Overview

Energy Trends to 2030

In preparing projections for *AEO2008*, EIA 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 *AEO2007* reference case (see Table 1). Readers are encouraged to review the full range of alternative cases included in other sections of *AEO2008*.

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. The reference case provides a clear basis against which alternative cases and policies can be compared. Although current laws and regulations may change over the next 25 years, and new ones may be created, it is not possible to predict what they will be or how they will be implemented [*1*].

EIA published an "early release" version of the *AEO2008* reference case in December 2007. Later that month, EISA2007 was enacted. The provisions in EISA2007 will have a major impact on energy markets, particularly liquid fuels. Given the year-long life of *AEO2008* and its use as a baseline for analyses of proposed policy changes, EIA decided to update the reference case to reflect the provisions of EISA2007. A short summary of the impact of including EISA-2007 is provided in the box on pages 3 and 4.

Trends in energy supply and demand are affected by many factors that are difficult to predict, including energy prices, U.S. and worldwide economic growth, advances in technologies, and future public policy decisions both in the United States and in other countries. As noted in *AEO2007*, energy markets are changing in response to readily observable factors, which include, among others: higher energy prices; the growing influence of developing countries on worldwide energy requirements; recently enacted legislation and regulations in the United States; changing public perceptions on issues related to emissions of air pollutants and greenhouse gases (GHGs) and the use of alternative fuels and; and the economic viability of various energy technologies.

Projections in the *AEO2008* reference case have been updated to better reflect trends that are expected to persist in the economy and in energy markets. For example, the projection for U.S. economic growth, a key determinant of U.S. energy demand, is lower in *AEO2008* than it was in *AEO2007*, reflecting an updated assumption for productivity improvement. Other key changes in the *AEO2008* projections include:

- Higher price projections for crude oil and natural gas
- Higher projections for delivered energy prices, reflecting both higher wellhead and minemouth prices and higher costs to transport, distribute, and refine fuels per unit supplied
- Slower projected growth in energy demand (particularly for natural gas but also for liquid fuels and coal)
- Faster projected growth in the use of nonhydroelectric renewable energy, resulting from a revised representation of State renewable portfolio standard (RPS) provisions
- Higher projections for domestic oil production, particularly in the near term
- Slower projected growth in energy imports, both natural gas and oil
- Slower projected growth in energy-related emissions of carbon dioxide (CO_2).

Coal, liquid fuels (excluding the biofuels portion of total liquids supply), and natural gas meet 80 percent of total U.S. primary energy supply requirements in 2030—down from an 85-percent share in 2006, reflecting the incorporation of EISA2007 provisions, slower economic growth, higher energy prices, lower total energy demand, and increased use of renewable energy when compared with *AEO2007*.

Economic Growth

The *AEO2008* reference case reflects reduced expectations for economic growth: U.S. gross domestic product (GDP) grows at an average annual rate of 2.4 percent from 2006 to 2030—0.4 percentage points slower than the rate in the *AEO2007* reference case over the same period. The main factor contributing to the slower rate of growth in GDP is a lower estimate of growth in labor productivity. Nonfarm business labor productivity grows by 1.9 percent per year in the *AEO2008* reference case, compared with 2.3 percent per year in *AEO2007*. Nonfarm employment growth is 0.9 percent per year in the *AEO2008* reference case, about the same as in *AEO2007*. From 2006 to 2030, total industrial shipments grow by

Impacts of Updating the AEO2008 Reference Case

EIA's decision to update the *AEO2008* early-release reference case was motivated by the enactment in December 2007 of EISA2007, which contains many provisions that will significantly influence future energy trends. The specific EISA2007 provisions modeled in *AEO2008* include updates to the renewable fuel standard (RFS) and the corporate average fuel economy (CAFE) standard for new light-duty vehicles (LDVs); updated and new appliance energy efficiency standards for boilers, dehumidifiers, dishwashers, clothes washers, and commercial walk-in refrigerators and freezers; lighting energy efficiency standards; provisions to reduce energy consumption in Federal buildings; and efficiency standards for industrial electric motors.

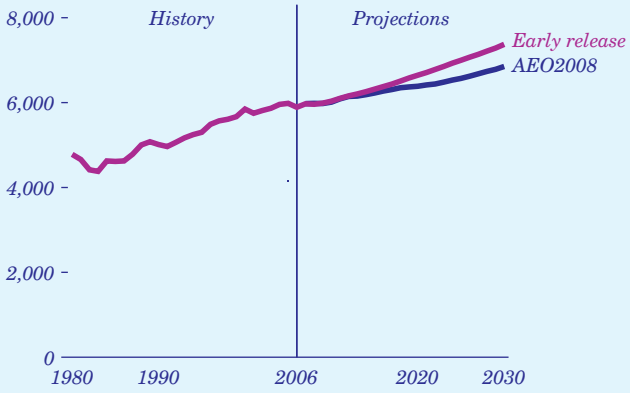
Consistent with the general approach used in past *AEO*s, the reference case does not consider those sections of EISA2007 that require appropriations for implementation or sections with highly uncertain impacts on energy markets. It also includes additional revisions that reflect historical data issued after the *AEO2008* early-release reference case was completed, new data from EIA's January 2008 *Short-Term Energy Outlook* (*STEO*), a more current economic outlook, and technical updates to the earlier version of NEMS.

Total energy consumption and greenhouse gas emissions

EISA2007 has a significant impact on both projected total energy consumption and GHG emissions. Total primary energy consumption in the *AEO2008* reference case grows by 18.5 quadrillion British thermal units (Btu), from 99.5 quadrillion Btu in 2006 to 118.0 quadrillion Btu in 2030—5.3 quadrillion Btu less than in the early-release reference case. Although other changes were also made, the inclusion of EISA2007 is by far the most important. In 2030, the projected consumption levels for liquid fuels, natural gas, and coal all are lower in the *AEO2008* reference case than they were in the early-release case.

Without the application of carbon capture and sequestration (CCS) technology, CO_2 emissions from the combustion of fossil fuels are proportional to the consumption and carbon content of the fuels. Inclusion of EISA2007 provisions in the *AEO2008* reference case both reduces total energy consumption and shifts consumption to fuels that are less carbon-intensive or are carbon-neutral. As a result, the projection for total energy-related CO_2 emissions in 2030 is 6,851 million metric tons in the *AEO2008* reference case, as compared with 7,373 million metric tons in the early-release reference case—a difference of 7 percent or 522 million metric tons (see figure below). The difference between the two cases grows over time, so that cumulative energy-related CO_2 emissions over the period from 2008 to 2030 are 5.3 billion metric tons lower in the *AEO2008* reference case than in the early-release reference case.

