 1993); and *World Economic Outlook*, Vol. 1 (Bala Cynwyd, PA, November 1995). **Population:** United Nations, *World Population Prospects: The 1994 Revision Annex Tables* (New York, NY, 1994), Tables A.1 and A.2.

Figure 60. Electricity Consumption per Capita by Region, 1993

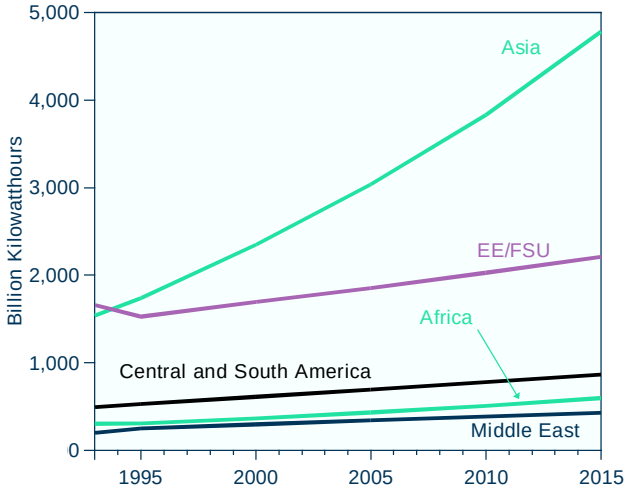


Sources: **Energy Consumption:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Population:** United Nations, *World Population Prospects: The 1994 Revision Annex Tables* (New York, NY, 1994), Tables A.1 and A.2.

Non-OECD Asia replaces the EE/FSU region as the largest non-OECD consumer of electricity early in the forecast horizon (Figure 61), as a result of the recent downturn in the EE/FSU economies and the relatively high economic growth rate projected for non-OECD Asia. Electricity demand in non-OECD Asia is expected to grow substantially from 1993 through 2015, at an average annual rate of 5.3 percent, as the region's GDP growth averages 6 percent per year and its total electricity use in 2015 is projected to be 3,250 billion kilowatthours higher than it was in 1993.

In the OECD countries, moderate growth in electricity demand is projected, averaging 2.0 percent per year between 1993 and 2015. In the industrial sector, electricity demand grows more rapidly than demand for oil and other fuels, primarily as a result of the growth of

Figure 61. Non-OECD Electricity Consumption by Region, 1993-2015



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Table 20. Electricity Consumption per Capita by Region, 1980, 1993, and 2015

(Megawatthours per Person)

Region/Country	1980	1993	2015
OECD North America			
United States	9.2	11.1	12.6
Canada	12.6	15.4	19.2
Mexico	0.9	1.2	2.5
OECD Pacific			
Japan	4.4	6.3	10.3
OECD Europe	4.0	5.0	7.8
EE/FSU	4.0	4.0	5.1
Non-OECD Asia	0.3	0.5	1.2
Middle East	0.9	1.3	1.6
Africa	0.4	0.4	0.5
Central and South America	0.9	1.3	1.7

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996). **Population:** United Nations, *World Population Prospects: The 1994 Revision Annex Tables* (New York, NY, 1994), Tables A.1 and A.2.

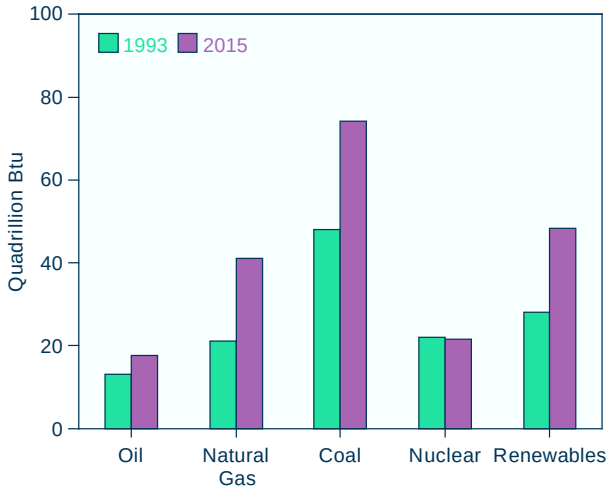
light industry. Electricity is also the energy source favored for many modern manufacturing processes. In the residential and commercial sectors, as urban populations grow and living standards improve, the number and variety of electrical appliances are expected to increase, spurring electricity demand.

Although the United States remains the largest consumer of electricity in the world, it has the lowest projected growth rate among the OECD countries for electricity demand in the *IEO96* forecast—1.4 percent per year between 1993 and 2015. Contributing to the slow growth trend are the current market saturation of many existing electrical appliances, expected improvements in equipment efficiencies, and utility investments in demand-side management programs. Mexico has the highest projected growth rate for electricity demand, at 4.7 percent per year between 1993 and 2015. Economic recovery is expected to be accompanied by 4.4-percent annual GDP growth, and Mexico's electricity consumption in 2015 is projected to be almost triple its 1993 level.

Primary Fuel Use

As detailed in the earlier chapters of this report, the fuel mix for world electricity generation is expected to change significantly over the forecast period (Figure 62 and Table 21). The natural gas share of total electricity generation is projected to increase worldwide from 16 percent in 1993 to 21 percent in 2015, largely due to increased utilization of natural gas in the OECD regions, where its share doubles from 9 percent of total generation in 1993 to 18 percent in 2015. The natural gas share declines slightly in non-OECD areas, from 25 to 24 percent; however, the heavy reliance of FSU and Middle East nations on natural gas for power generation keeps the overall share of natural gas higher for the non-OECD than for the OECD countries overall.

Figure 62. World Electricity Consumption by Fuel Type, 1993 and 2015



Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

Coal remains the primary fuel for electricity generation throughout the forecast, with a consistent share of 36 percent. Non-OECD Asia, which is projected to account for almost one-third of total non-OECD electricity demand in 2015, currently uses coal for about 60 percent of its total power needs; and its reliance on coal is expected to continue over the next two decades. Coal-fired generation in the other Asia subgroup of non-OECD countries, which includes a number of countries in the Pacific Rim region with rapidly growing economies (notably, South Korea, Taiwan, Thailand, the Philippines, and Indonesia), is expected to increase by almost 5 percent per year over the next 20 years, pushing the coal-fired share of total generation for the other Asia group from 28 percent in 1993 to 34 percent in 2015.

For all the fossil fuels (natural gas, coal, and oil), an increasing share in the world's total fuel use for electricity generation is projected—from 62 percent in 1993 to 66 percent in 2015. This is a reversal of the trend for the two previous decades, when generation from fossil fuels was losing share—decreasing from 71 to 62 percent of total generation—as nuclear power penetrated the market. As discussed in earlier chapters, the number of nuclear reactors retired over the forecast horizon is expected to surpass the number of new units being commissioned.

The renewable share of total electricity generation is also expected to increase, from 21 percent in 1993 to 23 percent in 2015. Hydropower, the dominant renewable source of energy for electricity production, is expected to show substantial growth in non-OECD countries. The regions primarily responsible for the continued penetration of hydropower are non-OECD Asia and Central and South America.

OECD North America

Electricity is expected to be the fastest growing end-use energy source in North America through 2015. Mexico leads the growth in electricity demand in North America at 4.7 percent per year, followed by Canada at 1.9 percent per year and the United States at 1.4 percent per year.

Table 21. World Energy Consumption for Electricity Generation by Region and Fuel, 1993-2015
(Quadrillion Btu)

Region/Fuel	History		Projections			
	1993	1995	2000	2005	2010	2015
OECD	**74.1**	**77.3**	**84.3**	**91.2**	**97.8**	**103.4**
Oil	5.4	5.7	5.6	5.8	5.9	5.8
Natural Gas	6.8	7.6	9.6	12.4	15.2	19.1
Coal	26.9	27.3	29.3	31.4	33.0	34.2
Nuclear	18.1	19.1	19.6	19.3	18.9	16.7
Renewables	16.8	17.7	20.1	22.4	24.8	27.6
Non-OECD	**58.4**	**61.7**	**72.0**	**82.9**	**95.5**	**109.0**
Oil	7.7	7.5	8.9	10.6	12.0	13.2
Natural Gas	14.3	14.5	17.0	19.3	22.4	26.0
Coal	21.2	23.5	27.3	32.1	37.1	43.0
Nuclear	4.0	3.9	4.8	5.0	5.4	4.9
Renewables	11.2	12.3	13.9	15.9	18.6	22.0
Total World	**132.5**	**139.0**	**156.3**	**174.2**	**193.4**	**212.5**
Oil	13.1	13.1	14.5	16.3	18.0	19.0
Natural Gas	21.2	22.1	26.6	31.8	37.6	45.1
Coal	48.1	50.7	56.6	63.5	70.1	77.2
Nuclear	22.1	23.0	24.4	24.3	24.3	21.6
Renewables	28.1	30.0	34.0	38.3	43.4	49.7

Note: OECD = Organization for Economic Cooperation and Development.
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

United States

Fossil fuels, which in 1994 accounted for 70 percent of electricity generation in the United States, are projected to account for 79 percent in 2015. Much of the increase is in the use of natural gas, which currently fuels 14 percent of total generation but grows to 27 percent by 2015, supplanting nuclear energy as the Nation's second-largest electricity source. Much of the increase in the use of natural gas is due to the favorable efficiencies of combined-cycle units and stable gas prices. U.S. utility gas prices are expected to increase by only 1.4 percent annually over the next two decades. Coal maintains a declining share of total generation, about 50 percent in 2015, compared to 52 percent in 1994. Long construction times for coal-fired plants and 19 gigawatts of coal-fired retirements contribute to the decline in its share [**2**].

As a result of the increased use of fossil fuels, the U.S. electric utility industry's share of national carbon emissions is projected to rise from 36 percent in 1994 to 38 percent in 2015. At the same time, as a result of the Clean Air Act Amendments of 1990, U.S. electricity producers will be required to reduce sulfur dioxide emissions by 10 million tons from 1980 levels by 2010. Utilities are complying with these goals by switching to lower sulfur coal and retrofitting plants with scrubbers. It is expected that almost 33 gigawatts of capacity will eventually be retrofitted with scrubbers to achieve the emissions reduction goal.

Both suppliers and consumers are grappling with ongoing changes in the structure of electricity markets in the United States. In particular, the Energy Policy Act of 1992 (EPACT) contains provisions with potentially significant impacts on the development of nonutility generators and the flow of electricity trade. EPACT creates a class of generators, referred to as exempt wholesale generators (EWGs), which can develop non-rate-based generating systems and market the power from them to utilities. EPACT also guarantees EWGs greater access to utility transmission systems and, in addition, allows them to participate in international development projects (see box on page 78). A series of rules have also been enacted promoting the formation of regional transmission groups (RTGs), whose mission is to coordinate and facilitate transmission planning and operation for utilities and nonutilities. These provisions will lead to an increase in nonutility generation and, to some degree, a restructuring of the electricity industry.

International Exempt Wholesale Generator Filings

The Energy Policy Act of 1992 (EPACT) substantially reformed previous legislation, making it easier for project developers to enter the U.S. domestic wholesale and international markets for electricity by exempting them from previous constraints. The law includes language that creates a new category of power producers, called exempt wholesale generators (EWGs). In short, EPACT allows U.S. utilities and project developers to build, own, and operate independent power projects in other countries without undue regulatory restrictions.

To build power projects overseas, developers must file with the Federal Energy Regulatory Commission (FERC), outlining the proposed ownership structure of the facility and providing details on the terms of power purchase agreements. In 1993, the first filing year, more than 3.8 gigawatts of proposed generating capacity was granted international EWG status under EPACT [**3**].

The table at right summarizes the international EWG filings granted in 1994, by the regions in which the power plants are to be located. This list pertains only to applications filed in 1994. It is presented to give the reader a general picture of where U.S. developers are investing in electric power generation internationally. It is not a complete list of U.S. investments in the global electric power industry.

Exempt Wholesale Generator Filings for International Power Projects, 1994

Region	Status	Capacity (Megawatts)
OECD North America	Operating	412.1
	Planned	358.6
	Total	**770.7**
OECD Europe	Operating	797.0
	Planned[a]	19.6
	Total	**816.6**
OECD Pacific	Operating	1,911.7
	Planned	300.0
	Total	**2,211.7**
Non-OECD Asia	Operating	1,432.0
	Planned	3,898.0
	Total	**5,330.0**
Central and South America	Operating	1,873.3
	Planned	903.5
	Total	**2,776.8**
Total Operating		**6,426.1**
Total Planned		**5,479.7**

[a]All projects in this category are in England and are currently under construction.

Source: Editors of *Utility Spotlight* in Cooperation with OnLocation, Inc., *The EWG Reference Guide: Analysis, Regulations and Filings, Exempt Wholesale Generator and Foreign Utility Companies* (McLean, VA, Spring 1995).

Experiments are already underway in some States to restructure electricity markets. The California Public Utility Commission (CPUC) has proposed implementation of a State-wide wholesale power pool under the control and operation of an independent transmission system operator. The operator would ensure transmission access to competing suppliers, derive generation costs through an auction, and reveal the actual generation costs to consumers (real-time pricing). The CPUC plan requires that power from qualifying facility and other contracts, and from nuclear and hydroelectric plants, be dispatched first without regard to their marginal costs. "Competitive transition charges" will be developed for some utility-owned assets that are not competitive and require additional cost recovery from ratepayers.

Electricity trade is expected to increase in the future throughout the United States, as provisions in EPACT allow for more open wholesale electricity markets. Electricity trade is already an important part of the U.S. electric power industry. Wholesale electricity purchases increased by 77 percent between 1986 and 1992, and approximately one-half of all electricity generated currently is purchased (or exchanged) in the wholesale markets before being sold to ultimate consumers.

Canada

Canada has abundant hydroelectric resources. Water is expected to remain the primary source of energy for electricity generation through 2010, despite its decline to a 57-percent share of total generation from a current share of 63 percent. As in the United States, no nuclear expansion is expected in Canada, resulting in a declining share for nuclear power, from 15 percent in 1992 to 14 percent in 2010. Generation from coal and natural gas is expected to make up for the declining shares of hydroelectricity and nuclear power. The share of coal-fired generation increases from 16 percent in 1992 to 20 percent in 2010, with the largest increase in coal use expected in Ontario, to make up for the declining nuclear share, and in the Atlantic provinces, which have no access to natural gas supplies. The share of gas-fired generation increases from 3 to 5 percent during the same period, mainly because of the installation of short-

leadtime generating capacity by utilities and the expansion of independent power production, much of which is already under contract. Because of the growth in generation from fossil fuels, Canada's carbon emissions will continue to rise. Emissions of sulfur dioxide are expected to decline substantially in Canada over the next two decades, largely in response to legislated limits [**4**].

The shape of the electric power industry is changing throughout Canada. In some jurisdictions, consideration is being given to unbundling electricity supply to its three principal functions—generation, transmission, and distribution. Utilities are facing increased competition from nonutility generators, and some industrial and municipal electricity purchasers are dissatisfied with their "captive customer" status [**5**, p. 5-1]. Privatization of North America's largest power utility, Ontario Hydro, is also being considered, excluding its nuclear assets. Although no such action is likely in the near future, Ontario Hydro is preparing for increased competition by internally restructuring to create separate business units for transmission, distribution, and generation, and by cutting costs.

The Canadian province of Alberta, which has three major investor-owned utilities, recently passed an open-access policy for wholesale power. A wholesale power pool, operated by an appointed pool operator, will be responsible for transmission planning and setting system tariffs. Power plants will be moved out of the utility's ratebase after being fully depreciated. The utilities in Alberta are also required to unbundle their services for accounting purposes as of January 1, 1996. Stranded costs are not a major issue in Alberta, since most existing units will be competitive in the new environment.

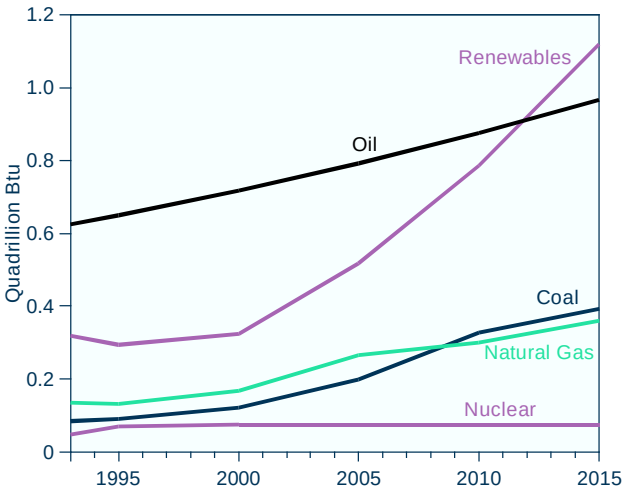
Electricity trade is also expected to play a larger role in Canada's electricity market, and Canadian utilities are beginning to engage in more regional planning. Previously, Canadian utilities engaged in trade predominantly with U.S. utilities, but recent developments in the United States have aroused interest in Canada for enhanced interprovincial cooperation and trade in electricity. Some Canadian utilities are also actively considering becoming members of U.S. regional transmission groups, in which transmission-owning members would provide others access to their networks [**5**, p. 5-2]. Energy marketers on both sides of the Canadian-U.S. border have also requested permission to export power to foreign markets. In general, permission has been granted, as long as the marketer can obtain transmission access.

