Chapter 5. Commercial Demand Module

The NEMS Commercial Demand Module (CDM) generates projections of commercial sector energy demand through 2040. The definition of the commercial sector is consistent with EIA's State Energy Data System (SEDS). That is, the commercial sector includes business establishments that are not engaged in transportation, manufacturing, or other types of industrial activity (e.g., agriculture, mining, or construction). The bulk of commercial sector energy is consumed within buildings; however, street lights, pumps, bridges, and public services are also included if the establishment operating them is considered commercial.

Because most of commercial energy consumption occurs in buildings, the commercial module relies on the data from the EIA Commercial Buildings Energy Consumption Survey (CBECS) for characterizing the commercial sector activity mix as well as the equipment stock and fuels consumed to provide end-use services [13].

The CDM projects consumption by fuel [14] at the Census division level using prices from the NEMS energy supply modules, macroeconomic variables from the NEMS Macroeconomic Activity Module (MAM), and external data sources for technology characterizations and other inputs. Energy demands are projected for 10 end-use services [15] for 11 building categories [16] in each of the 9 Census divisions (see Figure 5.1). The model begins by developing projections of floorspace for the 99 building category and Census division combinations. Next, the ten end-use service demands required for the projected floorspace are developed. The electricity generation and water and space heating supplied by distributed generation (DG) and combined heat and power (CHP) technologies are projected. Technologies are then chosen to meet the projected service demands for the seven major end uses. Once technologies are chosen, the energy consumed by the equipment stock (both existing and purchased equipment) is developed to meet the projected end-use service demands [17]. Minor end uses are modeled in less detail. Annual energy consumption of select miscellaneous end-use loads (MELs) are derived by combining existing and projected equipment stock, energy consumption per device, and hours of use where applicable.

Key assumptions

The key assumptions made by the commercial module are presented in terms of the flow of the calculations described above. The sections below summarize the assumptions in each of the CDM Submodules: floorspace, service demand, distributed generation, technology choice, and end-use consumption. The submodules are executed sequentially in the order presented, and the outputs of each submodule become the inputs to subsequently executed submodules. As a result, key projection drivers for the floorspace submodule are also key drivers for the service demand submodule, and so on.

Floorspace Submodule

Floorspace is projected by starting with the previous year's stock of floorspace and eliminating a portion to represent the age-related removal of buildings. Total floorspace is the sum of the surviving floorspace and new additions to the stock derived from the MAM floorspace growth projection [18].

Existing floorspace and attrition

Existing floorspace is based on the estimated floorspace reported in the 2003 Commercial Buildings Energy Consumption Survey (Table 5.1). Over time, the 2003 stock is projected to decline as buildings are removed from service (floorspace attrition). Floorspace attrition is estimated by a logistic decay function, the shape of which is dependent upon the values of two parameters: average building lifetime and gamma. The average building lifetime refers to the median expected lifetime of a particular building type. The gamma parameter corresponds to the rate at which buildings retire near their median expected lifetime. The current values for the average building lifetime and gamma vary by building type as presented in Table 5.2 [19].

New construction additions to floorspace

The commercial module develops estimates of projected commercial floorspace additions by combining the surviving floorspace estimates with the total floorspace projection from MAM. A total NEMS floorspace projection is calculated by applying the MAM assumed floorspace growth rate within each Census division and MAM building type to the corresponding NEMS CDM building types based on the CBECS building type shares. The NEMS surviving floorspace from the previous year is then subtracted from the total NEMS floorspace projection for the current year to yield new floorspace additions [20].

Service demand Submodule

Once the building stock is projected, the CDM develops a projection of demand for energy-consuming services required for the projected floorspace. The module projects service demands for the following explicit end-use services: space heating, space cooling, ventilation, water heating, lighting, cooking, refrigeration, personal computer office equipment, and other office equipment [21]. The service demand intensity (SDI) is measured in thousand Btu of end-use service demand per square foot and differs across service, Census division, and building type. The SDIs are based on a hybrid engineering and statistical approach of CBECS consumption data [22]. Projected service demand is the product of square feet and SDI for all end uses across the eleven building categories with adjustments for changes in shell efficiency for space heating and cooling.

