Commercial Demand Module

The NEMS Commercial Sector Demand Module generates forecasts of commercial sector energy demand through 2025. 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 or in 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. Since 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 commercial module forecasts consumption by fuel[14] at the Census division level using prices from the NEMS energy supply modules, and macroeconomic variables from the NEMS Macroeconomic Activity Module (MAM), as well as external data sources (technology characterizations, for example). Energy demands are forecast for ten end-use services[15] for eleven building categories[16] in each of the nine Census divisions (see Figure 5). The model begins by developing forecasts 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 and combined heat and power technologies are projected. Technologies are then chosen to meet the projected service demands for the seven major end uses.[17] 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.[18]

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 commercial module submodules: floorspace, service demand, technology choice, and end-use consumption. The four 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 forecast drivers for the floorspace submodule are also key drivers for the service demand submodule, and so on. The section summarizing the assumptions for the distributed generation submodule are presented following the end-use consumption section.

Floorspace Submodule

Floorspace is forecast 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 plus new additions to the stock derived from the MAM floorspace growth projection.[19]

Existing Floorspace and Attrition

Existing floorspace is based on the estimated floorspace reported in the *Commercial Buildings Energy Consumption Survey 1999* (Table 11). Over time, the 1999 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 12.[20]

Table 11. 1999 Total Floorspace by Census Division and Principal Building Activity
(Millions of Square Feet)

	Assem-bly	Educa-tion	Food Sales	Food Service	Health Care	Lodging	Large Office	Small Office	Merc/ Service	Ware-house	Other	Total
New England	378	575	10	40	86	169	565	311	824	429	348	3,735
Middle Atlantic	944	1,139	212	182	291	315	1,094	490	1,801	1,314	844	8,625
East North Central	1,202	1,506	115	463	336	725	1,096	847	2,183	1,983	751	11,205
West North Central	864	744	58	95	176	215	560	555	1,227	782	281	5,556
South Atlantic	848	997	156	302	312	825	1,507	1,077	2,611	1,909	457	11,001
East South Central	781	438	101	166	103	467	331	395	1,288	963	187	5,220
West South Central	1,028	913	135	207	215	303	663	644	1,569	1,085	501	7,264
Mountain	680	758	103	104	113	545	458	389	586	520	322	4,579
Pacific	1,074	1,580	105	292	233	956	1,145	969	1,698	1,493	607	10,152
United States	7,798	8,651	994	1,851	1,865	4,521	7,418	5,678	13,786	10,477	4,298	67,338

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

Source: Energy Information Administration, Commercial Buildings Energy Consumption Survey 1999 Public Use Data

Table 12. Floorspace Attrition Parameters

	Assem-bly	Educa-tion	Food Sales	Food Service	Health Care	Lodging	Large Office	Small Office	Merc/ Service	Ware-house	Other
Median Expected Lifetime (years)	48	48	36	36	48	36	36	36	36	36	42
gamma	2.2	3.0	1.6	1.9	2.3	2.2	1.7	1.6	2.4	1.9	2.5

Sources: Energy Information Administration, Commercial Buildings Energy Consumption Survey 1999, 1995, and 1992 Public Use Data, and Journal of Business and Economic Statistics, April 1986, Vol. 4, No. 2.

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 forecast 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 Commercial Demand Module's 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.[21]

Service Demand Submodule

Once the building stock is projected, the Commercial Demand module develops a forecast 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.[22] 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.[23] 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.

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 an index, which changes over time to reflect improvements in the building shell. This index is dimensioned by building type and Census division and applies directly to heating. For cooling, the effects are computed from the index, but differ from heating effects, because of different marginal effects of shell integrity and because of internal building loads. In the *AEO2004* reference case, shell improvements for new buildings are up to 22 percent more efficient than the 1999 stock of similar buildings. Over the forecast horizon, new building shells improve in efficiency by 7 percent relative to their efficiency in 1999. For existing buildings, efficiency is assumed to increase by 5 percent over the 1999 stock average. The shell efficiency index affects the space heating and cooling service demand intensities causing changes in fuel consumed for these services as the shell integrity improves.

Technology Choice Submodule

The technology choice submodule develops projections of the results of the capital purchase decisions for equipment fueled by 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 utilization of equipment (the capacity factors), relative technology capital costs, and operating and maintenance (O&M) costs.

Decision Types

In each forecast 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.[24] 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.

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 13 illustrates the proportions of floorspace subject to the different behavior rules for space heating technology choices in large office buildings.

