

World Energy Consumption

The IEO2003 projections indicate continued growth in world energy use, including large increases for the developing economies of Asia. Energy resources are thought to be adequate to support the growth expected through 2025.

The outlook presented in the *International Energy Outlook 2003 (IEO2003)* shows continuing strong growth for worldwide energy demand over the next 24 years. Total world energy consumption is expected to expand by 58 percent between 2001 and 2025, from 404 quadrillion British thermal units (Btu) in 2001 to 640 quadrillion Btu in 2025 (Table 1 and Figure 12). Overall, the global economy did not perform strongly in 2002. Growth in U.S. markets was hindered by several large corporate scandals and by relatively high world oil prices, and the slow U.S. economy had negative impacts on many global markets that rely heavily on exports to the United States. Nevertheless, the *IEO2003* mid-term outlook continues to show robust growth in energy consumption among the developing nations of the world (Figure 13), particularly in developing Asia (including China and India), where demand for energy is expected to more than double over the next quarter century.

This chapter begins with an overview of current economic trends that are influencing short-term energy markets, followed by a presentation of the *IEO2003* outlook for energy consumption by primary energy source and a discussion of projections for world carbon dioxide emissions resulting from the combustion of fossil fuels. Uncertainty in the forecast is highlighted by an examination of alternative assumptions about economic growth and their impacts on the *IEO2003* projections, and how future trends in energy intensity could influence the reference case projections. Next, a comparison of *IEO2003*

projections with forecasts available from other organizations is presented. The chapter ends with an examination of the performance of past *IEO* forecasts for the years 1990, 1995, and 2000.

World Economic Status

The global economy faltered at the end of 2002, and the United States managed a meager 1-percent annualized growth in the fourth quarter. U.S. stock markets felt the impact of a crisis of consumer confidence following several large corporate scandals in 2002. The weak performance of the U.S. economy in 2002 was felt in world markets as well. The United States is the world's largest economy, and many developing nations are largely dependent on exports to the United States to support their own economic expansion. Worldwide, economic growth is expected to recover over the short term, and in the *IEO2003* reference case, world gross domestic product (GDP) is projected to expand by an average of 3.1 percent per year over the 2001 to 2025 forecast period (Table 2).

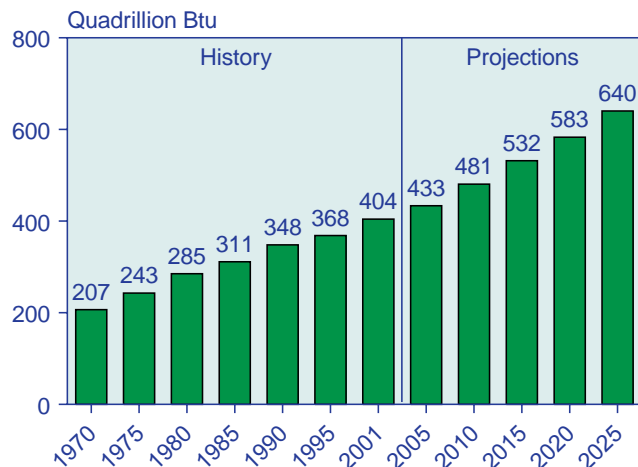
Continuing unrest in the Middle East, the war in Iraq, and a crippling strike in Venezuela aiming to oust President Hugo Chavez all helped to keep oil prices high through much of the past year and into 2003. The Organization of Petroleum Exporting Countries (OPEC) has managed markets to keep the basket oil price above \$22 per barrel (nominal) since March 8, 2002 (Figure 14) [1].

Table 1. World Energy Consumption and Carbon Dioxide Emissions by Region, 1990-2025

Region	Energy Consumption (Quadrillion Btu)				Carbon Dioxide Emissions (Million Metric Tons Carbon Equivalent)			
	1990	2001	2010	2025	1990	2001	2010	2025
Industrialized Countries	182.8	211.5	240.1	288.3	2,844	3,179	3,572	4,346
EE/FSU	76.3	53.3	65.9	82.3	1,337	856	1,038	1,267
Developing Countries	89.3	139.2	174.7	269.6	1,691	2,487	3,075	4,749
Asia	52.5	85.0	110.1	174.6	1,089	1,640	2,075	3,263
Middle East	13.1	20.8	25.0	36.0	231	354	420	601
Africa	9.3	12.4	14.4	20.0	179	230	261	361
Central and South America	14.4	20.9	25.2	39.0	192	263	319	523
Total World	348.4	403.9	480.6	640.1	5,872	6,522	7,685	10,361

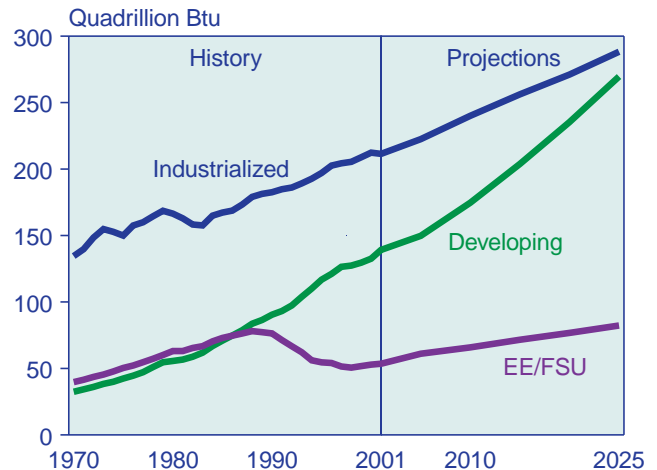
Sources: **1990 and 2001:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2010 and 2025:** EIA, System for the Analysis of Global Energy Markets (2003).

Figure 12. World Energy Consumption, 1970-2025



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

Figure 13. World Energy Consumption by Region, 1970-2025



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

Table 2. World Gross Domestic Product by Selected Countries and Regions, 1970-2025
(Billion 1997 U.S. Dollars)

Region	History			Projections				Average Annual Percent Change	
	1970	1990	2001	2010	2015	2020	2025	1970-2001	2001-2025
Industrialized Countries									
North America	4,068	7,723	10,588	14,192	16,645	19,246	22,218	3.1	3.1
United States	3,646	6,836	9,394	12,497	14,566	16,770	19,285	3.1	3.0
Canada	276	555	742	978	1,112	1,253	1,406	3.2	2.7
Mexico	145	332	452	717	967	1,223	1,528	3.7	5.2
Western Europe	4,506	7,597	9,460	11,694	13,125	14,724	16,395	2.4	2.3
France	751	1,299	1,593	1,974	2,214	2,497	2,781	2.5	2.3
Germany	1,149	1,879	2,274	2,780	3,100	3,450	3,811	2.2	2.2
Industrialized Asia	1,815	4,054	4,920	5,891	6,512	7,153	7,828	3.3	2.0
Japan	1,608	3,673	4,376	5,164	5,662	6,162	6,680	3.3	1.8
EE/FSU									
Former Soviet Union	625	1,009	654	957	1,152	1,360	1,600	0.1	3.8
Eastern Europe	236	348	390	561	689	853	1,044	1.6	4.2
Developing Countries									
Asia	472	1,739	3,525	5,856	7,528	9,513	11,752	6.7	5.1
China	106	427	1,201	2,191	2,949	3,935	5,085	8.2	6.2
India	113	268	521	832	1,077	1,390	1,775	5.1	5.2
Middle East	172	379	581	808	970	1,154	1,359	4.0	3.6
Africa	206	405	617	862	1,027	1,216	1,426	3.6	3.6
Central and South America	586	1,136	1,505	1,983	2,446	3,040	3,811	3.1	3.9
Total World	12,687	24,392	32,239	42,804	50,095	58,259	67,434	3.1	3.1

Sources: Global Insight, Inc., *World Economic Outlook*, Vol. 1 (Lexington, MA, Third Quarter 2002), and Energy Information Administration, System for the Analysis of Global Energy Markets (2003).

High world oil prices have the potential to further dampen economic expansion. The weakness of U.S. consumer demand—which has supported economic growth for some time—is matched by likely economic declines in Japan and stagnation in the European Union (EU). Another below-trend performance is expected for the world economy in 2003 before recovery in 2004.

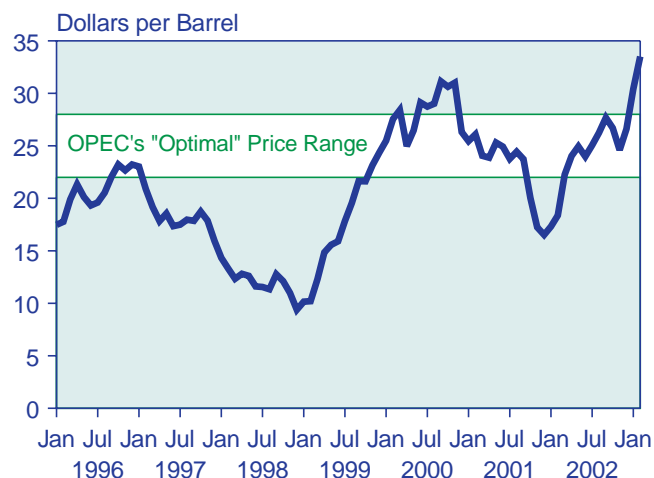
Industrialized World

The U.S. economy has suffered a number of setbacks in the past 3 years, including the terrorist attacks of September 2001, the significant loss of stock market wealth since 2000, and recent corporate accounting scandals, including U.S. energy company Enron and telecommunications company WorldCom Group [2]. Yet the recession of 2001 was one of the mildest on record, with recovery proceeding slowly in 2002. The recovery—attributed to continuing consumer spending, a strong housing market, and activist fiscal and monetary policies—has been slowed by falling consumer confidence, high oil prices, and war jitters. Debates over another government fiscal stimulus have just begun, but the eventual outcome may well provide a significant boost to the U.S. economy in 2003. U.S. GDP is projected to grow at an average annual rate of 3.0 percent per year from 2001 to 2025.

Canada's economy continued to outperform expectations in 2002. GDP growth in Canada exceeded that in the United States between 1999 and 2002, and in 2002 Canada recorded the strongest growth among the G-8 nations [3]. Housing starts, automobile sales, strong government spending, and a robust energy sector were leading contributors to Canada's economic growth. Although the pace of the country's growth did slow in conjunction with the general worldwide economic slowdown in 2002, it is expected to improve along with a recovery in the United States. Canada's economic growth rate is projected to average 2.7 percent per year over the projection period.