Table 5.1. 2003 Total floorspace by Census division and principal building activity

millions of square feet

	Assembly	Education	Food Sales	Food Service	Health Care	Lodging	Large Office	Small Office	Merc/ Service	Warehouse	Other	Total
New England	431	299	75	45	48	374	282	320	819	411	351	3,452
Middle Atlantic	1,243	1,384	163	127	310	797	1,523	1,065	1,641	1,112	1,177	10,543
East North Central	1,355	1,990	218	248	316	549	1,297	1,129	2,148	2,023	1,152	12,424
West North Central	772	552	102	206	123	595	219	704	1,045	994	369	5,580
South Atlantic	1,161	2,445	223	433	469	939	1,173	1,065	3,391	1,836	865	13,999
East South Central	546	341	67	99	134	368	195	371	985	390	223	3,719
West South Central	965	1,198	197	232	235	387	195	371	985	390	223	3,719
Mountain	411	640	64	32	94	438	230	535	1,087	506	168	4,207
Pacific	809	1,027	146	232	176	649	1,028	915	2,051	1,066	515	8,613
Total United States	7,693	9,874	1,255	1,654	1,905	5,096	6,861	6,605	15,242	10,078	5,395	71,658

Note: Totals may not equal sum of components due to independent rounding.

Source: U.S. Energy Information Administration, 2003 Commercial Buildings Energy Consumption Survey Public Use Data.

Table 5.2. Floorspace attrition parameters

	Assembly	Education	Food Sales	Food Service	Health Care	Lodging	Large Office	Small Office	Merc/ Service	Ware-house	Other
Median Expected Lifetime (years)	55	62	55	50	55	53	65	58	50	58	60
Gamma	2.2	2.1	2.3	2.0	2.5	2.1	2.0	2.0	2.2	2.0	2.3

Source: U.S. Energy Information Administration, Commercial Buildings Energy Consumption Survey 2003, 1999, 1995, 1992, and 1989 Public Use Data, 1986 Nonresidential Buildings Energy Consumption Survey, McGraw-Hill Construction Dodge Annual Starts- non-residential building starts, Northwest Energy Efficiency Alliance, Assessment of the Commercial Building Stock in the Pacific Northwest, KEMA-XENERGY, Inc., March 2004, and public information on demolitions.

Shell efficiency

The shell integrity of the building envelope is an important determinant of the heating and cooling loads for each type of building. In the NEMS Commercial Demand Module, the shell efficiency is represented by separate heating and cooling factors that change over time to reflect improvements in the building shell. The factors, dimensioned by building type and Census division, affect the space heating and cooling service demand intensities causing changes in fuel consumed for these services as the shell integrity improves. In the AEO2016 Reference case, building shells for new construction built in 2003 are up to 49% more efficient with respect to heating and up to 30% more efficient with respect to cooling relative to the average shell for

existing buildings of the same type. Over the projection horizon, new building shells improve in efficiency by 26% relative to their efficiency in 2003. For existing buildings, efficiency is assumed to increase by 6.9% over the 2003 stock average.

Distributed generation and combined heat and power

Program-driven installations of solar photovoltaic systems are based primarily on information from the GTM Research and the Solar Energy Industries Association (SEIA) quarterly report on U.S. solar market trends. Historical data from Form EIA-860, Annual Electric Generator Report, are used to derive electricity generation by Census division, building type, and fuel. A projection of distributed generation (DG) and combined heat and power (CHP) of electricity is developed based on the economic returns projected for DG and CHP technologies. The model uses a detailed cash-flow approach to estimate the internal rate of return for an investment. Penetration assumptions for distributed generation and CHP technologies are a function of the estimated internal rate of return relative to purchased electricity. Table 5.3 provides the cost and performance parameters for representative distributed generation and CHP technologies.

The model also incorporates endogenous learning for new DG and CHP technologies, allowing for declining technology costs as shipments increase. For fuel-cell and photovoltaic systems, parameter assumptions for the AEO2016 Reference case result in a 13% reduction in capital costs each time the installed capacity in the residential and commercial building sectors doubles (in the case of photovoltaics, utility-scale capacity is also included for learning). Doubling the installed capacity of microturbines results in a 10% reduction in capital costs and doubling the installed capacity of distributed wind systems results in a 3% reduction.

Technology Choice Submodule

The technology choice submodule develops projections of major end-use equipment to meet projected service demands using the three major fuels: electricity, natural gas, and distillate fuel. Capital purchase decisions are driven by assumptions concerning behavioral rule proportions and time preferences, described below, as well as projected fuel prices, average annual utilization of equipment (capacity factors), relative technology capital costs, and operating and maintenance (O&M) costs.

Decision types

In each projection year, equipment is potentially purchased for three decision types. Equipment must be purchased for newly added floorspace and to replace the portion of equipment in existing floorspace that is projected to wear out [23]. Equipment is also potentially purchased for retrofitting equipment that has become economically obsolete. The purchase of retrofit equipment occurs only if the annual operating costs of a current technology exceed the annualized capital and operating costs of a technology available as a retrofit candidate.

