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Contacts

The *International Energy Outlook* is prepared by the Energy Information Administration (EIA). General questions concerning the contents of the report should be referred to John J. Conti (john.conti@eia.doe.gov, 202-586-2222), Director, Office of Integrated Analysis and Forecasting. Specific questions about the report should be referred to Linda E. Doman (202/586-1041) or the following analysts:

World Energy and Economic Outlook	Linda Doman	(linda.doman@eia.doe.gov,	202-586-1041)
Macroeconomic Assumptions	Nasir Khilji	(nasir.khilji@eia.doe.gov,	202-586-1294)
Energy Consumption by End-Use Sector			
Residential Energy Use	John Cymbalsky	(john.cymbalsky@eia.doe.gov,	202-586-4815)
Commercial Energy Use	Erin Boedecker	(erin.boedecker@eia.doe.gov,	202-586-4791)
Industrial Energy Use	Linda Doman	(linda.doman@eia.doe.gov,	202-586-1041)
Transportation Energy Use	Eugene Reiser	(eugene.reiser@eia.doe.gov,	202-586-5840)
World Oil Markets	G. Daniel Butler	(george.butler@eia.doe.gov,	202-586-9503)
World Oil Demand	Linda Doman	(linda.doman@eia.doe.gov,	202-586-1041)
Natural Gas	Justine Barden	(justine.barden@eia.doe.gov	202-586-3508)
	Phyllis Martin	(phyllis.martin@eia.doe.gov,	202-586-9592)
Gas to Liquids	Aloulou Fawzi	(aloulou.fawzi@eia.doe.gov,	202-586-7818)
Coal	Michael Mellish	(michael.mellish@eia.doe.gov,	202-586-2136)
	Diane Kearney	(diane.kearney@eia.doe.gov,	202-586-2415)
Electricity	John Staub	(john.staub@eia.doe.gov,	202-586-6344)
Carbon Dioxide Emissions	Perry Lindstrom	(perry.lindstrom@eia.doe.gov,	202-586-0934)

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Preface

This report presents international energy projections through 2025, prepared by the Energy Information Administration, including outlooks for major energy fuels and associated carbon dioxide emissions.

The *International Energy Outlook 2005* (*IEO2005*) presents an assessment by the Energy Information Administration (EIA) of the outlook for international energy markets through 2025. U.S. projections appearing in *IEO2005* are consistent with those published in EIA's *Annual Energy Outlook 2005* (*AEO2005*), which was prepared using the National Energy Modeling System (NEMS). Although the *IEO* typically uses the same reference case as the *AEO*, *IEO2005* has adopted the October futures case from *AEO2005* as its reference case for the United States. The October futures case, which has an assumption of higher world oil prices than the *AEO2005* reference case, now appears to be a more likely projection. The reference case prices will be reconsidered for the next *AEO*. Based on information available as of July 2005, the *AEO2006* reference case will likely reflect world oil prices higher than those in the *IEO2005* reference case.

IEO2005 is provided as a 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 *IEO2005* projections are based on U.S. and foreign government laws in effect on March 1, 2005. The potential impacts of pending or proposed legislation, regulations, and standards are not reflected in the projections, nor are the impacts of legislation where the mechanisms for implementing the legislation have not yet been announced. For example, the *IEO2005* reference case forecast does not include the potential impacts of the Kyoto Protocol (which entered into force on February 16, 2005), because the treaty does not indicate the methods by which signatories will implement the Protocol. The Kyoto Protocol also does not address signatory obligations beyond the 2012 time frame, making it impossible in the context of a reference case projection for EIA to assess the impacts of the Protocol through 2025, the end of the *IEO2005* forecast horizon.

Projections in *IEO2005* are displayed according to three basic country groupings (see Appendix J for complete regional definitions). The mature market economies include projections for North America (United States, Canada, and Mexico); Western Europe; and mature market Asia (Japan and Australia/New Zealand). The emerging economies are represented by four separate regional subgroups: emerging Asia, Africa, Middle East, and Central and South America. China, India, and South Korea are represented in emerging Asia, and Brazil is represented in Central and South America. The transitional economies include projections for Eastern Europe and the former Soviet Union (EE/FSU). Russia is represented in the FSU.

The report begins with a review of world trends in energy demand and the major macroeconomic assumptions used in deriving the *IEO2005* projections. The time frame for historical data begins with 1970 and extends to 2002, providing a 32-year historical view of energy demand, and the projections extend to 2025, providing a 23-year forecast period. High economic growth and low economic growth cases were developed to depict a set of alternative growth paths for the energy forecast. The two cases consider higher and lower growth paths for regional gross domestic product (GDP) than assumed in the reference case. The resulting projections—and the uncertainty associated with international energy projections in general—are discussed in Chapter 1, "World Energy and Economic Outlook."

New to this report are regional projections of end-use energy consumption in the residential, commercial, industrial, and transportation sectors. Chapter 2 reviews worldwide forecasts for end-use sector energy consumption. Regional projections for energy consumption by fuel—petroleum, natural gas, and coal—are presented in Chapters 3, 4, and 5, along with reviews of the current status of each fuel on a worldwide basis. Chapter 6 discusses the projections for world electricity markets—including nuclear power, hydropower, and other commercial renewable energy resources—and presents forecasts of world installed generating capacity, which are new to this year's report. Finally, Chapter 7 discusses the outlook for global carbon dioxide emissions. With the entry into force of the Kyoto Protocol on February 16, 2005, this year's outlook includes a Kyoto Protocol scenario, which is also presented in Chapter 7.

Appendix A contains summary tables of the *IEO2005* reference case projections for world energy consumption, GDP, energy consumption by fuel, carbon dioxide

emissions, and regional population growth. The reference case projections of total foreign energy consumption and consumption of oil, natural gas, coal, and renewable energy were prepared using EIA's System for the Analysis of Global Energy Markets (SAGE), as were projections of net electricity consumption, energy consumed by fuel and region by end-use sector, and carbon dioxide emissions. In addition, the NEMS Coal Export Submodule was used to derive flows in international coal trade, presented in Chapter 5.

Summary tables of projections for the high and low economic growth cases are provided in Appendixes B and C, respectively, and reference projections of delivered energy consumption by end-use sector and region are presented in Appendix D. Appendix E contains summary tables of projections for world oil production capacity and oil production in the reference case and in two alternative cases, the high and low world oil price cases. The projections in Appendix E were derived from the International Energy Module of NEMS. Appendix F contains summary tables of projections for nuclear capacity in four nuclear growth cases. Appendix G provides a summary of assumptions underlying the *IEO2005* Kyoto Protocol case. Appendix H includes a set of comparisons of alternative forecasts with the *IEO2005* projections, as well as comparisons of historical *IEO* forecasts with actual historical data. Comparisons of the *IEO2005* and *IEO2004* forecasts are also presented in Appendix H. Appendix I describes the SAGE model, and Appendix J defines the regional designations included in the report.

Objectives of the *IEO2005* Projections

The projections in *IEO2005* 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 U.S. and foreign government laws effective as of March 1, 2005. Assuming fixed laws, 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 certainty.

Highlights

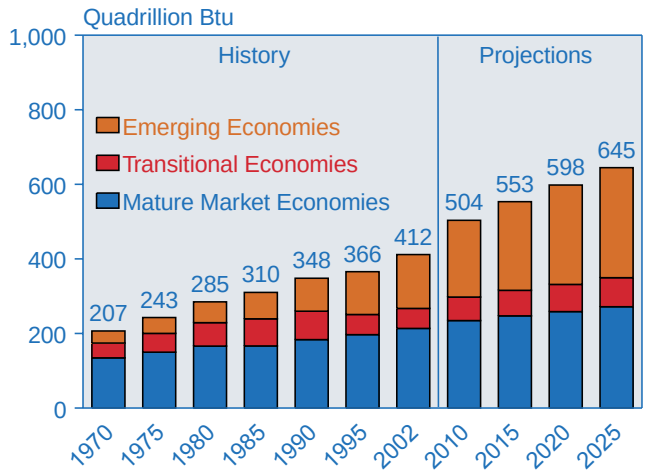
World energy consumption is projected to increase by 57 percent from 2002 to 2025. Much of the growth in worldwide energy use in the IEO2005 reference case forecast is expected in the countries with emerging economies.

In the *International Energy Outlook 2005* (*IEO2005*) reference case, world marketed energy consumption is projected to increase on average by 2.0 percent per year over the 23-year forecast horizon from 2002 to 2025—slightly lower than the 2.2-percent average annual growth rate from 1970 to 2002. Worldwide, total energy use is projected to grow from 412 quadrillion British thermal units (Btu) in 2002 to 553 quadrillion Btu in 2015 and 645 quadrillion Btu in 2025 (Figure 1).

Emerging economies account for much of the projected growth in marketed energy consumption over the next two decades, with energy use in the group more than doubling by 2025. Strong projected economic growth drives the demand for energy use in the region. Economic activity, as measured by gross domestic product (GDP) in purchasing power parity terms, is expected to expand by 5.1 percent per year in the emerging economies, as compared with 2.5 percent per year in the mature market economies and 4.4 percent per year in the transitional economies of Eastern Europe and the former Soviet Union (EE/FSU).

In contrast to the emerging economies, increases in energy consumption for the mature market economies and transitional economies are projected to be more modest. In the case of the mature market economies, well-established energy consumption patterns and infrastructure, along with a shift from energy-intensive industries to services, lead to a projected growth rate for energy demand that averages 1.1 percent per year over the projection period, compared with 3.2 percent per year in the emerging economies. Although a robust economic growth projection for the transitional economies should spur energy demand, the outlook for growth in the region's energy use is moderated somewhat by projected declines (i.e., improvements) in energy intensity as the EE/FSU countries continue to replace older, inefficient capital stock.

Figure 1. World Marketed Energy Consumption by Region, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Trends in end-use sector energy consumption can vary widely, according to the level and pace of economic development in a given region. On a worldwide basis, the industrial and transportation sectors show the fastest growth in the *IEO2005* reference case, averaging 2.1 percent per year in both sectors. Slower growth is projected in the residential and commercial sectors, averaging 1.5 percent and 1.9 percent per year, respectively, from 2002 to 2025 for the world as a whole. In the mature market economies, where population growth generally is slow or negative over the forecast, energy use in the commercial sector grows at a faster pace (1.3 percent per year) than in any other end-use sector, based on expectations of rapid increases in the use of new telecommunications technologies and office equipment as these nations continue to shift to service economies.

In the EE/FSU transitional economies, energy demand in the industrial and transportation sectors is projected to grow on average by 1.6 percent per year from 2002 to 2025, and slow or negative population growth as well as improvements in energy efficiency are expected to lead to lower growth rates for energy demand in the residential and commercial sectors. In the emerging countries, in contrast, strong growth in demand for energy is projected for every end-use sector, ranging from 3.1 percent per year in the residential sector to 3.6 percent per year in the commercial and transportation sectors. The higher growth rates reflect the relatively rapid economic and population growth expected for the emerging economies.

In the *IEO2005* reference case, the use of all energy sources increases over the forecast period (Figure 2). Fossil fuels (oil, natural gas, and coal) continue to supply

much of the energy used worldwide, and oil remains the dominant energy source, given its importance in the transportation and industrial end-use sectors. Non-fossil fuel use also grows over the forecast, but not as rapidly as fossil fuel use. The outlook for non-fossil fuels could, however, be altered by government policies or programs, such as environmental laws aimed at limiting or reducing pollutants from the combustion of fossil fuel consumption and encouraging the use of non-fossil fuels.

The *IEO2005* reference case has adopted the *Annual Energy Outlook 2005* (*AEO2005*) October futures case, which has an assumption of higher prices than the *AEO2005* reference case and now appears to be a more likely projection for oil prices. World oil prices rose by more than $9 per barrel (in nominal dollars) over the course of 2004 and are expected to add an additional $11 per barrel in 2005, brought about by tight oil market conditions that include low inventory levels, surging demand in emerging Asia, and the situation in Iraq; however, such developments are not indicative of the long-term trend in the *IEO2005* reference case. From anticipated high levels throughout 2005, world oil prices decline gradually through 2010 to $31 per barrel (in 2003 dollars) before beginning to rise to about $35 per barrel in 2025. Based on information available as of July 2005, the *AEO2006* reference case will likely reflect world oil prices higher than those in the *IEO2005* reference case.

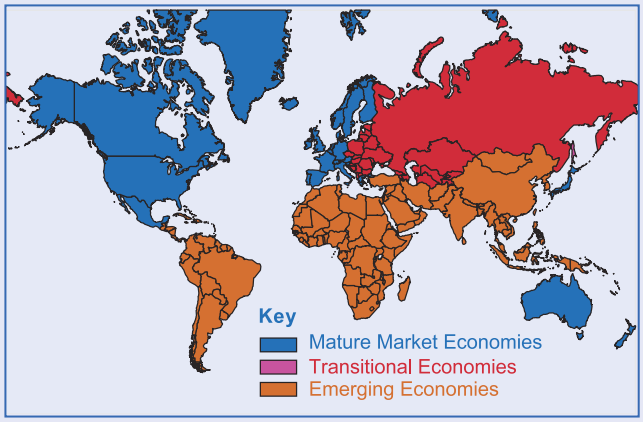
World oil use is expected to grow from 78 million barrels per day in 2002 to 103 million barrels per day in 2015 and

Regional Definitions in the *International Energy Outlook 2005*

Regular readers of the *International Energy Outlook* (*IEO*) will notice that, in this edition, the names used to describe country groupings have been changed. Although the organization of countries within the three major groupings has not changed, the nomenclature used in previous editions to describe the groups—namely, industrialized, EE/FSU, and developing—had become somewhat dated and did not accurately reflect the countries within them. Some analysts have argued that several of the countries in the "developing" group (South Korea and China, for instance) could fairly be called "industrialized" today.

IEO2005 uses country grouping designations based on relative levels of economic development. The three major groupings (or "regions") used in this report are the mature market economies, transitional economies, and emerging economies. The mature market economies include nations whose energy markets are generally well-established, and whose industrial sectors have trended away from more energy-intensive manufacturing industries toward less energy-intensive service industries. As shown in the map below, the mature market economies include the countries of North America (the United States, Canada, and Mexico), Western Europe, and "mature market" Asia (Japan, Australia, and New Zealand). The grouping of countries may be subject of some debate. For example, some may argue that Mexico should not be considered a mature market economy; however, it is included in North America because of its importance in energy trade in the region.

IEO2005 World Regions



The transitional economies include those nations that are transitioning away from the centrally planned economies of the Soviet Union to free market economies. This region is subdivided into Eastern Europe (EE) and the former Soviet Union (FSU), and within the FSU separate projections are provided for Russia. Although several countries in Eastern Europe, notably the Czech Republic and Poland, may be seen as approaching the same level of economic development as their Western European neighbors, the Eastern Europe aggregation still is useful, particularly given its importance to analysis of the impacts of the Kyoto Protocol: in most of the EE/FSU countries, carbon dioxide emissions in 2010 are expected to be well below their emissions targets for the first commitment period of the Protocol (2008-2012). Thus, in a modeling sense, the traditional grouping is useful.

The emerging economies include those countries whose economies are currently less developed, but whose energy use patterns, in general, are expected to begin resembling those of the mature market economies over the next two decades. The nations in this region, which typically have fairly energy-intensive industrial sectors, include such rapidly growing economies as China and India. Emerging Asia, the Middle East, Africa, and Central and South America are regional subgroups in the emerging economies region.

119 million barrels per day in 2025. The projection for oil demand in 2025 is somewhat lower than the 121 million barrels per day forecast in last year's outlook, due in large part to higher world oil price projections in *IEO2005*. Higher sustained world oil prices in this year's forecast dampen the mid-term projections in many parts of the world, particularly in the mature market and transitional economies. The impact of higher oil prices on demand would be even greater if not for the robust growth expected in China in the short term. China's oil use is projected to grow by an annual average of 7.5 percent from 2002 to 2010, before slowing to 2.9 percent per year for the remainder of the forecast.

The projected increment in worldwide oil use would require an increment in world oil production capacity of 42 million barrels per day over 2002 levels. Members of the Organization of Petroleum Exporting Countries (OPEC) are expected to be the major suppliers of the increased production that will be required to meet demand, and they account for 60 percent of the projected increase in world capacity. In addition, non-OPEC suppliers are expected to add nearly 17 million barrels per day of oil production capacity between 2002 and 2025. Substantial increments in new non-OPEC oil supply are expected to come from the Caspian Basin, Western Africa, and Central and South America.

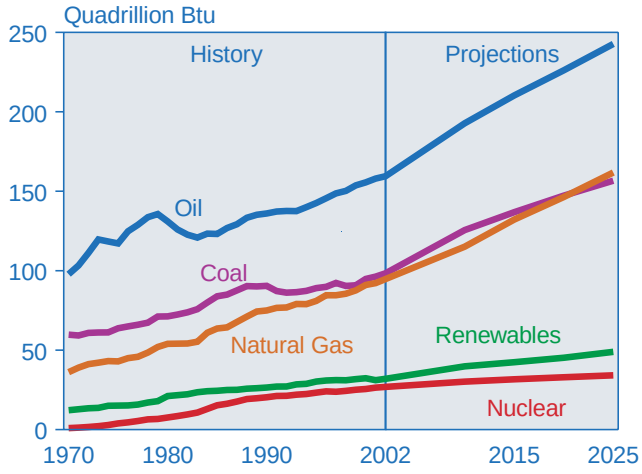
Natural gas is projected to be the fastest growing component of world primary energy consumption in the *IEO2005* reference case. Consumption of natural gas worldwide increases in the forecast by an average of 2.3 percent annually from 2002 to 2025, compared with projected annual growth rates of 1.9 percent for oil consumption and 2.0 percent for coal consumption. From 2002 to 2025, consumption of natural gas is projected to increase by 69 percent, from 92 trillion cubic feet to 156 trillion cubic feet, and its share of total energy consumption is projected to grow from 23 percent to 25 percent. The electric power sector accounts for 51 percent of the total incremental growth in worldwide natural gas demand over the forecast period (Figure 3).

Natural gas is seen as a desirable alternative for electricity generation in many parts of the world, given its relative efficiency in comparison with other energy sources, as well as the fact that it burns more cleanly than either coal or oil and thus is an attractive alternative for countries pursuing reductions in greenhouse gas emissions. Natural gas is also an important energy resource in the industrial sector. The industrial sector accounts for 36 percent of the growth in world natural gas demand over the 2002-2025 period.

World coal consumption is projected to increase from 5,262 million short tons in 2002 to 7,245 million short tons in 2015, at an average rate of 2.5 percent per year. From 2015 to 2025, the projected rate of increase in world coal consumption slows to 1.3 percent annually, and total consumption in 2025 is projected at 8,226 million short tons. Of the coal produced worldwide in 2002, 65 percent was shipped to electric power producers and 31 percent to industrial consumers. In the industrial sector coal is an important input for the manufacture of steel and for the production of steam and direct heat for other industrial applications.

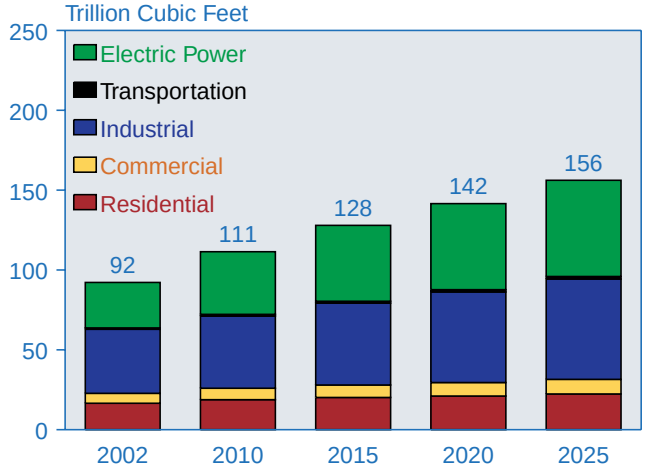
Coal is expected to maintain its importance as an energy source in both the electric power and industrial sectors, with the two sectors combined accounting for virtually

Figure 2. World Marketed Energy Use by Energy Type, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 3. World Natural Gas Consumption by End-Use Sector, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

all the growth in coal use in the mid-term forecast. To a large extent, the slight increase in the importance of coal in the industrial sector results from the substantial growth projected for industrial energy consumption in China, which has abundant coal reserves, limited access to other sources of energy, and a dominant position in world steel production. Coal is expected to remain the fuel of choice in China's rapidly expanding industrial sector.

World net electricity consumption nearly doubles in the reference case forecast, from 14,275 billion kilowatthours in 2002 to 21,400 billion kilowatthours in 2015 and 26,018 billion kilowatthours in 2025. More than one-half (59 percent) of the projected growth in demand occurs in the emerging economies, where electricity use increases on average by 4.0 percent per year from 2002 to 2025, as compared with 2.6 percent per year worldwide. Coal and natural gas are expected to remain the most important fuels for electricity generation worldwide throughout the forecast, accounting for 62 percent of the energy used for electricity production in 2025; however, increases are projected for consumption of all primary energy sources in electricity generation in the *IEO2005* reference case.

Consumption of electricity generated from nuclear power worldwide is projected to increase from 2,560 billion kilowatthours in 2002 to 3,270 billion kilowatthours in 2025 in the reference case. Prospects for nuclear power have improved in recent years, with higher capacity utilization rates reported for many existing nuclear facilities and the expectation that most existing plants in the mature market and transitional economy nations will be granted extensions to their operating lives. Further, higher fossil fuel prices and the entry into force of the Kyoto Protocol are expected to improve prospects for new nuclear power capacity over the forecast period.

In past editions of the *IEO*, declines in nuclear power were projected in the mid-term forecast as a result of expectations that few new reactors would be built, and that older reactors would be shut down when they reached the end of their operating lives. In *IEO2005*, world total installed nuclear capacity is not projected to decline before 2025, but rises from 361 gigawatts in 2002 to 401 gigawatts in 2015 and 422 gigawatts in 2025 (Figure 4). Between 2002 and 2025, 55 gigawatts of the world increment in nuclear capacity is projected for the emerging Asian economies alone, and another 19 gigawatts is projected for the transitional economies of the EE/FSU countries.

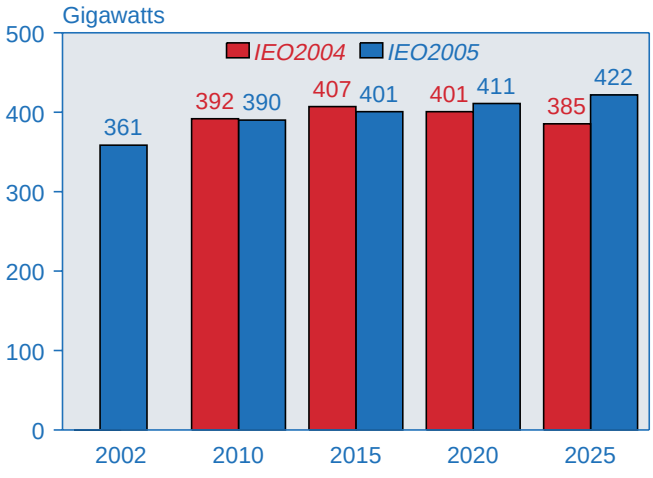
Hydroelectricity and other grid-connected renewable energy sources are expected to maintain an 8-percent share of total energy use worldwide throughout the projection period. Although the use of marketed renewable energy sources expands in the *IEO2005* reference case at an average annual rate of 1.9 percent from 2002 to 2025, the more rapid growth rates projected for natural gas and coal cause the renewable share of world energy use to remain flat.

Much of the projected growth in renewable electricity generation is expected to result from the completion of large hydroelectric facilities in emerging economies, particularly in Asia, where the need to expand electricity production with associated dams and reservoirs often outweighs concerns about environmental impacts and the relocation of populations. China, India, and Laos, among other emerging Asian economies, already are constructing or planning new large-scale hydroelectric facilities.

In the transitional economies, most additions to hydroelectric capacity are expected to come from repair or expansion of existing plants. Among the mature market economies, non-hydroelectric marketed renewables, such as wind, solar, geothermal, and biomass, are expected to account for most of the growth in renewable energy use, given government programs and policies to encourage their expansion. In the mature market and transitional economies, most hydroelectric resources either have already been developed or lie far from population centers.

Carbon dioxide is one of the most prevalent greenhouse gases in the atmosphere. Anthropogenic (human-caused) emissions of carbon dioxide result primarily from the combustion of fossil fuels for energy, and as a result world energy use has emerged at the center of the climate change debate. In the *IEO2005* reference case,

Figure 4. Comparison of *IEO2004* and *IEO2005* Projections for World Nuclear Generating Capacity, 2010-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **IEO2004:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004), web site www.eia.doe.gov/oiaf/ieo/index.html. **IEO2005:** EIA, System for the Analysis of Global Energy Markets (2005).

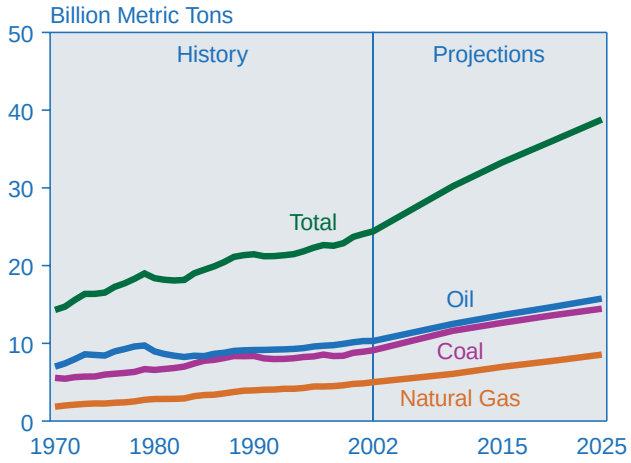
world carbon dioxide emissions are projected to rise from 24.4 billion metric tons in 2002 to 30.2 billion metric tons in 2010 and 38.8 billion metric tons in 2025 (Figure 5). Much of the projected increase in carbon dioxide emissions occurs among the emerging nations, accompanying large increases in fossil fuel use. The emerging economies account for 68 percent of the projected increment in carbon dioxide emissions between 2002 and 2025.

The Kyoto Protocol, which requires participating "Annex I" countries[1] to reduce their carbon dioxide emissions collectively to an annual average of about 5 percent below their 1990 level over the 2008-2012 period, became a legally binding treaty on February 16, 2005, 90 days after it was ratified by Russia. The *IEO2005* reference case forecast does not include the potential impacts of the Kyoto Protocol, because the treaty does not indicate the methods by which ratifying parties will implement their obligations either in the first commitment period or after 2012. To examine the implications of the treaty for energy use and carbon dioxide emissions, a Kyoto Protocol case was analyzed.

A number of assumptions were made in developing the *IEO2005* Kyoto Protocol case. First, it was assumed that energy use would not vary from the reference case forecast for countries that are not undertaking an emissions reduction commitment. In addition, assumptions were made about how the affected participating regions would achieve their reductions. In Western Europe, stated intentions that "most" of the emissions reductions will be achieved domestically resulted in an assumption that 50 percent of the aggregate emissions reduction for Western Europe will be met by domestic reductions. With no stated intention about levels of domestic reductions in Japan or in Canada, an assumption was made that for both countries a 25-percent share of their total reductions would be met domestically.

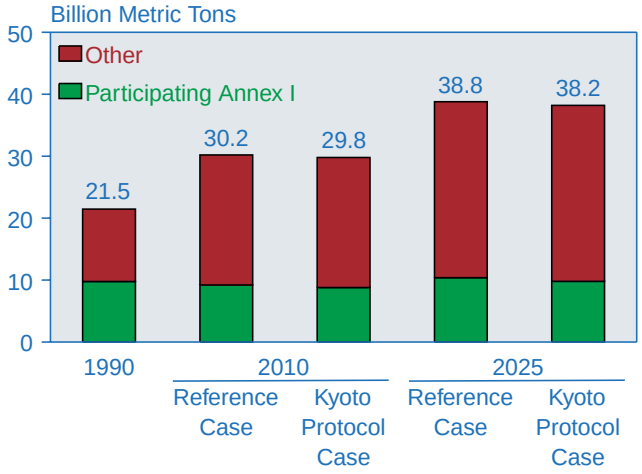
In the *IEO2005* Kyoto Protocol case, energy-related carbon dioxide emissions in the participating nations are projected to be 593 million metric tons lower than in the reference case in 2025. Achieving the national commitments under the treaty is projected to require marginal costs for emission reductions from domestic sources that range from $36 per metric ton of carbon dioxide in Canada to $64 per metric ton in Western Europe. Continued heavy reliance on coal and other fossil fuels, as projected for the emerging economies of the world, ensures that even when those nations that have ratified the Kyoto Protocol undertake to reduce their carbon dioxide emissions as required in the treaty, there still will be substantial increases in worldwide carbon dioxide emissions over the forecast horizon (Figure 6). In the *IEO2005* Kyoto Protocol case (assuming that the Kyoto targets remain constant over the entire forecast period), worldwide carbon dioxide emissions rise to 29.8 billion metric tons in 2010 and to 38.2 million metric tons in 2025.

Figure 5. World Carbon Dioxide Emissions by Fuel Type, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 6. World Carbon Dioxide Emissions in Two Cases, 1990, 2010, and 2025



Sources: **1990:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2010 and 2025:** EIA, System for the Analysis of Global Energy Markets (2005).

[1]Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Monaco, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and the United Kingdom. Turkey, Belarus, Australia, and the United States are Annex I nations that will not participate in the Protocol.

World Energy and Economic Outlook

The IEO2005 projections indicate continued growth in world energy use, including large increases for the emerging economies of Asia. Energy resources are thought to be adequate to support the growth expected through 2025.

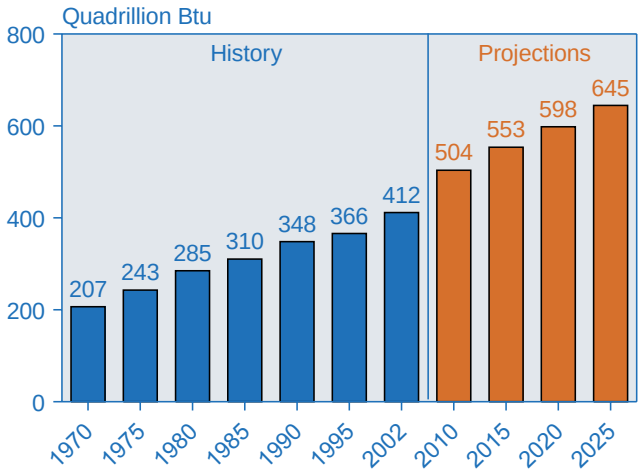
The *International Energy Outlook 2005* (*IEO2005*) projects strong growth for worldwide energy demand over the 23-year projection period from 2002 to 2025. Total world consumption of marketed energy is expected to expand from 412 quadrillion British thermal units (Btu) in 2002 to 553 quadrillion Btu in 2015 and then to 645 quadrillion Btu in 2025, or a 57-percent increase over the 2002 to 2025 time period (Table 1 and Figure 7).

In the *IEO2005* mid-term outlook, the emerging economies account for nearly two-thirds of the increase in world energy use, surpassing energy use in the mature market economies for the first time in 2020 (Figure 8). In 2025, energy demand in the emerging economies is expected to exceed that of the mature market economies by 9 percent.

Much of the growth in energy demand among the emerging economies is expected to occur in emerging Asia, which includes China and India; demand in this region is projected to more than double over the forecast period (Figure 9). Primary energy consumption in the emerging economies as a whole is projected to grow at an average annual rate of 3.2 percent between 2002 and 2025. In contrast, in the mature market economies—where energy consumption patterns are well established—energy use is expected to grow at a much slower average rate of 1.1 percent per year over the same period. In the transitional economies of Eastern Europe and the former Soviet Union (EE/FSU), growth in energy demand is projected to average 1.6 percent per year.

This chapter presents an overview of the *IEO2005* outlook for energy consumption by primary energy source

Figure 7. World Marketed Energy Consumption, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table 1. World Marketed Energy Consumption by Region, 1990-2025
(Quadrillion Btu)

Region	1990	2002	2015	2025	Average Annual Percent Change 1990-2002	Average Annual Percent Change 2002-2025
Mature Market Economies	**183.6**	**213.5**	**247.3**	**271.8**	**1.3**	**1.1**
Transitional Economies	**76.2**	**53.6**	**68.4**	**77.7**	**-2.9**	**1.6**
Emerging Economies	**88.4**	**144.3**	**237.8**	**295.1**	**4.2**	**3.2**
Asia	51.5	88.4	155.8	196.7	4.6	3.5
Middle East	13.1	22.0	32.4	38.9	4.4	2.5
Africa	9.3	12.7	19.3	23.4	2.7	2.7
Central and South America	14.5	21.2	30.4	36.1	3.2	2.3
Total World	**348.2**	**411.5**	**553.5**	**644.6**	**1.4**	**2.0**

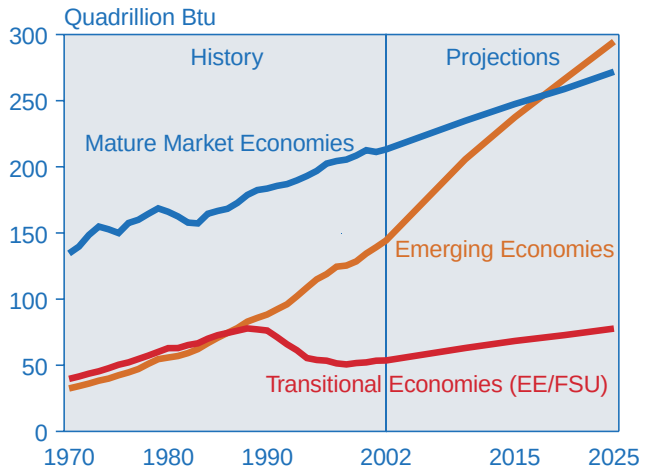
Note: Totals may not equal sum of components due to independent rounding.

Sources: **1990 and 2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2015 and 2025:** EIA, System for the Analysis of Global Energy Markets (2005).

and a look at the major assumptions that form the basis of the forecasts that appear in the report. The chapter includes a discussion of the *IEO2005* macroeconomic forecast in the context of recent economic developments in key mature market, transitional, and emerging economies.

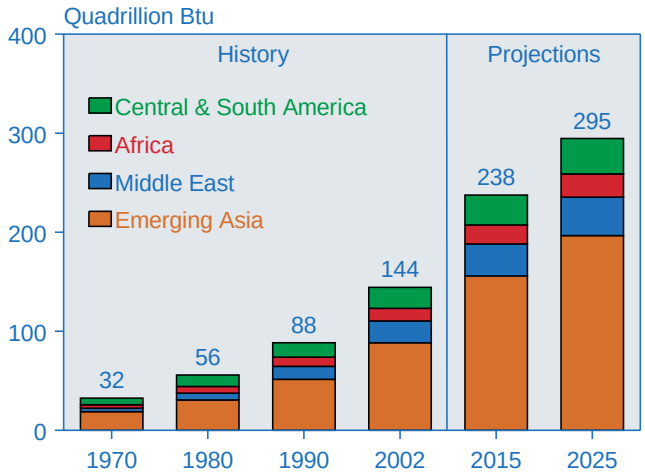
As with any set of forecasts, there is uncertainty associated with the *IEO2005* energy projections. In an effort to assess issues of uncertainty in the forecast, the following section considers some of the elements that drive the *IEO2005* projections, which can result in a fair amount of variation in forecasting. Alternative assumptions about economic growth and their impacts on the *IEO2005* projections are considered, as well as the possible effects of future trends in energy intensity on the reference case projections.

Figure 8. World Marketed Energy Use by Region, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 9. Marketed Energy Use in the Emerging Economies by Region, 1970-2025



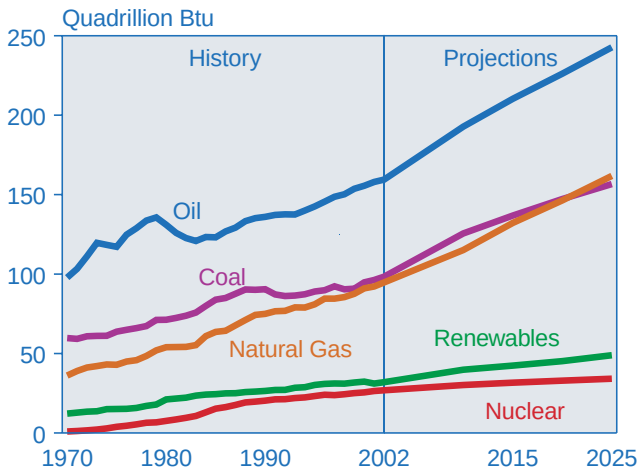
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Outlook for World Energy Consumption

The *IEO2005* reference case projects increased consumption of primary energy from all sources over the next two decades. Fossil fuels continue to supply much of the increment in marketed energy use worldwide throughout the forecast. Oil is expected to remain the dominant energy source over the projection period, with its share of total world energy consumption declining only slightly, from 39 percent in 2002 to 38 percent in 2025 (Figure 10).

Worldwide oil consumption is expected to rise from 78 million barrels per day in 2002 to 103 million barrels per day in 2015 and then to 119 million barrels per day in 2025. The projection for oil demand in 2025 is slightly lower than the 121 million barrels per day forecast in the *International Energy Outlook 2004* (*IEO2004*), and the difference is in large part explained by the change in expectations for world oil prices (Figure 11). In this year's outlook, world oil prices are assumed to stay higher for longer than anticipated in last year's report, and this dampens the mid-term projections for oil demand in many regions of the world—especially in the mature market economies and the EE/FSU. The impact of higher prices on world oil demand would be even

Figure 10. World Marketed Energy Use by Fuel Type, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

stronger without the robust growth expected for China in the near-term forecast. China's oil consumption is projected to increase at an average annual rate of 5.8 percent between 2002 and 2015, then slow to about half that rate in the remaining years of the forecast.

Worldwide, transportation and industry are the major growth sectors for oil demand. On a worldwide basis, the transportation sector—where there are currently no alternative fuels that compete widely with oil—accounts for about 60 percent of the total projected increase in oil use between 2002 and 2025, with the industrial sector accounting for virtually all the rest of the incremental demand.

Natural gas is projected to be the fastest growing primary energy source worldwide, maintaining average growth of 2.3 percent annually over the 2002 to 2025 period. Total world natural gas consumption is projected to rise from 92 trillion cubic feet in 2002 to 128 trillion cubic feet in 2015 and 156 trillion cubic feet in 2025.

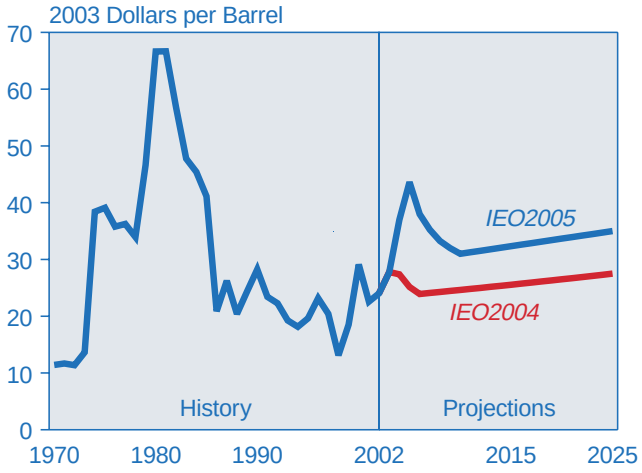
Natural gas is expected to remain an important supply source for new electric power generation in the forecast. It is seen as a desirable option for electric power in many parts of the world, given its efficiency relative to other energy sources and its low carbon content relative to other fossil fuels, making it a more attractive choice for countries interested in reducing greenhouse gas emissions. The industrial sector also remains an important end-use consumer for natural gas worldwide. The electric power sector accounts for nearly 50 percent of the increase in global natural gas demand over the 2002 to 2025 period, and the industrial sector accounts for another 36 percent.

Coal use worldwide is projected to increase by 2.0 billion short tons between 2002 and 2015 and by another 1.0 billion short tons between 2015 and 2025. In this year's outlook for coal, all regions of the world show some increase in coal use, except for Western Europe, where natural gas and, to a lesser extent, renewable energy sources are increasingly being substituted for coal to fuel electric power generation. On a regional basis, slightly lower coal use is anticipated relative to last year's outlook in the mature market economies. In the transitional economies of the EE/FSU region, coal use was expected to decline somewhat in the *IEO2004* forecast, but in this year's forecast it is expected to increase by 0.5 percent per year between 2002 and 2025.

The *IEO2005* forecast for coal use in the emerging economies is nearly 13 percent higher than in *IEO2004* (Figure 12). The largest increases in coal use worldwide are projected for China and India, where coal supplies are plentiful. Together, China and India account for 87 percent of the projected rise in coal use in the emerging economies region and 72 percent of the total world increase in coal demand over the forecast period.

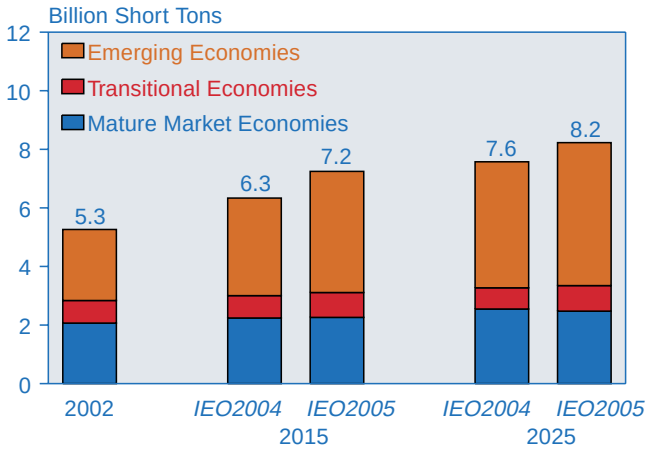
Electricity generation is expected to nearly double between 2002 and 2025, from 14,275 billion kilowatthours to 26,018 billion kilowatthours. The strongest

Figure 11. Comparison of *IEO2004* and *IEO2005* Projections for the U.S. Refiner Acquisition Cost of Imported Crude Oil, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *Annual Energy Review 2003*, DOE/EIA-0384(2003) (Washington, DC, September 2004), web site www.eia.doe.gov/emeu/aer/contents.html. **IEO2004:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004), web site www.eia.doe.gov/oiaf/ieo/index.html. **IEO2005:** *AEO-2005* October Futures Case from EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), web site www.eia.doe.gov/oiaf/aeo/index.html.

Figure 12. Comparison of *IEO2004* and *IEO2005* Projections for World Coal Consumption by Region, 2015 and 2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **IEO2004:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004), web site www.eia.doe.gov/oiaf/ieo/index.html. **IEO2005:** EIA, System for the Analysis of Global Energy Markets (2005).

growth in net electricity consumption is projected for the emerging economies of the world, averaging 4.0 percent per year in the *IEO2005* reference case, compared with a projected average increase of 2.6 percent per year worldwide. Robust economic growth in many of the emerging economies is expected to boost demand for electricity to run newly purchased home appliances for air conditioning, cooking, space and water heating, and refrigeration. More modest growth, averaging 1.5 percent per year, is projected for the mature market economies.

As noted above, natural gas is expected to be a favored choice for new electricity generation capacity built over the next two decades (Figure 13). Its relative environmental benefits and efficiency make natural gas an attractive alternative to coal-fired generation. Moreover, where fuel diversification is desired (as in China, where generation is heavily reliant on coal-fired capacity), natural gas is expected to gain share in the electric power mix over the forecast period. The natural gas share of total energy used to generate electricity worldwide increases in the forecast, from 18 percent in 2002 to 24 percent in 2025, with other energy sources showing small losses in market share.

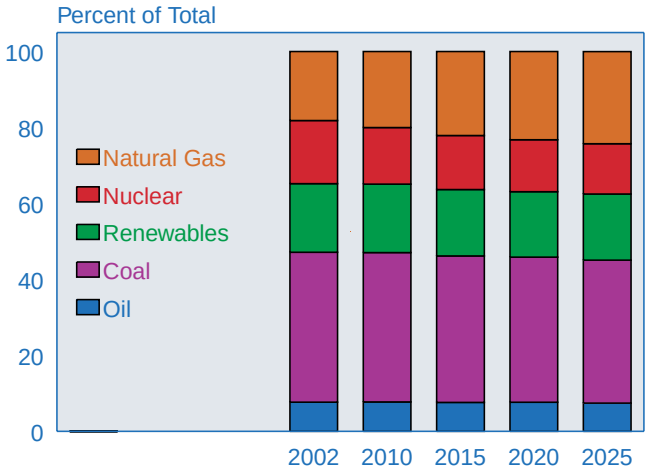
Worldwide, consumption of electricity generated from nuclear power is expected to increase from 2,560 billion kilowatthours in 2002 to 3,032 billion kilowatthours in 2015 and 3,270 billion kilowatthours in 2025. The *IEO2005* world forecast for nuclear electricity generation is, in general, more optimistic than last year's forecast; the projection for nuclear generation in 2025 is 13 percent higher in *IEO2005* than it was in *IEO2004*. Prospects for nuclear power have improved in recent years, with higher capacity utilization rates reported for many existing nuclear facilities and expectations that most existing plants in the mature market and transitional economy nations will receive approvals for extensions of their operating lives.

Higher fossil fuel prices and the entry into force of the Kyoto Protocol are expected to improve prospects for new nuclear power capacity over the forecast period, and the world nuclear generation forecast includes new construction of nuclear plants in several countries. In *IEO2005*, unlike past *IEO*s, the world's total installed nuclear capacity is not projected to decline before 2025 (Figure 14). In the *IEO2005* reference case, world nuclear capacity is projected to rise from 361 gigawatts in 2002 to 401 gigawatts in 2015 and 422 gigawatts in 2025.

In the emerging economies, consumption of electricity from nuclear power is projected to increase by 4.9 percent per year between 2002 and 2025. Emerging Asia, in particular, is expected to see the largest increment in installed nuclear generating capacity over the forecast, accounting for 96 percent of the total projected increase in nuclear power capacity for the emerging economies. Of the 55 gigawatts of additional installed nuclear generating capacity projected for emerging Asia, 24 gigawatts is projected for China, 12 gigawatts for India, and 12 gigawatts for South Korea.

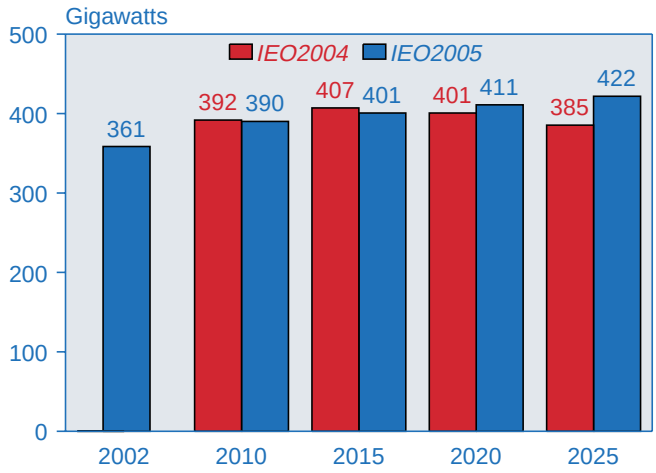
Although the use of hydroelectricity and other grid-connected renewable energy sources is expected to continue to expand over the projection period, increasing by 1.9 percent per year, more rapid growth is projected for both natural gas and coal demand in the reference case.

Figure 13. Fuel Shares of World Electricity Generation, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 14. Comparison of *IEO2004* and *IEO2005* Projections for World Nuclear Generating Capacity, 2010-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **IEO2004:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004), web site www.eia.doe.gov/oiaf/ieo/index.html. **IEO2005:** EIA, System for the Analysis of Global Energy Markets (2005).

Still, renewables are expected to retain an 8-percent share of total world energy consumption throughout the 2002 to 2025 period. Much of the growth in renewable energy sources is expected to result from large-scale hydroelectric power projects in the developing world, particularly among the nations of emerging Asia. China, India, and Laos, among other emerging Asian economies, are already constructing or have plans to construct ambitious hydroelectric projects in the coming decades.

World Economic Outlook

Economic growth is among the most important factors to be considered in projecting changes in the world's future energy consumption. In the *IEO2005* forecast, assumptions about regional economic growth—measured in terms of gross domestic product (GDP), in real 2000 U.S. dollars at purchasing power parity rates—underlie the projections of regional energy demand (see box on page 13 for discussion of real GDP at purchasing power parity rates).

Over the 2002 to 2025 period, world economic growth is projected to average 3.9 percent annually (Table 2). This growth projection is slightly higher than the *IEO2004* projection, because economic performance in most regions of the world was exceptionally strong in 2003 and 2004. The medium- to long-term outlook for worldwide economic growth depends on the underlying demographic and productivity trends in each economy, which will determine the nature and character of long-term growth, especially in developed, mature market economies that have well-established and stable political institutions and markets for goods and services, labor, and financial assets.

In emerging nations that still are in the process of building human and physical capital infrastructures,

Table 2. Average Annual Growth in World Gross Domestic Product by Selected Countries and Regions, 1979-2025
(Percent per Year)

Region	History				Projections			
	1979-2002	2002	2003	2004	2005	2005-2015	2015-2025	2002-2025
Mature Market Economies	**2.6**	**1.4**	**2.1**	**3.4**	**2.8**	**2.6**	**2.4**	**2.5**
United States	2.9	1.9	3.0	4.4	3.6	3.1	2.9	3.1
Canada	2.8	3.4	2.0	3.0	3.3	2.8	2.0	2.4
Mexico	2.7	0.7	1.3	4.0	3.7	3.9	4.1	3.9
Japan	2.5	-0.3	2.5	4.1	2.0	1.7	1.2	1.7
Western Europe	2.3	1.1	0.9	2.2	2.1	2.1	2.0	2.0
Australia/New Zealand	3.2	4.0	3.0	3.8	3.2	2.6	2.4	2.6
Transitional Economies	**-0.5**	**4.4**	**6.6**	**7.0**	**6.2**	**4.5**	**3.7**	**4.4**
Former Soviet Union	-1.0	5.2	7.9	7.8	6.7	4.6	3.7	4.6
Eastern Europe	0.9	2.7	3.7	5.1	4.9	4.3	3.8	4.1
Emerging Economies	**5.0**	**4.8**	**5.9**	**6.4**	**5.9**	**5.3**	**4.7**	**5.1**
Emerging Asia	6.8	5.9	7.3	6.9	6.4	5.7	4.9	5.5
China	9.4	8.0	9.1	8.6	7.2	6.4	5.3	6.2
India	5.6	4.6	8.2	5.7	6.4	5.4	5.2	5.5
South Korea	6.7	6.9	3.1	4.3	5.8	4.8	2.8	3.9
Other Asia	5.4	4.1	4.8	5.8	5.1	4.8	4.3	4.6
Middle East	2.4	4.8	3.1	7.4	6.2	4.4	3.9	4.3
Africa	2.4	3.4	3.9	4.6	5.0	4.2	3.6	4.0
Central and South America	2.2	-0.5	1.2	4.1	3.7	4.0	4.0	3.9
Brazil	2.4	1.9	-0.2	4.3	3.8	3.9	4.0	3.8
Total World								
Purchasing Power Parity Rates	**3.0**	**2.9**	**3.9**	**4.9**	**4.3**	**3.9**	**3.6**	**3.9**
Market Exchange Rates	**2.7**	**2.0**	**2.3**	**3.1**	**3.4**	**3.1**	**3.0**	**3.0**

Note: All growth rates presented in this table are expressed as purchasing power parity rates, except for the final line of the table, which presents world GDP growth rates expressed as market exchange rates.

Sources: **Purchasing Power Parity Rates:** A. Heston, R. Summers, and B. Aten, "Penn World Table Version 6.1" (Philadelphia, PA: Center for International Comparisons at the University of Pennsylvania (CICUP), October 2002), web site http://pwt.econ.upenn.edu/php_site/pwt_index.php. **Historical Growth Rates:** Global Insight, Inc., *World Overview* (Lexington, MA, various issues). **Projected GDP Growth Rates:** Global Insight, Inc., *World Overview*, First Quarter 2005 (Lexington, MA, March 2005); and Energy Information Administration, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington DC, January 2005). China's growth rates were adjusted downward, based on the analyst's judgment.

establishing credible and effective regulatory mechanisms to govern markets, and ensuring political stability, progress in achieving those goals will play an equally important role in determining medium- to long-term growth. The transitional economies face their own unique sets of problems as they continue moving from centrally planned to decentralized private markets. Therefore, in contrast to the mature market economies, there is a broader range of uncertainty around the reference case projections of economic growth for emerging and transitional economies.

Mature Market Economies

In the United States, GDP is projected to grow by an average of 3.1 percent per year between 2005 and 2015, with somewhat slower growth—2.9 percent per year—expected between 2015 and 2025 as the baby boom generation retires and labor force growth slows. Compared with the second half of the 1990s, U.S. GDP growth rates were lower from 2000 to 2002 but rebounded to 3.0 percent in 2003 and an estimated 4.4 percent in 2004. In the forecast, the U.S. economy stabilizes at its long-term growth path between 2005 and 2010.

Canada has the potential to maintain strong growth in productivity and its standard of living by increasing the labor force participation rate, focusing on immigration, strengthening policies on education and innovation, and reducing structural unemployment. Labor force growth is projected to slow in the medium to long term, however, and Canada's overall potential economic growth is expected to fall from the current 3.0 percent to 2.8 percent per year between 2005 and 2015 and 2.0 percent per year between 2015 and 2025.

In the *IEO2005* reference case, Mexico's GDP is projected to grow by an average of 3.9 percent per year from 2002 to 2025. Global financial markets remain friendly to Mexico in terms of the availability and cost of credit and the volume of foreign direct investment. In general, strong trade ties with the United States are expected to help cushion Mexico from deeper economic troubles. By the same token, Mexico's future growth is also more dependent on U.S. growth.

Western Europe's GDP is projected to grow by 2.0 percent per year between 2002 and 2025 in the reference case. Over the medium to long term there are structural impediments to economic growth in many Western European countries, related to the region's labor markets, product markets, and costly social welfare systems. Reforms to improve the competitiveness of European labor and product markets could yield significant dividends in terms of increases in regional output [***1***].

Japan's GDP growth is projected to average 1.7 percent per year from 2002 to 2015 and then to slow to 1.2 percent per year from 2015 to 2025. In the short term, Japan's highly skilled labor force and strong work ethic are expected to support the projected growth rate of 1.7 percent per year, provided that more flexible labor policies allowing greater mobility for workers are adopted. Toward the end of this decade, normal attrition is expected to eliminate surplus employment levels, especially in the industrial sector, allowing consolidation and improved efficiencies. More importantly, the bankrupt firms kept afloat by creditors are expected to be gone and, therefore, no longer a drain on the economy. In addition, the bad loans that have plagued Japan's banks are expected to be reduced to a point at which lending can resume. In the long term, after 2010, Japan's population is expected to decline, and the average age will continue to rise as a result of low birth rates and high longevity. As a result, transfer payments by the government to the elderly could become increasingly burdensome, leading to slower GDP growth.

Transitional Economies

Over the 2002-2025 period, an average annual growth of 4.6 percent is expected for the FSU as a whole. For the past several years, the FSU economies have been largely sheltered from global economic uncertainties, recording strong growth in each year since 2000. This trend is largely the result of robust domestic demand, in addition to the impact that rising oil prices have had on the oil-exporting nations of the region. High world oil prices have stimulated investment outlays, especially in the energy sector of the Caspian region. Given the volatility of energy market prices, however, it is unlikely that these economies will be able to sustain the growth rates recently achieved until diversification from energy becomes more broadly based. The long-term growth prospects of the FSU economies hinge on their success in economic diversification, as well as further improvements in domestic product and financial markets.

An average annual expansion of 4.1 percent per year is projected for Eastern Europe's GDP over the 2002 to 2025 period. The accession of 10 Eastern European countries to membership in the European Union in May 2004 (Poland, Czech Republic, Slovakia, Hungary, Estonia, Latvia, Lithuania, Slovenia, Malta, and Cyprus) is expected to boost consumer confidence and economic activity in the medium to long term. Membership in the European Union is expected to result in more foreign direct investment, bolstering domestic investment and growth.

Emerging Economies

Much of the growth in world economic activity between 2002 and 2025 is expected to occur among the nations of emerging Asia, where regional GDP is projected to grow by 5.5 percent per year. China, emerging Asia's largest economy, is expected to continue playing a major role on both the supply and demand sides of the global

economy. *IEO2005* projects an average annual growth rate of approximately 6.2 percent for China's economy over the 2002 to 2025 period. The country's economic growth is expected to be the highest in the world. In 2025, based on share of world GDP (converted using purchase power parity rates), China is expected to be the world's largest economy.

In terms of structural issues that have implications for the medium to long term, China still needs to reform

GDP Comparisons Based on Purchasing Power Parity Exchange Rates

Regular readers of the *International Energy Outlook* (*IEO*) will notice that, in this edition, the projections of real gross domestic product (GDP) for different countries and regions have been converted to U.S. dollars by using purchasing power parity (PPP) exchange rates. In all previous editions of the *IEO*, starting from 1985, market exchange rates were used for the conversion of real GDP projections.

PPP exchange rates are defined as rates of currency conversion that equalize the purchasing power of different currencies. For example, if the price of a hamburger in India is 60 rupees and in the United States it is $2.20, then the PPP exchange rate for hamburgers between India and the United States is 60 rupees to $2.20 or 27.3 rupees to the dollar. This concept of PPP for one good is generalized to a common basket of goods and services in the different countries to obtain PPP rates in practice. Market exchange rates on the other hand are the foreign currency prices of the dollar (or alternatively the dollar prices of foreign currencies) as traded in the foreign exchange markets.

In 2004 the average market exchange rate for a dollar in terms of Indian rupees was 45.3, compared with an average PPP rate of 7.3. Generally, PPP rates are much lower than market exchange rates in emerging economies, implying that a dollar buys a lot more in, for example, India or China than in the United States. Thus, converting emerging countries' GDPs into dollars at market exchange rates can understate the true size of their economies and their living standards.

Real GDP projections for country and regions have been employed as one of the major determinants in the world energy forecasts contained in every edition of *IEO*. It was stated in the *International Energy Outlook 2004* (pp. 17-18) that the energy projections were not affected by the choice between market exchange and PPP rates for GDP conversions, because both rates of conversion would leave unchanged the underlying rates of growth of real economic activity.[a] in the various countries/regions. However, some readers have rightly objected to the presentation of real GDP projections in a common currency based on market exchange rates,[b] because they understate the true size of emerging economies. As a result, their growth rates get relatively less weight than they should, and when they are aggregated to regions and finally to the world, the regional and world growth rates are underestimated. Furthermore, the internationally agreed System of National Accounts 1993, to which the United States is a signatory, states, "When the objective is to compare volumes of goods and services produced or consumed per head, data in national currencies must be converted into a common currency by means of purchasing power parities and not exchange rates."[c]

The use of PPP rates for converting national GDPs to a common currency has become widely accepted, and the Energy Information Administration has also adopted their use. Nevertheless, care needs to be exercised in interpreting the results.[d] Market exchange rates are appropriate when the outcome is closely linked to the current exchange rate (for example, for exports and imports, especially of internationally traded commodities like crude oil, automobiles, etc.). PPP exchange rates are generally regarded as providing a better measure of the change in global economic well-being and cost of living. In addition, they are generally thought to provide a more balanced estimate of the relative importance of rich and poor countries. On the other hand, while PPP is useful for showing how much a country's currency is worth in its home market, it does not measure effective purchasing power across borders.

[a]For *IEO2005*, GDP projections were first prepared for individual countries in terms of their own currencies and the 2000 prices of goods and services. The projections were then converted to 2000 U.S. PPP dollars by dividing each country's real GDP projections by the PPP exchange rate between the United States and that country in 2000. Had the market exchange rate that existed, on average, in 2000 between each currency and the dollar been used instead, the growth rate of the resulting series would not differ from the growth rate of the real GDP series derived by using the 2000 PPP rate.

[b]Ian Castles, Visiting Fellow, Asia Pacific School of Government, the Australian National University (formerly head of Australia's National Statistical Office); and David Henderson, Visiting Professor, Westminster School of Business, University of Westminster (formerly Chief Economist at the Organization for Economic Cooperation and Development).

[c]SNA 1993, para. 1.38. See web site http://unstats.un.org/unsd/sna1993/toctop.asp.

[d]The International Monetary Fund, the Organization for Economic Cooperation and Development, and some private-sector organizations use PPP exchange rates for their world economic growth projections. The World Bank and other groups in the private sector use market exchange rates.

overstaffed and inefficient state-owned companies and a banking system that is carrying a significant amount of nonperforming loans. Membership in the World Trade Organization is expected to force the government to pursue these reforms, which are expected to transform the Chinese economy into one that is more market oriented and, hence, more efficient.

Another Asian country with a rapidly emerging economy is India. The mid-term prospects for India's economy are positive, as it continues to privatize state enterprises and increasingly adopts free market policies. Average annual GDP growth in India over the 2002 to 2025 forecast period is projected at 5.5 percent. Accelerating structural reforms—including ending regulatory impediments to the consolidation of labor-intensive industries, labor market and bankruptcy reforms, and agricultural and trade liberalization—remain essential to stimulating potential growth and reducing poverty in the medium to long term [2]. With its vast and cheap labor force, India is well placed to reap the benefits of globalization in the long run.

Although the nations of Central and South America are on favorable economic growth paths, the region's growth rate remains well below potential. The weak international credit environment is a constraint, as are domestic economic and/or political problems in a number of countries. Growth in the region remains heavily dependent on the volume of foreign capital flows. In the long term, beyond macroeconomic stability and commitment to sound fiscal and monetary policies, the countries of Central and South America will have to tackle governance issues and attempt to correct severe economic disparities between the wealthy and the poor in the region's societies.

Higher oil prices have helped boost growth in the oil-exporting countries of the Middle East and Africa, and strong prices for many other commodities have helped a number of the region's commodity-exporting countries. For Africa as a whole, average annual GDP growth of 4.0 percent is projected over the 2002 to 2025 period. In the longer run, Africa will continue to face formidable obstacles to growth, such as low savings and investment rates, limited quantity and quality of infrastructure and human capital, negative perceptions on the part of international investors, and especially the impact of HIV/AIDS on population growth.

Alternative Growth Cases

Expectations for the future rates of economic growth are a major source of uncertainty in the *IEO2005* forecast. To account for the uncertainties associated with economic growth trends, *IEO2005* includes a high economic growth case and a low economic growth case in addition to the reference case. The reference case projections are based on a set of regional assumptions about economic growth paths—measured by GDP—and energy elasticity (the relationship between changes in energy consumption and changes in GDP). The two alternative growth cases are based on alternative assumptions about possible economic growth paths; assumptions about the elasticity of energy demand are held constant, at reference case values.

For the high and low economic growth cases, different assumptions are made about the range of possible economic growth rates among the industrial, transitional EE/FSU, and emerging economies. For the mature market economies, 0.5 percentage point is added to the reference case GDP growth rates for the high economic growth case and 0.5 percentage point is subtracted from the reference case GDP growth rates for the low economic growth case. Outside the industrialized world (excluding the FSU), reference case GDP growth rates are increased and decreased by 1.0 percentage point to provide the high and low economic growth case estimates.

The FSU suffered a severe economic collapse in the early part of the 1990s and, until recently, has shown wide variation in its year-to-year economic growth. Between 1990 and 2002, its annual GDP growth rate has varied from -14 percent in 1992 to +9 percent in 2000. Given this wide range, the FSU nations can be characterized as having a considerably more uncertain economic future than the nations in other regions of the world. As a result, 1.5 percentage points are added and subtracted from the reference case GDP assumptions to derive the high and low macroeconomic forecasts for the FSU region.

The *IEO2005* reference case shows total world energy consumption reaching 645 quadrillion Btu in 2025, with the mature market economies projected to consume 272 quadrillion Btu, the transitional EE/FSU countries 78 quadrillion Btu, and the emerging economies 295 quadrillion Btu. In the high economic growth case, total world energy use in 2025 is projected to be 708 quadrillion Btu, 64 quadrillion Btu (or 32 million barrels oil equivalent per day) higher than in the reference case. Under the assumptions of the low economic growth case, worldwide energy consumption in 2025 is projected to be 58 quadrillion Btu (29 million barrels oil equivalent per day) lower than in the reference case, at 586 quadrillion Btu. Thus, there is a range of 122 quadrillion Btu—about one-fifth of the total consumption projected for 2025 in the reference case—between the projections in the high and low economic growth cases (Figure 15).

Trends in Energy Intensity

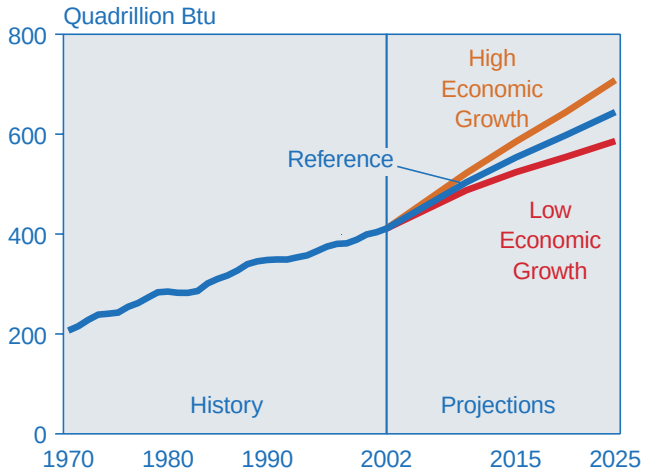
Another major source of uncertainty surrounding long-term forecasts is the relationship of energy use to

GDP—or energy intensity—over time. Economic growth and energy demand are linked, but the strength of that link varies among regions over time. In the mature market economies, history shows the link to be a relatively weak one, with energy demand lagging behind economic growth (Figure 16). In the emerging economies, demand and economic growth have been closely correlated with energy demand growth for much of the past three decades (Figure 17). Economic growth has only recently (that is, within the past decade or so) begun to outpace growth in energy use among the emerging economies of the world.

The historical behavior of energy intensity in the FSU is problematic. Since World War II, the EE/FSU economies have had higher levels of energy intensity than either the mature market or emerging economies. In the FSU, however, energy consumption generally grew more quickly than GDP until 1990 (Figure 18), when the collapse of the Soviet Union created a situation in which both income and energy use declined, but GDP fell more quickly and, as a result, energy intensity increased. Only since the late 1990s, after the 1997 devaluation of the Russian ruble, have the Russian and Ukrainian industrial sectors begun to strengthen. As a result, economic growth in the FSU has begun to outpace growth in energy use significantly, and energy intensity has begun to decline precipitously. Over the forecast horizon, energy intensity in the EE/FSU region is expected to continue to decline but still remain higher than in any other region of the world (Figure 19).

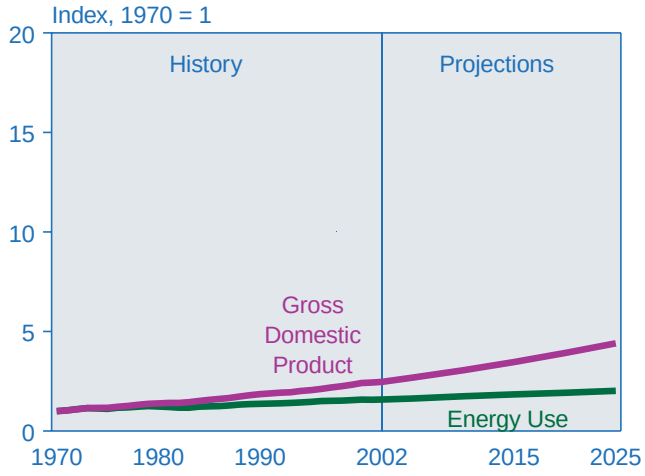
The stage of economic development and the standard of living of individuals in a given region strongly influence the link between economic growth and energy demand. Advanced economies with high living standards have a relatively high level of energy use per capita, but they also tend to be economies where per capita energy use is stable or changes very slowly. In mature market economies, there is a high penetration rate of modern appliances and motorized personal transportation equipment. To the extent that spending is directed to energy-consuming goods, it involves more often than

Figure 15. World Marketed Energy Consumption in Three Economic Growth Cases, 1970-2025



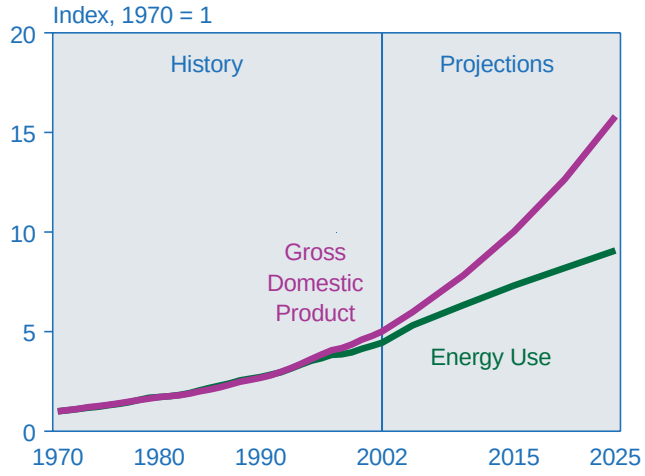
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 16. Growth in Energy Use and Gross Domestic Product for the Mature Market Economies, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 17. Growth in Energy Use and Gross Domestic Product for the Emerging Economies, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

not purchases of new equipment to replace old capital stock. The new stock is often more efficient than the equipment it replaces, resulting in a weaker link between income and energy demand.

The pace of improvement in energy intensity may change, given different assumptions of macroeconomic growth over time. Faster growth in income means a faster rate of decline in energy intensity. Worldwide energy intensity in the *IEO2005* high economic growth rate is projected to improve by 2.1 percent per year on average from 2002 to 2025, compared with 1.9 percent in the reference case. On the other hand, slower economic growth would result in a slower rate of decline in energy intensity. Under the *IEO2005* assumptions for GDP growth in the low macroeconomic growth case, world energy intensity is projected to decline by an average of only 1.5 percent per year over the projection period.

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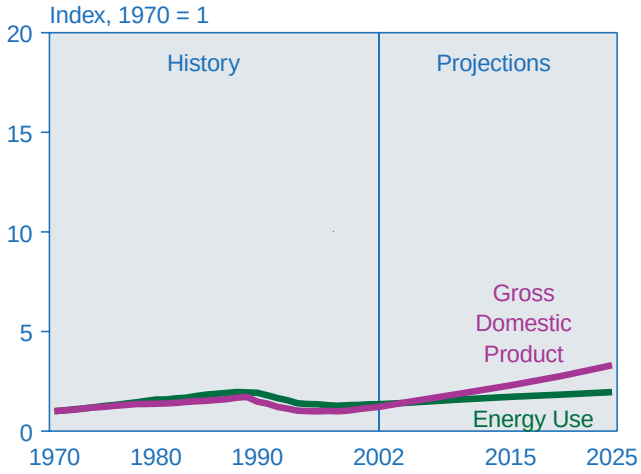
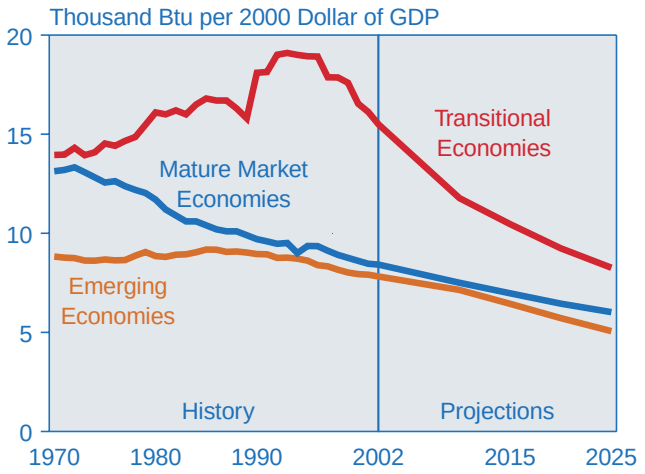
2. International Monetary Fund, "Economic Prospects and Policy Issues," in *World Economic Outlook: Globalization and External Imbalances* (Washington, DC, April 2005), p. 29, web site www.imf.org/external/pubs/ft/weo/2005/01/.

Figure 18. Growth in Energy Use and Gross Domestic Product for the Transitional Economies, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 19. Energy Intensity by Region, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Energy Consumption by End-Use Sector

In the IEO2005 projections, end-use energy consumption in the residential, commercial, industrial, and transportation sectors varies widely among regions and from country to country.

One way of looking at the future of world energy markets is to consider trends in energy consumption at the end-use sector level. With the exception of the transportation sector, which is almost universally dominated by petroleum products at present, the mix of energy use in the residential, commercial, and industrial sectors can vary widely from country to country, depending on a combination of regional factors, such as the availability of energy resources, the level of economic development, and political, social, and demographic factors. This chapter outlines the *International Energy Outlook 2005* (*IEO2005*) forecast for regional energy consumption by end-use sector.

Residential Sector

The residential sector is defined by the energy consumed in households, excluding transportation uses. The physical size of residential structures is the most important factor in determining the amount of energy used by their occupants. Larger homes require more energy to provide heating, air conditioning, and lighting, and they tend to include more energy-using appliances, such as televisions and laundry equipment. Smaller structures require less energy, because they contain less space to be heated or cooled, produce less heat transfer with the outdoor environment, and have fewer occupants.

The type and amount of energy used by households vary from country to country, depending on income levels, natural resources, and available energy infrastructure. In general, households in the mature market economies use more energy than those in the transitional or emerging economies, in part because they tend to include more energy-using appliances. Consequently, residential sector energy use generally is higher in the mature market economies (Figure 20). In most of the world's countries, residential energy use is expected to increase as households continue to purchase additional electricity-using appliances.

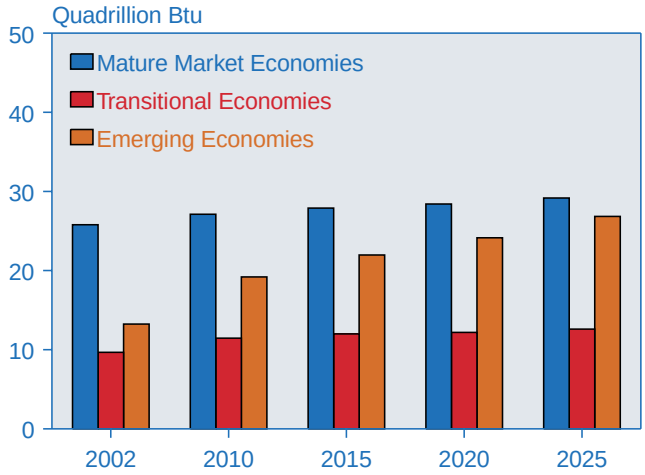
Mature Market Economies

Households in mature market economies use energy more intensively than those in less developed economies, primarily because of higher income levels. In North America, energy use in Mexico's residential sector is expected to nearly double by 2015 (relative to 2002), to 1.1 quadrillion Btu; growth in electricity demand is responsible for most of the projected increase. After 2015, the growth in Mexico's residential delivered energy use is expected to slow, reaching 1.3 quadrillion Btu in 2025. On average, the country's residential energy consumption increases in the forecast by 3.4 percent per year from 2002 to 2025.

In the United States, which is by far the largest residential energy consumer in the region (and in the world), total residential electricity use is projected to grow on average by 1.6 percent per year, to 5.4 quadrillion Btu in 2015 and 6.2 quadrillion Btu in 2025, from 4.3 quadrillion Btu in 2002. Increasing use of electric appliances contributes most to the expected growth in residential electricity demand through 2025.

