

Annual Energy Outlook 2004

With Projections to 2025

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Preface

The *Annual Energy Outlook 2004* (AEO2004) presents midterm forecasts of energy supply, demand, and prices through 2025 prepared by the Energy Information Administration (EIA). The projections are based on results from EIA's National Energy Modeling System (NEMS).

The report begins with an "Overview" summarizing the AEO2004 reference case. The next section, "Legislation and Regulations," discusses evolving legislation and regulatory issues. "Issues in Focus" includes discussions of future labor productivity growth; lower 48 natural gas depletion and productive capacity; natural gas supply options, with a focus on liquefied natural gas; natural gas demand for Canadian oil sands production; National Petroleum Council forecasts for natural gas; natural gas consumption in the industrial and electric power sectors; nuclear power plant construction costs; renewable electricity tax credits; and U.S. greenhouse gas intensity. It is followed by a discussion of "Energy Market Trends."

The analysis in AEO2004 focuses primarily on a reference case and four other cases that assume higher and lower economic growth and higher and lower world oil prices. Forecast tables for those cases are provided in Appendixes A through C. Appendix D provides a summary of key projections in oil equivalent units. Appendix E summarizes projected household expenditures for each fuel by region and household income quintiles. The major results for the alternative cases, which explore the impacts of

varying key assumptions in NEMS (such as technology penetration rates), are summarized in Appendix F. Appendix G briefly describes NEMS, the AEO2004 assumptions, and the alternative cases.

The AEO2004 projections are based on Federal, State, and local laws and regulations in effect on September 1, 2003. The potential impacts of pending or proposed legislation, regulations, and standards (and sections of existing legislation requiring funds that have not been appropriated) are not reflected in the projections. For example, AEO2004 does not include the potential impact of the pending Energy Policy Act of 2003. In general, the historical data used for AEO2004 projections are based on EIA's *Annual Energy Review 2003*, published in October 2003; however, data are taken from multiple sources. In some cases, only partial or preliminary 2002 data were available. Historical data are presented in this report for comparative purposes; documents referenced in the source notes should be consulted for official data values. The projections for 2003 and 2004 incorporate short-term projections from EIA's September 2003 *Short-Term Energy Outlook*.

Federal, State, and local governments, trade associations, and other planners and decisionmakers in the public and private sectors use the AEO2004 projections. They are published in accordance with Section 205c of the Department of Energy Organization Act of 1977 (Public Law 95-91), which requires the EIA Administrator to prepare annual reports on trends and projections for energy use and supply.

The projections in AEO2004 are not statements of what will happen but of what might happen, given the assumptions and methodologies used. The projections are business-as-usual trend forecasts, given known technology, technological and demographic trends, and current laws and regulations. Thus, they provide a policy-neutral reference case that can be used to analyze policy initiatives. EIA does not propose, advocate, or speculate on future legislative and regulatory changes. All laws are assumed to remain as currently enacted; however, the impacts of emerging regulatory changes, when defined, are reflected.

Because energy markets are complex, models are simplified representations of energy production and consumption, regulations, and producer and consumer behavior. Projections are highly dependent on the data, methodologies, model structures, and assumptions used in their development.

Behavioral characteristics are indicative of real-world tendencies rather than representations of specific outcomes.

Energy market projections are subject to much uncertainty. Many of the events that shape energy markets are random and cannot be anticipated, including severe weather, political disruptions, strikes, and technological breakthroughs. In addition, future developments in technologies, demographics, and resources cannot be foreseen with any degree of precision. Many key uncertainties in the AEO2004 projections are addressed through alternative cases.

EIA has endeavored to make these projections as objective, reliable, and useful as possible; however, they should serve as an adjunct to, not a substitute for, analytical processes in the examination of policy initiatives.

Contents

	Page
Overview	1
Legislation and Regulations	11
Introduction	12
Corporate Average Fuel Economy Standards for Light Trucks	13
California Low Emission Vehicle Program	13
California Carbon Standard For Light-Duty Vehicles	14
Regulation of Mercury and Fine Particulate Emissions	14
Extension of Deep Shelf Royalty Relief to Existing Leases	14
The Maritime Security Act of 2002 Amendments to the Deepwater Port Act	15
The Hackberry Decision	15
State Air Emission Regulations	16
New Source Review	20
The Energy Policy Act of 2003	21
Issues in Focus	29
Outlook for Labor Productivity Growth	30
Lower 48 Natural Gas Supply	33
Reassessment of Liquefied Natural Gas Supply Potential	39
Reassessment of Canadian Natural Gas Supply Potential	43
Natural Gas Consumption in Canadian Oil Sands Production	43
Natural Gas Consumption in the Industrial Sector	45
Natural Gas Consumption for Electric Power Generation	47
Natural Gas Markets: Comparison of <i>AEO2004</i> and National Petroleum Council Projections	49
Nuclear Power Plant Construction Costs	54
The Renewable Electricity Production Tax Credit	59
U.S. Greenhouse Gas Intensity	62
Market Trends	65
Trends in Economic Activity	66
International Oil Markets	68
Energy Demand	69
Energy Demand in Alternative Technology Cases	77
Electricity Sales	80
Electricity Generating Capacity	81
Electricity Fuel Costs and Prices	83
Electricity From Nuclear Power	84
Electricity From Renewable Sources	85
Electricity Alternative Cases	87
Natural Gas Consumption and Prices	89
Natural Gas Production	90
Natural Gas Imports and Wellhead Prices	91
Natural Gas Alternative Cases	92
Oil Prices and Reserve Additions	93
Oil Production	94
Alaskan Oil Production and Oil Imports	95
Petroleum Refining	96
Refined Petroleum Products	97
Coal Production and Prices	99
Coal Mining Labor Productivity	100
Coal Consumption	101
Carbon Dioxide Emissions	103
Emissions from Electricity Generation	105

