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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 2007*[1] (*AEO2007*), including general features of the model structure, assumptions concerning energy markets, and the key input data and parameters that are the most significant to 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

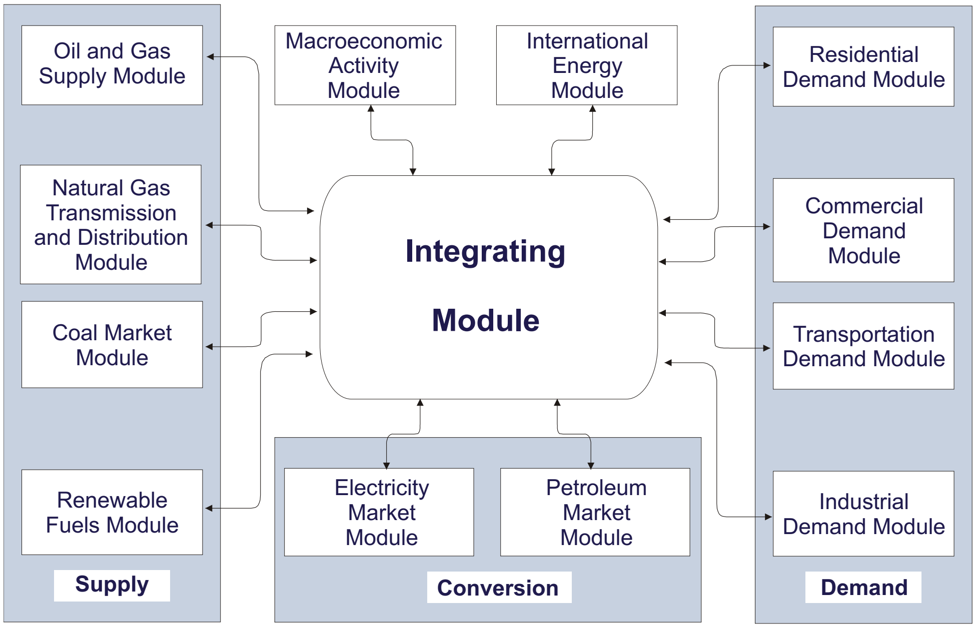
The projections in the *AEO2007* were produced with the National Energy Modeling System. NEMS is developed and maintained by the Office of Integrated Analysis and Forecasting of the Energy Information Administration (EIA) to provide projections of domestic energy-economy markets in the long term and 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 *AEO2007,* with the regional and other detailed results available on the EIA Forecasts and Analyses 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 Federal legislation and regulation that affect the sector and reports key emissions. NEMS generally reflects all current legislation and regulation that are defined sufficiently to be modeled as of October 31, 2006, such as the Energy Policy Act of 2005, the Working Families Tax Relief Act of 2004, and the America Jobs Creation Act of 2004, and the costs of compliance with regulations such as the new corporate average fuel economy (CAFE) standards, finalized in March 2006, and the new stationary diesel regulations issued by the U.S. Environmental Protection Agency (EPA) in July 2006. The NEMS components also reflect selected State legislation and regulations where implementing regulations are clear. The potential impacts of pending or proposed Federal and State 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 (MAM) provides a set of essential macroeconomic drivers to the energy modules and there is a macroeconomic feedback mechanism within NEMS. Key macroeconomic variables used in the energy modules include gross domestic product (GDP), disposable income, industrial output, new housing starts, new light-duty vehicle sales, interest rates, prices, and employment. The module uses the following models from Global Insight, Inc. (GII): 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 project regional economic drivers and a Commercial Floorspace Model to project 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 the response of world oil markets (supply and demand) to assumed world oil prices. The results/outputs of the module are a set of crude oil and product supply curves that are available to U.S. markets for each case/scenario analyzed. The import petroleum supply curves are made available to U.S. markets through the Petroleum Market Module (PMM) of NEMS in the form of 5 categories of imported crude oil and 17 international petroleum products, including supply curves for oxygenates and unfinished oils. The supply-curve calculations are based on historical market data and a world oil supply/demand balance which is developed from the *International Energy Outlook 2006*, current investment trends in exploration and development, and long-term resource economics for more than 80 countries/territories. The oil production estimates include both conventional and unconventional supply recovery technologies.