Mexico—which along with Canada is a U.S. partner in the North American Free Trade Agreement (NAFTA)—also returned to positive growth in 2002. High world oil prices helped Mexico avoid a substantial dip in GDP expansion in 2001 and allowed the country to achieve its 2002 fiscal deficit target of 0.65 percent of GDP [4]. In general, many analysts believe that the United States will cushion Mexico from the economic troubles that have hampered other countries in Latin America, and Mexico's GDP is expected to expand by a robust 5.2 percent per year on average over the next 24 years. Mexico is, however, more dependent on U.S. growth than are the other Latin American countries. The Fox Administration has announced plans to limit public spending in its 2003 budget because of fears that the U.S. recovery may be more prolonged than was expected in 2002 [5].

Figure 14. Refiner Acquisition Cost of Imported Crude Oil, 1996-2002



Source: Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(2003/04) (Washington, DC, April 2003).

Economic performance in other industrialized regions of the world has been equally or more lackluster. In Germany, Western Europe's largest economy, economic performance was anemic throughout 2002. The German government had few options for stimulus: the European Central Bank has been reluctant to cut EU interest rates to stimulate economic growth, and Germany is constrained from carrying out any fiscal policy changes because of the weak state of public finances and limits placed on the government by the EU's Stability and Growth Pact, which requires that EU member countries maintain deficits that do not exceed 3 percent of GDP in any single year [6]. The European Commission issued a warning to Germany on its breach of the deficit limit, threatening punishment if it did not take action to reduce its deficit before May 21, 2003 [7].

High unemployment and the costs associated with recovering from a devastating flood in the summer of 2002 have led the German government to delay a tax cut scheduled for January 2003, leading many analysts to believe that chances for a near-term economic recovery are remote [8]. In December, the European Central Bank moved to cut its benchmark interest rate by 0.5 percentage point, the first cut since November 2001, citing a lackluster "overall sentiment in the economy" [9]. The Bank stated that it was able to cut interest rates without fear of inflation because of the protracted sluggishness of economic growth among the EU member countries. Critics of the Bank's hesitancy to cut rates over the past year argue that the impact of the November interest rate cut may not be felt in Europe for up to a year, and that Germany, as well as France and Italy, may fall into recession in the meantime.

In Japan, the world's second largest economy continued to contract in 2002. After a decade of fiscal erosion, spiraling private debt, and price deflation, the country found itself in a position of acute vulnerability to any external shock. The government of prime minister Junichiro Koizumi has had only limited success in getting economic reforms passed in the Japanese Diet. Compromise postal reform bills were passed in June 2002, allowing a shift of the national postal service and its financial functions into a private corporation [10]. Koizumi is also attempting to shift fiscal policy away from government stimulus packages (implemented through public works) toward a tax cut.

In late September 2002, Koizumi announced a reshuffling of his cabinet, replacing his chief financial regulator, Hakuo Yanagisawa, with Heizo Takenaka, who is known to be a strong proponent of reform [11]. Mr. Takenaka has been assigned the roll of "economy czar" and has been charged with the task of cleaning up commercial banks that have accumulated an estimated \$423 billion in bad loans over the past 12 years. It is difficult to assess how successful Takenaka may be, and for the near-term future the Japanese economy is expected to continue only tepid performance. GDP in Japan is projected to grow by only 1.8 percent per year between 2001 and 2025, substantially lower than its 3.3-percent average over the past 30 years.

Central and South America

In 2002, substantial political and economic troubles arose among the nations of Central and South America. Uncertainties among the nations of the region include prospects for national elections in several large countries that may well change the political landscape, the continuing economic crisis in Argentina, political unrest in Venezuela, a renewed aggressive campaign against insurgency groups in Colombia, and mounting popular dissatisfaction with the Toledo government in Peru. As a result, projections for the region's economic growth have been lowered in *IEO2003*, along with expectations for increments in energy demand. Whereas last year's report (*IEO2002*) projected 4.5-percent average annual growth in GDP in Central and South America from 1999 to 2020, *IEO2003* projects only 3.6-percent annual growth for the same time period.

Brazil's economy, the largest in Central and South America, has been hampered by the lingering global economic weakness. Beginning in the second quarter of 2002, industrial production in Brazil began to weaken substantially, and unemployment rates increased precipitously. The Brazilian Central Bank lowered interest rates from 18.5 percent to 18 percent, but the high interest rates compounded the difficulty of achieving economic recovery [12]. In mid-October 2002, in an effort to halt the depreciation of the Brazilian real, the Bank

increased interest rates to a 3-year high of 21 percent in the hope that high interest rates would make short-term domestic investments more attractive by offering higher returns on domestic bonds [13].

Mounting dissatisfaction with the performance of the Brazilian economy fueled public support for the presidential candidacy of Luiz Inácio Lula da Silva, who was elected to the office on October 27, 2002, with 61 percent of the vote—the largest margin of victory by a presidential candidate in the history of the country [14]. Many analysts believe that the election of Lula will stall privatization efforts, with policies aimed at reversing the previous administration's move to liberalize many state-owned enterprises.

Fears that the Lula administration might be detrimental to prospects in Brazil are making foreign investors nervous about committing investment funds, making it difficult for the country to manage its \$260 billion public debt [15]. The Lula administration does not have much fiscal room to maneuver, however, given Brazil's past agreements with the International Monetary Fund (IMF) to hold down public deficits in return for loans and credit. The IMF, apparently believing that Brazil intends to honor its commitments, has approved a request for a 15-month standby credit of \$30.4 billion through December 2003, citing the country's "strong and consistent macroeconomic policies in recent years that have improved fundamentals" [16].

In Venezuela, the Chavez administration has faced growing discontent among union workers and businessmen as a result of its handling of the economy, particularly in dealings with state-owned *Petroleos de Venezuela (PDVSA)*. When Chavez attempted to replace PDVSA executives with political allies, demonstrations and protests were launched that culminated in an ultimately unsuccessful coup attempt in April 2002 [17]. Nevertheless, Chavez declared his intention to fulfill his complete presidential term and stay in office until 2007. Tensions in the country remained high, and a 2-month nationwide strike that began on December 2, 2002, resulted in a pronounced slowdown of operations at PDVSA [18]. Oil is the key source of revenue for Venezuela (accounting for some 80 percent of the country's total export revenues). Although world oil prices remained high in 2002, the country still saw a contraction in GDP of almost 10 percent in the second quarter of 2002, and unemployment stood at 16.4 percent. None of these developments bodes well for near-term economic growth in Venezuela.

Argentina, another key economy of the Central and South American region, experienced another disappointing economic year in 2002. After a deteriorating financial situation at the end of 2001 resulted in the rapid succession of five presidents, Eduardo Duhalde

assumed the role of interim president in January 2002. The economic situation has not shown much improvement, with real GDP contracting by 12 percent in 2002, and new elections are now scheduled for April 2003 [19]. There are hopes that the Argentine economy has begun to stabilize. After a year of negotiations, Argentina was able to secure a \$6.8 billion loan package from the IMF in January 2003. Under the terms of the agreement, the IMF has approved a short-term credit line of nearly \$3 billion to repay debts to multinational organizations that could not be postponed. It has also extended its deadline for repayment of some \$3.8 billion to August 31, 2003. The country faces around \$18 billion worth of repayments before the end of 2003.

Developing Asia

For the most part, the nations of developing Asia showed positive economic growth in 2002, and there is cautious optimism that national economies in the region will continue to expand despite slow economic growth in the industrialized world. The two largest economies in the region—China and India—both saw robust GDP growth in 2002, which is expected to continue in the near term. China and India alone are expected to see combined average economic growth of 5.9 percent per year from 2001 to 2025 in the *IEO2003* reference case.

The November 2001 accession of China into the World Trade Organization (WTO) gives analysts some reason for concern in the mid-term. Although WTO membership is expected to advance trading opportunities and a voice in future global economic organization negotiations, there is fear that unemployment may rise with the opening of China's markets to competition, accompanied by the potential for social discord, and that economic growth in the short term will be dampened [20]. To counteract the potential negative impacts of WTO membership, the Chinese government plans to increase spending on public works projects, releasing some 150 billion yuan (about \$18 billion) in special funds to finance the projects [21]. In the mid-term, China will still need to reform overstuffed and inefficient state-owned companies and a banking system that is carrying large nonperforming loans. In 2002, nonperforming loans accounted for 23 percent of total loans, and the government has set a target for state-owned banks to reduce them to 15 percent of the total by 2005 [22].

India's economy has also performed well over the past 2 years, with GDP increases of 5.4 percent in 2001 and an estimated 4.8 percent in 2002 [23] attributed to strong growth in the manufacturing sector and a robust recovery in the agricultural sector after a 2-year drought. Several legislative moves aimed at improving the country's privatization efforts were passed in 2002, including a July 2002 government announcement that it would allow companies that assume government stakes in

businesses to finance the acquisitions through external commercial loans, and the April 2002 abolition of the oil refinery sector's Administered Pricing Mechanism, which is expected to result in greater competition for India's refineries [24]. India's Power Minister, Suresh Prabhu, has announced that further legislation will be introduced to end the monopoly of state utilities on electricity distribution, allowing private companies to sell electricity directly to consumers. Analysts hope that the legislation will remove the distribution restrictions that have hampered India's efforts to reform its power sector and attract new foreign investment in the electricity sector [25]. Mid-term prospects for India are encouraging as the country continues to privatize state enterprises and increasingly adopts free market policies. In the *IEO2003* reference case, India's GDP is expected to expand by 5.2 percent per year on average between 2001 and 2025.

Economic growth in 2002 was sustained in other countries of developing Asia, with some exceptions. The pillar of economic expansion in the region continues to be consumer demand and exports. Many Asian nations rely on exports to the United States and other industrialized countries for revenues, and the slow economic growth among the nations of the industrialized world has slowed short-term growth in many of the region's developing countries. In particular, electronics exporting countries like Singapore, South Korea, and Taiwan are hoping that a recovery in demand for computer equipment and other electronics in the United States, Japan, and Western Europe will spur their GDP growth in 2003 [26].

Eastern Europe and the Former Soviet Union

Positive GDP growth continued in the transitional economies of the former Soviet Union (FSU) in 2002 but at slower rates than the near double-digit increases that were reported among the region's countries in 2000 and 2001. After the dissolution of the Soviet Union in the early 1990s, the region's GDP fell to \$545 billion (1997 dollars) in 1998, lower than its 1970 level. The FSU region is expected to sustain positive economic growth between 2001 and 2025, with a projected average GDP growth rate of 3.8 percent per year in the *IEO2003* reference case.

