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Introduction

This report presents the major assumptions of the National Energy Modeling System (NEMS) used to generate the projections in the *Annual Energy Outlook 2006*[1] (*AEO2006*), including general features of the model structure, assumptions concerning energy markets, and the key input data and parameters that are most significant in formulating the model results. Detailed documentation of the modeling system is available in a series of documentation reports.[2] A synopsis of NEMS, the model components, and the interrelationships of the modules is presented in *The National Energy Modeling System: An Overview*[3], which is updated once every few years.

The National Energy Modeling System

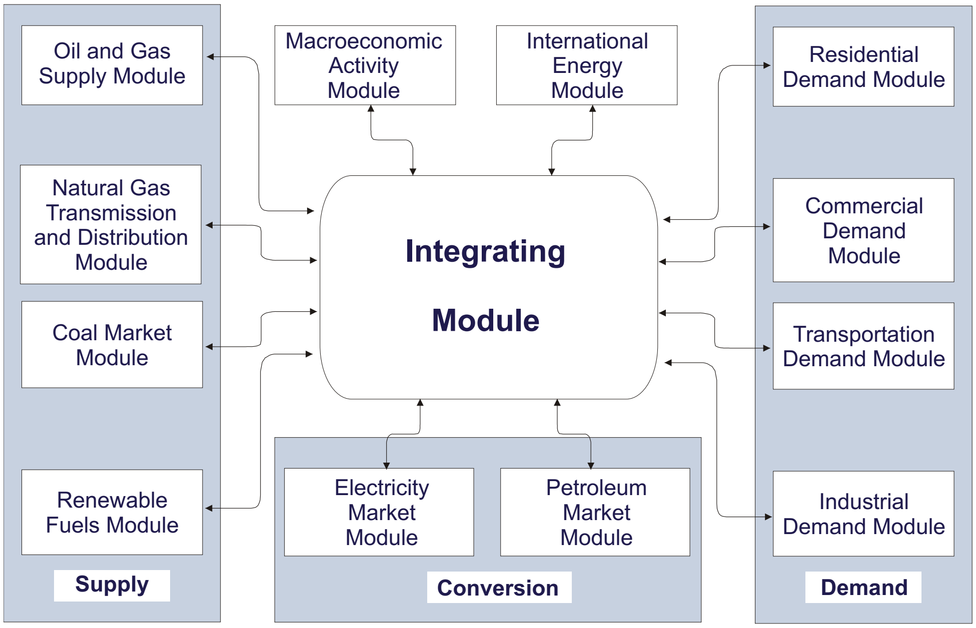
The projections in the *AEO2006* were produced with the National Energy Modeling System. NEMS is developed and maintained by the Office of Integrated Analysis and Forecasting of the Energy Information Administration (EIA) to provide projections of domestic energy-economy markets in the long term and perform policy analyses requested by decisionmakers in the White House, U.S. Congress, offices within the Department of Energy, including DOE Program Offices, and other government agencies. The AEO projections are also used by analysts and planners in other government agencies and outside organizations

The time horizon of NEMS is approximately 25 years, the period in which the structure of the economy and the nature of energy markets are sufficiently understood that it is possible to represent considerable structural and regional detail. Because of the diverse nature of energy supply, demand, and conversion in the United States, NEMS supports regional modeling and analysis in order to represent the regional differences in energy markets, to provide policy impacts at the regional level, and to portray transportation flows. The level of regional detail for the end-use demand modules is the nine Census divisions. Other regional structures include production and consumption regions specific to oil, gas, and coal supply and distribution, the North American Electric Reliability Council (NERC) regions and subregions for electricity, and the Petroleum Administration for Defense Districts (PADDs) for refineries. Maps illustrating the regional formats used in each module are included in this report. Only national results are presented in the *AEO2006,* with the regional and other detailed results available on the EIA Forecasting Home Page. (http://www.eia.doe.gov/oiaf/aeo/index.html)

For each fuel and consuming sector, NEMS balances the energy supply and demand, accounting for the economic competition between the various energy fuels and sources. NEMS is organized and implemented as a modular system (Figure 1). The modules represent each of the fuel supply markets, conversion sectors, and end-use consumption sectors of the energy system. NEMS also includes a macroeconomic and an international module. 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 such as economic activity, domestic production, and international petroleum supply availability.