Total annual carbon dioxide emissions in the early-release and AEO2008 reference cases, 1980-2030 (million metric tons)



Liquid fuels consumption and imports

The combination of a higher CAFE standard for new LDVs and an updated RFS has a substantial impact on the level and mix of liquids consumption. Total liquids consumption[a] in 2030 in the *AEO2008* reference case, including the impact of EISA2007, is 22.8 million barrels per day—2.1 million barrels per day lower than in the early-release reference case.

Conventional petroleum consumption in 2030, excluding biofuels but including coal-to-liquids (CTL) diesel (a nonrenewable fuel), is 2.9 million barrels per day less in the *AEO2008* reference case. On an energy basis, total liquids consumption is 44.0 quadrillion Btu in 2030 in the *AEO2008* reference case, about 9 percent lower than projected in the early-release case.

(continued on page 4)

[a]Liquid fuels include conventional petroleum products, ethanol, biodiesel, diesel from biomass, CTL, and gas-to-liquids.

1.3 percent per year in the *AEO2008* reference case, as compared with 2.0 percent per year in *AEO2007*.

Energy Prices

EIA raised the reference case path for world oil prices in *AEO2008* (although the upward adjustment is smaller than the last major adjustment, introduced in *AEO2006*). The real world crude oil price (which for the purposes of *AEO2008* is defined as the price of light, low-sulfur crude oil delivered in Cushing, Oklahoma, in 2006 dollars) declines gradually from current levels to $57 per barrel in 2016 ($68 per barrel in nominal dollars), as expanded investment in exploration and development brings new supplies to world markets. After 2016, real prices begin to rise (Figure 1), as demand continues to grow and higher cost supplies are brought to market. In 2030, the average real price of crude oil is $70 per barrel in 2006 dollars, or about $113 per barrel in nominal dollars. Alternative *AEO2008* cases address higher and lower world crude oil prices.

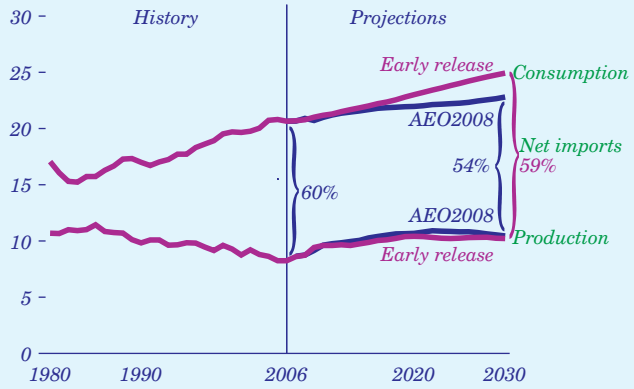
In developing its oil price outlook, EIA explicitly considered four factors: (1) growth in world liquids consumption; (2) the outlook for conventional oil production in countries outside the Organization of the Petroleum Exporting Countries (OPEC); (3) growth

Impacts of Updating the AEO2008 Reference Case (continued)

In the *AEO2008* reference case, because a large share of the biofuels consumed is produced domestically, net imports of liquid fuels (including both crude oil and products) are reduced by more relative to the early-release case than is total liquids consumption. Total net imports of liquids in 2030 are 2.4 million barrels per day lower in the *AEO2008* reference case than in the early-release case. As shown in the figure below, U.S. dependence on net imports of liquid fuels (including crude oil and refined liquids) on a volumetric basis declines in the *AEO2008* reference case from 60 percent in 2006 to 51 percent in 2022, followed by an increase to 54 percent in 2030—as compared with 59 percent in the early-release reference case. Even with the increase in biofuel use and the higher vehicle efficiency standards, however, petroleum products still account for 88 percent of total transportation energy consumption in the *AEO2008* reference case, compared with 96 percent in 2006.

The fuel mix for vehicles also changes between the two cases. The figure below shows the mix of fuels for LDVs in 2030 on an energy basis in the two cases. Biofuel consumption, excluding CTL, reaches 2.0 quadrillion Btu (23.5 billion gallons) in 2030, or about 11 percent of total demand for motor vehicle fuel in the *AEO2008* reference case—an increase of 0.6 quadrillion Btu (7.1 billion gallons) from the early-release reference case and 1.6 quadrillion Btu (18.2 billion gallons) more than in 2006. The increase in the *AEO2008* reference case includes more ethanol consumption—both ethanol blended with gasoline in E10 (gasoline containing up to 10 percent ethanol by volume) and as E85 (fuel containing a blend of 70 to 85 percent ethanol and 30 to 15 percent gasoline by volume)—and more biodiesel consumption than in the early-release projection.

U.S. liquids supply, consumption, and net imports in the early-release and AEO2008 reference cases, 1980-2030 (million barrels per day)



Light-duty vehicle energy use by fuel in the early-release and AEO2008 reference cases, 2030 (quadrillion Btu)

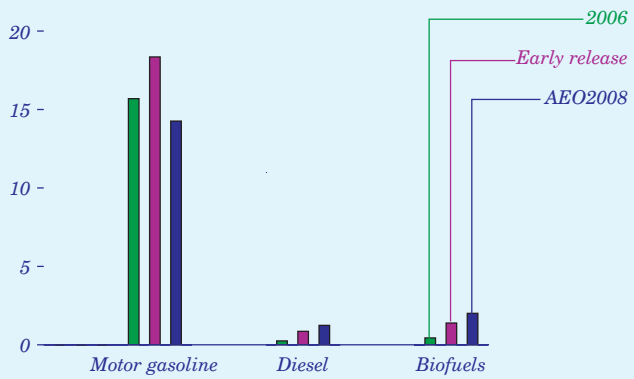
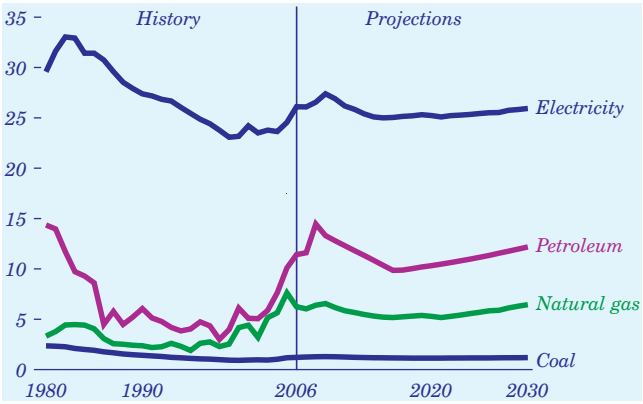


Figure 1. Energy prices, 1980-2030 (2006 dollars per million Btu)



in unconventional liquids production; and (4) OPEC behavior. With the forces driving demand outside the United States as strong as, or stronger than, previously expected but with global supply projections somewhat weaker, oil prices in *AEO2008* are higher than projected in *AEO2007* [*2*].

