The industrial demand module (IDM) forecasts energy consumption for fuels and feedstocks for nine manufacturing industries and six nonmanufacturing industries, subject to delivered prices of energy and macroeconomic variables representing the value of shipments for each industry. The module includes electricity generated through combined heat and power (CHP) systems that is either used in the industrial sector or sold to the electricity grid. The IDM structure is shown in Figure 7.

Industrial energy demand is projected as a combination of "bottom up" characterizations of the energy-using technology and "top down" econometric estimates of behavior. The influence of energy prices on industrial energy consumption is modeled in terms of the efficiency of use of existing capital, the efficiency of new capital acquisitions, and the mix of fuels utilized, given existing capital stocks. Energy conservation from technological change is represented over time by trend-based "technology possibility curves." These curves represent the aggregate efficiency of all new technologies that are likely to penetrate the future markets as well as the aggregate improvement in efficiency of 1998 technology.

IDM incorporates three major industry categories: energy–intensive manufacturing industries, nonenergy–intensive manufacturing industries, and nonmanufacturing industries. The level and type of modeling and the attention to detail is different for each. Manufacturing disaggregation is at the 3-digit North American Indusrial Classification System (NAICS) level, with some further disaggregation of more energy–intensive or large energy–consuming industries. Industries treated in more detail include food, paper, chemicals, glass, cement, steel, and aluminum. Energy product demands are calculated independently for each industry.

Each industry is modeled (where appropriate) as three interrelated components: buildings (BLD), boilers/steam/CHP (BSC), and process/assembly (PA) activities. Buildings are estimated to account for 6 percent of energy consumption in manufacturing industries (in nonmanufacturing industries, building energy consumption is assumed to be negligible).

Consequently, IDM uses a simple modeling approach for the BLD component. Energy consumption