In Western Europe and mature market Asia, unlike North America, residential delivered energy consumption combined is not projected to increase through 2025, because increases in electricity use are expected to be offset by decreases in fossil fuel use, and because population in both regions combined is projected to increase by less than 1.0 percent from 2002 to 2025. In Western Europe, residential electricity use is expected to grow by

Figure 20. Residential Sector Energy Consumption by Region, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

0.4 percent per year through 2025, adding 0.3 quadrillion Btu of consumption, while all other fuel use in the sector declines by 0.7 quadrillion Btu. A similar pattern is projected for mature market Asia but with smaller decreases in fossil fuel use, resulting in essentially no increase in residential delivered energy consumption from 2002 to 2025.

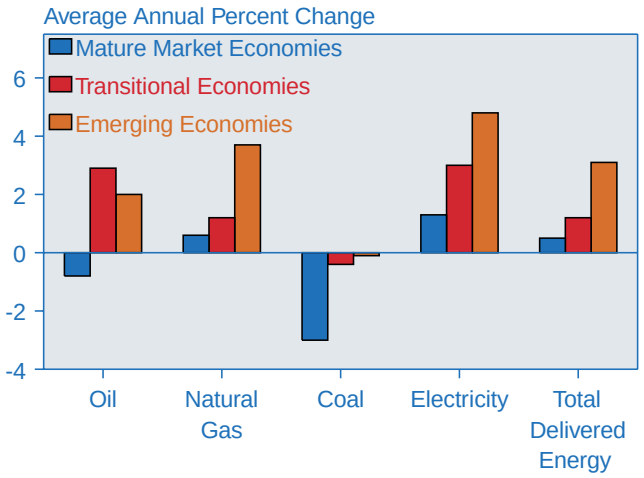
Transitional Economies

As households in Eastern Europe and the former Soviet Union (EE/FSU) transition to market economies, more energy services and energy-using appliances are expected to become available over time. Residential electricity use in the region is projected to nearly double, from 1.4 quadrillion Btu in 2002 to 2.2 quadrillion Btu in 2015 and 2.7 quadrillion Btu in 2025. The transition away from state-run district heating methods allows for increases in natural gas and oil consumption as well. Natural gas consumption in the region's residential sector is projected to grow by an average of 1.5 percent per year from 2002 through 2015 and an average of 1.2 percent per year from 2002 through 2025, as energy service companies increasingly serve homes directly, rather than through district services.

Emerging Economies

Household energy use is projected to increase most rapidly in the coming decades in the nations with emerging economies, relative to other nations (Figure 21). In China and India, population growth and urbanization will create large increases in demand for residential energy services. As a result, the emerging economies in 2025 are projected to nearly equal the mature market economies in residential energy use.

Figure 21. Growth in Residential Sector Delivered Energy Consumption by Region and Fuel, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2025:** EIA, System for the Analysis of Global Energy Markets (2005).

The demand for electricity in China is expected to more than triple by 2025, growing on average by 7.8 percent per year through 2015 and 5.6 percent per year through 2025. More rapid growth in electricity demand is projected for India's residential sector, but electricity consumption and total delivered energy consumption are projected to remain at about one-half those for China through 2025. China and India together accounted for 37 percent of delivered residential energy consumption in the emerging economies in 2002 and are projected to account for more than 43 percent in 2025. The Middle East, Africa, and Central and South America all are projected to see substantial increases in residential energy consumption as well, accounting for 42 percent of the 13.6 quadrillion Btu increase in residential sector delivered energy consumption in the emerging economies through 2025.

Commercial Sector

The commercial sector—often referred to as the services sector or the services and institutional sector—consists of businesses, institutions, and organizations that provide services. The sector encompasses many different types of buildings and a wide range of activities and energy-related services. Examples of commercial sector facilities include schools, stores, correctional institutions, restaurants, hotels, hospitals, museums, office buildings, banks, and even stadiums that hold sporting events. Most commercial energy use occurs in buildings or structures, supplying services such as space heating, water heating, lighting, cooking, and cooling. Energy consumed for services not associated with buildings, such as for traffic lights and city water and sewer services, is also categorized as commercial sector energy use.

Economic and population growth trends drive commercial sector activity and the resulting energy use. The need for services (health, education, financial, government) increases as populations increase. The degree to which these additional needs are met depends in large measure on economic resources—whether from domestic or foreign sources—and economic growth. Economic growth also determines the degree to which additional commercial sector activities are offered and utilized. Higher levels of economic activity and disposable income lead to increased demand for hotels and restaurants to meet business and leisure requirements; for office and retail space to house and service new and expanding businesses; and for cultural and leisure space such as theaters, galleries, and arenas.

Mature Market Economies

With population growth for the mature market economies as a whole expected to continue slowing, the rate of increase in the region's commercial energy demand is also expected to slow. In addition, further efficiency

improvements are expected to moderate energy demand growth over time as energy-using equipment is replaced with newer, more efficient stock. Conversely, strong economic growth in mature markets is expected to include continued growth in business activity, with its associated energy use, in areas such as retail and wholesale trade and business, financial, and leisure services. The combination of these factors is projected to cause commercial delivered energy consumption in this region to increase by 1.3 percent per year from 2002 to 2025 on average, from 16.8 quadrillion Btu in 2002 to 20.0 quadrillion Btu in 2015 and 22.6 quadrillion Btu in 2025 (Figure 22).

Commercial electricity demand in mature market economies is projected to grow by 1.9 percent per year from 2002 to 2025, with continued advances in technology and the introduction of new electronic appliances and equipment (Figure 23). Electricity delivered to commercial customers in the region, which totaled 7.9 quadrillion Btu in 2002, is projected to reach 10.1 quadrillion Btu in 2015 and 12.1 quadrillion Btu in 2025. Natural gas is expected to continue displacing petroleum products and coal as the preferred heating fuel in the mature market economies, especially in Western Europe and Japan.

Transitional Economies

Many of the EE/FSU countries—and the region as a whole—are expected to see their populations decline over the forecast period. Nevertheless, increasing commercial activity and rising incomes are expected to lead to 1.1-percent average annual growth in delivered energy use in the region's commercial sector between 2002 and 2025 (Figure 23). Commercial sector electricity consumption is projected to grow by 2.0 percent per year, to 1.1 quadrillion Btu in 2025, as the transitional nations approach the requirements of market-based economies, including increased adoption of electronic equipment. Commercial sector natural gas use is projected to grow by more than 50 percent, from 0.8 quadrillion Btu in 2002 to 1.2 quadrillion Btu in 2025. Most of the projected increase is attributable to the expectation that natural gas will be used to meet the heating needs of transitional countries to a greater extent than it has in the past, replacing coal and heating oil.

Emerging Economies

Economic growth and commerce are expected to increase rapidly in the emerging economies, fueling additional energy demand in the services sector. Faster population growth is also expected, relative to the growth rates for mature and transitional economies, portending increases in the need for education, health care, and social services and the energy required to provide them. Under these circumstances, commercial delivered energy use in the region is projected to nearly double between 2002 and 2015, to 9.6 quadrillion Btu, and to continue growing to 11.6 quadrillion Btu in 2025, at a 3.6-percent average annual growth rate from 2002 to 2025.

Electricity demand for commercial applications is expected to grow rapidly in emerging economies as more clinics, schools, and businesses gain access to electricity. Annual growth in commercial delivered electricity use is expected to average 4.3 percent through 2025 (Figure 23), with projected consumption of 5.4 quadrillion Btu in

Figure 22. Commercial Sector Energy Consumption by Region, 2002-2025

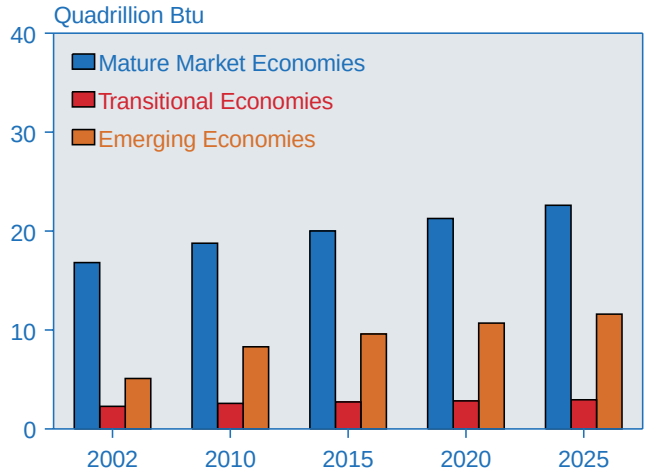


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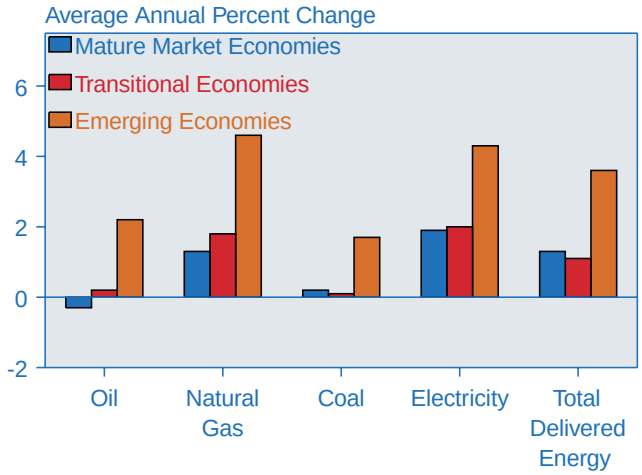
Figure 23. Growth in Commercial Sector Delivered Energy Consumption by Region and Fuel, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2025:** EIA, System for the Analysis of Global Energy Markets (2005).

2015 and 6.9 quadrillion Btu in 2025. The projected increase in commercial electricity demand is compounded in nations with quickly growing economies, such as China, as they begin to shift away from heavy manufacturing toward services.

Increasing commercial activity is expected to lead to rapid growth in natural gas demand as well. In the forecast, commercial demand for natural gas grows by 5.7 percent per year from 2002 through 2015 and by 4.6 percent per year from 2002 through 2025, as several developing countries focus on expanding the infrastructure necessary for delivery of this relatively clean fuel. Commercial sector oil consumption is expected to increase from 1.6 quadrillion Btu in 2002 to 2.4 quadrillion Btu in 2015 and 2.6 quadrillion Btu in 2025 in the emerging economies, increasing more rapidly in areas where natural gas availability is limited. Although consumption of coal is expected to increase in the forecast, its share of commercial energy use in the emerging economies is projected to decline from 8 percent in 2002 to 5 percent in 2025.

Industrial Sector

Energy is consumed in the industrial sector by a diverse group of industries—including manufacturing, agriculture, mining, and construction—and for a wide range of activities, such as process and assembly uses, space conditioning, and lighting. Overall energy demand in the industrial sector varies across regions and countries of the world, based on the level and mix of economic activity, technological development, and population, among other factors.

Worldwide, energy consumption in the industrial sector is projected to grow by 2.1 percent per year from 2002 to 2025. Industrial energy consumption is expected to increase in all countries and regions; however, industrial sector energy use in the mature market economies (in particular, Japan, the United States, and Western Europe) is expected to grow at a much slower pace—1.0 percent per year—than in the emerging economies (China and other emerging Asia and the Middle East), where industrial sector energy demand is projected to expand by 3.3 percent per year or more (Figure 24).

Mature Market Economies

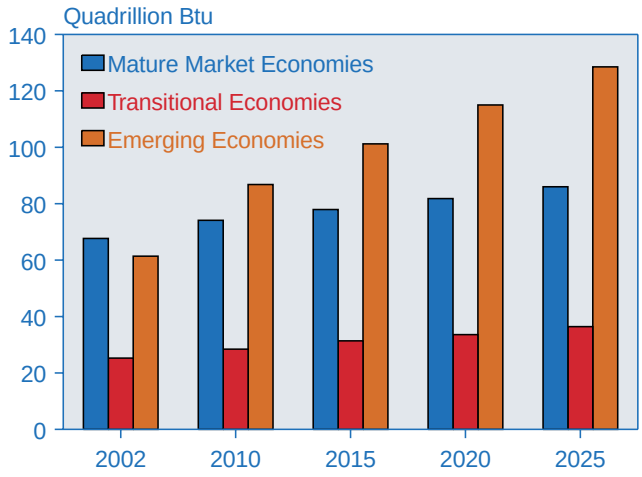
The mature market economies generally have more energy-efficient industrial operations and a mix of industrial output that is more heavily weighted toward non-energy-intensive sectors than do the other country groups. For example, in the United States, the manufacturing share of total industrial output has declined steadily over the past two decades, while the output share for service industries (included in the commercial sector) has increased. Additionally, within the U.S. manufacturing sector, a smaller share of output has been produced by the heavy, energy-intensive industries (such as steelmaking). These general trends are projected to continue.

Similar developments are expected for the other mature market economies, as increasing international trade fosters a shift toward a less energy-intensive mix of industrial activity. For example, many of Japan's heavy industries are reducing their output as demand for energy-intensive materials increasingly is met by imports from China and other Asian countries. In Germany, a decline in industrial energy intensity in the early 1990s was largely the result of closures of heavy industries in the former East Germany after reunification. Much of Germany's inefficient, energy-intensive eastern capacity has already been shut down, but further improvements are projected as capital stock is replaced and modernized.

Transitional Economies

In the EE/FSU countries, industrial sector energy use is projected to grow by 1.6 percent per year over the forecast period, from 25.3 quadrillion Btu in 2002 to 31.4 quadrillion Btu in 2015 and 36.4 quadrillion Btu in 2025 (Figure 24). During the Soviet era, abundant energy resources in the FSU, along with centralized decision-making, led to the construction of energy-inefficient industrial capacity. As the transition to market economies progresses, and as inefficient capacity is replaced with modern facilities, the intensity of energy use in the industrial sector of the transitional EE/FSU economies is projected to decline more rapidly than in rest of the world.

Figure 24. Industrial Sector Energy Consumption by Region, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Russia has the world's largest natural gas reserves. As a result, natural gas is projected to supply 40 percent of the increase in delivered energy use in the industrial sector of the FSU countries. In the transitional EE/FSU economies, only small changes in industrial fuel mix are projected from 2002 to 2025 (Figure 25)—most notably, electricity is projected to claim a growing share of delivered energy use in the FSU, and in the countries of Eastern Europe, natural gas is projected to make up a larger share at the expense of coal.

In 2002, in the aggregate, the transitional economies of the EE/FSU region had a higher ratio of industrial sector energy consumption to regional gross domestic product than did either the mature market or emerging nations. The relatively high ratio is a result of three factors: the transition to market-based economies has been slow; a higher proportion of total output from the region is from the industrial sector than in the developed countries (the service sectors are less energy-intensive than the manufacturing sectors); and much of the industrial sector's production is from inefficient Soviet-era facilities.

Emerging Economies

The emerging economies are expected to see the most rapid growth in industrial sector energy use worldwide over the projection period. Whereas mature market economies have shifted their industrial sector energy use from energy-intensive production (like steel and cement making) to service industries, the emerging economies still have fairly energy-intensive industrial sectors. Projections of industrial energy growth (although still relatively high) are lower than the recent historical rates for rapidly developing Asian countries like South Korea and China. Energy use for industrial sector purposes among the emerging economies is projected to grow by 3.9 percent per year from 2002 to 2015, before slowing to an average of 2.4 percent per year from 2015 to 2025 (Figure 26).

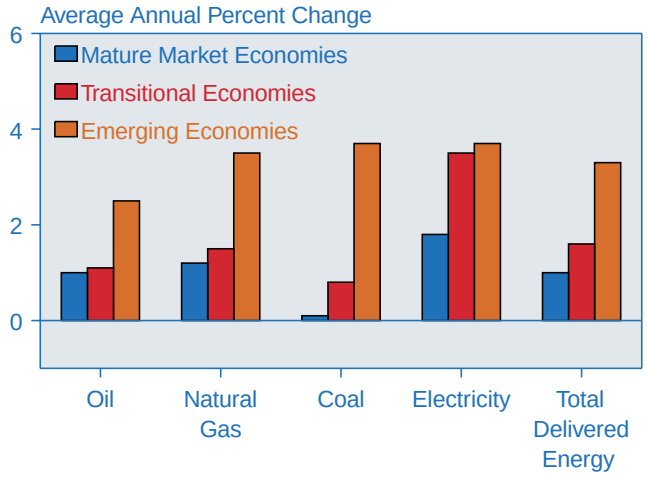
Natural gas and oil accounted for more than one-half of industrial energy consumption in 2002 in most regions of the world. China and India were exceptions to that generalization, and both countries use considerable amounts of coal (50 percent and 37 percent, respectively), mostly owing to their rich coal resources and lack of other domestic energy resources available for development.

Transportation Sector

Energy use in the transportation sector is dominated by petroleum product fuels. Barring any increase in the penetration of new technologies, such as hydrogen-fueled vehicles, the use of alternative fuels is expected to remain relatively modest through 2025. Thus, the *IEO2005* reference case projection of 2.1-percent average annual growth in the world's total energy use for transportation from 2002 to 2025 is paralleled by the forecast for transportation oil use (Table 3 and Figure 27).

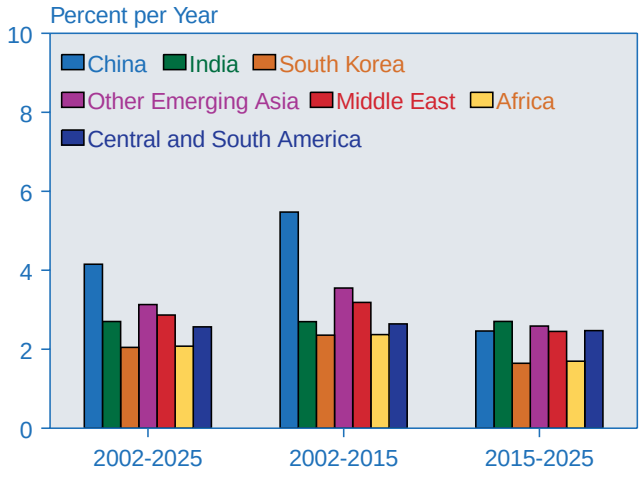
Energy use for the transportation sector is poised for its strongest growth in the Asian emerging economies. China is the key market that will lead regional consumption growth. India is also on a rapid growth path, and the region's mid-sized markets, such as Thailand and

Figure 25. Growth in Industrial Sector Delivered Energy Consumption by Region and Fuel, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2025:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 26. Average Annual Growth Rates for Industrial Energy Consumption in Emerging Economies, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Indonesia, also are projected to post strong growth. In China the number of cars has been growing by 20 percent per year, and the potential growth is almost unlimited. If the present patterns persist, China's car ownership would exceed the U.S. rate by 2030; however, large infrastructure barriers will have to be overcome for this to occur [*1*].

Mature Market Economies

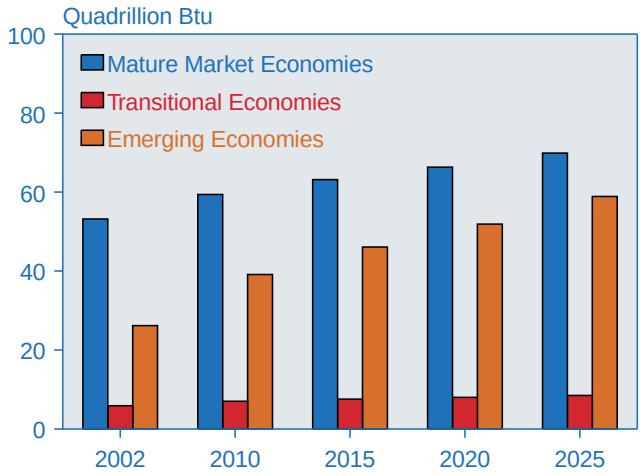
In general, the transportation sector of the mature market economies is fully established, with extensive infrastructure that includes highways, airport facilities, and rail systems. Energy demand in the mature market economies is projected to grow at an average annual rate of 1.2 percent, from 53.2 quadrillion Btu in 2002 to 63.2 quadrillion Btu in 2015 and 69.9 quadrillion Btu in 2025.

In the United States, the transportation sector accounts for almost one-fourth of the country's total energy consumption; and in the *IEO2005* reference case, U.S. transportation energy demand is projected to grow from 26.9 quadrillion Btu in 2002 to 34.2 quadrillion Btu in 2015 and 39.4 quadrillion Btu in 2025. The United States is the largest user of transportation energy among the mature market economies and is projected to consume 56 percent of the region's total for the transportation sector in 2025.

Fuel economy for the U.S. light-duty vehicle stock is projected to improve by 5 percent over the forecast period. Strong macroeconomic and demographic factors are expected to increase the demand for larger, more powerful vehicles in the United States; however, advanced technologies and materials are expected to provide increased performance and size while improving new vehicle fuel economy. Fuel economy standards for cars are assumed to stay at current levels of 27.5 miles per gallon, and light truck standards are expected to increase from 20.7 miles per gallon in 2004 to 22.2 miles per gallon by 2007 [**2**]. For the stock of freight trucks, fuel economy is projected to increase from 6.0 miles per gallon in 2002 to 6.6 miles per gallon in 2025. A larger gain, 24.1 percent, is expected for aircraft.

In comparison to the United States, transportation energy demand in Western Europe is projected to expand more slowly, from 16.3 quadrillion Btu in 2002 to

Figure 27. Transportation Sector Energy Consumption by Region, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table 3. Transportation Energy Consumption and Total Oil Consumption by Region, 2002-2025
(Quadrillion Btu)

Region	2002	Projections				Average Annual Percent Change	
		2010	2015	2020	2025	2002-2015	2002-2025
Mature Market Economies							
Transportation Energy	53.2	59.4	63.2	66.3	69.9	1.3	1.2
Total Oil	88.8	96.4	101.3	105.5	110.3	1.0	0.9
Transitional Economies							
Transportation Energy	5.9	7.0	7.6	8.0	8.5	1.9	1.6
Total Oil	11.4	13.1	13.9	14.8	15.7	1.5	1.4
Emerging Economies							
Transportation Energy	26.2	39.1	46.1	51.9	58.9	4.4	3.6
Total Oil	59.2	83.6	95.5	106.3	117.4	3.7	3.0
Total World							
Transportation Energy	85.3	105.5	116.8	126.2	137.2	2.5	2.1
Total Oil	159.4	193.1	210.6	226.6	243.4	2.2	1.9

Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

17.3 quadrillion Btu in 2015 and 18.0 quadrillion Btu in 2025. The transportation sector's share of total energy use is projected to remain about the same over the forecast period, at 24 percent. Low population growth, high taxes on transportation fuels, and environmental policies are expected to slow the rate of energy demand growth in Western Europe to an average rate of 0.4 percent per year over the 2002 to 2025 time period.

Oil is projected to remain Western Europe's largest energy source for transportation, with demand increasing by 0.3 percent per year on average from 2002 to 2025. Transportation accounts for more than one-half of the increment in total oil use projected for the region, with the industrial sector accounting for the remainder. Declines in oil use are projected for the region's residential and commercial sectors. The fastest rate of growth in Western Europe's transportation fuel use is expected to occur in the aviation sector. Demand for diesel fuel is expected to increase more rapidly than demand for gasoline, because most countries in Western Europe are expected to keep taxes on diesel fuel lower than those for gasoline throughout the forecast period.

Transportation energy use in Japan is projected to grow at an average rate of 0.2 percent per year from 2002 to 2025, from 4.2 quadrillion Btu in 2002 to 4.4 quadrillion Btu in 2015 and remaining at that level through 2025, mainly because of Japan's aging population, projected low birth rate, and high taxes levied on motorists. Passenger cars in Japan are subject to nine taxes, imposed on acquisition, ownership, and operation. The taxes, aimed at reducing oil imports and securing government funds for infrastructure projects, such as road maintenance and construction, account for one-tenth of total government revenues.

Transitional Economies

Energy demand in the EE/FSU transportation sector as a whole is projected to grow at an average annual rate of 1.6 percent, from 5.9 quadrillion Btu in 2002 to 7.6 quadrillion Btu in 2015 and 8.5 quadrillion Btu in 2025. The growth in transportation energy use in this region is expected to be led by expanding ownership of private automobiles and an increasing role of trucking in freight transportation.

Emerging Economies

For the emerging economies as a whole, transportation sector energy consumption is projected to grow by 3.6 percent per year, from 26.2 quadrillion Btu in 2002 to 46.1 quadrillion Btu in 2015 and 58.9 quadrillion Btu in 2025—the highest rate of growth in transportation energy use worldwide. In 2002, the emerging economies accounted for about 31 percent of world energy use for transportation. In 2025, their share is projected to be 43 percent, as the gap between transportation energy consumption in the emerging economies and in the mature market economies narrows substantially over the forecast (Figure 27).

China's energy use for transportation is projected to grow by an average of 6.0 percent per year over the forecast, from 4.1 quadrillion Btu in 2002 to 10.4 quadrillion Btu in 2015 and 15.5 quadrillion Btu in 2025. Virtually all of the increase in transportation energy consumption is projected to be in the form of petroleum products. Road transport is expected to be the primary factor in China's growing demand for transportation fuels. There were 7.5 million automobiles and 6.4 million commercial vehicles in China in 2002 (as compared with 136.0 million automobiles and 89.4 million commercial vehicles in the United States) [*3*]. Personal travel in China has soared in the past two decades, with passenger miles traveled increasing fivefold [*4*]. Those trends are expected to continue over the projection period.

In India, energy demand in the transportation sector is projected to grow at an average rate of 4.7 percent a year, from 1.4 quadrillion Btu in 2002 to 3.1 quadrillion Btu in 2015 and 4.1 quadrillion Btu in 2025. The transportation sector's share of total energy use is expected to grow from 10 percent in 2002 to 14 percent in 2025. In comparison with other countries in the emerging Asia region, some of India's transportation infrastructure is well developed—especially the railways (although many rural areas still are largely inaccessible by rail). India has the most extensive railway system in the world, dating back to colonial times. An estimated 1.6 million people are employed by the country's railway system, making it the world's largest employer [*5*].

In South Korea, transportation energy demand is projected to grow by 1.9 percent per year, from 1.7 quadrillion Btu in 2002 to 2.3 quadrillion Btu in 2015 and 2.6 quadrillion Btu in 2025. South Korea's total demand for oil is projected to grow at an average annual rate of 1.3 percent, from 4.5 quadrillion Btu in 2002 to 6.1 quadrillion Btu in 2025—much slower than the average of 8.0 percent per year over the past three decades, reflecting the relative maturity of the South Korean transportation sector. Just over one-half of the country's projected increase in oil demand is expected in the transportation sector, with much of the remainder in the industrial sector.

Energy demand in the transportation sector in the other emerging nations of Asia (the largest of which are Thailand, Indonesia, Malaysia, Singapore, Taiwan, and Hong Kong) is projected to grow from 6.2 quadrillion Btu in 2002 to 10.1 quadrillion Btu in 2015 and 13.1 quadrillion Btu in 2025. The transportation share of total energy use in the region is projected to increase from 27 percent in 2002 to 29 percent in 2025, as national economies continue to mature and rising standards of living result in increased motor transport.

The Middle East region has a relatively small population and is not a major energy consumer but rather an exporter; however, rapid population growth is expected to result in more energy use for transportation in the future. The region's energy demand for transportation is projected to grow from 4.5 quadrillion Btu in 2002 to 6.8 quadrillion Btu in 2015 and 8.0 quadrillion Btu in 2025. Demand for transportation fuels in traditional exporting countries such as Saudi Arabia, Kuwait, Iraq, Oman, the United Arab Emirates, Yemen, and, most notably, Iran made the region a net importer of gasoline in 2003; however, that trend is expected to be reversed by 2010, when planned expansions of refinery capacity come on line.

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2. Energy Information Administration, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, January 2004), Table A7, web site www.eia.doe.gov/oiaf/aeo/.
3. S.C. Davis and S.W. Diegel, *Transportation Energy Data Book: Edition 24*, ORNL-6973 (Oak Ridge, TN: Oak Ridge National Laboratory December 2004), Tables 3.1 and 3.2, web site http://cta.ornl.gov/data/Index.shtml.
4. International Energy Agency, *World Energy Outlook 2004* (Paris, France, October 2004), web site www.worldenergyoutlook.org.
5. World Markets Research Centre, "Automotive Sector Analysis: India and China" (October 18, 2004), web site www.wmrc.com.

World Oil Markets

IEO2005 projects that world crude oil prices in real 2003 dollars will decline from their current level by 2010, then rise gradually through 2025.

In the *International Energy Outlook 2005* (*IEO2005*) reference case, world demand for crude oil grows from 78 million barrels per day in 2002 to 103 million barrels per day in 2015 and to just over 119 million barrels per day in 2025. Much of the growth in oil consumption is projected for the emerging Asian nations, where strong economic growth results in a robust increase in oil demand. Emerging Asia (including China and India) accounts for 45 percent of the total world increase in oil use over the forecast period in the *IEO2005* reference case.

The projected increase in world oil demand would require an increment to world production capability of more than 42 million barrels per day relative to the 2002 crude oil production capacity of 80.0 million barrels per day. Producers in the Organization of Petroleum Exporting Countries (OPEC) are expected to be the major source of production increases. In addition, non-OPEC supply is expected to remain highly competitive, with major increments to supply coming from offshore resources, especially in the Caspian Basin, Latin America, and deepwater West Africa. The estimates of incremental production are based on current proved reserves and a country-by-country assessment of ultimately recoverable petroleum. In the *IEO2005* oil price cases, the substantial investment capital required to produce the incremental volumes is assumed to exist, and the investors are expected to receive at least a 10-percent return on investment.

In 2004, crude oil prices averaged $36 per barrel (see text box below), with prices turning upward throughout the year and well into 2005. Although OPEC production quotas (excluding Iraq) were raised from 23.5 million barrels per day in April 2004 to 28.0 million barrels per day in July 2005, world oil prices generally continued to rise [***1***]. In June 2005, crude oil futures prices exceeded $60 per barrel, a record high price in nominal dollars [**2**].

Several factors have worked to keep world crude oil prices high in the near term. First, world petroleum demand grew at a robust 3.4 percent (2.7 million barrels per day) in 2004, reflecting dramatic increases in China's demand for oil-generated power and oil-based transportation fuels, as well as a rebound in U.S. oil demand. Second, oil prices typically are sensitive to any incremental tightening of supply during periods of high economic growth. On the supply side, there was very little spare upstream capacity, and the spare downstream capacity was not always properly configured to produce the required slate of products. World oil inventories, in terms of "days of supply," were unusually low. Next, geopolitical tensions in major oil-producing countries—including the continuing the war in Iraq and uncertain prospects for a return to normalcy in Iraq's oil sector—and potential unrest in Nigeria and Venezuela contributed to the volatility in world oil markets.

Tempered by high world oil prices, growth in world petroleum demand in 2005 is expected to remain strong, while retreating somewhat from its 2004 pace. Any expectation of incremental supply tightness in non-OPEC supply or downstream refinery capacity could cause crude oil prices to increase even further. As a result, the refiner acquisition cost of imported crude oil in 2005 is expected to average more than $47 per barrel. OPEC producers may find it more challenging to maintain high oil prices over the next few years, however, given the projected increase in non-OPEC supply.

Despite evidence that OPEC members have achieved some of their price goals in recent years by using a price-band strategy, production cutbacks have historically had only limited success. OPEC's market management strategies have often ended in failure, and its successes for the most part have been the result of tight market conditions and disciplined participation by OPEC members. Currently, spare production capacity worldwide—with the exception of two or three Persian Gulf members of OPEC—is negligible, making OPEC's consensus building easier. Non-OPEC production is expected to show significant increases over the next 5

World Oil Prices in *IEO2005*

World oil prices in *IEO2005* are defined on the basis of "average refiner acquisition cost" of imported oil to the United States (IRAC). The IRAC price tends to be a few dollars less than the widely cited West Texas Intermediate (WTI) spot price. WTI is a higher quality, lighter, low-sulfur crude than that represented by IRAC. In recent months, IRAC has been as much as 6 dollars a barrel lower than the WTI. In 2004, WTI averaged $41.44 per barrel and IRAC averaged $36.00 per barrel (in nominal dollars).

years, and a number of OPEC member countries have announced plans to expand production capacity in the short term. In an oil market environment with substantial spare production capacity, it will be more difficult for OPEC to achieve agreement among its members; however, obstacles to investment in new production capacity in some areas with abundant resources may keep the growth in supply below its expected potential.

Although OPEC's share of world oil supply is projected to increase significantly over the next two decades, competitive forces are expected to remain strong enough to forestall efforts to escalate real oil prices significantly. Competitive forces operate within OPEC, between OPEC and non-OPEC sources of supply, and between conventional oil and other sources of energy (particularly, nonconventional oil, natural gas, and coal).

Non-OPEC producers have been somewhat slow in reacting to higher oil prices; however, there remains significant untapped production potential worldwide, especially in deepwater areas. Deepwater exploration and development initiatives generally are expected to be sustained worldwide, with the offshore Atlantic Basin emerging as a major future source of oil production in both Latin America and Africa.

Although the lag between higher prices and increases in drilling activity seems to have increased in the aftermath of the low price environment of 1998 and 1999, non-OPEC production has increased by more than 3 million barrels per day over the past 3 years and is expected to add an additional 0.7 million barrels per day in 2005. More than one-half of the worldwide increase in non-OPEC production over the next 2 years is expected to come from the former Soviet Union (FSU), and the remainder is expected to come mainly from the emerging economies of the Atlantic Basin (Latin America and West Africa). Technology and resource availability can sustain large increments in oil production capability at prices well below the current level.

Incorporating the recent price turbulence into the construction of an intermediate- and long-term oil market outlook is difficult and raises the following questions: Will OPEC maintain its cutback strategy in order to keep prices within a certain price band, or will the anticipated increase in non-OPEC production exert downward pressure on prices? Will China and other emerging economies of Asia be able to sustain the current robust economic growth and a corresponding increase in their demand for oil in the long term? Will technology guarantee that oil supply development will move forward even if a low world oil price environment returns?

The uncertainties associated with the *IEO2005* reference case projections are significant. The war in Iraq, the international war on terrorism, uncertain economic recovery in emerging Asia and Japan, the success of China's economic reforms and its political situation, the potential for social unrest in Venezuela and Nigeria, Brazil's impact on other Latin American economies, and uncertain prospects for the pace of economic recovery in the FSU all increase the risk of near-term political and policy discontinuities that could lead to oil market behavior quite different from that portrayed in the projections.

World Oil Demand

World oil consumption rose by about 2.7 million barrels per day in 2004, with the mature market economies accounting for only about one-fourth of the increase. Demand in the emerging economies rose by almost 1.9 million barrels per day, with China accounting for more than one-half of that increase. Current growth in the emerging Asian economies is beginning to show signs of a return to the rapid economic expansion of the early and mid-1990s. Latin America's oil demand continues to grow at a modest rate. In the FSU, oil demand is expected to show a modest increase for 2004. In 2005, global oil demand is expected to grow by about 2.2 million barrels per day [*3*].

In the *IEO2005* reference case forecast, growth in world oil demand averages 1.9 percent per year over the forecast period. Most of the world's incremental oil demand is projected for use in the transportation sector, where there are currently no competitive alternatives to petroleum; however, several of the technologies associated with nonconventional liquids (gas to liquids, coal to liquids, and energy crops that can be used to produce ethanol and biodiesel) could reduce the pressure on conventional oil supply from the transportation sector. Of the projected increase in oil use in the reference case over the 2002 to 2025 period, 61 percent occurs in the transportation sector (Figure 28). The industrial sector also accounts for a fairly large share of the projected increase in world oil consumption: 28 percent of the increase is expected to be for industrial sector uses, mostly for chemical and petrochemical processes.

On a regional basis, two parts of the world account for most of the projected growth in world oil demand: emerging Asia and North America (Figure 29). Outside North America, oil consumption in the mature market economy regions grows much more slowly—by 0.3 percent per year—in both Western Europe and mature market Asia, reflecting expectations of slow growth or declines in population and economic growth over the next two decades.

In the emerging economies, strong expansion of oil use is projected, as robust economic growth fuels demand for oil to fuel burgeoning industrial sectors and rapidly expanding transportation use. The fastest growth in oil demand is projected for the emerging Asian economies, at an average rate of 3.5 percent per year over the

forecast period, and the other emerging economy regions also are expected to experience fast-paced increases in oil use. From 2002 to 2025, consumption of petroleum is projected to increase on average by 2.1 percent per year in the Middle East, 2.5 percent per year in Central and South America, and 2.7 percent per year in Africa.

Economic development in Asia will be crucial to long-term growth in oil markets. China, India, and the other nations of emerging Asia are expected to experience combined economic growth of 5.5 percent per year between 2002 and 2025, the highest rate of growth in the world. This robust expansion in gross domestic product (GDP) translates to a 3.5-percent annual increase in regional oil use. The projected evolution of Asian oil demand in the reference case could strengthen economic ties between the Middle East and Asia, as Asian nations rely more and more on Middle East oil supplies.

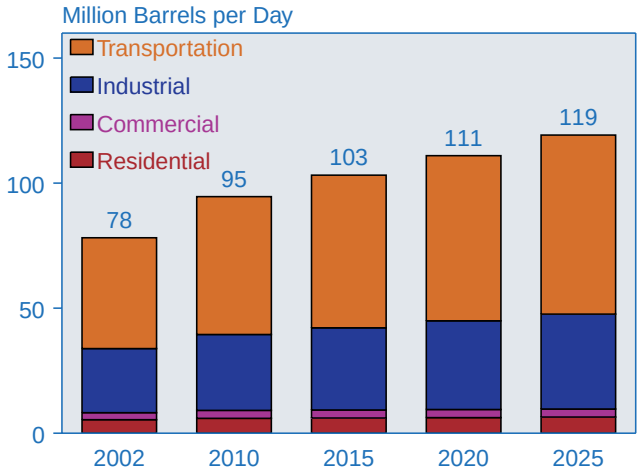
In the transitional economies of Eastern Europe and the FSU (EE/FSU), oil consumption increases on average by 1.4 percent per year in the reference case forecast, from 5.5 million barrels per day in 2002 to 7.6 million barrels per day in 2025. Oil use in the EE/FSU region dropped precipitously after the collapse of the Soviet regime in the early 1990s, from 10.0 million barrels per day in 1990 to 5.3 million barrels per day in 1997, as the region's GDP contracted by almost one-third. Growth in oil demand in the EE/FSU region has begun to recover in recent years and by 2002 had reached 5.5 million barrels per day. Positive economic growth returned to the FSU in 1999, when high world oil prices and a devalued ruble helped Russia, the region's largest economy and a major world oil exporter, post strong economic gains by boosting performance in its industrial sectors and increasing consumer demand for domestically produced goods. Even with the robust economic growth (an average of 4.4 percent per year) projected for the region, oil demand in the EE/FSU is not expected to be as strong in 2025 as it was in 1990.

World Oil Prices

The world oil price in the *International Energy Outlook 2005* (*IEO2005*) is defined as the annual average U.S. refiner acquisition cost of imported crude oil. Three distinct world oil price scenarios are represented in *IEO2005*, reaching $21, $35, and $48 per barrel in 2025, respectively, in the low world oil price, reference, and high world oil price cases in 2003 dollars. Although the *IEO* typically uses the same reference case as the *Annual Energy Outlook*, *IEO2005* has adopted the October futures case from the *Annual Energy Outlook 2005* (*AEO2005*) as its reference case for the United States. The October futures case, which has an assumption of higher world oil prices than in the *AEO2005* reference case, now appears to be a more likely projection.[2]

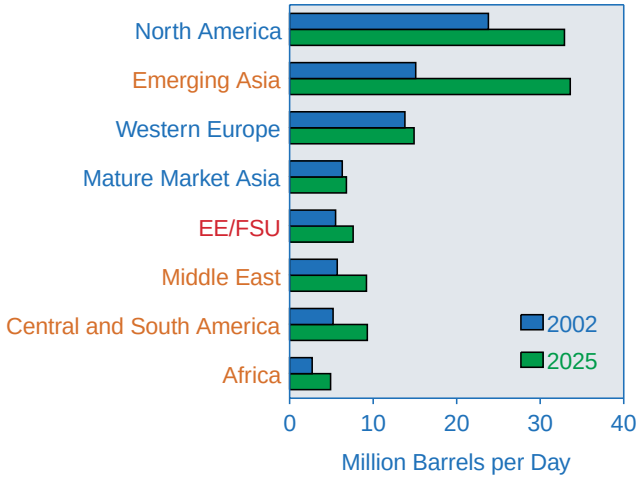
In October 2004, the New York Mercantile Exchange (NYMEX) oil futures prices implied that the annual average oil price in 2005 will exceed its 2004 level before

Figure 28. World Oil Consumption by End-Use Sector, 2002-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 29. World Oil Consumption by Region and Country Group, 2002 and 2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2025:** EIA, System for the Analysis of Global Energy Markets (2005).

[2]For detailed descriptions and comparisons of the *AEO2005* reference, October oil futures, and other world oil price cases, see Energy Information Administration, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), pp. 40-50, web site www.eia.doe.gov/oiaf/aeo. The reference case will be reconsidered for the next *AEO*. Based on information available as of July 2005, the *AEO2006* reference case will likely incorporate world oil prices higher than those in the *IEO2005* reference case.

falling back somewhat. The *AEO2005* October oil futures case is based on an extrapolation of oil prices loosely corresponding to the mid-term profile of prices on the NYMEX futures market in October 2004.

The low world oil price case reflects a future market where oil production becomes more competitive and plentiful. There are several ways in which this could come about. First, the OPEC countries could become less cohesive, with each producer attempting to sell as much of its production capacity as the market will allow. Another possibility would be a decline in the costs of non-OPEC oil production or the viable development of competitive alternatives. To forestall the penetration of alternatives and other sources of competition, OPEC would be expected to lower its price band and increase production. The high price case, in contrast, assumes that world oil prices will remain close to current levels for the foreseeable future.

Although oil prices rose by more than $9 per barrel over the course of 2004 and are expected to add an additional $7 per barrel in 2005, such developments are not indicative of the long-term trend in the *IEO2005* reference case. From anticipated high levels throughout 2005, oil prices are expected to decline gradually to $31 per barrel in 2010, then rise by about 0.8 percent per year to $35 in 2025 (all price projections in 2003 dollars unless otherwise noted).

The near-term price trajectory in the *IEO2005* reference case is considerably different from that in the *International Energy Outlook 2004* (*IEO2004*). Last year's reference case price path did not reflect the upward price pressure in 2004 brought about by the conditions that have led to market tightness. In both the *IEO2004* and *IEO2005* reference cases, oil prices rise gradually from about 2010 through 2025. This price path reflects the recognition that OPEC has been able to limit production for the purpose of firming up prices and that continued robust projections for oil demand, especially among the emerging economies, will to some extent maintain pressure on oil markets.

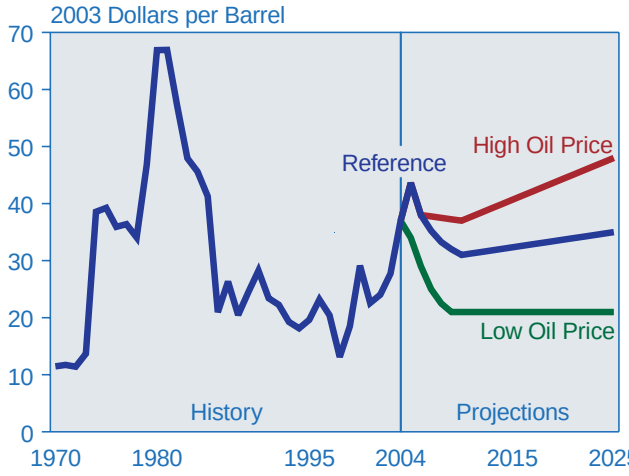
Three alternative long-term price paths are shown in Figure 30. In the *IEO2005* reference case, projected prices reach $35 per barrel in 2025 in 2003 dollars. In nominal dollars, the reference case price is expected to approach $60 per barrel in 2025. In the low price case, prices are projected to reach $21 per barrel in 2009 and to remain at about that level out to 2025. In the high price case, prices are projected to reach $37 per barrel in 2013 and increase steadily to $48 per barrel in 2025. While the three cases shown in Figure 30 vary widely, they do not span the full range of possible scenarios.

In all the *IEO2005* oil price cases, oil demand is expected to rise significantly over the projection period. In the high and low world oil price cases, the projected increases in oil consumption from 2002 to 2025 are 35 million barrels per day and 53 million barrels per day, respectively. Resources are not expected to be a key constraint on world demand to 2025. Rather more important are the political, economic, and environmental circumstances that could shape developments in oil supply and demand.

Oil prices have been highly volatile over the past 25 years, and periods of price volatility can be expected in the future principally because of unforeseen political and economic circumstances. It is well recognized that tensions in the Middle East, for example, could give rise to serious disruptions of normal oil production and trading patterns. On the other hand, market forces can play a significant role in restoring balance over an extended period. High real prices deter consumption and encourage the emergence of significant competition from large marginal sources of oil, which currently are uneconomical to produce, and other energy supplies. Persistently low prices have the opposite effects.

Limits to long-term oil price escalation include substitution of other fuels (such as natural gas) for oil, marginal sources of conventional oil that become reserves (i.e., economically viable) when prices rise, and nonconventional sources of oil that become reserves at still higher prices. Advances in exploration and production technologies are likely to bring prices down when such additional oil resources become part of the reserve base. There are some oil market analysts, however, who find this viewpoint overly optimistic, based on what they consider to be a significant overestimation of both proven reserves and ultimately recoverable resources.

Figure 30. World Oil Prices in Three Cases, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *Annual Energy Review 2003*, DOE/EIA-0384(2003) (Washington, DC, September 2004), web site www.eia.doe.gov/emeu/aer/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005). Note: *IEO2005* uses the *AEO2005* October oil futures case as its reference case.

The Composition of World Oil Supply

A three-step approach was used to determine the composition of world oil supply in the three *IEO2005* oil price cases. The first step determined whether the oil resource base would be sufficiently robust to meet worldwide demand. The second step determined how much non-OPEC oil (both conventional and nonconventional) could be produced at the assumed price path. An important criterion in the second step was whether producers would receive an adequate rate of return on their investment (usually 10 percent). With total non-OPEC supply having been established, the third step assumed that the remainder of the worldwide demand would be met by OPEC producers and determined an appropriate production capacity for each OPEC producer.

It is important to note what this simple three-step approach did and did not assume. A business-as-usual oil market environment was assumed. Disruptions in oil supply for any reason (war, terror, weather, geopolitics) were not assumed. It was assumed that all non-OPEC oil projects that show a favorable rate of return on investment would be funded, and that OPEC would act as the residual supplier of oil to the world. For the forecast period out to 2025, there is sufficient oil to meet worldwide demand. Peaking of world oil production is not anticipated until after 2030.

In the *IEO2005* reference case, world oil supply in 2025 is projected to exceed the 2002 level by almost 41 million barrels per day. Increases in production are expected for both OPEC and non-OPEC producers; however, only about 41 percent of the total increase is expected to come from non-OPEC areas. Over the past two decades, the growth in non-OPEC oil supply has resulted in an OPEC market share substantially under its historic high of 52 percent in 1973. New exploration and production technologies, aggressive cost-reduction programs by industry, and attractive fiscal terms to producers by governments all contribute to the outlook for continued growth in non-OPEC oil production.

The reference case projects that about 59 percent of the increase in petroleum demand over the next two decades will be met by an increase in production by members of OPEC rather than by non-OPEC suppliers. OPEC production in 2025 is projected to be more than 24 million barrels per day higher than it was in 2002 (Figure 31). The *IEO2005* estimates of OPEC production capacity in 2010 are slightly less than those projected in *IEO2004*, reflecting a shift toward non-OPEC supply projects in scenarios with higher prices. Some analysts suggest that OPEC members might pursue significant price escalation through conservative capacity expansion decisions rather than undertake major production expansion programs. Such behavior would tend to raise world oil prices.

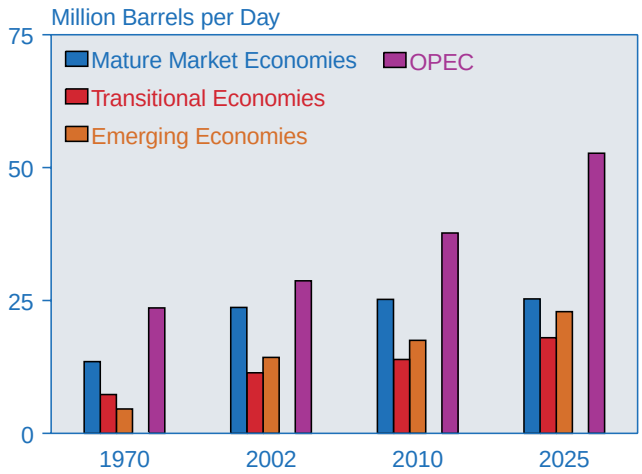
Reserves and Resources

Table 4 shows estimates of the conventional oil resource base by region out to the year 2025. Proved reserves are from the annual assessment of worldwide reserves published by *Oil & Gas Journal* [**4**]. Reserve growth and undiscovered estimates are based on the World Petroleum Assessment 2000 by the U.S. Geological Survey (USGS). The oil resource base is defined by three categories: remaining reserves (oil that has been discovered but not produced); reserve growth (increases in reserves resulting mainly from technological factors that enhance a field's recovery rate); and undiscovered (oil that remains to be found through exploration). The information in Table 4 is derived from the USGS mean estimate, which is an average assessment over a wide range of uncertainty for reserve growth and undiscovered resources. The *IEO2005* oil production forecast is based on the USGS mean estimate.

Expansion of OPEC Production Capacity

It is generally acknowledged that OPEC members with large reserves and relatively low costs for expanding production capacity can accommodate sizable increases in petroleum demand. In the *IEO2005* reference case, the production call on OPEC suppliers is projected to grow at a robust annual rate of 2.7 percent through 2025 (Table 5 and Figure 32). OPEC capacity utilization is expected to increase slightly after 2002, reaching almost 95 percent by 2015 and remaining at about that level for the duration of the projection period.

Figure 31. World Oil Production in the Reference Case by Region, 1970, 2002, 2010, and 2025



Sources: **1970 and 2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219 (2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2010 and 2025:** EIA, System for the Analysis of Global Energy Markets (2005).

Amidst enormous uncertainty, Iraq's role in OPEC in the next several years will be of particular interest. In 1999, Iraq expanded its production capacity to 2.8 million barrels per day in order to reach the slightly more than $5.2 billion in oil exports allowed by United Nations Security Council resolutions. The expansion was required because of the low price environment of early 1999. In the *IEO2005* reference case, Iraq is

Table 4. Estimated World Oil Resources, 1995-2025
(Billion Barrels)

Region	Proved Reserves	Reserve Growth	Undiscovered	Total
Mature Market Economies				
United States	21.9	76.0	83.0	180.9
Canada	178.8	12.5	32.6	223.9
Mexico	14.6	25.6	45.8	86.0
Western Europe	15.8	19.3	34.6	69.7
Japan	0.1	0.1	0.3	0.5
Australia/New Zealand	1.5	2.7	5.9	10.1
Transitional Economies				
Former Soviet Union	77.8	137.7	170.8	386.3
Eastern Europe	1.5	1.5	1.4	4.4
Emerging Economies				
China	18.3	19.6	14.6	52.5
India	5.4	3.8	6.8	16.0
Other Emerging Asia	11.0	14.6	23.9	49.5
Middle East	729.6	252.5	269.2	1,251.3
Africa	100.8	73.5	124.7	299.0
Central and South America	100.6	90.8	125.3	316.7
Total World	**1,277.7**	**730.2**	**938.9**	**2,946.8**
OPEC	885.2	395.6	400.5	1,681.3
Non-OPEC	392.5	334.6	538.4	1,265.5

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

Sources: **Proved Reserves as of January 1, 2005:** *Oil & Gas Journal*, Vol. 102, No. 47 (December 20, 2004), pp. 22-23. **Reserve Growth (Total) and Undiscovered:** U.S. Geological Survey, *World Petroleum Assessment 2000*, web site http://greenwood.cr.usgs.gov/energy/WorldEnergy/DDS-60. **Estimates of Regional Reserve Growth:** Energy Information Administration, *International Energy Outlook 2002*, DOE/EIA-0484(2002) (Washington, DC, March 2002), p. 32.

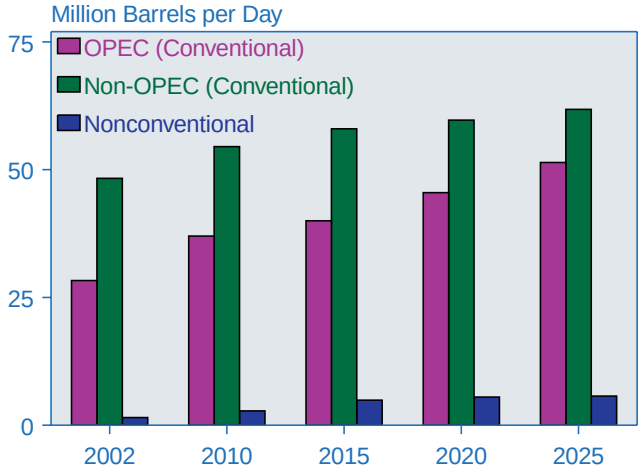
Table 5. OPEC Oil Production, 1990-2025
(Million Barrels per Day)

Year	Reference Case	High Oil Price	Low Oil Price
History			
1990	24.6	—	—
2002	28.7	—	—
Projections			
2010	37.7	33.3	42.8
2015	41.3	33.0	49.3
2020	46.8	35.4	57.3
2025	52.7	37.9	65.2

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219 (2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005). Note: *IEO2005* uses the *AEO2005* October oil futures case as its reference case.

Figure 32. OPEC, Non-OPEC, and Nonconventional Oil Production in the Reference Case, 2002 and 2010-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219 (2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

assumed to maintain its current oil production capacity of about 2.0 million barrels per day into 2005. Iraq has indicated a desire to expand its production capacity aggressively, to more than 6 million barrels per day, once the oil sector is deemed safe from terrorist activities. Preliminary discussions of exploration projects have already been held with potential outside investors, including France, Russia, and China. Such a significant increase in Iraqi oil exports would ease market tightness.

Given the requirements for OPEC production capacity expansion implied by the *IEO2005* estimates, much attention has been focused on the oil development, production, and operating costs of individual OPEC producers. With Persian Gulf producers enjoying a reserve-to-production ratio that exceeds 108 years, substantial capacity expansion clearly is feasible.

Production costs in Persian Gulf OPEC nations are less than $3 per barrel, and the capital investment required to increase production capacity by 1 barrel per day is less than $5,940 [**5**]. Assuming the *IEO2005* low price trajectory, total development and operating costs over the entire projection period would be about 24 percent of gross oil revenues. Thus, Persian Gulf OPEC producers can expand capacity at a cost that is a relatively small percentage of projected gross revenues.

For OPEC producers outside the Persian Gulf, the cost to expand production capacity by 1 barrel per day is considerably greater, exceeding $13,270 in some member nations; yet those producers can expect cost-to-revenue ratios of about 41 percent on investments to expand production capacity over the long term, even in the low price case [**5**]. Venezuela has the greatest potential for capacity expansion and could aggressively increase its production capacity by more than 1.0 million barrels per day, to between 4 and 5 million barrels per day in the mid-term. It is unclear, however, whether the current political climate will support the outside investment required for any substantial expansion of Venezuela's production capacity. Tables E1-E6 in Appendix E show the ranges of production potential for both OPEC and non-OPEC producers.

The reference case projection implies aggressive efforts by OPEC member nations to apply or attract investment capital to implement a wide range of production capacity expansion projects. The combination of potential profitability and the threat of competition from non-OPEC suppliers provides a rationale for the assumption of a relatively aggressive expansion strategy.

In the *IEO2005* reference case, OPEC members outside the Persian Gulf are expected to increase their production potential substantially, despite their higher capacity expansion costs. There is much optimism regarding Nigeria's offshore production potential, although it is unlikely to be developed until the middle to late part of this decade. In addition, increased optimism about the production potential of Algeria, Libya, and Venezuela supports the possibility of reducing the world's dependence on Persian Gulf oil.

Non-OPEC Supply

The growth in non-OPEC oil supplies played a significant role in the erosion of OPEC's market share over the past three decades, as non-OPEC supply became increasingly diverse. North America dominated non-OPEC supply in the early 1970s, the North Sea and Mexico evolved as major producers in the 1980s, and much of the new production in the 1990s came from the emerging economies of Latin America, West Africa, the non-OPEC Middle East, and China. In the *IEO2005* reference case, non-OPEC supply from proven reserves is expected to increase steadily, from 49.4 million barrels per day in 2002 to 66.2 million barrels per day in 2025 (Table 6).

There are several important differences between the *IEO2005* production profiles and those published in *IEO2004*:

- The U.S. production decline was somewhat more severe in the *IEO2004* projections than in this year's forecast, with *IEO2005* projecting lower exploration and production costs coupled with more optimistic finding rates in the National Petroleum Reserve-Alaska.
- The outlook for growth in Russia's oil production is slightly more optimistic in *IEO2005* as Russian companies in alliance with Western service companies continue to surprise industry experts with productivity increases in West Siberia.

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

Year	Reference Case	High Oil Price	Low Oil Price
History			
1990	42.1	—	—
2002	49.4	—	—
Projections			
2010	56.6	59.6	55.0
2015	61.7	66.7	59.0
2020	63.9	70.7	60.5
2025	66.2	75.1	62.4

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219 (2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005). Note: *IEO2005* uses the *AEO2005* October oil futures case as its reference case.

- The outlook for production of nonconventional liquids (especially from oil sands and ultra-heavy oils) is somewhat more optimistic in *IEO2005* as production costs decline and markets evolve.
- In the *IEO2005* projections, Caspian output is expected to exceed 3.3 million barrels per day in 2010 and to increase steadily thereafter. There still remains a great deal of uncertainty about export routes from the Caspian Basin region.

In *IEO2005*, the decline in North Sea production is slowed slightly, based on the implementation of strategies for redeveloping mature fields. Production from Norway, Western Europe's largest producer, is expected to peak at about 3.6 million barrels per day in 2006 and then decline gradually to about 2.5 million barrels per day by the end of the forecast period with the maturing of some of its larger and older fields. The United Kingdom sector is expected to produce about 2.2 million barrels per day in 2010, followed by a decline to 1.4 million barrels per day in 2025.

Two non-OPEC Persian Gulf producers are expected to increase output gradually through 2010. Enhanced recovery techniques are expected to increase current output in Oman by more than 190,000 barrels per day, with only a gradual production decline anticipated after 2010. Current oil production in Yemen is expected to increase by at least 50,000 barrels per day within the next 5 years, and those levels could show a slight increase throughout the projection period. Syria is expected to hold its production flat out to 2015, but little in the way of new resource potential will allow anything except declining production volumes from 2015 to 2025.

Oil producers in the Pacific Rim are expected to increase their production volumes significantly as a result of enhanced exploration and extraction technologies. India's deepwater prospects are expected to show some encouraging production increases in this decade, with the potential for significant increases near the end of the forecast period. Deepwater fields offshore from the Philippines have resulted in an improved reserve picture, with production expected to exceed 75,000 barrels per day by the end of the forecast period. Vietnam's long-term production potential still is viewed with considerable optimism, although exploration activity has been slower than originally hoped. Output from Vietnamese fields is projected to exceed 375,000 barrels per day in 2015.

Australia has continued to make additions to its proved reserves, and it is possible that its oil production could exceed 800,000 barrels per day by the end of this decade. Malaysia shows little potential for any significant new finds, and its output is expected to peak at around 750,000 barrels per day in this decade and then decline gradually to less than 700,000 barrels per day in 2025. Papua New Guinea continues to add to its reserve posture and is expected to achieve production volumes approaching 110,000 barrels per day by the end of this decade, followed by only a modest decline over the remainder of the forecast period. Exploration and test-well activity have pointed to some production potential for Bangladesh and Myanmar, but significant output is not expected until after 2010.

Oil producers in Central and South America have significant potential for increasing output over the next decade. Brazil became a million barrel per day producer in 1999, with considerable production potential waiting to be tapped. Brazil's production is expected to rise throughout the forecast period and to top 3.5 million barrels per day in 2025. Colombia's current economic downturn and civil unrest have delayed development of its upstream sector, but its output is expected to top 610,000 barrels per day within the decade and continue to show modest increases for the remainder of the forecast period. In both Brazil and Colombia, the oil sector would benefit significantly from the creation of favorable climates for foreign investment. Argentina is expected to increase its production volumes by at least 65,000 barrels per day over the next 3 years, and by the end of the decade it could possibly to become a million barrel per day producer. Although the current political situation in Ecuador is in transition, there is still optimism that Ecuador will double production volumes over the forecast period.

Several West African producers—Angola, Cameroon, Chad, Congo (Brazzaville), Equatorial Guinea, Gabon, Mauritania, Niger, Sao Tome and Principe, and Ivory Coast—are expected to reap the benefits of substantial exploration activity, especially if the current high prices persist. Angola is expected to become a million barrel per day producer by the end of this decade. Given the excellent deepwater exploration results, Angola could produce volumes of up to 3.4 million barrels per day in the later years of the forecast. The other West African producers with offshore tracts are expected to increase output by up to 1.1 million barrels per day for the duration of the forecast.

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

In North America, moderately declining U.S. output is expected to be supplemented by significant production increases in Canada and Mexico. Canada's conventional oil output is expected to contract steadily, by about 600,000 barrels per day over the next 20 years, but an additional 3.5 million barrels per day of nonconventional output from oil sands projects is expected to be added. Expected production volumes in Mexico exceed 4.2 million barrels per day by the end of the decade and continue to increase out to the end of the forecast period, by another 500,000 barrels per day.

With higher oil prices assumed to continue, oil production in the FSU is expected to exceed 15.0 million barrels per day in 2015, based in large part on a more optimistic outlook for investment in Russia. The long-term production potential for the FSU still is regarded with considerable optimism, especially for the resource-rich Caspian Basin region. The *IEO2005* reference case shows FSU output exceeding 17.5 million barrels per day in 2025, implying export volumes of more than 12 million barrels per day. In China, oil production is expected to decline slightly to about 3.5 million barrels per day in 2025. China has voiced an interest in expanding its domestic oil resource base and perhaps developing coal-to-liquids technologies.

The estimates for non-OPEC production potential presented in this outlook are based on such parameters as numbers of exploration wells, finding rates, reserve-to-production ratios, advances in both exploration and extraction technologies, and sensitivity to changes in the world oil price. A critical component of the forecasting methodology is the constraint placed on the exploration and development of non-OPEC undiscovered resources. For the purpose of the three *IEO2005* price cases, no more than 15, 30, and 45 percent of the mean USGS estimate of non-OPEC undiscovered oil is developed over the forecast period in the low, reference, and high price cases, respectively. In all price cases, OPEC producers are assumed to be the source of the required residual supply.

The expectation in the late 1980s and early 1990s was that non-OPEC production in the longer term would stagnate or decline gradually in response to resource constraints. The relatively insignificant cost of developing oil resources within OPEC countries (especially those in the Persian Gulf region) was considered such an overwhelming advantage that non-OPEC production potential was viewed with considerable pessimism. In actuality, however, despite several periods of relatively low prices, non-OPEC production has risen every year since 1993, adding more than 6.9 million barrels per day between 1993 and 2002.

It is expected that non-OPEC producers will continue to increase output, producing an additional 7.2 million barrels per day in 2010. Three factors generally are given credit for the impressive resiliency of non-OPEC production: development of new exploration and production technologies, efforts by the oil industry to reduce costs, and efforts by producer governments to promote exploration and development by encouraging outside investors with attractive fiscal terms.

Worldwide Petroleum Trade

In 2002, the mature market economies imported 16.6 million barrels of oil per day from OPEC producers. Of that total, 10.1 million barrels per day came from the Persian Gulf region. Oil movements to mature market economies represented 67 percent of the total petroleum exported by OPEC member nations and 60 percent of all Persian Gulf exports (Table 7). By the end of the forecast period, OPEC exports to mature market economies in the reference case are estimated to be about 10.3 million barrels per day higher than their 2002 level, and more than one-half of the increase is expected to come from the Persian Gulf region.

Despite such a substantial increase, the share of total petroleum exports that goes to the mature market economy nations in 2025 is projected to be almost 11 percentage points below their 2002 share, and the share of Persian Gulf exports going to the mature market economies is projected to fall by about 17 percent. The significant shift expected in the balance of OPEC export shares between the mature market economies and emerging economies is a direct result of the economic growth anticipated for the economically developing nations of the world, especially those of Asia. OPEC petroleum exports to emerging economies are expected to increase by 17 million barrels per day over the forecast period, with more than 70 percent of the increase going to the emerging economies of Asia. China, alone, is likely to import about 7.3 million barrels per day from OPEC in 2025, virtually all of which is expected to come from Persian Gulf producers.

North America's petroleum imports from the Persian Gulf in the reference case are expected to more than double over the forecast period (Figure 33). At the same time, over 46 percent of total North American imports in 2025 are expected to be from Atlantic Basin producers and refiners, with significant increases anticipated in crude oil imports from Latin American producers, including Venezuela, Brazil, Colombia, and Mexico. West African producers, including Nigeria and Angola, are also expected to increase their export volumes to North America. Caribbean Basin refiners are expected to account for most of the increase in North America's imports of refined products.

With a moderate decline in North Sea production, Western Europe is expected to import increasing amounts

from Persian Gulf producers and from OPEC member nations in both northern and western Africa. Substantial imports from the Caspian Basin are also expected. Mature market Asian nations are expected to increase their already heavy dependence on Persian Gulf oil. The emerging economies of the Pacific Rim are expected to more than double their total petroleum imports between 2002 and 2025.

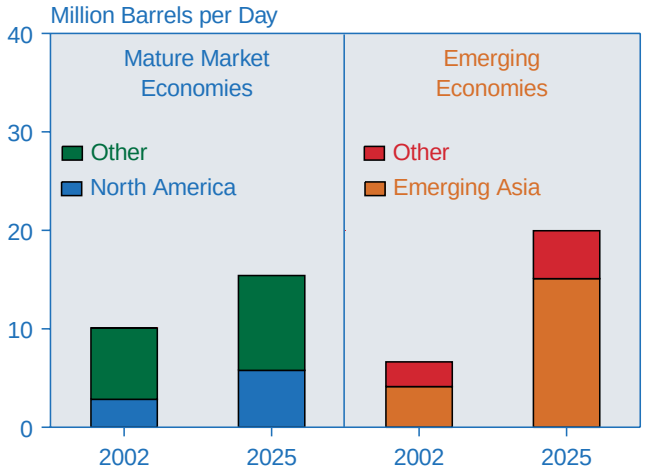
Worldwide crude oil distillation capacity was about 82 million barrels per day at the beginning of 2003. To meet the projected growth in international oil demand in the reference case, worldwide refining capacity would have to increase by more than 45 million barrels per day by 2025. Substantial growth in distillation capacity is expected in the Middle East, Central and South America, and especially in the Asia Pacific region. Refiners in North America and Europe, while making only modest additions to their distillation capacity, are expected to continue improving product quality and enhancing the usefulness of the heavier portion of the barrel through investment in downstream capacity. Likewise, future investments by emerging economies are expected to include more advanced configurations designed to meet the anticipated increase in demand for lighter products, especially transportation fuels.

Table 7. Worldwide Petroleum Trade in the Reference Case, 2002 and 2025
(Million Barrels per Day)

Exporting Region	Importing Region: Mature Market Economies: North America	Western Europe	Asia	Total	Emerging Market Economies: Pacific Rim	China	Rest of World	Total	Total Exports
				2002					
OPEC									
Persian Gulf	2.8	2.9	4.4	**10.1**	3.2	0.9	2.5	**6.6**	**16.7**
North Africa	0.6	2.1	0.0	**2.7**	0.1	0.0	0.0	**0.1**	**2.8**
West Africa	1.1	0.5	0.1	**1.7**	0.5	0.0	0.1	**0.6**	**2.3**
South America	1.7	0.1	0.1	**1.9**	0.1	0.0	0.3	**0.4**	**2.3**
Asia	0.0	0.0	0.2	**0.2**	0.4	0.0	0.0	**0.4**	**0.6**
Total OPEC	**6.2**	**5.6**	**4.8**	**16.6**	**4.3**	**0.9**	**2.9**	**8.1**	**24.7**
Non-OPEC									
North Sea	0.6	4.5	0.0	**5.1**	0.0	0.0	0.0	**0.0**	**5.1**
Caribbean Basin	0.6	0.1	0.0	**0.7**	0.1	0.0	0.1	**0.2**	**0.9**
Former Soviet Union	0.3	3.6	0.3	**4.2**	0.2	0.0	0.1	**0.3**	**4.5**
Other Non-OPEC	5.5	3.6	1.2	**10.3**	3.0	1.3	5.7	**10.0**	**20.3**
Total Non-OPEC	**7.0**	**11.8**	**1.5**	**20.3**	**3.3**	**1.3**	**5.9**	**10.5**	**30.8**
Total Petroleum Imports	**13.2**	**17.4**	**6.3**	**36.9**	**7.6**	**2.2**	**8.8**	**18.6**	**55.5**
				2025					
OPEC									
Persian Gulf	5.8	4.5	5.1	**15.4**	8.7	6.4	4.9	**20.0**	**35.4**
North Africa	0.5	3.1	0.1	**3.7**	0.8	0.3	0.5	**1.6**	**5.3**
West Africa	1.6	1.1	0.3	**3.0**	1.8	0.5	0.2	**2.5**	**5.5**
South America	3.9	0.1	0.4	**4.4**	0.1	0.0	0.4	**0.5**	**4.9**
Asia	0.1	0.0	0.3	**0.4**	0.6	0.1	0.2	**0.9**	**1.3**
Total OPEC	**11.9**	**8.8**	**6.2**	**26.9**	**12.0**	**7.3**	**6.2**	**25.5**	**52.4**
Non-OPEC									
North Sea	0.5	3.4	0.0	**3.9**	0.3	0.0	0.2	**0.5**	**4.4**
Caribbean Basin	1.4	0.5	0.2	**2.1**	0.6	0.0	0.8	**1.4**	**3.5**
Former Soviet Union	0.5	3.3	0.6	**4.4**	0.7	3.1	1.5	**5.3**	**9.7**
Other Non-OPEC	6.8	2.9	0.4	**10.1**	3.1	0.3	2.5	**5.9**	**16.0**
Total Non-OPEC	**9.2**	**10.1**	**1.2**	**20.5**	**4.7**	**3.4**	**5.0**	**13.1**	**33.6**
Total Petroleum Imports	**21.1**	**18.9**	**7.4**	**47.4**	**16.7**	**10.7**	**11.2**	**38.6**	**86.0**

Notes: Totals may not equal sum of components due to independent rounding.
Sources: **2002:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **2025:** EIA, Office of Integrated Analysis and Forecasting, IEO2005 WORLD Model run IEO2005.B25 (2005).

Figure 33. Imports of Persian Gulf Oil by Importing Region, 2002 and 2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219 (2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

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Natural Gas

Natural gas is the fastest growing primary energy source in the IEO2005 forecast. Consumption of natural gas is projected to increase by nearly 70 percent between 2002 and 2025, with the most robust growth in demand expected among the emerging economies.

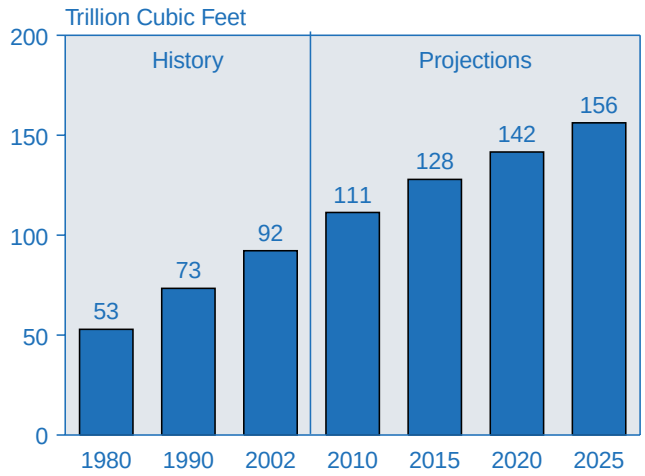
Natural gas is projected to be the fastest growing component of world primary energy consumption in the *International Energy Outlook 2005* (*IEO2005*) reference case. Consumption of natural gas worldwide increases in the forecast by an average of 2.3 percent annually from 2002 to 2025, compared with projected annual growth rates of 1.9 percent for oil consumption and 2.0 percent for coal consumption. From 2002 to 2025, consumption of natural gas is projected to increase by almost 70 percent, from 92 trillion cubic feet to 156 trillion cubic feet (Figure 34), and its share of total energy consumption on a Btu basis is projected to grow from 23 percent to 25 percent. The electric power sector accounts for almost one-half of the total incremental growth in worldwide natural gas demand over the forecast period.

On a regional basis, the largest increases in natural gas consumption worldwide are projected for the transitional economies of Eastern Europe and the former Soviet Union (EE/FSU) and for emerging Asia (Figures 35 and 36). Natural gas use in the EE/FSU expands by 63 percent over the projection period; and in emerging Asia, gas use is expected to nearly triple from 2002 to 2025. In the mature market economies, where natural gas markets are more established, consumption of natural gas is projected to increase by a more modest annual average of 1.6 percent from 2002 to 2025, with the largest incremental growth in the mature market economies projected for North America, at 11 trillion cubic feet.

The emerging economies are also expected to show the strongest growth in natural gas production, with a projected average increase of 4.1 percent per year from 2002 to 2025 in the reference case (Figure 37). In contrast, natural gas production in the transitional economies is projected to grow at an average annual rate of 2.3 percent, and production in the mature market economies is expected to increase by an average of only 0.6 percent per year from 2002 to 2025.

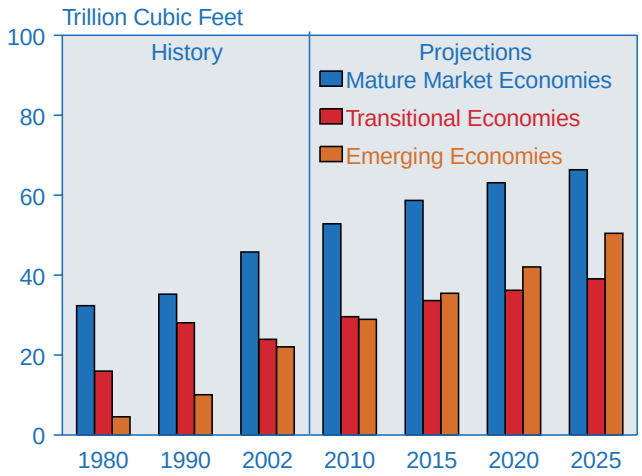
The disparity between the increase projected for natural gas consumption in the mature market economies and the much smaller increase projected for their gas production points to an increasing dependence on the transitional and emerging market economies for gas supplies (Figure 38). In 2002, the mature market economies accounted for 42 percent of the world's total natural gas production and 50 percent of the world's natural gas consumption; in 2025, they are projected to account

Figure 34. World Natural Gas Consumption, 1980-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

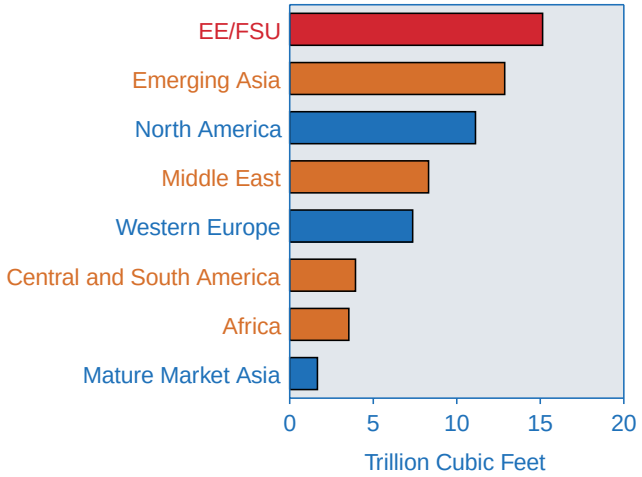
Figure 35. Natural Gas Consumption by Region, 1980-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

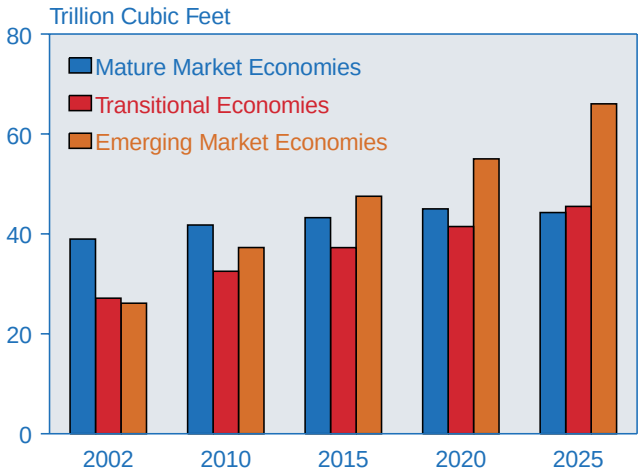
for only 29 percent of production and 43 percent of consumption. As a result, the mature market economies are expected to rely on imports of natural gas from other parts of the world to meet almost one-third of their natural gas consumption in 2025, up from 15 percent in 2002.

