

Highlights

World energy consumption is projected to increase by 54 percent from 2001 to 2025. Much of the growth in worldwide energy use is expected in the developing world in the IEO2004 reference case forecast.

In the *International Energy Outlook 2004 (IEO2004)* reference case, world marketed energy consumption is projected to increase by 54 percent over the 24-year forecast horizon from 2001 to 2025. Worldwide, total energy use is projected to grow from 404 quadrillion British thermal units (Btu) in 2001 to 623 quadrillion Btu in 2025 (Figure 2).

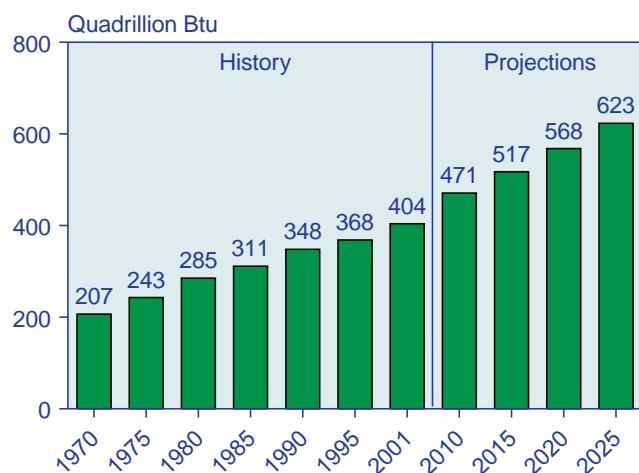
The *IEO2004* reference case outlook shows strongest growth in energy consumption among the developing nations of the world, as it has in past editions of this report (Figure 3). The fastest growth is projected for the nations of developing Asia, including China and India, where robust economic growth accompanies the increase in energy consumption over the forecast period. Gross domestic product (GDP) in developing Asia is expected to expand at an average annual rate of 5.1 percent, compared with 3.0 percent per year for the world as a whole. With such strong growth in GDP, demand for energy in developing Asia doubles over the forecast, accounting for 40 percent of the total projected increment in world energy consumption and 70 percent of the increment for the developing world alone.

In contrast to the developing world, slower growth in energy demand is projected for the industrialized world,

averaging 1.2 percent per year over the forecast period. Generally, the nations of the industrialized world can be characterized as mature energy consumers with comparatively slow population growth. Gains in energy efficiency and movement away from energy-intensive manufacturing to service industries result in the lower growth in energy consumption. In the transitional economies of Eastern Europe and the former Soviet Union (EE/FSU) energy demand is projected to grow by 1.5 percent per year in the *IEO2004* reference case. Slow or declining population growth in this region, combined with strong projected gains in energy efficiency as old, inefficient equipment is replaced, leads to the projection of more modest growth in energy use than in the developing world.

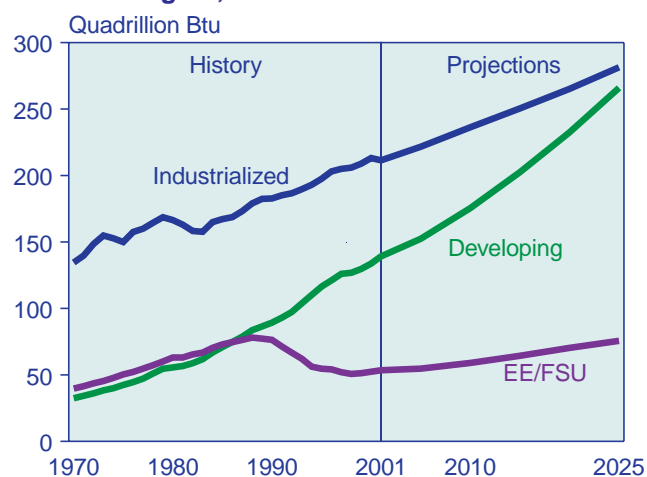
World oil prices rose by almost \$10 per barrel over the course of 2002 and remained high throughout 2003. Prices were influenced by political unrest in Venezuela and Nigeria, the war in Iraq, and the continued discipline of producers in the Organization of Petroleum Exporting Countries (OPEC) in adhering to production cutbacks. The *IEO2004* reference case expects little downward movement in world oil prices in 2004, given low oil inventories, a surge in developing Asia's oil

Figure 2. World Marketed 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 (2004).

