

# ***AEO2005* Overview**

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### Key Energy Issues to 2025

The Energy Information Administration (EIA), in preparing model forecasts for its *Annual Energy Outlook 2005* (AEO2005), evaluated a wide range of current trends and issues that could have major implications for U.S. energy markets over the 20-year forecast period, from 2005 to 2025. Trends in energy supply and demand are linked with such unpredictable factors as the performance of the U.S. economy overall, advances in technologies related to energy production and consumption, annual changes in weather patterns, and future public policy decisions [see endnote 1 on page 8]. *Among the most important issues identified as having the potential to affect the complex behavior of the domestic energy economy, oil prices and natural gas supply were considered to be of particular significance in increasing the uncertainty associated with the AEO2005 reference case projections.*

World crude oil prices—defined by the U.S. average refiner's acquisition cost of imported crude oil (IRAC)—reached a recent low of \$10.29 per barrel (in 2003 dollars) in December 1998. For the next 3 years, crude oil prices ranged between just under \$20 and just over \$30 per barrel. Since December 2001, however, prices have increased steadily, to about \$46 per barrel in October 2004.

Strong growth in the demand for oil worldwide, particularly in China and other developing countries, is generally cited as the driving force behind the sharp price increases seen over the past 3 years. Other factors contributing to the upward trend include a tight supply situation that has shown only limited response to higher prices; changing views on the economics of oil production; concerns about economic and political situations in the Middle East, Venezuela, Nigeria, and the former Soviet Union; and recent supply disruptions caused by weather events (Hurricane Ivan). The future path of prices is a key uncertainty facing world oil markets.

The AEO2005 reference case assumes that world crude oil prices will decline as growth in consumption slows and producers increase their productive capacity and output in response to current high prices. In contrast, the October 2004 prices from the New York Mercantile Exchange (NYMEX) futures market (corrected for the difference between futures prices and the IRAC) imply that the annual average price in 2005 will exceed the 2004 average price level, and that prices will then decline only slowly over the next few years, resulting in 2010 prices higher than those projected in the AEO2005 reference case. To evaluate the

likely effects of that possible price path on the U.S. energy economy, AEO2005 also includes an *October oil futures case*, discussed in the text box on page 11. In addition, when it is released in early 2005, the complete AEO2005 will include other cases based on alternative paths for world crude oil prices.

From 1986 to 2000, when U.S. natural gas consumption grew from 16.2 trillion cubic feet to a high of 23.3 trillion cubic feet, 40 percent of the increased demand was met by imports, predominantly from Canada. Based on the latest assessment from Canada's National Energy Board, however, it is unlikely that future production from Canada will be able to support a continued increase in U.S. imports.

In the AEO2005 reference case, U.S. natural gas consumption is projected to grow from 22 trillion cubic feet in 2003 to almost 31 trillion cubic feet in 2025. Most of the additional supply is expected to come from Alaska and imports of liquefied natural gas (LNG). A key issue for U.S. energy markets is whether the investments and regulatory approvals needed to make those natural gas supplies available will be forthcoming, and what the ramifications will be if they are not. The complete AEO2005 will include a *constrained natural gas supply case* to examine the implications of a possible future in which no Alaska natural gas pipeline is built, no new construction is started on additional LNG terminals, and production technology advances more slowly than it has in the past.

The following sections summarize the key trends in the AEO2005 reference case and compare them with last year's reference case (AEO2004). A summary of the AEO2005 reference case is provided in Table 1 on page 9.

### Economic Growth

In the AEO2005 reference case, the U.S. economy, as measured by gross domestic product (GDP), grows at an average annual rate of 3.1 percent from 2003 to 2025, slightly higher than the growth rate of 3.0 percent per year for the same period in AEO2004. Many of the determinants of economic growth are similar to those in AEO2004, but there are some important differences. Both the Federal funds rate and the nominal yield on the 10-year Treasury note are higher in the early years of the AEO2005 forecast but generally lower after 2010; the industrial value of shipments reflects a more pessimistic forecast for industrial output in view of the downward adjustment in domestic production for some manufacturing sectors in the early 2000s; and the U.S. population forecast in

*AEO2005* is higher, following the adoption of the interim population projections released by the U.S. Census Bureau in 2004.

## Energy Prices

In the *AEO2005* reference case, the annual average world oil price (IRAC) increases from \$27.73 per barrel (2003 dollars) in 2003 to \$35.00 per barrel in 2004 and then declines to \$25.00 per barrel in 2010 as new supplies enter the market. It then rises slowly to \$30.31 per barrel in 2025, about \$3 per barrel higher than the *AEO2004* projection of \$27.41 per barrel in 2025. In nominal dollars, the average world oil price is about \$52 per barrel in 2025.

The *AEO2005* world oil price forecast is characterized by decreasing prices through 2010 and moderately increasing prices thereafter (Figure 1). This is consistent with a forecast that projects increases in world petroleum demand, from about 80 million barrels per day in 2003 to more than 120 million barrels per day in 2025, which is met by increased oil production both from the Organization of Petroleum Exporting Countries (OPEC) and from non-OPEC nations. *AEO2005* projects OPEC oil production of 55 million barrels per day in 2025, 80 percent higher than the 31 million barrels per day produced in 2003. The forecast assumes that OPEC will pursue policies intended to increase production, that sufficient resources exist, and that access and capital will be available to expand production. Non-OPEC oil production is expected to increase from 49 to 65 million barrels per day between 2003 and 2025.

Average wellhead prices for natural gas in the United States are projected generally to decrease, from \$4.98 per thousand cubic feet (2003 dollars) in 2003 to \$3.64 per thousand cubic feet in 2010 as the initial availability of new import sources and increased

drilling expands available supply. After 2010, wellhead prices are projected to increase gradually (Figure 1), to \$4.79 per thousand cubic feet in 2025 (equivalent to about \$8.20 per thousand cubic feet in nominal dollars). Growth in LNG imports, Alaska production, and lower 48 production from nonconventional sources are not expected to increase sufficiently to offset the impacts of resource depletion and increased demand. The projected 2025 wellhead natural gas price in *AEO2005* is more than 30 cents per thousand cubic feet higher than the *AEO2004* projection, primarily as a result of lower assumed finding rates (reserve additions per well) for onshore resources.

