Report #:DOE/EIA-0554(2009)
Release date: March 2009
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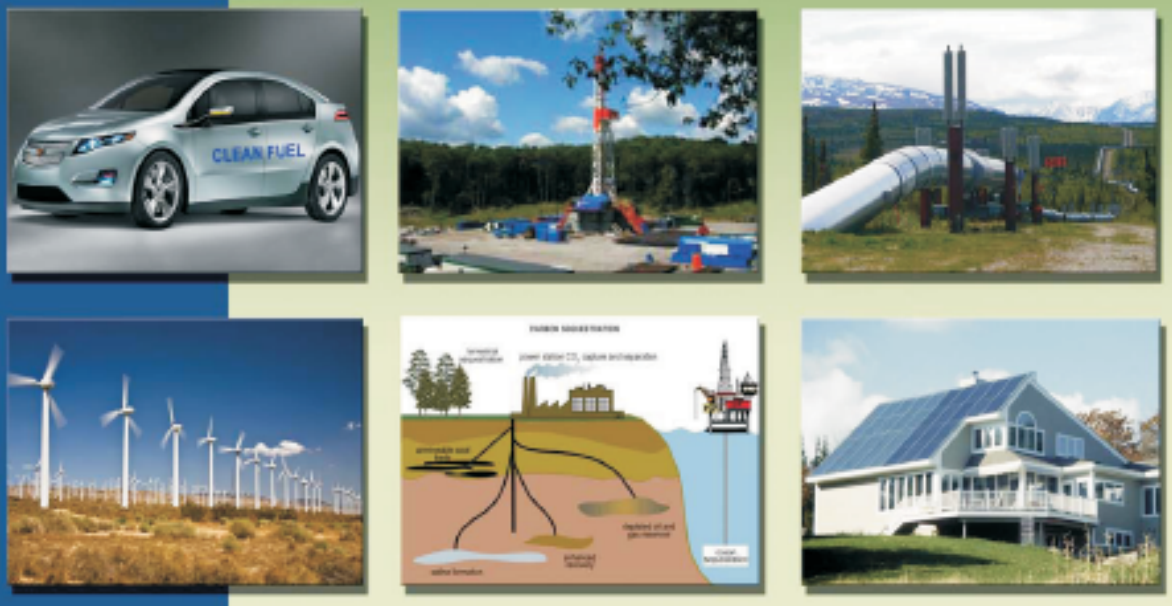
Assumptions to the Annual Energy Outlook 2009

With Projections to 2030



ENERGY INFORMATION ADMINISTRATION

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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 2009*[1] (*AEO2009*), including general features of the model structure, assumptions concerning energy markets, and the key input data and parameters that are the most significant in formulating the model results. Detailed documentation of the modeling system is available in a series of documentation reports.[2]

