

# International Energy Outlook

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## 2007

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# Highlights

*World marketed energy consumption is projected to increase by 57 percent from 2004 to 2030. Total energy demand in the non-OECD countries increases by 95 percent, compared with an increase of 24 percent in the OECD countries.*

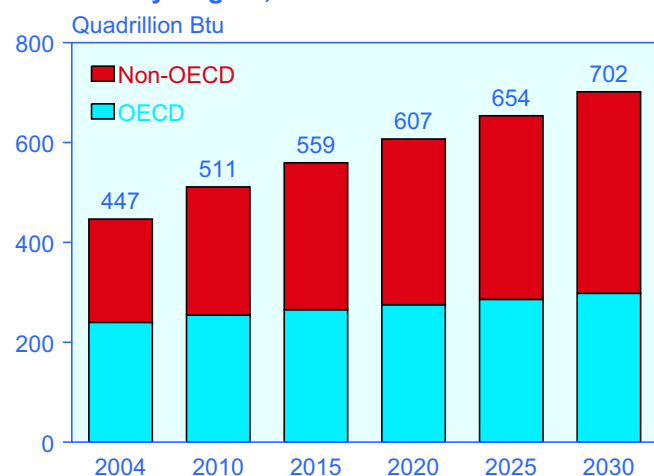
In the *IEO2007* reference case—which reflects a scenario where current laws and policies remain unchanged throughout the projection period—world marketed energy consumption is projected to grow by 57 percent over the 2004 to 2030 period. Total world energy use rises from 447 quadrillion British thermal units (Btu) in 2004 to 559 quadrillion Btu in 2015 and then to 702 quadrillion Btu in 2030 (Figure 1). Global energy demand grows despite the relatively high world oil and natural gas prices that are projected to persist into the mid-term outlook.

The most rapid growth in energy demand from 2004 to 2030 is projected for nations outside the Organization for Economic Cooperation and Development (non-OECD nations). Total non-OECD energy demand increases by 95 percent in the *IEO2007* reference case projection, as compared with an increase of 24 percent in OECD energy use. The robust growth in demand among the non-OECD nations is largely the result of strong projected economic growth. In all the non-OECD regions combined, economic activity—as measured by GDP in purchasing power parity terms—increases by 5.3 percent per year on average, as compared with an average of 2.5 percent per year for the OECD economies.

Trends in end-use sector energy consumption can vary widely, according to the level and pace of economic development in a given region. In the OECD region, where energy markets generally are well established, demand for delivered energy in each of the end-use sectors grows more slowly than in the non-OECD nations (Figure 2). For the industrial sector, energy-intensive industries continue to expand more rapidly in the non-OECD countries, where investors are attracted by lower costs and fewer environmental constraints, than in the OECD countries. In 1980, the OECD accounted for 52 percent of the world's industrial sector energy use. In 2004 the OECD share had fallen to 44 percent, and it is projected to decline to 33 percent in 2030, as non-OECD industrial energy use outpaces that in the OECD (Figure 3). For the OECD countries, industrial sector energy use is projected to grow at an average rate of 0.6 percent per year from 2004 to 2030; for the non-OECD countries, the projected increase averages 2.5 percent per year.

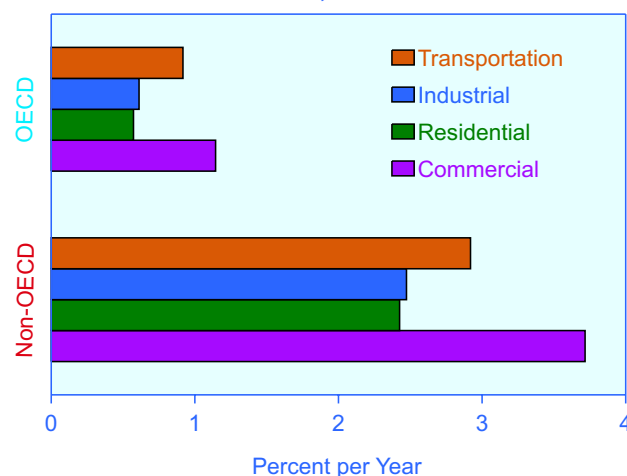
As in the industrial sector, energy use in the buildings and transportation sectors is projected to grow more slowly in the OECD countries than in the non-OECD countries in the *IEO2007* reference case. With slow or declining population growth in many OECD nations,

**Figure 1. World Marketed Energy Consumption by Region, 2004-2030**



Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).

**Figure 2. Average Annual Growth in Delivered Energy Consumption by Region and End-Use Sector, 2004-2030**



Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **2030:** EIA, *System for the Analysis of Global Energy Markets* (2007).

generally slow growth in energy use in the buildings sectors is projected, averaging 0.6 percent per year in the residential sector and 1.1 percent per year in the commercial sector from 2004 to 2030. For the non-OECD region as a whole, strong growth in demand for energy is projected in the buildings sectors, averaging 2.4 percent per year in the residential sector and 3.7 percent per year in the commercial sector.

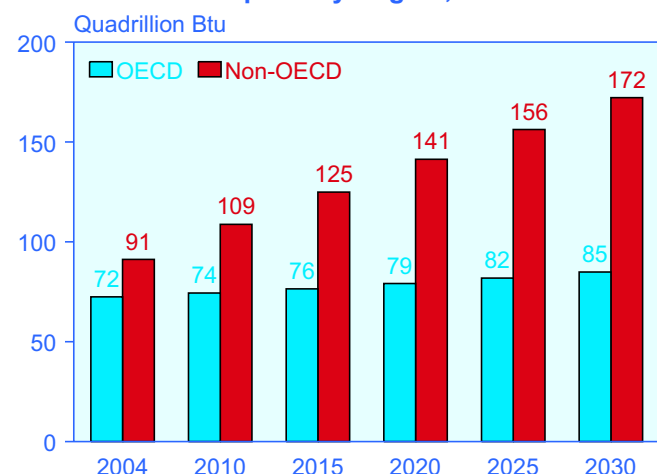
Historically, growth in transportation activity has been linked closely to income growth, indicating a strong relationship between per-capita GDP and passenger car travel per capita, especially in countries with developing economies. With robust economic growth projected for the developing non-OECD nations, transportation sector energy use increases by an average of 2.9 percent per year from 2004 to 2030, requiring extensive investment in the construction of transportation infrastructure (highways, fueling stations, airport facilities, rail systems, etc.) to support the fast-paced growth in demand. In the OECD countries, where extensive infrastructure is in place already and GDP is projected to grow much more slowly, demand for transportation fuels increases by 0.9 percent per year.

The IEO2007 reference case projects increased world consumption of marketed energy from all sources over the 2004 to 2030 projection period (Figure 4). Fossil fuels (petroleum and other liquid fuels,<sup>1</sup> natural gas, and coal)

are expected to continue supplying much of the energy used worldwide. Liquids supply the largest share of world energy consumption over the projection period, but their share falls from 38 percent in 2004 to 34 percent in 2030, largely in response to a reference case scenario in which real world oil prices remain near the current level through 2030. Liquids remain the dominant energy source, given their importance in the transportation and industrial end-use sectors; however, their share of the world energy market in this year's outlook is lessened in the projection, as other fuels replace liquids where possible outside those sectors. Fossil fuel prices in the reference case also support renewed interest in expanding the use of nuclear power and renewable energy sources to generate electricity.

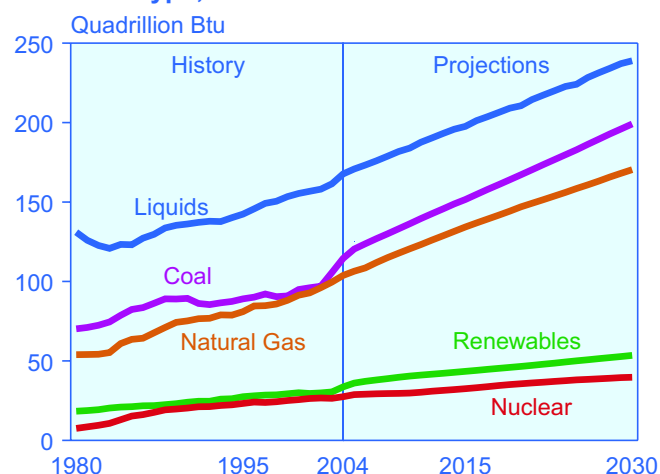
World use of petroleum and other liquids grows from 83 million barrels oil equivalent per day in 2004 to 97 million barrels per day in 2015 and 118 million barrels per day in 2030 in the reference case.<sup>2</sup> In most regions of the world, the role of liquid fuels outside the transportation sector continues to erode. Liquids remain the most important fuels for transportation, because there are few alternatives that can compete widely with petroleum-based liquid fuels. On a global basis, the transportation sector accounts for 68 percent of the total projected increase in liquids use from 2004 to 2030, followed by the industrial sector, which accounts for another 27 percent of the increase.

**Figure 3. Industrial Sector Delivered Energy Consumption by Region, 2004-2030**



Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).

**Figure 4. World Marketed Energy Use by Fuel Type, 1980-2030**



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).

<sup>1</sup>Petroleum and other liquid fuels include petroleum-derived fuels and non-petroleum-derived fuels, such as ethanol and biodiesel, coal-to-liquids, and gas-to-liquids. Petroleum coke, which is a solid, is included. Also included are natural gas liquids, crude oil consumed as a fuel, and liquid hydrogen.

<sup>2</sup>Throughout this report, liquids energy use is reported on a barrel equivalent basis, rather than a volumetric basis, because of the inclusion of biofuels (specifically, ethanol) in the liquids total. Ethanol is only two-thirds as efficient as petroleum-based motor gasoline.

