

# Overview

## Key Energy Issues to 2020

Over the past year, energy markets have been extremely volatile, with high prices for oil and natural gas and concerns for energy shortages earlier in the year giving way to an economic slowdown and lower prices following the September terrorist attacks in the United States. Those events are incorporated in the short-term projections for the *Annual Energy Outlook 2002 (AEO2002)*, but long-term volatility in energy markets is not expected to result from their impacts or from the impacts of such future events as supply disruptions or severe weather. *AEO2002* focuses on long-term events, including the supplies and prices of fossil fuels, the development of U.S. electricity markets, technology improvement, and the impact of economic growth on projected energy demand and carbon dioxide emissions through 2020.

The *AEO2002* projections assume a transition to full competitive pricing of electricity in States with specific deregulation plans. Other States are assumed to continue cost-of-service pricing. The projections include recent delays in restructuring plans in several States, as discussed in “Legislation and Regulations,” pages 11-13. Problems in California have slowed the trend to restructuring, and retail access in the State has been suspended. The projections include the contracts entered into by California to guarantee electricity supplies in the State, leading to higher electricity prices than in the *Annual Energy Outlook 2001 (AEO2001)*. Increased competition in electricity markets is also represented through changes in the financial structure of the industry and efficiency and operating improvements.

World oil prices remained relatively high through most of 2001, largely due to actions by the Organization of Petroleum Exporting Countries (OPEC) and some non-OPEC countries to restrain oil production. U.S. natural gas prices achieved record levels in 2001 due to a cold winter and tight supplies caused by reduced drilling in response to low prices in 1998 and 1999. Electricity prices also reached record levels in California, as a result of restructuring difficulties, tight natural gas markets, low hydroelectric generation levels, and other generation problems. Energy prices began to decline later in 2001, however, in response to the slowing economy and more normal supply markets for natural gas and electricity.

## Economic Growth

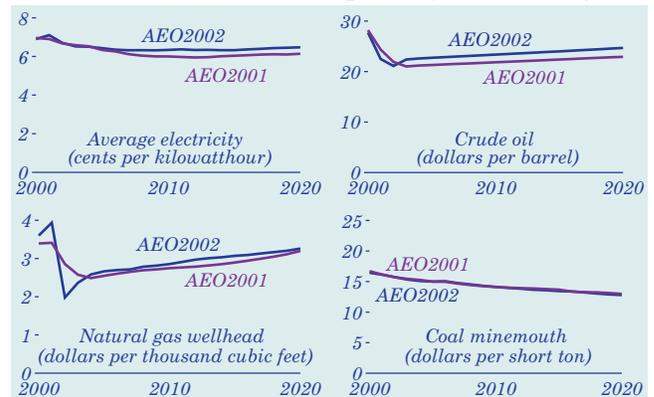
Although there was an economic slowdown in the United States in 2001, in the long term the U.S.

economy, as measured by gross domestic product (GDP), is projected to grow at an average annual rate of 3.0 percent from 2000 to 2020, similar to the rate of 2.9 percent projected in *AEO2001* for the same period. Most of the determinants of economic growth are similar to those projected in *AEO2001*, but there are some differences. For example, commercial floorspace is expected to increase at an average annual rate of 1.7 percent through 2020, as compared with 1.2 percent in *AEO2001*. The *AEO2002* projection has a significant impact on energy demand in the forecast for that sector and is more consistent with recent historical trends.

## Energy Prices

The average world oil price is projected to decline from \$27.72 per barrel in 2000 (2000 dollars) to \$22.48 per barrel in 2001, before beginning a gradual increase after 2002. In 2020, the projected price reaches \$24.68 per barrel (Figure 1), as compared with \$22.92 per barrel projected in *AEO2001*, largely due to higher projected world oil demand. Because of the effectiveness of OPEC in managing oil production and the generally slow response of non-OPEC supply to higher world oil prices, projected prices in the years following 2002 remain higher than in *AEO2001*.

