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Industrial Demand Module

The NEMS Industrial Demand Module estimates energy consumption by energy source (fuels and feedstocks) for 21 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[25] data.

Table 17. Industry Categories

Energy-Intensive Manufacturing		Nonenergy-Intensive Manufacturing		Nonmanufacturing Industries	
Food Products	(NAICS 311)	Metal-Based Durables		Agricultural Production -Crops	(NAICS 111)
		Fabricated Metal Productss	(NAICS 332)		
		Machinery	(NAICS 333)		
		Computer and Electronic Products	(NAICS 334)		
		Electrical Equipment	(NAICS 335)		
		Transportation Equipment	(NAICS 336)		
Paper and Allied Products	(NAICS 322)	Other Non-Intensive Manufacturing		Other Agriculture Including Livestock	(NAICS 112-115)
		Wood Products	(NAICS 321)		
		Plastic Products	(NAICS 326)		
		Balance of Manufacturing	(all remainig NAICS)		
Bulk Chemicals				Coal Mining	(NAICS 2121)
Inorganic	(NAICS 32512 to 32518)				
Organic	(NAICS 32511, 32519)				
Resins	(NAICS 3252)				
Agricultural	(NAICS 3253				
Glass and Glass Products	(NAICS 3272)			Oil and Gas Extraction	(NAICS 211)
Cement	(NAICS 32731)			Metal and Other Nonmetallic Mining	(NAICS 2122-2123)
Iron and Steel	(NAICS 3311-3312)			Construction	(NAICS 233-235)
Aluminum	(NAICS 3313)				

NAICS = North American Industry Classification System.

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 products, paper and allied products, bulk chemicals, glass and glass products, cement, iron and steel, 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 2002 baseline Unit Energy Consumption (UEC) estimates based on analysis of the Manufacturing Energy Consumption Survey (MECS) 2002.[26] 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 2002 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 2002 are assumed to require only 94 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[27] 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 2002 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 2030[1]	TPC[2]	REI 2002[3]	REI 2030[4]	TPC[2]
Food Products					
Process Heating	0.900	-0.0038	0.900	0.800	-0.0042
Process Cooling	0.875	-0.0048	0.850	0.750	-0.0045
Other	0.914	-0.0032	0.915	0.810	-0.0043
Paper & Allied Products					
Wood Preparation	0.792	-0.0083	0.882	0.701	-0.0082
Waste Pulping	0.936	-0.0024	0.936	0.936	-0.0000
Mechanical Pulping	0.816	-0.0072	0.931	0.701	-0.0101
Semi-chemical	0.954	-0.0017	0.971	0.937	-0.0013
Kraft, Sulfite, misc. Chemicals	0.870	-0.0049	0.914	0.827	-0.0036
Bleaching	0.798	-0.0080	0.878	0.719	-0.0071
Paper Making	0.869	-0.0050	0.885	0.852	-0.0014
Bulk Chemicals					
Process Heating	0.900	-0.0038	0.900	0.800	-0.0042
Process Cooling	0.875	-0.0048	0.850	0.750	-0.0045
Electro-Chemical	0.980	-0.0007	0.950	0.850	-0.0040
Other	0.914	-0.0032	0.915	0.810	-0.0043
Glass & Glass Products[5]					
Batch Preparation	0.941	-0.0022	0.882	0.882	0.0000
Melting/Refining	0.934	-0.0024	0.900	0.868	-0.0013
Forming	0.984	-0.0006	0.982	0.968	-0.0005
Post-Forming	0.978	-0.0008	0.968	0.955	-0.0005
Cement					
Dry Process	0.905	-0.0036	0.900	0.810	-0.0038
Wet Process[6]	0.951	-0.0018	NA	NA	NA
Finish Grinding	0.975	-0.0009	0.950	0.950	0.0000
Iron and Steel					
Coke Oven[6]	0.935	-0.0024	0.902	0.869	-0.0013
BF/BOF	0.994	-0.0002	0.987	0.987	0.0000
EAF	0.955	-0.0028	0.990	0.849	0.0055
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]	0.826	-0.0068	0.800	0.652	-0.0073
Cold Rolling[7]	0.737	-0.0108	0.924	0.474	-0.0236
Aluminum					
Alumina Refining	0.930	-0.0026	0.900	0.860	-0.0016
Primary Smelting	0.900	-0.0038	0.950	0.800	-0.0061
Secondary	0.875	-0.0048	0.850	0.750	-0.0045
Semi-Fabrication, Sheet	0.900	-0.0038	0.900	0.800	-0.0042
Semi-Fabrication, Other	0.925	-0.0028	0.950	0.850	-0.0040
Metal-Based Durables					
Fabricated Metals					
Process Heating	0.728	-0.0113	0.675	0.420	-0.0168
Process Cooling	0.669	-0.0143	0.638	0.385	-0.0178
Other	0.763	-0.0096	0.686	0.420	-0.0174

