NEMS represents domestic energy markets by explicitly representing the economic decision making involved in the production, conversion, and consumption of energy products. Where possible, NEMS includes explicit representation of energy technologies and their characteristics.

Since energy costs and availability and energy-consuming characteristics vary widely across regions, considerable regional detail is included. Other details of production and consumption categories are represented to facilitate policy analysis and ensure the validity of the results. A summary of the detail provided in NEMS is shown below.

Summary of NEMS Detail

Energ Acti it	Categories	Regions
Residential demand	Sixteen end-use services Three housing types Thirty–four end–use technologies	Nine Census divisions
Commercial demand	Ten end–use services Eleven building types Ten distributed generation technologies Sixty–four end-use technologies	Nine Census divisions
Industrial demand	Seven energy–intensive industries Eight non–energy–intensive industries Cogeneration	Four Census regions, shared to nine Census divisions
Transportation demand	Six car sizes Six light truck sizes Sixty–three conventional fuel-saving technologies for light–duty vehicles Gasoline, diesel, and thirteen alternative–fuel vehicle technologies for light-duty vehicles Twenty vintages for light-duty vehicles Narrow and wide–body aircraft Six advanced aircraft technologies Medium and heavy freight trucks Thirty–seven advanced freight truck technologie	Nine Census divisions
Electricity	Eleven fossil generation technologies Two distributed generation technologies Seven renewable generation technologies Conventional and advanced nuclear Marginal and average cost pricing Generation capacity expansion Seven environmental control technologies	Fifteen electricity supply regions (including Alaska and Hawaii) based on the North American Electric Reliability Council regions and subregions Nine Census divisions for demand
Renewables	Wind, geothermal, solar thermal, solar photovoltaic, landfill gas, biomass, conventional hydropower	Fifteen electricity supply regions
Oil supply	Onshore Deep and shallow offshore	Six lower 48 onshore regions Three lower 48 offshore regions Three Alaska regions
Natural gas supply	Conventional lower–48 onshore Lower–48 deep and shallow offshore Coalbed methane Gas shales Tight sands Canadian, Mexican, and liquefied natural gas Alaskan Gas	Six lower 48 onshore regions Three lower 48 offshore regions Three Alaska regions Eight liquefied natural gas import regions
Natural gas transmission and distribution	Core vs. noncore Peak vs. offpeak Pipeline capacity expansion	Twelve lower 48 regions Ten pipeline border points
Refining	Five crude oil categories Fourteen product categories More than 40 distinct technologies Refinery capacity expansion	Three refinery regions aggregated from Petroleum Administration for Defense Districts
Coal supply	Three sulfur categories Four thermal categories Underground and surface mining types Imports and Exports	Eleven supply regions Sixteen demand regions Sixteen export regions Twenty import regions

Major Assumptions

Each module of NEMS embodies many assumptions and data to characterize the future production, conversion, or consumption of energy in the United States. Two major assumptions concern economic growth in the United States and world oil prices, as determined by world oil supply and demand.

The *Annual Energy Outloook 2003 (AEO2003)* includes five primary fully–integrated cases: a reference case, a high and low economic growth case, and a high and low world oil price case. The reference case uses mid–range assumptions for both the economic growth rate and the world oil price. The primary determinant for differenct economic growth rates are growth in the labor force and productivity, while different assumptions on oil production in the Organization of Petroleum Exporting Countries (OPEC) lead to different levels of world oil prices.

In addition to the five primary fully–integrated cases, *AEO2003* includes 21 other cases that explore the impacts of varying key assumptions in the individual components of NEMS. Many of these cases involve changes in the assumptions that impact the penetration of new or improved technologies, which is a major uncertainty in formulating projections of future energy markets. Some of these cases are run as fully integrated cases (e.g., 2003 technology case, high technology case, high renewables, slow and rapid oil and gas technology cases, and low and high coal mining cost cases). Others exploit the modular structure of NEMS by running only a portion of the entire modeling system in order to focus on the first–order impacts of changes in the assumptions (e.g., advanced nuclear cost case, high electricity demand case, low and high fossil electric generating technology cases, and low and high technology cases in the residential, commercial, industrial, and transportation sectors).

