

Overview

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Key Energy Issues to 2020

Currently, most attention in energy markets is focused on near-term issues of world oil supply and prices, U.S. natural gas prices, and the transition to restructured electricity markets in several regions of the country. The *Annual Energy Outlook 2001 (AEO2001)* addresses the longer-term trends of electricity industry restructuring, fossil fuel supply and prices, and the impacts of economic growth on projected energy use and carbon dioxide emissions. *AEO2001* does not project short-term events, such as supply disruptions or severe weather.

The *AEO2001* projections assume a transition to full competitive pricing of electricity in States with specific deregulation plans—California, New York, New England, the Mid-Atlantic States, Illinois, Texas, Oklahoma, Michigan, Ohio, Arizona, New Mexico, and West Virginia. Other States are assumed to continue cost-of-service electricity pricing. A transition from regulated to competitive prices over a 10-year period from the beginning of restructuring in each region, and implementation of the provisions of California legislation regarding price caps, are assumed. Increased competition in electricity markets is also represented through assumed changes in the financial structure of the industry and efficiency and operating improvements.

World oil prices fell sharply through most of 1997 and 1998, due in part to economic developments in East Asia and the resulting oversupply of oil. Beginning in 1999, actions by the Organization of Petroleum Exporting Countries (OPEC) and some non-OPEC countries to restrain oil production have increased world oil prices. U.S. natural gas prices have also increased in 2000 due to higher than expected demand and to tight supplies caused by reduced drilling in reaction to low prices in 1998. Oil and gas markets are addressed on pages 27 and 28.

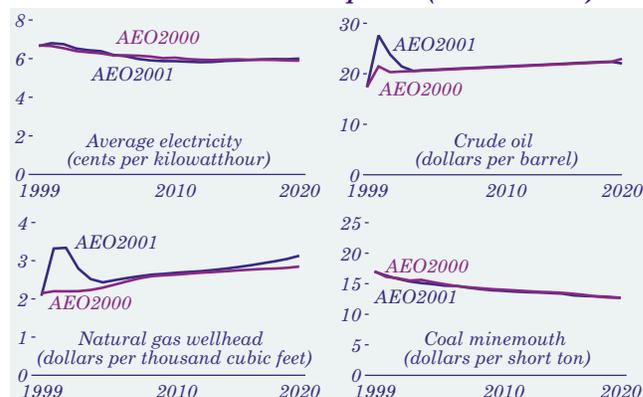
The projected growth rate of the U.S. economy, measured by gross domestic product (GDP), is considerably higher in *AEO2001* than in *AEO2000*, an average annual rate of 3.0 percent from 1999 to 2020, compared with 2.1 percent in *AEO2000*. Although part of the upward revision results from statistical and definitional changes in the National Income and Product Accounts, the projections also reflect a more optimistic view of long-run economic growth, which results in higher forecasts of energy consumption and carbon dioxide emissions in *AEO2001* than in

AEO2000. The macroeconomic projections are discussed on pages 22 and 56.

Prices

The average world oil price is projected to increase from \$17.35 per barrel in 1999 (1999 dollars) to about \$27.60 per barrel in 2000, falling to about \$20.50 per barrel by 2003. In 2020, the projected price reaches \$22.41 per barrel (Figure 1), similar to the *AEO2000* projection of \$22.33 per barrel. Higher demand in the forecast is offset by higher resource estimates from the U.S. Geological Survey. Projected prices over the next several years are higher in *AEO2001* than in *AEO2000* due to the production cutbacks by OPEC and several non-OPEC nations, a lag in the response of non-OPEC producers to price increases, and renewed demand growth in Asia.

Figure 1. Fuel price projections, 1999-2020: AEO2000 and AEO2001 compared (1999 dollars)



World oil demand is projected to increase from 75.5 million barrels per day in 1999 to 117.4 million barrels per day in 2020—higher than the *AEO2000* projection of 112.4 million barrels per day—due to higher projected demand in the United States, the Middle East, the former Soviet Union, the Pacific Rim developing countries, and China. Projected growth in production in both OPEC and non-OPEC nations leads to relatively slow projected growth of prices through 2020. OPEC oil production is expected to reach 57.6 million barrels per day in 2020, nearly double the 29.9 million barrels per day in 1999, assuming sufficient capital to expand production capacity. The United Nations resolution limiting Iraqi oil exports is assumed to remain in place through 2001. Once sanctions are lifted, Iraqi oil production is expected to reach 3.5 million barrels per day within 2 years and about 5 million barrels per day within a decade.

