Chapter 6. Industrial Demand Module

The NEMS Industrial Demand Module (IDM) estimates energy consumption by energy source (fuels and feedstocks) for 15 manufacturing and 6 non-manufacturing industries. The manufacturing industries are subdivided further into the energy-intensive manufacturing industries and non-energy-intensive manufacturing industries (Table 6.1). The manufacturing industries are modeled through the use of a detailed process-flow or end-use accounting procedure. The non-manufacturing industries are modeled with less detail because processes are simpler and there is less available data. The petroleum refining industry is not included in the IDM, as it is simulated separately in the Liquid Fuels Market Module (LFMM) of NEMS. The IDM calculates energy consumption for the four Census Regions (Table 6.2) and disaggregates regional energy consumption to the nine Census Divisions based on fixed shares from the U.S. Energy Information Administration (EIA) *State Energy Data System* [26].

Table 6.1. Industry categories and NAICS codes

Energy-Intensive Manufacturing		Non-Energy-Intensive Manufacturing		Non-Manufacturing	
Food products	(NAICS 311)	Metal-based durables			
Paper and allied products	(NAICS 322)	Fabricated metal products	(NAICS 332)	Agricultural crop production	(NAICS 111)
Bulk chemicals		Machinery	(NAICS 333)		
Inorganic	(NAICS 32512-32518)	Computer and electronic products	(NAICS 334)	Other agricultural production	(NAICS 112, 113, 115)
Organic	(NAICS 32511, 32519)	Electrical equipment and appliances	(NAICS 335)	Coal mining	(NAICS 2121)
Resins	(NAICS 3252)	Transportation equipment	(NAICS 336)	Oil and gas extraction	(NAICS 211)
Agricultural Chemicals	(NAICS 3253)	Other Wood Products	(NAICS 321)	Metal and other non-metallic mining	(NAICS 2122-2123)
Glass and glass products	(NAICS 3272, 327993)	Plastic and rubber products	(NAICS 326)	Construction	(NAICS 23)
Cement and Lime	(NAICS 32731, 32741)	Balance of manufacturing	(NAICS 31-33 not already classified)		
Iron and Steel	(NAICS 3311-3312, 324199)				
Aluminum	(NAICS 3313)				

NAICS = North American Industry Classification System (2007).

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

Table 6.2. Census regions, Census divisions, and states

Census Region	Census Divisions	States
1 (East)	1,2	CT, ME, MA, NH, NJ, NY, PA, RI, VT
2 (Midwest)	3, 4	IL, IN, IA, KS, MI, MN, MO, ND, NE, OH, SD, WI
3 (South)	5, 6, 7	AL, AR, DE, DC, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV
4 (West)	8, 9	AZ, AK, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY

The energy-intensive manufacturing industries, consisting of food products, paper and allied products, bulk chemicals, glass and glass products, cement and lime, iron and steel, and aluminum, are modeled in considerable detail. Most industries are modeled as three separate but interrelated components: the Process and Assembly (PA) Component, the Buildings (BLD) Component, and the Boiler, Steam, and 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. The iron and steel industry as well as the paper industry use a more sophisticated process flow model which incorporates the BSC within the PA component. For the manufacturing industries, the PA Component is separated into the major production processes or end uses. Petroleum refining (NAICS 32411) is modeled in detail in the LFMM of NEMS, and the projected energy consumption is reported in the manufacturing total.

Projections of refining energy use, lease and plant fuel, and fuels consumed in cogeneration in the oil and gas extraction industry (NAICS 211) are exogenous to the IDM, but endogenous to the NEMS modeling system

Key assumptions - Manufacturing

The IDM primarily uses a bottom-up 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 2010 baseline Unit Energy Consumption (UEC) estimates based on analysis and interpretations of the 2010 Manufacturing Energy Consumption Survey (MECS), which is conducted by EIA on a four-year survey cycle [27]. The UECs represent the energy required to produce one unit of the industry's output. A unit of output may be defined in terms of physical units (e.g., tons of steel) or in dollar value of shipments.

The IDM depicts the manufacturing industries, except for petroleum refining, with either a detailed process-flow or end-use approach. Generally, industries with homogeneous products use a process-flow approach, and those with heterogeneous products use an end-use approach. Industries that use a process-flow approach are paper, glass, cement and lime, iron and steel, and aluminum. Industries that use an end-use approach are food, bulk chemicals, the five metal-based durables industries, wood, plastic and rubber products, and balance of manufacturing. The dominant process technologies are characterized by a combination of UEC estimates and Technology Possibility Curves (TPC). The TPC represents the annual rate of change from the base year to the end year of the projection. For end-use industries the TPC depicts the assumed average annual rate of change in energy intensity of either a process step or an energy end use (e.g., heating or cooling). The TPCs for new and existing plants vary by industry, vintage and process. These assumed rates were developed using professional engineering judgments regarding the energy characteristics, year of availability, and rate of market adoptions of new process technologies.

Process and/assembly component for end-use models

For industries modelled using an end-use approach, 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. The unit energy consumption (UEC) is defined as the amount of energy to produce a unit of output; it measures the energy intensity of the process or end use.

The module distinguishes the UECs by three vintages of capital stock. The amount of energy consumption reflects the assumption that new vintage stock will consist of state-of-the-art technologies that have different efficiencies from the existing capital stock. Consequently, the amount of energy required to produce a unit of output using new capital stock is often less than that required by the existing capital stock. The old vintage consists of capital existing in 2010 and surviving after adjusting for assumed retirements each year (Table 6.3). New production capacity is assumed to be added in a given projection year such that sufficient surviving and new capacity is available to meet the level of an industry's output as determined in the NEMS Regional Macroeconomic Module. Middle vintage capital is that which is added after 2010 up through the year prior to the current projection year.

Table 6.3. Retirement rates

Industry	Retirement Rate (percent)	Industry	Retirement Rate (percent)
Food Products	1.7	Wood Products	1.3
Bulk Chemicals	1.7	Plastics and Rubber Products	1.3
Metal-based Durables	1.3	Balance of Manufacturing	1.3

Source: SAIC, IDM Base Year Update with MECS 2006 Data, unpublished data prepared for the Office of Integrated Analysis and Forecasting, Energy Information Administration, Washington, DC, August 2010.

To simulate technological progress and adoption of more energy-efficient technologies, the UECs are adjusted each projection year based on the assumed TPC for each step. The TPCs are derived from assumptions about the relative energy intensity (REI) of productive capacity by vintage (new capacity relative to existing stock in a given year) or over time (new or surviving capacity in 2040 relative to the 2010 stock). Over time, the UECs for new capacity change, and the rate of change is given by the TPC. The UECs of the surviving 2010 capital stock are also assumed to change over time, but not as rapidly as for new capital stock because of retrofitting.

The concepts of REIs and TPCs are a means of embodying assumptions regarding new technology adoption in the manufacturing industry and the associated change in energy consumption of capital without characterizing individual technologies in detail. This approach reflects the assumption that industrial plants will change energy consumption as owners replace old equipment with new, sometimes more efficient equipment, add new capacity, add new products, or upgrade their energy management practices. The reasons for the increased efficiency are not likely to be directly attributable to technology choice decisions, changing energy prices, or other factors readily subject to modeling. Instead, the module uses the REI and TPC concepts to characterize intensity trends for bundles of technologies available for major process steps or end use.

