Highlights

World energy consumption is projected to increase by 58 percent from 2001 to 2025. Much of the growth in worldwide energy use is expected in the developing world in the IEO2003 reference case forecast.

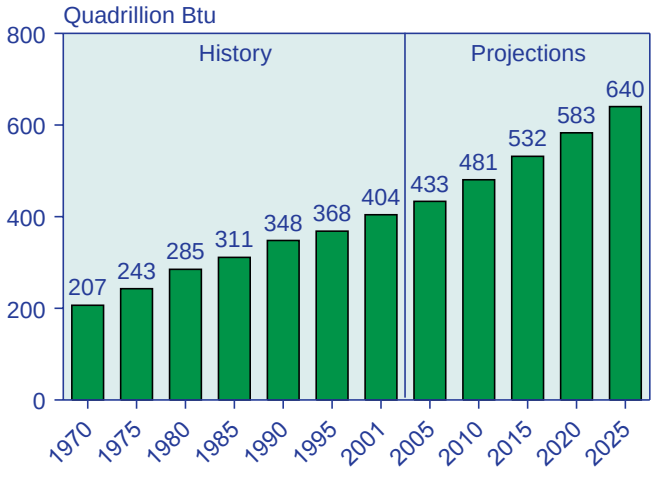
In the *International Energy Outlook 2003* (*IEO2003*) reference case, world energy consumption is projected to increase by 58 percent over a 24-year forecast horizon, from 2001 to 2025. Worldwide, total energy use is projected to grow from 404 quadrillion British thermal units (Btu) in 2001 to 640 quadrillion Btu in 2025 (Figure 2).

As in past editions of this report, the *IEO2003* reference case outlook continues to show robust growth in energy consumption among the developing nations of the world (Figure 3). The strongest growth is projected for developing Asia, where demand for energy is expected to more than double over the forecast period. An average annual growth rate of 3 percent is projected for energy use in developing Asia, accounting for nearly 40 percent of the total projected increment in world energy consumption and 69 percent of the increment for the developing world alone.

Expectations for growth in Central and South America have been lowered substantially from those reflected in last year's report. Political and economic problems surfacing among the nations of the region in the past year have tempered the previously optimistic mid-term outlook for their development. There is continuing unrest in Venezuela; the Argentine economy remains in crisis; the Colombian government has recently renewed an aggressive campaign against insurgency groups; and there is growing dissatisfaction with the Toledo government in Peru. The uncertainties associated with these developments have led to lower projections for the region's energy demand in the *IEO2003* forecast. Whereas energy demand in Central and South America was projected to grow by 3.8 percent per year between 1999 and 2020 in last year's report, the *IEO2003* reference case projects average annual growth of only 2.4 percent from 1999 through 2020 (Figure 4).

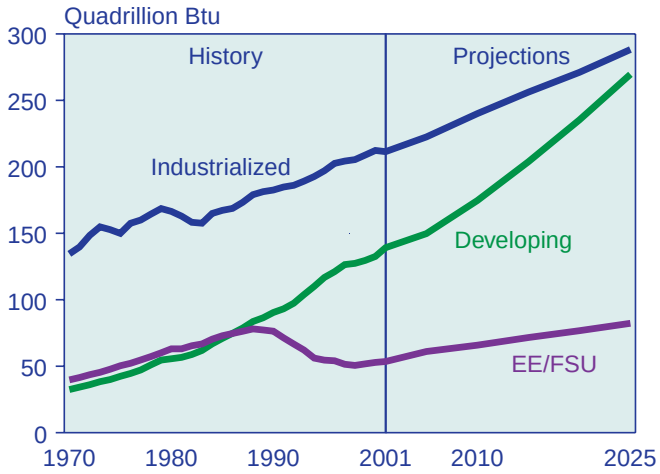
The *IEO2003* reference case expects world oil prices to remain high and volatile throughout 2003, largely because of the abnormally high stock builds that would be needed to bring oil markets back into balance following the disruption in Venezuelan and Iraqi exports. After 2004, prices are expected to return to the mid-term price trajectory anticipated in last year's outlook (Figure 5). World oil prices are projected to reach $27 per barrel in 2001 dollars ($48 per barrel in nominal dollars) at the end of the projection period.