The June 2000 recoverable oil resources assessment by the U.S. Geological Survey raised world resources by about 700 billion barrels from the 1994 assessment. As a result, non-OPEC oil production is expected to increase from 44.8 million barrels per day to 59.5 million barrels per day between 1999 and 2020, or 2.9 million barrels per day higher than in *AEO2000*. Production from the Caspian Basin is expected to reach 6 million barrels per day by 2020 with continued expansion of production from the offshore regions of West Africa and the North Sea. Both Brazil and Colombia are expected to be producing 1 million barrels per day before 2005, and production in Mexico and Canada is also expected to increase.

The average wellhead price of natural gas is projected to increase from \$2.08 per thousand cubic feet in 1999 to about \$3.30 per thousand cubic feet in 2000 and 2001, then decline through 2004. The projected price reaches \$3.13 per thousand cubic feet in 2020, \$0.28 per thousand cubic feet higher than in *AEO2000*, due to higher projected demand. Price increases are expected to be slowed by technological improvements in natural gas exploration and production. Average delivered prices are projected to increase at a slower rate than the wellhead price due to assumed cost reductions from efficiency improvements in the industry.

In *AEO2001*, the average minemouth price of coal is projected to decline from \$16.98 per ton in 1999 to \$12.70 per ton in 2020, the same price projected in *AEO2000*. Through 2020, the price is expected to decline due to increasing productivity in mining, a shift to lower-cost western production, and competitive pressures on labor costs.

Average electricity prices are projected generally to decline from 6.7 cents per kilowatthour in 1999 to 6.0 cents in 2020, increasing slightly at the end of the forecast due to rising natural gas prices. In 2020, the projected price is slightly higher than the 5.9 cents per kilowatthour projected in *AEO2000*. Higher projections for natural gas prices and for electricity demand—which would require more investment in new generating capacity—lead to the higher price projections. Electricity industry restructuring is expected to contribute to lower prices through reductions in operating and maintenance, administrative, and other costs. 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, as noted above. Because not all States have deregulated their electricity markets, the projections do not represent a fully restructured electricity market. State legislative actions to deregulate the electricity industry are discussed on page 41.

Consumption

Total energy consumption is projected to increase from 96.1 quadrillion British thermal units (Btu) to 127.0 quadrillion Btu between 1999 and 2020, an average annual increase of 1.3 percent. In 2020, this forecast is about 6 quadrillion Btu higher than projected in *AEO2000*, primarily because higher projected economic growth leads to higher demand forecasts in all end-use sectors.

Total residential energy consumption is projected to grow at an average rate of 1.2 percent per year, with the most rapid growth expected for computers, electronic equipment, and appliances. In 2020, the projected residential demand is 24.4 quadrillion Btu, 1.4 quadrillion Btu higher than in *AEO2000*. Higher projected economic growth results in higher forecasts for both disposable personal income and housing starts, increasing equipment purchases and raising the projected housing stock in 2020 by 1.5 percent. *AEO2001* also forecasts that new houses will become larger over time.

Commercial energy demand is projected to grow at an average annual rate of 1.4 percent, reaching 20.8 quadrillion Btu in 2020, 2.6 quadrillion Btu higher than in *AEO2000*. With higher projected economic growth in *AEO2001*, commercial floorspace is projected to grow more rapidly and, in 2020, is estimated to be 11 percent higher than projected in *AEO2000*. The most rapid increases in energy use are expected for computers, office equipment, and telecommunications and other equipment.

Industrial energy demand is projected to increase at an average rate of 1.0 percent per year, reaching 43.4 quadrillion Btu in 2020, 1.2 quadrillion Btu higher than in *AEO2000*. With higher projected economic growth, total industrial gross output is estimated to grow at an average annual rate of 2.6 percent from 1999 to 2020, compared with 1.9 percent in *AEO2000*; however, recent data indicate more rapid improvements in industrial energy intensity than previously estimated. Also, average annual growth in non-energy-intensive manufacturing is expected to be 3.3 percent, compared with 1.2 percent for energy-intensive manufacturing. Through 2020,

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more rapid assumed declines in industrial energy intensity, compared with *AEO2000*, are projected to offset some of the increase in demand that might be expected with higher industrial output. Cogeneration capacity is projected to increase by 19 gigawatts by 2020, 10 gigawatts more than in *AEO2000*.