To meet the increment in world liquids demand in the reference case, total supply in 2030 is projected to be 35 million barrels per day higher than the 2004 level of 83 million barrels per day. Conventional liquids production by members of the Organization of the Petroleum Exporting Countries (OPEC) contributes about 21 million barrels per day to the total increase, and conventional liquids production in non-OPEC countries adds another 6 million barrels per day (Figure 5). Unconventional resources (including biofuels, coal-to-liquids, and gas-to-liquids) from both OPEC and non-OPEC sources are expected to become increasingly competitive. World production of unconventional resources, which totaled only 2.6 million barrels per day in 2004, is projected to increase to 10.5 million barrels per day and account for 9 percent of total world liquids supply in 2030, on an oil equivalent basis, in the *IEO2007* reference case.

Natural gas consumption increases on average by 1.9 percent per year in the reference case, from a world total of 99.6 trillion cubic feet in 2004 to 129.0 trillion cubic feet in 2015 and 163.2 trillion cubic feet in 2030. Rising world oil prices after 2015 increase the demand for—and then the price of—natural gas, as it is used to displace the use of liquids in the industrial and electric power sectors. Although natural gas prices vary by region, they tend to rise as demand increases. Higher natural gas prices, in turn, make coal more cost-competitive, especially in the electric power sector. Among the end-use sectors, the industrial sector remains the largest consumer of natural gas worldwide, accounting for 43 percent of the world's total projected natural gas consumption in 2030.

Coal is the fastest-growing energy source worldwide in the *IEO2007* reference case projections. World coal consumption is projected to increase from 114.5 quadrillion

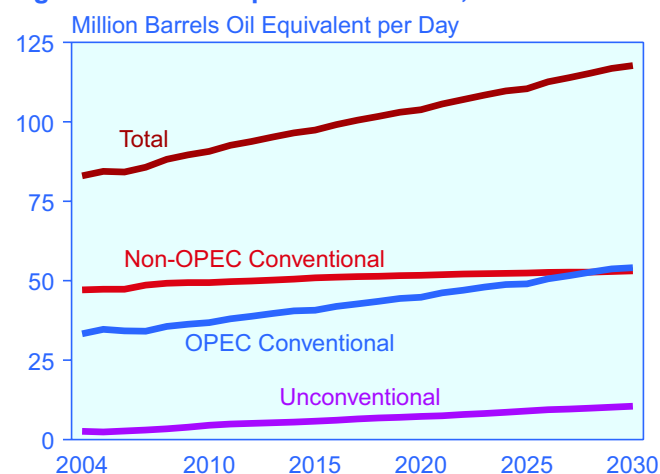
Btu in 2004 to 199.1 quadrillion Btu in 2030, at an average annual rate of 2.2 percent. World coal consumption increased sharply from 2003 to 2004, largely because of a 17-percent increase on a Btu basis in non-OECD Asia (mainly, China and India). Coal's share of total world energy use is projected to increase from 26 percent in 2004 to 28 percent in 2030.

The electric power sector accounts for about two-thirds of the world's coal consumption throughout the projection period, and the industrial sector accounts for most of the remainder. China's industrial sector is projected to account for about 78 percent of the total net increase in industrial coal use worldwide. China has abundant coal resources, limited reserves of oil and natural gas, and a leading position in world steel production.

World net electricity generation grows by 85 percent in the *IEO2007* reference case, from 16,424 billion kilowatthours in 2004 to 22,289 billion kilowatthours in 2015 and 30,364 billion kilowatthours in 2030. Most of the projected increase in electricity demand is in the non-OECD nations, where electricity generation increases on average by 3.5 percent per year from 2004 to 2030, as compared with 1.3 percent per year in the OECD nations. Coal and natural gas remain the most important fuels for electricity generation throughout the projection period, together accounting for 80 percent of the total increment in world electric power generation from 2004 to 2030 in the reference case (Figure 6).

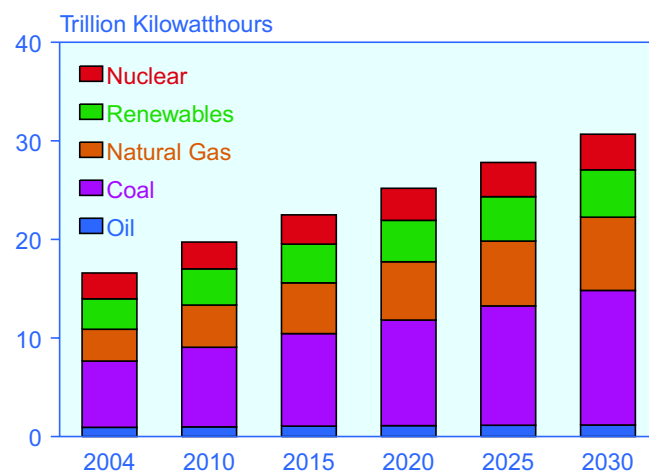
Electricity generation from nuclear power is projected to increase from 2,619 billion kilowatthours in 2004 to 3,619 billion kilowatthours in 2030. Higher fossil fuel prices, energy security concerns, improved reactor designs, and

**Figure 5. World Liquids Production, 2004-2030**



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).

**Figure 6. World Electricity Generation by Fuel, 2004-2030**



Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).

environmental considerations are expected to improve the prospects for new nuclear power capacity in many parts of the world, and a number of countries are expected to build new nuclear power plants. In the *IEO2007* reference case, the world's installed nuclear capacity grows from 368 gigawatts in 2004 to 481 gigawatts in 2030. Declines in nuclear capacity are projected only in OECD Europe, where several countries (including Germany and Belgium) have either plans or mandates to phase out nuclear power, and where some older reactors are expected to be retired and not replaced.

Nuclear power generation in the non-OECD countries is projected to increase by 4.0 percent per year from 2004 to 2030. The largest increase in installed nuclear generating capacity is expected in non-OECD Asia, where annual increases in nuclear capacity average 6.3 percent and account for 68 percent of the total projected increase in nuclear power capacity for the non-OECD region as a whole. Of the 58 gigawatts of additional installed nuclear generating capacity projected for non-OECD Asia between 2004 and 2030, 36 gigawatts is projected for China and 17 gigawatts for India. Russia also is expected to add substantial nuclear generating capacity over the mid-term projection, increasing capacity by 20 gigawatts.

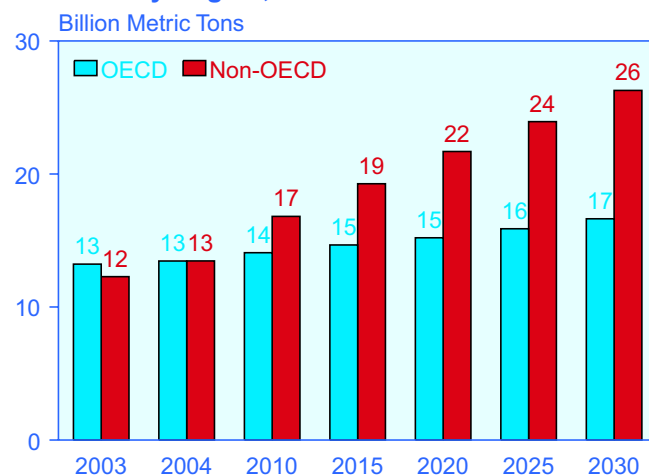
The use of hydroelectricity and other grid-connected renewable energy sources is expected to continue to expand over the projection period, increasing by 1.9 percent per year, at the same rate of growth as natural gas consumption in the reference case. Higher fossil fuel prices, particularly for natural gas in the electric power sector, allow renewable energy sources to compete economically in some areas. Where they are not economically competitive with fossil fuels, renewable energy sources may be supported by government policies and incentives. The renewables share of total world energy consumption is expected to rise from 7 percent in 2004 to 8 percent in 2030.

Much of the growth in renewable energy consumption is projected to come from mid- to large-scale hydroelectric facilities in non-OECD Asia and Central and South America, where several countries have hydropower facilities either planned or under construction. Outside of Canada and Turkey, hydropower capacity is not expected to grow substantially in the OECD nations, because most hydroelectric resources in the region already have been developed or lie far from population centers. Instead, most of the increase in OECD renewable energy consumption is expected to be in the form of nonhydroelectric resources, such as wind, solar, geothermal, municipal solid waste, and biomass.

In recent years, atmospheric concentrations of carbon dioxide—one of the most important greenhouse gases in the atmosphere—have been increasing at a rate of about 0.5 percent annually. Because anthropogenic (human-caused) emissions of carbon dioxide result primarily from the combustion of fossil fuels for energy, energy use has emerged at the center of the climate change debate. World carbon dioxide emissions continue to increase steadily in the *IEO2007* reference case, from 26.9 billion metric tons in 2004 to 33.9 billion metric tons in 2015 and 42.9 billion metric tons in 2030, an increase of 59 percent over the projection period.

From 2003 to 2004, carbon dioxide emissions from the non-OECD countries grew by almost 10 percent, largely because of a 17-percent increase in coal use in non-OECD Asia, while emissions from the OECD countries grew by less than 2 percent. The result of the large increase in non-OECD emissions was that 2004 marked the first time in history that energy-related carbon dioxide emissions from the non-OECD countries exceeded those from the OECD countries—although by only about 8 million metric tons (Figure 7). Further, because the projected average annual increase in emissions from 2004 to 2030 in the non-OECD countries (2.6 percent) is more than three times the increase projected for the OECD countries (0.8 percent), carbon dioxide emissions from the non-OECD countries in 2030, at 26.2 billion metric tons, are projected to exceed those from the OECD countries by 57 percent.

**Figure 7. World Carbon Dioxide Emissions by Region, 2003-2030**



Sources: **2003 and 2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).