**Figure 1. Energy price projections, 2000-2020: AEO2001 and AEO2002 compared (2000 dollars)**



World oil demand is projected to increase from 76.0 million barrels per day in 2000 to 118.9 million barrels per day in 2020, higher than the *AEO2001* projection of 117.4 million barrels per day, due to higher projected demand in the United States and developing countries, including the Pacific Rim and Central and South America. Growth in oil production in both OPEC and non-OPEC nations leads to the relatively slow growth of prices through 2020. OPEC oil production is expected to reach 57.5 million barrels per day in 2020, nearly double the 30.9 million barrels

per day produced in 2000, assuming sufficient capital to expand production capacity.

Non-OPEC oil production is expected to increase from 45.7 to 61.1 million barrels per day between 2000 and 2020, 1.7 million barrels per day higher than projected in *AEO2001*, due to higher projected production in the Caspian Basin, offshore West Africa, and Brazil. Production from the Caspian Basin is expected to exceed 6.5 million barrels per day by 2020. By 2010, projected production in Brazil reaches nearly 2 million barrels per day and in the offshore regions of West Africa exceeds 2 million barrels per day. North Sea production is expected to peak in the middle of the current decade, reaching 7.5 million barrels per day, with a slower decline rate than earlier expected. By 2010, oil production in Mexico is expected to increase by 30 percent above current levels.

The average wellhead price of natural gas is projected to increase from \$3.60 per thousand cubic feet in 2000 to nearly \$4 per thousand cubic feet in 2001, then decline sharply in 2002. The price is expected to reach \$3.26 per thousand cubic feet in 2020, slightly higher than the projection of \$3.20 per thousand cubic feet in *AEO2001*. Although projected natural gas demand in 2020 is 1.0 trillion cubic feet lower than was projected in *AEO2001*, the price is expected to be higher due to a less optimistic assessment of natural gas reserves discovered by exploratory drilling. As the expected demand for natural gas increases over time, price increases are slowed by technological improvements in natural gas exploration and production. The transmission and distribution margins to electricity generators are projected to be higher than in *AEO2001*, under the assumption that generators will pay higher rates to guarantee deliverability, particularly as natural gas is expected to be used more for baseload and intermediate-load generation.

In *AEO2002*, the average minemouth price of coal is projected to decline from \$16.45 per ton in 2000 to \$12.79 per ton in 2020, slightly lower than the price of \$12.99 per ton projected in *AEO2001*. Higher projected demand in *AEO2002* is met by increased production from lower cost western mines. Through 2020, the price is expected to decline with increasing productivity in mining, a shift to western production, and competitive pressures on labor costs.

Average electricity prices are projected to decline from 6.9 cents per kilowatthour in 2000 to 6.5 cents per kilowatthour in 2020, higher than the 6.1 cents per kilowatthour projected for 2020 in *AEO2001*, due

to higher projections for natural gas prices, electricity demand, particularly in the commercial sector, and natural gas margins to electricity generators. Electricity industry restructuring contributes to declining projected prices through reductions in operating and maintenance costs, administrative costs, and other costs. Electricity prices are projected to decline to 6.3 cents per kilowatthour by 2006 then rise in the last 5 years of the forecast as natural gas prices rise. Federal Energy Regulatory Commission actions on open access and other changes for competitive markets enacted by some State public utility commissions are included in the projections, but because not all States have deregulated their electricity markets, the projections do not represent a fully restructured electricity market.

### Energy Consumption

Total energy consumption is projected to increase from 99.3 to 130.9 quadrillion British thermal units (Btu) between 2000 and 2020, an average annual increase of 1.4 percent. In 2020, this forecast is nearly 4 quadrillion Btu higher than in *AEO2001*, primarily due to higher projected energy demand in the commercial and transportation sectors. The projections incorporate efficiency standards for new energy-using equipment in buildings and for motors mandated through 1994 by the National Appliance Energy Conservation Act of 1987 and the Energy Policy Act of 1992, including the new residential and commercial equipment standards.

Residential energy consumption is projected to grow at an average rate of 1.0 percent per year, with the most rapid growth for computers, electronic equipment, and appliances. In 2020, the projected residential demand is 24.3 quadrillion Btu, slightly lower than projected in *AEO2001*. Lower projected energy demand, particularly for natural gas, results from 2-percent lower housing starts in 2020, higher projected natural gas prices, and the new equipment efficiency standards announced in January 2001, as revised by the Bush Administration.