Contents

	Page
Forecast Comparisons	107
List of Acronyms	117
Notes and Sources	118
Appendixes	
A. Reference Case Forecast	133
B. Economic Growth Case Comparisons	163
C. Oil Price Case Comparisons	191
D. Crude Oil Equivalency Summary	219
E. Household Expenditures	221
F. Results from Side Cases	224
G. Major Assumptions for the Forecasts	237
H. Conversion Factors	262
Tables	
1. Total energy supply and disposition in the <i>AEO2004</i> reference case: summary, 2001-2025	9
2. Emissions from electricity generators in selected States, 2002	16
3. Existing State air emissions legislation with potential impacts on the electricity generation sector ..	17
4. Labor productivity growth in the nonfarm business sector, 1948-1973 and 1973-1995	31
5. Estimated changes in labor productivity growth between 1995-2000 and 1973-1995	31
6. Estimates of future steady-state growth in U.S. labor productivity	32
7. Principal deepwater fields in production or expected to start production by 2007	35
8. Tight sands gas production by region and basin, 2002-2025	37
9. Coalbed methane production by region and basin, 2002-2025	38
10. Shale gas production by region and basin, 2002-2025	38
11. Access status of undeveloped unconventional natural gas resources in the Rocky Mountain region, January 1, 2002	38
12. North American LNG regasification proposals as of December 1, 2003	41
13. Projected Canadian tar sands oil supply and potential range of natural gas consumption in the <i>AEO2004</i> reference case, 2002-2025	44
14. Overview of U.S. natural gas consumption and supply projections, 2002, 2010, and 2025	50
15. Growth rates for natural gas consumption in the industrial and electric power sectors, 2002-2025 ..	51
16. Lower 48 cumulative natural gas production, 2002-2025	53
17. Portion of the lower 48 natural gas resource base produced, 2002-2025	54
18. Key projections for renewable electricity in the reference and PTC extension cases, 2010 and 2025	61
19. Projected changes in U.S. greenhouse gas emissions, gross domestic product, and greenhouse gas intensity, 2002-2025	62
20. New car and light truck horsepower ratings and market shares, 1990-2025	75
21. Costs of producing electricity from new plants, 2010 and 2025	82
22. Technically recoverable U.S. natural gas resources as of January 1, 2002	91
23. Onshore and offshore lower 48 crude oil production in three cases, 2025	93
24. Technically recoverable U.S. oil resources as of January 1, 2002	93
25. Crude oil production from Gulf of Mexico offshore, 2002-2025	94
26. Petroleum consumption and net imports in five cases, 2002 and 2025	95
27. Forecasts of annual average economic growth, 2002-2025	108
28. Forecasts of world oil prices, 2005-2025	108
29. Forecasts of average annual growth rates for energy consumption, 2002-2025	109
30. Comparison of electricity forecasts, 2015 and 2025	111
31. Comparison of natural gas forecasts, 2015 and 2025	112
32. Comparison of petroleum forecasts, 2015, 2020, and 2025	113
33. Comparison of coal forecasts, 2015, 2020, and 2025	115

Figures	Page
1. Energy price projections, 2002-2025: <i>AEO2003</i> and <i>AEO2004</i> compared	2
2. Energy consumption by fuel, 1970-2025	5
3. Energy use per capita and per dollar of gross domestic product, 1970-2025	5
4. Electricity generation by fuel, 1970-2025	6
5. Total energy production and consumption, 1970-2025	7
6. Energy production by fuel, 1970-2025	7
7. Projected U.S. carbon dioxide emissions by sector and fuel, 1990-2025	8
8. Labor productivity growth in the nonfarm business sector	31
9. Lower 48 natural gas production, 1990-2025	33
10. Technically recoverable lower 48 natural gas resources as of January 1, 2002	33
11. Conventional onshore nonassociated natural gas reserve additions per well, 1990-2025	34
12. Conventional onshore natural gas wells drilled, 1990-2025	34
13. Gulf of Mexico natural gas production, 1990-2025	36
14. Lower 48 natural gas production by resource type, 1990-2025	36
15. Unconventional gas undeveloped resources by region as of January 1, 2002	36
16. Unconventional gas beginning-of-year proved reserves and production by region, 2002	37
17. Major sources of incremental natural gas supply, 2002-2025	39
18. U.S. quarterly LNG imports by contract type, 1996-2003	42
19. U.S. net imports of LNG, 2000-2025	42
20. U.S. net imports of LNG and Canadian natural gas, 1990-2025	43
21. Industrial natural gas consumption, history and projections, 1990-2025	45
22. Components of industrial natural gas consumption, 2002, 2010, and 2025	45
23. Industrial natural gas consumption and output, 1978-2002	46
24. Industrial natural gas prices, 2002-2025	46
25. Agricultural chemicals value of shipments, history and projections, 1990-2025	47
26. Annual additions to electricity generation capacity by fuel, 1950-2002	47
27. Natural gas consumption and gas-fired electricity generation in the electric power sector, 1995-2002	47
28. Natural gas consumption and gas-fired electricity generation in the electric power sector, 1995-2025	48
29. Average capacity factor for oil- and gas-fired power plants, 2002-2025	48
30. Lower 48 technically recoverable and accessible unproven natural gas resources, 2001-2025	51
31. Total U.S. end-use natural gas consumption, 2001-2025	51
32. Net imports of liquefied natural gas, 2001-2025	52
34. Total U.S. domestic natural gas production, 2001-2025	53
33. Net imports of natural gas from Canada, 2001-2025	53
35. Lower 48 onshore unconventional natural gas production, 2001-2025	54
36. Estimates of overnight capital costs for nuclear power plants	57
37. Projected improvement in U.S. greenhouse gas intensity, 2002-2025	63
38. Average annual growth rates of real GDP and economic factors, 1995-2025	66
39. Sectoral composition of output growth rates, 2002-2025	66
40. Sectoral composition of gross output, 2002, 2010, and 2025	66
41. Average annual real growth rates of economic factors in three cases, 2002-2025	67
42. Average annual GDP growth rate, 1970-2025	67
43. World oil prices in three cases, 1970-2025	68
44. U.S. gross petroleum imports by source, 2000-2025	68
45. Primary and delivered energy consumption, excluding transportation use, 1970-2025	69
46. Energy use per capita and per dollar of gross domestic product, 1970-2025	69
47. Delivered energy use by fossil fuel and primary energy use for electricity generation, 1970-2025	70
48. Primary energy consumption by sector, 1970-2025	70
49. Residential primary energy consumption by fuel, 1970-2025	71
50. Residential primary energy consumption by end use, 1990, 2002, 2010, and 2025	71
51. Efficiency indicators for selected residential appliances, 2002 and 2025	72