The National Energy Modeling System

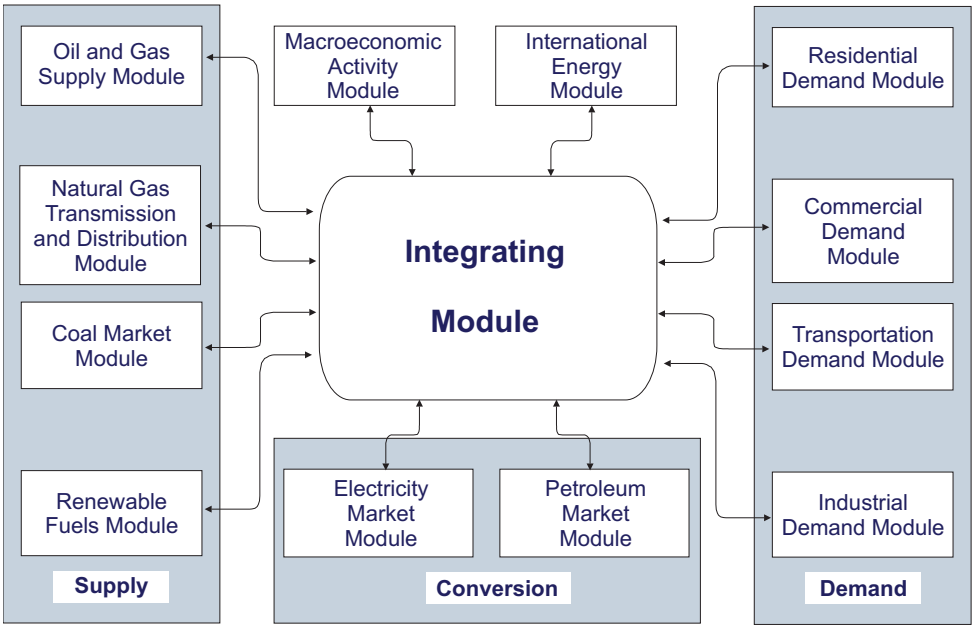
The projections in the *AEO2009* were produced with the NEMS, which is developed and maintained by the Office of Integrated Analysis and Forecasting of the Energy Information Administration (EIA) to provide projections of domestic energy-economy markets in the long term and perform policy analyses requested by decisionmakers in the White House, U.S. Congress, offices within the Department of Energy, including DOE Program Offices, and other government agencies. The Annual Energy Outlook (*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, natural 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 selected regional results are presented in the *AEO2009,* which predominately focuses on the national results. Complete regional and detailed results are 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 November 5, 2008, such as the Energy Improvement and Extension Act of 2008 (EIEA2008), the biofuel provisions of the Food, Conservation, and Energy Act of 2008, the Energy Independence and Security Act of 2007 (EISA2007), the Energy Policy Act of 2005, Military Construction Appropriations 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 new stationary diesel regulations issued by the U.S. Environmental Protection Agency (EPA) on July 11, 2006, which limit emissions of nitrogen oxides, particulate matter, sulfur dioxide, carbon monoxide, and hydrocarbons to the same levels required by the EPA's nonroad diesel engine regulations and court decisions that impact regulations such as the recent decisions by the D.C. Circuit of the U.S. Court of Appeals on February 8, 2008, to vacate the Clean Air Mercury Rule (CAMR) and on July 11, 2008, to vacate the Clean Air Interstate Rule (CAIR).[3] The NEMS components also reflect selected State legislation and regulations where implementing regulations are clear such as the October 2008 decision by the California Air Resources Board (CARB) on California's Low Carbon Fuel Standard (LCFS) requiring a 10-percent ethanol blend, by volume, in gasoline,. However, the potential impacts of pending or proposed legislation, regulations, and standards—or 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 NEMS. 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 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, value of industrial shipments, new housing starts, new light-duty vehicle sales, interest rates, and employment. The MAM module uses the following models from Global Insight, Inc.: 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 value of shipments 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 petroleum import 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 reduced-form models of international liquids supply and demand, current investment trends in exploration and development, and long-term resource economics for 221 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 the effects of both building shell and appliance standards, including the recently enacted provisions of the EISA2007. 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 a 10-year average and on State-level population projections. The Residential Demand Module projects an increase in the average square footage of both new construction and existing structures, 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 21 industries, 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 MAM, 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 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 generalized representation of cogeneration and a recycling component are also included. The use of energy for petroleum refining is modeled in the PMM, 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 industrial

shipments. Fleet vehicles are represented separately to allow analysis of the Energy Policy Act of 1992 (EPACT1992) and other legislation and legislative proposals. The transportation demand module also includes a component to assess the penetration of alternative-fuel vehicles. EPACT2005 and EIEA2008 are reflected in the assessment of the impact of tax credits on the purchase of hybrid gas-electric, alternative-fuel, and fuel-cell vehicles. The corporate average fuel economy and biofuel representation in the module reflect standards proposed by the National Highway Traffic Safety Administration and provisions in EISA2007.

The air transportation component explicitly represents air travel in domestic and foreign markets and includes the industry practice of parking aircraft in both domestic and international markets to reduce operating costs, as well as the movement of aging aircraft from passenger to cargo markets[4]. For passenger travel and air freight shipments, the model represents regional fuel use in regional, narrow-body, and wide-body aircraft. An infrastructure constraint is also modeled and can potentially limit overall growth in passenger and freight 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 and macroeconomic variables for costs of capital and domestic investment; environmental emissions laws and regulations; and electricity load shapes and demand. There are three primary submodules—capacity planning, fuel dispatching, and finance and pricing.