Table 18. Coefficients for Technology Possiblity Curves (Continued)

Industry/Process Unit	Existing Facilities		New Facilities		
	REI 2030[1]	TPC[2]	REI 2002[3]	REI 2030[4]	TPC[2]
Machinery					
Process Heating	0.728	-0.0113	0.675	0.330	-0.0252
Process Cooling	0.669	-0.0143	0.638	0.298	-0.0268
Other	0.763	-0.0096	0.686	0.328	-0.0261
Computers and Electronics					
Process Heating	0.900	-0.0038	0.900	0.800	-0.0042
Process Cooling	0.875	-0.0038	0.850	0.744	-0.0048
Other	0.914	-0.0032	0.915	0.810	-0.0043
Electrical Equipment					
Process Heating	0.900	-0.0038	0.900	0.800	-0.0042
Process Cooling	0.875	-0.0048	0.850	0.750	-0.0045
Other	0.914	-0.0032	0.915	0.810	-0.0043
Transportation Equipment					
Process Heating	0.863	-0.0053	0.765	0.633	-0.0067
Process Cooling	0.829	-0.0067	0.723	0.591	-0.0071
Other	0.882	-0.0045	0.778	0.640	-0.0069
Other Non-Intensive Manufacturing					
Wood Products					
Process Heating	0.728	-0.0113	0.630	0.392	-0.0168
Process Cooling	0.669	-0.0143	0.595	0.359	-0.0178
Other	0.763	-0.0096	0.641	0.392	-0.0174
Plastic Products					
Process Heating	0.854	-0.0056	0.675	0.559	-0.0067
Process Cooling	0.818	-0.0071	0.638	0.522	-0.0071
Other	0.874	-0.0048	0.686	0.565	-0.0069
Balance of Manufacturing					
Process Heating	0.728	-0.0113	0.675	0.462	-0.0134
Process Cooling	0.669	-0.0143	0.638	0.426	-0.0143
Other	0.763	-0.0096	0.686	0.464	-0.0139

[1]REI 2030 Existing Facilities = Ratio of 2030 energy intensity to average 2002 energy intensity for existing facilities.
[2]TPC = annual rate of change between 2002 and 2030.
[3]REI 2002 New Facilities = For new facilities, the ratio of state-of-the-art energy intensity to average 2002 energy intensity for existing facilities.
[4]REI 2030 New Facilities = Ratio of 2030 energy intensity for a new state-of-the-art facility to the average 2002 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(2007) (Washington, DC, 2007).

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.[28] As the motor stock changes over the forecast horizon, the overall efficiency of the motor population changes as well.