Figure 36. Increases in Natural Gas Consumption by Region and Country Group, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2025:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 37. Natural Gas Production by Region, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

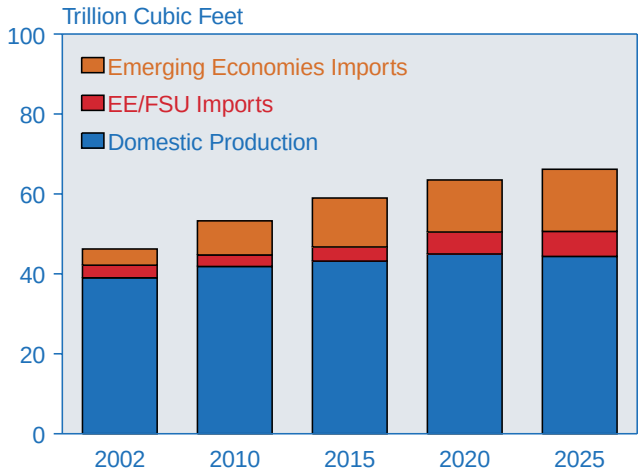
Reserves and Resources

As of January 1, 2005, proved world natural gas reserves, as reported by *Oil & Gas Journal*,[3] were estimated at 6,040 trillion cubic feet—36 trillion cubic feet (less than 1 percent) lower than the estimate for 2004 [***1***]. In general, world natural gas reserves have trended upward since the mid-1970s (Figure 39).

The largest revision to natural gas reserve estimates was made in Australia. The Australian government reported a two-thirds cut in its estimate of natural gas reserves between 2004 and 2005, from 90 trillion cubic feet to 29 trillion cubic feet. Higher reserve estimates were recorded for the emerging economies, mostly in Africa and the Middle East. Nigeria alone accounted for most of the increment in Africa, with a gain of 17 trillion cubic feet (11 percent), and Libya reported a smaller increase of 6 trillion cubic feet (12 percent). In the Middle East, Saudi Arabia increased its estimate of reserves by 4 trillion cubic feet (2 percent), accounting for all of the region's addition to reserves. Elsewhere, national estimates of natural gas reserves changed little over the 1-year period.

Almost three-quarters of the world's natural gas reserves are located in the Middle East and in the transitional economies of the EE/FSU (Figure 40). Russia, Iran, and Qatar combined account for about 58 percent of the world's natural gas reserves (Table 8). Reserves in

Figure 38. Natural Gas Consumption in Mature Market Economies by Source, 2002-2025



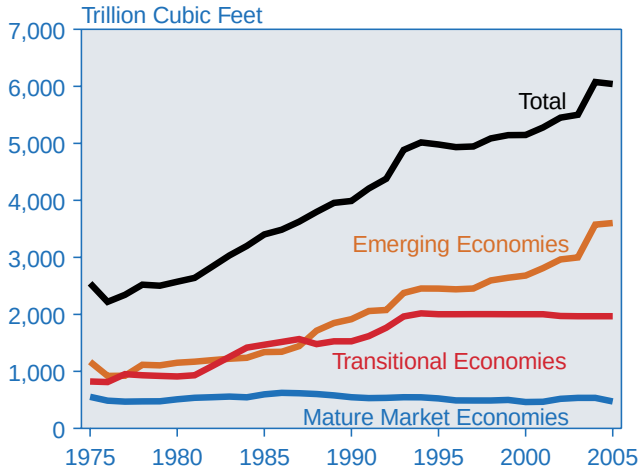
Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

[3]Proved Reserves, as reported by the *Oil & Gas Journal*, are estimated quantities that can be recovered under present technology and prices. Figures reported for Canada and the former Soviet Union, however, include reserves in the probable category. Natural gas reserves reported by the *Oil & Gas Journal* are compiled from voluntary survey responses and do not always reflect the most recent changes. Significant natural gas discoveries made during 2004 are not likely to be reflected in the reported reserves.

the rest of the world are fairly evenly distributed on a regional basis.

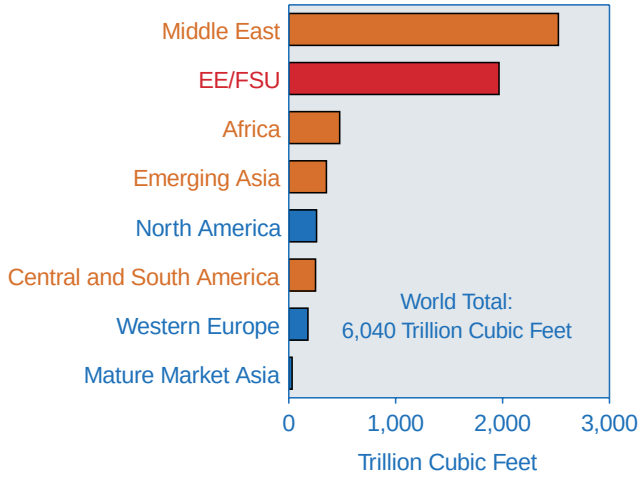
Despite high rates of increase in natural gas consumption, particularly over the past decade, most regional reserves-to-production ratios have remained high. Worldwide, the reserves-to-production ratio is estimated at 66.7 years [2]. Central and South America has a reserves-to-production ratio of 55.0 years, the FSU 77.4 years, and Africa 96.9 years. The Middle East's reserves-to-production ratio exceeds 100 years.

Figure 39. World Natural Gas Reserves by Region, 1975-2005



Sources: **1975-1993:** "Worldwide Oil and Gas at a Glance," *International Petroleum Encyclopedia* (Tulsa, OK: PennWell Publishing, various issues). **1994-2004:** *Oil & Gas Journal* (various issues).

Figure 40. World Natural Gas Reserves by Region as of January 1, 2005



Source: "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 102, No. 47 (December 20, 2004), pp. 22-23.

The U.S. Geological Survey (USGS) periodically assesses the long-term production potential of worldwide petroleum resources (oil, natural gas, and natural gas liquids). According to the most recent USGS estimates, released in the *World Petroleum Assessment 2000*, a significant volume of natural gas remains to be discovered. The mean estimate for worldwide undiscovered natural gas is 4,301 trillion cubic feet (Figure 41), which is approximately double the worldwide cumulative consumption forecast from 2002 to 2025 in *IEO2005*. Of the total natural gas resource base, an estimated 3,000 trillion cubic feet is in "stranded" reserves, usually located too far away from pipeline infrastructure or population centers to make transportation of the natural gas economical. Of the new natural gas resources expected to be added over the next 25 years, reserve growth accounts for 2,347 trillion cubic feet. More than one-half of the mean undiscovered natural gas estimate is expected to come from the FSU, the Middle East, and North Africa; and about one-fourth (1,065 trillion cubic feet) is expected to come from a combination of North, Central, and South America.

Table 8. World Natural Gas Reserves by Country as of January 1, 2005

Country	Reserves (Trillion Cubic Feet)	Percent of World Total
World	**6,040**	**100.0**
Top 20 Countries	**5,391**	**89.3**
Russia	1,680	27.8
Iran	940	15.6
Qatar	910	15.1
Saudi Arabia	235	3.9
United Arab Emirates	212	3.5
United States	189	3.1
Nigeria	176	2.9
Algeria	161	2.7
Venezuela	151	2.5
Iraq	110	1.8
Indonesia	90	1.5
Malaysia	29	0.5
Norway	75	1.2
Turkmenistan	74	1.2
Uzbekistan	71	1.2
Kazakhstan	66	1.1
Netherlands	65	1.1
Canada	62	1.0
Egypt	57	0.9
Ukraine	40	0.7
Rest of World	**649**	**10.7**

Source: "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 102, No. 47 (December 20, 2004), pp. 22-23.

Regional Forecasts

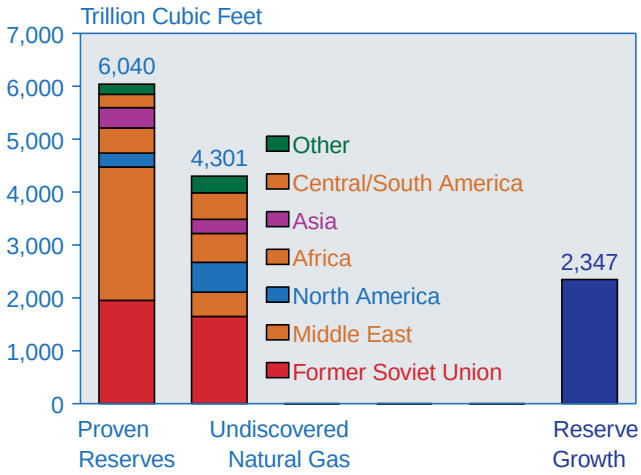
North America

North America's natural gas production[4] is expected to grow at an average annual rate of 0.5 percent between 2002 and 2025 in the *IEO2005* forecast, whereas its gas consumption (Figure 42) is expected to grow by 1.5 percent per year. In 2002, most of the natural gas consumed in North America was produced within the region (Figure 43). In 2015, however, North America is projected to consume 5.7 trillion cubic feet more than it produces, and in 2025 the gap between North America's natural gas production and consumption is projected to be 8.0 trillion cubic feet, illustrating the region's growing dependence on imports.

Currently, Canada supplies the bulk of U.S. imports of natural gas, the United States supplies most of Mexico's import needs, and less than 1 percent of North America's natural gas demand in 2002 was met by imports from outside the region (Figure 43). Imports from other regions are all in the form of liquefied natural gas (LNG) into the United States through one of five existing LNG regasification facilities. Four are onshore terminals that were built more than 20 years ago, located in Everett, Massachusetts, Cove Point, Maryland, Elba Island, Georgia, and Lake Charles, Louisiana. The fifth is the Gulf Gateway Energy Bridge, located in the offshore Gulf of Mexico. It is the first new U.S. LNG terminal to be constructed in more than 20 years, and it received its first cargo on March 17, 2005.

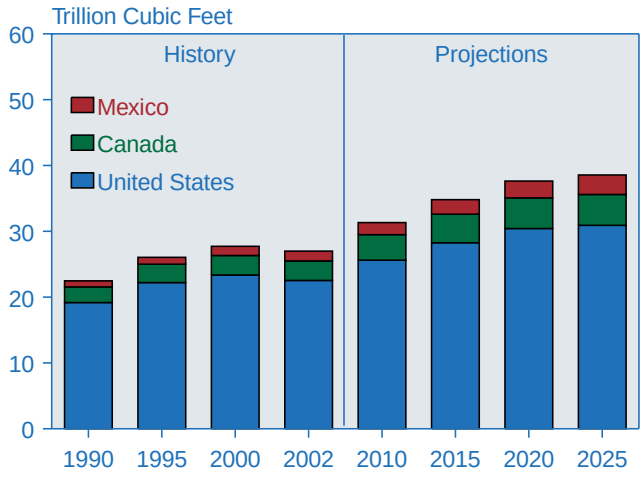
LNG imports are expected to increase substantially and play a prominent role in the future, with LNG imports into the United States surpassing pipeline imports from Canada by 2015. Although Mexico is expected to remain a net importer from the United States, LNG imports are expected to begin reducing Mexico's dependence on the United States in 2007.

Figure 41. World Natural Gas Resources by Region, 2005-2025



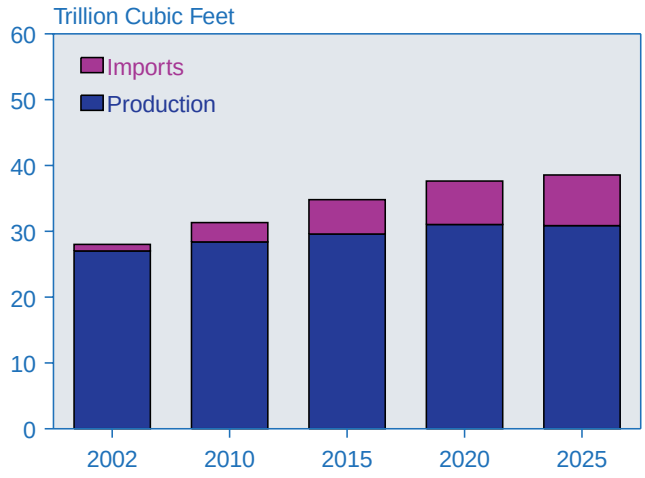
Source: U.S. Geological Survey, *World Petroleum Assessment 2000*, web site http://greenwood.cr.usgs.gov/energy/WorldEnergy/DDS-60; "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 102, No. 47 (December 20, 2004), pp. 22-23; and Energy Information Administration estimates.

Figure 42. Natural Gas Consumption in North America by Country, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 43. Natural Gas Supply in North America by Source, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

[4]U.S. domestic production does not include production from any areas that currently are off limits for oil and gas drilling or production from methane hydrates.

New LNG regasification facilities are expected to begin operating in Mexico, the United States, and Canada between 2005 and 2010. After 2010, the region's import capacity continues to expand throughout the remainder of the forecast period. More than 50 proposals to build new regasification facilities in North America have been put forth, and projects in all three countries have already received at least some of the needed regulatory approvals. If all the proposed facilities were constructed, they would add more than 20 trillion cubic feet to the region's import capacity, equivalent to almost 75 percent of the natural gas consumed in North America in 2002; however, the *IEO2005* reference case does not assume that all the proposed facilities will be built. Still, the level of activity is a clear indication that LNG is poised to play a much greater role in North American gas markets in the future.

According to EIA's *Annual Energy Outlook 2005* (*AEO-2005*), the share of total U.S. natural gas consumption met by net imports of LNG is expected to grow from about 1 percent in 2002 to 15 percent (4.3 trillion cubic feet) in 2015 and 21 percent (6.4 trillion cubic feet) in 2025. LNG terminals are expected to be built relatively early in the forecast, with new terminals receiving supplies on the Gulf Coast and in the Bahamas by 2010. A new terminal in Baja California, Mexico, is projected to begin operation in 2007 to serve Northern Mexico and Southern California, with additional capacity in Baja California added after 2020. Although new U.S. terminals are projected to be constructed along the East Coast after 2015, the Gulf Coast is expected to be the primary location for new LNG import capacity.

Most of the projected new U.S. LNG capacity is located in the Gulf of Mexico because of the locale's many advantages. There is spare capacity in the existing pipeline infrastructure to move natural gas to market, and deepwater ports are available to serve onshore facilities. In addition, offshore pipeline systems are in place to move natural gas to shore from offshore facilities. The extensive pipeline grid provides a ready ability to blend gases of varying heat content and thus, handle high-Btu LNG. Finally, the local environment appears to be favorable for the permitting of new facilities. Imports into new Gulf Coast terminals are expected to account for more than 70 percent of imports into new U.S. LNG terminals in 2025.

Canada is the only North American country that currently produces more natural gas than it consumes, and its domestic production is projected to continue to exceed its consumption through 2025. Most of Canada's natural gas production currently comes from the Western Sedimentary Basin. Although conventional production in the basin is in steady decline, the decreases are expected to be more than offset by increases in unconventional production in western Canada, conventional production in the MacKenzie Delta and Eastern Canada, and LNG imports. Supply is also expected to be supplemented by natural gas from the MacKenzie Delta. A pipeline to bring natural gas from the MacKenzie Delta to market is expected to open in 2010. In spite of these supply additions, pipeline imports from Canada are expected to decline toward the end of the forecast because of strong growth in Canada's internal need for natural gas.

In the *IEO2005* reference case, Canada's natural gas production is projected to grow at an average annual rate of 0.1 percent. Whereas in 2002, production exceeded consumption in Canada by 3.6 trillion cubic feet, excess production available for export to the United States is expected to drop to 2.5 trillion cubic feet in 2015 and to 2.1 trillion cubic feet in 2025.

In Mexico, natural gas consumption is expected to far outstrip production. Mexico's demand for natural gas is projected to grow at an average annual rate of 3.0 percent between 2002 and 2025, while production grows at a rate of only 1.7 percent annually. Most of the growth in consumption is expected to fuel electricity generation. Although consumption in the residential and commercial sectors combined accounted for less than 3 percent of the country's total natural gas use in 2002, pipeline infrastructure to serve residential and commercial users is expected to continue growing, allowing their natural gas consumption to increase tenfold from 2002 to 2025.

Mexico's dependence on natural gas imports, like that of the United States, is projected to increase. In the *IEO2005* reference case, imports are expected to grow from 13 percent of Mexico's total natural gas consumption in 2002 to 37 percent in 2025. The Mexican government is attempting to attract foreign capital to help in developing the country's own abundant resources and supporting production increases, but to date little increase has been seen, and it appears that LNG will be the biggest contributor to additional supply in the near term. In addition to import facilities in Baja California, Mexico, that will serve both Mexican and U.S. markets, an LNG facility is under construction at Altamira on Mexico's Gulf Coast, and two facilities currently are under consideration on the Pacific Coast, primarily to serve the Mexican market.

Western Europe

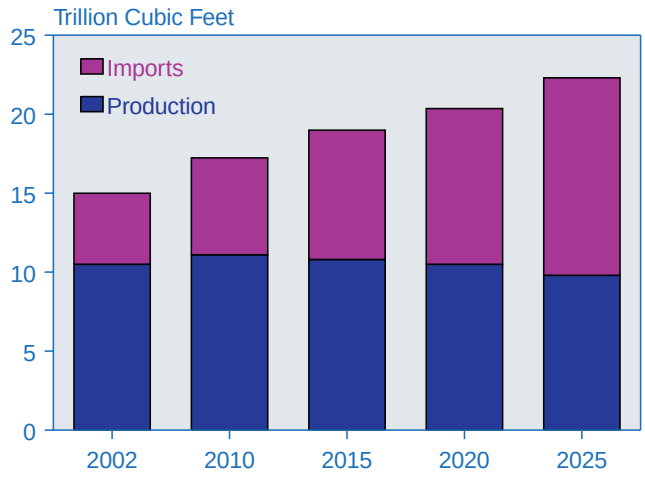
Natural gas is expected to be the fastest growing fuel source in Western Europe, with demand projected to grow at an annual average rate of 1.8 percent, from 15.0 trillion cubic feet in 2002 to 22.4 trillion cubic feet in 2025. More than 60 percent of incremental gas consumption in Western Europe between 2002 and 2025 is expected to be used for electric power generation. Natural gas is the

fuel of choice for new electricity generation capacity in Western Europe, where many nations are looking to replace oil- and coal-fired plants that are more carbon intensive than natural gas. In addition, natural gas is expected to remain more cost competitive than renewable energy sources, and countries such as Germany and Belgium have government policies that discourage the expansion of nuclear power capacity and may result in the retirement of existing nuclear power plants over the forecast period.

Natural gas consumption for electricity generation in Western Europe is projected to increase on average by 3.6 percent per year from 2002 to 2025, surpassing the use of coal and renewables for electricity generation (on a Btu basis) by 2015 and the use of nuclear power by 2025. The share of total electricity sector energy demand met by natural gas is projected to increase from 14 percent in 2002 to 23 percent in 2015 and 28 percent in 2025.

With the notable exception of Norway, natural gas production is in decline in most areas of Western Europe. In the mid-term future, production from Norway is expected to stave off a decline in the region's overall production; however, total natural gas production in Western Europe is still far from keeping pace with demand (Figure 44). Western Europe received net imports of 4.9 trillion cubic feet of natural gas in 2002, accounting for one-third of total gas consumption. The region's reliance on imported gas is projected to grow to more than 40 percent of demand in 2015 and more than 50 percent in 2025. Currently there are 10 LNG regasification terminals operating in Western Europe, and LNG receiving capacity is being expanded aggressively. More than 20 new facilities have been proposed, including 4 that are under construction. Egypt, a new addition to the list of LNG suppliers to the world as well as to Europe, sent its first-ever LNG cargo to Spain in March 2005.

Figure 44. Natural Gas Consumption in Western Europe by Source, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Mature Market Asia

In Japan, natural gas shows the largest incremental growth in demand among primary energy sources over the forecast period. Japan's natural gas consumption is projected to increase at an average annual rate of 1.5 percent, from 2.7 trillion cubic feet in 2002 to 3.8 trillion cubic feet in 2025. Natural gas use in the industrial sector is projected to grow by 3.4 percent per year on average from 2002 to 2025, and to claim an increasing share of the country's total gas consumption. Electricity generation remains by far the largest use for natural gas in Japan, however, despite an expected decline in its share of the total, from 71 percent in 2002 to 67 percent in 2025.

In Australia and New Zealand, the industrial sector currently is the predominant user of natural gas, and it is projected to account for more than one-half of all gas consumption in Australia and New Zealand throughout the forecast period. Natural gas is also the fastest growing fuel in the region's electricity sector. Natural gas consumption as a percentage of total energy use in the electric power sector is projected to grow from 11 percent in 2002 to nearly 13 percent in 2025, but this will have only a modest impact on the electric power sector fuel mix, which is dominated by coal. Even in 2025, coal is expected to account for almost 73 percent of energy consumption in Australia and New Zealand's electric power sector on a Btu basis.

Transitional Economies

In the EE/FSU countries, natural gas consumption in the electric power sector is expected to surpass consumption in the industrial sector by 2010, and to account for 44 percent and 43 percent of total gas consumption in 2025 in the FSU and Eastern Europe, respectively. Total natural gas demand in the EE/FSU region is projected to grow at an average annual rate of 2.2 percent from 2002 to 2025 (Figure 45). In both Eastern Europe and the FSU, the electric power sector is expected to account for nearly 60 percent of the total increment in natural gas use over the forecast period.

The FSU, which holds around 30 percent of the world's natural gas reserves, is much more dependent on natural gas for its energy supply than is Eastern Europe (51 percent of total energy consumption in the FSU was supplied by natural gas in 2002, compared with 23 percent in Eastern Europe). Natural gas production in the FSU is projected to grow at an average annual rate of just over 2 percent from 2002 to 2025, and exports are projected to increase to around one-quarter of total gas production in 2025 from 19 percent in 2002. Despite the Russian

government's recent dismantling of the oil giant Yukos, foreign companies—especially Western European companies—have increasingly been pursuing investments in Russia's upstream gas sector. Gazprom, the majority state-owned Russian gas company, currently has a spate of suitors from which to choose its partners in the development of the giant Shtokmanovskoye field [*3*].

Emerging Asia

In China, natural gas is currently a minor fuel in the overall energy mix, representing only 3 percent of total primary energy consumption in 2002; however, China is rapidly expanding infrastructure to facilitate the consumption of gas throughout the country as well as imports of gas into the country. Overall natural gas consumption in China is projected to grow at an average annual rate of 7.8 percent, from 1.2 trillion cubic feet in 2002 to 6.5 trillion cubic feet in 2025 (Figure 46). Only nuclear power generation is projected to grow more rapidly, at a 9.9-percent average annual rate over the forecast period.

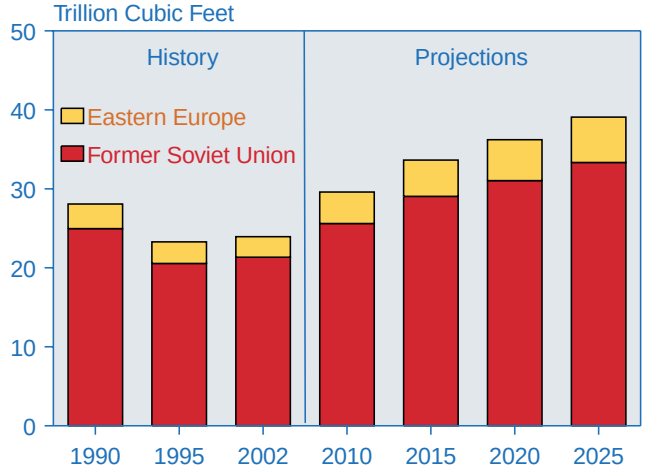
Natural gas consumption in China's residential sector, projected to more than double from 2002 to 2010, received a boost with the start of commercial operation of the West-East pipeline in December 2004. Most of the early natural gas coming off the pipeline has been going to residential consumers and the remainder to industrial consumers [*4*]. The pipeline is far from full utilization, because several natural-gas-fired electric power plants, which ultimately are to be the main consumers of West-East gas, are not yet complete and operational.

In the long term, the electric power sector is the main source of projected growth in China's natural gas demand, accounting for fully two-thirds of the total increment in China's natural gas consumption from 2002 to 2025. In 2002, natural gas consumption in the electric power sector was 0.2 trillion cubic feet, accounting for only 1 percent of the country's total electricity generation. In 2010, natural gas consumption in the electricity sector is projected to surpass consumption in the industrial and residential sectors, and in 2025 it is projected to surpass their combined consumption, accounting for more than one-half of China's total natural gas use.

In India, as in China, natural gas is currently a minor fuel in the overall energy mix, representing only 6.5 percent of total primary energy consumption. Also like China, India is rapidly expanding infrastructure to facilitate consumption and imports of gas. Overall, India's gas consumption is projected to grow at an average annual rate of 5.1 percent, from 0.9 trillion cubic feet in 2002 to 2.8 trillion cubic feet in 2025. The electric power sector is projected to account for 71 percent of the total incremental growth in India's natural gas demand from 2002 to 2025.

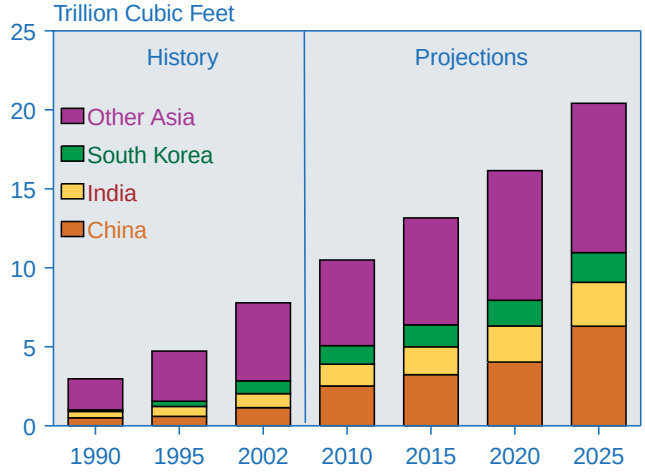
Total natural gas consumption in South Korea is projected to grow at an average annual rate of 3.7 percent from 2002 to 2025. In 2002, the residential sector was the country's predominant consumer of natural gas, accounting for 37 percent of the total, and the electric power sector was a close second, accounting for 34 percent of total gas use. In the forecast, natural gas use in South Korea's industrial sector increases on average by 7.0 percent per year from 2002 to 2025, compared with average annual growth of 1.7 percent in both the residential and electric power sectors. In 2015, more natural

Figure 45. Natural Gas Consumption in Transitional Economies, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 46. Natural Gas Consumption in Emerging Asia, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

gas consumption is expected in the country's industrial sector than in its residential or electric power sector. In 2025, industrial natural gas use is projected to account for more than 40 percent of all the natural gas consumed in South Korea.

High world oil prices, beginning in 1999, provided the impetus for the strong growth in gas use in South Korea's industrial sector, and it is partially at the expense of oil consumption that natural gas is expected to grow in this sector. On a Btu basis, the share of total industrial consumption attributable to natural gas is projected to grow from just 5 percent in 2002 to almost 16 percent in 2025, and the share attributable to oil is expected to shrink from 58 percent in 2002 to just under 50 percent in 2025.

In the other countries of emerging Asia, total natural gas consumption is projected to grow at an average annual rate of 2.9 percent from 2002 to 2025. Natural gas consumption in 2002 and throughout the forecast period is fairly evenly split between the industrial and electricity sectors, with each accounting for more than 40 percent of total gas consumption. Penetration of gas into the residential, commercial, and transportation sectors is projected to remain low with the three sectors combined continuing to account for less than 10 percent of total gas consumption in the other countries of emerging Asia throughout the forecast period. Natural gas infrastructure across the region is fragmented, with limited infrastructure outside producing areas, and extensive advances will be needed to meet growing demand in the long term.

Middle East

Natural gas consumption in the Middle East is projected to double between 2002 and 2025 (Figure 47). The overall share of natural gas in the Middle East's fuel consumption mix increases over the forecast period at the expense of oil, although oil will remain the region's predominant fuel source. The share of total Middle East energy demand met by natural gas is projected to increase from 39 percent in 2002 to 45 percent in 2025, while the share of total energy demand met by oil is projected to decline from 53 percent to 48 percent.

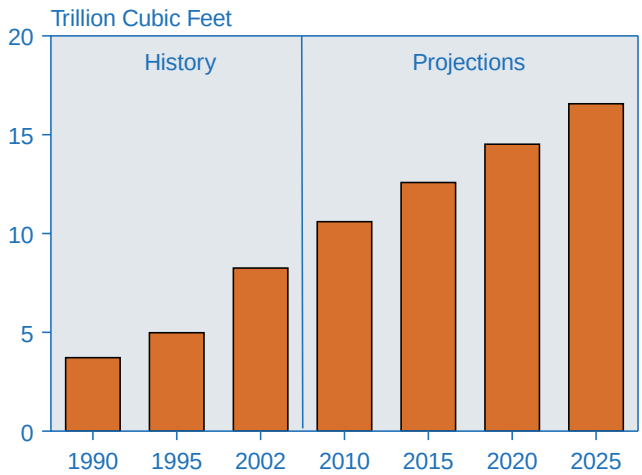
Natural gas is projected to retain its dominant position in the Middle East's power sector, with 1.9-percent average annual growth over the forecast period. In the industrial sector, however, natural gas use is projected to grow by 4.0 percent per year, accounting for more than two-thirds of the overall incremental growth in gas demand in the region from 2002 to 2025. The natural gas share of total energy consumed in the region's industrial sector is projected to grow from 46 percent in 2002 to 59 percent in 2025, and oil is expected to lose share in the sector (from 41 percent of industrial energy consumption in 2002 to just under 30 percent in 2025).

Oil-exporting countries in the region have deliberately sought to expand domestic gas use in order to make more oil available for export. Many gas-rich countries in the region are also developing projects to monetize their natural gas resources, in particular through LNG and, more recently, gas to liquids (GTL) projects (see box on page 46). Qatar has secured several high-profile deals that, when realized, will eventually boost its total LNG exports to 77 million metric tons per year. One such deal is for the construction of what will be the two largest liquefaction trains in the world, at 7.8 million metric tons per year each.

Africa

Natural gas consumption in Africa is projected to grow at an average annual rate of 4.0 percent from 2002 to 2025 (Figure 48), compared with average yearly growth rates of 2.7 percent for oil and 1.6 percent for coal. Gas consumption is expected to surpass coal consumption by 2025, with oil remaining the dominant fuel throughout the projection period. Incremental growth in Africa's gas demand from 2002 to 2025 is projected to be fairly even across sectors, with the industrial, residential, and electric sectors each accounting for around one-third of total growth. Significant flaring of associated gas is still common in Africa because of the remoteness of much of the production and a lack of infrastructure to use all the associated gas produced. Despite continuing instability in some countries of the region, the investment climate in Africa appears to be welcoming to foreigners, with massive investments planned for Egypt, Libya, Algeria, Nigeria, and other parts of West Africa.

Figure 47. Natural Gas Consumption in the Middle East, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Central and South America

Natural gas is expected to be the fastest growing fuel source in Central and South America, with demand projected to increase on average by 3.3 percent per year, from 3.6 trillion cubic feet in 2002 to 7.5 trillion cubic feet in 2025 (Figure 49). By 2010, natural gas is expected to overtake oil as the second most prevalent fuel for electricity generation in the region, with renewables—particularly, hydropower—retaining their dominant share in the sector throughout the forecast period.

The investment climate for natural gas production projects in Central and South America has been less than ideal. Although Venezuela appears to be more welcoming to foreign investment in its natural gas sector than its oil sector, negotiations, especially on the Mariscal Sucre project, continue with no final decisions taken [*5*]. In Bolivia, two successive presidents were forced to resign by street protests over the handling of the nation's natural gas resources. (Gonzalo Sanchez de Lozado resigned in October 2003, and Carlos Mesa resigned in June 2005.) Protestors have called for increased government involvement in the natural gas sector, including possible nationalization of the industry. On the other hand, Brazil is proceeding with natural gas exploration and hopes to become self-reliant in the gas sector in the future. Major investments in the natural gas sector are underway in Trinidad and Tobago and in Peru.

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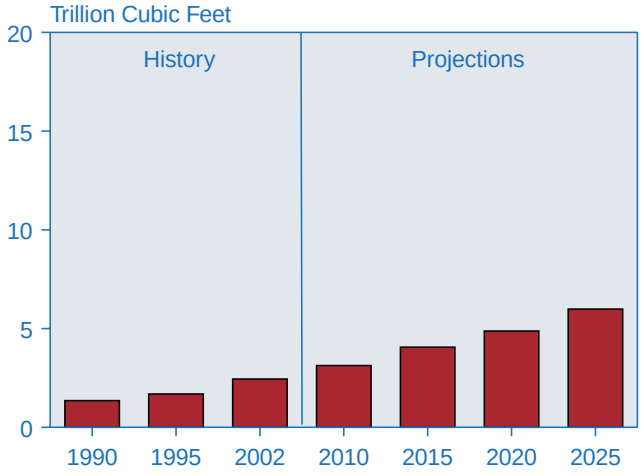
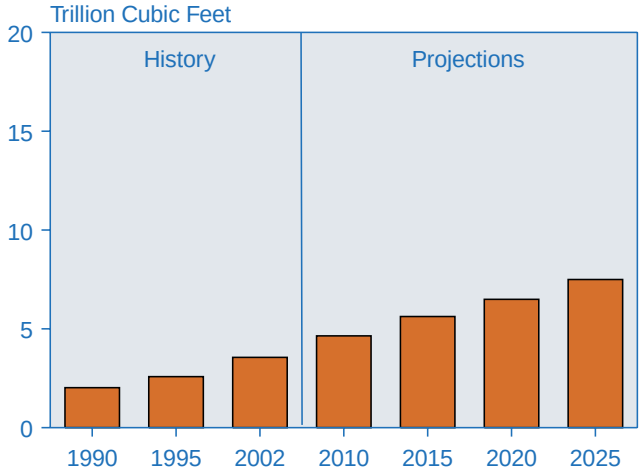
5. World Markets Research Centre, "Venezuela: Chevron Announces 'Significant' Gas Discovery in Deltana Platform," web site www.worldmarketsanalysis.com (June 21, 2005).

Figure 48. Natural Gas Consumption in Africa, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 49. Natural Gas Consumption in Central and South America, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Gas to Liquids: A New Frontier for Natural Gas

The relatively high world crude oil prices of the past 3 years have drawn attention to the potential for developing previously uneconomical natural gas reserves, such as associated gas (gas found jointly with oil in an oil field) or stranded gas (gas that lies far from markets, thus requiring major investments to commercialize). Converting these resources to liquids—either to liquefied natural gas (LNG) or to petroleum liquid substitutes, such as diesel, naphtha, motor gasoline, or other products (such as lubricants and waxes) by employing "gas to liquids" (GTL) technology—could provide a way to bring these gas resources to market. GTL has recently become attractive as an option for monetizing stranded gas and complementing traditional commercialization opportunities such as LNG or pipeline transportation.

The economics of GTL continue to improve with advances in technology and scale. Capital costs have dropped significantly, from more than $100,000 per barrel of total installed capacity for the original plants to a range of $25,000 to $30,000 per barrel of capacity today.[a] Moreover, Royal/Dutch Shell has commented that it expects to be able to reduce the costs to below $20,000 per barrel. By comparison, the costs associated with conventional petroleum refining are around $15,000 per barrel per stream day after several decades of technology improvements. The high oil prices of recent years, moreover, have made transportation fuels produced through GTL technology more commercially viable. Few companies release the detailed costs of their GTL conversion technologies, but according to ConocoPhillips, assuming that the cost of natural gas is $1.00 per million Btu, GTL fuel is cost competitive with diesel fuel at world oil prices above $20 per barrel (see table below).

Among the different GTL products, the diesel fraction, in particular, is highly valued in the downstream market because of its unique properties that meet environmental regulations aimed at tightening emissions standards for light- and heavy-duty diesel vehicles. The GTL fuel reduces emissions relative to conventional diesel, as it contains near-zero sulfur and aromatics. GTL fuel also exhibits a high cetane number that enhances engine combustion performance.[b] Because they are compatible with existing vehicle engines and fuel distribution infrastructures, GTL fuels are the most cost-effective in reducing emissions among the nonconventional fuels.

At present, worldwide there are at least 9 commercial GTL projects at various stages of planning and development for the period 2009 to 2012 that could bring to market an additional capacity of 580 thousand barrels per day (see figure). More than 19 additional proposed projects could double that capacity beyond 2012.[c]

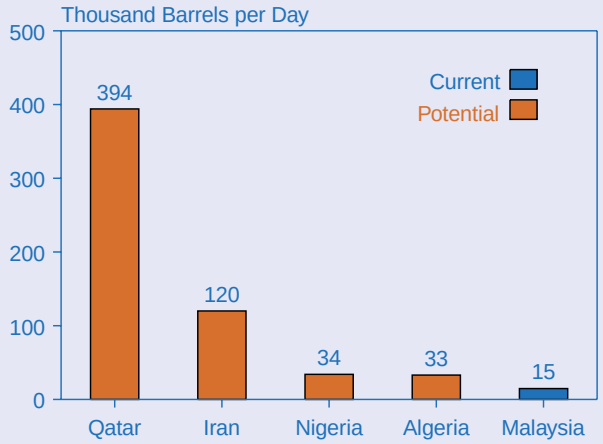
(continued on page 47)

Cost to Produce a Barrel of Diesel Fuel: Grass Roots Gas to Liquids Plant vs. Refinery
(2002 Dollars per Barrel)

Cost Component	GTL	Refinery
Natural Gas (at $1.00 per Million Btu)	$10.00	
Crude Oil (at $20 per Barrel)		$20.00
Operating Costs	$ 4.00	$ 2.50
Capital Recovery, Taxes	$14.00	$ 6.50
Total	**$28.00**	**$29.00**

Source: M. Culligan, ConocoPhillips, Director of Business Development-Qatar GTL Project, "GTL: New Technology for a New Industry," presentation at the Fifth Doha Gas Conference (March 1, 2005).

Current and Potential Gas to Liquids Capacity, 2005-2012



Note: In addition, a 45,000-barrel-per-day GTL plant in South Africa's Mossel Bay has been switched temporarily from processing coal to liquids to processing gas to liquids.

Sources: Interview with Abdullah Bin Hamad Al-Attiyah, Qatar Minister of Energy and Industry, at the Center for Strategic and International Studies in Washington, DC (May 9, 2005). Data from FACTS Inc., *Gas Databook I* (Honolulu, HI, 2005), p. 87; and "Algeria—Internatrional Tender for First Gas-to-Liquids Project," *Cedigaz News Report*, Vol. 44, No. 15 (April 15, 2005), p. 4.

[a]Personal correspondence with Sylvia Williams, Business Development Manager, Global GTL Development, Shell International Gas Limited (May 3, 2005).
[b]ACTED Consultants, "Gas to Liquids," Chemicals Australia Web Site, http://www.chemlink.com.au/gtl.htm (1999).
[c]FACTS Inc., *Gas Databook I: Asia-Pacific Natural Gas & LNG* (Honolulu, HI, 2005), p. 87.

Gas to Liquids: A New Frontier for Natural Gas (Continued)

These projects are being initiated by companies operating in gas-rich countries such as Qatar, Iran, Russia, Nigeria, Australia, and Algeria, where natural gas can be developed at a cost of less than $1.00 per million Btu.[d] Qatar's North Field, with an estimated 900 trillion cubic feet of natural gas reserves, and the adjoining South Pars field in Iran with an estimated 500 trillion cubic feet of reserves, are the cheapest natural gas resources in the world.[e] For other countries, such as Nigeria and Algeria, GTL complements their LNG industries. GTL offers promise for use in Nigeria to convert natural gas that would otherwise be flared. Huge capital investments are required for GTL, however, and project financing and the availability of qualified contractors and operators may limit the growth of GTL projects on a year-to-year basis.[f]

Six of the nine confirmed GTL projects are located in the state of Qatar as joint ventures based on an integrated development and production sharing agreement (DPSA) with major international oil companies. Foreign companies have favored this approach, because it gives them an opportunity to book part of the gas reserves on their balance sheet and support their upstream and downstream activities.[g] By 2011, Qatar is set to produce about 394,000 barrels of GTL products per day, the equivalent of 68 percent of the total confirmed new capacity.[h] A list of Qatar's GTL ventures is shown in the table below.

Unlike many other gas-producing countries, Qatar has established a favorable climate in terms of transparent business and investment policies. Foreign investors have also been encouraged to invest in Qatar's energy sector because of its stable tax regulations, enforcement of formal agreements, and the government's willingness to protect foreign investors through its legislature. In addition to the stable political climate, Qatar has invested substantially to develop infrastructure and services to support development of its natural gas resources. The country also provides guarantees for the safety of foreign employees and the potential for future development through expansion of existing facilities.[i] In the second quarter of 2005, Moody's Investor Service upgraded Qatar's rating for long-term foreign currency bonds and bank bonds from A3 to A1.[j]

Qatar has been able to reach agreements with a group of financial institutions to fund their gas-related projects (which exceed $60 billion) and has developed a master plan to expand its port and double the size of Ras Laffan Industrial city from 39 square miles to 77 square miles, in order to accommodate 7 GTL projects, 16 LNG trains, 5 gas processing plants, 6 to 7 ethylene plants, and a variety of other gas-related industries. By 2012, Qatar must produce nearly 25 billion cubic feet of natural gas per day to support its commitments. Some 10.3 billion cubic feet per day will be needed to produce 77 millions metric tons of LNG per year; 4 billion cubic feet per day for the 394,000 barrels per day of GTL; about 5 billion cubic feet per day for petrochemical, local power, and industrial projects; and about

(continued on page 48)

GTL Joint Venture Projects in Qatar
(2002 Dollars per Barrel)

Project	Initial Capacity (Barrels per Day)	Start Date	Final Capacity (Barrels per Day)
Oryx (QP/Sasol Chevron) . . .	34,000	2005	100,000
Pearl (Shell)	70,000	2009	140,000
ExxonMobil	154,000	2011	154,000
QP/Sasol Chevron	130,000	Delayed	130,000
Marathon	60,000	Delayed	120,000
ConocoPhillips	80,000	Delayed	160,000
Total	**528,000**		**804,000**

Source: Middle East Economic Survey (MEES), March 2005.

[d]Energy Information Administration, *Model Documentation: Natural Gas Transmission and Distribution Module*, DOE/EIA-M062 (Washington, DC, May 2005), Appendix F-27.
[e]FACTS Inc., "Iran's Gas Industry and Export Projects," *Gas Insights*, No. 45 (March 2005).
[f]M. Culligan, ConocoPhillips, Director of Business Development-Qatar GTL Project, "GTL: New Technology for a New Industry," presentation at the Fifth Doha Gas Conference (March 1, 2005).
[g]World Markets Research Centre, "Shell Holds Back on FID for Qatar GTL," web site www.worldmarketsanalysis.com (January 20, 2005).
[h]FACTS Inc., *Gas Databook I* (Honolulu, HI, 2005), p. 87.
[i]Keynote speech by Abdulla bin Hamad Al-Attiyah, Qatar Minister of Energy and Industry, at the Fifth Doha Gas Conference (February 28, 2005).
[j]"Third Annual Finance, Investment in Qatar Set To Open in London," *Gulf Times (Qatar)* (May 24, 2005).

Gas to Liquids: A New Frontier for Natural Gas (Continued)

2 billion cubic feet per day for exports through the Dolphin pipeline. Over a 25-year period (the duration of a long-term LNG or GTL contract), Qatar would need to produce 225 trillion cubic feet, or one-fourth of its North Field reserve.[k] Although the 900 trillion cubic feet of natural gas reserves from the North Field should be sufficient to support these projects on a sustainable basis, the quality of the gas and cost of development will vary from project to project. As a result, there could be delays in some of the plans.

In the *IEO2005* reference case, world demand for oil in the transportation sector is projected to grow by 2.1 percent per year, from 41.7 million barrels per day in 2002 to 67.3 million barrels per day in 2025. Even if all the proposed GTL projects worldwide materialized by 2025, assuming a 70-percent yield for diesel fuel from the natural gas stock, the expected GTL diesel supply of 1.2 million barrels per day in 2025 would represent only a fraction of total world transportation sector demand. Nevertheless, GTL diesel projects do provide gas-producing companies with an opportunity to add new value-added activities to their portfolios, as well as providing governments with an effective approach to meeting policy and environmental objectives.

[k]"Qatar Seeks New Math From North Field," *World Gas Intelligence* (June 1, 2005), pp. 2-3.

Coal

Although coal use is expected to be displaced by natural gas in some parts of the world, only a slight drop in its share of total energy consumption is projected by 2025. Coal continues to dominate electricity and industrial sector fuel markets in emerging Asia.

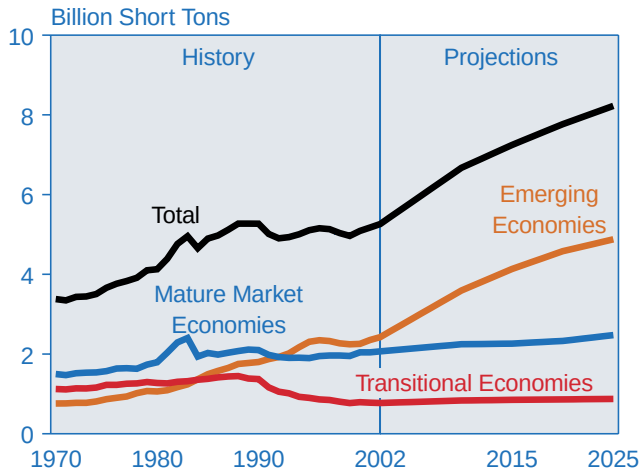
In the *International Energy Outlook 2005* (*IEO2005*) reference case, world coal consumption is projected to increase from 5,262 million short tons[5] in 2002 to 7,245 million tons in 2015, at an average rate of 2.5 percent per year. From 2015 to 2025, the projected rate of increase in world coal consumption slows to 1.3 percent annually, and total consumption in 2025 is projected at 8,226 million tons (Figure 50). World GDP and primary energy consumption also are projected to grow at a more rapid pace during the first half than during the second half of the forecast period, reflecting a gradual slowdown in growth of the economies of emerging Asia, which currently are expanding at a rapid pace.

Coal consumption in 2002—primarily in the electric power and industrial sectors—accounted for 24 percent of total world energy consumption (Figure 51). Of the coal produced worldwide, 65 percent was shipped to electricity producers, 31 percent to industrial consumers, and most of the remaining 4 percent to coal consumers in the residential and commercial sectors. In the industrial sector coal is an important input for the manufacture of steel and for the production of steam and direct heat for other industrial applications. Coal plays a limited role in the residential and commercial sectors, and although it was once an important fuel for transportation, its use for transportation is now virtually nonexistent.

Coal's share of world energy consumption in the electricity and industrial sectors is projected to remain relatively stable in the *IEO2005* forecast. As a consequence, its share of total world energy consumption remains near its 2002 share of 24 percent. In the electricity sector, coal's share of energy consumption is projected to decline slightly, from 39 percent in 2002 to 38 percent in 2025. In the industrial sector, its share is projected to rise from 20 percent in 2002 to 22 percent in 2015 and to remain at that level through 2025.

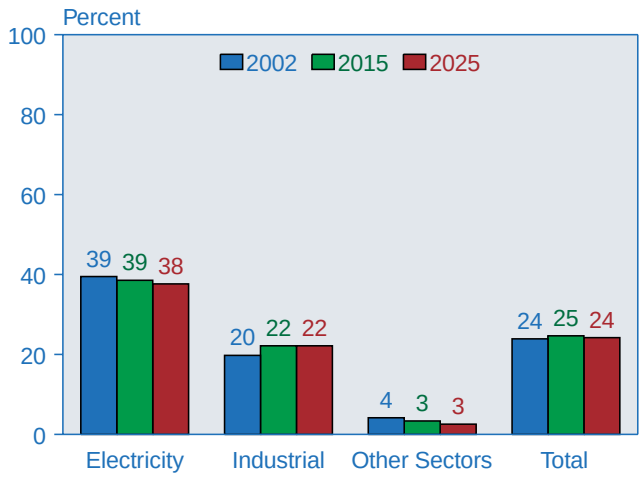
To a large extent, the slight increase in the importance of coal in the industrial sector results from the substantial growth projected for industrial energy consumption in China, which has abundant coal reserves, limited reserves of oil and natural gas, and a dominant position in world steel production. Coal is expected to remain the

Figure 50. World Coal Consumption by Region, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 51. Coal Share of World Energy Consumption by Sector, 2002, 2015, and 2025



Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2015 and 2025:** EIA, System for the Analysis of Global Energy Markets (2005).

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

fuel of choice in China's rapidly expanding industrial sector. In the IEO2005 reference case forecast, the coal share of China's industrial energy consumption increases from 50 percent in 2002 to 55 percent in 2025. In the rest of the world, coal's share of industrial energy consumption is projected to decline from 15 percent in 2002 to 13 percent in 2025.

International coal trade is projected to increase from 714 million tons in 2003 to 969 million tons in 2025, accounting for approximately 12 to 13 percent of total world coal consumption over the period. Steam coal (including coal for pulverized coal injection at blast furnaces) accounts for most of the projected increase in world coal trade. Details of recent changes in international coal markets and an assessment of the long-term outlook for world coal trade are provided at the end of this chapter.

Reserves

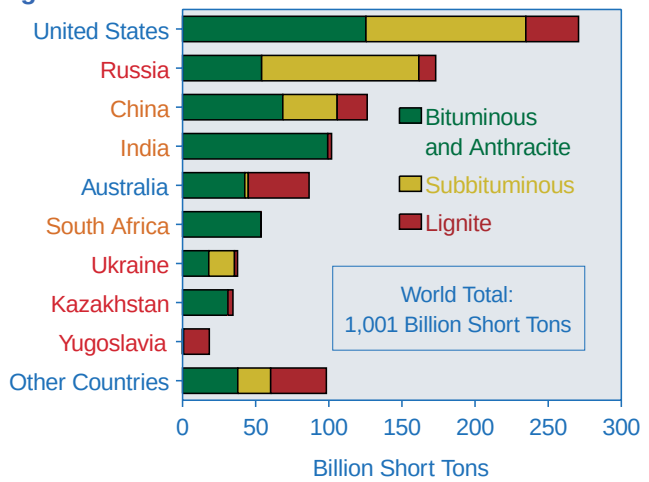
Total recoverable reserves of coal[6] around the world are estimated at 1,001 billion tons—enough to last approximately 190 years[7] at current consumption levels (Figure 52). Historically, estimates of world recoverable coal reserves, although relatively stable, have declined gradually from 1,167 billion tons at the beginning of 1990 to 1,083 billion tons in 2000 and 1,001 billion tons in 2003 [*1*]. The most recent assessment of world coal reserves includes a substantial downward adjustment for Germany, from 73 billion tons of recoverable coal reserves to 7 billion tons. The reassessment primarily reflects more restrictive criteria for the depth and thickness parameters associated with both underground and surface minable seams of coal [*2*].

Although coal deposits are widely distributed, 57 percent of the world's recoverable reserves are located in three countries: the United States (27 percent), Russia (17 percent), and China (13 percent). Another six countries—India, Australia, South Africa, Ukraine, Kazakhstan, and Yugoslavia—account for an additional 33 percent. In 2002, these nine countries, taken together, accounted for 90 percent of the world's estimated recoverable coal reserves and 78 percent of total world coal production [*3*]. By rank, bituminous and anthracite coal account for 53 percent of the world's estimated recoverable coal reserves (on a tonnage basis), subbituminous coal accounts for 30 percent, and lignite accounts for 17 percent.

Quality and geological characteristics of coal deposits are important parameters for coal reserves. Coal is a heterogeneous source of energy, with quality (e.g., characteristics such as heat, sulfur, and ash content) varying significantly from one region to the next and even within an individual coal seam. At the top end of the quality spectrum are premium-grade bituminous coals that are used to manufacture coke for the steelmaking process. Coking coals produced in the United States have an estimated heat content of 27.4 million Btu per ton and a relatively low sulfur content of approximately 0.8 percent by weight [*4*]. At the other end of the spectrum are reserves of low-Btu lignite or "brown coal." On a Btu basis, lignite reserves show considerable variation. Estimates published by the International Energy Agency indicate that the average heat content of lignite for major producing countries varies from a low of 4.6 million Btu per ton in Greece to a high of 12.3 million Btu per ton in Canada in 2002 [*5*].

A potential new entrant as a producer of lignite is Pakistan, where interest has been sparked by the identification of a huge lignite resource in the Tharparkar (Thar) Desert in the 1990s. The Thar coalfield covers an area of approximately 3,500 square miles and is estimated to contain 193 billion tons of lignite resources [*6*]. Four tracks of the Thar coalfield currently undergoing more detailed assessment, comprising an area of about 138 square miles, are estimated to contain 3 billion tons of recoverable coal reserves. This represents 89 percent of Pakistan's total recoverable reserves, as published by the World Energy Council [*7*]. Analyses of Thar lignite indicate a relatively high heat content, between 9.4 and 12.7 million Btu per ton [*8*]. The Pakistan government currently is working with two international companies,

Figure 52. World Recoverable Coal Reserves



Note: Data for the United States represent recoverable coal estimates as of January 1, 2004. Data for other countries are as of January 1, 2003.

Source: Energy Information Administration, *International Energy Annual 2003*, DOE/EIA-0219(2003) (Washington, DC, June 2005), Table 8.2, web site www.eia.doe.gov/iea/.

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

[7]Assuming that world coal consumption continues to increase at the same rate as is projected for the years 2015 through 2025 (1.3 percent per year), current estimated world coal reserves would last for only about 90 years.

the Shenhua Group and AES Corporation, toward the development of several minemouth power plants in the Thar coalfield [*9*].

Regional Demand Forecasts

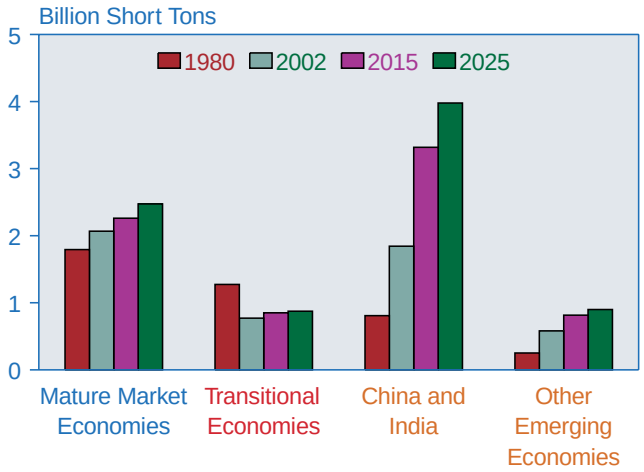
Mature Market Economies

Coal consumption in the mature market economies is projected to rise at a relatively even pace over the forecast horizon, from 2,067 million tons in 2002 to 2,261 million tons in 2015 and 2,474 million tons in 2025 (Figure 53). Much of the 407-million-ton increase in coal consumption projected for the mature market economies over the forecast period is the result of expected strong growth in U.S. coal demand. While modest increases in coal consumption are projected for Canada and Australia/New Zealand, coal consumption in Western Europe is projected to decline by 114 million tons between 2002 and 2025. In Western Europe, natural gas and renewable energy are projected to capture an increasing share of the region's total energy consumption, displacing both coal and nuclear energy.

North America

Coal use in North America is dominated by U.S. consumption. In 2002, the United States consumed 1,066 million tons, accounting for 93 percent of the regional total. U.S. consumption is projected to rise to 1,505 million tons in 2025. The United States has substantial coal reserves and has come to rely heavily on coal for electricity generation, a trend that continues in the forecast. Coal's share of total U.S. electricity generation is projected to decline slightly from 52 percent in 2002 to 51 percent in 2015 and then return to 53 percent in 2025 [*10*].

Figure 53. World Coal Consumption by Region, 1980, 2002, 2015, and 2025



Sources: **1980 and 2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219 (2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2015 and 2025:** EIA, System for the Analysis of Global Energy Markets (2005).

To a large extent, the projections of increasing prices for natural gas after 2010, combined with projections of relatively stable minemouth coal prices and slightly declining rates for domestic transportation of coal, are the key factors helping coal compete as a fuel for U.S. power generation. Increases in coal-fired generation are projected to result from both greater utilization of existing U.S. coal-fired generating capacity and an additional 89,500 megawatts of new coal-fired capacity by 2025 (3,600 megawatts of older coal-fired capacity is projected to be retired). The average utilization rate of coal-fired generating capacity is projected to rise from 70 percent in 2002 to 83 percent in 2025.

In Canada, coal's share of total energy consumption is projected to decline slightly over the forecast period, from 13 percent in 2002 to 12 percent in 2025. In the near term, the restart of four of Canada's nuclear generating units after 2002 is expected to restrain the need for coal in eastern Canada. Between September 2003 and January 2004, three of the four units, representing 2,000 megawatts of generating capacity, were returned to service—Unit 4 at the Ontario Power Generation (OPG) Pickering A plant and Units 3 and 4 at Bruce Power's Bruce A plant [*11*]. OPG's 500-megawatt Unit 1 at the Pickering A plant is scheduled to come back on line in late 2005.

In 2004, coal-fired generation accounted for 17 percent of Ontario's electricity supply, down from 23 percent in 2003, and its share could decline further in the future [*12*]. The Ontario government currently plans to shut down all of the Province's 7,560 megawatts of coal-fired generating capacity by early 2009, although the government has indicated that the shutdowns will not occur unless generation from alternative sources can be secured [*13*]. The decision is based primarily on the premise that the adverse health and environmental impacts of the plants' operation are unacceptable. In western Canada, increasing demand for electricity is expected to result in the need for additional coal-fired generating capacity, primarily in Alberta.

Mexico consumed 14 million tons of coal in 2002. In 2025 it is projected to consume 25 million tons. Two coal-fired generating plants, Rio Escondido (1,200 megawatts) and Carbon II (1,400 megawatts), operated by the state-owned utility Comisión Federal de Electricidad (CFE), consume approximately 10 million tons of coal annually, most of which comes from domestic mines [*14*]. In addition, CFE has recently switched its six-unit, 2,100-megawatt Petacalco plant, located on the Pacific coast, from oil to coal. Petacalco's estimated annual coal consumption is 6 million tons of imported coal, although CFE has maintained the option to generate with fuel oil. The utility plans to add an additional 700 megawatts of coal-fired capacity at the Petacalco plant late in the decade [*15*].

Western Europe

In Western Europe, environmental concerns play an important role in the competition among coal, natural gas, and nuclear power. Recently, other fuels—particularly, natural gas—have been gaining relative to coal in the generation market. Coal consumption in Western Europe has fallen by 36 percent since 1990, from 894 million tons to 573 million tons in 2002. The decline was smaller on a Btu basis, at 30 percent, reflecting the fact that much of it resulted from reduced consumption of low-Btu lignite in Germany.

Over the forecast period, coal consumption in Western Europe is projected to fall by an additional 20 percent (on a tonnage basis), reflecting a slower rate of decline than during the previous decade. Factors contributing to further cutbacks in coal consumption include continued penetration of natural gas for electricity generation, growing use of renewable fuels in the region, continuing pressure on member countries of the European Union to reduce subsidies that support domestic production of hard coal,[8] and relatively slow growth in overall energy consumption (0.5 percent per year). Despite a considerable drop in lignite consumption since 1990, this low-rank fuel continues to be an important component of the Western European coal market. In 2002, lignite accounted for 50 percent of the region's total coal consumption on a tonnage basis and 29 percent on a Btu basis [***16***].

Coal consumption in Western Europe's electric power sector is projected to decline from 6.4 quadrillion Btu in 2002 to 5.4 quadrillion Btu in 2015 and 4.8 quadrillion Btu in 2025. Germany is currently the leading coal-consuming country in Western Europe, a position it is expected to maintain over the forecast period. Much of the planned and recently completed work on coal-fired generating capacity in Western Europe is related to either the replacement or refurbishment of existing capacity. Germany, Spain, France, Italy, and Greece all are planning major projects to upgrade existing coal-fired generating facilities over the next two decades.

Mature Market Asia

Mature market Asia consists of Australia, New Zealand, and Japan. Australia is the world's leading coal exporter, and Japan is the world's leading coal importer. In 2002, Australian coal producers shipped 225 million tons of coal to international consumers and consumed another 160 million tons (both hard coal and lignite) domestically, primarily for electricity generation. Coal-fired power plants accounted for 78 percent of Australia's total electricity generation in 2002, a level that is projected to be maintained over the forecast horizon [***17***]. Overall coal use for Australia and New Zealand, taken together, is projected to increase by 47 million tons (29 percent), from 162 million tons in 2002 to 209 million tons in 2025. The most recent energy forecast released by the Australian government (August 2004) indicates that coal consumption in Australia will increase by 1.5 percent per year on a Btu basis from 2002 to 2020, which is slightly higher than the projected rate of 1.4 percent for Australia/New Zealand over the same period in the *IEO2005* reference case [***18***].

Japan, which is the seventh largest coal user globally (following China, India, the United States, Russia, Germany, and South Africa), imports nearly all the coal it consumes, much of it originating from Australia [***19***]. Currently, about 44 percent of the coal consumed in Japan is used by the country's steel industry (Japan is the world's second largest producer of both crude steel and pig iron, behind China) [***20***]. Coal is also used heavily in the Japanese power sector, and coal-fired plants generated 27 percent of the country's electricity supply in 2002 [***21***]. During the years 2001 through 2004, 8,700 megawatts of new coal-fired generating capacity was brought on line in Japan [***22***]. Additional coal-fired generating capacity originally scheduled to come on line between the end of 2004 and the end of 2008 has been postponed to later dates [***23***]. In the *IEO2005* forecast, increased use of other fuels for electricity generation (including natural gas, renewables, and nuclear), coupled with an outlook for slow economic growth and a decline in population, results in a relatively flat outlook for Japanese coal consumption.

Transitional Economies

Coal consumption in the transitional economies of Eastern Europe and the former Soviet Union (EE/FSU) is projected to rise over the forecast horizon from 771 million tons in 2002 to 850 million tons in 2015 and 874 million tons in 2025. In the EE/FSU countries, the process of economic reform and the transition to market-oriented economies from centrally planned economic systems continue to advance. The dislocations associated with institutional changes in the region have contributed substantially to declines in both production and consumption of coal. In 2002, coal consumption in the EE/FSU region was 44 percent lower (on a tonnage basis) than in 1990. In the *IEO2005* reference case, coal's share of total EE/FSU energy consumption is projected to decline from 22 percent in 2002 to 17 percent in 2025 (Figure 54). During this same period, natural gas' share of total energy consumption is projected to increase from 45 percent to 51 percent.

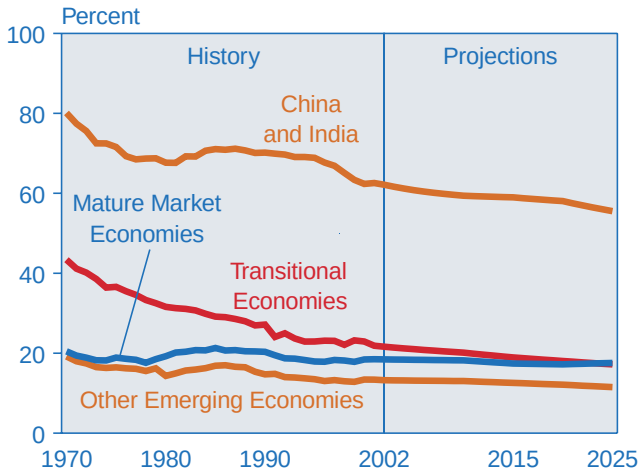
Substantial declines in economic output and energy demand following the breakup of the Soviet Union in 1991 led to considerable declines in both overall energy

[8]Internationally, the term "hard coal" is used to describe anthracite and bituminous coal. In data published by the International Energy Agency, coal of subbituminous rank is classified as hard coal for some countries and as brown coal (with lignite) for others.

consumption and coal consumption in the FSU. In 2002, total energy consumption in the FSU was 18.5 quadrillion Btu, or 30 percent, below the level in 1990, and coal consumption was down by 6.0 quadrillion Btu, or 45 percent. Reversing recent historical trends, coal consumption in Russia and the other FSU countries is projected to increase over the forecast period. Russia's coal consumption is projected to increase by 59 million tons (26 percent) from 2002 to 2025, and consumption in other FSU countries is projected to rise by 24 million tons (15 percent).

Of the 15 FSU countries, Russia, Ukraine, and Kazakhstan together account for virtually all the coal consumption and production in the region, and this is expected to remain the case in the future [***24***]. The *IEO2005* outlook for Russia's coal consumption is generally consistent with the long-term energy policy set forth in the August 2003 document, *Russia's Energy Strategy for the Period up to 2020* [***25***]. Although Russia's long-term energy strategy favors a considerable amount of new nuclear generating capacity, fossil-fuel-fired plants are expected to continue in their role as the primary source for electric power generation through 2020. For new fossil-fired generating capacity, Russia's energy strategy promotes the construction of advanced coal-fired generating capacity in the coal-rich Siberian region (central Russia) and recommends a focus on efficient natural-gas-fired capacity for the western and far eastern areas of the country. Coal consumption in other FSU countries is projected to increase slightly, primarily as the result of increased utilization of existing coal-fired generating capacity in Kazakhstan and Ukraine.

Figure 54. Coal Share of Total Energy Consumption by Region, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

In Eastern Europe, coal consumption is projected to increase slightly over the forecast period, from 374 million tons in 2002 to 394 million tons in 2025. Poland is the region's largest producer and consumer of coal and the second largest coal producer and consumer in all of Europe, outranked only by Germany [***26***]. In 2002, coal consumption in Poland totaled 149 million tons—40 percent of Eastern Europe's total coal consumption for the year. The most recent (January 2005) long-term energy policy put forth by the Polish government indicates that coal-fired generation should remain relatively constant, with new natural-gas-fired capacity used to meet future demand in the electricity sector [***27***]. Additional plans for both new coal-fired capacity and the refurbishment of existing capacity in other Eastern European countries, including Bosnia and Herzegovina, Bulgaria, the Czech Republic, Macedonia, Slovakia, and Yugoslavia, is a strong indicator that coal will continue to be an important source of energy in the region [***28***].

Emerging Asia

Coal consumption in the emerging economies of Asia is projected to more than double in the *IEO2005* reference case forecast, increasing from 2,118 million tons in 2002 to 3,715 million tons in 2015 and 4,435 million tons in 2025. The projected increase of 2,317 million tons from 2002 to 2025 represents 78 percent of the increase in worldwide coal consumption over the period. With substantial growth in coal consumption in China (1,819 million tons) and India (315 million tons) over the forecast period, emerging Asia's share of total world coal consumption is projected to rise from 40 percent in 2002 to 51 percent in 2015 and 54 percent in 2025.

Despite the tremendous increases in coal consumption projected for emerging Asia, coal's share of total energy consumption in the region is still projected to decline slightly, from 47 percent in 2002 to 44 percent in 2025. Much of the decline in coal's share is attributed to fast-paced growth projected for natural gas use in the region.

As very large countries (in terms of both population and landmass) with large domestic coal resources, China and India account for 71 percent of the total increase in coal use worldwide (on a Btu basis) over the forecast period; however, coal's share of energy use in China and India, and in emerging Asia as a whole, still is projected to decline. The large increases in coal consumption projected for China and India are based on an outlook for strong economic growth (averaging 6.2 percent per year in China and 5.5 percent per year in India from 2002 to 2025) and the expectation that much of the increased demand for energy will be met by coal, particularly in the industrial and electricity sectors.

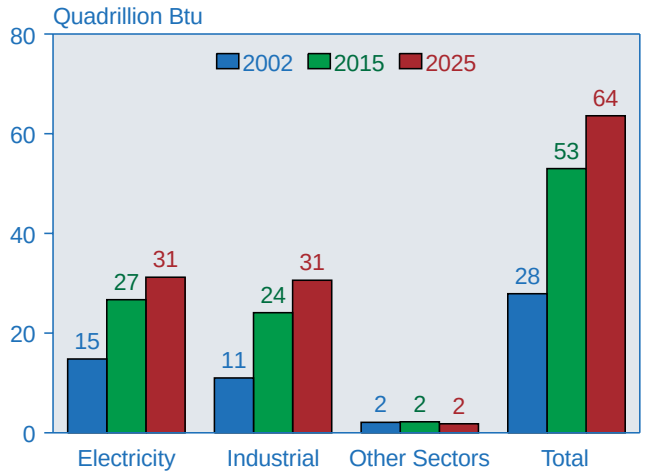
In China's electricity sector, coal use is projected to grow by 3.3 percent a year, from 14.8 quadrillion Btu in 2002 to

31.2 quadrillion Btu in 2025 (Figure 55). In comparison, coal consumption by electricity generators in the United States is projected to rise by 1.6 percent annually, from 19.8 quadrillion Btu in 2002 to 28.6 quadrillion Btu in 2025. One of the key implications of the substantial rise in coal use for electricity generation in China is that large financial investments in new coal-fired power plants and in the associated transmission and distribution systems will be needed. The projected growth in electricity sector coal demand for China would result in the need for 229,000 megawatts of additional coal-fired capacity (net of retirements) by 2025 [***29***]. At the end of 2002, China had an estimated 204,000 megawatts of coal-fired generating capacity.

In 2002, 47 percent of China's coal use was in the non-electricity sectors, primarily in the industrial sector. Over the forecast period, coal demand in China's non-electricity sectors is expected to increase by 19.4 quadrillion Btu (148 percent), raising the non-electricity share of total coal demand to 51 percent in 2025. Coal remains the primary source of energy in China's industrial sector, primarily because China has limited reserves of oil and natural gas. In 2002, China was the world's leading producer of both steel and pig iron [***30***].

With a substantial portion of the increase in China's demand for both oil and natural gas projected to be met by imports, the Chinese government is actively promoting the development of a large coal-to-liquids industry. Initial production of coal-based synthetic liquids in China is scheduled to commence in mid-2007 with the completion of the country's first coal-to-liquids plant. The plant, located in the Inner Mongolia Autonomous Region, is being built by the Shenhua Coal Liquefaction Corporation. Following the completion of a second production phase at the same site in 2010, the facility will be capable of converting approximately 17 million tons of coal to 37 million barrels of petroleum products annually (approximately 100,000 barrels per day) [***31***]. The Shenhua Coal Liquefaction Corporation plans to expand production of coal-based synthetic liquids to about 220 million barrels per year (approximately 600,000 barrels per day) in 2020, requiring an estimated 80 to100 million tons of coal per year as an input [***32***].

Figure 55. Coal Consumption in China by Sector, 2002, 2015, and 2025



Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2015 and 2025:** EIA, System for the Analysis of Global Energy Markets (2005).

In India, slightly less than 60 percent of the projected growth in coal consumption is attributable to increased demand for coal in the electricity sector, and the industrial sector accounts for most of the remaining increase. In 2002, electricity generation accounted for 67 percent of India's total coal use. The use of coal for electricity generation in India is projected to rise by 2.2 percent per year, from 5.1 quadrillion Btu in 2002 to 8.5 quadrillion Btu in 2025, requiring an additional 59,000 megawatts of coal-fired capacity (net of retirements) [***33***]. At the end of 2002, India had an estimated 66,000 megawatts of coal-fired generating capacity. Currently, the government is targeting the construction of approximately 40,000 megawatts of new coal-fired generating capacity for the country over the 10-year period ending March 2012 [***34***].

In the other areas of emerging Asia, a considerably smaller rise in coal consumption is projected over the forecast period, based on expectations for growth in coal-fired electricity generation in South Korea, Taiwan, and the member countries of the Association of Southeast Asian Nations (primarily Indonesia, Malaysia, the Philippines, Thailand, and Vietnam). In the electricity sector, coal use in the other emerging countries of Asia (including South Korea) is projected to increase by 2.6 percent per year, from 2.9 quadrillion Btu in 2002 to 5.2 quadrillion Btu in 2025.

The key motivation for increasing use of coal in other emerging Asia is to maintain a diversity of fuel supply for electricity generation. This objective is shared even in countries that have abundant reserves of natural gas, such as Thailand, Malaysia, Indonesia, and the Philippines. In the *IEO2005* forecast, coal's share of fuel consumption for electricity generation in the region (including South Korea) is projected to increase from 27 percent in 2002 to 30 percent in 2015, then decline to 26 percent in 2025 as consumption of natural gas for electricity generation increases.

Middle East

In 2002, Middle Eastern countries consumed 84 million tons of coal, with Turkey accounting for more than 86 percent of the total. Most of the coal consumed in Turkey is locally produced, low-Btu lignite [***35***]. Israel accounts for most of the region's remaining coal consumption.

Over the forecast period, coal consumption in the Middle East is projected to increase by 32 million tons.

Much of the increased use of coal projected for the Middle East is for electricity generation. In Turkey, the completion of two new coal-fired power plants in 2003 and 2005 is projected to add an additional 23 million tons to the country's annual coal consumption. The projects consist of a 1,300-megawatt hard-coal-fired plant being built on the southern coast of Turkey near Iskenderun, to be fueled by imported coal, and a 1,440-megawatt lignite-fired plant (Afsin-Elbistan B plant) being built in the lignite-rich Afsin-Elbistan region in southern Turkey [*36*]. Because of the extremely low heat content of the indigenous lignite feedstock for the Afsin-Elbistan B plant—approximately 4.0 million Btu per ton—annual fuel requirements are estimated to be 19 million tons [*37*]. In Israel, state-owned Israel Electric Corporation plans to bring an additional 1,100 megawatts of coal-fired generating capacity on line at Ashkelon in 2012, near the site of its 2,250-megawatt Rutenberg coal plant [*38*].

Africa

Africa's coal consumption is projected to increase by 81 million tons between 2002 and 2025, primarily to meet demand for electricity, which is projected to increase at a rate of 3.7 percent per year. South Africa currently accounts for 92 percent of the coal consumed in the continent and is expected to continue to account for much of the increase in Africa's total coal consumption over the forecast period. Additional growth in coal consumption is likely to occur in some of the other countries of southern Africa that also are well endowed with indigenous coal resources.

In South Africa, increasing demand for electricity in recent years has led to the decision by Eskom, the country's state-owned electricity supplier, to restart three large coal-fired plants (Camden, Grootvlei, and Komati) that have been closed for more than a decade [*39*]. The first of the three plants is to scheduled to come back on line in 2005, and the remaining plants are scheduled for restart in 2008. The plants have a combined generating capacity of 3,800 megawatts [*40*]. Projections of power shortages for southern Africa in the latter half of this decade have led to increased interest in new coal-fired power projects not only in South Africa but also in Zimbabwe, Tanzania, Swaziland, and Botswana [*41*].

