Chapter 6
Electricity

World electricity generation nearly doubles in the IEO2007 reference case from 2004 to 2030. In 2030, generation in the non-OECD countries is projected to exceed generation in the OECD countries by 30 percent.

In the *IEO2007* reference case, world demand for electricity advances strongly from 2004 to 2030. Global electricity generation increases by 2.4 percent per year over the projection period, from 16,424 billion kilowatthours in 2004 to 30,364 billion kilowatthours in 2030 (Figure 60). Much of the growth in electric power demand is projected for nations outside the OECD. Although the non-OECD nations consumed 26 percent less electricity than the OECD nations in 2004, total electricity generation in the non-OECD region in 2030 is projected to exceed generation in the OECD by 30 percent (Figure 61).

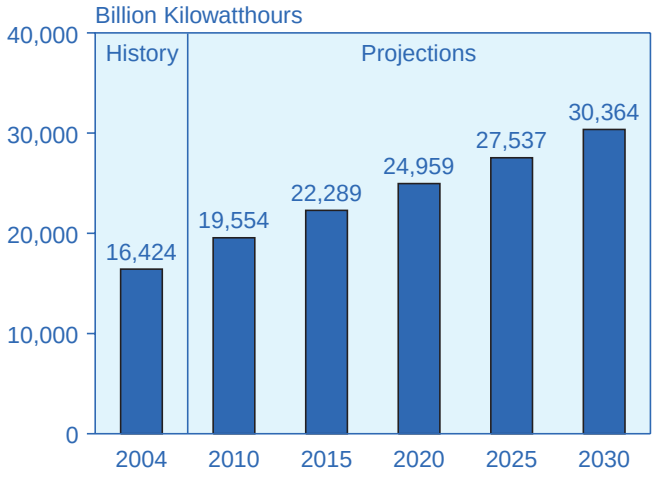
Total electricity demand in the non-OECD nations is expected to grow from 2004 to 2030 at an annual rate that is nearly triple the rate of growth for electricity demand in the OECD. The difference reflects the relative maturity of electricity infrastructure in the more developed OECD region, as well as the expectation that populations in the OECD countries generally will grow slowly or decline over the next 25 years. In addition, fast-paced growth in the developing non-OECD economies translates to rising standards of living and robust growth in consumer demand for lighting and appliances. Total electricity generation in the non-OECD region increases by an average of 3.5 percent per year in the *IEO2007* reference case, as compared with a projected annual growth rate for OECD electricity generation that averages 1.3 percent per year from 2004 to 2030.

Among the energy end-use sectors, the most rapid growth in total world demand for electricity is projected for the buildings (residential and commercial) sectors. Worldwide, total electric power consumption on a Btu basis in the buildings sectors increases by an average of 2.6 percent per year in the *IEO2007* reference case, as compared with an average growth rate of 2.2 percent per year for total electricity consumption in the industrial and transportation sectors combined. The most rapid rate of increase in electricity demand is projected for the commercial sector, both worldwide and by region, reflecting the expected growth of service activities as strong economic growth, particularly among the non-OECD countries, increases the demand for office space, hospitals, hotels, and other institutions or organizations (Figure 62).

Electricity Supply by Energy Source

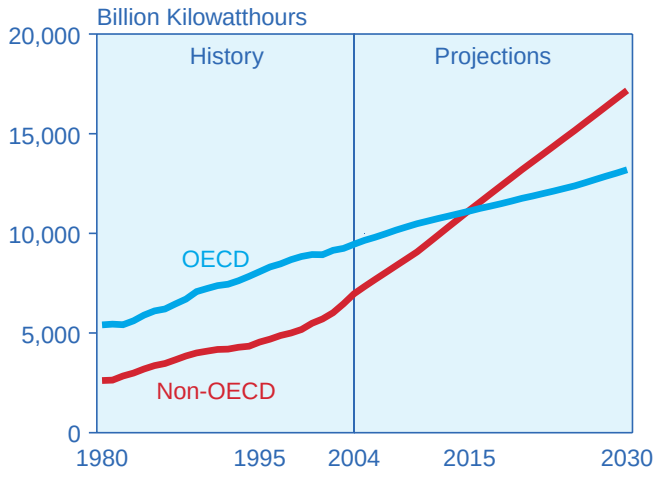
The mix of primary fuels used to generate electricity has changed a great deal over the past two decades on a

Figure 60. World Electric Power Generation, 2004-2030



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

Figure 61. 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. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

worldwide basis. Coal has continued to be the fuel most widely used for electricity generation, although generation from nuclear power increased rapidly from the 1970s through the mid-1980s, and natural-gas-fired generation grew rapidly in the 1980s and 1990s. The use of oil for electricity generation has been declining since the mid-1970s, when the oil embargo by Arab producers in 1973-1974 and the Iranian Revolution in 1979 produced oil price shocks.

More recently, high world oil prices—which have been trending upward since 2003—have further eroded the role of petroleum in the power sector. Higher world oil prices have encouraged a shift from oil-fired generation to natural gas and nuclear power and have reinforced coal's important role as an energy source for electricity generation. Today, relatively high world oil prices in combination with concerns about the environmental consequences of greenhouse gas emissions are raising renewed interest in nuclear power and renewable energy sources as alternatives to the use of coal and natural gas for electric power generation. Projections of future coal use are particularly sensitive to assumptions about future policies that might be adopted to mitigate greenhouse gas emissions.

Coal

In the *IEO2007* reference case, while natural gas is the fastest-growing energy source for electricity generation worldwide, coal continues to provide the largest share of the energy used for electric power production (Figure 63). In 2004, coal-fired generation accounted for 41 percent of world electricity supply; in 2030, its share is projected to be 45 percent. Sustained high prices for oil and natural gas make coal-fired generation more attractive economically, particularly in nations that are rich in coal resources, which include China, India, and the United States. The 2.8-percent projected annual growth rate for coal-fired electricity generation worldwide is exceeded only by the 3.3-percent rate projected for natural-gas-fired generation.

