Overview

Energy Trends to 2030

EIA, in preparing projections for the *AEO2007*, evaluated a wide range of trends and issues that could have major implications for U.S. energy markets between today and 2030. This overview focuses on one case, the reference case, which is presented and compared with the *AEO2006* reference case (see Table 1). Readers are encouraged to review the full range of alternative cases included in other sections of *AEO2007*. As in previous editions of the *Annual Energy Outlook* (*AEO*), the reference case assumes that current policies affecting the energy sector remain unchanged throughout the projection period. Some possible policy changes—notably, the adoption of policies to limit or reduce greenhouse gas emissions—could change the reference case projections significantly.

Trends in energy supply and demand are affected by many factors that are difficult to predict, such as energy prices, U.S. economic growth, advances in technologies, changes in weather patterns, and future public policy decisions. It is clear, however, that energy markets are changing gradually in response to such readily observable factors as the higher energy prices that have been experienced since 2000, the greater influence of developing countries on worldwide energy requirements, recently enacted legislation and regulations in the United States, and changing public perceptions of issues related to the use of alternative fuels, emissions of air pollutants and greenhouse gases, and the acceptability of various energy technologies, among others. Such changes are reflected in the *AEO2007* reference case, which projects increased consumption of biofuels (both ethanol and biodiesel), growth in coal-to-liquids (CTL) capacity and production, growing demand for unconventional transportation technologies (such as flexfuel, hybrid, and diesel vehicles), growth in nuclear power capacity and generation, and accelerated improvements in energy efficiency throughout the economy.

Despite the rapid growth projected for biofuels and other nonhydroelectric renewable energy sources and the expectation that orders will be placed for new nuclear power plants for the first time in more than 25 years, oil, coal, and natural gas still are projected to provide roughly the same 86-percent share of the total U.S. primary energy supply in 2030 that they did in 2005 (assuming no changes in existing laws and regulations). The expected rapid growth in the use of biofuels and other nonhydropower renewable energy sources begins from a very low current share of total energy use; hydroelectric power production, which accounts for the bulk of current renewable electricity supply, is nearly stagnant; and the share of total electricity supplied from nuclear power falls despite the projected new plant builds, which more than offset retirements, because the overall market for electricity continues to expand rapidly in the projection.

World oil prices since 2000 have been substantially higher than those of the 1990s, as have the prices of natural gas and coal (although coal prices began to rise somewhat later than oil and natural gas prices). The sustained increase in world oil prices caused EIA to reevaluate earlier oil price expectations in producing *AEO2006*. The long-term path of world oil prices in the *AEO2007* reference case is similar to that in the *AEO2006* reference case, although near-term prices in *AEO2007* are somewhat higher than those in *AEO2006*.

In the *AEO2007* reference case, real world crude oil prices, expressed in terms of the average price of imported light, low-sulfur crude oil to U.S. refiners, are projected to decline gradually from their 2006 average level through 2015, as expanded investment in exploration and development brings new supplies to the world market. After 2015, real prices begin to rise as demand continues to grow and higher cost supplies are brought to market. In 2030, the average real price of crude oil is projected to be above $59 per barrel in 2005 dollars, or about $95 per barrel in nominal dollars.

The energy price projections for natural gas and coal in the *AEO2007* reference case also are similar to those in *AEO2006*. The real wellhead price of natural

World Oil Price Concept Used in AEO2007

The world oil price in *AEO2007* is defined as the average price of low-sulfur, light crude oil imported into the United States—the same definition used in *AEO2006*. This price is approximately equal to the price of the light, sweet crude oil contract traded on the NYMEX exchange and the price of West Texas Intermediate (WTI) crude oil delivered to Cushing, Oklahoma. Prior to *AEO2006*, the world crude oil price was defined on the basis of the U.S. average imported refiners' acquisition cost of crude oil (IRAC), which represented the weighted average of all imported crude oil. On average, the IRAC price is $5 to $8 per barrel less than the price of imported low-sulfur, light crude oil.

gas is projected to decline from current levels through 2015, when new supplies enter the market, but it does not return to the levels of the 1990s. After 2015, the natural gas price rises to nearly $6.00 per thousand cubic feet in 2030 in 2005 dollars (about $9.60 per thousand cubic feet in nominal dollars). For coal, the average minemouth price ranges between $1.08 and $1.18 (2005 dollars) per million British thermal units (Btu) over the projection period; in 2030, the price of coal is projected to be roughly the same as it was in 2005, at $1.15 per million Btu ($1.85 per million Btu in nominal dollars). The 2030 price projection is higher than the *AEO2006* reference case projection of $1.11 per million Btu and much higher than projected in earlier *AEO*s—typically, below $0.90 per million Btu. Greater price increases are avoided, because lower cost production from surface mines in the West is projected to capture a growing share of the U.S. market.

The use of alternative fuels, such as ethanol, biodiesel, and CTL, is projected to increase substantially in the reference case as a result of the higher prices projected for traditional fuels and the support for alternative fuels provided in recently enacted Federal legislation. Ethanol use grows in the *AEO2007* reference case from 4 billion gallons in 2005 to 14.6 billion gallons in 2030 (about 8 percent of total gasoline consumption by volume). Ethanol use for gasoline blending grows to 14.4 billion gallons and E85 consumption to 0.2 billion gallons in 2030. The ethanol supply is expected to be produced from both corn and cellulose feedstocks, both of which are supported by ethanol tax credits included in EPACT2005 [*1*], but domestically grown corn is expected to be the primary source, accounting for 13.6 billion gallons of ethanol production in 2030.

Alternative sources of distillate fuel oil are projected to be key contributors to total supply (particularly, low-sulfur diesel fuels) in 2030. Consumption of biodiesel, also supported by tax credits in EPACT-2005, reaches 0.4 billion gallons in 2030, and distillate fuel oil produced from CTL reaches 5.7 billion gallons in 2030. In total, these two alternative sources of distillate fuel oil account for more than 7 percent of the total distillate pool in 2030.

The *AEO2007* reference case also reflects growing market penetration by unconventional vehicle technologies, such as flex-fuel, hybrid, and diesel vehicles. Sales of flex-fuel vehicles (FFVs), which are capable of using gasoline and E85, reach 2 million per year in 2030, or 10 percent of total sales of new light-duty vehicles. Sales of hybrids, including both full and mild hybrids [*2*], are projected to reach 2 million per year by 2030, accounting for another 10 percent of total light-duty vehicles sales. Diesel vehicles sales reach 1.2 million per year in 2030, or 6 percent of new light-duty vehicle sales. Including other alternative vehicle technologies (such as gaseous, electric, and fuel cell), all the projected sales of alternative vehicle technologies account for nearly 28 percent of projected new light-duty vehicle sales in 2030, up from just over 8 percent in 2005.

