NEMS Overview and Brief Description of Cases

The National Energy Modeling System

The projections in the *Annual Energy Outlook 2005* (*AEO2005*) are generated from the National Energy Modeling System (NEMS), developed and maintained by the Office of Integrated Analysis and Forecasting (OIAF) of the Energy Information Administration (EIA). In addition to its use in the development of the *AEO* projections, NEMS is also used in analytical studies for the U.S. Congress and other offices within the Department of Energy. The *AEO* forecasts are also used by analysts and planners in other government agencies and outside organizations.

The projections in NEMS are developed with the use of a market-based approach to energy analysis. For each fuel and consuming sector, NEMS balances energy supply and demand, accounting for economic competition among the various energy fuels and sources. The time horizon of NEMS is the midterm period, approximately 20 years into the future. In order to represent the regional differences in energy markets, the component modules of NEMS function at the regional level: the nine Census divisions for the end-use demand modules; production regions specific to oil, gas, and coal supply and distribution; the North American Electric Reliability Council (NERC) regions and subregions for electricity; and aggregations of the Petroleum Administration for Defense Districts (PADDs) for refineries.

NEMS is organized and implemented as a modular system. The modules represent each of the fuel supply markets, conversion sectors, and end-use consumption sectors of the energy system. NEMS also includes macroeconomic and international modules. The primary flows of information between each of these modules are the delivered prices of energy to the end user and the quantities consumed by product, region, and sector. The delivered prices of fuel encompass all the activities necessary to produce, import, and transport fuels to the end user. The information flows also include other data on such areas as economic activity, domestic production, and international petroleum supply availability.

The integrating module controls the execution of each of the component modules. To facilitate modularity, the components do not pass information to each other directly but communicate through a central data file. This modular design provides the capability to execute modules individually, thus allowing decentralized development of the system and independent analysis and testing of individual modules, permitting the use of the methodology and level of detail most appropriate for each energy sector. NEMS calls each supply, conversion, and end-use demand module in sequence until the delivered prices of energy and the quantities demanded have converged within tolerance, thus achieving an economic equilibrium of supply and demand in the consuming sectors. Solution is reached annually through the midterm horizon. Other variables are also evaluated for convergence, such as petroleum product imports, crude oil imports, and several macroeconomic indicators.

Each NEMS component also represents the impacts and costs of legislation and environmental regulations that affect that sector and reports key emissions. NEMS represents current legislation and environmental regulations as of October 31, 2004, such as the Clean Air Act Amendments (CAAA), and the costs of compliance with regulations, such as the new boiler limits established by the U.S. Environmental Protection Agency (EPA) under the CAAA on February 26, 2004; and the 13 SEER standard for new central air conditioners and heat pumps that was reestablished by the U.S. Court of Appeals, Second Circuit, after originally being set in January 2001.

In general, the historical data used for the *AEO2005* projections were based on EIA's *Annual Energy Review 2003*, published in September 2004 [*1*]; however, data were taken from multiple sources. In some cases, only partial or preliminary data were available for 2003. Carbon dioxide emissions were calculated by using carbon dioxide coefficients from the EIA report, *Emissions of Greenhouse Gases in the United States 2003*, published in December 2004 [*2*].

Historical numbers are presented for comparison only and may be estimates. Source documents should be consulted for the official data values. Some definitional adjustments were made to EIA data for the forecasts. For example, the transportation demand sector in *AEO2005* includes electricity used by railroads, which is included in the commercial sector in EIA's consumption data publications. Footnotes in the appendix tables of this report indicate the definitions and sources of all historical data.

NEMS Overview and Brief Description of Cases

The *AEO2005* projections for 2004 and 2005 incorporate short-term projections from EIA's October 2004 *Short-Term Energy Outlook* (*STEO*). For short-term energy projections, readers are referred to the monthly updates of the *STEO* [*3*].

Component Modules

The component modules of NEMS represent the individual supply, demand, and conversion sectors of domestic energy markets and also include international and macroeconomic modules. In general, the modules interact through values representing the prices of energy delivered to the consuming sectors and the quantities of end-use energy consumption.

Macroeconomic Activity Module

The Macroeconomic Activity Module provides a set of essential macroeconomic drivers to the energy modules and a macroeconomic feedback mechanism within NEMS. Key macroeconomic variables include gross domestic product (GDP), industrial output, interest rates, disposable income, prices, and employment. This module uses the following Global Insight models: Macroeconomic Model of the U.S. Economy, national Industry Model, and national Employment Model. In addition, EIA has constructed a Regional Economic and Industry Model to forecast regional economic drivers and a Commercial Floorspace Model to forecast 13 floorspace types in 9 Census divisions. For *AEO2005*, bulk chemicals are disaggregated into organic and inorganic chemicals, resins, and agricultural chemicals. In addition, the accounting framework for industrial output has changed from the Standard Industrial Classification (SIC) system to the North American Industry Classification System (NAICS), which has reclassified the components of gross industrial output and moved some manufacturing activities into services.

International Module

The International Module represents the world oil markets, calculating the average world oil price and computing supply curves for five categories of imported crude oil for the Petroleum Market Module (PMM) of NEMS, in response to changes in U.S. import requirements. Fourteen international petroleum product supply curves, including curves for oxygenates, are also calculated and provided to the PMM. A world oil supply/demand balance is created, including estimates for 16 oil consumption regions and 18 oil production regions. The oil production estimates include both conventional and nonconventional supply recovery technologies.