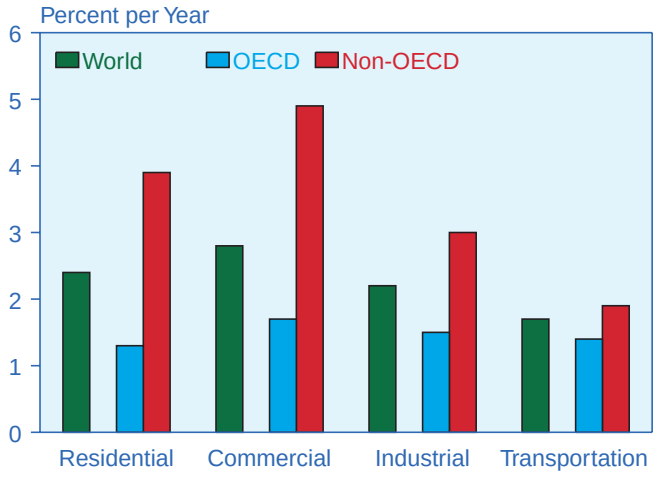
Natural Gas

Although natural gas is the fastest-growing energy source for electric power generation in the *IEO2007* reference case projection—increasing from 3,231 billion kilowatthours in 2004 to 7,423 billion kilowatthours in 2030—the total amount of electricity generated from natural gas continues to be only about one-half the total for coal, even in 2030. Natural-gas-fired combined-cycle capacity is an attractive choice for new power plants because of its fuel efficiency, operating flexibility (it can be brought on line in minutes rather than the hours it takes for coal-fired and other generating capacity), relatively short construction times (months instead of the years that coal-fired and nuclear power plants typically require), and investment costs that are lower than those for other technologies. Natural gas also burns more cleanly than coal or petroleum products, and as more governments begin implementing national or regional plans to reduce carbon dioxide emissions they may encourage the use of natural gas to displace oil and coal.

Oil

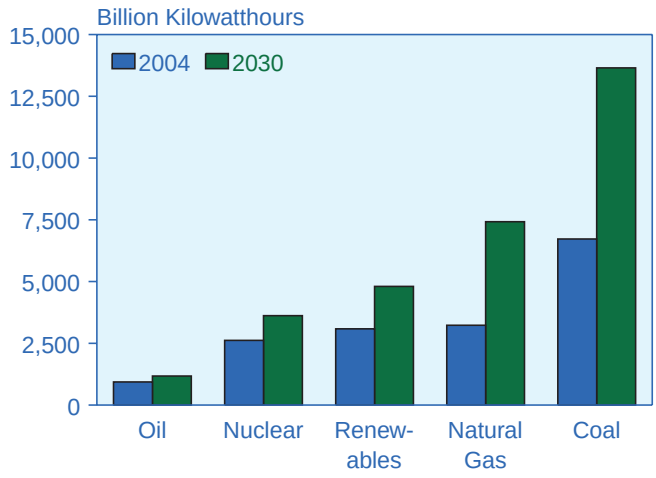
With world oil prices projected to reach $59 per barrel (in real 2005 dollars) at the end of the *IEO2007* projection in 2030, the expected rate of increase in oil use for electricity generation is the slowest among all energy sources. Worldwide, oil-fired generation is projected to increase by an average of 0.9 percent per year from 2004

Figure 62. Average Annual Change in End-Use Sector Electricity Demand, 2004-2030



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

Figure 63. World Electricity Generation by Fuel, 2004 and 2030



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

to 2030; and in the OECD nations, it is projected to decline by 0.3 percent per year. Only the non-OECD Middle East region, with its ample oil reserves and a current one-third share of total electricity generation fueled by oil, is projected to continue relying heavily on oil to meet its electricity needs.

Nuclear Power

The prospects for nuclear power have improved in recent years. Higher capacity utilization rates have been reported for many existing nuclear facilities, and most of the existing plants in OECD countries and the countries of non-OECD Europe and Eurasia (including Russia) are expected to be granted extensions to their operating lives. In the *IEO2007* reference case, electricity generation from nuclear power plants worldwide is projected to increase at an average rate of 1.3 percent per year, from 2,619 billion kilowatthours in 2004 to 3,619 billion kilowatthours in 2030.

In past editions of the *IEO*, it was anticipated that nuclear generation would decline in the later years of the projections, as aging nuclear reactors (especially among the OECD nations) were expected to be taken out of operation and not to be replaced. The role of nuclear power in meeting future electricity demand has been reconsidered more recently, given concerns about rising fossil fuel prices, energy security, and greenhouse gas emissions. On the other hand, issues related to plant safety, radioactive waste disposal, and the proliferation of nuclear weapons, which continue to raise public concerns in many countries, may hinder the development of new nuclear power reactors.

The projection for total electricity generation from the world's nuclear power plants in 2030 in the *IEO2007* reference case is 14 percent higher than the corresponding projection in *IEO2006*. On a regional basis, only OECD Europe—where some national governments, including those of Germany and Belgium, still have plans in place to phase out nuclear programs entirely—is projected to see a decline in nuclear power generation after 2010. Non-OECD Asia, in contrast, is poised for a robust expansion of nuclear generation. For example, in China, electricity generation from nuclear power is projected to grow at an average annual rate of 7.7 percent from 2004 to 2030, and in India it is projected to increase by an average of 9.1 percent per year.

Hydroelectricity and Other Renewables

In the *IEO2007* reference case, electricity generation from hydroelectric and other renewable energy resources is projected to increase at an average annual rate of 1.7 percent from 2004 to 2030. High oil and natural gas prices, which are expected to persist in the mid-term, encourage the use of renewables. Like nuclear power, renewable energy sources are attractive for environmental reasons. Further, government policies and incentives to increase the use of renewable energy sources for electricity generation encourage the development of renewable energy even when it cannot compete economically with fossil fuels. Nonetheless, the renewable share of world electricity generation falls slightly in the projection, from 19 percent in 2004 to 16 percent in 2030, as growth in the consumption of both coal and natural gas in the electricity generation sector worldwide exceeds the growth in renewable energy consumption. The capital costs of new power plants using renewable fuels remain relatively high in comparison with those for plants fired with coal or natural gas.