Commercial energy demand is projected to grow at an average annual rate of 1.7 percent, reaching 23.2 quadrillion Btu in 2020, 2.4 quadrillion Btu higher than in *AEO2001*. Commercial floorspace is projected to grow by an average of 1.7 percent per year, as compared with 1.2 percent per year in *AEO2001*, raising the demand for energy for many end uses in the commercial sector. The January 2001 equipment standards have a smaller impact in the commercial sector than in the residential sector. The most rapid increases in demand are projected for computers,

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office equipment, and telecommunications and other equipment.

Industrial energy demand is projected to increase at an average rate of 1.1 percent per year, reaching 43.8 quadrillion Btu in 2020, slightly higher than in the *AEO2001* forecast. Industrial gross output is projected to grow at an average annual rate of 2.6 percent; however, the growth is partially offset by an average projected decline in industrial energy intensity of 1.5 percent per year. Contributing to this decline is a continuing projected shift to less energy-intensive industries. The average annual growth in non-energy-intensive manufacturing is expected to be 3.3 percent, compared with 1.2 percent for energy-intensive manufacturing.

Transportation energy demand is projected to grow at an average annual rate of 1.9 percent, to 39.6 quadrillion Btu in 2020, 1.1 quadrillion Btu higher than in *AEO2001*. The projected energy demand for light-duty vehicles and heavy trucks is higher in *AEO2002*, because a reevaluation of recent trends in both travel and efficiency indicates more rapid growth in travel and slower growth in efficiency. In 2020, projected efficiency for new cars, new light trucks, and heavy trucks is lower by 0.8, 0.9, and 0.6 miles per gallon, respectively, than in *AEO2001*.

Electricity demand is projected to grow by 1.8 percent per year from 2000 through 2020, the same rate as in *AEO2001*; however, demand in 2020 is 2 percent higher than in *AEO2001*. The most rapid growth is expected for computers, office equipment, and a variety of residential and commercial appliances and equipment.

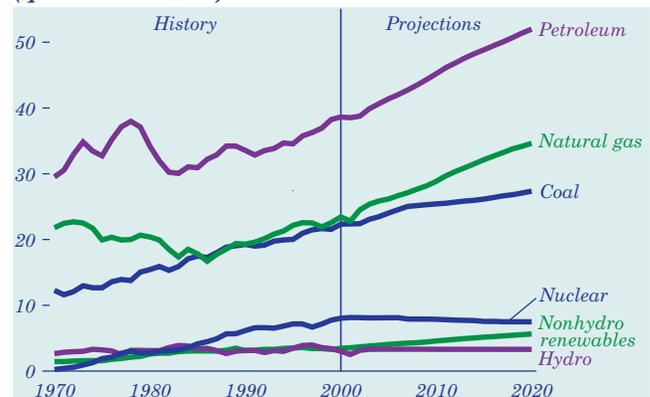
Demand for natural gas increases at an average annual rate of 2.0 percent (Figure 2), from 22.8 to 33.8 trillion cubic feet between 2000 and 2020, primarily due to rapid growth in demand for electricity generation. Total natural gas demand is projected to be 1.0 trillion cubic feet lower than in *AEO2001*, due to lower projected residential and electricity generation demand, offset in part by higher projected commercial demand.

In *AEO2002*, total coal consumption is projected to increase from 1,081 to 1,365 million tons between 2000 and 2020, an average increase of 1.2 percent per year. This projection is 68 million tons higher than the *AEO2001* projection due to higher projected demand for electricity generation, which constitutes about 90 percent of the domestic demand for coal.

Petroleum demand is projected to grow at an average annual rate of 1.5 percent through 2020, led by

growth in the transportation sector, which is expected to account for more than 70 percent of petroleum demand in 2020. Projected demand in 2020 is higher than in *AEO2001* by 830 thousand barrels per day due to higher transportation demand.