Table 6.4. Technology Possibility Curves and Relative Energy Intensities for end-use models

Industry/Process Unit	Existing Facility Reference REI 2040[1]	Existing Facility Reference TPC%	New Facility REI 2010[2]	New Facility Reference REI 2040[3]	New Facility Reference TPC%
Food Products-Milling					
Process Heating-Electricity	0.900	-0.351	0.900	0.800	-0.392
Process Heating-Steam	0.810	-0.701	0.900	0.711	-0.784
Process Cooling-Electricity	0.900	-0.351	0.900	0.800	-0.392
Process Cooling-Natural Gas	0.900	-0.351	0.900	0.800	-0.392
Other-Electricity	0.900	-0.351	0.900	0.800	-0.392
Other-Natural Gas	0.950	-0.171	0.950	0.850	-0.370
Food Products-Dairy					
Process Heating-Electricity	0.980	-0.067	0.970	0.950	-0.069
Process Heating-Steam	0.930	-0.242	0.950	0.850	-0.370
Process Cooling-Electricity	0.900	-0.351	0.900	0.800	-0.392
Process Cooling-Natural Gas	0.980	-0.067	0.970	0.950	-0.069
Other-Electricity	0.930	-0.242	0.960	0.850	-0.405
Other-Natural Gas	0.980	-0.067	0.970	0.950	-0.069
Food Products-Animal Processing					
Process Heating-Electricity	0.980	-0.067	0.970	0.950	-0.069
Process Heating-Steam	0.950	-0.171	0.950	0.900	-0.180
Process Cooling-Electricity	0.930	-0.242	0.950	0.850	-0.370
Process Cooling-Natural Gas	0.980	-0.067	0.970	0.950	-0.069
Other-Electricity	0.950	-0.171	0.980	0.900	-0.283
Other-Natural Gas	0.980	-0.067	0.970	0.950	-0.069
Food Products-Other					
Process Heating-Electricity	0.980	-0.067	0.970	0.950	-0.069
Process Heating-Steam	0.930	-0.242	0.950	0.850	-0.370
Process Cooling-Electricity	0.930	-0.242	0.950	0.850	-0.370
Process Cooling-Natural Gas	0.980	-0.067	0.970	0.950	-0.069
Other-Electricity	NA	-0.171	NA	NA	-0.125
Other-Natural Gas	0.980	-0.067	0.970	0.950	-0.069

Table 6.4. **Technology Possibility Curves and Relative Energy Intensities for end-use models** (cont.)

Industry/Process Unit	Existing Facility Reference REI 2040[1]	Existing Facility Reference TPC%	New Facility REI 2010[2]	New Facility Reference REI 2040[3]	New Facility Reference TPC%
Bulk Chemicals-Inorganic					
Process Heating-Electricity	0.893	-0.376	0.900	0.793	-0.420
Process Heating-Steam	0.798	-0.751	0.900	0.699	-0.840
Process Cooling-Electricity	0.867	-0.476	0.850	0.743	-0.446
Process Cooling-Natural Gas	0.893	-0.376	0.900	0.793	-0.420
Electro-Chemicals	0.979	-0.072	0.950	0.843	-0.396
Other-Electricity	0.908	-0.321	0.915	0.803	-0.434
Other-Natural Gas	0.893	-0.376	0.900	0.793	-0.420
Bulk Chemicals-Organic					
Process Heating-Electricity	0.893	-0.376	0.900	0.793	-0.420
Process Heating-Steam	0.635	-1.502	0.720	0.433	-1.679
Process Cooling-Electricity	0.867	-0.476	0.850	0.743	-0.446
Process Cooling-Natural Gas	0.798	-0.751	0.720	0.559	-0.840
Electro-Chemicals	0.979	-0.072	0.950	0.843	-0.396
Other-Electricity	0.908	-0.321	0.915	0.803	-0.434
Other-Natural Gas	0.798	-0.751	0.720	0.559	-0.840
Bulk Chemicals-Resin and Synthetic Rubber					
Process Heating-Electricity	0.893	-0.376	0.900	0.793	-0.420
Process Heating-Steam	0.635	-1.502	0.720	0.433	-1.679
Process Cooling-Electricity	0.867	-0.476	0.850	0.743	-0.446
Process Cooling-Natural Gas	0.798	-0.751	0.720	0.559	-0.840
Electro-Chemicals	0.979	-0.072	0.950	0.843	-0.396
Other-Electricity	0.908	-0.321	0.915	0.803	-0.434
Other-Natural Gas	0.798	-0.751	0.720	0.559	-0.840
Bulk Chemicals-Agricultural Chemicals					
Process Heating-Electricity	0.893	-0.376	0.900	0.793	-0.420
Process Heating-Steam	0.798	-0.751	0.900	0.699	-0.840
Process Cooling-Electricity	0.867	-0.476	0.850	0.743	-0.446
Process Cooling-Natural Gas	NA	-0.376	NA	NA	-0.420
Electro-Chemicals	.979	-0.072	0.950	0.843	-0.396
Other-Electricity	.908	-0.321	0.915	0.803	-0.434
Other-Natural Gas	.893	-0.376	0.900	0.793	-0.420

Table 6.4. Technology Possibility Curves and Relative Energy Intensities for end-use models (cont.)

Industry/Process Unit	Existing Facility Reference REI 2040[1]	Existing Facility Reference TPC%	New Facility REI 2010[2]	New Facility Reference REI 2040[3]	New Facility Reference TPC%
Fabricated Metals					
Process Heating-Electricity	0.712	-1.127	0.675	0.406	-1.679
Process Cooling-Electricity	0.650	-1.427	0.638	0.371	-1.784
Process Cooling-Natural Gas	0.712	-1.127	0.675	0.406	-1.679
Electro-Chemical Process	0.937	-0.216	0.713	0.441	-1.586
Other-Electricity	0.748	-0.962	0.686	0.406	-1.737
Machinery					
Process Heating-Electricity	0.712	-1.427	0.675	0.314	-2.519
Process Cooling-Electricity	0.650	-1.427	0.638	0.283	-2.676
Process Cooling-Natural Gas	0.712	-1.127	0.675	0.314	2.519
Electro-Chemical Process	0.937	-0.216	0.713	0.346	2.379
Other-Electricity	0.748	-0.962	0.686	0.311	-2.606
Computers and Electronics					
Process Heating-Electricity	0.798	-0.751	0.720	0.559	-0.840
Process Cooling-Electricity	0.751	-0.952	0.680	0.520	-0.892
Process Cooling-Natural Gas	NA	-0.751	NA	NA	-0.840
Electro-Chemical Process	0.958	-0.144	0.760	0.599	-0.793
Other-Electricity	0.824	-0.641	0.732	0.563	-0.869
Electrical Equipment					
Process Heating-Electricity	0.798	-0.751	0.720	0.559	-0.840
Process Heating-Steam	NA	-1.502	NA	NA	-1.679
Process Cooling-Electricity	0.751	-0.952	0.680	0.520	-0.892
Process Cooling-Natural Gas	0.798	-0.751	0.720	0.559	-0.840
Electro-Chemical Process	0.958	-0.144	0.760	0.599	-0.793
Other-Electricity	0.824	-0.641	0.732	0.563	-0.869
Transportation Equipment					
Process Heating-Electricity	0.854	-0.526	0.765	0.625	-0.672
Process Heating-Steam	0.728	-1.052	0.765	0.510	-1.343
Process Cooling-Electricity	0.818	-0.666	0.723	0.583	-0.714
Process Cooling-Natural Gas	0.854	-0.526	0.765	0.625	-0.672
Electro-Chemical Process	0.970	-0.101	0.808	0.667	-0.634
Other-Electricity	0.874	-0.449	0.778	0.631	-0.695

Table 6.4. Technology Possibility Curves and Relative Energy Intensities for end-use models (cont.)