Figure 2. 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 3. 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).

Outlook for World Energy Demand

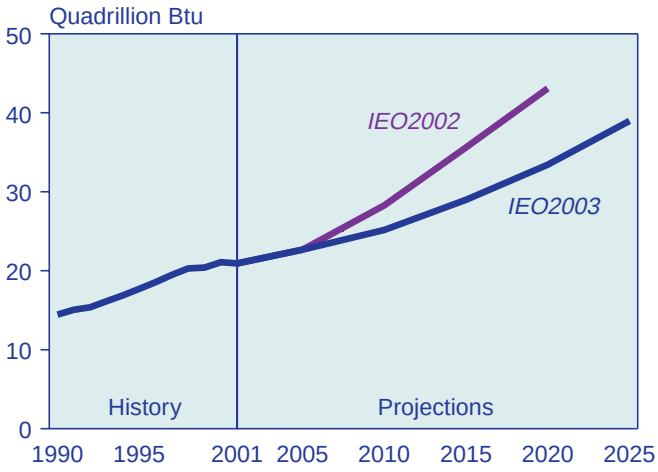
Much of the industrialized world remained in an economic slowdown in 2002. Growth in the United States was hindered by high world oil prices and several large corporate scandals that shook consumer confidence. The sluggish U.S. economy, in turn, had an adverse impact on many global markets that depend heavily on exports to the United States. The mid-term forecast assumes that growth in gross domestic product (GDP) and energy demand will rebound toward the trend projected in last year's outlook. The *IEO2003* reference case projects 1.3-percent average annual growth for energy consumption in the industrialized world between 2001 and 2025, similar to growth rate projected in last year's report.

In the *IEO2003* reference case, world oil consumption is projected to increase by 1.8 percent annually over the 24-year projection period, from 77 million barrels per day in 2001 to 119 million barrels per day in 2025. The projected increases in worldwide oil use would require an increment of a little more than 42 million barrels per day over 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, Latin America, and deepwater West Africa. Deepwater exploration and development initiatives are generally expected to be sustained worldwide, and the offshore Atlantic Basin is expected to emerge as a major source of oil production in both Latin America and 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 drops only slightly in the forecast, from 39 percent in 2001 to 38 percent in 2025, 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 next 24 years. 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.

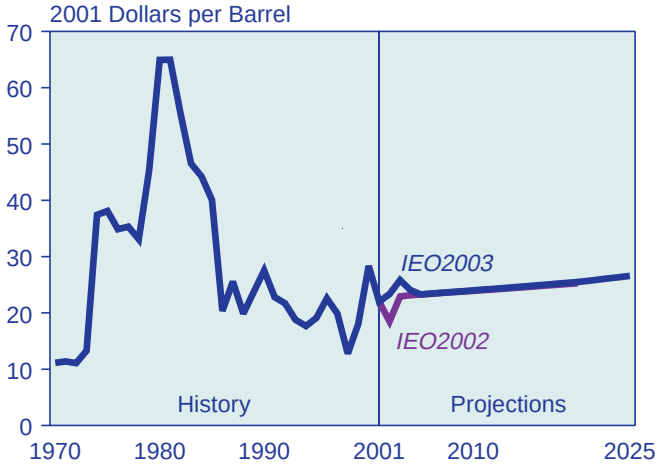
Although the nations of the industrialized world continue to consume more of the world's petroleum products than do those of the developing world, the gap is projected to narrow considerably over the forecast period. In 2001, developing nations consumed about two-thirds (64 percent) as much oil as the industrialized nations; by 2025 they are expected to consume around 86 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

Figure 4. Comparison of 2002 and 2003 Projections for Energy Consumption in Central and South America, 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/. ***IEO2002:*** EIA, *International Energy Outlook 2002*, DOE/EIA-0484(2002) (Washington, DC, March 2002), web site www.eia.doe.gov/oiaf/ieo/index.html. ***IEO2003:*** EIA, System for the Analysis of Global Energy Markets (2003).