Mexico

In order to meet an expected increase in electric power demand over the next decade, Mexico's 10-year electricity plan envisions that almost 15 gigawatts of new generating capacity will be needed, in addition to the efficiency measures that are being counted on to reduce electricity demand by 5 gigawatts during the same period. The Comisión Federal de Electricidad (CFE) plans to build 6.5 gigawatts, leaving 8.5 gigawatts to be supplied by the private sector. The country's cogeneration capacity is also expected to increase by 4 to 5 gigawatts by 2005.

Currently only 75 percent of the villages in Mexico are electrified, and as many as 140,000 villages have no access to electric power. Many of them are to be electrified through photovoltaic, wind, and small hydropower projects supported by PRONASOL, a poverty alleviation and rural development program. Mexico's geothermal capacity is also expected to grow by at least 40 percent from today's 800 megawatts over the next 5 years. Overall, the share of renewable consumption is expected to increase from about 26 percent to 39 percent of the total electricity supply by 2015. Mexico's CFE also has developed plans to increase coal-fired generating capacity fivefold by 2000 and to increase the use of natural gas in the power sector, to substitute for oil-fired generating capacity (Figure 63).

Figure 63. Electricity Consumption in Mexico by Fuel Type, 1993-2015



Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, January 1995). **Projections:** EIA, World Energy Projection System (1996).

The Mexican electric power industry is also changing the way it operates, by allowing private companies to invest in the electricity sector. In 1992, the "Regulation of Public Service of Electric Law" was passed, which allows private companies to invest in power production facilities and to import power as long as the power is supplied as a private service to the private sector. Any surplus power from private projects must be sold to the CFE. Several independent power projects are already planned as the result of the reforms, including Samalayuca II, a combined-cycle unit; Merida III, a gas conversion project; and Carbon II, which faces difficulties arising from environmental concerns about cross-border air pollution impacts on areas in the United States.

OECD Europe

Electricity demand in OECD Europe is expected to increase by more than 68 percent between 1993 and 2015, at a rate of 2.4 percent per year, largely as a result of continued economic growth in the region. Nevertheless, the projected growth in demand is below the expected rate of GDP growth, 2.6 percent per year, since many electricity markets in Europe have reached saturation and electricity intensity has already started to decline. Gas-fired capacity is expected to supply a significant portion of the increased demand, with an additional 93 gigawatts of gas-fired capacity expected by 2010, including 71 gigawatts of combined-cycle capacity. An additional 33 gigawatts of hydroelectric capacity is also expected [**6**].

As in most regions, the electric utility industry in OECD Europe is undergoing change in four key areas: (1) privatization of state-owned assets; (2) regulation; (3) restructuring of the industry; and (4) increased competition. The European Union energy ministers are also working on plans to create an internal electricity market, but progress has been slow due to the politics of "tampering" with state-owned monopolies. There has also been division over whether there should be a competitive market for distributors as well as for large industrial consumers. France opposes opening competition to distributors; however, the commission has said that distributors should be included to achieve benefits of competition for smaller customers [**7**].

Norway and the United Kingdom have been the most aggressive of the European countries in the introduction of competition into electricity markets. Both countries have unbundled generation, transmission, and distribution activities, introduced competition into generation supply, and established electricity spot markets. In 1995, the U.K. Office of Electricity Regulation further removed limitations on the ownership of power plants by allowing the regional electrical companies (RECs), whose primary function is distribution, to pursue unlimited generating projects, as long as their captive markets are protected.

In Finland, electricity legislation took effect in June 1995, removing licensing requirements for power plant construction, power sales to ultimate customers, and imports and exports. Mandated transmission access and unbundling of the accounting for various functional activities were also required under the legislation. A regulatory body will be established for oversight of the transmission network. The Finnish Government also announced that it is considering privatization of the State-owned utility, IVO [**8**].

Portugal recently separated its state-owned utility, Electricidade de Portugal (EdP), into three separate companies for the generation, transmission and distribution of electricity. EdP will coordinate the overall system's operations. Initially, generators will operate on the basis of the terms of agreements with the transmission company. Later, independent power producers will be able to sell directly to end users. A planning group will be established to determine capacity needs.

Spain has also opened power markets to the private sector, under legislation that allows independent power producers to supply all of the 10 gigawatts of new capacity needed by 2000, as well as 2 gigawatts of new cogeneration capacity. The legislation allows independent power producers to build plants and sell power, either to a central dispatching facility for use on the Spanish grid or directly to end users under negotiated tariffs. The legislation also separates the generation and transmission functions and allows industrial customers to choose power suppliers. New generating capacity can be owned by any Spanish national or company or by any member of the European Union (EU). For companies outside the EU there are restrictions on the level of equity that can be held [**9**].

On November 9, 1995, the Italian government passed legislation to privatize Italy's state-owned utility, Ente Nazionale per l'Energia Elettrica (ENEL), which owns more than 50 percent of the country's generating capacity. The remaining capacity is owned by municipal utilities, other small companies, and industrial self generators. Some of the municipal utilities are also considering privatization. To facilitate privatization, the government plans to split ENEL into at least two companies—one for transmission and distribution and one for generation. ENEL's 47.5 gigawatts of capacity will most likely be divided into several companies before privatization. The Italian government claims that ENEL is worth about $18.7 billion [**10**].

Turkey recently signed its first build-operate-transfer (BOT) agreement[10]—after 10 years of negotiation with banks, contractors, and foreign governments—for the Birecik hydroelectric project, which is to be built by an international consortium of developers. Government guarantees insure the project. The government approval of this project is expected to result in accelerated approval of other previously delayed BOT projects. Turkey's demand for electricity is expected to grow by 246 percent over the next 15 years as a result of rapid economic growth, requiring an estimated 160 new generating stations [**11**]. Total investment in the electric power industry in Turkey over the next 10 years is estimated at $32 billion, two-thirds of which will be used for new power plants and the remainder for distribution and transmission systems [**12**]. Turkey is also interconnecting with countries in the Middle East and Africa, with trade agreements scheduled to be approved in 1996.

In addition to domestic changes in electricity markets in Europe, increased coordination among nations is also underway. For example, Germany imports hydroelectric power from Scandinavian countries and exports thermal capacity, resulting in better utilization of both systems [**12**, pp. 7.15 and 8.15]. Finland has concrete plans to trade with Sweden, and the creation of a broad electricity market encompassing all of the Nordic countries (Finland, Norway, Sweden, and Denmark) is being examined. The Nordic countries are served by the NORDEL synchronized system, which has interconnections with the FSU system and undersea connections through Jutland and Germany to the Western European UCPTE system. The UCPTE system is a synchronized network that includes most of the countries in Western Europe.

There is already significant electricity trade within the European community on the UCPTE system, which has made France the largest international electricity trader in the world. Gross exports from France have been increasing by about 12 percent per year since 1985, as France markets its surplus nuclear capacity. In 1992, French exports totaled 61 billion kilowatthours, and they are expected to reach 70 billion kilowatthours in 2000, based on the terms of existing contracts. After 2000, France expects to begin importing winter peakload power in exchange for baseload power exports.

OECD Pacific

Demand for electricity is expected to grow more rapidly in the OECD Pacific region than in Europe and North America, in association with the high rate of economic growth anticipated for the region. Expected changes in the fuel mix used for generation are similar to those expected in other OECD countries, with emphasis on natural gas and coal. In Japan, however, coal-fired capacity will have an advantage over natural gas, which must be imported as liquefied natural gas from suppliers in Asia—in particular, Australia, Brunei, and Indonesia. Japan's use of coal as a fuel for electricity generation is projected almost to double by 2003. Nuclear capacity additions are also expected in Japan, which currently derives about 25 percent of its electricity generation from nuclear power. Although no new nuclear plants are anticipated outside of Japan, the additions in Japan will lead to an increase in the use of nuclear power for the OECD Pacific region as a whole.

In 1995, the New Zealand government issued a new electricity policy designed to create a competitive power market. The policy puts a limit on how much new capacity the state-owned Electricity Corporation of New Zealand (ECNZ) can build in the future, requiring at least 1.5 gigawatts of new capacity to be built by the private sector over the next few years. By January 1, 1996, ECNZ will be split into two companies, with ECNZ retaining 4,360 megawatts of existing capacity and an unnamed state-owned enterprise receiving 2,035 megawatts. The remaining 873 megawatts will be sold either to local distribution companies or to international buyers. Once the split is complete, ECNZ will not be allowed to build capacity if its market share is greater than 45 percent. The government has announced that it is instituting the plan in order to redirect government resources into "health, education, and debt reduction" [**13**].

Eastern Europe/Former Soviet Union

The EE/FSU region is projected to experience relatively slow growth in electricity demand over the forecast horizon, 1.3 percent annually, largely due to reduced economic growth rates and the slowdown of production in the industrial sector, particularly in the former Soviet Union. Economic recovery is anticipated for the late 1990s, which would spur growth in electricity consumption. More rapid increases are expected in Eastern Europe before 2000, because market reforms have been introduced more quickly there than in many of the FSU countries.

Total EE/FSU electricity consumption is expected to grow by less than 0.3 percent per year from 1993 to 2000, due to slow economic growth (0.6 percent per

[10]Build-operate-transfer agreements allow developers to finance and build a project and operate it until its costs are recovered and a profit is generated.

year). After 2000, as the region's economy recovers and grows by 3.7 percent per year, electricity use is projected to grow at an average annual rate of 1.8 percent through 2015. The demand for electricity is expected to lag behind GDP growth, because economic growth in the region is being driven by corrections of past economic distortions brought about by the misdevelopment of industry (i.e., centrally planned not market-driven economies) rather than underdevelopment as in other non-OECD countries [**14**. p. 17]. At the same time, the demand for electricity is expected to outpace population growth, resulting in increased consumption per person. Per capita consumption is projected to increase by 24 percent between 1993 and 2015, after declining in the 1980s.

Little construction of new generating capacity is expected in the EE/FSU region in the near term, since many countries currently have excess generating capability. It has been estimated that in some Central European countries, generating capacity currently exceeds demand by 20 to 100 percent [**15**, p. 17]. This period of surplus capacity is being used by some nations to develop new legislative and regulatory reforms, and some countries are undergoing a restructuring of the electric power industry similar to those underway around the world. In 1990, Poland began a major restructuring of its electric power system, creating three independent sectors for generation, transmission and distribution. The Polish Power Grid Company, which is fully owned by the state, maintains the transmission system. Distribution, which has the option to privatize in the near future, is provided by 33 joint stock companies owned by the state. Generation is provided by 32 independent generating companies [**15**, p. 20].

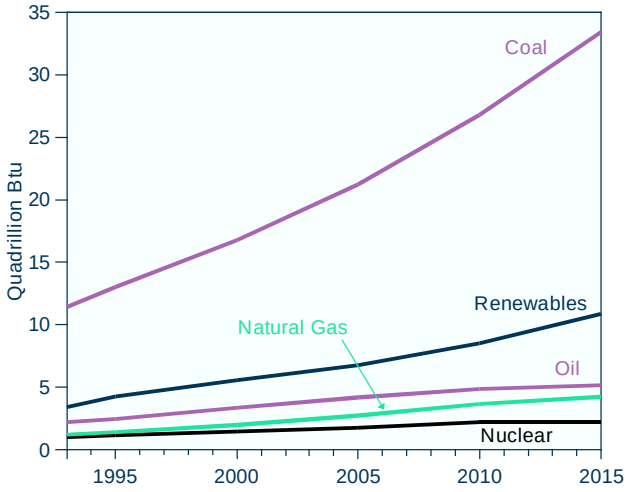
Hungary is also privatizing its electricity supply sector and is in the process of selling six electricity distribution companies and seven fossil-fueled power plants. The capacity for sale totals over 5 gigawatts and is worth $2 billion. MVR, the State-owned utility, is divesting all of its units except for the Paks nuclear power plant, which supplies 45 percent of Hungary's power. MVR will also retain ownership of the national transmission system and will be responsible for dispatching power from the units [**16**].

In the early 1990s, the Council of Mutual Economic Assistance (CMEA) coordinated large quantities of electricity flows between most of the EE/FSU countries (except Albania). With the dissolution of the CMEA and the Soviet bloc, electricity trade in the region is undergoing change. Most eastern European countries are determined to shift their trade toward the European Union at the expense of their former trading partners in the East. In 1992, the Czech Republic, Hungary, Poland, and Slovakia created a new institution, Centrel, to interconnect their electric power systems as a first step toward full integration with Western Europe's UCPTE system. The members of Centrel have agreed to adapt their standards to UCPTE requirements—an effort that will require substantial investment and time [**14**, pp. 15-16].

Non-OECD Asia

The non-OECD Asia region—which includes China, India, and Other Asia—is expected to experience the largest growth in electricity consumption of any region worldwide. Total electricity consumption is projected to grow by 3,250 billion kilowatthours between 1993 and 2015, or by 5.3 percent per year, with China accounting for more than half the growth. Growth in the region is largely spurred by strong economic growth: GDP is expected to grow by almost 6 percent annually over the next two decades. China also leads the region in terms of economic growth, at an annual average rate in excess of 7.7 percent. Increased electrification throughout the region is also anticipated, with per capita consumption projected to increase by more than 50 percent between 1993 and 2015, after more than doubling between 1980 and 1993. Coal remains the fuel of choice to meet the region's rising demand for electricity (Figure 64).

Figure 64. Electricity Consumption in Non-OECD Asia by Fuel Type, 1993-2015



Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, World Energy Projection System (1996).

China

Strong projected growth in electricity demand in China results from two factors. First is increased rural electrification. Although nearly 90 percent of the rural households in China had access to electric power at the end of 1993, some 120 million people were still without electric power [**17**]. The Chinese government plans to increase electrification to 95 percent by 2000. Second, the Chinese government is working to keep electric power growth in line with economic growth. To date, China's industrialization programs have not invested adequately in the electric power industry, resulting in shortfalls. According to the World Bank, the proportion of investment in the electric power industry in developing countries should be more than 2 percent of GDP. China's annual average ratio accounted for only 1.24 percent of GDP from 1980 to 1993. To make up for this shortfall, as well as keep up with continued economic growth, between 15 and 17 gigawatts of new capacity will be needed between 1995 and 1997 and more than 20 gigawatts between 1998 and 2000 [**18**, p. 3].

In addition to building new generating capacity, China is simultaneously expanding its power networks and improving the efficiencies of existing power plants. In the past, China advanced the construction of power plants, overlooking the development of transmission systems. As a result, many transmission facilities are obsolete, there are substantial line losses in many of the systems, and they are unable to meet growing demand in many urban and rural areas.

The Chinese government has established four mechanisms for meeting the nation's growing electricity demand. First, a new electricity tariff system is being established, and various pricing mechanisms are being investigated. Second, time-of-use pricing is being promoted. Third, a "rolling exploitation mechanism" for both hydropower and nuclear power is being established[11] to provide financing for new projects (see box on page 60, "China's Nuclear Expansion"). Fourth, a mechanism is being set up to enhance the utilization of foreign funds in the electric power industry [**18**, p. 4]. In January 1993, the government announced that China welcomes investors from foreign countries to develop the electric power industry through joint ventures and cooperative and solely funded arrangements. More than 10 large-scale projects are now being negotiated.

India

Electricity demand is expected to grow dramatically in India, by 7.6 percent per year between 1993 and 2000 and 4.6 percent annually after 2000. In 1993 alone, $4.8 billion was invested in India's electric power industry, and the overall market over the next 10 years is expected to be almost $140 billion [**19**].

Until 1990, the electric power industry in India was almost exclusively a public sector monopoly. The development of independent power producers began in 1990 and is still underway. One of the outstanding issues in this new environment is whether projects should be awarded through a competitive bidding system or through negotiations with a single company. In general, the latter approach has been preferred. In order to promote independent power producers, guarantees are offered by the Indian government. The government has also set standards for all foreign projects. For example, there is a maximum allowed debt-to-equity ratio of 4 to 1, and the use of local resources is limited to 40 percent of the total project cost [**20**].