NEMS Modular Structure

Overall, NEMS represents the behavior of energy markets and their interactions with the U.S. economy. The model achieves a supply/demand balance in the end-use demand regions, defined as the nine Census divisions (Figure 1), by solving for the prices of each energy product that will balance the quantities producers are willing to supply with the quantities consumers wish to consume. The system reflects market economics, industry structure, and existing energy policies and regulations that influence market behavior.

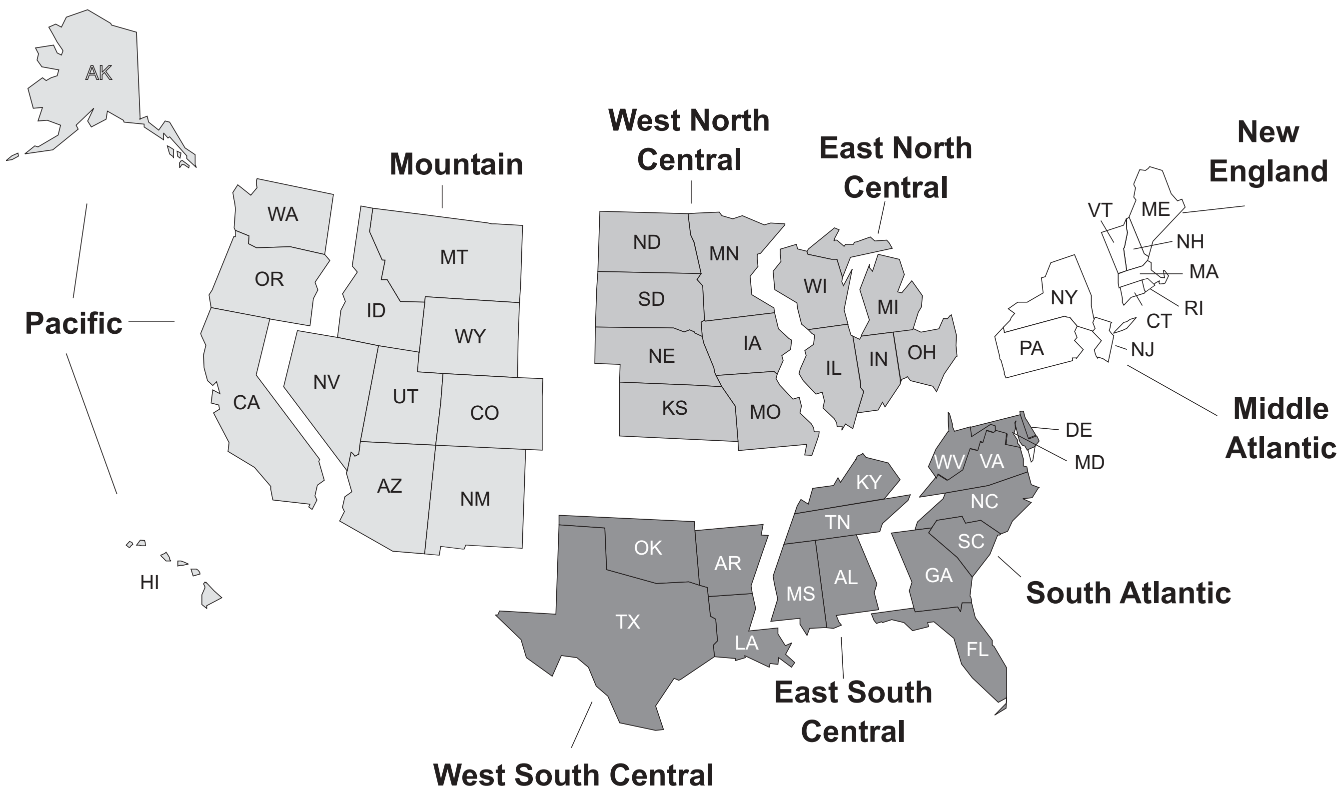
NEMS consists of four supply modules (oil and gas, natural gas transmission and distribution, coal, and renewable fuels); two conversion modules (electricity and petroleum refineries); four end-use demand modules (residential, commercial, transportation, and industrial); one module to simulate energy/economy interactions (macroeconomic activity); one module to simulate world oil markets (international energy activity); and one module that provides the mechanism to achieve a general market equilibrium among all the other modules (integrating module). Figure 2 depicts the high-level structure of NEMS.