Figure 3. World Marketed 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 (2004).

demand, and the regional uncertainty that surrounds the situation in Iraq. The world oil price path in the reference case is virtually the same as in last year's forecast, with prices projected to moderate after 2004 and then rise slowly to 2025 (Figure 4). World oil prices are projected to reach \$27 per barrel in 2002 dollars (\$51 per barrel in nominal dollars) at the end of the forecast period. These prices are average annual prices and exclude the volatility that may occur as a result of weather variations or possible disruptions in supply.

Outlook for World Energy Demand

The *IEO2004* reference case projects increased consumption of all primary energy sources over the 2001-2025 period (Figure 5). Fossil fuel prices for electricity production are projected to remain low relative to the costs of nuclear power and renewable energy sources; as a result, non-fossil fuels are not expected to be economically competitive with fossil fuels over the forecast. The outlook for fossil fuels could, however, be altered by government policies or programs, such as environmental laws aimed at limiting or reducing pollutants from the combustion of fossil fuel consumption and encouraging the use of non-fossil fuels. In the absence of such laws, consumption of oil, natural gas, and coal is expected to supply most of the primary energy needed to meet the projected demand for end-use consumption.

Oil is expected to remain the dominant energy source worldwide through 2025. In the *IEO2004* reference case, world oil demand increases by 1.9 percent annually over

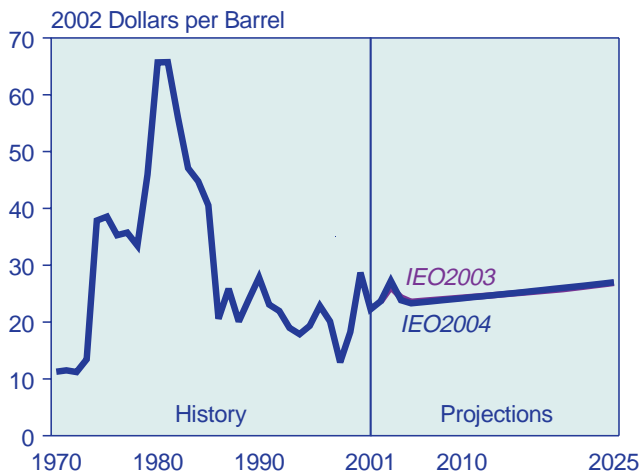
the 24-year projection period, from 77 million barrels per day in 2001 to 121 million barrels per day in 2025. Much of the increase in oil demand is projected to occur in the United States and in developing Asia. The United States, China, and the other nations of developing Asia account for nearly 60 percent of the increment in world oil demand in the *IEO2004* reference case.

The projected increment in worldwide oil use would require an increment to world productive capacity of more than 44 million barrels per day over current levels. Although OPEC producers are expected to be the major suppliers of increased production requirements, non-OPEC supply is expected to remain competitive, with major increments in supply coming from offshore resources, especially in the Caspian Basin, Latin America, and deepwater West Africa.

Over the past several decades, oil has been the world's foremost source of primary energy consumption, and it is expected to remain in that position throughout the 2001 to 2025 period. Oil's share of world energy is maintained throughout the forecast, at 39 percent, despite expectations that countries in many parts of the world will be switching from oil to natural gas and other fuels for their electricity generation (Figure 6). Robust growth in transportation energy use—overwhelmingly fueled by petroleum products—is expected to continue over the 24-year forecast period. As a result, oil is projected to retain its predominance in the global energy mix, notwithstanding increases in the penetration of new technologies such as hydrogen-fueled vehicles.