Residential and Commercial Demand Modules

The Residential Demand Module forecasts consumption of residential sector energy by housing type and end use, based on delivered energy prices, the menu of equipment available, the availability of renewable sources of energy, and housing starts. The Commercial Demand Module forecasts consumption of commercial sector energy by building types and nonbuilding uses of energy and by category of end use, based on delivered prices of energy, availability of renewable sources of energy, and macroeconomic variables representing interest rates and floorspace construction. Both modules estimate the equipment stock for the major end-use services, incorporating assessments of advanced technologies, including representations of renewable energy technologies and effects of both building shell and appliance standards. The commercial module incorporates combined heat and power (CHP) technology. The modules also include forecasts of distributed generation. Both modules incorporate changes to "normal" heating and cooling degree-days by Census division, based on State-level population projections. The Residential Demand Module projects that the average square footage of both new construction and existing structures is increasing, based on trends in the size of new construction and the remodeling of existing homes.

Industrial Demand Module

The Industrial Demand Module forecasts the consumption of energy for heat and power and for feedstocks and raw materials in each of 16 industry groups, subject to the delivered prices of energy and macroeconomic variables representing employment and the value of shipments for each industry. As noted in the description of the macroeconomic module, the value of shipments is now based on NAICS rather than SIC. The industries are classified into three groups—energy-intensive manufacturing, non-energy-intensive manufacturing, and nonmanufacturing. Of the eight energy-intensive industries, seven are modeled in the Industrial Demand Module, with components for boiler/steam/cogeneration, buildings, and process/ assembly use of energy. Bulk chemicals have been further disaggregated to organic, inorganic, resins, and other petroleum products. A representation of cogeneration and a recycling component are also included. The use of energy for petroleum refining is modeled in the Petroleum Market Module, and the projected consumption is included in the industrial totals.

Transportation Demand Module

The Transportation Demand Module forecasts consumption of transportation sector fuels, including petroleum products, electricity, methanol, ethanol, compressed natural gas, and hydrogen by transportation mode, vehicle vintage, and size class, subject to delivered prices of energy fuels and macroeconomic variables representing disposable personal income, GDP, population, interest rates, and the value of output for industries in the freight sector. Fleet vehicles are represented separately to allow analysis of CAAA and other legislative proposals, and the module includes a component to explicitly assess the penetration of alternative-fuel vehicles. The air transportation module explicitly represents the industry practice of parking aircraft to reduce operating costs and the movement of aircraft from the passenger to cargo markets as aircraft age [*4*]. For air freight shipments, the model employs narrow-body and wide-body aircraft only. The model also uses an infrastructure constraint that limits air travel growth to levels commensurate with industry-projected infrastructure expansion and capacity growth.

Electricity Market Module

The Electricity Market Module (EMM) represents generation, transmission, and pricing of electricity, subject to delivered prices for coal, petroleum products, natural gas, and biofuels; costs of generation by all generation plants, including capital costs; macroeconomic variables for costs of capital and domestic investment; enforced environmental emissions laws and regulations; and electricity load shapes and demand. There are three primary submodules—capacity planning, fuel dispatching, and finance and pricing. Nonutility generation, distributed generation, and transmission and trade are modeled in the planning and dispatching submodules. The levelized fuel cost of uranium fuel for nuclear generation is directly incorporated into the Electricity Market Module.

All specifically identified CAAA compliance options that have been promulgated by the EPA are explicitly represented in the capacity expansion and dispatch decisions; those that have not been promulgated are not incorporated (e.g., fine particulate proposal). Several States, primarily in the Northeast, have recently enacted air emission regulations that affect the electricity generation sector. Where firm State compliance plans have been announced, regulations are represented in *AEO2005*.

Renewable Fuels Module

The Renewable Fuels Module (RFM) includes submodules representing natural resource supply and technology input information for central-station, grid-connected electricity generation technologies, including conventional hydroelectricity, biomass (wood, energy crops, and biomass co-firing), geothermal, landfill gas, solar thermal electricity, solar photovoltaics, and wind energy. The RFM contains natural resource supply estimates representing the regional opportunities for renewable energy development. Investment tax credits for renewable fuels are incorporated, as currently legislated in the Energy Policy Act of 1992 [*5*]. They provide a 10-percent tax credit for business investment in solar energy (thermal non-power uses as well as power uses) and geothermal power. The credits have no expiration date.

Production tax credits for wind and some types of biomass-fueled plants are also represented. They provide a tax credit of 1.8 cents per kilowatthour for electricity produced in the first 10 years of plant operation. New plants that come on line before January 1, 2006, are eligible to receive the credit. For a description of significant changes made for *AEO2005* in the representation of biomass resource supply, conventional hydroelectricity, wind resources, cost and performance characteristics for wind technologies, and accounting of new renewable energy capacity from State renewable portfolio standards, mandates, and goals, see the “Renewable Fuels Module” chapter of *Assumptions for the Annual Energy Outlook 2005*.

Oil and Gas Supply Module

The Oil and Gas Supply Module represents domestic crude oil and natural gas supply within an integrated framework that captures the interrelationships among the various sources of supply: onshore, offshore, and Alaska by both conventional and nonconventional techniques, including gas recovery from coalbeds and low-permeability formations of sandstone and shale. This framework analyzes cash flow and profitability to compute investment and drilling for each of the supply sources, based on the prices for crude oil and natural gas, the domestic recoverable resource base, and the state of technology. Oil and gas production functions are computed at a level of 12 supply regions, including 3 offshore and 3 Alaskan regions. This module also represents foreign sources of natural gas, including pipeline imports and exports to Canada and Mexico, and liquefied natural gas (LNG) imports and exports.

Crude oil production quantities are input to the Petroleum Market Module in NEMS for conversion and blending into refined petroleum products. Supply curves for natural gas are input to the Natural Gas Transmission and Distribution Module for use in determining natural gas prices and quantities. International LNG supply sources and options for regional expansions of domestic regasification capacity are represented, based on the projected regional costs associated with gas supply, liquefaction, transportation, regasification, and natural gas market conditions.