The *IEO2007* projections for hydroelectricity and other renewable energy resources include only on-grid renewables. Non-marketed (noncommercial) biofuels from plant and animal sources are an important source of energy, particularly in non-OECD economies, and the International Energy Agency has estimated that some 2.5 billion people in developing countries depend on traditional biomass as their main fuel for cooking [***1***]. Non-marketed fuels and dispersed renewables (renewable energy consumed on the site of production, such as energy from solar panels used to heat water) are not included in the projections, however, because comprehensive data on their use are not available.

In combination, electricity generation from nuclear power and from renewable energy sources is projected to increase by 1.5 percent per year from 2004 to 2030. The development of non-fossil energy sources in electricity markets may be especially attractive to countries that are attempting to diversify away from fossil fuels, both to address energy security issues and to reduce carbon dioxide emissions.

Regional Electricity Markets

In the *IEO2007* reference case, the highest projected growth rates for electricity generation are for nations in the non-OECD region (Figure 64). Robust population growth and rising personal incomes in the non-OECD nations drive the projected growth in demand for electric power. In the OECD countries, where electric power infrastructures are relatively mature, national populations generally are expected to grow slowly or decline, and GDP growth is expected to be slower than in the developing nations, increases in demand for electricity are projected to be much slower than those in the non-OECD countries. For example, electricity demand in OECD North America is projected to grow by an annual average of 1.5 percent from 2004 to 2030, which is less than one-half the projected rates of increase in China and in India.

OECD Economies

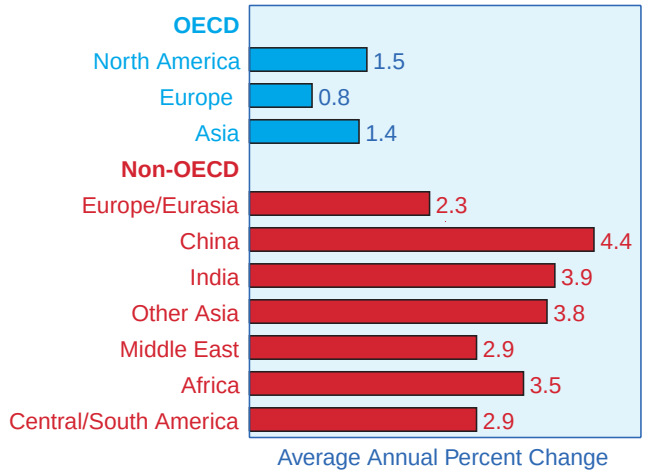
North America

In 2004, electricity generation in North America totaled 4,619 billion kilowatthours and accounted for 28 percent of the world's total generation. That share is projected to decline over the course of the projection period, as the non-OECD nations experience fast-paced growth in electric power demand. Still, North America is projected to account for 23 percent of the world's electric power generation in 2030.

The United States is the largest consumer of electricity in North America and is projected to remain in that position through 2030 (Figure 65). U.S. electricity generation—including both generation by electric power producers and on-site generation—is projected to increase steadily, at an average annual rate of 1.4 percent. Canada, like the United States, has a mature electricity market, and its generation is projected to increase by 1.5 percent per year from 2004 to 2030. Mexico's electricity generation grows at a faster rate—averaging 3.3 percent per year through 2030—reflecting the relatively undeveloped state of the country's electric power infrastructure.

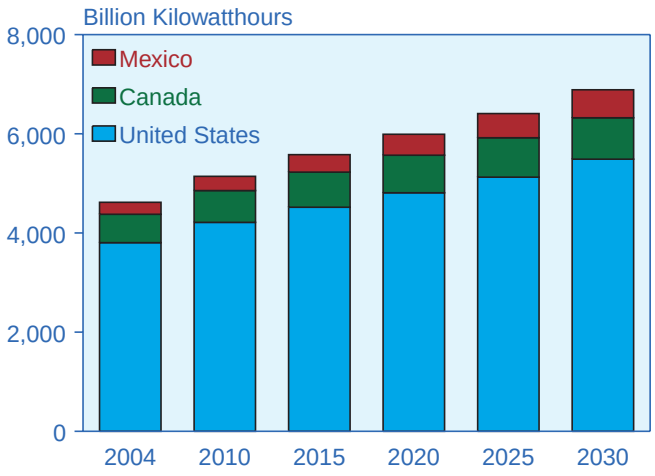
There are large differences in the mix of energy sources used to generate electricity in the three countries that make up OECD North America, and those differences are likely to become more pronounced in the future (Figure 66). In the United States, coal is the leading source of energy for power generation, accounting for 52 percent of the 2004 total; but in Canada, renewable energy sources (predominantly hydroelectricity) provided 60 percent of the nation's electricity generation in 2004. Most of Mexico's electricity generation currently is fueled by petroleum-based liquids and natural gas, which together accounted for 66 percent of its total electricity generation in 2004. In the reference case projections for 2030, U.S. reliance on coal is even greater than it was in 2004; Canada's hydropower resources (along with some generation from wind capacity scheduled to be built) continue to provide nearly 60 percent of its electricity; and the natural gas share of Mexico's total electricity generation increases to 54 percent (from 35 percent in 2004).

Figure 64. Annual Growth in Electricity Generation by Region, 2004-2030



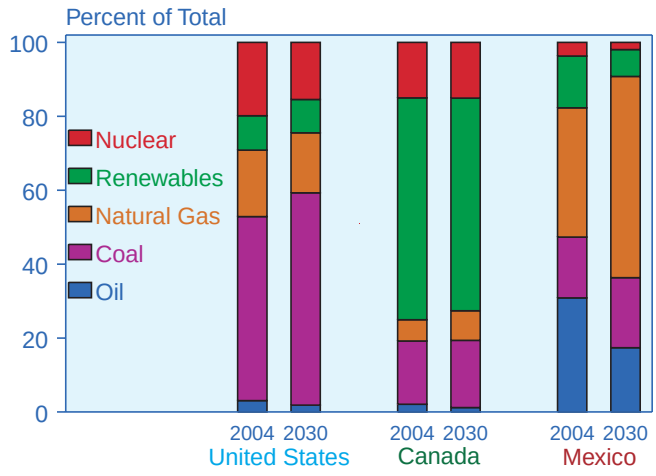
Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

