

Highlights

World energy consumption is projected to increase by 59 percent from 1999 to 2020. Much of the growth in worldwide energy use is expected in the developing world in the IEO2001 reference case forecast.

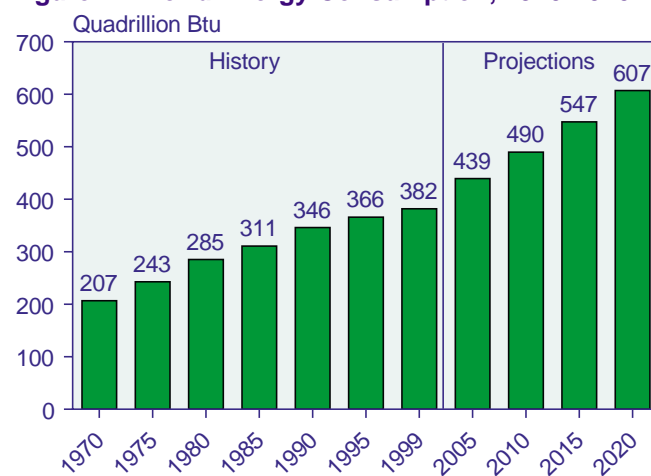
In the reference case projections for the *International Energy Outlook 2001 (IEO2001)*, world energy consumption is projected to increase by 59 percent over a 21-year forecast horizon, from 1999 to 2020. Worldwide energy use grows from 382 quadrillion British thermal units (Btu) in 1999 to 607 quadrillion Btu in 2020 (Figure 2 and Table 1). Many developments in 2000 influenced this year's outlook, including persistently high world oil prices, stronger than anticipated economic recovery in southeast Asia, and robust economic growth in the former Soviet Union that has been sustained for two consecutive years—the first time this has occurred since the collapse of the Soviet regime.

Much of the growth in worldwide energy use is expected in the developing world in the reference case forecast (Figure 3). In particular, energy demand in developing Asia and Central and South America is projected to more than double between 1999 and 2020. Both of these regions are expected to sustain energy demand growth of about 4 percent annually throughout the forecast, accounting for more than one-half of the total projected increment in world energy consumption and 81 percent of the increment for the developing world alone.

World oil prices have been extremely volatile for the past 3 years (Figure 4). In 1998, consumers benefited from oil prices that fell to \$10 per barrel—a result of oversupply caused by lower demand for oil both in southeast Asia, which was suffering from an economic recession, and in North America and Western Europe

because of warmer than expected winters. In 2000, however, world oil prices rebounded strongly, reaching a daily peak of \$37 per barrel, rates not seen since the Persian Gulf War of 1990-1991. The high prices can be traced to a tightening of production by the Organization of Petroleum Exporting Countries (OPEC) and several key non-OPEC countries (Russia, Mexico, Oman, and Norway) and a reluctance by oil companies to commit capital to major development efforts for fear of a return

Figure 2. World Energy Consumption, 1970-2020



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

Table 1. Energy Consumption and Carbon Emissions by Region, 1990-2020

Region	Energy Consumption (Quadrillion Btu)				Carbon Dioxide Emissions (Million Metric Tons Carbon Equivalent)			
	1990	1999	2010	2020	1990	1999	2010	2020
Industrialized	182.4	209.6	243.4	270.4	2,842	3,122	3,619	4,043
EE/FSU	76.3	50.5	60.3	72.3	1,337	810	940	1,094
Developing								
Asia	51.0	70.9	113.4	162.2	1,053	1,361	2,137	3,013
Middle East	13.1	19.3	26.9	37.2	231	330	451	627
Africa	9.3	11.8	16.1	20.8	179	218	294	373
Central and South America . .	13.7	19.8	29.6	44.1	178	249	394	611
Total	87.2	121.8	186.1	264.4	1,641	2,158	3,276	4,624
Total World	346.0	381.8	489.7	607.1	5,821	6,091	7,835	9,762

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

to low prices, in concert with unexpectedly strong demand recovery in the recovering economies of Asia. Unrest in the Middle East has also exacerbated the price volatility. Oil companies were also reluctant to refill abnormally low stock levels, because they feared a return to the low price environment of 1998.