As a result of recent strong economic growth worldwide, transitory shortages of experienced personnel, equipment, and construction materials in the oil industry, and political instability in some major producing regions, oil prices currently are above EIA's estimate of the long-run equilibrium price. EIA's expectations regarding the ultimate size of both conventional and unconventional liquid resources have not changed since last year's *AEO*.

The *AEO2008* reference case represents EIA's current judgment about the most likely behavior of key OPEC members in the mid-term. In the projection, OPEC countries increase production at a rate that keeps their market share of world liquids production at approximately 40 percent through 2030.

The *AEO2008* reference case also projects significant long-term potential for supply from non-OPEC producers. In several resource-rich regions—including Brazil, Azerbaijan, and Kazakhstan—high oil prices, expanded infrastructure, and new exploration and drilling technologies permit additional non-OPEC oil production. Also, with the economic viability of Canada's oil sands enhanced by higher world oil prices and advances in production technology, oil sands production is expected to reach 4 million barrels per day in 2030.

The price of natural gas also is higher in the *AEO2008* reference case. The real wellhead price of natural gas (in 2006 dollars) declines from current levels through 2016, as new supplies enter the market. After some fluctuations through 2021, real natural gas prices rise to $6.63 per thousand cubic feet in 2030 ($10.64 per thousand cubic feet in nominal dollars). The higher prices in the *AEO2008* reference case reflect an increase in production costs associated with recent trends that were discussed in *AEO2007* but were not reflected fully in the *AEO2007* reference case [*3*]. The higher natural gas prices also are supported by higher oil prices.

Minemouth coal prices in the *AEO2008* reference case, both nationally and regionally, are generally similar to those projected in the *AEO2007* reference case. By region, the largest price difference is for Wyoming's Powder River Basin, where the projected average minemouth price in 2030 is 12.1 percent above the *AEO2007* projection, at $0.66 (2006 dollars) per million Btu, reflecting a less optimistic outlook for improvements in coal mining productivity.

Average real minemouth coal prices (in 2006 dollars) fall from $1.21 per million Btu ($24.63 per short ton) in 2006 to $1.14 per million Btu ($22.45 per short ton) in 2018 in the *AEO2008* reference case, as prices moderate following a substantial run-up over the past few years. After 2020, coal prices rise as demand increases, reaching $1.19 per million Btu ($23.32 per short ton) in 2030. The 2020 and 2030 price projections are 2.6 percent and 0.9 percent higher, respectively, than those in the *AEO2007* reference case. Without adjustment for inflation, the average minemouth price of coal in the *AEO2008* reference case is $1.91 per million Btu ($37.42 per ton) in 2030.

AEO2008 projects higher prices for most energy fuels delivered to consumers. For example, in 2030, the average delivered price of natural gas (in 2006 dollars) is more than $1 per million Btu higher in the *AEO2008* reference case than was projected in *AEO2007*. In part, the higher delivered prices result from higher prices paid to fossil fuel producers at the wellhead or minemouth; but they also result from updates made to assumptions about the costs to transport, distribute, and refine the fuels to make them more consistent with recent trends. For example, as a result of declining use per customer and the growing cost of bringing supplies from new regions to market, margins between the delivered and wellhead prices of natural gas are higher than previously projected. Factors contributing to higher margins for liquid fuels include continued growth in the use of heavier and sourer crudes, growing demand for cleaner products,

and the rising cost of refinery safety and emissions abatement.

Increases in diesel fuel prices in recent years have led railroads to implement fuel adjustment surcharges on coal shipments, which are incorporated in the *AEO2008* reference case. The average real delivered price of coal to power plants (in 2006 dollars) increases from $1.69 per million Btu ($33.85 per short ton) in 2006 to $1.78 per million Btu ($35.03 per short ton) in 2030, 2.3 percent higher than in the *AEO2007* reference case. In nominal dollars, the average delivered price of coal to power plants is projected to reach $2.86 per million Btu ($56.22 per short ton) in 2030.

Electricity prices follow trends in the delivered prices of fuels to power plants in the reference case. From a peak of 9.3 cents per kilowatthour (2006 dollars) in 2009, average delivered electricity prices decline to 8.5 cents per kilowatthour in 2015 and then increase to 8.8 cents per kilowatthour in 2030. In the *AEO2007* reference case, with slightly lower expectations for delivered fuel prices and construction costs for all new technologies, electricity prices reached 8.3 cents per kilowatthour (2006 dollars) in 2030. In nominal dollars, the average delivered electricity price in the *AEO2008* reference case reaches 14.1 cents per kilowatthour in 2030.

Energy Consumption by Sector

Total primary energy consumption in the *AEO2008* reference case grows by 19 percent between 2006 and 2030 (an average rate of 0.7 percent per year), from 99.5 quadrillion Btu in 2006 to 118.0 quadrillion Btu in 2030—13.2 quadrillion Btu less than in the *AEO2007* reference case. In 2030, the levels of consumption projected for liquid fuels, natural gas, and coal are lower in the *AEO2008* reference case than they were in the *AEO2007* reference case. Among the most important factors leading to lower total energy demand in the *AEO2008* reference case are lower economic growth, greater use of more efficient appliances and vehicles, higher energy prices, and slower growth in energy-intensive industries.

Residential delivered energy consumption in the *AEO2008* reference case grows from 10.8 quadrillion Btu in 2006 to 12.9 quadrillion Btu in 2030, or by 0.7 percent per year (Figure 2). Higher delivered energy prices, slower growth in the housing stock, increases in lighting efficiency to meet the standards established in EISA2007, and a revised accounting of heating and cooling degree-days to better reflect recent temperature trends contribute to the lower level of residential energy use in the *AEO2008* projection, which is 0.9 quadrillion Btu lower than the *AEO2007* projection.