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

Industrial Sector Horsepower Range	2002 Stock Efficiency (%)	EPACT Minimum Efficiency (%)	EPACT Minimum Cost (2002$)	Premium Efficiency (%)	Premium Cost (2002$)
Food					
1 - 5 hp	81.3	86.7	446	89.2	607
6 - 20 hp	87.1	91.2	1,058	92.5	1,352
21 - 50 hp	90.1	93.0	1,908	93.8	2,612
51 - 100 hp	92.7	94.0	5,453	95.3	6,354
101 - 200 hp	93.5	94.6	10,507	95.2	11,548
201 - 500 hp	93.8	93.6	21,157	95.4	30,299
> 500 hp	93.0	94.1	28,403	na	na
Bulk Chemicals					
1 - 5 hp	82.0	87.0	446	89.4	607
6 - 20 hp	87.4	91.4	1,058	92.6	1,352
21 - 50 hp	90.4	93.1	1,908	93.9	2,612
51 - 100 hp	92.4	94.1	5,453	95.4	6,354
101 - 200 hp	93.5	94.7	10,507	95.3	11,548
201 - 500 hp	93.3	93.8	21,157	95.5	30,299
> 500 hp	93.2	94.2	28,403	na	na
Metal-Based Durables[1]					
1 - 5 hp	81.9	86.7	446	89.2	607
6 - 20 hp	89.9	91.3	1,058	92.5	1,352
21 - 50 hp	89.9	93.0	1,908	93.9	2,612
51 - 100 hp	92.0	94.0	5,453	95.3	6,354
101 - 200 hp	93.5	94.6	10,507	95.2	11,548
201 - 500 hp	93.7	93.7	21,157	95.4	30,299
> 500 hp	93.0	94.1	28,403	na	na
Other Non-Intensive Manufacturing[2]					
1 - 5 hp	83.0	86.7	446	89.2	607
6 - 20 hp	88.3	91.3	1,058	92.5	1,352
21 - 50 hp	90.3	93.0	1,908	93.9	2,612
51 - 100 hp	92.7	94.0	5,453	95.3	6,354
101 - 200 hp	94.3	94.6	10,507	95.2	11,548
201 - 500 hp	94.3	93.7	21,157	95.4	30,299
> 500 hp	92.9	94.1	28,403	na	na

[1] The Metal-Based Durables group includes five sectors that are modeled separately: Fabricated Metal Products; Machinery; Computer and Electronic Products; Electrical Equipment, Appliances, and Components; and Transportation Equipment

[2] The Other Non-Intensive Manufacturing group includes three sectors that are modeled separately: Wood Products; Plastics and Rubber Products; and Balance of Manufacturing.

Source: Energy Information Administration, *Model Documentation Report, Industrial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-M064(2007) (Washington, DC, 2007).

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 industries, the listed efficiencies for the different motor sizes vary across industries.

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 2002 so that the actual boiler fuel shares are produced for the relative prices that prevailed in 2002.

The byproduct fuels are consumed before the quantity of purchased fuels is estimated. The boiler fuel shares are based on the 2002 MECS.[29]

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.