Figure 5. Comparison of 2002 and 2003 World Oil Price Projections, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *Annual Energy Review 2001*, DOE/EIA-0384(2001) (Washington, DC, November 2002), web site www.eia.doe.gov/emeu/aer/contents.html. ***IEO2002:*** EIA, *International Energy Outlook 2002*, DOE/EIA-0484(2002) (Washington, DC, March 2002), web site www.eia.doe.gov/oiaf/ieo/index.html. ***IEO2003:*** EIA, *Annual Energy Outlook 2003*, DOE/EIA-0383(2003) (Washington, DC, January 2003), web site www.eia.doe.gov/oiaf/aeo/index.html.

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 electricity, and industrial demand for petrochemical feedstocks is increasing.

The fastest growing source of primary energy in the *IEO2003* reference case is projected to be natural gas. Over the 2001-2025 forecast period, consumption of natural gas is projected to nearly double in the reference case, to 176 trillion cubic feet in 2025. Natural gas use is expected to surpass coal use (on a Btu basis) by 2005, and by 2025 it is expected to exceed coal use by 31 percent (Figure 7). The natural gas share of total energy consumption is projected to increase from 23 percent in 2001 to 28 percent in 2025, and natural gas is expected to account for the largest increment in electricity generation (increasing by 41 quadrillion Btu and accounting for 53 percent of the total increment in energy use for electricity generation). Much of the projected growth in natural gas consumption throughout the world is in response to rising demand for natural gas to fuel efficient new gas turbine power plants.

In the industrialized world, natural gas is expected to make a greater contribution to incremental energy consumption among the major fuels, increasingly becoming the fuel of choice for new power generation capacity because of its environmental and economic advantages. In the developing countries, increments in natural gas use are expected to supply both power generation and industrial uses. The *IEO2003* reference case projects strong growth in natural gas use in the developing world—averaging 3.9 percent per year between 2001 and 2025—reflecting the growing popularity of the fuel as well as the expectation that the relatively immature gas markets of emerging countries will develop quickly in the coming years.

World coal use has been in a period of generally slow growth since the 1980s, and the trend is expected to continue through the projection period. The projected slow growth in coal consumption, averaging 1.5 percent per year through 2025, suggests that coal will account for a shrinking share of world energy consumption. In the *IEO2003* reference case, the coal share of total energy consumption is projected to fall from 24 percent in 2001 to 22 percent by 2025. Substantial declines in coal use are projected for Western Europe and the EE/FSU countries, where natural gas (and in the case of France, nuclear power) is increasingly being used for electricity generation and for other uses in the industrial and buildings sectors. The expected decline in coal's share of energy use would be even greater were it not for projected large increases in coal use in developing Asia, especially in China and India, where coal continues to dominate many fuel markets. 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 75 percent of the total expected increase in coal use worldwide (on a Btu basis).

Almost 55 percent of the coal consumed worldwide is used for electricity generation, and its role in the future is expected to be primarily as a fuel for power generation and secondarily as an energy source in a few key industrial sectors, such as steelmaking. Where coal is used in the industrial, residential, and commercial sectors, other energy sources—primarily, natural gas—are expected to