## Chapter 1

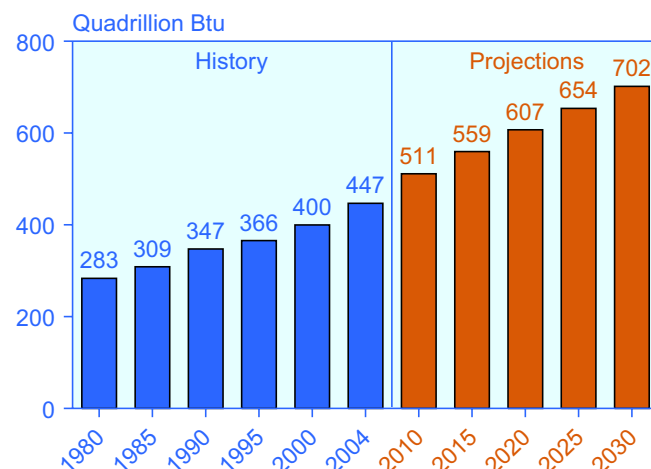
# World Energy and Economic Outlook

*In the IEO2007 reference case, total world consumption of marketed energy is projected to increase by 57 percent from 2004 to 2030. The largest projected increase in energy demand is for the non-OECD region.*

The IEO2007 reference case—which reflects a scenario where current laws and policies remain unchanged throughout the projection period—projects strong growth for worldwide energy demand from 2004 to 2030. Total world consumption of marketed energy is projected to increase from 447 quadrillion Btu in 2004 to 559 quadrillion Btu in 2015 and then to 702 quadrillion Btu in 2030—a 57-percent increase over the projection period (Table 1 and Figure 8).

The largest projected increase in energy demand is for the non-OECD region. Generally, countries outside the OECD<sup>3</sup> have higher projected economic growth rates and more rapid population growth than the OECD nations. In the IEO2007 reference case, energy consumption in the non-OECD region is projected to grow at an average annual rate of 2.6 percent from 2004 through 2030. In the OECD region, where national economies are more mature and population growth is expected to be relatively slower, energy use is projected to grow at the much slower average rate of 0.8 percent per year over

**Figure 8. World Marketed Energy Consumption, 1980-2030**



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

**Table 1. World Marketed Energy Consumption by Country Grouping, 2004-2030**  
(Quadrillion Btu)

Region	2004	2010	2015	2020	2025	2030	Average Annual Percent Change, 2003-2030
<b>OECD</b> .....	<b>239.8</b>	<b>254.4</b>	<b>265.2</b>	<b>275.1</b>	<b>285.9</b>	<b>298.0</b>	<b>0.8</b>
North America .....	120.9	130.3	137.4	145.1	153.0	161.6	1.1
Europe .....	81.1	84.1	85.8	86.1	87.5	89.2	0.4
Asia .....	37.8	39.9	42.1	43.9	45.4	47.2	0.9
<b>Non-OECD</b> .....	<b>206.9</b>	<b>256.6</b>	<b>294.2</b>	<b>331.9</b>	<b>367.8</b>	<b>403.5</b>	<b>2.6</b>
Europe and Eurasia .....	49.7	54.7	59.4	64.4	68.7	71.5	1.4
Asia .....	99.9	131.0	154.7	178.8	202.5	227.6	3.2
Middle East .....	21.1	26.3	29.5	32.6	35.5	38.2	2.3
Africa .....	13.7	16.9	19.2	21.2	23.1	24.9	2.3
Central and South America ....	22.5	27.7	31.5	34.8	38.0	41.4	2.4
<b>Total World</b> .....	<b>446.7</b>	<b>511.1</b>	<b>559.4</b>	<b>607.0</b>	<b>653.7</b>	<b>701.6</b>	<b>1.8</b>

Note: Totals may not equal sum of components due to independent rounding.

Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

<sup>3</sup>For consistency, OECD includes all members of the organization as of February 1, 2007, throughout all the time series presented in this publication.



the projection period. Energy use in the non-OECD region is projected to surpass that in the OECD region by 2010, and to be 35 percent greater than the non-OECD total in 2030 (Figure 9).

Much of the growth in energy demand among the non-OECD economies occurs in non-OECD Asia, which includes China and India. Energy demand in the non-OECD Asia region is projected to grow at an average rate of 3.2 percent per year, more than doubling over the 2004 to 2030 period and accounting for more than 65 percent of the increase in energy use for the non-OECD region as a whole. In 2004, energy consumption in the countries of non-OECD Asia made up just over 48 percent of the non-OECD total; in 2030, its share is projected to be above 56 percent (Figure 10).

Strong growth in energy demand is also projected for the other non-OECD regions. In the reference case projections, energy consumption increases at average annual rates of 2.4 percent in Central and South America, 2.3 percent in the Middle East and in Africa, and 1.4 percent in non-OECD Europe and Eurasia.

This chapter presents an overview of the *IEO2007* outlook for energy consumption by primary energy source and a look at the major assumptions that form the basis for the projections that appear in the report. It includes a discussion of the *IEO2007* macroeconomic forecast in the context of the key OECD and non-OECD regions.

As with any set of projections, there is significant uncertainty associated with the *IEO2007* energy projections. This chapter includes discussion of two sets of sensitivity cases, which vary some of the assumptions behind the *IEO2007* projections: high and low macroeconomic

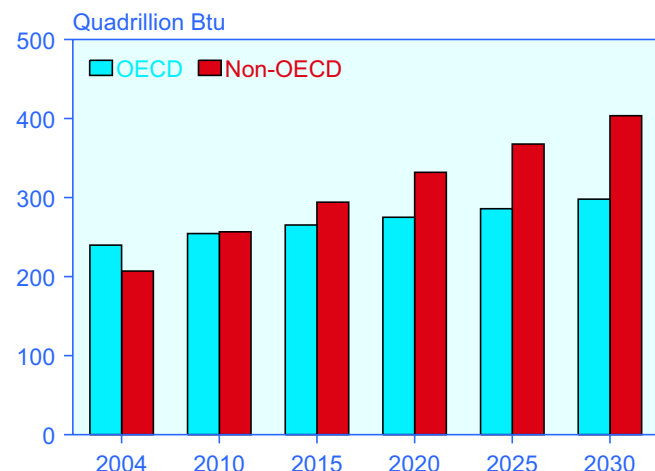
growth cases and high and low world oil price cases. These cases are intended to illustrate alternative scenarios rather than to identify any bounds on uncertainty, which can be affected by policy and technology developments, as well as price and growth paths. Also included is a discussion of the possible effects of future trends in energy intensity (the relationship between energy use and economic growth) on the reference case projections.

## Outlook for World Energy Consumption

The *IEO2007* reference case projects increased world consumption of marketed energy from all sources over the 2004 to 2030 period. Fossil fuels continue to supply much of the increment in marketed energy use worldwide throughout the projections. Liquids (primarily, oil and other petroleum products) are expected to continue to provide the largest share of world energy consumption over the projection period, but their share falls from 38 percent in 2004 to 34 percent in 2030 (Figure 11), largely because rising world oil prices dampen the demand for liquids after 2015.

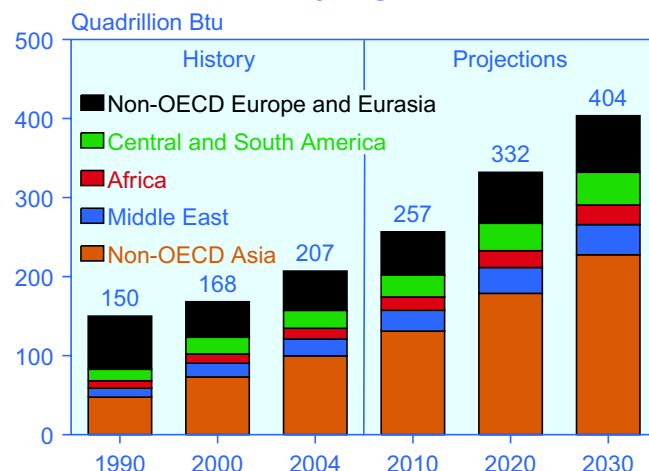
Worldwide liquids consumption is projected to increase from 83 million barrels per day in 2004 to 97 million barrels per day in 2015 and 118 million barrels per day in 2030. Liquids remain the most important fuels for transportation, because there are few alternatives that can be expected to compete widely with petroleum-based liquids; however, the role of oil outside the transportation sector continues to be eroded because of high world oil prices in most regions of the world. On a global basis, the transportation sector accounts for 68 percent of the total projected increase in liquids use between 2004 and 2030,

**Figure 9. World Marketed Energy Use: OECD and Non-OECD, 2004-2030**



Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).

**Figure 10. Marketed Energy Use in the Non-OECD Economies by Region, 1990-2030**



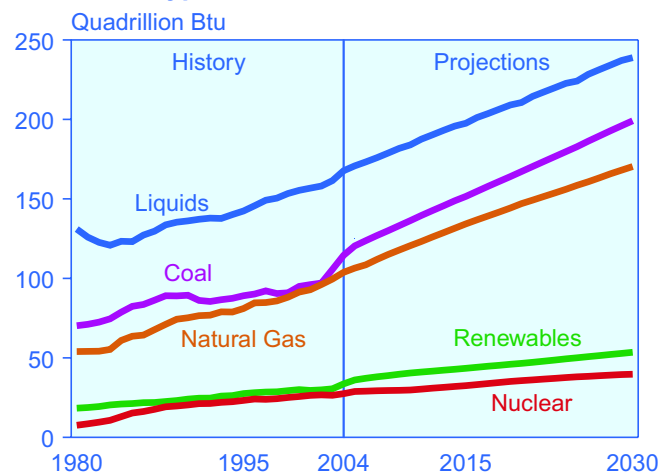
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).

followed by the industrial sector, which accounts for another 27 percent of the increment in world liquids demand.

Natural gas consumption increases by 1.9 percent per year on average over the projection period, from about 100 trillion cubic feet in 2004 to 163 trillion cubic feet in 2030. Rising world oil prices increase the demand for natural gas, as it is used to displace the use of liquids in the industrial and electric power sectors in many parts of the world. Industrial uses throughout the world are projected to make up 43 percent of total natural gas use in 2030. In addition, natural gas is both a more efficient fuel for electric power generation and less carbon intensive than other fossil fuels, and as a result it is an attractive energy source for the world's power generation. It is the world's fastest-growing energy source for electricity generation in the *IEO2007* reference case projection, leading to an increase in the electric power sector share of total natural gas use worldwide, from 31 percent in 2004 to 36 percent in 2030.

