Industrial Demand Module

The NEMS Industrial Demand Module estimates energy consumption by energy source (fuels and feedstocks) for 9 manufacturing and 6 nonmanufacturing industries. The manufacturing industries are further subdivided into the energy-intensive manufacturing industries and nonenergy-intensive manufacturing industries. The manufacturing industries are modeled through the use of a detailed process flow or end use accounting procedure, whereas the nonmanufacturing industries are modeled with substantially less detail (Table 17). The Industrial Demand Module forecasts energy consumption at the four Census region level (see Figure 5); energy consumption at the Census Division level is estimated by allocating the Census region forecast using the SEDS[26] data.

Table 17. Industry Categories

Energy-Intensive Manufacturing		Nonenergy-Intensive Manufacturing		Nonmanufacturing Industries	
Food and Kindred Products	(NAICS 311)	Metals-Based Durables	(NAICS 332-336)	Agricultural Production -Crops	(NAICS 111)
Paper and Allied Products	(NAICS 322)	Balance of Manufacturing	(all remaining manufacturing NAICS)	Other Agriculture Including Livestock	(NAICS112-115)
Bulk Chemicals	(NAICS 32B)			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)				

NAICS = North American Industry Classification System.

32B = Includes the following NAICS codes: 325110, 325120, 325181, 325188, 325192, 325199, 325211, 325212, 325222, 325311, 325312.

Source: Office of Management and Budget, North American Industry classification System (NAICS) - United States (Springfield, VA, National Technical Information Service).

The energy-intensive industries (food and kindred products, paper and allied products, bulk chemicals, glass and glass products, hydraulic cement, blast furnace and basic steel products, and aluminum) are modeled in considerable detail. Each industry is modeled as three separate but interrelated components consisting of the Process Assembly (PA) Component, the Buildings Component (BLD), and the Boiler/Steam/Cogeneration (BSC) Component. The BSC Component satisfies the steam demand from the PA and BLD Components. In some industries, the PA Component produces byproducts that are consumed in the BSC Component. For the manufacturing industries, the PA Component is separated into the major production processes or end uses.

Petroleum refining (North American Industry Classification System 32411) is modeled in detail in the Petroleum Market Module of NEMS, and the projected energy consumption is included in the manufacturing total. Forecasts of refining energy use, and lease and plant fuel and fuels consumed in cogeneration in the oil and gas extraction industry (North American Industry Classification System 211) are exogenous to the Industrial Demand Module, but endogenous to the NEMS modeling system.

Key Assumptions

The NEMS Industrial Demand Module primarily uses a bottom-up process modeling approach. An energy accounting framework traces energy flows from fuels to the industry's output. An important assumption in the development of this system is the use of 1998 baseline Unit Energy Consumption (UEC) estimates based on analysis of the Manufacturing Energy Consumption Survey (MECS) 1998.[27] The UECs represent the energy required to produce one unit of the industry's output. The output may be defined in terms of physical units (e.g., tons of steel) or in terms of the dollar value of shipments.

The module depicts the manufacturing industries (apart from petroleum refining, which is modeled in the Petroleum Market Module of NEMS) with a detailed process flow or end use approach. The dominant process technologies are characterized by a combination of unit energy consumption estimates and "technology possibility curves." The technology possibility curves indicate the energy intensity of new and existing stock relative to the 1998 stock over time. Rates of energy efficiency improvement assumed for new and existing plants vary by industry and process. These assumed rates were developed using professional engineering judgments regarding the energy characteristics, year of availability, and rate of market adoption of new process technologies.

Process/Assembly Component

The PA Component models each major manufacturing production step or end use for the manufacturing industries. The throughput production for each process step is computed as well as the energy required to produce it.

Within this component, the UECs are adjusted based on the technology possibility curves for each step. For example, state-of-the-art additions to waste fiber pulping capacity in 1998 are assumed to require only 93 percent as much energy as does the average existing plant (Table 18). The technology possibility curve is a means of embodying assumptions regarding new technology adoption in the manufacturing industry and the associated increased energy efficiency of capital without characterizing individual technologies. To some extent, all industries will increase the energy efficiency of their process and assembly steps. The reasons for the increased efficiency are not likely to be directly attributable to changing energy prices but due to other exogenous factors. Since the exact nature of the technology improvement is too uncertain to model in detail, the module employs a technology possibility curve to characterize the bundle of technologies available for each process step.