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

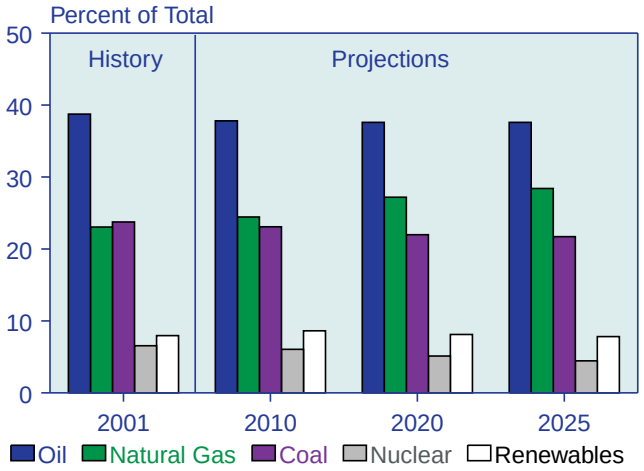


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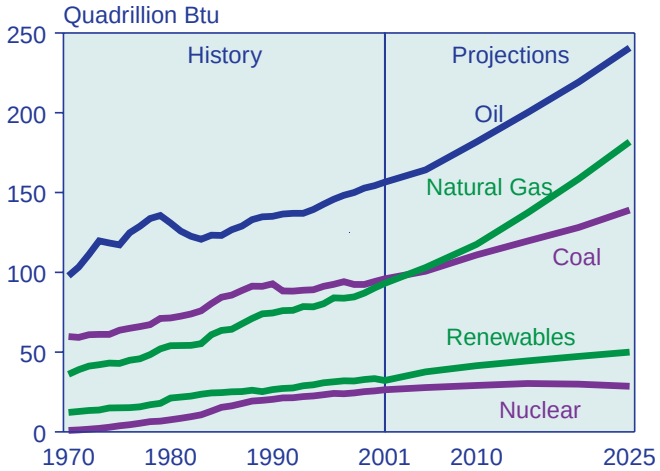
Figure 7. World Energy Consumption by Energy Source, 1970-2025



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gain market share. One exception is China, where coal continues to be the most widely used fuel in the country's rapidly growing industrial sector, reflecting the China's abundant coal reserves and limited access to other sources of energy. 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.

Nuclear power accounted for 19 percent of the world's total electricity supply in 2001. The *IEO2003* reference case projects a drop in the nuclear share of electricity, to 12 percent by 2025, as the current trend away from nuclear power in most countries continues. Although some nations are expected to construct new nuclear power plants during the forecast period, declines in nuclear capacity are projected for most of the countries with active nuclear power programs as older plants are retired. The economics of nuclear generating capacity generally compare unfavorably with other available technologies, and public concerns about plant safety, radioactive waste disposal, and weapons proliferation are expected to contribute to the decline of nuclear power in the long term.

Despite its declining share of global electricity production in the *IEO2003* reference case forecast, nuclear power will continue to be a significant source of electricity. Life extensions, higher capacity factors, and capacity uprates are expected to offset some of the capacity losses resulting from retirements. Further, some nations still are expected to continue building new units. Most future capacity additions are expected in Asia, with China, India, Japan, and South Korea projected to add a combined 45 gigawatts between 2001 and 2025. As of February 2003, the nations of developing Asia accounted for 17 of the 35 nuclear reactors under construction worldwide, including 8 in India, 4 in China, 2 each in South Korea and Taiwan, and 1 in North Korea.

Consumption of hydroelectricity and other renewable resources is projected to increase only moderately in the *IEO2003* reference case, at an average annual rate of 1.9 percent per year between 2001 and 2025. Renewable energy sources are not expected to be economically competitive with fossil fuels in the mid-term without significant support from government policies that would encourage their widespread expansion. Much of the growth in use of renewable energy is expected to result from the operation of new large-scale hydroelectric facilities in the developing world, particularly in developing Asia. Among other nations in the region, China, India, Malaysia, and Vietnam are currently constructing or planning large-scale hydroelectric projects. The first electricity generating units of China's 18,200-megawatt Three Gorges Dam project are scheduled to be installed in 2003; India is set to begin the final phase of reservoir filling for its 2,000-megawatt Tehri dam; and Malaysia has awarded the main construction contract for its 2,400-megawatt Bakun dam.

Over the projection period, worldwide net electricity consumption is projected to increase at an average annual rate of 2.4 percent, from 13.9 trillion kilowatthours in 2001 to 24.7 trillion kilowatthours in 2025. Strong growth in electricity use is expected in the countries of the developing world, particularly developing Asia, where robust economic growth is projected to support increased demand for electricity to run newly purchased home appliances for air conditioning, refrigeration, cooking, and space and water heating. China's electricity consumption is projected to nearly triple, growing by an average of 4.3 percent per year in the reference case. Slower growth in population and economic activity, as well as market saturation and efficiency gains for some electronic appliances, is expected to result in a more modest growth rate for electricity use in the industrialized world, at 1.7 percent per year.