Natural gas prices are likely to vary from region to region, depending on the size of available resources and their distance from end-use markets. In the United States, dependence on relatively expensive domestic supplies of unconventional natural gas and imports of liquefied natural gas (LNG) is expected to increase over the projection period, and projected prices in the U.S. market thus tend to be at the high end of the range. In Russia and the Middle East, where domestic resources of conventional natural gas are both abundant and readily accessible, natural gas prices are among the lowest in the world.

**Figure 11. World Marketed Energy Use by Fuel Type, 1980-2030**

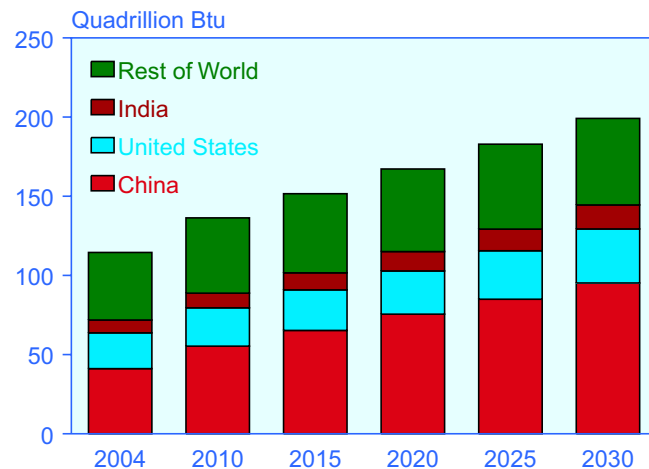


Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).

World coal consumption increased sharply from 2003 to 2004, largely because of a 17-percent increase on a Btu basis in non-OECD Asia (China and India). As a result, coal's share of total world energy use climbed from 25 percent in 2003 to 26 percent in 2004. With oil and natural gas prices expected to continue rising, coal is an attractive fuel for nations with access to ample coal resources—notwithstanding government policies aimed at reducing coal use—and its share of world energy consumption is projected to increase further, to 28 percent in 2030. In the *IEO2007* reference case projection, coal use worldwide increases by 37 quadrillion Btu from 2004 to 2015 and by another 48 quadrillion Btu from 2015 to 2030. In particular, the United States, China, and India are well-positioned to displace more expensive fuels with coal, and together the three nations account for 86 percent of the expected increase from 2004 to 2030 (Figure 12). Decreases in coal consumption are projected only for OECD Europe and Japan, where population growth is slow or declining, electricity demand growth is slow, and natural gas and nuclear power are likely to continue providing significant amounts of electricity.

Worldwide, electricity generation in 2030 is projected to total 30,364 billion kilowatthours, nearly double the 2004 total of 16,424 billion kilowatthours. The strongest growth in net electricity consumption is projected for the non-OECD region, averaging 3.5 percent per year in the *IEO2007* reference case (Figure 13). Robust economic growth in many of the non-OECD countries is expected to boost demand for electricity to run newly purchased home appliances for air conditioning, cooking, space and water heating, and refrigeration and to support the

**Figure 12. World Coal Consumption by Region, 2004-2030**



Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).



expansion of commercial services, including hospitals, office buildings, and shopping malls. In the OECD nations, where infrastructures are well established and population growth is slower, electricity generation is expected to grow by 1.3 percent per year on average over the projection period.

Natural gas and coal are projected to provide larger shares of the total energy used for electricity generation worldwide in 2030 than they did in 2004. The natural gas share increases from 20 percent to 24 percent and the coal share from 41 percent to 45 percent. The relative environmental benefits and efficiency of natural gas make it an attractive fuel choice for generation in many nations; however, higher oil and natural gas prices make coal the economic choice in the United States and non-OECD Asia, where coal resources are ample.

Electricity generation from nuclear power is projected to increase from 2,619 billion kilowatthours in 2004 to 2,972 billion kilowatthours in 2015 and 3,619 billion kilowatthours in 2030. Higher fossil fuel prices, energy security concerns, and environmental considerations are expected to improve the prospects for new nuclear power capacity in many parts of the world. In the *IEO2007* reference case, the world's total installed nuclear capacity rises from 368 gigawatts in 2004 to 481 gigawatts in 2030. Declines in nuclear capacity are projected only for OECD Europe, where several countries have either plans or mandates to phase out nuclear power, and some older reactors are expected to be retired and not replaced.

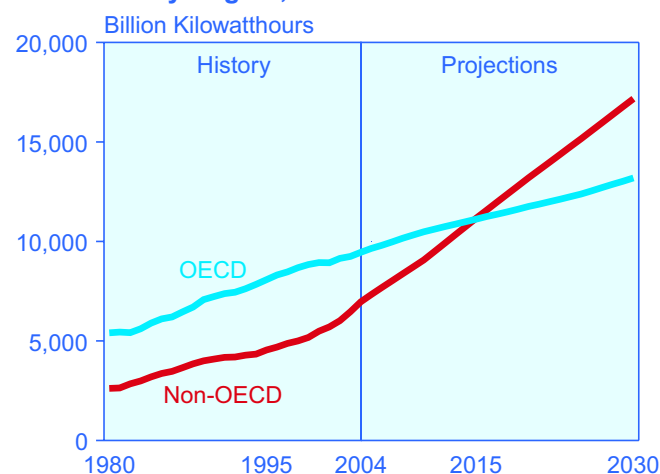
Nuclear power generation in the non-OECD countries is projected to increase by 4.0 percent per year from 2004 to 2030. The largest increase in installed nuclear generating

capacity is projected for non-OECD Asia, which accounts for 68 percent of the total projected increase in nuclear power capacity for the non-OECD region as a whole (Figure 14). Of the 58 gigawatts of additional installed nuclear generating capacity projected for non-OECD Asia between 2004 and 2030, 36 gigawatts is projected for China and 17 gigawatts for India. Russia also is expected to add substantial nuclear generating capacity over the mid-term projection, increasing capacity by 20 gigawatts. Several OECD nations with existing nuclear programs also increase their nuclear capacity in the *IEO2007* reference case, with South Korea adding a net 16 gigawatts, Japan 14 gigawatts, the United States 13 gigawatts, and Canada 6 gigawatts.

The use of hydroelectricity and other grid-connected renewable energy sources is expected to continue to expand over the projection period, increasing by 1.9 percent per year, at the same rate of growth as natural gas consumption in the reference case. Higher fossil fuel prices, particularly for natural gas in the electric power sector, along with government policies and programs to support renewable energy, allow renewable fuels to compete economically. The renewable share of total world energy use increases from 7 percent in 2004 to 8 percent in 2030.

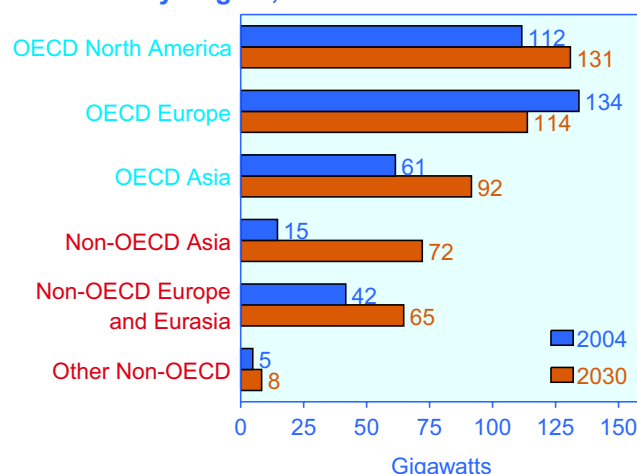
Much of the growth in renewable energy consumption is projected to come from mid- to large-scale hydroelectric facilities in non-OECD Asia and Central and South America, where several countries have hydropower facilities either planned or under construction. In non-OECD Asia, India has about 12,020 megawatts of hydroelectric capacity under construction, and letters of award have been issued for the 1,000-megawatt Tehri Pass project (scheduled for completion by 2012) and the

**Figure 13. World Electric Power Generation by Region, 1980-2030**



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

**Figure 14. World Nuclear Generating Capacity by Region, 2004 and 2030**



Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

1,200-megawatt Kotlibhel-IA project [1]. China also has a number of large-scale hydroelectric projects under construction, including the 18,200-megawatt Three Gorges Dam project (expected to be fully operational by 2009) and the 12,600-megawatt Xiluodu project on the Jisha River (scheduled for completion in 2020, as part of a 14-facility hydropower development plan) [2]. In the non-OECD region of Central and South America, Brazil has plans for a number of new hydropower projects that the country hopes to complete to keep up with electricity demand after 2010, including the 3,150-megawatt Santo Antonio and 3,300-megawatt Jirau projects on the Madeira River [3].

Outside of Canada and Turkey, hydropower capacity is not expected to grow substantially in the OECD nations, because most hydroelectric resources in the region already have been developed or lie far from population centers. Instead, most of the increase in OECD renewable energy consumption is expected to be in the form of nonhydroelectric resources, such as wind, solar, geothermal, municipal solid waste, and biomass.

## World Economic Outlook

Economic growth is among the most important factors to be considered in projecting changes in the world's energy consumption. In the *IEO2007* projections, assumptions about regional economic growth—measured in terms of GDP in real 2000 U.S. dollars at purchasing power parity rates—underlie the projections of regional energy demand.

The macroeconomic framework employed for the economic growth projections reflects the interaction of many important economic variables and underlying relationships, both in the short term and in the medium to long term. In the short term, households and businesses make spending decisions (the demand side) based on current financial conditions—for example, interest rates or the price of goods to be purchased.