**Figure 2. Energy consumption by fuel, 1970-2020 (quadrillion Btu)**



Renewable fuel consumption, including ethanol for gasoline blending, is projected to grow at an average rate of 1.7 percent per year through 2020, primarily due to State mandates for renewable electricity generation. Nearly 55 percent of the projected demand for renewables in 2020 is for electricity generation and the rest for dispersed heating and cooling, industrial uses, including cogeneration, and fuel blending. The projected demand for renewable fuels in 2020 is 0.7 quadrillion Btu higher than in *AEO2001*, mainly due to higher use of biomass for industrial cogeneration and increased generation from geothermal and wind energy.

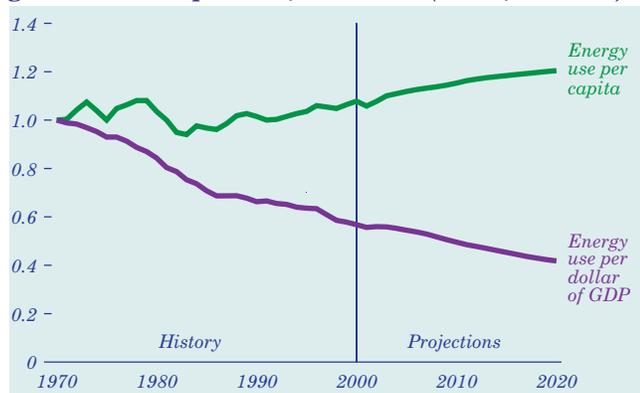
### Energy Intensity

Between 1970 and 1986, energy intensity, measured as energy use per dollar of GDP, declined at an average annual rate of 2.3 percent as the economy shifted to less energy-intensive industries and more efficient technologies in light of energy price increases (Figure 3). With slower price increases and growth of more energy-intensive industries, intensity declines moderated to an average of 1.5 percent per year between 1986 and 2000. Energy intensity is projected to continue to decline at an average annual rate of 1.5 percent through 2020, as continuing efficiency gains and structural shifts in the economy offset growth in demand for energy services.

Energy use per person generally declined from 1970 through the mid-1980s, increasing when energy prices declined. Per capita energy use increases slightly in the forecast, with efficiency gains only

partially offsetting higher demand for energy services.

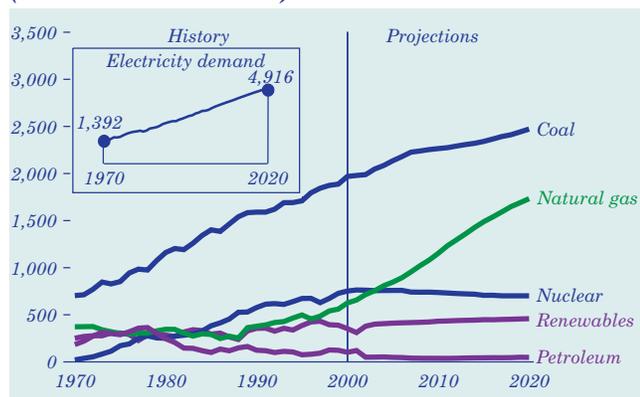
**Figure 3. Energy use per capita and per dollar of gross domestic product, 1970-2020 (index, 1970 = 1)**



### Electricity Generation

Generation from natural gas, coal, and renewable fuels is projected to increase through 2020 to meet growing demand for electricity and offset the projected retirement of some existing fossil-fuel-fired and nuclear units (Figure 4). The projected levels of generation from power plants using coal, nuclear, and renewable fuels are higher than in *AEO2001* due to higher projected electricity demand, assumed improvements in the operating costs and performance of nuclear plants, and higher natural gas prices, which reduce natural-gas-fired generation relative to *AEO2001*. The share of generation from natural gas is projected to increase from 16 percent in 2000 to 32 percent in 2020, and the share from coal is projected to decline from 52 percent to 46 percent as a more competitive electricity industry invests in the less capital-intensive and more efficient natural gas generation technologies.