Contents

Figures (continued)	Page
52. Commercial primary energy consumption by fuel, 1970-2025	72
53. Commercial primary energy consumption by end use, 2002, 2010, and 2025	73
54. Industrial primary energy consumption by fuel, 1970-2025	73
55. Industrial primary energy consumption by industry category, 1998-2025	74
56. Components of improvement in industrial delivered energy intensity, 1998-2025	74
57. Transportation energy consumption by fuel, 1975, 2002, 2010, and 2025	75
58. Transportation stock fuel efficiency by mode, 2002-2025	75
59. Technology penetration by mode of travel, 2025	76
60. Sales of advanced technology light-duty vehicles by fuel type, 2010 and 2025	76
61. Variation from reference case primary energy use by sector in two alternative cases, 2010, 2020, and 2025	77
62. Variation from reference case primary residential energy use in three alternative cases, 2002-2025	77
63. Buildings sector electricity generation from advanced technologies in alternative cases, 2010-2025	78
64. Variation from reference case primary commercial energy use in three alternative cases, 2002-2025	78
65. Industrial primary energy intensity in two alternative cases, 1998-2025	79
66. Changes in key components of the transportation sector in two alternative cases, 2025	79
67. Population, gross domestic product, and electricity sales, 1965-2025	80
68. Annual electricity sales by sector, 1970-2025	80
69. Additions to electricity generating capacity, 1999-2003	81
70. New generating capacity and retirements, 2002-2025	81
71. Electricity generation capacity additions by fuel type, including combined heat and power, 2002-2025	82
72. Levelized electricity costs for new plants, 2010 and 2025	82
73. Fuel prices to electricity generators, 1990-2025	83
74. Average U.S. retail electricity prices, 1970-2025	83
75. Electricity generation by fuel, 2002 and 2025	84
76. Nuclear power plant capacity factors, 1973-2025	84
77. Grid-connected electricity generation from renewable energy sources, 1970-2025	85
78. Nonhydroelectric renewable electricity generation by energy source, 2002-2025	85
79. Additions of renewable generating capacity, 2003-2025	86
80. Nonhydroelectric renewable electricity generation by energy source in four cases, 2010 and 2025	86
81. Cumulative new generating capacity by technology type in four fossil fuel technology cases, 2002-2025	87
82. Levelized electricity costs for new plants by fuel type in the advanced nuclear cost case, 2015 and 2025	87
83. Cumulative new generating capacity by technology type in three economic growth cases, 2002-2025	88
84. Cumulative new generating capacity by type in two cases, 2002-2025	88
85. Natural gas consumption by end-use sector, 1990-2025	89
86. Natural gas prices by end-use sector, 1970-2025	89
87. Natural gas production by source, 1990-2025	90
88. Lower 48 onshore natural gas production by supply region, 1990-2025	90
89. Net U.S. imports of natural gas, 1970-2025	91
90. Lower 48 natural gas wellhead prices in three cases, 1985-2025	91
91. Lower 48 natural gas production in three cases, 1970-2025	92
92. Lower 48 natural gas reserves in three cases, 1990-2025	92
93. Lower 48 crude oil wellhead prices in three cases, 1970-2025	93
94. U.S. petroleum consumption in five cases, 1970-2025	93
95. Lower 48 crude oil reserves in three cases, 1990-2025	93
96. Lower 48 crude oil production by source, 1970-2025	94

Figures (continued)	Page
97. Lower 48 crude oil production in three cases, 1990-2025	94
98. Alaskan crude oil production in three cases, 1990-2025	95
99. Petroleum supply, consumption, and imports, 1970-2025	95
100. Domestic refining capacity in three cases, 1975-2025	96
101. Worldwide refining capacity by region, 2002 and 2025	96
102. Petroleum consumption by sector, 1970-2025	97
103. Consumption of petroleum products, 1970-2025	97
104. U.S. ethanol consumption, 1993-2025	98
105. Components of refined product costs, 2002 and 2025	98
106. Coal production by region, 1970-2025	99
107. Average minemouth price of coal by region, 1990-2025	99
108. Coal mining labor productivity by region, 1990-2025	99
109. U.S. coal mine employment by region, 1970-2025	100
110. Average minemouth coal prices in three mining cost cases, 1990-2025	100
111. Electricity and other coal consumption, 1970-2025	101
112. Coal production by sulfur content, 2002, 2010 and 2025	101
113. Coal consumption in the industrial and buildings sectors, 2002, 2010, and 2025	102
114. U.S. coal exports and imports, 2002, 2010, and 2025	102
115. Carbon dioxide emissions by sector and fuel, 1990-2025	103
116. Carbon dioxide emissions from the electric power sector by fuel, 1990-2025	103
117. Carbon dioxide emissions in three economic growth cases, 1990-2025	104
118. Carbon dioxide emissions in three technology cases, 1990-2025	104
119. Sulfur dioxide emissions from electricity generation, 1990-2025	105
120. Nitrogen oxide emissions from electricity generation, 1990-2025	105

Overview

Overview

Key Energy Issues to 2025

For almost 4 years, natural gas prices have remained at levels substantially higher than those of the 1990s. This has led to a reevaluation of expectations about future trends in natural gas markets, the economics of exploration and production, and the size of the natural gas resource. The *Annual Energy Outlook 2004* (AEO2004) forecast reflects such revised expectations, projecting greater dependence on more costly alternative supplies of natural gas, such as imports of liquefied natural gas (LNG), with expansion of existing terminals and development of new facilities, and remote resources from Alaska and from the Mackenzie Delta in Canada, with completion of the Alaska Natural Gas Transportation System and the Mackenzie Delta pipeline.

Crude oil prices rose from under \$20 per barrel in the late 1990s to about \$35 per barrel in early 2003, driven in part by concerns about the conflict in Iraq, the situation in Venezuela, greater adherence to export quotas by members of the Organization of Petroleum Exporting Countries (OPEC), and changing views regarding the economics of oil production. AEO2004 reflects changes in expectations about the relative roles of various basins in providing future crude oil supplies.

Outside OPEC, the major sources of growth in crude oil production in the AEO2004 forecast are Russia, the Caspian Basin, non-OPEC Africa, and South and Central America. U.S. dependence on imported oil has grown over the past decade, with declining domestic oil production and growing demand. This trend is expected to continue. Net imports, which accounted for 54 percent of total U.S. petroleum demand in 2002—up from 37 percent in 1980 and 42 percent in 1990—are expected to account for 70 percent of total U.S. petroleum demand in 2025 in the AEO2004 forecast, higher than the *Annual Energy Outlook 2003* (AEO2003) projection of 68 percent.

The change in expectations for future natural gas prices, in combination with the substantial amount of new natural-gas-fired generating capacity recently completed or in the construction pipeline, has also led to a different view of future capacity additions. Although only a few years ago, natural gas was viewed as the fuel of choice for new generating plants, coal is now projected to play a more important role, particularly in the later years of the forecast. In the AEO2004 forecast, beyond the completion of plants currently under construction, little new generating capacity is expected to be added before 2010. With a higher long-term forecast for natural gas prices, the

competitive position of coal is expected to improve. As a result, cumulative additions of natural-gas-fired generating capacity between 2003 and 2025 are lower in the AEO2004 forecast than they were in AEO2003, and more additions of coal and renewable generating capacity are projected.

Economic Growth

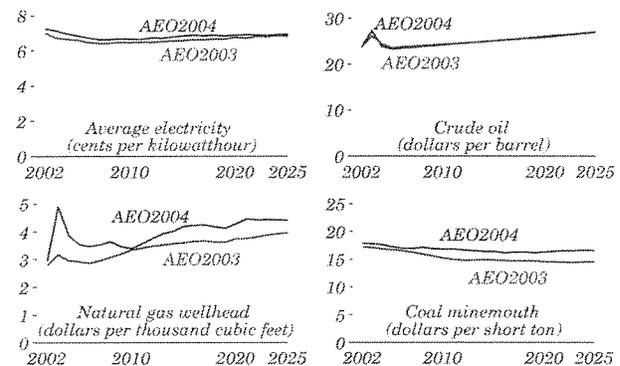
In the AEO2004 reference case, the U.S. economy, as measured by gross domestic product (GDP), grows at an average annual rate of 3.0 percent from 2002 to 2025, slightly lower than the growth rate of 3.1 percent per year for the same period in AEO2003. Most of the determinants of economic growth in AEO2004 are similar to those in AEO2003, but there are some important differences. For example, AEO2004 starts with lower nominal interest rates than AEO2003; the rate of inflation is generally higher; and unemployment levels are higher. Consequently, differences between AEO2004 and AEO2003 cannot be explained simply by differences in GDP growth.