Figure 65. Net Electricity Generation in OECD North America, 2004-2030



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

Figure 66. Net Electricity Generation in OECD North America by Fuel, 2004 and 2030



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

In the United States, electricity generation from natural-gas-fired power plants is projected to increase through 2020, as recently constructed plants are utilized more fully to meet growing demand. After 2020, generation from new coal-fired and nuclear power plants is expected to meet most of the growth in electricity demand. Total generation from nuclear power plants is projected to increase, from 789 billion kilowatthours in 2004 to 896 billion kilowatthours in 2030, as the result of expected capacity increases that include 12,500 megawatts at newly built plants and 3,000 megawatts from uprates of existing plants (offset by 2,600 megawatts of retirements). Generation from renewable energy sources also is projected to expand, from 370 billion kilowatthours in 2004 to 522 billion kilowatthours in 2030, stimulated by technology improvements, higher fossil fuel prices, and the expansion and extension of the Federal production tax credit for renewable generation through December 31, 2007, enacted in the Energy Policy Act of 2005.[15]

In Canada, generation from natural gas and from coal is projected to increase, and oil-fired generation is projected to decline. The Province of Ontario had announced plans to close all its coal-fired plants by the end of 2007, but that date has since been pushed back to 2011. Further, in late 2006, the Ontario Power Authority recommended that the government consider maintaining 3,000 megawatts of coal-fired capacity until at least 2014 to ensure that no power shortages would occur as a result of possible delays in the addition of new generating capacity [*2*]. In the *IEO2007* reference case, Canada's coal use for electricity generation continues to increase throughout the projection period, by an average of 1.7 percent per year; natural-gas-fired generation increases by 2.8 percent per year; generation from nuclear power increases by 1.5 percent per year; and renewable generation increases by 1.3 percent per year.

Several large- and small-scale hydroelectric facilities currently are either planned or under construction in Canada. Hydro-Québec has announced plans to construct a 768-megawatt powerhouse near Eastman and a smaller 120-megawatt facility at Sarcelle in Québec, both of which are expected to be fully commissioned by 2011 [*3*]. Other planned hydroelectric projects include a 1,550-megawatt plant at La Romaine in Québec, a 2,000-megawatt project at the Lower Churchill River/Gull Island site in Newfoundland and Labrador, and a 1,500-megawatt project (the Conawapa Generating Station) on the Lower Nelson River in Manitoba [*4*]. The *IEO2007* reference case does not anticipate that all the planned projects will be constructed, but given Canada's historical experience with hydropower and the commitments for construction, new hydroelectric capacity accounts for more than one-half of the 16,000 megawatts of additional renewable capacity projected to be added in Canada between 2004 and 2030.

While hydropower plays a major role in Canada's renewable electricity generation, the country also has plans to expand wind-powered generating capacity in the future. In 2006, the country's installed wind capacity was doubled, to 1,460 megawatts, giving Canada the world's twelfth-largest national installed wind capacity [*5*]. In the Canadian government's 2005 budget, its Wind Power Production Incentive (WPPI) was expanded to support the development of 4,000 megawatts of wind power by 2010, with qualifying wind producers eligible to receive an incentive of $0.01 per kilowatthour (Canadian dollars) for the first 10 years of production from new installations [*6*]. In addition, several Provincial governments have instituted their own incentives to support the construction of new wind capacity. The incentives (along with sustained higher world oil and natural gas prices) are expected to support the projected increase in Canada's use of wind power for electricity generation.

OECD Europe

Electricity generation in the nations of OECD Europe is projected to grow slowly, as a result of their slow population growth and their already well-established electricity markets. The region's total generation increases by an average of 0.8 percent per year in the *IEO2007* reference case, from 3,250 billion kilowatthours in 2004 to 3,564 billion kilowatthours in 2015 and 4,044 billion kilowatthours in 2030. Natural gas is expected to be by far the fastest-growing fuel for electricity generation in OECD Europe, increasing at an average rate of 3.3 percent per year from 2004 to 2030, while high world oil prices and environmental concerns lead to decreases in the use of petroleum and coal (Figure 67).

Renewable electricity generation in OECD Europe is also projected to increase over the period from 2004 to 2030. The use of renewables (primarily nonhydropower) for electricity generation is projected to grow by 1.4 percent per year on average from 2004 to 2030. Although most of the economically feasible hydroelectric resources in Europe already have been developed, the countries of OECD Europe have installed substantial amounts of alternative renewable energy capacity—consisting mainly of wind turbines—over the past several years. At present, 7 of the world's 10 largest markets for wind-powered electricity generation are in Europe,[16] and the 27-member European Union accounted for 65 percent of the world's total installed wind capacity as of

[15]The U.S. projections, which are consistent with those in EIA's *Annual Energy Outlook 2007* reference case, assume that the production tax credit will expire at the end of 2007.

[16]According to the Global Wind Energy Council, the 10 countries with the largest installed wind capacity are Germany, Spain, the United States, India, Denmark, China, Italy, United Kingdom, Portugal, and France.

the end of 2006 [7]. With many European countries setting new goals to increase nonhydropower renewable electricity generation, the role of wind power in meeting OECD Europe's electricity demand is likely to grow in the future.

Several countries in OECD Europe have policies in effect to reduce their use of nuclear power in the future. As a result, nuclear electricity generation in the region is projected to decline through 2025. After 2025, however, modest growth is projected for the region's nuclear power capacity, and its total nuclear electricity generation begins to rise at the end of the projection. In the *IEO2007* reference case, nuclear capacity in OECD Europe is projected to fall from 134 gigawatts in 2004 to 114 gigawatts in 2030 (as compared with the larger decline projected in the *IEO2006* reference case, to 95 gigawatts in 2030). Many nations in the region are reassessing the potential role of nuclear power in meeting demand for electricity, particularly because it is an energy source that does not produce carbon dioxide emissions. As a result, the *IEO2007* reference case projection anticipates that more nuclear power plant operating lives will be extended and fewer plants will be retired in the mid-term, and that there will be some new builds of nuclear capacity in France, Finland, and possibly other countries in OECD Europe.

