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Commercial Buildings Energy Consumption and Expenditures 1992

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Public Use Data Diskettes containing CBECS data are available through the Office of Scientific and Technical Information and the National Technical Information Service. (See Appendix I, "Related EIA Publications on Energy Consumption," for ordering information.) Selected tables are also available on the Electronic Publishing System (EPUB). For questions about the contents of EPUB reports and data, call (202) 586-8800.

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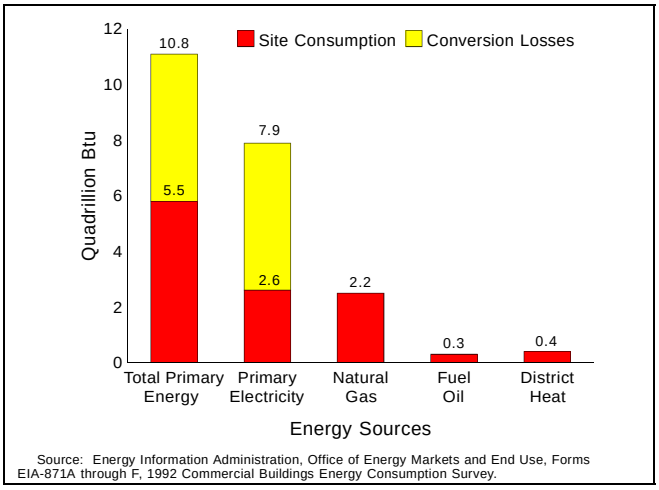
Executive Summary

Commercial Buildings Energy Consumption and Expenditures 1992 presents statistics about the amount of energy consumed in commercial buildings and the corresponding expenditures for that energy. These data are based on the 1992 Commercial Buildings Energy Consumption Survey (CBECS), a national energy survey of buildings in the commercial sector, conducted by the Energy Information Administration (EIA) of the U.S. Department of Energy.

- **Energy Consumption:** In 1992, the 4.8 million commercial buildings in the United States consumed 5.5 quadrillion Btu of electricity, natural gas, fuel oil, and district heat. Of those 5.5 quadrillion Btu, consumption of site electricity accounted for 2.6 quadrillion Btu, or 48.0 percent, and consumption of natural gas accounted for 2.2 quadrillion Btu, or 39.6 percent. Fuel oil consumption made up 0.3 quadrillion Btu, or 4.0 percent of the total, while consumption of district heat made up 0.4 quadrillion Btu, or 7.9 percent of energy consumption in that sector. When the energy losses that occur at the electricity generating plants are included, the overall energy consumed by commercial buildings increases to about 10.8 quadrillion Btu (Figure ES1).

- **Energy Expenditures:** Expenditures for the 5.5 quadrillion Btu of energy consumed in the commercial buildings sector totalled $71.8 billion. By energy source, $57.6 billion was spent for site electricity, $9.9 billion was spent for natural gas, $1.4 billion was spent for fuel oil, and $2.9 billion was spent for district heat.

Figure ES1. Energy Consumption in Commercial Buildings by Energy Source, 1992



Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A through F, 1992 Commercial Buildings Energy Consumption Survey.

- **Location:** By Census region, the South accounted for about 33 percent of the total 5.5 quadrillion Btu of energy consumption by commercial buildings. Of that total, buildings in the Midwest consumed 29 percent, while buildings in the Northeast and West consumed 20 percent and 18 percent, respectively.

- **Energy Intensities:** Energy consumption per square foot of building floorspace, or energy intensity, provides a common basis to compare data on energy consumption for different building categories and energy sources. For example, among the major energy sources, fuel oil consumption produced the lowest energy intensity at 21 thousand Btu per square foot. Consumption of natural gas and electricity produced energy intensities of 48 thousand Btu per square foot and 39 thousand Btu per square foot, respectively. Consumption of district heat produced the highest energy intensity at 83 thousand Btu per square foot.

- **Energy Intensities by Location:** Electricity intensities were higher in the West and South Census regions (12.6 kilowatthours per square foot) than in the Midwest and Northeast regions (10.1 kilowatthours per square foot), primarily due to greater use of air conditioning in those regions. The natural gas intensity was higher in the Midwest (52.7 cubic feet per square foot) than in the Northeast, primarily due to its use in the Midwest for space heating. The Northeast consumed 71 percent of the fuel oil used in the commercial buildings sector, mostly for main space heating.