Energy demand for transportation is projected to grow at an average annual rate of 1.8 percent, to 38.5 quadrillion Btu in 2020, 1.0 quadrillion Btu higher than in *AEO2000*. In *AEO2001*, the projections for light-duty vehicle and freight travel are higher than in *AEO2000* as a result of higher projected growth in personal income and industrial output. Higher light-duty vehicle travel in the forecast is partially offset by higher vehicle efficiency. New vehicle efficiency in 2020 is projected to be higher by 0.9 and 1.9 miles per gallon for new cars and light trucks, respectively, than in *AEO2000*, due to a reevaluation of the competitive potential of advanced technology vehicles.

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 refrigerator and fluorescent lamp ballast standards that become effective in July 2001 and April 2005, respectively. These are the only standards that are finalized with effective dates and specific efficiency levels.

Electricity demand is projected to grow by 1.8 percent per year from 1999 through 2020, higher than the rate of 1.3 percent forecast for the same period in *AEO2000*. The higher demand projection results from higher projected economic growth and a reevaluation of the potential for growth in electricity use for a variety of residential and commercial appliances and equipment, including personal computers.

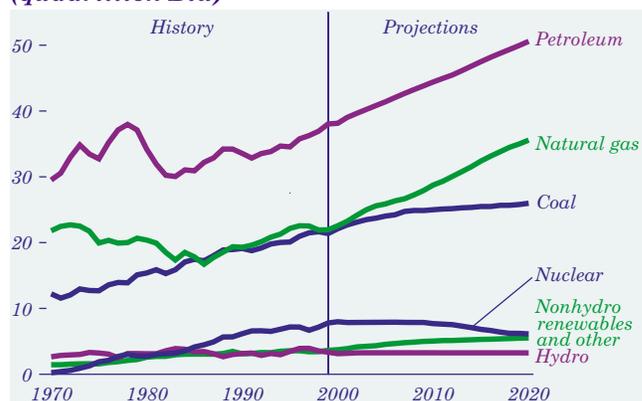
The overall demand for natural gas in the U.S. energy economy is projected to grow by 2.3 percent per year on average (Figure 2), from 21.4 trillion cubic feet in 1999 to 34.7 trillion cubic feet in 2020, primarily as a result of rapid projected growth in demand for electricity generation (excluding cogenerators), which is expected to triple between 1999 and 2020. The *AEO2001* forecast for total natural gas demand in 2020 is 3.2 trillion cubic feet higher than in *AEO2000*, mainly as a result of higher projected demand for natural gas in the electricity generation sector.

In *AEO2001*, total coal consumption is projected to increase from 1,035 million tons in 1999 to 1,297 million tons in 2020, an average increase of 1.1 percent per year. The 2020 projection is 18 million tons higher than in *AEO2000*, due to higher projected demand for industrial uses and for electricity generation, which constitutes about 90 percent of the demand for coal.

Petroleum demand is projected to grow from 19.5 million barrels per day in 1999 to 25.8 million in 2020—an average rate of 1.3 percent per year—led by growth in the transportation sector, which accounts for about 70 percent of U.S. petroleum consumption. Projected demand in 2020 is higher than in *AEO2000* by 730 thousand barrels per day primarily due to a higher projection for transportation fuel use.

Renewable fuel consumption, including ethanol for gasoline blending, is projected to grow at an average rate of 1.1 percent per year through 2020, primarily as a result of State mandates. In 2020, about 55 percent of renewables are used for electricity generation and the rest for dispersed heating and cooling, industrial uses (including cogeneration), and fuel blending. The *AEO2001* forecast for renewable energy demand in 2020 is 0.4 quadrillion Btu higher than in *AEO2000*, mainly due to higher projected use of biomass in the industrial sector.