Residential and Commercial Demand Modules

The Residential Demand Module projects energy consumption in the residential sector 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 energy consumption in the commercial sector by building type 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 Demand Module incorporates combined heat and power (CHP) technology. The modules also include projections 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 projects the consumption of energy for heat and power and for feedstocks and raw materials in each of 24 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 based on NAICS. The industries are classified into three groups—energy-intensive manufacturing, non-energy-intensive manufacturing, and nonmanufacturing. Of the 8 energy-intensive industries, 7 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 projects consumption of fuels in the transportation sector, 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.

The module also includes a component to assess the penetration of alternative-fuel vehicles explicitly. The air transportation module explicitly represents the industry practice of parking aircraft to reduce operating costs and the movement of aircraft from passenger to cargo markets as aircraft age. For air freight shipments, the model employs narrow-body and wide-body aircraft only. The model also uses an infrastructure constraint that limits growth in air travel 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 cost of uranium fuel for nuclear generation is incorporated directly in the EMM.

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). All specifically identified EPACT2005 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 *AEO2007*.

Renewable Fuels Module

The Renewable Fuels Module (RFM) includes submodules representing renewable 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 renewable resource supply estimates representing the regional opportunities for renewable energy development. Investment tax credits for renewable fuels are incorporated, as currently legislated in the EPACT1992 and EPACT2005. EPACT1992 provides a 10-percent tax credit for business investment in solar energy (thermal non-power uses as well as power uses) and geothermal power; these credits have no expiration date. EPACT2005 increases the tax credit to 30 percent for solar energy systems installed before January 1, 2008.

Production tax credits for wind, geothermal, landfill gas, and some types of hydroelectric and biomass-fueled plants are also represented. They provide a tax credit of up to 1.9 cents per kilowatthour for electricity produced in the first 10 years of plant operation. New plants that come on line before January 1, 2008, are eligible to receive the credit. Significant changes made for *AEO2007* in the accounting of new renewable energy capacity resulting from State renewable portfolio standards, mandates, and goals are described in *Assumptions to the Annual Energy Outlook 2007* [*8*].

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 among the various sources of supply: onshore, offshore, and Alaska by both conventional and unconventional techniques, including natural 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 construction of new regasification terminals in Canada, Mexico, and the United States as well as expansions of existing U.S. regasification terminals are represented, based on the projected regional costs associated with international gas supply, liquefaction, transportation, and regasification and world 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 and determines the associated capacity expansion requirements in an aggregate pipeline network, connecting the domestic and foreign supply regions with 12 demand regions. The flow of natural gas is determined for both a peak and off-peak period in the year. Key components of pipeline and distributor tariffs are included in separate pricing algorithms.

Petroleum Market Module

The Petroleum Market Module (PMM) projects 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 Petroleum Administration for Defense Districts (PADDs), using the same crude oil types represented in the International Energy 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.

AEO2007 represents the nationwide phase-in of gasoline with an annual average sulfur content of 30 ppm between 2005 and 2007, regulations that limit the sulfur content of highway diesel fuel to 15 ppm starting in mid-2006 and of all non-road and locomotive/marine diesel to 15 ppm by mid-2012, and the renewable fuels standard of 7.5 billion gallons by 2012. Demand growth and regulatory changes necessitate capacity expansion for refinery-processing units. Investments in capacity expansion assume a financing ratio of 60 percent equity and 40 percent debt, with a hurdle rate and an after-tax return on investment of about 9 percent [*9*]. End-use prices are based on the marginal costs of production, plus markups representing product marketing and distribution costs and State and Federal taxes [*10*]. Refinery capacity expansion at existing sites is permitted in all five refining regions modeled. *AEO2007* assumes MTBE will be phased out by the end of 2006 as a result of decisions made by the petroleum industry to discontinue MTBE blending with gasoline.