Positive economic growth only returned to the FSU in 1999, when high world oil prices and a devalued ruble helped Russia, the region's largest economy, post strong economic gains by boosting performance in its industrial sector and increasing consumer demand for domestically produced goods. In 2002, the Russian ruble continued to gather strength, making it possible for foreign goods to compete with domestic supplies. Household income also continued to improve, strengthening domestic consumer demand. High world oil prices have helped to support the Russian economy, but investors

have expressed fears that without greater transparency and a legal framework that would protect foreign investors, such as production sharing agreements for the energy sector, it will be difficult to attract the levels of foreign financial investment needed to support continued advances in Russia and many of the other former Soviet Republics [27].

As a region, Eastern Europe began to see sustained economic recovery much sooner than did the FSU countries. Most Eastern European countries saw positive GDP growth return by the mid-1990s. Catastrophic floods in August 2002 had strong negative impacts on the important regional economy of the Czech Republic. Also, the slowdown among the economies of the industrialized world dampened some demand for East European goods. Nevertheless, the nations of Eastern Europe are expected to perform modestly well in the near term.

A strong boost for Eastern Europe came in October 2002, when Ireland voted to accept the Nice Treaty, which allows for the expansion of EU membership [28]. Ireland is the only EU member that required a national referendum to approve the treaty (it was rejected by the Irish electorate in a previous referendum). Ten countries are to be invited to join the EU in 2004, including the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, and Slovenia in Eastern Europe, with Bulgaria and Romania to join in 2007. With the accessions expected to begin in 2004, the Eastern European region should begin to benefit from EU membership with increased regional aid, as well as easing of trade restrictions once the EU borders have been expanded. As a result, prospects for the region are expected to remain positive, and its total GDP is projected to expand by an average of 4.2 percent per year through 2025.

Outlook for Primary Energy Consumption

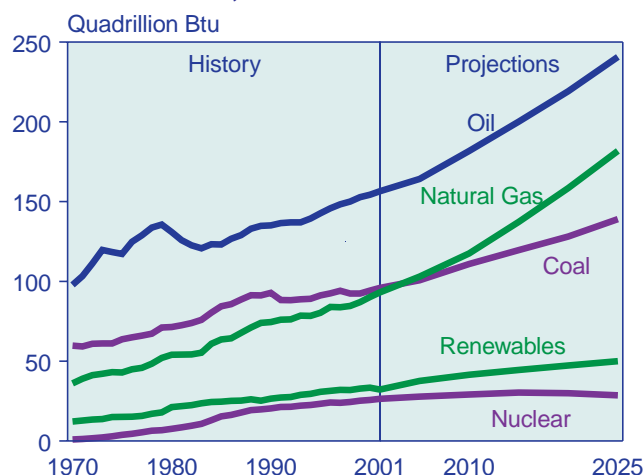
The *IEO2003* reference case projects that consumption of every primary energy source will increase over the 24-year forecast horizon (Figure 15 and Appendix A, Table A2). Much of the increment in future energy demand in the reference case is projected to be for fossil fuels (oil, natural gas, and coal), because it is expected that fossil fuel prices will remain relatively low, and that the cost of generating energy from other fuels will not be competitive. It is possible, however, that as environmental programs or government policies—particularly those designed to limit or reduce greenhouse gas emissions—are implemented, the outlook might change, and non-fossil fuels (including nuclear power and renewable energy sources such as hydroelectricity, geothermal, biomass, solar, and wind power) might become more attractive. The *IEO2003* projections assume that government policies or programs in place as of October 1, 2002, will remain constant over the forecast horizon.

Oil is expected to remain the dominant energy fuel throughout the forecast period, with its share of total world energy consumption falling only slightly from 39 percent in 2001 to 38 percent in 2025. In the industrialized world, increases in oil use are projected primarily in the transportation sector, where there are currently no available fuels to compete significantly with oil products. The *IEO2003* reference case projects declining oil use for electricity generation, with other fuels (especially natural gas) expected to be more favorable alternatives to oil-fired generation.

In the developing world, oil consumption is projected to increase for all end uses. In some countries where non-commercial fuels have been widely used in the past (such as fuel wood for cooking and home heating), diesel generators are now sometimes being used to dissuade rural populations from decimating surrounding forests and vegetation, most notably in Sub-Saharan Africa, Central and South America, and Southeast Asia [29]. Because the infrastructure necessary to expand natural gas use has not been as widely established in the developing world as it has in the industrialized world, natural gas use is expected to grow in the developing world, but not enough to accommodate all of the increase in demand for energy.

Natural gas is projected to be the fastest growing primary energy source worldwide, maintaining growth of 2.8 percent annually over the 2001-2025 period, nearly twice the rate of growth for coal use. Natural gas consumption is projected to rise from 90 trillion cubic feet in 2001 to 176 trillion cubic feet in 2025, primarily to fuel electricity generation. Gas is increasingly seen as the desired option for electric power, given the efficiency of

Figure 15. World Energy Consumption by Energy Source, 1970-2025



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

combined-cycle gas turbines relative to coal- or oil-fired generation, and the fact that it burns more cleanly than either coal or oil, making it a more attractive choice for countries interested in reducing greenhouse gas emissions.

Coal use worldwide is projected to increase by 2.2 billion short tons (at a rate of 1.5 percent per year) between 2001 and 2025. Substantial declines in coal use are projected for Western Europe and the EE/FSU countries, where natural gas is increasingly being used to fuel new growth in electric power generation and for other uses in the industrial and building sectors. In the developing world, however, even larger increases in coal use are expected. The largest increases are projected for China and India, where coal supplies are plentiful. Together these two countries account for 86 percent of the projected rise in coal use in the developing world over the forecast period.

Worldwide, consumption of electricity generated from nuclear power is expected to increase from 2,521 billion kilowatthours in 2001 to 2,737 billion kilowatthours in 2025. Until very recently, nuclear electricity consumption was expected to decline sharply by the end of the forecast. The prospects for nuclear power have been reassessed, however, in light of the higher capacity utilization rates reported for many existing nuclear facilities and the expectation that fewer retirements of existing plants will occur than previously projected. Further, extensions of operating licenses (or the equivalent) for nuclear power plants are expected to be granted among the countries of the industrialized world, slowing the decline in nuclear generation. In many of the industrialized countries, extending the operating life of a nuclear power plant is a decision left primarily to the owner and thus is essentially a question of economic viability. In the *IEO2003* reference case, world nuclear capacity is projected to rise from 353 gigawatts in 2001 to 393 gigawatts in 2015 before falling to 366 gigawatts in 2025 (Figure 16). In contrast, in last year's *IEO*, world nuclear capacity was projected to rise to 363 gigawatts in 2010 and then fall to 359 gigawatts in 2020.

The highest growth in nuclear generation is projected for the developing world, where consumption of electricity from nuclear power is projected to increase by 4.1 percent per year between 2001 and 2025. In particular, developing Asia is expected to see the greatest expansion in new nuclear generating capacity. As of February 2003, the nations of developing Asia accounted for 17 of the 35 reactors currently under construction worldwide, including 8 in India, 4 in China, 2 each in South Korea and Taiwan, and 1 in North Korea [30], accounting for 12 of the 30 gigawatts currently under construction.

Consumption of electricity from hydropower and other renewable energy sources is projected to grow by 1.9

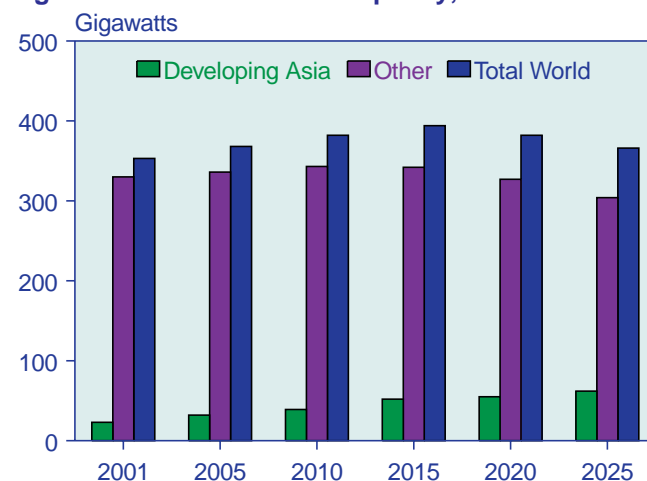
percent annually in the *IEO2003* forecast. With fossil fuel prices projected to remain relatively low in the reference case, renewable energy sources are not expected to be widely competitive, and the renewable share of total energy use is not expected to increase. Over the 2001-2025 forecast horizon, renewables maintain their share of total energy consumption at 8 percent. Moreover, despite the high rates of growth projected for alternative renewable energy sources, such as wind power in Western Europe and biomass and geothermal power in the United States, much of the growth in renewable energy sources will result from large-scale hydroelectric power projects in the developing world, particularly among the nations of developing Asia. China, India, Malaysia, and Vietnam are already constructing or have plans to construct ambitious hydroelectric projects over the projection period.

Outlook for Carbon Dioxide Emissions

World carbon dioxide emissions are expected to increase by 3.8 billion metric tons carbon equivalent over current levels by 2025—growing by 1.9 percent per year—if world energy consumption reaches the levels projected in the *IEO2003* reference case (Figure 17). According to this projection, world carbon dioxide emissions in 2025 would exceed 1990 levels by 76 percent. Oil and natural gas contribute about 1.5 and 1.3 billion metric tons, respectively, to the projected increase from 2001, and coal provides the remaining 1.1 billion metric tons carbon equivalent.

Carbon dioxide emissions from energy use in the industrialized countries are expected to increase by 1.2 billion metric tons carbon equivalent to 4.3 billion metric tons in

Figure 16. World Nuclear Capacity, 2001-2025



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

2025, or by about 1.3 percent per year (Figure 18). Emissions from the combustion of petroleum products account for more than 44 percent of the total increment expected for the industrialized world, and the increase in emissions from natural gas is expected to be more than twice as large as that from coal.

By 2020, carbon dioxide emissions in the developing world (including China and India) are expected to surpass those in the industrialized countries, even though developing countries are projected to use less energy than industrialized countries at that time (Figure 18). Total emissions in developing nations are expected to increase by 2.3 billion metric tons to a total of 4.7 billion metric tons carbon equivalent in 2025, representing about 59 percent of the projected increment worldwide. The sizable rise in emissions among the developing nations is partially a result of their continued heavy reliance on coal, the most carbon-intensive of the fossil fuels. Coal is used extensively in the developing Asia region, which has the highest expected rate of economic and energy growth in the forecast. Carbon dioxide emissions in developing Asia alone are projected to increase from 1.6 billion metric tons carbon equivalent in 2001 to 3.3 billion metric tons in 2025.