All specifically identified options promulgated by the EPA for compliance with the Clean Air Act Amendments of 1990 (CAAA90) are explicitly represented in the capacity expansion and dispatch decisions; those that have not been promulgated (e.g., fine particulate proposals) are not incorporated. All financial incentives for power generation expansion and dispatch specifically identified in EPACT2005 have been implemented. Several States, primarily in the Northeast, have recently enacted air emission regulations for carbon dioxide (CO_2) that affect the electricity generation sector, and these regulations are represented in *AEO2009*.

Although Federal legislation restricting greenhouse gas (GHG) emissions are not currently in place, regulators and the investment community are beginning to push energy companies to invest in less GHG-intensive technologies. This was captured in the *AEO2009* reference case through a 3-percentage point increase in the cost of capital when evaluating investments in new coal-fired power plants without carbon control and sequestration, and new coal-to-liquids plants.

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 (PV), 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 enacted. This includes a permanent 10-percent tax credit for business investment in solar energy (thermal non-power uses as well as power uses) and geothermal power (only available to those projects not accepting the production tax credit). In addition, the module reflects the increase in the tax credit to 30 percent for solar energy systems installed before January 1, 2017 and the extension of the credit to individual homeowners under EIEA2008.

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 2.0 cents per kilowatthour for electricity produced in the first 10 years of plant operation. For *AEO2009*, new plants coming on line before January 1, 2010, are eligible to receive the credit. *AEO2009* also accounts for new renewable energy capacity resulting from State renewable portfolio standard programs, mandates, and goals, as described in *Assumptions to the Annual Energy Outlook 2009* [5].

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. The 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 for 12 supply regions, including 3 offshore and 3 Alaskan regions. The 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 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 natural gas supply, liquefaction, transportation, and 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 and determines the associated capacity expansion requirements in an aggregate pipeline network, connecting the domestic and foreign supply regions with 12 U.S. 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. The module also represents foreign sources of natural gas, including pipeline imports and exports to Canada and Mexico, and imports and exports LNG.

Petroleum Market Module

The 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 biofuels (ethanol, biodiesel, and biomass-to-liquids (BTL)). The module represents refining activities in the five PADDs, as well as a less detailed representation of refining activities in the rest of the world. It explicitly models the requirements of EISA2007 and CAAA90 and the costs of automotive fuels, such as conventional and reformulated gasoline, and includes the production of biofuels for blending in gasoline and diesel.

AEO2009 represents regulations that limit the sulfur content of all nonroad and locomotive/marine diesel to 15 parts per million (ppm) by mid-2012. The module also reflects the new renewable fuels standard (RFS) in EISA2007 that requires the use of 36 billion gallons per year of biofuels by 2022 if achievable, with corn ethanol limited to 15 billion gallons per year. Demand growth and regulatory changes necessitate capacity expansion for refinery processing units. U.S. end-use prices are based on the marginal costs of production, plus markups representing the costs of product marketing, importing, transportation and distribution as well as applicable State and Federal taxes[6]. Refinery capacity expansion at existing sites is permitted in each E85, a blend of up to 85 percent ethanol by volume. In the *AEO2009*, the level of allowable non-E85 ethanol blending in California was raised from 5.7 percent to 10 percent in recent regulatory changes[7] which have set a framework for E10 emission standards. of the five refining regions modeled.

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 or less by volume (E10), as well as E85, a blend of up to 85 percent ethanol by volume. In the *AEO2009*, the level of allowable non-E85 ethanol blending in California was raised from 5.7 percent to 10 percent in recent regulatory changes[8] which have set a framework for E10 emission standards.