- **Principal Building Activity:** Office buildings consumed more total energy (1,247 trillion Btu), more electricity (206 billion kilowatthours), and more natural gas (377 billion cubic feet) than was consumed by commercial buildings used for any other principal activity, primarily because they accounted for more commercial floorspace than did buildings of most other activities. However, buildings in which the principal activity was either food sales or food service were, by far, the most electricity-intensive buildings (43.6 kilowatthours per square foot and 27 kilowatthours per square foot, respectively) partly due to use of more refrigeration equipment. Food service buildings also showed the highest natural gas intensity (133 cubic feet per square foot) probably because of their smaller size and longer weekly operating hours.

- **Other Energy Sources:** CBECS data on the consumption of other energy sources by commercial buildings revealed that buildings using wood tended to use the major energy sources less intensively (34.6 thousand Btu per square foot compared with the national average of 81 thousand Btu per square foot), while buildings using solar energy or passive solar features used the major energy sources more intensively (94.4 thousand Btu per square foot).

- **Natural Gas Transported for the Account of Others:** Natural gas transported for the account of others is natural gas that customers buy directly from a gas producer or broker and which the local distributing company delivers to the building. Natural gas bought under this purchasing arrangement is a small but growing portion of all natural gas consumed in the commercial buildings sector. In 1992, natural gas transported for the account of others made up approximately 13 percent of natural gas consumption in the commercial buildings sector; in 1989, it accounted for 12 percent of natural gas consumption.

1. Introduction

Commercial Buildings Energy Consumption and Expenditures 1992 is the second report based on data from the 1992 Commercial Buildings Energy Consumption Survey (CBECS). The first publication, *Commercial Buildings Characteristics 1992*, provided information on the number and size of commercial buildings for the energy-related characteristics of those buildings. This second report provides information on the energy consumption and expenditures of those buildings.

The CBECS, administered by the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE), is the only source of national-level data on commercial building characteristics and related energy consumption.

Background

EIA Surveys

By Congressional mandate, EIA collects, analyzes, and disseminates impartial, comprehensive data about the production and consumption of energy.[1] To comply with this mandate, EIA conducts two types of surveys: (1) supply surveys and (2) consumption surveys:

- Supply surveys gather information from energy suppliers and marketers on the quantities and prices of specific energy sources produced or supplied to the market. The results of these surveys are published in fuel-specific EIA publications and in the *Monthly Energy Review*.

- Consumption surveys gather information directly from energy end users on the types of energy they consume, along with information on the energy-related characteristics of commercial buildings, households, vehicles, and manufacturing establishments.[2] The results of these surveys are published in energy-consumption reports, such as this report, and in special analytical reports.

These surveys enable EIA to provide meaningful, objective, and accurate energy information for a wide audience that includes Congress, Federal and State agencies, industry, and the general public.

CBECS Methodology

EIA conducts the CBECS, a national sample energy survey of commercial buildings and their energy suppliers, every 3 years. Previous surveys were conducted for 1979, 1983, and 1986 under the title, "Nonresidential Buildings Energy Consumption Survey (NBECS)." In 1989, the survey name was changed to "Commercial Buildings Energy Consumption Survey (CBECS)." For consistency, all the surveys will be referred to as "CBECS" in this report.

The CBECS is conducted in two parts:

- In the first part, interviews are conducted with the building managers, owners, or tenants to collect information about the commercial building, such as the principal building activity, structural characteristics, building use, energy sources, energy-using equipment, and energy-efficiency measures.

- In the second part, after permission is obtained from the building respondents, questionnaires are mailed to the energy suppliers of these buildings to collect billing data on energy consumption and expenditures.

[1]EIA's responsibilities are specified in the Federal Energy Administration Act of 1974 (P.L. 93-275), as amended.

[2]See Appendix I, "Related EIA Publications on Energy Consumption," for a listing of publications from CBECS and from other EIA consumption surveys.

Energy Consumption Intensities

To analyze how intensively energy is used in buildings, it is useful to normalize consumption by the amount of floorspace in buildings. Two measures of floorspace are used. One includes the total floorspace in all buildings, while a second includes only the floorspace in buildings that actually use a specific energy source. The second measure of floorspace is conditional on the actual use of an energy source. Each measure of floorspace leads to a different measure of energy intensity and both are relevant, depending on the focus of the analysis.