Fuel ethanol and biodiesel are included in the PMM, because they are commonly blended into petroleum products. The module allows ethanol blending into gasoline at 10 percent by volume or less, as well as 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 (primarily, recycled cooking oil). Both soybean oil biodiesel and yellow grease biodiesel are assumed to be blended into highway diesel.

Alternative fuels such as coal-to-liquids (CTL) and gas-to-liquids (GTL) are modeled in the PMM, based on their economics relative to competing feedstocks and products. CTL facilities are likely to be built at locations close to coal supply and water sources, where liquid products and electricity could also be distributed to nearby demand regions. GTL facilities may be built on the North Slope of Alaska but would compete with lower 48 demand for gas delivered via an Alaska pipeline system for available natural gas resources.

Ethanol production is modeled from two feedstocks: Starchy crops such as corn and cellulosic materials such as switchgrass and poplars. Corn-based ethanol plants are based on well-known technology which converts sugars into ethanol. Ethanol from cellulosic sources is a new technology with no full-sized plants in operation at the present time. These two sources of ethanol production compete on an economic basis to meet the EPACT 2005 mandate.

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 and mercury allowance costs. Over the projection horizon, coal transportation costs in the CMM are projected to vary in response to changes in railroad productivity, the user cost of rail transportation equipment, and the cost of diesel.

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. The international coal market component of the module computes trade in 3 types of coal for 17 export and 20 import regions. U.S. coal production and distribution are computed for 14 supply and 14 demand regions.

Cases for the *Annual Energy Outlook 2007*

In preparing projections for the *AEO2007,* 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 *AEO2007* 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 2.9 percent from 2005 through 2030, supported by a 2.3 percent per year growth in productivity in nonfarm business and a 1.0 percent per year growth in nonfarm employment. In the *high economic growth case,* real GDP is projected to increase by 3.4 percent per year, with productivity and nonfarm employment growing at 2.8 percent and 1.3 percent per year, respectively. In the *low economic growth case*, the average annual growth in GDP, productivity and nonfarm employment is 2.3, 1.9 and 0.6 percent, respectively.

- **Price Cases** – The world oil price in *AEO2007* is represented by the average U.S. refiner's acquisition costs of imported low-sulfur light crude oil. 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 2014, before beginning to rise, reaching $59 per barrel in 2030 (in real 2005 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 $50 to $60 per barrel, in keeping with OPEC's stated goal of keeping potential competitors from eroding its market share. The low and high price cases define a wide range of potential price paths, which in 2030 span from $36 to $100 per barrel. These cases reflect differences in the assumptions about world energy resource availability, production costs, and 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, 29 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. 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.