Industry/Process Unit	Existing Facility Reference REI 2040[1]	Existing Facility Reference TPC%	New Facility REI 2010[2]	New Facility Reference REI 2040[3]	New Facility Reference TPC%
Wood Products					
Process Heating-Electricity	0.712	-1.127	0.630	0.379	-1.679
Process Heating-Steam	0.505	-2.253	0.630	0.226	-3.358
Process Cooling-Electricity	0.650	-1.427	0.595	0.347	-1.784
Process Cooling-Natural Gas	0.712	-1.127	0.670	0.379	-1.679
Electro-Chemical Process	0.937	-0.216	0.655	0.412	-1.586
Other-Electricity	0.748	-0.962	0.641	0.379	-1.737
Plastic Products					
Process Heating-Electricity	0.798	-0.751	0.675	0.524	-0.840
Process Heating-Steam	0.635	-1.052	0.675	0.406	-1.679
Process Cooling-Electricity	0.751	-0.952	0.638	0.487	-0.892
Process Cooling-Natural Gas	0.798	-0.751	0.675	0.524	-0.840
Electro-Chemical Process	0.958	-0.144	0.713	0.561	-0.793
Other-Electricity	0.824	-0.641	0.686	0.528	-0.869
Balance of Manufacturing					
Process Heating-Electricity	0.844	-0.563	0.675	0.551	-0.672
Process Heating-Steam	0.712	-1.127	0.675	0.450	-1.343
Process Cooling-Electricity	0.807	-0.714	0.638	0.514	-0.714
Process Cooling-Natural Gas	0.844	-0.563	0.675	0.551	-0.672
Electro-Chemical Process	0.968	-0.108	0.713	0.589	-0.634
Other-Electricity	0.844	-0.563	0.675	0.551	-0.672

[1]REI 2040 Existing Facilities = Ratio of 2040 energy intensity to average 2010 energy intensity for existing facilities.
[2]REI 2010 New Facilities = For new facilities, the ratio of state-of-the-art energy intensity to average 2010 energy intensity for existing facilities.
[3]REI 2040 New Facilities = Ratio of 2040 energy intensity for a new state-of-the-art facility to the average 2010 intensity for existing facilities.
Source: SAIC, IDM Base Year Update with MECS 2010 Data, unpublished data prepared for the Industrial Team, Office of Energy Consumption and Efficiency Analysis, Energy Information Administration, Washington, DC, July 2013.

Electric Motor Stock Model

One exception to the general approach in the PA component in the end-use models is the use of an electric motor technology model. Machine drive electricity consumption in the bulk chemicals industry, the food industry, the five metal-based durables industries, wood, plastics and rubber products, and balance of manufacturing is calculated by a motor stock model [28]. The beginning stock of motors is modified over the projection 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, the motor must meet the minimum efficiency standard and a premium efficiency motor is also available. Table 6.5 provides the beginning stock efficiency for seven motor size groups in each of the three industry groups, as well as efficiencies for replacement motors. All replacement motors are assumed to be premium high efficiency motors because of current regulations.

Table 6.5. Cost and performance parameters for industrial motor choice model

Industrial Sector Horsepower Range	Average Efficiency	Replacement Motor Efficiency	Rewind Cost (2002$)	Replacement Cost (2002$)
Food				
1-5 hp	81.3	89.5	230	442
6 - 20 hp	87.1	93.0	427	1047
21 - 50 hp	90.1	94.5	665	1889
51 - 100 hp	92.7	95.4	1258	5398
101 - 200 hp	93.5	96.2	2231	10,400
201 - 500 hp	93.8	96.2	4363	20,942
> 500 hp	93.0	96.2	5726	28,115
Bulk Chemicals				
1-5 hp	82.0	89.5	230	442
6 - 20 hp	87.4	93.0	427	1047
21 - 50 hp	90.4	94.5	665	1889
51 - 100 hp	92.4	95.4	1258	5398
101 - 200 hp	93.5	96.2	2231	10,400
201 - 500 hp	93.3	96.2	4363	20,942
> 500 hp	93.2	96.2	5726	28,115
Metal-Based Durables[a]				
1-5 hp	82.2	89.5	230	442
6-20 hp	87.3	93.0	427	1047
21-50 hp	90.1	94.5	665	1889
51-100 hp	92.4	95.4	1258	5398
101-200 hp	93.5	96.2	2231	10,400
201-500 hp	94.5	96.2	4363	20,942
>500 hp	94.4	96.2	5726	28,115
Balance of Manufacturing[b]				
1-5 hp	81.8	89.5	230	442
6-20 hp	86.6	93.0	427	1047
21-50 hp	89.9	94.5	665	1889
51-100 hp	92.1	95.4	1258	5398
101-200 hp	93.2	96.2	2231	10,400
201-500 hp	93.1	96.2	4363	20,942
>500 hp	93.1	96.2	5726	28,115

[a]The metal-based durables group includes five sectors that are modeled separately: Fabricated Metals; Machinery; Computers and Electronics; Electrical Equipment; and Transportation Equipment.

[b]The balance of manufacturing group includes three sectors that are modeled separately: Wood Products; Plastic and Rubber Products; and All Other Manufacturing.

Source: U.S. Energy Information Administration, Model Documentation Report, Industrial Sector Demand Module of the National Energy Modeling System (Washington, DC, September 2013).

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.

Petrochemical feedstock requirement

This subroutine estimates feedstock requirements for the major petrochemical intermediates such as ethylene, propylene, and butadiene. The primary feedstocks used to produce these chemicals are natural gas liquids (NGL) (ethane, propane, butane) and petrochemical (oil-based) feedstocks (gas oil, naphtha) [29]. Biomass is a potential raw material source, but it is assumed that there will be no biomass-based capacity over the projection period because of economic barriers. The type of feedstock not only determines the source of feedstock but also the energy for heat and power requirements to produce the chemicals.

To determine the relative amounts of feedstock (NGL or oil-based) baseline intensities, feedstock consumption intensities are derived from the 2010 MECS. Feedstock consumption of both types grows or declines with organic chemicals shipment value. It should be noted that there is no change in the feedstock intensity over time, i.e., all feedstock TPCs are assumed to be zero. Unlike most other processes represented in manufacturing PA components, chemical yields are governed by basic chemical stoichiometry which allows for specific yields under set conditions of pressure and temperature. For the projected LPG feedstock quantities, a further subdivision is made into refinery-produced propylene and ethane. All ethane produced by the NEMS Oil & Gas Supply Module is absorbed by the chemical model. The remaining balance of LPG feedstock requirement is a mixture of pentanes plus, butane, and propane. The historical (baseline) feedstock consumption values for 2015 were obtained from Table 6.6, which displays EIA’s assessment of historical annual feedstock consumption for chemicals.