Fuel shares for process and assembly energy use in the manufacturing industries[28] are adjusted for changes in relative fuel prices. In each industry, two logit fuel-sharing equations are applied to revise the initial fuel shares obtained from the process-assembly component. The resharing does not affect the industry's total energy use, only the fuel shares. The methodology adjusts total fuel shares across all process stages and vintages of equipment to account for aggregate market response to changes in relative fuel prices.

The fuel share adjustments are done in two stages. The first stage determines the fuel shares of electricity and nonelectric energy. (The non-electric energy group excludes boiler fuel and feedstocks.) The second stage determines the fossil fuel shares of nonelectric energy. In each stage, a new fuel-group share, $NEWSHR_i$, is established as a function of the initial, default fuel-group shares, $DEFLTSHR_j$ and fuel-group prices indices, $PRCRAT_i$. The $DEFLTSHR_i$ are the base year shares. The price indices are the ratio of the current year price to the base year price, in real dollars.

The form of the equation results in unchanged fuel shares when the price indices are all 1, or unchanged from their 1998 levels. The implied own-price elasticity of demand is about -0.1.

Byproducts produced in the PA Component serve as fuels for the BSC Component. In the industrial module, byproducts are assumed to be consumed before purchased fuel.

Table 18. Coefficients for Technology Possibility Curve

Industry/Process Unit	Existing Facilities		New Facilities		
	REI 2025[1]	TPC[2]	REI 1998[3]	REI 2025[4]	TPC[2]
Food & Kindred Products					
Process Heating	0.900	-0.0039	0.900	0.800	-0.0044
Process Cooling	0.876	-0.0049	0.850	0.750	-0.0046
Other	0.915	-0.0033	0.915	0.810	-0.0045
Paper & Allied Products					
Wood Preparation	0.922	-0.0030	0.873	0.845	-0.0012
Waste Pulping	0.942	-0.0022	0.936	0.882	-0.0022
Mechanical Pulping	0.917	-0.0032	0.868	0.834	-0.0015
Semi-chemical	0.873	-0.0050	0.876	0.747	-0.0059
Kraft, Sulfite, misc. Chemicals	0.816	-0.0075	0.876	0.632	-0.0121
Bleaching	0.871	-0.0051	0.900	0.742	-0.0071
Paper Making	0.796	-0.0084	0.900	0.592	-0.0154
Bulk Chemicals					
Process Heating	0.900	-0.0039	0.900	0.800	-0.0044
Process Cooling	0.876	-0.0049	0.850	0.751	-0.0046
Electro-Chemical	0.981	-0.0007	0.950	0.850	-0.0041
Other	0.915	-0.0033	0.913	0.808	-0.0045
Glass & Glass Products[5]					
Batch Preparation	0.940	-0.0023	0.882	0.882	0.0000
Melting/Refining	0.712	-0.0125	0.900	0.422	-0.0277
Forming	0.905	-0.0037	0.982	0.808	-0.0072
Post-Forming	0.925	-0.0029	0.968	0.850	-0.0048
Hydraulic Cement					
Dry Process	0.840	-0.0064	0.889	0.747	-0.0064
Wet Process[6]	0.935	-0.0025	NA	NA	NA
Finish Grinding	0.836	-0.0066	0.950	0.673	-0.0127
Blast Furnaces & Basic Steel					
Coke Oven[6]	0.915	-0.0033	0.874	0.830	-0.0019
BF/BOF	0.989	-0.0004	1.000	0.979	-0.0008
EAF	0.995	-0.0002	0.995	0.990	0.0000
Ingot Casting/Primary Rolling[6]	1.000	0.0000	NA	NA	NA
Continuous Casting[7]	1.000	0.0000	1.000	1.000	0.0000
Hot Rolling[7]	0.742	-0.0110	0.742	0.485	-0.0160
Cold Rolling[7]	0.738	-0.0112	0.924	0.474	-0.0244
Aluminum					
Alumina Refining	0.930	-0.0027	0.900	0.862	-0.0016
Primary Smelting	0.910	-0.0035	0.950	0.816	-0.0056
Secondary	0.781	-0.0091	0.750	0.561	-0.0107
Semi-Fabrication, Sheet	0.746	-0.0108	0.900	0.491	-0.0222
Semi-Fabrication, Other	0.873	-0.0050	0.950	0.748	-0.0088
Metal Based Durables					
Process Heating	0.900	-0.0039	0.900	0.799	-0.0044
Process Cooling	0.876	-0.0049	0.851	0.751	-0.0046
Electro-Chemical	0.981	-0.0007	0.955	0.855	-0.0041
Other	0.915	-0.0033	0.915	0.810	-0.0045