Table 1. Summary of *AEO2007* Cases

Case name	Description	Integration mode
Reference	Baseline economic growth (2.9 percent per year from 2005-2030), world oil price, and technology assumptions.	Fully integrated
Low Growth	Gross domestic product grows at an average annual rate of 2.3 percent from 2005 through 2030.	Fully integrated
High Growth	Gross domestic product grows at an average annual rate of 3.4 percent from 2005 through 2030.	Fully integrated
Low Price	More optimistic assumptions for worldwide crude oil and natural gas resources than in the reference case. World light, sweet crude oil prices are $36 per barrel in 2030, compared with $59 per barrel in the reference case (2005$).	Fully integrated
High Price	More pessimistic assumptions for worldwide crude oil and natural gas resources than in the reference case. World light, sweet crude oil prices are about $100 per barrel in 2030	Fully integrated
Residential: 2006 Technology	Future equipment purchases based on equipment available in 2006. Existing building shell efficiencies fixed at 2006 levels.	With commercial
Residential: High Technology	Earlier availability, lower costs, and higher efficiencies assumed for more advanced equipment. Building shell efficiencies for new construction meet ENERGY STAR requirements after 2010.	With commercial
Residential: Best Available Technology	Future equipment purchases and new building shells based on most efficient technologies available. Building shell efficiencies for new construction meet the criteria for most efficient components after 2006.	With commercial
Commercial: 2006 Technology	Future equipment purchases based on equipment available in 2006. Building shell efficiencies fixed at 2006 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 8.75 and 6.25 percent, respectively, from 2003 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 10.5 and 7.5 percent, respectively, from 2003 values by 2030.	With residential
Industrial: 2006 Technology	Efficiency of plant and equipment fixed at 2006 levels.	Standalone
Industrial: High Technology	Earlier availability, lower costs, and higher efficiencies assumed for more advanced equipment.	Standalone
Transportation: 2006 Technology	Efficiencies for new equipment in all modes of travel fixed at 2006 levels.	Standalone
Transportation: High Technology	Reduced costs and improved efficiencies assumed for advanced technologies.	Standalone
Integrated: 2006 Technology	Combination of the residential, commercial, industrial, and transportation 2006 technology cases, electricity low fossil technology case, low renewables case, and high nuclear cost case.	Fully integrated
Integrated: 2006 Technology	Combination of the residential, commercial, industrial, and transportation 2006 technology cases, electricity low fossil technology case, low renewables case, and high nuclear cost case.	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
Low Nuclear Cost	New nuclear capacity assumed to have 10 percent lower capital and operating costs in 2030 than in the reference case.	Fully integrated

Table 1. Summary of *AEO2007* Cases (cont.)

Case name	Description	Integration mode
High Nuclear Cost	Costs for new nuclear technology are assumed not to improve over time from 2006 levels in the reference case.	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
Low Renewables	New renewable generating technologies are assumed not to improve over time from 2006.	Fully Integrated
High Renewables	Levelized cost of energy for non-hydropower renewable generating technologies declines by 10 percent in 2030 from reference case values.	Fully Integrated
Renewables: Regional RPS	Represents various state renewable portfolio standards (RPS) programs, with targets aggregated on a regional basis. Assumes full compliance with targets, as limited by statutory authorizations for state funding, where applicable.	Fully Integrated
Lower Cost Ethanol, Reference Energy Prices	Capital costs of cellulosic ethanol decline by 26 percent and operating costs decline by 20 percent by 2018 from reference case values in 2012. Biomass supply was assumed to have greater availability than the reference cases at reference case prices. Assumed policies enacted that make market penetration of FFV exceed 80 percent by 2016, and that E85 fuel dispensing availability increases as it becomes more competitive. Case uses energy prices from reference case.	Fully Integrated
Lower Cost Ethanol, High Energy Prices	Capital costs of cellulosic ethanol decline by 26 percent and operating costs decline by 20 percent by 2018 from reference case values in 2012. Biomass supply was assumed to have greater availability than the reference cases at reference case prices. Assumed policies enacted that make market penetration of FFV exceed 80 percent by 2016, and that E85 fuel dispensing availability increases as it becomes more competitive. Case uses energy prices from high price case.	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: OCS Access	Drilling moratoria is assumed to expire in 2012 for oil and natural gas exploration and development in the Atlantic, Pacific, and Eastern Gulf of Mexico Outer Contiental Shelf.	Fully Integrated
Oil and Gas: ANWR	Federal oil and gas leasing permitted in the Arctic National Wildlife Refuge starting in 2007.	Fully Integrated
Low Coal 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
High Coal 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 *AEO2007*.

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	69.85	0.383	26.75
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 2005 average is 94.31.

Source: Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2005, DOE/EIA-0573(2005),* (Washington, DC, November 2006).

Notes and Sources

[1] Energy Information Administration, Annual Energy Outlook 2007 (AEO2007), DOE/EIA-0383(2007), (Washington, DC, February 2007).

[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).