Table 6.6. Feedstock use of fossil fuels, 2001-2015

quadrillion Btu

Year	Hydrocarbon Gas Liquids Feedstocks[1]	Petrochemical Feedstocks	Other Feedstocks[2]	Natural Gas[3]
2001	1.78	1.16	0.27	0.70
2002	1.88	1.21	0.28	0.68
2003	1.83	1.31	0.28	0.61
2004	1.92	1.53	0.28	0.54
2005	1.78	1.41	0.29	0.48
2006	1.85	1.42	0.30	0.40
2007	1.86	1.31	0.27	0.43
2008	1.70	1.12	0.28	0.47
2009[a]	1.85	0.90	0.35	0.48
2010	1.99	0.94	0.36R	0.51
2011	2.12	0.88	0.39R	0.55
2012	2.16	0.74	0.36R	0.58
2013	2.27R	0.74	0.37R	0.59
2014	231	0.69	0.38	0.63
2015[P]	2.33	0.65	0.37	0.68

[1]Includes natural gasoline -- hydrocarbon gas liquids were previously called natural gas liquids and natural gasoline is pentanes plus.

[2]Distillate fuel oil, residual fuel oil, waxes, still gas not burned as a refinery fuel and miscellaneous products.

[3]U.S. Energy Information Administration (EIA) has altered the methodology for the natural gas estimates. The estimates are based on data for methanol and ammonia production that are used to move the MECS values for nonfuel uses of natural gas in non-MECS years.

P=Preliminary.

R=Revised

Notes: Estimates of consumption for non-combustion use shown in this table are included in total energy consumption (see Table 1.3). See Note 2, "Non-Combustion Use of Fossil Fuels," at end of section. Because of changes in methodology, data series may be revised annually. Estimates of non-combustion use in this table are considered industrial uses with the exception of approximately half of the lubricants which are considered transportation use. Totals may not equal sum of components due to independent rounding. Web Pages: See http://www.eia.gov/totalenergy/data/annual/#summary for all data beginning in 1980.

For related information, see http://www.eia.gov/environment/.

Sources: Petroleum Products: 1980—EIA, Energy Data Reports, Petroleum Statement, Annual and Sales of Liquefied Petroleum Gases and Ethane in 1980. 1981 forward—EIA, Petroleum Supply Annual, annual reports, and unpublished data. Natural Gas: 1980—Bureau of the Census, 1980 Survey of Manufactures, Hydrocarbon, Coal, and Coke Materials Consumed. 1981 forward—U.S. Department of Commerce. Coal: 1980 forward—EIA estimates based on the methodology underlying the nonfuel emissions calculations in EIA's Emissions of Greenhouse Gases in the United States 2008. Percent of Total Energy Consumption: Derived by dividing total nonfuel by total energy consumption on Table 1.3.

Process/assembly component for process-flow models

Five energy-intensive industries are modelled using a process-flow approach instead of the end-use approach. Those industries are the cement and lime industry, the aluminum industry, the glass industry, the iron and steel industry, and the paper industry. The new modules use a suite of detailed technology choices for each process flow. Instead of the aggregate energy intensity evolving according to TPCs, the process-flow models use technology choice for each process flow. Energy requirements for each technology is obtained from technology estimates (e.g. expenditures, energy coefficients, and utility needs) from the Consolidated Impacts Modeling System (CIMS) database which is prepared by the Pacific Northwest National Laboratory. Depending on the industry, this data is calibrated using inputs from the U.S. Geological Survey (USGS) of the U.S. Department of the Interior, the Portland Cement Association and the latest MECS released by EIA [30, 31, 32].

The process-flow models calculate surviving capacity based retirement and needed capacity based on shipments and surviving capacity. The baseline capacity (as of year 2008 or 2009) is assumed to retire at a linear rate over a fixed period of time (20 years). Incremental, or added, capacity is assumed to retire according to a logistic survival function. The exact shape of the “S” curve can be obtained by parameters adjusted by the analyst. New capital equipment information (capital and operating costs, energy use, and emissions) were obtained from the CIMS database. Each step of the process flow allows for multiple technology choices whose fuel type and efficiency are known at the national level, as regional fuel breakouts are fixed using available EIA data.

Combined cement and lime industry

For the cement process flow, each step (raw material grinding, kiln – both rotation and burner, finished grinding) allows for multiple technology choices whose fuel type and efficiency are known at the national level, as regional fuel breakouts are fixed using available EIA data.

Cement has both dry and wet mill processes. Some technologies are available to both processes, while others are available to only one process. The technology choices within each group are:

1. Raw materials grinding: ball mill, roller mill
2. Kilns (rotators): rotary long with preheat, precalcining, and computer control (dry process only), rotary preheat with high-efficiency cooler (dry only), rotary preheat, precalcine with efficient cooler (dry process only), rotary wet standard with waste heat recovery boiler and cogeneration (wet process only)
3. Kilns (burners): standard fired by natural gas, efficient fired by natural gas, standard fired by oil, efficient fired by oil, standard fired by coal, standard fired by petroleum coke, standard fired by hazardous waste, standard fired by residue-derived fuel
4. Finish grinding: standard ball mill, finishing ball mill with high-efficiency separator, standard roller mill, finishing roller mill with high-efficiency separator

The technology slate in each of these process steps evolves over time and depends on the relative cost of equipment, cost of fuel, and fuel efficiency. Retirement of existing wet process kiln technology is assumed to be permanent; only dry process kilns can be added to replace retired wet kilns or to satisfy needed additional capacity.

The base year technology slate is determined from the latest CIMS database and calibrated for the year 2008 with dry and wet mill capacity cement fuel use data from the Portland Cement Association, the USGS, and the 2010 MECS. All new cement capacity, both for replacement and increased production, is assumed to be dry cement capacity. Existing wet capacity is assumed to retire at a linear rate over 20 years with no replacement. Imported clinker, additives, and fly-ash are assumed to make constant percentage contributions to the finished product and thus “displace” a certain amount of domestic clinker production, and therefore energy use.

Lime energy consumption is estimated separately from cement but presented together as the consolidated cement and lime energy consumption. Energy consumption and technology evolution in the lime industry are driven by the same methods implemented for cement, with different, industry-specific equipment choices. Lime shipments are now explicitly provided by the Macroeconomic Activity Module (MAM), rather than estimated as a percentage of the non-metallic minerals sector.

Aluminum industry

For the aluminum industry model, each step (alumina production, anode production, and electrolysis for primary aluminum production, and melting for secondary production), allows for multiple technology choices whose fuel type and efficiency are known, as well as other operating characteristics. Technology shares are known at the national level, with regional fuel breakouts based on fixed allocations using available EIA data.

The aluminum industry has both primary and secondary production processes, which vary greatly in their energy demands. As such, the extent of these processes are based on the aluminum industry’s projected production and its historical share of production processes attenuated by relevant regional energy prices. Therefore, the fraction of total throughput from each aluminum production process varies over the model projections. However, it is assumed based on expert judgment that no new primary aluminum plants will be built in the United States before 2040, although capacity expansion of existing primary smelters may occur.