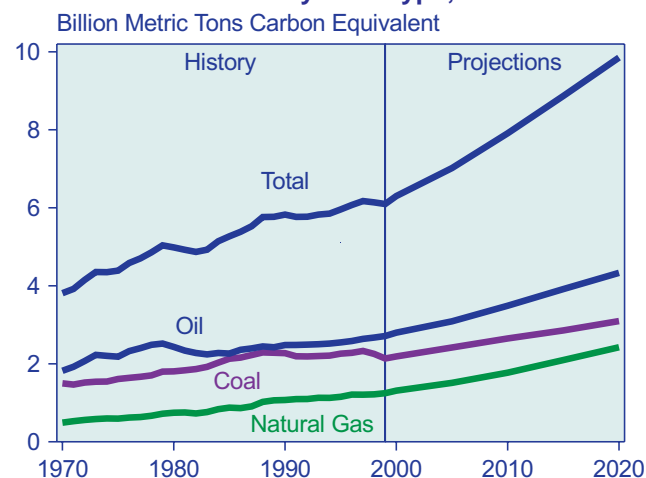
In the EE/FSU region as a whole, carbon dioxide emissions are not expected to return to their Soviet-era levels during the projection period. This year's reference case projection has been revised to reflect the expectation that coal use will not decline as precipitously as was

projected in previous editions of this report, particularly among the FSU countries. The region appears to be in the midst of sustained economic recovery after the political, social, and economic upheavals that followed the breakup of the Soviet Union in the early 1990s. Emissions are not expected to increase as quickly as energy use because of gains in energy efficiency resulting from the replacement of old, inefficient capital stock, and because in many countries in the region natural gas is expected to displace coal, particularly for new electricity generation capacity. The region may also be able to take advantage of its lower emissions levels should a worldwide carbon trading system be enacted in the future.

Worldwide, carbon dioxide emissions per person are projected to increase from about 1.1 metric tons in 1990 to 1.3 metric tons in 2025. Per capita emissions in the industrialized countries remain much higher than those in the rest of the world throughout the projection period, increasing from 3.2 to 3.6 metric tons per person between 1990 and 2010 and then to 4.2 metric tons per person in 2025 in the *IEO2003* reference case (Figure 19).

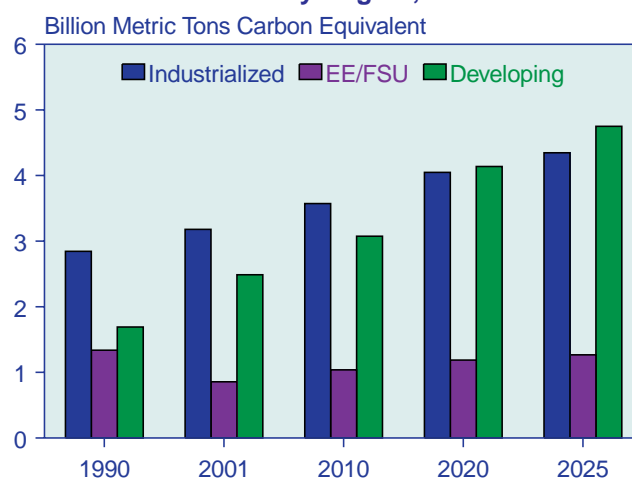
In December 2002 Canada and New Zealand ratified the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) [31]. As of February 24, 2003, 104 countries plus the European Community had ratified the treaty. Thirty of the ratifying nations are the so-called Annex I countries, which are required to limit or reduce their greenhouse gases relative to 1990 levels under the terms of the Protocol.²

Figure 17. World Energy-Related Carbon Dioxide Emissions by Fuel Type, 1970-2025



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

Figure 18. World Energy-Related Carbon Dioxide Emissions by Region, 1990-2025



Sources: **1990 and 2001:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219 (2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2003).

²As of February 24, 2003, the following Annex I countries had ratified, accepted, approved or acceded to the Kyoto Protocol: Austria, Belgium, Bulgaria, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

These 30 countries accounted for around 44 percent of the total Annex I emissions in 1990. The Kyoto Protocol enters into force 90 days after it has been ratified by at least 55 of the parties to the UNFCCC, including a representation of Annex I countries accounting for at least 55 percent of the total 1990 carbon dioxide emissions from the Annex I group. Although the United States had the largest share of Annex I emissions in 1990 at 35 percent, even without U.S. participation the Protocol could enter into force for other signatories. Russia has publicly announced plans to advance ratification of the Kyoto Protocol [32]. Because Russia accounted for 17 percent of the 1990 Annex I carbon dioxide emissions, its ratification would bring the Protocol into force as long as Russia meets the Protocol's requirements for verifying and monitoring emissions levels.

China and India also ratified the Kyoto Protocol in 2002. Although both countries account for significant amounts of the world's carbon dioxide emissions, their ratification does not affect the implementation of the Protocol, because neither country is an Annex I member. In 2001, China and India together accounted for 17 percent of total world carbon dioxide emissions, as compared with the 24-percent share made up by U.S. emissions in 2001.

In the United States, the Bush Administration has introduced initiatives aimed at reducing greenhouse gas intensity as an alternative to the Kyoto Protocol. Under the President's Clear Skies and Global Climate Change Initiatives, the United States will work to reduce greenhouse gas intensity by 18 percent by 2012 [33]. Carbon dioxide intensity is defined as the amount of carbon

dioxide emitted per dollar of GDP. This measurement illustrates the relationship between emissions and the expansion of economic activity. The Administration argues that reducing the amount of greenhouse gases emitted per dollar of GDP will slow the rate of increase in emissions without sacrificing needed economic growth.

World carbon dioxide intensity has improved (decreased) substantially over the past three decades, falling from 302 metric tons carbon equivalent per million 1997 dollars of GDP in 1970 to 202 metric tons per million 1997 dollars in 2001 (Table 3). Although the pace of improvement in emissions intensity is expected to slow over the forecast period, it still continues to improve in the reference case projections, dropping to 154 metric tons per million 1997 dollars in 2025.

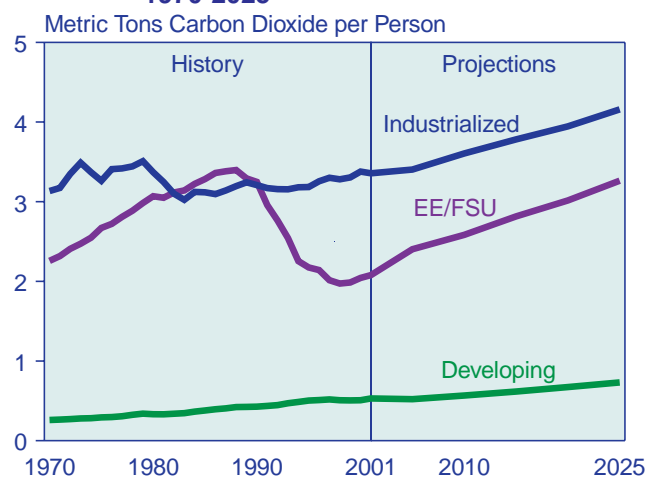
On a regional basis, the most rapid improvements in carbon dioxide intensity are expected to occur among the transitional economies of the EE/FSU and in China and India. In the FSU, economic recovery from the upheaval of the 1990s is expected to continue throughout the forecast. The FSU nations are also expected to replace old and inefficient capital stock and increasingly use less carbon-intensive natural gas for new electricity generation and other end uses rather than the more carbon-intensive oil and coal. Eastern European nations have been in economic recovery longer than has the FSU, and natural gas is expected to continue to displace coal use in the region, resulting in an average 2.8-percent annual improvement (decrease) in carbon intensity for Eastern Europe as a whole.

In developing Asia, fairly rapid improvements in carbon dioxide intensity are expected for China and India over the projection period, primarily as a result of rapid economic growth rather than a switch to less carbon-intensive fuels. Both China and India are projected to remain heavily dependent on fossil fuels, particularly coal, in the *IEO2003* reference case, but their annual GDP growth is projected to average 5.9 percent, compared with an expected 3.4-percent annual rate of increase in fossil fuel use from 2001 to 2025.

Alternative Growth Cases

A major source of uncertainty in the *IEO2003* forecast is the expected rate of future economic growth. *IEO2003* 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 (Figure 20).

Figure 19. Energy-Related Carbon Dioxide Emissions per Capita by Region, 1970-2025



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

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 developing economies. For the industrialized countries, one percentage point is added to the reference case GDP growth rates for the high economic growth case and one percentage point is subtracted from the reference case GDP growth rates for the low economic growth case. Outside the industrialized world and excluding China and the EE/FSU, reference case GDP growth rates are also increased and decreased by 1.0 percentage point to provide the high and low economic growth case estimates.

Because China had particularly high, often double-digit growth in GDP throughout much of the 1990s, it has the potential for a larger downturn in economic growth. In contrast, the EE/FSU region suffered a severe economic

collapse in the early part of the decade and has been trying to recover from it with mixed success. The EE/FSU nations have the potential for substantially higher economic growth if their current political and institutional problems moderate sufficiently to allow the recovery of a considerable industrial base. As a result of these uncertainties, 2.5 percentage points are subtracted from the reference case GDP assumptions for China to form the low economic growth case, and 1.0 percentage point is added to the reference case to form the high economic growth case. For the EE/FSU region, 1.0 percentage point is subtracted from the reference case assumptions to derive the low economic growth case, and 2.5 percentage points are added for the high economic growth case.