Time Preferences

The time preferences of owners of commercial buildings are assumed to be distributed among seven alternate time preference premiums (Table 14). Adding the time preference premiums to the 10-year Treasury Bill rate from 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

Table 13. 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	8	35	57	100
Retrofit Decision	0	5	95	100

Source: Energy Information Administration, *Model Documentation Report: Commercial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-M066(2004) (February 2004).

to prevent a single technology from dominating purchase decisions in the lifecycle cost comparisons. The distribution used for *AEO2004* 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 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. In accordance with Executive Order 13123 signed in June 1999, the Federal sector uses a rate comparable to the 10-year Treasury Bill rate when making purchase decisions.

Table 14. Assumed Distribution of Time Preference Premiums
(Percent)

Proportion of Floorspace-All Services Except Lighting	Proportion of Floorspace-Lighting	Time Preference Premium
27.0	27.0	1000.0
25.4	25.4	152.9
20.4	20.4	55.4
16.2	16.2	30.9
10.0	8.5	19.9
0.8	2.3	13.6
0.2	0.2	0.0
100.0	100.0	--

Source: Energy Information Administration, *Model Documentation Report: Commercial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-M066(2004) (February 2004).

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 (1999), 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 *AEO2004* result in a 30 percent reduction in the nonfinancial portion of a hurdle rate if the fuel price doubles. If the time preference premium input by the model user results in a hurdle rate below the assumed financial discount rate for the commercial sector, 15 percent, with base year fuel prices (such as the rate given in Table 14 for the Federal sector), no response to increasing fuel prices is assumed.

Technology Characterization Database

The technology characterization database organizes all relevant technology data by end use, fuel, and Census division. Equipment is identified in the database by a technology index as well as a vintage index, the index of the fuel it consumes, the index of the service it provides, its initial market share, the Census division index for which the entry under consideration applies, its efficiency (or 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. 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 15 provides a sample of the technology data for space heating in the New England Census division.

Table 15. Capital Cost and Efficiency Ratings of Selected Commercial Space Heating Equipment[1]

Equipment Type	Vintage	Efficiency[2]	Capital Cost ($2001 per Mbtu/hour) [3]	Maintenance Cost ($2001 per Mbtu/hour) [3]	Service Life (Years)
Electric Heat Pump	Current Standard	6.8	$81.39	$3.33	14
	2000- typical	7.5	$97.92	$3.33	14
	2000- high efficiency	9.8	$155.56	$3.33	14
	2005- typical	7.5	$97.22	$3.33	14
	2005- high efficiency	9.8	$155.56	$3.33	14
	2010 - typical	7.5	$97.22	$3.33	14
	2010 - high efficiency	9.8	$155.56	$3.33	14
	2020 - typical	7.8	$97.22	$3.33	14
	2020 - high efficiency	10.0	$150.00	$3.33	14
Ground-Source Heat Pump	2000- typical	3.4	$187.50	$1.46	20
	2000- high efficiency	4.0	$229.17	$1.46	20
	2005- typical	3.4	$166.67	$1.46	20
	2005- high efficiency	4.3	$229.17	$1.46	20
	2010- typical	3.4	$166.67	$1.46	20
	2010 - high efficiency	4.3	$208.33	$1.46	20
	2020 - typical	3.8	$166.67	$1.46	20
	2020 - high efficiency	4.5	$197.92	$1.46	20
Electric Boiler	Current Standard	0.98	$21.83	$0.14	21
Packaged Electric	1995	0.93	$19.77	$3.49	18
Natural Gas Furnace	Current Standard	0.80	$9.11	$1.00	15
	2000 - high efficiency	0.92	$14.82	$0.88	15
	2010 - typical	0.81	$8.70	$0.96	15
Natural Gas Boiler	Current Standard	0.80	$18.11	$0.55	25
	2000 - high efficiency	0.87	$33.82	$0.69	25
	2005 - typical	0.81	$17.87	$0.55	25
	2005 - high efficiency	0.90	$31.68	$0.67	25
Natural Gas Heat Pump	2005 - absorption	1.4	$173.61	$4.17	15
Distillate Oil Furnace	Current Standard	0.81	$14.25	$1.00	15
	2000	0.86	$23.75	$1.00	15
	2010	0.89	$22.69	$1.00	15
Distillate Oil Boiler	Current Standard	0.83	$15.76	$0.13	20
	2000 - high efficiency	0.88	$18.83	$0.12	20
	2005 - typical	0.83	$15.76	$013	20
	2005- high efficiency	0.88	$18.83	$0.12	20

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

[2]Efficiency measurements vary by equipment type. Electric air-source and natural gas heat pumps are rated for heating performance using the Heating Seasonal Performance Factor (HSPF); natural gas and distillate furnaces are based on Annual Fuel Utilization Efficiency; ground-source heat pumps are rated on coefficient of performance; and boilers are based on combustion efficiency.