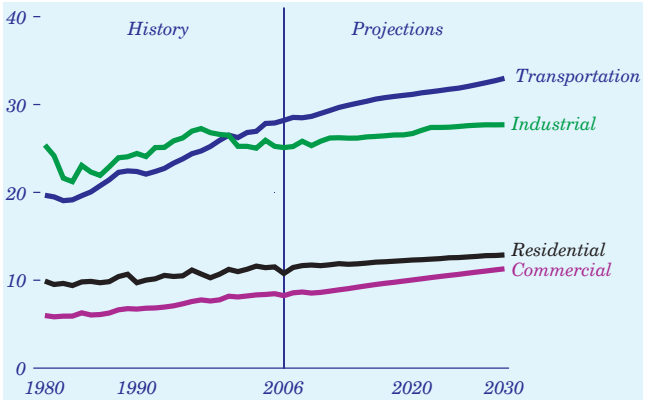
Higher delivered energy prices and slower growth in commercial square footage lead to slower growth in commercial energy consumption in the *AEO2008* reference case than in the *AEO2007* reference case. Delivered commercial energy consumption grows from 8.3 quadrillion Btu in 2006 to 11.3 quadrillion Btu in 2030, over 1 quadrillion Btu less than in the *AEO2007* reference case.

Since 1997, delivered energy consumption in the U.S. industrial sector has trended downward, falling from about 27 quadrillion Btu in 1997 to 25 quadrillion Btu in 2006, despite rising output. A number of factors have worked to reduce industrial energy consumption since 1997: economic weakness between 2000 and 2003, the hurricanes of 2005 that reduced activity in some industrial subsectors, and rising energy prices.

Industrial delivered energy consumption increases to 27.7 quadrillion Btu in 2030. Although the *AEO2008* reference case includes steady economic growth and declining energy prices in the near term, growth in the energy-intensive industries continues to be weak, reflecting increased competition from foreign regions with lower relative energy prices. Growth in the energy-intensive U.S. manufacturing industries averages 0.7 percent per year from 2006 to 2030, slower than the 1.3-percent average growth in *AEO2007*.

Delivered energy consumption in the transportation sector grows to 33.0 quadrillion Btu in 2030 in the *AEO2008* reference case, 6.3 quadrillion Btu less than in *AEO2007*. The lower projected level of consumption predominantly reflects the influence of the new

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



CAFE standard for LDVs specified in EISA2007 and slower economic growth, as well as the impact of higher fuel prices.

EISA2007 requires new LDVs, including both cars and trucks, to reach a combined average fuel economy of 35 miles per gallon (mpg) by 2020, based on the U.S. Environmental Protection Agency (EPA) test value used to measure compliance with the CAFE standard. The EPA CAFE test value generally differs from the estimated mpg value on the fuel economy label and, typically, exceeds the actual on-the-road fuel economy of a new vehicle by a significant margin. Despite these differences, the higher fuel economy standards in EISA2007 significantly improve the in-use fuel economy of the LDV stock. In the reference case, the average in-use fuel economy for the stock of LDVs in 2030 increases to 27.9 mpg, almost 40 percent above its 2006 level. To attain these fuel economy levels, the projection reflects increases in the sale of unconventional vehicle technologies [*4*], such as flex-fuel, hybrid, and diesel vehicles, and a slowdown in the growth of new light truck sales.

Energy Consumption by Primary Fuel

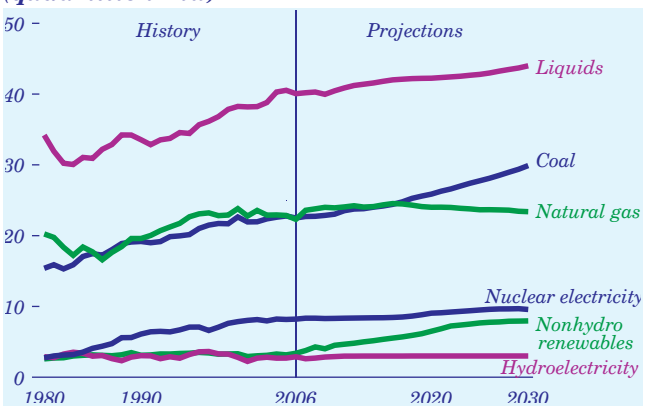
Total consumption of liquid fuels, including both fossil liquids and biofuels, grows from 20.7 million barrels per day in 2006 to 22.8 million barrels per day in 2030 in the *AEO2008* reference case (Figure 3), less than the *AEO2007* reference case projection of 26.9 million barrels per day in 2030. Liquid fuels consumption is lower in all sectors in *AEO2008* than in the *AEO2007* reference case, as a result of incorporation of the new LDV CAFE standard specified in EISA-2007, slower economic growth, and higher delivered prices for liquid fuels. Much of the difference is in the transportation sector.

In *AEO2008*, natural gas consumption increases from 21.7 trillion cubic feet in 2006 to 23.8 trillion cubic feet in 2016, then declines to 22.7 trillion cubic in 2030 (Figure 3). The projection for natural gas consumption in the *AEO2008* reference case is sharply lower than in *AEO2007*, where consumption grew to 26.1 trillion cubic feet in 2030. Consumption is lower in all sectors in *AEO2008*, and particularly in the industrial and electricity power sectors. Industrial natural gas use is 1.7 trillion cubic feet lower in 2030 in the *AEO2008* reference case (8.1 trillion cubic feet, compared with 9.8 trillion cubic feet in *AEO2007*), as a result of higher delivered prices for natural gas, lower economic growth, and a reassessment of natural gas use in the energy-intensive industries. In *AEO2008*, electricity generation accounts for 5.0 trillion cubic feet of natural gas use in 2030, compared with the *AEO2007* projection of 5.9 trillion cubic feet. The lower level of consumption in *AEO2008* results from higher natural gas prices and slower growth in electricity demand.