The measure of intensity that includes total floorspace is the Gross Energy Intensity, or Total Energy Intensity.

Gross Energy Intensity = Consumption/Total Square Feet

where

Consumption = total consumption of the sum of the major energy sources or a specific energy source in all buildings within a specific category.

Total Square Feet = total floorspace included in all the buildings within that category.

In this report, this measure of intensity is limited to the intensities for the sum of the major fuels.

The measure of intensity that includes only buildings that use a specific energy source is Conditional Energy Intensity or Energy Source-Specific Energy Intensity.

Conditional Energy Intensity = Consumption/Energy Source-Specific Square Feet

where

Consumption = total consumption of a specific energy source in all buildings within a specific category.

Energy Source-Specific Square Feet = floorspace included in buildings within that category, which actually use that particular energy source.

This measure of intensity is used when referring to a specific fuel intensity such as natural gas. For example, the natural gas intensity in office buildings actually using natural gas is 57.2 thousand Btu per square foot.

For consistency with the 1989 CBECS, the intensities in Section 3, "Detailed Tables," are referred to as Gross Energy Intensities and Conditional Energy Intensities.

CBECS Data Used in This Report

The statistics published in this report are from a randomly selected sample consisting of approximately 6,600 commercial buildings. This sample, based on a multistage area probability design, supplemented by a list sample of "large buildings," "recently constructed buildings," and "special buildings," represents the 4.8 million commercial buildings in the United States as of the spring of 1992.

EIA incorporated a longitudinal component into the 1992 CBECS by revisiting many of the same buildings that were sampled for the 1986 CBECS. The longitudinal data, which are not included in this report, provide an opportunity to study change in energy consumption between 1986 and 1992 at the building level. An analysis of these longitudinal data will be undertaken at a later date.

The four major energy sources for which billing data were collected in 1992 were electricity, natural gas, fuel oil (including kerosene), and district sources (steam, hot water, or chilled water from a central plant or utility). The use of other energy sources in the building, such as propane, wood, coal, and solar energy, was also determined during the building interview. However, with the exception of wood, no consumption statistics were gathered on these energy sources.

The consumption and expenditures estimates for the major energy sources for calendar year 1992 are presented in the form of net aggregate totals as well as consumption per building and dollars per million Btu. All tables include estimates for the amount of energy consumed at the site (site energy consumption) and Tables 3.2 and 3.14 also include estimates of consumption after accounting for conversion and transmission losses that occur in the electricity generation process (primary energy consumption).

This report also includes estimates of energy intensities. Energy intensities provide a method for controlling or adjusting the amount of energy consumed for the effects of various building characteristics, such as size, number of workers, and number of operating hours. The adjustment facilitates comparisons of energy consumption across time, energy sources, and building types.

Estimates of energy consumption and expenditures, for the Nation as a whole and for individual Census regions, are provided for the following building characteristics:

- Building size (square feet of floorspace)
- Building age (year constructed)
- Building structure (such as number of floors, type of wall and roof materials, and building shell conservation features)
- Building use (principal building activity, normal and additional operating hours, number of workers, and type of ownership or occupancy)
- Geographic location (four Census regions, and the nine Census divisions) and climate zone (measured in terms of the 45-year averages of heating and cooling degree-days)
- Energy sources used in the building (electricity, natural gas, fuel oil, district heat, and chilled water, as well as propane, wood, coal, and solar, with billing data obtained from the energy suppliers on the first five sources)
- Energy end uses (space heating, water heating, air conditioning, cooking, and manufacturing)[3]

[3]This report does not provide estimates for how much energy is used for a specific end use, but rather how much energy is used in buildings that use energy for a specific end use. Estimates of how much energy each end use consumes, based on 1989 CBECS data, are reported in *Energy End-Use Intensities in Commercial Buildings*, DOE/EIA-0555(94)2 (Washington, DC, 1994). A report on the 1992 data is also planned.