International investments in the electricity sector have changed course to some extent in recent years. First, much of the massive U.S. investment in foreign electricity ventures that began in the mid- to late 1990s—particularly in South America, Western Europe, and Australia—has slowed, in part because of the sluggish state of the global economy but also because of disappointing financial performance of many acquisitions. Foreign direct investment in the electricity sectors of the developing world has slowed as well, and the level of such activity in 2001 was only about one-fifth of the 1997 peak level. Mergers and acquisitions among U.S. electricity firms have also slowed substantially since peaking in 1999. Finally, the move toward electricity market restructuring—another trend that flourished in the 1990s—is also changing. Although some countries, including South Korea and Mexico, still are pursuing restructuring programs, others have delayed or modified their restructuring plans. For example, the United Kingdom has reformed its electricity pool in response to evidence of market manipulation, and in Ontario, Canada, a program of electricity price decontrol was reversed after a weather-related spike in retail prices in the summer of 2002.

Carbon Dioxide Emissions

Because estimates indicate that approximately 80 percent of all human-caused carbon dioxide emissions currently come from fossil fuel combustion, world energy use has emerged at the center of the climate change debate. In the *IEO2003* reference case, world carbon dioxide emissions are projected to rise from 6.5 billion metric tons carbon equivalent in 2001 to 7.7 billion

metric tons in 2010 and 10.4 billion metric tons in 2025 (Figure 8). 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 59 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 the change 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 *IEO2003* forecast, energy intensity in the industrialized countries is expected to improve (decrease) by 1.3 percent per year between 2001 and 2025, slightly slower than the 1.4 percent per year improvement observed in the region between 1970 and 2001. Energy intensity is expected to improve more rapidly in the developing countries—by 1.7 percent per year on average—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 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 2.1 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 Intensity

World carbon intensity has improved (decreased) substantially over the past three decades, falling from 302 metric tons per million 1997 dollars of GDP in 1970 to 202 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 154 metric tons per million 1997 dollars of GDP in 2025.

On a regional basis, the most rapid rates of improvement in carbon intensity are projected for the transitional economies of the EE/FSU and the developing Asian countries of China and India. In the FSU, economic recovery from the upheaval of the 1990s is expected to continue throughout the forecast. The FSU nations are also expected to replace old and inefficient capital stock and increasingly use less carbon-intensive natural gas for new electricity generation capacity and for other end