The integrating module of NEMS 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 storage location. 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. This modularity allows use of the methodology and level of detail most appropriate for each energy sector. NEMS solves by calling 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 projection horizon. Other variables are also evaluated for convergence such as petroleum product imports, crude oil imports, and several macroeconomic indicators.

Figure 1. National Energy Modeling System



Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Each NEMS component also represents the impact and cost of legislation and environmental regulations that affect the sector and reports key emissions. NEMS reflects all current legislation and environmental regulations that are defined sufficiently to be modeled as of October 31, 2005, such as the Energy Policy Act of 2005 and 1992 the Clean Air Act Amendments (CAAA), and the costs of compliance with regulations such as the Clean Air Interstate Rule (CAIR) and Clean Air Mercury Rule (CAMR) both of which were finalized and published on the U.S. Environmental Protection Agency web page in March 2005 and in the Federal Register in May 2005. The potential impacts of pending or proposed legislation, regulations, or standards—or of sections of legislation that have been enacted but that require funds or implementing regulations that have not been provided or specified—are not reflected in the sectors. A list of the specific Federal and selected State legislation and regulations included in the *AEO*, including how they are incorporated, is provided in Appendix A.

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. This section provides brief summaries of each of the modules.

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, new housing stats, new light duty vehicle sales, 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. The accounting framework for industrial output uses the North American Industry Classification System (NAICS).

International Module

The International Module represents 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. In addition, seventeen international petroleum product supply curves, including curves for oxygenates and unfinished oils, are also calculated and provided to the PMM. A world oil supply/demand balance is created, including estimates for 16 oil consumption regions and 19 oil production regions. The oil production estimates include both conventional and nonconventional supply recovery technologies.

Residential and Commercial Demand Modules

The Residential Demand Module projects 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 projects 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 18 industry groups, subject to the delivered prices of energy and macroeconomic variables representing employment and the value of shipments for each industry. The value of shipments is based on the NAICS. 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 are further disaggregated to organic, inorganic, resins, and agricultural chemicals. 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. For airfreight 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 EMM.

All specifically identified CAAA compliance options that have been promulgated by the U.S. Environmental Protection Agency (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). All specifically iidenfied Energy Policy Act of 2005 financial incentives for power generation expansion and dispatch have been implemented. 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 *AEO2006*.

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 hydroelectricity, biomass, 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 Acts of 1992 and 2005. 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, geothermal, landfill gas, and some types of hydroelectric and biomass-fueled plants are also represented. These provide a tax credit of up to 1.9 cents per kilowatt-hour tax credit for electricity produced in the first 10 years of plant operation. New plants that come online before January 1, 2008 are eligible to receive the credit.

Oil and Gas Supply Module

The Oil and Gas Supply Module (OGSM) represents domestic crude oil and natural gas supply within an integrated framework that captures the interrelationships between 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 PMM 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 (NGTDM) 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 world natural gas market conditions.

Natural Gas Transmission and Distribution Module

The 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. The flow of gas is determined for both peak and off-peak periods in the year. 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 and biodiesel fuels. The module represents refining activities in the five PADDs. The module uses the same crude oil types as the International Module. It explicitly models the requirements of CAAA and the costs of automotive fuels, such as conventional and reformulated gasoline, and includes biofuels production for blending in gasoline and diesel. *AEO2006* reflects State 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, Montana, Nebraska, New Hampshire, New Jersey, New York, North Carolina, Ohio, Rhode Island, South Dakota, Vermont, Washington, and Wisconsin. Furthermore, MTBE is assumed to phase out by the end of 2008 as a result of EPACT2005, which allows refiners to discontinue use of oxygenates in reformulated gasoline, and on the concern over MTBE's impact on surface water and groundwater resources.