Both domestic and imported ethanol count toward the RFS. Domestic ethanol production is modeled from two feedstocks: corn and cellulosic materials. Corn-based ethanol plants are numerous (more than 150 are now in operation, possessing a total production capacity of more than 10 billion gallons annually) and are based on a well-known technology that converts sugar into ethanol. Ethanol from cellulosic sources is a new technology with no pilot plants in operation; however, DOE awarded grants (up to $385 million) in 2007 to construct capacity totaling 147 million gallons per year, which *AEO2009* assumes will be operational starting in 2012. Imported ethanol may be produced from cane sugar or bagasse, the cellulosic byproduct of sugar milling. The sources of ethanol are modeled to compete on an economic basis and to meet the EISA2007 renewable fuels mandate.

Coal Market Module

The Coal Market Module (CMM) simulates mining, transportation, and pricing of coal, subject to end-use demand for coal differentiated by heat and sulfur content. U.S. coal production is represented in the CMM by 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), and other mine supply costs. Projections of U.S. coal distribution are determined by minimizing the cost of coal supplied, given coal demands by demand region and sector, environmental restrictions, and accounting for minemouth prices, transportation rates, and coal supply contracts. Over the projection horizon, coal transportation rates in the CMM are projected to vary in response to changes in railroad investment and market share (for western rates only).

The CMM produces projections of U.S. steam and metallurgical coal exports and imports, in the context of world coal trade. The CMM determines the pattern of world coal trade flows that minimizes the production and transportation costs of meeting a 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 2009*

In preparing projections for the *AEO2009*, 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 *AEO2009* 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 2.5 percent from 2007 through 2030, supported by a 2.0 percent per year growth in productivity in nonfarm business and a 0.9 percent per year growth in nonfarm employment. In the *high economic growth case,* real GDP is projected to increase by 3.0 percent per year, with productivity and nonfarm employment growing at 2.4 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 1.8, 1.5 and 0.5 percent, respectively.

- **Price Cases** – For purposes of the *AEO2009*, the world oil price is defined by the price of light, low-sulfur crude oil delivered in Cushing, Oklahoma. In the reference case, world oil prices increase quickly after the recession ends, reaching $110 per barrel in 2015 ($128 per barrel in nominal terms), as growth in world oil demand rebounds and investment in production capacity lags this expansion in demand. After 2015, real prices rise gradually as demand continues to grow and higher cost supplies are brought to market. In 2030, the average real price of crude oil is $130 per barrel in 2007 dollars, or about $189 per barrel in nominal dollars. The reference case represents EIA's current judgment about the most likely behavior of key Organization of Petroleum Exporting Country (OPEC) members in the mid term. In the projection, OPEC countries increase production at a rate that keeps their market share of world liquids production at approximately 41 percent through 2030. The low and high price cases define a wide range of potential price paths, which in 2030 span from $50 to $200 per barrel in real dollars. These cases reflect differences in the assumptions about access to energy

resources, production costs, and changes in OPEC behavior. The low price case assumes greater economic access to world crude oil 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 case assumes that the production of conventional crude oil will cost more than in the reference case and will be limited due to increased restrictions on economic access to non-OPEC resources and OPEC decisions to further limit its production.

In addition to these four cases, and the reference case, 31 additional alternative cases presented in Table 1.1 that explore the impact 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 1.1. Summary of *AEO2009* Cases

Case name	Description	Integration mode
Reference	Baseline economic growth (2.5 percent per year from 2007 through 2030), world oil price, and technology assumptions. Complete projection tables in Appendix A.	Fully integrated
Low Economic Growth	GDP grows at an average annual rate of 1.8 percent from 2007 through 2030. Other energy market assumptions are the same as in the reference case. Partial projection tables in Appendix B.	Fully integrated
High Economic Growth	GDP grows at an average annual rate of 3.0 percent from 2007 through 2030. Other energy market assumptions are the same as in the reference case. Partial projection tables in Appendix B.	Fully integrated
Low Oil Price	More optimistic assumptions for economic access to non-OPEC resources and the behavior of the OPEC than in the reference case. World light, sweet crude oil prices are $50 per barrel in 2030, compared with $130 per barrel in the reference case (2007 dollars). Other assumptions are the same as in the reference case. Partial projection tables in Appendix C.	Fully integrated
High Oil Price	More pessimistic assumptions for economic access to non-OPEC resources and OPEC behavior than in the reference case. World light, sweet crude oil prices are about $200 per barrel (2007 dollars) in 2030. Other assumptions are the same as in the reference case. Partial projection tables in Appendix C..	Fully integrated
Residential: 2009 Technology	Future equipment purchases based on equipment available in 2009. Existing building shell efficiencies fixed at 2009 levels. Partial projection tables in Appendix D.	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 2016. Partial projection tables in Appendix D.	With commercial
Residential: Best Available Technology	Future equipment purchases and new building shells based on most efficient technologies available by fuel. Building shell efficiencies for new construction meet the criteria for most efficient components after 2009. Partial projection tables in Appendix D.	With commercial
Commercial: 2009 Technology	Future equipment purchases based on equipment available in 2009. Building shell efficiencies fixed at 2009 levels. Partial projection tables in Appendix D.	With residential