The energy intensity of the new capital stock relative to 2002 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 20. 2002 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 Products	1	1.6	1.7	4.0	2.0	0.6	0.9
	2	7.2	7.7	16.9	4.4	2.2	0.8
	3	5.8	6.2	12.1	6.0	1.6	1.8
	4	2.5	2.7	7.5	3.7	1.0	1.6
Paper & Allied Products	1	1.9	2.0	3.6	0.0	0.2	0.8
	2	3.5	3.7	6.4	0.0	0.2	1.1
	3	7.1	7.5	14.0	0.0	0.5	2.5
	4	2.9	3.1	3.4	0.0	0.1	0.7
Bulk Chemicals	1	1.4	1.7	1.3	0.0	0.3	0.8
	2	3.1	3.7	2.3	0.0	0.5	0.8
	3	13.0	15.7	16.4	0.0	3.3	5.3
	4	0.9	1.1	1.1	0.0	0.2	0.1
Glass & Glass Products	1	0.3	0.5	2.2	0.0	0.5	0.5
	2	0.6	0.9	2.1	0.0	0.1	0.1
	3	0.8	1.3	3.3	0.0	0.8	0.8
	4	0.2	0.4	0.9	0.0	0.1	0.1
Cement	1	0.1	0.1	0.1	0.0	0.1	0.7
	2	0.2	0.2	0.4	0.0	0.1	1.4
	3	0.4	0.4	0.6	0.0	0.2	1.4
	4	0.2	0.2	0.3	0.0	0.1	1.4
Iron & Steel	1	0.6	0.7	3.4	0.0	0.5	0.8
	2	2.1	2.6	8.1	0.0	1.1	6.4
	3	2.0	2.5	3.2	0.0	0.5	0.8
	4	0.4	0.4	0.3	0.0	0.0	0.0
Aluminum	1	0.3	0.4	0.7	0.0	0.1	0.1
	2	0.8	1.1	1.6	0.0	0.3	0.1
	3	1.5	2.1	3.7	0.0	0.7	1.1
	4	0.3	0.4	0.5	0.0	0.1	0.0
Metal-Based Durables							
Fabricated Metal Products	1	2.2	2.4	7.4	2.1	0.2	0.1
	2	7.3	7.8	25.1	7.1	0.6	0.8
	3	5.2	5.6	15.2	4.3	0.4	1.3
	4	1.4	1.5	3.4	1.0	0.1	0.0
Machinery	1	1.9	2.6	4.7	2.4	0.2	0.0
	2	5.8	7.7	18.7	9.4	0.7	0.7
	3	3.7	5.0	6.9	3.5	0.2	0.3
	4	1.0	1.4	2.3	1.2	0.1	0.0
Computers & Electronic Products	1	5.2	11.3	7.1	8.9	0.5	0.1
	2	2.5	5.3	4.1	5.1	0.3	0.2
	3	4.2	9.2	2.7	3.3	0.1	0.0
	4	5.9	12.8	8.0	10.0	0.4	0.1

Table 20. 2002 Building Component Energy Consumption (cont.)
(Trillion Btu)

Industry	Region	Lighting Electricity Consumption	Building Use and Energy Source: HVAC Electricity Consumption	HVAC Natural Gas Consumption	HVAC Steam Consumption	Facility Support Total Consumptiion	Onsite Transportation Total Consumption
Electrical Equipmentt	1	0.9	1.2	3.0	1.3	0.1	0.1
	2	2.3	3.0	5.7	2.4	0.1	0.1
	3	2.8	3.7	5.5	2.3	0.2	0.8
	4	0.4	0.5	1.6	0.7	0.1	0.1
Transportation Equipment	1	2.2	2.8	6.6	0.9	0.4	0.0
	2	14.6	18.6	36.9	5.2	1.4	1.0
	3	7.5	9.5	14.5	2.0	0.6	0.8
	4	2.5	3.2	5.8	0.8	0.2	0.0
Other Non-Intensive Manufacturing							
Wood Products	1	0.3	0.3	0.7	1.1	0.2	1.7
	2	0.8	0.8	2.1	3.3	0.3	1.1
	3	2.9	2.9	3.7	5.8	0.6	3.5
	4	1.3	1.3	2.2	3.5	0.4	2.4
Plastic Products	1	2.1	2.6	3.1	0.0	0.2	0.8
	2	5.5	6.7	10.0	0.0	0.5	0.9
	3	6.0	7.3	12.4	0.0	0.7	1.0
	4	1.2	1.5	1.8	0.0	0.1	0.0
Balance of Manufacturing	1	6.9	9.7	7.0	0.0	0.8	0.8
	2	16.0	22.4	31.3	0.0	1.9	1.8
	3	26.2	36.8	62.4	0.0	3.2	3.1
	4	7.8	10.9	16.7	0.0	0.8	0.8

HVAC = Heating, Ventilation, Air Conditioning.