- Equipment (types of equipment used for space heating and cooling, water heating, lighting, and refrigeration, as well as distribution systems for the heating and cooling equipment; the percent of floorspace that is heated, cooled, and lit by various types of equipment; and the number of personal computers located in the building)

- Energy conservation and energy management practices, such as having a "dedicated" energy manager; reducing energy use during off-hours; having a computerized energy management control system (EMCS); maintaining heating, ventilation, and air conditioning (HVAC) systems regularly; and participating in demand-side management (DSM) programs.

All the numbers presented in this report are estimates rather than exact measures for the population. As described in Appendix B, "Nonsampling and Sampling Errors," the accuracy of each estimate is indicated by the relative standard error (RSE). No estimates were published that were based on data from fewer than 20 sample buildings or that had an RSE greater than 50 percent. All the estimates in the detailed tables include corresponding RSE's that can be calculated using RSE row and column factors. Overall, the RSE's for the 1992 CBECS are comparable to those for the corresponding aggregates from the 1989 survey, indicating a continuing high accuracy of the survey estimates. Unless otherwise noted, all differences between the statistics in Section 2, "At a Glance," are statistically significant. (See Section 3, "Detailed Tables," for further discussion of statistical significance.)

Because CBECS is a sample survey, every estimate of energy consumption has a standard error associated with it. Consequently, the apparent difference between any two numbers may not be statistically significant and, therefore, not a true difference. The apparent changes in electricity and natural gas consumption between 1989 and 1992 illustrate this principle. In the 1989 CBECS, electricity consumption was 2.8 quadrillion Btu, while in the 1992 CBECS, electricity consumption was 2.6 quadrillion Btu—a 7-percent decrease. In the 1989 CBECS, natural gas consumption was 2.1 quadrillion Btu, while in 1992, it was 2.2 quadrillion Btu—a 5-percent increase. However, given the magnitude of sampling error, the differences in both examples are not statistically significant. (See Section 3, "Detailed Tables," and Appendix B, "Nonsampling and Sampling Errors," for further discussion about calculating the standard error.)

The data for this report are based on the Building Characteristics Survey (Form EIA-871A) and the Energy Suppliers Survey (Forms EIA-871C through F). All data in this report are aggregated; any information on individual building names and addresses is confidential.

EIA gratefully acknowledges the cooperation of respondents and their energy suppliers for providing the information used to produce the estimates in this report.

Organization of This Report

This introductory section is followed by two sections: Section 2, "At a Glance," highlights information of special interest, summarizes a detailed breakdown of the data that are provided in Section 3, "Detailed Tables," and provides analysis that can be reproduced using CBECS Public Use Data files.[4] (For information about ordering these data files, see Appendix I, "Related EIA Publications on Energy Consumption.")

- Appendix A, "How the Survey Was Conducted," describes the sample design and data collection procedures.

- Appendix B, "Nonsampling and Sampling Errors," discusses adjustments to the collected data and factors affecting data quality.

- Appendix C, "CBECS Coverage Related to EIA Supply Surveys," discusses differences between the coverage of this survey and the EIA supply data sources.

- Appendix D, "Comparisons of CBECS, 1983 to 1992," compares the type of data that have been collected in each CBECS cycle, beginning with the 1983 survey.

[4]Exact replication of some figures may not be possible due to additional masking of some variables performed on the Public Use Data files for confidentiality.

- Appendix E, "Types of Buildings," describes the principal building activity categories.

- Appendix F, "U.S. Climate Zones and Census Regions and Divisions Maps," contains maps showing the Census regions and divisions and the climate zones by which the data in this report are organized.

- Appendix G, "Survey Forms," reproduces Forms EIA-871A and C through F, used to collect the data on which all estimates in this report are based. (The 1992 CBECS had no Form EIA-871B.)

- Appendix H, "Metric Conversion Factors," presents metric conversion factors.

- Appendix I, "Related EIA Publications on Energy Consumption," provides a list of related energy consumption publications for readers interested in earlier CBECS publications or consumption reports for the other sectors.

These appendices are followed by a glossary of statistical and engineering terms used in this report.

Evaluating the Energy Value of Electricity Consumption

Electricity consumption can be expressed in terms of either

- physical units, most commonly kilowatthours, or
- a common thermal unit, most commonly British thermal units (Btu).