In the long term, it is the ability to produce goods and services (the supply side) that ultimately determines the growth potential for any country's economy. Growth potential is influenced by population growth, labor force participation rates, productivity growth, and capital accumulation. In addition, for the developing economies, progress in building human and physical capital infrastructures, establishing credible regulatory mechanisms to govern markets, and ensuring political stability play more important roles in determining their medium- to long-term growth potential.

Over the 2004 to 2030 period, world real GDP growth is projected to average 4.1 percent annually in the reference case (Table 2 and Figure 15). When compared with the *IEO2006* reference case projection, the world economic growth projection in the *IEO2007* reference case is

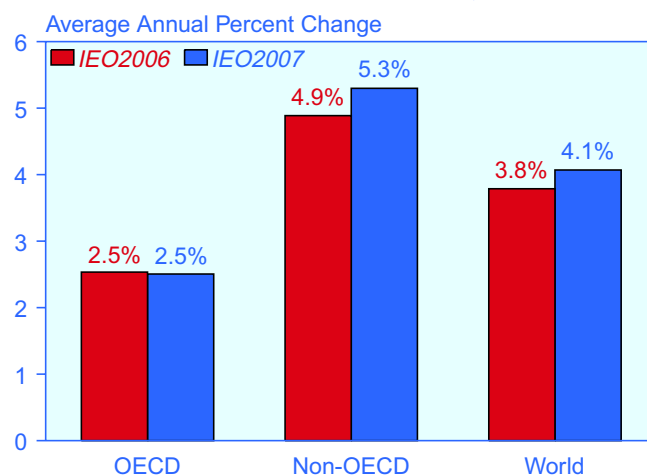
higher primarily because of more optimistic assumptions about the growth prospects of non-OECD countries, particularly, China and India.

The projected annual growth in world GDP over the next 25 years is higher than the rate recorded over the past 25 years, mainly because the countries that are expected to see more rapid growth make up an increasing share of world GDP. A number of the developing non-OECD nations have undertaken significant reforms over the past several years. Improved macroeconomic policies, trade liberalization, more flexible exchange rate regimes, and lower fiscal deficits have lowered their national inflation rates, reduced uncertainty, and improved their overall investment climates. More microeconomic structural reforms, such as privatization and regulatory reform, have also played key roles. In general, such reforms have resulted in growth rates that are above historical trends in many of the emerging economies over the past 5 to 10 years.

### OECD Economies

In the United States, compared with the second half of the 1990s, GDP growth rates were lower from 2000 to 2002 but rebounded to 2.5 percent in 2003, 3.9 percent in 2004, and 3.2 percent in 2005. GDP growth in 2006 is estimated at 3.3 percent. A downturn in the housing sector has been the major source of weakening over the past year, and reductions in manufacturing output indicate that the slowdown has spread throughout the economy. At the same time, however, corporate finances have been healthy, and real nonresidential investment has remained robust. The depreciation of the U.S. dollar

**Figure 15. Comparison of *IEO2006* and *IEO2007* Projections for OECD, Non-OECD, and World GDP Growth Rates, 2004-2030**



Sources: *IEO2006*: Energy Information Administration, *International Energy Outlook 2006*, DOE/EIA-0484(2006) (Washington, DC, June 2006), web site [www.eia.doe.gov/oiaf/ieo](http://www.eia.doe.gov/oiaf/ieo). *IEO2007*: Derived from Global Insight, Inc., *World Overview*, Fourth Quarter 2006 (Lexington, MA, January 2007).

against other major currencies has also boosted demand for domestic output.

In the reference case projections, the U.S. economy stabilizes at its long-term growth path by 2010. GDP is projected to grow by an average of 2.9 percent per year from 2004 to 2030—slower than the 3.1-percent annual average over the 1980 to 2004 period—because of the retirement of the baby boom generation and the resultant slowing of labor force growth.

Canada's labor force growth is projected to slow in the medium to long term, however, as baby boomers retire. The country's overall economic growth is projected to

fall from the current average of 2.9 percent per year to averages of 2.6 percent per year from 2007 to 2015 and 2.1 percent per year from 2015 to 2030.

In Mexico, real GDP is projected to grow by an average of 3.6 percent per year from 2004 to 2030. Mexico's strong performance in the past 5 years has been the result of favorable developments in several areas. First, lower inflation has allowed the central bank to lower key policy rates, which has encouraged domestic demand through greater investment. Second, high oil prices continue to spur government spending, including investment in infrastructure projects. Third, remittances from Mexicans working abroad continue to grow

**Table 2. Average Annual Growth in World Gross Domestic Product by Selected Countries and Regions, 1980-2030**  
(Percent per Year)

Region	History				Projections			
	1980-2004	2004	2005	2006	2007	2007-2015	2015-2030	2004-2030
<b>OECD North America</b> .....	<b>3.0</b>	<b>3.9</b>	<b>3.2</b>	<b>3.4</b>	<b>2.6</b>	<b>2.9</b>	<b>2.9</b>	<b>2.9</b>
United States .....	3.1	3.9	3.2	3.3	2.5	2.9	2.9	2.9
Canada .....	2.8	3.3	2.9	2.9	2.6	2.6	2.1	2.3
Mexico .....	2.5	4.2	3.0	4.4	3.8	3.6	3.6	3.6
<b>OECD Europe</b> .....	<b>2.4</b>	<b>2.6</b>	<b>2.1</b>	<b>3.0</b>	<b>2.3</b>	<b>2.4</b>	<b>2.2</b>	<b>2.3</b>
<b>OECD Asia</b> .....	<b>2.9</b>	<b>2.8</b>	<b>2.8</b>	<b>2.9</b>	<b>2.6</b>	<b>2.2</b>	<b>1.5</b>	<b>1.9</b>
Japan .....	2.3	2.3	2.6	2.5	2.1	1.4	0.7	1.1
South Korea .....	6.9	4.7	4.0	5.0	5.0	4.6	2.7	3.5
Australia/New Zealand .....	3.3	3.7	2.6	2.6	2.5	2.9	3.0	2.9
<b>Total OECD</b> .....	<b>2.7</b>	<b>3.2</b>	<b>2.7</b>	<b>3.1</b>	<b>2.5</b>	<b>2.6</b>	<b>2.4</b>	<b>2.5</b>
<b>Non-OECD Europe and Eurasia</b> ...	<b>0.0</b>	<b>8.2</b>	<b>6.6</b>	<b>7.1</b>	<b>6.6</b>	<b>4.7</b>	<b>3.5</b>	<b>4.3</b>
Russia .....	-0.4	7.2	6.4	6.4	5.7	4.1	3.1	3.7
Other .....	0.5	9.5	7.0	8.1	7.7	5.5	4.0	4.9
<b>Non-OECD Asia</b> .....	<b>7.1</b>	<b>8.7</b>	<b>8.5</b>	<b>8.6</b>	<b>8.0</b>	<b>6.3</b>	<b>5.1</b>	<b>5.8</b>
China .....	9.8	10.1	9.9	10.5	9.5	7.2	5.4	6.5
India .....	5.8	8.5	8.7	7.9	7.6	5.9	5.0	5.7
Other .....	5.3	6.5	5.9	5.8	5.4	4.9	4.3	4.6
<b>Middle East</b> .....	<b>2.4</b>	<b>6.5</b>	<b>5.7</b>	<b>5.0</b>	<b>5.2</b>	<b>4.5</b>	<b>3.8</b>	<b>4.2</b>
<b>Africa</b> .....	<b>2.6</b>	<b>5.1</b>	<b>4.9</b>	<b>5.4</b>	<b>5.4</b>	<b>5.1</b>	<b>4.6</b>	<b>4.9</b>
<b>Central and South America</b> .....	<b>2.2</b>	<b>6.0</b>	<b>4.6</b>	<b>4.8</b>	<b>4.7</b>	<b>4.0</b>	<b>3.7</b>	<b>3.9</b>
Brazil .....	2.1	4.9	2.3	3.0	4.0	3.6	3.3	3.4
<b>Total Non-OECD</b> .....	<b>3.9</b>	<b>7.9</b>	<b>7.3</b>	<b>7.5</b>	<b>7.0</b>	<b>5.7</b>	<b>4.7</b>	<b>5.3</b>
<b>Total World</b>								
<b>Purchasing Power Parity Rates</b> ..	<b>3.3</b>	<b>5.4</b>	<b>4.9</b>	<b>5.3</b>	<b>4.8</b>	<b>4.2</b>	<b>3.8</b>	<b>4.1</b>
<b>Market Exchange Rates</b> .....	<b>2.9</b>	<b>4.0</b>	<b>3.5</b>	<b>3.9</b>	<b>3.3</b>	<b>3.2</b>	<b>2.9</b>	<b>3.1</b>

Note: All regional real GDP growth rates presented in this table are based on 2000 purchasing power parity weights for the individual countries in each region, except for the final line of the table, which presents world GDP growth rates based on 2000 market exchange rate weights for all countries.

Sources: **Historical Growth Rates:** Global Insight, Inc., *World Overview* (Lexington, MA, various issues). **Projected GDP Growth Rates:** Global Insight, Inc., *World Overview*, Fourth Quarter 2006 (Lexington, MA, January 2007); and Energy Information Administration, *Annual Energy Outlook 2007*, DOE/EIA-0383(2007) (Washington DC, February 2007). GDP growth rates for China and India were adjusted downward, based on the analyst's judgment.

rapidly, boosting domestic consumption. Finally, Mexico's industrial production follows, and is heavily influenced by, U.S. GDP growth and outsourcing of employment. Global financial markets remain friendly to Mexico in terms of the availability and cost of credit and the volume of foreign direct investment. In general, strong trade ties with the United States are expected to help cushion Mexico from deeper economic troubles. By the same token, Mexico's future growth is also more dependent on U.S. growth.