Other Non-OECD Asia

Electricity demand in other non-OECD Asia countries is expected to more than double between 1993 and 2015. Strong growth of 6.3 percent annually is expected between 1993 and 2000, slowing to 3.4 percent from 2000 to 2015. This subgroup includes a number of countries in the Pacific Rim with rapidly growing economies and strong industrialization programs, notably, South Korea, Taiwan, Thailand, the Philippines, and Indonesia. Most of those countries have experienced tremendous growth in electricity consumption, and their governments generally have aggressive plans to continue the expansion of generating capacity. Some have embraced reforms in their power sectors, allowing privatization, deregulation and independent power producer participation. The reforms are expected to result in increased utilization of natural gas, the fuel favored by many developers because of its expected low price and the lower capital requirements for gas-fired technologies. Natural-gas-fired generation is expected to grow by 5 percent per year, supplying almost 20 percent of the region's consumption by 2015. Nevertheless, coal is expected to be the fuel of choice to meet the

[11]A "rolling exploitation mechanism" means that the income from the first plant does not need to be used for repayment of loans, but can be used for continued development of other power projects.

region's growing electricity demand. Coal-fired generation is expected to increase by almost 5 percent per year over the forecast horizon, supplying more than one-third of the region's electricity by 2015.

The Philippines has one of the most mature independent power markets in Asia and is continuing to reform and revitalize its electric power industry. The government-owned utility, the National Power Corporation (NPC), has actively pursued private sector participation in the power generation market. In 1994, growth in capacity additions by independent power producers outpaced NPC additions for the second year in a row. The NPC has put forth a decentralization plan that would establish NPC Holdings, a government-owned holding company with regional generation companies. The NPC would be the sole broker of power in the Philippines, whether generated by the NPC or by an independent power producer. The goal is to have NPC divest itself of all generating capability, transforming the company into an independent National Transmission Company. In this role, the NPC would provide open access to the Philippines wholesale electricity market while performing power planning and dispatching functions [**21**].

On September 3, 1994, the Taiwanese Ministry of Economic Affairs (MoEA) issued operational guidelines for opening that nation's electric power industry to independent power producers. The guidelines apply to generating companies that use hydropower or fossil fuels. Under the guidelines, total installed independent power producer capability cannot exceed 20 percent of the nation's total capacity; however, MoEA may adjust this share depending on actual needs. Also, power generated by independent power producers, surplus to on-site needs, must be sold to Taipower. The purchased power price will also be no larger than Taipower's avoided cost for the same type of unit in a given year. About 20 percent of the new capacity planned between now and 2010 (about 7,260 megawatts) is expected to be built by independent power producers. Under current MoEA rules, foreign investment is prohibited for electricity generation and distribution. Reform has been suggested to move electricity generation and distribution from the prohibited to the restricted list for foreign investment approval [**22**].

Middle East

The Middle East is expected to experience strong growth in electricity demand prior to 2000, almost 6 percent annually, with demand growth tapering off to 2.5 percent after 2000. The growth in demand, particularly before 2000, is spurred by moderate economic growth (3.4 percent annually through 2015) and further electrification and infrastructure improvements in some areas. Saudi Arabia alone plans to invest $2.84 billion over the next 6 years in various electric power projects in the country. The projects will be partially funded by an electricity consumption tax, which will be imposed in January 1996. In January 1995, the government also increased electricity rates by 63 percent for individuals and companies that consume more than 2 megawatthours per month [**23**]. The Middle East is the only non-OECD region in which a major shift in the fuel mix for power production is expected, with gas being substituted for oil in order to free up oil for export [**24**, p. 43].

Increased international cooperation and trade are also planned among a number of nations in the Middle East and in neighboring regions. Currently, five countries—Egypt (Africa), Jordan, Iraq, Syria, and Turkey (Europe)—are interconnecting their systems and discussing agreements for electricity transfers. Trade agreements are expected to be approved by the five countries in 1996. The first phase of the project is expected to include the following electricity trades: 400 megawatts between Turkey-Syria and Syria-Iraq; 300 megawatts between Syria and Jordan; 400 megawatts from Jordan to Egypt; and 300 megawatts from Egypt to Jordan. Transfers of up to 750 megawatts are expected in the next phase of the project between Turkey-Iraq, Turkey-Syria, and Syria-Iraq [**25**].

Africa

Africa's electricity market is projected to grow at an average rate of 3.2 percent per year between 1993 and 2015, as electrification extends to many poor rural areas and supply increases to serve electricity-starved industries in many African nations. Unlike many other regions of the world, which are expected to show strong growth in electricity demand before 2000, electricity consumption is expected to grow more rapidly in Africa after 2000, at an average annual rate of 3.3 percent.

Africa is a diverse continent, with wide national disparities in natural resources and levels of economic development. In 1992, South Africa consumed just over 50 percent of Africa's total electricity supply, North Africa (which, for this discussion, consists of Morocco, Algeria, Libya, Tunisia, and Egypt) just under 30 percent, and sub-Saharan Africa (the remaining African nations) 20 percent. In per capita terms, the contrast is dramatic: South Africa consumed 4.2 megawatthours per capita, North Africa 0.8 megawatthours per capita, and sub-Saharan Africa 0.14 megawatthours per capita [**24**, p. 210]. In comparison, the average consumption in OECD countries is 6.6 megawatthours per person.

In order to meet increases in demand, African countries are pursuing various strategies to bolster electricity supplies. The Egyptian Ministry of Electricity and Energy plans to undertake the country's first build-operate projects for the construction of three power plants. The final contracts for the planned power development schemes are expected to be signed in 1996 and 1997 [**26**]. In Ghana, the electric power industry is being restructured, turning to the private sector to supply 200 to 300 megawatts of new capacity per year. Ghana is giving private developers access to the national transmission grid and the freedom to sell power to its "electricity starved" industrial sector [**27**].

In South Africa, an aggressive program is underway to electrify an additional 1.75 million homes by 2000. Currently, electrification in South Africa is highly uneven, with many poor rural areas without electricity, while richer urban areas are almost fully electrified. Currently, only about 40 percent of the population has access to electric power, and the government hopes to increase the share to 72 percent by 2000. Lack of access to electricity in South Africa is largely due to transmission constraints rather than generating capacity shortfalls. Eskom, the national electric company, currently has surplus generating capability. It plans to meet its development program goals by extending the transmission system to areas currently not served. In addition to improvements in the domestic transmission system, South Africa is also expected to further develop its international connections, in order to expand electricity trade with utilities in neighboring regions. Eskom and utilities in neighboring countries have agreed to the establishment of a Southern Africa Power Pool, which would center around the utilization of coal-fired plants in South Africa and hydroelectric facilities in neighboring regions. By the end of 1995, the Botswana Power Corporation, Zimbabwe Electricity Supply Authority, Zambia Electricity Supply Corporation, and South Africa's Eskom were expected to be operating as a power pool [**28**].

Central and South America

In the 1950s, only 30 percent of the population of Central and South America was served by electricity. The region experienced strong economic growth during the 1960s and 1970s, which was matched by rapid expansion of the electrical infrastructure. Today, approximately 70 percent of the population has access to electricity as a result of large investments in generation, transmission, and distribution facilities in the 1960s and 1970. Consumption per person has also increased dramatically over the past dozen years, from 1.0 to 1.4 megawatthours—above the non-OECD average but still significantly below the OECD average of 6.6 megawatthours per capita in 1993.

Over the next two decades, electricity demand in Central and South America is expected to grow steadily at 2.6 percent annually. Demand is expected to increase to accommodate an expected 2.2-percent annual population growth rate, to expand the percentage of the population served by electricity, and to keep pace with economic growth. Increased demand will be met by new generating capacity and by greater utilization of existing capacity. There is currently surplus capacity in some Central and South American countries where demand growth has been lower than expected [**24**, p. 155]. For example, Venezuela currently has surplus capacity, which it is selling—and is expected to continue to sell—to Brazil and Colombia.

The electric power industry in Central and South America is also undergoing significant change. The overall economic climate, and the need of governments to focus their limited resources on social infrastructures, have led to a shortage of public financing for the region's capital-intensive electricity industry. Concurrently, international lending institutions face severe competition for their resources and are focusing their emphasis on sectors that cannot find financing from the private sector. There is also a general perception of large inefficiencies in the region's electricity production and consumption, which is moving many governments toward deregulation and privatization of electric power industries.

Chile, Argentina, and Peru have followed the lead of the United Kingdom in restructuring their power industries, including the separation of the industry's generation, transmission, and distribution activities. The restructuring is being followed by strong efforts to ensure competition and privatization. In Argentina, the unbundling of the industry has entailed the sale of state-owned assets and the formation of private companies, including 20 generation companies, 1 national and 5 regional transmission companies, and 6 private distribution companies. In the second half of 1995, 7 gigawatts of capacity were scheduled for privatization [**29**].

The Bolivian government, through its program to restructure and capitalize the electric power sector, also plans to unbundle the electric power industry into its three functional activities. In place of privatization,

Bolivia is capitalizing its power sector.[12] In essence, investors are not paying to acquire the company but are contributing capital in the constitution of a new corporation. This approach is intended both to introduce competition into the electric power industry and to redistribute wealth through dividend returns to Bolivian citizens [**29**].

Venezuela has taken steps toward privatizing its state-owned companies, but the process has been delayed several times. Electric power assets identified for privatization include two utilities, Energia Electrica de Venezuela and Ecenco, with combined capacity of 1.4 gigawatts, the 2-gigawatt Planta Centro thermoelectric plants, and part of the Cadafe Centro plants. Venezuela is offering its most financially troubled assets first. Venezuela's electric generating capacity totals 21 gigawatts, of which 75 percent is hydroelectric, and additions of some 8 gigawatts of hydropower capacity are planned over the next decade. This capacity expansion provides opportunities for private investment in Venezuela. During 1994, Venezuela secured a $500-million loan from the Inter-American Development Bank for development of the 2,160-megawatt Caruachi plant, the third in a series of three large hydropower projects on the Caroni River. Total cost of the Caruachi plant is $2.1 billion. Another 2-gigawatt plant is planned following construction of Caruachi. Investments in transmission and distribution are also expected.

Brazil is also privatizing its electricity sector. The first step toward privatization was taken in 1993, when legislation was enacted to allow large electricity consumers to build and operate their own generating facilities and sell any excess energy to a public utility. In 1995, Brazil passed two pieces of legislation as part of its larger restructuring effort. On February 13, 1995, the "Concession Law" was passed, which permits the private sector to invest in certain public services, such as the generation, transmission, and distribution of electricity—services that previously were under the domain of the government. Public service concessions must be granted through a public-bidding process, with the criteria for accepting a bid based on the service fee and payment offered by the bidder. On July 7, 1995, the Independent Power Law was signed. Under this new legislation, an independent power producer may sell electricity to a variety of customers, including retail customers connected to the national grid at transmission voltages of at least 69 kilovolts and with a minimum load of at least 10 megawatts [**30**].

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[12]Privatization entails the transfer of an asset to the private sector, with the dollars generated from the sale going to the national treasury. Capitalization entails the transfer of an asset to the private sector, with the dollars generated from the sale remaining in the company.

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Appendix A

World Energy Consumption, Oil Production, and Carbon Emissions Tables

Table A1. World Total Energy Consumption by Region, Reference Case, 1990-2015
(Quadrillion Btu)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**100.2**	**104.2**	**108.4**	**115.0**	**123.2**	**129.8**	**135.6**
United States[a]	84.4	87.3	90.6	95.1	100.4	104.7	108.0
Canada	11.0	11.7	12.5	14.0	15.4	16.5	17.6
Mexico	4.9	5.1	5.3	6.0	7.4	8.6	9.9
OECD Europe	**62.0**	**62.6**	**64.7**	**69.6**	**73.7**	**77.5**	**81.5**
OECD Pacific	**22.9**	**24.0**	**25.2**	**28.7**	**30.8**	**32.6**	**34.3**
Japan	18.1	19.0	19.9	23.0	24.9	26.2	27.6
Other OECD	4.8	5.0	5.2	5.7	6.0	6.3	6.7
Total OECD	**185.1**	**190.7**	**198.2**	**213.2**	**227.7**	**239.8**	**251.4**
Non-OECD							
EE/FSU	**75.3**	**60.9**	**58.3**	**63.6**	**68.7**	**74.0**	**79.7**
Former Soviet Union	58.7	47.3	44.1	48.0	51.6	55.5	59.6
Eastern Europe	16.6	13.6	14.2	15.6	17.0	18.5	20.1
Non-OECD Asia	**51.6**	**60.3**	**67.3**	**85.8**	**105.4**	**126.6**	**150.8**
China	27.0	31.6	35.0	43.9	54.2	66.7	81.8
India	8.0	9.1	10.3	13.3	16.6	19.5	22.5
Other Asia	16.6	19.6	22.1	28.6	34.6	40.4	46.6
Middle East	**11.3**	**12.2**	**12.9**	**14.7**	**16.5**	**18.1**	**19.9**
Africa	**10.5**	**10.3**	**10.5**	**11.7**	**13.1**	**14.5**	**16.0**
Central and South America	**14.0**	**14.8**	**15.4**	**17.5**	**19.7**	**22.1**	**24.6**
Total Non-OECD	**162.7**	**158.3**	**164.5**	**193.4**	**223.4**	**255.3**	**291.0**
Total World	**347.8**	**349.1**	**362.8**	**406.7**	**451.1**	**495.1**	**542.3**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table A1; and World Energy Projection System (1996).

Table A2. World Total Oil Consumption by Region, Reference Case, 1990-2015
(Million Barrels per Day)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**20.4**	**20.7**	**21.5**	**22.8**	**24.2**	**25.3**	**26.2**
United States[a]	17.0	17.2	17.8	18.8	19.9	20.7	21.2
Canada	1.7	1.7	1.8	1.9	1.9	2.0	2.1
Mexico	1.7	1.8	1.9	2.1	2.3	2.6	2.8
OECD Europe	**12.9**	**13.6**	**13.8**	**14.2**	**14.6**	**14.7**	**14.9**
OECD Pacific	**6.2**	**6.5**	**7.0**	**7.7**	**8.1**	**8.4**	**8.7**
Japan	5.1	5.4	5.8	6.4	6.6	6.9	7.1
Other OECD	1.0	1.1	1.2	1.3	1.4	1.5	1.6
Total OECD	**39.5**	**40.9**	**42.3**	**44.7**	**46.8**	**48.4**	**49.8**
Non-OECD							
EE/FSU	**10.0**	**7.0**	**5.8**	**6.2**	**7.3**	**8.3**	**9.3**
Former Soviet Union	8.4	5.8	4.5	4.9	5.7	6.6	7.5
Eastern Europe	1.6	1.2	1.3	1.4	1.5	1.7	1.9
Non-OECD Asia	**7.6**	**9.5**	**10.6**	**14.5**	**18.1**	**21.1**	**24.7**
China	2.3	3.1	3.5	4.4	5.4	6.7	8.2
India	1.2	1.3	1.4	1.9	2.4	2.8	3.3
Other Asia	4.2	5.1	5.7	8.1	10.3	11.7	13.2
Middle East	**3.5**	**3.5**	**3.7**	**4.2**	**4.7**	**5.3**	**5.9**
Africa	**2.1**	**2.2**	**2.3**	**2.6**	**2.9**	**3.3**	**3.6**
Central and South America	**3.4**	**3.7**	**3.8**	**4.5**	**4.9**	**5.2**	**5.6**
Total Non-OECD	**26.7**	**25.8**	**26.3**	**32.1**	**37.9**	**43.2**	**49.1**
Total World	**66.2**	**66.7**	**68.5**	**76.8**	**84.7**	**91.6**	**98.9**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table A21; and World Energy Projection System (1996).

Table A3. World Total Natural Gas Consumption by Region, Reference Case, 1990-2015
(Trillion Cubic Feet)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**22.1**	**24.1**	**25.1**	**26.6**	**29.2**	**31.6**	**34.9**
United States[a]	18.7	20.3	21.3	22.3	24.1	26.0	28.7
Canada	2.4	2.8	2.9	3.1	3.3	3.5	3.6
Mexico	0.9	1.0	0.9	1.2	1.9	2.1	2.6
OECD Europe	**10.2**	**11.6**	**12.9**	**15.6**	**18.4**	**21.2**	**24.3**
OECD Pacific	**2.6**	**2.9**	**2.8**	**3.5**	**4.2**	**4.5**	**5.0**
Japan	1.9	2.0	1.9	2.6	3.3	3.5	3.9
Other OECD	0.8	0.8	0.9	0.9	1.0	1.0	1.1
Total OECD	**35.0**	**38.5**	**40.8**	**45.7**	**51.9**	**57.3**	**64.2**
Non-OECD							
EE/FSU	**28.1**	**25.4**	**25.3**	**29.5**	**32.3**	**35.6**	**39.7**
Former Soviet Union	25.0	22.9	22.5	25.5	27.5	29.8	32.8
Eastern Europe	3.1	2.5	2.8	4.0	4.8	5.9	7.0
Non-OECD Asia	**3.0**	**3.7**	**4.4**	**6.4**	**8.9**	**11.9**	**14.5**
China	0.5	0.6	0.8	1.3	1.9	2.5	3.0
India	0.4	0.5	0.5	1.0	1.8	2.4	3.0
Other Asia	2.1	2.6	3.1	4.1	5.2	7.0	8.5
Middle East	**3.6**	**4.3**	**4.5**	**5.2**	**5.7**	**6.1**	**6.5**
Africa	**1.4**	**1.5**	**1.5**	**1.7**	**2.0**	**2.4**	**2.8**
Central and South America	**2.1**	**2.1**	**2.2**	**2.6**	**3.3**	**4.4**	**5.5**
Total Non-OECD	**38.1**	**37.0**	**38.0**	**45.3**	**52.3**	**60.4**	**69.1**
Total World	**73.1**	**75.5**	**78.8**	**91.0**	**104.2**	**117.7**	**133.3**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country. To convert cubic feet to cubic meters, divide each number in the table by 35.315.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table A13; and World Energy Projection System (1996).