Energy Prices

In the AEO2004 reference case, the average world oil price increases from \$23.68 per barrel (2002 dollars) in 2002 to \$27.25 per barrel in 2003 and then declines to \$23.30 per barrel in 2005. It then rises slowly to \$27.00 per barrel in 2025, about the same as the AEO2003 projection of \$26.94 per barrel in 2025 (Figure 1). Between 2002 and 2025, real world oil prices increase at an average rate of 0.6 percent per year in the AEO2004 forecast. In nominal dollars, the average world oil price is about \$29 per barrel in 2010 and about \$52 per barrel in 2025.

World oil demand is projected to increase from 78 million barrels per day in 2002 to 118 million barrels per day in 2025, less than the AEO2003 projection of 123 million barrels per day in 2025. In AEO2004,

Figure 1. Energy price projections, 2002-2025: AEO2003 and AEO2004 compared (2002 dollars)



projected demand for petroleum in the United States and Western Europe and, particularly, in China, India, and other developing nations in the Middle East, Africa, and South and Central America is lower than was projected in *AEO2003*. Growth in oil production in both OPEC and non-OPEC nations leads to relatively slow growth in prices through 2025. OPEC oil production is expected to reach 54 million barrels per day in 2025, almost 80 percent higher than the 30 million barrels per day produced in 2002. The forecast assumes that sufficient capital will be available to expand production capacity.

Non-OPEC oil production is expected to increase from 44.7 to 63.9 million barrels per day between 2002 and 2025. Production in the industrialized nations (United States, Canada, Mexico, Western Europe, and Australia) remains roughly constant at 24.2 million barrels per day in 2025, compared with 23.4 million barrels per day in 2002. In the forecast, increased nonconventional oil production, predominantly from oil sands in Canada, more than offsets a decline in conventional production in the industrialized nations.

The largest share of the projected increase in non-OPEC oil production is expected in Russia, the Caspian Basin, Non-OPEC Africa, and South and Central America (in particular, Brazil). Russian oil production is expected to continue to recover from the lows of the 1990s and to reach 10.9 million barrels per day in 2025, 43 percent above 2002 levels. Production from the Caspian Basin is expected to exceed 6.0 million barrels per day by 2025, compared with 1.7 million barrels per day in 2002. In 2025, projected production from South and Central America reaches 7.8 million barrels per day, up from 4.3 million barrels per day in 2002. A large portion of the increase in South and Central American production, 0.9 million barrels per day, is expected to come from nonconventional oil production in Venezuela. Non-OPEC African production is projected to grow from 3.1 million barrels per day in 2002 to 6.7 million barrels per day in 2025.

Average wellhead prices for natural gas (including both spot purchases and contracts) are projected to increase from \$2.95 per thousand cubic feet (2002 dollars) in 2002 to \$4.90 per thousand cubic feet in 2003, declining to \$3.40 per thousand cubic feet in 2010 as the initial availability of new import sources (such as LNG) and increased drilling in response to the higher prices increase supplies. With the exception of a temporary decline in natural gas wellhead prices just before 2020, when an Alaska pipeline is expected to be completed, wellhead prices are projected to increase

gradually after 2010, reaching \$4.40 per thousand cubic feet in 2025 (equivalent to about \$8.50 per thousand cubic feet in nominal dollars). LNG imports, Alaskan production, and lower 48 production from nonconventional sources are not expected to increase sufficiently to offset the impacts of resource depletion and increased demand. At \$4.40 per thousand cubic feet, the 2025 wellhead natural gas price in *AEO2004* is 44 cents higher than the *AEO2003* projection. The higher price projection results from reduced expectations for onshore and offshore production of non-associated gas, based on recent data indicating lower discoveries per well and higher costs for drilling in the lower 48 States.

In *AEO2004*, the average minemouth price of coal is projected to decline from \$17.90 (2002 dollars) in 2002 to a low of \$16.19 per short ton in 2016. Prices decline in the forecast because of increased mine productivity, a shift to western production, declines in rail transportation costs, and competitive pressures on labor costs. After 2016, however, average minemouth coal prices are projected to rise as productivity improvements slow and the industry faces increasing costs to open new mining areas to meet rising demand. In 2025, the average minemouth price is projected to be \$16.57 per short ton, still lower than the real price in 2002 but considerably higher than the *AEO2003* projection of \$14.56 per short ton. In nominal dollars, projected minemouth coal prices in *AEO2004* are equivalent to \$32 per short ton in 2025.

Average delivered electricity prices are projected to decline from 7.2 cents per kilowatthour in 2002 to a low of 6.6 cents (2002 dollars) in 2007 as a result of cost reductions in an increasingly competitive market—where excess generating capacity has resulted from the recent boom in construction—and continued declines in coal prices. In markets where electricity industry restructuring is still ongoing, it contributes to the projected price decline through reductions in operating and maintenance costs, administrative costs, and other miscellaneous costs. After 2007, average real electricity prices are projected to increase, reaching 6.9 cents per kilowatthour in 2025 (equivalent to 13.2 cents per kilowatthour in nominal dollars). In *AEO2003*, real electricity prices followed a similar pattern but were projected to be slightly lower in 2025, at 6.8 cents per kilowatthour. The higher price projection in *AEO2004* results primarily from higher expected costs for both generation and transmission of electricity. Higher generation costs reflect the higher projections for natural gas and coal prices in *AEO2004*, particularly in the later years of the forecast.

Overview

Energy Consumption

Total primary energy consumption in *AEO2004* is projected to increase from 97.7 quadrillion British thermal units (Btu) in 2002 to 136.5 quadrillion Btu in 2025 (an average annual increase of 1.5 percent). *AEO2003* projected total primary energy consumption at 139.1 quadrillion Btu in 2025. The *AEO2004* projections for total petroleum and natural gas consumption in 2025 are lower than those in *AEO2003*, and the projections for coal, nuclear, and renewable energy consumption are higher. Higher natural gas prices in the *AEO2004* forecast, and the effects of higher corporate average fuel economy (CAFE) standards for light trucks in the transportation sector, are among the most important factors accounting for the differences between the two forecasts.

Delivered residential energy consumption, excluding losses attributable to electricity generation, is projected to grow at an average rate of 1.0 percent per year between 2002 and 2025 (1.4 percent per year between 2002 and 2010, slowing to 0.8 percent per year between 2010 and 2025). The most rapid growth is expected in demand for electricity used to power computers, electronic equipment, and appliances. *AEO2004* projects residential energy demand totaling 14.2 quadrillion Btu in 2025 (slightly higher than the 14.1 quadrillion Btu projected in *AEO2003*). The *AEO2004* forecast includes more rapid growth in the total number of U.S. households than was projected in *AEO2003*; however, fewer new single-family homes are projected to be built than in the *AEO2003* forecast, because the mix of single- and multi-family units has been revised, based on preliminary data on housing characteristics from the Energy Information Administration's 2001 Residential Energy Consumption Survey. Multi-family units tend to be smaller and use less energy per household, offsetting some of the increase in projected energy demand due to the increase in the number of U.S. households.