Total coal consumption increases from 22.5 quadrillion Btu (1,114 million short tons) in 2006 to 29.9 quadrillion Btu (1,545 million short tons) in 2030 in the *AEO2008* reference case. As in the *AEO2007* reference case, coal consumption is projected to grow at a faster rate toward the end of the projection period, particularly after 2020, as coal use for new coal-fired generating capacity grows rapidly. In the *AEO2008* reference case, coal consumption in the electric power sector increases from 23.7 quadrillion Btu in 2020 to 27.5 quadrillion Btu in 2030, and coal use at CTL plants increases from 0.6 quadrillion Btu in 2020 to 1.0 quadrillion Btu in 2030. The projected increase in coal use for CTL plants is lower than in previous *AEO*s as a result of EISA2007, because investment dollars that previously would have gone into CTL capacity now flow to biomass-to-liquids (BTL) capacity; however, there is a great deal of uncertainty around this projection.

The *AEO2008* reference case projects substantially greater use of renewable energy than was projected in *AEO2007*. Total consumption of marketed renewable fuels—including ethanol for gasoline blending, biodiesel [*5*], and diesel from biomass [*6*], of which 2.8 quadrillion Btu in 2030 is included with liquids fuel consumption—grows by 3.0 percent per year in the reference case, from 6.8 quadrillion Btu in 2006 to 13.7 quadrillion Btu in 2030, compared with 9.9 quadrillion Btu in *AEO2007*. About 45 percent of the demand for renewables in 2030 is for grid-related

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



electricity generation (including combined heat and power [CHP]).

The rapid growth in the use of renewable fuels for transportation in *AEO2008* reflects the EISA2007 RFS, which sets a requirement for 21 billion gallons of advanced biofuels and 36 billion gallons of total renewable fuels by 2022. Included are requirements for 1 billion gallons of biodiesel and 16 billion gallons of cellulosic biofuels, both of which count toward the advanced biofuels requirement. The remaining 4 billion gallons of advanced biofuels may come from any source. The difference between advanced biofuels and total renewable fuels may be met by corn ethanol. Diesel fuels derived from biomass feedstocks count for 1.5 times their physical volume in the calculation of credits toward the RFS requirements, because diesel has a higher energy content per gallon than ethanol does.

Although the situation is very uncertain, the current state of the industry and EIA's present view of projected rates of technology development and market penetration of cellulosic biofuel technologies suggest that available quantities of cellulosic biofuels before 2022 will be insufficient to meet the new RFS targets for cellulosic biofuels, triggering both waivers and a modification of applicable volumes, as provided for in Section 211(o) of the Clean Air Act as amended by EISA2007. The modification of volumes reduces the overall target in 2022 from 36 billion gallons to 32.5 billion gallons in the *AEO2008* reference case.

Ethanol use in the *AEO2008* reference case, grows from 5.6 billion gallons in 2006 to 23.9 billion gallons in 2030—about 16 percent of total gasoline consumption by volume and about 65 percent more than in *AEO2007*. Ethanol use for gasoline blending grows to 13.4 billion gallons and E85 consumption to 10.5 billion gallons in 2030. The ethanol supply is expected to be produced from both corn and cellulose feedstocks, with corn accounting for 15.0 billion gallons and cellulose 6.9 billion gallons of ethanol production in 2030. Biodiesel use increases to 1.2 billion gallons in 2030, or about 1.5 percent of total diesel consumption by volume. In addition, consumption of BTL diesel grows to 4.5 billion gallons in 2030, or 5.3 percent of total diesel consumption by volume.

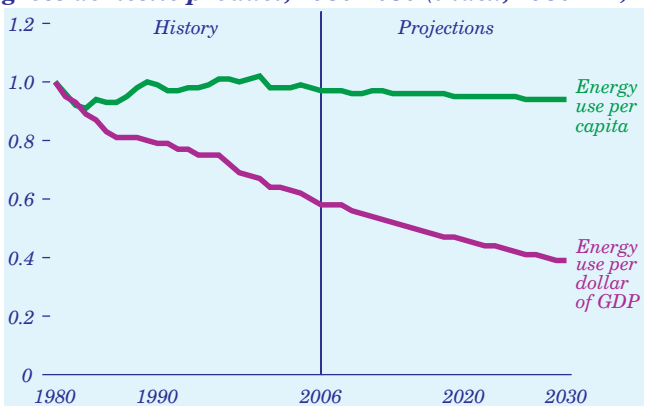
Excluding hydroelectricity, renewable energy consumption for electric power generation grows from 0.9 quadrillion Btu in 2006 to 3.2 quadrillion Btu in 2030, as compared with 2.1 quadrillion Btu in *AEO2007*. The higher level of nonhydroelectric renewable energy consumption in the *AEO2008* reference case reflects primarily a revised representation of State RPS programs, which require that specific and generally increasing shares of electricity sales be supplied by renewable resources, such as wind, solar, geothermal, and sometimes biomass or hydropower. Previous *AEO*s placed more weight on the "escape clauses" incorporated in many State RPS programs, given that the consumer costs of the programs would increase significantly if the Federal production tax credit (PTC) for qualifying renewable energy expired as provided for under current law. The new representation, which assumes that the State RPS goals will be met absent a clear contrary indication, results in significant additional growth of renewable generation from wind, biomass, and geothermal resources.

Energy Intensity

Energy intensity, measured as primary energy use (in thousand Btu) per dollar of GDP (in 2000 dollars), declines by about one-third from 2006 to 2030 in the *AEO2008* reference case (Figure 4). 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 rate of GDP growth.

Since 1992, the energy intensity of the U.S. economy has declined on average by 2.0 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 21 percent in 2006. In the *AEO2008* reference case, the energy-intensive industries' share of total industrial shipments continues to decline, although at a slower rate, to 18 percent in 2030.

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



Population is a key determinant of energy consumption, influencing demand for travel, housing, consumer goods, and services. Since 1990, the population has increased by about 20 percent and energy consumption by a comparable 18 percent in the United States, 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 affect the growth of energy consumption. Aging of the population, a gradual shift from the North to the South, and rising per-capita income will influence future trends. Overall, the U.S. population increases by 22 percent from 2006 to 2030 in the *AEO2008* reference case. Over the same period, energy consumption increases by 19 percent. The result is a decrease in energy consumption per capita at an annual rate of 0.1 percent per year from 2006 to 2030, a drop from the 0.3-percent yearly increase in the *AEO2007* reference case.

Recently, as energy prices have risen, the potential for more energy conservation has received increased attention. Although additional energy conservation is induced by higher energy prices in the *AEO2008* reference case and by the passage of EISA2007, no further 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.