In the electric power sector, the last new nuclear generating unit brought on line in the United States began operation in 1996. Since then, changes in U.S. nuclear capacity have resulted only from uprating of existing units and retirements. The *AEO2007* reference case projects total operable nuclear generating capacity of 112.6 gigawatts in 2030, including 3 gigawatts of additional capacity uprates, 9 gigawatts of new capacity built primarily in response to EPACT2005 tax credits, 3.5 gigawatts added in later years in response to higher fossil fuel prices, and 2.6 gigawatts of older plant retirements. As a result of the growth in available capacity, total nuclear generation is projected to grow from 780 billion kilowatthours in 2005 to 896 billion kilowatthours in 2030. Even with the projected increase in nuclear capacity and generation, however, the nuclear share of total electricity generation is expected to fall from 19 percent in 2005 to 15 percent in 2030.

Natural gas consumption is projected to grow to 26.1 trillion cubic feet in 2030, down from the projection of 26.9 trillion cubic feet in 2030 in the *AEO2006* reference case and well below the projections of 30 trillion cubic feet or more included in *AEO* reference cases only a few years ago. The generally higher natural gas prices projected in the *AEO2007* reference case result in lower projected growth of natural gas use for electricity generation over the last decade of the projection period. Total natural gas consumption is almost flat from 2020 through 2030, when growth in residential, commercial, and industrial consumption is offset by a decline in natural gas use for electricity generation as a result of greater coal use.

As in *AEO2006*, coal is projected to play a major role in the *AEO2007* reference case, particularly for electricity generation. Coal consumption is projected to increase from 22.9 quadrillion Btu (1,128 million short tons) in 2005 to more than 34 quadrillion Btu (1,772 million short tons) in 2030, with significant additions of new coal-fired generation capacity over

the last decade of the projection period, when rising natural gas prices are projected. The reference case projections for coal consumption are particularly sensitive to the underlying assumption that current energy and environmental policies remain unchanged throughout the projection period. Recent EIA service reports have shown that steps to reduce greenhouse gas emissions through the use of an economy-wide emissions tax or cap-and-trade system could have a significant impact on coal use [*3*].

Economic Growth

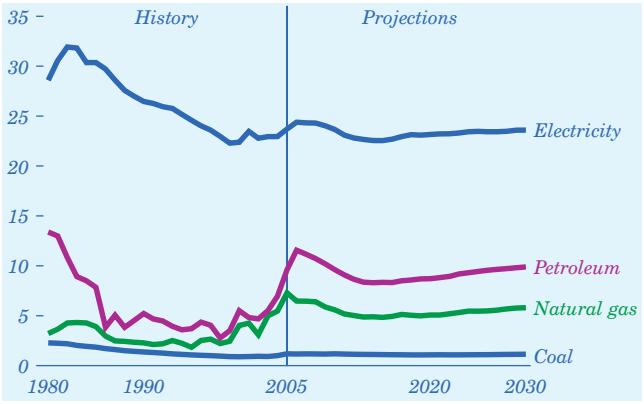
U.S. gross domestic product (GDP) is projected to grow at an average annual rate of 2.9 percent from 2005 to 2030 in the *AEO2007* reference case—0.1 percentage point lower than projected for the same period in the *AEO2006* reference case. The main factors influencing the change in long-term GDP are growth in the labor force and labor productivity. The slightly lower rate of growth in the *AEO2007* reference case reflects a slowing of the economy as a result of higher energy prices in the near term.

The projections for key interest rates (the Federal funds rate, the nominal yield on the 10-year Treasury note, and the AA utility bond rate) in the *AEO2007* reference case are slightly lower than those in the *AEO2006* reference case during most of the projection period, based on an expected lower rate of inflation over the long term. The projected value of industrial shipments is also lower in *AEO2007*, reflecting higher energy prices in the early years of the period.

Energy Prices

In the reference case—one of several cases included in *AEO2007*—the average world crude oil price declines slowly in real terms (2005 dollars), from a 2006 average of more than $69 per barrel ($11.56 per million Btu) to just under $50 per barrel ($8.30 per million Btu) in 2014 as new supplies enter the market, then rises slowly to about $59 per barrel ($9.89 per million Btu) in 2030 (Figure 1). The 2030 world oil price in the *AEO2007* reference case is slightly above the 2030 price in the *AEO2006* reference case. Alternative *AEO2007* cases address higher and lower world oil prices and U.S. natural gas prices.

Figure 1. Energy prices, 1980-2030 (2005 dollars per million Btu)



Oil prices are currently above EIA's estimate of long-run equilibrium prices, a situation that could persist for several more years. Temporary shortages of experienced personnel, equipment, and construction materials in the oil industry; political instability in some major producing regions; and recent strong economic growth in major consuming nations have combined to push oil prices well above equilibrium levels. Although some analysts believe that current high oil prices signal an unanticipated scarcity of petroleum resources, EIA's expectations regarding the ultimate size and cost of both conventional and unconventional liquid resources have not changed since last year's *AEO*.

This year's reference case anticipates substantial increases in conventional oil production in several Organization of the Petroleum Exporting Countries (OPEC) and non-OPEC countries over the next 10 years, as well as substantial development of unconventional production over the next 25 years. The prices in the *AEO2007* reference case are high enough to trigger entry into the market of some alternative energy supplies that are expected to become economically viable in the range of $25 to $50 per barrel. They include oil sands, ultra-heavy oils, gas-to-liquids (GTL), and CTL.

The *AEO2007* reference case represents EIA's current judgment about the expected behavior of OPEC in the mid-term. In the projection, OPEC increases production at a rate that keeps average prices in the range of $50 to $60 per barrel (2005 dollars) through 2030. This would not preclude the possibility that prices could move outside the $50 to $60 range for short periods of time over the next 25 years. OPEC is expected to recognize that allowing oil prices to remain above that level for an extended period could lower the long-run profits of OPEC producers by encouraging more investment in non-OPEC conventional and unconventional supplies and discouraging consumption of liquids worldwide.

The reference case also projects significant long-term supply potential from non-OPEC producers. In several resource-rich regions, with wars ending, new pipelines being built, new exploration and drilling technologies becoming available, and world oil prices rising, access to resources has increased and production has risen. For example, oil production in Angola has nearly doubled since the end of a 27-year civil war in 2002. In Azerbaijan and Kazakhstan, new investment has been stimulated by the 2006 opening of the Baku-Tbilisi-Ceyhan (BTC) pipeline connecting the Caspian and Mediterranean seas, and production in both countries is expected to increase by more than 1 million barrels per day from 2006 to 2010. Brazil's pioneering development of offshore deepwater drilling, coupled with clear government policies, has attracted foreign investment and steadily increased production. In Canada, where the economic viability of the country's oil sands has been enhanced by higher world oil prices and advances in production technology, production from those resources is expected to reach 3.7 million barrels per day in 2030.