Some technologies are available to both processes, while others are available to only one process. The technology choices within each production processing group are:

1. Primary smelting (Hall-Heroult electrolysis cell) is represented as smelting in four pre-bake anode technologies that denote standard and retrofitted choices and one inert anode wetted cathode choice.
2. Anode production, used in primary production only, is represented by three natural gas-fired furnaces under various configurations in forming and baking pre-bake anodes and the formation of Söderberg anodes. Note that anodes are a major requirement for the Hall-Heroult process.
3. Alumina production (Bayer Process) is used in primary production only and selects between existing natural gas facilities and those with retrofits.
4. Secondary production selects between two natural gas-fired melters – i.e., a standard and a melter with high efficiency

The technology slate in each of these process steps evolves over time and depends on the relative cost of equipment, cost of fuel, and fuel efficiency. The base year technology slate is determined from the latest CIMS database and calibrated for the base year 2010 MECS and the USGS. All new capacities for aluminum production, both for replacement and increased production needs, are now assumed to be either pre-existing primary production or new secondary production, based on historical trend data and projected energy prices. Similar to the energy-intensive technology of the cement industry, the lifespan of existing and new production capacity is assumed to be 20 and 30 years, respectively. In addition, production that has been idled is allowed to re-enter production before new equipment is built.

Glass industry

For the glass industry model, each step of the three glass product processes modeled in the IDM (flat glass, pressed and blown glass, glass containers) allows for multiple technology choices whose fuel type and efficiency are known, as well as other operating characteristics.

For flat glass (NAICS 327211) the process steps include batch preparation, furnace, form & finish, and tempering. For pressed and blown glass (NAICS 327212), the process steps include preparation, furnace, form & finish, and fire polish. For glass containers (NAICS 327213), the process steps include preparation, furnaces, and form & finish. For fiberglass ("mineral wool" – NAICS 327993), the process steps include preparation, furnaces, and form & finish. The final category ("glass from glass products" – NAICS 327215) was not modeled as a process flow with technology choice but instead endowed with fuel-specific UECs which evolved over time via TPC. Below is a summary list of technologies used in the glass sub-module. Not all of the technologies below are available to all processes.

1. The preparation step (collection, grinding, and mixing of raw materials including cullet) uses either a standard set of grinders/motors or an advanced set that is computer-controlled.
2. The furnaces, which melt the glass, are air-fueled or oxy-fueled burners which employ natural gas. Electric boosting furnace technology is also available. Direct electric (or Joule) heating is available for fiberglass production.
3. The form & finish process is done for all glass products and the technologies can be selected from high-pressure gas-fired computer-controlled or basic technology.
4. There is no known technology choice for the tempering step (flat glass) or the polish (blown glass). Placeholders for more-efficient future technology choices were implemented, but their introduction into these processes was rather limited.

As with the other sub-modules, the technology slate in each of these process steps evolves over time and depends on the relative cost of equipment, cost of fuel, and fuel efficiency. Oxy-fueled burners were added as a retrofit to the burner technologies, and their additive impact is determined by the relative price of natural gas vs. electricity.

Iron and Steel industry

The iron and steel industry includes the following major process steps: coke making, iron making, steel making, steel casting, and steel forming. Steel manufacturing plants can be classified as integrated or non-integrated. The classification is dependent upon the number of the major process steps that are performed in the facility. Integrated plants perform all the process steps, whereas non-integrated plants, in general, perform only the last three steps.

For the IDM, a process flow was developed to separate the process into five steps around which unit energy consumption values were estimated. Below is a summary list of steps and technologies:

1. Coke ovens convert metallurgical coal into coke.
2. Iron is produced in the blast furnace (BF), which is then charged into a basic oxygen furnace (BOF) or open hearth (OH) to produce raw steel.
3. The electric arc furnace (EAF) is used to produce raw steel from an all-scrap (recycled materials) charge, sometimes supplemented with direct reduced iron or hot briquetted iron.
4. The raw steel is cast into blooms, billets or slabs using continuous casting, or more rarely, ingots. Some ingot or cast steel is sold directly (e.g., forging-grade billets).
5. The majority is further processed ('hot rolled') into various mill products. Some of these are sold as hot rolled mill products, while others are further cold rolled to impart surface finish or other desirable properties.

Pulp and Paper industry

The paper and allied products industry's principal processes involve the conversion of wood fiber to pulp, and then paper and board to consumer products that are generally targeted at the domestic marketplace. The industry produces a full line of paper and board products, as well as dried pulp, which is sold as a commodity product to domestic and international paper and board manufacturers. Below is a summary list of steps and technologies.

1. Wood preparation involves removing the bark and chipping the whole tree into small pieces.
2. Pulping is the process by which fibrous cellulose in the wood is removed from the surrounding lignin. Pulping can be conducted with a chemical process or a mechanical process.
3. Pulp washing is the process of washing the pulp with water to remove the cooking chemicals and lignin from the fiber.
4. Drying, liquor evaporation, effluent treatment, and other miscellaneous steps are part of the pulping process. Prior to heat drying, pulps are sent to a pressing section to squeeze out as much water as possible though mechanical means. The pulp is compressed between two rotating rolls where the extent of water removal is dependent on the design of the machine and its running speed. When the pressed pulp leaves the pressing section, it has about 65% moisture content. There are various techniques for drying, each with a different energy footprint.
5. Bleaching is required to produce white paper stock.
6. Paperboard, newsprint, coated paper, uncoated paper, and tissue paper are final products. Production of final products requires drying, finishing, and stock prep.

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 on-site transportation. Space heating was further divided to estimate the amount provided by direct combustion of fossil fuels and that provided by steam (Table 6.7). Energy consumption in the BLD Component for an industry is estimated based on regional employment and output growth for that industry using the 2010 MECS as a basis.