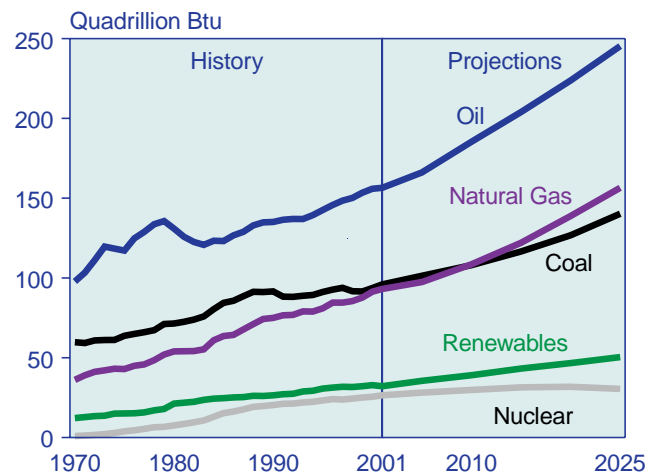
Although the nations of the industrialized world continue to consume more of the world's petroleum products than do those of the developing world, the gap is

Figure 4. Comparison of 2003 and 2004 World Oil Price Projections, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *Annual Energy Review 2002*, DOE/EIA-0384(2002) (Washington, DC, October 2003), web site www.eia.doe.gov/emeu/aer/contents.html. **IEO2003:** EIA, *International Energy Outlook 2003*, DOE/EIA-0484(2003) (Washington, DC, May 2003), web site www.eia.doe.gov/oiaf/ieo/index.html. **IEO2004:** EIA, *Annual Energy Outlook 2004*, DOE/EIA-0383(2004) (Washington, DC, January 2004), web site www.eia.doe.gov/oiaf/aeo/index.html.

Figure 5. World Marketed Energy Consumption by Energy Source, 1970-2025

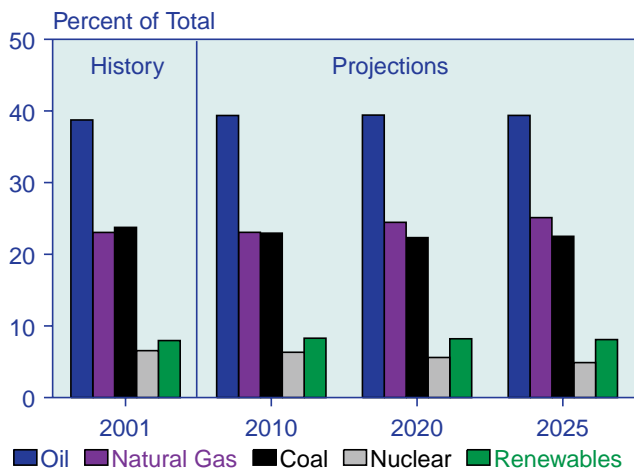


Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2004).

projected to narrow considerably over the forecast period. In 2001, developing nations consumed about two-thirds (64 percent) as much oil as the industrialized nations; by 2025 they are expected to consume 94 percent as much as the industrialized nations. In the industrialized world, increases in oil use are expected mainly in the transportation sector, where there are few economically competitive alternatives at present. In the developing world, oil demand is projected to grow in all end-use sectors. As the energy infrastructures of emerging economies improve, people are turning from traditional fuels for residential and commercial uses—such as wood burning for heating and cooking—to diesel-fired electricity, and industrial demand for petrochemical feedstocks is increasing.

The fastest growing source of primary energy in the *IEO2004* reference case is natural gas. Over the 2001-2025 forecast period, consumption of natural gas is projected to increase by 67 percent in the reference case, to 151 trillion cubic feet in 2025. The projection for natural gas consumption is lower than in last year's report, which showed worldwide demand for gas at 176 trillion cubic feet in 2025 (Figure 7). The lower forecast this year is the result of slightly lower assumptions for worldwide economic growth, a slower projected decline in nuclear power generation (which competes with natural gas in the power sector), and concerns about the long-term ability of natural gas producers to bring sufficient resources to market at prices competitive with those of other fuels. Natural gas use is expected to equal coal use (on a Btu basis) by 2010, and by 2025 it is expected to exceed coal use by 12 percent (Figure 5).