Energy Production and Imports

Net imports of energy are expected to continue meeting a major share of total U.S. energy demand (Figure 5). The increased use of biofuels resulting from EISA2007, much of which is domestically produced, and the reduction in demand for transportation fuels due to the new CAFE standards both serve to moderate growth in energy imports. Higher fuel prices over the projection period also spur increased domestic energy production (Figure 6) and moderate energy demand growth, further tempering growth in imports. The projected net import share of total U.S. energy consumption in 2030 is 27 percent, a decline from the 30-percent share in 2006.

The projection for U.S. crude oil production in the *AEO2008* reference case is higher than in the *AEO2007* reference case, primarily as a result of more production from the expansion of enhanced oil recovery (EOR) operations and, to a lesser extent, higher crude oil prices. U.S. crude oil production in the *AEO2008* reference case increases from 5.1 million barrels per day in 2006 to a peak of 6.3 million barrels per day in 2018, with production increases from the deep waters of the Gulf of Mexico and from onshore EOR projects. Domestic production subsequently declines to 5.6 million barrels per day in 2030, as increased production from new, smaller discoveries is inadequate to offset declines in production from large fields in Alaska and the Gulf of Mexico.

Total domestic liquids supply, including crude oil, natural gas plant liquids, refinery processing gains, and other refinery inputs (including ethanol, biodiesel, BTL, and liquids from coal) generally increase through 2022 in the *AEO2008* reference case, while imports of crude oil and other petroleum products remain flat. Total domestic liquids supply grows from 8.2 million barrels per day in 2006 to 10.4 million barrels per day in 2030.

In the *AEO2008* reference case, the net import share of total liquids supplied, including crude oil and refined products, drops from 60 percent in 2006 to 51 percent in 2022 and then increases to 54 percent in

Figure 5. Total energy production and consumption, 1980-2030 (quadrillion Btu)

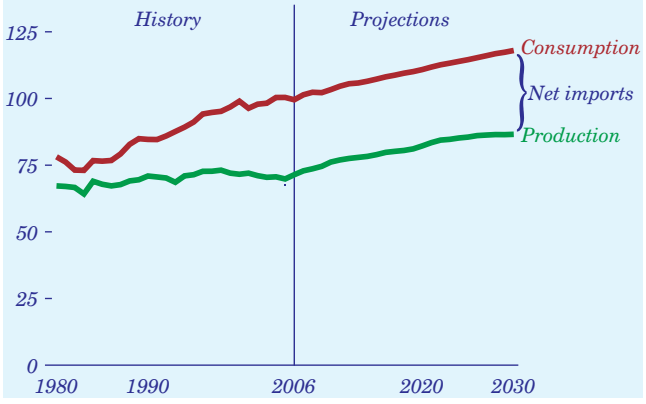
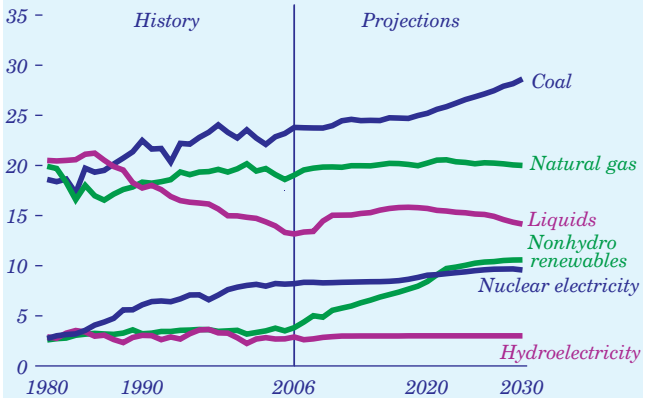


Figure 6. Energy production by fuel, 1980-2030 (quadrillion Btu)



2030. Net imports of crude oil and net imports of petroleum products in 2030 each are about 2.0 million barrels per day lower in the *AEO2008* reference case than in the *AEO2007* reference case. The primary reasons for the difference between the *AEO2008* and *AEO2007* projections for net imports of liquid fuels are a lower level of total liquids consumption and a higher level of biofuels consumption in the transportation sector in the *AEO2008* reference case.

Total domestic production of natural gas (including supplemental natural gas supplies) increases from 18.6 trillion cubic feet in 2006 to 20.0 trillion cubic feet in 2022 before declining to 19.5 trillion cubic feet in 2030 in the *AEO2008* reference case. The projections are lower than in the *AEO2007* reference case, which showed production increasing to 20.6 trillion cubic feet in 2030, primarily because of higher costs associated with exploration and development and, particularly in the last decade of the projection, lower demand for natural gas in *AEO2008*. Onshore production of unconventional natural gas is expected to be a key contributor to the growth in U.S. supply, increasing from 8.5 trillion cubic feet in 2006 to a peak of 9.6 trillion cubic feet in 2018 and generally holding at about that level through 2030.

The Alaska natural gas pipeline is expected to be completed in 2020 (2 years later than in the *AEO2007* reference case, because of delays in the resolution of issues between Alaska's State government and industry participants). After the pipeline goes into operation, Alaska's total natural gas production in the *AEO2008* reference case increases to 2.0 trillion cubic feet in 2021 (from 0.4 trillion cubic feet in 2006) and then remains at that level through 2030.

Net pipeline imports of natural gas from Canada and Mexico fall from 2.9 trillion cubic feet in 2006 to 0.3 trillion cubic feet in 2030 in the *AEO2008* reference case (compared with the *AEO2007* projection of 0.9 trillion cubic feet in 2030). The difference between the 2030 projections in *AEO2008* and *AEO2007* is largely the result of a higher level of exports to Mexico and lower demand in the United States.

Total net imports of LNG to the United States in the *AEO2008* reference case increase from 0.5 trillion cubic feet in 2006 to 2.8 trillion cubic feet in 2030, as compared with 4.5 trillion cubic feet in 2030 in *AEO2007*. The lower projection is attributable to two factors: higher costs throughout the LNG industry, especially in the area of liquefaction, and decreased U.S. natural gas consumption due to higher natural gas prices, slower economic growth, and expected greater competition for supplies in the global LNG market.

The future direction of the global LNG market is one of the key uncertainties in the *AEO2008* reference case. With many new international players entering LNG markets, the competition for available supplies is strong, and the amounts available to the U.S. market may vary considerably from year to year. The *AEO2008* reference case has been updated to reflect current market dynamics, which could change considerably as worldwide LNG markets evolve.