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

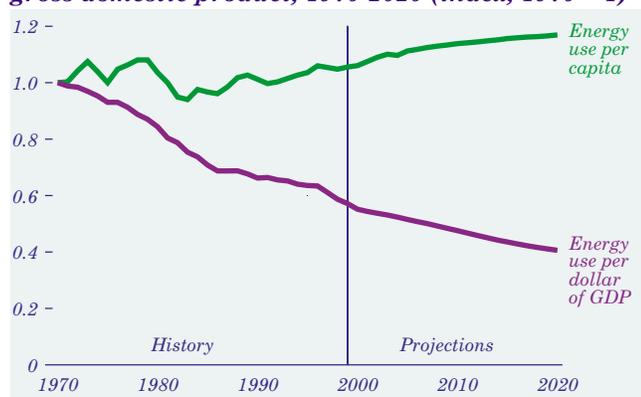


Energy Intensity

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 price

declines in some sectors) and growth of more energy-intensive industries, intensity declines moderated to an average of 1.3 percent per year between 1986 and 1999. Energy intensity is projected to decline at an average annual rate of 1.6 percent through 2020 as efficiency gains and structural shifts in the economy offset the expected growth in demand for energy services. The projected improvement is more rapid than in *AEO2000*, due to more rapid projected efficiency improvements in the industrial sector and growth in the non-energy-intensive industries.

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



Energy use per person generally declined from 1970 through the mid-1980s, then rose as energy prices fell. Per capita energy use is projected to increase slightly in the forecast as efficiency gains only partially offset higher demand for energy services.

Electricity Generation

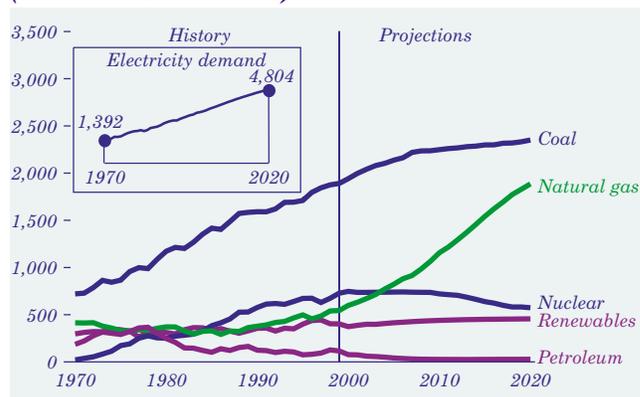
Electricity generation fueled by natural gas and coal is projected to increase through 2020 to meet growing demand for electricity and offset the projected retirement of existing nuclear units (Figure 4). The *AEO2001* projections for generation from natural gas, coal, and nuclear power are higher than in *AEO2000* as a result of higher projected electricity demand and improved operating costs and performance of nuclear plants. The share of natural gas generation is projected to increase from 16 percent in 1999 to 36 percent in 2020, and the coal share is projected to decline from 51 percent to 44 percent, because electricity industry restructuring favors the less capital-intensive and more efficient natural gas generation technologies.

Nuclear generating capacity is projected to decline from 1999 to 2020 but remains higher than in *AEO2000* due to a reevaluation of the costs of life

extension and higher projected natural gas prices. Retirements of nuclear plants in the forecast are based on operating and life extension costs compared with the cost of new generating capacity. Of the 97 gigawatts of nuclear capacity available in 1999, 26 gigawatts is projected to be retired by 2020, and no new plants are expected to be constructed by 2020.

The use of renewable energy technologies for electricity generation is projected to grow slowly because of the relatively low costs of fossil-fired generation and because electricity restructuring favors 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 expected growth of renewables. Total renewable generation, including cogenerators, is projected to increase by 0.7 percent per year and is similar to the projection in *AEO2000*.

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



Production and Imports

U.S. crude oil production is projected to decline at an average annual rate of 0.7 percent from 1999 to 2020, to 5.1 million barrels per day. Advances in exploration and production technologies do not offset declining oil resources. This forecast is 0.2 million barrels per day lower in 2020 than in *AEO2000*. Projected production is higher in the earlier years of the forecast when projected prices are higher, contributing to lower production later. Projected increases in natural gas plant liquids production and refinery gains generally offset the decline in crude oil production (Figure 5). The share of petroleum demand met by net imports is projected to increase from 51 percent in 1999 (measured in barrels per day) to 64 percent in 2020, the same as in *AEO2000*, due to rising demand (Figure 6).