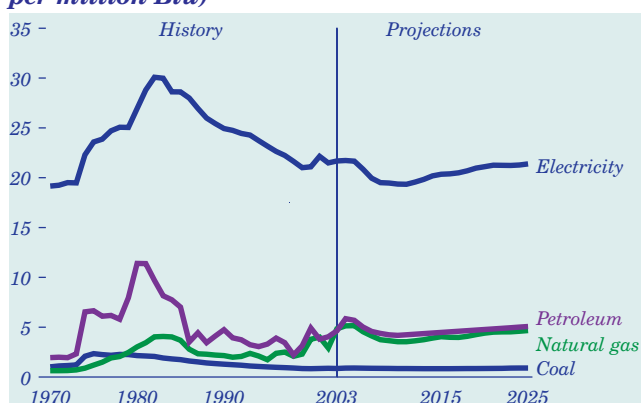
In *AEO2005*, the combination of more moderate increases in coal production, expected improvements in mine productivity, and a continuing shift to low-cost coal from the Powder River Basin in Wyoming leads to a gradual decline in the average minemouth price, to approximately \$17.00 per ton shortly after 2010. The price is projected to remain nearly constant between 2010 and 2020 (Figure 1), increasing after 2020 as rising natural gas prices and the need for baseload generating capacity lead to the construction of many new coal-fired generating plants. By 2025, the average minemouth price is projected to be \$18.26 per ton, which is higher than the *AEO2004* projection of \$16.82 per ton. The *AEO2005* projection is equivalent to an average minemouth coal price of \$31.25 per ton in nominal dollars in 2025.

Average delivered electricity prices are projected to decline from 7.4 cents per kilowatthour (2003 dollars) in 2003 to a low of 6.6 cents per kilowatthour in 2011 as a result of an increasingly competitive generation market and a decline in natural gas prices. After 2011, average real electricity prices are projected to increase (Figure 1), reaching 7.3 cents per kilowatthour in 2025 (equivalent to 12.5 cents per kilowatthour in nominal dollars). In *AEO2004*, real electricity prices followed a similar pattern but were projected to be slightly lower in 2025, at 7.0 cents per kilowatthour. The higher electricity price projection in *AEO2005* results primarily from higher expected fuel costs for coal- and natural-gas-fired electricity generation, particularly in the later years of the forecast.

## Energy Consumption

Total primary energy consumption in *AEO2005* is projected to increase from 98.2 quadrillion British thermal units (Btu) in 2003 to 133.2 quadrillion Btu in 2025 (an average annual increase of 1.4 percent). *AEO2004* projected energy consumption of 136.5 quadrillion Btu in 2025. Other than nuclear energy, the

**Figure 1. Energy prices, 1970-2025 (2003 dollars per million Btu)**



## AEO2005 Overview

*AEO2005* projections for the consumption of all energy sources in 2025 are lower than those in *AEO2004*. Among the most important factors accounting for the differences are higher energy prices, lower projected growth rates in industrial production, specific updates in the chemical and pulp and paper industries, revisions to the capital cost of generating technologies, and revisions to transportation sector vehicle miles traveled.

Consistent with population growth rates and household formation, delivered residential energy consumption is projected to grow from 11.6 quadrillion Btu in 2003 to 14.3 quadrillion Btu in 2025 (Figure 2), at an average rate of 0.9 percent per year between 2003 and 2025 (1.3 percent per year between 2003 and 2010, slowing to 0.8 percent per year between 2010 and 2025). The most rapid growth in energy demand in *AEO2005* is projected to be for electricity used to power computers, electronic equipment, and appliances. *AEO2005* includes changes in the residential sector that have offsetting influences on the forecast of energy consumption, including more rapid growth in the total number of U.S. households; higher delivered prices for natural gas, electricity, and distillate fuel; and a better accounting of additions to existing homes and the height of ceilings in new homes.

Consistent with the projected increase in commercial floorspace, delivered commercial energy consumption is projected to grow at an average annual rate of 1.9 percent between 2003 and 2025 (Figure 2), reaching 12.5 quadrillion Btu in 2025 (slightly more than the 12.2 quadrillion Btu projected in *AEO2004*). The most rapid increase in energy demand is projected for electricity used for computers, office equipment, telecommunications, and miscellaneous small appliances. The higher forecast for commercial energy

consumption in *AEO2005* results from a higher projected rate of growth in commercial floorspace, averaging 1.7 percent per year between 2003 and 2025, as compared with the projected average of 1.5 percent per year in *AEO2004*.

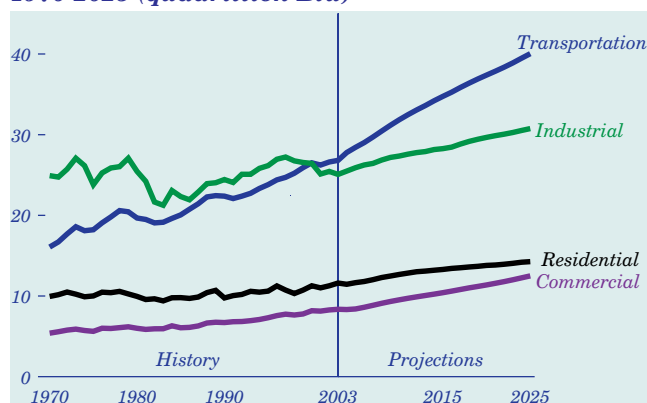
Delivered industrial energy consumption in *AEO2005* is projected to increase at an average rate of 1.0 percent per year between 2003 and 2025 (Figure 2), reaching 30.8 quadrillion Btu in 2025 (significantly lower than the *AEO2004* forecast of 33.4 quadrillion Btu). The *AEO2005* forecast includes slower projected growth in the dollar value of industrial product shipments relative to *AEO2004*, because of the slowdown in production growth in recent years and a reassessment of the prospects for growth in the chemical and pulp and paper industries.

Energy consumption in the transportation sector is projected to grow at an average annual rate of 1.8 percent between 2003 and 2025 in the *AEO2005* forecast (Figure 2), reaching 40.0 quadrillion Btu in 2025 (1.1 quadrillion Btu lower than the *AEO2004* projection). Two factors account for the reduction in projected transportation energy use from *AEO2004* to *AEO2005*: first, expectations about light vehicle travel per capita have been reduced, based on new historical population and income data; and second, fuel economy data have been updated, resulting in a slightly improved average fuel economy for the light-duty vehicle stock over the forecast.