Source: Energy Information Administration, *Model Documentation Report: Industrial Demand Module of the National Energy Modeling System*, DOE/EIA-M064(2007), (Washington, DC, 2007).

Table 21. 2002 Boiler Fuel Consumption and Logit Parameter
(trilliion Btu)

Industry	Region	Alpha	Natural Gas	Coal	Oil	Renewables
Food Products	1	-1.50	28	2	5	2
	2	-1.50	125	154	4	15
	3	-1.50	86	10	3	33
	4	-1.50	53	13	4	6
Paper & Allied Products	1	-1.50	56	28	25	87
	2	-1.50	64	75	13	103
	3	-1.50	157	97	61	864
	4	-1.50	48	14	4	164
Bulk Chemicals	1	-1.50	43	3	56	0
	2	-1.50	98	34	46	0
	3	-1.50	685	194	271	0
	4	-1.50	50	1	3	0
Glass & Glass Products	1	-1.50	0	0	6	2
	2	-1.50	1	0	0	1
	3	-1.50	1	0	9	1
	4	-1.50	0	0	0	0
Cement	1	-1.50	0	1	0	0
	2	-1.50	0	2	0	0
	3	-1.50	0	3	0	0
	4	-1.50	0	2	0	0
Iron & Steel	1	-1.50	10	7	4	0
	2	-1.50	24	1	67	0
	3	-1.50	9	0	22	0
	4	-1.50	1	0	10	0
Aluminum	1	-1.50	2	0	0	1
	2	-1.50	5	0	0	0
	3	-1.50	10	0	0	8
	4	-1.50	2	0	0	0
Metal-Based Durables						
Fabricated Metal Products	1	-1.50	2	0	0	2
	2	-1.50	7	0	1	2
	3	-1.50	5	0	0	0
	4	-1.50	1	0	0	0
Machinery	1	-1.50	2	0	0	1
	2	-1.50	9	1	0	1
	3	-1.50	3	0	0	0
	4	-1.50	1	0	0	0

Table 21. 2002 Boiler Fuel Consumption and Logit Parameter (cont.)
(trilliion Btu)

Industry	Region	Alpha	Natural Gas	Coal	Oil	Renewables
Computers and Electronic Products	1	-1.50	10	0	2	0
	2	-1.50	5	0	0	0
	3	-1.50	4	0	0	0
	4	-1.50	11	0	0	0
Electrical Equipment	1	-1.50	1	0	0	0
	2	-1.50	2	0	0	0
	3	-1.50	2	0	0	0
	4	-1.50	1	0	0	0
Transportation Equipment	1	-1.50	5	8	3	8
	2	-1.50	31	0	1	11
	3	-1.50	12	2	2	2
	4	-1.50	5	0	0	1
Other Non-Intensive Manufacturing						
Wood Products	1	-1.50	1	0	0	11
	2	-1.50	4	0	0	20
	3	-1.50	7	1	1	142
	4	-1.50	4	0	0	56
Plastic Products	1	-1.50	6	2	2	1
	2	-1.50	21	20	1	1
	3	-1.50	24	0	4	2
	4	-1.50	4	0	0	0
Balance of Manufacturing	1	-1.50	15	9	43	8
	2	-1.50	68	50	16	3
	3	-1.50	137	54	54	7
	4	-1.50	35	7	1	2

Alpha: User-specified.

Source: Energy Information Administration, *Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-064(2007), (Washington, DC, 2007).

The forecast 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.

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 added in 2002 and earlier and is assumed to retire at a fixed rate each year (Table 23). Middle vintage capital is that which is added after 2002 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-2003 capital stock.

Table 22. Cost Characteristics of Industrial CHP Systems

System	Size (kilowatts)	Installed Cost ($2005 per kilowatt)[1] 2005	2030
1 Engine	1000	1,194	860
2 Engine	3000	947	808
3 Gas Turbine	3000	1,330	1,100
4 Gas Turbine	5000	1,026	851
5 Gas Turbine	10000	960	834
6 Gas Turbine	25000	809	707
7 Gas Turbine	40000	700	646
8 Combined Cycle	100000	736	684

[1]Costs are given in 2005 dollars in original source document.