Natural Gas Transmission and Distribution Module

The Natural Gas Transmission and Distribution Module (NGTDM) represents the transmission, distribution, and pricing of natural gas, subject to end-use demand for natural gas and the availability of domestic natural gas and natural gas traded on the international market. The module tracks the flows of natural gas in an aggregate, domestic pipeline network, connecting the domestic and foreign supply regions with 12 demand regions. This capability allows the analysis of impacts of regional capacity constraints in the interstate natural gas pipeline network and the identification of pipeline capacity expansion requirements. Peak and off-peak periods are represented for natural gas transmission, and core and non-core markets are represented at the burner tip. Key components of pipeline and distributor tariffs are included in the pricing algorithms.

Petroleum Market Module

The Petroleum Market Module (PMM) forecasts prices of petroleum products, crude oil and product import activity, and domestic refinery operations (including fuel consumption), subject to the demand for petroleum products, the availability and price of imported petroleum, and the domestic production of crude oil, natural gas liquids, and alcohol fuels. The module represents refining activities in the five PADDs. The module uses the same crude oil types as the International Energy Module. It explicitly models the requirements of CAAA and the costs of automotive fuels, such as oxygenated and reformulated gasoline, and includes oxygenate production and blending for reformulated gasoline. *AEO2005* reflects legislation that bans or limits the use of the gasoline blending component methyl tertiary butyl ether (MTBE) in Arizona, California, Colorado, Connecticut, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New York, Ohio, South Dakota, Washington, and Wisconsin.

The Federal oxygen requirement for reformulated gasoline in Federal nonattainment areas is assumed to remain intact. The nationwide phase-in of gasoline with an annual average sulfur content of 30 ppm between 2005 and 2007, and the diesel regulations that limit the sulfur content to 15 ppm in highway diesel starting mid-2006 and in all nonroad and locomotive/marine diesel fuel by mid-2012, are represented in *AEO2005*. Growth in demand and the costs of the regulations lead to capacity expansion for refinery-processing units, assuming a financing ratio of 60 percent equity and 40 percent debt, with a hurdle rate and an after-tax return on investment at about 10 percent [6]. End-use prices are based on the marginal costs of production, plus markups representing product and distribution costs and State and Federal taxes [7]. Refinery capacity expansion at existing sites may occur in all five refining regions modeled.

Fuel ethanol and biodiesel are included in PMM because they are commonly blended into petroleum products. The PMM allows ethanol blending into gasoline at 10 percent by volume or less and also allows limited quantities of E85, a blend of up to 85 percent ethanol by volume. Ethanol is produced primarily in the Midwest from corn or other starchy crops, and it is expected to be produced from cellulosic material in other regions in the future. Biodiesel is produced from soybean oil or yellow grease, which is primarily recycled cooking oil. Soybean oil biodiesel is assumed to be blended into highway diesel, and yellow grease biodiesel is assumed to be blended into non-highway diesel.

Coal Market Module

The Coal Market Module (CMM) simulates mining, transportation, and pricing of coal, subject to the end-use demand for coal differentiated by heat and sulfur content. U.S. coal production is represented in the CMM using 40 separate supply curves—differentiated by region, mine type, coal rank, and sulfur content. The coal supply curves include a response to capacity utilization of mines, mining capacity, labor productivity, and factor input costs (mining equipment, mining labor, and fuel requirements). Projections of U.S. coal distribution are determined in the CMM through the use of a linear programming algorithm that determines the least-cost supplies of coal for a given set of coal demands by demand region and sector, accounting for minemouth prices, transportation costs, existing coal supply contracts, and sulfur allowance costs. Over the forecast horizon, coal transportation costs in the CMM are projected to vary in response to changes in railroad productivity and the user cost of rail transportation equipment.

The CMM produces projections of U.S. steam and metallurgical coal exports, in the context of world coal trade. The CMM's linear programming algorithm determines the pattern of world coal trade flows that minimizes the production and transportation costs of meeting a pre-specified set of regional world coal import demands, subject to constraints on export capacities by country and coal type and trade flows.

U.S. coal production and distribution are computed for 14 supply and 14 demand regions. The international coal market component of the module computes trade in 3 types of coal for 16 export and 20 import regions. Projections of annual U.S. coal imports, specified by demand region and sector, are developed exogenously based primarily on the capability and plans of existing coal-fired power plants to import coal and announced plans to expand coal import infrastructure.

Annual Energy Outlook 2005 Cases

Table F1 provides a summary of the cases used to derive the *AEO2005* forecasts. For each case, the table gives the name used in this report, a brief description of the major assumptions underlying the projections, a designation of the mode in which the case was run in NEMS (either fully integrated, partially integrated, or standalone), and a reference to the pages in the body of the report and in this appendix where the case is discussed.

The following section describes cases listed in Table F1. The reference case assumptions for each sector are described at web site www.eia.doe.gov/oiaf/aeo/assumption/. Regional results and other details of the projections are available at web site www.eia.doe.gov/oiaf/aeo/supplement/.