Total electricity consumption, including both purchases from electric power producers and on-site generation, is projected to grow from 3,657 billion kilowatthours in 2003 to 5,467 billion kilowatthours in 2025, increasing at an average rate of 1.8 percent per year. Rapid growth in electricity use for computers, office equipment, and a variety of electrical appliances in the end-use sectors is partially offset in the *AEO2005* forecast by improved efficiency in these and other, more traditional electrical applications and by slower growth in electricity demand in the industrial sector.

Total demand for natural gas is projected to increase at an average annual rate of 1.5 percent from 2003 to 2025 (Figure 3), primarily as a result of increasing use for electricity generation and industrial applications, which together account for about 75 percent of the projected growth in natural gas demand from 2003 to 2025. Total projected consumption of natural gas in 2025 is 0.7 trillion cubic feet lower in *AEO2005* than was projected in *AEO2004*. The growth in demand for natural gas slows in the later years of the forecast (0.9 percent per year from 2015 to 2025, compared with

**Figure 2. Delivered energy consumption by sector, 1970-2025 (quadrillion Btu)**





2.1 percent per year from 2003 to 2010), as rising natural gas prices lead to the construction of more coal-fired capacity for electricity generation.

In *AEO2005*, total coal consumption is projected to increase from 1,095 million short tons in 2003 to 1,508 million short tons in 2025—59 million short tons less than the *AEO2004* projection of 1,567 million short tons in 2025. From 2003 to 2025, coal consumption is projected to grow by 1.5 percent per year in the *AEO2005* forecast. The primary reason for the lower growth is an update of assumptions made about the relative capital costs of new coal- and natural-gas-fired power plants in the *AEO2005* forecast. In *AEO2005*, total coal consumption for electricity generation is projected to increase by an average of 1.6 percent per year, from 1,004 million short tons in 2003 to 1,425 million short tons in 2025, compared with the *AEO2004* projection of 1,477 million short tons in 2025.

Total petroleum demand is projected to grow at an average annual rate of 1.5 percent in the *AEO2005* forecast, from 20.0 million barrels per day in 2003 to 27.9 million barrels per day in 2025. In *AEO2005*, an increase of 0.3 million barrels per day in petroleum use for electricity generation in 2025, relative to the *AEO2004* projection, is more than offset by a reduction of 0.7 million barrels per day in total petroleum use in the industrial and transportation sectors in 2025—the result of projected higher energy prices, slower growth in industrial production, and improved average fuel economy for light-duty vehicles.

Total marketed renewable fuel consumption (including ethanol for gasoline blending, of which 0.2 quadrillion Btu is included with “petroleum products” consumption in Table 1), is projected to grow by 1.5 percent per year in *AEO2005*, from 6.1 quadrillion Btu in 2003 to 8.5 quadrillion Btu in 2025, as a

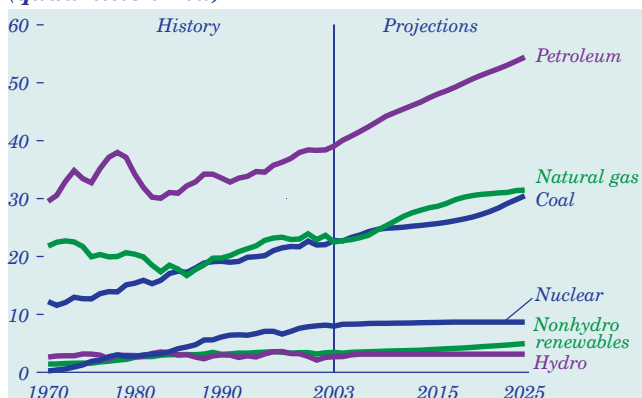
result of State mandates for renewable electricity generation, higher natural gas prices, and the effect of production tax credits. About 60 percent of the projected demand for renewables in 2025 is for grid-related electricity generation (including combined heat and power), and the rest is for dispersed heating and cooling, industrial uses, and fuel blending. Despite higher fossil fuel prices, the projected demand for renewables in 2025 in *AEO2005* is 0.9 quadrillion Btu less than in *AEO2004*. Renewable generating technologies are not as competitive in *AEO2005*, because the costs for natural gas technologies are lower, wind technology costs are about 10 percent higher, and several geothermal projects that were assumed to be completed in the *AEO2004* forecast are not included in *AEO2005*.

## Energy Intensity

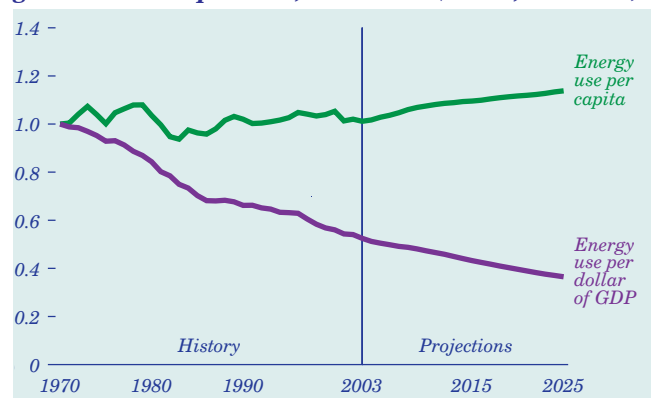
Energy intensity, as measured by energy use per 2000 dollar of GDP, is projected to decline at an average annual rate of 1.6 percent in the *AEO2005* forecast, with efficiency gains and structural shifts in the economy offsetting growth in demand for energy services (Figure 4). The rate of decline is faster in *AEO2005* than the projected rate of 1.4 percent per year in *AEO2004*, because higher energy prices in the *AEO2005* forecast are projected to result in generally lower energy consumption and a more rapid shift of energy use away from industrial uses to energy services. The projected rate of decline in *AEO2005* falls between the historical averages of 2.3 percent per year from 1970 to 1986, when energy prices increased in real terms, and 0.7 percent per year from 1986 to 1992, when energy prices were generally falling.