Table 5.3. Capital cost and performance parameters of selected commercial distributed generation technologies

Technology Type	Year of Introduction	Average Generating Capacity (kW_{DC})	Electrical Efficiency	Combined Efficiency (Elec. + Thermal)	Installed Capital Cost (2015 $ per kW_{DC})*	Service Life (Years)
Solar Photovoltaic	2015	40	0.17	N/A	$3,436	30
	2020	40	0.20	N/A	$2,339	30
	2030	40	0.26	N/A	$1,763	30
	2040	40	0.28	N/A	$1,715	30
Fuel Cell	2015	200	0.36	0.58	$5,458	20
	2020	200	0.36	0.58	$4,800	20
	2030	200	0.37	0.58	$3,662	20
	2040	200	0.38	0.60	$2,795	20
Natural Gas Engine	2015	373	0.33	0.85	$2,176	20
	2020	373	0.33	0.85	$2,204	20
	2030	373	0.33	0.85	$2,176	20
	2040	373	0.33	0.85	$1,137	20
Oil-fired Engine	2015	340	0.33	0.77	$2,016	20
	2020	340	0.33	0.77	$2,043	20
	2030	340	0.33	0.77	$2,016	20
	2040	340	0.33	0.77	$1,980	20
Natural Gas Turbine	2015	1210	0.24	0.86	$2,224	20
	2020	1222	0.25	0.86	$2,254	20
	2030	1247	0.25	0.87	$2,223	20
	2040	1272	0.26	0.87	$2,185	20
Natural Gas Microturbine	2015	250	0.26	0.62	$3,404	20
	2020	253	0.26	0.62	$3,404	20
	2030	258	0.27	0.63	$3,403	20
	2040	263	0.27	0.64	$3,344	20
Wind	2015	100	0.13	0.00	$5,900	30
	2020	100	0.13	0.00	$5,521	30
	2030	100	0.13	0.00	$4,847	30
	2040	100	0.13	0.00	$4,235	30

* The original source documents presented solar photovoltaic costs in 2008 dollars and all other technologies in 2010 dollars. Costs for solar photovoltaic, fuel cell, microturbine, and wind technologies include learning effects.

Sources: U.S. Energy Information Administration, Commercial and Industrial CHP Technology Cost and Performance Data Analysis for EIA SENTECH, Inc., and SAIC, Inc., June 2010; U.S. Energy Information Administration, Photovoltaic (PV) Cost and Performance Characteristics for Residential and Commercial Applications Final Report, ICF International, August 2010; U.S. Energy Information Administration, Review of Distributed Generation and Combined Heat and Power Technology Performance and Cost Estimates and Analytic Assumptions for National Energy Modeling System Draft Report, Leidos, January 2016; and U.S. Energy Information Administration, The Cost and Performance of Distributed Wind Turbines, 2010-35 Final Report, ICF International, August 2010.

Behavioral rules

The commercial module allows the use of three alternate assumptions about equipment choice behavior. These assumptions constrain the equipment selections to three choice sets, which are progressively more restrictive. The choice sets vary by decision type and building type:

- Unrestricted Choice Behavior - This rule assumes that commercial consumers consider all types of equipment that meet a given service, across all fuels, when faced with a capital purchase decision.
- Same Fuel Behavior - This rule restricts the capital purchase decision to the set of technologies that consume the same fuel that currently meets the decision maker's service demand.
- Same Technology Behavior - Under this rule, commercial consumers consider only the available models of the same technology and fuel that currently meet service demand when facing a capital stock decision.

Under any of the above three behavior rules, equipment that meets the service at the lowest annualized lifecycle cost is chosen. Table 5.4 illustrates the proportions of floorspace subject to the different behavior rules for space heating technology choices in large office buildings.