In the *AEO2007* reference case, world liquids demand is projected to increase from about 84 million barrels per day in 2005 to 117 million barrels per day in 2030. OPEC liquids production is projected to total 48 million barrels per day in 2030, 40 percent higher than the 34 million barrels per day produced in 2005 and almost 2 million barrels per day above the *AEO2006* reference case projection of 46 million barrels per day in 2030. The Middle East OPEC producers and Venezuela have the resources to boost their output substantially over the period. Non-OPEC liquids production is projected to increase from 50 million barrels per day in 2005 to 70 million in 2030, as compared with the *AEO2006* reference case projection of 72 million barrels per day.

The average U.S. wellhead price for natural gas in the *AEO2007* reference case declines gradually from the current level, as increased drilling brings on new supplies and new import sources become available. The average price falls to just under $5 per thousand cubic feet in 2015 (2005 dollars), then rises gradually to about $6 per thousand cubic feet in 2030 (equivalent to $9.63 per thousand cubic feet in nominal dollars). Imports of liquefied natural gas (LNG), new natural gas production in Alaska, and production from unconventional sources in the lower 48 States are not expected to increase sufficiently to offset the impacts of resource decline and increased demand. The trend in projected wellhead natural gas prices in the *AEO2007* reference case is similar to that in the *AEO2006* reference case.

Minemouth coal prices in the *AEO2007* reference case are higher in most regions of the country than was projected in the *AEO2006* reference case, because of higher mining costs. The largest price increase relative to the *AEO2006* reference case is expected in Appalachia, an area that has been extensively mined, and where mining costs appear to be rising. At the national level, higher Appalachian coal prices are offset over the 25-year projection period by the increasing share of total coal production expected to come from relatively low-cost western mines, such as those in the Powder River Basin in Wyoming.

Average real minemouth coal prices (in 2005 dollars) are expected to fall from $1.15 per million Btu ($23.34 per short ton) in 2005 to $1.08 per million Btu ($21.51 per short ton) in 2019 in the reference case, as prices moderate following a rapid run-up over the past few years. After 2019, new coal-fired power plants are expected to increase total coal demand, and prices are projected to rise to $1.15 per million Btu ($22.60 per short ton) in 2030. The projected 2020 and 2030 prices are 4.2 percent and 1.4 percent higher, respectively, than those in the *AEO2006* reference case. Without adjustment for inflation, the average minemouth price of coal in the *AEO2007* reference case rises to $1.85 per million Btu ($36.38 per ton) in 2030.

The projected price of coal delivered to power plants is also higher in the *AEO2007* reference case than in the *AEO2006* reference case, reflecting higher minemouth prices and higher transportation costs. Increases in diesel fuel prices in recent years have led railroads to implement fuel adjustment charges, which are incorporated in the *AEO2007* reference case. The average delivered price of coal to power plants is projected to increase from $1.53 per million Btu ($30.83 per short ton) in 2005 to $1.69 per million Btu ($33.52 per short ton) in 2030 in 2005 dollars, 7.0 percent higher than in the *AEO2006* reference case. In nominal dollars, the average delivered price of coal to power plants is projected to reach $2.72 per million Btu ($53.98 per short ton) in 2030.

Electricity prices follow the prices of fuels to power plants in the reference case, falling initially as fuel prices retreat after the rapid increases of recent years and then rising slowly. From a peak of 8.3 cents per kilowatthour (2005 dollars) in 2006, average delivered electricity prices decline to a low of 7.7 cents per kilowatthour in 2015 and then increase to 8.1 cents

per kilowatthour in 2030. In the *AEO2006* reference case, with lower expectations for delivered fuel prices and the added costs of maintaining reliability, electricity prices increased to 7.7 cents per kilowatthour (2005 dollars) in 2030. Without adjustment for inflation, average delivered electricity prices in the *AEO2007* reference case are projected to reach 13 cents per kilowatthour in 2030.

Energy Consumption

Total primary energy consumption in the *AEO2007* reference case is projected to increase at an average rate of 1.1 percent per year, from 100.2 quadrillion Btu in 2005 to 131.2 quadrillion Btu in 2030—3.4 quadrillion Btu less than in the *AEO2006* reference case. In 2030, the projected consumption levels for liquid fuels, natural gas, and coal all are lower in the *AEO2007* reference case than in the *AEO2006* reference case. Among the most important factors accounting for the differences are higher energy prices, particularly for coal, but also for natural gas and petroleum in the earlier part of the projection, slightly lower economic growth and greater use of more efficient appliances that reduces energy consumption in the residential and commercial sectors and slows the growth of electricity demand.

As a result of demographic trends and housing preferences, residential delivered energy consumption in the *AEO2007* reference case is projected to grow from 11.6 quadrillion Btu in 2005 to 13.8 quadrillion Btu in 2030, or by 0.7 percent per year (Figure 2). In comparison, the corresponding *AEO2006* projection was 14.0 quadrillion Btu in 2030. Higher projected electricity prices in the *AEO2007* reference case and increases in end-use efficiency for most services contribute to the slightly lower level of residential energy use.

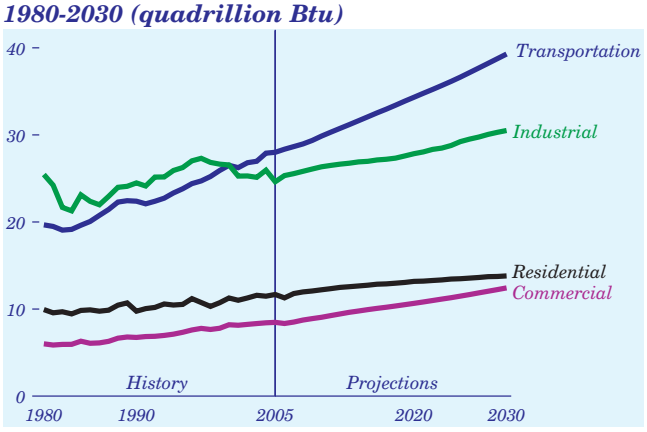
Consistent with projected growth in commercial floorspace in the *AEO2007* reference case, delivered commercial energy consumption is projected to grow from 8.5 quadrillion Btu in 2005 to 12.4 quadrillion Btu in 2030, about the same as the *AEO2006* reference case projection. Higher projected electricity prices, along with revisions to provide better accounting of miscellaneous uses of electricity, lead to lower growth in commercial electricity consumption in the *AEO2007* reference case than was projected in the *AEO2006* reference case. That reduction is offset, however, by a higher projected level of natural gas use in the commercial sector (as compared with the *AEO2006* reference case), because higher electricity prices are expected to prompt more use of combined heat and power (CHP) to satisfy electricity and space conditioning requirements.