Table 18. Coefficients for Technology Possiblity Curves (Continued)

Industry/Process Unit	Existing Facilities		New Facilities		
	REI 2025[1]	TPC[2]	REI 1998[3]	REI 2025[4]	TPC[2]
Balance of Manufacturing					
Process Heating	0.900	-0.0039	0.900	0.799	-0.0044
Process Cooling	0.876	-0.0049	0.851	0.751	-0.0046
Electro-Chemical	0.981	-0.0007	0.955	0.855	-0.0041
Other	0.915	-0.0033	0.915	0.810	-0.0045
Non-Manufacturing	0.973	-0.0010	0.900	0.853	-0.0020

[1]REI 2025 Existing Facilities = Ratio of 2025 energy intensity to average 1998 energy intensity for existing facilities.

[2]TPC = annual rate of change between 1998 and 2025.

[3]REI 1998 New Facilities = For new facilities, the ratio of state-of-the-art energy intensity to average 1998 energy intensity for existing facilities.

[4]REI 2025 New Facilities = Ratio of 2025 energy intensity for a new state-of-the-art facility to the average 1998 intensity for existing facilities.

[5]REIs and TPCs apply to virgin and recycled materials.

[6]No new plants are likely to be built with these technologies.

[7]Net shape casting is projected to reduce the energy requirements for hot and cold rolling rather than for the continuous casting step.

NA = Not applicable.

BF = Blast furnace.

BOF = Basic oxygen furnace.

EAF = Electric arc furnace.

Source: Energy Information Administration, *Model Documentation Report*, *Industrial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-M064(2004) (Washington, DC, 2004).

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 an old motor fails, an economic choice is made on whether to repair or replace the motor. 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. Table 19 provides the beginning stock efficiency for seven motor size groups in each of the four industries, as well as efficiencies for EPACT minimum and premium motors. There is no premium motor option for the largest size group because the Motor Master database does not provide characteristics for premium motors larger than 350 horsepower.[29] As the motor stock changes over the forecast horizon, the overall efficiency of the motor population changes as well.

Buildings Component

The total buildings energy demand by industry for each region is a function of regional industrial employment and output. Building energy consumption was estimated for building lighting, hvac (heating,ventilation, and air conditioning), facility support, and onsite transportation. Space heating was further divided to estimate the amount provided by direct combustion of fossil fuels and that provided by steam (Table 20). Energy consumption in the BLD Component for an industry is estimated based on regional employment and output growth for that industry.

Boiler/Steam/Combined Heat and Power Component

The steam demand and byproducts from the PA and BLD Components are passed to the BSC Component, which applies a heat rate and a fuel share equation (Table 21) to the boiler steam requirements to compute the required energy consumption.

The boiler fuel shares apply only to the fuels that are used in non-combined heat and power (CHP) boilers. The portion of the steam demand that is met with cogenerated steam reduces the amount of boiler fuel that would otherwise be required. The non-CHP boiler fuel shares are calculated using a logit formulation. The equation is calibrated to 1998 so that the actual boiler fuel shares are produced for the relative prices that prevailed in 1998.

