

Highlights

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

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

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

In contrast to the emerging economies, increases in energy consumption for the mature market economies and transitional economies are projected to be more

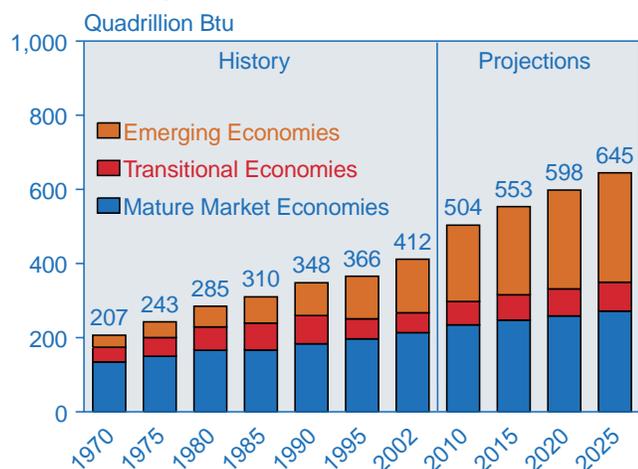
modest. In the case of the mature market economies, well-established energy consumption patterns and infrastructure, along with a shift from energy-intensive industries to services, lead to a projected growth rate for energy demand that averages 1.1 percent per year over the projection period, compared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

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

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

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

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



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

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

The *IEO2005* reference case has adopted the *Annual Energy Outlook 2005 (AEO2005)* October futures case, which has an assumption of higher prices than the *AEO2005* reference case and now appears to be a more likely projection for oil prices. World oil prices rose by

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

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

Regional Definitions in the *International Energy Outlook 2005*

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

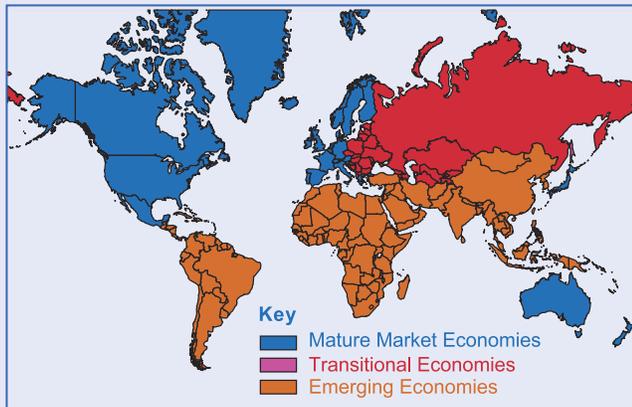
IEO2005 uses country grouping designations based on relative levels of economic development. The three major groupings (or “regions”) used in this report are the mature market economies, transitional economies, and emerging economies. The mature market economies include nations whose energy markets are generally well-established, and whose industrial sectors have trended away from more energy-intensive manufacturing industries toward less energy-intensive service industries. As shown in the map below, the

mature market economies include the countries of North America (the United States, Canada, and Mexico), Western Europe, and “mature market” Asia (Japan, Australia, and New Zealand). The grouping of countries may be subject of some debate. For example, some may argue that Mexico should not be considered a mature market economy; however, it is included in North America because of its importance in energy trade in the region.

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

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

IEO2005 World Regions

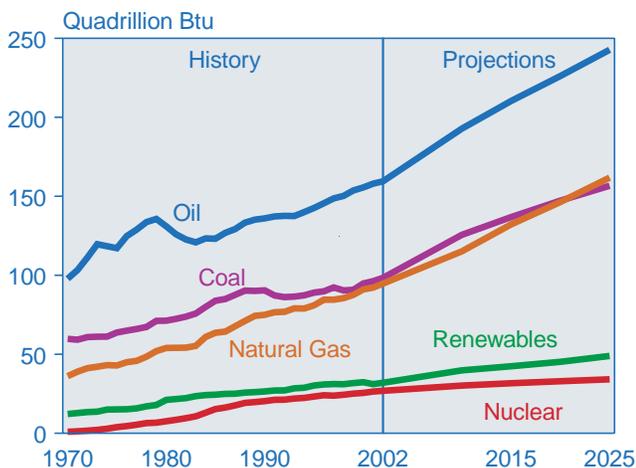


119 million barrels per day in 2025. The projection for oil demand in 2025 is somewhat lower than the 121 million barrels per day forecast in last year's outlook, due in large part to higher world oil price projections in *IEO2005*. Higher sustained world oil prices in this year's forecast dampen the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

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

Natural gas is projected to be the fastest growing component of world primary energy consumption in the *IEO2005* reference case. Consumption of natural gas worldwide increases in the forecast by an average of 2.3 percent annually from 2002 to 2025, compared with projected annual growth rates of 1.9 percent for oil consumption and 2.0 percent for coal consumption. From

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



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

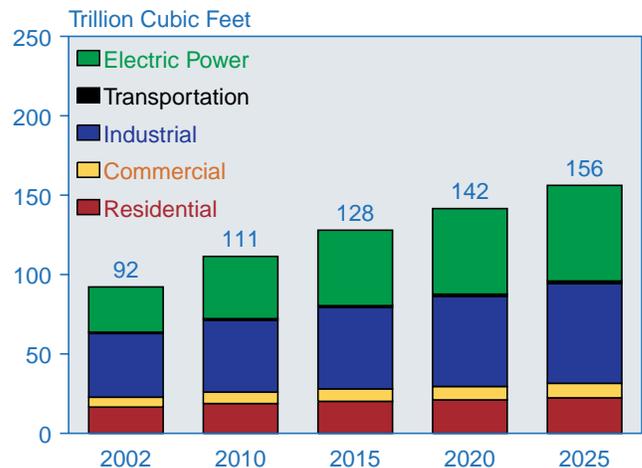
2002 to 2025, consumption of natural gas is projected to increase by 69 percent, from 92 trillion cubic feet to 156 trillion cubic feet, and its share of total energy consumption is projected to grow from 23 percent to 25 percent. The electric power sector accounts for 51 percent of the total incremental growth in worldwide natural gas demand over the forecast period (Figure 3).