The physical unit provides a clear understanding of the amount of a particular energy source being used, while the thermal unit is a measure of convenience used to aggregate or compare various energy sources measured in different physical units. Converting kilowatthours of electricity to Btu is not a trivial issue, because the amount of input energy needed to create a kilowatthour of electricity is far greater than the amount of useful energy in the kilowatthour at its point-of-use (in the CBECS, the building). Therefore, meaningful conversions of electricity use from kilowatthour to Btu can be given in terms of:

- Site (point-of-use) electricity at the universal value of 3,412 Btu per kilowatthour. This measurement is most useful to engineers, energy managers, building owners and others trying to improve energy efficiency.
- Primary (embodied) electricity, at a value that reflects the content of the energy inputs used to produce the electricity. This rate is most useful to policymakers and analysts who are considering global resources and environmental issues. (It is about 3 times the amount of site electricity use, as discussed below.)

For convenience and consistency, the factor used in this report to convert electricity use to primary energy is 10,302 Btu per kilowatthour. This factor represents the approximate average energy input to the generation process for fossil-fuel utility plants in the United States in 1992 (Energy Information Administration, *Monthly Energy Review* [August 1994]). Note: Specific conversion values for the range of electricity estimates in this report are unknown. Applying the single value to the range of electricity estimates in this report provides only a rough approximation of primary electricity because:

- for some types of utility energy inputs, hydroelectric, wood/waste, wind, and solar (thermal or photovoltaic), there is no generally accepted conversion rate
- the fossil-fueled, nuclear and geothermal generation processes have known, but different, conversion rates, so the overall conversion rate for these energy sources is a function of their mix.

Estimates of primary electricity using this conversion factor should thus be treated with caution. They should be considered rough alternative measures to site energy as indicators of the importance of electricity in the commercial buildings sector.

At a Glance

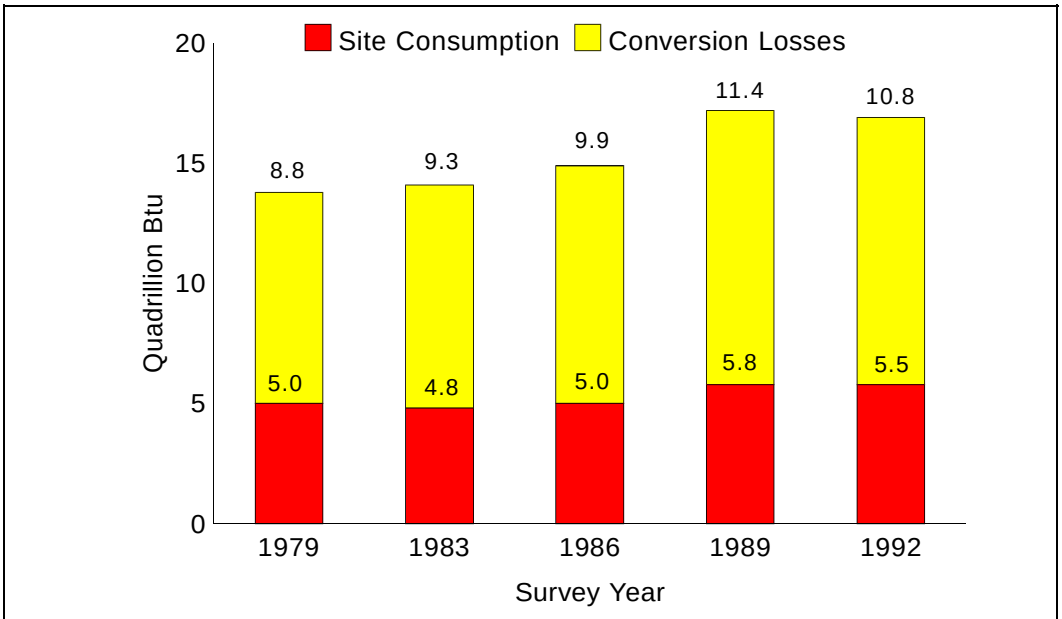
2. Energy Consumption and Expenditures in Commercial Buildings, 1992

This section aims to provide a snapshot of what occurred in 1992 in a very complex part of the energy picture—the commercial buildings sector. An overview of consumption and expenditures for the sum of the four major energy sources in the commercial buildings sector is followed by discussions of the impacts of building characteristics and energy efficiency features and energy management programs on total energy consumption. The section also discusses the impacts of building characteristics on electricity and natural gas consumption, as well as topics related to those energy sources: electric utility-sponsored Demand-Side Management (DSM) programs and natural gas transported for the account of others. An overview of fuel oil and district heat consumption and a comparison between energy consumption in government-owned and nongovernment-owned buildings conclude this section.