Central and South America

Historically, coal has not been a major source of energy in Central and South America. In 2002, coal accounted for about 4 percent of the region's total energy consumption, and in past years its share has never exceeded 5 percent. In the electricity sector, hydroelectric power has met much of the region's electricity demand, and new power plants are now being built to use natural gas produced in the region. Over the forecast period, a combination of fuels—natural gas, oil, and renewable energy (including hydropower and other renewables)—is expected to fuel most of the region's projected increase in electricity generation. In the *IEO2005* reference case, coal is projected to maintain a 4-percent share of Central and South America's total primary energy consumption.

Brazil, with the world's eighth largest steel industry in 2002, accounted for more than 62 percent of the region's coal demand (on a tonnage basis); Colombia, Chile, Argentina, Peru, and Venezuela accounted for much of the remainder [*42*]. In the forecast, Brazil accounts for most of the growth in coal consumption projected for the region, with increased use of coal expected for both steelmaking and electricity production. Brazil's steel companies currently plan to expand production capacity by a substantial amount over the next few years to meet increasing domestic and international demand for steel [*43*]. Brazil's three southernmost States, Rio Grande do Sul, Santa Catarina, and Parana, which contain most of the country's coal reserves, are actively promoting the construction of several new coal-fired power plants [*44*]. The new coal projects being promoted by the government of Rio Grande do Sul represent a key component of its plan to become self-sufficient in electricity supply.

Trade

Overview

Compared with world coal consumption, the amount of coal traded in international markets is relatively small. In 2003, world imports of coal amounted to 714 million tons (Figure 56 and Table 9), representing 13 percent of total world consumption. In 2025, coal imports worldwide are projected to total 969 million tons, or 12 percent of world coal consumption.

The world coal market consists of essentially two distinct markets—a steam coal market and a coking coal market. The international steam coal market consists largely of (1) demand for coal for electricity generation, (2) demand for coal to produce steam and direct heat for industrial applications, and (3) demand for coal to be used in blast furnaces for steelmaking. The international market for coking coal consists solely of demand for coal coke as a fuel and reducing agent for smelting iron ore in blast furnaces.

Growth in international coal trade in recent years has resulted primarily from increased demand for steam coal for electricity generation, particularly in Asia. In contrast, the world market for coking coal has been relatively stable, as Asian steel producers have increased their imports and Europe and the Americas have decreased imports. Most recently, increased imports of coking coal by China in 2003 and 2004 have contributed to the upward trend for coking coal imports to Asia.

Two factors that have contributed to the relatively flat trend in world coking coal imports are continuing increases in steel production from electric arc furnaces (which do not use coal coke as an input), primarily in Europe and North America; and technological improvements at blast furnaces, including greater use of pulverized coal injection and higher average injection rates per ton of hot metal produced [*45*].

In the *IEO2005* forecast, world steam coal trade is projected to increase by 1.5 percent per year, from 504 million tons in 2003 to 693 million tons in 2025. Increased exports to Asia, primarily to fuel new coal-fired generating capacity, account for most of the projected expansion in the world steam coal market. World coking coal trade is projected to increase by 1.3 percent per year, from 210 million tons in 2003 to 276 million tons in 2025. Increased imports of coking coal are projected for China, South Korea, Taiwan, India, and Brazil, where expansions in blast-furnace-based steel production are expected.

Asia

Based primarily on strong growth in electricity demand, Asia's demand for imported coal remains poised for additional increases over the forecast period (Figure 57). In the *IEO2005* forecast, South Korea, Taiwan, India, China, and Malaysia are projected to account for most of the projected growth in coal imports to Asia.

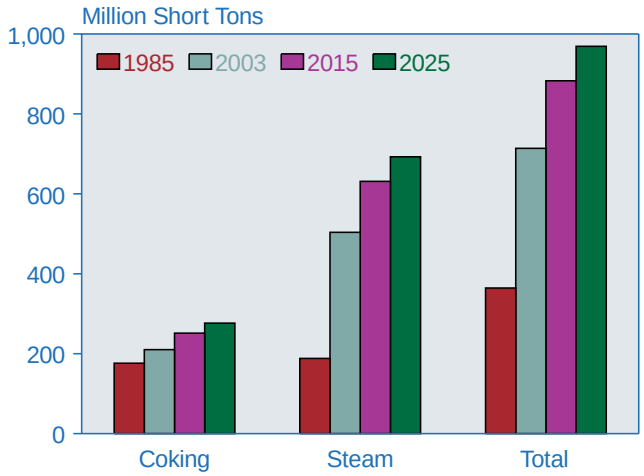
Although Japan's share of total world coal trade has been declining, it continues to be the world's leading importer of coal and is projected to account for 19 percent of total world imports in 2025, less than its 2003 share of 25 percent [*46*]. In 2003, Japan relied almost entirely on imported coal for domestic consumption, purchasing 182 million tons of coal from foreign suppliers. In *IEO2005*, expectations of slow economic growth (1.7 percent per year from 2002 to 2025) and a shift to a less energy-intensive economy lead to relatively small changes in Japan's total energy consumption (average annual growth of 0.5 percent) and virtually no change in coal consumption. As a result, Japan's coal imports are projected to remain near the 2003 level throughout the forecast. Japan's share of total Asian coal imports, which declined from 85 percent in 1980 to 46 percent in 2003 primarily as a result of increases in coal imports by South Korea, Taiwan, and India, is projected to continue falling to 29 percent in 2025.

South Korea, currently the second leading importer of coal worldwide, is expected to maintain that position over the forecast period. Coal imports to South Korea are projected to increase from 77 million tons in 2003 to 143 million tons in 2025. As a result, South Korea's share of Asian coal imports is projected to rise from 19 percent in 2003 to 22 percent in 2025. From 2004 through 2010, South Korean electricity generators plan to add more than 8,000 megawatts of new coal-fired generating capacity [*47*].

China and India, which import relatively small quantities of coal at present, are expected to account for much of the remaining increase in coal imports projected for Asia. From 2003 to 2025, coal imports by China and India, taken together, are projected to increase by 109 million tons. Increased imports of coking coal account for approximately half of the overall increase in coal imports projected for China and India, which is unlike the outlook for other Asian countries, where fuel requirements for new coal-fired power plants are the key source of coal demand. Imports by China and India have the potential to be even higher than projected, but it is assumed in the forecast that domestic coal will be given first priority in meeting the large projected increase (2.1 billion tons) in coal consumption in the two countries.

Elsewhere in Asia, recent and planned additions of coal-fired capacity have increased and will continue to add to coal import demand in the region. In both Malaysia and Taiwan, coal imports are projected to rise substantially over the forecast period to fuel new coal-fired power plants. Diversification of fuel supply for electricity generation is the key factor underlying Malaysia's plans for additional coal-fired generating capacity [*48*]. Taiwan Power cites cost advantages over natural-gas- and oil-fired plants as the key factor underlying its plans for new coal plants [*49*]. In Thailand, the 1,434-megawatt

Figure 56. World Coal Trade, 1985, 2003, 2015, and 2025



Sources: **1985:** Energy Information Administration (EIA), *Annual Prospects for World Coal Trade 1987*, DOE/EIA-0363(87) (Washington, DC, May 1987). **2003:** SSY Consultancy and Research, Ltd., *SSY's Coal Trade Forecast*, Vol. 14, No. 2 (London, UK, May 2005); and Energy Information Administration, *Quarterly Coal Report*, October-December 2003, DOE/EIA-0121(2003/4Q) (Washington, DC, March 2004). **2015 and 2025:** Energy Information Administration, National Energy Modeling System run IEO2005.D060605B.

Table 9. World Coal Flows by Importing and Exporting Regions, Reference Case, 2003, 2015, and 2025
(Million Short Tons)

Exporters	Importers											
	Steam				Coking				Total			
	Europe[a]	Asia	Americas	Total[b]	Europe[a]	Asia[c]	Americas	Total[b]	Europe[a]	Asia	Americas	Total[b]
	2003											
Australia	12.5	96.1	6.8	**115.8**	29.0	85.1	8.1	**122.3**	41.5	181.3	14.9	**238.1**
United States	3.0	0.2	18.5	**21.8**	14.0	0.0	7.2	**21.2**	17.0	0.3	25.7	**43.0**
South Africa	70.2	5.5	0.4	**77.2**	1.0	0.0	0.5	**1.6**	71.2	5.5	1.0	**78.7**
Former Soviet Union	24.2	9.5	0.0	**33.8**	2.7	4.5	0.0	**7.2**	26.9	14.0	0.0	**41.0**
Poland	15.1	0.0	0.0	**15.1**	1.3	0.0	0.0	**1.3**	16.4	0.0	0.0	**16.4**
Canada	0.0	0.9	0.7	**1.5**	8.1	13.9	4.1	**26.2**	8.1	14.7	4.7	**27.7**
China	6.2	81.2	1.1	**89.0**	0.1	12.6	1.8	**14.4**	6.3	93.8	2.8	**103.4**
South America[d]	32.5	0.0	25.2	**57.8**	0.0	0.0	0.0	**0.0**	32.5	0.0	25.2	**57.8**
Indonesia[e]	16.9	70.6	2.9	**91.8**	0.1	15.8	0.1	**16.0**	17.0	86.4	3.0	**107.8**
Total	**180.7**	**263.9**	**55.6**	**503.7**	**56.3**	**131.9**	**21.8**	**210.1**	**237.0**	**395.9**	**77.4**	**713.9**
	2015											
Australia	2.5	137.3	0.8	**140.7**	28.6	121.9	11.9	**162.4**	31.1	259.2	12.7	**303.1**
United States	5.9	1.1	4.0	**11.0**	8.9	0.8	6.5	**16.2**	14.7	1.8	10.5	**27.1**
South Africa	56.0	28.8	4.0	**88.7**	0.9	0.0	0.8	**1.7**	56.8	28.8	4.8	**90.4**
Former Soviet Union	41.5	23.6	0.0	**65.1**	3.1	9.4	0.0	**12.5**	44.6	33.0	0.0	**77.5**
Poland	6.2	0.0	0.5	**6.7**	1.1	0.0	0.0	**1.1**	7.3	0.0	0.5	**7.8**
Canada	1.5	0.0	0.0	**1.5**	8.6	15.3	12.7	**36.6**	10.2	15.3	12.7	**38.1**
China	0.0	90.4	0.0	**90.4**	0.0	6.8	0.0	**6.8**	0.0	97.2	0.0	**97.2**
South America[d]	53.8	0.0	47.4	**101.2**	0.0	0.0	0.0	**0.0**	53.8	0.0	47.4	**101.2**
Indonesia[e]	13.3	108.3	4.5	**126.1**	0.0	14.3	0.0	**14.3**	13.3	122.7	4.5	**140.5**
Total	**180.7**	**389.5**	**61.3**	**631.5**	**51.1**	**168.4**	**31.9**	**251.5**	**231.8**	**558.0**	**93.2**	**883.0**
	2025											
Australia	0.0	164.7	0.8	**165.5**	29.4	141.1	15.1	**185.6**	29.4	305.8	15.9	**351.2**
United States	0.0	1.0	4.1	**5.1**	6.9	0.0	7.7	**14.6**	6.9	1.0	11.8	**19.7**
South Africa	48.0	40.1	4.2	**92.3**	0.2	0.0	0.9	**1.1**	48.2	40.1	5.1	**93.4**
Former Soviet Union	42.0	26.5	0.0	**68.5**	4.2	9.9	0.0	**14.1**	46.2	36.4	0.0	**82.6**
Poland	4.4	0.0	0.0	**4.4**	0.6	0.0	0.0	**0.6**	5.0	0.0	0.0	**5.0**
Canada	0.0	0.0	0.0	**0.0**	9.5	18.5	10.8	**38.8**	9.5	18.5	10.8	**38.8**
China	0.0	93.7	0.0	**93.7**	0.0	7.4	0.0	**7.4**	0.0	101.1	0.0	**101.1**
South America[d]	69.4	0.0	56.6	**126.0**	0.0	0.0	0.0	**0.0**	69.4	0.0	56.6	**126.0**
Indonesia[e]	6.3	124.8	6.3	**137.3**	0.0	14.3	0.0	**14.3**	6.3	139.1	6.3	**151.6**
Total	**170.1**	**450.7**	**72.0**	**692.8**	**50.8**	**191.2**	**34.4**	**276.5**	**220.9**	**641.9**	**106.5**	**969.2**

[a]Coal flows to Europe include shipments to the Middle East and Africa. In 2003, coal imports to the Middle East and Africa totaled 40.2 million tons.

[b]In 2003, total world coal flows include a balancing item used to reconcile discrepancies between reported exports and imports. The 2003 balancing items by coal type were 3.5 million tons (steam coal), 0.1 million tons (coking coal), and 3.6 million tons (total).

[c]Includes 14.3 million tons of coal for pulverized coal injection at blast furnaces shipped to Japanese steelmakers in 2003.

[d]Coal exports from South America are projected to originate from mines in Colombia and Venezuela.

[e]In 2003, coal exports from Indonesia include shipments from other countries not modeled for the forecast period. The 2003 non-Indonesian exports by coal type were 8.4 million tons (steam coal), 1.7 million tons (coking coal), and 10.0 million tons (total).

Notes: Data exclude non-seaborne shipments of coal to Europe and Asia. 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: **2003:** SSY Consultancy and Research, Ltd., *SSY's Coal Trade Forecast*, Vol. 14, No. 2 (London, UK, May 2005); and Energy Information Administration, *Quarterly Coal Report*, October-December 2003, DOE/EIA-0121(2003/4Q) (Washington, DC, March 2004). **2015 and 2025:** Energy Information Administration, National Energy Modeling System run IEO2005.D060605B.

Map Ta Phut plant is scheduled to be fully operational in early 2007 [***50***].

During the 1980s, Australia became the leading coal exporter in the world, primarily by meeting increased demand for steam coal in Asia. Exports of Australian coking coal also increased, as countries such as Japan began using some of Australia's semi-soft or weak coking coals[9] in their coke oven blends. 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 [***51***] to 33 percent in 2003, is projected to remain relatively steady over the forecast period, accounting for 36 percent of total trade in 2025. Australia is expected to continue as the major exporter to Asia, with its share of the region's total coal import demand projected to increase from 46 percent in 2003 to 48 percent in 2025 (Table 9).

Two other major suppliers of coal to Asian markets are China and Indonesia. In 2003, China exported 94 million tons of coal to other Asian countries, representing 24 percent of total Asian coal imports, and Indonesian producers exported 78 million tons to Asia, or 20 percent of the region's total imports for the year. Over the forecast period, increasing domestic demand for coal in both China and Indonesia is projected to limit growth in their coal exports.

The United States, once a major supplier of coal to Asia, is currently only a minor participant in the Asian market. The U.S. share of Asia's coal imports declined from 28 percent in 1980 to less than 0.1 percent in 2003 [***52***]. In 2004, however, limited supplies of coking coal in the international market and a weaker U.S. dollar led to renewed interest in Appalachian coking coal. U.S. coking coal exports to Asia, which declined from a peak of more than 24 million tons in 1982 to virtually nothing in 2002 and 2003, were more than 5 million tons in 2004 [***53***]. U.S. steam coal exports to Asia increased from 0.2 million tons in 2003 to 2.3 million tons in 2004.

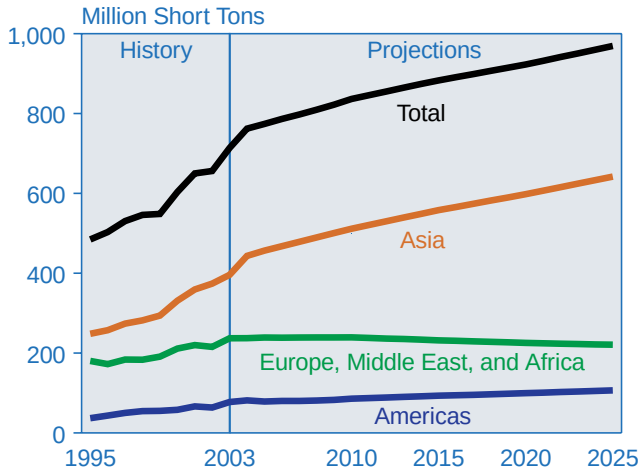
Europe, Middle East, and Africa

Coal imports to Europe, the Middle East, and Africa, taken as a whole, are projected to increase from 237 million tons in 2003 to 239 million tons in 2010 and then decline to 221 million tons in 2025 (Figure 57 and Table 9). In the *IEO2005* forecast, projected declines in overall imports to the countries of Western Europe are partly offset by increases projected for Turkey, Romania, Bulgaria, and Israel.

In Western Europe, environmental pressures and competition from natural gas are expected gradually to reduce the reliance on steam coal for electricity generation, and further improvements in the steelmaking process are expected to continue to reduce the amount of coal required for steel production. Strict environmental standards are expected to result in the closure of some of Western Europe's older coke plants and to make it difficult to get approvals for plants, thus increasing import requirements for coal coke but reducing imports of coking coal. Projected reductions in domestic coal production in the United Kingdom, Germany, Spain, and France are not expected to be replaced by equivalent volumes of coal imports. Rather, increased use of natural gas and renewable energy is expected to replace much of the reduction in domestic energy supply projected to result from continuing declines in the region's indigenous coal production.

In 2003, the leading suppliers of imported coal to the countries of Europe, the Middle East, and Africa were South Africa (30 percent), Australia (18 percent), South America (14 percent), and the former Soviet Union (11 percent). Over the forecast period, low-cost coal from South America (primarily from Colombia and Venezuela) is projected to meet an increasing share of European coal import demand, displacing some coal from such higher cost suppliers as the United States and Poland.

Figure 57. Coal Imports by Major Importing Region, 1995-2025



Sources: **History:** SSY Consultancy and Research, Ltd., *SSY's Coal Trade Forecast*, Vol. 14, No. 2 (London, UK, May 2005); International Energy Agency, *Coal Information 2001* (Paris, France, September 2001), and previous issues; and Energy Information Administration, *Quarterly Coal Report*, October-December 2003, DOE/EIA-0121(2003/4Q) (Washington, DC, March 2004), and previous issues. **Projections:** Energy Information Administration, National Energy Modeling System run IEO2005.D060605B.

[9]Semi-soft or weak coking coal is blended with hard coking coal before being charged into the coke oven to produce coke. Semi-soft coal needs to be blended because, used alone, it does not produce coke with sufficient strength. Coal coke is used primarily to smelt iron ore in blast furnaces, acting as a source of heat and as a chemical reducing agent for the production of pig iron.

Recent Developments in World Coal Trade

The years 2003 and 2004 saw two solid back-to-back increases in international coal shipments. In 2003, world coal trade rose to 714 million tons, an increase of 9 percent from 2002. Preliminary data for 2004 indicate that world coal trade reached approximately 760 million tons, for an additional increase of 6 percent over 2003.[a] Gains in coal shipments to each of the three major coal import demand regions discussed in this chapter contributed to the 100-million-ton-plus increase in world coal trade for the 2-year period.

In addition to the substantial increases in international coal trade in 2003 and 2004, other notable developments for the period were sharp upward movements in both ocean freight rates and coal export prices. During 2003, ocean freight rates for coal rose to near all-time record highs. Much of the increase was attributable to substantial growth in imports of iron ore by Chinese steel producers, which in turn created a shortage of ocean vessels for transporting other dry bulk products, including coal.[b] China imported 163 million tons of iron ore in 2003, an increase of 33 percent from 2002.[c] According to Global Insight, Inc., substantial amounts of new shipping capacity projected to come on line by the end of 2007 should help to alleviate the current capacity shortage, which in turn should lead to some reductions in freight rates.[d] Global Insight estimates that between the beginning of 2004 and the end of 2007 annual dry-bulk-shipping capacity will expand by approximately 550 million tons, while demand for annual dry-bulk-shipping will increase by only 309 million tons.

While freight rates for coal retreated some from the historic highs reached in early 2004, coal export prices (both steam and coking) began increasing in late 2003 and continued to rise throughout 2004. Limited supply of export coal is the primary explanation given for the substantial rise in coal export prices. Some of the factors that restrained export supply during the year included (1) substantial shipping delays at Australian coal ports, as expansions in port infrastructure have not kept pace with the recent surge in China's demand for iron ore and coking coal; (2) reduced exports of steam coal out of South Africa, mostly due to rail-related shipping delays; and (3) reduced exports and increased imports of coking coal by China. Relative to 2003, China imported an additional 4 million tons of coking coal in 2004 and exported 8 million tons less. Other factors affecting coal export prices in 2003 and 2004 were the effects of higher freight rates on international coal markets, increasing concentration in the ownership of coal export supply, and increasing importance of coal-on-gas competition in international power supply.[e]

Taken together, higher freight rates and coal export prices led to considerably higher prices for imports of steam and coking coal. Quarterly data on average steam coal prices, published by the International Energy Agency, indicate that the average price of coal imported to the European Union in the fourth quarter of 2004 (nominal dollars per ton) was up by 92 percent from the fourth quarter of 2002,[f] and the average price of steam coal imported to Japan was up by 67 percent. For coking coal, the prices of imported coal to the European Union and Japan in the fourth quarter of 2004 were 60 and 54 percent higher, respectively, than in the fourth quarter of 2002. In late 2004, annual negotiations between Japanese steel mills and Australian coking coal producers established a new benchmark price for Japan's current fiscal year (ending on March 31, 2006) at $113.40 per ton free-on-board (f.o.b.) port of exit, which was more than double the benchmark price of $51.70 per ton for the previous year.[g]

To date, higher coal prices do not appear to have had a significant effect on the demand for coal in international markets. In the electric power sector, the price of natural gas, coal's key competitor in this sector, has also been high. In the industrial sector, steel producers have seen increasing profits despite higher prices for coking coal and iron ore, as strong worldwide demand for steel has led to considerably higher prices for their products. As indicated, coal freight rates are expected to retreat some from recent high levels as new shipping capacity comes on line over the next few years. In turn,

(continued on page 60)

[a]SSY Consultancy and Research Ltd., *SSY's Coal Trade Forecast*, Vol. 14, No. 2 (May 2005); and Energy Information Administration, *Quarterly Coal Report, October-December 2004*, DOE/EIA-0121(2004/4Q) (Washington, DC, March 2005), Tables 10, 12, and 14.

[b]"Ocean Freight Rates Continue To Soar, Little Relief in Sight," *Coal Americas, Energy Publishing LLC*, No. 29 (November 3, 2003), p. 1.

[c]"Steel/Iron Ore: Iron Ore Exports, Iron Ore Imports and Steel Production," *Monthly Shipping Review SSY* (April 21, 2005), p. 7.

[d]Global Insight, Inc., *Global Coal Trade and Price Report (2004)* (Lexington, MA, December 2004), pp. xviii-xxii.

[e]"Worsening Australian Coal Port Congestion," *Monthly Shipping Review SSY* (April 21, 2005), p. 4; and "Supply Dynamics on the Move," *Petroleum Economist* (October 6, 2004).

[f]International Energy Agency, *Databases for Energy Prices and Taxes, 2nd Quarter 2005*, web site http://data.iea.org.

[g]T. Grant-Taylor, "Coal Prices Steaming Ahead," *The Courier Mail* (February 7, 2005), p. 18; and S. Wyatt, "Coup for Coking Coal Exports," *Australian Financial Review* (December 13, 2004), p. 17.

Recent Developments in World Coal Trade (Continued)

this should lead to some downward pressure on the non-transportation component of the delivered price of coal in markets such as Europe, where Australian coal should again be able to compete with coal originating from South Africa and South America.

Along with strong growth in world coal trade in recent years, the geographical composition of coal supply for international markets has changed. While emerging coal exporting countries such as China, Colombia, and Indonesia have increased their output substantially over the past few years, several of the more established coal-exporting countries such as the United States, South Africa, Canada, and Poland have seen their exports remain relatively constant or decline. Between 1998 and 2003, coal exports from China expanded by a substantial 190 percent, from 36 million tons to 103 million tons.[h]

[h]SSY Consultancy and Research Ltd, *SSY's Coal Trade Forecast*, Vol. 14, No. 2 (May 2005).

Despite South America's current foothold and expected gains in Europe, South Africa is projected to maintain its position as the leading supplier of coal to Europe throughout much of the forecast period. Currently, plans call for a 15-million-ton expansion of South Africa's Richards Bay Coal Terminal by the end of 2007, increasing the facility's annual throughput capacity to 95 million tons [***54***].

The Americas

Compared with European and Asian coal markets, imports of coal to North and South America are relatively small, totaling 77 million tons in 2003 (Table 9). Coal imports to the United States accounted for 32 percent of the 2003 regional total, followed by Canada at 30 percent and Brazil at 20 percent [***55***]. Most of the imports to Brazil were coking coal, and a majority of the remaining import tonnage was steam coal used for pulverized coal injection at steel mills [***56***].

Over the *IEO2005* forecast period, coal imports to the Americas are projected to increase by 29 million tons, with most of the additional tonnage going to the United States and Brazil. Coal imports to the United States are projected to increase from 25 million tons in 2003 to 46 million tons in 2025 [***57***]. This outlook is based on the capability and plans of existing coal-fired generating plants to import coal (primarily plants located on the eastern seaboard and in the southeastern part of the country) and announced plans to expand coal import infrastructure [***58***]. In Brazil, the country's expanding steel industry is projected to require increasing quantities of imported coal.

Partially offsetting the projected growth in coal imports elsewhere in the Americas, Canadian imports are expected to decline substantially over the next few years as the Ontario government moves ahead with the shutdown of the Province's five coal-fired generating plants. Ontario imported 20 million tons of coal in 2003, primarily from U.S. coal mines in Central Appalachia and the Powder River Basin [***59***]. After Ontario, Nova Scotia and New Brunswick account for most of Canada's remaining import tonnage. In 2003, Nova Scotia imported 2.0 million tons of coal and New Brunswick imported 1.4 million tons. U.S. coal exports to Canada are projected to fall from 21 million tons in 2003 to 7 million tons in 2025 [***60***].

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Electricity

Electricity consumption nearly doubles in the IEO2005 projection period. The emerging economies of Asia are expected to lead the increase in world electricity use.

The *International Energy Outlook 2005 (IEO2005)* reference case projects that world net electricity consumption will nearly double over the next two decades.[10] Over the forecast period, world electricity demand is projected to grow at an average rate of 2.6 percent per year, from 14,275 billion kilowatthours in 2002 to 21,400 billion kilowatthours in 2015 and 26,018 billion kilowatthours in 2025 (Figure 58). More than one-half (59 percent) of the projected growth in demand occurs in the emerging economies, with the mature market and transitional economies accounting for 28 percent and 14 percent, respectively.

This chapter examines the future of electricity supply and demand, beginning with a discussion of regional demand projections and the trends in expansion anticipated over the next two decades. The remainder of the chapter discusses the projections for electricity generating capacity, with particular attention to how the regional fuel mix might change over the forecast period. Regional differences in fuel diversity, operating efficiencies, and ability to meet growing demand for electric power are reviewed.

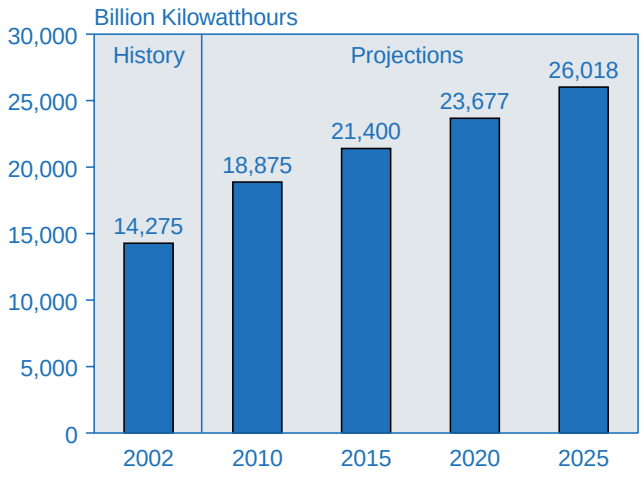
Net Electricity Consumption

Growth in net electricity consumption is expected to be most rapid among the emerging economies of the world, with annual average growth of 4.0 percent from 2002 to 2025 (Figure 59). In contrast, electricity demand is projected to increase by an average of 1.5 percent per year in the mature market economies and an average of 3.1 percent per year in the transitional economies of Eastern Europe and the former Soviet Union (EE/FSU). On an absolute quantity basis, China and the United States lead the projected growth in net electricity consumption, adding 2,803 and 1,819 billion kilowatthours over the 23-year forecast to their respective annual net consumption levels.

Mature Market Economies

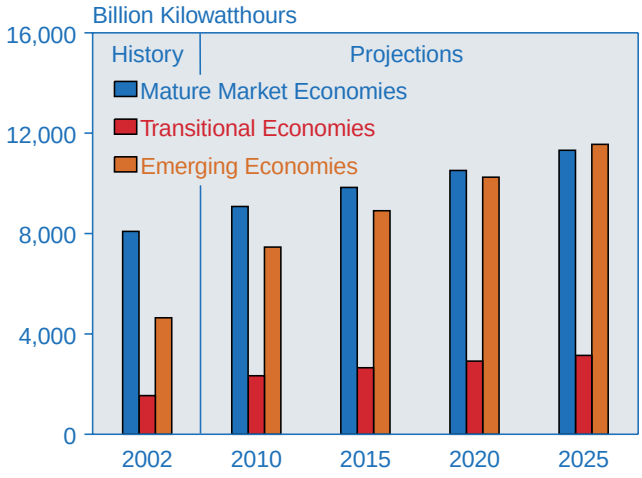
Electricity use in the mature market economies is expected to increase more slowly than in the emerging and transitional economies, averaging 1.5 percent per year in the *IEO2005* reference case over the projection period. In the mature market economies, the electricity

Figure 58. World Net Electricity Consumption, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 59. World Net Electricity Consumption by Region, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

[10] In *IEO2005*, "net electricity consumption" includes both electricity and heat produced for sale to the grid. It does not include electricity generated on site at industrial facilities.

sector is well established, and equipment efficiency gains are expected to temper the growth in electricity demand.

Although parts of the United States still have excess natural-gas-fired electricity capacity that was installed during the boom in construction between 2000 and 2004, strong economic growth throughout the country will require the development of additional generation capacity. Electricity demand in the United States is projected to increase from 3,651 billion kilowatthours in 2002 to 5,470 billion kilowatthours in 2025. Demand growth is expected to be particularly strong in the commercial sector, averaging 2.4 percent per year. Rapid additions to commercial floorspace, the continuing penetration of new telecommunications technologies and medical imaging equipment, and increased use of office equipment are projected to offset efficiency gains for electric equipment in the sector. In the industrial and residential sectors electricity consumption is expected to grow at more moderate rates, averaging 1.3 percent per year and 1.6 percent per year, respectively.

Net electricity consumption in Western Europe is projected to increase in the *IEO2005* reference case from 2,556 billion kilowatthours in 2002 to 3,072 billion kilowatthours in 2025. Electricity demand growth in the region will, in part, be influenced by the progress it makes in liberalizing its electric power markets. Western Europe's drive to reduce cross-border barriers throughout the regional economy is expected to increase competition in its electricity and natural gas markets, offsetting some of the increased costs that will result from reduced reliance on coal-fired and nuclear power plants and increased reliance on natural gas and renewables for electricity production.

All electricity customers in the European Union (EU) will have the right to choose their suppliers by July 2007. Furthermore, in 2004 new EU directives entered into force, requiring energy companies to unbundle formerly vertically integrated supply chains and mandating the establishment of uniform, well-defined regulatory bodies to increase information transparency, helping to increase competition in the electricity sector and, as a result, restrain price increases [***1***].

In addition, populations in Western Europe and Japan are expected either to remain at current levels or to decline slightly toward the end of the forecast period, and as a result it is unlikely that demand for electricity in the residential sector will increase substantially. Western Europe and Japan are expected to have the slowest growth in residential electricity consumption, averaging 0.4 and 0.6 percent per year, respectively, and in commercial electricity consumption, averaging 0.8 and 0.9 percent per year, respectively.

Transitional Economies

Electricity demand among the EE/FSU transitional economies is projected to increase at an average annual rate of 3.1 percent over the 2002-2025 period. This is higher than the 1.5-percent average annual increase over the past 30 years, mostly as a result of the precipitous drop in electricity use that followed the fall of the Soviet regime in the early 1990s. Net electricity consumption in the EE/FSU region is projected to climb from 1,544 billion kilowatthours in 2002 to 3,145 billion kilowatthours in 2025.

Many of the FSU countries are attempting to reform or liberalize their electricity sectors—for the most part, to attract much needed private and foreign investment to repair and expand aging and neglected infrastructure. In Russia, for instance, little investment was made in the 1990s to upgrade the country's electricity system, and especially its transmission and distribution infrastructure, which includes some operational transformers that date back to the 1930s [***2***]. A recent major electricity blackout in Moscow underscores the infrastructure problem. On May 25, 2005, between 2 and 4 million people were left without electricity for several hours following an explosion at a Moscow substation that had been operating for more than 40 years.

Russia's thermal generating capacity is scheduled for privatization as part of the country's electric power sector restructuring plan, with nuclear power plants remaining under state control and hydroelectric facilities placed under the control of a single state-owned company [***3***]. The state-owned Unified Energy Systems utility has created 6 wholesale power generating companies and 14 territorial generating companies to be privatized in 2005; however, the government has delayed the privatization until early 2006.

Outside Russia, the progress toward electricity sector reform has been mixed. Kazakhstan appears to be in the most advanced stage of restructuring in the region. Restructuring of the power sector in Kazakhstan began in 1995 with the unbundling of distribution, transmission, and generation functions [***4***], and by 1998, the government had privatized most of the country's generating capacity, as well as a number of distribution companies, and was allowing direct electricity sales to large end users.

Ukraine's privatization effort began in 1997, and each of the country's regional electricity distributors has been partially privatized [***5***]. Progress has been slow for a number of reasons, however. Only minor percentages have been offered to investors, and investors are required to commit to substantial, long-term investments in the electricity infrastructure. In addition, Lithuania, Azerbaijan, and Uzbekistan have started

power sector liberalization, although their progress also has been slow.

In Eastern Europe, efforts to restructure and liberalize national electricity sectors have been driven by the accession of several countries[11] to the EU. EU membership has compelled many nations of the region to reform electricity markets in order to meet EU standards. The Czech Republic plans to begin selling its 67.8-percent stake in the Ceske Energeticke Zavody generator sometime in 2006 to comply with EU rules on electricity sector liberalization [*6*], and 10 of the 12 power producers in Hungary are owned by foreign companies.

Emerging Economies

Emerging economies are projected to more than double their net electricity consumption, from 4,645 billion kilowatthours in 2002 to 11,554 billion kilowatthours in 2025. The projected growth in net electricity consumption for the emerging market economies is driven in large part by gross domestic product (GDP) and population growth assumptions (see box on page 69). GDP growth is in turn dependent on access to reliable electricity supplies.

Because of the links between reliable electricity supply, GDP growth, and living standards, many of the nations with emerging economies are attempting to increase access to reliable electricity supply. The need to increase their citizens' access to electricity has led many governments of the emerging economies to implement a variety of strategies, such as privatization to increase investment in the electricity sector, enacting government policies to encourage investment from potential foreign participants, and introducing rural electrification schemes aimed at bringing electricity to rural communities, both to improve standards of living and to increase the productivity of rural societies. The International Energy Agency has estimated that 1.6 billion people lacked access to electricity in 2002 and that, despite projected gains in electrification rates, the number of people without access to electricity will fall only slightly (to 1.4 billion in 2030), mostly as a result of continued population growth in developing countries [*7*].

As an example of the efforts being made to improve electrification, India announced plans in March 2005 to continue subsidizing electricity consumption for rural and poor households that use less than 30 kilowatthours per month. Currently, 45 percent of households in India do not have access to electricity. The new legislation has set a target of electrifying all households by 2010. As in the past, the ongoing challenge in providing electricity to the poor is paying for the electricity. Some progress has been made in reducing cross-sector subsidy burdens; however, even with commercial and industrial consumers subsidizing poor consumers, regional electricity companies still are expected to pay for some of the subsidies [*8*]. The burden of subsidies is amplified by inadequate revenue collection systems and outright theft of electricity. For example, in 2002 India's regional electricity companies lost $5.3 billion [*9*].

India's new electricity policy also places considerable emphasis on reliability. The policy "requires that within six months the Central Electricity Authority must launch its first National Electricity Plan, covering the period to 2017. Central to the plans is the provision of adequate generation capacity by 2012 based on 85 percent availability and including reserves of at least 5 percent" [*10*].

In China, news reports over the past few years have highlighted electricity generation shortfalls during periods of peak demand. To close the annual supply shortages and meet further growth in demand, China's 11th five-year plan includes plans for expanding electricity generation capacity to 570 gigawatts by 2010. In order to meet this rapid rate of expansion, roughly 8 percent annually, investments of $20 to $30 billion per year will be needed [*11*]. It appears, however, that building more power plants may not provide a complete solution to China's electric power limitations. Equally important is supplying primary fuel to the power plants and constructing transmission lines to reach electricity consumers. The Chinese State Grid Corporation estimates that investments of $10 billion per year will be needed for upgrading electricity transmission infrastructure alone [*12*].

The potential impacts of lack of electric power infrastructure on China's economy are illustrated by recent developments in the country's industrial sector. Three-quarters of the electricity consumed in China is used for manufacturing and heavy industry [*13*]. When electricity shortages occurred in the summer of 2004, some industrial production had to be cut. In 2004 Beijing shut down approximately 6,400 industrial facilities for one week and then staggered their operations for the duration of the summer to avoid consumption peaks [*14*]. It is clear that, unless the Chinese electricity infrastructure can keep pace with demand for electric power, the negative impact of electricity shortages on the industrial sector could have significant detrimental impacts on the country's economy.

Electricity Supply

To meet the world's projected electricity demand over the 2002 to 2025 forecast period, an extensive expansion of installed generating capacity will be required.

[11]The Czech Republic, Hungary, Poland, Slovakia, and Slovenia acceded to the European Union in May 2004. Bulgaria and Romania are scheduled to join in 2007.

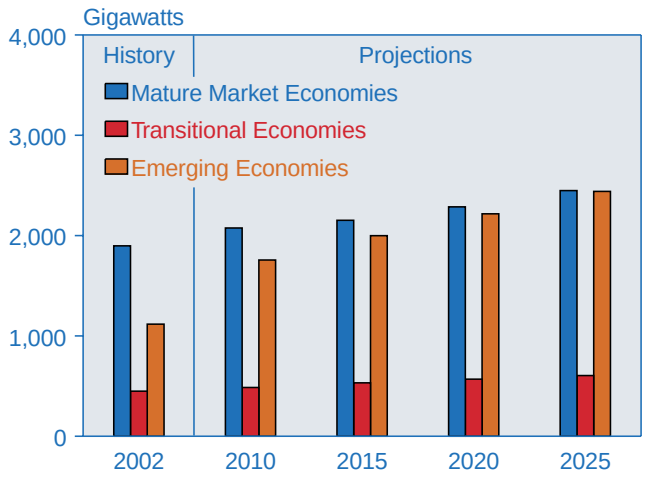
Worldwide installed electricity generating capacity is expected to grow from 3,315 gigawatts in 2002 to 5,495 gigawatts in 2025 in the *IEO2005* reference case, at a 2.2-percent average annual growth rate (Figure 60).

In *IEO2005*, "generating capacity" is defined as the hourly level of production when a power plant is operating at full capacity. Baseload generation typically operates as close to full capacity as possible. Peaking systems, such as natural gas turbines, typically operate at times of peak demand—that is, those times of the day when electricity use is at its highest. In contrast, most renewable electricity generation systems[12] cannot be relied upon to meet peak demand. Instead, renewable systems are operated whenever resources are available. Wind turbines do not operate when wind speeds are either too low or too high; hydroelectric power is vulnerable to drought; and solar systems do not operate at night. That said, even fossil fuel and nuclear power plants cannot operate at 100 percent capacity all year long. Outages for annual maintenance, as well as seasonal and daily fluctuations in demand, reduce their "operating capacity" relative to their "nameplate capacity."

The mix of primary fuels used to generate electricity has changed a great deal over the past three decades on a worldwide basis. Coal has remained the dominant fuel, although electricity generation from nuclear power increased rapidly from the 1970s through the mid-1980s, and natural-gas-fired generation has grown rapidly in the 1980s and 1990s. In contrast, in conjunction with the high world oil prices brought on by the oil price shocks after the oil embargo by the Organization of Arab Petroleum Exporting Countries (OAPEC)[13] in 1973-1974 and the Iranian Revolution in 1979, the use of oil for electricity generation has been slowing since the mid-1970s. High world oil prices encouraged switching from oil-fired generation to natural gas and nuclear power and reinforced coal's important role in world electric power generation.

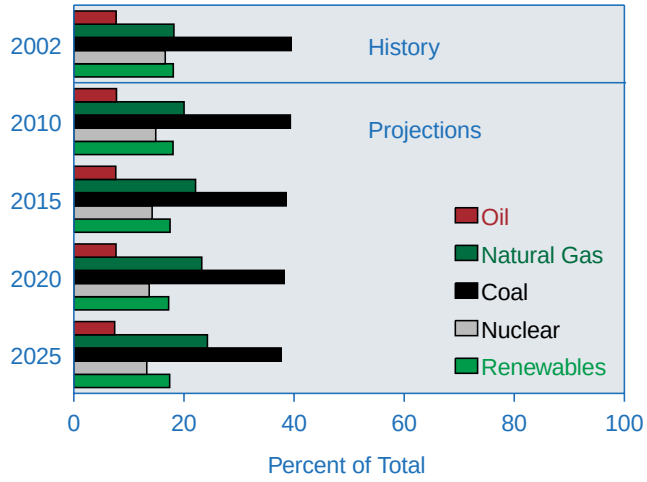
In the *IEO2005* reference case, continued increases in the use of natural gas for electricity generation are expected worldwide (Figure 61). Coal is projected to continue to retain the largest market share for electricity generation, but its importance is expected to be moderated somewhat by a rise in natural gas use. The role of nuclear power in the world's electricity markets is projected to lessen, although some new reactors are expected to be added over the forecast horizon, mostly in the emerging and transitional economies. Generation from hydropower and other renewable energy sources is projected to grow by 54 percent over the next 23 years, but their share of total electricity generation is projected to remain near the current level of 18 percent.

Figure 60. World Electricity Generation Capacity by Region, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 61. Fuel Shares of World Electricity Generation, 2002-2025



Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

[12]The generation capacity data presented in this chapter as "renewables" include hydropower, wind, geothermal, solar, and other. The data for hydropower include conventional hydro impoundment, run-of-river, and pumped storage because of the difficulty in distinguishing among the various technologies on a worldwide basis. A further challenge is accounting for distributed small-scale hydroelectricity production. Therefore, the renewable generation capacity figures may underrepresent total installed capacity. Biomass-fired capacity is not included (except for cases where biomass is added to the coal stream in coal-fired power plants and in the U.S. data) because of limited data availability.

[13]OAPEC includes Saudi Arabia, Iran, Iraq, the United Arab Emirates, Kuwait, and Qatar.

Coal

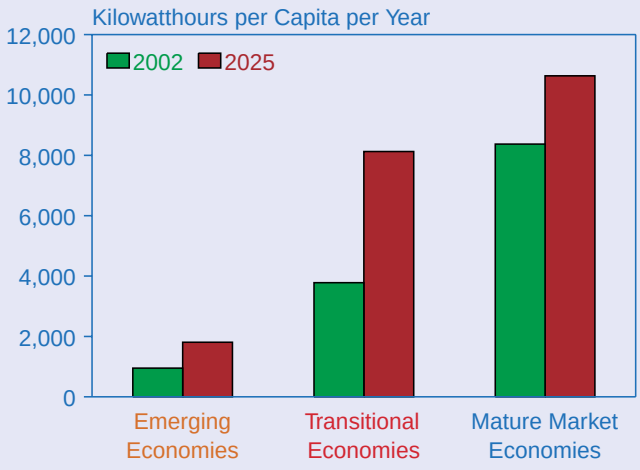
In the *IEO2005* reference case, coal continues to be the dominant fuel for generation of electricity and combined heat and power (district heat).[14] In 2025, coal is projected to fuel 38 percent of the world's electricity generation, compared with a 24-percent share for natural gas. Coal-fired capacity is expected to grow by 1.5 percent per year, from 987 gigawatts in 2002 to 1,403 gigawatts in 2025 (Figure 62). Installed coal-fired capacity, as a share of total world capacity, declines from 30 percent to 26 percent over the forecast.

By country, the United States and China currently are the leaders in terms of installed coal-fired capacity, at 311 and 204 gigawatts, respectively. In China, strong growth in natural-gas-fired capacity is projected to push coal's share down from 65 percent to 52 percent of total

Electricity Consumption per Capita

Net electricity consumption in the world's emerging economies is projected to grow by 149 percent from 2002 to 2025. By that measure, the emerging economies would surpass the mature market economies in terms of total annual electricity consumption; in terms of per capita consumption, however, the emerging economies are expected to continue trailing the mature market economies (see figure below). With the emerging economies expected to account for 82 percent of the world's population in 2025, the projected increase in demand forecast for the region translates to an increase in per capita net electricity consumption from 950 kilowatthours per person in 2002 to 1,807 kilowatthours per person in 2025. Even with this strong growth, per capita consumption for the emerging economies as a whole would remain much lower than that for the mature market economies. Net electricity use per capita in the mature market economies is projected to increase from 8,371 kilowatthours per person in 2002 to 10,632 kilowatthours per person in 2025.

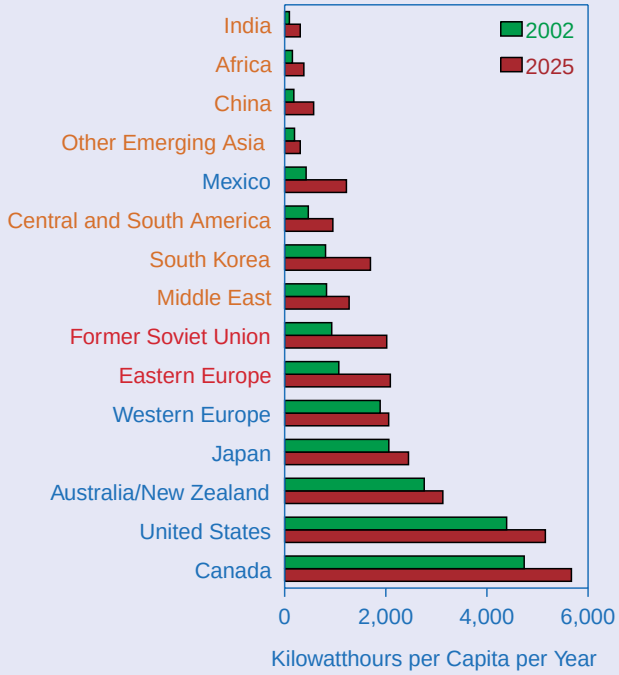
Electricity Consumption per Capita by Region, 2002 and 2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2025:** EIA, System for the Analysis of Global Energy Markets (2005).

The differences in per capita electricity consumption among the emerging, transitional, and mature market economies are especially stark in the residential sector, which can serve as a proxy for living standards. For example, in the residential sector on a per person basis, Canada and the United States consumed over 24 times more electricity than China in 2002, 29 times more than Africa, and 47 times more than India. Although the differences are expected to narrow over the forecast period, they still would be substantial in 2025, with per capita electricity use in the United States remaining 9 times higher than in China, 14 times higher than in Africa, and 17 times higher than in India (see figure below).

Residential Sector Electricity Consumption per Capita by Country Group, 2002 and 2025



Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2025:** EIA, System for the Analysis of Global Energy Markets (2005).

[14]Only in the EE/FSU region is heat a significant portion of the output from central power stations.

generating capacity. In the United States, coal-fired power plants are expected to continue supplying most of the country's electricity through 2025 [*15*]. In 2002, coal-fired plants in the United States (including utilities, independent power producers, and end-use combined heat and power) accounted for 51 percent of all electricity generation. While the output from U.S. coal-fired power plants increases in the forecast, from 1,881 billion kilowatthours in 2002 to 2,890 billion kilowatthours in 2025, their share of total generation decreases slightly, to 50 percent, as a result of a rapid increase in natural-gas-fired generation.

Coal consumption in the United States as a share of fuels used for electricity generation is expected to rise from 52 to 53 percent over the forecast. In terms of installed capacity, coal's share of the total will hold steady at 35 percent. Coal is used for baseload generation, which explains why it accounts for only 35 percent of U.S. capacity but generates more than one-half of the country's electricity.

Western Europe, Eastern Europe, and the FSU all are projected to see declines in coal-fired generating capacity over the forecast period. Not surprisingly, the three regions are also expected to see large increases in installed natural-gas-fired capacity.

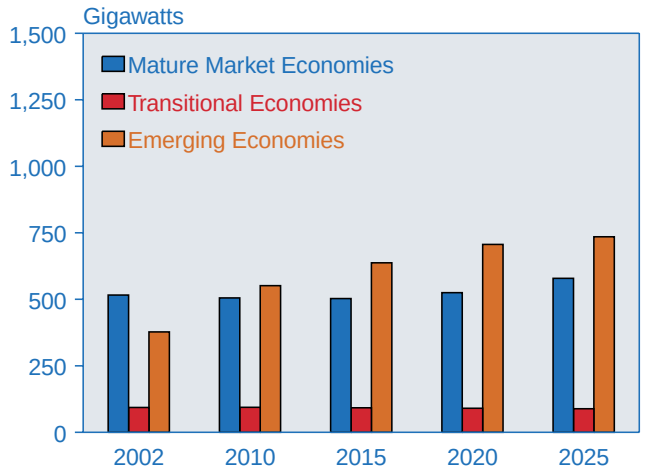
Natural Gas

Additions to natural gas capacity are projected to increase the world's gas-fired generating capacity by approximately 3.9 percent per year from 2002 to 2025 (Figure 63), at a faster rate than projected for any other energy source. Natural-gas-fired capacity is an attractive choice for new power plants because of its fuel efficiency, operating flexibility, rapid deployment, and lower installation costs compared to other technologies. This development represents a major change in the fleet of electricity generation plants. Because of the shorter installation time and lower investment costs for gas-fired combined-cycle generation in comparison to coal, total installed natural gas capacity (combined with oil capacity) is expected to surpass coal-fired installed generation capacity by 2010—1,207 gigawatts versus 1,151 gigawatts. The combined share of natural gas and oil in world installed generating capacity is projected to rise from 36 percent in 2002 to 47 percent in 2025.

In the United States, the electric power sector is projected to account for an ever-larger share of total natural gas demand. About 23 percent of total U.S. natural gas consumption in 2002 was in the electric power sector, and in 2025 its share is projected to be to 31 percent [*16*]. Natural-gas-fired generation capacity is expected to grow more rapidly than capacity using any other energy source from 2002 to 2020. From 2020 to 2025, however, natural gas prices are projected to increase substantially, and as a result coal-fired capacity is expected to lead new additions [*17*].

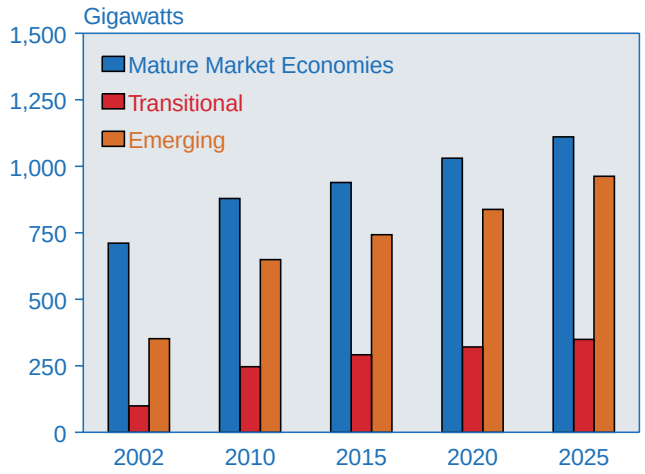
Western Europe, Japan, and Canada are similarly expected to favor natural gas capacity over other fuels for new generating capacity because of lower investment costs and shorter construction times, as well as the fact that gas is an advantageous economic alternative to other fossil fuels. Moreover, these regions have instituted energy policies to limit the use of coal in the

Figure 62. World Coal-Fired Generation Capacity by Region, 2002-2025



Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 63. World Natural-Gas- and Oil-Fired Generation Capacity by Region, 2002-2025



Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

electricity generation sector. With the Kyoto Protocol now in effect, further efforts to reduce greenhouse gas emissions will likely encourage more reliance on natural gas [***18***].

The FSU region, with its access to rich natural gas resources, also increases its reliance on natural gas for electricity generation in the *IEO2005* reference case forecast. Natural gas already provides about 45 percent of the total energy used for electricity generation in the FSU, and the region's reliance on gas-fired generation is projected to increase even further over the next decades, to 55 percent in 2025.

Natural gas consumption in China's electric power sector is projected to increase rapidly from a relatively low total of 0.2 quadrillion Btu in 2002 to 4.3 quadrillion Btu in 2025, at an impressive 14.7-percent average annual growth rate. In comparison, India, South Korea, and the rest of emerging Asia combined are expected to see an increase of 3.7 quadrillion Btu over the period, and natural gas use for electricity generation in the United States is projected to grow by 3.9 quadrillion Btu.

Oil

Relatively little change is expected in oil-fired generation capacity. Oil's share of the world's installed capacity declines over the projection period, from an 8-percent market share in 2002 to 7 percent in 2025. Oil has more value in the transportation sector and in limited applications for distributed diesel-fired generators than in central power plant applications. The only region expected to see a sizable increase in oil-fired electric power capacity is the Middle East, where some new oil-fired capacity is expected to be built. Oil use for electricity generation in the Middle East is expected to increase from 2.1 quadrillion Btu in 2002 to 4.1 quadrillion Btu in 2025.

In recent years, China has shown fairly strong growth in oil-fired electricity generation, because peak electricity demand continues to outpace on-grid electricity generation, and Chinese industry has had to rely on diesel generators to cope with annual summer power shortages. That situation is expected to continue in the short term, but as planned capacity fueled by natural gas, coal, nuclear, and hydropower comes on line and the country's national electricity grid matures, the demand for oil used to generate electricity is expected to moderate.

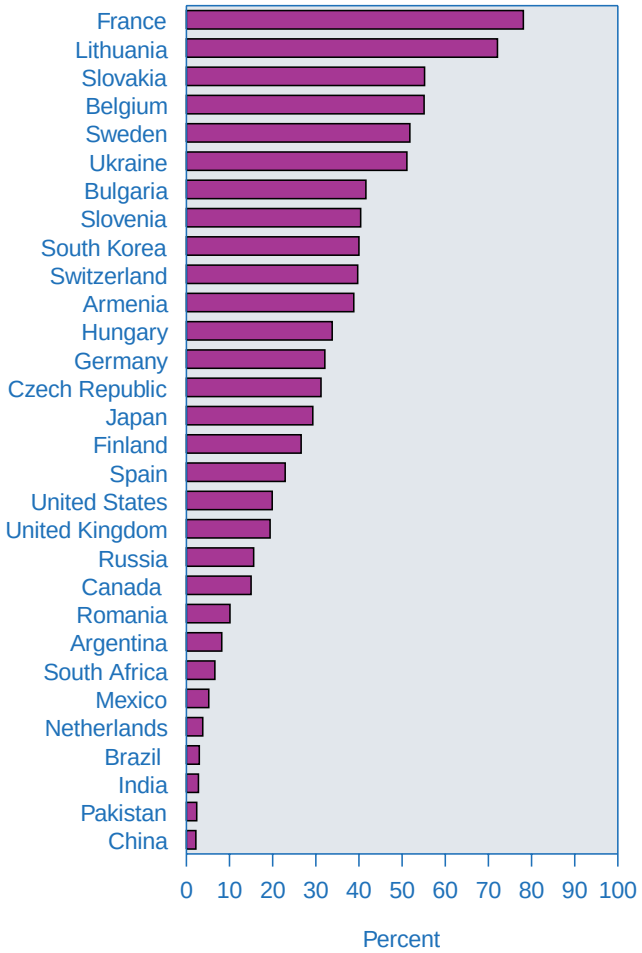
Nuclear Power

In the *IEO2005* reference case, electricity generation from nuclear power plants around the world is projected to increase from 2,560 billion kilowatthours in 2002 to 3,032 billion kilowatthours in 2015 and 3,270 billion kilowatthours in 2025, and the world's nuclear-powered generating capacity is projected to increase from 361 gigawatts in 2002 to 422 gigawatts in 2025. In past editions of the *IEO*, in contrast, declines in nuclear power were projected in the mid-term forecast as a result of expectations that few new reactors would be built and that older reactors would be shut down when they reached the end of their operating lives.

Prospects for nuclear power have improved in recent years, with higher capacity utilization rates reported for many existing nuclear facilities and the expectation that most existing plants in the mature market and transitional economy nations will be granted extensions to their operating lives. Further, higher fossil fuel prices and the entry into force of the Kyoto Protocol are expected to improve prospects for new nuclear power capacity over the forecast period. Nevertheless, nuclear power trends can be difficult to anticipate for a variety of political and social reasons, and considerable uncertainty is associated with nuclear power forecasts (see box on page 72).

Nuclear power is an important source of electricity in many countries of the world. In 2003, 19 countries depended on nuclear power for at least 20 percent of their electricity generation (Figure 64). As of March 2005,

Figure 64. Nuclear Shares of National Electricity Generation, 2004



Source: International Atomic Energy Agency, Reference Data Series 2, "Power Reactor Information System," web site www.iaea.org/programmes/a2/ (June 2005).

How Nuclear Power Could Shape World Electricity Markets: Two Nuclear Power Development Scenarios

Two opposing scenarios of nuclear power development can be used to assess the potential of nuclear power in the electricity markets of the future. In a "strong nuclear power revival" case developed for *IEO2005*, few nuclear plants are retired, and new builds increase the world's total nuclear generating capacity to 570 gigawatts in 2025. In contrast, a "weak nuclear power" case assumes that nuclear power programs, especially in Western Europe and the EE/FSU, are dismantled, few new nuclear power plants are constructed, and installed nuclear power capacity falls to 297 gigawatts in 2025. The *IEO2005* reference case projects an increase in world nuclear capacity, from 361 gigawatts in 2002 to 422 gigawatts in 2025.

In very few instances is the decision to build nuclear power capacity left entirely to corporations or utilities that would base their decisions solely on economics. In general, government policy (with an eye to public opinion) guides the development of nuclear power. The OAPEC oil embargo of 1973-74 led some nations to pursue nuclear power programs aggressively in the 1970s, mostly with strong public support; but subsequent accidents at the Three Mile Island nuclear power plant in the United States in 1979 and Chernobyl in the Soviet Union in 1986 pushed public opinion and national energy policies away from nuclear power. In the United States, rapidly increasing capital costs and repeated construction delays virtually ended construction of nuclear power plants; and in Europe, both before and after the Chernobyl disaster, several European governments, including Italy, Austria, Belgium, Germany, and Sweden announced their intentions to withdraw from the nuclear power arena.

For many years analysts expected social, economic, and political pressures to cause a substantial slowdown of nuclear power expansion in the short term and a decline in nuclear generating capacity in the long term. More recently, however, there has been talk of a "renaissance" in the nuclear power programs of the United States and some European countries, as fossil fuel prices have remained relatively high, and energy security issues, concerns about air pollution and global warming, and the high performance levels of existing nuclear power plants have come to the forefront.[a] On the other hand, a future adverse event involving nuclear power, such as another Chernobyl-sized nuclear power plant accident or a terrorist event involving an attack on a nuclear plant or using processed nuclear materials to commit an act of terrorism, could strengthen negative perceptions of nuclear power.

The table on the opposite page summarizes the projected fuel mix for the world's installed electric power capacity in three cases: the *IEO2005* reference case, strong nuclear power revival case, and weak nuclear power case. With the same macroeconomic assumptions in each of the three cases, it is not surprising that they all project the same total (about 5,500 gigawatts) for world installed electricity capacity in 2025.

Much of the expansion in nuclear generating capacity projected in the strong nuclear power revival case—a total of 148 gigawatts—is in regions with older, more mature nuclear power markets. Many Western European and EE/FSU countries have established nuclear power industries, and they would be capable of staving off the decline in nuclear power capacity projected in the reference case by reversing planned phaseouts of existing nuclear power plants, lengthening operating lives, and constructing new nuclear capacity in response to, for example, concerns about climate change.

In the strong nuclear case, Western Europe's projected nuclear generating capacity in 2025 is 52 gigawatts higher than in the reference, the EE/FSU's is 36 gigawatts higher, and Japan's is 15 gigawatts higher. The *IEO2005* strong nuclear case assumes that emerging economies with nuclear power expansion plans, including China, India, and South Korea, expand the development of nuclear power to the greatest extent possible. Therefore, in the strong nuclear revival case the emerging nations are able to increase their nuclear capacity by adding a combined 37 gigawatts of additional capacity by 2025 relative to the reference case values.

Construction and operation of 148 gigawatts of additional nuclear capacity in 2025 in the strong nuclear revival case would have the greatest impact on the fuel shares of natural gas, oil, and renewables in the fuel mix for world electricity generation (see table). Because Western Europe, the EE/FSU, and Japan all are projected to see declines or minimal growth in coal-fired capacity in the reference case, there is little or no opportunity for new nuclear capacity to displace coal. As a result, the strong nuclear revival case shows declines of 96 gigawatts in natural gas and oil capacity and 32 gigawatts in renewable electricity capacity in 2025 relative to the reference case projections.

In the weak nuclear power case, almost every region loses some nuclear capacity by 2025 relative to the reference case. Only for the Middle East and Mexico, with

(continued on page 73)

[a]S. Taub and J.-L. Wang, *The U.S. Nuclear Power Business: Poised for Expansion?* (Cambridge, MA: Cambridge Energy Research Associates, May 2005), p. 1 (private report).

How Nuclear Power Could Shape World Electricity Markets: Two Nuclear Power Development Scenarios (Continued)

their relatively small nuclear power industries, are the 2025 projections unchanged from those in the reference case.[b] Total world installed nuclear capacity in 2025 is 125 gigawatts lower in the weak nuclear case than in the reference case. Western Europe sheds the largest amount of nuclear capacity in 2025 in the weak nuclear case (50 gigawatts), followed by the EE/FSU (27 gigawatts), emerging Asia (24 gigawatts), and Japan (14 gigawatts).

In emerging Asia, coal-fired capacity makes up for most of the loss of nuclear capacity in the weak nuclear case, with 20 gigawatts of additional coal capacity constructed in China, India, and South Korea compared to the reference case in 2025. The other emerging Asian countries construct an additional 7 gigawatts of natural-gas-fired and oil-fired capacity in the weak nuclear case. In Western Europe, the EE/FSU, and Japan, natural gas, oil, and renewables are used to make up for the loss of nuclear capacity, with 63 gigawatts of additional natural-gas- and oil-fired capacity and 10 gigawatts of additional renewable capacity constructed relative to the reference case projections in 2025.

World Installed Electricity Generation Capacity by Fuel in Three Nuclear Capacity Cases, 2002-2025
(Gigawatts)

Analysis Case and Fuel Type	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
***IEO2005* Reference Case**						
Natural Gas and Oil	1,207	1,851	2,071	2,304	2,560	3.3
Coal	987	1,151	1,232	1,322	1,403	1.5
Nuclear	361	390	401	411	422	0.7
Renewable	763	927	980	1,036	1,110	1.6
Total	**3,318**	**4,319**	**4,684**	**5,073**	**5,495**	**2.2**
Strong Nuclear Power Revival Case						
Natural Gas and Oil	1,207	1,849	2,041	2,254	2,464	3.2
Coal	987	1,153	1,232	1,320	1,397	1.5
Nuclear	361	395	449	498	570	2.0
Renewable	763	928	970	1,020	1,078	1.5
Total	**3,318**	**4,326**	**4,692**	**5,092**	**5,509**	**2.2**
Weak Nuclear Power Case						
Natural Gas and Oil	1,207	1,865	2,087	2,342	2,626	3.4
Coal	987	1,160	1,245	1,339	1,426	1.6
Nuclear	361	360	357	340	297	-0.8
Renewable	763	934	987	1,050	1,127	1.7
Total	**3,318**	**4,318**	**4,677**	**5,071**	**5,476**	**2.2**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

[b]For the purposes of this analysis, U.S. nuclear capacities were not varied across the nuclear cases. While EIA recognizes that there is potential for increases or decreases in U.S. nuclear power capacity in the future, no analysis has been done to quantify that potential. As a result, U.S. numbers are held constant to levels reported in the *Annual Energy Outlook 2005*.

there were 441 nuclear power reactors in operation around the world, and another 25 were under construction. Five new nuclear power plants began operation in 2004—one each in China, Japan, and Russia and two in Ukraine—and Canada's Bruce 3 reactor was reconnected to the grid. Five nuclear power plants were permanently shut down in 2004—one in Lithuania and four in the United Kingdom.

For the mature market economies, the reference case assumes that, in the long term, retirements of existing plants as they reach the end of their operating lives will not be balanced by the construction of new nuclear power capacity, and there will be a slight decline in installed nuclear capacity toward the end of the forecast. Few new builds are expected in the mature market economies outside of Japan, France, and Finland.

Western Europe's nuclear capacity is projected to drop from 127 gigawatts in 2002 to 115 gigawatts in 2015 and 95 gigawatts in 2025. In Japan, however, nuclear capacity is projected to expand by 9 gigawatts between 2002 and 2025. U.S. nuclear capacity is projected to increase from 99 gigawatts in 2002 to 103 gigawatts in 2025, in part because of the return of the Browns Ferry reactor, scheduled for 2007. Life extensions and higher capacity factors are expected to play a major role in sustaining the U.S. nuclear industry. Thus, despite a declining share of global electricity production, nuclear power is projected to continue in its role as an important source of electric power.

In contrast to the mature market economies, rapid growth in nuclear power capacity is projected for Russia and for the world's emerging economies (Figure 65). The EE/FSU and emerging economies combined are projected to add 42 gigawatts of nuclear capacity between 2002 and 2015 and another 35 gigawatts between 2015 and 2025. Over the forecast period, the largest additions of nuclear capacity are expected in emerging Asia (China, India, and South Korea) and in Russia. China is projected to add 24 gigawatts of nuclear capacity in the *IEO2005* reference case, India 12 gigawatts, South Korea 12 gigawatts, and Russia 14 gigawatts. Among the mature market economies, only Japan is expected to add a sizable amount of nuclear capacity, a total of 9 gigawatts between 2002 and 2025.

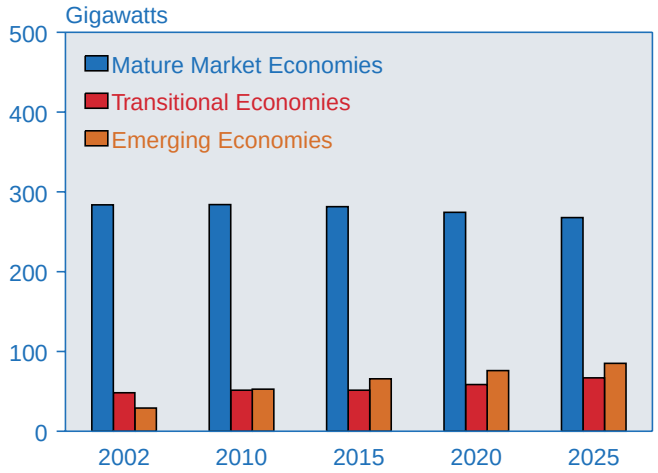
Hydroelectricity and Other Renewables

In the *IEO2005* reference case, moderate growth in the world's consumption of hydroelectricity and other renewable energy resources is projected over the forecast period. Most renewable energy sources are not expected to compete economically with fossil fuels in the mid-term forecast. In the absence of significant government policies, such as those aimed at reducing the impacts of carbon-emitting energy sources on the environment, it will be difficult to extend the use of renewables on a large scale. Worldwide, the use of hydroelectricity and other renewable energy is projected to increase by an average of 1.9 percent per year, from 32.1 quadrillion Btu in 2002 to 42.4 quadrillion Btu in 2015 and 48.9 quadrillion Btu in 2025.

The *IEO2005* projections for hydroelectricity and other renewable energy resources include only on-grid renewables. Non-marketed (noncommercial) biofuels from plant and animal sources are an important source of energy, particularly in the developing world, and the International Energy Agency has estimated that some 2.4 billion people in developing countries depend on traditional biomass for heating and cooking [***19***]. However, because comprehensive data on the use of non-marketed fuels and dispersed renewables (renewable energy consumed on the site of its production, such as solar panels used to heat water) are not available, they are not included in the projections. Both non-marketed fuels and dispersed renewables are considered in formulating end-use energy demands.

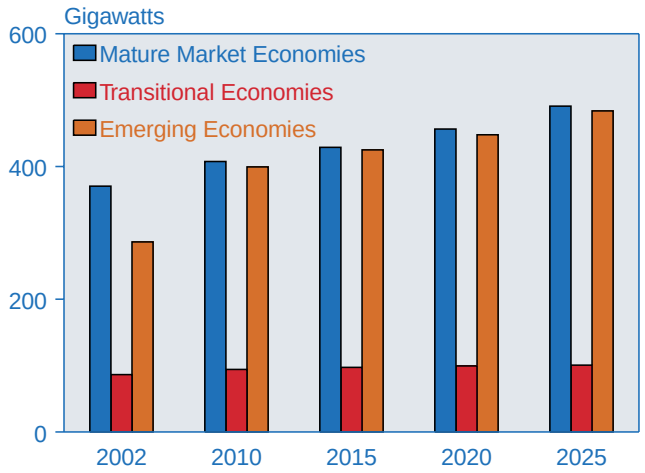
Much of the projected growth in renewable generation is expected to result from the completion of large hydroelectric facilities in the countries with emerging economies (Figure 66), particularly in Asia, where the need to expand electricity production with associated dams and reservoirs often outweighs concerns about environmental impacts and the relocation of populations. China,

Figure 65. World Nuclear Power Generation Capacity by Region, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 66. World Hydroelectric and Other Renewable Generation Capacity by Region, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

India, and Laos, among other emerging Asian economies, already are constructing or planning new large-scale hydroelectric facilities. In 2004, India's 1,500-megawatt Nathpa Jhakri project on the Sutlej River in Himachal Pradesh became fully operational [***20***]. In 2005, the World Bank approved financing for the $1.2 billion Nam Theun project in Laos [***21***]. The 1,070-megawatt hydroelectric project in Laos has been the subject of much debate and delay over the past several years, but with financial support from the World Bank and Asia Development Bank the project might come on line as early as 2009 [***22***].China's 11th five-year plan expects 42 gigawatts of additional hydroelectric generating capacity by 2010 [***23***].

Many nations of Central and South America have plans to expand their already well-established hydroelectric resources. Brazil, Peru, and even oil-rich Venezuela have plans to increase hydroelectric capacity over the next decade. Brazil is the largest energy market in Central and South America, and more than 80 percent of its electricity generation comes from hydroelectric sources. As a result, Brazil is especially vulnerable to drought-induced shortages in electricity supply. In general, the nations of Central and South America are not expected to expand hydroelectric resources dramatically but instead are expected to invest in other sources of electricity—particularly natural-gas-fired capacity—that will allow them to diversify electricity supplies and reduce their reliance on hydropower. Brazil had planned to increase the natural gas share of its generation to 12 percent by 2012, but regulatory and price risks have slowed the construction timetables for its planned new gas-fired power plants [***24***].

Hydroelectric capacity outside the emerging economies is not expected to grow substantially. Among the mature market nations, only Canada is expected to construct any sizable hydroelectric projects over the forecast period. An estimated 34,371 megawatts of new hydroelectric capacity currently is under consideration for future development in Canada [***25***]. In the EE/FSU countries, most additions to hydroelectric capacity are expected to come from repair or expansion of existing plants. In the mature market and transitional economies, most hydroelectric resources either have already been developed or lie far from population centers.

Wind power has shown the fastest growth among renewable energy sources in recent years. In many emerging economies, small wind and wind-hybrid installations are effective in bringing electric power to rural areas that cannot be connected to national grids; and among the mature market economies, the growth in wind power has been particularly robust. Western Europe and the United States accounted for nearly 90 percent of all new wind installations in 2003—adding a combined 5,952 megawatts of new wind capacity [***26***]. Germany, Spain, and Denmark all were among the top five wind installers in 2003. Germany added the most wind capacity in 2003, 2,645 megawatts, bringing the country's total installed wind capacity to 14,609 megawatts. In the United States, because the Federal production tax credit for wind plants was not extended until late in 2004, only a little more than 200 megawatts of new wind capacity was added in 2004 [***27***]. In 2005, however, more than 1,000 megawatts of new U.S. wind capacity is expected to enter service.

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Energy-Related Carbon Dioxide Emissions

In the coming decades, responses to environmental issues could affect patterns of energy use around the world. Actions to limit greenhouse gas emissions could alter the level and composition of energy-related carbon dioxide emissions by energy source.

Carbon dioxide is one of the most prevalent greenhouse gases in the atmosphere. Anthropogenic (human-caused) emissions of carbon dioxide result primarily from the combustion of fossil fuels for energy, and as a result world energy use has emerged at the center of the climate change debate. In the *International Energy Outlook 2005* (*IEO2005*) reference case, world carbon dioxide emissions are projected to rise from 24,409 million metric tons in 2002 to 33,284 million metric tons in 2015 and 38,790 million metric tons in 2025 (Figure 67).[15]

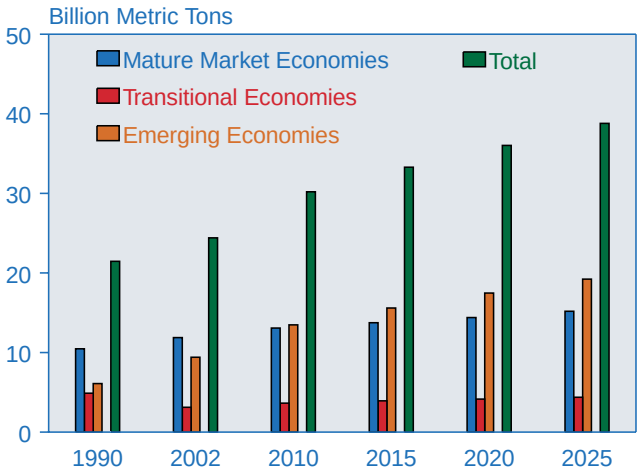
The Kyoto Protocol, which requires participating "Annex I" countries to reduce their greenhouse gas emissions collectively to an annual average of about 5 percent below their 1990 level over the 2008-2012 period, became a legally binding treaty on February 16, 2005, 90 days after it was ratified by Russia. Russia's ratification brought the total number of signatories to more than 55 countries, including Annex I signatories that accounted for more than 55 percent of Annex I carbon dioxide emissions in 1990. The Annex I countries include the 24 original members of the Organization for Economic Cooperation and Development (including the United States), the European Union, and 14 countries with economies in transition (Russia, Ukraine, Estonia, Latvia, Lithuania, and Eastern Europe).[16]

The *IEO2005* reference case projections are based on U.S. and foreign government laws in effect on March 1, 2005. The potential impacts of pending or proposed legislation, regulations, and standards are not reflected in the projections, nor are the impacts of legislation for which implementing mechanisms have not been announced. The *IEO2005* reference case forecast does not include the potential impacts of the Kyoto Protocol, because the treaty does not indicate the methods by which ratifying parties will implement their obligations. Moreover, the Protocol does not address signatory obligations beyond 2012, making it impossible to assess its impacts on energy markets and carbon dioxide emissions through 2025 in the context of a reference case projection.

Another difficulty in projecting energy-related carbon dioxide emissions in the context of the Kyoto Protocol is that, in the 5-year increments of the System for the Analysis of Global Energy Markets (SAGE) model, upon which this forecast is based, 2010 is the only projection year that is part of the Protocol's first commitment period. Further, the specific energy-consuming sectors that will be affected in each country and region have not been identified.