**Figure 4. Electricity generation by fuel, 1970-2020 (billion kilowatthours)**



Nuclear generating capacity is projected to decline from 2000 to 2020, but a reevaluation of the aging-related costs for nuclear plants and the expectation of higher natural gas prices lead to a higher projection than in *AEO2001*. Nuclear plant retirements in the forecast are based on the cost of maintaining operation compared with the cost of new capacity. Of the 98 gigawatts of nuclear capacity available in 2000, 10 gigawatts are projected to be retired by 2020, as compared with 26 gigawatts of retirements in *AEO2001*. No new nuclear plants are expected to be constructed by 2020 in the reference case, based on the relative economics of alternative technologies.

Renewable technologies are projected to grow slowly because of the relatively low costs of fossil-fired generation and because competitive electricity markets favor less capital-intensive natural gas technologies over coal and baseload renewables. Where enacted, State renewable portfolio standards, which specify a minimum share of generation or sales from renewable sources, contribute to the growth of renewables. With higher expected levels of industrial cogeneration and wind and geothermal generation, total renewable generation, including cogenerators, is projected to increase by 1.3 percent per year to a 2020 level that is slightly higher than in *AEO2001*.

### Energy Production and Imports

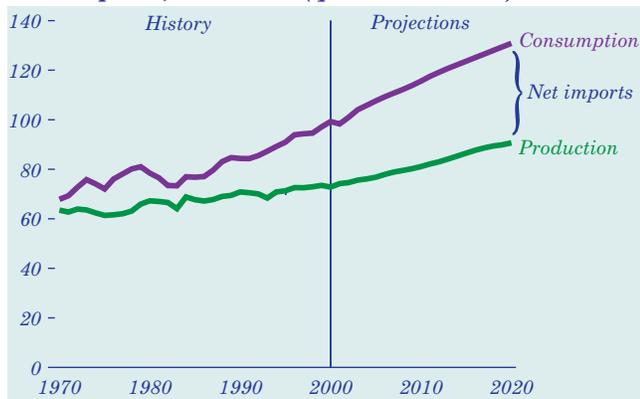
Total energy consumption is expected to increase more rapidly than domestic energy production through 2020. As a result, net imports of energy are projected to meet a growing share of energy demand (Figure 5). Projected U.S. crude oil production declines at an average annual rate of 0.2 percent from 2000 to 2020, to 5.6 million barrels per day. Production is projected to increase in the latter half of the forecast and is 0.6 million barrels per day higher in 2020 than in *AEO2001*, due to production from more fields in the National Petroleum Reserve-Alaska, which is expected to begin in 2010. As a result of projected increases in natural gas plant liquids production, total petroleum production is expected to increase through 2020 (Figure 6). Increasing demand for petroleum is projected to raise the share of demand met by net imports from 53 percent in 2000 to 62 percent in 2020 (lower than the 64-percent share in *AEO2001*, due to higher domestic production).

As demand for natural gas increases in the forecast, production is expected to increase from 19.1 to 28.5 trillion cubic feet between 2000 and 2020, an average

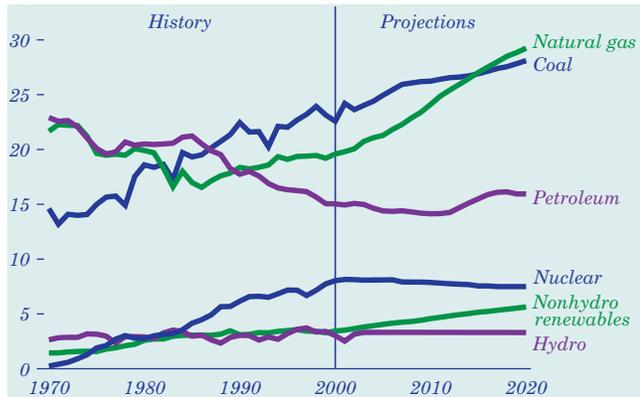
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annual rate of 2.0 percent. Projected production in 2020 is 0.6 trillion cubic feet lower than in *AEO2001*, because the projected rate of growth in demand is lower in *AEO2002*. Net imports, primarily from Canada, are projected to increase from 3.5 to 5.5 trillion cubic feet between 2000 and 2020. Net imports of liquefied natural gas (LNG) are projected to increase to 0.8 trillion cubic feet by 2020. The remaining two of the four existing U.S. LNG import facilities have announced plans to reopen, and three of the four have announced capacity expansion plans.