Table 6.7. 2010 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 Consumption	Onsite Transportation Total Consumption
Food Products	1	2.1	2.1	3.3	2.1	1.7	0.9
	2	9.7	9.7	14.8	4.9	7.4	0.9
	3	6.8	6.8	8.7	5.5	4.4	1.6
	4	3.5	3.5	7.4	4.7	3.8	3.0
Paper & Allied Products	1	1.2	1.3	2.8	0.0	0.3	0.9
	2	3.7	4.0	3.3	0.0	0.3	0.9
	3	6.8	7.4	7.1	0.0	0.7	2.0
	4	3.2	3.4	2.2	0.0	0.3	0.9
Bulk Chemicals	1	0.8	1.0	3.7	0.0	2.8	5.2
	2	2.9	3.5	5.8	0.0	3.9	5.6
	3	7.7	9.3	15.0	0.0	9.0	9.7
	4	0.9	1.0	3.7	0.0	2.8	5.0
Glass & Glass Products	1	0.4	0.5	3.8	0.0	3.2	3.4
	2	0.7	0.9	4.1	0.0	3.3	3.4
	3	0.9	1.2	4.5	0.0	3.4	3.5
	4	0.3	0.4	3.4	0.0	3.1	3.4
Cement	1	0.1	0.1	0.6	0.0	0.6	1.1
	2	0.3	0.3	0.6	0.0	0.6	1.1
	3	0.4	0.4	0.7	0.0	0.7	1.1
	4	0.2	0.2	0.5	0.0	0.5	0.6
Iron & Steel	1	0.8	0.8	1.9	0.0	0.7	0.6
	2	2.7	2.7	8.7	0.0	1.9	2.4
	3	3.1	3.1	3.6	0.0	1.0	1.7
	4	0.4	0.4	1.0	0.0	0.6	0.6
Aluminum	1	0.2	0.2	0.5	0.0	0.2	0.2
	2	0.8	0.8	1.0	0.0	0.3	0.3
	3	0.8	8.8	2.6	0.0	0.7	0.8
	4	0.3	0.3	0.4	0.0	0.1	0.2
Metal-Based Durables	1	1.8	1.5	5.1	2.9	0.6	1.4
Fabricated Metal Products	2	6.6	5.6	16.3	9.1	1.2	1.5
	3	5.2	4.4	8.8	5.0	0.8	1.7
	4	1.4	1.2	2.6	1.5	0.2	0.3
Machinery	1	1.6	2.3	4.2	0.7	0.2	0.2
	2	4.8	6.8	20.7	3.6	0.9	0.9
	3	3.1	4.3	8.6	1.5	0.5	0.7
	4	0.6	0.8	0.5	0.1	0.1	0.2

Table 6.7. 2010 Building component energy consumption (cont.)

Industry	Region	Lighting Electricity Consumption	HVAC Electricity Consumption	HVAC Natural Gas Consumption	HVAC Steam Consumption	Facility Support Total Consumption	Onsite Transportation Total Consumption
			Building Use and Energy Source				
Computers & Electronic Products	1	2.2	5.6	4.2	2.5	0.9	0.8
	2	2.0	4.9	4.4	2.7	0.9	0.8
	3	4.2	10.5	4.4	2.7	0.9	0.8
	4	4.1	10.2	9.4	5.7	1.2	0.8
Transportation Equipment	1	1.6	2.0	4.8	0.4	0.6	0.2
	2	10.5	13.1	23.1	2.1	2.0	1.2
	3	6.1	7.6	10.1	0.9	1.1	0.8
	4	2.5	3.1	3.9	0.4	0.3	0.2
Electrical Equipment	1	0.7	1.0	1.7	1.3	0.5	0.5
	2	1.1	1.6	2.6	2.1	0.4	0.4
	3	2.1	3.1	4.0	3.1	0.6	0.4
	4	0.2	0.3	0.1	0.1	0.1	0.4
Other Non-Intensive Manufacturing							
Wood Products	1	0.2	0.2	0.8	2.5	0.5	0.4
	2	0.6	0.5	1.6	4.9	0.7	1.7
	3	2.4	1.8	2.7	8.4	0.7	2.1
	4	0.8	0.6	1.3	4.0	0.3	4.2
Plastic Products	1	0.8	0.9	1.8	0.0	0.2	0.3
	2	4.5	5.6	7.7	0.0	0.5	0.7
	3	5.5	6.8	10.3	0.0	0.7	0.8
	4	2.5	3.0	2.1	0.0	0.2	0.2
Balance of Manufacturing	1	5.5	9.1	13.4	0.0	0.9	1.2
	2	10.5	17.4	20.6	0.0	1.7	2.1
	3	15.7	26.0	28.1	0.0	2.6	3.4
	4	4.5	7.5	9.5	0.0	0.6	0.8

HVAC = Heating, Ventilation, Air Conditioning.

Source: SAIC, IDM Base Year Update with MECS 2010 Data, unpublished data prepared for the Industrial Team, Office of Energy Consumption and Efficiency Analysis, Energy Information Administration, Washington, DC, July 2013.

Boiler, steam, and cogeneration component

With the exception of the iron and steel and pulp and paper industries, 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 6.8) to the boiler steam requirements to compute the required energy consumption. The iron and steel and pulp and paper industries have independent BSC and cogeneration related modeling that is calculated as part of the PA step.

The boiler fuel shares apply only to the fuels that are used in boilers for steam-only applications. Fuel use for the portion of the steam demand associated with combined heat and power (CHP) is described in the next section. Some fuel switching for the remainder of the boiler fuel use is assumed and is calculated with a logit-sharing equation where fuel shares are a function of fuel prices. The equation is calibrated to 2010 so that the 2010 fuel shares are produced for the relative prices that prevailed in 2010.

The byproduct fuels, production of which is estimated in the PA Component, are assumed to be consumed without regard to price, independent of purchased fuels. The boiler fuel share equations and calculations are based on the 2010 MECS and information from the Council of Industrial Boiler Owners. [33]

Table 6.8. 2010 Boiler fuel component and logit parameter

trillion Btu

	Region	Alpha	Natural Gas	Coal	Oil	Renewables
Food Products	1	-2.0	33	1	3	1
	2	-2.0	147	131	3	31
	3	-2.0	85	14	6	31
	4	-2.0	74	18	3	8
Bulk Chemicals	1	-2.0	17	0	7	8
	2	-2.0	164	43	6	52
	3	-2.0	705	60	13	352
	4	-2.0	21	44	4	5
Glass & Glass Products	1	-2.0	1	0	2	1
	2	-2.0	1	0	2	1
	3	-2.0	1	0	2	1
	4	-2.0	0	0	2	1
Cement	1	-2.0	0	0	0	1
	2	-2.0	0	0	0	5
	3	-2.0	0	0	0	3
	4	-2.0	0	0	0	1
Aluminum	1	-2.0	1	0	0	0
	2	-2.0	3	0	0	1
	3	-2.0	8	0	1	1
	4	-2.0	1	0	0	0
Metal-Based Durables						
Fabricated Metal Products	1	-2.0	4	0	0	0
	2	-2.0	12	0	0	0
	3	-2.0	6	0	0	0
	4	-2.0	2	0	0	0
Machinery	1	-2.0	1	0	0	1
	2	-2.0	4	0	1	1
	3	-2.0	2	0	0	0
	4	-2.0	0	0	0	0

Table 6.8. 2010 Boiler fuel component and logit parameter (cont.)
trillion Btu

	Region	Alpha	Natural Gas	Coal	Oil	Renewables
Computer & Electronic Products	1	-2.0	3	0	1	0
	2	-2.0	3	0	1	0
	3	-2.0	3	0	1	0
	4	-2.0	7	0	1	0
Electrical Equipment	1	-2.0	1	0	1	0
	2	-2.0	2	0	0	0
	3	-2.0	3	0	0	0
	4	-2.0	0	0	0	0
Transportation Equipment	1	-2.0	3	8	2	1
	2	-2.0	17	-5	1	3
	3	-2.0	7	1	2	1
	4	-2.0	3	0	0	0
Other Non-Intensive Manufacturing						
Wood Products	1	-2.0	0	0	1	79
	2	-2.0	1	0	2	31
	3	-2.0	4	0	2	188
	4	-2.0	2	0	2	54
Plastic Products	1	-2.0	3	2	1	0
	2	-2.0	16	0	0	0
	3	-2.0	21	0	1	0
	4	-2.0	4	0	0	0
Balance of Manufacturing	1	-2.0	35	-10	0	3
	2	-2.0	54	29	0	42
	3	-2.0	74	42	0	128
	4	-2.0	25	7	0	0

Alpha: User-specified.
Source: U.S. Energy Information Administration, Model Documentation Report, Industrial Sector Demand Module of the National Energy Modeling System, (Washington, DC 2014).