Macroeconomic Growth Cases

In addition to the *AEO2005* reference case, the *low economic growth* and *high economic growth cases* were developed to reflect the uncertainty in forecasts of economic growth. The alternative cases are intended to show the projected effects of alternative growth assumptions on energy markets. The cases are described as follows:

- The *low economic growth case* assumes lower growth rates for population (0.6 percent per year), nonfarm employment (0.8 percent per year), and productivity (1.8 percent per year), resulting in higher projections for prices and interest rates and lower projections for industrial output growth. In the *low economic growth case*, economic output is projected to increase by 2.5 percent per year from 2003 through 2025, and growth in GDP per capita is projected to average only 1.9 percent per year.
- The *high economic growth case* assumes higher projected growth rates for population (1.0 percent per year), nonfarm employment (1.6 percent per year), and productivity (2.7 percent per year). With higher productivity gains and employment growth, inflation and interest rates are projected to be lower than in the reference case, and consequently economic output is projected to grow at a higher rate (3.6 percent per year) than in the reference case (3.1 percent). GDP per capita is expected to grow by 2.5 percent per year, compared with 2.2 percent in the reference case.

World Oil Market Cases

The world oil price in *AEO2005* is the annual average U.S. refiner's acquisition cost of imported crude oil (IRAC). Five distinct world oil price scenarios are represented in *AEO2005*, with prices reaching approximately $21, $30, $35, $39, and $48 per barrel in 2025, respectively, in the low world oil price, reference, October oil futures, high A world oil price, and high B world oil price cases in 2003 dollars. Because these oil price cases are not directly integrated with a world economic model, the impacts of world oil prices on international economies is not directly accounted for in this analysis.

- The *reference case* represents EIA's current judgment regarding the expected behavior of the Organization of Petroleum Exporting Countries (OPEC) in the mid-term, where production is adjusted to keep world oil prices in the $25 to $31

Table F1. Summary of the *AEO2005* cases

Case name	Description	Integration mode	Reference in text	Reference in Appendix F
Reference	Baseline economic growth (3.1 percent per annum), world oil price falling to about $25 per barrel by 2010 and rising to $30.31 per barrel, and technology assumptions.	Fully integrated	—	—
Low Economic Growth	Gross domestic product grows at an average annual rate of 2.5 percent from 2003 through 2025, compared with the reference case growth of 3.1 percent. Reference case assumptions otherwise.	Fully integrated	p. 73	p. 215
High Economic Growth	Gross domestic product grows at an average annual rate of 3.6 percent from 2003 through 2025, compared with the reference case growth of 3.1 percent. Reference case assumptions otherwise.	Fully integrated	p. 73	p. 215
Low World Oil Price	Reference case assumptions except that the world oil prices are $20.99 per barrel in 2025, compared with $30.31 per barrel in the reference case.	Fully integrated	p. 74	p. 218
October Oil Futures	World oil prices continue to rise in near term and are $35.00 per barrel in 2025, compared with $30.31 per barrel in the reference case.	Fully integrated	p. 44	p. 218
High A World Oil Price	Reference case assumptions except that the world oil prices are $39.24 per barrel in 2025, compared with $30.31 per barrel in the reference case.	Fully integrated	p. 74	p. 218
High B World Oil Price	World oil prices remain high and are $48.00 per barrel in 2025, compared with $30.31 per barrel in the reference case.	Fully integrated	p. 74	p. 218
Residential: 2005 Technology	Future equipment purchases based on equipment available in 2005. Existing building shell efficiencies fixed at 2005 levels.	With commercial	p. 84	p. 218
Residential: High Technology	Relative to the reference case, earlier availability, lower costs, and higher efficiencies assumed for more advanced equipment. Heating shell efficiency increases by 21 percent from 2002 values by 2025.	With commercial	p. 84	p. 218
Residential: Best Available Technology	Relative to the reference case, future equipment purchases and new building shells based on most efficient technologies available. Heating shell efficiency increases by 25 percent from 2002 values by 2025.	With commercial	p. 84	p. 218
Commercial: 2005 Technology	Relative to the reference case, future equipment purchases are based on equipment available in 2005. Building shell efficiencies are fixed at 2005 levels.	With residential	p. 85	p. 219
Commercial: High Technology	Earlier availability, lower costs, and higher efficiencies assumed for more advanced equipment. Heating shell efficiencies for new and existing buildings increase by 8.75 and 6.25 percent, respectively, from 1999 values by 2025.	With residential	p. 85	p. 219
Commercial: Best Available Technology	Future equipment purchases based on most efficient technologies available. Heating shell efficiencies for new and existing buildings increase by 10.5 and 7.5 percent, respectively, from 1999 values by 2025.	With residential	p. 85	p. 219
Residential and Commercial: SEER 12	Replaces the recently enacted SEER 13 standard with the previously set level of SEER 12.	Fully integrated	p. 13	p. 218
Residential and Commercial: Warmer temperatures	Summer and winter temperatures trend to the average of the 5 warmest of the past 30 years by 2025.	Fully integrated	p. 55	p. 219

Table F1. Summary of the *AEO2005* cases (continued)