Because energy markets are heterogeneous, a single methodology does not adequately represent all supply, conversion, and end-use demand sectors. The modularity of the NEMS design provides the flexibility for each component of the U.S. energy system to use the methodology and coverage that is most appropriate. Furthermore, modularity provides the capability to execute the modules individually or in collections of modules, which facilitates the development and analysis of the separate component modules. The interactions among these modules are controlled by the integrating module.

The NEMS global data structure is used to coordinate and communicate the flow of information among the modules. These data are passed through common interfaces via the integrating module. The global data structure includes energy market prices and consumption; macroeconomic variables; energy production, transportation, and conversion information; and centralized model control variables, parameters, and assumptions. The global data structure excludes variables that are defined locally within the modules and are not communicated to other modules.

A key subset of the variables in the global data structure is the end-use prices and quantities of fuels which are used to equilibrate the NEMS energy balance in the convergence algorithm. These delivered prices of energy and the quantities demanded are defined 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 regions for the price and quantity variables in the global data structure are the nine Census divisions. The four Census regions (shown in Figure 1 by breaks between State groups) and nine Census divisions are a common, mainstream level of regionality widely used by EIA and other organizations for data collection and analysis.

Figure 1. Census Divisions



Division 1

New England

Connecticut

Maine

Massachusetts

New Hampshire

Rhode Island

Vermont

Division 2

Middle Atlantic

New Jersey

New York

Pennsylvania

Division 3

East North Central

Illinois

Indiana

Michigan

Ohio

Wisconsin

Division 4

West North Central

Iowa

Kansas

Minnesota

Missouri

Nebraska

North Dakota

South Dakota

Division 5

South Atlantic

Delaware

District of Columbia

Florida

Georgia

Maryland

North Carolina

South Carolina

Virginia

West Virginia

Division 6

East South Central

Alabama

Kentucky

Mississippi

Tennessee

Division 7

West South Central

Arkansas

Louisiana

Oklahoma

Texas

Division 8

Mountain

Arizona

Colorado

Idaho

Montana

Nevada

New Mexico

Utah

Wyoming

Division 9

Pacific

Alaska

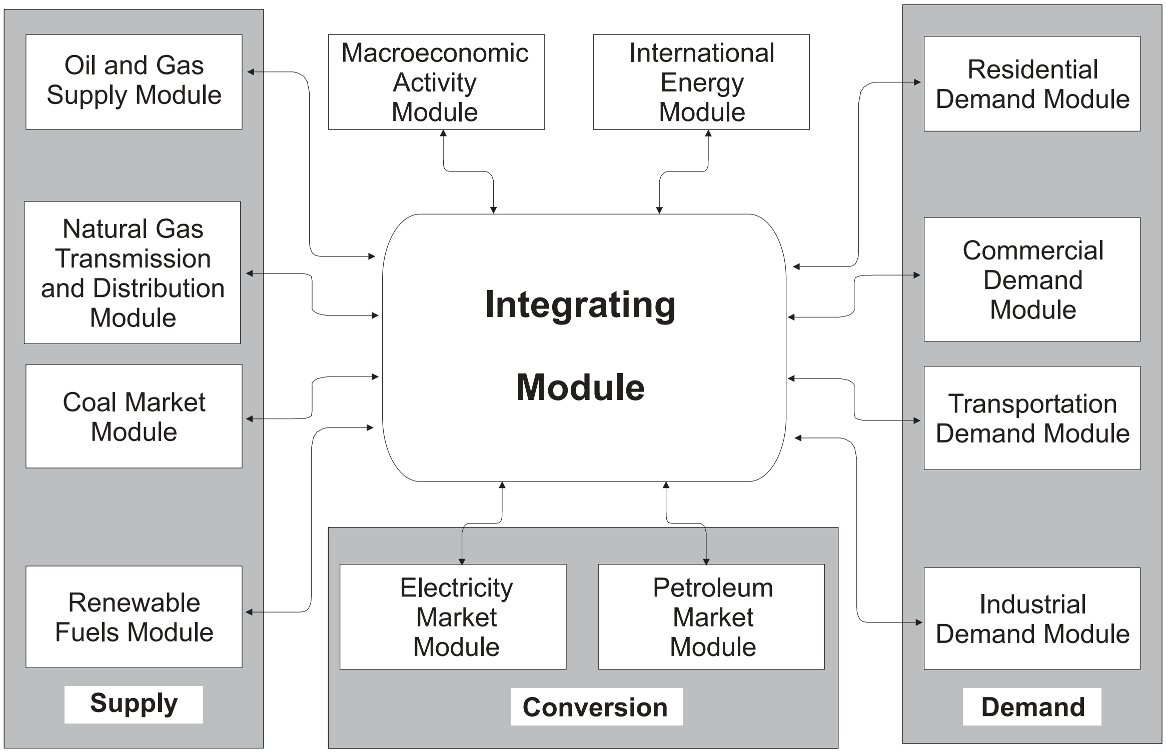
California

Hawaii

Oregon

Washington

Figure 2. National Energy Modeling System



Integrating Module

The NEMS integrating module controls the entire NEMS solution process as it iterates to determine a general market equilibrium across all the NEMS modules. It has the following functions:

- Manages the NEMS global data structure