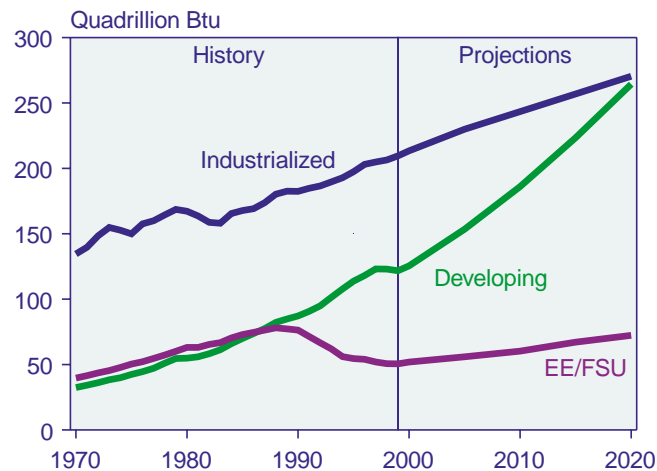
The *IEO2001* reference case expects world oil prices to increase from \$17.35 per barrel in 1999 (1999 dollars) to about \$27.60 in 2000, then fall to \$20.50 per barrel by 2003 and return to the price trajectory anticipated in last year's outlook for the mid-term. World oil prices are expected to reach \$22 per barrel in 1999 dollars (\$36 per

barrel in nominal dollars) at the end of the projection period—about the same as in last year's forecast (Figure 5).

High world oil prices and improved domestic industrial production helped Russia, the largest economy in the former Soviet Union (FSU), to record two consecutive years of positive economic growth for the first time since the breakup of the Soviet Union in the early 1990s. The collapse of the Russian ruble in 1998 led to a boost in industrial production as it became too expensive to import goods from abroad. Russian industrial output experienced double digit growth through much of 2000; and production increases, supplemented by the revenues obtained in the high oil price environment, allowed the Russian economy to advance strongly in 1999 and 2000. The improved economic outlook for Russia and the rest of the FSU is expected to result in energy demand growth for the region of 1.7 percent per year between 1999 and 2020, reaching 56 quadrillion Btu at the end of the forecast.

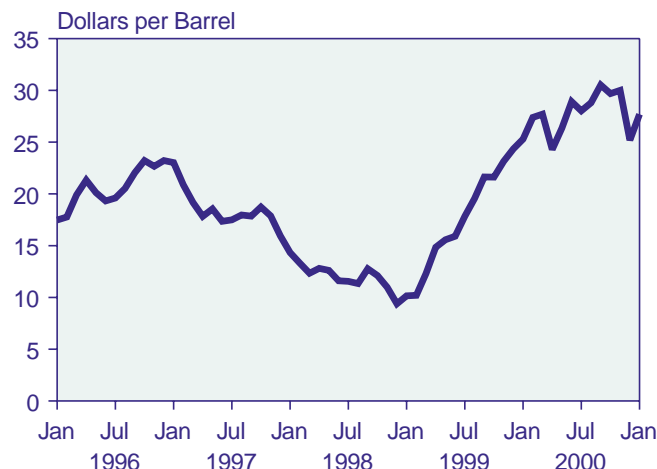
The industrialized world also was affected by the high world oil price environment of 2000. Concerns in the United States about a recurrence of the previous winter's shortage of home heating fuel oil for the Northeast—given the very low stock levels of August 2000—led the Clinton Administration to allow industry access to as much as 30 million barrels of crude oil from the Nation's Strategic Petroleum Reserve. Within the European Union, member countries Spain and France