Table 19. Cost and Performance Parameters for Industrial Motor Choice Model

Industrial Sector Horsepower Range	1998 Stock Efficiency (%)	EPACT Minimum Efficiency (%)	EPACT Minimum Cost (2002$)	Premium Efficiency (%)	Premium Cost (2002$)
Food					
1 - 5 hp	81.3	86.7	327	88.9	351
6 - 20 hp	87.1	91.4	901	92.7	947
21 - 50 hp	90.1	92.6	1,448	93.7	1,618
51 - 100 hp	92.7	94.4	3,338	95.1	3,430
101 - 200 hp	93.5	94.6	6,734	95.9	7,670
201 - 500 hp	93.8	93.4	12,147	96.1	13,560
> 500 hp	93.0	94.8	19,148	na	na
Bulk Chemicals					
1 - 5 hp	82.0	86.9	327	89.1	351
6 - 20 hp	87.4	91.6	901	92.9	947
21 - 50 hp	90.4	92.7	1,448	93.8	1,618
51 - 100 hp	92.4	94.4	3,338	95.2	3,430
101 - 200 hp	93.5	94.7	6,734	96.0	7,670
201 - 500 hp	93.3	93.6	12,147	96.1	13,560
> 500 hp	93.2	94.9	19,148	na	na
Metal-Based Durables					
1 - 5 hp	81.9	86.8	327	88.9	351
6 - 20 hp	87.0	91.5	901	92.8	947
21 - 50 hp	90.0	92.6	1,448	93.8	1,618
51 - 100 hp	92.0	94.4	3,338	95.1	3,430
101 - 200 hp	93.5	94.6	6,734	95.9	7,670
201 - 500 hp	93.7	93.5	12,147	96.1	13,560
> 500 hp	93.0	94.8	19,148	na	na
Balance of Manufacturing					
1 - 5 hp	82.9	86.8	327	88.9	351
6 - 20 hp	88.3	91.5	901	92.8	947
21 - 50 hp	90.3	92.6	1,448	93.8	1,618
51 - 100 hp	92.7	94.4	3,338	95.1	3,430
101 - 200 hp	94.3	94.6	6,734	95.9	7,670
201 - 500 hp	94.3	93.5	12,147	96.1	13,560
> 500 hp	92.9	94.8	19,148	na	na

Source: Energy Information Administration, *Model Documentation Report, Industrial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-M064(2004) (Washington, DC, 2004).

Note: The efficiencies listed in this table are operating efficiencies based on average part-loads. Because the average part-load is not the same for all industires, the listed efficiencies for the different motor sizes vary across industries.

The byproduct fuels are consumed before the quantity of purchased fuels is estimated. The boiler fuel shares are based on the 1998 MECS.[30]

Combined Heat and Power

Combined heat and power (CHP) plants, which are designed to produce electricity and useful heat, have been used in the industrial sector for many years. The CHP estimates in the module are based on the assumption that the historical relationship between industrial steam demand and CHP will continue in the future.

Table 20. 1998 Building Component Energy Consumption (Trillion Btu)

		Building Use and Energy Source					
Industry	Region	Lighting Electricity Consumption	HVAC Electricity Consumption	HVAC Natural Gas Consumption	HVAC Steam Consumption	Facility Support Total Consumptiion	Onsite Transportation Total Consumption
Food & Kindred Products	1	1.5	1.7	2.5	1.9	0.9	0.4
	2	6,5	7.3	12.1	9.1	4.4	1.8
	3	5.6	6.3	7.7	5.8	2.9	2.6
	4	2.5	2.8	5.6	4.2	1.9	1.3
Paper & Allied Products	1	2.4	2.7	1.5	0.3	0.7	1.7
	2	4.0	4.5	3.4	0.6	1.3	1.0
	3	7.6	8.5	8.8	1.6	2.8	3.0
	4	3.0	3.4	3.3	0.6	1.1	1.0
Bulk Chemicals	1	1.1	1.6	0.4	0.0	0.4	0.0
	2	3.3	4.8	1.5	0.0	1.2	0.0
	3	10.2	14.7	18.3	0.0	4.9	0.0
	4	1.0	1.5	1.0	0.0	0.4	0.0
Glass & Glass Products	1	0.4	0.6	1.5	0.0	0.0	0.0
	2	0.5	0.8	1.6	0.0	0.0	0.0
	3	0.8	1.2	2.3	0.0	0.0	0.0
	4	0.2	0.4	0.6	0.0	0.0	0.0
Hydraulic Cement	1	0.1	0.1	0.0	0.0	0.0	0.1
	2	0.2	0.2	0.0	0.0	0.0	0.5
	3	0.4	0.4	0.0	0.0	0.0	0.5
	4	0.2	0.2	0.0	0.0	0.0	0.3
Blast Furnaces & Basic Steel	1	0.9	0.7	1.9	0.0	0.5	0.5
	2	2.5	2.1	10.8	0.0	2.2	1.5
	3	2.0	1.7	4.4	0.0	1.1	1.2
	4	0.5	0.4	1.0	0.0	0.3	0.2
Aluminum	1	0.3	0.3	0.4	0.0	0.2	0.2
	2	0.9	1.1	1.0	0.0	0.4	0.1
	3	1.4	1.8	3.2	0.0	1.0	0.1
	4	1.4	1.7	0.4	0.0	0.4	0.1
Metal Based Durables	1	12.4	15.7	28.1	10.8	5.2	3.4
	2	39.1	49.4	100.1	38.4	14.4	7.5
	3	25.2	31.8	45.0	17.3	11.3	7.1
	4	13.9	17.6	19.6	7.5	4.6	1.8
Balance of Manufacturing	1	10.0	13.6	18.7	15.5	3.9	6.2
	2	22.0	29.8	38.1	31.5	8.4	3.6
	3	37.1	50.3	53.4	44.2	13.0	11.5
	4	9.4	12.8	21.7	17.9	4.1	3.7