Since 1992, energy intensity has declined on average by 1.9 percent per year. During this period, the role of energy-intensive industries in the U.S. economy has fallen sharply. The share of industrial output from

**Figure 3. Energy consumption by fuel, 1970-2025 (quadrillion Btu)**



**Figure 4. Energy use per capita and per dollar of gross domestic product, 1970-2025 (index, 1970 = 1)**



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the energy-intensive industries declined on average by 1.3 percent per year from 1992 to 2003. In the *AEO2005* forecast, the energy-intensive industries' share of total industrial output is projected to continue declining but at a slower rate of 0.8 percent per year, which leads to the projected slower annual rate of reduction in energy intensity.

Historically, energy use per person has varied over time with the level of economic growth, weather conditions, and energy prices, among many other factors. During the late 1970s and early 1980s, energy consumption per capita fell in response to high energy prices and weak economic growth. Starting in the late 1980s and lasting through the mid-1990s, energy consumption per capita increased with declining energy prices and strong economic growth. Per capita energy use is projected to increase in *AEO2005*, with growth in demand for energy services only partially offset by efficiency gains. Per capita energy use increases by an average of 0.5 percent per year between 2003 and 2025 in *AEO2005*, slightly less than was projected in *AEO2004* (0.7 percent per year), as a result of the higher energy prices in *AEO2005*.

The potential for more energy conservation has received increased attention recently as energy prices have risen. Although energy conservation is projected to be induced through energy price increases, *AEO2005* does not assume policy-induced conservation measures beyond those in existing legislation and regulation, nor does it assume behavioral changes beyond those experienced in the past.

### Electricity Generation

In *AEO2005*, the projected average price for natural gas delivered to electricity generators is 45 cents per million Btu higher in 2025 than was projected in *AEO2004*; however, the impact of the higher prices is offset by the assumption that capital costs for new natural-gas-fired power plants will be lower than assumed in *AEO2004*, as well as the inclusion of more recently completed and announced plans for gas-fired power plants. As a result, in *AEO2005*, projected cumulative capacity additions and generation from natural-gas-fired power plants are higher than in *AEO2004*, and capacity additions and generation from coal-fired power plants are lower. The *AEO2005* projection of 1,406 billion kilowatthours of electricity generation from natural gas in 2025 is 8 percent higher than in *AEO2004* (1,304 billion kilowatthours) and more than twice the 2003 level of about 630 billion kilowatthours (Figure 5). Less new gas-fired capacity is added in the later years of the forecast because of the projected rise in natural gas prices.

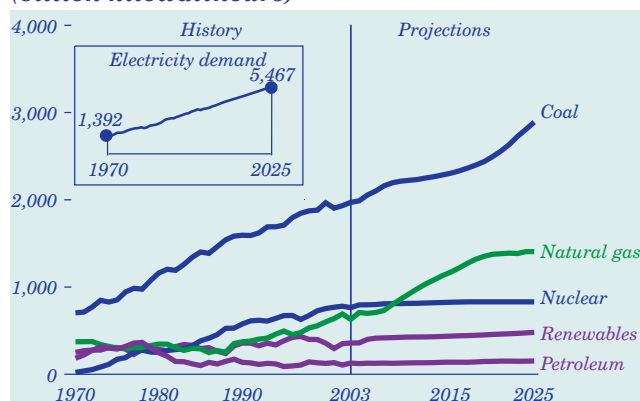
The natural gas share of electricity generation (including generation in the end-use sectors) is projected to increase from 16 percent in 2003 to 24 percent in 2025. The share from coal is projected to decrease from 51 percent in 2003 to 50 percent in 2025. *AEO2005* projects that 87 gigawatts of new coal-fired generating capacity will be constructed between 2004 and 2025 (compared with 112 gigawatts in *AEO2004*).

Nuclear generating capacity in *AEO2005* is projected to increase from 99.2 gigawatts in 2003 to 102.7 gigawatts in 2025—about the same as in *AEO2004*—as a result of uprates of existing plants between 2003 and 2025. All existing nuclear plants are projected to continue to operate, but new plants are not expected to be economical. Total nuclear generation is projected to grow from 764 billion kilowatthours in 2003 to 830 billion kilowatthours in 2025 in *AEO2005*.

The use of renewable technologies for electricity generation is projected to grow slowly, both because of the relatively low costs of fossil-fired generation and because competitive electricity markets favor less capital-intensive technologies. Where enacted, State renewable portfolio standards, which specify a minimum share of generation or sales from renewable sources, are included in the forecast. *AEO2005* also includes the extension of the production tax credit for wind and biomass through December 31, 2005, as indicated in H.R. 4520, the American Jobs Creation Act of 2004. *AEO2004* assumed that the production tax credit would end on December 31, 2003, its statutory expiration date at the time *AEO2004* was prepared.

Total renewable generation in *AEO2005*, including combined heat and power generation, is projected to grow from 359 billion kilowatthours in 2003 to 489 billion kilowatthours in 2025, increasing by 1.4 percent per year.

**Figure 5. Electricity generation by fuel, 1970-2025 (billion kilowatthours)**



## Energy Production and Imports

Total energy consumption is expected to increase more rapidly than domestic energy supply through 2025. As a result, net imports of energy are projected to meet a growing share of energy demand (Figure 6). Net imports are expected to constitute 38 percent of total U.S. energy consumption in 2025, up from 27 percent in 2003.

Projected U.S. crude oil production increases from 5.7 million barrels per day in 2003 to a peak of 6.2 million barrels per day in 2009 as a result of increased production offshore, predominantly from the deep waters of the Gulf of Mexico. Beginning in 2010, U.S. crude oil production begins to decline, falling to 4.7 million barrels per day in 2025.

Total domestic petroleum supply (crude oil, natural gas plant liquids, refinery processing gains, and other refinery inputs) follows the same pattern as crude oil production in the *AEO2005* forecast, increasing from 9.1 million barrels per day in 2003 to a peak of 9.8 million barrels per day in 2009, then declining to 8.8 million barrels per day in 2025 (Figure 7).

In 2025, net petroleum imports, including both crude oil and refined products, are expected to account for 68 percent of demand (on the basis of barrels per day), up from 56 percent in 2003. Despite an expected increase in distillation capacity at domestic refineries, net imports of refined petroleum products account for a growing portion of total net imports, increasing from 14 percent in 2003 to 16 percent in 2025 (as compared with 20 percent in *AEO2004*).