Figure 6. World Energy Consumption Shares by Fuel Type, 2001, 2010, 2020, and 2025



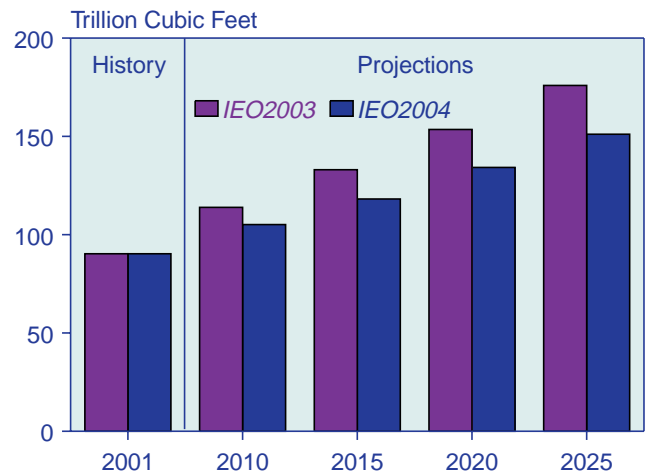
Sources: **2001:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2004).

Natural gas is expected to remain an important supply source for new electric power generation in the future. It is seen as the desired option for electric power, given its relative efficiency and environmental advantages in comparison with other fossil energy sources. Natural gas burns more cleanly than either coal or oil, making it a more attractive choice for countries seeking to reduce greenhouse gas emissions.

The growing importance of natural gas in the electric power sector is more pronounced in the industrialized and EE/FSU regions than in the developing world. In the industrialized nations and the EE/FSU, for the most part the natural gas infrastructure is considered mature, and the gas share of total electricity generation is projected to grow from 20 percent in 2001 to 30 percent in 2025. In the developing world, the natural gas infrastructure has not yet been as widely established. As a result, the projected increase in the natural gas share of total generation in the developing world is smaller—from 14 percent in 2001 to 17 percent in 2025.

Coal remains an important fuel in the world's electricity markets and is expected to continue to dominate energy markets in developing Asia. World coal use has been in a period of generally slow growth since the 1980s, and that trend is expected to continue through the projection period. With the projected growth in coal consumption averaging 1.5 percent per year through 2025, coal's share of total world energy consumption declines slightly in the *IEO2004* reference case forecast, from 24 percent in 2001 to 23 percent in 2025.

Figure 7. Comparison of 2003 and 2004 Projections for World Natural Gas Consumption, 2001, 2010, 2020, and 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/. **IEO2003:** EIA, *International Energy Outlook 2003*, DOE/EIA-0484(2003) (Washington, DC, March 2003), web site www.eia.doe.gov/oiaf/ieo/index.html. **IEO2004:** EIA, *System for the Analysis of Global Energy Markets* (2004).

Coal use is projected to increase in all regions except for Western Europe and the EE/FSU (excluding Russia), where coal is expected to be displaced by natural gas and, in the case of France, nuclear power for electric power generation. Large increments in coal use are projected for developing Asia, especially in China and India. As very large countries in terms of both population and land mass, and with ample domestic coal resources, China and India are projected to account for 67 percent of the total increase in coal use worldwide (on a Btu basis).

Currently, of the coal consumed worldwide, 64 percent is used for electricity generation; and in almost every region, power generation accounts for most of the projected growth in coal consumption. Significant amounts of coal are also used for steel production. Where coal is used in the industrial, residential, and commercial sectors, other energy sources—primarily, natural gas—are expected to gain market share. One exception is China. With China's abundant coal reserves and limited access to other sources of energy, coal continues to be the most widely used fuel in the country's rapidly growing industrial sector. Consumption of coking coal is projected to decline slightly in most regions of the world as a result of technological advances in steelmaking, increasing output from electric arc furnaces, and continuing replacement of steel by other materials in end-use applications.