After falling to relatively low levels in the early 1980s, industrial energy consumption recovered and peaked in 1997. In the 2000 to 2003 period, industrial sector activity was reduced by an economic recession; in some industrial subsectors, the hurricanes of 2005 also resulted in reduced activity. In the *AEO2007* reference case, the industrial sector is projected to

Reorganization of Fuel Categories in AEO2007

AEO2007 includes, for the first time, a reorganized breakdown of fuel categories that reflects the increasing importance, both now and in the future, of conversion technologies that can produce liquid fuels from natural gas, coal, and biomass. In the past, petroleum production, net imports of petroleum, and refinery gain could be balanced against the supply of liquid fuels and other petroleum products. Now, with other primary energy sources being used to produce significant amounts of liquid fuels, those inputs must be added in order to balance production and supply. Conversely, the use of coal, biomass, and natural gas for liquid fuels production must be accounted for in order to balance net supply against net consumption for each primary fuel. In *AEO2007*, the conversion of non-petroleum primary fuels to liquid fuels is explicitly modeled, along with petroleum refining, as part of a broadly defined refining activity that is included in the industrial sector. Unlike earlier *AEO*s, *AEO2007* specifically accounts for conversion losses and co-product outputs in the broadly defined refining activity.

Figure 2. Delivered energy consumption by sector, 1980-2030 (quadrillion Btu)



return to more typical output growth rates, and industrial energy consumption is expected to reflect the trend. The industrial value of shipments in the reference case is projected to grow by 2.0 percent per year from 2005 to 2030—more slowly than in the *AEO2006* reference case (2.1 percent per year) due to a slight slowdown in projected investment spending, higher energy prices, and increased competition from imports. Delivered industrial energy consumption in the *AEO2007* reference case is projected to reach 30.5 quadrillion Btu in 2030, significantly lower than the *AEO2006* reference case projection of 32.9 quadrillion Btu.

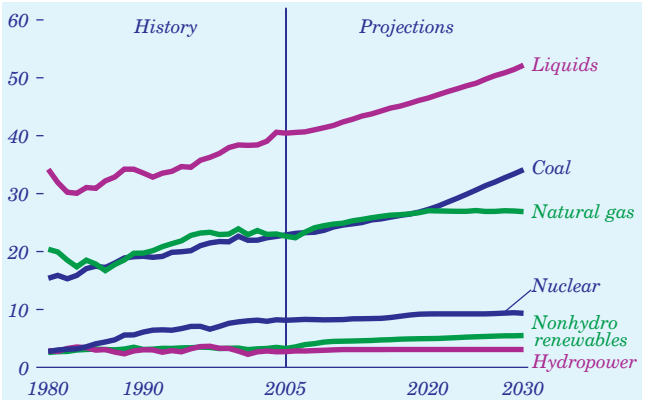
Total industrial energy consumption is boosted in *AEO2007* by strong growth in the production of nontraditional fuels, such as CTL and biofuels. Approximately 0.9 quadrillion Btu of coal is projected to be used to produce liquids in 2030, up from virtually no CTL production in 2005. Biofuels consumption in the industrial sector is projected to grow from 0.2 quadrillion Btu in 2005 to 0.9 quadrillion Btu in 2030. Much of the nontraditional fuel consumption is accounted for in the refining sector. Excluding energy consumption by refiners from the industrial total reveals that delivered energy consumption in 2030 for nonrefining industrial uses is projected to be only about 3 quadrillion Btu above 2005 levels (24.2 quadrillion Btu in 2030 compared with 21.1 quadrillion Btu in 2005).

Delivered energy consumption in the transportation sector is projected to total 39.3 quadrillion Btu in 2030 in the *AEO2007* reference case, 0.4 quadrillion Btu lower than the *AEO2006* projection. The slightly lower level of consumption predominantly reflects the influence of slower economic growth. Travel demand for light-duty vehicles is a significant determinant of total transportation energy demand, and over the past 20 years it has grown by about 3 percent annually. In the *AEO2007* reference case it is projected to grow at an average rate of 1.9 percent per year through 2030, reflecting demographic factors (for example, a leveling off of the increase in the labor force participation rate for women) and higher energy prices. The projected average fuel economy of new light-duty vehicles in 2030 is 29.2 miles per gallon, or 4 miles per gallon higher than the current average. Projected increases in new vehicle fuel economy are due not only to new Federal CAFE standards for light trucks but also to market-driven increases in the sale of unconventional vehicle technologies, such as flex-fuel, hybrid, and diesel vehicles, and a slowdown in the growth of new light truck sales.

Total electricity consumption, including both purchases from electric power producers and on-site generation, is projected to grow from 3,821 billion kilowatthours in 2005 to 5,478 billion kilowatthours in 2030, increasing at an average annual rate of 1.5 percent in the *AEO2007* reference case. In comparison, total electricity consumption of 5,619 billion kilowatthours in 2030 was projected in the *AEO2006* reference case. A larger portion of the projected growth in electricity use for computers, office equipment, and a variety of electrical appliances is offset in the *AEO2007* reference case by improved efficiency in those and other, more traditional electrical applications.

Total consumption of natural gas in the *AEO2007* reference case is projected to increase from 22.0 trillion cubic feet in 2005 to 26.1 trillion cubic feet in 2030 (Figure 3), with virtually no growth over the last decade of the projection. Compared with *AEO2006*, industrial natural gas use is lower (8.6 trillion cubic feet in 2030 in the *AEO2007* reference case, versus 8.8 trillion cubic feet in the *AEO2006* reference case) as a result of better efforts to account for natural gas demand in the metal durables and balance of manufacturing sectors than in previous *AEO*s. In comparison with *AEO2006*, lower projected natural gas consumption in the residential, industrial, and electric power sectors more than offsets higher projected consumption in the commercial sector in the *AEO2007* reference case (4.2 trillion cubic feet in 2030 in *AEO2007* compared with 4.0 trillion cubic feet in *AEO2006*). The increase results from lower delivered natural gas prices projected for the commercial sector in the *AEO2007* reference case.

Figure 3. Energy consumption by fuel, 1980-2030 (quadrillion Btu)



Total coal consumption is projected to increase from 22.9 quadrillion Btu in 2005 to 34.1 quadrillion Btu in 2030 in the *AEO2007* reference case, or from 1,128 million short tons in 2005 to 1,772 million short tons in 2030. As in the *AEO2006* reference case, coal consumption is projected to grow at a faster rate toward the end of the projection period in the *AEO2007* reference case, particularly after 2020, as coal use for new coal-fired generating capacity and for CTL production grows rapidly. In the *AEO2007* reference case, coal consumption in the electric power sector is projected to increase from 25.1 quadrillion Btu in 2020 to 31.1 quadrillion Btu in 2030, and coal use at CTL plants is projected to increase from 0.4 quadrillion Btu in 2020 to 1.8 quadrillion Btu in 2030.

Total consumption of liquid fuels and other petroleum products is projected to grow from 20.7 million barrels per day in 2005 to 26.9 million barrels per day in 2030 in the *AEO2007* reference case (Figure 3), less than the *AEO2006* reference case projection of 27.6 million barrels per day in 2030. In 2030, liquid fuels consumption in the residential sector is slightly higher in the *AEO2007* reference case, due to a lower projection for distillate fuel oil prices; lower in the industrial sector, due to higher liquefied petroleum gas prices and slower growth in industrial production; and lower in the transportation sector, due to slower economic growth.