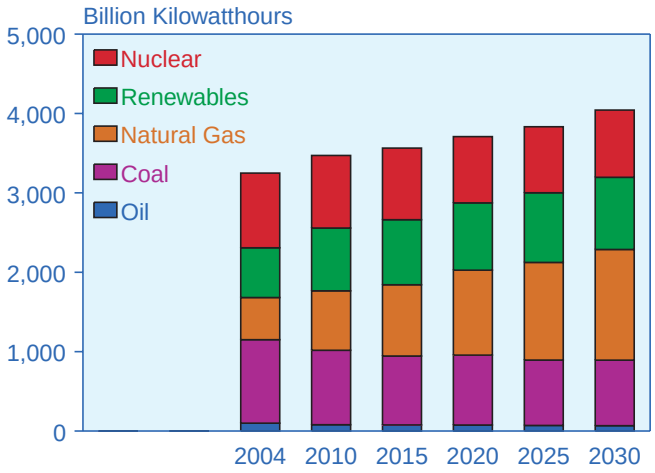
OECD Asia

Total electricity generation in OECD Asia is projected to increase by 1.4 percent per year on average, from 1,586 billion kilowatthours in 2004 to 2,259 billion kilowatthours in 2030. Japan accounts for the largest share of electricity generation in the region today and continues to do so in the mid-term projection, despite its having the slowest-growing electricity market in the region (Figure 68). Japan's electricity generation increases at a 1.0-percent average annual rate in the *IEO2007* reference case, as compared with projected rates of 1.4 percent per year in Australia/New Zealand and 2.3 percent per year in South Korea. Japan's electricity markets can be characterized as mature, and its aging population and relatively slow projected economic growth in the mid-term translate to slow growth in demand for electric power. In contrast, both Australia/New Zealand and South Korea are projected to have more robust income and population growth in the mid-term, leading to more rapid growth in demand for electricity.

The fuel mix for electricity generation varies widely among the three economies that make up the OECD Asia region (Figure 69). In Japan, natural gas, coal, and nuclear power make up the bulk of the current electric power mix, with natural gas and nuclear accounting for about 56 percent of total generation and coal another 25 percent. The remaining portion is split between renewables and petroleum-based liquids. In 2030, Japan is projected to rely on natural gas, nuclear power, and coal for about 83 percent of its electric power supply, with coal's share declining to 19 percent as both natural gas and nuclear power displace its use.

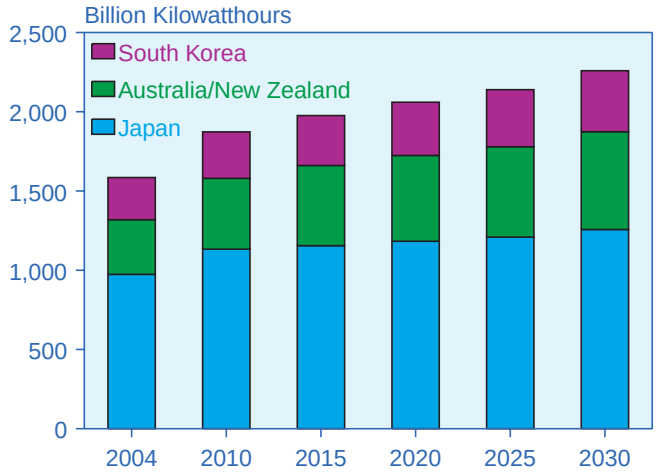
Australia and New Zealand, with their rich coal resources, rely on coal for nearly three-fourths of their combined electricity generation. Another 18 percent comes from renewable energy sources—primarily, hydropower. The Australia/New Zealand region uses negligible amounts of oil for electricity generation and no nuclear power, and that is not expected to change over the projection period. Natural-gas-fired generation

Figure 67. Net Electricity Generation in OECD Europe by Fuel, 2004-2030



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

Figure 68. Net Electricity Generation in OECD Asia, 2004-2030



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

is expected to grow strongly in the region, reducing coal's share in 2030.

In South Korea, coal and nuclear power currently provide 44 percent and 36 percent of total electricity generation, respectively. Strong expansion is projected for South Korea's nuclear power program: in 2030, nuclear electricity generation is projected to be nearly equal to coal-fired generation, with both providing about 41 percent of the country's total electricity.

Non-OECD Economies

Non-OECD Europe and Eurasia

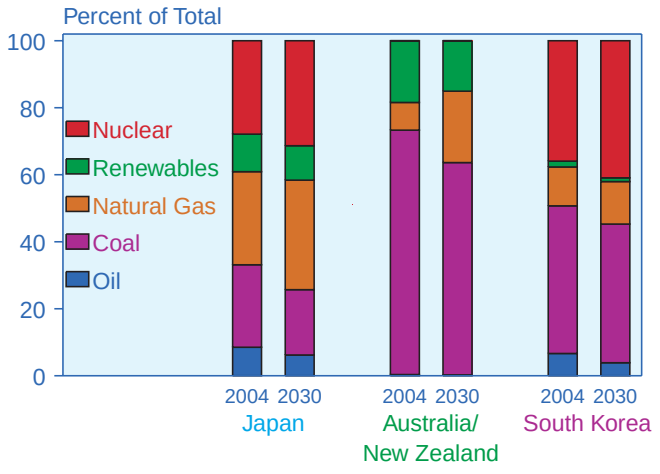
Total electricity generation in non-OECD Europe and Eurasia is projected to grow at an average rate of 2.3 percent per year in the *IEO2007* reference case, from 1,497 billion kilowatthours in 2004 to 2,036 billion kilowatthours in 2015 and 2,731 billion kilowatthours in 2030. Russia, the region's largest economy, accounted for 59 percent of its total generation in 2004 and is projected to account for 55 percent of the regional total in 2030 (Figure 70).

The non-OECD Europe and Eurasia region as a whole possesses ample natural gas resources. As a result, it is expected that much of its electricity supply will continue to be provided from natural-gas-fired power plants. Natural gas is the region's fastest-growing source of electric power in the *IEO2007* reference case, increasing by 3.2 percent per year from 2004 to 2030. Coal-fired and nuclear power plants also are important regional sources of electricity generation, with projected annual increases averaging 2.2 percent and 2.3 percent, respectively, over the same period. Renewable generation, largely from hydroelectric facilities, is projected to increase more slowly, at an average rate of 0.7 percent per year, largely as a result of repairs and expansions at existing hydroelectric projects rather than new hydropower or nonhydropower renewable generating facilities. Liquids play only a minor role in the electric power markets of non-OECD Europe and Eurasia, and their role is not expected to expand in the future.