Over the projection period, worldwide net electricity consumption is projected to nearly double between 2001 and 2025, from 13,290 billion kilowatthours to 23,072 billion kilowatthours. Strong growth in electricity use is expected in the countries of the developing world, where electricity demand increases by an average of 3.5 percent per year in the *IEO2004* reference case, compared with a projected average increase of 2.3 percent per year worldwide. Robust economic growth in many of the developing nations is expected to boost demand for electricity to run newly purchased home appliances for air conditioning, cooking, space and water heating, and refrigeration. For the industrialized world and the transitional economies of the EE/FSU, where electricity markets are more mature, slower average growth rates of 1.6 percent per year and 2.0 percent per year, respectively, are projected.

Worldwide, electricity generation from nuclear power is projected to increase from 2,521 billion kilowatthours in 2001 to 3,032 billion kilowatthours in 2020, before declining slightly to 2,906 billion in 2025. The nuclear power forecast is higher than in last year's outlook, because the prospects for nuclear power have been reassessed in light of higher capacity utilization rates reported for

many existing nuclear facilities and the expectation that fewer retirements of existing plants will occur than previously projected. 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 the United States, natural gas prices are projected to be higher than in previous forecasts, and as a result no U.S. nuclear power units are expected to be retired in the *IEO2004* reference case.

The largest increase in nuclear generation is expected for the developing world, where consumption of electricity from nuclear power increases by an average of 4.1 percent per year from 2001 to 2025 in the reference case. In particular, developing Asia is expected to see the greatest increase in worldwide nuclear generating capacity, accounting for 96 percent of the total projected increment in nuclear capacity in the developing world. Of the 44 gigawatts of additional installed nuclear generating capacity projected for developing Asia, 19 gigawatts is projected for China, 15 gigawatts for South Korea, and 6 gigawatts for India.

In the *IEO2004* reference case, moderate growth in the world's consumption of hydroelectricity and other renewable energy resources is projected over the next 24 years, averaging 1.9 percent per year in the *IEO2004* reference case. Much of the projected growth in renewable generation is expected to result from the completion of large hydroelectric facilities in developing countries, particularly in developing Asia. China, India, and other developing Asian countries are constructing or planning new, large-scale hydroelectric facilities. Among the industrialized nations, only Canada has plans to construct any sizable hydroelectric projects over the forecast period. Much of the expected increment in renewable energy consumption in the industrialized world is projected to be nonhydropower renewables, including particularly wind energy in Western Europe and the United States. In addition, biomass and geothermal energy sources are expected to grow rapidly in the United States.

Carbon Dioxide Emissions

Carbon dioxide is one of the most prevalent greenhouse gases in the atmosphere. Anthropogenic emissions of carbon dioxide result primarily from the combustion of fossil fuels for energy use, and as a result world energy use has emerged at the center of the climate change debate. In the *IEO2004* reference case, world carbon dioxide emissions are projected to rise from 23.9 billion metric tons in 2001 to 27.7 billion metric tons in 2010 and 37.1 billion metric tons in 2025 (Figure 8).²

²In keeping with current international practice, *IEO2004* presents data on carbon dioxide emissions in million metric tons carbon dioxide equivalent. The figures can be converted to carbon equivalent units by multiplying by 12/44.

Much of the projected increase in carbon dioxide emissions is expected in the developing world (Figure 9), accompanying the large increases in energy use projected for the region's emerging economies. Developing countries account for 61 percent of the projected increment in carbon dioxide emissions between 2001 and 2025. 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, there still would be substantial increases in worldwide carbon dioxide emissions over the forecast horizon.