Table A4. World Total Coal Consumption by Region, Reference Case, 1990-2015
(Million Short Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**957**	**986**	**1,002**	**1,070**	**1,137**	**1,185**	**1,229**
United States[a]	895	926	937	990	1,046	1,082	1,120
Canada	57	52	58	72	78	81	83
Mexico	5	7	7	9	13	22	26
OECD Europe	**917**	**704**	**719**	**757**	**788**	**809**	**832**
OECD Pacific	**235**	**233**	**234**	**253**	**264**	**273**	**278**
Japan	130	128	126	142	150	157	160
Other OECD	105	105	108	111	114	116	117
Total OECD	**2,110**	**1,922**	**1,954**	**2,081**	**2,189**	**2,266**	**2,339**
Non-OECD							
EE/FSU	**1,375**	**1,016**	**1,026**	**1,008**	**1,006**	**968**	**926**
Former Soviet Union	854	569	562	550	547	540	531
Eastern Europe	521	447	464	458	460	428	394
Non-OECD Asia	**1,570**	**1,777**	**1,941**	**2,313**	**2,752**	**3,289**	**3,931**
China	1,125	1,273	1,380	1,685	2,036	2,465	2,998
India	259	298	335	400	483	560	619
Other Asia	187	206	225	228	233	263	315
Middle East	**7**	**8**	**10**	**10**	**12**	**13**	**13**
Africa	**157**	**157**	**156**	**166**	**174**	**183**	**193**
Central and South America	**34**	**31**	**35**	**49**	**63**	**78**	**93**
Total Non-OECD	**3,143**	**2,989**	**3,167**	**3,546**	**4,007**	**4,530**	**5,156**
Total World	**5,253**	**4,912**	**5,122**	**5,627**	**6,196**	**6,796**	**7,495**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Range values for OECD 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 due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.To convert short tons to metric tons, divide each number in the table by 1.102.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table A16; and World Energy Projection System (1996).

Table A5. World Net Nuclear Energy Consumption by Region, Reference Case, 1990-2015
(Billion Kilowatthours)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**648**	**704**	**762**	**763**	**748**	**696**	**520**
United States[a]	577	610	658	664	649	610	434
Canada	69	89	97	91	91	79	79
Mexico	2	5	7	7	7	7	7
OECD Europe	**703**	**774**	**783**	**813**	**786**	**768**	**722**
OECD Pacific	**182**	**234**	**257**	**281**	**296**	**329**	**345**
Japan	182	234	257	281	296	329	345
Other OECD	0	0	0	0	0	0	0
Total OECD	**1,533**	**1,711**	**1,802**	**1,857**	**1,830**	**1,793**	**1,587**
Non-OECD							
EE/FSU	**256**	**258**	**239**	**289**	**270**	**265**	**220**
Former Soviet Union	201	205	194	234	212	206	161
Eastern Europe	54	54	45	55	58	59	58
Non-OECD Asia	**88**	**95**	**110**	**143**	**172**	**213**	**216**
China	0	2	13	13	20	31	32
India	6	6	8	11	12	18	18
Other Asia	82	87	89	119	140	164	165
Middle East	**0**	**0**	**0**	**0**	**0**	**4**	**5**
Africa	**8**	**7**	**9**	**9**	**9**	**9**	**9**
Central and South America	**9**	**8**	**9**	**9**	**18**	**18**	**18**
Total Non-OECD	**361**	**369**	**367**	**449**	**469**	**510**	**467**
Total World	**1,894**	**2,080**	**2,161**	**2,292**	**2,300**	**2,290**	**2,026**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table A8; and World Energy Projection System (1996).

Table A6. World Consumption of Hydroelectricity and Other Renewable Energy by Region, Reference Case, 1990-2015
(Quadrillion Btu)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**9.6**	**10.3**	**11.0**	**12.2**	**13.6**	**15.2**	**17.0**
United States[a]	6.2	6.7	7.1	7.4	7.7	8.2	8.9
Canada	3.0	3.3	3.7	4.5	5.4	6.2	6.9
Mexico	0.4	0.3	0.3	0.3	0.5	0.8	1.1
OECD Europe	**4.6**	**5.1**	**5.3**	**5.8**	**6.3**	**6.9**	**7.6**
OECD Pacific	**1.4**	**1.4**	**1.4**	**2.2**	**2.4**	**2.7**	**3.1**
Japan	0.9	1.0	1.0	1.6	1.9	2.0	2.3
Other OECD	0.4	0.4	0.5	0.5	0.6	0.7	0.8
Total OECD	**15.6**	**16.8**	**17.7**	**20.1**	**22.4**	**24.8**	**27.6**
Non-OECD							
EE/FSU	**2.8**	**2.9**	**2.9**	**2.9**	**3.3**	**3.9**	**4.6**
Former Soviet Union	2.4	2.4	2.5	2.6	2.8	2.9	3.1
Eastern Europe	0.4	0.4	0.5	0.3	0.5	1.0	1.5
Non-OECD Asia	**3.2**	**3.4**	**4.2**	**5.5**	**6.7**	**8.5**	**10.8**
China	1.3	1.5	1.7	2.6	3.8	5.2	7.0
India	0.7	0.7	0.9	1.2	1.3	1.4	1.7
Other Asia	1.1	1.2	1.6	1.6	1.6	1.8	2.1
Middle East	**0.1**	**0.2**	**0.2**	**0.3**	**0.4**	**0.5**	**0.5**
Africa	**0.6**	**0.6**	**0.5**	**0.7**	**0.8**	**0.9**	**1.0**
Central and South America	**3.9**	**4.2**	**4.4**	**4.5**	**4.7**	**4.9**	**5.0**
Total Non-OECD	**10.6**	**11.2**	**12.3**	**13.9**	**15.9**	**18.6**	**22.0**
Total World	**26.3**	**28.1**	**30.0**	**34.0**	**38.3**	**43.4**	**49.7**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table A1; and World Energy Projection System (1996).

Table A7. World Total Net Electricity Consumption by Region, Reference Case, 1990-2015
(Billion Kilowatthours)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**3,257**	**3,422**	**3,584**	**3,809**	**4,130**	**4,471**	**4,870**
United States[a]	2,713	2,862	2,975	3,136	3,362	3,605	3,889
Canada	433	448	486	522	568	618	672
Mexico	112	112	123	151	200	249	309
OECD Europe	**2,116**	**2,196**	**2,374**	**2,708**	**3,022**	**3,343**	**3,680**
OECD Pacific	**918**	**970**	**1,066**	**1,275**	**1,423**	**1,548**	**1,667**
Japan	738	781	841	1,010	1,122	1,212	1,297
Other OECD	180	189	225	265	301	336	370
Total OECD	**6,290**	**6,588**	**7,024**	**7,792**	**8,575**	**9,362**	**10,218**
Non-OECD							
EE/FSU	**1,907**	**1,656**	**1,523**	**1,689**	**1,850**	**2,022**	**2,205**
Former Soviet Union	1,488	1,300	1,148	1,250	1,344	1,445	1,553
Eastern Europe	418	357	375	439	506	577	653
Non-OECD Asia	**1,263**	**1,532**	**1,733**	**2,345**	**3,037**	**3,829**	**4,781**
China	551	698	748	1,026	1,381	1,848	2,457
India	257	293	354	489	647	800	962
Other Asia	455	540	631	830	1,010	1,181	1,363
Middle East	**190**	**196**	**245**	**293**	**339**	**381**	**426**
Africa	**285**	**299**	**304**	**362**	**430**	**507**	**593**
Central and South America	**448**	**490**	**527**	**608**	**690**	**776**	**863**
Total Non-OECD	**4,092**	**4,173**	**4,330**	**5,297**	**6,347**	**7,515**	**8,869**
Total World	**10,382**	**10,761**	**11,355**	**13,090**	**14,922**	**16,877**	**19,087**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Electricity consumption equals generation plus imports minus exports minus distribution losses.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995), Table 6.2. **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table A8; and World Energy Projection System (1996).

Table A8. World Total Carbon Emissions by Region, Reference Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**1,560**	**1,604**	**1,653**	**1,758**	**1,883**	**1,983**	**2,084**
United States[a]	1,337	1,374	1,413	1,490	1,584	1,659	1733
Canada	136	138	145	161	171	179	186
Mexico	87	92	95	107	128	146	165
OECD Europe	**1,023**	**982**	**1,014**	**1,083**	**1,146**	**1,201**	**1,262**
OECD Pacific	**402**	**413**	**432**	**481**	**513**	**534**	**556**
Japan	310	319	333	375	401	417	435
Other OECD	91	94	99	106	112	116	121
Total OECD	**2,985**	**2,999**	**3,099**	**3,322**	**3,542**	**3,718**	**3,901**
Non-OECD							
EE/FSU	**1,375**	**1,068**	**1,021**	**1,093**	**1,174**	**1,250**	**1,335**
Former Soviet Union	1,034	790	729	779	842	907	981
Eastern Europe	341	278	292	314	333	344	354
Non-OECD Asia	**1,097**	**1,284**	**1,418**	**1,784**	**2,179**	**2,599**	**3,087**
China	625	729	799	988	1,203	1,462	1,779
India	167	193	216	272	340	400	456
Other Asia	305	362	403	524	635	737	852
Middle East	**206**	**218**	**232**	**263**	**293**	**323**	**355**
Africa	**212**	**204**	**210**	**231**	**254**	**279**	**305**
Central and South America	**192**	**201**	**211**	**251**	**287**	**327**	**368**
Total Non-OECD	**3,082**	**2,976**	**3,091**	**3,622**	**4,187**	**4,777**	**5,451**
Total World	**6,068**	**5,975**	**6,190**	**6,944**	**7,730**	**8,495**	**9,353**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. The U.S. numbers include carbon emissions attributable to renewable energy sources.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table A19; and World Energy Projection System (1996).

Table A9. World Carbon Emissions from Oil Use by Region, Reference Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**722**	**724**	**750**	**798**	**850**	**891**	**922**
United States[a]	583	583	602	638	677	705	721
Canada	67	67	71	75	78	82	85
Mexico	71	75	78	86	95	105	116
OECD Europe	**537**	**566**	**573**	**591**	**605**	**612**	**620**
OECD Pacific	**252**	**262**	**282**	**310**	**325**	**337**	**350**
Japan	210	218	235	258	269	278	287
Other OECD	41	44	47	52	56	59	63
Total OECD	**1,511**	**1,553**	**1,605**	**1,700**	**1,780**	**1,840**	**1,892**
Non-OECD							
EE/FSU	**427**	**300**	**248**	**268**	**311**	**356**	**400**
Former Soviet Union	355	248	195	209	246	284	320
Eastern Europe	71	52	54	59	65	72	80
Non-OECD Asia	**326**	**406**	**454**	**619**	**774**	**902**	**1,053**
China	98	132	149	189	232	284	348
India	49	54	60	81	101	117	137
Other Asia	179	220	246	349	441	501	568
Middle East	**147**	**148**	**157**	**178**	**199**	**223**	**249**
Africa	**88**	**91**	**98**	**111**	**123**	**136**	**151**
Central and South America	**140**	**151**	**157**	**184**	**201**	**215**	**230**
Total Non-OECD	**1,128**	**1,095**	**1,114**	**1,360**	**1,608**	**1,833**	**2,084**
Total World	**2,639**	**2,648**	**2,718**	**3,060**	**3,388**	**3,673**	**3,976**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table A19; and World Energy Projection System (1996).

Table A10. World Carbon Emissions from Natural Gas Use by Region, Reference Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**323**	**352**	**367**	**389**	**427**	**462**	**510**
United States[a]	274	297	312	327	353	381	421
Canada	36	41	42	45	48	51	53
Mexico	13	14	13	17	27	30	36
OECD Europe	**145**	**165**	**184**	**223**	**264**	**305**	**352**
OECD Pacific	**40**	**43**	**42**	**53**	**64**	**69**	**76**
Japan	28	31	29	39	49	53	60
Other OECD	12	12	13	14	15	16	16
Total OECD	**507**	**560**	**594**	**665**	**756**	**836**	**937**
Non-OECD							
EE/FSU	**387**	**350**	**350**	**409**	**448**	**495**	**554**
Former Soviet Union	338	310	305	346	373	403	444
Eastern Europe	49	39	44	63	75	92	109
Non-OECD Asia	**44**	**55**	**65**	**95**	**134**	**178**	**218**
China	8	8	12	20	30	38	45
India	6	7	8	14	26	35	46
Other Asia	31	39	46	61	78	104	127
Middle East	**55**	**66**	**69**	**79**	**87**	**93**	**99**
Africa	**21**	**24**	**23**	**26**	**31**	**37**	**43**
Central and South America	**32**	**32**	**34**	**39**	**50**	**67**	**85**
Total Non-OECD	**540**	**526**	**541**	**648**	**751**	**870**	**998**
Total World	**1,047**	**1,086**	**1,135**	**1,312**	**1,507**	**1,706**	**1,936**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table A19; and World Energy Projection System (1996).

Table A11. World Carbon Emissions from Coal Use by Region, Reference Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**516**	**528**	**536**	**571**	**606**	**630**	**652**
United States[a]	480	495	499	525	555	573	591
Canada	33	30	33	41	44	46	47
Mexico	2	4	4	4	7	11	13
OECD Europe	**342**	**250**	**257**	**269**	**277**	**283**	**291**
OECD Pacific	**110**	**108**	**108**	**118**	**123**	**128**	**130**
Japan	72	70	69	78	82	86	88
Other OECD	38	38	39	40	41	42	42
Total OECD	**967**	**886**	**900**	**958**	**1,006**	**1,041**	**1,073**
Non-OECD							
EE/FSU	**561**	**419**	**423**	**416**	**415**	**399**	**381**
Former Soviet Union	340	231	228	224	222	220	216
Eastern Europe	221	187	195	192	193	179	165
Non-OECD Asia	**727**	**823**	**899**	**1,070**	**1,271**	**1,519**	**1,816**
China	519	589	638	779	942	1,140	1,387
India	112	132	148	177	213	247	273
Other Asia	95	103	112	114	116	131	157
Middle East	**4**	**5**	**6**	**6**	**7**	**7**	**7**
Africa	**103**	**90**	**89**	**95**	**100**	**105**	**111**
Central and South America	**19**	**18**	**20**	**28**	**36**	**44**	**53**
Total Non-OECD	**1,415**	**1,354**	**1,436**	**1,614**	**1,828**	**2,074**	**2,369**
Total World	**2,382**	**2,240**	**2,337**	**2,571**	**2,835**	**3,116**	**3,442**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table A19; and World Energy Projection System (1996).

Table A12. World Total Energy Consumption by Region, High Economic Growth Case, 1990-2015
(Quadrillion Btu)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**100.2**	**104.2**	**108.5**	**117.8**	**127.9**	**136.6**	**144.3**
United States[a]	84.4	87.3	90.8	97.4	104.3	110.2	115.0
Canada	11.0	11.7	12.5	14.2	16.0	17.3	18.7
Mexico	4.9	5.1	5.3	6.1	7.7	9.0	10.6
OECD Europe	**62.0**	**62.6**	**64.7**	**70.5**	**75.5**	**80.2**	**85.2**
OECD Pacific	**22.9**	**24.0**	**25.2**	**29.2**	**31.8**	**33.9**	**36.1**
Japan	18.1	19.0	19.9	23.5	25.7	27.4	29.1
Other OECD	4.8	5.0	5.2	5.7	6.1	6.5	7.0
Total OECD	**185.1**	**190.7**	**198.4**	**217.5**	**235.2**	**250.7**	**265.6**
Non-OECD							
EE/FSU	**75.3**	**60.9**	**58.3**	**68.8**	**78.9**	**90.0**	**102.5**
Former Soviet Union	58.7	47.3	44.1	51.9	59.2	67.4	76.6
Eastern Europe	16.6	13.6	14.2	16.9	19.6	22.6	25.9
Non-OECD Asia	**51.6**	**60.3**	**67.3**	**90.7**	**116.8**	**146.4**	**181.5**
China	27.0	31.6	35.0	45.8	58.9	75.5	96.2
India	8.0	9.1	10.3	14.3	18.9	23.4	28.2
Other Asia	16.6	19.6	22.1	30.7	39.0	47.5	57.2
Middle East	**11.3**	**12.2**	**12.9**	**15.5**	**18.3**	**20.9**	**23.9**
Africa	**10.5**	**10.3**	**10.5**	**12.4**	**14.4**	**16.7**	**19.2**
Central and South America	**14.0**	**14.8**	**15.4**	**18.4**	**21.8**	**25.5**	**29.5**
Total Non-OECD	**162.7**	**158.3**	**164.5**	**205.8**	**250.1**	**299.4**	**356.6**
Total World	**347.8**	**349.1**	**362.9**	**423.2**	**485.4**	**550.1**	**622.2**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B1; and World Energy Projection System (1996).