As domestic coal demand grows in the *AEO2008* reference case, U.S. coal production (excluding waste coal) increases at an average rate of 0.8 percent per year, from 23.8 quadrillion Btu (1,163 million short tons) in 2006 to 28.6 quadrillion Btu (1,455 million short tons) in 2030—15 percent less than in the *AEO2007* reference case. Production from mines west of the Mississippi River provides the largest share of the incremental coal production. On a Btu basis, 59 percent of domestic coal production originates from States west of the Mississippi River in 2030, up from 49 percent in 2006.

Typically, trends in U.S. coal production are linked to its use for electricity generation, which currently accounts for 91 percent of total coal consumption. Coal consumption in the electric power sector in the *AEO2008* reference case, at 27.5 quadrillion Btu in 2030, is less than in the *AEO2007* reference case (31.1 quadrillion Btu in 2030). Slower growth in overall electricity demand, combined with more generation from nuclear and renewable energy, underlies the reduced outlook for electricity sector coal consumption. Another emerging market for coal is CTL. Coal use in CTL plants grows from 0.6 quadrillion Btu (42 million short tons) in 2020 to 1.0 quadrillion Btu (64 million short tons) in 2030.

Electricity Generation

Total electricity consumption, including both purchases from electric power producers and on-site generation, grows from 3,814 billion kilowatthours in 2006 to 4,972 billion kilowatthours in 2030, increasing at an average annual rate of 1.1 percent in the *AEO2008* reference case. 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 *AEO2008*

projection is lower than in the *AEO2007* reference case (1.5 percent per year). The reduced rate of growth in *AEO2008* results from slower economic growth, the imposition of new efficiency standards in EISA2007, and higher electricity prices.

In the *AEO2008* reference case, electricity generation from natural-gas-fired power plants increases sharply from 2006 to 2008 and then remains relatively stable for the next decade, growing by 3 percent from 2008 to 2016—less rapidly than in the *AEO2007* reference case. After 2016, however, generation from new coal, nuclear, and renewable plants displaces some natural-gas-fired generation (Figure 7). In the *AEO2008* reference case, 741 billion kilowatthours of electricity is generated from natural gas in 2030, 21 percent less than the 937 billion kilowatthours in 2030 in the *AEO2007* reference case.

In the *AEO2008* reference case, the natural gas share of electricity generation (including generation in the end-use sectors) remains between 20 percent and 21 percent through 2017 before falling to 14 percent in 2030. The coal share remains between 48 percent and 49 percent from 2006 through 2018 before increasing to 54 percent in 2030. Additions to coal-fired generating capacity in the *AEO2008* reference case total 104 gigawatts from 2006 to 2030 (as compared with 156 gigawatts in the *AEO2007* reference case), including 4 gigawatts at CTL plants and 29 gigawatts at integrated gasification combined-cycle plants. Given the assumed continuation of current energy and environmental policies in the reference case, CCS technology does not come into use during the projection period.

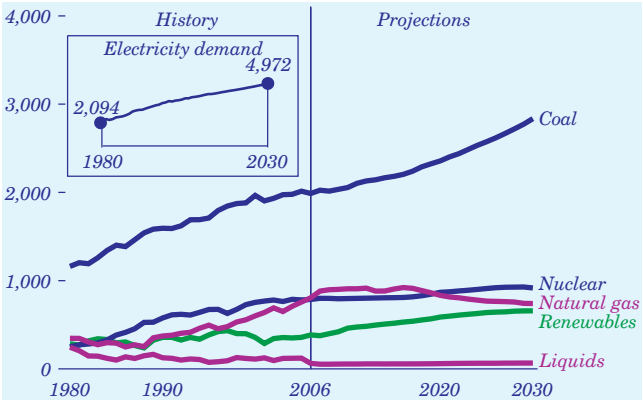
Nuclear generating capacity in the *AEO2008* reference case increases from 100.2 gigawatts in 2006 to 114.9 gigawatts in 2030. The increase includes 17 gigawatts of capacity at newly built nuclear power plants (33 percent more than in the *AEO2007* reference case) and 2.7 gigawatts expected from uprates of existing plants, partially offset by 4.5 gigawatts of retirements.

Rules issued by the Internal Revenue Service in 2006 for the EPACT2005 PTC for new nuclear plants allow the credits to be shared out on a prorated basis to more than 6 gigawatts of new capacity. In the *AEO2008* reference case the credits are shared out to 8 gigawatts of new nuclear capacity, and another 9 gigawatts of capacity is built without credits.

Total electricity generation from nuclear power plants grows from 787 billion kilowatthours in 2006 to 917 billion kilowatthours in 2030 in the *AEO2008* reference case, accounting for about 18 percent of total generation in 2030. Additional nuclear capacity is built in some of the alternative *AEO2008* cases, particularly those that project higher demand for electricity or higher fossil fuel prices.

The use of renewable technologies for electricity generation is stimulated by improved technology, higher fossil fuel prices, and short-term extensions of the EPACT2005 tax credits. The reference case also includes State RPS programs for which legislation is in place. Total renewable generation in the *AEO2008* reference case, including CHP and end-use generation, grows by 2.2 percent per year, from 385 billion kilowatthours in 2006 to 656 billion kilowatthours in 2030. The projection for renewable generation in the *AEO2008* reference case, which includes State and regional programs, is significantly higher than the *AEO2007* projection.

Figure 7. Electricity generation by fuel, 1980-2030 (billion kilowatthours)



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), 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 liquid fuels in between. In the *AEO2008* reference case, the coal share of total energy use increases from 23 percent in 2006 to 25 percent in 2030, while the share of natural gas falls from 22 percent to 20 percent, and the liquids share falls from 40 percent to 37 percent. The combined share of carbon-neutral renewable and nuclear

energy grows from 15 percent in 2006 to 17 percent in 2030.

Taken together, projected growth in the absolute level of primary energy consumption and a shift toward a fuel mix with slightly lower average carbon content cause projected energy-related emissions of CO_2 (Figure 8) to grow by 16 percent from 2006 to 2030—slightly lower than the projected 19-percent increase in total energy use. Over the same period, the economy becomes less carbon-intensive, because the 16-percent increase in CO_2 emissions is about one-fifth of the projected increase in GDP (79 percent), and emissions per capita decline by 5 percent. In the *AEO2008* reference case, projected energy-related CO_2 emissions grow from 5,890 million metric tons in 2006 to 6,851 million metric tons in 2030. By comparison, in the *AEO2007* reference case, energy-related CO_2 emissions were projected to grow by about 35 percent, to 7,950 million metric tons in 2030, reflecting both a higher projection of overall energy use and, to a lesser extent, a different mix of energy sources.