Time preferences

Commercial building owners' time preferences regarding current versus future expenditures are assumed to be distributed among seven alternate time preference premiums. Adding the risk-adjusted time preference premiums to the 10-year Treasury note rate from the MAM results in implicit discount rates, also known as hurdle rates, applicable to the assumed proportions of commercial floorspace. The effect of the use of this distribution of discount rates is to prevent a single technology from dominating purchase decisions in the lifecycle cost comparisons. The distribution used for AEO2016 assigns some floorspace a very high discount or hurdle rate to simulate floorspace which will never retrofit existing equipment and which will only purchase equipment with the lowest capital cost. Discount rates for the remaining six segments of the distribution get progressively lower, simulating increased sensitivity to the fuel costs of the equipment that is purchased. The share of floorspace assigned to each rate in the distribution varies by end-use service. Table 5.5 illustrates the distribution of time preference premiums for space heating and lighting in 2016. The proportion of floorspace assumed for the 0.0 time preference premium represents an estimate of the federally-owned commercial floorspace that is subject to purchase decisions in a given year. The federal sector is expected to purchase energy-efficient equipment to meet the federal buildings performance standards of the Energy Policy Act of 2005 (EPAct2005) and the Energy Independence and Security Act of 2007 (EISA2007) whenever cost-effective. For federal purchase decisions relating to energy conservation, cost-effectiveness is determined using a discount rate based on long-term Treasury bond rates, approximated in the commercial module by the 10-year Treasury note rate. For lighting, the proportion of floorspace assumed for the 0.0 time preference premium is increased to include all federal floorspace starting in 2009 to represent the EISA2007 provision that all federal buildings be equipped with energy-efficient lighting fixtures and bulbs to the maximum extent feasible, including when replacing bulbs in existing fixtures.

Table 5.4. Assumed behavior rules for choosing space heating equipment in large office buildings

percent

	Unrestricted	Same Fuel	Same Technology	Total
New Equipment Decision	21	30	49	100
Replacement Decision	7	31	62	100
Retrofit Decision	1	4	95	100

Source: U.S. Energy Information Administration, Model Documentation Report: Commercial Demand Module of the National Energy Modeling System, DOE/EIA-M066(2014) (August 2014).

Table 5.5. Assumed distribution of risk-adjusted time preference premiums for space heating and lighting equipment in 2015

percent

Time Preference Premium	Proportion of Floorspace-space Heating (2016)	Proportion of Floorspace-Lighting (2016)
1000.0	26.5	26.4
100.0	22.6	22.5
45.0	19.6	19.3
25.0	19.2	19.3
15.0	10.5	8.5
6.5	1.3	1.3
0.0	0.3	2.7
--	100.0	100.0

Source: U.S. Energy Information Administration, Model Documentation Report: Commercial Demand Module of the National Energy Modeling System, DOE/EIA-M066(2014) (August 2014).

The distribution of hurdle rates used in the commercial module is also affected by changes in fuel prices. If a fuel's price rises relative to its price in the base year (2003), the nonfinancial portion of each hurdle rate in the distribution decreases to reflect an increase in the relative importance of fuel costs, expected in an environment of rising prices. Parameter assumptions for AEO2016 result in a 30% reduction in the nonfinancial portion of a hurdle rate if the fuel price doubles. If the risk-adjusted time preference premium input by the model user results in a hurdle rate below the assumed financial discount rate–15% for the commercial sector–with base year fuel prices (such as the 0.0 rate given in Table 5.5), no response to increasing fuel prices is assumed.

Technology characterization menu

The technology characterization menu organizes all relevant major end-use equipment data. Equipment is indexed by technology, vintage, fuel, end-use service provided, and Census division (or building type for ventilation, lighting, and refrigeration end uses). Initial market share, efficiency (coefficient of performance or efficacy in the case of lighting equipment), installed capital cost per unit of service demand satisfied, operating and maintenance cost per unit of service demand satisfied, average service life, year of initial availability, and last year available for purchase are also characterized. Equipment may only be selected to satisfy service demand if the year in which the decision is made falls within the window of availability.

Equipment acquired prior to the lapse of its availability continues to be treated as part of the existing stock and is subject to replacement or retrofitting. This flexibility in limiting equipment availability allows the direct modeling of equipment efficiency standards. Table 5.6 provides a sample of the technology data for space heating in the New England Census division.

An option has been included to allow endogenous price-induced technological change in the determination of equipment costs and availability for the menu of equipment. This concept allows future technologies faster diffusion into the marketplace if fuel prices increase markedly for a sustained period of time. The option was not exercised for the AEO2016 model runs.

End-Use Consumption Submodule

The end-use consumption submodule calculates the consumption of each of the three major fuels (electricity, natural gas, and distillate fuel oil) for the ten end-use services plus fuel consumption for CHP and district services. For the ten end-use services, energy consumption is calculated as the end-use service demand met by a particular type of equipment divided by its efficiency, summed over all existing equipment types. This calculation includes dimensions for Census division, building type, and fuel. Consumption of the five minor fuels (residual fuel oil, liquefied petroleum gas, motor gasoline, kerosene, and coal) is projected based on historical trends.