Despite the challenges, it is important to address the possible impacts of the Kyoto Protocol, because they could strongly influence future energy trends. Accordingly, this chapter begins with a presentation of the *IEO2005* reference case forecast for regional carbon dioxide emissions, which can serve as an estimate against which future emissions reductions can be measured. The *IEO2005* Kyoto Protocol case assumes that the emissions goals of the Protocol will be met by the countries that have ratified the treaty and have obligations to limit or reduce their greenhouse gas emissions, using a combination of domestic actions and purchases of international emissions permits. Results from the Kyoto

Figure 67. World Carbon Dioxide Emissions by Region, 1990-2025



Sources: **1990 and 2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219 (2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

[15]In keeping with current international practice, *IEO2005* presents data on greenhouse gas emissions in million metric tons carbon dioxide equivalent. The figures can be converted to carbon equivalent units by multiplying by 12/44.

[16]As of May 27, 2005, 149 countries and the European Community had ratified, accepted, acceded to, or approved the Kyoto Protocol. A list of the 149 countries is provided in Appendix J.

Protocol case are analyzed in the second part of the chapter.

Reference Case

Carbon Dioxide Emissions

In the *IEO2005* reference case, world carbon dioxide emissions from the consumption of fossil fuels are expected to grow at an average rate of 2.0 percent per year from 2002 to 2025. Emissions in 2025 are projected to total 38,790 million metric tons, exceeding 1990 levels by 81 percent. Combustion of petroleum products contributes 5,454 million metric tons to the projected increase from 2002, coal 5,353 million metric tons, and natural gas 3,540 million metric tons (Figure 68). Although coal use is projected to grow at a slower rate than natural gas use over the projection period, coal is a more carbon-intensive fuel than natural gas. As a result, the increment in carbon dioxide emissions from coal combustion is larger than the increment in emissions from natural gas.

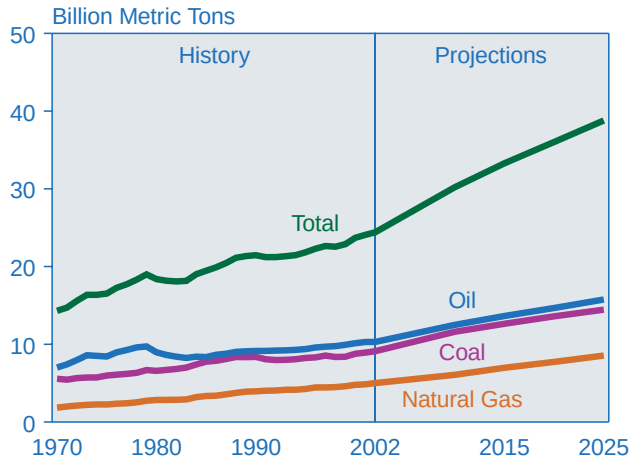
The mature market economies, for the most part, are growing more slowly than the emerging economies, and their growth tends to be in less energy-intensive sectors. As a result, carbon dioxide emissions from the mature market economies are projected to grow by 1.1 percent per year from 2002 to 2025, absent binding constraints (Figure 69 and Table 10). Emissions from North America are projected to grow the most rapidly among the mature market regions, by 1.5 percent per year. North America's average annual increase in gross domestic product (GDP) is 3.1 percent over the forecast horizon, and that strong economic growth, combined with projected increases in population, drives the demand for fossil fuels and thus the projected increase in carbon dioxide emissions.

In contrast to North America, Western Europe and mature market Asia are projected to have fairly modest growth in GDP (2.0 and 1.8 percent per year, respectively) and either flat or declining population numbers over the forecast. Thus, only limited growth in demand for energy is projected for those regions, leading to slower growth in emissions. For Western Europe, carbon dioxide emissions are projected to grow by 0.5 percent per year on average from 2002 to 2025, and for mature market Asia the projected average annual increase in emissions is 0.6 percent.

The economic collapse of the transitional economies of Eastern Europe and the former Soviet Union (EE/FSU) dampened the growth of carbon dioxide emissions worldwide between 1990 and 2002. In the *IEO2005* reference case, carbon dioxide emissions in the EE/FSU region are projected to increase on average by 1.5 percent per year, to 3,937 million metric tons in 2015 and 4,386 million metric tons in 2025 (Figure 70). The transitional economies are dominated by Russia, the region's largest economy, which accounts for 51 percent of its energy consumption and 45 percent of related carbon dioxide emissions.

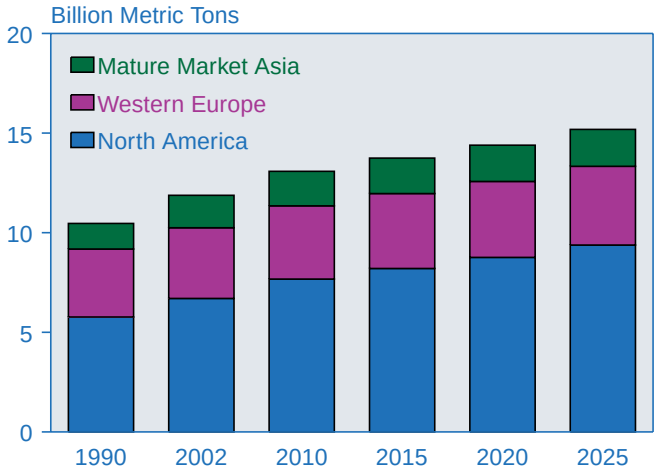
Although GDP growth in the EE/FSU region is projected to average 4.4 percent per year from 2002 to 2025, improvements in energy infrastructure are expected to keep the growth in energy demand at an annual average of 1.6 percent. In addition, an increase in natural gas as a share of total energy production and a drop in coal's

Figure 68. World Carbon Dioxide Emissions by Fuel Type, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 69. Carbon Dioxide Emissions in the Mature Market Economies, 1990-2025



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share are expected to lower the carbon intensity of energy supply in the region and keep carbon dioxide emissions in the transitional economies well below their 1990 level of 4,894 million metric tons.

For the world's emerging economies, the reference case projects strong economic growth driven largely by the energy-intensive industrial and transportation sectors. Accordingly, carbon dioxide emissions in the emerging economies are projected to grow at twice the rate projected for the transitional economies and almost three times the rate for the mature market economies, averaging 3.2 percent per year from 2002 to 2025. The most rapid increases in carbon dioxide emissions are projected for the nations of emerging Asia (Figure 71).

Carbon Dioxide Intensity

World carbon dioxide intensity has improved (decreased) substantially over the past three decades, falling from 853 metric tons per million 2000 U.S. dollars of GDP in 1970 to 517 metric tons per million dollars in 2002. Although the pace of improvement in emissions intensity is expected to be slower over the 2002 to 2025 period than over the past three decades, a continuing decline in intensity is projected in the reference case, to 422 metric tons per million dollars in 2015 and 344 metric tons per million dollars in 2025.

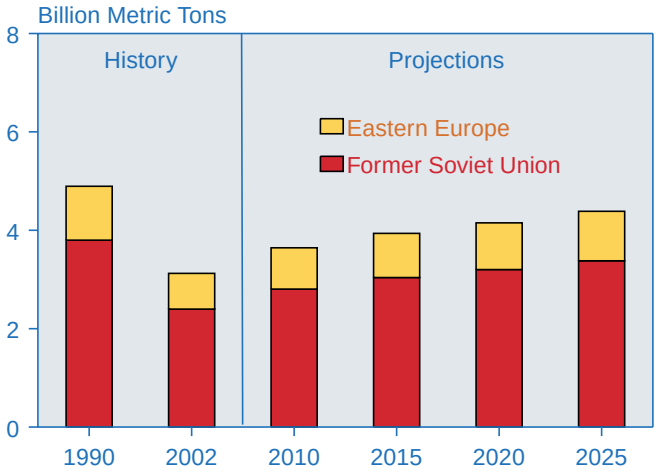
On a regional basis, the most rapid rates of improvement in carbon dioxide intensity are projected for the transitional economies of the EE/FSU and for the emerging

Table 10. World Carbon Dioxide Emissions by Region, 1990-2025
(Million Metric Tons)

Region	History		Projections				Average Annual Percent Change	
	1990	2002	2010	2015	2020	2025	1990-2002	2002-2025
Mature Market Economies	**10,465**	**11,877**	**13,080**	**13,745**	**14,392**	**15,183**	**1.1**	**1.1**
North America	5,769	6,701	7,674	8,204	8,759	9,379	1.3	1.5
Western Europe	3,413	3,549	3,674	3,761	3,812	3,952	0.3	0.5
Mature Market Asia	1,284	1,627	1,731	1,780	1,822	1,852	2.0	0.6
Transitional Economies	**4,894**	**3,124**	**3,643**	**3,937**	**4,151**	**4,386**	**-3.7**	**1.5**
Emerging Economies	**6,101**	**9,408**	**13,478**	**15,602**	**17,480**	**19,222**	**3.7**	**3.2**
Asia	3,890	6,205	9,306	10,863	12,263	13,540	4.0	3.5
Middle East	845	1,361	1,761	1,975	2,163	2,352	4.1	2.4
Africa	655	854	1,122	1,283	1,415	1,524	2.2	2.5
Central and South America	711	988	1,289	1,480	1,639	1,806	2.8	2.7
Total World	**21,460**	**24,409**	**30,201**	**33,284**	**36,023**	**38,790**	**1.1**	**2.0**

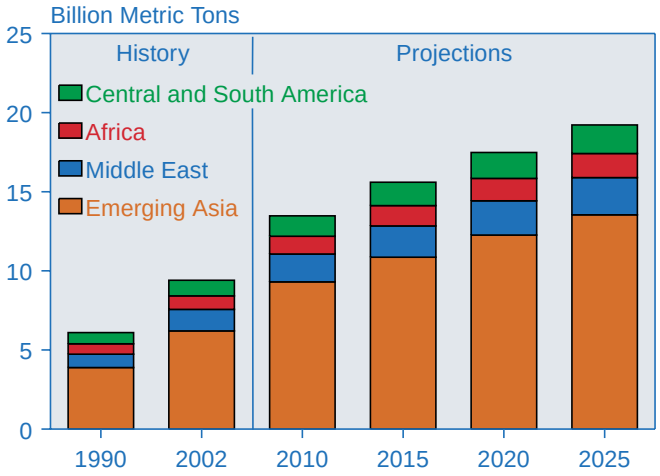
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 70. Carbon Dioxide Emissions in the Transitional Economies, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219 (2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 71. Carbon Dioxide Emissions in the Emerging Economies, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219 (2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

economies of China and India. In the FSU, economic recovery from the upheaval of the 1990s is expected to continue throughout the forecast. The FSU nations are also expected to replace old, inefficient capital stock as economic recovery progresses.

The Eastern European nations began their economic recovery much earlier than the nations of the FSU. As a result of strong investment in improving the efficiency of energy use among Eastern European countries and a push to increase the use of natural gas, carbon dioxide intensity fell by more than 43 percent in Eastern Europe between 1990 and 2002, as compared with an increase of almost 4 percent in Russia and a decrease of 27 percent in the other FSU nations. Improvement in carbon dioxide intensity in Eastern Europe is projected to continue over the projection period, at an average rate of 2.6 percent per year (Table 11).

Emerging Asia is expected to see fairly rapid improvement in carbon dioxide intensity over the 2002-2025 period, primarily as a result of rapid economic growth rather than a switch to less carbon-intensive fuels. China and India, in particular, are expected to remain heavily reliant on fossil fuels, especially coal, in the *IEO2005* reference case, but their combined annual GDP growth is projected to average 5.9 percent, compared with an expected 3.9-percent annual rate of increase in fossil fuel use over the projection period. China's carbon dioxide intensity is expected to decrease by 2.1 percent per year on average between 2002 and 2025 and India's by 2.4 percent per year.

Rates of improvement in carbon dioxide intensity could vary considerably in the future, based on technological advances, government policy initiatives, and economic growth rates. In the *IEO2005* reference case, world carbon dioxide intensity is projected to fall from 517 metric tons per million 2000 dollars of GDP in 2002 to 344 metric tons per million dollars in 2025; however, if world economic growth expands to the levels projected in the *IEO2005* high economic growth case, carbon dioxide intensity could fall more quickly, to 325 metric tons per million dollars in 2025. In contrast, if the world economy expands more slowly, as in the low economic growth case, carbon dioxide intensity could decline to a projected 383 metric tons per million dollars in 2025.

Table 11. Carbon Dioxide Intensity by Region and Country, 1970-2025
(Metric Tons per Million 2000 U.S. Dollars of Gross Domestic Product)

Region	History				Projections				Average Annual Percent Change	
	1970	1980	1990	2002	2010	2015	2020	2025	1990-2002	2002-2025
Mature Market Economies										
North America										
United States	1,117	917	701	571	501	459	423	393	-2.1	-1.6
Canada	1,046	883	691	612	562	527	495	481	-1.7	-1.0
Mexico	351	405	452	377	340	317	286	255	0.2	-1.7
Western Europe	695	624	471	377	333	307	281	264	-1.9	-1.5
Mature Market Asia										
Japan	627	497	348	359	310	291	274	259	-1.7	-1.4
Australia/New Zealand	1,094	715	702	721	667	621	583	544	-1.3	-1.2
Transitional Economies										
Russia	837	897	820	850	635	568	504	445	0.0	-2.8
Other FSU	1,211	1,210	1,843	1,346	926	801	682	602	0.3	-3.4
Eastern Europe	1,454	1,445	1,198	679	549	482	422	372	-2.3	-2.6
Emerging Economies										
Asia	890	766	637	470	434	389	343	300	-2.0	-1.9
China	2,560	1,943	1,252	605	570	500	436	375	-4.4	-2.1
India	286	312	346	324	272	242	212	185	0.4	-2.4
South Korea	791	868	698	680	555	515	484	454	-0.5	-1.7
Middle East	506	566	894	951	833	761	687	621	2.0	-1.8
Africa	522	542	609	595	549	518	477	431	0.4	-1.4
Central and South America	481	409	408	414	407	383	347	314	-0.5	-1.2
Total World	**853**	**753**	**649**	**517**	**461**	**422**	**381**	**344**	**-1.6**	**-1.8**

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Kyoto Protocol Case

Modeling Approach

Under the Kyoto Protocol, participating Annex I nations are required to reduce or limit emissions of carbon dioxide and other greenhouse gases over the first commitment period (January 2008 to December 2012) to a level that was determined as part of the negotiation process. The year 1990 was used as the base year for most countries, although some were allowed to use other years.[17] To fulfill their obligations under the treaty, the Annex I countries must limit their emissions over the 5-year commitment period to an annual average that is at or below their commitment goals. Because the SAGE model used to generate *IEO2005* forecasts projects in 5-year increments, 2010 is used as the basis year for achieving commitments in the first period.[18]

The SAGE model comprises 15 regions. In the Kyoto Protocol case, the model regions affected by the treaty are Canada, Japan, Western Europe, Eastern Europe, and the FSU. Although New Zealand has ratified the Protocol and intends to honor the terms of the treaty, Australia has not. In SAGE, New Zealand and Australia are treated as a single entity; and Australia's energy use far exceeds New Zealand's. Therefore, projections for Australia/New Zealand are not included in the results of the Kyoto Protocol case.

In the formulation of the Kyoto Protocol case, assumptions were made about how the affected regions would achieve their reductions, based whenever possible on official government statements. For instance, the European Union (EU) has stated that "most" of its greenhouse gas emissions reductions must be achieved domestically. The Kyoto Protocol case therefore assumes that 50 percent of the aggregate emission reduction for Western Europe will be met by domestic reductions, as opposed to using the international market mechanisms allowed under the Protocol (see box on page 83).

Both Japan and Canada have higher domestic reduction costs than Western Europe, and neither country has announced its intentions on the specific share of reductions that must be reached through domestic actions. In the Kyoto Protocol case, both countries are assumed to achieve 25 percent of their total reductions domestically.

In the *IEO2005* Kyoto Protocol case, a country or region is first required to achieve its domestic reduction goal. After the domestic requirement has been met, the country or region is free to seek other means of meeting its overall reduction goal—for example, by trading carbon permits internationally. In SAGE, the "shadow price" of reducing carbon dioxide emissions by 1 metric ton in a given country or region is used to determine the price that the country or region would be willing to pay for the next additional reduction of 1 metric ton. If the price of a carbon permit traded internationally exceeds the shadow price of the domestic reduction, then the country or region would be better off achieving that reduction domestically. If the price of a purchased permit is less than the shadow price, then the country or region would be expected to choose the trading option.

Unlike the mature market economies that have ratified the Kyoto Protocol, the EE/FSU transitional economies have reported estimated emissions that are below their Kyoto goal levels. Over the forecast period the credits they provide would be enough to satisfy all the other Annex I countries' demand for reductions once their domestic goals are met. The credits available from the EE/FSU countries have no direct costs, because they do not require any actions to be taken. Under the model structure of perfect competition, price equals cost; however, a transaction cost of $10 per ton was imposed in the SAGE model in order to derive a price greater than zero.

Summary

The Kyoto Protocol case assumes that energy use will not vary from the reference case forecast for Annex I countries that are not expected to participate in the treaty (the United States and Australia, for example) or for countries that are not required to make reductions according to the terms of the treaty (China and India, for example). As a result, only the projections for energy use in the Annex I nations committed to participating in the Kyoto Protocol are changed in the Kyoto Protocol case. For the participating Annex I group, total energy demand in the Kyoto Protocol case is projected to be 3 quadrillion Btu lower than in the reference case in 2010, and almost 4 quadrillion Btu lower in 2025, assuming that the Kyoto targets remain constant over the entire forecast period (Table 12).

In the Kyoto Protocol case, energy-related carbon dioxide emissions in the participating nations are projected to be 402 million metric tons lower than in the reference case in 2010 and 593 million metric tons lower in 2025. Total coal use among the participating Annex I nations in 2025 is projected to be about 18 percent lower than in the reference case in 2025, and the carbon dioxide emissions associated with their coal use are projected to be nearly 21 percent lower than in the reference case, primarily because of the expected penetration of carbon sequestration technologies in Western Europe. These technologies sequester 90 percent of the emissions from coal-fired generation. The penetration of the sequestration technology also limits the potential for renewables development.

[17]The countries using a base year other than 1990 are Bulgaria (1988), Hungary (1985-87), Poland (1988), and Romania (1989).
[18]For detailed assumptions in the Kyoto Protocol case, see Appendix G.

Total oil consumption for the participating nations is almost 2 quadrillion Btu lower in the Kyoto Protocol case in 2025, and the emissions associated with their oil use are 143 million metric tons lower. In the short term, natural gas is expected to displace coal use among the participating Annex I nations, because natural gas is cleaner than coal and has an economic advantage over nuclear and renewable energy sources that produce no net carbon dioxide emissions. In the longer term, as the marginal costs of carbon dioxide reductions increase, natural gas becomes less attractive than the non-fossil fuels, especially nuclear power, which is projected to begin to displace natural gas by 2025. The projection for natural gas consumption in the Kyoto Protocol case is 2.8 quadrillion Btu higher than the reference case projection in 2010 and 1.7 quadrillion Btu in 2025, when non-fossil fuel use is projected to be 1.4 quadrillion Btu higher in the Kyoto Protocol case than in the reference case.

The projected penetration of renewable fuels in the energy markets of participating Annex I countries is lower in the Kyoto Protocol case than in the reference case, for a number of reasons. Electricity generation from nuclear power is 1.9 percent higher in the Kyoto Protocol case than in the reference case in 2010 and 12.5 percent higher in 2025; and total energy use is 1.8 percent lower in 2010 and 1.7 percent lower in 2025. As a result, even though generation from non-fossil fuels makes up a larger share of total energy consumption in the Kyoto Protocol case than in the reference case, renewable generation is lower.

Regional Projections

Canada

Canada is the only Annex I country in North America that has ratified the Kyoto Protocol. Its goal is to reduce carbon dioxide emissions to 6 percent below 1990 levels, to a total of about 444 million metric tons in 2010, or 35 percent below the *IEO2005* reference case projection of 681 million metric tons. As indicated above, it is assumed that 59.3 million metric tons (25 percent) of the carbon dioxide emission reductions in Canada will be met through domestic actions, and 177.8 million metric tons (75 percent) will be met through the Protocol's market mechanisms.

In April 2005, Canada unveiled its plan for compliance, based on multiple approaches. The plan includes binding constraints on the country's electric power sector and large-scale industrial emitters, subsidies for wind power, a "partnership fund" between government and industry, soil management goals, and programs in consumer awareness and voluntary reductions by automakers. The Canadian government also has budgeted $3.2 billion to $4.0 billion for purchases of carbon credits, depending on the permit price [***1***].

The Kyoto Protocol case projects that, at the 25-percent domestic level, the marginal cost for emission reductions from domestic sources in Canada will be around $26 per metric ton of carbon dioxide in 2010 and, assuming that constraints are held constant after 2012, about $36 per metric ton in 2025. Canada's energy demand in 2010 is projected to be 0.3 quadrillion Btu (1.8 percent) lower in the Kyoto Protocol case than in the *IEO2005* reference case, and its energy-related carbon dioxide emissions in 2010 are projected to be 59 million metric tons (8.7 percent) lower (Table 13). In 2025, its projected energy demand is 0.5 quadrillion Btu below the reference case level (assuming that the Kyoto goals for Canada will not change over the forecast period), and its energy-related carbon dioxide emissions are 91 million metric tons lower than in the reference case.

Canada's coal consumption and associated carbon dioxide emissions are projected to be about 41 percent lower in 2010 and 55 percent lower in 2025 in the Kyoto Protocol case than in the reference case. Emissions associated with oil consumption are projected to be about the same in the two cases in 2025, and emissions from natural gas use are projected to be 5.2 percent higher in 2010 and 11.6 percent higher in 2025. Canada's consumption of non-fossil energy in 2025 is projected to be 0.9 percent

Table 12. Energy Consumption and Carbon Dioxide Emissions by Fuel in Participating Annex I Countries in Two Cases, 2010 and 2025

	Energy Consumption (Quadrillion Btu)				Carbon Dioxide Emissions (Million Metric Tons)			
	2010		2025		2010		2025	
Fuel	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case
Oil	58.1	56.8	63.2	61.4	3,803	3,719	4,142	3,998
Natural Gas	54.9	57.6	71.3	73.1	2,896	3,046	3,765	3,863
Coal	27.0	22.1	26.7	21.9	2,504	2,036	2,472	1,943
Nuclear	17.3	17.7	18.3	20.6	—	—	—	—
Renewables	14.4	14.4	17.8	16.9	—	—	—	—
Total	**171.7**	**168.6**	**197.3**	**193.8**	**9,203**	**8,801**	**10,386**	**9,793**

Source: Energy Information Administration, System for the Analysis of Global Energy Markets (2005).

higher in the Kyoto Protocol case than in the reference case.

Western Europe

The countries of Western Europe have ratified the Kyoto Protocol individually, and the EU has adopted a goal of reducing its member countries' aggregate carbon dioxide emissions to 8 percent below their 1990 level, or to an average of 3,123 million metric tons per year during the first commitment period. That goal, which is about 15 percent below the 2010 projection in the *IEO2005* reference case, would require a reduction of 545 million metric tons from the reference case level, 50 percent of which (273 million metric tons) is assumed to be met through domestic programs.

The EU has developed its own plan for emissions trading in the 2005 to 2007 period, in preparation for the first Kyoto commitment period in 2008. The EU Greenhouse Gas Emission Trading Scheme (EU ETS) allocates emissions to more than 12,000 specific installations across 25 member countries and requires reductions or permits to meet those allocated goals; however, there have been some mixed messages coming out of the EU in the

Market Mechanisms Under the Kyoto Protocol

In order to help participating countries meet their goals, the Kyoto Protocol includes market mechanisms that are designed to allow some flexibility in reaching reduction targets. The three primary market mechanisms are described below.

Clean Development Mechanism (CDM): The CDM is designed to promote participation by emerging economies in projects that lead to certified and verifiable emissions reductions. It allows Annex I countries to invest in emissions reduction projects in non-Annex I countries and apply credits received for those projects toward meeting their commitment goals. Currently, CDM reductions achieved between 2000 and 2012 may be used to meet requirements in the first commitment period, 2008 to 2012.

Several recent studies have estimated that the average annual demand for CDM Certified Emissions Reductions (CERs) will be between 50 and 500 million metric tons, and that the cost of a CER will be between $5 and $15 per metric ton.[a] Emission reductions in 2010 of 400 million metric tons carbon dioxide equivalent would require annual investments of $10 billion. For reference, annual foreign direct investment in emerging economies between 1997 and 2002 averaged $140 billion,[b] and it is estimated that the emerging economies will need a total of $192 billion annually in energy investments between 2001 and 2010.

Finally, CDM projects generally require a leadtime of 4 to 5 years to begin receiving credits. Because of risks to both the buyers and sellers of CERs derived from CDM projects and the abundance of excess emissions credits—so-called "hot air"—that could be sold internationally over the forecast period, the *IEO2005* Kyoto Protocol case does not explicitly include CDM projects. However, CDM projects serve as a mitigating factor to prevent the countries in possession of hot air credits from exercising monopoly power, since in many cases CDM projects would offer the best alternative to emissions trading after participating countries have met their domestic goals.

Emissions Trading: This market mechanism allows emitters who are in an advantageous position with regard to emissions reductions (as most of the EE/FSU countries currently are) to make further reductions below their target levels and sell the difference to emitters whose domestic reduction costs are relatively high. In theory, such trading would allow the necessary emission reduction to be achieved in the aggregate at the lowest possible cost, regardless of where they take place. Indeed, Russia and Ukraine could in theory meet all the required reductions of Annex B countries.[c] After domestic emissions reduction goals are achieved, the *IEO2005* Kyoto Protocol case assumes that additional reductions will be achieved by emissions trading.

Joint Implementation (JI): This market mechanism is similar to the CDM, except that JI projects would involve only the Annex B countries, and only reductions achieved during the 2008-2012 commitment period may be used. Because the SAGE model aggregates all the Western European countries into one region, JI is implicit in the projections for Western Europe. In contrast, because Canada and Japan are represented as single regions in SAGE, each must achieve its domestic goals (in the modeling process) independently of JI projects. As with CDM projects, the *IEO2005* Kyoto Protocol case assumes that emissions trading will be the least-cost alternative to reductions once domestic goals are achieved.

[a]E. Haites, *Estimating the Market Potential for the Clean Development Mechanism: Review of Models and Lessons Learned*. Prepared for the World Bank Carbon Finance Business PCF*plus* Research Program, the International Energy Agency, and the International Emissions Trading Association (Washington DC: PCF*plus* Report 19, June 2004), p. v, web site www.iea.org/textbase/papers/2004/cdm.pdf.
[b]E. Haites, *Estimating the Market Potential for the Clean Development Mechanism: Review of Models and Lessons Learned*, p. iv.
[c]Annex B countries are the mature market economies that are part of Annex I, excluding the transitional economies.

months since the EU ETS was implemented. Earlier indications were that the EU wanted to meet its Kyoto goals with a "significant element of their [reduction] efforts" coming from domestic cuts [2], but recent analysis has indicated that the cost of achieving domestic reductions in countries such as the United Kingdom may have been underestimated [3].

The *IEO2005* Kyoto Protocol case assumes that 50 percent of the emission reductions in Western Europe will be based on domestic actions, and the cost projections are highly sensitive to that assumption. At the 50-percent domestic reduction level, the cost of reducing carbon dioxide emissions in the region is projected to be $48 per metric ton in 2010, rising to $64 per metric ton in 2025. Western Europe's total projected energy demand is 2.2 quadrillion Btu lower in the Kyoto Protocol case than in the reference case in 2010 and 2.8 quadrillion Btu lower in 2025 (Table 14). Energy-related carbon dioxide emissions are projected to be 273 million metric tons lower than in the reference case in 2010 and 415 million metric tons lower in 2025.

Western Europe's coal consumption is projected to be 46 percent lower in 2010 in the Kyoto Protocol case than in the reference case, and the carbon dioxide emissions associated with its coal use are projected to be 45 percent lower. In 2025, however, when coal use in Western Europe is projected to be 47 percent lower than in the reference case, coal-related emissions are projected to be 58 percent lower, because technologies become available in Western Europe by 2025 that will allow 90 percent of the carbon dioxide emissions associated with coal combustion to be captured and sequestered. Oil consumption and related emissions are projected to be about 5 percent lower in the Kyoto Protocol case in 2025; natural gas consumption and associated emissions are projected to be almost 7 percent higher in 2025; and consumption of non-fossil fuels is projected to be 2.4 percent higher than in the reference case in 2025.

Japan

Japan's goal for reducing carbon dioxide emissions under the Kyoto Protocol is estimated at 930 million metric tons, or 6 percent below its 1990 emissions level. That target represents a reduction of about 280 million metric tons or 23 percent from the *IEO2005* reference case projection for 2010. If 25 percent of the goal is to be met domestically, energy-related carbon dioxide emissions will have to be cut by 70.1 million metric tons from the reference case projection in 2010, with the remaining

Table 13. Energy Consumption and Carbon Dioxide Emissions by Fuel in Canada in Two Cases, 2010 and 2025

	Energy Consumption (Quadrillion Btu)				Carbon Dioxide Emissions (Million Metric Tons)			
	2010		2025		2010		2025	
Fuel	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case
Oil	4.9	4.9	5.5	5.5	306	305	344	341
Natural Gas	4.0	4.2	4.8	5.4	210	220	253	282
Coal	1.8	1.1	2.3	1.0	166	97	210	93
Nuclear	1.2	1.2	1.2	1.2	—	—	—	—
Renewables	3.8	3.9	5.1	5.1	—	—	—	—
Total	**15.6**	**15.3**	**18.8**	**18.3**	**681**	**622**	**807**	**716**

Source: Energy Information Administration, System for the Analysis of Global Energy Markets (2005).

Table 14. Energy Consumption and Carbon Dioxide Emissions by Fuel in Western Europe in Two Cases, 2010 and 2025

	Energy Consumption (Quadrillion Btu)				Carbon Dioxide Emissions (Million Metric Tons)			
	2010		2025		2010		2025	
Fuel	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case
Oil	29.2	28.3	31.0	29.5	1,951	1,901	2,074	1,967
Natural Gas	17.7	20.1	22.9	24.5	934	1,066	1,210	1,290
Coal	8.2	4.5	6.9	3.6	783	428	661	281
Nuclear	9.0	9.3	7.8	9.0	—	—	—	—
Renewables	6.1	5.9	7.4	6.6	—	—	—	—
Total	**70.2**	**68.0**	**76.1**	**73.3**	**3,668**	**3,395**	**3,952**	**3,537**

Source: Energy Information Administration, System for the Analysis of Global Energy Markets (2005).

reduction of 210.4 million metric tons accomplished through purchases of emissions permits. In the *IEO2005* Kyoto Protocol case, Japan's domestic effort is projected to yield marginal costs of $49 per metric ton of carbon dioxide in 2010 and $43 per metric ton in 2025.

Japan's energy demand in 2010 is projected to be 0.8 quadrillion Btu lower in the Kyoto Protocol case than in the reference case (Table 15). Assuming that the country's goals for the first commitment period remain in place at the same level through 2025, its total energy demand in 2025 is projected to be 0.5 quadrillion Btu lower than in the reference case, and its energy-related carbon dioxide emissions are projected to be 70 million metric tons lower than the reference case projection in 2010 and 78 million metric tons lower in 2025.

Japan's coal consumption is projected to be 7.5 percent lower in 2025 in the Kyoto Protocol case than in the reference case, with a smaller reduction (3.6 percent) projected for oil consumption relative to the reference case projection in 2025. Because natural gas is expected to be used as a substitute for coal in the short run to help Japan reach its Kyoto goal, emissions associated with natural gas consumption are projected to be 4.1 percent higher in the Kyoto Protocol case than in the reference case in 2010.

In March 2005, a proposed fossil fuel tax was stopped by a government panel chaired by Prime Minister Junichiro Koizumi [*4*]. Currently, the Japanese plan calls for voluntary industry efforts as the cornerstone of the plan to meet its goals in the first commitment period. A shrinking population is expected to help Japan meet its goals in later years.

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4. A. Mollet, "Policy Update: Japan," *World Fuels Today* (March 31, 2005), p. 2.

Table 15. Energy Consumption and Carbon Dioxide Emissions by Fuel in Japan in Two Cases, 2010 and 2025

	Energy Consumption (Quadrillion Btu)				Carbon Dioxide Emissions (Million Metric Tons)			
	2010		2025		2010		2025	
Fuel	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case	Reference Case	Kyoto Protocol Case
Oil	10.9	10.4	11.0	10.6	657	623	662	628
Natural Gas	3.2	3.3	3.9	3.8	167	174	208	198
Coal	4.3	3.8	4.1	3.8	386	343	372	338
Nuclear	3.3	3.3	4.0	4.4	—	—	—	—
Renewables	1.2	1.2	1.7	1.6	—	—	—	—
Total	**22.9**	**22.1**	**24.7**	**24.2**	**1,211**	**1,141**	**1,242**	**1,164**

Source: Energy Information Administration, System for the Analysis of Global Energy Markets (2005).

Appendix A

Reference Case Projections:

- World Energy Consumption
- Gross Domestic Product
- Carbon Dioxide Emissions
- World Population

Table A1. World Total Primary Energy Consumption by Region, Reference Case, 1990-2025
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**100.9**	**115.2**	**117.7**	**134.2**	**143.6**	**152.9**	**162.1**	**1.4**
United States[a]	84.6	96.3	98.0	110.6	117.6	125.1	132.4	1.3
Canada	11.1	12.8	13.1	15.6	16.9	17.8	18.8	1.6
Mexico	5.1	6.1	6.6	8.0	9.1	10.0	10.9	2.2
Western Europe	**59.9**	**68.0**	**67.4**	**70.2**	**72.2**	**73.4**	**76.1**	**0.5**
Mature Market Asia	**22.7**	**28.0**	**28.4**	**30.4**	**31.5**	**32.5**	**33.6**	**0.7**
Japan	18.3	21.9	22.0	22.9	23.6	24.1	24.7	0.5
Australia/New Zealand	4.5	6.1	6.5	7.5	7.9	8.4	8.8	1.4
Total Mature Market	**183.6**	**211.2**	**213.5**	**234.7**	**247.3**	**258.7**	**271.8**	**1.1**
Transitional Economies								
Former Soviet Union	**60.9**	**42.0**	**42.4**	**49.7**	**53.9**	**57.2**	**61.0**	**1.6**
Russia	39.1	27.7	27.5	31.3	33.5	35.7	37.9	1.4
Other FSU	21.8	14.3	14.9	18.4	20.4	21.5	23.1	1.9
Eastern Europe	**15.3**	**11.4**	**11.2**	**13.3**	**14.5**	**15.6**	**16.7**	**1.7**
Total Transitional	**76.2**	**53.4**	**53.6**	**63.0**	**68.4**	**72.8**	**77.7**	**1.6**
Emerging Economies								
Emerging Asia	**51.5**	**84.7**	**88.4**	**133.6**	**155.8**	**176.3**	**196.7**	**3.5**
China	27.0	40.9	43.2	73.1	86.1	97.7	109.2	4.1
India	8.0	13.8	14.0	19.6	22.7	26.0	29.3	3.3
South Korea	3.8	8.0	8.4	10.6	11.8	12.7	13.5	2.1
Other Asia	12.7	21.9	22.9	30.3	35.1	39.9	44.6	2.9
Middle East	**13.1**	**20.9**	**22.0**	**28.7**	**32.4**	**35.6**	**38.9**	**2.5**
Africa	**9.3**	**12.5**	**12.7**	**16.7**	**19.3**	**21.4**	**23.4**	**2.7**
Central and South America	**14.5**	**21.2**	**21.2**	**26.8**	**30.4**	**33.2**	**36.1**	**2.3**
Brazil	5.8	8.4	8.6	10.2	11.6	13.2	15.1	2.5
Other Central/South America	8.8	12.7	12.6	16.6	18.8	20.0	21.1	2.3
Total Emerging	**88.4**	**139.2**	**144.3**	**205.8**	**237.8**	**266.6**	**295.1**	**3.2**
Total World	**348.2**	**403.9**	**411.5**	**503.5**	**553.5**	**598.1**	**644.6**	**2.0**

[a]Includes the 50 States and the District of Columbia.

Notes: 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 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A2. World Total Energy Consumption by Region and Fuel, Reference Case, 1990-2025
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America								
Oil	40.6	46.2	47.1	53.8	57.8	61.6	65.2	1.4
Natural Gas	23.2	27.3	28.2	32.2	35.8	38.7	39.6	1.5
Coal	20.7	23.8	23.9	27.1	27.9	29.6	33.2	1.4
Nuclear	6.9	8.9	9.0	9.8	9.9	10.0	9.9	0.4
Other	9.5	9.0	9.5	11.3	12.1	13.0	14.1	1.7
Total	**100.9**	**115.2**	**117.7**	**134.2**	**143.6**	**152.9**	**162.1**	**1.4**
Western Europe								
Oil	25.9	28.9	28.6	29.2	29.7	30.0	31.0	0.3
Natural Gas	9.7	15.2	15.4	17.7	19.5	20.9	22.9	1.8
Coal	12.4	8.7	8.6	8.2	7.8	7.3	6.9	-1.0
Nuclear	7.4	9.1	9.2	9.0	8.9	8.4	7.8	-0.7
Other	4.5	6.0	5.5	6.1	6.4	6.8	7.4	1.3
Total	**59.9**	**68.0**	**67.4**	**70.2**	**72.2**	**73.4**	**76.1**	**0.5**
Mature Market Asia								
Oil	12.4	13.0	13.1	13.4	13.8	13.9	14.1	0.3
Natural Gas	2.5	4.0	4.0	4.4	5.1	5.3	5.7	1.6
Coal	4.2	6.5	6.8	7.4	7.4	7.6	7.6	0.4
Nuclear	2.0	3.1	3.0	3.3	3.4	3.7	4.0	1.2
Other	1.6	1.5	1.6	1.7	1.9	2.0	2.3	1.6
Total	**22.7**	**28.0**	**28.4**	**30.4**	**31.5**	**32.5**	**33.6**	**0.7**
Total Mature Market								
Oil	79.0	88.0	88.8	96.4	101.3	105.5	110.3	0.9
Natural Gas	35.4	46.5	47.5	54.3	60.3	64.9	68.2	1.6
Coal	37.3	39.0	39.4	42.7	43.1	44.5	47.7	0.8
Nuclear	16.3	21.1	21.2	22.1	22.3	22.0	21.7	0.1
Other	15.6	16.5	16.6	19.1	20.3	21.8	23.8	1.6
Total	**183.6**	**211.2**	**213.5**	**234.7**	**247.3**	**258.7**	**271.8**	**1.1**
Transitional Economies								
Oil	21.0	11.9	11.4	13.1	13.9	14.8	15.7	1.4
Natural Gas	28.8	23.8	24.3	30.0	34.1	36.7	39.6	2.2
Coal	20.7	11.7	11.6	12.7	12.9	13.1	13.4	0.6
Nuclear	2.9	3.1	3.3	3.8	3.9	4.6	5.3	2.1
Other	2.8	3.0	3.1	3.4	3.4	3.6	3.6	0.7
Total	**76.2**	**53.4**	**53.6**	**63.0**	**68.4**	**72.8**	**77.7**	**1.6**
Emerging Economies								
Emerging Asia								
Oil	16.1	30.4	31.4	47.0	54.4	61.8	69.5	3.5
Natural Gas	3.2	7.6	8.2	11.4	14.3	17.5	22.3	4.4
Coal	28.1	39.9	41.5	62.6	72.8	81.1	86.8	3.3
Nuclear	0.9	1.8	2.0	3.8	4.8	5.7	6.5	5.3
Other	3.2	4.9	5.4	8.8	9.5	10.2	11.6	3.4
Total	**51.5**	**84.7**	**88.4**	**133.6**	**155.8**	**176.3**	**196.7**	**3.5**

See notes at end of table.

Table A2. World Total Energy Consumption by Region and Fuel, Reference Case, 1990-2025 (Continued)
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Emerging Economies (Continued)								
Middle East								
Oil	8.0	11.3	11.7	15.1	16.6	17.7	18.8	2.1
Natural Gas	3.9	8.0	8.6	11.1	13.2	15.2	17.4	3.1
Coal	0.8	1.2	1.1	1.5	1.5	1.5	1.5	1.4
Nuclear	0.0	0.0	0.0	0.1	0.1	0.1	0.1	—
Other	0.4	0.4	0.5	1.0	1.0	1.1	1.1	3.3
Total	**13.1**	**20.9**	**22.0**	**28.7**	**32.4**	**35.6**	**38.9**	**2.5**
Africa								
Oil	4.2	5.4	5.5	7.6	8.7	9.5	10.1	2.7
Natural Gas	1.5	2.5	2.6	3.4	4.4	5.2	6.4	4.0
Coal	3.0	3.7	3.7	4.6	5.0	5.3	5.3	1.6
Nuclear	0.1	0.1	0.1	0.1	0.2	0.2	0.2	1.0
Other	0.6	0.8	0.8	1.0	1.1	1.2	1.4	2.2
Total	**9.3**	**12.5**	**12.8**	**16.7**	**19.3**	**21.4**	**23.4**	**2.7**
Central and South America								
Oil	7.7	11.0	10.7	13.9	15.8	17.4	18.9	2.5
Natural Gas	2.2	3.8	3.8	5.0	6.1	7.0	8.1	3.3
Coal	0.6	0.7	0.8	1.1	1.2	1.2	1.3	2.2
Nuclear	0.1	0.2	0.2	0.2	0.4	0.3	0.4	2.4
Other	3.9	5.4	5.7	6.6	7.0	7.2	7.4	1.2
Total	**14.5**	**21.2**	**21.2**	**26.8**	**30.4**	**33.2**	**36.1**	**2.3**
Total Emerging								
Oil	36.1	58.1	59.2	83.6	95.5	106.3	117.4	3.0
Natural Gas	10.8	21.9	23.3	30.9	37.9	45.0	54.2	3.7
Coal	32.4	45.6	47.1	69.8	80.4	89.1	95.0	3.1
Nuclear	1.1	2.2	2.3	4.3	5.5	6.3	7.1	5.0
Other	8.0	11.5	12.4	17.3	18.6	19.8	21.5	2.4
Total	**88.4**	**139.2**	**144.3**	**205.8**	**237.8**	**266.6**	**295.1**	**3.2**
Total World								
Oil	136.0	158.0	159.4	193.1	210.6	226.6	243.4	1.9
Natural Gas	75.0	92.2	95.2	115.2	132.4	146.6	162.1	2.3
Coal	90.5	96.3	98.1	125.2	136.4	146.8	156.1	2.0
Nuclear	20.3	26.4	26.9	30.2	31.7	32.9	34.1	1.0
Other	26.4	31.1	32.1	39.8	42.4	45.2	48.9	1.9
Total	**348.2**	**403.9**	**411.5**	**503.5**	**553.5**	**598.1**	**644.6**	**2.0**

Notes: 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 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A3. World Gross Domestic Product (GDP) by Region, Reference Case, 1990-2025
(Billion 2000 Dollars)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**8,478**	**11,774**	**11,997**	**15,567**	**18,142**	**21,055**	**24,285**	**3.1**
United States[a]	7,113	9,891	10,075	13,084	15,216	17,634	20,292	3.1
Canada	684	929	961	1,211	1,378	1,527	1,675	2.4
Mexico	681	955	962	1,272	1,548	1,893	2,318	3.9
Western Europe	**7,246**	**9,314**	**9,416**	**11,044**	**12,255**	**13,563**	**14,958**	**2.0**
Mature Market Asia	**3,258**	**3,891**	**3,904**	**4,691**	**5,123**	**5,530**	**5,914**	**1.8**
Japan	2,840	3,294	3,284	3,911	4,240	4,533	4,792	1.7
Australia/New Zealand	419	597	621	780	883	997	1,122	2.6
Total Mature Market	**18,982**	**24,980**	**25,317**	**31,302**	**35,519**	**40,148**	**45,157**	**2.5**
Transitional Economies								
Former Soviet Union	**3,306**	**2,274**	**2,392**	**3,827**	**4,672**	**5,627**	**6,707**	**4.6**
Russia	2,241	1,583	1,657	2,543	3,019	3,571	4,192	4.1
Other FSU	1,065	691	735	1,283	1,653	2,056	2,516	5.5
Eastern Europe	**914**	**1,040**	**1,068**	**1,527**	**1,863**	**2,253**	**2,702**	**4.1**
Total Transitional	**4,220**	**3,314**	**3,460**	**5,354**	**6,535**	**7,880**	**9,409**	**4.4**
Emerging Economies								
Emerging Asia	**6,108**	**12,456**	**13,196**	**21,467**	**27,953**	**35,723**	**45,110**	**5.5**
China	1,807	5,087	5,494	9,716	13,003	16,919	21,699	6.2
India	1,684	3,021	3,160	5,031	6,524	8,430	10,807	5.5
South Korea	335	619	662	988	1,209	1,399	1,592	3.9
Other Asia	2,282	3,728	3,880	5,732	7,216	8,975	11,012	4.6
Middle East	**945**	**1,365**	**1,431**	**2,113**	**2,594**	**3,147**	**3,789**	**4.3**
Africa	**1,075**	**1,387**	**1,434**	**2,044**	**2,476**	**2,968**	**3,533**	**4.0**
Central and South America	**1,744**	**2,400**	**2,388**	**3,168**	**3,870**	**4,717**	**5,753**	**3.9**
Brazil	1,022	1,344	1,370	1,783	2,170	2,638	3,209	3.8
Other Central/South America	722	1,056	1,018	1,385	1,699	2,080	2,544	4.1
Total Emerging	**9,871**	**17,608**	**18,449**	**28,793**	**36,892**	**46,555**	**58,185**	**5.1**
Total World	**33,073**	**45,901**	**47,227**	**65,449**	**78,947**	**94,582**	**112,752**	**3.9**

[a]Includes the 50 States and the District of Columbia.

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

Sources: A. Heston, R. Summers, and B. Aten, "Penn World Table Version 6.1" (Center for International Comparisons at the University of Pennsylvania, October 2002), web site http://pwt.econ.upenn.edu/php_site/pwt_index.php; Global Insight, Inc., *World Overview, First Quarter 2005* (Lexington, MA, March 2005); and Energy Information Administration, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington DC, January 2005), Table A19.

Table A4. World Oil Consumption by Region, Reference Case, 1990-2025
(Million Barrels per Day)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**20.5**	**23.7**	**23.8**	**27.2**	**29.2**	**31.1**	**32.9**	**1.4**
United States[a]	17.0	19.6	19.7	22.5	24.2	25.8	27.3	1.4
Canada	1.7	2.0	2.1	2.3	2.5	2.5	2.6	1.0
Mexico	1.8	2.0	2.0	2.3	2.5	2.8	3.0	1.8
Western Europe	**12.5**	**14.0**	**13.8**	**14.1**	**14.3**	**14.4**	**14.9**	**0.3**
Mature Market Asia	**6.1**	**6.4**	**6.3**	**6.5**	**6.6**	**6.7**	**6.8**	**0.3**
Japan	5.3	5.4	5.3	5.3	5.4	5.4	5.3	0.0
Australia/New Zealand	0.8	1.0	1.0	1.2	1.3	1.4	1.5	1.6
Total Mature Market	**39.1**	**44.1**	**43.9**	**47.7**	**50.1**	**52.2**	**54.6**	**1.0**
Transitional Economies								
Former Soviet Union	**8.4**	**4.3**	**4.1**	**4.7**	**4.9**	**5.2**	**5.5**	**1.3**
Russia	5.4	2.7	2.6	3.0	3.1	3.3	3.4	1.3
Other FSU	3.0	1.6	1.5	1.8	1.8	1.9	2.0	1.3
Eastern Europe	**1.7**	**1.4**	**1.4**	**1.6**	**1.8**	**1.9**	**2.1**	**1.7**
Total Transitional	**10.0**	**5.7**	**5.5**	**6.3**	**6.7**	**7.2**	**7.6**	**1.4**
Emerging Economies								
Emerging Asia	**7.7**	**14.7**	**15.1**	**22.7**	**26.3**	**29.8**	**33.6**	**3.5**
China	2.3	4.9	5.2	9.2	10.7	12.3	14.2	4.5
India	1.2	2.2	2.2	3.1	3.7	4.2	4.9	3.5
South Korea	1.0	2.1	2.2	2.6	2.8	2.9	2.9	1.3
Other Asia	3.1	5.5	5.6	7.9	9.2	10.4	11.6	3.2
Middle East	**3.8**	**5.5**	**5.7**	**7.3**	**8.0**	**8.6**	**9.2**	**2.1**
Africa	**2.1**	**2.6**	**2.7**	**3.7**	**4.3**	**4.6**	**4.9**	**2.7**
Central and South America	**3.8**	**5.4**	**5.2**	**6.8**	**7.8**	**8.5**	**9.3**	**2.5**
Brazil	1.5	2.2	2.2	2.5	2.8	3.2	3.7	2.3
Other Central/South America	2.3	3.2	3.1	4.3	5.0	5.3	5.6	2.6
Total Emerging	**17.3**	**28.2**	**28.7**	**40.6**	**46.3**	**51.6**	**57.0**	**3.0**
Total World	**66.5**	**78.0**	**78.2**	**94.6**	**103.2**	**111.0**	**119.2**	**1.9**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A5. World Natural Gas Consumption by Region, Reference Case, 1990-2025
(Trillion Cubic Feet)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**22.5**	**26.6**	**27.4**	**31.3**	**34.8**	**37.6**	**38.6**	**1.5**
United States[a]	19.2	22.2	23.0	25.6	28.3	30.4	30.9	1.3
Canada	2.4	2.9	3.0	3.9	4.3	4.6	4.7	2.0
Mexico	0.9	1.4	1.5	1.8	2.2	2.6	3.0	3.0
Western Europe	**10.1**	**14.9**	**15.0**	**17.3**	**19.0**	**20.4**	**22.4**	**1.8**
Mature Market Asia	**2.6**	**3.8**	**3.8**	**4.2**	**4.8**	**5.1**	**5.4**	**1.6**
Japan	1.9	2.7	2.7	3.0	3.4	3.6	3.8	1.5
Australia/New Zealand	0.8	1.1	1.1	1.2	1.4	1.4	1.6	1.7
Total Mature Market	**35.2**	**45.2**	**46.2**	**52.8**	**58.7**	**63.1**	**66.4**	**1.6**
Transitional Economies								
Former Soviet Union	**25.0**	**20.8**	**21.3**	**25.6**	**29.0**	**31.0**	**33.3**	**2.0**
Russia	17.3	14.4	14.6	16.2	17.9	19.5	20.7	1.5
Other FSU	7.7	6.4	6.8	9.4	11.1	11.6	12.6	2.7
Eastern Europe	**3.1**	**2.7**	**2.6**	**4.0**	**4.6**	**5.2**	**5.8**	**3.5**
Total Transitional	**28.1**	**23.5**	**23.9**	**29.6**	**33.6**	**36.2**	**39.1**	**2.2**
Emerging Economies								
Emerging Asia	**3.0**	**7.2**	**7.8**	**10.6**	**13.3**	**16.3**	**20.7**	**4.3**
China	0.5	1.1	1.2	2.6	3.4	4.2	6.5	7.8
India	0.4	0.9	0.9	1.4	1.8	2.3	2.8	5.1
South Korea	0.1	0.7	0.8	1.2	1.4	1.6	1.9	3.7
Other Asia	2.0	4.6	4.9	5.4	6.8	8.2	9.5	2.9
Middle East	**3.7**	**7.6**	**8.3**	**10.6**	**12.6**	**14.5**	**16.6**	**3.1**
Africa	**1.4**	**2.3**	**2.4**	**3.1**	**4.1**	**4.9**	**6.0**	**4.0**
Central and South America	**2.0**	**3.5**	**3.6**	**4.6**	**5.6**	**6.5**	**7.5**	**3.3**
Brazil	0.1	0.4	0.5	0.9	1.3	1.7	2.1	6.8
Other Central/South America	1.9	3.1	3.1	3.8	4.3	4.8	5.4	2.4
Total Emerging	**10.1**	**20.6**	**22.0**	**29.0**	**35.6**	**42.2**	**50.7**	**3.7**
Total World	**73.4**	**89.3**	**92.2**	**111.4**	**127.9**	**141.6**	**156.2**	**2.3**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A6. World Coal Consumption by Region, Reference Case, 1990-2025
(Million Short Tons)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**972**	**1,144**	**1,152**	**1,326**	**1,375**	**1,457**	**1,629**	**1.5**
United States[a]	904	1,060	1,066	1,227	1,271	1,351	1,505	1.5
Canada	59	70	72	78	80	81	99	1.4
Mexico	9	15	14	21	24	25	25	2.6
Western Europe	**894**	**572**	**573**	**544**	**514**	**486**	**459**	**-1.0**
Mature Market Asia	**233**	**326**	**341**	**374**	**373**	**386**	**386**	**0.5**
Japan	126	173	179	184	181	179	177	0.0
Australia/New Zealand	106	153	162	190	191	207	209	1.1
Total Mature Market	**2,099**	**2,042**	**2,067**	**2,245**	**2,261**	**2,328**	**2,474**	**0.8**
Transitional Economies								
Former Soviet Union	**848**	**396**	**397**	**450**	**462**	**471**	**480**	**0.8**
Russia	462	242	229	283	293	292	288	1.0
Other FSU	386	154	168	167	169	179	192	0.6
Eastern Europe	**524**	**384**	**374**	**384**	**388**	**390**	**394**	**0.2**
Total Transitional	**1,372**	**779**	**771**	**834**	**850**	**860**	**874**	**0.5**
Emerging Economies								
Emerging Asia	**1,555**	**2,033**	**2,118**	**3,196**	**3,715**	**4,138**	**4,435**	**3.3**
China	1,124	1,357	1,422	2,302	2,704	3,037	3,242	3.6
India	256	414	421	544	614	674	736	2.5
South Korea	49	75	80	97	116	130	142	2.5
Other Asia	127	188	196	253	281	298	316	2.1
Middle East	**66**	**98**	**84**	**116**	**117**	**118**	**116**	**1.4**
Africa	**152**	**188**	**186**	**231**	**249**	**267**	**267**	**1.6**
Central and South America	**27**	**34**	**36**	**48**	**52**	**56**	**59**	**2.2**
Brazil	17	22	22	30	33	36	41	2.7
Other Central/South America	10	12	14	18	20	20	18	1.2
Total Emerging	**1,799**	**2,353**	**2,424**	**3,592**	**4,134**	**4,579**	**4,878**	**3.1**
Total World	**5,270**	**5,174**	**5,262**	**6,670**	**7,245**	**7,767**	**8,226**	**2.0**

[a]Includes the 50 States and the District of Columbia.

Notes: Totals may not equal sum of components due to independent rounding. 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 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A7. World Nuclear Energy Consumption by Region, Reference Case, 1990-2025
(Billion Kilowatthours)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**649**	**850**	**860**	**937**	**953**	**957**	**952**	**0.4**
United States[a]	577	769	780	813	826	830	830	0.3
Canada	69	73	71	114	117	117	112	2.0
Mexico	3	8	9	10	10	10	10	0.2
Western Europe	**703**	**870**	**876**	**864**	**854**	**802**	**752**	**-0.7**
Mature Market Asia	**192**	**303**	**295**	**319**	**330**	**351**	**380**	**1.1**
Japan	192	303	295	319	330	351	380	1.1
Australia/New Zealand	0	0	0	0	0	0	0	—
Total Mature Market	**1,544**	**2,024**	**2,032**	**2,120**	**2,136**	**2,110**	**2,083**	**0.1**
Transitional Economies								
Former Soviet Union	**201**	**210**	**224**	**275**	**279**	**332**	**399**	**2.5**
Russia	115	125	134	151	153	173	218	2.1
Other FSU	86	85	90	124	125	160	181	3.1
Eastern Europe	**54**	**72**	**79**	**89**	**98**	**105**	**113**	**1.6**
Total Transitional	**256**	**282**	**302**	**364**	**376**	**437**	**512**	**2.3**
Emerging Economies								
Emerging Asia	**88**	**178**	**194**	**367**	**464**	**551**	**620**	**5.2**
China	0	17	23	72	137	162	200	9.8
India	6	18	18	67	89	123	132	9.1
South Korea	50	107	113	169	179	185	196	2.4
Other Asia	32	36	40	60	59	81	93	3.8
Middle East	**0**	**0**	**0**	**6**	**6**	**6**	**6**	**—**
Africa	**8**	**11**	**12**	**13**	**14**	**15**	**15**	**0.9**
Central and South America	**9**	**21**	**19**	**20**	**35**	**33**	**34**	**2.5**
Brazil	2	14	14	14	23	23	24	2.3
Other Central/South America	7	7	5	6	11	10	10	2.9
Total Emerging	**105**	**209**	**225**	**406**	**519**	**605**	**675**	**4.9**
Total World	**1,905**	**2,515**	**2,560**	**2,890**	**3,032**	**3,152**	**3,270**	**1.1**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A8. World Consumption of Hydroelectricity and Other Renewable Energy by Region, Reference Case, 1990-2025
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**9.5**	**9.0**	**9.5**	**11.3**	**12.1**	**13.0**	**14.1**	**1.7**
United States[a]	6.0	5.2	5.9	6.9	7.2	7.7	8.3	1.5
Canada	3.1	3.4	3.3	3.8	4.2	4.6	5.1	1.9
Mexico	0.3	0.4	0.4	0.6	0.6	0.7	0.7	3.0
Western Europe	**4.5**	**6.0**	**5.5**	**6.1**	**6.4**	**6.8**	**7.4**	**1.3**
Mature Market Asia	**1.6**	**1.5**	**1.6**	**1.7**	**1.9**	**2.0**	**2.3**	**1.6**
Japan	1.1	1.0	1.1	1.2	1.3	1.5	1.7	1.9
Australia/New Zealand	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.8
Total Mature Market	**15.6**	**16.5**	**16.6**	**19.1**	**20.3**	**21.8**	**23.8**	**1.6**
Transitional Economies								
Former Soviet Union	**2.4**	**2.5**	**2.5**	**2.7**	**2.7**	**2.7**	**2.7**	**0.4**
Russia	1.8	1.8	1.9	2.2	2.2	2.2	2.2	0.7
Other FSU	0.6	0.7	0.6	0.6	0.6	0.6	0.6	-0.6
Eastern Europe	**0.4**	**0.6**	**0.6**	**0.6**	**0.7**	**0.8**	**0.9**	**1.6**
Total Transitional	**2.8**	**3.0**	**3.1**	**3.4**	**3.4**	**3.6**	**3.6**	**0.7**
Emerging Economies								
Emerging Asia	**3.2**	**4.9**	**5.4**	**8.8**	**9.5**	**10.2**	**11.6**	**3.4**
China	1.3	2.6	3.1	5.2	5.7	6.2	6.7	3.4
India	0.7	0.8	0.7	1.3	1.4	1.4	1.7	3.8
South Korea	0.0	0.0	0.0	0.1	0.1	0.1	0.1	4.6
Other Asia	1.1	1.4	1.5	2.2	2.3	2.5	3.0	3.1
Middle East	**0.4**	**0.4**	**0.5**	**1.0**	**1.0**	**1.1**	**1.1**	**3.3**
Africa	**0.6**	**0.8**	**0.8**	**1.0**	**1.1**	**1.2**	**1.4**	**2.2**
Central and South America	**3.9**	**5.4**	**5.7**	**6.6**	**7.0**	**7.2**	**7.4**	**1.2**
Brazil	2.2	2.8	3.0	3.3	3.4	3.7	4.0	1.2
Other Central/South America	1.7	2.6	2.7	3.4	3.5	3.5	3.5	1.2
Total Emerging	**8.0**	**11.5**	**12.4**	**17.3**	**18.6**	**19.8**	**21.5**	**2.4**
Total World	**26.4**	**31.1**	**32.1**	**39.8**	**42.4**	**45.2**	**48.9**	**1.9**

[a]Includes the 50 States and the District of Columbia.

Notes: Totals may not equal sum of components due to independent rounding. U.S. totals include net electricity imports, methanol, and liquid hydrogen.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A9. World Net Electricity Consumption by Region, Reference Case, 1990-2025
(Billion Kilowatthours)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**3,369**	**4,247**	**4,328**	**5,193**	**5,693**	**6,208**	**6,741**	**1.9**
United States[a]	2,827	3,554	3,651	4,272	4,643	5,043	5,470	1.8
Canada	435	508	487	644	713	774	828	2.3
Mexico	107	185	190	277	337	390	443	3.8
Western Europe	**2,069**	**2,551**	**2,556**	**2,613**	**2,786**	**2,872**	**3,072**	**0.8**
Mature Market Asia	**930**	**1,136**	**1,202**	**1,273**	**1,358**	**1,434**	**1,506**	**1.0**
Japan	765	910	971	1,000	1,060	1,110	1,154	0.8
Australia/New Zealand	166	226	231	273	299	324	352	1.8
Total Mature Market	**6,368**	**7,934**	**8,086**	**9,079**	**9,837**	**10,514**	**11,319**	**1.5**
Transitional Economies								
Former Soviet Union	**1,488**	**1,131**	**1,154**	**1,794**	**2,048**	**2,254**	**2,421**	**3.3**
Russia	955	769	780	1,043	1,188	1,323	1,469	2.8
Other FSU	533	363	374	750	860	932	951	4.1
Eastern Europe	**418**	**389**	**390**	**540**	**606**	**663**	**724**	**2.7**
Total Transitional	**1,906**	**1,520**	**1,544**	**2,334**	**2,654**	**2,917**	**3,145**	**3.1**
Emerging Economies								
Emerging Asia	**1,259**	**2,711**	**2,914**	**4,909**	**5,843**	**6,723**	**7,552**	**4.2**
China	551	1,302	1,457	2,801	3,327	3,816	4,260	4.8
India	257	509	510	773	961	1,150	1,340	4.3
South Korea	93	247	267	381	436	480	520	2.9
Other Asia	358	653	680	955	1,119	1,278	1,433	3.3
Middle East	**263**	**547**	**574**	**861**	**997**	**1,106**	**1,203**	**3.3**
Africa	**286**	**410**	**422**	**622**	**755**	**867**	**980**	**3.7**
Central and South America	**463**	**715**	**735**	**1,070**	**1,314**	**1,550**	**1,818**	**4.0**
Brazil	229	338	352	457	563	697	864	4.0
Other Central/South America	234	377	383	613	751	853	955	4.0
Total Emerging	**2,272**	**4,383**	**4,645**	**7,462**	**8,909**	**10,246**	**11,554**	**4.0**
Total World	**10,546**	**13,836**	**14,275**	**18,875**	**21,400**	**23,677**	**26,018**	**2.6**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A10. World Carbon Dioxide Emissions by Region, Reference Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**5,769**	**6,624**	**6,701**	**7,674**	**8,204**	**8,759**	**9,379**	**1.5**
United States[a]	4,989	5,692	5,751	6,561	6,988	7,461	7,981	1.4
Canada	473	573	588	681	726	757	807	1.4
Mexico	308	359	363	432	490	541	591	2.1
Western Europe	**3,413**	**3,585**	**3,549**	**3,674**	**3,761**	**3,812**	**3,952**	**0.5**
Mature Market Asia	**1,284**	**1,610**	**1,627**	**1,731**	**1,780**	**1,822**	**1,852**	**0.6**
Japan	990	1,182	1,179	1,211	1,232	1,240	1,242	0.2
Australia/New Zealand	294	429	448	520	548	582	610	1.4
Total Mature Market	**10,465**	**11,819**	**11,877**	**13,080**	**13,745**	**14,392**	**15,183**	**1.1**
Transitional Economies								
Former Soviet Union	**3,798**	**2,393**	**2,399**	**2,804**	**3,040**	**3,201**	**3,379**	**1.5**
Russia	2,347	1,553	1,522	1,732	1,857	1,971	2,063	1.3
Other FSU	1,452	840	877	1,072	1,183	1,230	1,317	1.8
Eastern Europe	**1,095**	**744**	**726**	**839**	**898**	**951**	**1,006**	**1.4**
Total Transitional	**4,894**	**3,137**	**3,124**	**3,643**	**3,937**	**4,151**	**4,386**	**1.5**
Emerging Economies								
Emerging Asia	**3,890**	**5,967**	**6,205**	**9,306**	**10,863**	**12,263**	**13,540**	**3.5**
China	2,262	3,176	3,322	5,536	6,506	7,373	8,133	4.0
India	583	1,009	1,025	1,369	1,581	1,786	1,994	2.9
South Korea	234	431	451	549	623	676	723	2.1
Other Asia	811	1,351	1,407	1,853	2,154	2,428	2,689	2.9
Middle East	**845**	**1,311**	**1,361**	**1,761**	**1,975**	**2,163**	**2,352**	**2.4**
Africa	**655**	**840**	**854**	**1,122**	**1,283**	**1,415**	**1,524**	**2.5**
Central and South America	**711**	**998**	**988**	**1,289**	**1,480**	**1,639**	**1,806**	**2.7**
Brazil	250	343	342	433	502	583	679	3.0
Other Central/South America	461	655	646	856	979	1,056	1,128	2.5
Total Emerging	**6,101**	**9,116**	**9,408**	**13,478**	**15,602**	**17,480**	**19,222**	**3.2**
Total World	**21,460**	**24,072**	**24,409**	**30,201**	**33,284**	**36,023**	**38,790**	**2.0**

[a]Includes the 50 States and the District of Columbia.

Note: The U.S. numbers include carbon dioxide emissions attributable to renewable energy sources.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A11. World Carbon Dioxide Emissions from Oil Use by Region, Reference Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**2,639**	**2,983**	**2,987**	**3,426**	**3,688**	**3,931**	**4,164**	**1.5**
United States[a]	2,178	2,458	2,457	2,826	3,037	3,239	3,436	1.5
Canada	222	268	274	306	323	334	344	1.0
Mexico	239	258	256	295	328	358	385	1.8
Western Europe	**1,739**	**1,933**	**1,911**	**1,951**	**1,985**	**2,003**	**2,074**	**0.4**
Mature Market Asia	**768**	**808**	**796**	**821**	**841**	**852**	**862**	**0.3**
Japan	655	668	657	657	665	664	662	0.0
Australia/New Zealand	113	140	139	164	177	188	201	1.6
Total Mature Market	**5,145**	**5,724**	**5,695**	**6,199**	**6,515**	**6,786**	**7,100**	**1.0**
Transitional Economies								
Former Soviet Union	**1,224**	**607**	**581**	**667**	**698**	**736**	**776**	**1.3**
Russia	783	378	356	412	429	464	493	1.4
Other FSU	441	229	225	255	269	273	283	1.0
Eastern Europe	**243**	**197**	**192**	**222**	**245**	**265**	**286**	**1.7**
Total Transitional	**1,468**	**803**	**773**	**889**	**943**	**1,002**	**1,062**	**1.4**
Emerging Economies								
Emerging Asia	**1,116**	**1,886**	**1,940**	**2,922**	**3,386**	**3,850**	**4,340**	**3.6**
China	345	638	669	1,193	1,385	1,599	1,845	4.5
India	165	278	279	390	466	542	621	3.5
South Korea	138	236	241	284	306	318	326	1.3
Other Asia	468	733	751	1,055	1,229	1,392	1,548	3.2
Middle East	**568**	**781**	**804**	**1,037**	**1,140**	**1,220**	**1,297**	**2.1**
Africa	**304**	**369**	**377**	**523**	**599**	**653**	**697**	**2.7**
Central and South America	**541**	**729**	**712**	**926**	**1,053**	**1,155**	**1,259**	**2.5**
Brazil	210	281	275	322	356	407	465	2.3
Other Central/South America	330	448	437	604	697	748	794	2.6
Total Emerging	**2,529**	**3,764**	**3,834**	**5,408**	**6,178**	**6,878**	**7,594**	**3.0**
Total World	**9,142**	**10,292**	**10,302**	**12,496**	**13,635**	**14,665**	**15,756**	**1.9**

[a]Includes the 50 States and the District of Columbia.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A12. World Carbon Dioxide Emissions from Natural Gas Use by Region, Reference Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**1,207**	**1,423**	**1,470**	**1,691**	**1,880**	**2,033**	**2,083**	**1.5**
United States[a]	1,026	1,189	1,227	1,380	1,523	1,639	1,665	1.3
Canada	127	157	160	210	234	251	253	2.0
Mexico	54	77	83	102	123	142	165	3.0
Western Europe	**514**	**803**	**812**	**934**	**1,029**	**1,104**	**1,210**	**1.8**
Mature Market Asia	**133**	**209**	**209**	**234**	**268**	**280**	**300**	**1.6**
Japan	89	150	147	167	187	200	208	1.5
Australia/New Zealand	44	59	62	67	81	80	92	1.7
Total Mature Market	**1,854**	**2,436**	**2,491**	**2,859**	**3,177**	**3,416**	**3,594**	**1.6**
Transitional Economies								
Former Soviet Union	**1,352**	**1,119**	**1,147**	**1,376**	**1,561**	**1,668**	**1,791**	**2.0**
Russia	928	768	776	865	954	1,036	1,105	1.5
Other FSU	424	351	371	512	607	632	686	2.7
Eastern Europe	**167**	**139**	**136**	**209**	**241**	**271**	**301**	**3.5**
Total Transitional	**1,519**	**1,258**	**1,283**	**1,585**	**1,802**	**1,940**	**2,093**	**2.2**
Emerging Economies								
Emerging Asia	**167**	**402**	**434**	**601**	**754**	**924**	**1,176**	**4.4**
China	31	66	71	163	209	259	401	7.8
India	24	46	48	75	96	125	152	5.1
South Korea	6	44	48	69	82	96	111	3.7
Other Asia	106	246	267	294	366	444	512	2.9
Middle East	**205**	**421**	**457**	**586**	**696**	**803**	**916**	**3.1**
Africa	**80**	**130**	**139**	**178**	**230**	**277**	**340**	**4.0**
Central and South America	**116**	**202**	**203**	**265**	**321**	**370**	**428**	**3.3**
Brazil	6	22	26	57	87	111	140	7.6
Other Central/South America	110	181	177	208	234	260	288	2.1
Total Emerging	**569**	**1,156**	**1,232**	**1,630**	**2,001**	**2,375**	**2,860**	**3.7**
Total World	**3,942**	**4,849**	**5,006**	**6,074**	**6,980**	**7,731**	**8,547**	**2.4**

[a]Includes the 50 States and the District of Columbia.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A13. World Carbon Dioxide Emissions from Coal Use by Region, Reference Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**1,923**	**2,214**	**2,247**	**2,537**	**2,616**	**2,774**	**3,110**	**1.4**
United States[a]	1,784	2,042	2,070	2,335	2,407	2,561	2,858	1.4
Canada	123	148	154	166	169	172	210	1.4
Mexico	15	24	23	36	39	41	42	2.6
Western Europe	**1,160**	**849**	**825**	**783**	**740**	**699**	**661**	**-1.0**
Mature Market Asia	**383**	**593**	**622**	**675**	**671**	**690**	**689**	**0.4**
Japan	245	364	375	386	380	376	372	0.0
Australia/New Zealand	138	229	247	289	291	314	317	1.1
Total Mature Market	**3,465**	**3,656**	**3,694**	**3,995**	**4,026**	**4,162**	**4,459**	**0.8**
Transitional Economies								
Former Soviet Union	**1,222**	**667**	**671**	**761**	**781**	**796**	**812**	**0.8**
Russia	635	408	390	456	473	471	465	0.8
Other FSU	587	260	281	304	308	325	347	0.9
Eastern Europe	**685**	**409**	**397**	**408**	**412**	**414**	**419**	**0.2**
Total Transitional	**1,907**	**1,076**	**1,068**	**1,169**	**1,193**	**1,210**	**1,231**	**0.6**
Emerging Economies								
Emerging Asia	**2,607**	**3,679**	**3,831**	**5,784**	**6,724**	**7,488**	**8,024**	**3.3**
China	1,886	2,472	2,582	4,181	4,911	5,514	5,887	3.6
India	394	684	698	903	1,019	1,119	1,222	2.5
South Korea	90	152	161	196	235	263	286	2.5
Other Asia	237	371	389	504	559	592	629	2.1
Middle East	**72**	**110**	**100**	**138**	**140**	**140**	**139**	**1.4**
Africa	**271**	**340**	**338**	**421**	**453**	**485**	**486**	**1.6**
Central and South America	**54**	**66**	**73**	**98**	**106**	**114**	**120**	**2.2**
Brazil	34	40	41	54	59	66	74	2.6
Other Central/South America	20	26	32	44	47	48	46	1.6
Total Emerging	**3,003**	**4,196**	**4,342**	**6,441**	**7,423**	**8,227**	**8,768**	**3.1**
Total World	**8,375**	**8,928**	**9,105**	**11,604**	**12,642**	**13,600**	**14,458**	**2.0**

[a]Includes the 50 States and the District of Columbia.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table A14. World Population by Region, Reference Case, 1990-2025
(Millions)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**364**	**417**	**423**	**457**	**477**	**497**	**517**	**0.9**
United States[a]	253	286	289	310	324	337	351	0.9
Canada	28	31	31	33	34	35	36	0.6
Mexico	83	100	103	113	120	125	130	1.0
Western Europe	**376**	**391**	**392**	**396**	**397**	**397**	**397**	**0.1**
Mature Market Asia	**144**	**150**	**151**	**153**	**153**	**152**	**151**	**0.0**
Japan	124	127	127	128	127	126	123	-0.1
Australia/New Zealand	20	23	24	25	26	27	28	0.7
Total Mature Market	**884**	**959**	**966**	**1,006**	**1,028**	**1,047**	**1,065**	**0.4**
Transitional Economies								
Former Soviet Union	**290**	**289**	**288**	**283**	**280**	**277**	**272**	**-0.2**
Russia	148	145	144	138	133	129	124	-0.6
Other FSU	141	144	144	145	147	148	148	0.1
Eastern Europe	**122**	**121**	**121**	**119**	**118**	**117**	**115**	**-0.2**
Total Transitional	**412**	**410**	**408**	**402**	**398**	**393**	**387**	**-0.2**
Emerging Economies								
Emerging Asia	**2,791**	**3,288**	**3,355**	**3,658**	**3,850**	**4,022**	**4,168**	**0.9**
China	1,155	1,285	1,300	1,365	1,402	1,429	1,445	0.5
India	846	1,033	1,059	1,174	1,246	1,312	1,369	1.1
South Korea	43	47	48	49	50	50	50	0.2
Other Asia	746	923	949	1,071	1,152	1,230	1,304	1.4
Middle East	**193**	**247**	**255**	**294**	**322**	**349**	**375**	**1.7**
Africa	**622**	**814**	**844**	**984**	**1,085**	**1,188**	**1,292**	**1.9**
Central and South America	**358**	**428**	**437**	**481**	**509**	**534**	**557**	**1.1**
Brazil	149	174	178	193	202	210	216	0.9
Other Central/South America	210	254	260	288	307	324	341	1.2
Total Emerging	**3,965**	**4,777**	**4,891**	**5,418**	**5,765**	**6,092**	**6,392**	**1.2**
Total World	**5,261**	**6,145**	**6,266**	**6,825**	**7,191**	**7,533**	**7,844**	**1.0**

[a]Includes the 50 States and the District of Columbia.

Sources: **United States:** Energy Information Administration, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/. **Other Countries:** United Nations, Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: 2002 Revision and World Urbanization Prospects* (New York, NY, July 11, 2003).