Russia has announced plans to increase its nuclear power capacity over the mid-term, in order to lessen the reliance of its power sector on natural gas and preserve what is becoming one of its most valuable export commodities. As a result, electricity production from Russia's nuclear power plants is projected to grow by 3.2 percent per year on average in the reference case, while natural-gas-fired generation increases at the slower rate of 2.5 percent per year.

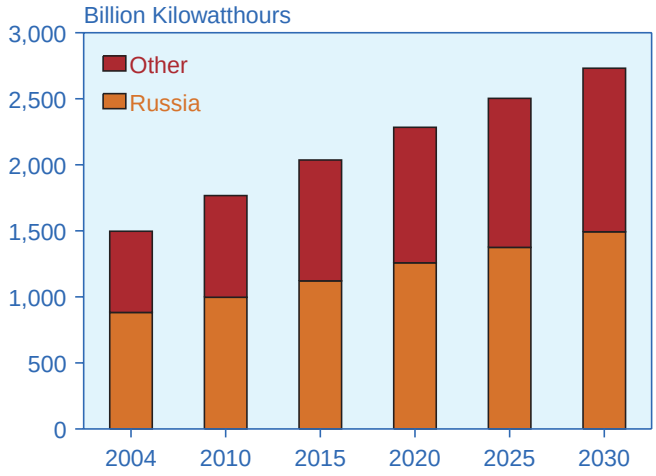
Only 3 gigawatts of new nuclear generating capacity has become operational in Russia since 1991. In 2006, Russian Prime Minister Mikhail Fradkov approved an ambitious plan to complete the construction of 10 new 1,000-megawatt reactors and begin construction on another 10 reactors by 2015 [*8*]. There is some question, however, as to whether the plan can be achieved within the announced time frame. One problem is that tariffs on nuclear power currently are much lower than those on thermal generation, and in the past the Russian nuclear power industry has not had sufficient funds to complete the construction on new reactors on schedule. The Russian government has acknowledged that raising nuclear tariffs to parity with the tariffs on thermal generation will be necessary to attract the private-sector capital investment needed for its nuclear power expansion plan to succeed, and the plan includes assumptions that both

Figure 69. Net Electricity Generation in OECD Asia by Fuel, 2004 and 2030



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

Figure 70. Net Electricity Generation in Non-OECD Europe and Eurasia, 2004-2030



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

capital costs and operating costs will be reduced. Nevertheless, the *IEO2007* reference case projects some delay in meeting the current construction schedule. In the outlook, a net 5 gigawatts of nuclear capacity is added to Russia's existing 22 gigawatts by 2015. Thereafter, it is likely that another 15 gigawatts of nuclear capacity will be added by 2030.

Non-OECD Asia

Non-OECD Asia—led by China and India—is projected to be the region with the fastest growth in electric power generation worldwide, averaging 4.2 percent per year from 2004 to 2030. The nations of non-OECD Asia are expected to see continued robust economic growth, with corresponding increases in demand for electricity to power lighting, heating and cooling, household appliances, and other electronic devices associated with rising standards of living. Total electricity generation in the non-OECD Asia region nearly triples over the projection period, from 3,517 billion kilowatthours in 2004 to 10,185 billion kilowatthours in 2030 (Figure 71).

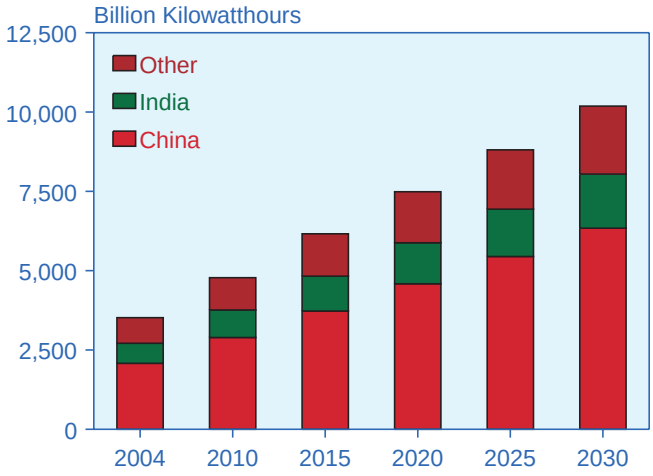
China and India account for the world's largest projected increases in national electric power demand over the 2004 to 2030 period. China already is the world's largest coal consumer, and India is the third largest (after the United States). In 2004, the combined coal use of China and India was equal to that of the entire OECD region, and in 2030 it is projected to exceed the OECD total by more than 85 percent. A sizable portion of the coal consumed in China and India is expected to be used for power generation. In China, the coal share of generation is projected to reach 84 percent in 2030, despite higher annual growth rates for natural-gas-fired and nuclear power generation (Figure 72). In India, coal's share is projected to decline to 69 percent of the country's total power generation in 2030.

In both China and India, consumption of petroleum liquids for electricity generation is projected to remain modest, as relatively high world oil prices make other fuels economically more attractive. Some increases in oil use for electricity generation are projected for other countries in the region, because many rural areas that currently do not have access to transmission lines are expected to replace noncommercial energy sources with electricity from diesel-fired generators until transmission infrastructure can be put into place. Nevertheless, the liquids share of electricity generation in non-OECD Asia is projected to fall from 4 percent in 2004 to 2 percent in 2030.

Non-OECD Asia is expected to lead the world in the installation of new nuclear capacity over the projection period, accounting for 51 percent of the projected net increment in nuclear capacity worldwide. China is projected to add 36 gigawatts of nuclear capacity by 2030, India 17 gigawatts, and the other countries of non-OECD Asia a combined 6 gigawatts. Strong growth in nuclear capacity in China and India will help both countries improve fuel diversification in their power sectors, although thermal generation will continue to dominate in both countries. In China, the nuclear share of total electricity generation is projected to rise from 2 percent in 2004 to 5 percent in 2030, and in India it is projected to rise from 2 percent to 8 percent.