Equipment efficiency

The average energy consumption of a particular appliance is based initially on estimates derived from the 2003 CBECS. As the stock efficiency changes over the model simulation, energy consumption decreases nearly as much as, but not quite proportionally to, the increase in efficiency. The difference is due to the calculation of efficiency using the harmonic average and also the efficiency rebound effect discussed below. For example, if on average, electric heat pumps are now 10% more efficient than in 2003, then all else constant (weather, real energy prices, shell efficiency, etc.), energy consumption per heat pump would now average about 9% less. The service demand and technology choice submodules together determine the average efficiency of the stocks used in adjusting the initial average energy consumption.

Adjusting for weather and climate

Recognition of the effect of weather on space heating and air conditioning is necessary to avoid projecting abnormal weather conditions into the future. In the CDM, proportionate adjustments are made to space heating and air conditioning demand by Census division. These adjustments are based on National Oceanic and Atmospheric Administration (NOAA) heating degree day (HDD) and cooling degree day (CDD) data. Short-term projections are informed by NOAA's 15-month outlook from their Climate Prediction Center [24], which often encompasses the first forecast year. Projections of degree days beyond that are informed by a 30-year linear trend of each state's degree days, which are then population-weighted to the Census division level. In this way, the CDM accounts for projected population migrations across the nation and continues any realized historical changes in degree days at the state level. A 10% increase in HDD would increase space heating consumption by 10% over what it would have been, while a 10% increase in CDD would increase cooling consumption by about 12.5%.

Table 5.6. Capital cost and efficiency ratings of selected commercial space heating equipment[1]

Equipment Type	Vintage	Efficiency[2]	Capital Cost (2013$ per MBtu/ hour)[3]	Maintenance Cost (2013$ per MBtu/ hour)[3]	Service Life (Years)
Rooftop Air-Source Heat Pump	2003 installed base	3.10	$67.78	$1.47	15
	2013 current standard/typical	3.30	$81.39	$1.47	15
	2013 high	3.40	$102.78	$1.47	15
	2020 typical	3.30	$80.28	$1.47	15
	2020 high	3.40	$102.78	$1.47	15
Ground-Source Heat Pump	2003 installed base	3.40	$545.83	$3.13	25
	2013 typical	3.60	$514.58	$3.13	25
	2013 mid	3.70	$530.21	$3.13	25
	2013 high	4.00	$571.88	$3.13	25
	2020 typical	3.80	$514.88	$3.13	25
	2020 high	4.20	$571.88	$3.13	25
	2030 typical	4.00	$514.58	$3.13	25
	2030 high	4.40	$571.88	$3.13	25
Electric Boiler	2003 installed base	0.94	$16.68	$0.26	15
	2012 installed base	0.94	$21.13	$0.26	15
Electric Resistance Heater	2003 installed base	0.98	$21.76	$0.01	18
Natural Gas Heat Pump	2003 Installed base (residential type)	1.30	$218.33	$2.67	15
	2013 typical (engine-driven rooftop)	1.40	$300.00	$4..92	15
	2020 typical (engine-driven rooftop)	1.40	$300.00	$4.92	15
	2030 typical (engine-driven rooftop)	1.40	$300.00	$4.92	15
Natural Gas Furnace	2003 installed base	0.71	$8.46	$1.13	15
	2013 current standard/typical	0.78	$9.21	$1.03	15
	2013 high	0.88	$11.78	$2.66	15
	2020 typical	0.79	$10.95	$1.03	15
	2020 high	0.88	$11.78	$2.66	15
	2030 typical	0.79	$10.95	$1.03	15
	2030 high	0.89	$11.78	$2.66	15
Natural Gas Boiler	2003 installed base	0.76	$29.36	$0.79	30
	2013 current standard/typical	0.80	$31.64	$0.75	30
	2013 mid-range	0.85	$33.97	$071	30
	2013 high	0.98	$32.33	$0.61	30
	2020 typical	0.82	$32.62	$0.73	30
	2020 high	0.98	$32.33	$0.61	30
	2030 typical	0.83	$33.06	$0.72	30

Table 5.6. Capital cost and efficiency ratings of selected commercial space heating equipment[1] (cont.)

Equipment Type	Vintage	Efficiency[2]	Capital Cost (2013$ per MBtu/hour)[3]	Maintenance Cost (2013$ per MBtu/hour)[3]	Service Life (Years)
Distillate Oil Furnace	2003 installed base	0.76	$14.46	$1.05	15
	2013 typical	0.80	$14.40	$1.01	15
	2020 typical	0.80	$14.40	$1.01	15
Distillate Oil Boiler	2003 installed base	0.79	$17.83	$0.17	30
	2013 current standard	0.82	$19.82	$0.17	30
	2013 typical	0.83	$20.68	$0.17	30
	2013 high	0.89	$30.90	$0.15	30
	2020 typical	0.83	$20.68	$0.17	30
	2020 high	0.89	$30.90	$0.15	30

[1]Equipment listed is for the New England Census division, but is also representative of the technology data for the rest of the United States. See the source reference below for the complete set of technology data.