Combined heat and power

CHP plants, which are designed to produce both 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, and that the rate of additional CHP penetration will depend on the economics of retrofitting CHP plants to replace steam generated from existing non-CHP boilers. The technical potential for CHP is primarily based on supplying thermal requirements (i.e., matching thermal loads). Capacity additions are then determined by the interaction of CHP investment payback periods (with the time value of money included) derived using operating hours reported in EIA's published statistics, market penetration rates for investments with those payback periods, and regional deployment for these systems as characterized by the "collaboration coefficients" in Table 6.9. Assumed installed costs for the CHP systems are given in Table 6.10.

Table 6.9. Regional collaboration coefficients for CHP deployment

Census Region	Collaboration Coefficient
Northeast	1.46
Midwest	1.34
South	0.33
West	1.06

Source: Calculated from American Council for an Energy-Efficient Economy, "Challenges Facing Combined Heat and Power Today: A State-by-State Assessment," September 2011, www.aceee.org/research-report/ie111 and Energy Information Administration, Office of Energy Analysis.

Table 6.10. Cost characteristics of industrial CHP systems

trillion Btu

System	Size Kilowatts (kW)	Reference 2010	Installed Cost 2005$ per KWh)[1] Reference: 2035
Engine	1,000	1,440	576
	2,000	1,260	396
Gas turbine	3,510	1,719	1,496
	5,670	1,152	1,023
	14,990	982	869
	25,000	987	860
	40,000	875	830
Combined cycle	100,000	723	684

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

Source: U.S. Energy Information Administration, Model Documentation Report, Industrial Sector Demand Module of the National Energy Modeling System (Washington, DC, September 2013).

Key assumptions - non-Manufacturing

The non-manufacturing sector consists of three industries: agriculture, mining and construction. These industries all use electricity, natural gas, diesel fuel, and gasoline. The mining industry also uses coal, natural gas liquids (NGL), and residual fuel oil, and the construction industry also uses other petroleum in the form of asphalt and road oil. Except for oil and gas extraction, almost all of the energy use in the non-manufacturing sector takes place in the process and assembly step. Oil and gas extraction uses a significant amount of residual fuel oil in the BSC component. Table 6.10 shows the baseline unit energy consumption values for the non-manufacturing subsectors in 2010.

The non-manufacturing sector consists of three industries: agriculture, mining and construction. These industries use electricity, natural gas, hydrocarbon gas liquids (HGL), diesel fuel, and gasoline. The mining industry also uses coal and residual fuel oil, and the construction industry also uses other petroleum in the form of asphalt and road oil. Except for oil and gas extraction, almost all of the energy use in the non-manufacturing sector takes place in the process and assembly step. Oil and gas extraction uses a significant amount of residual fuel oil in the BSC component.

Unlike the manufacturing sector, the non-manufacturing sector does not have a single source of data for energy consumption estimates. Instead, UECs for the non-manufacturing sector are derived from various sources of data collected by a number of government agencies.

Non-manufacturing data was revised using EIA and Census Bureau sources to provide more realistic projections of diesel and gasoline for off-road vehicle use, allocate natural gas, HGL use, and electricity. Sources used are EIA's Fuel Oil and Kerosene Sales (FOKS) [34] for distillate consumption, Agricultural Resource Management Survey (ARMS) [35] and the Census Bureau's Census of Mining [36] and Census of Construction. [37] Combining these sources, there is now more consumption of distillate and less consumption of motor gasoline. Also, the use of HGL is now accounted for in the agriculture and in the construction industries. Nonmanufacturing consumption is no longer dictated solely by the SEDS–MECS difference as it has been in previous years.

Agriculture Sector

U.S. agriculture consists of three major sub-sectors:

- crop production, which is dependent primarily on regional environments and crops demanded;
- animal production, which is largely dependent on food demands and feed accessibility;
- all remaining agricultural activities, which are primarily composed of forestry and logging.

These sub-industries have historically been tightly coupled due to competing use of land area. For example, crops produced for animal feed cannot be consumed by humans; forests provide the feedstock of the paper and wood industries but in turn do not allow the growth of crops or limit or prevent grazing of animals. Forestry and logging are not modelled within NEMS.

Baseline energy consumption data for the two agriculture sectors (crops and other agriculture) are based on data from the Census of Agriculture and a special tabulation from the National Agricultural Statistics Service (USDA-NASS). Expenditures for four energy sources are collected from crop farms and livestock farms as part of the Agricultural Resource Management Survey (ARMS). These data are converted from dollar expenditures to energy quantities using fuel prices from NASS and EIA.

Mining Sector

The mining sector comprises of three sectors: coal mining, metal and nonmetal mining, and oil and gas extraction. Energy use is based on what equipment is used at the mine and onsite vehicles used. All mines use extraction equipment and lighting, but only coal and metal and nonmetal mines use grinding and ventilation. As with the agriculture module described above, TPCs are influenced by efficiency changes in buildings and transportation equipment.

Coal mining production is obtained from the Coal Market Module (CMM). Currently, it is assumed that 70% of the coal is mined at the surface and the rest is mined underground. As these shares evolve, however, so does the energy consumed, since surface mines use less energy overall than underground mining. Moreover, the energy consumed for coal mining depends on coal mine productivity, which is also obtained from the CMM. Diesel fuel and electricity are the predominant fuels used in coal mining. Electricity used for coal grinding is calculated using the raw grinding process step from the cement sub-module. In metal and non-metal mining, energy use is similar to coal mining. Output used for metal and non-metal mining is derived from the MAM'S variable for "other" mining which also provides the shares of each.

For oil and natural gas extraction, production is derived from the Oil and Gas Supply Module (OGSM). Energy use depends upon the fuel extracted as well as whether the well is conventional or unconventional (e.g., extraction from tight and shale formations), percentage of dry wells, and well depth. Oil and gas extraction also includes fuel consumed for liquefied natural gas liquefaction, although at present this amount is very trivial.

Construction Sector

The construction sector uses diesel fuel, gasoline, electricity and HGL as energy sources. Construction also uses asphalt and road oil as a nonfuel energy source. Asphalt and road oil use is tied to state and local government real investment in highways and streets, and this investment is derived from the MAM. TPCs for diesel and gasoline fuels are directly tied to the Transportation Demand Module's heavy-and medium-duty vehicle efficiency projections. For non-vehicular construction equipment, TPCs are a weighted average of vehicular TPCs and highway investment.

Legislation and regulations

Energy Improvement and Extension Act of 2008

Under EIEA2008 Title I, "Energy Production Incentives," Section 103 provides an Investment Tax Credit (ITC) for qualifying Combined Heat and Power (CHP) systems placed in service before January 1, 2017. Systems with up to 15 megawatts of electrical capacity qualify for an ITC up to 10% of the installed cost. For systems between 15 and 50 megawatts, the percentage tax credit declines linearly with the capacity, from 10% to 3%. To qualify, systems must exceed 60% fuel efficiency, with a minimum of 20% each for useful thermal and electrical energy produced. The provision was modeled in AEO2015 by adjusting the assumed capital cost of industrial CHP systems to reflect the applicable credit.