The nationwide phase-in of gasoline with an annual average sulfur content of 30 ppm between 2005 and 2007, 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 by mid-2012, and the renewable fuels standard of 7.5 billion gallons by 2012, are represented in *AEO2006*. Growth in demand and 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 9 percent. End-use prices are based on the marginal costs of production, plus markups representing product and distribution costs, and State and Federal taxes. 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 assumes that ethanol will be blended into gasoline at up to 10 percent by volume or into E85 at up to 85 percent by volume, depending on relative market economics. 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. Both soybean oil and yellow grease biodiesel are assumed to be blended into highway diesel.

Coal Market Module

The Coal Market Module (CMM) simulates mining, and transportation, and pricing of coal, subject to the end-use demand for coal differentiated by heat, sulfur, and mercury 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 transportation costs, existing coal supply contracts, and sulfur and mercury 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 and imports, 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 and trade flows.

U.S. coal production and distribution are computer for 154 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.

Cases for the *Annual Energy Outlook 2006*

In preparing projections for the *AEO2006,* EIA evaluated a wide range of trends and issues that could have major implications for U.S. energy markets between now and 2030. Besides the reference case, the *AEO2006* presents detailed results for four alternative cases that differ from each other due to fundamental assumptions concerning the domestic economy and world oil market conditions. These alternative cases include the following:

- **Economic Growth** - In the *reference case*, real GDP grows at an average annual rate of 3.0 percent from 2003 through 2030, supported by a 2.3 percent per year growth in productivity in nonfarm business and a 0.8 percent per year growth in nonfarm employment. In the *high economic growth case,* real GDP is projected to increase by 3.5 percent per year, with productivity and nonfarm employment growing at 2.7 percent and 1.4 percent per year, respectively. In the *low economic growth case*, the average annual growth in GDP, productivity and nonfarm employment is 2.4, 1.8 and 0.7 percent, respectively.

- **Price Cases** – The world oil price in *AEO2006* is represented by the average U.S. refiner's acquisition costs of imported low-sulfur light crude oil, in order to be more consistent with prices typically reported in the media. The low-sulfur light crude oil price is similar to the West Texas Intermediate (WTI) crude oil price. In the reference case, world oil prices moderate from current levels through 2015, before beginning to rise, reaching $57 per barrel in 2030 (in real 2004 dollars). The reference case represents EIA's current judgment regarding the expected behavior of OPEC producers in the long term, adjusting production to keep world oil prices in a range of $40 to $50 per barrel, in keeping with OPEC's stated goal of keeping potential competitors from eroding its market share. The low and high world oil price cases define a wide range of potential price paths, which in 2030 span from $34 to $96 per barrel. These cases reflect differences in the assumptions about world energy resource availability and production costs, not changes in OPEC behavior. The low price case assumes greater world crude oil and natural gas resources that are less expensive to produce and a future market where all oil and natural gas production becomes more competitive and plentiful than the reference case. The high price cases assumes that world crude oil and natural gas resources, including OPEC's, are lower and require greater cost to produce than assumed in the reference case.

In addition to these four cases, 27 additional alternative cases presented in Table 1 explore the impacts of changing key assumptions on individual sectors.

Many of the side cases were designed to examine the impacts of varying key assumptions for individual modules or a subset of the NEMS modules, and thus the full market consequences, such as the consumption or price impacts, are not captured. In a fully integrated run, the impacts would tend to narrow the range of the differences from the reference case. For example, the best available technology side case in the residential demand assumes that all future equipment purchases are made from a selection of the most efficient technologies available in a particular year. In a fully integrated NEMS run, the lower resulting fuel consumption would have the effect of lowering the market prices of those fuels with the concomitant impact of increasing economic growth, thus stimulating some additional consumption. As another example, the higher electricity demand side case results in higher electricity prices due to the need to add additional capacity to the grid. If this were a fully integrated run, the demand for electricity would be reduced as a result of higher prices, thus moderating somewhat the higher demand. The results of single model or partially integrated cases should be considered the maximum range of the impacts that could occur with the assumptions defined for the case.