Over the long term, OECD Europe's GDP is projected to grow by 2.3 percent per year from 2004 to 2030 in the reference case, in line with what OECD considers to be potential output growth in the region's economies [4]. According to the International Monetary Fund, structural impediments to economic growth still remain in many countries of OECD Europe, related to the region's labor markets, product markets, and costly social welfare systems. Reforms to improve the competitiveness of European labor and product markets could yield significant dividends in terms of increases in regional output [5].

After a decade of stagnation and several false starts, economic growth in Japan has been more robust since 2003. While low by the standards of pre-1990 Japan, the recent growth in GDP exceeds the potential (no more than 2 percent real growth) for a country with a declining labor force and population and an industrial technology that has already caught up with, and in some cases surpassed, the best elsewhere in the world [6]. With the continued decline in its labor force over the projection period, Japan's annual GDP growth is projected to slow, averaging 1.4 percent from 2007 to 2015 and 0.7 percent from 2015 to 2030. In the short term, Japan's highly skilled labor force and strong work ethic are expected to support the projected average growth rate of 1.4 percent per year, as more flexible labor policies allowing greater mobility for workers are adopted.

Economic growth in the rest of OECD Asia is expected to be somewhat stronger than in Japan. In the medium to long term, South Korea's growth is projected to taper off and be sustained by productivity growth as labor force growth slows. Prospects in both Australia and New Zealand are healthy, given their consistent track records of fiscal prudence and structural reforms aimed at maintaining competitive product markets and flexible labor markets.

### Non-OECD Economies

Over the 2004 to 2030 period, economic growth in non-OECD Europe and Eurasia as a whole is projected to average 4.3 percent annually. For the past several years, the non-OECD nations of Europe and Eurasia have largely been sheltered from global economic uncertainties, recording strong economic growth in each year

since 2000, primarily as a result of robust domestic demand, the growth bonus associated with ascension of some countries (including Estonia, Latvia, Lithuania, and Slovenia) to the European Union, and the impacts of rising oil prices on the oil-exporting nations of the region (including Russia, Kazakhstan, Azerbaijan, and Turkmenistan). High world oil prices have stimulated investment outlays, especially in the energy sector of the Caspian region; however, given the volatility of energy market prices, it is unlikely that the region's economies will be able to sustain the growth rates recently achieved until diversification from energy becomes more broadly based. The long-term growth prospects for the former Soviet Republic economies of Eurasia hinge on their success in economic diversification, as well as further improvements in domestic product and financial markets.

Much of the growth in world economic activity between 2004 and 2030 is expected to occur among the nations of non-OECD Asia, where regional GDP growth is projected to average 5.8 percent per year. China, non-OECD Asia's largest economy, is expected to continue playing a major role on both the supply and demand sides of the global economy. *IEO2007* projects an average annual growth rate of approximately 6.5 percent for China's economy over the 2004 to 2030 period. The country's economic growth is expected to be the highest in the world.

Structural issues that have implications for medium- to long-term growth in China include the pace of reform affecting inefficient state-owned companies and a banking system that is carrying a significant amount of nonperforming loans. The development of domestic capital markets to maintain macroeconomic stability and ensure that China's large savings are used efficiently supports the medium-term growth projection.

India is another Asian country with a rapidly emerging economy. The medium-term prospects for India's economy are positive, as it continues to privatize state enterprises and increasingly adopts free market policies. Average annual GDP growth in India over the 2004 to 2030 projection period is 5.7 percent. Accelerating structural reforms—including ending regulatory impediments to the consolidation of labor-intensive industries, labor market and bankruptcy reforms, and agricultural and trade liberalization—remains essential to stimulate potential growth and reduce poverty in the medium to long term. With its vast and relatively cheap labor force, India is well positioned to reap the benefits of globalization.

In the rest of non-OECD Asia, economic activity has remained robust, with exports increasing in response to a rebound in global demand for high-technology products and stronger import demand from China [7]. Over



the medium term, national economic growth rates in the region are expected to be roughly constant over the 2004 to 2015 period, before tapering off gradually to an average of 4.3 percent per year from 2015 to 2030 as labor force growth rates decline and economies mature.

Although the nations of Central and South America registered a combined 6-percent increase in GDP in 2004 (their best performance in 20 years), the region's growth prospects are hampered by a weak international credit environment, as well as domestic economic and/or political problems in a number of countries. Growth in the region remains heavily dependent on the volume of foreign capital flows.

Rising oil production and prices have helped boost economic growth in the oil-exporting countries of the Middle East. Many of the oil-importing countries in the region have also benefited from spillover effects on trade, tourism, and financial flows from the region's oil exporters. Real GDP growth in the Middle East region in 2006 is estimated at 5 percent. Medium-term prospects for the region remain favorable, given that a significant portion of the recent increase in oil revenues is expected to be permanent.

Economic growth in Africa has maintained a healthy pace of more than 4 percent per year since 2000, driven by increased earnings from hydrocarbon exports, strong global demand and favorable international prices for some other export commodities, vigorous domestic demand, and significant foreign direct investment and foreign aid [8]. Over the 2004 to 2030 period, Africa's combined economy is projected to grow at an annual

rate of 4.9 percent. This projection, optimistic by historical standards, is supported by the region's strong economic activity over the past 5 years, which has resulted from expansion of primary exports and robust domestic demand in many of Africa's national economies. Nevertheless, both economic and political factors—such as low savings and investment rates, lack of strong economic and political institutions, limited quantity and quality of infrastructure and human capital, negative perceptions on the part of international investors, protracted civil unrest and political disturbances, and especially the impact of HIV/AIDS on population growth—present formidable obstacles to growth in a number of African countries.

## Alternative Macroeconomic Growth Cases

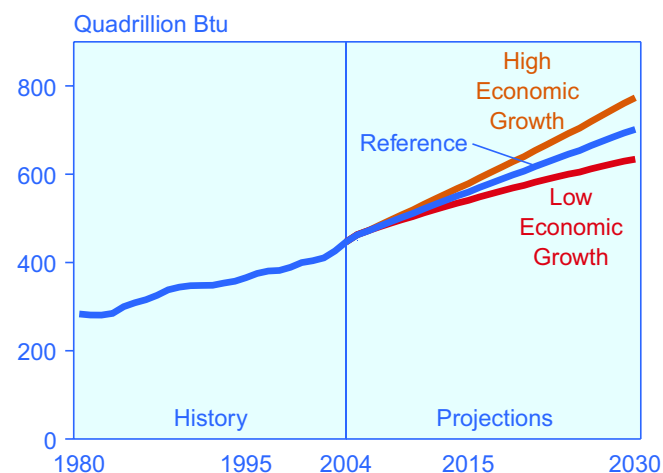
Expectations for the future rates of economic growth are a major source of uncertainty in the *IEO2007* projections. To illustrate the uncertainties associated with economic growth trends, *IEO2007* includes a high macroeconomic growth case and a low macroeconomic growth case in addition to the reference case. The two alternative growth cases use different assumptions about future economic growth paths, while maintaining the same relationship between changes in GDP and changes in energy consumption that is used in the reference case.

In the high economic growth case, 0.5 percentage point is added to the growth rate assumed for each region or country in the reference case. In the low economic growth case, 0.5 percentage point is subtracted from the reference case growth rate. The *IEO2007* reference case shows total world energy consumption reaching 702 quadrillion Btu in 2030—298 quadrillion Btu in the OECD countries and 404 quadrillion Btu in the non-OECD countries. In the high economic growth case, total world energy use in 2030 is projected at 773 quadrillion Btu, 72 quadrillion Btu (or about 36 million barrels oil equivalent per day) higher than in the reference case. In the low economic growth case, world energy consumption in 2030 is projected to be 68 quadrillion Btu (34 million barrels oil equivalent per day) lower than in the reference case. Thus, there is a range of 140 quadrillion Btu—about one-fifth of the total consumption projected for 2030 in the reference case—between the projections for 2030 in the high and low macroeconomic growth cases (Figure 16).

## Alternative World Oil Price Cases

The impacts of world oil prices on energy demand and its composition are another large source of uncertainty in the *IEO2007* projections. To illustrate the impacts, *IEO2007* includes two alternative price cases. In the *IEO2007* high world oil price case, world oil prices climb from \$43 per barrel (2005 real dollars) in 2004 to \$100 per

**Figure 16. World Marketed Energy Consumption in Three Economic Growth Cases, 1980-2030**



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).



barrel in 2030. In the low price case, oil prices moderate fairly quickly to \$49 per barrel in 2010 and then further to \$34 per barrel in 2015 and remain at that level through 2030 (Figure 17). Despite the considerable difference between oil prices in the low and high price cases in 2030 (around \$70 per barrel), the projections for total world energy consumption in the reference and alternative oil price cases do not vary substantially.

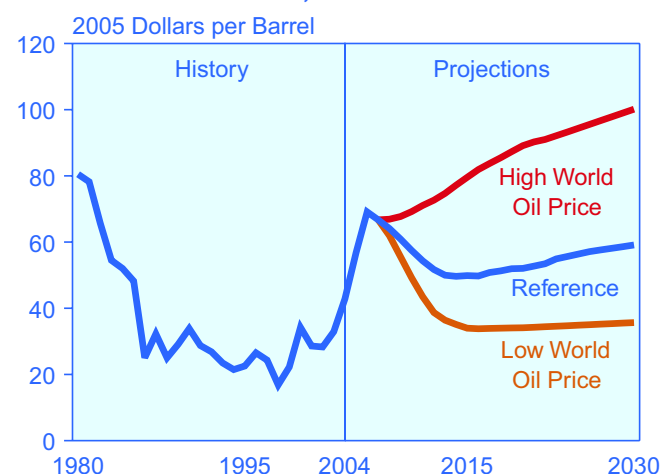
There is, however, a larger impact on the energy mix. In 2030, total world energy use in the high and low world oil price cases is separated by only 38 quadrillion Btu (Figure 18). In comparison, the difference between the

low and high macroeconomic growth case projections is 140 quadrillion Btu. The potential effects of higher and lower oil prices on world GDP can also be seen in the low and high world oil price cases (see box on page 14). In the long run, the projections for economic growth are not affected substantially by the oil price assumptions. The most significant variations are GDP increases of around 1 percent in the low price case relative to the reference case in 2015 for some regions outside the Middle East and, in the oil-exporting Middle East region only, a 1-percent drop in GDP in 2015. In 2030, however, there are virtually no differences among GDP projections for any region in the different cases, because the world's economies have had sufficient time to adjust to the lower or higher oil prices.