HVAC = Heating, Ventilation, Air Conditioning.

Source: Energy Information Administration, *Model Documentation Report: Industrial Demand Module of the National Energy Modeling System*, DOE/EIA-M064(2004), (Washington, DC, 2004).

Table 21. Logit Function Parameters for Estimating Boiler Fuel Shares

Industry	Region	Alpha	Natural Gas	Steam Coal	Oil
Food & Kindred Products	1	-0.25	0.84	0.04	0.12
	2	-0.25	0.63	0.36	0.02
	3	-0.25	0.80	0.10	0.10
	4	-0.25	0.77	0.17	0.06
Paper & Allied Products	1	-0.25	0.29	0.18	0.53
	2	-0.25	0.50	0.47	0.03
	3	-0.25	0.52	0.35	0.12
	4	-0.25	0.87	0.09	0.04
Bulk Chemicals	1	-0.25	0.50	0.01	0.49
	2	-0.25	0.45	0.21	0.33
	3	-0.25	0.54	0.10	0.36
	4	-0.25	0.38	0.53	0.08
Glass & Glass Products	1	-0.25	1.00	0.00	0.00
	2	-0.25	1.00	0.00	0.00
	3	-0.25	1.00	0.00	0.00
	4	-0.25	1.00	0.00	0.00
Hydraulic Cement	1	-0.25	0.04	0.96	0.00
	2	-0.25	0.31	0.69	0.00
	3	-0.25	0.40	0.60	0.00
	4	-0.25	0.56	0.44	0.00
Blast Furnaces & Basic Steel	1	-0.25	0.98	0.01	0.01
	2	-0.25	0.69	0.14	0.17
	3	-0.25	0.86	0.06	0.08
	4	-0.25	0.97	0.01	0.02
Aluminum	1	-0.25	1.00	0.00	0.00
	2	-0.25	1.00	0.00	0.00
	3	-0.25	1.00	0.00	0.00
	4	-0.25	1.00	0.00	0.00
Metal Based Durables	1	-0.25	0.68	0.15	0.16
	2	-0.25	0.74	0.24	0.02
	3	-0.25	0.85	0.03	0.08
	4	-0.25	0.97	0.00	0.03
Balance of Manufacturing	1	-0.25	0.59	0.24	0.18
	2	-0.25	0.67	0.30	0.04
	3	-0.25	0.67	0.25	0.08
	4	-0.25	0.79	0.17	0.04

Alpha: User-specified.

Source: Energy Information Administration, *Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-064(2004), (Washington, DC, 2004).

In 2002, EIA comprehensively reviewed and revised how it collects, estimates, and reports fuel use for facilities producing electricity. The review addressed both 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. These changes were first reflected in the *Annual Energy Review 2001*, DOE/EIA-0384(2001), (Washington, DC, November 2002), and are discussed in detail in Appendix H of that publication.