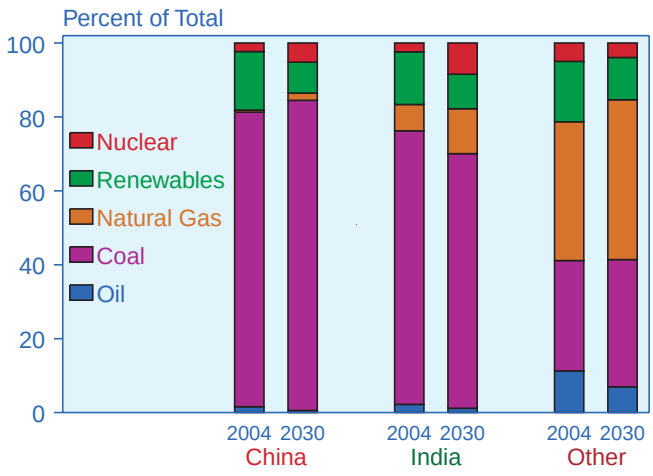
Although electricity generation from renewable energy sources is projected to grow at an average annual rate of 2.0 percent, the renewable share of total generation declines as the shares if fossil fuels and nuclear power

Figure 71. Net Electricity Generation in Non-OECD Asia, 2004-2030



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

Figure 72. Net Electricity Generation in Non-OECD Asia by Fuel, 2004 and 2030



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

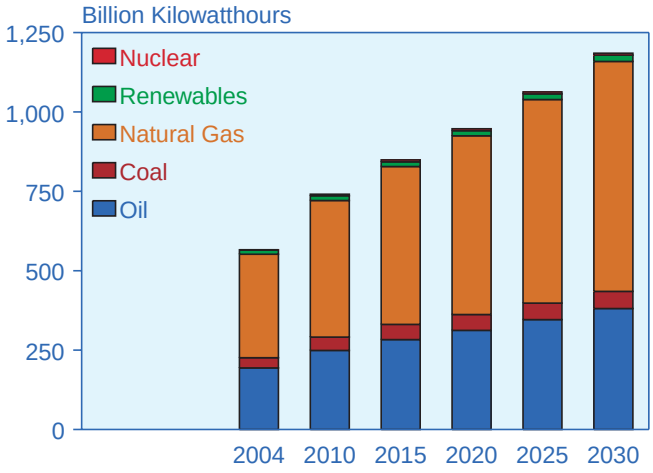
grow more strongly in the region. The renewable share of non-OECD Asian generation falls from 16 percent in 2004 to 9 percent in 2030. Much of the growth in non-OECD Asia's renewable energy consumption is projected to come from mid- to large-scale hydroelectric facilities. Several countries in the region have hydropower facilities either planned or under construction. In India, for instance, about 12,020 megawatts of hydroelectric capacity is under construction, and letters of award have been issued for the 1,000-megawatt Tehri Pass project (scheduled for completion by 2012) and the 1,200-megawatt Kotlibhel-IA project [***9***]. 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) [***10***].

Middle East

Electric power generation in the Middle East region is projected to grow by 2.9 percent per year, from 567 billion kilowatthours in 2004 to 1,185 billion kilowatthours in 2030 (Figure 73). Most of the countries in the Middle East region have well-established electricity infrastructures, with electrification rates above 90 percent [***11***]. (Yemen, the region's poorest economy, is the exception, with only an estimated 50 percent of the population having access to electric power in 2002.) Nevertheless, population and income growth in the region are expected to result in growing demand for electric power in the future.

Natural gas is the largest source of energy for electricity generation in the Middle East, and it is expected to continue in that role. In 2004, natural-gas-fired generation accounted for 58 percent of the region's total power supply. In 2030, the natural gas share is projected to be 61 percent, as the petroleum share of generation decreases slightly over the projection period. Petroleum is a valuable export commodity for many nations of the Middle East, and there is increasing interest in the use of domestic natural gas for electricity generation in order to make more oil assets available for export.

Figure 73. Net Electricity Generation in the Middle East by Fuel, 2004-2030



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

The Middle East is the only region in the world where petroleum liquids are expected to continue accounting for a sizable portion of the fuel mix for electricity generation throughout the projection period. The Middle East region as a whole relied on oil-fired capacity to meet 34 percent of its total generation needs in 2004, and that share is projected to fall only slightly, to 32 percent, in 2030. The rich petroleum resources in the Middle East are expected to allow nations of the region to continue using oil for electricity generation, even as high world oil prices result in the displacement of oil in other regions. Oil-fired generation in the Middle East is projected to increase by an average of 2.6 percent per year from 2004 to 2030.

Other energy sources make only minor contributions to the Middle East region's electricity supply. Israel is the only country in the region that uses significant amounts of coal to generate electric power [***12***], and Iran is the only one projected to add nuclear capacity, with completion of its Bushehr 1 reactor expected by 2010. Finally, because there is little incentive for countries in the Middle East to increase their use of renewable energy sources, renewables are projected to account for a modest 2 percent of the region's total electricity generation throughout the projection period.

Africa

In Africa, demand for electricity is projected to grow at an average annual rate of 3.5 percent in the *IEO2007* reference case. Thermal generation accounted for most of the region's total electricity supply in 2004 and is expected to be in the same position through 2030. Coal-fired power plants, which were the region's largest source of electricity in 2004, accounting for 45 percent of total generation, are projected to provide a 46-percent share in 2030, as natural-gas-fired generation expands strongly from 25 percent of the total in 2004 to 38 percent in 2030 (Figure 74).

At present, South Africa's two nuclear reactors are the only ones operating in the region, accounting for about 3 percent of Africa's total electricity generation. In the *IEO2007* reference case, 1,000 megawatts of new nuclear capacity (net) is projected to become operational in Africa over the 2004 to 2030 period; however, the nuclear share of total generation is expected to fall to 2 percent in 2030.