Table A13. World Total Oil Consumption by Region, High Economic Growth Case, 1990-2015
(Million Barrels per Day)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**20.4**	**20.7**	**21.5**	**23.3**	**25.1**	**26.6**	**28.0**
United States[a]	17.0	17.2	17.8	19.2	20.7	21.8	22.7
Canada	1.7	1.7	1.8	1.9	2.0	2.1	2.3
Mexico	1.7	1.8	1.9	2.2	2.4	2.7	3.0
OECD Europe	**12.9**	**13.6**	**13.8**	**14.4**	**14.9**	**15.3**	**15.6**
OECD Pacific	**6.2**	**6.5**	**7.0**	**7.8**	**8.3**	**8.7**	**9.1**
Japan	5.1	5.4	5.8	6.5	6.9	7.2	7.5
Other OECD	1.0	1.1	1.2	1.3	1.4	1.6	1.7
Total OECD	**39.5**	**40.9**	**42.3**	**45.5**	**48.4**	**50.6**	**52.7**
Non-OECD							
EE/FSU	**10.0**	**7.0**	**5.8**	**6.8**	**8.3**	**10.1**	**12.0**
Former Soviet Union	8.4	5.8	4.5	5.3	6.6	8.0	9.6
Eastern Europe	1.6	1.2	1.3	1.5	1.8	2.1	2.4
Non-OECD Asia	**7.6**	**9.5**	**10.6**	**15.4**	**20.2**	**24.6**	**30.0**
China	2.3	3.1	3.5	4.6	5.9	7.6	9.6
India	1.2	1.3	1.4	2.1	2.7	3.3	4.1
Other Asia	4.2	5.1	5.7	8.7	11.6	13.7	16.3
Middle East	**3.5**	**3.5**	**3.7**	**4.4**	**5.2**	**6.1**	**7.1**
Africa	**2.1**	**2.2**	**2.3**	**2.8**	**3.3**	**3.8**	**4.4**
Central and South America	**3.4**	**3.7**	**3.8**	**4.7**	**5.4**	**6.0**	**6.7**
Total Non-OECD	**26.7**	**25.8**	**26.3**	**34.1**	**42.4**	**50.6**	**60.1**
Total World	**66.2**	**66.7**	**68.5**	**79.7**	**90.8**	**101.2**	**112.8**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B21; and World Energy Projection System (1996).

Table A14. World Total Natural Gas Consumption by Region, High Economic Growth Case, 1990-2015
(Trillion Cubic Feet)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**22.1**	**24.1**	**25.1**	**27.7**	**31.1**	**34.0**	**37.1**
United States[a]	18.7	20.3	21.3	23.4	25.7	28.1	30.5
Canada	2.4	2.8	2.9	3.1	3.4	3.6	3.8
Mexico	0.9	1.0	0.9	1.2	2.0	2.3	2.8
OECD Europe	**10.2**	**11.6**	**12.9**	**15.8**	**18.9**	**21.9**	**25.4**
OECD Pacific	**2.6**	**2.9**	**2.8**	**3.6**	**4.4**	**4.7**	**5.2**
Japan	1.9	2.0	1.9	2.6	3.4	3.7	4.1
Other OECD	0.8	0.8	0.9	0.9	1.0	1.1	1.1
Total OECD	**35.0**	**38.5**	**40.8**	**47.1**	**54.3**	**60.6**	**67.8**
Non-OECD							
EE/FSU	**28.1**	**25.4**	**25.3**	**31.9**	**37.1**	**43.3**	**51.1**
Former Soviet Union	25.0	22.9	22.5	27.6	31.6	36.2	42.1
Eastern Europe	3.1	2.5	2.8	4.3	5.5	7.1	9.0
Non-OECD Asia	**3.0**	**3.7**	**4.4**	**6.8**	**10.0**	**13.9**	**17.8**
China	0.5	0.6	0.8	1.4	2.1	2.8	3.5
India	0.4	0.5	0.5	1.0	2.0	2.8	3.8
Other Asia	2.1	2.6	3.1	4.4	5.9	8.3	10.5
Middle East	**3.6**	**4.3**	**4.5**	**5.4**	**6.3**	**7.0**	**7.8**
Africa	**1.4**	**1.5**	**1.5**	**1.8**	**2.2**	**2.8**	**3.4**
Central and South America	**2.1**	**2.1**	**2.2**	**2.7**	**3.6**	**5.1**	**6.6**
Total Non-OECD	**38.1**	**37.0**	**38.0**	**48.6**	**59.3**	**72.1**	**86.7**
Total World	**73.1**	**75.5**	**78.8**	**95.7**	**113.7**	**132.7**	**154.5**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country. To convert cubic feet to cubic meters, divide each number in the table by 35.315.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B13; and World Energy Projection System (1996).

Table A15. World Total Coal Consumption by Region, High Economic Growth Case, 1990-2015
(Million Short Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**957**	**986**	**1,002**	**1,086**	**1,163**	**1,218**	**1,281**
United States[a]	895	926	937	1,004	1,068	1,110	1,165
Canada	57	52	58	73	81	85	88
Mexico	5	7	7	9	14	23	28
OECD Europe	**917**	**704**	**719**	**768**	**808**	**837**	**870**
OECD Pacific	**235**	**233**	**234**	**257**	**271**	**283**	**292**
Japan	130	128	126	145	155	164	169
Other OECD	105	105	108	112	117	119	122
Total OECD	**2,110**	**1,922**	**1,954**	**2,111**	**2,241**	**2,338**	**2,443**
Non-OECD							
EE/FSU	**1,375**	**1,016**	**1,026**	**1,089**	**1,156**	**1,179**	**1,192**
Former Soviet Union	854	569	562	595	627	656	683
Eastern Europe	521	447	464	495	529	522	509
Non-OECD Asia	**1,570**	**1,777**	**1,941**	**2,431**	**3,025**	**3,768**	**4,687**
China	1,125	1,273	1,380	1,757	2,212	2,788	3,527
India	259	298	335	429	551	670	774
Other Asia	187	206	225	245	262	310	386
Middle East	**7**	**8**	**10**	**11**	**13**	**14**	**16**
Africa	**157**	**157**	**156**	**174**	**192**	**211**	**231**
Central and South America	**34**	**31**	**35**	**51**	**69**	**90**	**112**
Total Non-OECD	**3,143**	**2,989**	**3,167**	**3,757**	**4,456**	**5,262**	**6,238**
Total World	**5,253**	**4,912**	**5,122**	**5,868**	**6,698**	**7,601**	**8,681**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Range values for OECD 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 due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.To convert short tons to metric tons, divide each number in the table by 1.102.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B16; and World Energy Projection System (1996).

Table A16. World Net Nuclear Energy Consumption by Region, High Economic Growth Case, 1990-2015
(Billion Kilowatthours)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**648**	**704**	**762**	**765**	**751**	**700**	**525**
United States[a]	577	610	658	664	649	610	434
Canada	69	89	97	93	95	82	83
Mexico	2	5	7	8	8	8	8
OECD Europe	**703**	**774**	**783**	**823**	**805**	**793**	**753**
OECD Pacific	**182**	**234**	**257**	**286**	**306**	**343**	**364**
Japan	182	234	257	286	306	343	364
Other OECD	0	0	0	0	0	0	0
Total OECD	**1,533**	**1,711**	**1,802**	**1,874**	**1,862**	**1,837**	**1,642**
Non-OECD							
EE/FSU	**256**	**258**	**239**	**312**	**310**	**323**	**283**
Former Soviet Union	201	205	194	253	244	250	207
Eastern Europe	54	54	45	59	66	72	75
Non-OECD Asia	**88**	**95**	**109**	**152**	**192**	**248**	**262**
China	0	2	13	13	21	34	37
India	6	6	8	12	14	22	23
Other Asia	82	87	89	127	157	193	203
Middle East	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Africa	**8**	**7**	**9**	**9**	**10**	**10**	**11**
Central and South America	**9**	**8**	**0**	**16**	**20**	**24**	**27**
Total Non-OECD	**361**	**369**	**358**	**489**	**532**	**605**	**582**
Total World	**1,894**	**2,080**	**2,159**	**2,364**	**2,394**	**2,442**	**2,225**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B8; and World Energy Projection System (1996).

Table A17. World Consumption of Hydroelectricity and Other Renewable Energy by Region, High Economic Growth Case, 1990-2015
(Quadrillion Btu)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**9.6**	**10.3**	**11.0**	**12.4**	**14.0**	**16.1**	**18.6**
United States[a]	6.2	6.7	7.1	7.5	7.9	8.7	10.0
Canada	3.0	3.3	3.7	4.5	5.6	6.5	7.4
Mexico	0.4	0.3	0.3	0.3	0.5	0.8	1.2
OECD Europe	**4.6**	**5.1**	**5.3**	**5.8**	**6.5**	**7.1**	**7.9**
OECD Pacific	**1.4**	**1.4**	**1.4**	**2.2**	**2.5**	**2.8**	**3.2**
Japan	0.9	1.0	1.0	1.7	1.9	2.1	2.4
Other OECD	0.4	0.4	0.5	0.5	0.6	0.7	0.8
Total OECD	**15.6**	**16.8**	**17.7**	**20.4**	**23.0**	**26.1**	**29.7**
Non-OECD							
EE/FSU	**2.8**	**2.9**	**2.9**	**3.2**	**3.8**	**4.8**	**5.9**
Former Soviet Union	2.4	2.4	2.5	2.8	3.2	3.6	4.0
Eastern Europe	0.4	0.4	0.5	0.3	0.6	1.2	2.0
Non-OECD Asia	**3.2**	**3.4**	**4.2**	**5.8**	**7.4**	**9.8**	**13.0**
China	1.3	1.5	1.7	2.7	4.1	5.9	8.3
India	0.7	0.7	0.9	1.3	1.5	1.7	2.1
Other Asia	1.1	1.2	1.6	1.8	1.9	2.2	2.6
Middle East	**0.1**	**0.2**	**0.2**	**0.3**	**0.4**	**0.5**	**0.7**
Africa	**0.6**	**0.6**	**0.5**	**0.7**	**0.9**	**1.0**	**1.2**
Central and South America	**3.9**	**4.2**	**4.4**	**4.7**	**5.2**	**5.6**	**6.0**
Total Non-OECD	**10.6**	**11.2**	**12.3**	**14.8**	**17.8**	**21.7**	**26.8**
Total World	**26.3**	**28.1**	**30.0**	**35.2**	**40.7**	**47.8**	**56.5**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B1; and World Energy Projection System (1996).

Table A18. World Total Net Electricity Consumption by Region, High Economic Growth Case, 1990-2015
(Billion Kilowatthours)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**3,257**	**3,422**	**3,584**	**3,905**	**4,308**	**4,738**	**5,238**
United States[a]	2,713	2,862	2,975	3,218	3,511	3,828	4,194
Canada	433	448	486	533	589	648	714
Mexico	112	112	123	154	208	262	330
OECD Europe	**2,116**	**2,196**	**2,374**	**2,744**	**3,096**	**3,459**	**3,845**
OECD Pacific	**918**	**970**	**1,066**	**1,298**	**1,466**	**1,612**	**1,754**
Japan	738	781	841	1,030	1,159	1,265	1,368
Other OECD	180	189	225	268	307	347	386
Total OECD	**6,290**	**6,588**	**7,024**	**7,947**	**8,871**	**9,808**	**10,837**
Non-OECD							
EE/FSU	**1,907**	**1,656**	**1,523**	**1,825**	**2,125**	**2,461**	**2,838**
Former Soviet Union	1,488	1,300	1,148	1,351	1,543	1,756	1,996
Eastern Europe	418	357	375	474	582	704	842
Non-OECD Asia	**1,263**	**1,532**	**1,733**	**2,484**	**3,376**	**4,437**	**5,767**
China	551	698	748	1,070	1,501	2,090	2,890
India	257	293	354	525	737	957	1,203
Other Asia	455	540	631	889	1,138	1,390	1,674
Middle East	**190**	**196**	**245**	**308**	**376**	**439**	**511**
Africa	**285**	**299**	**304**	**381**	**475**	**584**	**712**
Central and South America	**448**	**490**	**527**	**640**	**762**	**895**	**1,036**
Total Non-OECD	**4,092**	**4,173**	**4,330**	**5,639**	**7,113**	**8,816**	**10,864**
Total World	**10,382**	**10,761**	**11,355**	**13,586**	**15,983**	**18,624**	**21,700**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Electricity consumption equals generation plus imports minus exports minus distribution losses.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995), Table 6.2. **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B8; and World Energy Projection System (1996).

Table A19. World Total Carbon Emissions by Region, High Economic Growth Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**1,560**	**1,604**	**1,653**	**1,802**	**1,958**	**2,083**	**2,209**
United States[a]	1,337	1,374	1,413	1,529	1,648	1,742	1,835
Canada	136	138	145	164	177	187	198
Mexico	87	92	95	109	133	154	176
OECD Europe	**1,023**	**982**	**1,014**	**1,098**	**1,175**	**1,243**	**1,319**
OECD Pacific	**402**	**413**	**432**	**489**	**528**	**555**	**585**
Japan	310	319	333	382	414	435	458
Other OECD	91	94	99	107	114	120	126
Total OECD	**2,985**	**2,999**	**3,099**	**3,389**	**3,661**	**3,882**	**4,113**
Non-OECD							
EE/FSU	**1,375**	**1,068**	**1,021**	**1,181**	**1,349**	**1,521**	**1,718**
Former Soviet Union	1,034	790	729	842	966	1,102	1,260
Eastern Europe	341	278	292	339	383	419	457
Non-OECD Asia	**1,097**	**1,284**	**1,418**	**1,884**	**2,411**	**2,999**	**3,710**
China	625	729	799	1,031	1,307	1,654	2,093
India	167	193	216	292	388	479	570
Other Asia	305	362	403	562	716	867	1,046
Middle East	**206**	**218**	**232**	**277**	**325**	**372**	**427**
Africa	**212**	**204**	**210**	**244**	**281**	**322**	**367**
Central and South America	**192**	**201**	**211**	**264**	**316**	**377**	**442**
Total Non-OECD	**3,082**	**2,976**	**3,091**	**3,849**	**4,682**	**5,591**	**6,663**
Total World	**6,068**	**5,975**	**6,190**	**7,238**	**8,343**	**9,473**	**10,775**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. The U.S. numbers include carbon emissions attributable to renewable energy sources.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B19; and World Energy Projection System (1996).

Table A20. World Carbon Emissions from Oil Use by Region, High Economic Growth Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**722**	**724**	**750**	**817**	**883**	**937**	**984**
United States[a]	583	583	602	653	704	741	769
Canada	67	67	71	76	81	86	91
Mexico	71	75	78	88	99	110	124
OECD Europe	**537**	**566**	**573**	**599**	**620**	**634**	**648**
OECD Pacific	**252**	**262**	**282**	**315**	**335**	**351**	**368**
Japan	210	218	235	263	278	290	303
Other OECD	41	44	47	52	57	61	65
Total OECD	**1,511**	**1,553**	**1,605**	**1,732**	**1,838**	**1,922**	**1,999**
Non-OECD							
EE/FSU	**427**	**300**	**248**	**290**	**358**	**433**	**515**
Former Soviet Union	355	248	195	226	282	345	412
Eastern Europe	71	52	54	64	75	88	103
Non-OECD Asia	**326**	**406**	**454**	**658**	**864**	**1,051**	**1,278**
China	98	132	149	197	252	321	409
India	49	54	60	87	115	141	171
Other Asia	179	220	246	374	497	590	698
Middle East	**147**	**148**	**157**	**188**	**221**	**257**	**299**
Africa	**88**	**91**	**98**	**116**	**136**	**157**	**182**
Central and South America	**140**	**151**	**157**	**194**	**221**	**248**	**276**
Total Non-OECD	**1,128**	**1,095**	**1,114**	**1,446**	**1,799**	**2,147**	**2,550**
Total World	**2,639**	**2,648**	**2,718**	**3,178**	**3,638**	**4,068**	**4,550**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B19; and World Energy Projection System (1996).