[3]Capital and maintenance costs are given in 2001 dollars.

Source: Energy Information Administration, “Technology Forecast Updates - Residential and Commercial Building Technologies - Reference Case”, Arthur D. Little, Inc., Reference Number 8675309, October 2001.

Starting with *AEO2000*, an option to allow endogenous price-induced technological change has been included in the determination of equipment costs and availability for the menu of equipment. This concept allows future technologies faster diffusion into the market place if fuel prices increase markedly for a sustained period of time. Although no price-induced change would have been expected using *AEO2004* reference case fuel prices, the option was not exercised for the *AEO2004* model runs.

End-Use Consumption Submodule

The end-use consumption submodule calculates the consumption of each of the three major fuels for the ten end-use services plus fuel consumption for combined heat and power 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 and summed over all existing equipment types. This calculation includes dimensions for Census division, building type, and fuel. Consumption of the five minor fuels is forecast based on historical trends.

Equipment Efficiency

The average energy consumption of a particular appliance is based initially on estimates derived from CBECS 1999. As the stock efficiency changes over the model simulation, energy consumption decreases nearly, but not quite proportionally to the efficiency increase. 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 percent more efficient than in 1999, then all else constant (weather, real energy prices, shell efficiency, etc.), energy consumption per heat pump would now average about 9 percent 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

Weather in any given year always includes short-term deviations from the expected longer-term average (or 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 commercial module, 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) data for Heating Degree Days (HDD) and Cooling Degree Days (CDD). A 10 percent increase in HDD would increase space heating consumption by 10 percent over what it would have been otherwise. The commercial module makes weather adjustments for the years 2000 through 2003. After 2003, long term weather patterns are assumed based on 30-year averages of HDD and CDD.

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 -0.1 is currently used for commercial refrigeration. A value of -0.05 is currently used for PC and non-PC office equipment and other minor uses of electricity. For example, for lighting this value implies that for a 1 percent increase in the price of a fuel, there will be a corresponding decrease in energy consumption of 0.25 percent. 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 percent increase in efficiency will reduce the cost of providing the service by 10 percent. 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 percent (-10 percent 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.

Distributed Generation and Combined Heat and Power

Nonutility power production applications within the commercial sector are currently concentrated in education, health care, office and warehouse buildings. Program driven installations of solar photovoltaic systems are based on information from DOE's Photovoltaic and Million Solar Roofs programs as well as

DOE and industry news releases and the National Renewable Energy Laboratory's Renewable Electric Plant Information System. Historical data from Form EIA-860B, *Annual Electric Generator Report - Nonutility*, are used to derive electricity generation for 2000 through 2002 by Census division, building type and fuel. A forecast of distributed generation and combined heat and power (CHP) of electricity is developed based on the economic returns projected for distributed generation and CHP technologies. The model uses a detailed cash-flow approach to estimate the number of years required to achieve a cumulative positive cash flow (some technologies may never achieve a cumulative positive cash flow). Penetration assumptions for distributed generation and CHP technologies are a function of the estimated number of years required to achieve a positive cash flow. Table 16 provides the cost and performance parameters for representative distributed generation and CHP technologies.

Table 16. Capital Cost and Performance Parameters of Selected Commercial Distributed Generation Technologies

Technology Type	Year	Average Generating Capacity (kW)	Electrical Efficiency	Combined Efficiency (Elec.+Thermal)	Installed Capital Cost ($2003 per kW of Capacity)*	Service Life (Years)
Solar Photovoltaic	2002	25	0.14	N/A	$6,500	30
	2005	25	0.16	N/A	$6,000	30
	2010	25	0.18	N/A	$4,750	30
	2015	25	0.20	N/A	$3,779	30
	2020	25	0.22	N/A	$3,178	30
	2025	25	0.22	N/A	$2,650	30
Fuel Cell	2002	200	0.36	0.75	$5,200	20
	2005	200	0.36	0.75	$5,200	20
	2010	200	0.49	0.72	$2,500	20
	2015	200	0.50	0.72	$2,150	20
	2020	200	0.51	0.72	$1,800	20
	2025	200	0.52	0.73	$1,450	20
Natural Gas Engine	2002	200	0.31	0.77	$1,160	20
	2005	200	0.32	0.77	$1,130	20
	2010	200	0.33	0.77	$1,030	20
	2015	200	0.33	0.78	$ 980	20
	2020	200	0.34	0.78	$ 930	20
	2025	200	0.34	0.79	$ 915	20
Oil-Fired Engine	2002	200	0.31	0.83	$1,320	20
	2006	200	0.31	0.82	$1,240	20
	2010	200	0.31	0.82	$1.150	20
	2015	200	0.31	0.81	$1,040	20
	2020	200	0.31	0.81	$ 990	20
	2025	200	0.31	0.81	$ 990	20
Natural Gas Turbine	2002	1000	0.22	0.65	$1,909	20
	2005	1000	0.23	0.66	$1,909	20
	2010	1000	0.24	0.67	$1,678	20
	2015	1000	0.25	0.68	$1,622	20
	2020	1000	0.26	0.69	$1,566	20
	2025	1000	0.27	0.70	$1,538	20
Natural Gas Micro Turbine	2002	200	0.25	0.61	$1,926	20
	2005	200	0.30	0.63	$1,620	20
	2010	200	0.36	0.63	$1,415	20
	2015	200	0.37	0.64	$1,143	20
	2020	200	0.38	0.65	$ 870	20
	2025	200	0.39	0.65	$ 818	20