The most significant change in the *AEO2005* energy supply projections is in the outlook for natural gas, particularly domestic lower 48 onshore production and LNG imports. Domestic natural gas production increases from 19.1 trillion cubic feet in 2003 to 21.8 trillion cubic feet in 2025 in the *AEO2005* forecast;

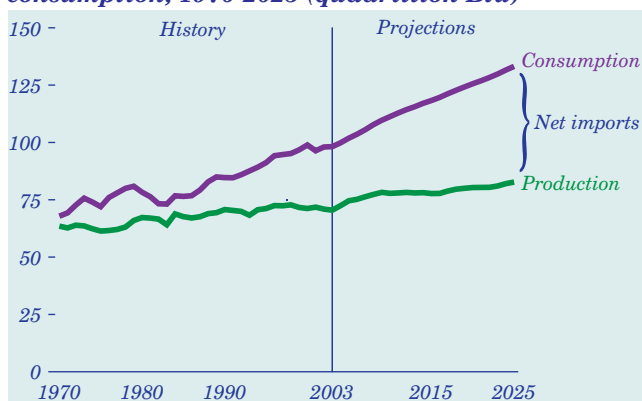
*AEO2004* projected 24.0 trillion cubic feet of domestic natural gas production in 2025.

The projection for conventional onshore production of natural gas is lower in *AEO2005* than it was in *AEO2004*, because of slower reserve growth, fewer new discoveries, and higher exploration and development costs. Lower 48 onshore natural gas production is projected to increase from 13.9 trillion cubic feet in 2003 to a peak of 15.7 trillion cubic feet in 2012 before falling to 14.7 trillion cubic feet in 2025. In *AEO2004*, lower 48 onshore production reached 16.3 trillion cubic feet in 2025.

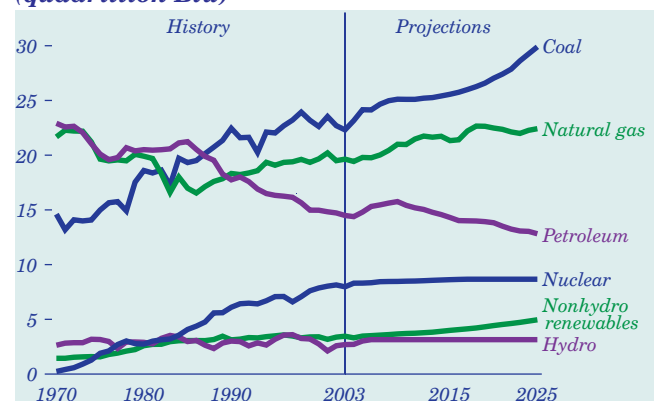
Offshore natural gas production in 2025 is also somewhat lower in *AEO2005* than it was in the *AEO2004* forecast. Lower 48 offshore production, which was 4.7 trillion cubic feet in 2003, is projected to increase in the near term (to 5.3 trillion cubic feet by 2014) because of the expected development of some large deepwater fields, including Mad Dog, Entrada, and Thunder Horse. After 2014, offshore production is projected to decline to 4.9 trillion cubic feet in 2025.

Although the projection for net U.S. imports of natural gas from Canada in 2025 in *AEO2005* is about the same as in *AEO2004*, the pattern of growth is very different in *AEO2005*. *AEO2004* projected that the 2002 level of net Canadian imports (3.6 trillion cubic feet) could be sustained through 2012 before falling off. *AEO2005* expects net Canadian imports to decline from 2003 levels of 3.1 trillion cubic feet to about 2.5 trillion cubic feet in 2009, followed by an increase after 2010 to 3.0 trillion cubic feet in 2015 as a result of rising natural gas prices, the introduction of gas from the Mackenzie Delta, and increased production of coalbed methane. After 2015, because of reserve depletion effects and growing domestic demand in Canada, net U.S. imports are projected to decline to 2.6 trillion cubic feet in 2025. The *AEO2005* forecast reflects revised expectations about Canadian natural

**Figure 6. Total energy production and consumption, 1970-2025 (quadrillion Btu)**



**Figure 7. Energy production by fuel, 1970-2025 (quadrillion Btu)**



gas production, particularly coalbed methane and conventional production in Alberta, based in part on data and projections from Canada's National Energy Board and other sources.

Growth in U.S. natural gas supplies will depend on unconventional domestic production, natural gas from Alaska, and imports of LNG. Total nonassociated unconventional natural gas production is projected to grow from 6.6 trillion cubic feet in 2003 to 8.6 trillion cubic feet in 2025. With completion of an Alaskan natural gas pipeline in 2016, Alaska's total production is projected to increase from 0.4 trillion cubic feet in 2003 to 2.2 trillion cubic feet in 2025. The four existing U.S. LNG terminals (Everett, Massachusetts; Cove Point, Maryland; Elba Island, Georgia; and Lake Charles, Louisiana) are all expected to expand by 2007, and additional facilities are expected to be built in the lower 48 States, serving the Gulf, Mid-Atlantic, and South Atlantic States, including a new facility in the Bahamas serving Florida via a pipeline. Another facility is projected to be built in Baja California, Mexico, serving a portion of the California market. Total net LNG imports to the United States and the Bahamas are projected to increase from 0.4 trillion cubic feet in 2003 to 6.4 trillion cubic feet in 2025, about one-third more than the *AEO2004* projection of 4.8 trillion cubic feet.

As domestic coal demand grows in *AEO2005*, U.S. coal production is projected to increase at an average rate of 1.5 percent per year, from 1,083 million short tons in 2003 to 1,488 million short tons in 2025. The *AEO2005* projection for coal production in 2025 is 55 million short tons less than in *AEO2004* because of revisions in the relative capital costs and efficiencies for new coal- and natural-gas-fired generating capacity in *AEO2005*, which lead to a lower projected level of coal demand than was projected in *AEO2004*, despite higher natural gas prices in *AEO2005*. Production from mines west of the Mississippi River is expected to provide the largest share of the incremental coal production. In 2025, nearly two-thirds of coal production is projected to originate from the western States.