The most significant impacts of the higher and lower world oil price assumptions are on the mix of energy fuels consumed in each region, particularly liquids and coal (Figure 19). In the high price case, total world energy use in 2030 is about 20 quadrillion Btu lower, and world liquids consumption is 29 quadrillion Btu lower, than projected in the reference case. Natural gas consumption is also lower in 2030, by a more modest 5 quadrillion Btu, whereas the projections for coal, nuclear power, and renewable energy consumption are higher than those in the reference case.

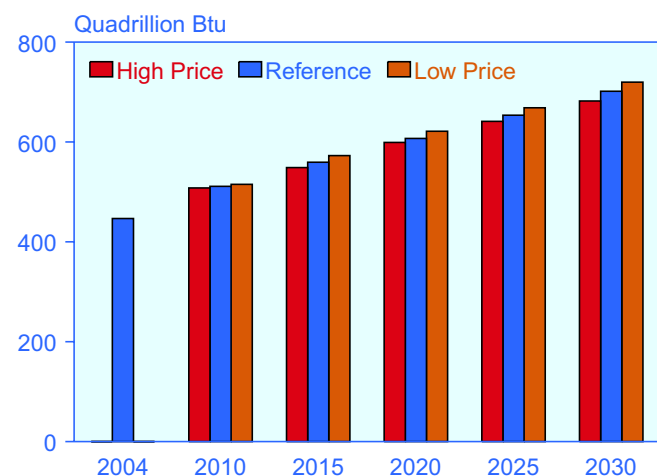
In the low world oil price case, lower prices both allow consumers to increase their use of liquids for transportation purposes and discourage the migration away from liquids to other energy sources in sectors where fuel substitution is fairly easy to achieve (as opposed to the transportation sector, where there are still relatively few alternatives to petroleum-based fuels). Total liquids

**Figure 17. World Oil Prices in Three World Oil Price Cases, 1980-2030**



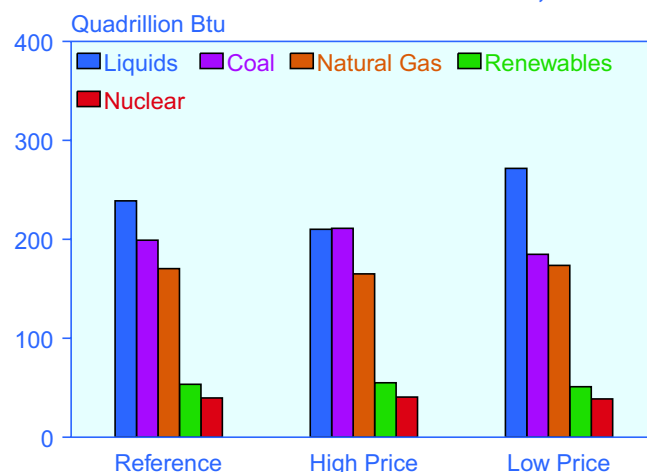
Source: Energy Information Administration (EIA), *Annual Energy Outlook 2007*, DOE/EIA-0383(2007) (Washington, DC, February 2007), web site [www.eia.doe.gov/oiaf/aeo](http://www.eia.doe.gov/oiaf/aeo).

**Figure 18. World Marketed Energy Consumption in Three World Oil Price Cases, 2004-2030**



Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, *System for the Analysis of Global Energy Markets* (2007).

**Figure 19. World Marketed Energy Consumption in Three World Oil Price Cases, 2030**



Note: Liquids supply sources include both conventional and unconventional sources.

Source: Energy Information Administration, *System for the Analysis of Global Energy Markets* (2007).

## World GDP: Potential Impacts of High and Low Oil Prices

Price paths in the *IEO2007* high and low world oil price cases are not characterized by disruption but rather represent sustained movements relative to the reference case oil price path. The assumptions behind the oil price cases are that the price changes do not come as a shock and that the central banks of developed countries are able to carry out active monetary policies effectively, because core inflation does not get out of hand and exchange rates do not change from those in the reference case. Further, it is assumed that national fiscal policies do not vary from those in the reference case. If any of these assumptions were changed, the economic projections in the alternative cases would be altered.

Global Insight, Inc.'s Global Scenario Model was employed to project the alternative paths of world economic growth in the high and low world oil price cases relative to the reference case. The figures below represent percentage differences, over time, in nominal world oil prices (left) and real world GDP (right) in the high and low world oil price cases relative to those in the reference case. In the high price case, oil prices rise steadily to 62 percent above reference case prices within 8 years (2014). Thereafter the difference widens gradually, to 76 percent above reference case prices in 2030. In the low price case, oil prices are 28 percent below reference case prices in 2013, after which the difference widens to 43 percent in 2030.

Because world oil prices fall proportionately less in the low price case than they rise in the high price case (relative to the reference case), changes in GDP projections

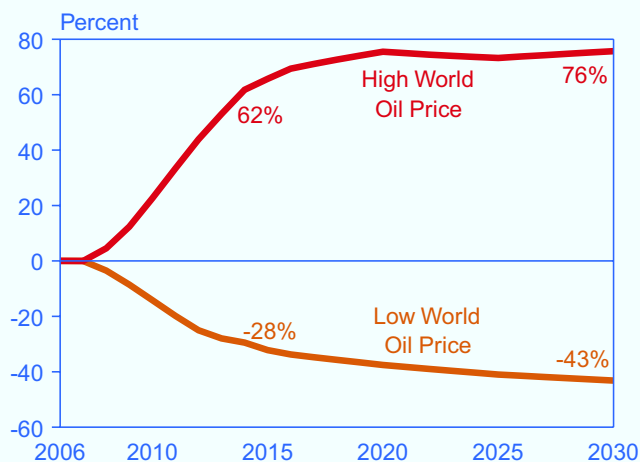
in the two price cases relative to those in the reference case are not symmetrical. Also, because most of the deviation from reference case prices in the high and low cases occurs by approximately 2014, differences from the reference case GDP projections are greatest at that point in time, then begin to narrow as the rates at which oil prices change become more similar across the three cases.

Higher (and lower) oil prices relative to the reference case affect national economies both internally and in their interactions with other nations through exports and imports. In the short term, as higher oil prices feed through the economy and reduce purchasing power, real aggregate expenditures on goods and services decline.<sup>a</sup> With aggregate demand for output falling behind aggregate supply, unemployment increases, energy-intensive capital stock begins to become obsolete, and real GDP is lower.

In oil-importing countries that also have major oil-producing sectors, like the United States, higher oil prices increase the flow of economic resources into oil production activities. At the same time, national expenditures on petroleum imports increase, with negative repercussions for real GDP. Countries wholly dependent on oil imports, like Japan, are forced to spend more for their energy purchases. Oil-importing countries with export-dependent economies, like South Korea, are affected even more severely, as their energy expenditures climb while export revenues fall because worldwide demand is lower. In addition, with

*(continued on page 15)*

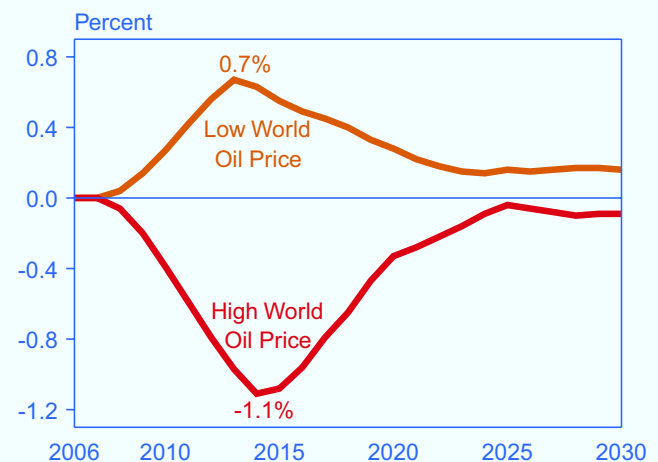
**Differences from Reference Case World Oil Price Projections in the High and Low World Oil Price Cases, 2006-2030**



Source: Global Insight, Inc., Global Scenario Model (February 2007).

<sup>a</sup>The discussion here focuses on economic effects in the high oil price case. In the low oil price case, effects will be diametrically opposite.

**Differences from Reference Case World Real GDP Projections in the High and Low World Oil Price Cases, 2006-2030**



Source: Global Insight, Inc., Global Scenario Model (February 2007).

### World GDP: Potential Impacts of High and Low Oil Prices (Continued)

higher aggregate prices, interest rates tend to rise. Oil-exporting countries, like Saudi Arabia and Russia, see more revenue from their oil exports, boosting incomes and increasing their demand for goods and services and their real GDP.