The *IEO2003* reference case shows total world energy consumption reaching 640 quadrillion Btu in 2025, with the industrialized world projected to consume 288

Table 3. World Carbon Dioxide Intensity by Selected Countries and Regions, 1970-2025
(Metric Tons Carbon Equivalent per Million 1997 U.S. Dollars)

Region	History				Projections				Average Annual Percent Change	
	1970	1980	1990	2001	2005	2010	2020	2025	1970-2001	2001-2025
Industrialized Countries										
North America										
United States	315	258	198	166	154	144	124	116	-2.0	-1.5
Canada	346	297	232	209	203	190	157	146	-1.6	-1.5
Mexico	183	225	253	213	212	193	169	161	+0.5	-1.1
Western Europe										
United Kingdom	223	191	143	104	95	88	77	73	-2.4	-1.5
France	146	132	79	68	61	55	49	48	-2.4	-1.4
Germany	233	194	144	98	90	83	70	67	-2.8	-1.5
Italy	133	120	105	96	89	84	72	67	-1.0	-1.5
Netherlands	213	211	181	158	142	134	111	101	-1.0	-1.9
Industrialized Asia										
Japan	125	105	73	72	69	65	59	57	-1.7	-1.0
Australia/New Zealand	323	216	210	199	189	180	155	148	-1.5	-1.2
EE/FSU										
Former Soviet Union	897	977	1,027	1,000	1,012	862	691	621	+0.4	-2.0
Eastern Europe	975	1,013	864	518	430	380	291	261	-2.0	-2.8
Developing Countries										
Asia										
China	2,646	2,241	1,445	693	555	506	400	363	-4.2	-2.7
India	471	538	571	480	425	386	313	285	+0.1	-2.1
South Korea	255	282	215	217	185	169	147	137	-0.5	-1.9
Middle East	364	410	608	610	545	520	463	442	+1.7	-1.3
Africa	352	380	442	373	341	303	268	254	+0.2	-1.6
Central and South America	188	168	169	175	173	161	145	137	-0.2	-1.0
Total World	302	276	241	202	190	180	161	154	-1.3	-1.1

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

quadrillion Btu, the transitional EE/FSU countries 82 quadrillion Btu, and the developing world 270 quadrillion Btu. In the high economic growth case, total world energy use in 2025 is projected to be 763 quadrillion Btu, 123 quadrillion Btu (or 62 million barrels of oil equivalent) higher than in the reference case (Figure 21). Under the assumptions of the low economic growth case, worldwide energy consumption in 2025 would be 98 quadrillion Btu (or 49 million barrels of oil equivalent) lower than in the reference case, at 542 quadrillion Btu. Thus, there is a substantial range of 221 quadrillion Btu, or about one-third of the total consumption projected for 2025 in the reference case, between the projections in the high and low economic growth cases. Corresponding to the range of the energy consumption forecasts, carbon dioxide emissions in 2025 are projected to total 8.6 billion metric tons carbon equivalent in the low economic growth case (1.8 billion metric tons less than the reference case projection of 10.4 billion metric tons carbon equivalent) and 12.4 billion metric tons carbon equivalent in the high economic growth case (2.0 billion metric tons higher than the reference case projection).

Trends in Energy Intensity

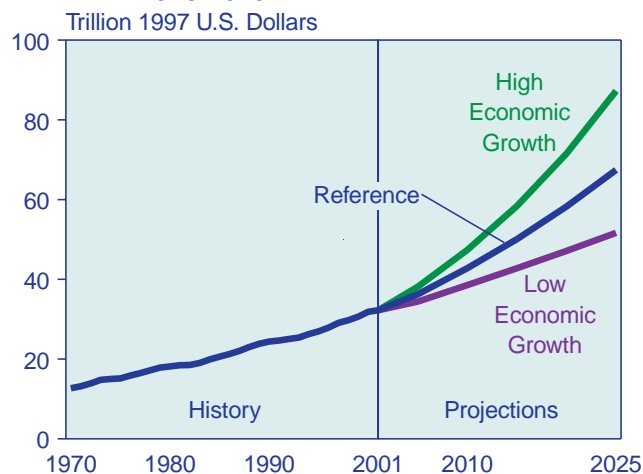
Another major source of uncertainty surrounding a long-term forecast is the relationship of energy use to GDP over time. Economic growth and energy demand are linked, but the strength of that link varies among regions and their stages of economic development. In industrialized countries, history shows the link to be a relatively weak one, with energy demand lagging behind economic growth. In developing countries,

demand and economic growth have been more closely correlated in the past, with energy demand growth tending to track the rate of economic expansion.

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 industrialized or the developing countries. In the FSU, however, energy consumption grew more quickly than GDP until 1990, 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. Over the forecast horizon, energy intensity is expected to decline in the region as the EE/FSU nations continue to recover from the economic and social problems of the early 1990s. Still, energy intensity in the EE/FSU is expected to be more than double that in the developing world and five times that in the industrialized world in 2025 (Figure 22).

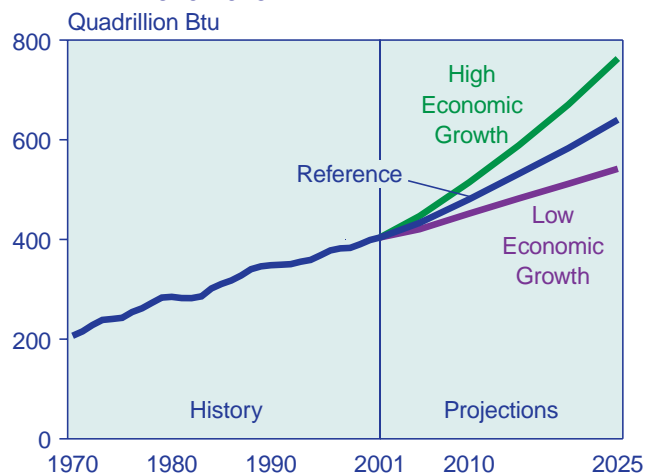
The stage of economic development and the standard of living of individuals in a given region strongly influence the link between economic growth and energy demand. Advanced economies with high living standards have a relatively high level of energy use per capita, but they also tend to be economies where per capita energy use is stable or changes very slowly. In the industrialized countries, 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 not purchases of new equipment to replace old capital stock. The new stock is often more efficient than

Figure 20. World Gross Domestic Product in Three Economic Growth Cases, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** Global Insight, Inc., *World Economic Outlook*, Vol. 1 (Lexington, MA, Third Quarter 2002); and EIA, System for the Analysis of Global Energy Markets (2003).

Figure 21. World Energy Consumption in Three Economic Growth Cases, 1970-2025



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

the equipment it replaces, resulting in a weaker link between income and energy demand.

Changing growth patterns of energy intensity could have dramatic impacts on energy consumption in the projection period, particularly among the developing countries. For instance, if energy intensities in each of the developing countries are assumed to improve (decline) annually by a percentage equal to the single greatest annual improvement recorded between 1990 and 2000, energy intensity in the developing world as a whole would fall by 74 percent between 2001 and 2025. Historically, the average of the largest single-year improvements in energy intensity for each of the developing nations has been 5 percent, and the single-year improvements for individual developing countries have ranged from 9 percent (China) to 1 percent (Brazil). If energy intensity in each of the developing countries improved annually over the forecast period at the highest historical rate of improvement recorded for each country in a single year, their combined energy consumption in 2025 would be 105 quadrillion Btu, as compared with the reference case projection of 270 quadrillion Btu.

If, on the other hand, energy intensity in each of the developing countries changed annually at the lowest historical rate of improvement (or the highest rate of worsening) recorded for a single year from 1990 to 2000, energy intensity in the developing world as a whole would increase (worsen) by 169 percent between 2001 and 2025. Historically, the average of the largest single-year increases in energy intensity for each of the

developing nations (including the smallest historical decreases in countries where energy intensity has improved every year) has been 4 percent, ranging from an increase of 10 percent (South Korea) to a decrease of 4 percent (China). If energy intensity in each of the developing countries worsened (increased) annually over the forecast period at the highest historical rate recorded for each country in a single year (or improved by the lowest rate recorded for each country where energy intensity has improved every year), their combined energy consumption in 2025 would be 1,078 quadrillion Btu—68 percent higher than the reference case projection.

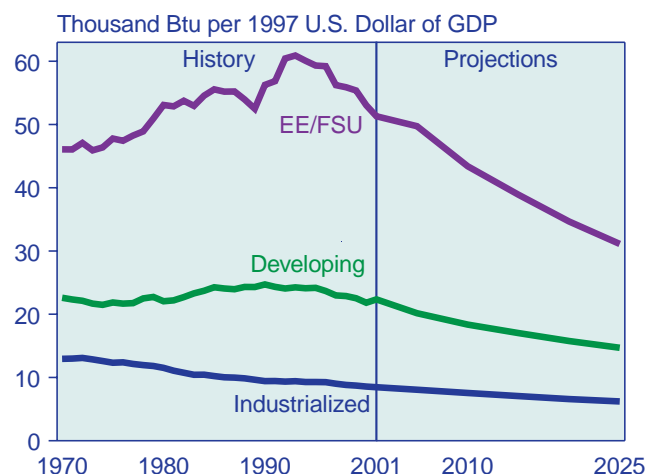
Forecast Comparisons

Three organizations provide forecasts comparable to those in *IEO2003*. The International Energy Agency (IEA) provides “business as usual” projections to the year 2030 in its *World Energy Outlook 2002*. Petroleum Economics, Ltd. (PEL) and Petroleum Industry Research Associates (PIRA) publish world energy forecasts to the year 2015. For this comparison, 2000 is used as the base year for all the forecasts (because IEA does not publish data for any other historical years), and the comparisons extend only to 2020. Although IEA’s forecast extends to 2030, it does not publish a projection for 2025.

Regional breakouts among the forecasting groups vary, complicating the comparisons. For example, *IEO2003* includes Mexico in North America and IEA includes Mexico in Organization for Economic Cooperation and Development (OECD) North America, but the two other forecasts include Mexico in Latin America. As a result, for purposes of this comparison, Mexico has been removed from North America in the *IEO2003* projections and added to Central and South America to form a “Latin America” country grouping that matches the other series. PIRA includes only Japan in industrialized Asia, whereas industrialized Asia in the *IEO2003* forecast comprises Japan, Australia, and New Zealand. *IEO2003* includes Turkey in the Middle East, but IEA includes Turkey, as well as the Czech Republic, Hungary, and Poland, 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, and Poland in Eastern Europe, as does *IEO2003*. Although most of the differences involve fairly small countries, they contribute to the variations among the forecasts.

All the forecasts provide projections out to the year 2010 (Table 4). The growth rates for energy consumption among the reference case forecasts for the 2000-2010 time period are similar, ranging between 1.9 and 2.1 percent per year. All the forecasts for total energy consumption fall well within the range of variation defined by the

Figure 22. World Energy Intensity by Region, 1970-2020



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

IEO2003 low and high economic growth cases; in fact, all are within a range of 0.2 percentage points around the *IEO2003* reference case.