Table 1.1. Summary of *AEO2009* Cases (cont.)

Case name	Description	Integration mode
Commercial: HighTechnology	Earlier availability, lower costs, and higher efficiencies assumed for more advanced equipment. Building shell efficiencies for new and existing buildings increase by 8.8 and 6.3 percent, respectively, from 2003 values by 2030. Partial projection tables in Appendix D.	With residential
Commercial: Best Available Technology	Future equipment purchases based on most efficient technologies available by fuel. Building shell efficiencies for new and existing buildings increase by 10.5 and 7.5 percent, respectively, from 2003 values by 2030. Partial projection tables in Appendix D.	With residential
Industrial: 2009 Technology	Efficiency of plant and equipment fixed at 2009 levels. Partial projection tables in Appendix D.	Standalone
Industrial: High Technology	Earlier availability, lower costs, and higher efficiencies assumed for more advanced equipment. Partial projection tables in Appendix D.	Standalone
Transportation: Low Technology	Assumes advanced technologies are more costly and less efficient then in reference case. Partial projection tables in Appendix D	Standalone
Transportation: High Technology	Assumes advanced technologies are less costly and more efficient then in reference case. Partial projection tables in Appendix D.	Standalone
Electricity: Low Nuclear Cost	New nuclear capacity assumed to have 25 percent lower capital and operating costs in 2030 than in the reference case. Partial projection tables in Appendix D.	Fully Integrated
Electricity: High Nuclear Cost	Costs for new nuclear technology assumed not to improve from 2009 levels in the reference case. Existing nuclear plants are assumed to retire after 55 years. Partial projection tables in Appendix D.	Fully Integrated
Electricity: Low Fossil Technology Cost	Capital and operating costs for all new fossil-fired generating technologies improve by 25 percent in 2030 from reference case values. Partial projection tables in Appendix D.	Fully Integrated
Electricity: High Fossil Technology Cost	Costs for new advanced fossil generating technologies assumed not to improve over time from 2009. Partial projection tables in Appendix D.	Fully Integrated
Electricity: Frozen Plant Capital Costs	Base overnight costs for all new electric generating technologies are frozen at 2013 levels. Cost decreases due to learning still occur, but no declines in costs due to commodity price changes are assumed.	Fully Integrated
Electricity: High Plant Capital Costs	Base overnight costs for all new electric generating technologies continue increasing throughout the projection, through a cost factor in 2030 that is 25 percentage points above the 2013 factor. Cost decreases due to learning can still occur and may partially offset the increases.	Fully Integrated
Electricity: Falling Plant Capital Costs	Base overnight costs for all new electric generating technologies fall more rapidly than in the reference case, by assuming a cost factor 25 percentage points below the reference case cost factor in 2030.	Fully Integrated
Renewable Fuels: High Renewable Technology Cost	New renewable generating technologies assumed not to improve over time from 2009. Partial projection tables in Appendix D.	Fully integrated
Renewable Fuels: Low Renewable Technology Cost	Levelized cost of energy for non-hydropower renewable generating technologies declines by 25 percent in 2030 from reference case values. Partial projection tables in Appendix D.	Fully integrated
Renewable Fuels: Production Tax Credit Extension	PTC for certain renewable generation is assumed to be extended to projects constructed through 2019.	Fully integrated

Table 1.1. Summary of *AEO2009* Cases (cont.)