Table A21. World Carbon Emissions from Natural Gas Use by Region, High Economic Growth Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**323**	**352**	**367**	**406**	**454**	**497**	**543**
United States[a]	274	297	312	343	377	412	447
Canada	36	41	42	46	50	53	57
Mexico	13	14	13	17	28	32	39
OECD Europe	**145**	**165**	**184**	**226**	**271**	**316**	**368**
OECD Pacific	**40**	**43**	**42**	**54**	**66**	**72**	**80**
Japan	28	31	29	40	51	56	63
Other OECD	12	12	13	14	15	16	17
Total OECD	**507**	**560**	**594**	**686**	**792**	**884**	**990**
Non-OECD							
EE/FSU	**387**	**350**	**350**	**441**	**514**	**603**	**712**
Former Soviet Union	338	310	305	374	428	490	571
Eastern Europe	49	39	44	68	86	112	141
Non-OECD Asia	**44**	**55**	**65**	**102**	**150**	**208**	**266**
China	8	8	12	21	32	43	53
India	6	7	8	15	30	42	57
Other Asia	31	39	46	65	88	123	156
Middle East	**55**	**66**	**69**	**83**	**97**	**107**	**119**
Africa	**21**	**24**	**23**	**27**	**35**	**43**	**52**
Central and South America	**32**	**32**	**34**	**41**	**56**	**77**	**102**
Total Non-OECD	**540**	**526**	**541**	**694**	**852**	**1,038**	**1,251**
Total World	**1,047**	**1,086**	**1,135**	**1,380**	**1,643**	**1,923**	**2,240**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B19; and World Energy Projection System (1996).

Table A22. World Carbon Emissions from Coal Use by Region, High Economic Growth Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**516**	**528**	**536**	**579**	**620**	**649**	**683**
United States[a]	480	495	499	533	567	589	619
Canada	33	30	33	42	46	48	50
Mexico	2	4	4	4	7	12	14
OECD Europe	**342**	**250**	**257**	**273**	**284**	**293**	**304**
OECD Pacific	**110**	**108**	**108**	**120**	**127**	**133**	**137**
Japan	72	70	69	79	85	90	93
Other OECD	38	38	39	41	42	43	44
Total OECD	**967**	**886**	**900**	**972**	**1,031**	**1,076**	**1,124**
Non-OECD							
EE/FSU	**561**	**419**	**423**	**449**	**477**	**486**	**491**
Former Soviet Union	340	231	228	242	255	267	278
Eastern Europe	221	187	195	207	222	219	213
Non-OECD Asia	**727**	**823**	**899**	**1,124**	**1,397**	**1,740**	**2,165**
China	519	589	638	813	1,023	1,290	1,631
India	112	132	148	189	243	296	342
Other Asia	95	103	112	122	131	154	192
Middle East	**4**	**5**	**6**	**6**	**7**	**8**	**9**
Africa	**103**	**90**	**89**	**100**	**110**	**121**	**133**
Central and South America	**19**	**18**	**20**	**29**	**40**	**51**	**64**
Total Non-OECD	**1,415**	**1,354**	**1,436**	**1,709**	**2,031**	**2,406**	**2,862**
Total World	**2,382**	**2,240**	**2,337**	**2,681**	**3,062**	**3,482**	**3,985**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B19; and World Energy Projection System (1996).

Table A23. World Total Energy Consumption by Region, Low Economic Growth Case, 1990-2015
(Quadrillion Btu)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**100.2**	**104.2**	**108.4**	**112.4**	**118.4**	**123.0**	**127.0**
United States[a]	84.4	87.3	90.6	92.9	96.5	99.2	101.2
Canada	11.0	11.7	12.5	13.7	14.9	15.8	16.6
Mexico	4.9	5.1	5.3	5.9	7.1	8.1	9.3
OECD Europe	**62.0**	**62.6**	**64.7**	**68.6**	**71.9**	**74.9**	**78.0**
OECD Pacific	**22.9**	**24.0**	**25.2**	**28.2**	**29.9**	**31.3**	**32.6**
Japan	18.1	19.0	19.9	22.6	24.1	25.1	26.2
Other OECD	4.8	5.0	5.2	5.6	5.9	6.2	6.4
Total OECD	**185.1**	**190.7**	**198.2**	**209.2**	**220.2**	**229.2**	**237.6**
Non-OECD							
EE/FSU	**75.3**	**60.9**	**58.3**	**61.2**	**64.0**	**67.0**	**70.2**
Former Soviet Union	58.7	47.3	44.1	46.2	48.1	50.3	52.5
Eastern Europe	16.6	13.6	14.2	15.0	15.9	16.8	17.7
Non-OECD Asia	**51.6**	**60.3**	**67.3**	**79.4**	**91.0**	**102.5**	**114.6**
China	27.0	31.6	35.0	40.3	45.8	52.0	58.8
India	8.0	9.1	10.3	12.4	14.5	16.3	18.0
Other Asia	16.6	19.6	22.1	26.7	30.7	34.2	37.8
Middle East	**11.3**	**12.2**	**12.9**	**14.0**	**14.9**	**15.7**	**16.6**
Africa	**10.5**	**10.3**	**10.5**	**11.2**	**11.8**	**12.5**	**13.3**
Central and South America	**14.0**	**14.8**	**15.4**	**16.6**	**17.9**	**19.2**	**20.4**
Total Non-OECD	**162.7**	**158.3**	**164.5**	**182.3**	**199.6**	**216.9**	**235.1**
Total World	**347.8**	**349.1**	**362.8**	**391.5**	**419.8**	**446.1**	**472.7**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B1; and World Energy Projection System (1996).

Table A24. World Total Oil Consumption by Region, Low Economic Growth Case, 1990-2015
(Million Barrels per Day)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**20.4**	**20.7**	**21.5**	**22.2**	**23.2**	**23.9**	**24.4**
United States[a]	17.0	17.2	17.8	18.3	19.1	19.5	19.8
Canada	1.7	1.7	1.8	1.8	1.9	1.9	2.0
Mexico	1.7	1.8	1.9	2.1	2.2	2.4	2.7
OECD Europe	**12.9**	**13.6**	**13.8**	**14.1**	**14.2**	**14.3**	**14.3**
OECD Pacific	**6.2**	**6.5**	**7.0**	**7.5**	**7.8**	**8.0**	**8.3**
Japan	5.1	5.4	5.8	6.2	6.4	6.6	6.7
Other OECD	1.0	1.1	1.2	1.3	1.4	1.5	1.5
Total OECD	**39.5**	**40.9**	**42.3**	**43.8**	**45.3**	**46.2**	**46.9**
Non-OECD							
EE/FSU	**10.0**	**7.0**	**5.8**	**6.0**	**6.8**	**7.5**	**8.2**
Former Soviet Union	8.4	5.8	4.5	4.7	5.3	6.0	6.6
Eastern Europe	1.6	1.2	1.3	1.3	1.4	1.5	1.6
Non-OECD Asia	**7.6**	**9.5**	**10.6**	**13.5**	**15.8**	**17.4**	**19.3**
China	2.3	3.1	3.5	4.1	4.6	5.2	5.9
India	1.2	1.3	1.4	1.8	2.1	2.3	2.6
Other Asia	4.2	5.1	5.7	7.6	9.1	9.9	10.8
Middle East	**3.5**	**3.5**	**3.7**	**4.0**	**4.2**	**4.6**	**4.9**
Africa	**2.1**	**2.2**	**2.3**	**2.5**	**2.7**	**2.8**	**3.0**
Central and South America	**3.4**	**3.7**	**3.8**	**4.3**	**4.4**	**4.5**	**4.7**
Total Non-OECD	**26.7**	**25.8**	**26.3**	**30.2**	**33.9**	**36.9**	**40.0**
Total World	**66.2**	**66.7**	**68.5**	**74.1**	**79.2**	**83.1**	**87.0**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B21; and World Energy Projection System (1996).

Table A25. World Total Natural Gas Consumption by Region, Low Economic Growth Case, 1990-2015
(Trillion Cubic Feet)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**22.1**	**24.1**	**25.1**	**25.6**	**27.5**	**29.3**	**32.0**
United States[a]	18.7	20.3	21.3	21.5	22.6	24.0	26.2
Canada	2.4	2.8	2.9	3.0	3.1	3.3	3.4
Mexico	0.9	1.0	0.9	1.2	1.8	2.0	2.4
OECD Europe	**10.2**	**11.6**	**12.9**	**15.4**	**17.9**	**20.4**	**23.3**
OECD Pacific	**2.6**	**2.9**	**2.8**	**3.4**	**4.1**	**4.4**	**4.7**
Japan	1.9	2.0	1.9	2.5	3.1	3.4	3.7
Other OECD	0.8	0.8	0.9	0.9	1.0	1.0	1.0
Total OECD	**35.0**	**38.5**	**40.8**	**44.4**	**49.6**	**54.1**	**60.0**
Non-OECD							
EE/FSU	**28.1**	**25.4**	**25.3**	**28.4**	**30.1**	**32.3**	**35.0**
Former Soviet Union	25.0	22.9	22.5	24.5	25.7	27.0	28.9
Eastern Europe	3.1	2.5	2.8	3.8	4.4	5.3	6.1
Non-OECD Asia	**3.0**	**3.7**	**4.4**	**5.9**	**7.8**	**9.9**	**11.5**
China	0.5	0.6	0.8	1.2	1.6	2.0	2.1
India	0.4	0.5	0.5	0.9	1.5	2.0	2.4
Other Asia	2.1	2.6	3.1	3.8	4.6	5.9	6.9
Middle East	**3.6**	**4.3**	**4.5**	**4.9**	**5.2**	**5.3**	**5.4**
Africa	**1.4**	**1.5**	**1.5**	**1.6**	**1.8**	**2.1**	**2.4**
Central and South America	**2.1**	**2.1**	**2.2**	**2.4**	**3.0**	**3.8**	**4.6**
Total Non-OECD	**38.1**	**37.0**	**38.0**	**43.2**	**47.9**	**53.3**	**58.8**
Total World	**73.1**	**75.5**	**78.8**	**87.7**	**97.5**	**107.4**	**118.8**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country. To convert cubic feet to cubic meters, divide each number in the table by 35.315.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B13; and World Energy Projection System (1996).

Table A26. World Total Coal Consumption by Region, Low Economic Growth Case, 1990-2015
(Million Short Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**957**	**986**	**1,002**	**1,053**	**1,106**	**1,142**	**1,165**
United States[a]	895	926	937	974	1,018	1,044	1,075
Canada	57	52	58	70	75	77	78
Mexico	5	7	7	8	13	21	24
OECD Europe	**917**	**704**	**719**	**747**	**768**	**781**	**796**
OECD Pacific	**235**	**233**	**234**	**249**	**257**	**263**	**265**
Japan	130	128	126	139	145	151	152
Other OECD	105	105	108	110	112	112	113
Total OECD	**2,110**	**1,922**	**1,954**	**2,049**	**2,131**	**2,185**	**2,226**
Non-OECD							
EE/FSU	**1,375**	**1,016**	**1,026**	**969**	**938**	**876**	**815**
Former Soviet Union	854	569	562	529	510	489	468
Eastern Europe	521	447	464	440	428	387	347
Non-OECD Asia	**1,570**	**1,777**	**1,941**	**2,132**	**2,350**	**2,612**	**2,906**
China	1,125	1,273	1,380	1,547	1,721	1,922	2,157
India	259	298	335	372	423	467	493
Other Asia	187	206	225	213	206	223	256
Middle East	**7**	**8**	**10**	**10**	**11**	**11**	**11**
Africa	**157**	**157**	**156**	**157**	**158**	**159**	**160**
Central and South America	**34**	**31**	**35**	**46**	**57**	**67**	**78**
Total Non-OECD	**3,143**	**2,989**	**3,167**	**3,315**	**3,514**	**3,725**	**3,970**
Total World	**5,253**	**4,912**	**5,122**	**5,364**	**5,645**	**5,910**	**6,208**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Range values for OECD 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 due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.To convert short tons to metric tons, divide each number in the table by 1.102.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B16; and World Energy Projection System (1996).

Table A27. World Net Nuclear Energy Consumption by Region, Low Economic Growth Case, 1990-2015
(Billion Kilowatthours)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**648**	**704**	**762**	**761**	**744**	**692**	**515**
United States[a]	577	610	658	664	649	610	434
Canada	69	89	97	90	88	75	74
Mexico	2	5	7	7	7	7	7
OECD Europe	**703**	**774**	**783**	**803**	**769**	**743**	**692**
OECD Pacific	**182**	**234**	**257**	**275**	**287**	**315**	**328**
Japan	182	234	257	275	287	315	328
Other OECD	0	0	0	0	0	0	0
Total OECD	**1,533**	**1,711**	**1,802**	**1,839**	**1,799**	**1,750**	**1,534**
Non-OECD							
EE/FSU	**256**	**258**	**239**	**277**	**252**	**240**	**193**
Former Soviet Union	201	205	194	225	198	187	142
Eastern Europe	54	54	45	53	54	53	51
Non-OECD Asia	**88**	**95**	**109**	**132**	**151**	**177**	**171**
China	0	2	13	11	16	23	22
India	6	6	8	10	11	15	14
Other Asia	82	87	89	111	124	139	134
Middle East	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Africa	**8**	**7**	**9**	**8**	**8**	**8**	**7**
Central and South America	**9**	**8**	**0**	**16**	**20**	**24**	**27**
Total Non-OECD	**361**	**369**	**358**	**435**	**431**	**449**	**399**
Total World	**1,894**	**2,080**	**2,159**	**2,274**	**2,230**	**2,199**	**1,933**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B8; and World Energy Projection System (1996).

Table A28. World Consumption of Hydroelectricity and Other Renewable Energy by Region, Low Economic Growth Case, 1990-2015
(Quadrillion Btu)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**9.6**	**10.3**	**11.0**	**12.1**	**13.4**	**14.9**	**16.5**
United States[a]	6.2	6.7	7.1	7.4	7.7	8.2	8.9
Canada	3.0	3.3	3.7	4.4	5.2	5.9	6.5
Mexico	0.4	0.3	0.3	0.3	0.5	0.7	1.0
OECD Europe	**4.6**	**5.1**	**5.3**	**5.7**	**6.2**	**6.7**	**7.3**
OECD Pacific	**1.4**	**1.4**	**1.4**	**2.1**	**2.4**	**2.6**	**2.9**
Japan	0.9	1.0	1.0	1.6	1.8	2.0	2.1
Other OECD	0.4	0.4	0.5	0.5	0.6	0.7	0.8
Total OECD	**15.6**	**16.8**	**17.7**	**19.9**	**21.9**	**24.2**	**26.7**
Non-OECD							
EE/FSU	**2.8**	**2.9**	**2.9**	**2.8**	**3.1**	**3.5**	**4.1**
Former Soviet Union	2.4	2.4	2.5	2.5	2.6	2.7	2.7
Eastern Europe	0.4	0.4	0.5	0.3	0.5	0.9	1.3
Non-OECD Asia	**3.2**	**3.4**	**4.2**	**5.1**	**5.8**	**6.8**	**8.1**
China	1.3	1.5	1.7	2.4	3.2	4.1	5.1
India	0.7	0.7	0.9	1.2	1.1	1.2	1.4
Other Asia	1.1	1.2	1.6	1.5	1.5	1.6	1.7
Middle East	**0.1**	**0.2**	**0.2**	**0.3**	**0.4**	**0.4**	**0.5**
Africa	**0.6**	**0.6**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
Central and South America	**3.9**	**4.2**	**4.4**	**4.3**	**4.2**	**4.2**	**4.2**
Total Non-OECD	**10.6**	**11.2**	**12.3**	**13.1**	**14.2**	**15.7**	**17.7**
Total World	**26.3**	**28.1**	**30.0**	**33.0**	**36.2**	**39.9**	**44.4**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B1; and World Energy Projection System (1996).

Table A29. World Total Net Electricity Consumption by Region, Low Economic Growth Case, 1990-2015
(Billion Kilowatthours)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**3,257**	**3,422**	**3,584**	**3,716**	**3,962**	**4,213**	**4,515**
United States[a]	2713	2862	2,975	3,057	3,221	3,388	3,593
Canada	433	448	486	512	548	589	633
Mexico	112	112	123	148	193	236	289
OECD Europe	**2,116**	**2,196**	**2,374**	**2,673**	**2,949**	**3,231**	**3,522**
OECD Pacific	**918**	**970**	**1,066**	**1,253**	**1,381**	**1,487**	**1,586**
Japan	738	781	841	990	1,087	1,161	1,230
Other OECD	180	189	225	262	295	326	355
Total OECD	**6,290**	**6,588**	**7,024**	**7,642**	**8,292**	**8,931**	**9,622**
Non-OECD							
EE/FSU	**1,907**	**1,656**	**1,523**	**1,624**	**1,725**	**1,831**	**1,942**
Former Soviet Union	1,488	1,300	1,148	1,202	1,254	1,309	1,368
Eastern Europe	418	357	375	422	471	522	574
Non-OECD Asia	**1,263**	**1,532**	**1,733**	**2,171**	**2,628**	**3,108**	**3,642**
China	551	698	748	942	1,168	1,441	1,768
India	257	293	354	455	566	667	767
Other Asia	455	540	631	773	894	1,001	1,108
Middle East	**190**	**196**	**245**	**278**	**306**	**330**	**354**
Africa	**285**	**299**	**304**	**344**	**389**	**439**	**493**
Central and South America	**448**	**490**	**527**	**578**	**625**	**672**	**718**
Total Non-OECD	**4,092**	**4,173**	**4,330**	**4,995**	**5,674**	**6,381**	**7,150**
Total World	**10,382**	**10,761**	**11,355**	**12,637**	**13,965**	**15,312**	**16,772**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. Electricity consumption equals generation plus imports minus exports minus distribution losses.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995), Table 6.2. **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B8; and World Energy Projection System (1996).