Energy Intensity

Energy intensity (that is, the relationship between energy consumption and growth in gross domestic product) is an important factor that affects changes in energy consumption 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 *IEO2004* forecast, energy intensity in the industrialized countries is expected to improve (decrease) by an average of 1.2 percent per year between 2001 and 2025, slightly slower than the 1.4 percent per year improvement for the region between 1970 and 2001. Energy intensity is expected to improve more rapidly in the developing countries—by 1.8 percent per year on average—as their economies begin to behave more like those of the industrialized countries as a result of the

improvement in standards of living expected to accompany projected economic expansion (Figure 10).

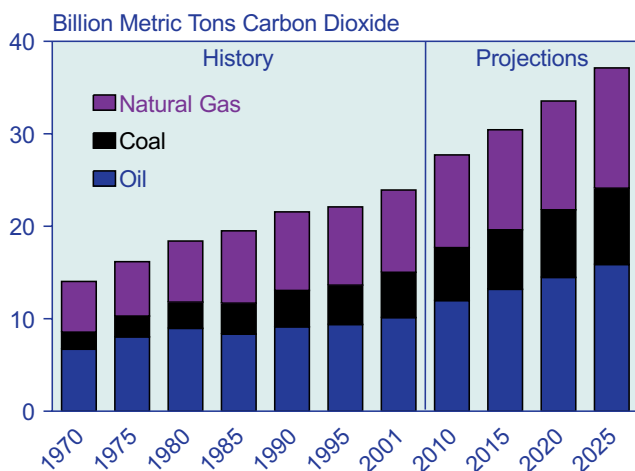
For more than three decades, the EE/FSU has maintained a much higher level of energy intensity than either the industrialized or developing countries. Over the forecast horizon the region's energy intensity is expected to improve—by 2.5 percent per year on average—in concert with expected recovery from 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.

Carbon Dioxide Intensity

World carbon dioxide intensity has improved (decreased) substantially over the past three decades, falling from 1,100 metric tons per million 1997 dollars of GDP in 1970 to 739 metric tons per million 1997 dollars in 2001. Although the pace of improvement in emissions intensity is expected to slow over the forecast period, a continuing decline is projected in the reference case, to 566 metric tons per million 1997 dollars of GDP in 2025.

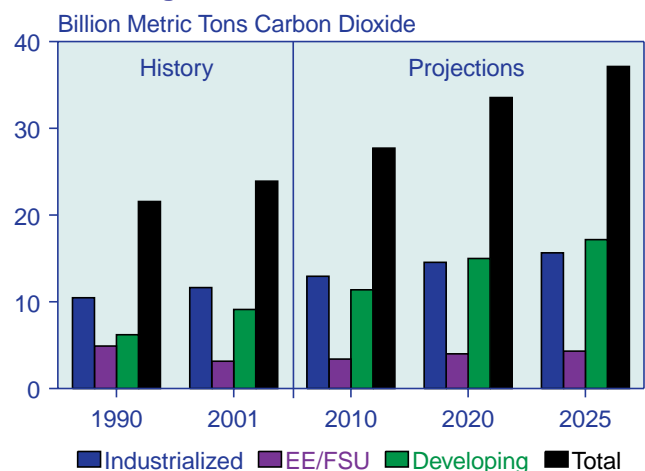
On a regional basis, the most rapid rates of improvement in carbon dioxide intensity are projected for the transitional economies of the EE/FSU and for China. In the FSU, economic recovery from the upheaval of the 1990s is expected to continue throughout the forecast. The FSU nations are also expected to replace old and inefficient capital stock as economic recovery progresses. Eastern European nations began their economic recovery much earlier than the nations of the former Soviet Union. As a result of strong investment in improving the efficiency

Figure 8. World Carbon Dioxide Emissions by Fossil Fuel, 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* (2004).

Figure 9. World Carbon Dioxide Emissions by Region, 1990-2025



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* (2004).