**Figure 5. Total energy production and consumption, 1970-2020 (quadrillion Btu)**



**Figure 6. Energy production by fuel, 1970-2020 (quadrillion Btu)**



U.S. coal production is projected to increase at an average annual rate of 1.3 percent, from 1,084 million tons in 2000 to 1,397 million tons in 2020, as domestic demand grows. Projected production in 2020 is 66 million tons higher than in *AEO2001*. Coal exports are projected to decline slightly through 2020, as European demand for imports declines as a result of environmental concerns and competition from other producers.

Renewable energy production is projected to increase from 6.5 to 8.9 quadrillion Btu between 2000 and 2020, with growth in industrial biomass, ethanol, and all sources of renewable electricity generation, with the exception of solar. Renewable energy production in 2020 is 0.6 quadrillion Btu higher than projected in *AEO2001*, due to higher expected levels of industrial cogeneration and generation from geothermal and wind energy.

## Carbon Dioxide Emissions

Carbon dioxide emissions from energy use are projected to increase at an average rate of 1.5 percent per year, from 1,562 million metric tons carbon equivalent in 2000 to 2,088 million in 2020 (Figure 7). Projected emissions in 2020 are higher by 47 million metric tons carbon equivalent than in *AEO2001*, due to higher projected energy demand in the commercial and transportation sectors and more coal-fired electricity generation than in *AEO2001*. The higher projection for nuclear generation in *AEO2002* offsets some of the increase that would otherwise be expected to result from new fossil-fired capacity, but carbon dioxide emissions still are expected to increase more rapidly than total energy consumption, as a result of increasing use of fossil fuels, a slight decline in nuclear generation, and slow growth in renewable generation.

The projections do not include future actions that might be taken to reduce carbon dioxide emissions but do include voluntary actions to reduce energy demand and emissions. Carbon dioxide emissions and international negotiations for emissions reductions are discussed on pages 22-25. Special analyses of emissions reductions, including carbon dioxide, are summarized on pages 37-50.

**Figure 7. Projected U.S. carbon dioxide emissions by sector and fuel, 1990-2020 (million metric tons carbon equivalent)**