Hydroelectricity and other marketed renewable energy sources are expected to grow slowly in Africa. As they have in the past, non-marketed renewables can be expected to continue providing energy to Africa's rural areas; however, it is often difficult for African nations to find funding or international support for larger commercial projects. Still, plans for several hydroelectric projects in the region have been advanced recently, and they may help boost supplies of marketed renewable energy in the mid-term. Several (although not all) of the announced projects are expected to be completed in the mid-term outlook, allowing the region's consumption of marketed renewable energy to grow by 0.7 percent per year from 2004 to 2030.

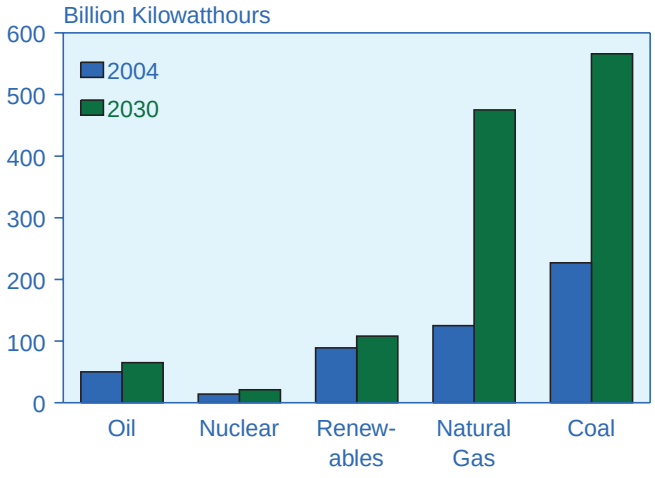
In 2006, the Export-Import Bank of China signed a memorandum of understanding with the government of Mozambique to provide a $2.3 billion loan package that would include construction of the 1,300-megawatt Mphanda Nkuwa hydroelectric dam on the Zambezi River [***13***]. In addition, there are plans to expand the existing hydroelectric facility at Cahora Bassa and to construct a new North Bank Cahora Bassa dam. The African Development Fund has estimated that the additions could increase Mozambique's installed generating capacity by 2,000 megawatts and raise its national electrification rate from 6 percent in 2006 to 20 percent in 2020 [***14***]. In Angola, there are plans to refurbish existing hydropower facilities at Capanda and Cambambe and increase their capacity to 520 megawatts and 700 megawatts, respectively in the near term [***15***]. Nigeria has plans to expand its renewable generating capacity by 3,500 megawatts in the mid-term, mostly in the form of small hydroelectric projects, in an attempt to diversify the country's energy mix away from oil and natural gas [***16***].

Central and South America

Electricity generation in Central and South America is projected to increase steadily in the *IEO2007* reference case, from 882 billion kilowatthours in 2004 to 1,838 billion kilowatthours in 2030 (Figure 75). Brazil, the region's largest economy, is expected to remain its largest electricity producer as well, accounting for 54 percent of total projected electricity generation in the Central and South America region in 2030.

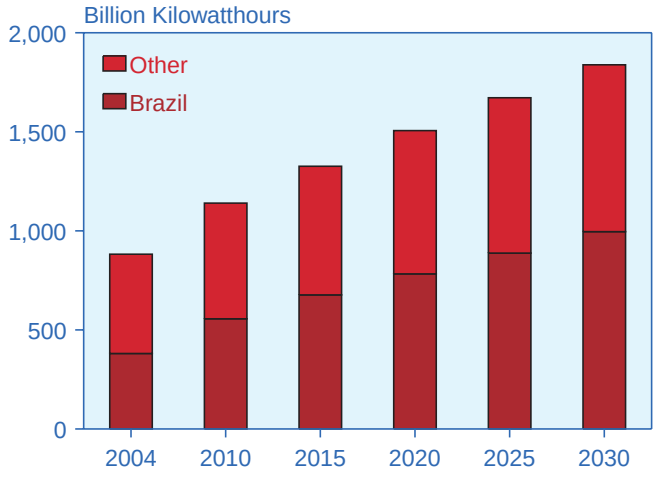
Throughout Central and South America, significant shares of national electric power supplies are derived from renewable energy sources—primarily, hydropower. In times of drought, such heavy reliance on hydroelectricity has been problematic, resulting in widespread power shortages. Hydroelectric generation accounted for 83 percent of Brazil's total electricity supply in 2004, and despite ongoing efforts to diversify the fuel mix for the country's electricity generation, hydropower is projected to remain Brazil's predominant source of electricity through 2030 (Figure 76). In combination, the other nations of Central and South America rely on hydropower for a smaller percentage of their electricity supply (51 percent in 2004); and in 2030, the share of hydropower and other renewable energy sources in their combined fuel use for electricity generation is projected to be 47 percent. Robust growth in the use of natural gas and nuclear power is projected to lessen the region's overall reliance on hydropower in the mid-term.

Figure 74. Net Electricity Generation in Africa by Fuel, 2004 and 2030



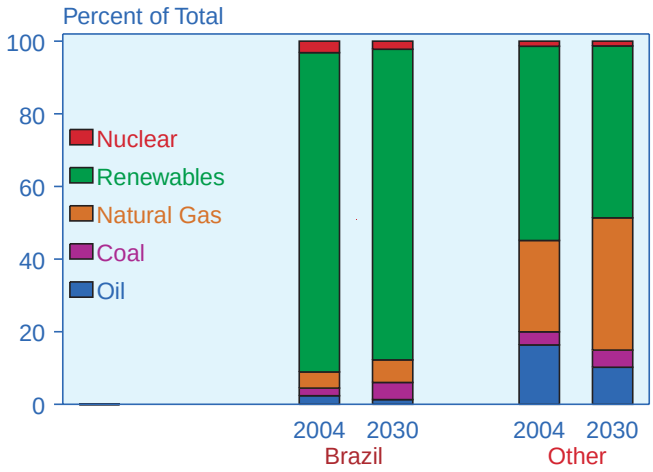
Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **2030:** EIA, System for the Analysis of Global Energy Markets (2007).

Figure 75. Net Electricity Generation in Central and South America, 2004-2030



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

Figure 76. Net Electricity Generation in Central and South America by Fuel, 2004 and 2030



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