Case name	Description	Integration mode
Oil and Gas: Rapid Technology	Cost, finding rate, and success rate parameters are adjusted for 50 percent more rapid improvement than in the reference case. Partial projection tables in Appendix D.	Fully Integrated
Oil and Gas: Slow Technology	Cost, finding rate, and success rate parameters are adjusted for 50 percent slower improvement than in the reference case. Partial projection tables in Appendix D.	Fully Integrated
Oil and Gas: High LNG Supply	LNG imports are set exogenously to a factor times the reference case levels from 2010 forward, with the remaining assumptions unchanged from the reference case. The factor starts at 1.0 in 2010 and increases linearly to 5.0 in 2030. Partial projection tables in Appendix D.	Fully Integrated
Oil and Gas: Low LNG Supply	LNG imports held constant at 2009 levels, with remaining assumptions from the reference case. Partial projection tables in Appendix D.	Fully Integrated
Oil and Gas: ANWR	The Arctic National Wildlife Refuge (ANWR) in Alaska is opened to Federal oil and natural gas leasing, with remaining assumptions from the reference case. Partial projection tables in Appendix D.	Fully Integrated
Oil and Gas: No Alaska Pipeline	A natural gas pipeline from the North Slope of Alaska to the Lower 48 States is assumed not to be built during the projection period.	Fully Integrated
Oil and Gas: OCS Limited	Access to the Atlantic , Pacific , and Gulf of Mexico Outer Continental Shelf (OCS) is limited by reinstatement of leasing moratoria that lapsed in 2008.	Fully Integrated
Coal: Low Coal Cost	Productivity growth rates for coal mining are assumed to be higher than in the reference case, and coal mining wages, mine equipment, and coal transportation rates are assumed to be lower. Partial projection tables in Appendix D.	Fully Integrated
Coal: High Coal Cost	Productivity growth rates for coal mining are assumed to be lower than in the reference case, and coal mining wages, mine equipment, and coal transportation rates are assumed to be higher. Partial projection tables in Appendix D.	Fully integrated
Integrated 2009 Technology	Combination of the residential, commercial, and industrial 2009 technology cases; and the electricity high fossil technology cost, high renewable technology cost, and high nuclear cost cases. Partial projection tables in Appendix D	Fully integrated
Integrated High Technology	Combination of the residential, commercial, industrial, and transportation high technology cases; and the electricity low fossil technology cost, low renewable technology cost, and low nuclear cost cases. Partial projection tables in Appendix D.	Fully integrated
No GHG Concerns	Assumes that a greenhouse gas emission reduction policy is not enacted and markets do not alter their investment decisions in anticipation of such a policy.	Fully Integrated
LW110	Based on the greenhouse gas emissions reduction policy proposed by Senators Lieberman and Warner in the 110th Congress (S. 2191).	Fully Integrated
No 2008 Tax Legislation	Removes EIEA2008 tax legislation from reference case.	Fully Integrated

Carbon Dioxide 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 emission factor for each fossil fuel. The emissions factors are expressed in millions of metric tons carbon dioxide emitted per quadrillion Btu of energy use, or equivalently, in kilograms carbon dioxide per million Btu. The adjusted emissions factors are multiplied by the energy consumption of the fossil fuel to arrive at the carbon dioxide emissions projections.

For fuel uses of energy, the combustion fractions are assumed to be 1.00 in keeping with international conventions.[9] Previously, a small fraction of the carbon content of the fuel was assumed to remain unoxidized. 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 direct emissions from renewable blending stock (ethanol) is omitted. Similarly, direct emissions from biodiesel are omitted from reported carbon dioxide emissions. Table 1.2 presents the assumed carbon dioxide coefficients at full combustion, the combustion fractions, and the adjusted carbon dioxide emission factors used for *AEO2009*.