All projections are generally based on Federal, State, and local laws and regulations in effect on or before October 31, 2005. The potential impacts of pending or proposed legislation, regulations, and standards—of sections of legislation that have been enacted but that require implementing regulations or appropriation of funds that are not provided or specified in the legislation itself—are not reflected in the projections. Examples of Federal and State legislation that is included are the Energy Policy Act of 2005, which, among other actions, includes mandatory energy conservation standards, creates numerous business and public tax credits for energy efficient appliances, hybrid vehicles, small biodiesel producers, and new nuclear capacity, creates a renewable fuels standard, eliminates the oxygen content requirement for Federal Reformulated Gasoline, extends royalty relief for offshore oil and natural gas producers, and extends and expands the production tax credit for electricity generated from renewable fuels; the Military Construction Appropriations Act of 2005, which contains provisions to support construction of the Alaska natural gas pipeline, including Federal loan guarantees during construction; the Working Families Tax Relief Act of 2004, which includes an extension of the 1.8-cent PTC for wind and closed-loop biomass to December 31, 2005; tax deductions for qualified clean-fuel and electric vehicles; and changes in the rules governing oil and gas well depletion; the American Jobs Creation Act of 2004, which includes incentives and tax credits for biodiesel fuels, a modified depreciation schedule for the Alaska natural gas pipeline, and an expansion of the 1.8-cent renewable energy production tax credit (PTC) to include geothermal and solar generation technologies; the Maritime Security Act of 2002, which amended the Deepwater Port Act of 1974 to include offshore natural gas facilities; State renewable portfolio standards, including the California renewable portfolio standards passed on September 12, 2002; State of Alaska's Right-Of-Way Leasing Act Amendments of 2001, which prohibit leases across State land for a "northern" or "over-the-top" natural gas pipeline route running east from the North Slope to Canada's MacKenzie River Valley; the Outer Continental Shelf Deep Water Royalty Relief Act of 1995 and subsequent provisions on royalty relief for new leases issued after November 2000 on a lease-by-lease basis; the Omnibus Budget Reconciliation Act of 1993, which added 4.3 cents per gallon to the Federal tax on highway fuels; the Energy Policy Act of 1992 (EPACT1992); the Clean Air Act Amendments of 1990 (CAAA90), which include new standards for motor gasoline and diesel fuel and for heavy-duty vehicle emissions; the National Appliance Energy Conservation Act of 1987; and State programs for restructuring of the electricity industry.

Table 1. Summary of *AEO2006* Cases

Case name	Description	Integration mode
Reference	Baseline economic growth (3.0 percent per year), world oil price, and technology assumptions.	Fully integrated
Low Economic Growth	Gross domestic product grows at an average annual rate of 2.4 percent from 2004 through 2030.	Fully integrated
High Economic Growth	Gross domestic product grows at an average annual rate of 3.5 percent from 2004 through 2030.	Fully integrated
Low Price	More optimistic assumptions for worldwide crude oil and natural gas resources than in the reference case. World oil prices are $28 per barrel in 2030, compared with $ 50 per barrel in the reference case, and lower 48 wellhead natural gas prices $ 4.96 per thousand cubic feet in 2030, compared with $ 5.92 in the reference case.	Fully integrated
High Price	More pessimistic assumptions for worldwide crude oil and natural gas resources than in the reference case. World oil prices are about $ 90 per barrel in 2030 and lower 48 wellhead natural gas prices $ 7.72 per thousand cubic feet in 2030.	Fully integrated
Residential: 2005 Technology	Future equipment purchases based on equipment available in 2005. Existing building shell efficiencies fixed at 2005 levels.	With commercial
Residential: High Technology	Earlier availability, lower costs, and higher efficiencies assumed for more advanced equipment. Building shell efficiencies increase by 22 percent from 2003 values by 2030.	With commercial
Residential: Best Available Technology	Future equipment purchases and new building shells based on most efficient technologies available. Building shell efficiencies increase by 26 percent from 2003 values by 2030.	With commercial
Commercial: 2005 Technology	Future equipment purchases based on equipment available in 2005. Building shell efficiencies fixed at 2005 levels.	With residential
Commercial: HighTechnology	Earlier availability, lower costs, and higher efficiencies assumed for more advanced equipment. Building shell efficiencies for new and existing buildings increase by 10.4 and 7.4 percent, respectively, from 1999 values by 2030.	With residential
Commercial Best Available Technology	Future equipment purchases based on most efficient technologies available. Building shell efficiencies for new and existing buildings increase by 12.4 and 8.9 percent, respectively, from 1999 values by 2030.	With residential
Industrial: 2005 Technology	Efficiency of plant and equipment fixed at 2005 levels.	Standalone