Case name	Description	Integration mode	Reference in text	Reference in Appendix F
Residential and Commercial: Colder temperatures	Summer and winter temperatures trend to the average of the 5 coldest of the past 30 years by 2025.	Fully integrated	p. 55	p. 219
Industrial: 2005 Technology	Efficiency of plant and equipment fixed at 2005 levels.	Standalone	p. 85	p. 219
Industrial: High Technology	Earlier availability, lower costs, and higher efficiencies assumed for more advanced equipment.	Standalone	p. 85	p. 219
Transportation: 2005 Technology	Efficiencies for new equipment in all modes of travel are fixed at 2005 levels.	Standalone	p. 86	p. 220
Transportation: High Technology	Reduced costs and improved efficiencies are assumed for advanced technologies.	Standalone	p. 86	p. 220
Transportation: A.B.1493 California Only	Accounts for adoption of vehicle carbon dioxide emissions standards in California.	Fully integrated	p. 27	p. 220
Transportation: A.B.1493 Extended	Accounts for adoption of vehicle carbon dioxide emissions standards in California, New York, Maine, Massachusetts, and Vermont.	Fully integrated	p. 27	p. 220
Integrated 2005 Technology	Baseline macroeconomic drivers, combining the residential, commercial, industrial, and transportation 2005 technology assumptions with electricity low fossil technology and low renewable technology assumptions.	Fully integrated	p. 110	—
Integrated High Technology	Combination of the residential, commercial, industrial, and transportation high technology cases, electricity high fossil technology case, high renewables case, and advanced nuclear cost case.	Fully integrated	p. 110	—
Electricity: Advanced Nuclear Cost	New nuclear capacity is assumed to have 20 percent lower capital and operating costs in 2025 than in the reference case.	Fully integrated	p. 93	p. 220
Electricity: Nuclear Vendor Estimate	New nuclear capacity is assumed to have lower capital costs based on vendor goals.	Fully integrated	p. 93	p. 221
Electricity: High Fossil Technology	Costs and efficiencies for advanced fossil-fired generating technologies improve by 10 percent in 2025 from reference case values.	Fully integrated	p. 93	p. 221
Electricity: Low Fossil Technology	New advanced fossil generating technologies are assumed not to improve over time from 2005.	Fully integrated	p. 93	p. 221
Electricity: Proposed Clean Air Interstate Rule (pCAIR)	Limits on NO_x and SO_2 emissions.	Fully integrated	p.31	p. 221
Renewables: Low Renewables	New renewable generating technologies are assumed not to improve over time after 2005.	Fully Integrated	p. 94	p. 221
Renewables: High Renewables	Levelized cost of energy for nonhydropower renewable generating technologies declines by 10 percent in 2025 from reference case values.	Fully Integrated	p. 94	p. 221
Renewables: PTC Extension	The production tax credit (PTC) for wind expires in 2005. *AEO2005* does not assume its extension consistent with the approach generally taken toward public policy in the forecast. This scenario assumes the extension of the PTC through 2015.	Fully integrated	p. 58	p. 222
Oil and Gas: Rapid Technology	Cost, finding rate, and success rate technology parameters adjusted for 50 percent more rapid improvement than in the reference case.	Fully integrated	p. 97	p. 222

Table F1. Summary of the *AEO2005* cases (continued)

Case name	Description	Integration mode	Reference in text	Reference in Appendix F
Oil and Gas: Slow Technology	Cost, finding rate, and success rate technology parameters adjusted for 50 percent slower improvement than in the reference case.	Fully integrated	p. 97	p. 222
Oil and Gas: Restricted Natural Gas Supply	The slow oil and gas technology case with no Alaskan pipeline and no new U.S. LNG regasification terminals except those already under construction. Proposed expansions of existing U.S. LNG terminals are permitted to go into operation as currently scheduled.	Fully integrated	p. 66	p. 222
Oil and Gas: No Nonroad Diesel Rule	No new nonroad diesel rules.	Fully integrated	p. 14	p. 222

per barrel range and in keeping with their noted goal of keeping potential competitors from taking their market share. Since OPEC, particularly the Persian Gulf nations, is expected to be the dominant supplier of oil in the international market over the midterm, the organization's production choices will significantly affect world oil prices.

- The *low world oil price case* could result from a future market where all oil production becomes more competitive and plentiful.

- The world crude oil price in the *October oil futures case* was developed by extrapolating the U.S. refiner's acquisition cost of imported crude oil based loosely on the rate of growth of futures prices for West Texas Intermediate crude oil on the New York Mercantile Exchange. The prices in the *October oil futures case* continue to rise through 2005, reaching $44 per barrel, before gradually declining to $31 per barrel in 2010, $6 higher then the reference case projection. After 2010, prices rise to $35 per barrel in 2025, about $5 per barrel higher than in the reference case. Prices are above those in the reference case over the entire projection, but below those in the *high A world oil price case* and the *high B world oil price case*.

- The *high A world oil price case* could result from a more cohesive and market-assertive OPEC with lower production goals and other nonfinancial (geopolitical) considerations, including possibly a change in the target price band.

- The *high B world oil price case* could result from a number of possible events. For example, a very high world oil price could result from robust growth in worldwide oil demand, especially in the developing economies, coupled with the inability or unwillingness of OPEC producers to sufficiently expand their oil production capacity.

Buildings Sector Cases

In addition to the *AEO2005* reference case, three standalone technology-focused cases using the Residential and Commercial Demand Modules of NEMS were developed to examine the effects of changes to equipment and building shell efficiencies, and an integrated cooling efficiency standard case was developed to analyze the effect of the recently implemented 13 SEER standard for central air conditioners and heat pumps.

For the residential sector, the four technology-focused cases are as follows:

- The *2005 technology case* assumes that all future equipment purchases are based only on the range of equipment available in 2005. Existing building shell efficiencies are assumed to be fixed at 2005 levels.

- The *high technology case* assumes earlier availability, lower costs, and higher efficiencies for more advanced equipment [*8*]. Heating shell efficiency in 2025 is projected to be 21 percent higher than the 2002 level.

- The *best available technology case* assumes that all future equipment purchases are made from a menu of technologies that includes only the most efficient models available in a particular year, regardless of cost. Heating shell efficiency is projected to increase by 25 percent over 2002 levels by 2025.

- A *cooling efficiency standard case* for residential and commercial technologies is an integrated case designed to analyze the effects of the recently enacted central air conditioner and heat pump standard on buildings-related energy use (residential and commercial). This case replaces the 13 SEER standard, which is used in the *AEO2005* reference case, with the previously enacted 12 SEER standard, effective in 2006.