### Carbon Dioxide Emissions

Carbon dioxide emissions from energy use are projected to increase from 5,789 million metric tons in 2003 to 8,062 million metric tons in 2025 in *AEO2005*, an average annual increase of 1.5 percent (Figure 8). The carbon dioxide emissions intensity of the U.S. economy is projected to fall from 558 metric tons per million dollars of GDP in 2003 to 397 metric tons per million dollars in 2025—an average decline

of 1.5 percent per year. In comparison, *AEO2004* projected a 1.4-percent average annual decline in emissions intensity and 8,142 million metric tons of carbon dioxide emissions in 2025.

By sector, projected carbon dioxide emissions from the residential, commercial, and electric power sectors in 2025 are higher in *AEO2005* than they were in *AEO2004* because of higher projected energy consumption in each of those sectors (particularly, electricity consumption in the residential and commercial sectors and natural gas and petroleum consumption for electricity generation in the electric power sector), whereas *AEO2005* projects lower energy consumption in the industrial and transportation sectors in 2025 and lower carbon dioxide emissions in both sectors than were projected in *AEO2004*. In the electric power sector, the higher *AEO2005* projections for carbon dioxide emissions from natural gas and petroleum use for generation more than offset the lower projection for emissions from coal-fired generation. In total, however, the lower levels of carbon dioxide emissions projected for the industrial and transportation sectors in 2025 outweigh the higher levels projected for the other energy-consuming sectors, so that total emissions in 2025 are lower in the *AEO2005* forecast than they were in *AEO2004*. The *AEO* projections do not include future policy actions or agreements that might be taken to reduce carbon dioxide emissions.

### Note

[1] The projections in *AEO2005* are based on Federal and State laws and regulations in effect on October 31, 2004. The potential impacts of pending or proposed legislation, regulations, and standards—or of sections of legislation that have been enacted but that require funds or implementing regulations that have not been provided or specified—are not reflected in the projections.

**Figure 8. Projected U.S. carbon dioxide emissions by sector and fuel, 1990-2025 (million metric tons)**

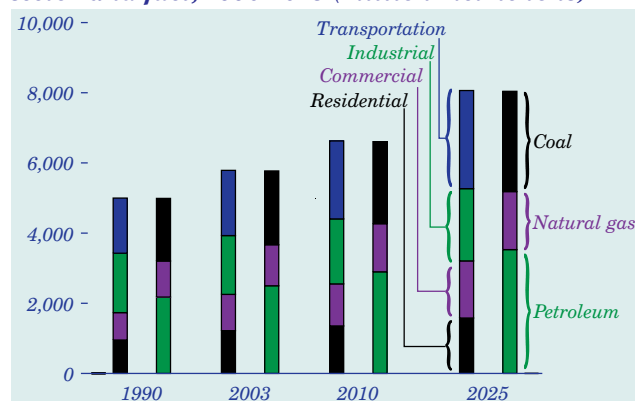




Table 1. Total energy supply and disposition in the AEO2005 reference case: summary, 2002-2025

Energy and economic factors	2002	2003	2010	2015	2020	2025	Average annual change, 2003-2025
<b>Primary energy production (quadrillion Btu)</b>							
Petroleum . . . . .	14.71	14.38	15.41	14.31	13.83	12.82	-0.5%
Dry natural gas . . . . .	19.48	19.58	20.97	21.33	22.48	22.42	0.6%
Coal . . . . .	22.70	22.66	25.10	25.56	27.04	29.90	1.3%
Nuclear power . . . . .	8.14	7.97	8.49	8.62	8.67	8.67	0.4%
Renewable energy . . . . .	5.79	5.89	6.85	7.13	7.57	8.10	1.5%
Other . . . . .	1.12	0.93	0.97	0.78	0.77	0.82	-0.5%
<b>Total . . . . .</b>	<b>71.94</b>	<b>71.42</b>	<b>77.79</b>	<b>77.73</b>	<b>80.35</b>	<b>82.73</b>	<b>0.7%</b>
<b>Net imports (quadrillion Btu)</b>							
Petroleum . . . . .	22.64	24.10	28.61	33.10	36.87	41.11	2.5%
Natural gas . . . . .	3.59	3.32	5.06	7.19	8.08	8.87	4.6%
Coal/other (- indicates export) . . . . .	-0.47	-0.43	-0.14	0.19	0.25	0.58	NA
<b>Total . . . . .</b>	<b>25.75</b>	<b>26.99</b>	<b>33.53</b>	<b>40.47</b>	<b>45.21</b>	<b>50.55</b>	<b>2.9%</b>
<b>Consumption (quadrillion Btu)</b>							
Petroleum products . . . . .	38.41	39.09	44.84	48.07	51.30	54.42	1.5%
Natural gas . . . . .	23.59	22.54	26.11	28.69	30.73	31.47	1.5%
Coal . . . . .	21.98	22.71	24.95	25.71	27.27	30.48	1.3%
Nuclear power . . . . .	8.14	7.97	8.49	8.62	8.67	8.67	0.4%
Renewable energy . . . . .	5.79	5.89	6.85	7.13	7.57	8.10	1.5%
Other . . . . .	0.07	0.02	0.03	0.07	0.05	0.04	4.1%
<b>Total . . . . .</b>	<b>97.99</b>	<b>98.22</b>	<b>111.27</b>	<b>118.29</b>	<b>125.60</b>	<b>133.18</b>	<b>1.4%</b>
<b>Petroleum (million barrels per day)</b>							
Domestic crude production . . . . .	5.74	5.68	6.02	5.49	5.21	4.73	-0.8%
Other domestic production . . . . .	3.60	3.38	3.59	3.77	4.00	4.10	0.9%
Net imports . . . . .	10.54	11.24	13.37	15.40	17.11	19.11	2.4%
Consumption . . . . .	19.71	20.00	22.98	24.67	26.32	27.93	1.5%
<b>Natural gas (trillion cubic feet)</b>							
Production . . . . .	19.03	19.13	20.49	20.85	21.97	21.91	0.6%
Net imports . . . . .	3.50	3.24	4.94	7.02	7.89	8.66	4.6%
Consumption . . . . .	22.98	21.95	25.44	27.96	29.95	30.67	1.5%
<b>Coal (million short tons)</b>							
Production . . . . .	1,105	1,083	1,238	1,270	1,345	1,488	1.5%
Net imports . . . . .	-23	-18	-9	3	7	20	NA
Consumption . . . . .	1,066	1,095	1,229	1,273	1,352	1,508	1.5%
<b>Prices (2003 dollars)</b>							
World oil price (dollars per barrel) . . . . .	24.10	27.73	25.00	26.75	28.50	30.31	0.4%
Domestic natural gas at wellhead (dollars per thousand cubic feet) . . . . .	3.06	4.98	3.64	4.16	4.53	4.79	-0.2%
Domestic coal at minemouth (dollars per short ton) . . . . .	18.23	17.93	17.30	16.89	17.25	18.26	0.1%
Average electricity price (cents per kilowatthour) . . . . .	7.4	7.4	6.6	6.9	7.2	7.3	-0.1%
<b>Economic indicators</b>							
Real gross domestic product (billion 2000 dollars) . . . . .	10,075	10,381	13,084	15,216	17,634	20,292	3.1%
GDP chain-type price index (index, 2000=1.000) . . . . .	1.041	1.060	1.218	1.373	1.563	1.814	2.5%
Real disposable personal income (billion 2000 dollars) . . . . .	7,560	7,734	9,594	11,192	12,783	14,990	3.1%
Value of manufacturing shipments (billion 1996 dollars) . . . . .	5,067	5,105	6,165	6,850	7,633	8,469	2.3%
<b>Energy intensity (thousand Btu per 2000 dollar of GDP) . . . . .</b>	<b>9.73</b>	<b>9.47</b>	<b>8.51</b>	<b>7.78</b>	<b>7.13</b>	<b>6.57</b>	<b>-1.6%</b>
<b>Carbon dioxide emissions (million metric tons) . . . . .</b>	<b>5,751</b>	<b>5,789</b>	<b>6,627</b>	<b>7,052</b>	<b>7,520</b>	<b>8,062</b>	<b>1.5%</b>