[2]Efficiency metrics vary by equipment type. Electric rooftop air-source heat pumps, ground-source and natural gas heat pumps are rated for heating performance using coefficient of performance (COP); natural gas and distillate furnaces and boilers reflect thermal efficiency.

Source: U.S. Energy Information Administration, "EIA - Technology Forecast Updates - Residential and Commercial Building Technologies - Reference Case," Navigant Consulting, Inc., March 2014.

Short-term price effect and efficiency rebound

It is assumed that energy consumption for a given end-use service is affected by the marginal cost of providing that service. That is, all else equal, a change in the price of a fuel will have an inverse, but less than proportional, effect on fuel consumption. The current value for the short-term price elasticity parameter is -0.25 for all major end uses except refrigeration. A value of -0.10 is currently used for commercial refrigeration. A value of -0.05 is currently used for personal computers (PC) and non-PC office equipment and other minor uses of electricity. For example, for lighting, this value implies that for a 1.0% increase in the price of a fuel, there will be a corresponding decrease in energy consumption of 0.25%. Another way of affecting the marginal cost of providing a service is through equipment efficiency. As equipment efficiency changes over time, so will the marginal cost of providing the end-use service. For example, a 10% increase in efficiency will reduce the cost of providing the service by 10%. The short-term elasticity parameter for efficiency rebound effects is -0.15 for affected end uses; therefore, the demand for the service will rise by 1.5% (-10% x -0.15). Currently, all services are affected by the short-term price effect and services affected by efficiency rebound are space heating and cooling, water heating, ventilation and lighting.

Legislation and regulations

The Clean Power Plan

The Clean Power Plan (CPP) rule, issued under Section 111(d) of the Clean Air Act, allows states to comply with emissions targets by incentivizing energy efficiency in buildings. In the NEMS commercial model, the effects of incentivizing energy efficiency are modeled using subsidies for energy efficient heating, cooling, water heating, ventilation, lighting, and refrigeration technologies. These subsidies are accumulated with an assumed 50% added for administrative costs and sent to the power sector along with the accumulated energy savings for emission credits.

Consolidated Appropriations Act of 2016 (H.R. 2029)

The H.R.2029 legislation passed in December 2015 extends the investment tax credit (ITC) provisions of the Energy Policy Act of 2005 for renewable energy technologies. The five year ITC extension for solar energy systems allows for a 30% tax credit through 2019, then decreasing to 26% in 2020, 22% in 2021, then remaining at 10% from 2022 and after. The credit is directly incorporated into the cash-flow approach for projecting distributed generation by commercial photovoltaic systems and factored into the installed capital cost assumptions for solar water heaters.

American Recovery and Reinvestment Act of 2009 (ARRA2009)

The ARRA2009 legislation passed in February 2009 provides energy-efficiency funding for federal agencies, State Energy Programs, and block grants. To account for the impact of this funding, states are assumed to adopt and enforce the ASHRAE 90.1-2007 standard by 2018 for building shell measures, and all public buildings (federal, state, and local) are assumed to use the 10-year Treasury note rate for purchase decisions related to both new construction and replacement equipment while stimulus funding is available. A percentage of the State Energy Program and Conservation Block Grant funding is assumed to be used for solar photovoltaic and small wind turbine installations. Additional stimulus funding is applied to fuel cell installations.

The ARRA2009 provisions remove the cap on the 30% business investment tax credit (ITC) for wind turbines. The ITC is still available for systems installed through 2016. These credits are directly incorporated into the cash-flow approach for distributed generation systems.

Energy Improvement and Extension Act of 2008 (EIEA2008)

The EIEA2008 legislation passed in October 2008 extends the ITC provisions of the Energy Policy Act of 2005 and expands the credit to include additional technologies. The ITCs of 30% for solar energy systems and fuel cells and 10% for microturbines are extended through 2016. The cap on the fuel cell credit has been increased from $500 to $1,500 per half kilowatt of capacity. The EIEA2008 provisions expand the ITC to include a 10% credit for CHP systems and ground-source heat pumps and a 30% credit for wind turbines with the wind credit capped at $4,000. The expanded credits are available for systems installed through 2016. These credits are directly incorporated into the cash-flow approach for distributed generation systems, including CHP, and factored into the installed capital cost assumptions for solar water heaters and ground-source heat pumps effective in 2009 and 2010, and bans the manufacture or import of mercury vapor lamp ballasts effective January 1, 2008.