Figure 3. World Energy Consumption by Region, 1970-2020



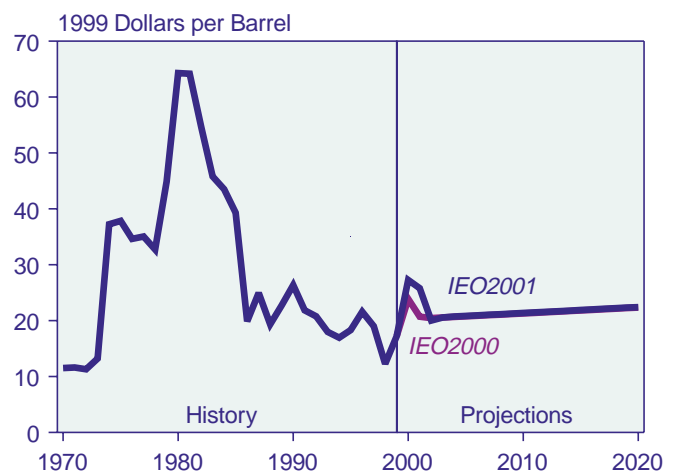
Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

Figure 4. Refiner Acquisition Cost of Imported Crude Oil, 1996-2000



Source: Energy Information Administration, "Crude Oil Price Summary," MER Spreadsheet, Table 9.1, web site www.eia.doe.gov/emeu/mer/prices (October 2000).

Figure 5. Comparison of 2000 and 2001 World Oil Price Projections



Sources: **History:** Energy Information Administration (EIA), *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000). **IEO2000:** EIA, *International Energy Outlook 2000*, DOE/EIA-0484(2000) (Washington, DC, March 2000). **IEO2001:** 1999-2002—EIA, *Short-Term Energy Outlook*, on-line version (February 7, 2001), web site www.eia.doe.gov/emeu/steo/pub/contents.html. 2003-2020—EIA, *Annual Energy Outlook 2001*, DOE/EIA-0383(2001) (Washington, DC, December 2000).

expressed the desire to follow the U.S. lead, but the International Energy Agency, United Kingdom, and Germany opposed the move, and the stocks ultimately were not released. Multiple strikes to protest high fuel prices were launched or threatened throughout Western Europe in the third quarter of 2000 by truckers, farmers, and taxi drivers (whose livelihood is immediately affected by the cost of fuel), expressing consumer anger that is rarely seen in the ordinarily high fuel cost environment of that region.

Worldwide, oil consumption rose by slightly less than 1 million barrels per day in 2000, with nonindustrialized nations accounting for all of increase and, of that, Pacific Rim countries and China responsible for about 50 percent. The increases in worldwide oil demand projected in the reference case would require an increment of 43 million barrels per day relative to current productive capacity. OPEC producers are expected to be the major beneficiaries of increased production requirements, but non-OPEC supply is expected to remain competitive, with major increments of supply coming from offshore resources, especially in the Caspian Basin and deep-water West Africa. Deepwater exploration and development initiatives are generally expected to be sustained worldwide, with offshore West Africa emerging as a major future source of oil production. 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.

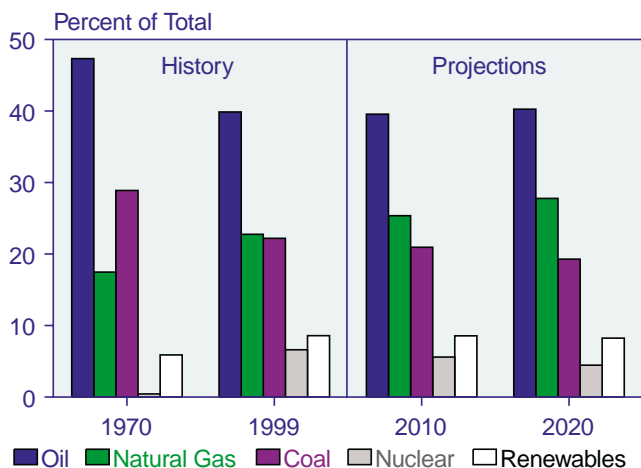
Oil currently provides a larger share of world energy consumption than any other energy source, and it is

expected to remain in that position through 2020 (Figure 6). The share of total world energy consumption attributed to oil is projected to remain unchanged over the 1999-2020 time period at 40 percent. Oil's market share does not increase in the forecast because countries in many parts of the world are expected to switch to natural gas and other fuels, particularly for electricity generation. World oil consumption is projected to increase by 2.3 percent annually over the 21-year projection period, from 75 million barrels per day in 1999 to 120 million barrels per day in 2020.