For the commercial sector, the four technology-focused cases are as follows:

- The *2005 technology case* assumes that all future equipment purchases are based only on the range of equipment available in 2005. Building shell efficiencies are assumed to be fixed at 2005 levels.
- The *high technology case* assumes earlier availability, lower costs, and/or higher efficiencies for more advanced equipment than in the reference case [*9*]. Heating shell efficiencies for new and existing buildings are assumed to increase by 8.75 and 6.25 percent, respectively, from 1999 values by 2025—a 25-percent improvement relative to the reference case.
- The *best available technology* case assumes that all future equipment purchases are made from a menu of technologies that includes only the most efficient models available in a particular year in the *high technology case*, regardless of cost. Heating shell efficiencies for new and existing buildings are assumed to increase by 10.5 and 7.5 percent, respectively, from 1999 values by 2025—a 50-percent improvement relative to the reference case.
- A *cooling efficiency standard case* is as described for the residential sector above.

Two additional integrated cases were developed, in combination with assumptions for electricity generation from renewable fuels, to analyze the sensitivity of the projections to changes in generating technologies that use renewable fuels and in the availability of renewable energy sources. For the Residential and Commercial Demand Modules:

- The *high renewables case* assumes greater improvements in residential and commercial photovoltaic systems than in the reference case. The high renewables assumptions result in capital cost estimates for 2025 that are approximately 10 percent lower than reference case costs for distributed photovoltaic technologies.
- The *low renewables case* assumes that costs and performance levels for residential and commercial photovoltaic systems remain constant at 2005 levels through 2025.

To illustrate the potential impacts of warmer and colder weather on buildings energy consumption relative to the reference case, two additional integrated cases were developed. For the residential and commercial demand modules:

- The *warmer temperature case* assumes that State-level heating and cooling degree-days trend to the average of the 5 warmest years of the past 30 years by 2025.
- The *colder temperature case* assumes that State-level heating and cooling degree-days trend to the average of the 5 coldest years of the past 30 years by 2025.

Industrial Sector Cases

In addition to the *AEO2005* reference case, two standalone cases using the Industrial Demand Module of NEMS were developed to examine the effects of less rapid technology change and adoption and more rapid technology change and adoption. The Industrial Demand Module was also used as part of and integrated *high renewables case*. For the industrial sector:

- The *2005 technology case* holds the energy efficiency of plant and equipment constant at the 2005 level over the forecast. In this case, delivered energy intensity falls by 1.0 percent annually. Because the level and composition of industrial output are the same in the reference, 2005 technology, and high technology cases, any change in primary energy intensity in the two technology cases is attributable to efficiency changes. The *2005 technology case* was run with only the Industrial Demand Module rather than as fully integrated NEMS runs. Consequently, no potential feedback effects from energy market interactions were captured.
- The *high technology case* assumes earlier availability, lower costs, and higher efficiency for more advanced equipment [*10*]. The *high technology case* also assumes a more rapid rate of improvement in the recovery of biomass byproducts from industrial processes, at 1.0 percent per year as compared with 0.1 percent per year in the reference case. The same assumption is also incorporated in the *integrated high renewable case*, which focuses on electricity generation. While the choice of 1 percent recovery is an assumption of the *high*

technology case, it is based on the expectation that there would be higher recovery rates and substantially increased use of CHP in that case. Changes in aggregate energy intensity result both from changing equipment and production efficiency and from changing composition of industrial output. Because the composition of industrial output remains the same as in the reference case, delivered energy intensity falls by 1.6 percent annually in the *high technology case*. In the reference case, delivered energy intensity falls by 1.6 percent annually between 2003 and 2025.

Transportation Sector Cases

In addition to the *AEO2005* reference case, two standalone cases using the Transportation Demand Module of NEMS were developed to examine the effects of less rapid technology change and adoption and more rapid technology change and adoption. For the transportation sector:

- The *2005 technology case* assumes that new fuel efficiency levels remain constant at 2005 levels through the forecast horizon unless emission and/or efficiency regulations require the implementation of technology that affects vehicle efficiency. For example, the new light truck corporate average fuel economy (CAFE) standards require an increase in fuel economy through 2007, and increases in heavy truck emission standards are required through 2010. As a result, the technology available for light truck efficiency improvement is frozen at 2007 levels, and the technology available to heavy trucks is frozen at 2010 levels.

- For the *high technology case*, light-duty conventional and alternative-fuel vehicle characteristics reflect more optimistic assumptions for incremental fuel economy improvements and costs [*11*]. In the air travel sector, the *high technology case* reflects lower costs for improved thermodynamics, advanced aerodynamics, and weight reduction materials, which provides a 25-percent improvement in new aircraft efficiency compared to the reference case in 2025. In the freight truck sector, the *high technology case* assumes more optimistic incremental fuel efficiency improvements for engine and emission control technologies [*12*]. More optimistic assumptions for fuel efficiency improvements are also made for the rail and shipping sectors.

Both cases were run with only the Transportation Demand Module rather than as fully integrated NEMS runs. Consequently, no potential macroeconomic feedback on travel demand was captured, nor were changes in fuel prices incorporated.

In addition to the technology cases, two cases were developed to measure the impact of recently enacted carbon dioxide emission standards for light-duty vehicles in California (Assembly Bill 1493). These cases measure the energy and fuel price impacts that occur regionally, and vehicle sales impacts that occur in those States adopting A.B.1493.