Notes: Quantities are derived from historical volumes and assumed thermal conversion factors. Other production includes liquid hydrogen, methanol, supplemental natural gas, 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. Some refinery inputs appear as petroleum product consumption. Other consumption includes net electricity imports, liquid hydrogen, and methanol.

Source: AEO2005 National Energy Modeling System, run AEO2005.D102004A.

## The October oil futures case

The recent experience with higher and more volatile oil prices has added to uncertainty about the long-term path of crude oil prices. The *AEO2005* reference case assumes that world crude oil prices, defined by the average U.S. refiner's acquisition cost of imported crude oil (IRAC), will decline as consumption slows and producers increase their productive capacity and output in response to current high prices, whereas October oil futures prices for West Texas Intermediate crude oil (WTI) on the New York Mercantile Exchange (NYMEX) implied that the average annual oil price in 2005 will exceed its 2004 level before falling back somewhat, to levels that still would be above those projected in the reference case (even after correcting for the difference between the WTI and average IRAC prices).

To evaluate the likely effects of that possible price path on the U.S. energy economy, *AEO2005* includes an *October oil futures case*, which is based on an extrapolation of IRAC oil prices loosely corresponding to the recent mid-term profile of WTI prices on the NYMEX futures market. In the October oil futures case, world crude oil prices are assumed to average \$44 per barrel in 2005 (in 2003 dollars) before falling to about \$31 per barrel in 2010—about \$6 per barrel higher than the reference case projection. Prices are assumed to remain above those in the reference case over the entire projection and to be about \$5 per barrel higher than the reference case projection in 2025, at \$35 per barrel (see figure below).

The *AEO2005* reference case and October oil futures case are based on different assumptions about oil production from the Organization of Petroleum Exporting Countries (OPEC)—higher in

the reference case and lower in the October oil futures case—reflecting uncertainty about future levels of production from the Persian Gulf region. OPEC is assumed to be the principal source of the marginal supply needed to meet increases in demand; consequently, OPEC production varies more than non-OPEC production in response to changes in demand requirements. OPEC production in 2025 is projected to be about 55 million barrels per day in the reference case and about 50 million barrels per day in the October oil futures case.

U.S. domestic consumption of petroleum in 2025 is projected to be slightly lower in the October oil futures case than in the reference case (27.3 million and 27.9 million barrels per day, respectively). Most of the difference is the result of lower projected demand for transportation fuels in the October oil futures case. In 2025, total demand for petroleum in the U.S. transportation sector is projected to be 19.5 million barrels per day in the October oil futures case, compared with 19.8 million barrels per day in the reference case.

Higher oil prices in the October oil futures case are projected to have a small impact on U.S. economic activity, primarily in the first 5 years of the forecast. From 2005 to 2010, U.S. gross domestic product (GDP) is a cumulative \$194 billion (about 0.3 percent) lower in the October oil futures case than in the reference case. By 2025, however, the GDP projections are nearly identical in the reference and October oil futures cases. The projections for electricity and natural gas prices are not appreciably different in the two cases, which differ primarily in their projections for the delivered price of petroleum products, with impacts mainly in the transportation sector.

In response to higher oil prices, total domestic petroleum supply in 2025 is projected to be higher in the October oil futures case (9.3 million barrels per day) than in the reference case (8.8 million barrels per day), which in combination with the lower demand projection leads to a lower projected level of total petroleum imports in the October oil futures case. Including crude oil and refined products, total net imports in the October oil futures case (18.0 million barrels per day) are 1.1 million barrels per day lower than in the reference case (19.1 million barrels per day). As a result, the import share of total U.S. petroleum demand is 66 percent in the October oil futures

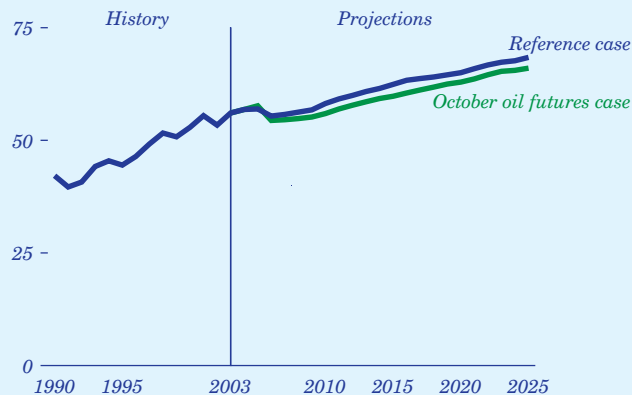
**World oil prices in two cases, 1990-2025**  
(2003 dollars per barrel)



(continued on page 11)

***The October oil futures case (continued)***

case, compared with 68 percent in the reference case (see figure below). In 2003, the import share of U.S. demand was 56 percent.