Energy Independence and Security Act of 2007 (EISA2007)

The EISA2007 legislation passed in December 2007 provides standards for specific explicitly modeled commercial equipment. The EISA2007 requires specific energy-efficiency measures in commercial walk-in coolers and walk-in freezers effective January 1, 2009, with an additional update effective in 2017. Incandescent and halogen lamps must meet standards for maximum allowable wattage based on lumen output starting in 2012 and metal halide lamp fixtures using lamps between 150 and 500 watts are required to have a minimum ballast efficiency ranging from 88% to 94%, depending on ballast type, effective January 1, 2009. Additional requirements become effective in 2017.

The EISA2007 requirement for federal buildings to use energy-efficient lighting fixtures and bulbs to the maximum extent possible is represented by adjusting the proportion of the commercial sector assumed to use the 10-year Treasury note rate as an implicit discount or hurdle rate for lighting.

Energy Policy Act of 2005 (EPACT2005)

The passage of the EPACT2005 in August 2005 provides additional minimum efficiency standards for commercial equipment. Some of the standards for explicitly modeled equipment, effective January 1, 2010, include an increased Energy Efficiency Rating (EER) for small package air conditioning and heating equipment; daily electricity consumption limits by volume for commercial refrigerators, freezers, and refrigerator-freezers; and electricity consumption limits per 100 pounds of ice produced based on equipment type and capacity for automatic ice makers. The EPACT2005 adds standards for medium-base compact fluorescent lamps effective January 1, 2006, for ballasts for Energy Saver fluorescent lamps effective in 2009 and 2010, and bans the manufacture or import of mercury vapor lamp ballasts effective January 1, 2008.

Several efficiency standards in the EPACT2005 pertain to equipment not explicitly represented in the NEMS Commercial Demand Module. For low-voltage dry-type transformers, effects of the standard are included in estimating the share of projected miscellaneous electricity use attributable to transformer losses. For illuminated exit signs, traffic signals, and commercial premise spray valves, assumed energy reductions are calculated based on per-unit savings relative to a baseline unit and the estimated share of installed units and sales that already meet the standard. Total projected reductions are phased in over time to account for stock turnover. Under the EPACT2005 standards, illuminated exit signs and traffic signal modules must meet ENERGY STAR program requirements as of January 1, 2006. The requirements limit input power demand to 5 watts or less per face for exit signs. Nominal wattages for traffic signal modules are limited to 8 to 15 watts, based on module type. Effective January 1, 2007, low-voltage dry-type distribution transformers are required to meet the National Electrical Manufacturers Association Class I Efficiency Levels with minimum efficiency levels ranging from 97% to 98.9% based on output. Commercial pre-rinse spray valves [25] must have a maximum flow rate of 1.6 gallons per minute, effective January 1, 2006, with energy reductions attributed to hot water use.

The EPACT2005 expands the business investment tax credit to 30% for solar property installed in 2006 and 2007. ITCs of 30% for fuel cells and 10% for microturbine power plants are also available for property installed in 2006 and 2007. The EPACT2005 tax credit provisions were extended in December 2006 to cover equipment installed in 2008. These credits are directly incorporated into the cash-flow approach for

distributed generation systems and factored into the installed capital cost assumptions for solar hot water heaters.

Energy Policy Act of 1992 (EPACT1992)

A key assumption incorporated in the technology selection process is that the equipment efficiency standards described in the EPACT1992 constrain minimum equipment efficiencies. The effects of standards are modeled by modifying the technology database to eliminate equipment that no longer meets minimum efficiency requirements. Some of the EPACT1992 standards implemented in the module include: gas and oil-fired boilers—minimum combustion efficiency of 0.80 and 0.83, respectively, amended to minimum thermal efficiency of 0.80 and 0.81, respectively, in 2012; gas and oil-fired furnaces—minimum thermal efficiency of 0.80 and 0.81, respectively; electric water heaters—minimum energy factor of 0.85; and gas and oil water heaters—minimum thermal efficiency of 0.80 and 0.78, respectively. A fluorescent lamp ballast standard effective in 2005 mandates electronic ballasts with a minimum ballast efficacy factor of 1.17 for 4-foot, 2-lamp ballasts and 0.63 for 8-foot, 2-lamp ballasts. Fluorescent lamps and incandescent reflector lamb bulbs must meet amended standard levels for minimum average lamp efficacy in 2012. Recent updates for commercial refrigeration equipment include maximum energy consumption standards for refrigerated vending machines and display cases based on volume.