The projection for additions to fossil-fueled cogeneration is based on assessing capacity that could be added to generate the industrial steam requirements that are not already met by existing CHP. The technical potential for onsite CHP is primarily based on supplying thermal requirements. Capacity additions are then determined by the interaction of payback periods and market penetration rates. Installed cost for the cogeneration systems is given in Table 22.

Table 22. Cost Characteristics of Industrial CHP Systems

System	Size (kilowatts)	Installed Cost ($2003 per kilowatt)[1]		O&M Cost ($2003 per kilowatthour)[1]	
		2003	2020	2003	2020
1 Engine	1000	940	840	0.013	0.008
2 Engine	3000	935	830	0.009	0.008
3 Gas Turbine	1000	1910	NA	0.0096	NA
4 Gas Turbine	5000	1024	840	0.0059	0.005
5 Gas Turbine	10000	930	790	0.0055	0.005
6 Gas Turbine	25000	800	705	0.0049	0.004
7 Gas Turbine	40000	702	660	0.0042	0.004
8 Combined Cycle	100000	692	655	0.0036	0.003

[1]Costs are given in 2003 dollars in original source document.

NA = The 1000 kilowatt gas turbine is not expected to be a viable option in the future.

Source: Energy Information Administration, *Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System,* DOE/EIA-MO64(2004) (Washington, DC, 2004).

Technology

The amount of energy consumption reported by the industrial module is also a function of the vintage of the capital stock that produces the output. It is assumed that new vintage stock will consist of state-of-the-art technologies that are more energy efficient than the average efficiency of the existing capital stock. Consequently, the amount of energy required to produce a unit of output using new capital stock is less than that required by the existing capital stock. Capital stock is grouped into three vintages: old, middle, and new. The old vintage consists of capital in production prior to 1999 and is assumed to retire at a fixed rate each year (Table 23). Middle vintage capital is that which is added after 1998 but not including the year of the forecast. New production capacity is built in the forecast years when the capacity of the existing stock of capital in the industrial model cannot produce the output projected by the NEMS Regional Macroeconomic Model. Capital additions during the forecast horizon are retired in subsequent years at the same rate as the pre-1999 capital stock.

The energy intensity of the new capital stock relative to 1998 capital stock is reflected in the parameter of the technology possibility curve estimated for the major production steps for each of the energy-intensive industries. These curves are based on engineering judgment of the likely future path of energy intensity changes (Table 20). The energy intensity of the existing capital stock also is assumed to decrease over time, but not as rapidly as new capital stock. The net effect is that over time the amount of energy required to produce a unit of output declines. Although total energy consumption in the industrial sector is projected to increase, overall energy intensity is projected to decrease.

Table 23. Retirement Rates

Industry	Retirement Rate (percent)	Industry	Retirement Rate (percent)
Food and Kindred Products	1.7	Glass and Glass Products	1.3
Pulp and Paper	2.3	Hydraulic Cement	1.2
Bulk Chemicals	1.7	Aluminum	
Blast Furnance and Basic Steel Products		Metal Based Duration	
Blast Furnace and Basic Stell Products	1.5	Other Non-Intensive Manufacturing	
Electric Arc Furnace	1.5		
Coke Ovens	1.5		
Other Stell	2.9		

Note: Except for the Blast Furnace and Basic Steel Products Industry, the retirement rate is the same for each process step or end-use within an industry.

Source: Energy Information Administration, *Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-MO64(2004), (Washington, DC, 2004).

Legislation

Energy Policy Act of 1992 (EPACT)

EPACT contains several implications for the industrial module. These implications concern efficiency standards for boilers, furnaces, and electric motors. The industrial module uses heat rates of 1.25 (80 percent efficiency) and 1.22 (82 percent efficiency) for gas and oil burners respectively. These efficiencies meet the EPACT standards. EPACT mandates minimum efficiencies for all motors up to 200 horsepower purchased after 1998. The choices offered in the motor model are all at least as efficient as the EPACT minimums.

Clean Air Act Amendments of 1990 (CAAA90)

The CAAA90 contains numerous provisions that affect industrial facilities. Three major categories of such provisions are as follows: process emissions, emissions related to hazardous or toxic substances, and SO2 emissions.