Delivered commercial energy consumption is projected to grow at an average annual rate of 1.7 percent between 2002 and 2025, reaching 12.2 quadrillion Btu in 2025 (slightly less than the 12.3 quadrillion Btu projected in *AEO2003*). The most rapid increase in energy demand is projected for electricity used for computers, office equipment, telecommunications, and miscellaneous small appliances. Commercial floorspace is projected to grow by an average of 1.5 percent per year between 2002 and 2025, identical to the rate of growth in *AEO2003* for the same period.

Delivered industrial energy consumption in *AEO2004* is projected to increase at an average rate of 1.3 percent per year between 2002 and 2025, reaching

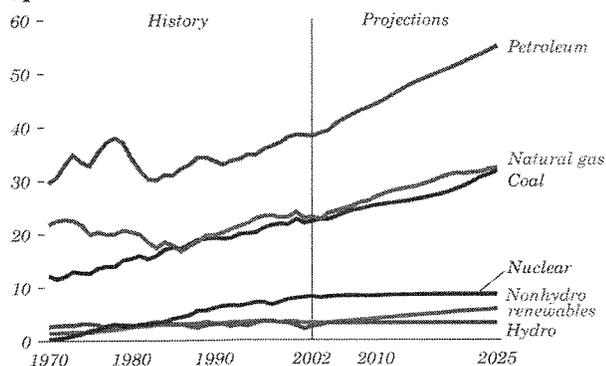
33.4 quadrillion Btu in 2025 (lower than the *AEO2003* forecast of 34.8 quadrillion Btu). The *AEO2004* forecast includes slower projected growth in the dollar value of industrial product shipments and higher energy prices (particularly natural gas) than in *AEO2003*; however, those effects are offset in part by more rapid projected growth in the energy-intensive industries.

Delivered energy consumption in the transportation sector is projected to grow at an average annual rate of 1.9 percent between 2002 and 2025 in the *AEO2004* forecast, reaching 41.2 quadrillion Btu in 2025 (2.5 quadrillion Btu lower than the *AEO2003* projection). Two factors account for the reduction in projected transportation energy use from *AEO2003* to *AEO2004*. First is the adoption of new Federal CAFE standards for light trucks—including sport utility vehicles. The new CAFE standards require that the light trucks sold by a manufacturer have a minimum average fuel economy of 21.0 miles per gallon for model year 2005, 21.6 miles per gallon for model year 2006, and 22.2 miles per gallon for model years 2007 and beyond. (The old standard was 20.7 miles per gallon in all years.) As a result, the average fuel economy for all new light-duty vehicles is projected to increase to 26.9 miles per gallon in 2025 in *AEO2004*, as compared with 26.1 miles per gallon in *AEO2003*. Second is the lower forecast for industrial product shipments in *AEO2004*, leading to a projection for freight truck travel in 2025 that is 7 percent lower than the *AEO2003* projection.

Total electricity consumption, including both purchases from electric power producers and on-site generation, is projected to grow from 3,675 billion kilowatthours in 2002 to 5,485 billion kilowatthours in 2025, increasing at an average rate of 1.8 percent per year (slightly below the 1.9-percent average annual increase projected in *AEO2003*). Rapid growth in electricity use for computers, office equipment, and a variety of electrical appliances in the residential and commercial sectors is partially offset in the *AEO2004* forecast by improved efficiency in these and other, more traditional electrical applications, by the effects of demand-side management programs, and by slower growth in electricity demand for some applications, such as air conditioning, which have reached near-maximum penetration levels in regional markets.

Total demand for natural gas is projected to increase at an average annual rate of 1.4 percent from 2002 to 2025. From 22.8 trillion cubic feet in 2002, natural gas consumption increases to 31.4 trillion cubic feet in 2025 (Figure 2), primarily as a result of increasing use for electricity generation and

Figure 2. Energy consumption by fuel, 1970-2025 (quadrillion Btu)



industrial applications, which together account for almost 70 percent of the projected growth in natural gas demand from 2002 to 2025. The annual rate of increase in natural gas demand varies over the projection period. In particular, the growth in demand for natural gas slows in the later years of the forecast (growing by 0.6 percent per year from 2020 to 2025, as compared with 1.6 percent per year from 2002 to 2020), as rising prices for natural gas make it less competitive for electricity generation. The *AEO2004* projection for total consumption of natural gas in 2025 is 3.5 trillion cubic feet lower than in *AEO2003*.

In *AEO2004*, total coal consumption is projected to increase from 1,066 million short tons (22.2 quadrillion Btu) in 2002 to 1,567 million short tons (31.7 quadrillion Btu) in 2025. From 2002 to 2025, coal use (based on tonnage) is projected to grow by 1.7 percent per year on average, compared with the *AEO2003* projection of 1.4 percent per year. From 2002 to 2025, on a Btu basis, coal use is projected to grow by 1.6 percent per year. (Because of differences in the Btu content of coal across the Nation and changes in the regional mix of coal supply over time, the rate of growth varies, depending on whether it is measured in short tons or Btu.) The primary reason for the change in the rate of growth is higher natural gas prices in the *AEO2004* forecast. In *AEO2004*, total coal consumption for electricity generation is projected to increase by an average of 1.8 percent per year (1.7 percent per year on a Btu basis), from 976 million short tons in 2002 to 1,477 million short tons in 2025, compared with the *AEO2003* projection of 1,350 million short tons in 2025.

Total petroleum demand is projected to grow at an average annual rate of 1.6 percent in the *AEO2004* forecast, from 19.6 million barrels per day in 2002 to 28.3 million barrels per day in 2025. *AEO2003* projected a 1.8-percent annual average

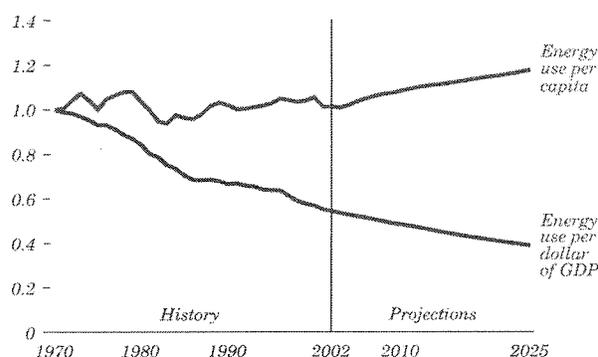
growth rate over the same period. The largest share of the difference between the two forecasts is attributable to the transportation sector. In 2025, total petroleum demand for transportation is 1.2 million barrels per day lower in *AEO2004* than it was in *AEO2003*.

Total renewable fuel consumption, including ethanol for gasoline blending, is projected to grow by 1.9 percent per year on average, from 5.8 quadrillion Btu in 2002 to 9.0 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. Projected demand for renewables in 2025 in *AEO2004* is 0.2 quadrillion Btu higher than in *AEO2003*, with more wind and geothermal energy consumption and less biomass fuel consumption expected in the *AEO2004* forecast.