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Figure 5. Energy production by fuel, 1970-2020 (quadrillion Btu)

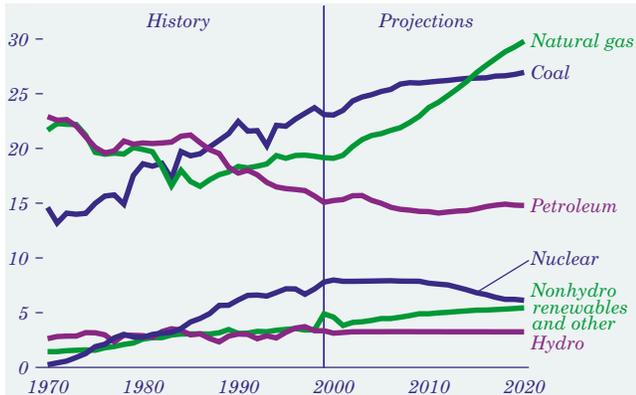
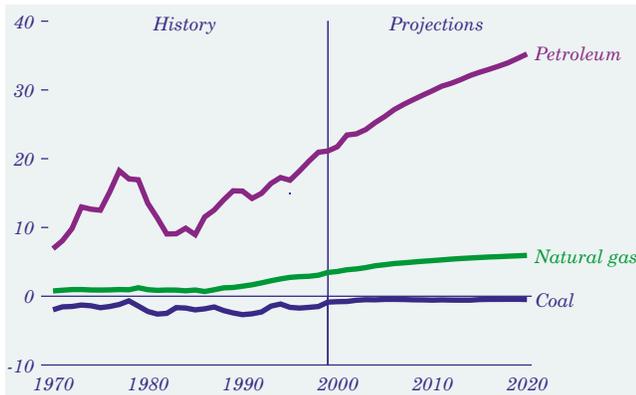


Figure 6. Net energy imports by fuel, 1970-2020 (quadrillion Btu)



U.S. natural gas production is projected to increase from 18.7 trillion cubic feet in 1999 to 29.0 trillion cubic feet in 2020, an average annual rate of 2.1 percent, due to growing demand. Projected production is 2.6 trillion cubic feet higher in 2020 than in *AEO2000*. Net imports of natural gas, primarily from Canada, are projected to increase from 3.4 trillion cubic feet in 1999 to 5.8 trillion cubic feet in 2020. Net imports of liquefied natural gas are expected to increase to 0.7 trillion cubic feet by 2020 as two facilities in the United States—Elba Island, Georgia, and Cove Point, Maryland—are expected to reopen in 2003.

Coal production is projected to increase at an average annual rate of 0.9 percent, from 1,105 million tons in 1999 to 1,331 million tons in 2020, as projected domestic demand grows. Projected production in 2020 is 15 million tons higher than in *AEO2000*, due to higher demand. U.S. net coal exports are projected to decline through 2020, with European demand for U.S. coal expected to decline for

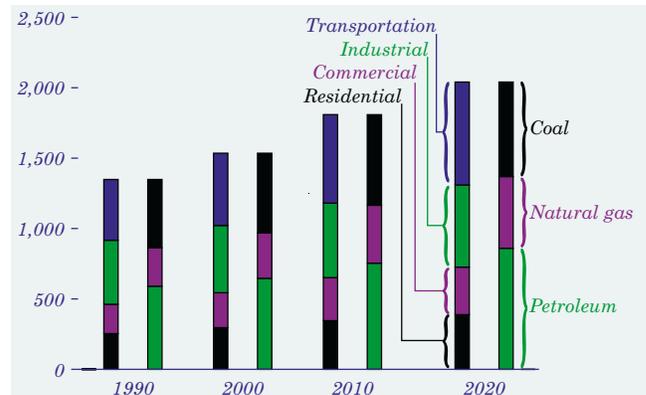
environmental reasons and as a result of competition from other producers.

Renewable energy production is projected to increase from 6.6 quadrillion Btu in 1999 to 8.3 quadrillion Btu in 2020, with growth in geothermal, wind, biomass, and landfill gas generation, industrial biomass, and ethanol. Renewables production in 2020 is estimated to be 0.3 quadrillion Btu higher than in *AEO2000*, as a result of higher expected use of biomass in the industrial sector.

Carbon Dioxide Emissions

Carbon dioxide emissions from energy use are projected to increase at an average rate of 1.4 percent per year from 1,511 to 2,041 million metric tons carbon equivalent between 1999 and 2020 (Figure 7). Projected emissions in 2020 are higher by 62 million metric tons carbon equivalent than in *AEO2000*, due mainly to higher projected economic growth. Higher projected growth in households, commercial floor-space, industrial output, and disposable income leads to higher forecasts for end-use demand and electricity generation. Partly offsetting these trends are more rapid projected declines in industrial energy intensity and higher projected nuclear generation than in *AEO2000*.