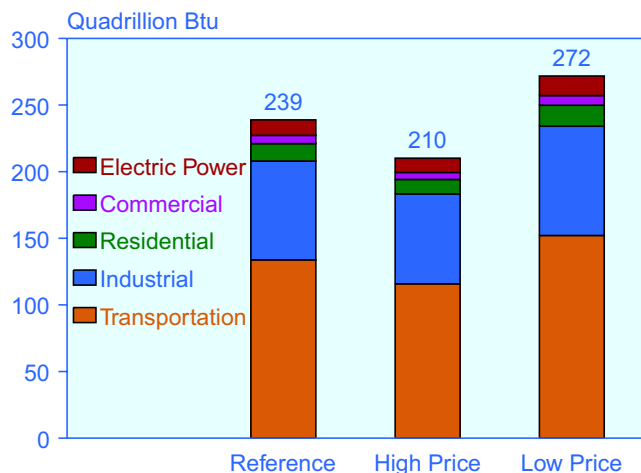
Over time, the world economy adjusts back to its long-term (reference case) growth path. In the medium term, increases in unemployment lead to downward adjustments in wages and prices. In developed countries, central banks react by lowering key policy rates, thus boosting interest-sensitive aggregate demand. After 2015, the rebound effects of lower employment costs, lower prices, and lower interest rates outweigh the contractionary effects of higher oil prices, leading to stronger real GDP growth and lower inflation. As aggregate demand increases in the oil-exporting countries with higher oil revenues, their demand for imports grows, increasing the demand for exports from the oil-importing countries. As a result, in 2030, the world economy ends up with almost the same real GDP growth rate and unemployment rate as in the reference case, although the composition and sources of world output, international trade, and capital flows are qualitatively different from those in the reference case.

Real GDP in the high and low world oil price cases deviates from its reference case path for a considerable period of time, but as the world economy adjusts to the higher or lower oil prices, the deviation becomes smaller. Thus, world real GDP in 2030 is approximately the same in the three cases. Using 2006 and 2030 as end points to compute average annual growth rates in world real GDP, the rates in the three cases are approximately the same; however, that calculation does not portray adequately the dynamic movements of the world economy and the extent of the differences across the three cases. The present discounted sum of changes in real GDP over the projection period gives a better indication of net effects on the world economy. The sums of the changes in world GDP from the reference case (discounted at 7 percent) in the low and high price cases over the 2006-2030 period are \$2,937 billion and -\$4,226 billion, respectively, representing approximately 0.3 percent and -0.4 percent of the sum of discounted real GDP in the reference case—taking into account factor displacements, dislocations, and adjustments as well as gainers and losers within and across countries.

consumption in 2030 is 33 quadrillion Btu higher in the low price case than projected in the reference case, reflecting increased demand in all the end-use sectors. The transportation sector shows the largest increase in liquids consumption in 2030 in the low world oil price relative to the reference case, at 18 quadrillion Btu (Figure 20).

In the *IEO2007* reference case, world oil prices rise steadily after 2015, to \$59 per barrel in 2030. As a result, liquids consumption is curtailed in countries that have other fuel options available—especially in the electric power sector, where coal and other fuels can be substituted. In the reference case, worldwide use of liquids for electricity generation grows by only 1.0 quadrillion Btu from 2004 to 2030. In the low world oil price case, the corresponding increase is 4.0 quadrillion Btu, as countries in both the OECD and non-OECD regions retain their oil-fired generating capacity in the lower price environment.

**Figure 20. World Liquids Consumption in Three World Oil Price Cases, 2030**



Source: Energy Information Administration, System for the Analysis of Global Energy Markets (2007).

### Trends in Energy Intensity

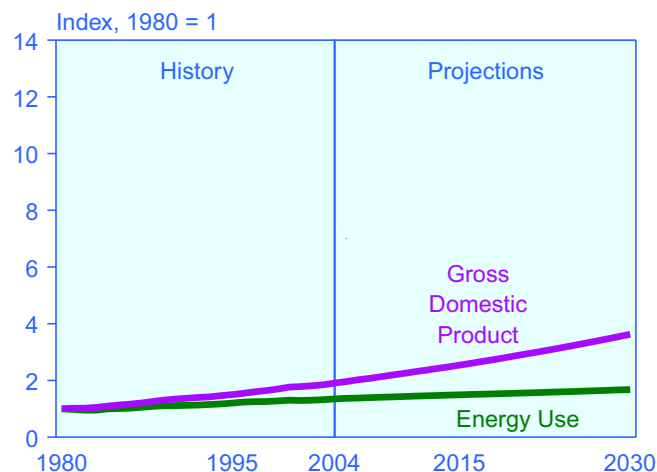
Another major source of uncertainty in the projections is the changing relationship of energy use to GDP—or energy intensity—over time. Economic growth and energy demand are linked, but the strength of that link varies among regions. In the OECD nations, history shows the link to be a relatively weak one, with energy demand lagging behind economic growth (Figure 21). In the non-OECD region, except for non-OECD Europe and Eurasia, economic growth has been closely correlated with energy demand growth for much of the past three decades (Figure 22). Only recently, within the past decade or so, has economic growth begun to outpace the growth in energy use among the world's emerging economies.

Historically, non-OECD Europe and Eurasia have had higher levels of energy intensity than either the OECD or other non-OECD economies. In non-OECD Europe and Eurasia, energy consumption generally grew more rapidly than GDP until 1990 (Figure 23), when the collapse of the Soviet Union created a situation in which both income and energy use declined but GDP fell more quickly. As a result, energy intensity increased. Only since the late 1990s, after the 1997 devaluation of the

Russian ruble, did the Russian and Ukrainian industrial sectors begin to strengthen. Since then, economic growth in non-OECD Europe and Eurasia has begun to outpace growth in energy use significantly, and energy intensity has begun a precipitous decline. The region's energy intensity is projected to continue declining in the *IEO2007* reference case, while still remaining higher than in any other part of the world (Figure 24).

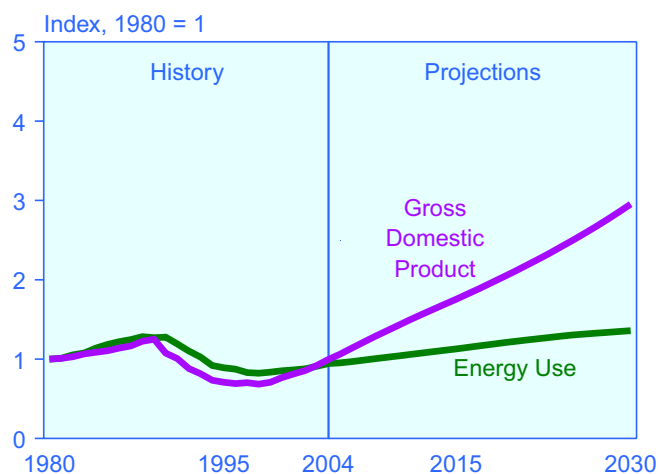
The stage of economic development and the standard of living of individuals in a given region strongly influence

**Figure 21. Growth in Energy Use and Gross Domestic Product for the OECD Economies, 1980-2030**



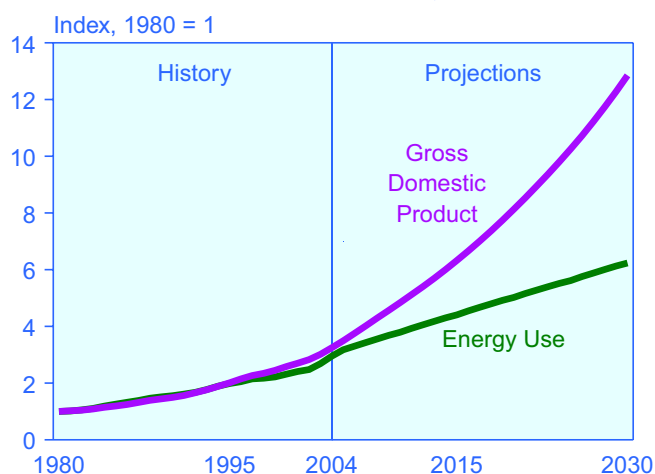
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

**Figure 23. Growth in Energy Use and Gross Domestic Product for the Non-OECD Economies of Europe and Eurasia, 1980-2030**



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

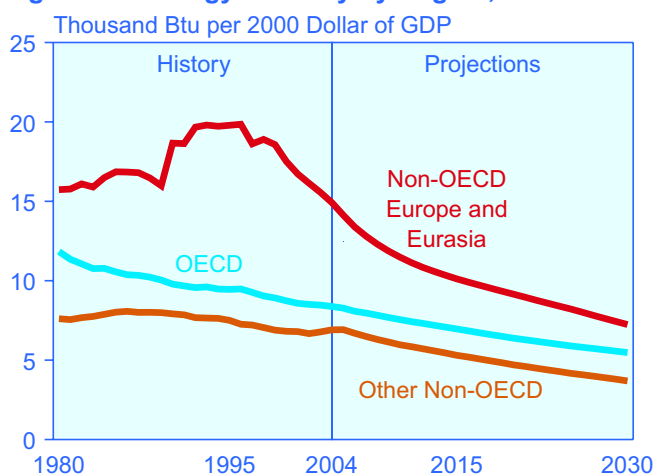
**Figure 22. Growth in Energy Use and Gross Domestic Product for the Non-OECD Economies, 1980-2030**



Note: Non-OECD economies in this figure exclude non-OECD Europe and Eurasia.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

**Figure 24. Energy Intensity by Region, 1980-2030**



Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site [www.eia.doe.gov/iea](http://www.eia.doe.gov/iea). **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

the link between economic growth and energy demand. Advanced economies with high living standards have relatively high levels of energy use per capita, but they also tend to be economies where per capita energy use is stable or changes very slowly. In the OECD economies, there is a high penetration rate of modern appliances and motorized personal transportation equipment. To the extent that spending is directed to energy-consuming goods, it involves more often than not purchases of new equipment to replace old capital stock. The new stock is often more efficient than the equipment it replaces, resulting in a weaker link between income and energy demand.

The pace of improvement in energy intensity may change, given different assumptions of macroeconomic growth over time. Faster growth in income generally leads to a faster rate of improvement (decline) in energy intensity. In the *IEO2007* high macroeconomic growth case, worldwide energy intensity is projected to decline by 2.3 percent per year on average from 2004 to 2030, as compared with 2.2 percent in the reference case. On the other hand, slower economic growth generally leads to a slower rate of improvement in energy intensity. In the low macroeconomic growth case, world energy intensity is projected to decline by an average of only 2.1 percent per year over the projection period.

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