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

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

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

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



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

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

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

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

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

Hydroelectricity and other grid-connected renewable energy sources are expected to maintain an 8-percent share of total energy use worldwide throughout the projection period. Although the use of marketed renewable energy sources expands in the *IEO2005* reference case at an average annual rate of 1.9 percent from 2002 to 2025,

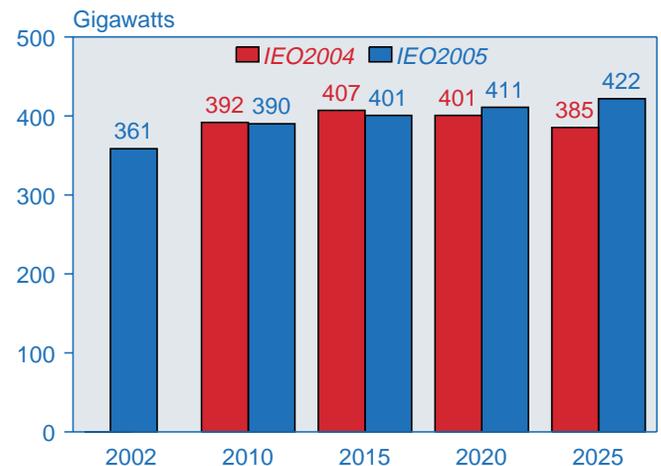
the more rapid growth rates projected for natural gas and coal cause the renewable share of world energy use to remain flat.

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

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

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

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



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

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

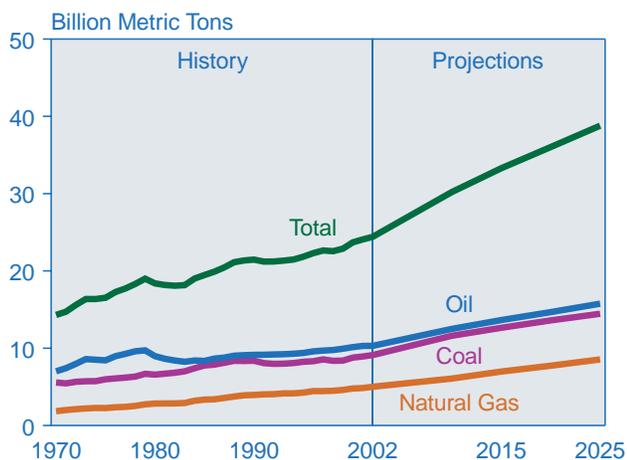
The Kyoto Protocol, which requires participating “Annex I” countries¹ to reduce their carbon dioxide emissions collectively to an annual average of about 5 percent below their 1990 level over the 2008-2012 period, became a legally binding treaty on February 16, 2005, 90 days after it was ratified by Russia. The *IEO2005* reference case forecast does not include the potential impacts of the Kyoto Protocol, because the treaty does not indicate the methods by which ratifying parties will implement their obligations either in the first commitment period or after 2012. To examine the implications of the treaty for energy use and carbon dioxide emissions, a Kyoto Protocol case was analyzed.

A number of assumptions were made in developing the *IEO2005* Kyoto Protocol case. First, it was assumed that energy use would not vary from the reference case forecast for countries that are not undertaking an emissions reduction commitment. In addition, assumptions were made about how the affected participating regions

would achieve their reductions. In Western Europe, stated intentions that “most” of the emissions reductions will be achieved domestically resulted in an assumption that 50 percent of the aggregate emissions reduction for Western Europe will be met by domestic reductions. With no stated intention about levels of domestic reductions in Japan or in Canada, an assumption was made that for both countries a 25-percent share of their total reductions would be met domestically.

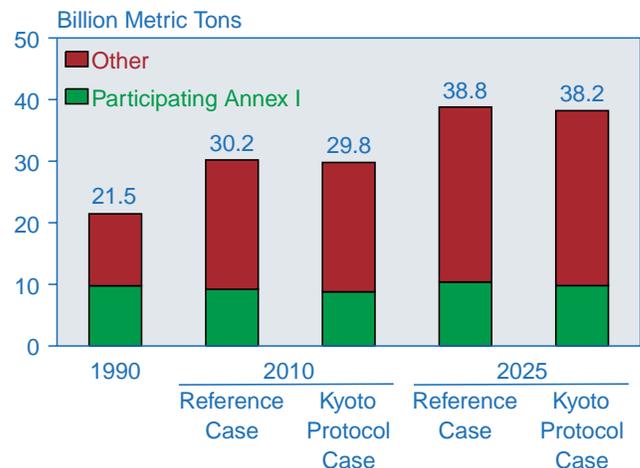
In the *IEO2005* Kyoto Protocol case, energy-related carbon dioxide emissions in the participating nations are projected to be 593 million metric tons lower than in the reference case in 2025. Achieving the national commitments under the treaty is projected to require marginal costs for emission reductions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

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



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

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



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

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