Total consumption of marketed renewable fuels in the *AEO2007* reference case (including ethanol for gasoline blending, of which 1.2 quadrillion Btu in 2030 is included with liquid fuels consumption) is projected to grow from 6.2 quadrillion Btu in 2005 to 9.9 quadrillion Btu in 2030 (Figure 3). The robust growth is a result of State renewable portfolio standard (RPS) programs, mandates, and goals for renewable electricity generation; technological advances; high petroleum and natural gas prices; and Federal tax credits, including those in EPACT2005.

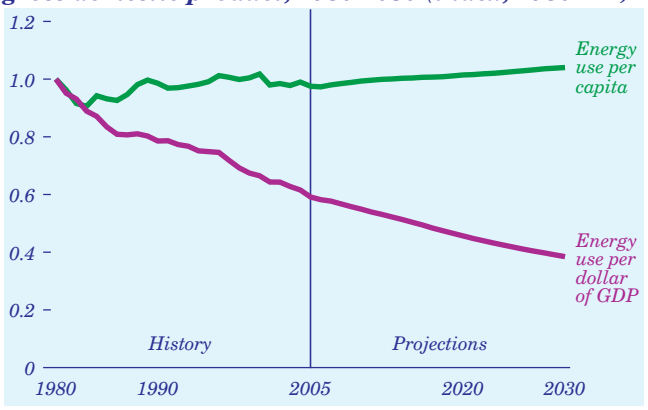
Ethanol consumption grows more rapidly in *AEO2007* than was projected in the *AEO2006* reference case, but total consumption of marketed renewable fuels in 2030 is somewhat lower in the *AEO2007* reference case. The *AEO2007* reference case projects slower growth in geothermal generation of electric power (0.5 quadrillion Btu in the *AEO2007* reference case compared with 1.5 quadrillion Btu in *AEO2006* in 2030), based on a reevaluation of historical progress in installing new geothermal capacity and the availability of resources. In the *AEO2007* reference case, more than 50 percent of the projected demand for renewables is for grid-connected electricity generation, including CHP, and the rest is for dispersed heating and cooling, industrial uses, and fuel blending.

The *AEO2007* reference case projects 21 percent more ethanol consumption in 2030 than was projected in the *AEO2006* reference case—14.6 billion gallons, compared with 12.1 billion gallons. As corn and biofeedstock supplies increase, and with price advantages over other motor gasoline blending components, ethanol consumption grows from 4.0 billion gallons in 2005 to 11.2 billion gallons in 2012 in the *AEO2007* reference case. This far exceeds the required 7.5 billion gallons in the Renewable Fuel Standard (RFS) that was enacted as part of EPACT2005. Ethanol supply in *AEO2007* is dominated by corn-based production, as a result of its cost advantages and eligibility for tax credits. Production of cellulosic ethanol is projected to total only 0.3 billion gallons in 2030, and ethanol imports are projected to total 0.8 billion gallons—a level consistent with the *AEO2006* reference case projection.

Energy Intensity

Energy intensity, measured as energy use per dollar of GDP (in 2000 dollars), is projected to decline at an average annual rate of 1.8 percent from 2005 to 2030 in the *AEO2007* reference case (Figure 4), about the same rate as in the *AEO2006* reference case (1.7 percent). Although energy use generally increases as the economy grows, continuing improvement in the energy efficiency of the U.S. economy and a shift to less energy-intensive activities are projected to keep the rate of energy consumption growth lower than the GDP growth rate.

Figure 4. Energy use per capita and per dollar of gross domestic product, 1980-2030 (index, 1980 = 1)



Since 1992, the energy intensity of the U.S. economy has declined on average by 1.9 percent per year, in part because the share of industrial shipments accounted for by the energy-intensive industries has fallen from 30 percent in 1992 to 26 percent in 2005. In the *AEO2007* reference case, the energy-intensive industries' share of total industrial shipments is projected to continue declining, although at a slower rate, to 24 percent in 2030.

Population is a key determinant of energy consumption, influencing demand for travel, housing, consumer goods, and services. Since 1990, both population and energy consumption in the United States have increased by about 18 percent, with annual variations in energy use per capita resulting from variations in weather and economic factors. The age, income, and geographic distribution of the population also affects energy consumption growth. The aging of the population, a gradual shift from the North to the South, and rising per-capita income will influence future trends. Overall, population in the reference case is projected to increase by 23 percent from 2005 to 2030. Over the same period, energy consumption is projected to increase by 31 percent. The result is a projected increase in energy consumption per capita, at an annual rate of 0.3 percent per year from 2005 to 2030—about the same rate as projected in the *AEO2006* reference case.

Recently, as energy prices have risen, the potential for more energy conservation has received increased attention. Although some additional energy conservation is induced by higher energy prices in the *AEO2007* reference case, no policy-induced conservation measures are assumed beyond those in existing legislation and regulation, nor does the reference case assume behavioral changes beyond those observed in the past.

Electricity Generation

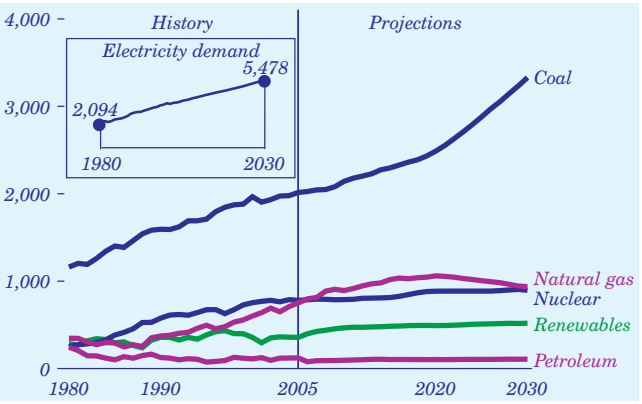
U.S. electricity consumption—including both purchases from electric power producers and on-site generation—is projected to increase steadily in the *AEO2007* reference case, at an average rate of 1.5 percent per year. In comparison, electricity consumption grew by annual rates of 4.2 percent, 2.6 percent, and 2.3 percent in the 1970s, 1980s, and 1990s, respectively. The growth rate in the *AEO2007* projection is lower than was projected in the *AEO2006* reference case, and it leads to lower projections for new plant additions and electricity generation.

In the *AEO2007* reference case, electricity generation from natural-gas-fired power plants is projected to increase from 2005 to 2020, as recently built plants are used more intensively to meet growing demand. Coal-fired generation is projected to increase less rapidly than was projected in the *AEO2006* reference case. After 2020, however, generation from new coal and nuclear plants is expected to displace some natural-gas-fired generation (Figure 5). In the *AEO2007* reference case, 937 billion kilowatthours of electricity is projected to be generated from natural gas in 2030, 6 percent less than the *AEO2006* reference case projection of 993 billion kilowatthours in 2030.