The regions for which the largest variations are seen among the forecasts are the Middle East and Africa, with more moderate differences in the projections for Latin America, developing Asia, and the EE/FSU. For both the Middle East and Africa the projected average annual growth rates vary by 1.4 percentage points among the reference case forecasts. For the Middle East, *IEO2003* projects the lowest growth in energy demand in the region at 2.3 percent per year between 2000 and 2010. PEL projects the highest average growth for the Middle East in the 2000-2010 period, at 3.7 percent per year. The PEL and PIRA projections exceed the upper range defined by the *IEO2003* high economic growth case, demonstrating the great uncertainties among the forecasts about the political and economic future of this region in the next decade. For Africa, *IEO2003* also projects the slowest growth in energy use between 2000 and 2010 at 1.9 percent per year, and IEA projects the highest growth rate at 3.3 percent per year. Both the IEA and PEL projections are higher than the *IEO2003* high economic growth case estimate of 2.6 percent per year.

For Latin America, the projected growth rates for the 2000 to 2010 time period vary by 0.9 percentage points

among the forecasts, ranging from 2.1 percent per year (PIRA) to 3.0 percent per year (IEA). Only the IEA forecast exceeds the *IEO2003* high economic growth case estimate of 2.6 percent. Projections for the EE/FSU differ by a range of 0.8 percentage points, varying from 1.7-percent annual growth in energy demand between 2000 and 2010 (PEL) to 2.5 percent per year (PIRA). The *IEO2003* reference case projects that energy use in the EE/FSU will increase by 2.3 percent per year over the period.

IEO2003, PIRA, and PEL provide forecasts for energy use in 2015, the end of the PEL and PIRA forecast horizons (Table 5), and their projections for worldwide growth in energy consumption between 2000 and 2015 are similar, ranging from 1.9 percent per year (PEL) to 2.2 percent per year (PIRA), with *IEO2003* expecting average annual growth of 2.0 percent. Regionally, however, there are some differences in the expectations for growth in energy demand, particularly in the industrialized world. Both PIRA and PEL are much more pessimistic about economic expansion in industrialized Asia. PEL expects Japan, Australia, and New Zealand to experience almost no growth in energy use over the 2000-2015 period (0.2 percent per year), whereas *IEO2003* projects 1.2-percent annual growth. The PEL forecast falls well below the lower bound of 0.6 percent per year defined by the *IEO2003* low economic growth case.

Table 4. Comparison of Energy Consumption Growth Rates by Region, 2000-2010
(Average Annual Percent Growth)

Region	<i>IEO2003</i>			<i>IEO2002</i>	IEA	PIRA	PEL
	Low Growth	Reference	High Growth				
Industrialized Countries	0.8	1.1	1.6	1.0	1.1	1.0	1.0
United States and Canada	1.1	1.3	1.7	1.2	1.1	1.0	1.2
Western Europe	0.2	0.8	1.3	0.9	1.1	1.1	1.0
Pacific	0.6	1.2	1.8	0.9	1.2	0.7 ^a	0.5
EE/FSU	1.9	2.4	3.9	1.7	1.8	2.5	1.7
Former Soviet Union	2.2	2.6	4.2	1.7	—	—	1.8
Eastern Europe	0.9	1.5	3.1	1.7	—	—	1.2
Developing Countries	1.7	2.7	3.4	2.9	3.2	3.9	3.4
Asia	1.9	3.2	3.9	4.3	3.4	3.9	3.7
China	2.1	3.9	4.6	5.3	3.2	4.4	4.0
Other Asia ^b	1.7	2.5	3.3	3.5	3.6	3.5	3.5
Middle East	1.4	2.1	3.0	3.0	2.8	3.3	3.7
Africa	1.2	1.9	2.6	2.5	3.3	2.6	2.7
Latin America	1.7	2.2	2.6	2.7	3.0	2.1	2.4
Total World	1.3	1.9	2.6	2.2	1.9	2.1	2.0

^aJapan only.

^bOther Asia includes India and South Korea.

Sources: **IEO2003**: Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2003). **IEO2002**: EIA, *International Energy Outlook 2002*, DOE/EIA-0484(2002) (Washington, DC, March 2002), Table A1, p. 179. **IEA**: International Energy Agency, *World Energy Outlook 2002* (Paris, France, September 2002), pp. 410-497. **PIRA**: PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2002), Tables 11-4, 11-6, and 11-7. **PEL**: Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, June 2002), Table 2i.

IEO2003 and IEA provide energy consumption projections for 2020 (Table 6). IEA projects slightly slower growth in world energy demand over the 2000-2020 period. In particular, expectations for demand growth in the United States and Canada are lower in the IEA

forecast than in the *IEO2003* reference case. *IEO2003* also expects a higher growth rate in consumption for the EE/FSU over this time period, at 1.9 percent per year compared with the IEA forecast of 1.5 percent per year. On the other hand, IEA foresees much stronger growth

Table 5. Comparison of Energy Consumption Growth Rates by Region, 2000-2015
(Average Annual Percent Growth)

Region	<i>IEO2003</i>			<i>IEO2002</i>	PIRA	PEL
	Low Growth	Reference	High Growth			
Industrialized Countries	0.8	1.1	1.6	1.2	1.0	0.5
United States and Canada	1.1	1.4	1.7	1.5	1.1	1.1
Western Europe	0.2	0.7	1.3	0.9	0.9	0.8
Pacific	0.6	1.2	1.8	0.9	0.7	0.2
EE/FSU	1.6	2.1	3.5	1.8	2.5	1.7
Former Soviet Union	1.8	2.3	3.6	1.8	—	1.8
Eastern Europe	1.0	1.6	3.4	1.7	—	1.2
Developing Countries	1.8	2.9	3.6	3.8	3.4	3.2
Asia	2.0	3.3	4.0	4.2	3.8	3.5
China	2.1	3.9	4.5	5.0	4.2	3.5
Other Asia ^a	1.9	2.7	3.6	3.4	3.6	3.4
Middle East	1.3	2.3	3.2	3.0	3.3	3.3
Africa	1.3	2.0	2.7	2.6	2.5	2.6
Latin America	1.9	2.6	3.1	3.8	2.3	2.7
Total World	1.3	1.9	2.6	2.3	2.2	1.9

^aOther Asia includes India and South Korea.

Sources: *IEO2003*: Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2003). *IEO2002*: EIA, *International Energy Outlook 2002*, DOE/EIA-0484(2002) (Washington, DC, March 2002), Table A1, p. 179. **PIRA**: PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2002), Tables II-4, II-6, and II-7. **PEL**: Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, June 2002), Table 2i.

Table 6. Comparison of Energy Consumption Growth Rates by Region, 2000-2020
(Average Annual Percent Growth)

Region	<i>IEO2003</i>			<i>IEO2002</i>	IEA
	Low Growth	Reference	High Growth		
Industrialized Countries	0.7	1.1	1.6	1.2	1.0
United States and Canada	1.1	1.4	1.7	1.4	1.1
Western Europe	0.2	0.7	1.4	0.9	0.9
Pacific	0.6	1.1	1.7	0.9	1.0
EE/FSU	1.2	1.9	3.3	1.7	1.5
Former Soviet Union	1.4	2.0	3.2	1.7	—
Eastern Europe	0.8	1.8	3.6	1.7	—
Developing Countries	1.9	2.9	3.7	3.7	3.1
Asia	2.0	3.2	4.0	4.0	3.1
China	2.1	3.8	4.5	4.8	3.0
Other Asia ^a	1.9	2.7	3.6	3.2	3.3
Middle East	1.5	2.3	3.3	2.9	2.5
Africa	1.4	2.1	2.8	2.6	3.4
Latin America	2.1	2.7	3.3	3.8	2.9
Total World	1.2	1.9	2.6	2.2	1.8

^aOther Asia includes India and South Korea.

Sources: *IEO2003*: Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2003). *IEO2002*: EIA, *International Energy Outlook 2002*, DOE/EIA-0484(2002) (Washington, DC, March 2002), Table A1, p. 179. **IEA**: International Energy Agency, *World Energy Outlook 2002* (Paris, France, September 2002), pp. 410-497.

in Africa's energy consumption, projecting 3.4-percent average annual growth between 2000 and 2020, well in excess of the *IEO2003* high economic growth case projection of 2.8 percent per year.

Finally, the projections vary not only with respect to levels of total energy demand but also with respect to the composition of primary energy inputs. All the forecasts provide energy consumption projections by fuel in 2010 (Table 7). In terms of oil consumption, all the forecasts expect similar growth worldwide between 2000 and 2010. Oil demand is projected to increase by between 1.5 percent per year (*IEO2003*) and 1.8 percent per year (PIRA). All the forecasts expect natural gas use to grow more rapidly than other fuels between 2000 and 2010 and nuclear power to grow more slowly than any other fuel. The projections for growth in coal use vary among the forecasts, from 1.4 percent per year (PEL and IEA) to 2.2 percent per year (PIRA), with *IEO2003* projecting 1.6-percent average annual growth from 2000 to 2010. Although IEA projects the slowest growth among the forecasts for coal, it projects the highest growth rate for renewable energy sources (2.8 percent per year), making up for any shortfall in projected coal use.

PEL, PIRA, and *IEO2003* provide world energy consumption projections by fuel for 2015 (Table 8). The three forecasts offer similar views of the future use of natural gas, which is the fastest growing primary fuel type for each forecast between 2000 and 2015, ranging from 2.8 percent per year (*IEO2003*) to 3.3 percent per year (PIRA). In all the forecasts, the slowest growth is projected for nuclear power. The *IEO2003* reference case projection for growth in nuclear power consumption, at 1.1 percent per year, is higher than the two other forecasts (PEL, 0.3 percent per year and PIRA, 0.4 percent per year).

IEO2003 and IEA are the only forecasts that provide projections for 2020 (Table 9). The IEA forecast shows slower projected growth than the *IEO2003* forecast for every fuel type except renewable energy; however, the overall trends are similar in the two forecasts, with growth in natural gas use expected to exceed that for oil and coal and nuclear power expected to be the slowest growing energy source over the 2000-2020 time period.

Table 7. Comparison of World Energy Consumption Growth Rates by Fuel, 2000-2010
(Average Annual Percent Growth)

Fuel	<i>IEO2003</i>			<i>IEO2002</i>	IEA	PIRA	PEL
	Low Growth	Reference	High Growth				
Oil	0.8	1.5	2.3	2.2	1.7	1.8	1.6
Natural Gas	2.1	2.5	3.4	3.0	3.0	3.2	3.3
Coal	0.7	1.7	2.4	1.9	1.4	2.2	1.4
Nuclear	1.3	1.3	1.5	0.7	1.1	0.5	0.9
Renewable/Other	2.2	2.4	2.6	2.1	2.8	1.5	2.2
Total	1.3	1.9	2.6	2.2	1.9	2.1	2.0

Sources: *IEO2003*: Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2003). *IEO2002*: EIA, *International Energy Outlook 2002*, DOE/EIA-0484(2002) (Washington, DC, March 2002), Table A1, p. 179. *IEA*: International Energy Agency, *World Energy Outlook 2002* (Paris, France, September 2002), pp. 410-497. *PIRA*: PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2002), Table 11-8. *PEL*: Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, June 2002), Table 2i.