Energy Intensity

Energy intensity, as measured by energy use per dollar of GDP, is projected to decline at an average annual rate of 1.5 percent in the *AEO2004* forecast, with efficiency gains and structural shifts in the economy offsetting growth in demand for energy services (Figure 3). This rate of improvement, the same as projected in *AEO2003*, is generally consistent with recent historical experience. With energy prices increasing between 1970 and 1986, energy intensity declined at an average annual rate of 2.3 percent, as the economy shifted to less energy-intensive industries, product mix changed, and more efficient technologies were adopted. Between 1986 and 1992, however, when energy prices were generally falling, energy intensity declined at an average rate of only 0.7 percent a year. Since 1992, it has declined on average by 1.9 percent a year.

Figure 3. Energy use per capita and per dollar of gross domestic product, 1970-2025 (index, 1970 = 1)



Overview

Energy use per person generally declined from 1970 through the mid-1980s but began to increase as energy prices declined in the late 1980s and 1990s. Per capita energy use is projected to increase in the forecast, with growth in demand for energy services only partially offset by efficiency gains. Per capita energy use increases by an average of 0.7 percent per year between 2002 and 2025 in *AEO2004*, the same as in *AEO2003*.

The potential for more energy conservation has received increased attention recently as a potential contributor to the balancing of energy supply and demand as energy supplies become tighter and prices rise. *AEO2004* does not assume policy-induced conservation measures beyond those in existing legislation and regulation or behavioral changes that could result in greater energy conservation.

Electricity Generation

In the *AEO2004* forecast, the projected average price for natural gas delivered to electricity generators is 25 cents per million Btu higher in 2025 than was projected in *AEO2003*. As a result, cumulative additions of natural-gas-fired generating capacity between 2003 and 2025 are lower than projected in *AEO2003*, generation from gas-fired plants in 2025 is lower, and generation from coal, petroleum, nuclear, and renewable fuels is higher. Cumulative natural gas capacity additions between 2003 and 2025 are 219 gigawatts in *AEO2004*, compared with 292 gigawatts in *AEO2003*. The *AEO2004* projection of 1,304 billion kilowatt-hours of electricity generation from natural gas in 2025 is still nearly double the 2002 level of 682 billion kilowatt-hours (Figure 4), reflecting utilization of the new capacity added over the past few years and the construction of new natural-gas-fired capacity later in the forecast period to meet increasing demand and replace capacity that is expected to be retired. Less new gas-fired capacity is added in the later years of

the forecast because of the projected rise in prices for natural gas and the current surplus of capacity in many regions of the country. In *AEO2003*, 1,678 billion kilowatt-hours of electricity was projected to be generated from natural gas in 2025.

The natural gas share of electricity generation (including generation in the end-use sectors) is projected to increase from 18 percent in 2002 to 22 percent in 2025 (as compared with 29 percent in the *AEO2003* forecast). The share from coal is projected to increase from 50 percent in 2002 to 52 percent in 2025 as rising natural gas prices improve the cost competitiveness of coal-fired technologies. *AEO2004* projects that 112 gigawatts of new coal-fired generating capacity will be constructed between 2003 and 2025 (compared with 74 gigawatts in *AEO2003*).

Nuclear generating capacity in the *AEO2004* forecast is projected to increase from 98.7 gigawatts in 2002 to 102.6 gigawatts in 2025, including uprates of existing plants equivalent to 3.9 gigawatts of new capacity between 2002 and 2025. In *AEO2003*, total nuclear capacity reached a peak of 100.4 gigawatts in 2006 before declining to 99.6 gigawatts in 2025. In a departure from *AEO2003*, no existing U.S. nuclear units are retired in the *AEO2004* reference case. Like *AEO2003*, *AEO2004* assumes that the Browns Ferry nuclear plant will begin operation in 2007 but projects that no new nuclear facilities will be built before 2025, based on the relative economics of competing technologies.

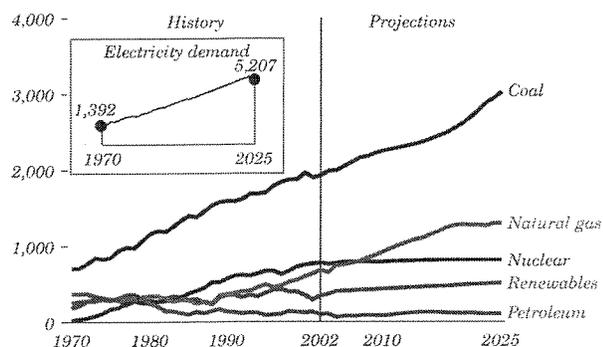
Renewable technologies are projected to grow slowly because of the relatively low costs of fossil-fired generation and because competitive electricity markets favor less capital-intensive technologies in the competition for new capacity. Where enacted, State renewable portfolio standards, which specify a minimum share of generation or sales from renewable sources, are included in the forecast. The production tax credit for wind and biomass is assumed to end on December 31, 2003, its statutory expiration date at the time *AEO2004* was prepared.

Total renewable generation, including combined heat and power generation, is projected to increase from 339 billion kilowatt-hours in 2002 to 518 billion kilowatt-hours in 2025, at an average annual growth rate of 1.9 percent. *AEO2003* projected slower growth in renewable generation, averaging 1.4 percent per year from 2002 to 2025.

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

Figure 4. Electricity generation by fuel, 1970-2025 (billion kilowatt-hours)



to meet a growing share of energy demand (Figure 5). Net imports are expected to constitute 36 percent of total U.S. energy consumption in 2025, up from 26 percent in 2002.

Projected U.S. crude oil production increases from 5.6 million barrels per day in 2002 to a peak of 6.1 million barrels per day in 2008 as a result of increased production offshore, predominantly from the deep waters of the Gulf of Mexico. Beginning in 2009, U.S. crude oil production begins a gradual decline, falling to 4.6 million barrels per day in 2025—an average annual decline of 0.9 percent between 2002 and 2025. The *AEO2004* projection for U.S. crude oil production in 2025 is 0.7 million barrels per day lower than was projected in *AEO2003*. The projections for Alaskan production and offshore production in 2025 both are lower than in *AEO2003* (by 660,000 and 120,000 barrels per day, respectively), based on revised expectations about the discovery of new speculative fields in Alaska and on an update of the cost of offshore production.

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 *AEO2004* forecast, increasing from 9.2 million barrels per day in 2002 to a peak of 9.7 million barrels per day in 2008, then declining to 8.6 million barrels per day in 2025 (Figure 6). The projected drop in total domestic petroleum supply would be greater without a projected increase of 590,000 barrels per day in the production of natural gas plant liquids (a rate of increase that is consistent with the projected growth in domestic natural gas production).

In 2025, net petroleum imports, including both crude oil and refined products (on the basis of barrels per day), are expected to account for 70 percent of demand, up from 54 percent in 2002. Despite an

expected increase in domestic refinery distillation capacity of 5 million barrels per day, net refined petroleum product imports account for a growing portion of total net imports, increasing from 13 percent in 2002 to 20 percent in 2025 (as compared with 34 percent in *AEO2003*).