Figure 8. World Carbon Dioxide Emissions by Fossil Fuel, 1970-2025

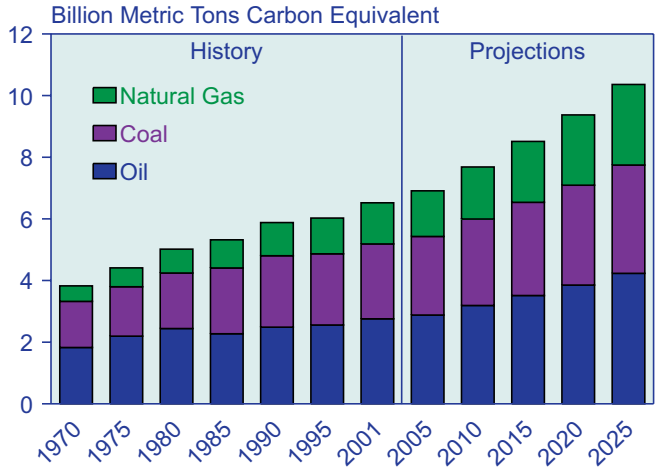

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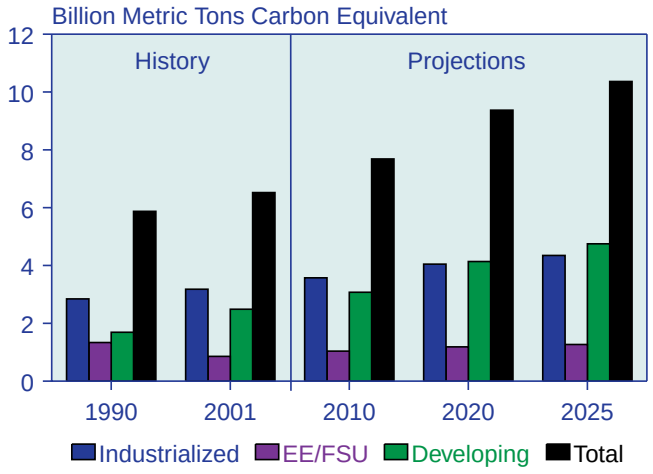
Figure 9. World Carbon Dioxide Emissions by Region, 1990-2025



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uses rather than more carbon-intensive oil or 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 (Figure 11).

In developing Asia, fairly rapid improvements in carbon intensity are projected for China and India, 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.

The rate of improvement in carbon dioxide intensity could vary considerably in the future. Technological advances and government policy initiatives have the potential to affect the rate of improvement in carbon intensity, and different rates of economic improvement could also considerably alter future carbon intensity levels. In the *IEO2003* reference case, world carbon dioxide intensity is projected to fall from 202 metric tons carbon equivalent per million 1997 dollars of GDP in 2001 to 154 metric tons per million dollars in 2025; however, if world economic growth expanded to the levels projected in the high economic growth case, carbon dioxide intensity could fall more quickly, to 142 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 166 metric tons per million dollars in 2025.

Figure 10. World Energy Intensity by Region, 1970-2020

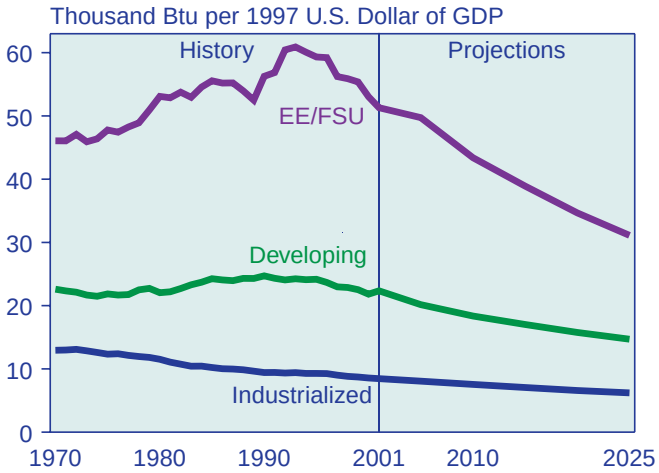

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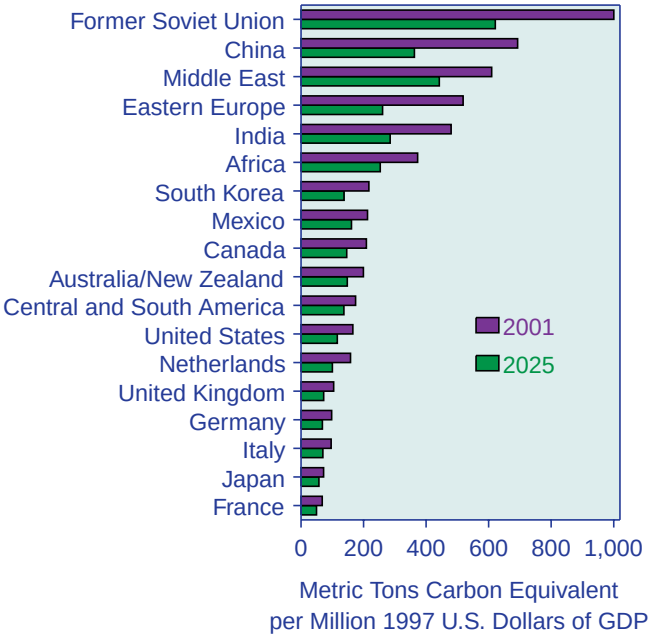
Figure 11. World Carbon Dioxide Intensity by Selected Countries and Regions, 2001 and 2025



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