Process emissions requirements were specified for numerous industries and/or activities (40 CFR 60). Similarly, 40 CFR 63 requires limitations on almost 200 specific hazardous or toxic substances. These specific requirements are not explicitly represented in the NEMS industrial model because they are not directly related to energy consumption projections.

Section 406 of the CAAA90 requires the Environmental Protection Agency (EPA) to regulate industrial SO_2 emissions at such time that total industrial SO_2 emissions exceed 5.6 million tons per year (42 USC 7651). Since industrial coal use, the main source of SO_2 emissions, has been declining, EPA does not anticipate that specific industrial SO_2 regulations will be required (Environmental Protection Agency, *National Air Pollutant Emission Trends: 1990-1998*, EPA-454/R-00-002, March 2000, Chapter 4). Further, since industrial coal use is not projected to increase, the industrial cap is not expected be a factor in industrial energy consumption projections.

High Technology, 2004 Technology, Advanced Nuclear, and High Renewables Cases

The *high technology case* assumes earlier availability, lower costs, and higher efficiency for more advanced equipment. (Table 24)[31] The *high technology case* also assumes that the rate at which biomass byproducts will be recovered from industrial processes increases from 0.1 percent per year to 1.0 percent per year. The availability of additional biomass leads to an increase in biomass-based cogeneration. Changes in aggregate energy intensity result both from changing equipment and production efficiency and from changes in the composition of industrial output. Since the composition of industrial output remains the same as in the reference case, primary energy intensity declines by 1.5 percent annually compared with the reference case, in which primary energy intensity is projected to decline 1.3 percent annually.

The *2004 technology case* holds the energy efficiency of plant and equipment constant at the 2004 level over the forecast. Both cases were run with only the Industrial Demand Module rather than as a fully integrated NEMS run, (i.e., the other demand models and the supply models of NEMS were not executed). Consequently, no potential feedback effects from energy market interactions were captured.

AEO2004 also analyzed an integrated high technology case (*consumption high technology*), which combines the *high technology cases* of the four end-use demand sectors, the *electricity high fossil technology case,* the *advanced nuclear case,* and *the high renewables case*.

The *high renewables case* assumes that the rate at which biomass byproducts will be recovered from industrial processes increases from 0.1 percent per year to 1.0 percent per year. The availability of additional biomass leads to an increase in biomass-based CHP.

Table 24. Coefficients for Technology Possibility Curves, High Technology Case

Industry/Process Unit	Existing Facilities		New Facilities		
	REI 2025[1]	TPC[2]	REI 1998[3]	REI 2025[4]	TPC[2]
Food & Kindred Products					
Process Heating	0.829	-0.0069	0.900	0.629	-0.0132
Process Cooling	0.829	-0.0069	0.850	0.594	-0.0132
Other	0.829	-0.0069	0.915	0.639	-0.0132
Paper & Allied Products					
Wood Preparation	0.843	-0.0063	0.873	0.790	-0.0037
Waste Pulping	0.900	-0.0039	0.936	0.809	-0.0054
Mechanical Pulping	0.883	-0.0046	0.868	0.805	-0.0028
Semi-chemical	0.814	-0.0076	0.876	0.634	-0.0119
Kraft, Sulfite, misc. Chemicals	0.714	-0.0124	0.876	0.411	-0.0276
Bleaching	0.779	-0.0092	0.900	0.544	-0.0185
Paper Making	0.687	-0.0138	0.900	0.343	-0.0351
Bulk Chemicals					
Process Heating	0.843	-0.0063	0.900	0.644	-0.0123
Process Cooling	0.843	-0.0063	0.850	0.609	-0.0123
Electro-Chemical	0.843	-0.0063	0.950	0.680	-0.0123
Other	0.843	-0.0063	0.915	0.654	-0.0123
Glass & Glass Products[5]					
Batch Preparation	0.857	-0.0057	0.882	0.645	0.0115
Melting/Refining	0.710	-0.0126	0.900	0.418	-0.0280
Forming	0.866	-0.0053	0.982	0.682	-0.0134
Post-Forming	0.805	-0.0080	0.968	0.531	-0.0220
Hydraulic Cement					
Dry Process	0.788	-0.0088	0.889	0.558	-0.0171
Wet Process[6]	0.788	-0.0088	NA	NA	NA
Finish Grinding	0.823	-0.0072	0.950	0.628	-0.0152
Blast Furnaces & Basic Steel					
Coke Oven[6]	0.592	-0.0192	0.874	0.502	-0.0203
BF/BOF	0.905	-0.0037	1.000	0.678	-0.0143
EAF	0.801	-0.0082	0.990	0.632	-0.0165
Ingot Casting/Primary Rolling[6]	1.000	0.0000	NA	NA	NA
Continuous Casting[7]	0.932	-0.0026	1.000	0.867	-0.0053
Hot Rolling[7]	0.427	-0.0310	0.750	0.093	-0.0743
Cold Rolling[7]	0.383	-0.0349	0.924	0.023	-0.1278
Aluminum					
Alumina Refining	0.859	-0.0056	0.900	0.678	-0.0104
Primary Smelting	0.816	-0.0075	0.950	0.582	-0.0180
Secondary	0.667	-0.0149	0.750	0.388	-0.0241
Semi-Fabrication, Sheet	0.689	-0.0137	0.900	0.353	-0.0341
Semi-Fabrication, Other	0.706	-0.0128	0.950	0.346	-0.0367
Metal Based Durables					
Process Heating	0.814	-0.0076	0.900	0.614	-0.0141
Process Cooling	0.814	-0.0076	0.851	0.580	-0.0141
Electro-Chemical	0.814	-0.0076	0.955	0.651	-0.0141
Other	0.814	-0.0076	0.915	0.624	-0.0141