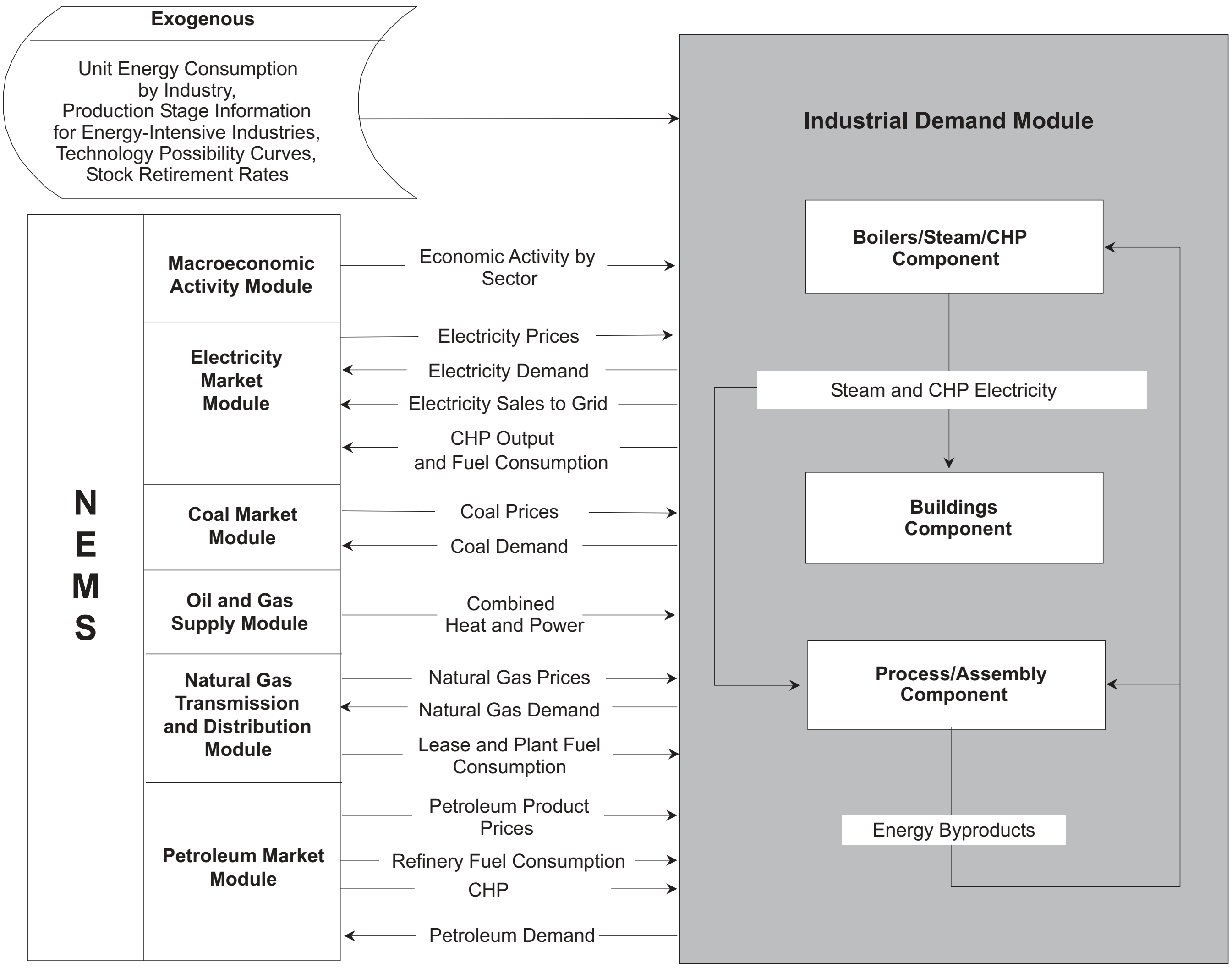
Economic Subsectors Within the IDM

Energy-Intensive Manufacturing	Nonmanufacturing Industries
Food and Kindred Products (NAICS 311)	Agricultural Production - Crops (NAICS 111)
Paper and Allied Products (NAICS 322)	Other Agriculture including Livestock (NAICS 112-115)
Bulk Chemicals (NAICS 325)	Coal Mining (NAICS 2121)
Glass and Glass Products (NAICS 3272)	Oil and Gas Extraction (NAICS 211)
Hydraulic Cement (NAICS 32731)	Metal and Other Nonmetallic Mining (NAICS 2122-2123)
Blast Furnaces and Basic Steel (NAICS 331111)	Construction (NAICS 233-235)
Aluminum (NAICS 3313)	
Nonenergy-Intensive Manufacturing	
Metals-Based Durables (NAICS 332-336)	
Other Manufacturing (all remaining manufacturing NAICS)	

NAICS = North American Industry Classification System.

IDM Outputs	Inputs from NEMS	Exogenous Inputs
Energy demand by service and fuel type Electricity sales to grid Cogeneration output and fuel consumption	Energy product prices Economic output by industry Refinery fuel consumption Lease and plant fuel consumption Cogeneration from refineries and oil and gas production	Production stages in energy-intensive industries Technology possibility curves Unit energy consumption Stock retirement rates

Figure 7. Industrial Demand Module Structure



in industrial buildings is assumed to grow at the same rate as the average growth rate of employment and output in that industry. The BSC component consumes energy to meet the steam demands from the other two components and to provide internally generated electricity to the BLD and PA components. The boiler component consumes fossil fuels to produce steam, which is passed to the PA component.

IDM models "traditional" combined heat and power (CHP) based on steam demand from the BLD and the PA components. The "nontraditional" CHP units are represented in the electricity market module since these units are mainly grid-serving, electricity-price-driven entities.

CHP capacity, generation, and fuel use are calculated from exogenous data on existing and planned capacity additions and new additions determined from an engineering and economic evaluation. Existing CHP capacity and planned additions are derived from Form EIA-860B, "Annual Electric Generator Report-Nonutility," formerly Form EIA-867, "Annual Nonutility Power Producer Report." Existing CHP capacity is assumed to remain in service throughout the forecast or, equivalently, to be refurbished or replaced with similar units of equal capacity.

EIA has comprehensively reviewed and revised how it collects, estimates, and reports fuel use for facilities producing electricity. The review addressed both

Fuel Consuming Activities for the Energy-Intensive Manufacturing Subsectors

End Use Characterization

Food: direct fuel, hot water/steam, refrigeration, and other electric.

Bulk Chemicals: direct fuel, hot water/steam, electrolytic, and other electric.

Process Step Characterization

Pulp and Paper: wood preparation, waste pulping, mechanical pulping, semi-chemical pulping, Kraft pulping, bleaching, and papermaking.

Glass: batch preparation, melting/refining, and forming.

Cement: dry process clinker, wet process clinker, and finish grinding.

Steel: coke oven, open hearth steel making, basic oxygen furnace steel making, electric arc furnace steel making, ingot casting, continuous casting, hot rolling, and cold rolling.

Aluminum: only primary aluminum smelting is explicitly included.

inconsistent reporting of the fuels used for electric power across historical years and changes in the electric power marketplace that have been inconsistently represented in various EIA survey forms and publications. In comparison with EIA's past energy data publications, the impact of the definition changes for the industrial sector is to reduce measured natural gas consumption. For example, the previously reported value for 2000 has been revised from 9.39 trillion cubic feet to 8.25 trillion cubic feet. In comparison with past energy data publications, the impact of the definition changes and new data sources for total energy use increases measured natural gas consumption. Total natural gas consumption in 2000 is 0.6 trillion cubic feet higher than was previously reported. A more detailed discussion of this update is available in EIA's *Annual Energy Review 2001*, Appendix H, "Estimating and Presenting Power Sector Fuel Use in EIA Publications and Analyses," web site www.eia.doe.gov/emeu/aer/pdf/pages/sec_h.pdf.