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



The projections do not include future legislative or regulatory actions that might be taken to reduce carbon dioxide emissions but do include certain voluntary actions to reduce energy demand and emissions. Carbon dioxide emissions and international negotiations for emissions reductions are discussed on pages 45 and 97.

Table 1. Summary of results for five cases

Sensitivity Factors	1998	1999	2020				
			Reference	Low Economic Growth	High Economic Growth	Low World Oil Price	High World Oil Price
Primary Production (quadrillion Btu)							
Petroleum	15.68	15.08	14.79	14.08	15.42	13.21	16.34
Natural Gas	19.19	19.16	29.79	27.44	31.17	28.99	29.80
Coal	23.76	23.09	26.95	25.97	29.42	26.20	27.66
Nuclear Power	7.19	7.79	6.13	5.91	6.31	6.09	6.09
Renewable Energy	6.62	6.58	8.31	7.91	8.75	8.19	8.37
Other	0.65	1.65	0.34	0.32	0.34	0.33	0.40
Total Primary Production	73.10	73.35	86.30	81.64	91.40	83.02	88.67
Net Imports (quadrillion Btu)							
Petroleum (including SPR)	20.95	21.12	35.22	32.18	38.76	39.57	32.38
Natural Gas	3.06	3.46	5.94	5.72	5.96	5.87	5.66
Coal/Other (- indicates export)	-1.41	-0.85	-0.47	-0.52	-0.36	-0.47	-0.47
Total Net Imports	22.60	23.73	40.69	37.38	44.36	44.97	37.57
Discrepancy	0.86	0.94	-0.04	0.05	-0.10	0.60	-0.17
Consumption (quadrillion Btu)							
Petroleum Products	37.16	38.03	50.59	46.73	54.82	52.74	49.49
Natural Gas	21.96	21.95	35.57	33.00	36.97	34.68	35.31
Coal	21.61	21.43	26.20	25.19	28.77	25.45	26.92
Nuclear Power	7.19	7.79	6.13	5.91	6.31	6.09	6.09
Renewable Energy	6.63	6.59	8.31	7.92	8.76	8.20	8.38
Other	0.29	0.34	0.23	0.23	0.23	0.23	0.23
Total Consumption	94.84	96.14	127.03	118.98	135.86	127.39	126.42
Prices (1999 dollars)							
World Oil Price (dollars per barrel)	12.02	17.35	22.41	21.16	23.51	15.10	28.42
Domestic Natural Gas at Wellhead (dollars per thousand cubic feet)	2.02	2.08	3.13	2.66	3.68	3.01	3.25
Domestic Coal at Minemouth (dollars per short ton)	18.02	16.98	12.70	12.79	12.80	12.84	12.87
Average Electricity Price (cents per kilowatt-hour)	6.8	6.7	6.0	5.6	6.4	5.9	6.1
Economic Indicators							
Real Gross Domestic Product (billion 1996 dollars)	8,516	8,876	16,515	14,757	18,202	16,565	16,474
(annual change, 1999-2020)	—	—	3.0%	2.5%	3.5%	3.0%	3.0%
GDP Chain-Type Price Index (index, 1996=1.00)	1.029	1.045	1.680	1.907	1.472	1.674	1.686
(annual change, 1999-2020)	—	—	2.3%	2.9%	1.6%	2.3%	2.3%
Real Disposable Personal Income (billion 1996 dollars)	6,165	6,363	11,842	10,907	12,739	11,902	11,786
(annual change, 1999-2020)	—	—	3.0%	2.6%	3.4%	3.0%	3.0%
Gross Manufacturing Output (billion 1992 dollars)	3,704	3,749	6,726	6,149	7,735	6,730	6,724
(annual change, 1999-2020)	—	—	2.8%	2.4%	3.5%	2.8%	2.8%
Energy Intensity							
(thousand Btu per 1996 dollar of GDP)	11.14	10.84	7.70	8.07	7.47	7.69	7.68
(annual change, 1999-2020)	—	—	-1.6%	-1.4%	-1.8%	-1.6%	-1.6%
Carbon Dioxide Emissions							
(million metric tons carbon equivalent)	1,495	1,511	2,041	1,916	2,193	2,051	2,033
(annual change, 1999-2020)	—	—	1.4%	1.1%	1.8%	1.5%	1.4%

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.