The industrialized countries continue to consume more of the world's petroleum products than do the developing countries, but the gap is projected to close substantially over the projection period. By 2020, developing countries are expected to consume almost the same amount of oil as the industrialized countries (Figure 7). Almost all the increase in oil use in the industrialized world is expected to occur in the transportation sector, where there are few economically competitive alternatives to oil currently available. In the developing world, however, oil demand is projected to grow in all end use sectors as emerging economies shift from noncommercial fuels (such as fuel wood for home heating and cooking) to diesel generators.

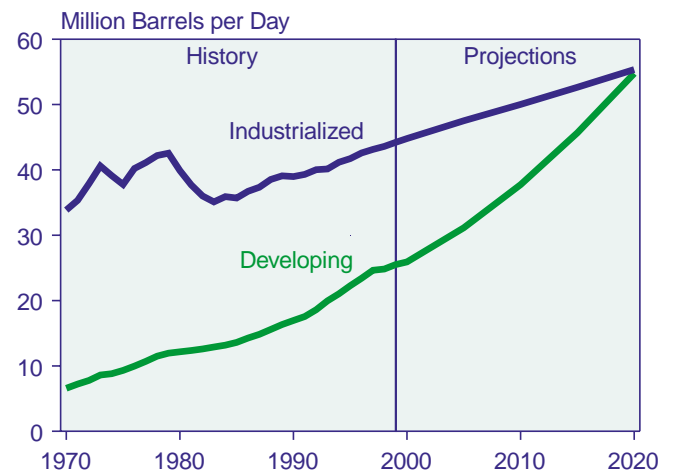
Natural gas remains the fastest growing component of primary world energy consumption. Over the *IEO2001* forecast period, gas use is projected to nearly double in the reference case, reaching 162 trillion cubic feet in 2020. Gas use surpassed coal use (on a Btu basis) for the first time in 1999, and by 2020 it is expected to exceed coal use by 44 percent (Figure 8). The gas share of total energy

Figure 6. World Energy Consumption Shares by Fuel Type, 1970, 1999, 2010, and 2020



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

Figure 7. Oil Consumption in the Industrialized and Developing Regions, 1970-2020



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

consumption is projected to increase from 23 percent in 1999 to 28 percent in 2020, and natural gas is expected to account for the largest increment in electricity generation (increasing by 32 quadrillion Btu or 41 percent of the total increment in energy used for electricity generation). Combined-cycle gas turbine power plants offer some of the highest commercially available plant efficiencies, and natural gas is environmentally attractive because it emits less sulfur dioxide, carbon dioxide, and particulate matter than does oil or coal.

In the industrialized world, natural gas is expected to make a greater contribution to incremental energy consumption among the major fuels, increasingly becoming the choice for new power generation because of its environmental and economic advantages. In the developing countries, increments in gas use are expected to supply both power generation and other uses, including fuel for industry. Gas use in the developing world is projected to grow at a faster rate than any other fuel category in the *IEO2001* reference case, an average of 5.2 percent per year, compared to 3.7 percent per year for oil and 3.1 percent for coal.

Coal's share of total energy consumption is projected to fall slightly in the *IEO2001* reference case, from 22 percent in 1999 to 19 percent in 2020 (Figure 6). Only a slight loss from its historical share is expected, because large increases in energy use are projected for the developing countries of Asia, especially China and India, which rely heavily on coal and have significant coal resources. As very large countries in terms of both population and land mass, China and India are projected to account for 30 percent of the world's total increase in energy