The most significant change made in the *AEO2004* energy supply projections is in the outlook for natural gas. Total natural gas supply is projected to increase at an average annual rate of 1.4 percent in *AEO2004*, from 22.6 trillion cubic feet in 2002 to 31.3 trillion cubic feet in 2025, which is 3.3 trillion cubic feet less than the 2025 projection in *AEO2003*. Domestic natural gas production increases from 19.1 trillion cubic feet in 2002 to 24.1 trillion cubic feet in 2025 in the *AEO2004* forecast, an average increase of 1.0 percent per year. *AEO2003* projected 26.8 trillion cubic feet of domestic natural gas production in 2025.

The projection for conventional onshore production of natural gas is lower in *AEO2004* than it was in *AEO2003*, because slower reserve growth, fewer new discoveries, and higher exploration and development costs are expected. In particular, reserves added per well drilled in the Midcontinent and Southwest regions are projected to be about 30 percent lower than projected in *AEO2003*. Offshore natural gas production is also lower in *AEO2004* than in *AEO2003* because of the tendency to find more oil than natural gas in the offshore and at higher costs than previously anticipated. Recent data from the Minerals Management Service show that about three-quarters of the hydrocarbons discovered in deepwater fields are oil, compared with 50 percent assumed in *AEO2003*. Conventional production of associated-dissolved and nonassociated natural gas in the onshore and offshore remains important, meeting 39 percent of total U.S. supply requirements in 2025, down from 56 percent in 2002.

Figure 5. Total energy production and consumption, 1970-2025 (quadrillion Btu)

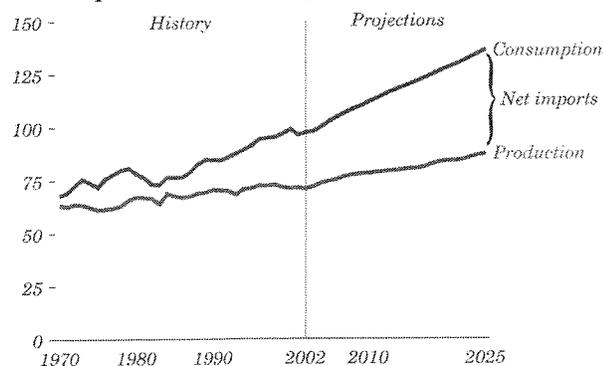
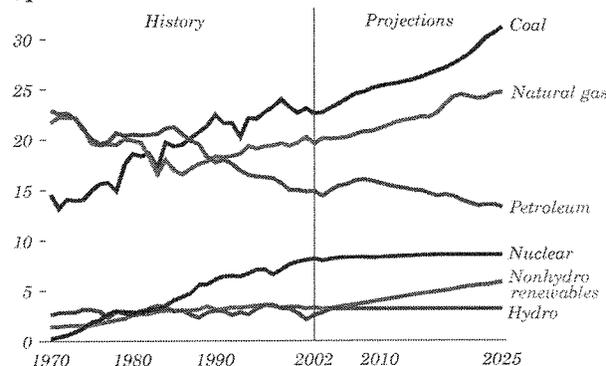


Figure 6. Energy production by fuel, 1970-2025 (quadrillion Btu)



Overview

Canadian imports are also projected to be sharply lower in *AEO2004* than in *AEO2003*. Net imports of natural gas from Canada are projected to remain at about the 2002 level of 3.6 trillion cubic feet through 2010 and then decline to 2.6 trillion cubic feet in 2025 (compared with the *AEO2003* projection of 4.8 trillion cubic feet in 2025). The lower forecast in *AEO2004* reflects revised expectations about Canadian natural gas production, particularly coalbed methane and conventional production in Alberta, based on data and projections from the Canadian National Energy Board and other sources.

Growth in U.S. natural gas supplies will be dependent on unconventional domestic production, natural gas from Alaska, and imports of LNG. Total nonassociated unconventional natural gas production is projected to grow from 5.9 trillion cubic feet in 2002 to 9.2 trillion cubic feet in 2025. With completion of an Alaskan natural gas pipeline in 2018, total Alaskan production is projected to increase from 0.4 trillion cubic feet in 2002 to 2.7 trillion cubic feet in 2025. The four existing U.S. LNG terminals (Everett, Massachusetts; Cove Point, Maryland; Elba Island, Georgia; and Lake Charles, Louisiana) all are 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, with a new small facility in New England and a new facility in the Bahamas serving Florida via a pipeline. Another facility is projected to be built in Baja California, Mexico, serving the California market. Total net LNG imports are projected to increase from 0.2 trillion cubic feet in 2002 to 4.8 trillion cubic feet in 2025, more than double the *AEO2003* projection of 2.1 trillion cubic feet.

As domestic coal demand grows in *AEO2004*, U.S. coal production is projected to increase at an average rate of 1.5 percent per year, from 1,105 million short tons in 2002 to 1,543 million short tons in 2025. Projected production in 2025 is 103 million short tons higher than in *AEO2003* because of a substantial increase in projected coal demand for electricity generation resulting from higher natural gas prices. Production from mines west of the Mississippi River is expected to provide the largest share of the incremental production. In 2025, nearly two-thirds of coal production is projected to originate from the western States.

Renewable energy production is projected to increase from 5.8 quadrillion Btu in 2002 to 9.0 quadrillion

Btu in 2025, with growth in industrial biomass, ethanol for gasoline blending, and most sources of renewable electricity generation (including conventional hydroelectric, geothermal, biomass, and wind). The *AEO2004* projection for renewable energy production in 2025 is 0.2 quadrillion Btu higher than was projected in *AEO2003* as a result of higher projections for electricity generation from geothermal and wind energy.

Carbon Dioxide Emissions

Carbon dioxide emissions from energy use are projected to increase from 5,729 million metric tons in 2002 to 8,142 million metric tons in 2025 in *AEO2004*, an average annual increase of 1.5 percent (Figure 7). This is slightly less than the projected rate of increase over the same period in *AEO2003*, 1.6 percent per year.

By sector, projected carbon dioxide emissions from residential, commercial, and electric power sector sources are higher in *AEO2004* than they were in *AEO2003* because of an updated estimate of 2002 emissions and higher projected energy consumption in each of the three sectors—particularly, coal consumption for electricity generation in the electric power sector. Projected carbon dioxide emissions from the industrial and transportation sectors are lower in the *AEO2004* forecast, because of lower projections for industrial natural gas consumption and the new CAFE standards for light trucks as well as other changes in the transportation sector that lead to lower petroleum consumption. The *AEO* projections do not include future policy actions or agreements that might be taken to reduce carbon dioxide emissions.