Table 1. Summary of *AEO2006* Cases (cont.)

Case name	Description	Integration mode
Industrial: High Technology	Earlier availability, lower costs, and higher efficiencies assumed for more advanced equipment.	Standalone
Transportation: 2005 Technology	Efficiencies for new equipment in all modes of travel fixed at 2005 levels.	Standalone
Transportation: High Technology	Reduced costs and improved efficiencies assumed for advanced technologies.	Standalone
Transportation: Alternative CAFE	Assumes that manufacturers adhere to the proposed fleetwide increases in light truck CAFE standards to 24 miler per gallon for model year 2011.	Standalone
Integrated: 2005 Technology	Combination of the residential, commercial, industrial, and transportation 2005 technology cases, electricity low fossil technology case, and assumption of renewable technologies fixed at 2005 levels.	Fully integrated
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
Electricity: Advanced Nuclear Cost	New nuclear capacity assumed to have 20 percent lower capital and operating costs in 2030 than in the reference case.	Fully integrated
Electricity: Nuclear Vendor Estimate	New nuclear capacity assumed to have lower capital costs based on vendor goals.	Fully Integrated
Electricity: Low Fossil Technology	New advanced fossil generating technologies assumed not to improve over time from 2006.	Fully Integrated
Electricity: High Fossil Technology	Costs and efficiencies for advanced fossil- fired generating technologies improve by 10 percent in 2030 from reference case values.	Fully Integrated
Electricity: Mercury Control Technologies	Cost and performance for halogenated activated carbon injection technology used to determine its impact on mercury removal requirements from coal-fired power plants.	Fully Integrated
Renewables: Low Renewables	New renewable generating technologies assumed not to improve over time from 2006.	Fully Integrated
Renewables: High Renewables	Levelized cost of energy for nonhydropower renewable generating technologies declines by 10 percent in 2030 from reference case values. Lower capital cost for cellulose ethanol plants.	Fully Integrated
Oil and Gas: Slow Technology	Cost, finding rate, and success rate parameters adjusted for 50- percent slower improvement than in the reference case.	Fully integrated
Oil and Gas: Rapid Technology	Cost, finding rate, and success rate parameters adjusted for 50- percent more rapid improvement than in the reference case.	Fully integrated
Oil and Gas: Low LNG	LNG imports exogenously set to 30 percent less than the results from the high price case, with remaining assumptions from the reference case.	Fully integrated
Oil and Gas: High LNG	LNG imports exogenously set to 30 percent more than the results from the low price case, with remaining assumptions from the reference case.	Fully Integrated
Oil and Gas: ANWR	Federal oil and gas leasing permitted in the Arctic National Wildlife Refuge starting in 2005.	Fully Integrated
Coal: Low Cost	Productivity for coal mining and coal transportation assumed to increase more rapidly than in the reference case. Coal mining wages, mine equipment and coal transportation equipment costs assumed to be lower than in the reference case.	Fully Integrated
Coal: High Cost	Productivity for coal mining and coal transportation assumed to increase more slowly than in the reference case. Coal mining wages, mine equipment and coal transportation equipment costs assumed to be higher than in the reference case.	Fully integrated