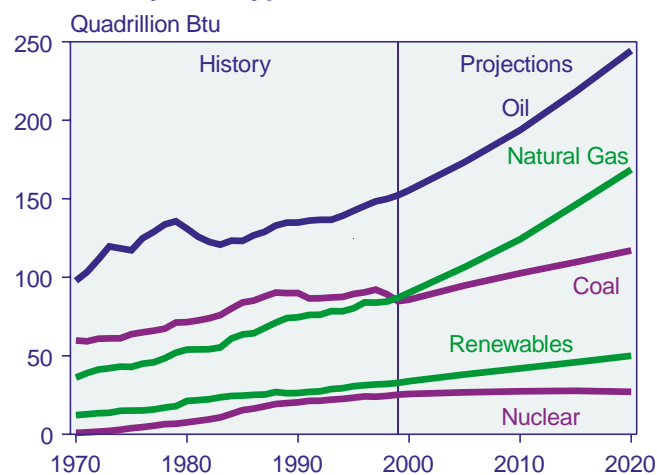
consumption over the forecast period, and the expected increases in coal use in China and India are projected to account for 92 percent of the total expected increase in coal use worldwide (on a Btu basis). Almost 60 percent of the coal consumed worldwide is used for electricity generation, and virtually all of the projected growth in the world's consumption of coal is for electricity. One exception is China, where coal continues to be the main fuel in a rapidly growing industrial sector, reflecting the country's abundant coal reserves and limited access to alternative sources of energy.

The prospects for nuclear power to continue its role of meeting a significant share of worldwide electricity consumption are uncertain, despite projected growth of 2.7 percent per year in total electricity demand through 2020. In the *IEO2001* reference case, worldwide nuclear capacity is projected to increase to 365 gigawatts in 2010, then begin to decline, falling to 351 gigawatts in 2020. Most of the growth in nuclear capacity is expected to occur in the developing world (particularly in developing Asia), where consumption of electricity generated from nuclear plants is projected to increase by 4.9 percent per year between 1999 and 2020. In contrast, older reactors are expected to be retired in the industrialized world and the EE/FSU, and few new reactors are planned to replace them. Exceptions include France and Japan, where several new reactors are expected to begin operating in the next decade or so.

Renewable energy use is expected to increase by 53 percent between 1999 and 2020, but its current 9-percent share of total energy consumption is projected to drop to 8 percent by 2020. Although energy prices reached record high levels in 2000, the *IEO2001* reference case projection expects energy prices over the long term to remain relatively low, constraining the expansion of hydroelectricity and other renewable resources. Much of the growth in renewable energy use in the *IEO2001* reference case is attributable to large-scale hydroelectric projects in the developing world, particularly in developing Asia, where China, India, and other developing Asian nations (Nepal and Malaysia among others) already are building or planning to build hydroelectric projects that exceed 1,000 megawatts. Hydroelectricity and other renewable energy consumption is projected to grow by 4.0 percent per year in developing Asia over the projection period, with particularly strong growth projected for China.

The world's use of electricity is projected to increase by two-thirds over the forecast horizon, from 13 trillion kilowatt-hours in 1999 to 22 trillion kilowatt-hours in 2020. The strongest growth rates in electricity consumption are projected for the developing world. The most rapid expansion in electricity use in the reference case is expected for developing Asia and Central and South

Figure 8. World Energy Consumption by Fuel Type, 1970-2020



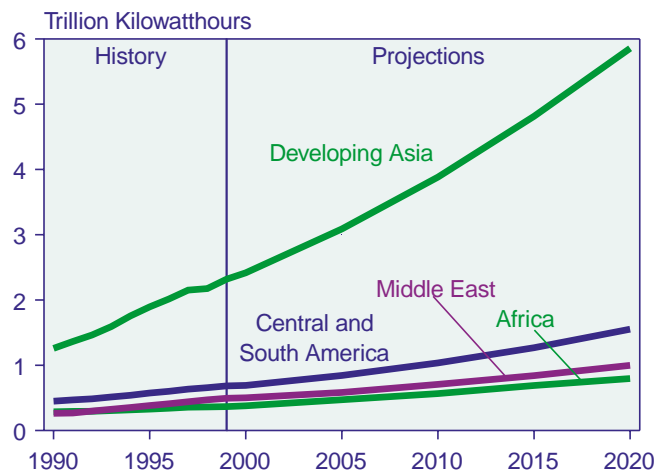
Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

America, with average annual growth rates exceeding 3.5 percent between 1999 and 2020 (Figure 9). In the industrialized world, electricity consumption is expected to grow at a more modest pace. Slower population and economic growth, along with the market saturation of certain electronic appliances (such as washers and dryers) and efficiency gains from electrical appliances help to explain the expected slower growth of electricity use in the industrialized nations, although growing computer usage and the introduction of new electronic devices could modulate that trend in the future.