Table 1.2. 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 (net of ethanol)	70.88	1.000	70.88
Liquefied Petroleum Gas			
Used as Fuel	63.00	1.000	63.00
Used as Feedstock	61.44	0.200	12.29
Jet Fuel	70.88	1.000	70.88
Distillate Fuel (net of biodiesel)	73.15	1.000	73.15
Residual Fuel	78.80	1.000	78.80
Asphalt and Road Oil	75.61	0.000	0.00
Lubricants	74.21	0.500	37.11
Petrochemical Feedstocks	69.85	0.386	26.93
Kerosene	72.31	1.000	72.31
Petroleum Coke	102.12	0.782	79.87
Petroleum Still Gas	64.20	1.000	64.20
Other Industrial	74.54	1.000	74.54
Coal			
Residential and Commercial	95.35	1.000	95.35
Metallurgical	93.71	1.000	93.71
Coke	114.14	1.000	114.14
Industrial Other	93.98	1.000	93.98
Electric Utility[1]	94.70	1.000	94.70
Natural Gas			
Used as Fuel	53.06	1.000	53.06
Used as Feedstocks	53.06	0.523	27.73

[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 projection. The 2007 average is 94.70.

Source: Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2007, DOE/EIA-0573(2007),* (Washington, DC, December 2008).

Notes and Sources

[1] Energy Information Administration, *Annual Energy Outlook 2009* (*AEO2009*), DOE/EIA-0383(2009), (Washington, DC, February 2009).

[2] NEMS documentation reports are available on the EIA Homepage (http://tonto.eia.doe.gov/reports/reports_kindD.asp?type=model documentation).

[3] On December 23, 2008, after the November 5 cutoff date for inclusion of changes in Federal and State laws and regulations in *AEO2009*, the United States Court of Appeals for the District of Columbia issued a new ruling that remanded but did not vacate CAIR, noting that "Allowing CAIR to remain in effect until it is replaced by a rule consistent with our opinion would at least temporarily preserve the environmental values." Source: United States Court of Appeals for the District of Columbia Circuit, No. 05-1244, web site www.epa.gov/airmarkets/progsregs/cair/docs/CAIRRemandOrder.pdf. This change allows the EPA to modify CAIR to address the objections raised by the Court in its earlier decision while leaving the rule in place. The change is not reflected in *AEO2009*.

[4] Jet Information Services, Inc., *World Jet Inventory Year-End 2006* (Utica, NY, March 2007); and personal communication from Stuart Miller (Jet Information Services).

[5] Energy Information Administration, *Assumptions to the Annual Energy Outlook 2009*, DOE/EIA-0554 (2009) (Washington, DC, February 2009), web site www.eia.doe.gov/oiaf/aeo/assumption

[6] For gasoline blended with ethanol, the tax credit of 51 cents (nominal) per gallon of ethanol is assumed to be available for 2008. However, this tax credit is reduced to 45 cents as mandated by the “Food, Conservation, and Energy Act of 2008” (the “Farm Bill”) starting in 2009 (the year after the annual U.S. ethanol consumption surpasses 7.5 billion gallons); the tax credit is set to expire after 2010. In addition, modeling updates include the Farm Bill’s mandated extension of the 54 cent/gallon import tariff to Dec. 31, 2010. Finally, again in accordance with the Farm Bill, a new cellulosic producer’s tax credit of $1.01/gallon is implemented in the model (valid through 2012); however, this tax credit is reduced by the aforementioned blender’s tax credit amount. Thus, in 2009 and 2010, the cellulosic producer’s tax credit is modeled as $1.01 - $0.45 = $0.56/gallon, and in 2011 and 2012 it is $1.01/gallon. http://www.arb.ca.gov/regact/2007/carfg07/carfg07.htm.

[7] Energy Information Administration, *Assumptions to the Annual Energy Outlook 2009*, DOE/EIA-0554 (2009) (Washington, DC, February 2009), web site www.eia.doe.gov/oiaf/aeo/assumption.

[8] Energy Information Administration, *Assumptions to the Annual Energy Outlook 2009*, DOE/EIA-0554 (2009) (Washington, DC, February 2009), web site www.eia.doe.gov/oiaf/aeo/assumption

[9] The Intergovernmental Panel on Climate Change 2006, 2006 IPCC Guidelines For National Greenhouse Gas Inventories, prepared by the National Greenhouse Gas Inventories Program, published: IGES, Japan, 2006.