Calculation of unplanned CHP capacity additions begins in 2001. Modeling of unplanned capacity additions is done in two parts: biomass-fueled and fossil-fueled. Biomass CHP capacity is assumed to be added to the extent possible as additional biomass waste products are produced, primarily in the pulp and paper industry. The amount of biomass CHP capacity added is equal to the quantity of new biomass available (in Btu), divided by the total heat rate from biomass steam turbine CHP.

Additions to fossil-fueled CHP capacity are limited to gas turbine plants. It is assumed that the technical potential for CHP is based primarily on supplying thermal requirements. First, the model assesses the amount of capacity that could be added to generate the industrial steam requirements not met by existing CHP. The second step is an economic evaluation of gas turbine prototypes for each steam load segment. Finally, CHP additions are projected based on a range of acceptable payback periods.

The PA component accounts for the largest share of direct energy consumption for heat and power, 55 percent. For the seven most energy-intensive industries, process steps or end uses are modeled using engineering concepts. The production process is decomposed into the major steps, and the energy relationships among the steps are specified.

The energy intensities of the process steps or end uses vary over time, both for existing technology and for technologies expected to be adopted in the future. In IDM, this variation is based on engineering judgment and is reflected in the parameters of technology possibility curves, which show the declining energy intensity of existing and new capital relative to the 1998 stock.

IDM uses "technology bundles" to characterize technological change in the energy-intensive industries. These bundles are defined for each production process step for five of the industries and for end use in two of the industries. The process step industries are pulp and paper, glass, cement, steel, and aluminum. The end-use industries are food and bulk chemicals.

Machine drive electricity consumption in the food, bulk chemicals, metal-based durables, and balance of manufacturing sectors is calculated by a motor stock model. The beginning stock of motors is modified over the forecast horizon as motors are added to accommodate growth in shipments for each sector, as motors are retired and replaced, and as failed motors are rewound. When a new motor is added, either to accommodate growth or as a replacement, an economic choice is made between purchasing a motor which meets the EPACT minimum for efficiency or a premium efficiency motor. There are seven motor size groups in each of the four industries. The EPACT efficiency standards only apply to the five smallest groups (up to 200 horsepower). As the motor stock changes over the forecast horizon, the overall efficiency of the motor population changes as well.

The unit energy consumption is defined as the energy use per ton of throughput at a process step or as energy use per dollar of shipments for the end use industries. The “Existing UEC” is the current average installed intensity as of 1998. The “New 1998 UEC” is the intensity expected to prevail for a new installation in 1999. Similarly, the “New 2025 UEC” is the intensity expected to prevail for a new installation in 2025. For intervening years, the intensity is interpolated.

The rate at which the average intensity declines is determined by the rate and timing of new additions to capacity. In IDM, the rate and timing of new additions are functions of retirement rates and industry growth rates.

IDM uses a vintaged capital stock accounting framework that models energy use in new additions to the stock and in the existing stock. This capital stock is represented as the aggregate vintage of all plants built within an industry and does not imply the inclusion of specific technologies or capital equipment.

The capital stock is grouped into three vintages: old, middle, and new. The old vintage consists of capital in production prior to 1998, which is assumed to retire at a fixed rate each year. Middle-vintage capital is that added after 1998, excluding the year of the forecast. New production capacity is built in the forecast years when the capacity of the existing stock of capital in IDM cannot produce the output forecasted by the NEMS regional submodule of the macroeconomic activity module. Capital additions during the forecast horizon are retired in subsequent years at the same rate as the pre-1998 capital stock.

The energy-intensive and/or large energy-consuming industries are modeled with a structure that explicitly describes the major process flows or “stages of production” in the industry (some industries have major consuming uses).

Technology penetration at the level of major processes in each industry is based on a technology penetration curve relationship. A second relationship can provide additional energy conservation resulting from increases in relative energy prices. Major process choices (where applicable) are determined by industry production, specific process flows, and exogenous assumptions.

IDM achieves fuel switching by application of a logit function methodology for estimating fuel shares in the boilers/steam/CHP component. A small amount of additional fuel switching capability takes place within the PA component.

Recycling, waste products, and byproduct consumption are modeled using parameters based on off-line analysis and assumptions about the manufacturing processes or technologies applied within industry. These analyses and assumptions are mainly based upon environmental regulations such as government requirements about the share of recycled paper used in offices. IDM also accounts for trends within industry toward the production of more specialized products such as specialized steel which can be produced using scrap material versus raw iron ore.