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

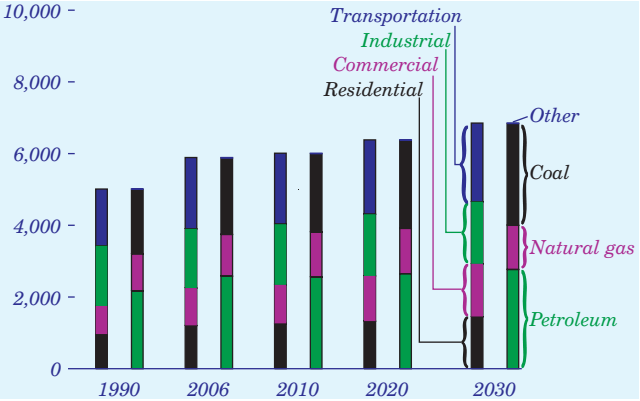


Table 1. Total energy supply and disposition in the *AEO2008* and *AEO2007* reference cases, 2006-2030

Energy and economic factors	2006	2010		2020		2030	
		AEO2008	*AEO2007*	*AEO2008*	*AEO2007*	*AEO2008*	*AEO2007*
Primary energy production (quadrillion Btu)							
Petroleum	13.16	15.03	14.42	15.71	14.85	14.15	13.71
Dry natural gas	19.04	19.85	19.93	20.24	21.41	20.00	21.15
Coal	23.79	23.97	24.47	25.2	26.61	28.63	33.52
Nuclear electricity	8.21	8.31	8.23	9.05	9.23	9.57	9.33
Hydroelectricity	2.89	2.92	3.02	3.00	3.08	3.00	3.09
Biomass	2.94	4.05	4.22	6.42	4.69	8.12	5.26
Other renewable energy	0.88	1.51	1.18	2.00	1.33	2.45	1.44
Other	0.50	0.54	0.67	0.58	0.89	0.64	1.12
Total	**71.41**	**76.17**	**76.13**	**82.21**	**82.09**	**86.56**	**88.63**
Net imports (quadrillion Btu)							
Petroleum	26.69	23.93	25.19	24.03	28.92	26.52	34.74
Natural gas	3.56	3.96	4.67	3.66	5.48	3.28	5.59
Coal/other (- indicates export)	-0.28	-0.84	-0.19	1.06	0.93	1.86	1.57
Total	**29.98**	**27.04**	**29.66**	**28.75**	**35.33**	**31.66**	**41.90**
Consumption (quadrillion Btu)							
Liquid fuels	40.06	40.46	41.76	42.24	46.52	43.99	52.17
Natural gas	22.30	23.93	24.73	24.01	27.04	23.39	26.89
Coal	22.50	23.03	24.24	25.87	27.29	29.90	34.14
Nuclear electricity	8.21	8.31	8.23	9.05	9.23	9.57	9.33
Hydroelectricity	2.89	2.92	3.02	3.00	3.08	3.00	3.09
Biomass	2.50	3.01	3.30	4.50	3.64	5.51	4.06
Other renewable energy	0.88	1.51	1.18	2.00	1.33	2.45	1.44
Net electricity imports	0.19	0.18	0.04	0.17	0.04	0.20	0.04
Total	**99.50**	**103.30**	**106.50**	**110.80**	**118.16**	**118.00**	**131.16**
Liquid fuels (million barrels per day)							
Domestic crude oil production	5.10	5.93	5.67	6.23	5.89	5.59	5.39
Other domestic production	3.19	3.69	4.03	4.46	4.49	4.85	5.08
Net imports	12.45	11.39	11.79	11.36	13.56	12.41	16.37
Consumption	20.65	20.99	21.59	21.96	24.03	22.80	26.95
Natural gas (trillion cubic feet)							
Production	18.57	19.35	19.42	19.73	20.86	19.49	20.61
Net imports	3.46	3.85	4.55	3.55	5.35	3.18	5.45
Consumption	21.66	23.25	24.02	23.33	26.26	22.72	26.12
Coal (million short tons)							
Production	1,177	1,179	1,202	1,281	1,336	1,467	1,704
Net imports	-15	-34	-7	46	41	78	68
Consumption	1,114	1,145	1,195	1,327	1,377	1,545	1,772
Prices (2006 dollars)							
Imported low-sulfur, light crude oil (dollars per barrel)	66.02	74.03	59.23	59.70	53.64	70.45	60.93
Imported crude oil (dollars per barrel)	59.05	65.18	52.76	51.55	47.89	58.66	53.21
Domestic natural gas at wellhead (dollars per thousand cubic feet)	6.42	6.33	5.93	5.44	5.39	6.63	6.16
Domestic coal at minemouth (dollars per short ton)	24.63	26.16	24.94	22.51	22.24	23.32	23.29
Average electricity price (cents per kilowatthour)	8.9	9.2	8.3	8.6	8.1	8.8	8.3
Economic indicators							
Real gross domestic product (billion 2000 dollars)	11,319	12,453	12,790	15,984	17,077	20,219	22,494
GDP chain-type price index (index, 2000=1.000)	1.166	1.26	1.253	1.52	1.495	1.871	1.815
Real disposable personal income (billion 2000 dollars)	8,397	9,472	9,568	12,654	13,000	16,246	17,535
Value of manufacturing shipments (billion 2000 dollars)	5,821	5,997	6,298	7,113	7,779	7,997	9,502
Primary energy intensity (thousand Btu per 2000 dollar of GDP)	**8.79**	**8.30**	**8.33**	**6.93**	**6.92**	**5.84**	**5.83**
Carbon dioxide emissions (million metric tons)	**5,890**	**6,011**	**6,214**	**6,384**	**6,944**	**6,851**	**7,950**

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. For nuclear electricity, both production and consumption numbers are based on its fossil-fuel-equivalent energy content.

Sources: AEO2008 National Energy Modeling System, run AEO2008.D030208F; and AEO2007 National Energy Modeling System, run AEO2007.D112106A.