Appendix B

High Economic Growth Case Projections:

- **World Energy Consumption**
- **Gross Domestic Product**
- **Carbon Dioxide Emissions**

Table B1. World Total Primary Energy Consumption by Region, High Economic Growth Case, 1990-2025
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**100.9**	**115.2**	**117.7**	**138.4**	**150.0**	**160.8**	**173.0**	**1.7**
United States[a]	84.6	96.3	98.0	114.2	123.1	131.5	141.4	1.6
Canada	11.1	12.8	13.1	16.0	17.6	18.7	20.0	1.9
Mexico	5.1	6.1	6.6	8.2	9.4	10.5	11.7	2.5
Western Europe	**59.9**	**68.0**	**67.4**	**71.5**	**74.3**	**76.9**	**80.7**	**0.8**
Mature Market Asia	**22.7**	**28.0**	**28.4**	**31.0**	**32.6**	**34.0**	**35.6**	**1.0**
Japan	18.3	21.9	22.0	23.4	24.4	25.2	26.1	0.8
Australia/New Zealand	4.5	6.1	6.5	7.6	8.2	8.8	9.5	1.7
Total Mature Market	**183.6**	**211.2**	**213.5**	**241.0**	**256.9**	**271.7**	**289.3**	**1.3**
Transitional Economies								
Former Soviet Union	**60.9**	**42.0**	**42.4**	**51.7**	**57.5**	**62.1**	**67.3**	**2.0**
Russia	39.1	27.7	27.5	32.7	35.9	38.9	41.8	1.8
Other FSU	21.8	14.3	14.9	19.0	21.5	23.2	25.5	2.4
Eastern Europe	**15.3**	**11.4**	**11.2**	**13.8**	**15.4**	**16.9**	**18.5**	**2.2**
Total Transitional	**76.2**	**53.4**	**53.6**	**65.5**	**72.8**	**79.0**	**85.8**	**2.1**
Emerging Economies								
Emerging Asia	**51.5**	**84.7**	**88.4**	**139.8**	**167.4**	**194.7**	**223.2**	**4.1**
China	27.0	40.9	43.2	76.3	92.2	107.6	123.5	4.7
India	8.0	13.8	14.0	20.3	24.1	28.2	32.5	3.7
South Korea	3.8	8.0	8.4	11.2	12.8	14.2	15.5	2.7
Other Asia	12.7	21.9	22.9	31.9	38.3	44.8	51.5	3.6
Middle East	**13.1**	**20.9**	**22.0**	**30.1**	**34.9**	**39.3**	**44.1**	**3.1**
Africa	**9.3**	**12.5**	**12.7**	**17.4**	**20.6**	**23.4**	**26.1**	**3.2**
Central and South America	**14.5**	**21.2**	**21.2**	**28.1**	**32.4**	**35.7**	**39.6**	**2.8**
Brazil	5.8	8.4	8.6	10.6	12.2	14.0	16.2	2.8
Other Central/South America	8.8	12.7	12.6	17.5	20.2	21.7	23.5	2.7
Total Emerging	**88.4**	**139.2**	**144.3**	**215.3**	**255.2**	**293.0**	**333.0**	**3.7**
Total World	**348.2**	**403.9**	**411.5**	**521.7**	**585.0**	**643.7**	**708.1**	**2.4**

[a]Includes the 50 States and the District of Columbia.

Notes: 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 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table B2. World Total Energy Consumption by Region and Fuel, High Economic Growth Case, 1990-2025
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America								
Oil	40.6	46.2	47.1	56.6	61.5	66.3	71.2	1.8
Natural Gas	23.2	27.3	28.2	33.0	37.6	39.7	41.0	1.6
Coal	20.7	23.8	23.9	27.5	28.5	31.1	35.9	1.8
Nuclear	6.9	8.9	9.0	9.8	9.9	10.0	9.9	0.4
Other	9.5	9.0	9.5	11.5	12.4	13.6	15.0	2.0
Total	**100.9**	**115.2**	**117.7**	**138.4**	**150.0**	**160.8**	**173.0**	**1.7**
Western Europe								
Oil	25.9	28.9	28.6	29.8	30.8	31.5	32.9	0.6
Natural Gas	9.7	15.2	15.4	18.3	20.2	22.4	25.1	2.2
Coal	12.4	8.7	8.6	8.2	7.8	7.4	7.1	-0.9
Nuclear	7.4	9.1	9.2	9.0	8.9	8.4	7.8	-0.7
Other	4.5	6.0	5.5	6.3	6.6	7.2	7.9	1.6
Total	**59.9**	**68.0**	**67.4**	**71.5**	**74.3**	**76.9**	**80.7**	**0.8**
Mature Market Asia								
Oil	12.4	13.0	13.1	13.7	14.2	14.5	14.8	0.5
Natural Gas	2.5	4.0	4.0	4.6	5.4	5.7	6.1	1.9
Coal	4.2	6.5	6.8	7.5	7.5	7.9	8.3	0.8
Nuclear	2.0	3.1	3.0	3.3	3.4	3.7	4.0	1.2
Other	1.6	1.5	1.6	1.8	2.0	2.2	2.4	2.0
Total	**22.7**	**28.0**	**28.4**	**31.0**	**32.6**	**34.0**	**35.6**	**1.0**
Total Mature Market								
Oil	79.0	88.0	88.8	100.1	106.5	112.4	118.9	1.3
Natural Gas	35.4	46.5	47.5	55.9	63.3	67.8	72.2	1.8
Coal	37.3	39.0	39.4	43.3	43.8	46.4	51.2	1.1
Nuclear	16.3	21.1	21.2	22.1	22.3	22.0	21.7	0.1
Other	15.6	16.5	16.6	19.6	21.0	23.1	25.4	1.9
Total	**183.6**	**211.2**	**213.5**	**241.0**	**256.9**	**271.7**	**289.3**	**1.3**
Transitional Economies								
Oil	21.0	11.9	11.4	13.7	14.9	16.3	17.7	1.9
Natural Gas	28.8	23.8	24.3	31.6	37.1	40.8	44.9	2.7
Coal	20.7	11.7	11.6	12.9	13.4	13.7	14.2	0.9
Nuclear	2.9	3.1	3.3	3.8	3.9	4.6	5.3	2.1
Other	2.8	3.0	3.1	3.4	3.5	3.6	3.7	0.7
Total	**76.2**	**53.4**	**53.6**	**65.5**	**72.8**	**79.0**	**85.8**	**2.1**
Emerging Economies								
Emerging Asia								
Oil	16.1	30.4	31.4	49.2	58.8	68.4	79.2	4.1
Natural Gas	3.2	7.6	8.2	12.5	16.8	21.2	27.6	5.4
Coal	28.1	39.9	41.5	65.4	77.5	88.6	97.5	3.8
Nuclear	0.9	1.8	2.0	3.8	4.8	5.7	6.5	5.3
Other	3.2	4.9	5.4	8.8	9.5	10.7	12.4	3.7
Total	**51.5**	**84.7**	**88.4**	**139.8**	**167.4**	**194.7**	**223.2**	**4.1**

See notes at end of table.

Table B2. World Total Energy Consumption by Region and Fuel, High Economic Growth Case, 1990-2025 (Continued)
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Emerging Economies (Continued)								
Middle East								
Oil	8.0	11.3	11.7	15.7	17.9	19.7	21.6	2.7
Natural Gas	3.9	8.0	8.6	11.8	14.3	16.8	19.7	3.6
Coal	0.8	1.2	1.1	1.5	1.6	1.6	1.6	1.8
Nuclear	0.0	0.0	0.0	0.1	0.1	0.1	0.1	—
Other	0.4	0.4	0.5	1.0	1.1	1.1	1.1	3.3
Total	**13.1**	**20.9**	**22.0**	**30.1**	**34.9**	**39.3**	**44.1**	**3.1**
Africa								
Oil	4.2	5.4	5.5	7.9	9.3	10.4	11.3	3.2
Natural Gas	1.5	2.5	2.6	3.6	4.8	5.8	7.4	4.6
Coal	3.0	3.7	3.7	4.7	5.2	5.8	5.8	2.0
Nuclear	0.1	0.1	0.1	0.1	0.2	0.2	0.2	1.0
Other	0.6	0.8	0.8	1.0	1.2	1.3	1.4	2.4
Total	**9.3**	**12.5**	**12.8**	**17.4**	**20.6**	**23.4**	**26.1**	**3.2**
Central and South America								
Oil	7.7	11.0	10.7	14.6	17.1	19.0	21.3	3.0
Natural Gas	2.2	3.8	3.8	5.0	6.3	7.0	8.4	3.5
Coal	0.6	0.7	0.8	1.4	1.6	1.8	2.0	4.1
Nuclear	0.1	0.2	0.2	0.2	0.4	0.3	0.4	2.4
Other	3.9	5.4	5.7	6.8	7.1	7.4	7.6	1.3
Total	**14.5**	**21.2**	**21.2**	**28.1**	**32.4**	**35.7**	**39.6**	**2.8**
Total Emerging								
Oil	36.1	58.1	59.2	87.5	103.1	117.6	133.4	3.6
Natural Gas	10.8	21.9	23.3	32.9	42.1	50.9	63.1	4.4
Coal	32.4	45.6	47.1	73.0	85.8	97.8	106.9	3.6
Nuclear	1.1	2.2	2.3	4.2	5.4	6.3	7.0	5.0
Other	8.0	11.5	12.4	17.5	18.8	20.5	22.5	2.6
Total	**88.4**	**139.2**	**144.3**	**215.3**	**255.2**	**293.0**	**333.0**	**3.7**
Total World								
Oil	136.0	158.0	159.4	201.3	224.5	246.2	270.0	2.3
Natural Gas	75.0	92.2	95.2	120.5	142.5	159.5	180.2	2.8
Coal	90.5	96.3	98.1	129.3	143.0	157.9	172.3	2.5
Nuclear	20.3	26.4	26.9	30.1	31.6	32.9	34.1	1.0
Other	26.4	31.1	32.1	40.5	43.3	47.2	51.6	2.1
Total	**348.2**	**403.9**	**411.5**	**521.7**	**585.0**	**643.7**	**708.1**	**2.4**

Notes: 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 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table B3. World Gross Domestic Product (GDP) by Region, High Economic Growth Case, 1990-2025
(Billion 2000 Dollars)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**8,478**	**11,774**	**11,997**	**16,311**	**19,353**	**22,784**	**26,977**	**3.6**
United States[a]	7,113	9,891	10,075	13,740	16,260	19,089	22,570	3.6
Canada	684	929	961	1,255	1,459	1,654	1,856	2.9
Mexico	681	955	962	1,316	1,635	2,041	2,550	4.3
Western Europe	**7,246**	**9,314**	**9,416**	**11,456**	**13,001**	**14,717**	**16,602**	**2.5**
Mature Market Asia	**3,258**	**3,891**	**3,904**	**4,865**	**5,436**	**6,005**	**6,573**	**2.3**
Japan	2,840	3,294	3,284	4,057	4,500	4,925	5,331	2.1
Australia/New Zealand	419	597	621	808	935	1,080	1,242	3.1
Total Mature Market	**18,982**	**24,980**	**25,317**	**32,632**	**37,790**	**43,507**	**50,152**	**3.0**
Transitional Economies								
Former Soviet Union	3,306	2,274	2,392	4,205	5,459	6,997	8,881	5.9
Russia	2,241	1,583	1,657	2,712	3,357	4,143	5,074	5.0
Other FSU	1,065	691	735	1,493	2,102	2,854	3,807	7.4
Eastern Europe	**914**	**1,040**	**1,068**	**1,632**	**2,074**	**2,613**	**3,268**	**5.0**
Total Transitional	**4,220**	**3,314**	**3,460**	**5,837**	**7,533**	**9,610**	**12,149**	**5.6**
Emerging Economies								
Emerging Asia	**6,108**	**12,456**	**13,196**	**22,841**	**30,905**	**41,069**	**53,951**	**6.3**
China	1,807	5,087	5,494	10,313	14,327	19,372	25,834	7.0
India	1,684	3,021	3,160	5,357	7,221	9,698	12,928	6.3
South Korea	335	619	662	1,054	1,344	1,623	1,929	4.8
Other Asia	2,282	3,728	3,880	6,118	8,014	10,375	13,260	5.5
Middle East	**945**	**1,365**	**1,431**	**2,256**	**2,884**	**3,646**	**4,575**	**5.2**
Africa	**1,075**	**1,387**	**1,434**	**2,184**	**2,757**	**3,445**	**4,277**	**4.9**
Central and South America	**1,744**	**2,400**	**2,388**	**3,393**	**4,317**	**5,483**	**6,966**	**4.8**
Brazil	1,022	1,344	1,370	1,911	2,423	3,069	3,889	4.6
Other Central/South America	722	1,056	1,018	1,482	1,894	2,414	3,077	4.9
Total Emerging	**9,871**	**17,608**	**18,449**	**30,674**	**40,863**	**53,643**	**69,770**	**6.0**
Total World	**33,073**	**45,901**	**47,227**	**69,144**	**86,186**	**106,760**	**132,071**	**4.6**

[a]Includes the 50 States and the District of Columbia.

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

Sources: A. Heston, R. Summers, and B. Aten, "Penn World Table Version 6.1" (Center for International Comparisons at the University of Pennsylvania, October 2002), web site http://pwt.econ.upenn.edu/php_site/pwt_index.php; Global Insight, Inc., *World Overview, First Quarter 2005* (Lexington, MA, March 2005); and Energy Information Administration, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/.

Table B4. World Oil Consumption by Region, High Economic Growth Case, 1990-2025
(Million Barrels per Day)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**20.5**	**23.7**	**23.8**	**28.5**	**31.1**	**33.5**	**36.0**	**1.8**
United States[a]	17.0	19.6	19.7	23.8	25.8	27.9	30.0	1.8
Canada	1.7	2.0	2.1	2.4	2.6	2.7	2.8	1.2
Mexico	1.8	2.0	2.0	2.3	2.6	2.9	3.2	2.1
Western Europe	**12.5**	**14.0**	**13.8**	**14.4**	**14.8**	**15.2**	**15.9**	**0.6**
Mature Market Asia	**6.1**	**6.4**	**6.3**	**6.6**	**6.9**	**7.0**	**7.1**	**0.5**
Japan	5.3	5.4	5.3	5.4	5.5	5.6	5.6	0.2
Australia/New Zealand	0.8	1.0	1.0	1.2	1.3	1.4	1.6	1.9
Total Mature Market	**39.1**	**44.1**	**43.9**	**49.5**	**52.8**	**55.7**	**59.0**	**1.3**
Transitional Economies								
Former Soviet Union	**8.4**	**4.3**	**4.1**	**4.9**	**5.3**	**5.7**	**6.2**	**1.8**
Russia	5.4	2.7	2.6	3.1	3.3	3.6	3.9	1.8
Other FSU	3.0	1.6	1.5	1.8	2.0	2.1	2.3	1.8
Eastern Europe	**1.7**	**1.4**	**1.4**	**1.7**	**1.9**	**2.1**	**2.4**	**2.3**
Total Transitional	**10.0**	**5.7**	**5.5**	**6.6**	**7.2**	**7.9**	**8.6**	**1.9**
Emerging Economies								
Emerging Asia	**7.7**	**14.7**	**15.1**	**23.8**	**28.4**	**33.1**	**38.3**	**4.1**
China	2.3	4.9	5.2	9.6	11.4	13.5	16.1	5.1
India	1.2	2.2	2.2	3.2	3.9	4.6	5.4	4.0
South Korea	1.0	2.1	2.2	2.7	3.0	3.2	3.4	1.9
Other Asia	3.1	5.5	5.6	8.4	10.1	11.7	13.4	3.9
Middle East	**3.8**	**5.5**	**5.7**	**7.6**	**8.7**	**9.6**	**10.5**	**2.7**
Africa	**2.1**	**2.6**	**2.7**	**3.9**	**4.6**	**5.1**	**5.5**	**3.2**
Central and South America	**3.8**	**5.4**	**5.2**	**7.2**	**8.4**	**9.3**	**10.4**	**3.0**
Brazil	1.5	2.2	2.2	2.7	3.0	3.5	4.1	2.8
Other Central/South America	2.3	3.2	3.1	4.5	5.4	5.8	6.3	3.2
Total Emerging	**17.3**	**28.2**	**28.7**	**42.5**	**50.0**	**57.0**	**64.7**	**3.6**
Total World	**66.5**	**78.0**	**78.2**	**98.6**	**110.0**	**120.6**	**132.3**	**2.3**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table B5. World Natural Gas Consumption by Region, High Economic Growth Case, 1990-2025
(Trillion Cubic Feet)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**22.5**	**26.6**	**27.4**	**32.1**	**36.6**	**38.6**	**39.9**	**1.6**
United States[a]	19.2	22.2	23.0	26.3	29.8	31.2	31.7	1.4
Canada	2.4	2.9	3.0	4.0	4.5	4.7	4.9	2.2
Mexico	0.9	1.4	1.5	1.9	2.3	2.7	3.2	3.4
Western Europe	**10.1**	**14.9**	**15.0**	**17.8**	**19.8**	**21.9**	**24.5**	**2.2**
Mature Market Asia	**2.6**	**3.8**	**3.8**	**4.4**	**5.2**	**5.5**	**5.9**	**1.9**
Japan	1.9	2.7	2.7	3.2	3.6	4.0	4.2	2.0
Australia/New Zealand	0.8	1.1	1.1	1.2	1.6	1.5	1.6	1.7
Total Mature Market	**35.2**	**45.2**	**46.2**	**54.4**	**61.5**	**66.0**	**70.2**	**1.8**
Transitional Economies								
Former Soviet Union	**25.0**	**20.8**	**21.3**	**26.9**	**31.5**	**34.4**	**37.6**	**2.5**
Russia	17.3	14.4	14.6	17.1	19.4	21.6	23.4	2.1
Other FSU	7.7	6.4	6.8	9.9	12.1	12.8	14.2	3.3
Eastern Europe	**3.1**	**2.7**	**2.6**	**4.2**	**5.1**	**5.8**	**6.7**	**4.2**
Total Transitional	**28.1**	**23.5**	**23.9**	**31.2**	**36.6**	**40.2**	**44.2**	**2.7**
Emerging Economies								
Emerging Asia	**3.0**	**7.2**	**7.8**	**11.7**	**15.7**	**19.8**	**25.5**	**5.3**
China	0.5	1.1	1.2	3.1	4.5	5.8	9.0	9.3
India	0.4	0.9	0.9	1.4	2.0	2.8	3.3	5.9
South Korea	0.1	0.7	0.8	1.2	1.5	1.8	2.1	4.2
Other Asia	2.0	4.6	4.9	5.9	7.7	9.5	11.1	3.6
Middle East	**3.7**	**7.6**	**8.3**	**11.2**	**13.6**	**16.0**	**18.8**	**3.6**
Africa	**1.4**	**2.3**	**2.4**	**3.4**	**4.4**	**5.4**	**6.9**	**4.6**
Central and South America	**2.0**	**3.5**	**3.6**	**4.6**	**5.8**	**6.5**	**7.8**	**3.5**
Brazil	0.1	0.4	0.5	0.9	1.4	1.7	2.2	7.0
Other Central/South America	1.9	3.1	3.1	3.8	4.4	4.8	5.6	2.6
Total Emerging	**10.1**	**20.6**	**22.0**	**30.9**	**39.5**	**47.7**	**59.0**	**4.4**
Total World	**73.4**	**89.3**	**92.2**	**116.5**	**137.6**	**153.9**	**173.4**	**2.8**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table B6. World Coal Consumption by Region, High Economic Growth Case, 1990-2025
(Million Short Tons)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**972**	**1,144**	**1,152**	**1,347**	**1,403**	**1,524**	**1,756**	**1.8**
United States[a]	904	1,060	1,066	1,246	1,297	1,405	1,617	1.8
Canada	59	70	72	79	81	94	113	2.0
Mexico	9	15	14	22	24	25	26	2.7
Western Europe	**894**	**572**	**573**	**546**	**518**	**491**	**468**	**-0.9**
Mature Market Asia	**233**	**326**	**341**	**380**	**378**	**404**	**424**	**1.0**
Japan	126	173	179	186	184	183	188	0.2
Australia/New Zealand	106	153	162	194	195	220	236	1.6
Total Mature Market	**2,099**	**2,042**	**2,067**	**2,273**	**2,299**	**2,418**	**2,648**	**1.1**
Transitional Economies								
Former Soviet Union	**848**	**396**	**397**	**460**	**479**	**493**	**510**	**1.1**
Russia	462	242	229	289	304	306	306	1.3
Other FSU	386	154	168	171	175	188	204	0.9
Eastern Europe	**524**	**384**	**374**	**389**	**397**	**405**	**417**	**0.5**
Total Transitional	**1,372**	**779**	**771**	**850**	**876**	**898**	**928**	**0.8**
Emerging Economies								
Emerging Asia	**1,555**	**2,033**	**2,118**	**3,339**	**3,954**	**4,519**	**4,974**	**3.8**
China	1,124	1,357	1,422	2,402	2,876	3,325	3,636	4.2
India	256	414	421	566	647	714	805	2.9
South Korea	49	75	80	110	136	160	183	3.7
Other Asia	127	188	196	261	295	321	350	2.6
Middle East	**66**	**98**	**84**	**119**	**123**	**125**	**126**	**1.8**
Africa	**152**	**188**	**186**	**234**	**260**	**288**	**291**	**2.0**
Central and South America	**27**	**34**	**36**	**65**	**71**	**84**	**90**	**4.1**
Brazil	17	22	22	40	43	53	61	4.5
Other Central/South America	10	12	14	26	28	30	29	3.3
Total Emerging	**1,799**	**2,353**	**2,424**	**3,757**	**4,407**	**5,017**	**5,481**	**3.6**
Total World	**5,270**	**5,174**	**5,262**	**6,880**	**7,582**	**8,333**	**9,057**	**2.4**

[a]Includes the 50 States and the District of Columbia.

Notes: Totals may not equal sum of components due to independent rounding. 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 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table B7. World Nuclear Energy Consumption by Region, High Economic Growth Case, 1990-2025
(Billion Kilowatthours)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**649**	**850**	**860**	**937**	**953**	**957**	**952**	**0.4**
United States[a]	577	769	780	813	826	830	830	0.3
Canada	69	73	71	114	117	117	112	2.0
Mexico	3	8	9	10	10	10	10	0.2
Western Europe	**703**	**870**	**876**	**864**	**854**	**802**	**752**	**-0.7**
Mature Market Asia	**192**	**303**	**295**	**319**	**330**	**351**	**380**	**1.1**
Japan	192	303	295	319	330	351	380	1.1
Australia/New Zealand	0	0	0	0	0	0	0	—
Total Mature Market	**1,544**	**2,024**	**2,032**	**2,120**	**2,136**	**2,110**	**2,083**	**0.1**
Transitional Economies								
Former Soviet Union	**201**	**210**	**224**	**275**	**279**	**332**	**399**	**2.5**
Russia	115	125	134	151	153	173	218	2.1
Other FSU	86	85	90	124	125	160	181	3.1
Eastern Europe	**54**	**72**	**79**	**89**	**98**	**105**	**113**	**1.6**
Total Transitional	**256**	**282**	**302**	**364**	**376**	**437**	**512**	**2.3**
Emerging Economies								
Emerging Asia	**88**	**178**	**194**	**367**	**464**	**551**	**620**	**5.2**
China	0	17	23	72	137	162	200	9.8
India	6	18	18	67	89	123	132	9.1
South Korea	50	107	113	169	179	185	196	2.4
Other Asia	32	36	40	60	59	81	93	3.8
Middle East	**0**	**0**	**0**	**6**	**6**	**6**	**6**	**—**
Africa	**8**	**11**	**12**	**13**	**14**	**15**	**15**	**0.9**
Central and South America	**9**	**21**	**19**	**20**	**35**	**33**	**34**	**2.5**
Brazil	2	14	14	14	23	23	24	2.3
Other Central/South America	7	7	5	6	11	10	10	2.9
Total Emerging	**105**	**209**	**225**	**406**	**519**	**605**	**675**	**4.9**
Total World	**1,905**	**2,515**	**2,560**	**2,890**	**3,032**	**3,152**	**3,270**	**1.1**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table B8. World Consumption of Hydroelectricity and Other Renewable Energy by Region, High Economic Growth Case, 1990-2025
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**9.5**	**9.0**	**9.5**	**11.5**	**12.4**	**13.6**	**15.0**	**2.0**
United States[a]	6.0	5.2	5.9	7.0	7.5	8.1	8.9	1.8
Canada	3.1	3.4	3.3	3.9	4.3	4.9	5.4	2.2
Mexico	0.3	0.4	0.4	0.6	0.6	0.7	0.7	3.2
Western Europe	**4.5**	**6.0**	**5.5**	**6.3**	**6.6**	**7.2**	**7.9**	**1.6**
Mature Market Asia	**1.6**	**1.5**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.0**
Japan	1.1	1.0	1.1	1.3	1.5	1.6	1.9	2.4
Australia/New Zealand	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.8
Total Mature Market	**15.6**	**16.5**	**16.6**	**19.6**	**21.0**	**23.1**	**25.4**	**1.9**
Transitional Economies								
Former Soviet Union	**2.4**	**2.5**	**2.5**	**2.7**	**2.7**	**2.7**	**2.7**	**0.4**
Russia	1.8	1.8	1.9	2.1	2.2	2.2	2.2	0.7
Other FSU	0.6	0.7	0.6	0.6	0.6	0.6	0.6	-0.6
Eastern Europe	**0.4**	**0.6**	**0.6**	**0.7**	**0.8**	**0.9**	**1.0**	**1.9**
Total Transitional	**2.8**	**3.0**	**3.1**	**3.4**	**3.5**	**3.6**	**3.7**	**0.7**
Emerging Economies								
Emerging Asia	**3.2**	**4.9**	**5.4**	**8.8**	**9.5**	**10.7**	**12.4**	**3.7**
China	1.3	2.6	3.1	5.2	5.7	6.2	6.7	3.4
India	0.7	0.8	0.7	1.3	1.4	1.6	2.0	4.4
South Korea	0.0	0.0	0.0	0.1	0.1	0.1	0.1	4.6
Other Asia	1.1	1.4	1.5	2.2	2.4	2.8	3.6	3.9
Middle East	**0.4**	**0.4**	**0.5**	**1.0**	**1.1**	**1.1**	**1.1**	**3.3**
Africa	**0.6**	**0.8**	**0.8**	**1.0**	**1.2**	**1.3**	**1.4**	**2.4**
Central and South America	**3.9**	**5.4**	**5.7**	**6.8**	**7.1**	**7.4**	**7.6**	**1.3**
Brazil	2.2	2.8	3.0	3.3	3.5	3.8	4.1	1.3
Other Central/South America	1.7	2.6	2.7	3.4	3.6	3.6	3.5	1.3
Total Emerging	**8.0**	**11.5**	**12.4**	**17.5**	**18.8**	**20.5**	**22.5**	**2.6**
Total World	**26.4**	**31.1**	**32.1**	**40.5**	**43.3**	**47.2**	**51.6**	**2.1**

[a]Includes the 50 States and the District of Columbia.

Notes: Totals may not equal sum of components due to independent rounding. U.S. totals include net electricity imports, methanol, and liquid hydrogen.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table B9. World Net Electricity Consumption by Region, High Economic Growth Case, 1990-2025
(Billion Kilowatthours)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**3,369**	**4,247**	**4,328**	**5,314**	**5,906**	**6,500**	**7,172**	**2.2**
United States[a]	2,827	3,554	3,651	4,364	4,803	5,254	5,785	2.0
Canada	435	508	487	666	750	831	907	2.7
Mexico	107	185	190	285	353	416	479	4.1
Western Europe	**2,069**	**2,551**	**2,556**	**2,676**	**2,858**	**3,076**	**3,366**	**1.2**
Mature Market Asia	**930**	**1,136**	**1,202**	**1,307**	**1,417**	**1,518**	**1,622**	**1.3**
Japan	765	910	971	1,026	1,103	1,171	1,237	1.1
Australia/New Zealand	166	226	231	281	314	347	385	2.2
Total Mature Market	**6,368**	**7,934**	**8,086**	**9,297**	**10,181**	**11,095**	**12,159**	**1.8**
Transitional Economies								
Former Soviet Union	**1,488**	**1,131**	**1,154**	**1,904**	**2,246**	**2,542**	**2,788**	**3.9**
Russia	955	769	780	1,043	1,188	1,323	1,469	2.8
Other FSU	533	363	374	861	1,058	1,219	1,319	5.6
Eastern Europe	**418**	**389**	**390**	**566**	**652**	**733**	**820**	**3.3**
Total Transitional	**1,906**	**1,520**	**1,544**	**2,469**	**2,899**	**3,275**	**3,609**	**3.8**
Emerging Economies								
Emerging Asia	**1,259**	**2,711**	**2,914**	**5,152**	**6,304**	**7,443**	**8,588**	**4.8**
China	551	1,302	1,457	2,938	3,589	4,222	4,833	5.4
India	257	509	510	807	1,028	1,259	1,504	4.8
South Korea	93	247	267	400	473	539	605	3.6
Other Asia	358	653	680	1,006	1,213	1,423	1,646	3.9
Middle East	**263**	**547**	**574**	**907**	**1,080**	**1,231**	**1,375**	**3.9**
Africa	**286**	**410**	**422**	**661**	**829**	**983**	**1,143**	**4.4**
Central and South America	**463**	**715**	**735**	**1,134**	**1,456**	**1,704**	**1,997**	**4.4**
Brazil	229	338	352	457	563	697	864	4.0
Other Central/South America	234	377	383	677	893	1,007	1,133	4.8
Total Emerging	**2,272**	**4,383**	**4,645**	**7,852**	**9,669**	**11,361**	**13,102**	**4.6**
Total World	**10,546**	**13,836**	**14,275**	**19,619**	**22,749**	**25,731**	**28,870**	**3.1**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table B10. World Carbon Dioxide Emissions by Region, High Economic Growth Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**5,769**	**6,624**	**6,701**	**7,925**	**8,579**	**9,236**	**10,062**	**1.8**
United States[a]	4,989	5,692	5,751	6,783	7,308	7,856	8,561	1.7
Canada	473	573	588	700	761	809	866	1.7
Mexico	308	359	363	442	510	572	635	2.5
Western Europe	**3,413**	**3,585**	**3,549**	**3,862**	**3,952**	**4,007**	**4,152**	**0.7**
Mature Market Asia	**1,284**	**1,610**	**1,627**	**1,768**	**1,836**	**1,910**	**1,983**	**0.9**
Japan	990	1,182	1,179	1,236	1,270	1,294	1,319	0.5
Australia/New Zealand	294	429	448	532	566	616	663	1.7
Total Mature Market	**10,465**	**11,819**	**11,877**	**13,555**	**14,367**	**15,153**	**16,197**	**1.4**
Transitional Economies								
Former Soviet Union	**3,798**	**2,393**	**2,399**	**2,924**	**3,253**	**3,494**	**3,758**	**2.0**
Russia	2,347	1,553	1,522	1,830	2,012	2,166	2,304	1.8
Other FSU	1,452	840	877	1,094	1,241	1,328	1,454	2.2
Eastern Europe	**1,095**	**744**	**726**	**868**	**950**	**1,029**	**1,119**	**1.9**
Total Transitional	**4,894**	**3,137**	**3,124**	**3,793**	**4,203**	**4,523**	**4,876**	**2.0**
Emerging Economies								
Emerging Asia	**3,890**	**5,967**	**6,205**	**9,754**	**11,689**	**13,554**	**15,389**	**4.0**
China	2,262	3,176	3,322	5,796	6,982	8,145	9,238	4.5
India	583	1,009	1,025	1,424	1,679	1,927	2,209	3.4
South Korea	234	431	451	576	675	761	846	2.8
Other Asia	811	1,351	1,407	1,958	2,353	2,721	3,095	3.5
Middle East	**845**	**1,311**	**1,361**	**1,846**	**2,132**	**2,392**	**2,674**	**3.0**
Africa	**655**	**840**	**854**	**1,163**	**1,368**	**1,548**	**1,701**	**3.0**
Central and South America	**711**	**998**	**988**	**1,370**	**1,610**	**1,806**	**2,042**	**3.2**
Brazil	250	343	342	459	539	637	758	3.5
Other Central/South America	461	655	646	910	1,071	1,168	1,284	3.0
Total Emerging	**6,101**	**9,116**	**9,408**	**14,132**	**16,799**	**19,299**	**21,806**	**3.7**
Total World	**21,460**	**24,072**	**24,409**	**31,480**	**35,369**	**38,976**	**42,879**	**2.5**

[a]Includes the 50 States and the District of Columbia.

Note: The U.S. numbers include carbon dioxide emissions attributable to renewable energy sources.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table B11. World Carbon Dioxide Emissions from Oil Use by Region, High Economic Growth Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**2,639**	**2,983**	**2,987**	**3,594**	**3,912**	**4,221**	**4,530**	**1.8**
United States[a]	2,178	2,458	2,457	2,975	3,225	3,490	3,755	1.9
Canada	222	268	274	317	345	353	363	1.2
Mexico	239	258	256	302	342	379	412	2.1
Western Europe	**1,739**	**1,933**	**1,911**	**1,987**	**2,055**	**2,106**	**2,195**	**0.6**
Mature Market Asia	**768**	**808**	**796**	**838**	**867**	**888**	**905**	**0.6**
Japan	655	668	657	670	684	691	692	0.2
Australia/New Zealand	113	140	139	168	183	197	213	1.9
Total Mature Market	**5,145**	**5,724**	**5,695**	**6,420**	**6,835**	**7,215**	**7,630**	**1.3**
Transitional Economies								
Former Soviet Union	**1,224**	**607**	**581**	**698**	**749**	**811**	**876**	**1.8**
Russia	783	378	356	428	459	497	537	1.8
Other FSU	441	229	225	270	290	314	339	1.8
Eastern Europe	**243**	**197**	**192**	**232**	**263**	**293**	**325**	**2.3**
Total Transitional	**1,468**	**803**	**773**	**931**	**1,012**	**1,104**	**1,200**	**1.9**
Emerging Economies								
Emerging Asia	**1,116**	**1,886**	**1,940**	**3,062**	**3,659**	**4,266**	**4,947**	**4.2**
China	345	638	669	1,242	1,485	1,754	2,086	5.1
India	165	278	279	406	496	591	692	4.0
South Korea	138	236	241	296	328	351	371	1.9
Other Asia	468	733	751	1,118	1,349	1,571	1,798	3.9
Middle East	**568**	**781**	**804**	**1,083**	**1,232**	**1,357**	**1,484**	**2.7**
Africa	**304**	**369**	**377**	**547**	**644**	**716**	**781**	**3.2**
Central and South America	**541**	**729**	**712**	**972**	**1,136**	**1,266**	**1,414**	**3.0**
Brazil	210	281	275	338	384	446	522	2.8
Other Central/South America	330	448	437	634	752	820	892	3.2
Total Emerging	**2,529**	**3,764**	**3,834**	**5,664**	**6,670**	**7,605**	**8,626**	**3.6**
Total World	**9,142**	**10,292**	**10,302**	**13,015**	**14,517**	**15,924**	**17,457**	**2.3**

[a]Includes the 50 States and the District of Columbia.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table B12. World Carbon Dioxide Emissions from Natural Gas Use by Region, High Economic Growth Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**1,207**	**1,423**	**1,446**	**1,735**	**1,976**	**2,087**	**2,153**	**1.7**
United States[a]	1,026	1,189	1,203	1,415	1,604	1,680	1,709	1.5
Canada	127	157	160	215	243	255	264	2.2
Mexico	54	77	83	104	128	151	180	3.4
Western Europe	**514**	**803**	**812**	**964**	**1,068**	**1,183**	**1,325**	**2.2**
Mature Market Asia	**133**	**209**	**209**	**245**	**287**	**303**	**324**	**1.9**
Japan	89	150	147	176	201	219	232	2.0
Australia/New Zealand	44	59	62	70	87	84	92	1.7
Total Mature Market	**1,854**	**2,436**	**2,467**	**2,944**	**3,331**	**3,572**	**3,801**	**1.9**
Transitional Economies								
Former Soviet Union	**1,352**	**1,119**	**1,147**	**1,447**	**1,694**	**1,849**	**2,018**	**2.5**
Russia	928	768	776	909	1,036	1,149	1,245	2.1
Other FSU	424	351	371	538	658	700	773	3.2
Eastern Europe	**167**	**139**	**136**	**222**	**265**	**306**	**351**	**4.2**
Total Transitional	**1,519**	**1,258**	**1,283**	**1,670**	**1,959**	**2,155**	**2,369**	**2.7**
Emerging Economies								
Emerging Asia	**167**	**402**	**434**	**648**	**871**	**1,103**	**1,437**	**5.3**
China	31	66	71	193	275	353	549	9.3
India	24	46	48	78	109	150	182	5.9
South Korea	6	44	48	58	72	88	106	3.5
Other Asia	106	246	267	320	416	512	600	3.6
Middle East	**205**	**421**	**457**	**621**	**754**	**886**	**1,040**	**3.6**
Africa	**80**	**130**	**139**	**191**	**252**	**308**	**390**	**4.6**
Central and South America	**116**	**202**	**203**	**265**	**331**	**370**	**445**	**3.5**
Brazil	6	22	26	48	75	93	122	7.0
Other Central/South America	110	181	177	217	255	277	323	2.6
Total Emerging	**569**	**1,156**	**1,232**	**1,725**	**2,208**	**2,667**	**3,312**	**4.4**
Total World	**3,942**	**4,849**	**4,982**	**6,338**	**7,499**	**8,395**	**9,483**	**2.8**

[a]Includes the 50 States and the District of Columbia.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table B13. World Carbon Dioxide Emissions from Coal Use by Region, High Economic Growth Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**1,923**	**2,214**	**2,247**	**2,576**	**2,670**	**2,907**	**3,357**	**1.8**
United States[a]	1,784	2,042	2,070	2,372	2,458	2,664	3,075	1.7
Canada	123	148	154	168	173	201	240	2.0
Mexico	15	24	23	36	40	42	43	2.7
Western Europe	**1,160**	**849**	**825**	**786**	**745**	**706**	**673**	**-0.9**
Mature Market Asia	**383**	**593**	**622**	**685**	**681**	**719**	**754**	**0.8**
Japan	245	364	375	391	385	384	395	0.2
Australia/New Zealand	138	229	247	294	296	335	359	1.6
Total Mature Market	**3,465**	**3,656**	**3,694**	**4,047**	**4,096**	**4,332**	**4,784**	**1.1**
Transitional Economies								
Former Soviet Union	**1,222**	**667**	**671**	**779**	**810**	**834**	**863**	**1.1**
Russia	635	408	390	492	517	521	521	1.3
Other FSU	587	260	281	286	292	314	342	0.9
Eastern Europe	**685**	**409**	**397**	**414**	**422**	**430**	**443**	**0.5**
Total Transitional	**1,907**	**1,076**	**1,068**	**1,192**	**1,232**	**1,264**	**1,306**	**0.9**
Emerging Economies								
Emerging Asia	**2,607**	**3,679**	**3,831**	**6,044**	**7,159**	**8,184**	**9,005**	**3.8**
China	1,886	2,472	2,582	4,362	5,222	6,038	6,604	4.2
India	394	684	698	939	1,073	1,186	1,335	2.9
South Korea	90	152	161	222	275	323	369	3.7
Other Asia	237	371	389	519	588	638	697	2.6
Middle East	**72**	**110**	**100**	**142**	**146**	**149**	**150**	**1.8**
Africa	**271**	**340**	**338**	**425**	**472**	**525**	**530**	**2.0**
Central and South America	**54**	**66**	**73**	**133**	**143**	**170**	**183**	**4.1**
Brazil	34	40	41	73	80	98	113	4.5
Other Central/South America	20	26	32	60	64	71	70	3.4
Total Emerging	**3,003**	**4,196**	**4,342**	**6,743**	**7,921**	**9,028**	**9,868**	**3.6**
Total World	**8,375**	**8,928**	**9,105**	**11,983**	**13,248**	**14,624**	**15,958**	**2.5**

[a]Includes the 50 States and the District of Columbia.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), high economic growth case, AEO2005 National Energy Modeling System, run HM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Appendix C

Low Economic Growth Case Projections:

- **World Energy Consumption**
- **Gross Domestic Product**
- **Carbon Dioxide Emissions**

Table C1. World Total Primary Energy Consumption by Region, Low Economic Growth Case, 1990-2025
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**100.9**	**115.2**	**117.7**	**131.7**	**139.1**	**146.3**	**152.8**	**1.1**
United States[a]	84.6	96.3	98.0	108.6	114.0	119.7	124.9	1.1
Canada	11.1	12.8	13.1	15.3	16.4	17.1	17.6	1.3
Mexico	5.1	6.1	6.6	7.8	8.7	9.5	10.3	1.9
Western Europe	**59.9**	**68.0**	**67.4**	**69.0**	**70.2**	**70.6**	**72.2**	**0.3**
Mature Market Asia	**22.7**	**28.0**	**28.4**	**29.8**	**30.5**	**31.0**	**31.5**	**0.5**
Japan	18.3	21.9	22.0	22.5	22.8	23.0	23.2	0.2
Australia/New Zealand	4.5	6.1	6.5	7.3	7.7	8.0	8.3	1.1
Total Mature Market	**183.6**	**211.2**	**213.5**	**230.5**	**239.8**	**247.9**	**256.5**	**0.8**
Transitional Economies								
Former Soviet Union	**60.9**	**42.0**	**42.4**	**47.8**	**50.7**	**52.8**	**55.6**	**1.2**
Russia	39.1	27.7	27.5	30.3	31.8	33.1	34.6	1.0
Other FSU	21.8	14.3	14.9	17.5	18.9	19.7	21.0	1.5
Eastern Europe	**15.3**	**11.4**	**11.2**	**12.8**	**13.6**	**14.3**	**15.0**	**1.3**
Total Transitional	**76.2**	**53.4**	**53.6**	**60.7**	**64.4**	**67.1**	**70.6**	**1.2**
Emerging Economies								
Emerging Asia	**51.5**	**84.7**	**88.4**	**127.8**	**144.2**	**158.4**	**172.8**	**3.0**
China	27.0	40.9	43.2	69.7	79.6	87.7	96.2	3.5
India	8.0	13.8	14.0	18.9	21.5	24.0	26.4	2.8
South Korea	3.8	8.0	8.4	10.3	11.1	11.5	11.9	1.5
Other Asia	12.7	21.9	22.9	28.9	32.0	35.2	38.3	2.3
Middle East	**13.1**	**20.9**	**22.0**	**27.2**	**29.7**	**31.9**	**34.0**	**1.9**
Africa	**9.3**	**12.5**	**12.7**	**16.1**	**18.1**	**19.6**	**21.1**	**2.2**
Central and South America	**14.5**	**21.2**	**21.2**	**25.3**	**27.8**	**29.3**	**31.1**	**1.7**
Brazil	5.8	8.4	8.6	9.5	10.4	11.4	12.7	1.7
Other Central/South America	8.8	12.7	12.6	15.8	17.3	17.8	18.4	1.7
Total Emerging	**88.4**	**139.2**	**144.3**	**196.3**	**219.8**	**239.3**	**259.0**	**2.6**
Total World	**348.2**	**403.9**	**411.5**	**487.5**	**523.9**	**554.2**	**586.1**	**1.5**

[a]Includes the 50 States and the District of Columbia.

Notes: 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 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table C2. World Total Energy Consumption by Region and Fuel, Low Economic Growth Case, 1990-2025
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America								
Oil	40.6	46.2	47.1	53.0	56.3	59.2	61.7	1.2
Natural Gas	23.2	27.3	28.2	31.1	33.8	36.2	37.5	1.2
Coal	20.7	23.8	23.9	26.8	27.5	28.5	30.6	1.1
Nuclear	6.9	8.9	9.0	9.8	9.9	10.0	9.9	0.4
Other	9.5	9.0	9.5	11.0	11.5	12.3	13.1	1.4
Total	**100.9**	**115.2**	**117.7**	**131.7**	**139.1**	**146.3**	**152.8**	**1.1**
Western Europe								
Oil	25.9	28.9	28.6	28.4	28.7	28.6	29.2	0.1
Natural Gas	9.7	15.2	15.4	17.4	18.9	20.0	21.6	1.5
Coal	12.4	8.7	8.6	8.2	7.7	7.3	6.9	-1.0
Nuclear	7.4	9.1	9.2	9.0	8.9	8.4	7.8	-0.7
Other	4.5	6.0	5.5	6.0	6.0	6.4	6.7	0.8
Total	**59.9**	**68.0**	**67.4**	**69.0**	**70.2**	**70.6**	**72.2**	**0.3**
Mature Market Asia								
Oil	12.4	13.0	13.1	13.1	13.3	13.2	13.2	0.1
Natural Gas	2.5	4.0	4.0	4.3	4.7	5.0	5.2	1.2
Coal	4.2	6.5	6.8	7.4	7.3	7.3	7.2	0.2
Nuclear	2.0	3.1	3.0	3.3	3.4	3.7	4.0	1.2
Other	1.6	1.5	1.6	1.7	1.7	1.8	2.0	1.0
Total	**22.7**	**28.0**	**28.4**	**29.8**	**30.5**	**31.0**	**31.5**	**0.5**
Total Mature Market								
Oil	79.0	88.0	88.8	94.6	98.2	101.1	104.2	0.7
Natural Gas	35.4	46.5	47.5	52.7	57.5	61.2	64.2	1.3
Coal	37.3	39.0	39.4	42.3	42.5	43.1	44.7	0.5
Nuclear	16.3	21.1	21.2	22.1	22.3	22.0	21.7	0.1
Other	15.6	16.5	16.6	18.7	19.3	20.5	21.7	1.2
Total	**183.6**	**211.2**	**213.5**	**230.5**	**239.8**	**247.9**	**256.5**	**0.8**
Transitional Economies								
Oil	21.0	11.9	11.4	12.5	12.9	13.4	13.9	0.9
Natural Gas	28.8	23.8	24.3	28.5	31.5	33.0	35.1	1.6
Coal	20.7	11.7	11.6	12.5	12.6	12.7	12.8	0.4
Nuclear	2.9	3.1	3.3	3.8	3.9	4.6	5.3	2.1
Other	2.8	3.0	3.1	3.4	3.4	3.4	3.5	0.5
Total	**76.2**	**53.4**	**53.6**	**60.7**	**64.4**	**67.1**	**70.6**	**1.2**
Emerging Economies								
Emerging Asia								
Oil	16.1	30.4	31.4	44.6	50.2	55.2	60.6	2.9
Natural Gas	3.2	7.6	8.2	10.5	12.2	14.2	17.1	3.2
Coal	28.1	39.9	41.5	60.7	68.4	74.3	78.9	2.8
Nuclear	0.9	1.8	2.0	3.8	4.8	5.7	6.5	5.3
Other	3.2	4.9	5.4	8.1	8.6	9.0	9.6	2.6
Total	**51.5**	**84.7**	**88.4**	**127.8**	**144.2**	**158.4**	**172.8**	**3.0**

See notes at end of table.

Table C2. World Total Energy Consumption by Region and Fuel, Low Economic Growth Case, 1990-2025 (Continued)
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Emerging Economies (Continued)								
Middle East								
Oil	8.0	11.3	11.7	14.1	15.0	15.6	16.2	1.4
Natural Gas	3.9	8.0	8.6	10.6	12.2	13.8	15.3	2.5
Coal	0.8	1.2	1.1	1.4	1.4	1.4	1.4	1.1
Nuclear	0.0	0.0	0.0	0.1	0.1	0.1	0.1	—
Other	0.4	0.4	0.5	1.0	1.0	1.1	1.1	3.2
Total	**13.1**	**20.9**	**22.0**	**27.2**	**29.7**	**31.9**	**34.0**	**1.9**
Africa								
Oil	4.2	5.4	5.5	7.3	8.1	8.6	9.0	2.2
Natural Gas	1.5	2.5	2.6	3.1	4.0	4.8	5.7	3.4
Coal	3.0	3.7	3.7	4.6	4.8	4.9	4.9	1.2
Nuclear	0.1	0.1	0.1	0.1	0.2	0.2	0.2	1.0
Other	0.6	0.8	0.8	1.0	1.1	1.2	1.3	2.1
Total	**9.3**	**12.5**	**12.8**	**16.1**	**18.1**	**19.6**	**21.1**	**2.2**
Central and South America								
Oil	7.7	11.0	10.7	12.8	14.0	14.9	15.9	1.7
Natural Gas	2.2	3.8	3.8	4.8	5.6	6.3	7.1	2.7
Coal	0.6	0.7	0.8	1.0	1.0	1.1	1.1	1.5
Nuclear	0.1	0.2	0.2	0.2	0.4	0.3	0.4	2.4
Other	3.9	5.4	5.7	6.5	6.7	6.7	6.7	0.7
Total	**14.5**	**21.2**	**21.2**	**25.3**	**27.8**	**29.3**	**31.1**	**1.7**
Total Emerging								
Oil	36.1	58.1	59.2	78.8	87.3	94.3	101.7	2.4
Natural Gas	10.8	21.9	23.3	29.1	34.0	39.0	45.1	2.9
Coal	32.4	45.6	47.1	67.6	75.7	81.6	86.3	2.7
Nuclear	1.1	2.2	2.3	4.2	5.4	6.3	7.0	5.0
Other	8.0	11.5	12.4	16.6	17.4	18.0	18.7	1.8
Total	**88.4**	**139.2**	**144.3**	**196.3**	**219.8**	**239.3**	**259.0**	**2.6**
Total World								
Oil	136.0	158.0	159.4	185.9	198.4	208.8	219.8	1.4
Natural Gas	75.0	92.2	95.2	110.4	123.0	133.2	144.5	1.8
Coal	90.5	96.3	98.1	122.4	130.8	137.4	143.8	1.7
Nuclear	20.3	26.4	26.9	30.1	31.6	32.9	34.1	1.0
Other	26.4	31.1	32.1	38.7	40.1	41.9	43.9	1.4
Total	**348.2**	**403.9**	**411.5**	**487.5**	**523.9**	**554.2**	**586.1**	**1.5**

Notes: 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 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table C3. World Gross Domestic Product (GDP) by Region, Low Economic Growth Case, 1990-2025
(Billion 2000 Dollars)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**8,478**	**11,774**	**11,997**	**15,036**	**17,099**	**19,324**	**21,567**	**2.6**
United States[a]	7,113	9,891	10,075	12,640	14,336	16,163	17,957	2.5
Canada	684	929	961	1,169	1,300	1,408	1,509	2.0
Mexico	681	955	962	1,228	1,463	1,753	2,102	3.5
Western Europe	**7,246**	**9,314**	**9,416**	**10,639**	**11,537**	**12,478**	**13,446**	**1.6**
Mature Market Asia	**3,258**	**3,891**	**3,904**	**4,520**	**4,822**	**5,084**	**5,309**	**1.3**
Japan	2,840	3,294	3,284	3,768	3,990	4,165	4,298	1.2
Australia/New Zealand	419	597	621	752	832	920	1,011	2.1
Total Mature Market	**18,982**	**24,980**	**25,317**	**30,196**	**33,458**	**36,885**	**40,322**	**2.0**
Transitional Economies								
Former Soviet Union	**3,306**	**2,274**	**2,392**	**3,465**	**3,963**	**4,466**	**4,978**	**3.2**
Russia	2,241	1,583	1,657	2,298	2,550	2,819	3,091	2.7
Other FSU	1,065	691	735	1,167	1,413	1,647	1,887	4.2
Eastern Europe	**914**	**1,040**	**1,068**	**1,426**	**1,667**	**1,930**	**2,217**	**3.2**
Total Transitional	**4,220**	**3,314**	**3,460**	**4,891**	**5,630**	**6,397**	**7,196**	**3.2**
Emerging Economies								
Emerging Asia	**6,108**	**12,456**	**13,196**	**20,134**	**25,191**	**30,911**	**37,462**	**4.6**
China	1,807	5,087	5,494	9,137	11,762	14,704	18,108	5.3
India	1,684	3,021	3,160	4,714	5,873	7,289	8,973	4.6
South Korea	335	619	662	924	1,084	1,199	1,303	3.0
Other Asia	2,282	3,728	3,880	5,358	6,472	7,719	9,078	3.8
Middle East	**945**	**1,365**	**1,431**	**1,975**	**2,324**	**2,701**	**3,114**	**3.4**
Africa	**1,075**	**1,387**	**1,434**	**1,909**	**2,214**	**2,541**	**2,896**	**3.1**
Central and South America	**1,744**	**2,400**	**2,388**	**2,951**	**3,454**	**4,034**	**4,714**	**3.0**
Brazil	1,022	1,344	1,370	1,660	1,936	2,254	2,626	2.9
Other Central/South America	722	1,056	1,018	1,291	1,518	1,781	2,088	3.2
Total Emerging	**9,871**	**17,608**	**18,449**	**26,969**	**33,183**	**40,188**	**48,186**	**4.3**
Total World	**33,073**	**45,901**	**47,227**	**62,056**	**72,271**	**83,469**	**95,703**	**3.1**

[a]Includes the 50 States and the District of Columbia.

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

Sources: A. Heston, R. Summers, and B. Aten, "Penn World Table Version 6.1" (Center for International Comparisons at the University of Pennsylvania, October 2002), web site http://pwt.econ.upenn.edu/php_site/pwt_index.php; Global Insight, Inc., *World Overview, First Quarter 2005* (Lexington, MA, March 2005); and Energy Information Administration, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/.

Table C4. World Oil Consumption by Region, Low Economic Growth Case, 1990-2025
(Million Barrels per Day)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**20.5**	**23.7**	**23.8**	**26.7**	**28.4**	**29.8**	**31.1**	**1.2**
United States[a]	17.0	19.6	19.7	22.2	23.5	24.8	25.9	1.2
Canada	1.7	2.0	2.1	2.3	2.4	2.5	2.5	0.7
Mexico	1.8	2.0	2.0	2.2	2.4	2.6	2.8	1.5
Western Europe	**12.5**	**14.0**	**13.8**	**13.7**	**13.8**	**13.8**	**14.1**	**0.1**
Mature Market Asia	**6.1**	**6.4**	**6.3**	**6.4**	**6.4**	**6.4**	**6.4**	**0.1**
Japan	5.3	5.4	5.3	5.2	5.2	5.1	5.0	-0.2
Australia/New Zealand	0.8	1.0	1.0	1.2	1.2	1.3	1.4	1.3
Total Mature Market	**39.1**	**44.1**	**43.9**	**46.8**	**48.6**	**50.1**	**51.6**	**0.7**
Transitional Economies								
Former Soviet Union	**8.4**	**4.3**	**4.1**	**4.5**	**4.6**	**4.7**	**4.9**	**0.7**
Russia	5.4	2.7	2.6	2.8	2.9	3.0	3.1	0.7
Other FSU	3.0	1.6	1.5	1.7	1.7	1.8	1.8	0.7
Eastern Europe	**1.7**	**1.4**	**1.4**	**1.6**	**1.7**	**1.8**	**1.8**	**1.2**
Total Transitional	**10.0**	**5.7**	**5.5**	**6.1**	**6.3**	**6.5**	**6.7**	**0.9**
Emerging Economies								
Emerging Asia	**7.7**	**14.7**	**15.1**	**21.5**	**24.2**	**26.7**	**29.3**	**2.9**
China	2.3	4.9	5.2	8.8	9.9	11.1	12.5	3.9
India	1.2	2.2	2.2	2.9	3.4	3.9	4.3	3.0
South Korea	1.0	2.1	2.2	2.4	2.6	2.6	2.6	0.7
Other Asia	3.1	5.5	5.6	7.4	8.3	9.1	9.8	2.5
Middle East	**3.8**	**5.5**	**5.7**	**6.9**	**7.3**	**7.6**	**7.9**	**1.4**
Africa	**2.1**	**2.6**	**2.7**	**3.6**	**4.0**	**4.2**	**4.4**	**2.2**
Central and South America	**3.8**	**5.4**	**5.2**	**6.3**	**6.9**	**7.3**	**7.8**	**1.7**
Brazil	1.5	2.2	2.2	2.3	2.5	2.7	3.1	1.5
Other Central/South America	2.3	3.2	3.1	3.9	4.4	4.6	4.7	1.9
Total Emerging	**17.3**	**28.2**	**28.7**	**38.2**	**42.3**	**45.8**	**49.4**	**2.4**
Total World	**66.5**	**78.0**	**78.2**	**91.1**	**97.2**	**102.3**	**107.7**	**1.4**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table C5. World Natural Gas Consumption by Region, Low Economic Growth Case, 1990-2025
(Trillion Cubic Feet)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**22.5**	**26.6**	**27.4**	**30.3**	**32.9**	**35.2**	**36.5**	**1.2**
United States[a]	19.2	22.2	23.0	24.7	26.7	28.4	29.3	1.1
Canada	2.4	2.9	3.0	3.8	4.2	4.4	4.4	1.8
Mexico	0.9	1.4	1.5	1.8	2.1	2.4	2.8	2.7
Western Europe	**10.1**	**14.9**	**15.0**	**17.0**	**18.4**	**19.5**	**21.0**	**1.5**
Mature Market Asia	**2.6**	**3.8**	**3.8**	**4.1**	**4.5**	**4.8**	**4.9**	**1.2**
Japan	1.9	2.7	2.7	2.9	3.2	3.3	3.4	1.0
Australia/New Zealand	0.8	1.1	1.1	1.1	1.3	1.4	1.6	1.5
Total Mature Market	**35.2**	**45.2**	**46.2**	**51.3**	**55.9**	**59.5**	**62.5**	**1.3**
Transitional Economies								
Former Soviet Union	**25.0**	**20.8**	**21.3**	**24.4**	**26.9**	**28.0**	**29.7**	**1.5**
Russia	17.3	14.4	14.6	15.4	16.6	17.6	18.5	1.0
Other FSU	7.7	6.4	6.8	8.9	10.3	10.5	11.2	2.2
Eastern Europe	**3.1**	**2.7**	**2.6**	**3.7**	**4.1**	**4.5**	**4.9**	**2.8**
Total Transitional	**28.1**	**23.5**	**23.9**	**28.1**	**31.0**	**32.5**	**34.6**	**1.6**
Emerging Economies								
Emerging Asia	**3.0**	**7.2**	**7.8**	**9.9**	**11.4**	**13.3**	**16.0**	**3.2**
China	0.5	1.1	1.2	2.0	2.6	3.0	4.0	5.6
India	0.4	0.9	0.9	1.3	1.7	2.0	2.3	4.3
South Korea	0.1	0.7	0.8	1.1	1.3	1.5	1.7	3.1
Other Asia	2.0	4.6	4.9	5.4	5.9	6.8	8.0	2.1
Middle East	**3.7**	**7.6**	**8.3**	**10.1**	**11.6**	**13.1**	**14.6**	**2.5**
Africa	**1.4**	**2.3**	**2.4**	**2.9**	**3.7**	**4.4**	**5.3**	**3.4**
Central and South America	**2.0**	**3.5**	**3.6**	**4.5**	**5.2**	**5.8**	**6.5**	**2.7**
Brazil	0.1	0.4	0.5	0.8	1.2	1.5	1.9	6.2
Other Central/South America	1.9	3.1	3.1	3.6	4.0	4.3	4.7	1.8
Total Emerging	**10.1**	**20.6**	**22.0**	**27.4**	**32.0**	**36.7**	**42.4**	**2.9**
Total World	**73.4**	**89.3**	**92.2**	**106.8**	**118.9**	**128.7**	**139.5**	**1.8**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table C6. World Coal Consumption by Region, Low Economic Growth Case, 1990-2025
(Million Short Tons)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**972**	**1,144**	**1,152**	**1,307**	**1,354**	**1,406**	**1,508**	**1.2**
United States[a]	904	1,060	1,066	1,208	1,252	1,303	1,393	1.2
Canada	59	70	72	77	78	79	91	1.0
Mexico	9	15	14	21	24	25	25	2.6
Western Europe	**894**	**572**	**573**	**543**	**513**	**484**	**457**	**-1.0**
Mature Market Asia	**233**	**326**	**341**	**371**	**368**	**368**	**364**	**0.3**
Japan	126	173	179	184	180	176	174	-0.1
Australia/New Zealand	106	153	162	187	188	192	190	0.7
Total Mature Market	**2,099**	**2,042**	**2,067**	**2,221**	**2,235**	**2,258**	**2,330**	**0.5**
Transitional Economies								
Former Soviet Union	**848**	**396**	**397**	**442**	**448**	**453**	**457**	**0.6**
Russia	462	242	229	278	284	280	274	0.8
Other FSU	386	154	168	164	164	172	183	0.4
Eastern Europe	**524**	**384**	**374**	**379**	**381**	**379**	**382**	**0.1**
Total Transitional	**1,372**	**779**	**771**	**821**	**829**	**832**	**839**	**0.4**
Emerging Economies								
Emerging Asia	**1,555**	**2,033**	**2,118**	**3,096**	**3,493**	**3,793**	**4,033**	**2.8**
China	1,124	1,357	1,422	2,234	2,543	2,782	2,959	3.2
India	256	414	421	523	574	621	672	2.1
South Korea	49	75	80	94	109	113	114	1.6
Other Asia	127	188	196	246	268	277	287	1.7
Middle East	**66**	**98**	**84**	**110**	**113**	**111**	**109**	**1.1**
Africa	**152**	**188**	**186**	**229**	**239**	**245**	**244**	**1.2**
Central and South America	**27**	**34**	**36**	**43**	**46**	**48**	**51**	**1.5**
Brazil	17	22	22	26	28	31	35	2.0
Other Central/South America	10	12	14	17	18	18	16	0.7
Total Emerging	**1,799**	**2,353**	**2,424**	**3,479**	**3,891**	**4,197**	**4,437**	**2.7**
Total World	**5,270**	**5,174**	**5,262**	**6,521**	**6,955**	**7,287**	**7,606**	**1.6**

[a]Includes the 50 States and the District of Columbia.

Notes: Totals may not equal sum of components due to independent rounding. 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 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table C7. World Nuclear Energy Consumption by Region, Low Economic Growth Case, 1990-2025
(Billion Kilowatthours)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**649**	**850**	**860**	**937**	**953**	**957**	**952**	**0.4**
United States[a]	577	769	780	813	826	830	830	0.3
Canada	69	73	71	114	117	117	112	2.0
Mexico	3	8	9	10	10	10	10	0.2
Western Europe	**703**	**870**	**876**	**864**	**854**	**802**	**752**	**-0.7**
Mature Market Asia	**192**	**303**	**295**	**319**	**330**	**351**	**380**	**1.1**
Japan	192	303	295	319	330	351	380	1.1
Australia/New Zealand	0	0	0	0	0	0	0	—
Total Mature Market	**1,544**	**2,024**	**2,032**	**2,120**	**2,136**	**2,110**	**2,083**	**0.1**
Transitional Economies								
Former Soviet Union	**201**	**210**	**224**	**275**	**279**	**332**	**399**	**2.5**
Russia	115	125	134	151	153	173	218	2.1
Other FSU	86	85	90	124	125	160	181	3.1
Eastern Europe	**54**	**72**	**79**	**89**	**98**	**105**	**113**	**1.6**
Total Transitional	**256**	**282**	**302**	**364**	**376**	**437**	**512**	**2.3**
Emerging Economies								
Emerging Asia	**88**	**178**	**194**	**367**	**464**	**551**	**620**	**5.2**
China	0	17	23	72	137	162	200	9.8
India	6	18	18	67	89	123	132	9.1
South Korea	50	107	113	169	179	185	196	2.4
Other Asia	32	36	40	60	59	81	93	3.8
Middle East	**0**	**0**	**0**	**6**	**6**	**6**	**6**	**—**
Africa	**8**	**11**	**12**	**13**	**14**	**15**	**15**	**0.9**
Central and South America	**9**	**21**	**19**	**20**	**35**	**33**	**34**	**2.5**
Brazil	2	14	14	14	23	23	24	2.3
Other Central/South America	7	7	5	6	11	10	10	2.9
Total Emerging	**105**	**209**	**225**	**406**	**519**	**605**	**675**	**4.9**
Total World	**1,905**	**2,515**	**2,560**	**2,890**	**3,032**	**3,152**	**3,270**	**1.1**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table C8. World Consumption of Hydroelectricity and Other Renewable Energy by Region, High Economic Growth Case, 1990-2025
(Quadrillion Btu)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**9.5**	**9.0**	**9.5**	**11.0**	**11.5**	**12.3**	**13.1**	**1.4**
United States[a]	6.0	5.2	5.9	6.8	6.9	7.3	7.7	1.2
Canada	3.1	3.4	3.3	3.7	4.0	4.3	4.6	1.5
Mexico	0.3	0.4	0.4	0.6	0.6	0.7	0.7	3.0
Western Europe	**4.5**	**6.0**	**5.5**	**6.0**	**6.0**	**6.4**	**6.7**	**0.8**
Mature Market Asia	**1.6**	**1.5**	**1.6**	**1.7**	**1.7**	**1.8**	**2.0**	**1.0**
Japan	1.1	1.0	1.1	1.1	1.2	1.2	1.4	1.0
Australia/New Zealand	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.8
Total Mature Market	**15.6**	**16.5**	**16.6**	**18.7**	**19.3**	**20.5**	**21.7**	**1.2**
Transitional Economies								
Former Soviet Union	**2.4**	**2.5**	**2.5**	**2.7**	**2.7**	**2.7**	**2.7**	**0.4**
Russia	1.8	1.8	1.9	2.1	2.2	2.2	2.2	0.7
Other FSU	0.6	0.7	0.6	0.6	0.6	0.6	0.6	-0.6
Eastern Europe	**0.4**	**0.6**	**0.6**	**0.6**	**0.7**	**0.7**	**0.8**	**0.8**
Total Transitional	**2.8**	**3.0**	**3.1**	**3.4**	**3.4**	**3.4**	**3.5**	**0.5**
Emerging Economies								
Emerging Asia	**3.2**	**4.9**	**5.4**	**8.1**	**8.6**	**9.0**	**9.6**	**2.6**
China	1.3	2.6	3.1	4.7	4.9	5.1	5.7	2.6
India	0.7	0.8	0.7	1.3	1.4	1.4	1.5	3.2
South Korea	0.0	0.0	0.0	0.1	0.1	0.1	0.1	4.6
Other Asia	1.1	1.4	1.5	2.0	2.2	2.4	2.4	2.1
Middle East	**0.4**	**0.4**	**0.5**	**1.0**	**1.0**	**1.1**	**1.1**	**3.2**
Africa	**0.6**	**0.8**	**0.8**	**1.0**	**1.1**	**1.2**	**1.3**	**2.1**
Central and South America	**3.9**	**5.4**	**5.7**	**6.5**	**6.7**	**6.7**	**6.7**	**0.7**
Brazil	2.2	2.8	3.0	3.2	3.3	3.4	3.6	0.7
Other Central/South America	1.7	2.6	2.7	3.3	3.4	3.3	3.1	0.7
Total Emerging	**8.0**	**11.5**	**12.4**	**16.6**	**17.4**	**18.0**	**18.7**	**1.8**
Total World	**26.4**	**31.1**	**32.1**	**38.7**	**40.1**	**41.9**	**43.9**	**1.4**

[a]Includes the 50 States and the District of Columbia.

Notes: Totals may not equal sum of components due to independent rounding. U.S. totals include net electricity imports, methanol, and liquid hydrogen.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table C9. World Net Electricity Consumption by Region, Low Economic Growth Case, 1990-2025
(Billion Kilowatthours)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**3,369**	**4,247**	**4,328**	**5,086**	**5,501**	**5,910**	**6,314**	**1.7**
United States[a]	2,827	3,554	3,651	4,193	4,502	4,821	5,147	1.5
Canada	435	508	487	624	677	723	757	1.9
Mexico	107	185	190	270	322	366	409	3.4
Western Europe	**2,069**	**2,551**	**2,556**	**2,592**	**2,712**	**2,775**	**2,916**	**0.6**
Mature Market Asia	**930**	**1,136**	**1,202**	**1,241**	**1,304**	**1,356**	**1,403**	**0.7**
Japan	765	910	971	976	1,020	1,053	1,081	0.5
Australia/New Zealand	166	226	231	265	284	302	322	1.5
Total Mature Market	**6,368**	**7,934**	**8,086**	**8,919**	**9,517**	**10,041**	**10,633**	**1.2**
Transitional Economies								
Former Soviet Union	**1,488**	**1,131**	**1,154**	**1,688**	**1,864**	**1,996**	**2,101**	**2.6**
Russia	955	769	780	1,037	1,132	1,226	1,335	2.4
Other FSU	533	363	374	650	732	769	765	3.2
Eastern Europe	**418**	**389**	**390**	**514**	**561**	**600**	**640**	**2.2**
Total Transitional	**1,906**	**1,520**	**1,544**	**2,201**	**2,425**	**2,595**	**2,741**	**2.5**
Emerging Economies								
Emerging Asia	**1,259**	**2,711**	**2,914**	**4,674**	**5,408**	**6,057**	**6,638**	**3.6**
China	551	1,302	1,457	2,667	3,081	3,440	3,747	4.2
India	257	509	510	739	897	1,048	1,194	3.8
South Korea	93	247	267	362	401	426	446	2.2
Other Asia	358	653	680	907	1,028	1,144	1,251	2.7
Middle East	**263**	**547**	**574**	**816**	**918**	**992**	**1,051**	**2.7**
Africa	**286**	**410**	**422**	**583**	**686**	**764**	**841**	**3.0**
Central and South America	**463**	**715**	**735**	**1,012**	**1,192**	**1,366**	**1,540**	**3.3**
Brazil	229	338	352	442	529	631	761	3.4
Other Central/South America	234	377	383	570	663	735	779	3.1
Total Emerging	**2,272**	**4,383**	**4,645**	**7,085**	**8,204**	**9,179**	**10,070**	**3.4**
Total World	**10,546**	**13,836**	**14,275**	**18,205**	**20,146**	**21,815**	**23,444**	**2.2**

[a]Includes the 50 States and the District of Columbia.

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

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table C10. World Carbon Dioxide Emissions by Region, Low Economic Growth Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**5,769**	**6,624**	**6,701**	**7,562**	**8,001**	**8,413**	**8,840**	**1.2**
United States[a]	4,989	5,692	5,751	6,472	6,818	7,171	7,530	1.2
Canada	473	573	588	667	711	729	755	1.1
Mexico	308	359	363	422	471	513	555	1.9
Western Europe	**3,413**	**3,585**	**3,549**	**3,590**	**3,641**	**3,658**	**3,741**	**0.2**
Mature Market Asia	**1,284**	**1,610**	**1,627**	**1,698**	**1,725**	**1,735**	**1,740**	**0.3**
Japan	990	1,182	1,179	1,189	1,195	1,185	1,173	0.0
Australia/New Zealand	294	429	448	508	531	550	566	1.0
Total Mature Market	**10,465**	**11,819**	**11,877**	**12,849**	**13,367**	**13,806**	**14,321**	**0.8**
Transitional Economies								
Former Soviet Union	**3,798**	**2,393**	**2,399**	**2,695**	**2,852**	**2,939**	**3,061**	**1.1**
Russia	2,347	1,553	1,522	1,687	1,766	1,823	1,876	0.9
Other FSU	1,452	840	877	1,008	1,086	1,116	1,184	1.3
Eastern Europe	**1,095**	**744**	**726**	**808**	**848**	**879**	**913**	**1.0**
Total Transitional	**4,894**	**3,137**	**3,124**	**3,503**	**3,701**	**3,817**	**3,974**	**1.1**
Emerging Economies								
Emerging Asia	**3,890**	**5,967**	**6,205**	**8,922**	**10,082**	**11,042**	**11,968**	**2.9**
China	2,262	3,176	3,322	5,321	6,064	6,679	7,247	3.4
India	583	1,009	1,025	1,315	1,480	1,635	1,798	2.5
South Korea	234	431	451	517	572	588	602	1.3
Other Asia	811	1,351	1,407	1,770	1,967	2,140	2,321	2.2
Middle East	**845**	**1,311**	**1,361**	**1,664**	**1,810**	**1,932**	**2,051**	**1.8**
Africa	**655**	**840**	**854**	**1,083**	**1,203**	**1,291**	**1,367**	**2.1**
Central and South America	**711**	**998**	**988**	**1,193**	**1,323**	**1,420**	**1,532**	**1.9**
Brazil	250	343	342	390	435	489	556	2.1
Other Central/South America	461	655	646	803	888	931	975	1.8
Total Emerging	**6,101**	**9,116**	**9,408**	**12,862**	**14,419**	**15,685**	**16,917**	**2.6**
Total World	**21,460**	**24,072**	**24,409**	**29,214**	**31,486**	**33,308**	**35,212**	**1.6**

[a]Includes the 50 States and the District of Columbia.