In the United States, electricity prices increased sharply in California, New York, and several other States in the summer of 2000. In California, San Jose and San Francisco experienced rolling blackouts, and customers of San Diego Gas and Electric saw their bills triple. California's implementation of deregulation and inadequate new generating capacity were blamed for the price spikes. Nevertheless, the trend to consolidate the U.S. electricity industry continues. Consolidation has occurred through the sale of individual electricity assets, particularly generation assets. For the first time in the United States, nuclear generation assets have changed ownership. A recent development is the purchase of U.S. electric utility plants by foreign companies, primarily by a handful of companies from the United Kingdom but also including some Japanese companies and at least one French company.

Despite the recent pressure on transportation fuels from oil prices that hit 10-year highs in 2000, transportation energy use is expected to continue robust growth over

Figure 9. Net Electricity Consumption in the Developing World by Region, 1990-2020



Note: Net electricity consumption is equal to generation plus imports minus exports and distribution losses.

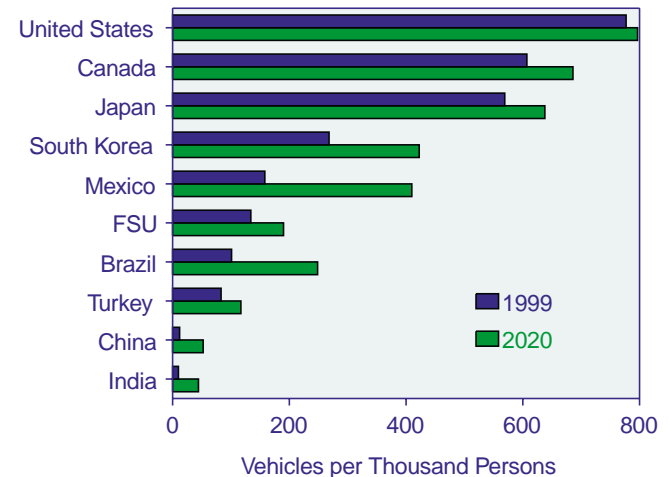
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, *World Energy Projection System* (2001).

the next two decades, especially in the developing world, where relatively immature transportation infrastructures are expected to grow rapidly as national and regional economies expand. In the *IEO2001* reference case, energy use for transportation is projected to increase by 4.8 percent per year in the developing world, compared with average annual increases of 1.6 percent for the industrialized countries, where transportation systems are largely established and motorization levels (per capita vehicle ownership) are, in many nations, expected to reach saturation levels over the 21-year forecast horizon.

In urban centers of the developing world, car ownership is often seen as one of the first symbols of emerging prosperity. Per capita motorization in much of the developing world is projected to more than double between 1999 and 2020, although population growth is expected to keep motorization levels low relative to those in the industrialized world. For example, the U.S. per capita motorization level in 2020 is projected at 797 vehicles per thousand persons, but in China—where motorization is expected to grow fivefold over the forecast horizon—the projected motorization level in 2020 is only 52 vehicles per thousand persons (Figure 10).

Global climate change—one of the most wide-reaching environmental issues of recent years—serves as a prime example of the divergent concerns of energy and the environment. Carbon dioxide emissions resulting from the combustion of fossil fuels currently are estimated to account for three-fourths of human-caused carbon dioxide emissions worldwide and are believed to be contributing to the rise in atmospheric concentrations of carbon dioxide since pre-industrial times. World carbon dioxide emissions are projected to rise from 6.1 billion metric tons carbon equivalent in 1999 to 7.8 billion metric tons