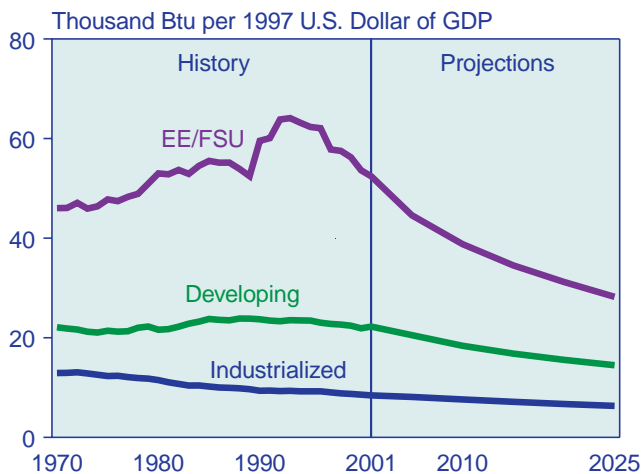
of energy use among Eastern European countries and a push to increase the use of natural gas, carbon dioxide intensity fell by nearly 40 percent in Eastern Europe between 1990 and 2001, as compared with only 5 percent in Russia and 9 percent in the other FSU nations. Improvement in carbon dioxide intensity in Eastern Europe is projected to continue over the projection period, at an average rate of 2.9 percent per year (Figure 11).

Developing Asia is expected to see fairly rapid improvement in carbon dioxide intensity over the 2001-2025 period, primarily as a result of rapid economic growth, rather than a switch to less carbon-intensive fuels. China, in particular, is expected to remain heavily reliant on fossil fuels, especially coal, in the *IEO2004* reference case, but its annual GDP growth is projected to average 6.1 percent, compared with an expected 3.4-percent annual rate of increase in fossil fuel use over

the projection period. China's carbon dioxide intensity is expected to decrease by 2.6 percent per year on average between 2001 and 2025.

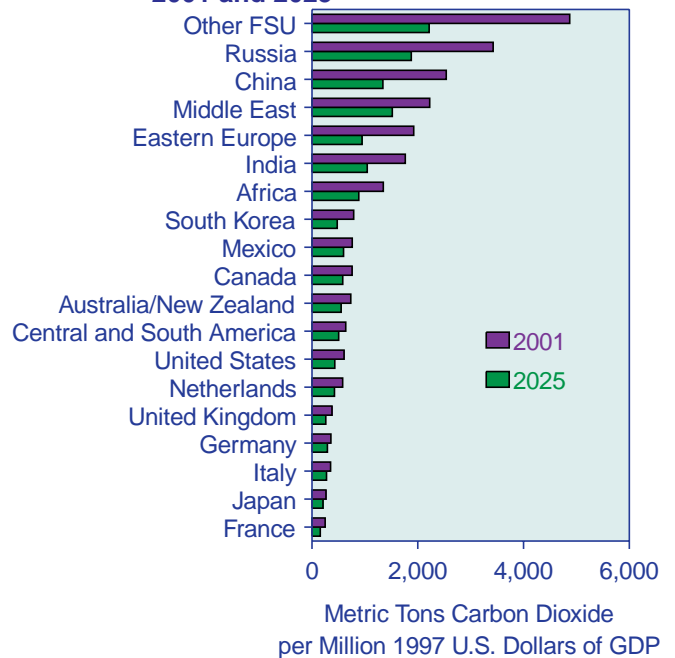
Rates of improvement in carbon dioxide intensity could vary considerably in the future, based on technological advances, government policy initiatives, and economic growth rates. In the *IEO2004* reference case, world carbon dioxide intensity is projected to fall from 739 metric tons per million 1997 dollars of GDP in 2001 to 566 metric tons per million dollars in 2025; however, if world economic growth expanded to the levels projected in the *IEO2004* high economic growth case, carbon dioxide intensity could fall more quickly, to 558 metric tons per million dollars in 2025. In contrast, if world GDP expanded more slowly, as in the low economic growth case, world carbon dioxide intensity would decline to a projected 575 metric tons per million dollars in 2025.

Figure 10. 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 (2004).

Figure 11. World Carbon Dioxide Intensity by Selected Countries and Regions, 2001 and 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/. **2025:** EIA, System for the Analysis of Global Energy Markets (2004).