Table 24. Coefficients for Technology Possibility Curves, High Technology Case (Continued)

Industry/Process Unit	Existing Facilities REI 2025[1]	Existing Facilities TPC[2]	New Facilities REI 1998[3]	New Facilities REI 2025[4]	New Facilities TPC[2]
Other Non-Intensive Manufacturing					
Process Heating	0.821	-0.0073	0.900	0.617	-0.0139
Process Cooling	0.821	-0.0073	0.851	0.583	-0.0139
Electro-Chemical	0.821	-0.0073	0.955	0.655	-0.0139
Other	0.821	-0.0073	0.915	0.625	-0.0139
Non-Manufacturing	0.947	-0.0020	0.900	0.808	-0.0040

[1]REI 2025 Existing Facilities = Ratio of 2025 energy intensity to average 1998 energy intensity for existing facilities.

[2]TPC = annual rate of change between 1998 and 2025.

[3]REI 1998 New Facilities = For new facilities, the ratiio of State-of-the-art energy intensity to average 1998 energy intensity for existing facilities.

[4]REI 2025 New Facilities = Ratio of 2025 energy intensity for a new State-of-the-art facility to the average 1998 intensity for existing facilities.

[5] REIs and TPCs apply to virgin and recycled materials.

[6]No new plants are likely to be built with these technologies.

[7]Net shape casting is projected to reduce the energy requirements for hot and cold rolling rather than for the continuous casting step.

NA = Not applicable.

BF = Blast furnace.

BOF = Basic oxygen furnace.

EAF = Electric arc furnace.

Source: Energy Information Administration, *Model Documentation Report*, *Industrial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-M064(2004) (Washington, DC, 2004).

Notes and Sources

[26] Energy Information Administration, State Energy Data Report 1999, DOE/EIA-0214(99), (Washington, D.C., May 2001).

[27] Energy Information Administration, Manufacturing Energy Consumption Survey, web site www.eia.doe.gov/emeu/mecs/mecs98/datatables/contents.html.

[28] Aluminum is excluded due to its almost exclusive reliance on electricity in the process and assembly component.

[29] U.S., Department of Energy (2003). Motor Master+ 4.0 software database; available online: http://mm3.energy.wsu.edu/mmplus/default.stm.

[30] Energy Information Administration, Manufacturing Energy Consumption Survey, web site www.eia.doe.gov/emeu/mecs/mecs98/datatables/contents.html.

[31] These assumptions are based in part on Arthur D. Little, Industrial Model: Update on Energy Use and Industrial Characteristics (September 2001).