- Executes all or any of the user-selected modules in an iterative convergence algorithm
- Checks for convergence and reports variables that remain out of convergence
- Implements convergence relaxation on selected variables between iterations to accelerate convergence
- Updates expected values of the key NEMS variables.

The integrating module executes the demand, conversion, and supply modules iteratively until it achieves an economic equilibrium of supply and demand in all the consuming and producing sectors. Each module is called in sequence and solved, assuming that all other variables in the energy markets are fixed. The modules are called iteratively until the end-use prices and quantities remain constant within a specified tolerance, a condition defined as convergence. Equilibration is achieved annually throughout the midterm period, currently 2025, for each of the nine Census divisions.

In addition, the macroeconomic and international modules are executed iteratively to incorporate the feedback on the economy and international markets from changes in the domestic energy markets. Convergence tests check the stability of a set of key macroeconomic and international trade variables in response to interactions with the domestic energy system.

The NEMS algorithm executes the system of modules until convergence is reached. The solution procedure for one iteration involves the execution of all the component modules, as well as the updating of expectation variables (related to foresight assumptions) for use in the next iteration. The system is executed sequentially for each year in the forecast period. During each iteration within a year, each of the modules is executed in turn, with intervening convergence checks that isolate specific modules that are not converging. A convergence check is made for each price and quantity variable to see whether the percentage change in the variable is within the assumed tolerance. To avoid unnecessary iterations for changes in insignificant values, the quantity convergence check is omitted for quantities less than a user-specified minimum level. The order of execution of the modules may affect the rate of convergence but will generally not prevent convergence to an equilibrium solution or significantly alter the results. An optional relaxation routine can be executed to dampen swings in solution values between iterations. With this option, the current iteration values are reset partway between solution values from the current and previous iterations.

Because of the modular structure of NEMS and the iterative solution algorithm, any single module or subset of modules can be executed independently. Modules not executed are bypassed in the calling sequence, and the values they would calculate and provide to the other modules are held fixed at the values in the global data structure, which are the solution values from a previous run of NEMS. This flexibility is an aid to independent development, debugging, and analysis.