Figure 7. Projected U.S. carbon dioxide emissions by sector and fuel, 1990-2025 (million metric tons)

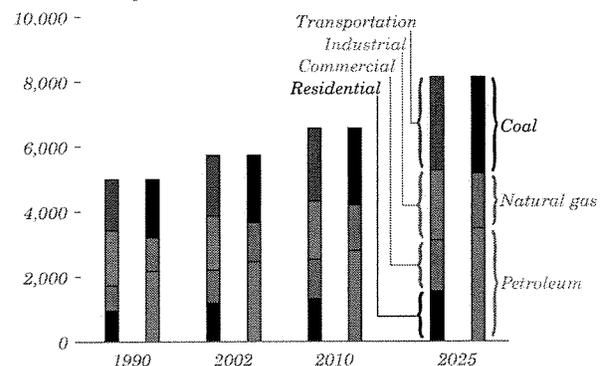


Table 1. Total energy supply and disposition in the AEO2004 reference case: summary, 2001-2025

Energy and economic factors	2001	2002	2010	2015	2020	2025	Average annual change, 2002-2025
Primary energy production (quadrillion Btu)							
Petroleum	14.70	14.47	15.66	14.91	13.95	13.24	-0.4%
Dry natural gas	20.23	19.56	21.05	22.20	24.43	24.64	1.0%
Coal	23.97	22.70	25.25	26.14	27.92	31.10	1.4%
Nuclear power	8.03	8.15	8.29	8.48	8.53	8.53	0.2%
Renewable energy	5.25	5.84	7.18	7.84	8.45	9.00	1.9%
Other	0.53	1.13	0.88	0.79	0.81	0.84	-1.3%
Total	72.72	71.85	78.30	80.36	84.09	87.33	0.9%
Net imports (quadrillion Btu)							
Petroleum	23.29	22.56	28.13	33.20	37.25	41.69	2.7%
Natural gas	3.69	3.58	5.63	6.39	6.63	7.41	3.2%
Coal/other (- indicates export)	-0.67	-0.51	0.06	0.26	0.43	0.61	NA
Total	26.31	25.63	33.82	39.84	44.31	49.71	2.9%
Consumption (quadrillion Btu)							
Petroleum products	38.49	38.11	44.15	48.26	51.35	54.99	1.6%
Natural gas	23.05	23.37	26.82	28.74	31.21	32.21	1.4%
Coal	22.04	22.18	25.23	26.32	28.30	31.73	1.6%
Nuclear power	8.03	8.15	8.29	8.48	8.53	8.53	0.2%
Renewable energy	5.25	5.84	7.18	7.84	8.46	9.00	1.9%
Other	0.08	0.07	0.11	0.11	0.07	0.03	-4.6%
Total	96.94	97.72	111.77	119.75	127.92	136.48	1.5%
Petroleum (million barrels per day)							
Domestic crude production	5.74	5.62	5.93	5.53	4.95	4.61	-0.9%
Other domestic production	3.11	3.60	3.59	3.72	3.94	3.98	0.4%
Net imports	10.90	10.54	13.17	15.52	17.48	19.67	2.7%
Consumption	19.71	19.61	22.71	24.80	26.41	28.30	1.6%
Natural gas (trillion cubic feet)							
Production	19.79	19.13	20.59	21.72	23.89	24.08	1.0%
Net imports	3.60	3.49	5.50	6.24	6.47	7.24	3.2%
Consumption	22.48	22.78	26.15	28.03	30.44	31.41	1.4%
Coal (million short tons)							
Production	1,138	1,105	1,230	1,285	1,377	1,543	1.5%
Net imports	-29	-23	-2	6	14	23	NA
Consumption	1,060	1,066	1,229	1,291	1,391	1,567	1.7%
Prices (2002 dollars)							
World oil price (dollars per barrel)	22.25	23.68	24.17	25.07	26.02	27.00	0.6%
Domestic natural gas at wellhead (dollars per thousand cubic feet)	4.14	2.95	3.40	4.19	4.28	4.40	1.8%
Domestic coal at minemouth (dollars per short ton)	17.79	17.90	16.88	16.47	16.32	16.57	-0.3%
Average electricity price (cents per kilowatthour)	7.4	7.2	6.6	6.8	6.9	6.9	-0.2%
Economic indicators							
Real gross domestic product (billion 1996 dollars)	9,215	9,440	12,190	14,101	16,188	18,520	3.0%
GDP chain-type price index (index, 1996=1.000)	1.094	1.107	1.301	1.503	1.774	2.121	2.9%
Real disposable personal income (billion 1996 dollars)	6,748	7,032	8,894	10,330	11,864	13,826	3.0%
Value of manufacturing shipments (billion 1996 dollars)	5,368	5,285	6,439	7,345	8,344	9,491	2.6%
Energy intensity (thousand Btu per 1996 dollar of GDP)	10.53	10.36	9.17	8.50	7.91	7.37	-1.5%
Carbon dioxide emissions (million metric tons)	5,691.7	5,729.3	6,558.8	7,028.4	7,535.6	8,142.0	1.5%

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.

Sources: Tables A1, A19, and A20.

Reference Case Forecast

Table A10. Electricity Trade
(Billion Kilowatthours, Unless Otherwise Noted)

Electricity Trade	Reference Case						Annual Growth 2002-2025 (percent)
	2001	2002	2010	2015	2020	2025	
Interregional Electricity Trade							
Gross Domestic Firm Power Trade	142.7	138.9	107.1	70.7	41.5	41.5	-5.1%
Gross Domestic Economy Trade	182.1	209.9	229.7	221.2	218.4	183.4	-0.6%
Gross Domestic Trade	324.8	348.8	336.8	291.8	259.9	224.9	-1.9%
Gross Domestic Firm Power Sales (million 2002 dollars)	7126.8	6932.4	5345.8	3528.2	2074.2	2074.2	-5.1%
Gross Domestic Economy Sales (million 2002 dollars)	8870.2	6809.8	7629.6	8674.0	8663.8	7319.5	0.3%
Gross Domestic Sales (million 2002 dollars)	15997.0	13742.1	12975.3	12202.2	10738.0	9393.7	-1.6%
International Electricity Trade							
Firm Power Imports From Canada and Mexico	12.1	9.5	5.8	2.6	0.0	0.0	-21.9%
Economy Imports From Canada and Mexico	26.3	26.8	41.3	40.9	28.9	15.1	-2.5%
Gross Imports From Canada and Mexico	38.4	36.3	47.2	43.5	28.9	15.2	-3.7%
Firm Power Exports To Canada and Mexico	6.6	5.6	8.7	3.9	0.0	0.0	N/A
Economy Exports To Canada and Mexico	9.8	8.7	7.7	7.7	7.7	7.7	-0.6%
Gross Exports To Canada and Mexico	16.4	14.3	16.4	11.5	7.7	7.7	-2.7%

N/A = Not applicable.

Note: Totals may not equal sum of components due to independent rounding. Data for 2001 and 2002 are model results and may differ slightly from official EIA data reports. Firm Power Sales are capacity sales, meaning the delivery of the power is scheduled as part of the normal operating conditions of the affected electric systems. Economy Sales are subject to curtailment or cessation of delivery by the supplier in accordance with prior agreements or under specified conditions.

Sources: 2001 and 2002 interregional firm electricity trade data: North American Electric Reliability Council (NERC), Electricity Sales and Demand Database 1999. 2001 and 2002 Mexican electricity trade data: DOE Form FE-718R, "Annual Report of International Electrical Export/Import Data." 2001: National Energy Board, *Annual Report 2001*. 2002 Canadian electricity trade data: National Energy Board, Annual Report 2002. Projections: Energy Information Administration, AEO2004 National Energy Modeling System run AEO2004.D101703E.