The Energy Independence and Security Act of 2007 (EISA2007)

Under EISA2007, the motor efficiency standards established under the Energy Policy Act of 1992 (EPACT1992) are superseded for purchases made after 2011. Section 313 of EISA2007 increases or creates minimum efficiency standards for newly manufactured and imported general purpose electric motors. The efficiency standards are raised for general purpose, integral-horsepower induction motors with the exception of fire pump motors. Minimum standards were created for seven types of poly-phase, integral-horsepower induction motors and National Electrical Manufacturers Association (NEMA) design "B" motors (201-500 hp) that were not previously covered by EPACT standards. In 2013, the Energy Policy and Conservation Act was amended (Public Law 113-67) and efficiency standards were revised in a subsequent DOE rulemaking (10 CFR 431.25). For motors manufactured after June 1, 2016, efficiency standards for current regulated motor types [38] were expanded to include 201-500 hp motors. Also, special and definite purpose motors of from 1-500 hp and NEMA design "A" motors from 201-500 hp became subject to efficiency standards. The 2014 regulations were modelled in the AEO2016 by modifying the specifications for new motors in electric motor technology choice module.

Energy Policy Act of 1992 (EPACT1992)

EPACT1992 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 at least 1.25 (80% efficiency) and 1.22 (82% efficiency) for gas and oil burners, respectively. These efficiencies meet the EPACT1992 standards. EPACT1992 mandates minimum efficiencies for all motors up to 200 hp purchased after 1998. The choices offered in the motor efficiency assumptions are all at least as efficient as the EPACT minimums.

Clean Air Act Amendments of 1990 (CAAA1990)

he CAAA1990 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 sulfur dioxide (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 CAAA1990 requires the U.S. Environmental Protection Agency (EPA) to regulate industrial SO2 emissions at such time that total industrial SO2 emissions exceed 5.6 million tons per year (42 USC 7651). Since industrial coal use, the main source of SO2 emissions, has been declining, EPA does not anticipate that specific industrial SO2 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. (Emissions due to coal-to-liquids CHP plants are included with the electric power sector because they are subject to the separate emission limits of large electricity generating plants.)

Maximum Achievable Control Technology for Industrial Boilers (Boiler MACT)

Section 112 of the Clean Air Act (CAA) requires the regulation of air toxics through implementation of the National Standards for Hazardous Air Pollutants (NESHAP) for industrial, commercial, and institutional boilers. The final regulations, known as Boiler MACT, are modeled in AEO2015. Pollutants covered by Boiler MACT include the hazardous air pollutants (HAP), hydrogen chloride (HCl), mercury (HG), dioxin/furan, carbon monoxide (CO), and particulate matter (PM). Generally, industries comply with the Boiler MACT regulations by including regular maintenance and tune-ups for smaller facilities and emission limits and performance tests for larger facilities. Boiler MACT is modeled as an upgrade cost in the MAM. These upgrade costs are classified as “nonproductive costs” which are not associated with efficiency improvements. The effect of these costs in the MAM is a reduction in shipments coming into the IDM.

California Assembly Bill 32: Emissions cap-and-trade as part of the Global Warming Solutions Act of 2006 (AB32)

AB32 established a comprehensive, multi-year program to reduce Greenhouse Gas (GHG) emissions in California, including a cap-and-trade program. In addition to the cap-and-trade program, AB32 also authorizes the low carbon fuel standard (LCFS); energy efficiency goals and programs in transportation, buildings; and industry; combined heat and power goals; and renewable portfolio standards.

For AEO2015, the cap-and-trade provisions were modeled for industrial facilities, refineries, and fuel providers. GHG emissions include both non-CO2 and specific non-CO2 GHG emissions. The allowance price, representing the incremental cost of complying with AB32 cap-and-trade, is modeled in the NEMS Electricity Market Module via a region-specific emissions constraint. This allowance price, when added to market fuel prices, results in higher effective fuel prices in the demand sectors. Limited banking and borrowing, as well as a price containment reserve and offsets, have been modeled in NEMS. AB32 is not modeled explicitly in the IDM, but enters the module implicitly through higher effective fuel prices and macroeconomic effects of higher prices, all of which affect energy demand and emissions. In June 2014, AB32 regulations were clarified and revised [39], but these revisions were not added to the IDM because they did not materially affect model calculation or results.

Notes and sources

[26] U.S. Energy Information Administration, State Energy Data System, based on energy consumption by state through 2011, as downloaded in August, 2013, from www.eia.gov/state/seds/.

[27] U. S. Energy Information Administration, Manufacturing Energy Consumption Survey 2010, http://www.eia.gov/consumption/manufacturing/index.cfm.

[28] U.S. Department of Energy (2007). Motor Master+ 4.0 software database; available at updated link http://www1.eere.energy.gov/manufacturing/downloads/MM41Setup.exe.

[29] In NEMS, hydrocarbon gas liquids (HGL), which comprise natural gas liquids (NGL) and olefins, are reported as Liquefied Petroleum Gas (LPG).

[30] Roop, Joseph M., "The Industrial Sector in CIMS-US," Pacific Northwest National Laboratory, 28th Industrial Energy Technology Conference, May, 2006.

[31] U.S. Department of the Interior, U.S. Geological Survey, Minerals Yearbook, cement data was made available under a non-disclosure agreement, http://minerals.usgs.gov/minerals/pubs/commodity/cement/myb1-2012-cemen.pdf.

[32] Portland Cement Association, U.S. and Canadian Portland Cement Industry Plant Information Summary, cement data was made available under a non-disclosure agreement, http://www.cement.org .

[33] Personal correspondence with the Council of Industrial Boiler Owners.

[34] U.S. Energy Information Administration, Fuel Oil and Kerosene Survey (FOKS), http://www.eia.gov/dnav/pet/pet_cons_821usea_dcu_nus_a.htm.

[35] Agriculture Research Management Survey (ARMS), United States Dept. of Agriculture, Economic Research Service, http://ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices.aspx.

Notes and sources (cont.)

[36] U.S. Census Bureau, 2012 Economic Census Mining: Industry Series: Selected Supplies, Minerals Received for Preparation, Purchased Machinery, and Fuels Consumed by Type for the United States: 2012 (Washington, DC: February 27, 2015) available at: https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_21SM1&prodType=table

[37] U.S. Census Bureau, 2012 Economic Census; Construction: Industry Series: Detailed Statistics by Industry for the United States: 2012 (Washington, DC: January 12, 2015) available at: https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_23SG01&prodType=table

[38] Federal Register 79 FR 103 pp. 30934-31014, Washington, DC: May 29, 2014. Available at http://www.gpo.gov/fdsys/pkg/FR-2014-05-29/pdf/2014-11201.pdf

[39] California Air Resources Board "California Code of Regulations, Title 17, Division 3, Chapter 1, Subchapter 10, Article 5 §95800 - §96022" Sacramento, CA: June 14, 2014. Available at http://www.arb.ca.gov/cc/capandtrade/capandtrade/unofficial_c&t_012015.pdf