Table 8. Comparison of World Energy Consumption Growth Rates by Fuel, 2000-2015
(Average Annual Percent Growth)

Fuel	<i>IEO2003</i>			<i>IEO2002</i>	PIRA	PEL
	Low Growth	Reference	High Growth			
Oil	0.9	1.7	2.5	2.2	1.8	1.6
Natural Gas	2.2	2.8	3.5	3.1	3.3	3.2
Coal	0.7	1.6	2.2	1.8	2.2	1.1
Nuclear	1.0	1.1	1.6	0.5	0.4	0.3
Renewable/Other	1.9	2.1	2.5	2.2	1.7	2.3
Total	1.3	1.9	2.6	2.2	2.2	1.9

Sources: *IEO2003*: Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2003). *IEO2002*: EIA, *International Energy Outlook 2002*, DOE/EIA-0484(2002) (Washington, DC, March 2002), Table A1, p. 179. *PIRA*: PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2002), Table 11-8. *PEL*: Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, June 2002), Table 2i.

Table 9. Comparison of World Energy Consumption Growth Rates by Fuel, 2000-2020
(Average Annual Percent Growth)

Fuel	IEO2003			IEO2002	IEA
	Low Growth	Reference	High Growth		
Oil	1.0	1.7	2.6	2.2	1.7
Natural Gas	2.3	2.8	3.5	3.1	2.7
Coal	0.6	1.6	2.2	1.8	1.4
Nuclear	0.7	0.8	1.3	0.4	0.3
Renewable/Other	1.6	1.9	2.4	2.1	2.7
Total	1.3	1.9	2.6	2.2	1.8

Sources: **IEO2003**: Energy Information Administration (EIA), System for the Analysis of Global Energy Markets (2003). **IEO2002**: EIA, *International Energy Outlook 2002*, DOE/EIA-0484(2002) (Washington, DC, March 2002), Table A1, p. 179. **IEA**: International Energy Agency, *World Energy Outlook 2002* (Paris, France, September 2002), p. 410.

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 19-year history of the series, we present a comparison of IEO forecasts produced for the years 1990, 1995, and 2000. The forecasts are compared with actual data published in EIA's *International Energy Annual 2001*, 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, mid-term 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), 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 10). In the first edition of the report, IEO85, projections were made for 1990 and 1995. IEO86 saw the 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 and this year the IEO2003 forecast extends to 2025 for the first time.

Table 10. Years Included in IEO Projections by Edition, 1985-2003

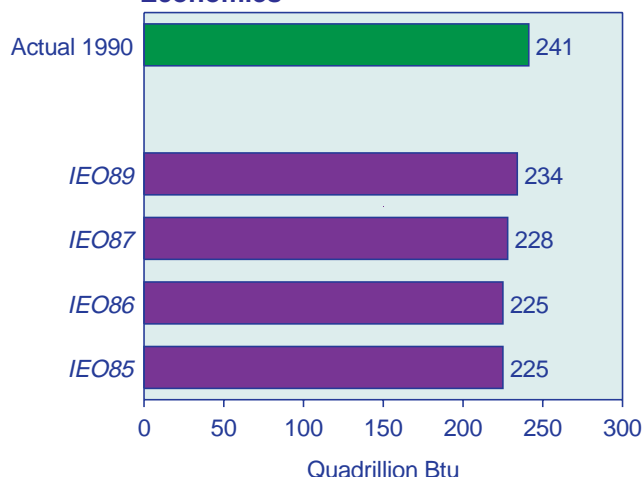
Edition	1990	1995	2000	2005	2010	2015	2020	2025
IEO85	x	x						
IEO86	x	x	x					
IEO87	x	x	x					
IEO89	x	x	x					
IEO90		x	x		x			
IEO91		x	x		x			
IEO92		x	x		x			
IEO93		x	x		x			
IEO94			x	x	x			
IEO95			x	x	x			
IEO96		x	x	x	x	x		
IEO97			x	x	x	x		
IEO98			x	x	x	x	x	
IEO99			x	x	x	x	x	
IEO2000 ..				x	x	x	x	
IEO2001 ..				x	x	x	x	
IEO2002 ..				x	x	x	x	
IEO2003 ..				x	x	x	x	x

Sources: Energy Information Administration, *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Comparisons of Forecasts for Market Economies

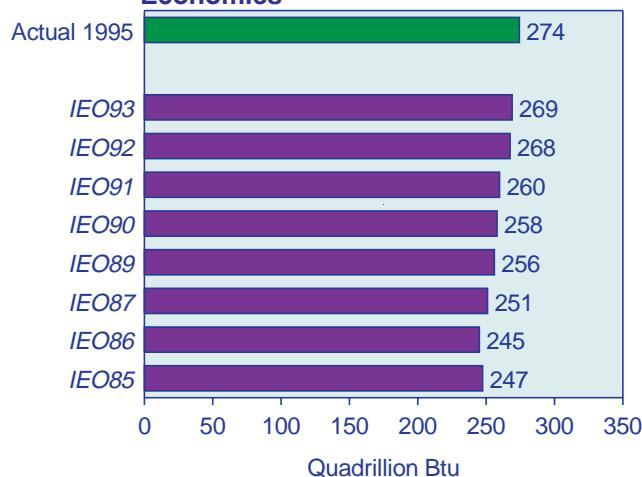
Projections for market economies were made in the eight issues of the *IEO* that were published between 1985 and 1993 (no *IEO* was published in 1988). Historical data for total regional energy consumption in 1990 show that the *IEO* projections from those early years were consistently lower than the 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

Figure 23. Comparison of *IEO* Forecasts with 1990 Energy Consumption in Market Economies



Sources: Energy Information Administration, *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure 24. Comparison of *IEO* Forecasts with 1995 Energy Consumption in Market Economies



Sources: Energy Information Administration, *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

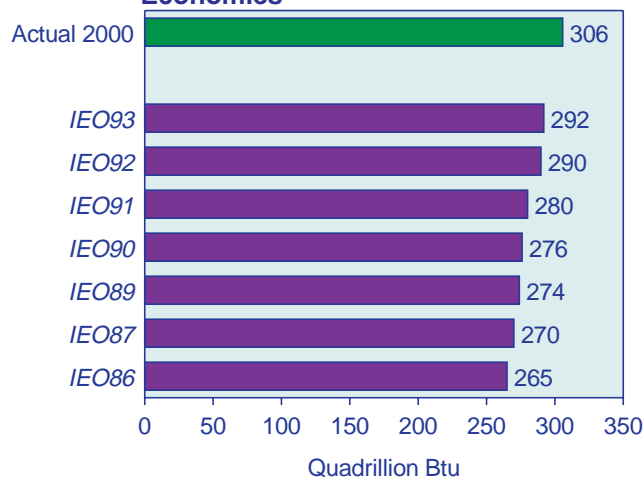
projected energy consumption in the market economies ran between 3 and 7 percent below the actual amounts published in the *International Energy Annual 2000* (Figure 23).

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 24). 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 25). The consumption estimates for the market economies increased in each edition, from 265 quadrillion Btu in *IEO86* to 292 quadrillion Btu in *IEO93*. Even as late 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

Figure 25. Comparison of *IEO* Forecasts with 2000 Energy Consumption in Market Economies



Sources: Energy Information Administration, *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

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.”

Comparisons of Forecasts for Year 1995

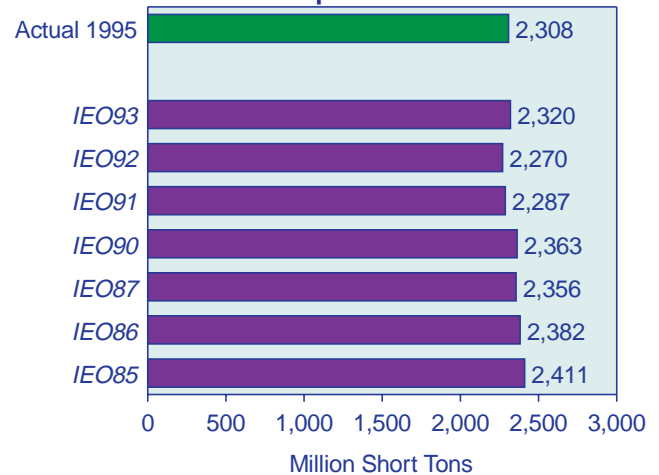
IEO90 marked the first release of a worldwide energy consumption forecast. In *IEO90* through *IEO93*, the forecasts for worldwide energy demand in 1995 were between 1 and 4 percent higher than the actual amounts consumed (Figure 26). Much of the difference can be explained by the unanticipated collapse 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 3.5 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 27) 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 28). The *IEO85* and *IEO86* reports projected that

oil would account for only about 40 percent of total energy consumption for the market economies in 1995, whereas oil actually accounted for 45 percent of the total in 1995.