The 10% Business Investment Tax Credit for solar energy property included in EPACT1992 is directly incorporated into the cash-flow approach for projecting distributed generation by commercial photovoltaic systems. For solar water heaters, the tax credit is factored into the installed capital cost assumptions used in the technology choice submodule.

Energy efficiency programs

Several energy efficiency programs affect the commercial sector. These programs are designed to stimulate investment in more efficient building shells and equipment for heating, cooling, lighting, and miscellaneous end-use loads (MELs). The commercial module includes several features that allow projected efficiency to increase in response to voluntary programs (e.g., the distribution of risk-adjusted time preference premiums and shell efficiency parameters). Retrofits of equipment for space heating, air conditioning and lighting are incorporated in the distribution of premiums given in Table 5.5. Also, the shell efficiency of new and existing buildings is assumed to increase from 2003 through 2040. Shells for new buildings increase in efficiency by 26.0% over this period, while shells for existing buildings increase in efficiency by 6.9%.

Notes and sources

[13] U.S. Energy Information Administration, 2003 Commercial Buildings Energy Consumption Survey (CBECS) Public Use Files, http://www.eia.gov/consumption/commercial/data/2003/index.cfm?view=microdata

[14] The fuels accounted for by the commercial module are electricity, natural gas, distillate fuel oil, residual fuel oil, liquefied petroleum gas (LPG), coal, motor gasoline, and kerosene. Current commercial use of biomass (wood, municipal solid waste) is also included. In addition to these fuels, the use of solar energy is projected based on an exogenous estimate of existing solar photovoltaic system installations, projected installations due to state and local incentive programs, and the potential endogenous penetration of solar photovoltaic systems and solar thermal water heaters. The use of wind energy is projected based on an estimate of existing distributed wind turbines and the potential endogenous penetration of wind turbines in the commercial sector.

[15] The end-use services in the commercial module are heating, cooling, water heating, ventilation, cooking, lighting, refrigeration, PC and non-PC office equipment and a category denoted “miscellaneous end-use loads (MELs)” to account for all other minor end uses.

[16] The 11 building categories are assembly, education, food sales, food services, health care, lodging, large offices, small offices, mercantile/services, warehouse, and other.

[17] The detailed documentation of the commercial module contains additional details concerning model structure and operation. Refer to U.S. Energy Information Administration, Model Documentation Report: Commercial Demand Module of the National Energy Modeling System, DOE/EIA M066(2014) (August 2014).

[18] The commercial floorspace equations of the Macroeconomic Activity Model are estimated using the McGraw-Hill Construction Research & Analytics database of historical floorspace estimates. The McGraw-Hill Construction estimate for commercial floorspace in the United States is approximately 16% lower than the estimate obtained from the CBECS used for the Commercial module. See F.W. Dodge, Building Stock Database Methodology and 1991 Results, Construction Statistics and Forecasts, F.W. Dodge, McGraw-Hill.

[19] The commercial module performs attrition for nine vintages of floorspace developed using stock estimates from the previous five CBECS and historical floorspace additions data from McGraw-Hill Construction data.

[20] In the event that the computation of additions produces a negative value for a specific building type, it is assumed to be zero.

[21] “Other office equipment” includes copiers, fax machines, scanners, multi-function devices, data center servers, and other miscellaneous office equipment. A tenth category denoted “miscellaneous end-use loads (MELs)” includes equipment such as elevators, escalators, medical and other laboratory equipment, laundry, communications equipment, security equipment, transformers, and miscellaneous electrical appliances. Commercial energy consumed outside of buildings and for combined heat and power is also included in the “MELs” category.

Notes and sources (cont.)

[22] Based on 2003 CBECS end-use-level consumption data developed using the methodology described in Estimation of Energy End-Use Intensities, http://www.eia.gov/consumption/commercial/estimation-enduse-consumption.cfm .

[23] The proportion of equipment retiring is inversely related to the equipment life.

[24] National Oceanic and Atmospheric Administration, National Weather Service, Experimental Monthly Degree Day Forecast, http://www.cpc.ncep.noaa.gov/pacdir/DDdir/ddforecast.txt. Explanation of forecast is available at http://www.cpc.ncep.noaa.gov/pacdir/DDdir/N1.html.

[25] Commercial pre-rinse spray valves are handheld devices used to remove food residue from dishes and flatware before cleaning.