Note: The U.S. numbers include carbon dioxide emissions attributable to renewable energy sources.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table C11. World Carbon Dioxide Emissions from Oil Use by Region, Low Economic Growth Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**2,639**	**2,983**	**2,987**	**3,403**	**3,627**	**3,816**	**3,983**	**1.3**
United States[a]	2,178	2,458	2,457	2,816	2991	3,154	3,229	1.3
Canada	222	268	274	300	321	325	325	0.7
Mexico	239	258	256	287	314	338	360	1.5
Western Europe	**1,739**	**1,933**	**1,911**	**1,898**	**1,912**	**1,911**	**1,950**	**0.1**
Mature Market Asia	**768**	**808**	**796**	**803**	**811**	**810**	**812**	**0.1**
Japan	655	668	657	642	641	632	623	-0.2
Australia/New Zealand	113	140	139	161	170	178	189	1.3
Total Mature Market	**5,145**	**5,724**	**5,695**	**6,105**	**6,350**	**6,538**	**6,746**	**0.7**
Transitional Economies								
Former Soviet Union	**1,224**	**607**	**581**	**638**	**649**	**668**	**689**	**0.7**
Russia	783	378	356	392	399	410	423	0.8
Other FSU	441	229	225	246	251	258	266	0.7
Eastern Europe	**243**	**197**	**192**	**212**	**227**	**239**	**251**	**1.2**
Total Transitional	**1,468**	**803**	**773**	**850**	**876**	**907**	**940**	**0.9**
Emerging Economies								
Emerging Asia	**1,116**	**1,886**	**1,940**	**2,773**	**3,122**	**3,441**	**3,785**	**2.9**
China	345	638	669	1,138	1,287	1,441	1,626	3.9
India	165	278	279	374	435	495	555	3.0
South Korea	138	236	241	271	284	286	285	0.7
Other Asia	468	733	751	990	1,115	1,219	1,318	2.5
Middle East	**568**	**781**	**804**	**973**	**1,033**	**1,074**	**1,113**	**1.4**
Africa	**304**	**369**	**377**	**501**	**557**	**594**	**623**	**2.2**
Central and South America	**541**	**729**	**712**	**849**	**932**	**991**	**1,055**	**1.7**
Brazil	210	281	275	295	315	349	390	1.5
Other Central/South America	330	448	437	553	617	542	666	1.8
Total Emerging	**2,529**	**3,764**	**3,834**	**5,095**	**5,644**	**6,100**	**6,577**	**2.4**
Total World	**9,142**	**10,292**	**10,302**	**12,050**	**12,870**	**13,545**	**14,262**	**1.4**

[a]Includes the 50 States and the District of Columbia.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table C12. World Carbon Dioxide Emissions from Natural Gas Use by Region, Low Economic Growth Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**1,207**	**1,423**	**1,446**	**1,635**	**1,779**	**1,904**	**1,971**	**1.4**
United States[a]	1,026	1,189	1,203	1,333	1,437	1,532	1,579	1.2
Canada	127	157	160	203	224	238	238	1.8
Mexico	54	77	83	99	118	134	154	2.7
Western Europe	**514**	**803**	**812**	**939**	**1,035**	**1,109**	**1,216**	**1.8**
Mature Market Asia	**133**	**209**	**209**	**225**	**250**	**263**	**273**	**1.2**
Japan	89	150	147	161	175	183	185	1.0
Australia/New Zealand	44	59	62	64	75	80	88	1.5
Total Mature Market	**1,854**	**2,436**	**2,467**	**2,777**	**3,026**	**3,223**	**3,383**	**1.4**
Transitional Economies								
Former Soviet Union	**1,352**	**1,119**	**1,147**	**1,310**	**1,445**	**1,506**	**1,599**	**1.5**
Russia	928	768	776	823	883	936	986	1.0
Other FSU	424	351	371	487	562	570	612	2.2
Eastern Europe	**167**	**139**	**136**	**194**	**218**	**236**	**256**	**2.8**
Total Transitional	**1,519**	**1,258**	**1,283**	**1,503**	**1,662**	**1,742**	**1,855**	**1.6**
Emerging Economies								
Emerging Asia	**167**	**402**	**434**	**545**	**638**	**739**	**891**	**3.2**
China	31	66	71	126	159	187	246	5.6
India	24	46	48	73	92	109	127	4.3
South Korea	6	44	48	56	67	74	87	2.6
Other Asia	106	246	267	291	319	369	431	2.1
Middle East	**205**	**421**	**457**	**561**	**644**	**726**	**808**	**2.5**
Africa	**80**	**130**	**139**	**165**	**211**	**251**	**299**	**3.4**
Central and South America	**116**	**202**	**203**	**256**	**297**	**330**	**373**	**2.7**
Brazil	6	22	26	46	68	83	102	6.2
Other Central/South America	110	181	177	210	229	247	270	1.9
Total Emerging	**569**	**1,156**	**1,232**	**1,526**	**1,789**	**2,047**	**2,371**	**2.9**
Total World	**3,942**	**4,849**	**4,982**	**5,806**	**6,478**	**7,012**	**7,608**	**1.9**

[a]Includes the 50 States and the District of Columbia.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table C13. World Carbon Dioxide Emissions from Coal Use by Region, Low Economic Growth Case, 1990-2025
(Million Metric Tons Carbon Dioxide)

Region/Country	History			Projections				Average Annual Percent Change, 2002-2025
	1990	2001	2002	2010	2015	2020	2025	
Mature Market Economies								
North America	**1,923**	**2,214**	**2,247**	**2,504**	**2,575**	**2,672**	**2,864**	**1.1**
United States[a]	1,784	2,042	2,070	2,304	2,370	2,464	2,630	1.0
Canada	123	148	154	164	166	167	193	1.0
Mexico	15	24	23	36	39	41	41	2.6
Western Europe	**1,160**	**849**	**825**	**774**	**731**	**691**	**653**	**-1.0**
Mature Market Asia	**383**	**593**	**622**	**670**	**664**	**661**	**654**	**0.2**
Japan	245	364	375	387	378	370	365	-0.1
Australia/New Zealand	138	229	247	284	285	291	289	0.7
Total Mature Market	**3,465**	**3,656**	**3,694**	**3,948**	**3,970**	**4,024**	**4,172**	**0.5**
Transitional Economies								
Former Soviet Union	**1,222**	**667**	**671**	**748**	**758**	**765**	**773**	**0.6**
Russia	635	408	390	473	484	477	467	0.8
Other FSU	587	260	281	275	274	288	306	0.1
Eastern Europe	**685**	**409**	**397**	**402**	**404**	**403**	**406**	**0.1**
Total Transitional	**1,907**	**1,076**	**1,068**	**1,150**	**1,162**	**1,168**	**1,179**	**0.4**
Emerging Economies								
Emerging Asia	**2,607**	**3,679**	**3,831**	**5,604**	**6,322**	**6,862**	**7,292**	**2.8**
China	1,886	2,472	2,582	4,057	4,617	5,052	5,374	3.2
India	394	684	698	867	952	1,031	1,116	2.1
South Korea	90	152	161	190	220	228	231	1.6
Other Asia	237	371	389	489	533	552	572	1.7
Middle East	**72**	**110**	**100**	**131**	**134**	**132**	**129**	**1.1**
Africa	**271**	**340**	**338**	**417**	**435**	**446**	**444**	**1.2**
Central and South America	**54**	**66**	**73**	**88**	**94**	**98**	**104**	**1.5**
Brazil	34	40	41	49	52	57	64	2.0
Other Central/South America	20	26	32	40	42	41	39	0.9
Total Emerging	**3,003**	**4,196**	**4,342**	**6,240**	**6,986**	**7,538**	**7,970**	**2.7**
Total World	**8,375**	**8,928**	**9,105**	**11,338**	**12,118**	**12,731**	**13,320**	**1.7**

[a]Includes the 50 States and the District of Columbia.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), low economic growth case, AEO2005 National Energy Modeling System, run LM2005.D102004A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Appendix D

Reference Case Projections by End-Use Sector and Region

Table D1. Delivered Energy Consumption in the United States by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	1.5	1.4	1.4	1.4	1.4	-0.5
Natural Gas	5.0	5.6	5.9	6.1	6.2	0.9
Coal	0.0	0.0	0.0	0.0	0.0	-0.6
Electricity	4.3	5.0	5.4	5.8	6.2	1.6
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.4	0.4	0.4	0.4	0.4	-0.1
Total	**11.3**	**12.5**	**13.1**	**13.7**	**14.1**	**1.0**
Commercial						
Oil	0.7	0.8	0.8	0.9	0.9	0.9
Natural Gas	3.2	3.5	3.7	4.0	4.2	1.2
Coal	0.1	0.1	0.1	0.1	0.1	0.3
Electricity	4.1	5.0	5.6	6.3	7.1	2.4
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.1	0.1	0.1	0.1	0.1	0.2
Total	**8.2**	**9.5**	**10.4**	**11.3**	**12.4**	**1.8**
Industrial						
Oil	9.2	10.1	10.4	10.9	11.3	0.9
Natural Gas	8.9	9.4	9.9	10.4	10.7	0.8
Coal	2.1	2.0	1.9	1.9	1.8	-0.6
Electricity	3.3	3.8	4.0	4.2	4.4	1.3
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	1.8	2.1	2.2	2.4	2.5	1.5
Total	**25.2**	**27.4**	**28.4**	**29.8**	**30.8**	**0.9**
Transportation						
Oil	26.1	30.5	33.3	35.8	38.3	1.7
Natural Gas	0.7	0.8	0.8	1.0	1.0	1.4
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.1	0.1	0.1	0.1	0.1	2.0
Total	**26.9**	**31.4**	**34.2**	**36.8**	**39.4**	**1.7**
All End-Use Sectors						
Oil	37.5	42.8	45.9	49.0	51.9	1.4
Natural Gas	17.8	19.3	20.3	21.4	22.1	0.9
Coal	2.2	2.1	2.1	2.0	1.9	-0.5
Electricity	11.8	13.9	15.1	16.4	17.8	1.8
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	2.3	2.6	2.7	2.8	3.0	1.2
Delivered Energy	**71.6**	**80.7**	**86.1**	**91.7**	**96.8**	**1.3**
Electricity-Related Losses	26.4	29.9	31.5	33.4	35.6	1.3
Total	**98.0**	**110.6**	**117.6**	**125.1**	**132.4**	**1.3**
Electric Power						
Oil	0.9	1.2	1.2	1.2	1.3	1.6
Natural Gas	5.8	7.0	8.7	9.8	9.6	2.3
Coal	19.8	22.8	23.6	25.3	28.6	1.6
Nuclear	8.1	8.5	8.6	8.7	8.7	0.3
Renewables	3.6	4.3	4.6	4.8	5.3	1.7
Total	**38.2**	**43.7**	**46.7**	**49.8**	**53.5**	**1.5**
Total Energy Consumption						
Oil	38.4	44.0	47.1	50.2	53.2	1.4
Natural Gas	23.6	26.3	29.0	31.2	31.7	1.3
Coal	22.0	24.9	25.7	27.3	30.5	1.4
Nuclear	8.1	8.5	8.6	8.7	8.7	0.3
Renewables	5.9	6.9	7.2	7.7	8.3	1.5
Total	**98.0**	**110.6**	**117.6**	**125.1**	**132.4**	**1.3**

Sources: **2002:** Based on Energy Information Administration (EIA), *Annual Energy Review 2003*, DOE/EIA-0384(2003) (Washington, DC, September 2004). **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table D2. Delivered Energy Consumption in Canada by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.2	0.2	0.2	0.2	0.2	0.1
Natural Gas	0.5	0.6	0.6	0.5	0.6	0.1
Coal	0.0	0.0	0.0	0.0	0.0	0.2
Electricity	0.5	0.6	0.6	0.7	0.7	1.4
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**1.2**	**1.3**	**1.4**	**1.4**	**1.4**	**0.7**
Commercial						
Oil	0.4	0.4	0.5	0.5	0.5	0.6
Natural Gas	0.4	0.5	0.5	0.5	0.5	0.7
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.5	0.6	0.7	0.7	0.8	2.2
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**1.3**	**1.5**	**1.6**	**1.7**	**1.8**	**1.3**
Industrial						
Oil	1.3	1.5	1.6	1.7	1.8	1.4
Natural Gas	1.9	2.1	2.4	2.5	2.6	1.5
Coal	0.5	0.6	0.6	0.7	0.7	1.9
Electricity	0.7	1.0	1.1	1.3	1.4	2.9
Heat	0.0	0.0	0.0	0.0	0.1	1.8
Renewables	0.1	0.0	0.0	0.0	0.0	-2.5
Total	**4.5**	**5.2**	**5.8**	**6.2**	**6.6**	**1.7**
Transportation						
Oil	2.3	2.6	2.7	2.7	2.8	0.8
Natural Gas	0.0	0.0	0.0	0.0	0.0	7.8
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.0	0.0	0.0	0.0	0.0	-0.7
Total	**2.3**	**2.6**	**2.7**	**2.8**	**2.8**	**0.8**
All End-Use Sectors						
Oil	4.2	4.7	4.9	5.1	5.2	1.0
Natural Gas	2.9	3.1	3.4	3.6	3.7	1.1
Coal	0.5	0.6	0.6	0.7	0.7	1.9
Electricity	1.7	2.2	2.4	2.6	2.8	2.3
Heat	0.0	0.0	0.0	0.0	0.1	1.8
Renewables	0.1	0.0	0.1	0.1	0.1	0.2
Delivered Energy	**9.3**	**10.6**	**11.5**	**12.1**	**12.6**	**1.3**
Electricity-Related Losses	3.7	5.0	5.4	5.7	6.2	2.2
Total	**13.1**	**15.6**	**16.9**	**17.8**	**18.8**	**1.6**
Electric Power						
Oil	0.2	0.2	0.2	0.2	0.2	1.4
Natural Gas	0.1	0.9	1.0	1.2	1.1	9.1
Coal	1.2	1.2	1.2	1.2	1.6	1.1
Nuclear	0.8	1.2	1.2	1.2	1.2	1.6
Renewables	3.2	3.7	4.2	4.6	5.0	2.0
Total	**5.5**	**7.2**	**7.8**	**8.4**	**9.0**	**2.2**
Total Energy Consumption						
Oil	4.4	4.9	5.1	5.3	5.5	1.0
Natural Gas	3.0	4.0	4.4	4.8	4.8	2.0
Coal	1.7	1.8	1.9	1.9	2.3	1.4
Nuclear	0.8	1.2	1.2	1.2	1.2	1.6
Renewables	3.3	3.8	4.2	4.6	5.1	1.9
Total	**13.1**	**15.6**	**16.9**	**17.8**	**18.8**	**1.6**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D3. Delivered Energy Consumption in Mexico by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.4	0.5	0.5	0.5	0.5	0.5
Natural Gas	0.0	0.1	0.1	0.2	0.2	10.8
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.1	0.3	0.4	0.5	0.5	5.8
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.1	0.1	—
Total	**0.6**	**0.9**	**1.1**	**1.2**	**1.3**	**3.4**
Commercial						
Oil	0.1	0.2	0.2	0.2	0.2	2.6
Natural Gas	0.0	0.0	0.0	0.1	0.1	9.6
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.1	0.1	0.2	0.2	0.2	5.3
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	6.0
Total	**0.2**	**0.3**	**0.4**	**0.5**	**0.5**	**4.4**
Industrial						
Oil	0.8	0.8	0.9	1.0	1.1	1.4
Natural Gas	1.0	1.1	1.1	1.1	1.2	0.5
Coal	0.1	0.1	0.1	0.1	0.1	3.4
Electricity	0.4	0.5	0.6	0.6	0.7	2.7
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	6.4
Total	**2.3**	**2.5**	**2.7**	**2.9**	**3.2**	**1.4**
Transportation						
Oil	1.9	2.4	2.7	3.0	3.3	2.4
Natural Gas	0.0	0.0	0.0	0.0	0.0	16.0
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.0	0.0	0.0	0.0	0.0	0.8
Total	**1.9**	**2.4**	**2.8**	**3.0**	**3.3**	**2.5**
All End-Use Sectors						
Oil	3.2	3.9	4.3	4.7	5.1	2.0
Natural Gas	1.1	1.2	1.3	1.4	1.5	1.5
Coal	0.1	0.1	0.1	0.1	0.1	3.4
Electricity	0.6	0.9	1.1	1.3	1.5	4.0
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.1	0.1	0.1	13.7
Delivered Energy	**5.0**	**6.1**	**6.9**	**7.6**	**8.3**	**2.2**
Electricity-Related Losses	1.6	1.9	2.1	2.4	2.6	2.1
Total	**6.6**	**8.0**	**9.1**	**10.0**	**10.9**	**2.2**
Electric Power						
Oil	1.1	1.1	1.2	1.4	1.4	1.2
Natural Gas	0.5	0.8	1.1	1.3	1.6	5.2
Coal	0.2	0.3	0.3	0.3	0.3	2.3
Nuclear	0.1	0.1	0.1	0.1	0.1	0.3
Renewables	0.4	0.6	0.6	0.6	0.7	2.6
Total	**2.2**	**2.8**	**3.3**	**3.7**	**4.1**	**2.7**
Total Energy Consumption						
Oil	4.3	5.0	5.6	6.1	6.5	1.8
Natural Gas	1.6	1.9	2.3	2.7	3.1	3.0
Coal	0.3	0.4	0.4	0.4	0.5	2.6
Nuclear	0.1	0.1	0.1	0.1	0.1	0.3
Renewables	0.4	0.6	0.6	0.7	0.7	3.0
Total	**6.6**	**8.0**	**9.1**	**10.0**	**10.9**	**2.2**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D4. Delivered Energy Consumption in Western Europe by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	2.7	2.4	2.3	2.1	2.0	-1.3
Natural Gas	4.4	4.4	4.4	4.4	4.6	0.1
Coal	0.2	0.1	0.1	0.1	0.1	-3.3
Electricity	2.5	2.6	2.6	2.7	2.8	0.4
Heat	0.5	0.5	0.5	0.5	0.5	-0.5
Renewables	0.0	0.1	0.1	0.1	0.1	2.1
Total	**10.3**	**10.1**	**10.0**	**9.8**	**9.9**	**-0.2**
Commercial						
Oil	1.0	0.9	0.9	0.8	0.8	-0.9
Natural Gas	1.1	1.2	1.3	1.4	1.5	1.1
Coal	0.0	0.0	0.0	0.0	0.0	-0.1
Electricity	2.1	2.3	2.4	2.5	2.6	0.8
Heat	0.1	0.2	0.1	0.1	0.1	0.1
Renewables	0.0	0.0	0.0	0.0	0.0	7.7
Total	**4.4**	**4.6**	**4.7**	**4.8**	**5.0**	**0.6**
Industrial						
Oil	7.2	7.8	8.0	8.3	8.7	0.8
Natural Gas	6.2	6.8	7.3	8.0	8.7	1.5
Coal	2.1	2.3	2.2	2.1	2.1	0.0
Electricity	3.4	3.8	4.3	4.4	4.9	1.6
Heat	7.2	7.8	8.0	8.3	8.7	0.9
Renewables	0.1	0.2	0.2	0.2	0.2	2.8
Total	**26.2**	**28.7**	**30.0**	**31.3**	**33.3**	**1.1**
Transportation						
Oil	16.0	16.6	17.1	17.2	17.8	0.5
Natural Gas	0.0	0.0	0.0	0.0	0.0	1.4
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.2	0.2	0.2	0.2	0.2	-0.2
Total	**16.3**	**16.9**	**17.3**	**17.5**	**18.0**	**0.4**
All End-Use Sectors						
Oil	26.9	27.8	28.2	28.4	29.3	0.4
Natural Gas	11.8	12.4	13.1	13.8	14.7	1.0
Coal	2.3	2.5	2.4	2.2	2.1	-0.2
Electricity	8.3	8.9	9.5	9.8	10.5	1.0
Heat	0.9	0.9	0.8	0.8	0.7	-0.9
Renewables	0.2	0.3	0.3	0.3	0.3	2.8
Delivered Energy	**50.3**	**52.7**	**54.3**	**55.3**	**57.7**	**0.6**
Electricity-Related Losses	17.2	17.4	17.9	18.0	18.4	0.3
Total	**67.4**	**70.2**	**72.2**	**73.4**	**76.1**	**0.5**
Electric Power						
Oil	1.8	1.4	1.5	1.6	1.8	0.0
Natural Gas	3.6	5.3	6.4	7.1	8.2	3.6
Coal	6.4	5.8	5.4	5.1	4.8	-1.3
Nuclear	9.2	9.0	8.9	8.4	7.8	-0.7
Renewables	5.3	5.8	6.1	6.5	7.1	1.2
Total	**26.3**	**27.2**	**28.3**	**28.6**	**29.7**	**0.5**
Total Energy Consumption						
Oil	28.6	29.2	29.7	30.0	31.0	0.3
Natural Gas	15.4	17.7	19.5	20.9	22.9	1.8
Coal	8.6	8.2	7.8	7.3	6.9	-1.0
Nuclear	9.2	9.0	8.9	8.4	7.8	-0.7
Renewables	5.5	6.1	6.4	6.8	7.4	1.3
Total	**67.4**	**70.2**	**72.2**	**73.4**	**76.1**	**0.5**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D5. Delivered Energy Consumption in Japan by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.7	0.6	0.6	0.5	0.5	-1.2
Natural Gas	0.4	0.3	0.3	0.3	0.3	-0.7
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.9	1.0	1.0	1.0	1.0	0.6
Heat	0.0	0.0	0.0	0.0	0.0	-3.4
Renewables	0.0	0.0	0.0	0.0	0.0	1.8
Total	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	**-0.1**
Commercial						
Oil	1.3	1.2	1.1	1.0	0.9	-1.5
Natural Gas	0.2	0.3	0.3	0.4	0.5	3.4
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.9	1.0	1.0	1.1	1.1	0.9
Heat	0.0	0.0	0.0	0.0	0.0	4.4
Renewables	0.0	0.0	0.0	0.0	0.0	7.2
Total	**2.4**	**2.5**	**2.5**	**2.5**	**2.5**	**0.2**
Industrial						
Oil	4.1	4.2	4.3	4.5	4.5	0.5
Natural Gas	0.2	0.4	0.4	0.5	0.5	3.4
Coal	2.2	2.1	2.1	2.1	2.1	-0.2
Electricity	1.0	1.4	1.5	1.6	1.7	2.3
Heat	0.0	0.0	0.0	0.0	0.0	63.8
Renewables	0.2	0.1	0.1	0.1	0.1	-5.0
Total	**7.7**	**8.1**	**8.4**	**8.7**	**8.9**	**0.7**
Transportation						
Oil	4.2	4.3	4.4	4.4	4.4	0.2
Natural Gas	0.0	0.0	0.0	0.0	0.0	—
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.1	0.1	0.1	0.1	0.1	-0.3
Total	**4.2**	**4.4**	**4.4**	**4.4**	**4.4**	**0.2**
All End-Use Sectors						
Oil	10.2	10.3	10.4	10.3	10.3	0.1
Natural Gas	0.8	0.9	1.1	1.2	1.3	2.1
Coal	2.2	2.1	2.1	2.1	2.1	-0.2
Electricity	2.9	3.4	3.6	3.8	3.9	1.3
Heat	0.0	0.0	0.0	0.0	0.0	5.8
Renewables	0.2	0.1	0.1	0.1	0.1	-2.3
Delivered Energy	**16.3**	**16.9**	**17.3**	**17.5**	**17.8**	**0.4**
Electricity-Related Losses	5.7	6.0	6.3	6.6	7.0	0.9
Total	**22.0**	**22.9**	**23.6**	**24.1**	**24.7**	**0.5**
Electric Power						
Oil	0.8	0.6	0.7	0.7	0.7	-0.3
Natural Gas	2.0	2.2	2.5	2.6	2.6	1.3
Coal	2.0	2.2	2.1	2.1	2.0	0.1
Nuclear	3.0	3.3	3.4	3.7	4.0	1.2
Renewables	0.8	1.1	1.2	1.3	1.5	2.6
Total	**8.6**	**9.5**	**9.9**	**10.4**	**10.9**	**1.0**
Total Energy Consumption						
Oil	10.9	10.9	11.1	11.0	11.0	0.0
Natural Gas	2.8	3.2	3.5	3.8	3.9	1.5
Coal	4.2	4.3	4.2	4.2	4.1	0.0
Nuclear	3.0	3.3	3.4	3.7	4.0	1.2
Renewables	1.1	1.2	1.3	1.5	1.7	1.9
Total	**22.0**	**22.9**	**23.6**	**24.1**	**24.7**	**0.5**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D6. Delivered Energy Consumption in Australia/New Zealand by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.0	0.0	0.0	0.0	0.0	0.3
Natural Gas	0.1	0.1	0.1	0.1	0.1	0.1
Coal	0.0	0.0	0.0	0.0	0.0	-0.6
Electricity	0.2	0.2	0.3	0.3	0.3	1.2
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	0.9
Total	**0.4**	**0.4**	**0.4**	**0.4**	**0.5**	**0.8**
Commercial						
Oil	0.0	0.0	0.0	0.0	0.0	0.5
Natural Gas	0.1	0.1	0.1	0.1	0.1	0.5
Coal	0.0	0.0	0.0	0.0	0.0	0.4
Electricity	0.2	0.2	0.3	0.3	0.3	1.8
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	7.8
Total	**0.3**	**0.3**	**0.4**	**0.4**	**0.4**	**1.5**
Industrial						
Oil	0.5	0.8	0.9	1.0	1.1	3.7
Natural Gas	0.6	0.8	0.8	0.9	1.0	1.9
Coal	0.3	0.3	0.4	0.4	0.4	2.0
Electricity	0.4	0.4	0.5	0.5	0.6	2.1
Heat	0.0	0.0	0.0	0.0	0.0	-9.0
Renewables	0.0	0.0	0.0	0.0	0.0	-0.8
Total	**1.8**	**2.3**	**2.6**	**2.9**	**3.2**	**2.5**
Transportation						
Oil	1.6	1.7	1.7	1.8	1.8	0.7
Natural Gas	0.0	0.0	0.0	0.0	0.0	14.0
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.0	0.0	0.0	0.0	0.0	-1.6
Total	**1.6**	**1.7**	**1.8**	**1.8**	**1.9**	**0.8**
All End-Use Sectors						
Oil	2.1	2.5	2.7	2.8	3.0	1.6
Natural Gas	0.8	1.0	1.0	1.1	1.2	1.7
Coal	0.3	0.3	0.4	0.4	0.4	1.9
Electricity	0.8	0.9	1.0	1.1	1.2	1.8
Heat	0.0	0.0	0.0	0.0	0.0	-9.0
Renewables	0.0	0.0	0.0	0.0	0.0	1.0
Delivered Energy	**4.0**	**4.7**	**5.1**	**5.5**	**5.9**	**1.7**
Electricity-Related Losses	2.5	2.7	2.8	2.9	2.9	0.7
Total	**6.5**	**7.5**	**7.9**	**8.4**	**8.8**	**1.3**
Electric Power						
Oil	0.0	0.0	0.0	0.0	0.0	1.6
Natural Gas	0.3	0.3	0.5	0.4	0.5	1.7
Coal	2.4	2.8	2.8	3.0	3.0	1.0
Nuclear	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.5	0.5	0.5	0.6	0.6	0.8
Total	**3.2**	**3.7**	**3.8**	**4.0**	**4.1**	**1.1**
Total Energy Consumption						
Oil	2.1	2.5	2.7	2.9	3.1	1.6
Natural Gas	1.2	1.3	1.5	1.5	1.7	1.7
Coal	2.7	3.1	3.2	3.4	3.4	1.1
Nuclear	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.5	0.5	0.5	0.6	0.6	0.8
Total	**6.5**	**7.5**	**7.9**	**8.4**	**8.8**	**1.4**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D7. Delivered Energy Consumption in the Former Soviet Union by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.2	0.3	0.4	0.5	0.5	3.5
Natural Gas	3.3	3.8	4.1	4.1	4.3	1.2
Coal	0.3	0.4	0.4	0.3	0.3	0.1
Electricity	0.9	1.2	1.5	1.7	1.9	3.2
Heat	3.0	3.6	3.5	3.3	3.1	0.1
Renewables	0.0	0.0	0.0	0.0	0.0	-34.3
Total	**7.8**	**9.4**	**9.8**	**9.9**	**10.2**	**1.2**
Commercial						
Oil	0.1	0.1	0.1	0.1	0.1	1.4
Natural Gas	0.6	0.7	0.8	0.8	0.9	2.0
Coal	0.0	0.0	0.0	0.0	0.0	1.1
Electricity	0.4	0.5	0.6	0.6	0.7	1.9
Heat	0.5	0.4	0.3	0.3	0.3	-2.4
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**1.5**	**1.7**	**1.8**	**1.9**	**1.9**	**1.0**
Industrial						
Oil	3.1	3.5	3.4	3.6	3.8	0.8
Natural Gas	10.2	10.0	11.5	12.3	13.8	1.3
Coal	3.4	3.6	3.8	4.0	4.2	1.0
Electricity	2.4	4.1	4.7	5.2	5.5	3.7
Heat	1.9	2.5	2.6	2.6	2.7	1.6
Renewables	0.0	0.0	0.0	0.0	0.0	6.5
Total	**21.0**	**23.7**	**26.1**	**27.7**	**30.0**	**1.6**
Transportation						
Oil	4.2	5.0	5.4	5.7	6.0	1.6
Natural Gas	0.0	0.0	0.0	0.0	0.0	1.5
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.3	0.3	0.3	0.2	0.2	-0.6
Total	**4.5**	**5.3**	**5.6**	**5.9**	**6.3**	**1.5**
All End-Use Sectors						
Oil	7.6	8.9	9.3	9.8	10.4	1.4
Natural Gas	14.1	14.6	16.4	17.3	19.0	1.3
Coal	3.7	4.0	4.2	4.4	4.6	0.9
Electricity	4.0	6.1	7.0	7.7	8.3	3.2
Heat	5.4	6.5	6.4	6.2	6.1	0.6
Renewables	0.0	0.0	0.0	0.0	0.0	8.9
Delivered Energy	**34.8**	**40.1**	**43.3**	**45.4**	**48.4**	**1.4**
Electricity-Related Losses	7.6	9.6	10.6	11.8	12.6	2.2
Total	**42.4**	**49.7**	**53.9**	**57.2**	**61.0**	**1.6**
Electric Power						
Oil	0.9	0.9	0.9	1.0	0.9	0.4
Natural Gas	7.7	11.5	13.2	14.3	14.9	2.9
Coal	3.6	4.3	4.3	4.2	4.2	0.8
Nuclear	2.5	2.9	2.9	3.5	4.2	2.3
Renewables	2.5	2.7	2.7	2.7	2.7	0.4
Total	**17.0**	**22.2**	**24.0**	**25.6**	**27.0**	**2.0**
Total Energy Consumption						
Oil	8.5	9.8	10.2	10.8	11.4	1.3
Natural Gas	21.7	26.1	29.6	31.6	33.9	2.0
Coal	7.3	8.3	8.5	8.6	8.8	0.8
Nuclear	2.5	2.9	2.9	3.5	4.2	2.3
Renewables	2.5	2.7	2.7	2.7	2.7	0.4
Total	**42.4**	**49.7**	**53.9**	**57.2**	**61.0**	**1.6**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D8. Delivered Energy Consumption in Eastern Europe by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.1	0.1	0.1	0.1	0.1	1.2
Natural Gas	0.6	0.7	0.7	0.8	0.8	1.1
Coal	0.2	0.2	0.2	0.2	0.2	-1.0
Electricity	0.4	0.6	0.7	0.8	0.8	2.7
Heat	0.4	0.4	0.4	0.4	0.4	-0.7
Renewables	0.0	0.0	0.0	0.0	0.1	22.6
Total	**1.9**	**2.1**	**2.2**	**2.3**	**2.4**	**1.1**
Commercial						
Oil	0.1	0.1	0.1	0.1	0.1	-0.9
Natural Gas	0.2	0.3	0.3	0.3	0.3	1.3
Coal	0.0	0.1	0.0	0.0	0.0	-0.4
Electricity	0.3	0.4	0.4	0.5	0.5	2.1
Heat	0.1	0.1	0.1	0.1	0.1	-0.6
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**0.7**	**0.9**	**0.9**	**1.0**	**1.0**	**1.3**
Industrial						
Oil	1.1	1.2	1.4	1.5	1.7	1.7
Natural Gas	1.1	1.5	1.7	1.9	2.1	2.7
Coal	1.3	1.1	1.2	1.2	1.3	0.1
Electricity	0.6	0.8	0.9	1.0	1.1	3.0
Heat	0.1	0.1	0.2	0.2	0.2	1.1
Renewables	0.0	0.0	0.0	0.0	0.0	13.6
Total	**4.3**	**4.7**	**5.3**	**5.9**	**6.4**	**1.8**
Transportation						
Oil	1.4	1.7	1.9	2.0	2.2	2.0
Natural Gas	0.0	0.0	0.0	0.0	0.0	—
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.0	0.0	0.0	0.0	0.0	-1.1
Total	**1.4**	**1.8**	**1.9**	**2.1**	**2.2**	**1.9**
All End-Use Sectors						
Oil	2.7	3.1	3.5	3.8	4.1	1.8
Natural Gas	2.0	2.4	2.7	3.0	3.3	2.1
Coal	1.6	1.4	1.5	1.5	1.6	-0.1
Electricity	1.4	1.8	2.1	2.3	2.5	2.6
Heat	0.6	0.6	0.6	0.6	0.6	-0.2
Renewables	0.0	0.0	0.0	0.1	0.1	9.2
Delivered Energy	**8.3**	**9.5**	**10.4**	**11.2**	**12.1**	**1.6**
Electricity-Related Losses	2.9	3.9	4.1	4.4	4.7	2.1
Total	**11.2**	**13.3**	**14.5**	**15.6**	**16.7**	**1.7**
Electric Power						
Oil	0.2	0.2	0.2	0.3	0.3	1.2
Natural Gas	0.6	1.5	1.9	2.1	2.4	6.7
Coal	2.7	3.0	3.0	3.0	3.0	0.4
Nuclear	0.9	0.9	1.0	1.1	1.2	1.3
Renewables	0.6	0.6	0.7	0.8	0.8	1.3
Total	**5.0**	**6.3**	**6.8**	**7.3**	**7.7**	**1.9**
Total Energy Consumption						
Oil	2.9	3.4	3.7	4.0	4.3	1.7
Natural Gas	2.6	4.0	4.6	5.1	5.7	3.5
Coal	4.3	4.4	4.5	4.5	4.5	0.2
Nuclear	0.9	0.9	1.0	1.1	1.2	1.3
Renewables	0.6	0.6	0.7	0.8	0.9	1.6
Total	**11.2**	**13.3**	**14.5**	**15.6**	**16.7**	**1.7**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D9. Delivered Energy Consumption in China by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.5	0.8	1.0	1.3	1.6	5.0
Natural Gas	0.3	0.7	1.0	1.1	1.3	6.0
Coal	1.6	1.9	1.9	1.7	1.6	-0.2
Electricity	0.8	1.7	2.1	2.5	2.8	5.6
Heat	0.1	0.3	0.3	0.3	0.3	3.0
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**3.5**	**5.5**	**6.3**	**6.9**	**7.7**	**3.5**
Commercial						
Oil	0.8	1.1	1.1	1.2	1.2	2.1
Natural Gas	0.0	0.1	0.1	0.2	0.2	7.5
Coal	0.2	0.3	0.3	0.2	0.2	0.6
Electricity	0.4	0.8	1.0	1.1	1.3	5.1
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**1.4**	**2.3**	**2.6**	**2.8**	**3.0**	**3.4**
Industrial						
Oil	4.8	7.1	8.4	9.7	10.9	3.6
Natural Gas	0.8	1.0	1.2	1.4	1.6	3.3
Coal	11.0	20.0	24.1	27.6	30.6	4.6
Electricity	4.1	6.9	8.1	9.3	10.3	4.0
Heat	1.2	1.6	1.8	2.1	2.3	3.1
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**21.9**	**36.6**	**43.7**	**50.1**	**55.7**	**4.2**
Transportation						
Oil	3.8	8.0	10.1	12.1	15.2	6.2
Natural Gas	0.0	0.0	0.1	0.1	0.2	19.7
Coal	0.2	0.1	0.1	0.0	0.0	-100.0
Electricity	0.1	0.1	0.1	0.1	0.1	3.5
Total	**4.1**	**8.2**	**10.4**	**12.3**	**15.5**	**6.0**
All End-Use Sectors						
Oil	9.9	17.0	20.7	24.3	29.0	4.8
Natural Gas	1.2	1.9	2.4	2.8	3.3	4.7
Coal	13.0	22.3	26.3	29.5	32.4	4.0
Electricity	5.4	9.6	11.4	13.0	14.5	4.4
Heat	1.3	1.9	2.2	2.4	2.6	3.1
Renewables	0.0	0.0	0.1	0.1	0.1	—
Delivered Energy	**30.8**	**52.6**	**63.0**	**72.1**	**82.0**	**4.3**
Electricity-Related Losses	12.4	20.4	23.1	25.6	27.2	3.5
Total	**43.2**	**73.1**	**86.1**	**97.7**	**109.2**	**4.1**
Electric Power						
Oil	0.7	1.9	1.3	1.0	0.2	-5.2
Natural Gas	0.2	1.2	1.5	2.1	4.3	14.7
Coal	14.8	22.9	26.7	30.1	31.2	3.3
Nuclear	0.2	0.7	1.4	1.7	2.1	9.9
Renewables	3.1	5.2	5.7	6.1	6.6	3.3
Total	**19.1**	**31.9**	**36.6**	**41.0**	**44.4**	**3.7**
Total Energy Consumption						
Oil	10.6	18.9	21.9	25.3	29.2	4.5
Natural Gas	1.3	3.1	4.0	4.9	7.6	7.8
Coal	27.9	45.1	53.0	59.6	63.6	3.6
Nuclear	0.2	0.7	1.4	1.7	2.1	9.9
Renewables	3.1	5.2	5.7	6.2	6.7	3.4
Total	**43.2**	**73.1**	**86.1**	**97.7**	**109.2**	**4.1**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D10. Delivered Energy Consumption in India by End-Use Sector and Fuel, 2002-2025
(Billion Kilowatthours)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.9	1.2	1.4	1.7	2.0	3.7
Natural Gas	0.0	0.0	0.0	0.0	0.0	1.7
Coal	0.2	0.3	0.3	0.3	0.3	1.3
Electricity	0.3	0.7	1.0	1.2	1.4	6.5
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.1	—
Total	**1.5**	**2.3**	**2.8**	**3.3**	**3.9**	**4.3**
Commercial						
Oil	0.0	0.0	0.0	0.0	0.0	—
Natural Gas	0.0	0.0	0.0	0.1	0.1	—
Coal	0.1	0.3	0.4	0.3	0.3	3.1
Electricity	0.3	0.6	0.8	1.0	1.2	6.1
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**0.4**	**1.0**	**1.2**	**1.4**	**1.5**	**5.7**
Industrial						
Oil	2.0	2.3	2.6	2.9	3.3	2.1
Natural Gas	0.6	0.6	0.7	0.8	0.9	2.2
Coal	2.1	2.8	3.3	3.7	4.2	3.1
Electricity	0.9	1.2	1.4	1.7	1.9	3.3
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	3.3
Total	**5.6**	**7.0**	**8.0**	**9.1**	**10.4**	**2.7**
Transportation						
Oil	1.4	2.4	3.0	3.5	3.9	4.6
Natural Gas	0.0	0.0	0.0	0.1	0.1	—
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.0	0.1	0.1	0.1	0.1	2.0
Total	**1.4**	**2.5**	**3.1**	**3.6**	**4.1**	**4.7**
All End-Use Sectors						
Oil	4.3	6.0	7.1	8.2	9.3	3.4
Natural Gas	0.6	0.7	0.8	1.0	1.1	3.0
Coal	2.5	3.5	3.9	4.3	4.8	2.9
Electricity	1.6	2.6	3.3	3.9	4.6	4.7
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.1	23.1
Delivered Energy	**9.0**	**12.8**	**15.1**	**17.5**	**19.9**	**3.5**
Electricity-Related Losses	5.0	6.8	7.7	8.6	9.5	2.8
Total	**14.0**	**19.6**	**22.7**	**26.0**	**29.3**	**3.3**
Electric Power						
Oil	0.2	0.3	0.4	0.5	0.7	6.1
Natural Gas	0.3	0.8	1.0	1.4	1.7	7.5
Coal	5.1	6.4	7.2	7.9	8.5	2.2
Nuclear	0.2	0.7	0.9	1.3	1.4	8.4
Renewables	0.7	1.3	1.3	1.3	1.7	3.6
Total	**6.6**	**9.5**	**10.9**	**12.5**	**14.0**	**3.3**
Total Energy Consumption						
Oil	4.5	6.3	7.5	8.7	10.0	3.5
Natural Gas	0.9	1.4	1.8	2.4	2.9	5.1
Coal	7.6	9.9	11.1	12.2	13.4	2.5
Nuclear	0.2	0.7	0.9	1.3	1.4	8.4
Renewables	0.7	1.3	1.4	1.4	1.7	3.8
Total	**14.0**	**19.6**	**22.7**	**26.0**	**29.3**	**3.3**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D11. Delivered Energy Consumption in South Korea by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.2	0.2	0.2	0.1	0.1	-3.0
Natural Gas	0.3	0.4	0.4	0.5	0.5	1.7
Coal	0.0	0.0	0.0	0.0	0.0	-5.5
Electricity	0.1	0.2	0.3	0.3	0.3	3.5
Heat	0.0	0.0	0.0	0.0	0.0	-1.1
Renewables	0.0	0.0	0.0	0.0	0.0	1.7
Total	**0.7**	**0.9**	**0.9**	**0.9**	**0.9**	**1.0**
Commercial						
Oil	0.3	0.4	0.4	0.3	0.3	0.0
Natural Gas	0.1	0.1	0.2	0.2	0.2	5.5
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.3	0.4	0.5	0.5	0.5	2.6
Heat	0.0	0.0	0.0	0.0	0.0	-4.6
Renewables	0.0	0.0	0.0	0.0	0.0	9.1
Total	**0.7**	**0.9**	**1.0**	**1.0**	**1.1**	**2.1**
Industrial						
Oil	2.0	2.4	2.6	2.7	2.8	1.4
Natural Gas	0.2	0.4	0.5	0.7	0.9	7.0
Coal	0.8	0.7	0.8	0.9	0.9	0.6
Electricity	0.4	0.7	0.8	0.9	1.0	3.4
Heat	0.1	0.1	0.1	0.1	0.1	1.1
Renewables	0.0	0.0	0.0	0.0	0.0	15.3
Total	**3.5**	**4.2**	**4.8**	**5.2**	**5.6**	**2.0**
Transportation						
Oil	1.7	2.1	2.3	2.4	2.5	1.9
Natural Gas	0.0	0.0	0.0	0.0	0.0	0.4
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.0	0.0	0.0	0.0	0.0	-0.4
Total	**1.7**	**2.1**	**2.3**	**2.4**	**2.6**	**1.9**
All End-Use Sectors						
Oil	4.2	5.0	5.4	5.6	5.7	1.4
Natural Gas	0.6	0.9	1.1	1.4	1.6	4.5
Coal	0.8	0.7	0.8	0.9	0.9	0.5
Electricity	0.9	1.3	1.5	1.6	1.8	3.2
Heat	0.1	0.1	0.1	0.1	0.1	0.0
Renewables	0.0	0.0	0.0	0.0	0.0	7.2
Delivered Energy	**6.6**	**8.1**	**9.0**	**9.6**	**10.2**	**1.9**
Electricity-Related Losses	1.8	2.5	2.9	3.1	3.4	2.8
Total	**8.4**	**10.6**	**11.8**	**12.7**	**13.5**	**2.1**
Electric Power						
Oil	0.3	0.3	0.3	0.4	0.4	0.8
Natural Gas	0.3	0.4	0.4	0.4	0.5	1.7
Coal	0.9	1.4	1.8	2.0	2.2	3.8
Nuclear	1.1	1.8	1.9	1.9	2.0	2.6
Renewables	0.0	0.1	0.1	0.1	0.1	4.4
Total	**2.8**	**3.9**	**4.5**	**4.9**	**5.2**	**2.8**
Total Energy Consumption						
Oil	4.5	5.3	5.8	6.0	6.1	1.3
Natural Gas	0.9	1.3	1.6	1.8	2.1	3.7
Coal	1.8	2.1	2.6	2.9	3.1	2.5
Nuclear	1.1	1.8	1.9	1.9	2.0	2.6
Renewables	0.0	0.1	0.1	0.1	0.1	4.6
Total	**8.4**	**10.6**	**11.8**	**12.7**	**13.5**	**2.1**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D12. Delivered Energy Consumption in Other Emerging Asia by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.8	1.0	0.9	0.9	0.8	0.3
Natural Gas	0.2	0.3	0.3	0.4	0.5	3.7
Coal	0.0	0.0	0.0	0.0	0.0	-1.1
Electricity	0.6	1.0	1.1	1.3	1.4	3.4
Heat	0.0	0.0	0.0	0.0	0.0	0.4
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**1.7**	**2.3**	**2.5**	**2.6**	**2.8**	**2.2**
Commercial						
Oil	0.2	0.3	0.4	0.4	0.4	2.8
Natural Gas	0.1	0.2	0.2	0.3	0.3	3.7
Coal	0.0	0.0	0.0	0.0	0.0	0.7
Electricity	0.5	0.7	0.7	0.8	0.9	2.9
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**0.8**	**1.2**	**1.4**	**1.5**	**1.6**	**3.0**
Industrial						
Oil	3.0	4.5	5.3	6.1	6.8	3.6
Natural Gas	2.2	2.8	3.2	3.7	4.1	2.7
Coal	2.2	2.6	2.9	3.3	3.7	2.3
Electricity	1.1	1.6	1.9	2.3	2.6	4.0
Heat	0.0	0.0	0.0	0.0	0.0	0.5
Renewables	0.0	0.0	0.0	0.0	0.0	3.2
Total	**8.5**	**11.5**	**13.4**	**15.3**	**17.3**	**3.1**
Transportation						
Oil	6.2	8.6	10.1	11.5	13.0	3.3
Natural Gas	0.0	0.0	0.0	0.0	0.1	15.5
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.0	0.0	0.0	0.0	0.0	—
Total	**6.2**	**8.6**	**10.1**	**11.6**	**13.1**	**3.3**
All End-Use Sectors						
Oil	10.2	14.4	16.7	18.9	21.0	3.2
Natural Gas	2.6	3.3	3.8	4.4	5.0	3.0
Coal	2.2	2.6	3.0	3.4	3.8	2.3
Electricity	2.2	3.3	3.8	4.4	4.9	3.6
Heat	0.0	0.0	0.0	0.0	0.0	0.5
Renewables	0.0	0.0	0.0	0.0	0.0	14.7
Delivered Energy	**17.2**	**23.6**	**27.4**	**31.0**	**34.8**	**3.1**
Electricity-Related Losses	5.7	6.7	7.8	8.9	9.9	2.4
Total	**22.9**	**30.3**	**35.1**	**39.9**	**44.6**	**2.9**
Electric Power						
Oil	1.5	2.1	2.5	2.9	3.2	3.2
Natural Gas	2.5	2.2	3.1	4.0	4.7	2.8
Coal	2.0	2.8	3.0	3.0	3.0	1.9
Nuclear	0.4	0.6	0.6	0.8	1.0	4.0
Renewables	1.5	2.2	2.3	2.5	2.9	3.1
Total	**7.9**	**10.0**	**11.6**	**13.3**	**14.8**	**2.8**
Total Energy Consumption						
Oil	11.7	16.5	19.2	21.8	24.2	3.2
Natural Gas	5.1	5.6	6.9	8.4	9.7	2.9
Coal	4.2	5.4	6.0	6.4	6.8	2.1
Nuclear	0.4	0.6	0.6	0.8	1.0	4.0
Renewables	1.5	2.2	2.3	2.5	3.0	3.1
Total	**22.9**	**30.3**	**35.1**	**39.9**	**44.6**	**3.0**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D13. Delivered Energy Consumption in the Middle East by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	1.0	1.2	1.2	1.1	1.1	0.6
Natural Gas	1.0	1.2	1.3	1.4	1.4	1.5
Coal	0.1	0.1	0.1	0.1	0.1	0.6
Electricity	0.7	1.2	1.4	1.5	1.6	3.6
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.1	0.1	0.1	0.1	0.1	3.7
Total	**2.8**	**3.7**	**4.0**	**4.2**	**4.4**	**1.9**
Commercial						
Oil	0.2	0.3	0.3	0.3	0.4	3.3
Natural Gas	0.2	0.2	0.2	0.3	0.3	2.5
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.5	0.7	0.8	0.9	1.0	3.1
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	26.0
Total	**0.8**	**1.2**	**1.3**	**1.5**	**1.6**	**3.1**
Industrial						
Oil	3.9	4.7	4.9	5.2	5.3	1.4
Natural Gas	4.3	6.1	7.4	9.0	10.7	4.0
Coal	0.4	0.6	0.6	0.6	0.6	1.2
Electricity	0.8	1.1	1.2	1.4	1.5	2.8
Heat	0.0	0.0	0.0	0.0	0.0	0.0
Renewables	0.0	0.0	0.0	0.0	0.0	2.3
Total	**9.4**	**12.4**	**14.2**	**16.1**	**18.1**	**2.9**
Transportation						
Oil	4.5	5.9	6.7	7.3	7.9	2.4
Natural Gas	0.0	0.1	0.1	0.1	0.1	—
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.0	0.0	0.0	0.0	0.0	-0.8
Total	**4.5**	**6.0**	**6.8**	**7.4**	**8.0**	**2.5**
All End-Use Sectors						
Oil	9.5	12.0	13.1	13.9	14.7	1.9
Natural Gas	5.5	7.6	9.1	10.7	12.5	3.6
Coal	0.5	0.6	0.6	0.6	0.6	1.1
Electricity	2.0	2.9	3.4	3.8	4.1	3.2
Heat	0.0	0.0	0.0	0.0	0.0	0.0
Renewables	0.1	0.1	0.1	0.1	0.2	4.3
Delivered Energy	**17.6**	**23.3**	**26.3**	**29.2**	**32.1**	**2.6**
Electricity-Related Losses	4.4	5.4	6.0	6.4	6.8	1.9
Total	**22.0**	**28.7**	**32.4**	**35.6**	**38.9**	**2.5**
Electric Power						
Oil	2.1	3.0	3.5	3.8	4.1	2.9
Natural Gas	3.1	3.5	4.1	4.5	4.9	1.9
Coal	0.6	0.9	0.9	0.9	0.9	1.6
Nuclear	0.0	0.1	0.1	0.1	0.1	—
Renewables	0.5	0.9	0.9	0.9	1.0	3.1
Total	**6.4**	**8.3**	**9.4**	**10.2**	**10.9**	**2.4**
Total Energy Consumption						
Oil	11.7	15.1	16.6	17.7	18.8	2.1
Natural Gas	8.6	11.1	13.2	15.2	17.4	3.1
Coal	1.1	1.5	1.5	1.5	1.5	1.4
Nuclear	0.0	0.1	0.1	0.1	0.1	—
Renewables	0.5	1.0	1.0	1.1	1.1	3.3
Total	**22.0**	**28.7**	**32.4**	**35.6**	**38.9**	**2.5**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D14. Delivered Energy Consumption in Africa by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.5	0.6	0.6	0.5	0.5	-0.3
Natural Gas	0.3	0.7	1.0	1.2	1.5	6.8
Coal	0.2	0.1	0.1	0.1	0.1	-2.3
Electricity	0.4	0.9	1.2	1.4	1.7	6.0
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**1.4**	**2.3**	**2.8**	**3.3**	**3.8**	**4.3**
Commercial						
Oil	0.0	0.0	0.0	0.0	0.0	1.3
Natural Gas	0.0	0.0	0.0	0.1	0.1	14.3
Coal	0.0	0.0	0.0	0.0	0.0	0.7
Electricity	0.2	0.3	0.4	0.4	0.4	4.6
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**0.2**	**0.4**	**0.5**	**0.5**	**0.6**	**4.3**
Industrial						
Oil	1.5	1.9	2.1	2.3	2.5	2.3
Natural Gas	0.9	1.3	1.5	1.8	2.1	3.9
Coal	1.6	1.8	1.8	1.8	1.8	0.6
Electricity	0.8	0.9	1.0	1.1	1.2	1.8
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	-2.5
Total	**4.8**	**5.9**	**6.5**	**7.1**	**7.7**	**2.1**
Transportation						
Oil	2.9	4.2	4.9	5.4	5.7	3.1
Natural Gas	0.0	0.0	0.0	0.0	0.0	-3.8
Coal	0.0	0.0	0.0	0.0	0.0	-6.4
Electricity	0.0	0.0	0.0	0.0	0.0	0.5
Total	**2.9**	**4.2**	**5.0**	**5.4**	**5.8**	**3.1**
All End-Use Sectors						
Oil	4.9	6.7	7.6	8.3	8.8	2.6
Natural Gas	1.2	2.0	2.5	3.1	3.7	4.9
Coal	1.8	1.9	2.0	2.0	2.0	0.4
Electricity	1.4	2.1	2.6	3.0	3.3	3.8
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	-1.7
Delivered Energy	**9.3**	**12.7**	**14.7**	**16.3**	**17.8**	**2.8**
Electricity-Related Losses	3.4	4.0	4.6	5.2	5.6	2.3
Total	**12.7**	**16.7**	**19.3**	**21.4**	**23.4**	**2.7**
Electric Power						
Oil	0.6	0.9	1.0	1.2	1.3	3.7
Natural Gas	1.4	1.4	1.8	2.2	2.7	2.9
Coal	1.9	2.7	3.0	3.3	3.4	2.5
Nuclear	0.1	0.1	0.2	0.2	0.2	1.0
Renewables	0.8	1.0	1.1	1.2	1.4	2.3
Total	**4.8**	**6.1**	**7.1**	**8.1**	**8.9**	**2.7**
Total Energy Consumption						
Oil	5.5	7.6	8.7	9.5	10.1	2.7
Natural Gas	2.6	3.4	4.4	5.2	6.4	4.0
Coal	3.7	4.6	5.0	5.3	5.3	1.6
Nuclear	0.1	0.1	0.2	0.2	0.2	1.0
Renewables	0.8	1.0	1.1	1.2	1.4	2.2
Total	**12.7**	**16.7**	**19.3**	**21.4**	**23.4**	**2.7**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Table D15. Delivered Energy Consumption in Central and South America by End-Use Sector and Fuel, 2002-2025
(Quadrillion Btu)

Sector/Fuel	2002	Projections				Average Annual Percent Change, 2002-2025
		2010	2015	2020	2025	
Residential						
Oil	0.5	0.7	0.8	0.8	0.8	1.7
Natural Gas	0.4	0.5	0.6	0.7	0.8	3.2
Coal	0.0	0.0	0.0	0.0	0.0	0.5
Electricity	0.7	1.1	1.4	1.6	1.8	4.2
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	2.7
Total	**1.6**	**2.3**	**2.7**	**3.0**	**3.4**	**3.3**
Commercial						
Oil	0.1	0.2	0.2	0.2	0.2	3.4
Natural Gas	0.1	0.1	0.2	0.2	0.2	2.8
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.6	1.0	1.2	1.5	1.6	4.8
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	—
Total	**0.8**	**1.3**	**1.6**	**1.9**	**2.1**	**4.4**
Industrial						
Oil	3.6	4.2	4.7	5.2	5.6	1.9
Natural Gas	2.3	2.7	3.3	3.7	4.3	2.8
Coal	0.6	0.8	0.8	0.9	1.0	2.1
Electricity	1.1	1.5	1.8	2.2	2.7	4.1
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	-2.8
Total	**7.6**	**9.3**	**10.7**	**12.0**	**13.7**	**2.6**
Transportation						
Oil	5.3	7.3	8.3	9.0	9.8	2.7
Natural Gas	0.1	0.1	0.1	0.1	0.1	0.2
Coal	0.0	0.0	0.0	0.0	0.0	—
Electricity	0.0	0.0	0.0	0.0	0.0	1.0
Total	**5.4**	**7.4**	**8.4**	**9.1**	**9.9**	**2.7**
All End-Use Sectors						
Oil	9.6	12.4	14.0	15.2	16.5	2.4
Natural Gas	2.9	3.4	4.1	4.7	5.4	2.8
Coal	0.6	0.8	0.8	0.9	1.0	2.1
Electricity	2.3	3.7	4.5	5.3	6.2	4.3
Heat	0.0	0.0	0.0	0.0	0.0	—
Renewables	0.0	0.0	0.0	0.0	0.0	-0.5
Delivered Energy	**15.5**	**20.3**	**23.5**	**26.1**	**29.1**	**2.8**
Electricity-Related Losses	5.7	6.6	6.9	7.1	7.0	0.9
Total	**21.2**	**26.8**	**30.4**	**33.2**	**36.1**	**2.3**
Electric Power						
Oil	1.1	1.5	1.9	2.2	2.5	3.5
Natural Gas	1.0	1.6	2.0	2.3	2.7	4.6
Coal	0.2	0.3	0.3	0.3	0.3	2.5
Nuclear	0.2	0.2	0.4	0.3	0.4	2.4
Renewables	5.6	6.6	6.9	7.2	7.4	1.2
Total	**8.1**	**10.2**	**11.4**	**12.4**	**13.3**	**2.2**
Total Energy Consumption						
Oil	10.7	13.9	15.8	17.4	18.9	2.5
Natural Gas	3.8	5.0	6.1	7.0	8.1	3.3
Coal	0.8	1.1	1.2	1.2	1.3	2.2
Nuclear	0.2	0.2	0.4	0.3	0.4	2.4
Renewables	5.7	6.6	7.0	7.2	7.4	1.2
Total	**21.2**	**26.8**	**30.4**	**33.2**	**36.1**	**2.3**

Sources: **2002:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Appendix E

Projections of Oil Production Capacity and Oil Production in Three Cases:

- **Reference**
- **High World Oil Price**
- **Low World Oil Price**

Table E1. World Oil Production Capacity by Region and Country, Reference Case, 1990-2025
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	2002	2010	2015	2020	2025
OPEC						
Persian Gulf						
Iran	3.2	3.7	4.0	4.3	4.7	5.0
Iraq	2.2	2.0	3.5	4.2	5.3	6.6
Kuwait	1.7	2.1	2.9	3.5	4.5	5.2
Qatar	0.5	0.8	0.6	0.7	0.8	0.8
Saudi Arabia	8.6	9.2	14.0	14.5	15.4	16.3
United Arab Emitates	2.5	2.9	3.3	3.6	4.5	5.4
Total Persian Gulf	**18.7**	**20.7**	**28.3**	**30.8**	**35.2**	**39.3**
Other OPEC						
Algeria	1.3	1.6	2.0	2.1	2.4	2.8
Indonesia	1.5	1.3	1.5	1.5	1.5	1.5
Libya	1.5	1.6	2.0	2.2	2.5	2.9
Nigeria	1.8	2.3	2.6	3.0	3.4	3.9
Venezuela	2.4	3.1	3.5	4.1	4.7	5.6
Total Other OPEC	**8.5**	**9.9**	**11.6**	**12.9**	**14.5**	**16.7**
Total OPEC	**27.2**	**30.6**	**39.9**	**43.7**	**49.7**	**56.0**
Non-OPEC						
Mature Market Economies						
United States	9.7	9.3	9.9	9.7	9.5	9.3
Canada	2.0	2.9	3.5	4.8	4.9	5.1
Mexico	3.0	3.6	4.3	4.6	4.7	4.9
North Sea	4.0	6.3	5.8	5.4	5.1	4.5
Australia and New Zealand	0.7	0.8	1.0	0.9	0.9	0.9
Other	0.7	0.8	0.7	0.7	0.7	0.7
Total Mature Market	**20.1**	**23.7**	**25.2**	**26.1**	**25.8**	**25.4**
Transitional Economies						
Former Soviet Union	11.4	11.2	13.6	15.3	16.5	17.6
Eastern Europe	0.3	0.2	0.3	0.4	0.4	0.5
Total Transitional	**11.7**	**11.4**	**13.9**	**15.7**	**16.9**	**18.1**
Emerging Economies						
China	2.8	3.0	3.7	3.6	3.6	3.5
Other Asia	1.7	2.4	2.7	2.8	2.9	2.8
Middle East	1.4	1.9	2.3	2.5	2.6	2.8
Africa	2.1	3.1	4.0	5.1	5.8	6.8
Central and South America	2.4	3.9	4.8	5.9	6.4	6.9
Total Emerging	**10.4**	**14.3**	**17.5**	**19.9**	**21.2**	**22.7**
Total Non-OPEC	**42.2**	**49.4**	**56.6**	**61.7**	**63.9**	**66.2**
Total World	**69.4**	**80.0**	**96.5**	**105.4**	**113.6**	**122.2**

Note: OPEC = Organization of Petroleum Exporting Countries.

Sources: **History:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005); and U.S. Department of the Interior, U.S. Geological Survey, *World Petroleum Assessment 2000* (Reston, VA, July 2000).

Table E2. World Oil Production Capacity by Region and Country, High Oil Price Case, 1990-2025
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	2002	2010	2015	2020	2025
OPEC						
Persian Gulf						
Iran	3.2	3.7	4.0	4.0	4.2	4.5
Iraq	2.2	2.0	3.1	3.1	3.5	4.0
Kuwait	1.7	2.1	2.9	2.9	3.3	3.5
Qatar	0.5	0.8	0.6	0.6	0.7	0.8
Saudi Arabia	8.6	9.2	10.4	10.5	10.8	11.0
United Arab Emitates	2.5	2.9	3.4	3.4	3.7	4.0
Total Persian Gulf	**18.7**	**20.7**	**24.4**	**24.5**	**26.2**	**27.8**
Other OPEC						
Algeria	1.3	1.6	1.8	1.8	2.0	2.2
Indonesia	1.5	1.3	1.4	1.4	1.4	1.4
Libya	1.5	1.6	1.8	1.8	2.0	2.2
Nigeria	1.8	2.3	2.4	2.4	2.7	2.9
Venezuela	2.4	3.1	3.2	3.2	3.5	3.9
Total Other OPEC	**8.5**	**9.9**	**10.6**	**10.6**	**11.6**	**12.6**
Total OPEC	**27.2**	**30.6**	**35.0**	**35.1**	**37.8**	**40.4**
Non-OPEC						
Mature Market Economies						
United States	9.7	9.3	10.2	10.5	10.9	11.0
Canada	2.0	2.9	4.0	5.4	5.9	6.4
Mexico	3.0	3.6	4.5	4.9	5.1	5.3
North Sea	4.0	6.3	6.2	5.8	5.4	4.9
Australia and New Zealand	0.7	0.8	1.0	1.0	1.0	0.9
Other	0.7	0.8	0.7	0.7	0.7	0.7
Total Mature Market	**20.1**	**23.7**	**26.6**	**28.3**	**29.0**	**29.2**
Transitional Economies						
Former Soviet Union	11.4	11.2	14.1	16.6	17.8	19.6
Eastern Europe	0.3	0.2	0.4	0.4	0.4	0.5
Total Transitional	**11.7**	**11.4**	**14.5**	**17.0**	**18.2**	**20.1**
Emerging Economies						
China	2.8	3.0	3.7	3.7	3.8	3.7
Other Asia	1.7	2.4	2.9	3.1	3.0	3.0
Middle East	1.4	1.9	2.4	2.6	2.8	3.0
Africa	2.1	3.1	4.4	5.7	6.7	8.1
Central and South America	2.4	3.9	5.2	6.4	7.2	8.0
Total Emerging	**10.4**	**14.3**	**18.5**	**21.5**	**23.5**	**25.8**
Total Non-OPEC	**42.2**	**49.4**	**59.6**	**66.7**	**70.7**	**75.1**
Total World	**69.4**	**80.0**	**94.6**	**101.8**	**108.5**	**115.5**

Note: OPEC = Organization of Petroleum Exporting Countries.

Sources: **History:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005); and U.S. Department of the Interior, U.S. Geological Survey, *World Petroleum Assessment 2000* (Reston, VA, July 2000).

Table E3. World Oil Production Capacity by Region and Country, Low Oil Price Case, 1990-2025
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	2002	2010	2015	2020	2025
OPEC						
Persian Gulf						
Iran	3.2	3.7	4.8	5.6	6.2	6.9
Iraq	2.2	2.0	4.0	5.7	7.1	8.6
Kuwait	1.7	2.1	3.6	4.5	5.4	6.2
Qatar	0.5	0.8	0.8	0.8	0.8	0.9
Saudi Arabia	8.6	9.2	15.6	16.5	18.1	20.4
United Arab Emitates	2.5	2.9	4.0	4.8	6.0	7.0
Total Persian Gulf	**18.7**	**20.7**	**32.8**	**37.9**	**43.6**	**50.0**
Other OPEC						
Algeria	1.3	1.6	2.2	2.6	3.1	3.7
Indonesia	1.5	1.3	1.5	1.5	1.5	1.5
Libya	1.5	1.6	2.2	2.6	3.3	3.9
Nigeria	1.8	2.3	3.3	4.3	5.5	6.4
Venezuela	2.4	3.1	4.6	5.4	6.4	7.3
Total Other OPEC	**8.5**	**9.9**	**13.8**	**16.4**	**19.8**	**22.8**
Total OPEC	**27.2**	**30.6**	**46.6**	**54.3**	**63.4**	**72.8**
Non-OPEC						
Mature Market Economies						
United States	9.7	9.3	9.5	9.1	8.9	8.4
Canada	2.0	2.9	3.4	4.3	4.4	4.4
Mexico	3.0	3.6	4.2	4.5	4.5	4.7
North Sea	4.0	6.3	5.7	5.2	4.8	4.3
Australia and New Zealand	0.7	0.8	0.9	0.9	0.9	0.8
Other	0.7	0.8	0.7	0.7	0.7	0.7
Total Mature Market	**20.1**	**23.7**	**24.4**	**24.7**	**24.2**	**23.3**
Transitional Economies						
Former Soviet Union	11.4	11.2	13.1	14.9	15.8	16.9
Eastern Europe	0.3	0.2	0.3	0.4	0.4	0.4
Total Transitional	**11.7**	**11.4**	**13.4**	**15.3**	**16.2**	**17.3**
Emerging Economies						
China	2.8	3.0	3.6	3.4	3.4	3.3
Other Asia	1.7	2.4	2.6	2.7	2.6	2.6
Middle East	1.4	1.9	2.2	2.4	2.5	2.7
Africa	2.1	3.1	4.0	4.9	5.5	6.7
Central and South America	2.4	3.9	4.8	5.6	6.1	6.5
Total Emerging	**10.4**	**14.3**	**17.2**	**19.0**	**20.1**	**21.8**
Total Non-OPEC	**42.2**	**49.4**	**55.0**	**59.0**	**60.5**	**62.4**
Total World	**69.4**	**80.0**	**101.6**	**113.3**	**123.9**	**135.2**

Note: OPEC = Organization of Petroleum Exporting Countries.

Sources: **History:** Energy Information Administration (EIA), Energy Markets and Contingency Information Division. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005); and U.S. Department of the Interior, U.S. Geological Survey, *World Petroleum Assessment 2000* (Reston, VA, July 2000).

Table E4. World Oil Production by Region and Country, Reference Case, 1990-2025
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	2002	2010	2015	2020	2025
Conventional Production	**66.7**	**76.6**	**91.5**	**98.0**	**105.2**	**113.2**
OPEC	**24.6**	**28.3**	**37.0**	**40.0**	**45.5**	**51.4**
Asia	1.5	1.4	1.6	1.5	1.5	1.5
Middle East	16.3	19.0	25.8	27.9	32.1	36.7
North Africa	2.7	3.0	3.6	3.9	4.4	4.6
West Africa	1.8	2.0	2.5	2.7	3.1	3.6
South America	2.3	2.9	3.5	4.0	4.4	5.0
Non-OPEC	**42.1**	**48.3**	**54.5**	**58.0**	**59.7**	**61.8**
Mature Market Economies	**20.1**	**22.9**	**23.5**	**23.0**	**22.4**	**21.8**
United States	9.7	9.3	9.9	9.7	9.5	9.3
Canada	2.0	2.1	1.8	1.7	1.6	1.6
Mexico	3.0	3.6	4.3	4.6	4.7	4.9
Western Europe	4.6	6.9	6.4	6.0	5.6	5.0
Japan	0.1	0.2	0.1	0.1	0.1	0.1
Australia and New Zealand	0.7	0.8	1.0	0.9	0.9	0.9
Transitional Economies	**11.6**	**11.4**	**13.9**	**15.7**	**16.8**	**18.0**
Former Soviet Union	**11.3**	**11.2**	**13.6**	**15.3**	**16.4**	**17.5**
Russia	11.3	9.6	10.3	10.8	11.1	11.3
Caspian and Other FSU	0.0	1.6	3.3	4.5	5.3	6.2
Eastern Europe	**0.3**	**0.2**	**0.3**	**0.4**	**0.4**	**0.5**
Emerging Economies	**10.4**	**14.0**	**17.1**	**19.3**	**20.5**	**22.0**
China	2.8	3.0	3.7	3.6	3.6	3.5
Other Asia	1.7	2.4	2.7	2.8	2.8	2.7
Middle East	1.4	1.9	2.3	2.5	2.6	2.8
Africa	2.1	2.9	3.8	4.9	5.5	6.5
Central and South America	2.4	3.8	4.6	5.5	6.0	6.5
Nonconventional Production	**0.0**	**1.5**	**2.8**	**4.9**	**5.5**	**5.7**
United States	0.0	0.0	0.0	0.0	0.0	0.0
Other North America	0.0	0.8	1.7	3.1	3.3	3.5
Western Europe	0.0	0.0	0.0	0.0	0.1	0.1
Asia	0.0	0.0	0.0	0.0	0.1	0.1
Middle East	0.0	0.0	0.1	0.2	0.2	0.2
Africa	0.0	0.2	0.2	0.2	0.3	0.3
Central and South America	0.0	0.5	0.8	1.4	1.5	1.5
Liquids Production	**66.7**	**78.1**	**94.3**	**102.9**	**110.7**	**118.9**
OPEC	24.6	28.7	37.7	41.3	46.8	52.7
Non-OPEC	42.1	49.4	56.6	61.7	63.9	66.2
Persian Gulf Production as a Percentage of World Consumption	**24.5%**	**24.3%**	**27.5%**	**27.3%**	**29.2%**	**31.0%**

Notes: OPEC = Organization of Petroleum Exporting Countries. Conventional production includes crude oil (including lease condensates), natural gas liquids, other hydrogen hydrocarbons for refinery feedstocks, refinery gains, alcohol, and liquids produced from coal and other sources. Nonconventional liquids include production from oil sands, ultra-heavy oils, gas to liquids technologies, coal to liquids technologies, biofuel technologies, and shale oil. 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, System for the Analysis of Global Energy Markets (2005); and U.S. Department of the Interior, U.S. Geological Survey, *World Petroleum Assessment 2000* (Reston, VA, July 2000).

Table E5. World Oil Production by Region and Country, High Oil Price Case, 1990-2025
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	2002	2010	2015	2020	2025
Conventional Production	**66.7**	**76.6**	**88.5**	**92.6**	**97.3**	**102.4**
OPEC	**24.5**	**30.2**	**32.0**	**31.2**	**33.1**	**35.0**
Asia	1.5	1.4	1.3	1.2	1.1	1.0
Middle East	16.2	20.9	22.3	21.8	23.3	25.1
North Africa	2.7	3.0	3.1	3.0	3.2	3.1
West Africa	1.8	2.0	2.2	2.1	2.3	2.4
South America	2.3	2.9	3.1	3.1	3.2	3.4
Non-OPEC	**42.2**	**46.4**	**56.5**	**61.4**	**64.2**	**67.4**
Mature Market Economies	**20.1**	**22.9**	**24.3**	**24.1**	**23.9**	**23.2**
United States	9.7	9.3	10.1	10.1	10.1	9.8
Canada	2.0	2.1	1.9	1.7	1.7	1.7
Mexico	3.0	3.6	4.5	4.9	5.1	5.3
Western Europe	4.6	6.9	6.7	6.3	5.9	5.4
Japan	0.1	0.2	0.1	0.1	0.1	0.1
Australia and New Zealand	0.7	0.8	1.0	1.0	1.0	0.9
Transitional Economies	**11.7**	**9.5**	**14.4**	**16.9**	**18.1**	**20.0**
Former Soviet Union	**11.4**	**9.3**	**14.0**	**16.5**	**17.7**	**19.5**
Russia	11.4	7.7	10.7	11.6	12.0	12.5
Caspian and Other FSU	0.0	1.6	3.3	4.9	5.7	7.0
Eastern Europe	**0.3**	**0.2**	**0.4**	**0.4**	**0.4**	**0.5**
Emerging Economies	**10.4**	**14.0**	**17.8**	**20.4**	**22.2**	**24.2**
China	2.8	3.0	3.7	3.7	3.8	3.7
Other Asia	1.7	2.4	2.8	3.0	2.9	2.9
Middle East	1.4	1.9	2.4	2.6	2.8	3.0
Africa	2.1	2.9	4.1	5.2	6.1	7.4
Central and South America	2.4	3.8	4.8	5.9	6.6	7.2
Nonconventional Production	**0.0**	**1.5**	**4.3**	**7.1**	**8.8**	**10.5**
United States	0.0	0.0	0.1	0.4	0.8	1.2
Other North America	0.0	0.8	2.1	3.7	4.2	4.7
Western Europe	0.0	0.0	0.1	0.1	0.1	0.1
Asia	0.0	0.0	0.1	0.1	0.2	0.2
Middle East	0.0	0.0	0.2	0.3	0.4	0.6
Africa	0.0	0.2	0.3	0.5	0.6	0.7
Central and South America	0.0	0.5	1.4	2.0	2.5	3.0
Liquids Production	**66.7**	**78.1**	**92.8**	**99.7**	**106.1**	**112.9**
OPEC	24.5	30.6	33.3	33.0	35.4	37.9
Non-OPEC	42.2	47.5	59.6	66.7	70.7	75.1
Persian Gulf Production as a Percentage of World Consumption	**24.4%**	**26.7%**	**22.7%**	**20.1%**	**19.7%**	**18.4%**

Notes: OPEC = Organization of Petroleum Exporting Countries. Conventional production includes crude oil (including lease condensates), natural gas liquids, other hydrogen hydrocarbons for refinery feedstocks, refinery gains, alcohol, and liquids produced from coal and other sources. Nonconventional liquids include production from oil sands, ultra-heavy oils, gas to liquids technologies, coal to liquids technologies, biofuel technologies, and shale oil. 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, System for the Analysis of Global Energy Markets (2005); and U.S. Department of the Interior, U.S. Geological Survey, *World Petroleum Assessment 2000* (Reston, VA, July 2000).

Table E6. World Oil Production by Region and Country, Low Oil Price Case, 1990-2025
(Million Barrels per Day)

Region/Country	History (Estimates)		Projections			
	1990	2002	2010	2015	2020	2025
Conventional Production	**66.7**	**76.6**	**96.4**	**106.1**	**115.9**	**126.6**
OPEC	**24.5**	**28.3**	**43.4**	**50.3**	**58.7**	**67.6**
Asia	1.5	1.4	1.8	1.9	1.9	2.0
Middle East	16.2	19.0	30.3	35.1	41.4	48.4
North Africa	2.7	3.0	4.3	4.9	5.7	6.0
West Africa	1.8	2.0	2.9	3.4	4.0	4.7
South America	2.3	2.9	4.1	5.0	5.7	6.5
Non-OPEC	**42.2**	**48.3**	**53.0**	**55.8**	**57.2**	**59.0**
Mature Market Economies	**20.1**	**22.9**	**22.8**	**22.0**	**21.4**	**20.4**
United States	9.7	9.3	9.5	9.1	8.9	8.4
Canada	2.0	2.1	1.8	1.6	1.6	1.5
Mexico	3.0	3.6	4.2	4.5	4.5	4.7
Western Europe	4.6	6.9	6.3	5.8	5.4	4.9
Japan	0.1	0.2	0.1	0.1	0.1	0.1
Australia and New Zealand	0.7	0.8	0.9	0.9	0.9	0.8
Transitional Economies	**11.7**	**11.4**	**13.4**	**15.3**	**16.2**	**17.3**
Former Soviet Union	**11.4**	**11.2**	**13.1**	**14.9**	**15.8**	**16.9**
Russia	11.4	9.6	10.0	10.5	10.6	10.9
Caspian and Other FSU	0.0	1.6	3.1	4.4	5.2	6.0
Eastern Europe	**0.3**	**0.2**	**0.3**	**0.4**	**0.4**	**0.4**
Emerging Economies	**10.4**	**14.0**	**16.8**	**18.5**	**19.6**	**21.3**
China	2.8	3.0	3.6	3.4	3.4	3.3
Other Asia	1.7	2.4	2.6	2.7	2.6	2.6
Middle East	1.4	1.9	2.2	2.4	2.5	2.7
Africa	2.1	2.9	3.8	4.7	5.3	6.5
Central and South America	2.4	3.8	4.6	5.3	5.8	6.2
Nonconventional Production	**0.0**	**1.5**	**2.6**	**4.0**	**4.3**	**4.3**
United States	0.0	0.0	0.0	0.0	0.0	0.0
Other North America	0.0	0.8	1.6	2.7	2.8	2.9
Western Europe	0.0	0.0	0.0	0.0	0.0	0.0
Asia	0.0	0.0	0.0	0.0	0.0	0.0
Middle East	0.0	0.0	0.0	0.0	0.0	0.0
Africa	0.0	0.2	0.2	0.2	0.2	0.2
Central and South America	0.0	0.5	0.8	1.1	1.3	1.2
Liquids Production	**66.7**	**78.1**	**99.0**	**110.1**	**120.2**	**130.9**
OPEC	24.5	28.7	44.0	51.1	59.7	68.5
Non-OPEC	42.2	49.4	55.0	59.0	60.5	62.4
Persian Gulf Production as a Percentage of World Consumption	**24.4%**	**24.3%**	**30.6%**	**31.9%**	**34.5%**	**37.0%**

Notes: OPEC = Organization of Petroleum Exporting Countries. Conventional production includes crude oil (including lease condensates), natural gas liquids, other hydrogen hydrocarbons for refinery feedstocks, refinery gains, alcohol, and liquids produced from coal and other sources. Nonconventional liquids include production from oil sands, ultra-heavy oils, gas to liquids technologies, coal to liquids technologies, biofuel technologies, and shale oil. 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, System for the Analysis of Global Energy Markets (2005); and U.S. Department of the Interior, U.S. Geological Survey, *World Petroleum Assessment 2000* (Reston, VA, July 2000).