***U.S. import share of petroleum products supplied in two cases, 1990-2025 (percent)***

In the U.S. energy market, the transportation sector consumes about two-thirds of all petroleum products and the industrial sector about one-quarter. The remaining 10 percent is divided among the residential, commercial, and electric power sectors. With limited opportunities for fuel switching in the transportation and industrial sectors, large price-induced changes in U.S. petroleum consumption are unlikely, unless changes in petroleum prices are very large or there are significant changes in the efficiencies of petroleum-using equipment. The results of the October oil futures case indicate that sustained increases in world oil prices would have to be significantly greater than those assumed for this case in order to have a major impact on U.S. energy markets.

The table on page 12 summarizes key projections from the October oil futures forecast.

## AEO2005 Overview

### Total energy supply and disposition in the October oil futures case: summary, 2002-2025

Energy and economic factors	2002	2003	2010	2015	2020	2025	Average annual change, 2003-2025
<b>Primary energy production (quadrillion Btu)</b>							
Petroleum .....	14.71	14.38	15.75	14.98	14.21	13.38	-0.3%
Dry natural gas .....	19.48	19.58	21.34	21.89	23.09	22.72	0.7%
Coal .....	22.70	22.66	25.05	25.52	27.07	29.91	1.3%
Nuclear power .....	8.14	7.97	8.49	8.62	8.67	8.67	0.4%
Renewable energy .....	5.79	5.89	6.85	7.15	7.60	8.26	1.5%
Other .....	1.12	0.93	1.16	0.94	0.90	0.97	0.2%
<b>Total .....</b>	<b>71.94</b>	<b>71.42</b>	<b>78.64</b>	<b>79.09</b>	<b>81.54</b>	<b>83.91</b>	<b>0.7%</b>
<b>Net imports (quadrillion Btu)</b>							
Petroleum .....	22.64	24.10	27.15	31.23	35.09	38.96	2.2%
Natural gas .....	3.59	3.32	4.85	6.96	7.96	8.81	4.5%
Coal/other (- indicates export) .....	-0.47	-0.43	-0.14	0.19	0.26	0.59	NA
<b>Total .....</b>	<b>25.75</b>	<b>26.99</b>	<b>31.85</b>	<b>38.37</b>	<b>43.31</b>	<b>48.36</b>	<b>2.7%</b>
<b>Consumption (quadrillion Btu)</b>							
Petroleum products .....	38.41	39.09	43.98	47.11	50.22	53.21	1.4%
Natural gas .....	23.59	22.54	26.29	29.01	31.21	31.71	1.6%
Coal .....	21.98	22.71	24.91	25.67	27.31	30.50	1.3%
Nuclear power .....	8.14	7.97	8.49	8.62	8.67	8.67	0.4%
Renewable energy .....	5.79	5.89	6.85	7.15	7.61	8.27	1.5%
Other .....	0.07	0.02	0.03	0.07	0.05	0.04	4.6%
<b>Total .....</b>	<b>97.99</b>	<b>98.22</b>	<b>110.55</b>	<b>117.63</b>	<b>125.07</b>	<b>132.40</b>	<b>1.4%</b>
<b>Petroleum (million barrels per day)</b>							
Domestic crude production .....	5.74	5.68	6.16	5.78	5.36	4.98	-0.6%
Other domestic production .....	3.60	3.38	3.77	3.94	4.19	4.30	1.1%
Net imports .....	10.54	11.24	12.61	14.45	16.21	18.03	2.2%
Consumption .....	19.71	20.00	22.54	24.17	25.76	27.30	1.4%
<b>Natural gas (trillion cubic feet)</b>							
Production .....	19.03	19.13	20.85	21.38	22.55	22.19	0.7%
Net imports .....	3.50	3.24	4.73	6.79	7.77	8.60	4.5%
Consumption .....	22.98	21.95	25.61	28.27	30.42	30.91	1.6%
<b>Coal (million short tons)</b>							
Production .....	1,105	1,083	1,235	1,268	1,344	1,484	1.4%
Net imports .....	-23	-18	-9	3	7	20	NA
Consumption .....	1,066	1,095	1,227	1,271	1,351	1,505	1.5%
<b>Prices (2003 dollars)</b>							
World oil price (dollars per barrel) .....	24.10	27.73	30.99	32.33	33.67	35.00	1.1%
Domestic natural gas at wellhead (dollars per thousand cubic feet) .....	3.06	4.98	3.63	4.11	4.45	4.83	-0.1%
Domestic coal at minemouth (dollars per short ton) .....	18.23	17.93	17.45	16.99	17.54	18.52	0.1%
Average electricity price (cents per kilowatthour) .....	7.4	7.4	6.6	7.0	7.2	7.3	-0.1%
<b>Economic indicators</b>							
Real gross domestic product (billion 2000 dollars) .....	10,075	10,381	13,063	15,216	17,641	20,293	3.1%
GDP chain-type price index (index, 2000=1.000) .....	1.041	1.060	1.219	1.371	1.559	1.811	2.5%
Real disposable personal income (billion 2000 dollars) .....	7,560	7,734	9,540	11,152	12,745	14,945	3.0%
Value of manufacturing shipments (billion 1996 dollars) .....	5,067	5,105	6,167	6,872	7,669	8,506	2.3%
<b>Energy intensity (thousand Btu per 2000 dollar of GDP) .....</b>	<b>9.73</b>	<b>9.47</b>	<b>8.47</b>	<b>7.74</b>	<b>7.09</b>	<b>6.53</b>	<b>-1.7%</b>
<b>Carbon dioxide emissions (million metric tons) .....</b>	<b>5,751</b>	<b>5,789</b>	<b>6,561</b>	<b>6,988</b>	<b>7,461</b>	<b>7,981</b>	<b>1.5%</b>

Notes: Quantities are derived from historical volumes and assumed thermal conversion factors. Other production includes liquid hydrogen, methanol, supplemental natural gas, 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. Some refinery inputs appear as petroleum product consumption. Other consumption includes net electricity imports, liquid hydrogen, and methanol.

Source: AEO2005 National Energy Modeling System, run CF2005.D111104A.