In the *AEO2007* reference case, the natural gas share of electricity generation (including generation in the end-use sectors) is projected to increase from 19 percent in 2005 to 22 percent around 2016, before falling to 16 percent in 2030. The coal share is projected to decline slightly, from 50 percent in 2005 to 49 percent in 2020, before increasing to 57 percent in 2030. Additions to coal-fired generating capacity in the *AEO2007* reference case are projected to total 156 gigawatts from 2005 to 2030 (as compared with 174 gigawatts in the *AEO2006* reference case), including 11 gigawatts at CTL plants and 67 gigawatts at integrated gasification combined-cycle (IGCC) plants. Given the assumed continuation of current energy and environmental policies in the reference case, carbon capture and sequestration (CCS) technology is not projected to come into use during the projection period.

Nuclear generating capacity in the *AEO2007* reference case is projected to increase from 100 gigawatts in 2005 to 112.6 gigawatts in 2030. The increase includes 12.5 gigawatts of capacity at newly built

Figure 5. Electricity generation by fuel, 1980-2030 (billion kilowatthours)



nuclear power plants (more than double the 6 gigawatts of new additions projected in the *AEO2006* reference case) and 3 gigawatts expected from uprates of existing plants, offset by 2.6 gigawatts of retirements.

Rules issued by the Internal Revenue Service (IRS) in 2006 for the EPACT2005 production tax credit (PTC) for new nuclear plants allow the credits to be shared out on a prorated basis to more than the 6 gigawatts of new capacity assumed in the *AEO2006* reference case. In the *AEO2007* reference case it is assumed that the credits will be shared out to 9 gigawatts of new nuclear capacity, and that 3.5 additional gigawatts of capacity will be built without credits. *AEO2007* also reflects the change in the PTC for new nuclear power plants that was included in the Gulf Opportunity Zone Act of 2005 (P.L. 109-135), eliminating the indexing provision in the value of the credit that had been provided in EPACT2005.

Total electricity generation from nuclear power plants is projected to grow from 780 billion kilowatthours in 2005 to 896 billion kilowatthours in 2030 in the *AEO2007* reference case, accounting for about 15 percent of total generation in 2030. Additional nuclear capacity is projected in some of the alternative *AEO2007* cases, particularly those that project higher demand for electricity or even higher fossil fuel prices.

The use of renewable technologies for electricity generation is projected to grow, stimulated by improved technology, higher fossil fuel prices, and extended tax credits in EPACT2005. Like the *AEO2006* reference case, the *AEO2007* reference case also includes the extension and expansion of the Federal PTC for renewable generation through December 31, 2007, as enacted in EPACT2005. Total renewable generation in the *AEO2007* reference case, including CHP and end-use generation, is projected to grow by 1.5 percent per year, from 357 billion kilowatthours in 2005 to 519 billion kilowatthours in 2030. The projection for renewable generation in the *AEO2007* reference case is lower than the comparable *AEO2006* projection, because new, less positive cost and performance characteristics are assumed for several renewable technologies.

In the *AEO2007* reference case, projected emissions of sulfur dioxide (SO_2) from electric power plants in 2030 are 64 percent lower, emissions of nitrogen oxides (NO_x) are 37 percent lower, and emissions of mercury are 70 percent lower than their 2005 levels. The reductions are about the same as those projected in the *AEO2006* reference case.

Energy Production and Imports

Net imports of energy on a Btu basis are projected to meet a growing share of total U.S. energy demand (Figure 6). In the *AEO2007* reference case, net imports are expected to constitute 32 percent of total U.S. energy consumption in 2030 (about the same as in the *AEO2006* reference case), up from 30 percent in 2005. Rising fuel prices over the projection period are expected to spur increases in domestic energy production (Figure 7) and to moderate the growth in demand, thus tempering the projected growth in imports.

The projections for U.S. crude oil production in the *AEO2007* reference case are significantly different from those in the *AEO2006* reference case. U.S. crude oil production in the *AEO2007* reference case is projected to increase from 5.2 million barrels per day in 2005 to a peak of 5.9 million barrels per day in 2017 as a result of increased production offshore, predominantly from the deep waters of the Gulf of

Figure 6. Total energy production and consumption, 1980-2030 (quadrillion Btu)

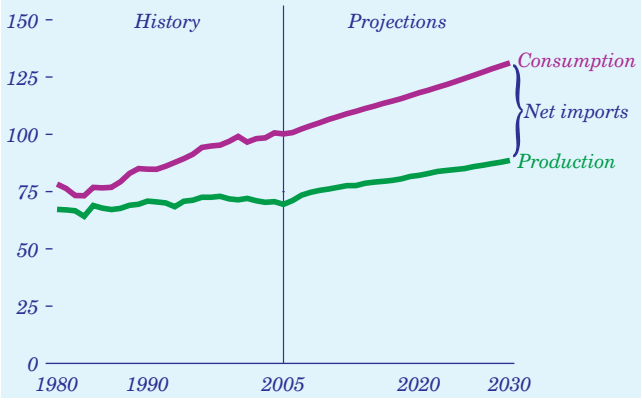
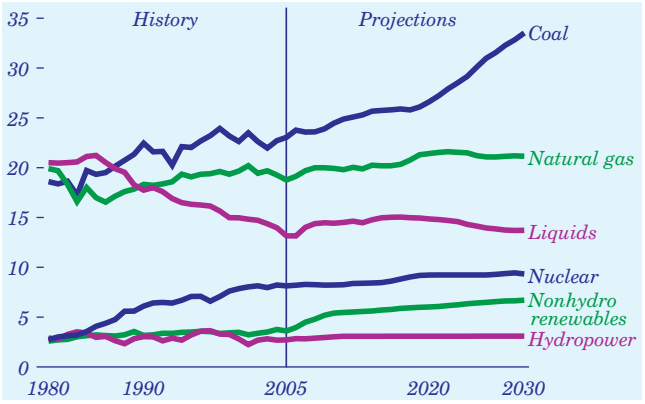


Figure 7. Energy production by fuel, 1980-2030 (quadrillion Btu)



Mexico. Production is subsequently projected to fall to 5.4 million barrels per day in 2030. The *AEO2006* reference case projected a much steeper decline in production from 2017 to 2030, with crude oil production falling from a slightly lower level of 5.8 million barrels per day in 2017 to 4.6 million barrels per day in 2030. The difference is attributable primarily to a slower decline in lower 48 onshore oil production in the *AEO2007* reference case, mostly as a result of increased production from enhanced oil recovery technology and, to a lesser extent, significantly higher resource assumptions for the Bakken Shale formation in the Williston Basin.

Total domestic liquids production, including crude oil, natural gas plant liquids, refinery processing gains, and other refinery inputs, is projected to increase steadily throughout the projection in the *AEO2007* reference case, as growth in refinery processing gains and other refinery inputs offsets the projected decline in crude oil production after 2017. Total supply is projected to grow from 8.3 million barrels per day in 2005 to 10.5 million barrels per day in 2030. In the *AEO2006* reference case, total domestic liquids supply in 2030 was slightly lower, at 10.4 million barrels per day. The higher crude oil production in the *AEO2007* reference case, when compared with the *AEO2006* reference case, is partially offset by lower production of natural gas liquids and lower refinery processing gains.