Figure 10. Motorization Levels in Selected Countries, 1999 and 2020



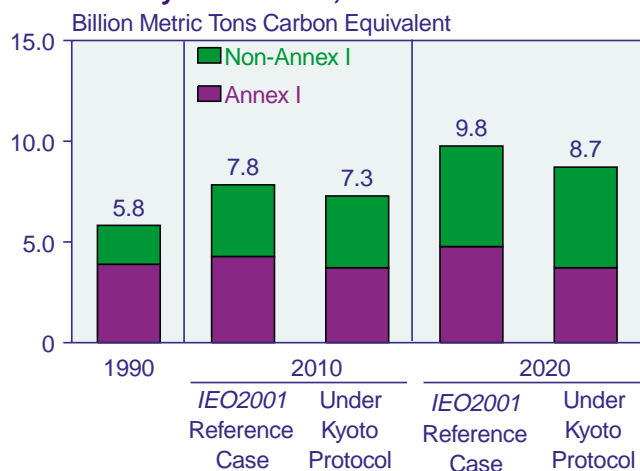
Source: Energy Information Administration, *World Energy Projection System* (2001).

per year in 2010 and to 9.8 billion metric tons in 2020 (Table 1). The *IEO2001* projections are based on current laws and regulations and do not take into account the potential impact of policies that might be enacted to limit or reduce carbon dioxide emissions, such as the Kyoto Protocol, which if signed by the required number of signatories would require all signatories to reduce or limit carbon dioxide emissions relative to their 1990 levels between 2008 and 2012.

Much of the projected increase in carbon dioxide emissions is expected to occur in the developing world, where emerging economies are expected to produce the largest increases in energy consumption. Developing countries alone account for 81 percent of the projected increment in carbon dioxide emissions between 1990 and 2010 and 76 percent between 1990 and 2020. Continued heavy reliance on coal and other fossil fuels, as projected for the developing countries, would ensure that even if the industrialized world undertook efforts to reduce carbon dioxide emissions, worldwide carbon dioxide emissions would still grow substantially over the forecast horizon (Figure 11).

The *IEO2001* projections, like all forecasts, are accompanied by a measure of uncertainty. One way to quantify the uncertainty is to consider the relationship between

Figure 11. World Carbon Dioxide Emissions in the *IEO2001* Reference Case and Under the Kyoto Protocol, 2010 and 2020

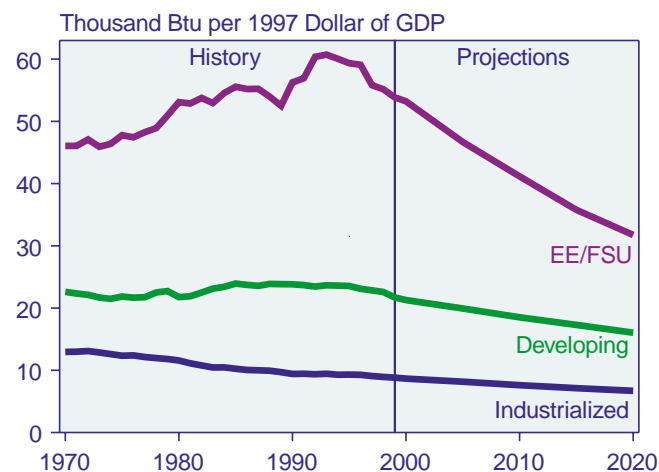


Sources: **1990:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

energy consumption and growth in gross domestic product (that is, energy intensity) over time. In the industrialized countries, history shows the link between energy consumption and economic growth to be a relatively weak one, with growth in energy demand lagging behind economic growth. In the developing countries, the two have been more closely correlated, with energy demand growing in parallel with economic expansion.

In the *IEO2001* forecast, energy intensity in the industrialized countries is expected to improve (decrease) by 1.3 percent per year between 1999 and 2020, about the same rate of improvement observed in the region projected between 1970 and 1999. Energy intensity is also projected to improve in the developing countries—by 1.4 percent per year—as their economies begin to behave more like those of the industrialized countries as a result of improving standards of living that accompany the projected economic expansion (Figure 12). The EE/FSU has always maintained a much higher level of energy intensity than either the industrialized or developing countries. Over the forecast horizon, energy intensity is expected to improve in the EE/FSU region in concert with expected recovery from the economic and social declines of the early 1990s; however, it is still expected to be twice as high as in the developing world and five times as high as in the industrialized world.

Figure 12. World Energy Intensity by Region, 1970-2020



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