- The *A.B.1493 California only case* assumes that only California adopts the new standards. The *A.B.1493 extended case* assumes that, in addition, New York, Maine, Massachusetts, and Vermont also adopt the light-duty vehicle carbon emissions standards. These cases assume that fuel economy impacts are limited to those States adopting the regulation, and that the fuel economy and sales mix of vehicles sold in all other States remain at the levels projected in the reference case. EIA estimates that meeting the requirements of A.B. 1493 will require new car fuel economy to increase from 27.5 miles per gallon in 2009 to 39.9 miles per gallon in 2016 and new light truck fuel economy to increase from 22.2 miles per gallon in 2009 to 26.4 miles per gallon in 2016.

Electricity Sector Cases

In addition to the reference case, four integrated cases with alternative electric power assumptions were developed to analyze the uncertainties regarding future costs and performance of new generating technologies. Two of the cases examine alternative nuclear assumptions, and two examine alternative fossil technology assumptions. Reference case values for technology characteristics are determined in consultation with industry and government specialists; however, there is always uncertainty surrounding newer, untested designs. The electricity cases analyze what could happen if costs of advanced designs are either higher or lower than assumed in the reference case. The cases are fully integrated to allow feedback between the potential shifts in fuel consumption and fuel prices.

Nuclear Technology Cases

- The cost assumptions for the *advanced nuclear cost case* reflect a 20-percent reduction in the capital and operating costs for advanced nuclear technology in 2025, relative to the reference case. Because the reference case assumes that some learning occurs regardless of new orders and construction, the reference case already projects a 10-percent reduction in capital costs between 2005 and 2025. The *advanced nuclear cost case* assumes a 28-percent reduction between 2005 and 2025.

- The *nuclear vendor estimate case* assumptions are consistent with estimates from British Nuclear Fuel Limited (BNFL) for the manufacture of their Advanced Pressurized Water Reactor (AP1000). In this case, the overnight capital cost of a new advanced nuclear unit is assumed to be 18 percent lower initially than assumed in the reference case and 38 percent lower in 2025. For both advanced nuclear cases, cost and performance characteristics for all other technologies are as assumed in the reference case.

Fossil Technology Cases

- In the *high fossil technology case*, capital costs, heat rates, and operating costs for advanced coal and natural gas generating technologies are assumed to be 10 percent lower than reference case levels in 2025. Because learning is assumed to occur in the reference case, costs and performance in the high case are reduced from initial levels by more than 10 percent. Heat rates in the *high fossil technology case* fall to between 17 and 23 percent below initial levels, and capital costs are reduced by 22 to 26 percent between 2005 and 2025, depending on the technology.
- In the *low fossil technology case*, capital costs and heat rates for coal gasification combined-cycle units and advanced combustion turbine and combined-cycle units do not decline during the forecast period but remain fixed at the 2005 values assumed in the reference case.

Details about annual capital costs, operating and maintenance costs, plant efficiencies, and other factors used in the high and low fossil technology cases are described in the detailed assumptions, which are available at web site www.eia.doe.gov/oiaf/aeo/assumption/.

An additional integrated case was also run to analyze the potential impacts of the EPA's proposed Clean Air Interstate Rule. A detailed description of the rule and a discussion of the sensitivity case results are included in the "Legislation and Regulations" section of this report, pages 34-36.

- The *proposed Clean Air Interstate Rule (pCAIR) case* was run to analyze the potential effects of a rule proposed by the EPA that would cap emissions of sulfur dioxide (SO_2) and nitrogen oxide (NO_x) from electricity generators. The emissions caps in 2010 are 3.86 million short tons SO_2 and 1.6 million tons NO_x. In 2015 the requirements drop to 2.71 million tons SO_2 and 1.33 million tons NO_x. Generators can meet the targets through cap-and-trade programs, or by installing emission control technologies.

Renewable Fuels Cases

In addition to the *AEO2005* reference case, three integrated cases with alternative assumptions about renewable fuels were developed to examine the effects of less and more aggressive improvement in renewable technologies and the extension of existing production tax credits for wind and other renewables through 2015. The cases are as follows:

- In the *low renewables case*, capital costs, operations and maintenance costs, and performance levels for wind, solar, biomass, and geothermal resources are assumed to remain constant at 2005 levels through 2025.
- In the *high renewables case*, the levelized costs of energy for nonhydroelectric generating technologies using renewable resources are assumed to decline, to 10 percent below the reference case costs for the same technologies in 2025. For most renewable resources, lower costs are accomplished by reducing the capital costs of new plant construction. To reflect recent trends in wind energy cost reductions, however, it is assumed that wind plants ultimately achieve the 10-percent cost reduction through a combination of performance improvement (an increased capacity factor) and capital cost reductions. Biomass supplies are also assumed to be 10 percent greater for each supply step. Annual limits are placed on the development of geothermal sites, because they require incremental development to assure that the resource is viable. In the *high renewables case*, the annual limits on capacity additions at geothermal sites are raised from 25 megawatts per year through 2015 to 50 megawatts per year for all forecast years. All other cases are assumed to retain the 25-megawatt limit through 2015. Other generating technologies and forecast assumptions remain unchanged from those in the reference

case. In the *high renewables case*, the rate of improvement in the recovery of biomass byproducts from industrial processes is also increased. More rapid improvement in cellulosic ethanol production technology is also assumed, and cellulosic ethanol production is assumed to capture a higher share of the renewable transportation fuels market, resulting in increased cellulosic ethanol supply compared with the reference case.

- Under the Working Families Tax Relief Act of 2004, the production tax credit for wind and some biomass has been extended to plants in service by December 31, 2005. It has also been expanded under the American Jobs Creation Act of 2004 to include other renewable resources. Although the credit has been allowed to expire and then retroactively extended several times, *AEO2005* does not assume its extension beyond 2005, consistent with the approach generally taken toward public policy in the forecast. The *PTC extension case*, discussed in “Issues in Focus,” pages 58-62, assumes the extension of the PTC through 2015, as expanded in current law. All technology and cost assumptions are otherwise the same as in the *AEO2005* reference case.