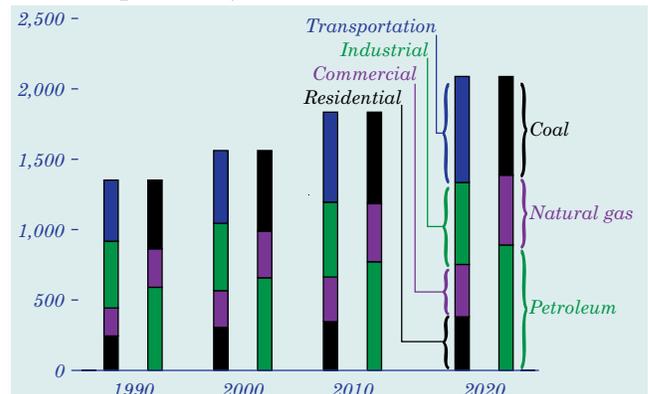


Table 1. Summary of results for five cases

Sensitivity Factors	1999	2000	2020				
			Reference	Low Economic Growth	High Economic Growth	Low World Oil Price	High World Oil Price
<b>Primary Production (quadrillion Btu)</b>							
Petroleum . . . . .	15.06	15.04	15.95	15.52	16.39	14.40	17.73
Natural Gas . . . . .	19.20	19.59	29.25	27.98	29.72	28.54	30.03
Coal . . . . .	23.15	22.58	28.11	26.88	30.08	27.58	29.04
Nuclear Power . . . . .	7.74	8.03	7.49	7.38	7.49	7.31	7.58
Renewable Energy . . . . .	6.69	6.46	8.93	8.59	9.37	8.90	8.97
Other . . . . .	1.66	1.10	0.93	0.91	0.73	0.40	1.06
<b>Total Primary Production . . . . .</b>	<b>73.50</b>	<b>72.80</b>	<b>90.66</b>	<b>87.26</b>	<b>93.79</b>	<b>87.13</b>	<b>94.40</b>
<b>Net Imports (quadrillion Btu)</b>							
Petroleum (including SPR) . . . . .	21.19	22.28	35.04	32.39	38.25	38.65	31.51
Natural Gas . . . . .	3.50	3.60	5.64	5.12	6.40	5.90	5.17
Coal/Other (- indicates export) . . . . .	-0.96	-0.77	-0.29	-0.38	-0.15	-0.31	-0.29
<b>Total Net Imports . . . . .</b>	<b>23.73</b>	<b>25.11</b>	<b>40.39</b>	<b>37.13</b>	<b>44.49</b>	<b>44.25</b>	<b>36.40</b>
Discrepancy . . . . .	0.13	-1.37	0.20	0.25	0.04	-0.04	0.51
<b>Consumption (quadrillion Btu)</b>							
Petroleum Products . . . . .	38.25	38.63	51.99	48.84	55.60	53.78	50.96
Natural Gas . . . . .	22.57	23.43	34.63	32.84	35.87	34.17	34.04
Coal . . . . .	21.56	22.34	27.35	26.08	29.41	26.83	28.27
Nuclear Power . . . . .	7.74	8.03	7.49	7.38	7.49	7.31	7.58
Renewable Energy . . . . .	6.70	6.48	8.94	8.59	9.38	8.91	8.98
Other . . . . .	0.28	0.38	0.44	0.40	0.48	0.42	0.46
<b>Total Consumption . . . . .</b>	<b>97.10</b>	<b>99.29</b>	<b>130.85</b>	<b>124.13</b>	<b>138.24</b>	<b>131.42</b>	<b>130.29</b>
<b>Prices (2000 dollars)</b>							
World Oil Price (dollars per barrel) . . . . .	17.60	27.72	24.68	23.45	25.81	17.64	30.58
Domestic Natural Gas at Wellhead (dollars per thousand cubic feet) . . . . .	2.27	3.60	3.26	2.94	3.65	3.07	3.40
Domestic Coal at Minemouth (dollars per short ton) . . . . .	17.01	16.45	12.79	12.56	13.23	12.67	12.95
Average Electricity Price (cents per kilowatthour) . . . . .	6.7	6.9	6.5	6.2	6.8	6.4	6.5
<b>Economic Indicators</b>							
Real Gross Domestic Product (billion 1996 dollars) . . . . .	8,857	9,224	16,525	14,901	18,102	16,561	16,496
(annual change, 2000-2020) . . . . .	—	—	3.0%	2.4%	3.4%	3.0%	2.9%
GDP Chain-Type Price Index (index, 1996=1.00) . . . . .	1.047	1.070	1.826	2.067	1.608	1.797	1.859
(annual change, 2000-2020) . . . . .	—	—	2.7%	3.3%	2.1%	2.6%	2.8%
Real Disposable Personal Income (billion 1996 dollars) . . . . .	6,320	6,539	11,698	10,791	12,541	11,685	11,723
(annual change, 2000-2020) . . . . .	—	—	3.0%	2.5%	3.3%	2.9%	3.0%
Gross Manufacturing Output (billion 1992 dollars) . . . . .	3,804	4,022	7,003	6,473	8,023	7,026	6,977
(annual change, 2000-2020) . . . . .	—	—	2.8%	2.4%	3.5%	2.8%	2.8%
<b>Energy Intensity</b>							
(thousand Btu per 1996 dollar of GDP) . . . . .	10.97	10.77	7.92	8.34	7.64	7.94	7.90
(annual change, 2000-2020) . . . . .	—	—	-1.5%	-1.3%	-1.7%	-1.5%	-1.5%
<b>Carbon Dioxide Emissions</b>							
(million metric tons carbon equivalent) . . . . .	1,517	1,562	2,088	1,980	2,215	2,103	2,083
(annual change, 2000-2020) . . . . .	—	—	1.5%	1.2%	1.8%	1.5%	1.5%

Notes: Specific assumptions underlying the alternative cases are defined in the Economic Activity and International Oil Markets sections beginning on page 56. 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.

Sources: Tables A1, A19, A20, B1, B19, B20, C1, C19, and C20.

# Legislation and Regulations

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