Appendix F

Projections of Nuclear Generating Capacity

- **Reference Case**
- **Strong Nuclear Power Revival Case**
- **Weak Nuclear Power Case**
- **Kyoto Protocol Case**

Table F1. World Nuclear Generating Capacity by Region and Country, Reference Case, 2002-2025
(Gigawatts)

Region/Country	2002	Projections			
		2010	2015	2020	2025
Mature Market Economies					
North America	**110.9**	**116.5**	**118.1**	**118.6**	**117.9**
United States	98.9	100.6	102.2	102.7	102.7
Canada	10.6	14.5	14.5	14.5	13.8
Mexico	1.4	1.4	1.4	1.4	1.4
Western Europe	**127.0**	**120.1**	**114.9**	**104.6**	**95.1**
Mature Market Asia	**45.9**	**47.4**	**48.5**	**51.2**	**54.8**
Japan	45.9	47.4	48.5	51.2	54.8
Australia/New Zealand	0.0	0.0	0.0	0.0	0.0
Total Mature Market	**283.8**	**284.1**	**281.5**	**274.4**	**267.8**
Transitional Economies					
Former Soviet Union	**36.5**	**39.2**	**38.2**	**44.5**	**51.8**
Russia	21.2	24.6	23.9	28.1	35.5
Other FSU	15.2	14.7	14.3	16.3	16.3
Eastern Europe	**11.7**	**12.2**	**13.2**	**14.1**	**15.1**
Total Transitional	**48.2**	**51.5**	**51.4**	**58.5**	**66.9**
Emerging Economies					
Emerging Asia	**24.3**	**49.0**	**60.1**	**70.7**	**79.7**
China	2.2	10.8	18.1	21.1	26.0
India	2.9	7.9	10.5	14.2	15.3
South Korea	13.7	22.0	23.3	24.1	25.5
Other	5.6	8.3	8.2	11.3	13.0
Middle East	**0.0**	**0.9**	**0.9**	**0.9**	**0.9**
Africa	**1.8**	**1.9**	**2.0**	**2.0**	**2.0**
Central and South America	**3.0**	**2.8**	**4.8**	**4.4**	**4.4**
Brazil	2.0	1.9	3.1	3.1	3.1
Other	1.0	0.9	1.6	1.3	1.3
Total Emerging	**29.1**	**54.6**	**67.8**	**78.1**	**87.1**
Total World	**361.2**	**390.1**	**400.7**	**411.0**	**421.8**
Nations Participating in Kyoto Protocol Annex I					
Canada	10.6	13.7	15.8	17.3	18.8
Western Europe	127.0	125.0	130.2	132.0	147.0
Japan	45.9	48.5	61.5	66.8	69.6
Eastern Europe	11.7	12.2	13.2	14.1	15.1
Former Soviet Union	36.5	38.9	38.2	42.8	50.1
Total Annex I Participants	**231.8**	**238.2**	**258.9**	**273.0**	**300.6**

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

Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table F2. World Nuclear Generating Capacity by Region and Country, Strong Nuclear Power Revival Case, 2002-2025
(Gigawatts)

Region/Country	2002	Projections			
		2010	2015	2020	2025
Mature Market Economies					
North America	**110.9**	**115.7**	**119.5**	**123.7**	**126.3**
United States	98.9	100.6	102.2	102.7	102.7
Canada	10.6	13.7	15.8	17.3	18.8
Mexico	1.4	1.4	1.4	3.7	4.9
Western Europe	**127.0**	**125.0**	**130.2**	**132.0**	**147.0**
Mature Market Asia	**45.9**	**48.5**	**61.5**	**66.8**	**69.6**
Japan	45.9	48.5	61.5	66.8	69.6
Australia/New Zealand	0.0	0.0	0.0	0.0	0.0
Total Mature Market	**283.8**	**289.2**	**311.1**	**322.5**	**343.0**
Transitional Economies					
Former Soviet Union	**36.5**	**42.0**	**49.6**	**61.7**	**72.0**
Russia	21.2	27.4	31.8	41.5	46.9
Other FSU	15.2	14.7	17.8	20.3	25.1
Eastern Europe	**11.7**	**12.0**	**15.2**	**20.6**	**30.9**
Total Transitional	**48.2**	**54.1**	**64.8**	**82.3**	**102.9**
Emerging Economies					
Emerging Asia	**24.3**	**44.9**	**63.7**	**77.2**	**100.4**
China	2.2	9.9	21.1	23.3	28.9
India	2.9	6.3	9.4	12.6	16.2
South Korea	13.7	20.6	23.3	26.0	30.1
Other	5.6	8.0	9.9	15.3	25.2
Middle East	**0.0**	**0.9**	**3.1**	**6.3**	**9.1**
Africa	**1.8**	**1.8**	**2.1**	**3.6**	**6.4**
Central and South America	**3.0**	**4.8**	**4.8**	**6.0**	**8.4**
Brazil	2.0	3.1	3.1	3.1	5.5
Other	1.0	1.6	1.6	2.8	2.8
Total Emerging	**29.1**	**52.3**	**73.7**	**93.1**	**124.3**
Total World	**361.2**	**395.6**	**449.6**	**498.0**	**570.1**
Nations Participating in Kyoto Protocol Annex I					
Canada	10.6	13.7	15.8	17.3	18.8
Western Europe	127.0	125.0	130.2	132.0	147.0
Japan	45.9	48.5	61.5	66.8	69.6
Eastern Europe	11.7	12.0	15.2	20.6	30.9
Former Soviet Union	36.5	41.7	48.3	57.7	66.7
Total Annex I Participants	**231.8**	**240.8**	**271.0**	**294.4**	**333.0**

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

Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table F3. World Nuclear Generating Capacity by Region and Country, Weak Nuclear Power Case, 2002-2025
(Gigawatts)

Region/Country	2002	Projections			
		2010	2015	2020	2025
Mature Market Economies					
North America	**110.9**	**114.2**	**114.6**	**114.9**	**111.2**
United States	98.9	100.6	102.2	102.7	102.7
Canada	10.6	12.1	11.0	10.8	7.1
Mexico	1.4	1.4	1.4	1.4	1.4
Western Europe	**127.0**	**107.1**	**94.6**	**73.2**	**45.2**
Mature Market Asia	**45.9**	**46.8**	**47.4**	**45.1**	**40.5**
Japan	45.9	46.8	47.4	45.1	40.5
Australia/New Zealand	0.0	0.0	0.0	0.0	0.0
Total Mature Market	**283.8**	**268.0**	**256.6**	**233.2**	**196.9**
Transitional Economies					
Former Soviet Union	**36.5**	**36.8**	**37.0**	**34.6**	**30.3**
Russia	21.2	23.7	23.9	21.5	18.9
Other FSU	15.2	13.1	13.1	13.1	11.4
Eastern Europe	**11.7**	**10.7**	**10.8**	**11.4**	**10.2**
Total Transitional	**48.2**	**47.5**	**47.8**	**46.0**	**40.4**
Emerging Economies					
Emerging Asia	**24.3**	**39.0**	**47.5**	**54.4**	**55.7**
China	2.2	8.6	12.8	16.8	18.5
India	2.9	5.7	6.2	7.8	10.0
South Korea	13.7	16.8	20.6	22.8	23.3
Other	5.6	7.9	7.9	7.0	3.9
Middle East	**0.0**	**0.9**	**0.9**	**0.9**	**0.9**
Africa	**1.8**	**1.8**	**1.8**	**2.0**	**0.3**
Central and South America	**3.0**	**2.8**	**2.5**	**3.1**	**2.5**
Brazil	2.0	1.9	1.9	2.5	2.5
Other	1.0	0.9	0.6	0.6	0.0
Total Emerging	**29.1**	**44.5**	**52.7**	**60.4**	**59.5**
Total World	**361.2**	**360.1**	**357.1**	**339.7**	**296.8**
Nations Participating in Kyoto Protocol Annex I					
Canada	10.6	13.7	15.8	17.3	18.8
Western Europe	127.0	125.0	130.2	132.0	147.0
Japan	45.9	48.5	61.5	66.8	69.6
Eastern Europe	11.7	10.7	10.8	11.4	10.2
Former Soviet Union	36.5	36.8	37.0	34.6	29.3
Total Annex I Participants	**231.8**	**234.6**	**255.3**	**262.2**	**274.9**

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

Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Table F4. World Nuclear Generating Capacity by Region and Country, Kyoto Protocol Case, 2002-2025
(Gigawatts)

Region/Country	2002	Projections			
		2010	2015	2020	2025
Mature Market Economies					
North America	**110.9**	**116.5**	**118.1**	**118.6**	**118.0**
United States	98.9	100.6	102.2	102.7	102.7
Canada	10.6	14.5	14.5	14.5	13.9
Mexico	1.4	1.4	1.4	1.4	1.4
Western Europe	**127.0**	**123.3**	**119.7**	**117.9**	**109.8**
Mature Market Asia	**45.9**	**47.7**	**51.5**	**61.1**	**61.1**
Japan	45.9	47.7	51.5	61.1	61.1
Australia/New Zealand	0.0	0.0	0.0	0.0	0.0
Total Mature Market	**283.8**	**287.5**	**289.3**	**297.6**	**288.9**
Transitional Economies					
Former Soviet Union	**36.5**	**40.1**	**42.8**	**50.0**	**54.9**
Russia	21.2	25.5	28.5	31.8	35.5
Other FSU	15.2	14.7	14.3	18.2	19.4
Eastern Europe	**11.7**	**12.3**	**14.3**	**16.2**	**19.8**
Total Transitional	**48.2**	**52.5**	**57.1**	**66.1**	**74.7**
Emerging Economies					
Emerging Asia	**24.3**	**49.0**	**60.1**	**70.7**	**79.7**
China	2.2	10.8	18.1	21.1	26.0
India	2.9	7.9	10.5	14.2	15.3
South Korea	13.7	22.0	23.3	24.1	25.5
Other	5.6	8.3	8.2	11.3	13.0
Middle East	**0.0**	**0.9**	**0.9**	**0.9**	**0.9**
Africa	**1.8**	**1.9**	**2.0**	**2.0**	**2.0**
Central and South America	**3.0**	**2.8**	**4.8**	**4.4**	**4.4**
Brazil	2.0	1.9	3.1	3.1	3.1
Other	1.0	0.9	1.6	1.3	1.3
Total Emerging	**29.1**	**54.6**	**67.8**	**78.1**	**87.1**
Total World	**361.2**	**394.6**	**414.2**	**441.8**	**450.7**
Nations Participating in Kyoto Protocol Annex I					
Canada	10.6	14.5	14.5	14.5	13.9
Western Europe	127.0	123.3	119.7	117.9	109.8
Japan	45.9	47.7	51.5	61.1	61.1
Eastern Europe	11.7	12.3	14.3	16.2	19.8
Former Soviet Union	36.5	39.8	42.8	48.3	53.2
Total Annex I Participants	**231.8**	**237.6**	**242.8**	**257.9**	**257.8**

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

Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383(2005) (Washington, DC, February 2005), October futures case, AEO2005 National Energy Modeling System, run CF2005.D111104A, web site www.eia.doe.gov/oiaf/aeo/; and System for the Analysis of Global Energy Markets (2005).

Appendix G

Key Assumptions for the *IEO2005* Kyoto Protocol Case

Energy-Related Emissions of Greenhouse Gases

The System for the Analysis of Global energy Markets (SAGE)—the model used by the Energy Information Administration (EIA) to prepare the *International Energy Outlook 2005* (*IEO2005*) mid-term projections—does not include non-energy-related emissions of greenhouse gases, which are estimated at about 15 to 20 percent of total greenhouse gas emissions, based on inventories submitted to the United Nations Framework Convention on Climate Change (UNFCCC). SAGE models global energy supply and demand and, therefore, does not address agricultural and other non-energy-related emissions.

EIA implicitly assumes that percentage reductions of non-energy-related emissions and their associated abatement costs will be similar to those for energy-related emissions. Non-energy-related greenhouse gas emissions are likely to grow faster than energy-related emissions; however, the marginal abatement costs for non-energy-related greenhouse gas emissions are not known and cannot be estimated reliably. In SAGE, each region's emissions reduction goal under the Kyoto Protocol is based only on the corresponding estimate of that region's energy-related carbon dioxide emissions, as determined by EIA data. It is assumed that the required reductions will also be proportionately less than if all gases were included.

Carbon Dioxide Emissions

For *IEO2005*, EIA modeled only energy-related carbon dioxide emissions. Energy-related emissions of other greenhouse gases, such as methane, nitrous oxide, and sulfur hexafluoride, are not included in the analysis. The current SAGE framework uses historical data on fuel consumption and emissions from EIA's *International Energy Annual 2002* to calibrate the base year for the model's Reference Energy System (RES). The *International Energy Annual* does not provide historical data for methane and nitrous oxide emissions, and currently there are no plans to do so in the future.

EIA assumes that emissions reduction proportions and abatement costs for energy-related methane and nitrous oxide will be sufficiently similar to those for carbon dioxide that—given their lesser share of total emissions (approximately 15 percent from energy and non-energy sources combined)—the per-unit carbon price derived by modeling carbon dioxide alone is representative of the abatement costs for all energy-related greenhouse gas emissions. The UNFCCC estimates that total Annex I emissions of greenhouse gases (in carbon dioxide equivalents) in 2002 had the following composition: energy-related carbon dioxide, 78.1 percent; non-energy-related carbon dioxide, 3.8 percent; methane, 10.0 percent; nitrous oxide, 6.4 percent; and other gases, 1.7 percent.[19]

Emissions Reduction Targets

The emissions reduction targets modeled in SAGE were derived from EIA's historical data on greenhouse gas emissions, not on UNFCCC data. Similarly, the historical values for fuel consumption used in SAGE are based on EIA data. For methodological reasons, the EIA and UNFCCC data on emissions differ; therefore, the emissions targets used for the *IEO2005* analysis differ from those used by the UNFCCC, as shown by the examples in Table G1.

Table G1. Differences Between *IEO2005* and UNFCCC Regional Emissions Reduction Targets for 2010

SAGE Region	EIA Target (Thousand Metric Tons)	UNFCCC Target (Thousand Metric Tons)	Difference	
			Thousand Metric Tons	Percent of *IEO2005* Target
Canada	444,375	396,591	47,784	10.75
Eastern Europe	1,056,157	967,862	88,295	8.36
Former Soviet Union	3,091,752	3,080,200	11,552	0.37
Japan	930,230	985,432	-55,202	-5.93
Western Europe	3,122,701	2,936,310	186,391	5.97

Sources: **EIA Target:** Derived from Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **UNFCC Target:** United Nations Framework Convention on Climate Change (UNFCCC), Greenhouse Gas Inventory Database, web site http://ghg.unfccc.int/index.html, queried for 1990 or base year "Total Fuel Combustion (Sectoral Approach)" for CO_2 for all Annex I countries.

[19]United Nations Framework Convention on Climate Change (UNFCCC), Greenhouse Gas Inventory Database, Queried for 2002 "National Totals" and "Total Fuel Combustion (Sectoral Approach)" for all GHGs for all Annex I countries except Russia, Poland, and Liechtenstein, web site http://ghg.unfccc.int/index.html.

Regional Aggregration

SAGE aggregates individual countries into 15 fixed global regions and forecasts all energy consumption activity and consequent emissions at the regional level. Because the model does not distinguish specific countries within a region, the methodology in effect creates a joint emissions reduction target for all participating Annex I countries in the region. For regions with a mix of participating and non-participating countries (e.g., Western Europe, Eastern Europe, and the former Soviet Union), the "joint target" by methodological necessity includes the non-participating countries (but with no emissions reduction obligation from their baselines).

This approach makes it somewhat easier for countries to achieve their targets. It allows, by definition, the equivalent of "off-book" joint implementation projects and emission credit trading among participants and non-participants in a single region. Further, renewable resources located in one area may be employed to meet demand from another area within a single large region, with no transmission costs. The associated carbon price, therefore, tends to be understated based on these two assumptions.

The SAGE model results show that Eastern Europe and the former Soviet Union have sufficient room under their emissions reduction targets to meet all the permit trading demand generated by other signatory regions through 2025. Therefore, the *IEO2005* projections do not include Clean Development Mechanism projects, which are likely to be more costly than purchases of emission permits.

Reduction Targets Through 2025

Under the terms of the Kyoto Protocol, emissions reduction targets continue in the second commitment period (beyond 2012) at the same levels as in the initial commitment period. In SAGE, those target levels are assumed to continue through 2025.

Macroeconomic Impacts

In SAGE, elasticity of demand is modeled with respect to the costs of energy end-use services; however, the response of gross domestic product (GDP) to higher energy prices is not modeled. That is, SAGE does not model the macroeconomic impacts of the Kyoto Protocol.

SAGE derives demand for energy end-use services (residential space heating, personal road transportation, etc.) as a function of exogenously developed macroeconomic drivers (GDP, population, etc.). The SAGE linear program then solves for the least-cost technology mix that will meet the projected demand. Although SAGE does not endogenously change the projections provided exogenously for the macroeconomic drivers, most of the effect of higher energy prices is captured in the elastic demand. Furthermore, higher GDP growth projections tend to increase the introduction of newer, more efficient technologies.

Minimum Market Shares

SAGE imposes minimum market shares for some energy-efficient technologies (e.g., new, more efficient personal automobiles, such as gas-electric hybrids) that have capital costs higher than those of less efficient competing technologies. (Because of the "winner-take-all" nature of linear program models, the more efficient but more costly technologies would not be selected without the imposed minimum shares.)

For the *IEO2005* Kyoto Protocol case, EIA assumed no increase in the minimum market share imposed for energy-efficient new technologies. Although in the Kyoto Protocol case their costs compare more favorably with the costs for their less energy-efficient competitors than in the reference case, the new technologies still cost more and therefore enter the forecast only at their imposed minimum market shares. Furthermore, SAGE does not adjust for changes in consumer preferences, such as switching to subcompact cars that have both lower capital costs and lower operating costs. This attribute of the model tends to yield a higher projected carbon price than would be expected if such changes in consumer behavior were included in the analysis.

Appendix H

Comparisons With Other Forecasts, and Performance of Past *IEO* Forecasts for 1990, 1995, and 2000

Forecast Comparisons

Three organizations provide forecasts comparable with those in the *International Energy Outlook 2005* (*IEO2005*). The International Energy Agency (IEA) provides "business as usual" projections to the year 2030 in its *World Energy Outlook 2004*; Petroleum Economics, Ltd. (PEL) publishes world energy forecasts to 2025; and Petroleum Industry Research Associates (PIRA) provides projections to 2015. For this comparison, 2002 is used as the base year for all the forecasts, and the comparisons extend to 2025. Although IEA's forecast extends to 2030, it does not publish a projection for 2025.

In addition to forecasts from other organizations, the *IEO2005* projections are also compared with those in last year's report (*IEO2004*). Because 2002 data were not available when *IEO2004* forecasts were prepared, the growth rates from *IEO2004* are computed from 2001.

Regional breakouts among the forecasting groups vary, complicating the comparisons. For example, *IEO2005* and PIRA include Mexico in North America; IEA includes Mexico in Organization for Economic Cooperation and Development (OECD) North America; but PEL includes Mexico in Latin America. Because the IEA and *IEO2005* provide separate forecasts for Mexico, for purposes of this comparison, Mexico has been removed from North America in the *IEO2005* and IEA projections and is included with Central and South America to form a "Latin America" country grouping. Unfortunately, PIRA does not provide separate forecasts for Mexico, and so PIRA's North American forecasts are somewhat inconsistent with the other forecasts.

Further, PIRA includes only Japan in mature market Asia, whereas mature market Asia in the *IEO2005* forecast comprises Japan, Australia, and New Zealand, and the IEA forecasts an OECD Pacific that includes those three countries plus South Korea. *IEO2005* includes Turkey in the Middle East, but IEA includes Turkey—as well as the Czech Republic, Hungary, Poland, and Slovakia—in "OECD Europe" (which is designated as "Western Europe" for this comparison). PEL also places Turkey in Western Europe but includes the Czech Republic, Hungary, Poland, and Slovakia in Eastern Europe, as does *IEO2005*. Although most of the differences involve fairly small countries, they do contribute to the variations among the forecasts.

All the forecasts provide projections out to the year 2010 (Table H1). The 2002-2010 time period shows wide variation among the forecasters' expectations. This is, in part, reflective of the volatility experienced over the past several years in the world's energy markets. Growth rates for energy consumption among the reference case forecasts range from 2.0 percent per year (PEL) to 2.7 percent per year (PIRA), with the *IEO2005* forecast projecting 2.6 percent per year. The forecasters are in general agreement that energy demand in the mature market economies will expand more slowly than in the transitional economies, and that the fastest growth in world energy use will occur among the emerging economies. However, the *IEO2005* reference case forecasts much slower energy demand growth for Western Europe than do any of the other forecasts, and in fact all the other forecasts fall above the range defined by the *IEO2005* high economic growth case for the 2002 to 2010 period.

The IEA forecast anticipates much higher growth for mature market Asia than any of the other forecasts, though this may likely be the case because the IEA figures include projections for South Korea, in addition to Japan, Australia, and New Zealand. IEA's 2002-2010 growth rate for mature market Asia exceeds that of the *IEO2005* high economic growth case.

In the transitional EE/FSU region, forecasts are largely in agreement about expected growth, except for the PIRA forecast. PIRA is much more optimistic about projected growth for the EE/FSU region than any other forecast, and PIRA's 2.7 percent per year projected growth rate for the EE/FSU falls above the *IEO2005* high economic growth case of 2.5 percent per year for the 2002 to 2010 period.

The IEA projections for the developing world are also generally lower than the *IEO2005* projections. The IEA growth rates are lower than the projected growth rates in *IEO2005* for each developing region, and they fall below the *IEO2005* low economic growth case for China and Africa. For China, the IEA's projection of 3.4-percent annual growth in energy demand between 2002 and 2010 is substantially lower than the 6.8 percent per year forecast in the *IEO2005* reference case. In part, this may be explained by China's particularly high economic growth and corresponding energy demand growth that accompanied it in 2003 and 2004, which would not have

been anticipated when the IEA forecast was being prepared for publication.

Similarly to IEA's China forecast, PEL has a lower growth rate than the *IEO2005* low economic growth case, at 4.0 percent per year. The PEL forecast (March 2004) is among the oldest of the forecasts in the comparison group, and, as with IEA, the unanticipated explosive growth in China's energy demand in the past few years probably explains the differences between the PEL and *IEO2005* forecasts. The PIRA forecast for the 2002 to 2010 period is very similar to the *IEO2005* reference case projections for the developing world, with the exception of the Middle East, where PIRA projects growth in energy demand which exceeds that in the *IEO2005* high economic growth case.

The *IEO2005* reference case forecast is higher than in last year's outlook for the 2000 to 2010 period, particularly for the transitional EE/FSU and emerging economy regions. For the EE/FSU, projected growth in energy use is substantially higher in *IEO2005* than in *IEO2004* (with demand growth averaging 2.0 percent and 1.1 percent per year, respectively, in the two forecasts). In the case of the emerging economies, much of the upward revision can be attributed to China and the other emerging Asia nations, where unexpectedly strong growth in energy demand was recorded over the past 2 years and is reflected in the 10-year forecast period. In the case of the EE/FSU, the higher forecast in *IEO2005* reflects substantially higher expectations for economic growth over the time period (5.6 percent per year in *IEO2005* and 4.5 percent per year in *IEO2004*). This growth is largely attributed to the impact of recent high world oil prices on oil exporters in the FSU.

IEO2005, PIRA, and PEL provide forecasts for energy use in 2015 (Table H2), which is the end of the PIRA forecast horizon. Their projections for worldwide growth in energy consumption between 2002 and 2015 vary from 2.0 percent per year (PEL) to 2.6 percent per year (PIRA), with *IEO2005* expecting average annual growth of 2.3 percent. As it does for 2002-2010, PIRA forecasts much faster growth in energy use for the EE/FSU during 2002-2015 than does *IEO2005*. In China and the Middle East, PIRA's energy growth projections exceed the *IEO2005* high economic growth case forecasts. Whereas the *IEO2005* reference case anticipates that China's energy demand growth will slow in the 2010 to 2015 period, PIRA does not. The PEL growth rates are, for the most part, fairly similar to those in the *IEO2005* forecast. Only the growth rates for China are substantially lower than the *IEO2005* reference case; it appears that PEL did not anticipate the strong near-term growth in China, and this is reflected through the 2015 time horizon.

The *IEO2005* reference case projection of worldwide growth in energy use, at 2.3 percent per year for the 2002 to 2015 period, is higher than was projected in *IEO2004*. By region, the largest differences between the two forecasts are within the developing world, with the *IEO2004* forecasts for China, other emerging Asia, the Middle East, and Africa falling below those of the *IEO2005* low economic growth case. In all cases, the forecasts for

Table H1. Comparison of Energy Consumption Growth Rates by Region, 2002-2010
(Average Annual Percent Growth)

Region	*IEO2005*			*IEO2004*	IEA	PIRA	PEL
	Low Growth	Reference	High Growth				
Mature Market Economies	**0.9**	**1.2**	**1.5**	**1.2**	**1.4**	**1.2**	**1.1**
United States and Canada	1.4	1.6	2.0	1.7	1.4	1.2	1.2
Western Europe	0.3	0.5	0.7	0.5	1.1	1.2	1.0
Mature Market Asia	0.6	0.8	1.1	1.1	1.6	1.0[a]	1.0
Transitional Economies	**1.5**	**2.0**	**2.5**	**1.1**	**1.8**	**2.7**	**1.8**
Emerging Economies	**3.8**	**4.4**	**5.0**	**2.6**	**3.1**	**4.5**	**3.4**
China	6.2	6.8	7.4	3.6	3.4	6.7	4.0
Other Emerging Asia[b]	3.2	3.7	4.3	2.4	3.2	3.8	3.3
Middle East	2.7	3.4	4.0	2.0	3.2	4.4	3.3
Africa	3.0	3.4	3.9	1.8	2.7	3.6	3.1
Latin America	2.2	2.8	3.4	2.2	2.7	2.3	2.6
Total World	**2.1**	**2.6**	**3.0**	**1.7**	**2.2**	**2.7**	**2.0**

[a]Japan only.
[b]Other Asia includes India and South Korea.

Sources: ***IEO2005*:** Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2005). ***IEO2004*:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004), Table A1, p. 163. **IEA:** International Energy Agency, *World Energy Outlook 2004* (Paris, France, October 2004), pp. 430-517. **PIRA:** PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2004). **PEL:** Petroleum Economics, Ltd., *World Long Term Oil and Energy Outlook* (London, United Kingdom, March 2004).

economic growth are somewhat higher, particularly for China, in *IEO2005* than in *IEO2004*. This largely explains the upward revision in energy use in the developing regions.

IEO2005, PEL, and IEA provide energy consumption projections for 2020 (Table H3). The three forecasts have similar projections for energy demand growth from 2002 to 2020, projecting average annual increases in the world's total energy consumption that range from 1.9 percent (IEA and PEL) to 2.1 percent (*IEO2005*). The highest growth rates are projected for the emerging economies and the slowest for the mature market economies. The largest variations among the regional forecasts are for China, where growth expectations for energy use range from 2.9 percent per year (IEA) to 4.6

Table H2. Comparison of Energy Consumption Growth Rates by Region, 2002-2015
(Average Annual Percent Growth)

Region	*IEO2005*			*IEO2004*	PIRA	PEL
	Low Growth	Reference	High Growth			
Mature Market Economies	**0.9**	**1.1**	**1.4**	**1.2**	**1.1**	**1.0**
United States and Canada	1.2	1.5	1.8	1.6	1.1	1.2
Western Europe	0.3	0.5	0.8	0.6	1.1	0.8
Mature Market Asia	0.5	0.8	1.0	1.0	0.8[a]	0.9
Transitional Economies	**1.4**	**1.9**	**2.4**	**1.4**	**2.5**	**1.8**
Emerging Economies	**3.2**	**3.8**	**4.4**	**2.7**	**4.3**	**3.2**
China	4.8	5.4	6.0	3.7	6.2	3.8
Other Emerging Asia[b]	2.8	3.4	4.0	2.5	3.6	3.2
Middle East	2.4	3.0	3.6	2.1	4.3	3.1
Africa	2.7	3.2	3.8	2.1	3.6	3.0
Latin America	2.1	2.7	3.2	2.2	2.3	2.5
Total World	**1.9**	**2.3**	**2.7**	**1.8**	**2.6**	**2.0**

[a]Japan only.
[b]Other Asia includes India and South Korea.
Sources: ***IEO2005*:** Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2005). ***IEO2004*:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004), Table A1, p. 163. **PIRA:** PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2004). **PEL:** Petroleum Economics, Ltd., *World Long Term Oil and Energy Outlook* (London, United Kingdom, March 2004).

Table H3. Comparison of Energy Consumption Growth Rates by Region, 2002-2020
(Average Annual Percent Growth)

Region	*IEO2005*			*IEO2004*	IEA	PEL
	Low Growth	Reference	High Growth			
Mature Market Economies	**0.8**	**1.0**	**1.3**	**1.2**	**1.1**	**1.0**
United States and Canada	1.2	1.4	1.7	1.5	1.1	1.2
Western Europe	0.3	0.5	0.7	0.6	0.9	0.7
Mature Market Asia	0.5	0.7	1.0	1.0	1.3	0.8
Transitional Economies	**1.2**	**1.7**	**2.2**	**1.5**	**1.5**	**1.8**
Emerging Economies	**2.8**	**3.4**	**4.0**	**2.7**	**2.8**	**3.1**
China	4.0	4.6	5.2	3.6	2.9	3.6
Other Emerging Asia[b]	2.5	3.1	3.7	2.5	2.9	3.2
Middle East	2.1	2.7	3.3	2.1	3.0	2.9
Africa	2.4	2.9	3.4	2.2	2.6	2.9
Latin America	1.9	2.4	2.9	2.3	2.7	2.5
Total World	**1.7**	**2.1**	**2.5**	**1.8**	**1.9**	**1.9**

[a]Japan only.
[b]Other Asia includes India and South Korea.
Sources: ***IEO2005*:** Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2005). ***IEO2004*:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004), Table A1, p. 163. **IEA:** International Energy Agency, *World Energy Outlook 2004* (Paris, France, October 2004), pp. 430-517. **PEL:** Petroleum Economics, Ltd., *World Long Term Oil and Energy Outlook* (London, United Kingdom, March 2004).

percent per year (*IEO2005*). IEA is more optimistic than the other forecasts about energy demand growth in mature market Asia, where the 1.3-percent annual rate projected by IEA exceeds the rate in the *IEO2005* high economic growth case.

As was the case for the 2002-2010 and 2002-2015 comparisons, China is the region with the largest differences between the *IEO2005* and *IEO2004* reference case forecasts for 2002-2020. The *IEO2005* reference case projects annual energy demand growth for China that is a full percentage point higher than in last year's forecast, and last year's reference case projection is lower than that in the *IEO2005* low economic growth case.

IEO2005 and PEL are the only forecasts that extend to 2025 (the IEA forecast extends to 2030, but no forecast is proffered for 2025). For the 2002 to 2025 period (Table H4), the two forecasts are largely in agreement, with the PEL projections falling within the range provided by the *IEO2005* low and high economic growth cases. Again, the largest difference between the two forecasts is for China, with PEL projecting 3.5-percent average annual growth in China's energy demand from 2002 to 2025 and *IEO2005* projecting a 4.1-percent average.

The forecasts vary not only with respect to levels of total energy demand but also with respect to the mix of primary energy inputs. All the forecasts provide energy consumption projections by fuel in 2010 (Table H5). There is a wide range of views among the forecasts regarding the mix of fuels that will fulfill projected demand. Whereas *IEO2005* and PIRA expect coal to be the fastest growing fuel source in the 2002 to 2010 period—at 3.1 percent per year and 3.9 percent per year, respectively—IEA and PEL expect much lower growth for coal.

IEO2005, IEA, and PEL all project fairly strong relative growth in nuclear power demand over the time period, but PIRA projects worldwide nuclear demand growth rates that are about half those of the other forecasts. IEA projects much higher growth in renewable energy use than any of the other forecasts, although all the forecasts expect growth in renewables to average 2.0 percent per year or above from 2002 to 2010. The expectations for growth in oil demand range from 1.8 percent per year (PEL) to 2.4 percent per year (*IEO2005*). The relatively bullish *IEO2005* forecast for the 2002 to 2010 period is almost entirely due to increases in China's oil demand. All the forecasts expect relatively strong growth in natural gas use.

The *IEO2005* projections are higher than the *IEO2004* projections for each energy source, largely as a result of the unanticipated strong expansion of energy demand in recent years. This year's reassessment of the near-term forecast is so profound relative to last year's forecast that the *IEO2004* projections for every fuel type except oil fall below those in the *IEO2005* low economic growth case.

PEL, PIRA, and *IEO2005* provide world energy consumption projections by fuel for 2015 (Table H6). PIRA remains much more bullish in its projections for coal demand over this time period, exceeding the *IEO2005*

Table H4. Comparison of Energy Consumption Growth Rates by Region, 2002-2025
(Average Annual Percent Growth)

Region	*IEO2005*			*IEO2004*	PEL
	Low Growth	Reference	High Growth		
Mature Market Economies	**0.8**	**1.0**	**1.3**	**1.1**	**0.9**
United States and Canada	1.1	1.4	1.6	1.5	1.1
Western Europe	0.3	0.5	0.8	0.7	0.6
Mature Market Asia	0.5	0.7	1.0	1.0	0.7
Transitional Economies	**1.2**	**1.6**	**2.1**	**1.5**	**1.7**
Emerging Economies	**2.5**	**3.1**	**3.7**	**2.7**	**3.0**
China	3.5	4.1	4.7	3.5	3.5
Other Emerging Asia[b]	2.3	2.9	3.5	2.5	3.1
Middle East	1.9	2.5	3.1	2.1	2.8
Africa	2.2	2.7	3.2	2.3	2.9
Latin America	1.7	2.3	2.7	2.5	2.4
Total World	**1.5**	**2.0**	**2.4**	**1.8**	**1.9**

[a]Japan only.
[b]Other Asia includes India and South Korea.

Sources: ***IEO2005*:** Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2005). ***IEO2004*:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004), Table A1, p. 163. **PEL:** Petroleum Economics, Ltd., *World Long Term Oil and Energy Outlook* (London, United Kingdom, March 2004).

high economic growth case. In contrast, PEL is much more pessimistic about coal use over the 2002 to 2015 period, and its projected growth rate for worldwide coal demand is lower than that in the *IEO2005* low economic growth case. *IEO2005* expects nuclear power to expand by 1.3 percent per year, as compared with 0.9 percent per year in the PEL forecast and 0.7 percent per year in the PIRA forecast.

IEO2005, PEL, and IEA provide energy consumption projections for 2020 (Table H7). The three forecasts largely agree about the growth rate for total energy use, ranging from 1.9 percent per year (PEL and IEA) to 2.1 percent per year (I*EO2005*) between 2002 and 2020. That said, the projected fuel mixes differ among the forecasts. Whereas *IEO2005* expects nuclear power generation to grow by 1.1 percent per year from 2002 to 2020, both IEA

Table H5. Comparison of World Energy Consumption Growth Rates by Fuel, 2002-2010
(Average Annual Percent Growth)

	IEO2005						
Fuel	**Low Growth**	**Reference**	**High Growth**	***IEO2004***	**IEA**	**PIRA**	**PEL**
Oil	1.9	2.4	3.0	1.9	2.0	2.2	1.8
Natural Gas	1.9	2.4	3.0	1.7	2.7	2.8	3.0
Coal	2.8	3.1	3.5	1.3	1.8	3.9	1.6
Nuclear	1.5	1.5	1.5	1.3	1.5	0.7	1.3
Renewable/Other	2.4	2.7	2.9	2.2	3.2	2.3	2.0
Total	**2.1**	**2.6**	**3.0**	**1.7**	**2.2**	**2.7**	**2.0**

Sources: ***IEO2005*:** Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2005). ***IEO2004*:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004), Table A1, p. 163. **IEA:** International Energy Agency, *World Energy Outlook 2004* (Paris, France, October 2004), pp. 430-517. **PIRA:** PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2004). **PEL:** Petroleum Economics, Ltd., *World Long Term Oil and Energy Outlook* (London, United Kingdom, March 2004).

Table H6. Comparison of World Energy Consumption Growth Rates by Fuel, 2002-2015
(Average Annual Percent Growth)

	IEO2005					
Fuel	**Low Growth**	**Reference**	**High Growth**	***IEO2004***	**PIRA**	**PEL**
Oil	1.7	2.2	2.7	1.9	2.1	1.8
Natural Gas	2.0	2.6	3.2	2.0	3.0	3.0
Coal	2.2	2.6	2.9	1.4	3.6	1.5
Nuclear	1.3	1.3	1.3	1.2	0.7	0.9
Renewable/Other	1.7	2.2	2.3	2.1	2.4	2.1
Total	**1.9**	**2.3**	**2.7**	**1.8**	**2.6**	**2.0**

Sources: ***IEO2005*:** Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2005). ***IEO2004*:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004). **PIRA:** PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2004). **PEL:** Petroleum Economics, Ltd., *World Long Term Oil and Energy Outlook* (London, United Kingdom, March 2004).

Table H7. Comparison of World Energy Consumption Growth Rates by Fuel, 2002-2020
(Average Annual Percent Growth)

	IEO2005					
Fuel	**Low Growth**	**Reference**	**High Growth**	***IEO2004***	**IEA**	**PEL**
Oil	1.5	2.0	2.4	1.9	1.8	1.7
Natural Gas	1.9	2.4	2.9	2.1	2.6	2.9
Coal	1.9	2.3	2.7	1.5	1.6	1.5
Nuclear	1.1	1.1	1.1	1.0	0.6	0.7
Renewable/Other	1.5	1.9	2.2	2.0	2.7	2.1
Total	**1.7**	**2.1**	**2.5**	**1.8**	**1.9**	**1.9**

Sources: ***IEO2005*:** Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2005). ***IEO2004*:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004). **IEA:** International Energy Agency, *World Energy Outlook 2004* (Paris, France, October 2004), pp. 430-517. **PEL:** Petroleum Economics, Ltd., *World Long Term Oil and Energy Outlook* (London, United Kingdom, March 2004).

and PEL project much slower growth (0.6 percent and 0.7 percent per year, respectively). *IEO2005* projects smaller increases in natural gas demand than the other two forecasts. IEA is more optimistic about the growth potential of renewable energy sources, projecting 2.7-percent annual growth between 2002 and 2020, as compared with the *IEO2005* reference case projection of 1.9 percent and the PEL projection of 2.1 percent.

For the 2002 to 2020 period, the *IEO2005* reference case projections by fuel are generally higher than in last year's report. In particular, coal demand is expected to grow by 2.3 percent per year from 2002 to 2020 in *IEO2005*, but in *IEO2004* coal demand was expected to increase by 1.5 percent per year. The increase in coal use relative to last year's outlook is due to increases in demand among the emerging Asian economies.

As noted above, the only two forecasts for the 2002 to 2025 period, *IEO2005* and PEL, are largely in agreement with respect to the increase in total energy demand (Table H8). PEL projects an average annual growth rate of 1.9 percent for total world demand and *IEO2005* 2.0 percent per year. The fuel mix does vary between the two forecasts, with PEL projecting stronger growth in natural gas use than *IEO2005* (in fact, PEL's growth rate exceeds the projected rate in the *IEO2005* high economic growth case). In contrast, *IEO2005* expects stronger growth in coal use and nuclear power. The *IEO2005* reference case forecast shows generally higher growth on a by-fuel basis than last year's report, except for oil, which grows slightly slower in the 2002 to 2025 period, and renewables, for which the projected growth rates are the same in the *IEO2004* and *IEO2005* forecasts.

Performance of Past *IEO* Forecasts for 1990, 1995, and 2000

In an effort to measure how well the *IEO* projections have estimated future energy consumption trends over the 20-year history of the series, a comparison of *IEO* forecasts produced for the years 1990, 1995, and 2000 is presented here. The forecasts are compared with actual data published in EIA's *International Energy Annual 2002*, as part of EIA's commitment to provide users of the *IEO* with a set of performance measures to assess the forecasts produced by this agency.

The *IEO* has been published since 1985. In *IEO85*, midterm projections were derived only for the world's market economies. That is, no projections were prepared for the centrally planned economies (CPE) of the Soviet Union, Eastern Europe, Cambodia, China, Cuba, Laos, Mongolia, North Korea, and Vietnam. The *IEO85* projections extended to 1995 and included forecasts of energy consumption for 1990 and 1995 and primary consumption of oil, natural gas, coal, and "other fuels." *IEO85* projections were also presented for several individual countries and subregions: the United States, Canada, Japan, the United Kingdom, France, West Germany, Italy, the Netherlands, other OECD Europe, other OECD (Australia, New Zealand, and the U.S. Territories), OPEC, and other developing countries. Beginning with *IEO86*, nuclear power projections were published separately from the "other fuel" category.

Regional aggregations have changed from report to report. In 1990, the report coverage was expanded for the first time from only the market economies to the entire world. Projections for China, the FSU, and other CPE countries were provided separately. Starting with *IEO94*, the regional presentation was changed from market economies and CPE countries to OECD, Eurasia (China, FSU, and Eastern Europe), and "Rest of World." Beginning in 1995 and essentially continuing until the current issue, the regional presentation changed to further group the world according to economic development: industrialized nations (essentially the OECD before the entry of South Korea and the Eastern European nations, the Czech Republic, Hungary, Poland, and Slovakia), the transitional economies of the EE/FSU, and the developing world (including China and India).

The forecast time horizon has also changed over the years (Table H9). In the first edition of the report, *IEO85*, projections were made for 1990 and 1995. *IEO86* saw the

Table H8. Comparison of World Energy Consumption Growth Rates by Fuel, 2002-2025
(Average Annual Percent Growth)

Fuel	*IEO2005*			*IEO2004*	PEL
	Low Growth	Reference	High Growth		
Oil	1.4	1.8	2.3	1.9	1.6
Natural Gas	1.8	2.3	2.8	2.2	2.9
Coal	1.7	2.1	2.5	1.6	1.4
Nuclear	1.0	1.0	1.0	0.6	0.6
Renewable/Other	1.4	1.9	2.1	1.9	2.0
Total	**1.5**	**2.0**	**2.4**	**1.8**	**1.9**

Sources: ***IEO2005*:** Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2005). ***IEO2004*:** EIA, *International Energy Outlook 2004*, DOE/EIA-0484(2004) (Washington, DC, April 2004). **PEL:** Petroleum Economics, Ltd., *World Long Term Oil and Energy Outlook* (London, United Kingdom, March 2004).

addition of projection year 2000. In *IEO91*, forecasts were no longer published for 1990, but forecasts for 2010 were added to the report. The projection horizon remained the same until *IEO96*, when projection year 2015 was added. In 1998, the forecast was extended again, out to 2020. With *IEO2003*, the forecast period was extended to 2025.

Comparisons of Forecasts for Market Economies

Projections for market economies were made in the eight issues of the *IEO* that were published between 1985 and 1993 (no *IEO* was published in 1988). Historical data for total regional energy consumption in 1990 show that the *IEO* projections from those early years were consistently lower than the actual data for the market economies. For the four editions of the *IEO* printed between 1985 and 1989 in which 1990 projections were presented, total projected energy consumption in the market economies ran between 3 and 7 percent below the actual amounts published in the *International Energy Annual 2001* (Figure H1).

In addition, market economy projections for 1995 in the 1985 through 1993 *IEO* reports (EIA did not release forecasts for 1995 after the 1993 report) were consistently lower than the actual, historical 1995 data (Figure H2). Most of the difference is attributed to those market economy countries outside the OECD. Through the years, EIA's economic growth assumptions for OPEC and other market economy countries outside the OECD have been low. The 1993 forecast was, as one might expect, the most accurate of the forecasts for 1995, but its projection for OPEC and the other market economy countries was still more than 10 percent below the actual number.

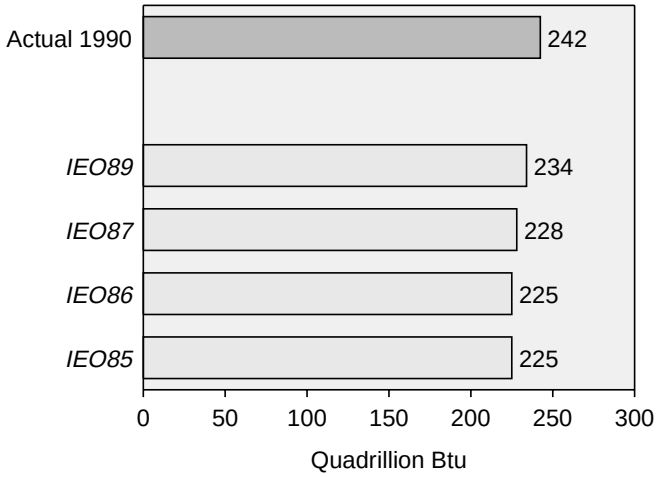
Similarly to the year 1995 projections, year 2000 projections were also consistently lower than actual 2000 data in each of the *IEOs* published between 1986 and 1993 (Figure H3). The consumption estimates for the market economies increased in each edition, from 265 quadrillion Btu in *IEO86* to 292 quadrillion Btu in *IEO93*. As late

Table H9. Years Included in *IEO* Projections by Edition, 1985-2005

Edition	1990	1995	2000	2005	2010	2015	2020	2025
IEO85	x	x						
IEO86	x	x	x					
IEO87	x	x	x					
IEO89	x	x	x					
IEO90		x	x		x			
IEO91		x	x		x			
IEO92		x	x		x			
IEO93		x	x		x			
IEO94			x	x	x			
IEO95			x	x	x			
IEO96		x	x	x	x	x		
IEO97			x	x	x	x		
IEO98			x	x	x	x	x	
IEO99			x	x	x	x	x	
IEO2000				x	x	x	x	
IEO2001				x	x	x	x	
IEO2002				x	x	x	x	
IEO2003				x	x	x	x	x
IEO2004					x	x	x	x
IEO2005					x	x	x	x

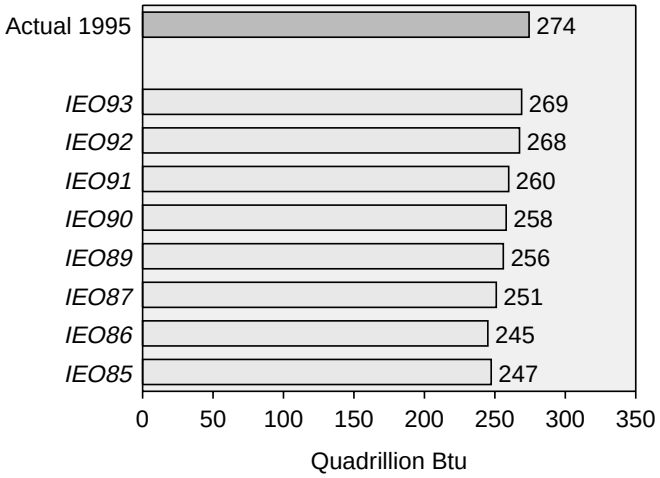
Sources: Energy Information Administration, *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure H1. Comparison of *IEO* Forecasts with 1990 Energy Consumption in Market Economies



Sources: Energy Information Administration, *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure H2. Comparison of *IEO* Forecasts with 1995 Energy Consumption in Market Economies

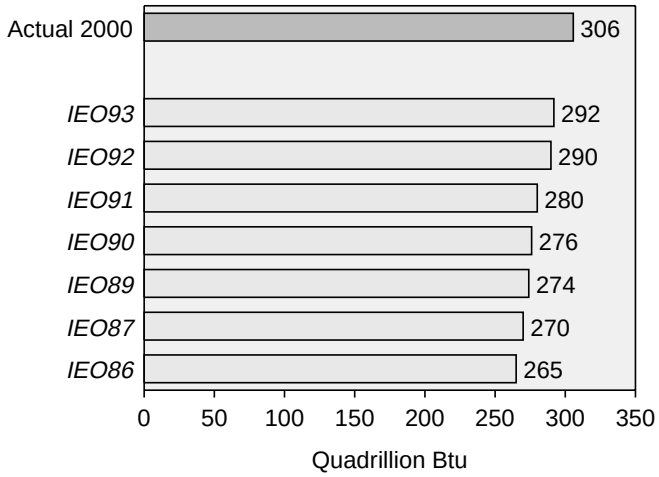


Sources: Energy Information Administration, *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

as 1993, the *IEO* forecasts were underestimating consumption of all energy sources in the market economies, by between 2 percent (oil) and 7 percent (natural gas and nuclear power).

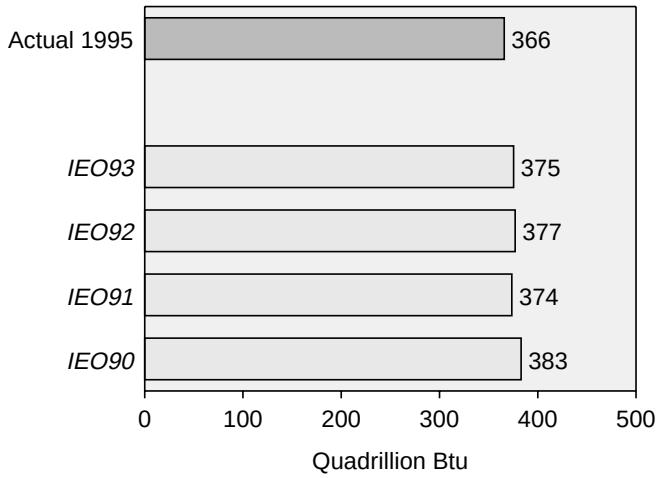
As noted above, in the 1994 edition of the *IEO*, the regional aggregation "market economies" was dropped altogether and replaced with delineation of member countries of the OECD, Eurasia, and Rest of World (ROW). As a result of that reorganization, it is not possible to recreate a forecast for the CPE countries: except for China, the FSU, and Eastern Europe, the remaining CPE countries—noted above—were included in "other ROW."

Figure H3. Comparison of *IEO* Forecasts with 2000 Energy Consumption in Market Economies



Sources: Energy Information Administration, *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure H4. Comparison of *IEO* Forecasts with 1995 World Energy Consumption



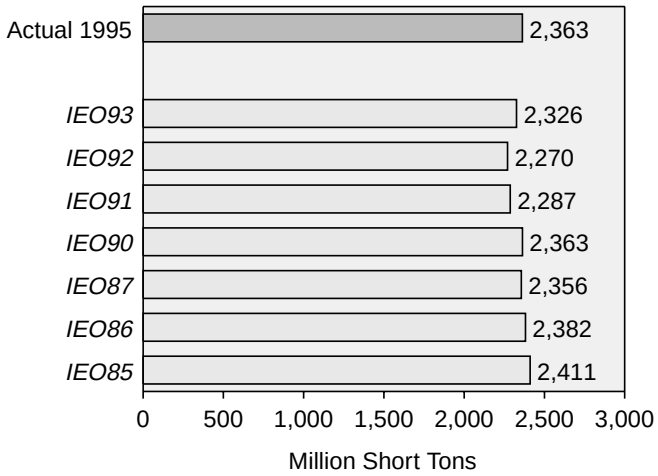
Sources: Energy Information Administration, *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Comparisons of Forecasts for Year 1995

IEO90 marked the first release of a worldwide energy consumption forecast. In *IEO90* through *IEO93*, the forecasts for worldwide energy demand in 1995 were between 1 and 4 percent higher than the actual amounts consumed (Figure H4). Much of the difference can be explained by the unanticipated collapse of the Soviet Union economies in the early 1990s. The *IEO* forecasters could not foresee the extent to which energy consumption would fall in the FSU region. In *IEO90*, total energy consumption in the FSU was projected to reach 67 quadrillion Btu in 1995. The projection was reduced steadily in the next three *IEO* reports, but even in *IEO93* energy demand for 1995 in the FSU region was projected to be 53 quadrillion Btu, as compared with actual 1995 energy consumption of 43 quadrillion Btu—a difference equivalent to about 5 million barrels of oil per day.

Forecasts for 1995 can also be compared in terms of their depiction of the fuel mix. Every *IEO* after 1990 projected the share of each energy source relative to total energy consumption within 2.6 percentage points of the actual 1995 distribution. The earliest *IEOs* tended to be too optimistic about the growth of coal use in the market economies (Figure H5) and too pessimistic about the recovery of oil consumption after the declines in the early 1980s that followed the price shocks caused by oil embargoes in 1973 and 1974 and the 1979-1980 revolution in Iran (Figure H6). The *IEO85* and *IEO86* reports projected that oil would account for only about 40 percent of total

Figure H5. Comparison of *IEO* Forecasts with 1995 Coal Consumption in Market Economies



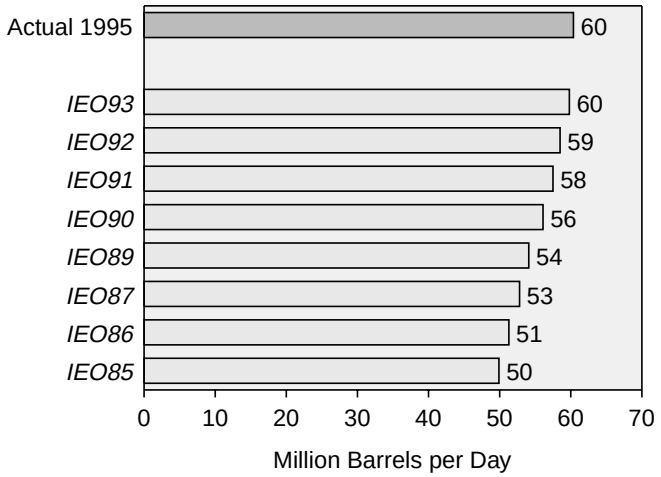
Sources: Energy Information Administration, *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

energy consumption for the market economies in 1995, whereas oil actually accounted for 45 percent of the total in 1995.

The 1995 forecasts for world coal consumption that appeared in the *IEOs* printed between 1990 and 1993 were consistently high, between 5 and 17 percent higher than actual coal use (Figure H7), largely because of overestimates for the FSU and Eastern Europe—regions that experienced substantial declines in coal consumption during the years following the collapse of the Soviet Union. Most of the projections for the FSU by fuel were greater than the actual consumption numbers, with the exception of hydroelectricity and other renewable resources (Figure H8). Natural gas use did not decline as much as oil and coal use, because natural gas is a plentiful resource in the region and was used extensively to fuel the domestic infrastructure; however, even the *IEO* estimates for 1995 natural gas use were 18 to 26 percent higher than the actual use.

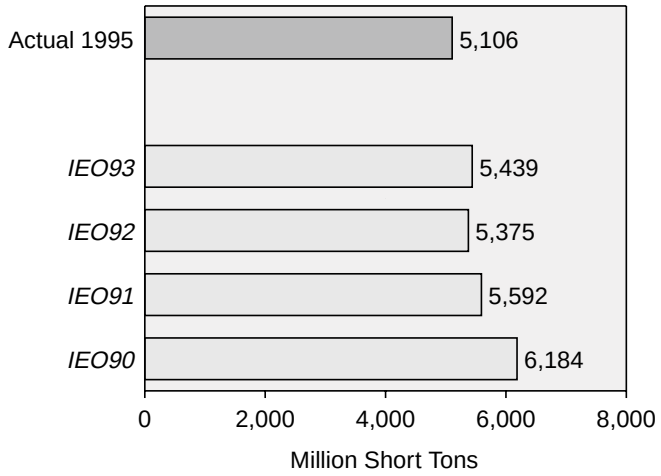
The *IEO* projections for total energy consumption in China were below the actual 1995 consumption level in *IEO90* (by 13 percent) and *IEO91* (by 8 percent) but higher in *IEO92* (by 6 percent) and about the same in *IEO93*. The underestimates in the earlier *IEOs* balanced, in part, the overestimates for the EE/FSU countries; however, even the 4- to 17-percent underestimate of projected 1995 coal use in China could not make up

Figure H6. Comparison of *IEO* Forecasts with 1995 Oil Consumption in Market Economies



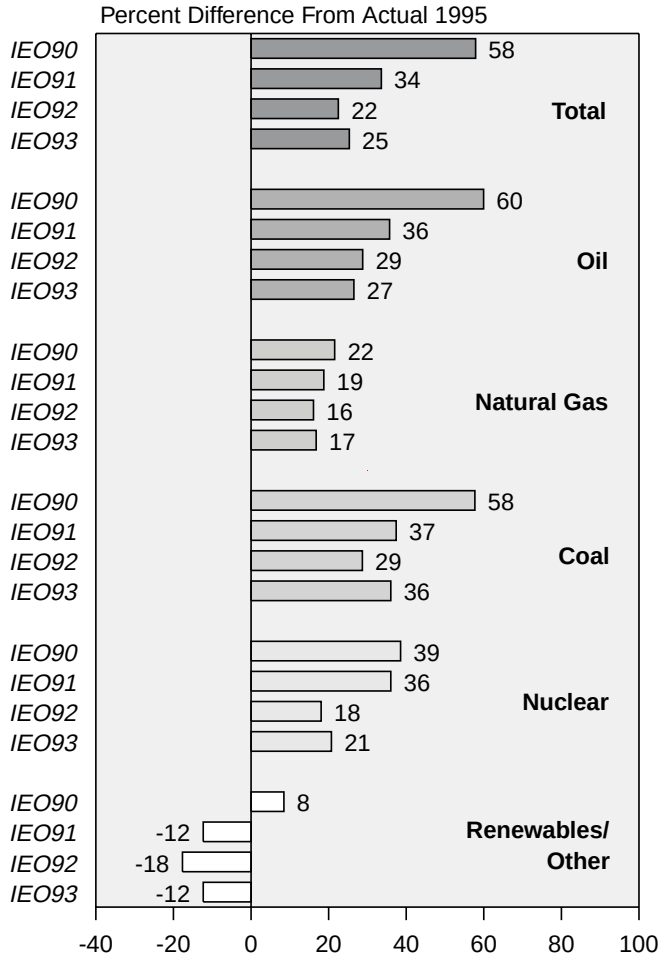
Sources: Energy Information Administration, *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure H7. Comparison of *IEO* Forecasts with 1995 World Coal Consumption



Sources: Energy Information Administration, *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure H8. Comparison of *IEO* Forecasts with 1995 Energy Consumption in the Former Soviet Union by Fuel Type



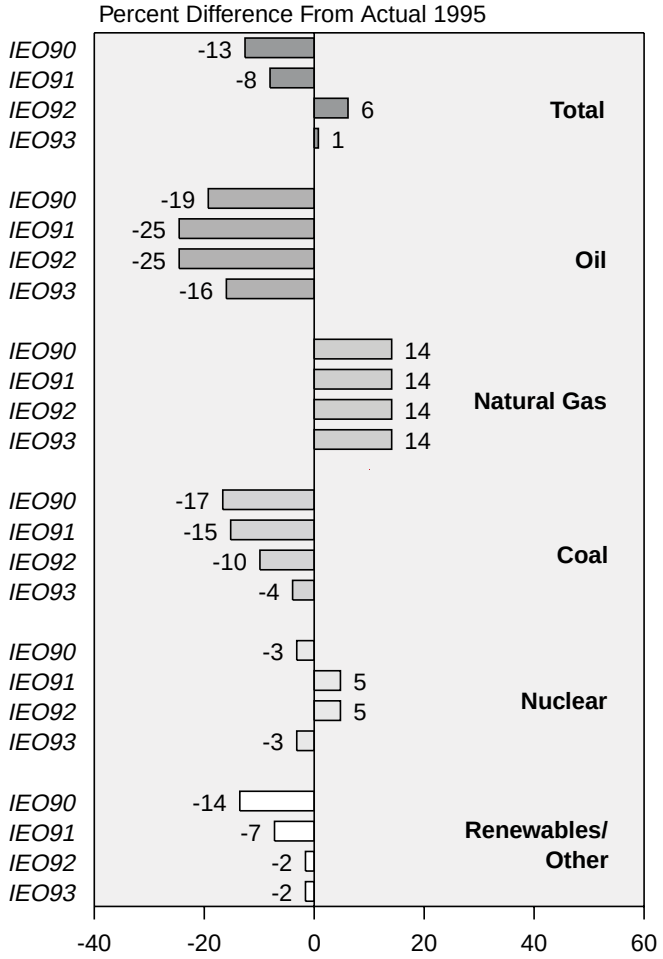
Sources: Energy Information Administration, *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

for the 29- to 58-percent overestimate of FSU coal use. In terms of other fuels, the *IEO* forecasts consistently overestimated China's natural gas consumption and underestimated its oil consumption. Nuclear power forecasts were fairly close for China, within 5 percent of the actual consumption (Figure H9). It is noteworthy, however, that consumption of natural gas and nuclear power was quite small in 1995, so that any variation between actual historical consumption and the projections results in a large percentage difference. EIA consistently underestimated economic growth in China. As late as 1993, EIA expected GDP in China to grow by about 7.3 percent per year during the decade of the 1990s, whereas it actually grew by 10.7 percent per year between 1990 and 1995.

Comparisons of Forecasts for Year 2000

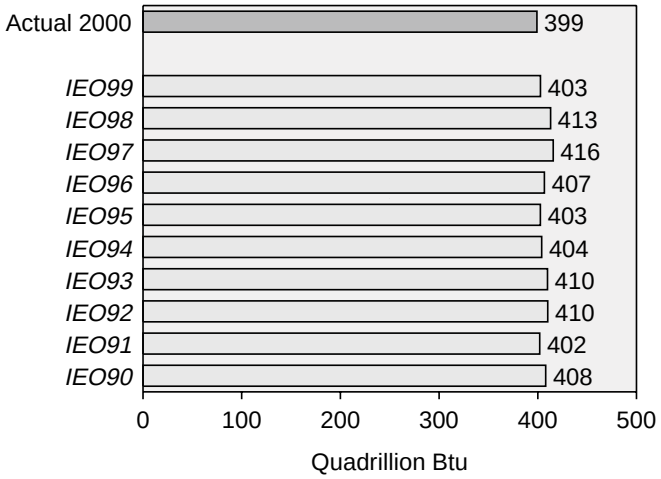
Ten editions of the *IEO* report contained worldwide forecasts for the year 2000 (*IEO90* through *IEO99*). The forecasts of total world energy consumption for 2000 were all above, but within 5 percent of, the actual total (Figure H10). *IEO97* provided the highest estimate of world energy use in 2000. This may seem surprising at first glance, but it is also true that the economic recession that would take hold in 1998 among the emerging economies of southeast Asia had not occurred and was not foreseen in the *IEO97* forecast. In fact, *IEO97* overestimated year 2000 energy use in emerging Asia by 9 quadrillion Btu, or about 12 percent (Figure H11), and in mature market Asia by 3 quadrillion Btu (9 percent).

Figure H9. Comparison of *IEO* Forecasts with 1995 Energy Consumption in China by Fuel Type



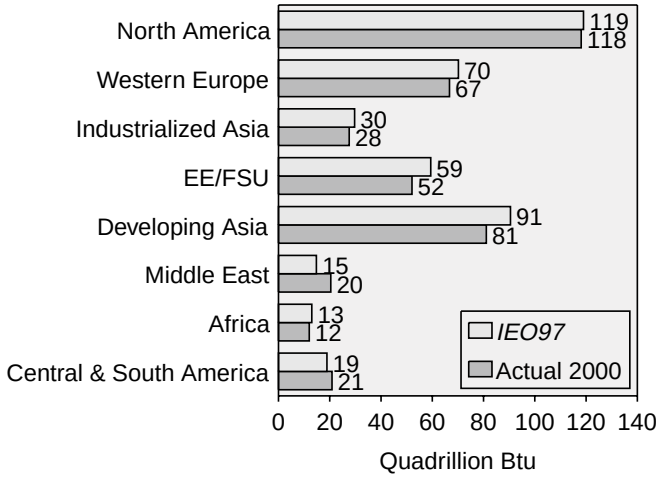
Sources: Energy Information Administration, *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure H10. Comparison of *IEO* Forecasts with 2000 World Energy Consumption



Sources: Energy Information Administration, *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure H11. Comparison of *IEO97* Forecasts with 2000 Energy Consumption by Region



Sources: Energy Information Administration, *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/, and *International Energy Outlook 1997*, DOE/EIA-0484(97) (Washington, DC, April 1997).

Projections for the EE/FSU in *IEO97* were also too optimistic, overestimating the rate of economic recovery in the region and as a result overestimating the growth in energy consumption by 12 quadrillion Btu (22 percent). *IEO97* did not anticipate the August 1998 devaluation of the Russian ruble and the economic recession that followed in the FSU region. By *IEO99*, total EE/FSU energy use had been adjusted downward to 52 quadrillion Btu—just slightly lower than the region's actual consumption in 2000.

The projections for year 2000 by fuel were mixed in terms of accuracy. For all energy sources except coal, total world consumption forecasts fell within 13 percent of the actual levels. As was the case with forecasts for the years 1990 and 1995, world coal consumption projections were consistently high relative to actual consumption in 2000. The world coal forecast presented in *IEO90* was 30 percent higher than actual 2000 values. The forecasts for the CPE countries were responsible for the large discrepancy between projected *IEO90* and actual coal consumption in 2000. In fact, *IEO90* projected that the market economies would consume 2,801 million short tons of coal in 2000, and the actual estimate for coal use among the market economies was 2,969. However, in the CPE countries—including the EE/FSU—*IEO90* projected that coal use would climb to 3,841 million short tons in 2000, whereas actual coal consumption was only 2,119 million short tons.

Much of the discrepancy between the *IEO90* projection and actual 2000 coal consumption can be attributed to the FSU. As noted above, *IEO90* did not foresee the collapse of the Soviet regime in 1990 when the report projections were prepared. Indeed, coal use in the FSU in *IEO90* was expected to expand to 1,132 million short tons in 2000, whereas in reality coal use in the FSU began to decline precipitously after 1990, hitting a low of 391 million short tons in 1998 before edging up somewhat to 405 million short tons in 2000. The story was similar for Eastern Europe and the other CPE countries (excluding China), where coal use in 2000 was overestimated by 202 percent in *IEO90*.

The year 2000 forecasts for oil, natural gas, and hydroelectricity and other renewable energy sources were, for the most part, higher than actual levels. In contrast, projections for nuclear power were consistently lower than the actual 2000 values. Interestingly, the forecasts for the United States were largely responsible for the underestimation. Even in *IEO99*—the latest *IEO* that included projections for 2000—analysts were expecting nuclear power to begin to decline. In *IEO90* there was widespread pessimism about the future of nuclear power in the mid-term, given the aftermath of Chernobyl and the problems associated with nuclear waste disposal. In the political climate of the early 1990s, *IEO90* could not anticipate the life extensions and consistently improving efficiencies that have allowed nuclear power plants to generate more electricity and operate with shorter downtimes for maintenance, even without expanding their installed capacities.

The comparison of *IEO* projections and historical data in the context of political and social events underscores the importance of those events in shaping the world's energy markets. Such comparisons also point out how important a model's assumptions are to the derivation of accurate forecasts. The political and social upheaval in the EE/FSU dramatically affected the accuracy of the projections for the region. If higher economic growth rates had been assumed for China, more accurate forecasts for that region might have been achieved. It is important for users of the *IEO* or any other projection series to realize the limitations of the forecasts. Failing an ability to predict future volatility in social, political, or economic events, the projections should be viewed as a plausible path or trend for the future and not as a precise prediction of future events.

Appendix I

System for the Analysis of Global Energy Markets (SAGE)

The projections of world energy consumption appearing in this year's *International Energy Outlook* (*IEO*) are based on the Energy Information Administration's (EIA's) international energy modeling tool, System for the Analysis of Global Energy markets (SAGE). SAGE is an integrated set of regional models that provide a technology-rich basis for estimating regional energy consumption. For each region, reference case estimates of 42 end-use energy service demands (e.g., car, commercial truck, and heavy truck road travel; residential lighting; steam heat requirements in the paper industry) are developed on the basis of economic and demographic projections. Projections of energy consumption to meet the energy demands are estimated on the basis of each region's existing energy use patterns, the existing stock of energy-using equipment, and the characteristics of available new technologies, as well as new sources of primary energy supply.

Period-by-period market simulations aim to provide each region's energy services at minimum cost by simultaneously making end-use equipment and primary energy supply decisions. For example, in SAGE, if there is an increase in residential lighting energy service, either existing generation equipment must be used more intensively or new equipment must be installed. The choice of generation equipment (type and fuel) incorporates analysis of both the characteristics of alternative generation technologies and the economics of primary energy supply.

The *IEO* 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. Projections of carbon dioxide emissions resulting from fossil fuel use are also provided. All projections are computed in 5-year intervals through the year 2025. Further, more detailed tables that emphasize the end-use demand-driven nature of SAGE are new to this year's report.

SAGE provides projections for 15 regions or countries, including the North American countries of the United States, Canada, and Mexico; Western Europe; Japan; Australia/New Zealand; Eastern Europe; the former Soviet Union (FSU); China; India; South Korea; other developing Asia; the Middle East; Africa; and Central and South America. An offline procedure is used to develop projections for Russia in the FSU and for Brazil in Central and South America.

Projections of world oil prices over the forecast horizon are provided to SAGE 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 SAGE model is available in a two-volume set. The first volume provides a general understanding of the model's design, theoretical basis, necessary user-defined assumptions, and output. It also lists the software necessary to develop and analyze the results of SAGE-based policy and energy market scenarios. In addition, Volume I includes a Reference Guide, which explains each equation in detail. The second volume serves as a User's Guide for those actively developing SAGE-based scenario analyses. The documentation is available on EIA's web site in the model documentation section of "Current Publications" (http://www.eia.doe.gov/bookshelf/docs.html). SAGE documentation is also available as part of the documentation for the MARKAL family of models (http://www.etsap.org/MRKLDOC-III_SAGE.pdf).

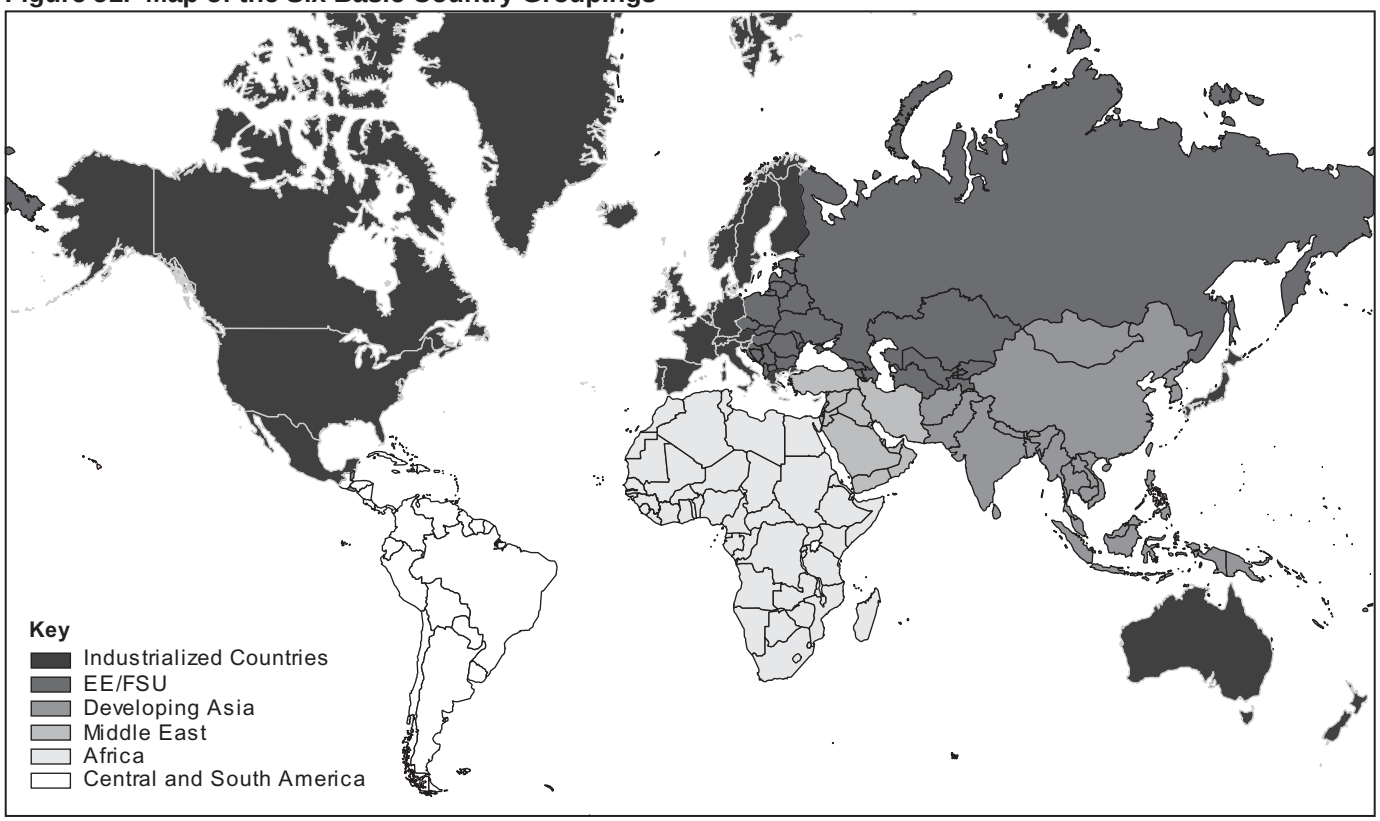
Appendix J

Regional Definitions

The six basic country groupings used in this report (Figure J1) are defined as follows:

- **Mature Market Economies** (15 percent of the 2005 world population): **North America**—United States, Canada, and Mexico; **Western Europe**—Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom; **Mature Market Asia**—Japan, Australia, and New Zealand.
- **Transitional Economies** (6 percent of the 2005 world population): **Eastern Europe (EE)**—Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Macedonia, Poland, Romania, Serbia and Montenegro, Slovakia, and Slovenia; **Former Soviet Union (FSU)**—Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
- **Emerging Economies** (78 percent of the 2005 world population):
  - **Emerging Asia** (53 percent of the 2005 world population)—Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia (Kampuchea), China, Fiji, French Polynesia, Guam, Hong Kong, India, Indonesia, Kiribati, Laos, Malaysia, Macau, Maldives, Mongolia, Myanmar (Burma), Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, South Korea, Sri Lanka, Taiwan, Thailand, Tonga, Vanuatu, and Vietnam.
  - **Middle East** (4 percent of the 2005 world population)—Bahrain, Cyprus, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, the United Arab Emirates, and Yemen.
  - **Africa** (14 percent of the 2005 world population)—Algeria, Angola, Benin, Botswana, Burkina Faso,

Figure J1. Map of the Six Basic Country Groupings



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

Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo (Brazzaville), Congo (Kinshasa), Djibouti, Egypt, Equatorial Guinea, Eritrea, 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, Zambia, and Zimbabwe.

- **Central and South America** (7 percent of the 2005 world population)—Antarctica, 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, Puerto Rico, St. Kitts-Nevis, St. Lucia, St. Vincent/Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos Islands, Uruguay, U.S. Virgin Islands, and Venezuela.

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

- **Countries that have ratified, accepted, acceded, or approved the Kyoto Climate Change Protocol on Greenhouse Gas Emissions as of May 27, 2005:** Albania, Algeria, Antigua and Barbuda, Argentina, Armenia, Austria, Azerbaijan, Bahamas, Bangladesh, Barbados, Belgium, Belize, Benin, Bhutan, Bolivia, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Cuba, Cyprus, Czech Republic, Congo (Kinshasa), Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Estonia, Ethiopia, Fiji, Finland, France, Gambia, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guyana, Honduras, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Kiribati, Kuwait, Kyrgyzstan, Laos, Latvia, Lesotho, Liberia, Liechtenstein, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Marshall Islands, Mauritius, Mexico, Micronesia, Mongolia, Morocco , Mozambique, Myanmar, Namibia, Nauru, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Niue, North Korea, Norway, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Moldova, Romania, Russia, Rwanda, Saint Lucia, St. Vincent/Grenadines, Samoa, Saudi Arabia, Senegal, Seychelles, Slovakia, Slovenia, Solomon Islands, South Africa, South Korea, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Tanzania, Thailand, Macedonia, Togo, Trinidad and Tobago, Tunisia, Turkmenistan, Tuvalu, Uganda, Ukraine, United Arab Emirates, United Kingdom, Uruguay, Uzbekistan, Vanuatu, Venezuela, Vietnam, and Yemen.
- **Annex I Countries** (countries participating in the Kyoto Climate Change Protocol on Greenhouse Gas Emissions): Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and the United Kingdom.[20]
- **European Union (EU):** Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.
- **G8:** Canada, France, Germany, Italy, Japan, Russia, United Kingdom, and the United States.
- **North American Free Trade Agreement (NAFTA) Member Countries:** Canada, Mexico, and the United States.
- **Organization for Economic Cooperation and Development (OECD):** Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, South Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.
- **Organization of Petroleum Exporting Countries (OPEC):** Algeria, 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.

[20]Turkey and Belarus are Annex I nations that have not ratified the Framework Convention on Climate Change and did not commit to quantifiable emissions targets under the Kyoto Protocol. In 2001, the United States withdrew from the Protocol. In 2002, Australia announced that it will not ratify the Kyoto Protocol unless the United States does.