Table A30. World Total Carbon Emissions by Region, Low Economic Growth Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**1,560**	**1,604**	**1,653**	**1,716**	**1,808**	**1,877**	**1,955**
United States[a]	1,337	1,374	1,413	1,453	1,520	1,568	1,625
Canada	136	138	145	158	165	170	175
Mexico	87	92	95	105	123	138	154
OECD Europe	**1,023**	**982**	**1,014**	**1,069**	**1,118**	**1,160**	**1,207**
OECD Pacific	**402**	**413**	**432**	**472**	**497**	**513**	**528**
Japan	310	319	333	367	388	400	412
Other OECD	91	94	99	105	110	113	116
Total OECD	**2,985**	**2,999**	**3,099**	**3,257**	**3,424**	**3,550**	**3,690**
Non-OECD							
EE/FSU	**1,375**	**1,068**	**1,021**	**1,050**	**1,095**	**1,132**	**1,175**
Former Soviet Union	1,034	790	729	749	785	822	864
Eastern Europe	341	278	292	302	310	310	311
Non-OECD Asia	**1,097**	**1,284**	**1,418**	**1,649**	**1,878**	**2,098**	**2,336**
China	625	729	799	907	1,017	1,140	1,281
India	167	193	216	253	298	333	363
Other Asia	305	362	403	488	563	624	693
Middle East	**206**	**218**	**232**	**250**	**265**	**279**	**296**
Africa	**212**	**204**	**210**	**220**	**230**	**241**	**254**
Central and South America	**192**	**201**	**211**	**238**	**260**	**283**	**306**
Total Non-OECD	**3,082**	**2,976**	**3,091**	**3,407**	**3,727**	**4,034**	**4,367**
Total World	**6,068**	**5,975**	**6,190**	**6,664**	**7,150**	**7,583**	**8,058**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union. The U.S. numbers include carbon emissions attributable to renewable energy sources.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B19; and World Energy Projection System (1996).

Table A31. World Carbon Emissions from Oil Use by Region, Low Economic Growth Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**722**	**724**	**750**	**779**	**816**	**842**	**862**
United States[a]	583	583	602	622	649	665	673
Canada	67	67	71	73	75	78	80
Mexico	71	75	78	84	91	99	108
OECD Europe	**537**	**566**	**573**	**584**	**590**	**592**	**593**
OECD Pacific	**252**	**262**	**282**	**304**	**315**	**323**	**333**
Japan	210	218	235	253	261	266	272
Other OECD	41	44	47	51	54	57	60
Total OECD	**1,511**	**1,553**	**1,605**	**1,667**	**1,722**	**1,757**	**1,787**
Non-OECD							
EE/FSU	**427**	**300**	**248**	**258**	**290**	**322**	**352**
Former Soviet Union	355	248	195	201	230	257	282
Eastern Europe	71	52	54	57	61	65	70
Non-OECD Asia	**326**	**406**	**454**	**574**	**675**	**744**	**821**
China	98	132	149	173	196	221	250
India	49	54	60	75	88	98	109
Other Asia	179	220	246	326	391	425	462
Middle East	**147**	**148**	**157**	**169**	**180**	**193**	**207**
Africa	**88**	**91**	**98**	**105**	**111**	**118**	**126**
Central and South America	**140**	**151**	**157**	**175**	**182**	**187**	**192**
Total Non-OECD	**1,128**	**1,095**	**1,114**	**1,281**	**1,438**	**1,564**	**1,698**
Total World	**2,639**	**2,648**	**2,718**	**2,949**	**3,160**	**3,321**	**3,486**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B19; and World Energy Projection System (1996).

Table A32. World Carbon Emissions from Natural Gas Use by Region, Low Economic Growth Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**323**	**352**	**367**	**375**	**402**	**428**	**467**
United States[a]	274	297	312	314	330	351	384
Canada	36	41	42	44	46	49	50
Mexico	13	14	13	16	26	28	34
OECD Europe	**145**	**165**	**184**	**220**	**258**	**295**	**336**
OECD Pacific	**40**	**43**	**42**	**52**	**62**	**66**	**72**
Japan	28	31	29	38	48	51	56
Other OECD	12	12	13	14	15	15	15
Total OECD	**507**	**560**	**594**	**647**	**722**	**789**	**876**
Non-OECD							
EE/FSU	**387**	**350**	**350**	**393**	**417**	**448**	**487**
Former Soviet Union	338	310	305	333	348	366	391
Eastern Europe	49	39	44	60	69	83	96
Non-OECD Asia	**44**	**55**	**65**	**89**	**117**	**148**	**172**
China	8	8	12	18	25	30	32
India	6	7	8	13	23	29	36
Other Asia	31	39	46	57	69	88	103
Middle East	**55**	**66**	**69**	**75**	**79**	**80**	**82**
Africa	**21**	**24**	**23**	**24**	**28**	**32**	**36**
Central and South America	**32**	**32**	**34**	**37**	**46**	**58**	**70**
Total Non-OECD	**540**	**526**	**541**	**618**	**687**	**767**	**848**
Total World	**1,047**	**1,086**	**1,135**	**1,264**	**1,410**	**1,556**	**1,724**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B19; and World Energy Projection System (1996).

Table A33. World Carbon Emissions from Coal Use by Region, Low Economic Growth Case, 1990-2015
(Million Metric Tons)

Region/Country	History		Projections				
	1990	1993	1995	2000	2005	2010	2015
OECD							
OECD North America	**516**	**528**	**536**	**562**	**590**	**607**	**625**
United States[a]	480	495	499	517	540	552	568
Canada	33	30	33	40	43	44	45
Mexico	2	4	4	4	7	11	12
OECD Europe	**342**	**250**	**257**	**265**	**270**	**274**	**278**
OECD Pacific	**110**	**108**	**108**	**116**	**120**	**123**	**124**
Japan	72	70	69	76	79	82	83
Other OECD	38	38	39	40	40	41	41
Total OECD	**967**	**886**	**900**	**943**	**980**	**1,003**	**1,027**
Non-OECD							
EE/FSU	**561**	**419**	**423**	**400**	**387**	**361**	**336**
Former Soviet Union	340	231	228	215	207	199	190
Eastern Europe	221	187	195	185	180	162	145
Non-OECD Asia	**727**	**823**	**899**	**986**	**1,086**	**1,206**	**1,343**
China	519	589	638	716	796	889	998
India	112	132	148	164	187	206	218
Other Asia	95	103	112	106	103	111	127
Middle East	**4**	**5**	**6**	**5**	**6**	**6**	**6**
Africa	**103**	**90**	**89**	**90**	**90**	**91**	**92**
Central and South America	**19**	**18**	**20**	**26**	**32**	**38**	**44**
Total Non-OECD	**1,415**	**1,354**	**1,436**	**1,508**	**1,601**	**1,703**	**1,821**
Total World	**2,382**	**2,240**	**2,337**	**2,451**	**2,581**	**2,706**	**2,848**

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

Notes: OECD = Organization for Economic Cooperation and Development. EE/FSU = Eastern Europe/Former Soviet Union.

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1993*, DOE/EIA-0219(93) (Washington, DC, May 1995). **Projections:** EIA, *Annual Energy Outlook 1996*, DOE/EIA-0383(96) (Washington, DC, January 1996), Table B19; and World Energy Projection System (1996).

Table A34. World Oil Production Capacity by Region and Country, Reference Case, 1990-2015
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	1994	2000	2005	2010	2015
OPEC						
Persian Gulf						
Iran	3.2	3.9	4.3	5.2	5.5	6.0
Iraq	2.2	0.6	4.4	5.7	6.7	7.2
Kuwait	1.7	2.3	2.9	3.6	4.2	4.5
Qatar	0.5	0.6	0.6	0.6	0.6	0.5
Saudi Arabia	8.5	10.5	11.5	12.8	14.9	21.2
United Arab Emirates	2.5	2.6	3.1	3.7	4.5	4.8
Total Persian Gulf	**18.6**	**20.5**	**26.8**	**31.6**	**36.4**	**44.2**
Other OPEC						
Algeria	1.4	1.1	1.5	1.3	1.1	0.9
Gabon	0.3	0.4	0.3	0.3	0.3	0.2
Indonesia	1.5	1.6	1.4	1.1	1.0	0.9
Libya	1.6	1.6	1.8	2.1	2.3	2.4
Nigeria	1.8	2.2	2.4	2.6	2.7	2.7
Venezuela	2.6	2.8	3.3	4.0	4.5	4.8
Total Other OPEC	**9.2**	**9.7**	**10.7**	**11.4**	**11.9**	**11.9**
Total OPEC	**27.8**	**30.2**	**37.5**	**43.0**	**48.3**	**56.1**
Non-OPEC						
OECD						
United States	9.7	9.4	8.5	8.4	8.8	9.4
Canada	2.0	2.3	2.6	2.5	2.4	2.3
Mexico	3.0	3.2	3.2	3.2	3.1	3.1
Australia	0.7	0.6	0.6	0.6	0.5	0.5
North Sea	3.8	5.4	6.2	5.4	4.7	3.8
Other OECD	0.8	0.9	0.8	0.7	0.7	0.6
Total OECD	**20.0**	**21.8**	**21.9**	**20.8**	**20.2**	**19.6**
Eurasia						
China	2.8	2.9	3.1	3.1	3.0	3.0
Former Soviet Union	11.4	7.0	7.3	8.4	9.6	10.3
Eastern Europe	0.3	0.3	0.3	0.2	0.2	0.2
Total Eurasia	**14.5**	**10.3**	**10.7**	**11.7**	**12.8**	**13.5**
Other Non-OPEC						
Central and South America	2.4	2.8	3.9	4.0	3.9	3.7
Middle East	1.3	1.8	2.3	2.2	2.1	2.0
Africa	1.9	2.0	2.4	2.4	2.3	2.2
Asia	1.7	1.9	2.6	2.7	2.5	2.3
Total Other Non-OPEC	**7.4**	**8.5**	**11.1**	**11.4**	**10.8**	**10.1**
Total Non-OPEC	**41.9**	**40.6**	**43.7**	**43.9**	**43.8**	**43.2**
Total World	**69.7**	**70.8**	**81.2**	**86.9**	**92.1**	**99.2**

Notes: OPEC = Organization of Petroleum Exporting Countries. OECD = Organization for Economic Cooperation and Development.

Sources: **History:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **Projections:** EIA, Office of Integrated Analysis and Forecasting, "DESTINY" International Energy Forecast Software (Dallas, TX: Petroconsultants, 1996).

Table A35. World Oil Production Capacity by Region and Country, High Oil Price Case, 1990-2015
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	1994	2000	2005	2010	2015
OPEC						
Persian Gulf						
Iran	3.2	3.9	3.8	4.3	4.9	5.4
Iraq	2.2	0.6	4.0	4.5	5.8	6.5
Kuwait	1.7	2.3	2.8	3.1	3.5	3.8
Qatar	0.5	0.6	0.5	0.5	0.5	0.4
Saudi Arabia	8.5	10.5	10.3	11.1	12.9	18.7
United Arab Emirates	2.5	2.6	2.8	3.0	3.5	3.8
Total Persian Gulf	**18.6**	**20.5**	**24.2**	**26.5**	**31.1**	**38.6**
Other OPEC						
Algeria	1.4	1.1	1.3	1.0	0.7	0.5
Gabon	0.3	0.4	0.3	0.2	0.2	0.1
Indonesia	1.5	1.6	1.2	0.9	0.7	0.6
Libya	1.6	1.6	1.6	1.7	1.6	1.8
Nigeria	1.8	2.2	2.2	2.3	2.4	2.3
Venezuela	2.6	2.8	2.9	3.3	3.9	4.2
Total Other OPEC	**9.2**	**9.7**	**9.5**	**9.4**	**9.5**	**9.5**
Total OPEC	**27.8**	**30.2**	**33.7**	**35.9**	**40.6**	**48.1**
Non-OPEC						
OECD						
United States	9.7	9.4	9.4	10.0	10.7	11.2
Canada	2.0	2.3	2.6	2.5	2.4	2.3
Mexico	3.0	3.2	3.3	3.3	3.2	3.1
Australia	0.7	0.6	0.7	0.6	0.6	0.4
North Sea	3.8	5.4	6.2	5.6	4.8	4.1
Other OECD	0.8	0.9	0.8	0.7	0.6	0.5
Total OECD	**20.0**	**21.8**	**22.8**	**22.7**	**22.3**	**21.7**
Eurasia						
China	2.8	2.9	3.2	3.2	3.1	3.1
Former Soviet Union	11.4	7.0	7.4	8.7	9.9	10.6
Eastern Europe	0.3	0.3	0.3	0.2	0.2	0.2
Total Eurasia	**14.5**	**10.3**	**10.9**	**12.1**	**13.2**	**13.9**
Other Non-OPEC						
Central and South America	2.4	2.8	3.9	4.1	4.0	3.8
Middle East	1.3	1.8	2.3	2.3	2.1	2.0
Africa	1.9	2.0	2.4	2.5	2.4	2.2
Asia	1.7	1.9	2.7	2.8	2.6	2.4
Total Other Non-OPEC	**7.4**	**8.5**	**11.3**	**11.7**	**11.2**	**10.4**
Total Non-OPEC	**41.9**	**40.6**	**45.0**	**46.5**	**46.7**	**45.9**
Total World	**69.7**	**70.8**	**78.7**	**82.4**	**87.3**	**94.0**

Notes: OPEC = Organization of Petroleum Exporting Countries. OECD = Organization for Economic Cooperation and Development.

Sources: **History:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **Projections:** EIA, Office of Integrated Analysis and Forecasting, "DESTINY" International Energy Forecast Software (Dallas, TX: Petroconsultants, 1996).

Table A36. World Oil Production Capacity by Region and Country, Low Oil Price Case, 1990-2015
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	1994	2000	2005	2010	2015
OPEC						
Persian Gulf						
Iran	3.2	3.9	4.7	5.4	6.3	6.7
Iraq	2.2	0.6	4.9	6.4	7.6	8.0
Kuwait	1.7	2.3	3.1	3.9	4.9	5.1
Qatar	0.5	0.6	0.7	0.7	0.6	0.6
Saudi Arabia	8.5	10.5	12.3	14.5	19.6	28.5
United Arab Emirates	2.5	2.6	3.2	3.9	5.2	5.3
Total Persian Gulf	**18.6**	**20.5**	**28.9**	**34.8**	**44.2**	**54.2**
Other OPEC						
Algeria	1.4	1.1	1.6	1.4	1.3	1.0
Gabon	0.3	0.4	0.4	0.3	0.3	0.3
Indonesia	1.5	1.6	1.5	1.3	1.2	1.1
Libya	1.6	1.6	2.2	2.4	2.6	2.8
Nigeria	1.8	2.2	2.5	2.8	2.9	3.0
Venezuela	2.6	2.8	3.7	4.5	4.9	5.6
Total Other OPEC	**9.2**	**9.7**	**11.9**	**12.7**	**13.2**	**13.8**
Total OPEC	**27.8**	**30.2**	**40.8**	**47.5**	**57.4**	**68.0**
Non-OPEC						
OECD						
United States	9.7	9.4	7.9	7.1	7.0	7.0
Canada	2.0	2.3	2.5	2.4	2.3	2.2
Mexico	3.0	3.2	3.2	3.1	3.0	2.9
Australia	0.7	0.6	0.6	0.6	0.5	0.5
North Sea	3.8	5.4	6.1	5.4	4.6	3.7
Other OECD	0.8	0.9	0.8	0.7	0.7	0.6
Total OECD	**20.0**	**21.8**	**21.0**	**19.3**	**18.1**	**17.0**
Eurasia						
China	2.8	2.9	3.1	3.0	2.9	2.9
Former Soviet Union	11.4	7.0	7.2	8.2	9.2	9.9
Eastern Europe	0.3	0.3	0.3	0.2	0.2	0.2
Total Eurasia	**14.5**	**10.3**	**10.5**	**11.4**	**12.4**	**12.9**
Other Non-OPEC						
Central and South America	2.4	2.8	3.8	3.9	3.7	3.6
Middle East	1.3	1.8	2.2	2.2	2.0	1.9
Africa	1.9	2.0	2.3	2.4	2.2	2.1
Asia	1.7	1.9	2.5	2.6	2.4	2.2
Total Other Non-OPEC	**7.4**	**8.5**	**10.9**	**11.1**	**10.5**	**9.7**
Total Non-OPEC	**41.9**	**40.6**	**42.5**	**41.8**	**40.9**	**39.6**
Total World	**69.7**	**70.8**	**83.3**	**89.3**	**98.3**	**107.6**

Notes: OPEC = Organization of Petroleum Exporting Countries. OECD = Organization for Economic Cooperation and Development.