Source: Energy Information Administration, *Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System,* DOE/EIA-MO64(2007) (Washington, DC, 2007).

Table 23. Retirement Rates

Industry	Retirement Rate (percent)	Industry	Retirement Rate (percent)
Food Products	1.7	Glass and Glass Products	1.3
Pulp and Paper	2.3	Cement	1.2
Bulk Chemicals	1.7	Aluminum	
Iron & Steel		Metal-Based Durables	1.3
Blast Furnace and Basic Stell Products	1.5	Other Non-Intensive Manufacturing	1.3
Electric Arc Furnace	1.5		
Coke Ovens	2.5		
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(2007), (Washington, DC, 2007).

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.[30]

High Technology, 2006 Technology, Advanced Nuclear, and High Renewables Cases

The *high technology case* assumes earlier availability, lower costs, and higher efficiency for more advanced equipment. (Tables 24 and 25)[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 0.7 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, delivered energy intensity declines by 1.4 percent annually compared with the reference case, in which delivered energy intensity is projected to decline 1.2 percent annually.

The *2006 technology case* holds the energy efficiency of plant and equipment constant at the 2006 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.

AEO2007 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 0.7 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 Faciliies	
	REI 2030[1]	TPC[2]	REI 2030[3]	TPC[2]
Food Products				
Process Heating	0.889	-0.004	0.702	-0.009
Process Cooling	0.889	-0.004	0.702	-0.009
Other	0.889	-0.004	0.702	-0.009
Paper & Allied Products				
Wood Preparation	0.747	-0.010	0.532	-0.018
Waste Pulping	0.898	-0.004	0.800	-0.006
Mechanical Pulping	0.771	-0.009	0.580	-0.017
Semi-chemical	0.948	-0.002	0.777	-0.008
Kraft, Sulfite, misc. Chemicals (a)	0.827	-0.007	0.549	-0.018
Bleaching	0.758	-0.010	0.627	-0.012
Paper Making	0.766	-0.009	0.451	-0.024
Bulk Chemicals				
Process Heating	0.893	-0.004	0.710	-0.009
Process Cooling	0.893	-0.004	0.710	-0.009
Electro-Chemical	0.893	-0.004	0.710	-0.009
Other	0.893	-0.004	0.710	-0.009
Glass & Glass Products[4]				
Batch Preparation	0.941	-0.002	0.819	-0.003
Melting/Refining	0.822	-0.007	0.449	-0.025
Forming	0.965	-0.001	0.826	-0.006
Post-Forming	0.971	-0.001	0.865	-0.004
Cement				
Dry Process	0.800	-0.008	0.531	-0.019
Wet Process[6]	0.894	-0.004	NA	NA
Finish Grinding	0.850	-0.006	0.600	-0.016
Iron & Steel				
Coke Oven[5]	0.845	-0.006	0.637	-0.012
BF/BOF	0.950	-0.002	0.785	-0.008
EAF	0.845	-0.006	0.655	-0.015
Ingot Casting/Primary Rolling[5]	1.000	-0.000	NA	NA
Continuous Casting[6]	1.000	-0.000	1.000	0.000
Hot Rolling[6]	0.761	-0.010	0.337	-0.030
Cold Rolling[6]	0.706	-0.012	0.400	-0.029
Aluminum				
Alumina Refining	0.915	-0.003	0.576	-0.016
Primary Smelting	0.800	-0.008	0.522	-0.021
Secondary	0.825	-0.007	0.376	-0.029
Semi-Fabrication, Sheet/plate/foil	0.750	-0.010	0.457	-0.024
Semi-Fabrication, Other	0.825	-0.007	0.467	-0.025
Metal-Based Durables				
Fabricated Metals				
Process Heating	0.704	-0.0124	0.380	-0.0203
Process Cooling	0.647	-0.0155	0.369	-0.0193
Other	0.741	-0.0106	0.386	-0.0203