Emissions

Carbon dioxide emissions from energy use are dependent on the carbon content of the fossil fuel, the fraction of the fuel consumed in combustion, and the consumption of that fuel. The product of the carbon content at full combustion and the combustion fraction yields an adjusted carbon dioxide emission factor for each fossil fuel. The emissions factors are expressed in millions of metric tons carbon equivalent of carbon dioxide emitted per quadrillion Btu of energy use, or equivalently, in kilograms carbon equivalent of carbon dioxide per million Btu. The adjusted emissions factors are multiplied by the energy consumption of that fossil fuel to arrive at the carbon dioxide emissions projections.

For fuel uses of energy, the combustion fractions are assumed to be 0.99 for liquid fuels and 0.995 for gaseous fuels. The carbon dioxide in nonfuel use of energy, such as for asphalt and petrochemical feedstocks, is assumed to be sequestered in the product and not released to the atmosphere. For energy categories that are mixes of fuel and nonfuel uses, the combustion fractions are based on the proportion of fuel use. Any carbon dioxide emitted by biogenic renewable sources, such as biomass and alcohols, is considered balanced by the carbon dioxide sequestration that occurred in its creation. Therefore, following convention, net emissions of carbon dioxide from biogenic renewable sources are taken as zero, and no emission coefficient is reported. In calculating carbon dioxide emissions for motor gasoline, the emissions from renewable blending stock (ethanol) is omitted.

Table 2 presents the carbon dioxide coefficients at full combustion, the combustion fractions, and the adjusted carbon dioxide emission factors used for *AEO2006*.

Table 2. Carbon Dioxide Emission Factors
(million metric tons carbon dioxide equivalent per quadrillion Btu)

Fuel Type	Carbon Dioxide Coefficient at Full Combustion	Combustion Fraction	Adjusted Emissions Factor
Petroleum			
Motor Gasoline	70.88	0.990	70.17
Liquefied Petroleum Gas			
Used as Fuel	63.07	0.995	62.75
Used as Feedstock	61.67	0.500	30.83
Jet Fuel	70.88	0.990	70.17
Distillate Fuel	73.15	0.990	72.42
Residual Fuel	78.80	0.990	78.01
Asphalt and Road Oil	75.61	0.000	0.00
Lubricants	74.21	0.500	37.11
Petrochemical Feedstocks	71.02	0.370	26.28
Kerosene	72.31	0.990	71.58
Petroleum Coke	102.12	0.500	51.06
Petroleum Still Gas	64.20	0.995	63.88
Other Industrial	74.43	0.990	73.68
Coal			
Residential and Commercial	95.48	0.990	94.53
Metallurgical	93.98	0.990	93.04
Industrial Other	94.38	0.990	93.44
Electric Utility[1]	95.26	0.990	94.31
Natural Gas			
Used as Fuel	53.06	0.995	52.79
Used as Feedstocks	53.06	0.774	41.07

[1]Emission factors for coal used for electricity generation are specified by coal supply region and types of coal, so the average carbon dioxide contents for coal varies throughout the forecast. The 2003 average is 94.31.

Source: Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2004, DOE/EIA-0573(2004), (Washington, DC, December 2005).*

Notes and Sources

[1] Energy Information Administration, Annual Energy Outlook 2006 (AEO2006), DOE/EIA-0383(2006), (Washington, DC, February 2006).

[2] NEMS documentation reports are available on the EIA Homepage (http://www.eia.doe.gov/bookshelf.html).

[3] Energy Information Administration, The National Energy Modeling System: An Overview 2003, DOE/EIA-0581(2003), (Washington, DC, March 2003).