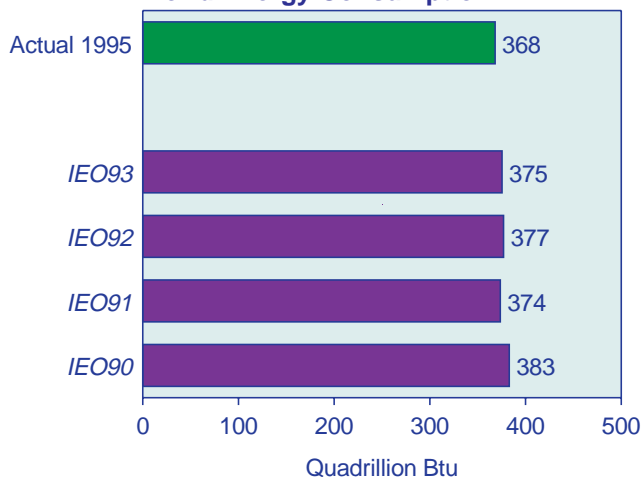
The 1995 forecasts for world coal consumption that appeared in the *IEOs* printed between 1990 and 1993 were consistently high, between 3 and 19 percent higher than actual coal use (Figure 29), largely because of overestimates for the FSU and Eastern Europe—regions that experienced substantial declines in coal consumption

Figure 27. Comparison of *IEO* Forecasts with 1995 Coal Consumption in Market Economies



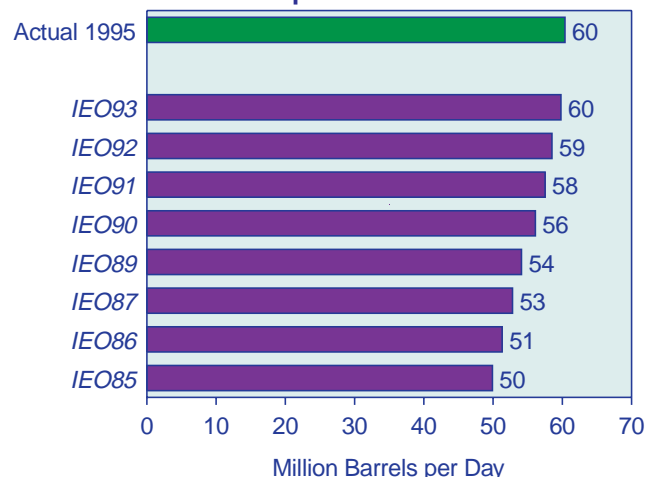
Sources: Energy Information Administration, *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure 26. Comparison of *IEO* Forecasts with 1995 World Energy Consumption



Sources: Energy Information Administration, *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure 28. Comparison of *IEO* Forecasts with 1995 Oil Consumption in Market Economies

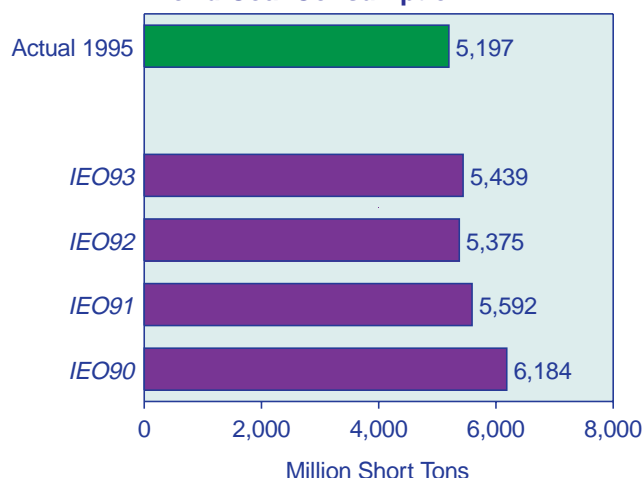


Sources: Energy Information Administration, *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

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 30). Natural gas use did not decline as much as oil and coal use, because 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 16 to 22 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 for the 30- to 54-percent overestimate of FSU coal use. In terms of other fuels, the *IEO* forecasts consistently overestimated China's gas consumption and underestimated its oil consumption. Nuclear power forecasts were fairly close for China, within 5 percent of the actual consumption (Figure 31). 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.

Figure 29. Comparison of *IEO* Forecasts with 1995 World Coal Consumption

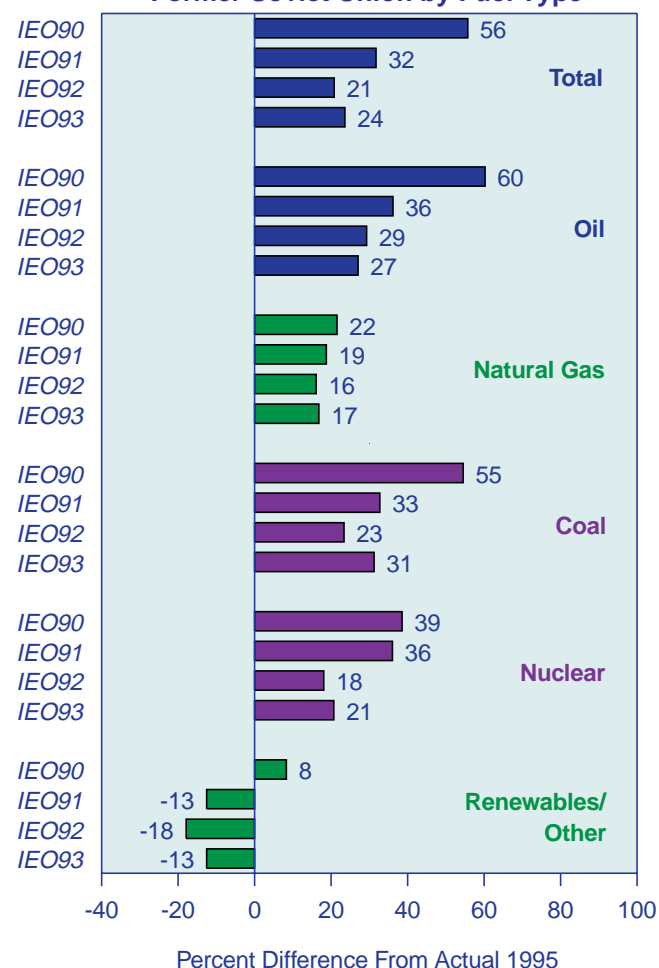


Sources: Energy Information Administration, *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

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 32). *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 developing Asia by 10 quadrillion Btu, or about 14 percent (Figure 33) and in industrialized Asia by 2 quadrillion Btu (8 percent). 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

Figure 30. Comparison of *IEO* Forecasts with 1995 Energy Consumption in the Former Soviet Union by Fuel Type



Sources: Energy Information Administration, *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

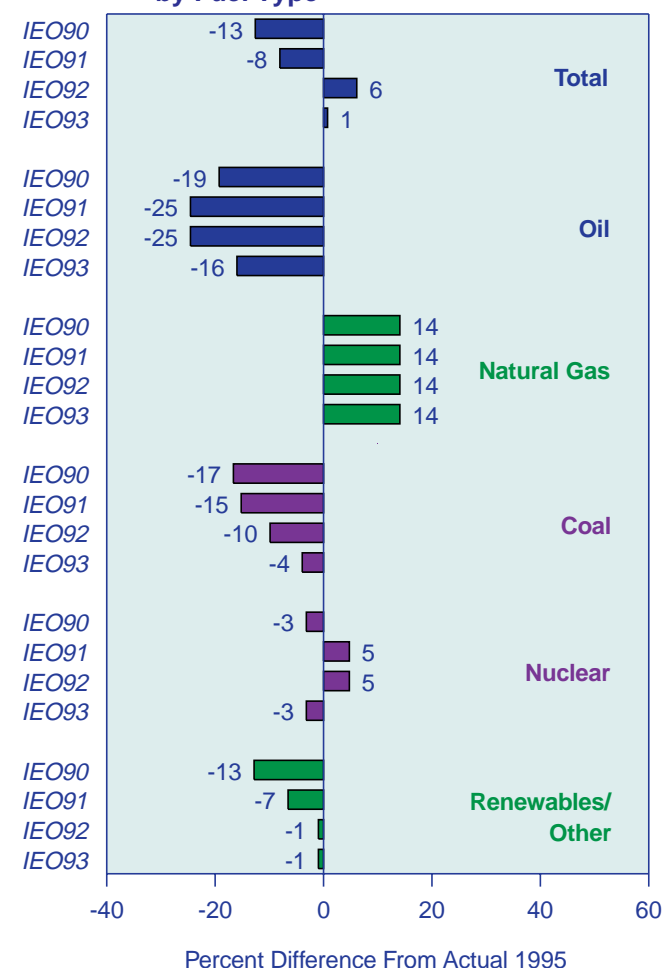
energy consumption by 7 quadrillion Btu (13 percent). *IEO97* did not anticipate the August 1998 devaluation of the Russian ruble and economic recession that followed in the FSU region. By *IEO99*, total EE/FSU energy use had been adjusted downward to 52 quadrillion Btu—just slightly lower than the region’s 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 12 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 2,904. 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 2,211 million short tons.

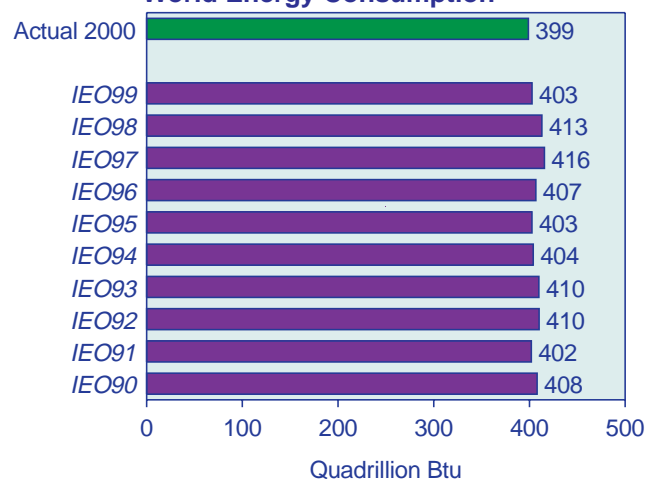
Much of the discrepancy between the *IEO90* projection and actual 2000 coal consumption can be attributed to

Figure 31. Comparison of *IEO* Forecasts with 1995 Energy Consumption in China by Fuel Type



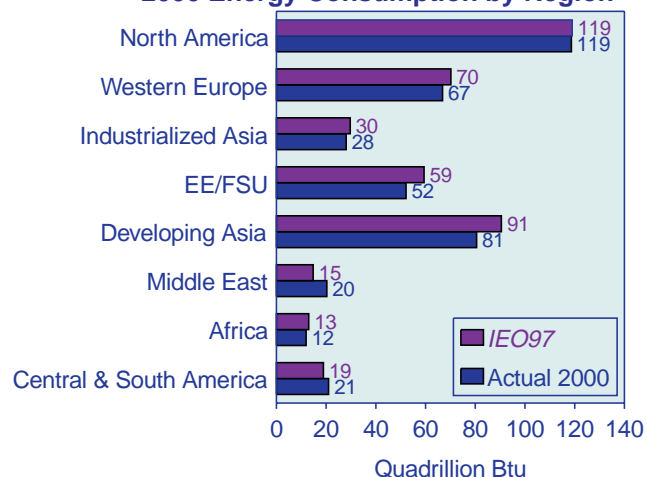
Sources: Energy Information Administration, *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure 32. Comparison of *IEO* Forecasts with 2000 World Energy Consumption



Sources: Energy Information Administration, *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/, and *International Energy Outlook*, DOE/EIA-0484 (Washington, DC, various years).

Figure 33. Comparison of *IEO97* Forecasts with 2000 Energy Consumption by Region



Sources: Energy Information Administration, *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/, and *International Energy Outlook 1997*, DOE/EIA-0484(97) (Washington, DC, April 1997).

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 421 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 157 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 Eastern Europe and the 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 used as a plausible path or trend for the future and not as a precise prediction of future events.

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