In the *AEO2007* reference case, the net liquids import share of total supply, including both crude oil and refined products, drops from 60 percent of total liquids supply in 2005 to 54 percent in 2009, before increasing to 61 percent in 2030. In the *AEO2006* reference case, net liquids imports accounted for 62 percent of product supplied in 2030. Net crude oil imports in 2030 are 0.4 million barrels per day lower, and net product imports are 0.5 million barrels per day lower, in the *AEO2007* reference case than projected in the *AEO2006* reference case.

The primary reason for the difference between the *AEO2006* and *AEO2007* projections for net imports of liquid fuels is a lower level of total liquids consumption, by 0.6 million barrels per day in 2030 in the *AEO2007* reference case, and a greater increase in refinery distillation capacity, which increases from 17.1 million barrels per day in 2005 to 20.0 million barrels per day in 2030 in the *AEO2007* reference case, as compared with 19.3 million barrels per day in 2030 in the *AEO2006* reference case. In addition, the *AEO2007* reference case includes greater investment in heavy oil processing as a result of changes in expected crude slates and pricing differentials. Imports of refined petroleum products account for 20 percent of total net imports in 2030 (about the same as in 2005) in the *AEO2007* reference case, as compared with 22 percent in the *AEO2006* reference case.

Total domestic natural gas production, including supplemental natural gas supplies, increases from 18.3 trillion cubic feet in 2005 to 21.1 trillion cubic feet in 2022, before declining to 20.6 trillion cubic feet in 2030 in the *AEO2007* reference case. In comparison, domestic natural gas production was projected to peak at 21.6 trillion cubic feet in 2019 in the *AEO2006* reference case. Through 2012, natural gas production in the *AEO2007* reference case is generally higher than in the *AEO2006* reference case. After 2012, production in the *AEO2007* reference case is consistently below that in the *AEO2006* reference case. Lower natural gas consumption in the last 18 years of the projection results in lower domestic natural gas production—primarily, offshore and onshore nonassociated conventional production—in the *AEO2007* reference case.

In the *AEO2007* reference case, lower 48 offshore production of natural gas grows from 3.4 trillion cubic feet in 2005 to a peak of 4.6 trillion cubic feet in 2015 as new resources come online in the Gulf of Mexico. After 2015, lower 48 offshore production declines to 3.3 trillion cubic feet in 2030, as investment is inadequate to maintain production levels. In the *AEO2006* reference case, offshore natural gas production was projected to peak at 5.1 trillion cubic feet in 2015 before falling to 4.0 trillion cubic feet in 2030. Onshore nonassociated conventional production of natural gas in the *AEO2007* reference case is higher than was projected in the *AEO2006* reference case through 2012, after which it falls below the projection in the *AEO2006* reference case.

Lower 48 production of unconventional natural gas is expected to be a major contributor to growth in U.S. natural gas supplies. In the *AEO2007* reference case, unconventional natural gas production is projected to account for 50 percent of domestic U.S. natural gas production in 2030 (compared with a 45-percent share in the *AEO2006* reference case). Throughout the projection period, the level of unconventional natural gas production in the *AEO2007* reference case is

higher, reaching 10.2 trillion cubic feet in 2030, than in the *AEO2006* reference case (9.5 trillion cubic feet in 2030), due to the addition of the Fayetteville and Woodford shale resources and generally higher natural gas prices.

Construction planning for the Alaska natural gas pipeline is expected to start 3 years later than projected in the *AEO2006* reference case due to startup delays and a longer than anticipated construction time period, with pipeline completion in 2018. After the pipeline goes into operation, Alaska's total natural gas production is projected to increase from 0.5 trillion cubic feet in 2005 to 2.2 trillion cubic feet in 2021 in the *AEO2007* reference case. Although the timing differs, this is the same level that was projected in the *AEO2006* reference case.

With the exception of the last few years of the projection, net pipeline imports of natural gas from Canada and Mexico, predominantly from Canada, in the *AEO2007* reference case are higher than in the *AEO2006* reference case. Net pipeline imports vary between 2.6 and 3 trillion cubic feet from 2005 to 2013 in the *AEO2007* reference case, then decline to 0.9 trillion cubic feet in 2030—0.3 trillion cubic feet lower than projected in the *AEO2006* reference case. The decline reflects resource depletion in Alberta, growing domestic demand in Canada, and a downward reassessment of the potential for unconventional natural gas production from coal seams and tight formations in Canada.

The *AEO2007* reference case projects that LNG imports will meet much of the increased U.S. demand for natural gas, as was the case in the *AEO2006* reference case. In addition to new terminals, including four that are currently under construction, expansions of three of the four existing onshore U.S. LNG terminals (Cove Point, Maryland; Elba Island, Georgia; and Lake Charles, Louisiana) are included in the *AEO2007* reference case. Because of liquefaction project delays, supply constraints at a number of liquefaction facilities, and rapid growth in global LNG demand, the U.S. LNG market is expected to be tight until 2012. Total net imports of LNG to the United States in the *AEO2007* reference case are projected to increase from 0.6 trillion cubic feet in 2005 to 4.5 trillion cubic feet in 2030 (0.2 trillion cubic feet higher than in the *AEO2006* reference case).

As domestic coal demand grows in the *AEO2007* reference case, U.S. coal production increases at an average rate of 1.6 percent per year, from 1,131 million short tons in 2005 to 1,691 million short tons in 2030, slightly less than in the *AEO2006* reference case. Production from mines west of the Mississippi River is expected to provide the largest share of the incremental coal production. In 2030, almost 68 percent of domestic coal production is projected to originate from States west of the Mississippi.

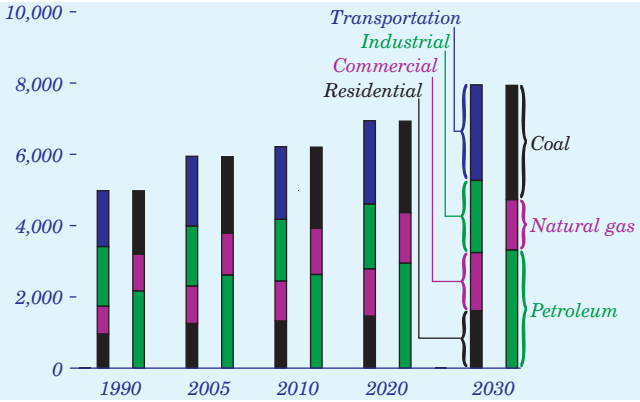
Typically, trends in U.S. coal production are linked to its use for electricity generation, which currently accounts for more than 90 percent of total coal consumption. Projected coal consumption in the electric power sector in the *AEO2007* reference case is slightly higher than projected in the *AEO2006* reference case (1,570 million short tons versus 1,502 million short tons in 2030), because coal captures a larger share of total electricity generation in the *AEO2007* reference case. Another fast-growing market for coal is CTL. Coal use in CTL plants is projected to grow from 26 million short tons in 2020 to 112 million short tons in 2030. By 2025, coal use for CTL production becomes the second largest use of coal in the *AEO2007* reference case, after electric power generation.