*Installed costs are given in 2003 dollars in the original source document.

Sources: National Renewable Energy Laboratory, *Gas-Fired Distributed Generation Technology Characterization: Fuel Cell Systems*, Final Draft, August 2003, National Renewable Energy Laboratory, *Gas-Fired Distributed Generation Technology Characterization: Gas Turbines*, Final Draft, August 2003, National Renewable Energy Laboratory, *Gas-Fired Distributed Generation Technology Characterization: Microturbines*, Final Draft, July 2003, National Renewable Energy Laboratory, *Gas-Fired Distributed Generation Technology Characterization: Reciprocating Engines*, Final Draft, July 2003, Navigant Consulting, Inc., *The Changing Face of Renewable Energy*, public study (Navigant Consulting, June 2003), and ONSITE SYCOM Energy Corporation, *The Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector*, (Washington, DC, January 2000).

The model also incorporates endogenous "learning" for new distributed generation and CHP technologies, allowing for declining technology costs as shipments increase. For fuel cell and photovoltaic systems, parameter assumptions for the *AEO2004* reference case result in a 13 percent reduction in capital costs each time the number of units shipped to the buildings sectors (residential and commercial) doubles. Doubling the number of microturbines shipped results in a 7 percent reduction in capital costs.

Legislation and Other Federal Programs

Energy Policy Act of 1992 (EPACT)

A key assumption incorporated in the technology selection process is that the equipment efficiency standards described in the EPACT 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. For standards effective January 1, 1994, affected equipment includes electric heat pumps—minimum heating system performance factor of 6.8, gas and oil-fired boilers—minimum combustion efficiency of 0.8 and 0.83, respectively, gas and oil-fired furnaces—minimum thermal efficiency of 0.8 and 0.81, respectively, fluorescent lighting—minimum efficacy of 75 lumens per watt, incandescent lighting—minimum efficacy of 16.9 lumens per watt, air-cooled, air conditioners—minimum energy efficiency ratio of 8.9, electric water heaters—minimum energy factor of 0.85, and gas and oil water heaters—minimum thermal efficiency of 0.78. Updated standards are effective October 29, 2003 for gas water heaters—minimum thermal efficiency of 0.8. An additional standard affecting fluorescent lamp ballasts becomes effective April 1, 2005. The standard 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.

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 other end uses. The commercial module includes several features that allow projected efficiency to increase in response to voluntary programs (e.g., the distribution of 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 14. Also, the shell efficiency of new and existing buildings is assumed to increase from 1999 through 2025. Shells for new buildings increase in efficiency by 7 percent over this period, while shells for existing buildings increase in efficiency by 5 percent.

Commercial Technology Cases and Alternative Renewables Cases

In addition to the *AEO2004* reference case, three side cases were developed to examine the effect of equipment and building standards on commercial energy use—a *2004 technology case*, a *high technology case*, and a *best available technology case*. These side cases were analyzed in stand-alone (not integrated with the NEMS demand and supply modules) buildings (residential and commercial) modules runs and thus do not include supply-responses to the altered commercial consumption patterns of the three cases. *AEO2004* also analyzed an *integrated high technology case*, which combines the *high technology cases* of the four end-use demand sectors, the *electricity high fossil technology case,* the *advanced nuclear cost case*, and the *high renewables case,* and an *integrated 2004 technology case*, which combines the *2004 technology cases* of the four end-use demand sectors, the *electricity low fossil technology case*, and the *low renewables case*.