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

Industry/Process Unit	Existing Facilities		New Facilities	
	REI 2030[1]	TPC[2]	REI 2030[4]	TPC[2]
Machinery				
Process Heating	0.704	-0.0124	0.284	-0.0305
Process Cooling	0.647	-0.0155	0.280	-0.0290
Other	0.741	-0.0106	0.288	-0.0305
Computers and Electronics				
Process Heating	0.890	-0.0041	0.780	-0.0051
Process Cooling	0.892	-0.0041	0.736	-0.0052
Other	0.905	-0.0035	0.793	-0.0051
Electrical Equipment				
Process Heating	0.890	-0.0041	0.780	-0.0051
Process Cooling	0.865	-0.0052	0.742	-0.0048
Other	0.905	-0.0035	0.793	-0.0051
Transportation Equipment				
Process Heating	0.849	-0.0058	0.609	-0.0081
Process Cooling	0.817	-0.0072	0.581	-0.0077
Other	0.870	-0.0050	0.619	-0.0051
Other Non-Intensive Manufacturing				
Wood Products				
Process Heating	0.705	-0.0124	0.356	-0.0202
Process Cooling	0.647	-0.0154	0.341	-0.0196
Other	0.742	-0.0106	0.354	-0.0209
Plastic Products				
Process Heating	0.840	-0.0062	0.538	-0.0081
Process Cooling	0.805	-0.0077	0.511	-0.0079
Other	0.862	-0.0053	0.542	-0.0084
Balance of Manufacturing				
Process Heating	0.705	-0.0124	0.428	-0.0162
Process Cooling	0.647	-0.0154	0.409	-0.0157
Other	0.742	-0.0106	0.428	-0.0167

,1REI 2030 Existing Facilities = Ratio of 2030 energy intensity to average 2002 energy intensity for existing facilities.

[2]TPC = annual rate of change between 2002 and 2030.

[3]REI 2030 New Facilities = Ratio of 2030 energy intensity for a new State-of-the-art facility to the average 2002 intensity for existing facilities.

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

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

[6]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(2007) (Washington, DC, 2007).

Table 25. Cost Characteristics of Industrial CHP Systems, High Technology Case

System	Size (kilowatts)	Installed Cost ($2005 per kilowatt)[1]	
		2005	2030
1 Engine	1000	1,194	860
2 Engine	3000	947	798
3 Gas Turbine	3000	1,330	901
4 Gas Turbine	5000	1,026	785
5 Gas Turbine	10000	960	778
6 Gas Turbine	25000	809	677
7 Gas Turbine	40000	700	633
8 Combined Cycle	100000	736	668

[1]Costs are given in 2005 dollars in original source document.

Source: Energy Information Administration, *Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System,* DOE/EIA-MO64(2007) (Washington, DC, 2007).

Notes and Sources

[25] Energy Information Administration, State Energy Data System, 2003, www.eia.doe.gov/emeu/_seds.html

[26] Energy Information Administration, Manufacturing Energy Consumption Survey, web site www.eia.doe.gov/emeu/mecs/mecs2002/data02/shelltables.html.

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

[28] U.S., Department of Energy (2005). Motor Master+ 4.0 software database; available online: http://www1.eere.energy.gov/industry/bestpractices/software.html#mm.

[29] Energy Information Administration, Manufacturing Energy Consumption Survey, web site www.eia.doe.gov/emeu/mecs/mecs2002/data02/shelltables.html.

[30] Emissions due to coal-to-liquids plants are included with the electric power sector because these are also large electricity generating plants.

[31] These assumptions are based in part on Energy Information Administration, Industrial Technology and Data Analysis Supporting the NEMS Industrial Model (Focis Associates, October 2005).