Energy-Related Carbon Dioxide Emissions

Absent the application of CCS technology, which is not expected to come into use without changes in current policies that are not included in the reference case, carbon dioxide (CO_2) emissions from the combustion of fossil fuels are proportional to fuel consumption and carbon content, with coal having the highest carbon content, natural gas the lowest, and petroleum in between. In the *AEO2007* reference case, the coal share of total energy use increases from 23 percent in 2005 to 26 percent in 2030, while the share of natural gas falls from 23 percent to 20 percent, and the liquids share remains at about 40 percent. The combined share of carbon-neutral renewable and nuclear energy is stable from 2005 to 2030 at about 14 percent.

Taken together, projected growth in the absolute level of primary energy consumption and a shift toward a fuel mix with slightly higher average carbon content cause projected energy-related emissions of

Figure 8. U.S. carbon dioxide emissions by sector and fuel, 1990-2030 (million metric tons)



CO_2 to grow by an average of 1.2 percent per year from 2005 to 2030 (Figure 8)—slightly higher than the average annual increase in total energy use. At the same time, the economy becomes less carbon intensive: the percentage increase in CO_2 emissions is about one-third of the projected increase in GDP, and emissions per capita increase by only 9 percent over the 25-year projection period. Projections of energy-related CO_2 emissions in the *AEO2007* reference case are slightly lower than those in the *AEO2006* reference case, consistent with the comparable difference in projections for overall energy use.

Table 1. Total energy supply and disposition in the *AEO2007* and *AEO2006* reference cases, 2005-2030

Energy and economic factors	2005	2010		2020		2030	
		AEO2007	*AEO2006*	*AEO2007*	*AEO2006*	*AEO2007*	*AEO2006*
Primary energy production (quadrillion Btu)							
Petroleum	13.30	14.42	14.83	14.85	14.41	13.71	12.25
Dry natural gas	18.77	19.93	19.13	21.41	22.09	21.15	21.45
Coal	23.20	24.47	25.78	26.61	27.30	33.52	34.10
Nuclear power	8.13	8.23	8.44	9.23	9.09	9.33	9.09
Hydropower	2.71	3.02	3.03	3.08	3.04	3.09	3.04
Biomass	2.71	4.22	3.90	4.69	4.66	5.26	5.07
Other renewable energy	0.76	1.18	1.27	1.33	1.92	1.44	2.61
Other	0.22	0.67	0.97	0.89	1.22	1.12	1.39
Total	**69.80**	**76.13**	**77.36**	**82.09**	**83.73**	**88.63**	**89.00**
Net imports (quadrillion Btu)							
Petroleum	26.94	25.19	26.25	28.92	30.46	34.74	36.56
Natural gas	3.67	4.67	4.45	5.48	5.15	5.59	5.72
Coal/other (- indicates export)	-0.42	-0.19	-0.58	0.93	0.90	1.57	2.02
Total	**30.19**	**29.66**	**30.12**	**35.33**	**36.50**	**41.90**	**44.30**
Consumption (quadrillion Btu)							
Liquid fuels	40.61	41.76	43.14	46.52	48.15	52.17	53.59
Natural gas	22.63	24.73	24.04	27.04	27.70	26.89	27.65
Coal	22.87	24.24	25.09	27.29	27.65	34.14	34.49
Nuclear power	8.13	8.23	8.44	9.23	9.09	9.33	9.09
Hydropower	2.71	3.02	3.03	3.08	3.04	3.09	3.04
Biomass	2.38	3.30	3.25	3.64	3.73	4.06	4.09
Other renewable energy	0.76	1.18	1.27	1.33	1.92	1.44	2.61
Net electricity imports	0.08	0.04	0.07	0.04	0.05	0.04	0.05
Total	**100.19**	**106.50**	**108.34**	**118.16**	**121.32**	**131.16**	**134.60**
Liquid fuels (million barrels per day)							
Domestic crude oil production	5.18	5.67	5.88	5.89	5.55	5.39	4.57
Other domestic production	3.04	4.03	3.98	4.49	4.87	5.08	5.82
Net imports	12.57	11.79	12.36	13.56	14.47	16.37	17.29
Consumption	20.75	21.59	22.18	24.03	24.82	26.95	27.57
Natural gas (trillion cubic feet)							
Production	18.30	19.42	18.65	20.86	21.52	20.61	20.90
Net imports	3.57	4.55	4.35	5.35	5.02	5.45	5.57
Consumption	21.98	24.02	23.35	26.26	26.92	26.12	26.86
Coal (million short tons)							
Production	1,131	1,189	1,261	1,323	1,355	1,691	1,703
Net imports	-21	-7	-26	41	36	68	83
Consumption	1,128	1,195	1,233	1,377	1,390	1,772	1,784
Prices (2005 dollars)							
Imported low-sulfur, light crude oil (dollars per barrel)	56.76	57.47	48.50	52.04	52.00	59.12	58.42
Imported crude oil (dollars per barrel)	49.19	51.20	45.12	46.47	46.14	51.63	51.27
Domestic natural gas at wellhead (dollars per thousand cubic feet)	7.51	5.76	5.15	5.22	5.02	5.98	6.07
Domestic coal at minemouth (dollars per short ton)	23.34	24.20	22.80	21.58	20.72	22.60	22.29
Average electricity price (cents per kilowatthour)	8.1	8.1	7.5	7.9	7.4	8.1	7.7
Economic indicators							
Real gross domestic product (billion 2000 dollars)	11,049	12,790	13,043	17,077	17,541	22,494	23,112
GDP chain-type price index (index, 2000=1.000)	1.127	1.253	1.235	1.495	1.597	1.815	2.048
Real disposable personal income (billion 2000 dollars)	8,105	9,568	9,622	13,000	13,057	17,535	17,562
Value of manufacturing shipments (billion 2000 dollars)	5,763	6,298	6,355	7,779	7,778	9,502	9,578
Primary energy intensity (thousand Btu per 2000 dollar of GDP)	**9.07**	**8.33**	**8.31**	**6.92**	**6.92**	**5.83**	**5.82**
Carbon dioxide emissions (million metric tons)	**5,945**	**6,214**	**6,365**	**6,944**	**7,119**	**7,950**	**8,114**

Notes: Quantities are derived from historical volumes and assumed thermal conversion factors. Other production includes liquid hydrogen, methanol, and some inputs to refineries. Net imports of petroleum include crude oil, petroleum products, unfinished oils, alcohols, ethers, and blending components. Other net imports include coal coke and electricity.

Sources: AEO2007 National Energy Modeling System, run AEO2007.D112106A; and AEO2006 National Energy Modeling System, run AEO2006.D111905A.

Legislation and Regulations