Sources: **History:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **Projections:** EIA, Office of Integrated Analysis and Forecasting, "DESTINY" International Energy Forecast Software (Dallas, TX: Petroconsultants, 1996).

Table A37. World Oil Production Capacity by Region and Country, High Non-OPEC Supply Case, 1990-2015
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	1994	2000	2005	2010	2015
OPEC						
Persian Gulf						
Iran	3.2	3.9	4.1	4.6	4.8	5.3
Iraq	2.2	0.6	4.2	5.0	5.8	6.4
Kuwait	1.7	2.3	2.8	3.2	3.6	4.0
Qatar	0.5	0.6	0.6	0.5	0.5	0.4
Saudi Arabia	8.5	10.5	11.0	11.3	12.9	18.8
United Arab Emirates	2.5	2.6	3.0	3.3	3.9	4.3
Total Persian Gulf	**18.6**	**20.5**	**25.7**	**27.9**	**31.5**	**39.2**
Other OPEC						
Algeria	1.4	1.1	1.4	1.1	0.9	0.7
Gabon	0.3	0.4	0.3	0.3	0.2	0.2
Indonesia	1.5	1.6	1.3	0.9	0.8	0.7
Libya	1.6	1.6	1.7	1.8	1.9	2.0
Nigeria	1.8	2.2	2.2	2.2	2.2	2.2
Venezuela	2.6	2.8	3.1	3.4	3.7	3.9
Total Other OPEC	**9.2**	**9.7**	**10.0**	**9.7**	**9.7**	**9.7**
Total OPEC	**27.8**	**30.2**	**35.7**	**37.6**	**41.2**	**48.9**
Non-OPEC						
OECD						
United States	9.7	9.4	8.5	8.4	8.8	9.4
Canada	2.0	2.3	2.6	2.6	2.7	2.6
Mexico	3.0	3.2	3.5	3.8	4.0	3.9
Australia	0.7	0.6	0.7	0.7	0.7	0.6
North Sea	3.8	5.4	6.5	6.4	6.1	6.0
Other OECD	0.8	0.9	0.8	0.8	0.8	0.7
Total OECD	**20.0**	**21.8**	**22.7**	**22.8**	**23.1**	**23.2**
Eurasia						
China	2.8	2.9	3.2	3.5	3.8	3.6
Former Soviet Union	11.4	7.0	7.6	9.6	11.0	11.1
Eastern Europe	0.3	0.3	0.3	0.3	0.3	0.3
Total Eurasia	**14.5**	**10.3**	**11.2**	**13.5**	**15.0**	**15.0**
Other Non-OPEC						
Central and South America	2.4	2.8	3.9	4.4	4.4	4.2
Middle East	1.3	1.8	2.3	2.5	2.4	2.4
Africa	1.9	2.0	2.4	2.7	2.8	2.6
Asia	1.7	1.9	2.7	3.0	3.0	2.8
Total Other Non-OPEC	**7.4**	**8.5**	**11.4**	**12.5**	**12.5**	**12.0**
Total Non-OPEC	**41.9**	**40.6**	**45.3**	**48.8**	**50.6**	**50.2**
Total World	**69.7**	**70.8**	**81.0**	**86.4**	**91.8**	**99.1**

Notes: OPEC = Organization of Petroleum Exporting Countries. OECD = Organization for Economic Cooperation and Development.

Sources: **History:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **Projections:** EIA, Office of Integrated Analysis and Forecasting, "DESTINY" International Energy Forecast Software (Dallas, TX: Petroconsultants, 1996).

Table A38. World Oil Production by Region and Country, Reference Case, 1990-2015
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	1994	2000	2005	2010	2015
OPEC						
Persian Gulf	15.9	18.2	23.4	29.8	35.8	43.7
Other OPEC	8.6	9.3	9.4	10.8	11.7	11.8
Total OPEC	**24.5**	**27.5**	**32.8**	**40.6**	**47.5**	**55.5**
Non-OPEC						
OECD						
United States	9.7	9.4	8.5	8.4	8.8	9.4
Canada	2.0	2.3	2.6	2.5	2.4	2.3
Mexico	3.0	3.2	3.2	3.2	3.1	3.1
OECD Europe	4.6	6.1	6.8	6.1	5.2	4.3
Other OECD	0.7	0.7	0.8	0.7	0.7	0.6
Total OECD	**20.0**	**21.7**	**21.9**	**20.8**	**20.2**	**19.6**
Eurasia						
China	2.8	2.9	3.1	3.1	3.0	3.0
Former Soviet Union	11.4	7.0	7.3	8.4	9.6	10.3
Eastern Europe	0.3	0.3	0.3	0.2	0.2	0.2
Total Eurasia	**14.5**	**10.2**	**10.7**	**11.7**	**12.8**	**13.5**
Other Non-OPEC						
Central and South America	2.4	2.8	3.9	4.0	3.9	3.7
Pacific Rim	1.7	1.9	2.1	2.3	2.2	2.1
Other	3.3	3.8	5.1	5.1	4.8	4.3
Total Other Non-OPEC	**7.4**	**8.5**	**11.1**	**11.4**	**10.8**	**10.1**
Total Non-OPEC	**41.9**	**40.4**	**43.7**	**43.9**	**43.8**	**43.2**
Total World	**66.4**	**67.9**	**76.5**	**84.5**	**91.3**	**98.7**
Persian Gulf Production as a Percentage of World Consumption	**26.0**	**29.1**	**33.5**	**38.0**	**41.4**	**46.2**

Notes: OPEC = Organization of Petroleum Exporting Countries. OECD = Organization for Economic Cooperation and Development. Production includes crude oil (including lease condensates), natural gas liquids, other hydrogen and hydrocarbons for refinery feedstocks, refinery gains, alcohol, and liquids produced from coal and other sources. Totals may not equal sum of components due to independent rounding.

Sources: **History:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **Projections:** EIA, Office of Integrated Analysis and Forecasting, "DESTINY" International Energy Forecast Software (Dallas, TX: Petroconsultants, 1996).

Table A39. World Oil Production by Region and Country, High Oil Price Case, 1990-2015
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	1994	2000	2005	2010	2015
OPEC						
Persian Gulf	15.9	18.2	20.8	24.8	30.1	37.8
Other OPEC	8.6	9.3	8.2	8.8	9.2	9.3
Total OPEC	**24.5**	**27.5**	**29.0**	**33.6**	**39.3**	**47.1**
Non-OPEC						
OECD						
United States	9.7	9.4	9.4	10.0	10.7	11.2
Canada	2.0	2.3	2.6	2.5	2.4	2.3
Mexico	3.0	3.2	3.3	3.3	3.2	3.1
OECD Europe	4.6	6.1	6.9	6.2	5.3	4.4
Other OECD	0.7	0.7	0.8	0.7	0.7	0.6
Total OECD	**20.0**	**21.7**	**22.8**	**22.7**	**22.3**	**21.7**
Eurasia						
China	2.8	2.9	3.2	3.2	3.1	3.1
Former Soviet Union	11.4	7.0	7.4	8.7	9.9	10.6
Eastern Europe	0.3	0.3	0.3	0.2	0.2	0.2
Total Eurasia	**14.5**	**10.2**	**10.9**	**12.1**	**13.2**	**13.9**
Other Non-OPEC						
Central and South America	2.4	2.8	3.9	4.1	4.0	3.8
Pacific Rim	1.7	1.9	2.2	2.3	2.3	2.1
Other	3.3	3.8	5.2	5.2	4.9	4.5
Total Other Non-OPEC	**7.4**	**8.5**	**11.3**	**11.7**	**11.2**	**10.4**
Total Non-OPEC	**41.9**	**40.4**	**45.0**	**46.5**	**46.7**	**45.9**
Total World	**66.4**	**67.9**	**74.0**	**80.1**	**86.0**	**93.0**
Persian Gulf Production as a Percentage of World Consumption	**26.0**	**29.1**	**31.1**	**33.9**	**37.5**	**43.1**

Notes: OPEC = Organization of Petroleum Exporting Countries. OECD = Organization for Economic Cooperation and Development. Production includes crude oil (including lease condensates), natural gas liquids, other hydrogen and hydrocarbons for refinery feedstocks, refinery gains, alcohol, and liquids produced from coal and other sources. Totals may not equal sum of components due to independent rounding.

Sources: **History:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **Projections:** EIA, Office of Integrated Analysis and Forecasting, "DESTINY" International Energy Forecast Software (Dallas, TX: Petroconsultants, 1996).

Table A40. World Oil Production by Region and Country, Low Oil Price Case, 1990-2015
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	1994	2000	2005	2010	2015
OPEC						
Persian Gulf	15.9	18.2	25.8	34.3	43.4	53.5
Other OPEC	8.6	9.3	10.6	12.5	12.9	13.6
Total OPEC	**24.5**	**27.5**	**36.4**	**46.8**	**56.3**	**67.1**
Non-OPEC						
OECD						
United States	9.7	9.4	7.9	7.1	7.0	7.0
Canada	2.0	2.3	2.5	2.4	2.3	2.2
Mexico	3.0	3.2	3.2	3.1	3.0	2.9
OECD Europe	4.6	6.1	6.8	6.0	5.1	4.2
Other OECD	0.7	0.7	0.7	0.7	0.6	0.6
Total OECD	**20.0**	**21.7**	**21.0**	**19.3**	**18.1**	**17.0**
Eurasia						
China	2.8	2.9	3.1	3.0	2.9	2.9
Former Soviet Union	11.4	7.0	7.2	8.2	9.2	9.9
Eastern Europe	0.3	0.3	0.3	0.2	0.2	0.2
Total Eurasia	**14.5**	**10.2**	**10.5**	**11.4**	**12.4**	**12.9**
Other Non-OPEC						
Central and South America	2.4	2.8	3.8	3.9	3.7	3.6
Pacific Rim	1.7	1.9	2.1	2.2	2.1	2.0
Other	3.3	3.8	5.0	5.0	4.6	4.2
Total Other Non-OPEC	**7.4**	**8.5**	**10.9**	**11.1**	**10.5**	**9.7**
Total Non-OPEC	**41.9**	**40.4**	**42.5**	**41.8**	**40.9**	**39.6**
Total World	**66.4**	**67.9**	**78.9**	**88.6**	**97.2**	**106.7**
Persian Gulf Production as a Percentage of World Consumption	**26.0**	**29.1**	**35.2**	**41.2**	**46.5**	**51.8**

Notes: OPEC = Organization of Petroleum Exporting Countries. OECD = Organization for Economic Cooperation and Development. Production includes crude oil (including lease condensates), natural gas liquids, other hydrogen and hydrocarbons for refinery feedstocks, refinery gains, alcohol, and liquids produced from coal and other sources. Totals may not equal sum of components due to independent rounding.

Sources: **History:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **Projections:** EIA, Office of Integrated Analysis and Forecasting, "DESTINY" International Energy Forecast Software (Dallas, TX: Petroconsultants, 1996).

Table A41. World Oil Production by Region and Country, High Non-OPEC Supply Case, 1990-2015
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	1994	2000	2005	2010	2015
OPEC						
Persian Gulf	15.9	18.2	22.4	26.3	31.1	38.8
Other OPEC	8.6	9.3	8.8	9.3	9.5	9.6
Total OPEC	**24.5**	**27.5**	**31.2**	**35.6**	**40.6**	**48.4**
Non-OPEC						
OECD						
United States	9.7	9.4	8.5	8.4	8.8	9.4
Canada	2.0	2.3	2.6	2.6	2.7	2.6
Mexico	3.0	3.2	3.5	3.8	4.0	3.9
OECD Europe	4.6	6.1	7.3	7.1	6.8	6.5
Other OECD	0.7	0.7	0.8	0.9	0.8	0.8
Total OECD	**20.0**	**21.7**	**22.7**	**22.8**	**23.1**	**23.2**
Eurasia						
China	2.8	2.9	3.2	3.5	3.8	3.6
Former Soviet Union	11.4	7.0	7.6	9.6	11.0	11.1
Eastern Europe	0.3	0.3	0.3	0.3	0.3	0.3
Total Eurasia	**14.5**	**10.2**	**11.2**	**13.5**	**15.0**	**15.0**
Other Non-OPEC						
Central and South America	2.4	2.8	3.9	4.4	4.4	4.2
Pacific Rim	1.7	1.9	2.3	2.6	2.6	2.6
Other	3.3	3.8	5.3	5.6	5.5	5.3
Total Other Non-OPEC	**7.4**	**8.5**	**11.4**	**12.5**	**12.5**	**12.0**
Total Non-OPEC	**41.9**	**40.4**	**45.3**	**48.8**	**50.6**	**50.2**
Total World	**66.4**	**67.9**	**76.5**	**84.4**	**91.2**	**98.6**
Persian Gulf Production as a Percentage of World Consumption	**26.0**	**29.1**	**32.2**	**33.9**	**36.3**	**41.3**

Notes: OPEC = Organization of Petroleum Exporting Countries. OECD = Organization for Economic Cooperation and Development. Production includes crude oil (including lease condensates), natural gas liquids, other hydrogen and hydrocarbons for refinery feedstocks, refinery gains, alcohol, and liquids produced from coal and other sources. Totals may not equal sum of components due to independent rounding.

Sources: **History:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **Projections:** EIA, Office of Integrated Analysis and Forecasting, "DESTINY" International Energy Forecast Software (Dallas, TX: Petroconsultants, 1996).

Appendix B

World Energy Projection System

Appendix B

World Energy Projection System

The projections of world energy consumption published annually by the Energy Information Administration (EIA) in the *International Energy Outlook (IEO)* are derived from the World Energy Projection System (WEPS). WEPS is an integrated set of personal-computer-based spreadsheets containing data compilations, assumption specifications, descriptive analysis procedures, and projection models. The WEPS accounting framework incorporates projections from independently documented models and assumptions about the future energy intensity of economic activity (ratios of total energy consumption divided by gross domestic product [GDP]) and about the rate of incremental energy requirements met by natural gas, coal, and renewable energy sources (hydroelectricity, geothermal, solar, wind, biomass, and other renewable sources).

WEPS provides projections of total world primary energy consumption, as well as projections of energy consumption by primary energy type (oil, natural gas, coal, nuclear, and hydroelectric and other renewable resources), and projections of net electricity consumption. Carbon emissions resulting from fossil fuel use are derived from the energy consumption projections. All projections are computed in 5-year intervals through the year 2015. For both historical series and projection series, WEPS provides analytical computations of energy intensity and energy elasticity (the percentage change in energy consumption per percentage change in GDP).

WEPS projections are provided for regions and selected countries. Projections are made for 6 individual countries, 4 of which—United States, Canada, Mexico, and Japan—are members of the Organization for Economic Cooperation and Development (OECD). In the non-OECD, individual projections are made for China and India. Beyond these individual countries, the rest of the world is divided into regions. Regions in the OECD include North America (Canada, Mexico, and the United States), Europe, and Pacific (Japan and Other OECD, which includes Australia, New Zealand, and the U.S. Territories). Regions in the non-OECD grouping include Eastern Europe (EE), the former Soviet Union (FSU), non-OECD Asia (China, India, and Other Asia), Middle East, Africa, and Central and South America.

The process of creating the projections begins with the calculation of a Reference Case total energy consumption projection for each country or region for each 5-year interval in the forecast period. The total energy consumption projection for each forecast year is the product of an assumed GDP growth rate, an assumed energy elasticity, and the total energy consumption for the prior forecast year. For the first year of the forecast, the prior year consumption is based on historical data. Subsequent calculations are based on the energy consumption projections for the preceding years.

Projections of world oil supply are provided to WEPS from EIA's International Energy Module, which is a submodule of the National Energy Modeling System (NEMS). Projections of world nuclear energy consumption are derived from nuclear power electricity generation projections from EIA's International Nuclear Model (INM), PC Version (PC-INM). All U.S. projections are taken from EIA's *Annual Energy Outlook (AEO)*.

A full description of the WEPS is provided in a model documentation report: Energy Information Administration, *World Energy Projection System Model Documentation*, DOE/EIA-M050(92) (Washington, DC, June 1992). The report presents a thorough description of each of the spreadsheets associated with the WEPS, along with descriptions of the methodologies and assumptions used to produce the projections. It is available from the National Energy Information Center (202/586-8800).

The WEPS is archived annually after publication of the *IEO*. The *IEO96* WEPS archive package will be available for purchase from the National Technical Information Service (703/487-4650) in summer 1996. The archive package will allow users to replicate the projections that appear in *IEO96*. It is coded in Lotus 1-2-3 for Windows, Release 5.0, and can be executed on any IBM-compatible personal computer in a Windows 3.1 environment. The package requires about 5 megabytes of hard disk space and about 640 kilobytes of random access memory (RAM).