The *2004 technology case* assumes that all future equipment purchases are made based only on equipment available in 2004. This case assumes building shell efficiency to be fixed at 2004 levels. In the reference case, existing building shells are allowed to increase in efficiency by 5 percent over 1999 levels, and new building shells improve by 7 percent by 2025 relative to new buildings in 1999.

The *high technology case* assumes earlier availability, lower costs, and/or higher efficiencies for more advanced equipment than the reference case. Equipment assumptions were developed by engineering technology experts, considering the potential impact on technology given increased research and development into more advanced technologies. In the *high technology case*, building shell efficiencies are assumed to improve 25 percent more than in the reference case after 2004. Existing building shells, therefore, increase by 6.25 percent relative to 1999 levels and new building shells by 8.75 percent relative to their efficiency in 1999 by 2025.

The *best available technology case* assumes that all equipment purchases after 2004 are based on the highest available efficiency in the high technology case in a particular simulation year, disregarding the economic costs of such a case. It is designed to show how much the choice of the highest-efficiency equipment could affect energy consumption. Shell efficiencies in this case are assumed to improve 50 percent more than in the reference case after 2004, i.e., existing shells increase by 7.5 percent relative to 1999 levels and new building shells by 10.5 percent relative to their efficiency in 1999 by 2025.

Fuel shares, where appropriate for a given end use, are allowed to change in the technology cases as the available technologies from each technology type compete to serve certain segments of the commercial floorspace market. For example, in the *best available technology case*, the most efficient gas furnace technology competes with the most efficient electric heat pump technology. This contrasts with the reference case, in which, a greater number of technologies for each fuel with varying efficiencies all compete to serve the heating end use. In general, the fuel choice will be affected as the available choices are constrained or expanded, and will thus differ across the cases.

Three integrated cases that focus on electricity generation incorporate alternative assumptions for non-hydro renewable energy technologies, including residential and commercial photovoltaic systems. In each of these cases, assumptions regarding non-renewable technologies are not changed from the reference case.

The *low renewables case* assumes that the cost and performance characteristics for residential and commercial photovoltaic systems remain fixed at 2004 levels through the forecast horizon.

The *high renewables case* assumes that costs for residential and commercial photovoltaic systems are 10 percent lower than reference case cost estimates by 2025.

The *DOE program goals case* assumes greater improvements in residential and commercial photovoltaic systems than in the reference and *high renewables cases*. The renewables assumptions for the program goals case result in capital cost estimates for 2025 that approximate DOE's Office of Energy Efficiency and Renewable Energy technology characterizations for distributed photovoltaic technologies[25], about 46 percent lower than reference case cost estimates for commercial photovoltaic systems in 2025. The *DOE program goals case*, which uses these assumptions, focuses on electricity generation.

Notes and Sources

[13] Energy Information Administration, 1999 Commercial Buildings Energy Consumption Survey (CBECS) Public Use Files, web site www.eia.doe.gov/emeu/cbecs/1999publicuse/99microdat.html.

[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. In addition to these fuels the use of solar energy is projected based on an exogenous forecast of projected solar photovoltaic system installations under the Million Solar Roofs program, State and local incentive programs, and the potential endogenous penetration of solar photovoltaic systems and solar thermal water heaters.

[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 other 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] Minor end uses are modeled based on penetration rates and efficiency trends.

[18] The detailed documentation of the commercial module contains additional details concerning model structure and operation. Refer to Energy Information Administration, Model Documentation Report: Commercial Sector Demand Module of the National Energy Modeling System, DOE/EIA M066(2004), (January 2004).

[19] The commercial floorspace equations of the Macroeconomic Activity Model are estimated using the F.W. Dodge Statistics and Forecasts Group database of historical floorspace estimates. The F.W. Dodge estimate for commercial floorspace in the U.S. is approximately 20 percent 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.

[20] The commercial module performs attrition for 9 vintages of floorspace developed from the CBECS 1999 stock estimate and historical floorspace additions data from F.W. Dodge data.

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

[22] “Other office equipment” includes copiers, fax machines, typewriters, cash registers, mainframe computers, and other miscellaneous office equipment. A tenth category denoted other includes equipment such as elevators, medical, and other laboratory equipment, 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 “other” category.

[23] Based on updated estimates using CBECS 1999 building-level consumption data and CBECS 1995 end-use-level consumption data and the methodology described in Estimation of Energy End-Use Intensities, web site www.eia.doe.gov/emeu/cbecs/tech_end_use.html.

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

[25] For current DOE technology characterizations for photovoltaic systems see web site www.eren.doe.gov/power/pdfs/techchar.pdf.