Oil and Gas Supply Cases

Two alternative technology cases were created to assess the sensitivity of the projections to changes in the assumed rates of progress in oil and natural gas supply technologies. A third case examines the impacts of potential obstacles that may restrict delivery of domestic and foreign natural gas supplies.

- In the *rapid technology case*, the parameters representing the effects of technological progress on finding rates, drilling, lease equipment and operating costs, and success rates for conventional oil and natural gas in the *AEO2005* reference case were increased by 50 percent relative to the reference case. A number of key exploration and production technologies for unconventional natural gas were also increased by 50 percent in the *rapid technology case*. Key Canadian supply parameters were also increased to simulate the assumed impacts of more rapid oil and gas technology penetration on the Canadian supply potential. All other parameters in the model were kept at the reference case values, including technology parameters for other modules, parameters affecting foreign oil supply, and assumptions about imports and exports of LNG and natural gas trade between the United States and Mexico. Specific detail by region and fuel category is presented in *Assumptions to the Annual Energy Outlook 2005*, which is available at web site www.eia.doe.gov/oiaf/aeo/assumption/.

- In the *slow technology case*, the parameters representing the effects of technological progress on finding rates, drilling, lease equipment and operating costs, and success rates for conventional oil and natural gas in the *AEO2005* reference case were reduced by 50 percent. A number of key exploration and production technologies for unconventional natural gas were also reduced by 50 percent in the *slow technology case*. Key Canadian supply parameters were also increased to simulate the assumed impacts of slow oil and gas technology penetration on Canadian supply potential. All other parameters in the model were kept at the reference case values.

- The *restricted natural gas supply case* acknowledges that the future supply of natural gas could be more constrained than is projected in the reference case, both because of public opposition to the construction of large new natural gas projects, and because the future rate of technological progress could be significantly lower than the historic rate. The *restricted natural gas supply case* incorporates three assumptions: (1) the Alaska natural gas pipeline is *not* built before 2025; (2) all proposed expansions at existing LNG terminals are constructed, but *no* new U.S. LNG regasification terminals are built during the forecast unless they are already fully permitted and under construction; and (3) the future rate of technological progress for oil and gas exploration and development is one-half the historic rate, as specified in the *slow technology case*.

Petroleum Market Cases

Two petroleum market cases were developed and analyzed. The first evaluates the impact of the EPA’s new nonroad diesel rule on diesel consumption and prices. The second case is part of the *advanced renewable case*, which evaluates the impact of more optimistic assumptions about biomass supplies on the production and use of cellulosic ethanol.

- The impacts of the new 500 ppm and 15 ppm low sulfur diesel rule on nonroad diesel markets have been implemented in NEMS and are incorporated in the *AEO2005* reference case. To establish a basis for comparison, the *nonroad diesel emissions rule case* was developed, excluding the impacts of the rule, as discussed in "Legislation and Regulations," pages 14-17.

- The *high renewables case* uses more optimistic assumptions about the availability of renewable energy sources. The supply curve for cellulosic ethanol is shifted in each forecast year relative to the reference case, making larger quantities available at any given price earlier than in the reference case. Commercialization of cellulosic ethanol follows the same path from year to year as the reference case but begins in 2006 rather than 2010.

Coal Market Cases

No alternative cases were run for coal markets in *AEO2005*.

Notes

[*1*] Energy Information Administration, *Annual Energy Review 2003*, DOE/EIA-0384(2003) (Washington, DC, September 2004).

[*2*] Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004).

[*3*] Energy Information Administration, *Short-Term Energy Outlook*, web site www.eia.doe.gov/emeu/steo/pub/contents.html. Portions of the preliminary information were also used to initialize the PMM projection.

[*4*] Jet Information Services, Inc., *World Jet Inventory Year-End 2003* (Woodinville, WA, March 2004), and personal communications with Bill Francoins at Jet Information Services and Thomas C. Hoang at Boeing.

[*5*] National Energy Policy Act of 1992, P.L. 102-486, Title III, Section 303, and Title V, Sections 501 and 507.

[*6*] The hurdle rate for a coal-to-liquids (CTL) plant is assumed to be 12.3 percent because of the higher economic risk involved in this technology.

[*7*] For gasoline blended with ethanol the tax credit of 51 cents (nominal) per gallon of ethanol is assumed to be extended through 2025, based on the fact that the ethanol tax credit has been continuously in force for the past 25 years and was just extended recently by the American Jobs Creation Act of 2004 from 2007 to 2010.

[*8*] High technology assumptions are based on Energy Information Administration, *EIA—Technology Forecast Updates—Residential and Commercial Building Technologies—Advanced Adoption Case* (Navigant Consulting, Inc., September 2004).

[*9*] High technology assumptions are based on Energy Information Administration, *EIA—Technology Forecast Updates—Residential and Commercial Building Technologies—Advanced Adoption Case* (Navigant Consulting, Inc., September 2004).

[*10*] These assumptions are based in part on Energy Information Administration, *Industrial Model—Updates on Energy Use and Industrial Characteristics* (Arthur D. Little, Inc., September 2001).

[*11*] Energy Information Administration, *Documentation of Technologies Included in the NEMS Fuel Economy Model for Passenger Cars and Light Trucks* (Energy and Environmental Analysis, September 2003).

[*12*] A. Vyas, C. Saricks, and F. Stodolsky, *Projected Effect of Future Energy Efficiency and Emissions Improving Technologies on Fuel Consumption of Heavy Trucks* (Argonne, IL: Argonne National Laboratory, 2001).