Total Energy Consumption and Expenditures

Total site energy consumption and expenditures in the U.S. commercial sector remained relatively stable between 1989 and 1992, following an annual increase of about 1 percent per year between 1979 and 1989 (Figure 2.1). In 1992, the Nation's 4.8 million commercial buildings (67.9 billion square feet and 71.2 million workers) consumed 5.5 quadrillion Btu of electricity, natural gas, fuel oil, and district heat (steam or hot water from a central plant or utility), with corresponding expenditures of $71.8 billion. These consumption figures represent the amount of energy delivered to the building and exclude losses associated with the electricity-generation and distribution process. Including these losses, the total amount of energy used in the commercial sector in 1992 was 10.8 quadrillion Btu.

Figure 2.1. Total Energy Consumption by Survey Year, 1979-1992

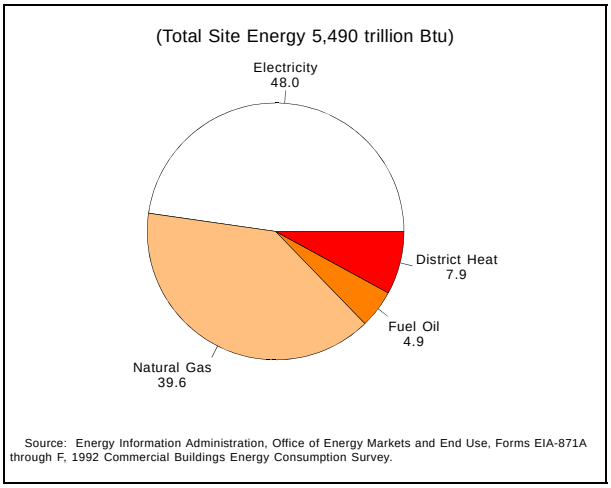


Note: Conversion losses were calculated using approximate fossil-fuel heat rates for electricity for each survey year using the Btu per kilowatthour reported in the EIA Monthly Energy Review, August 1994, Table A8.

Source: Energy Information Administration, Office of Energy Markets and End Use, Nonresidential Buildings Energy Consumption Surveys 1979, 1983, and 1986 and Commercial Buildings Energy Consumption Surveys 1989 and 1992.

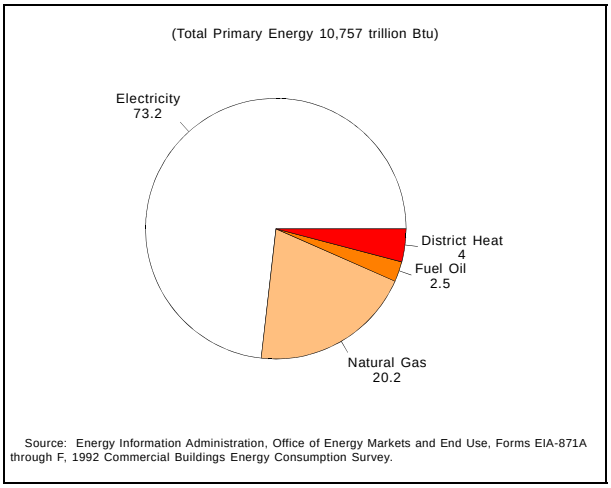
At the site, buildings used somewhat more electricity than natural gas—2.6 quadrillion Btu and 2.2 quadrillion Btu, respectively. Site electricity accounted for 48.0 percent of the total site energy consumption, and natural gas accounted for 39.6 percent of that total. Taking into account the conversion losses of about 5.3 quadrillion Btu estimated to have occurred in the electricity-generation process, electricity consumption totaled 7.9 quadrillion Btu, 73.2 percent of the total primary energy consumption, and slightly over three times the consumption of natural gas. The remaining 0.7 quadrillion Btu was divided between fuel oil, which accounted for 0.3 quadrillion Btu, or 4.9 percent of the site energy consumption, and district heat, which accounted for 0.4 quadrillion Btu, or 7.9 percent of the site consumption (Figures 2.2 and 2.3). In 1989, site electricity consumption made up 47.9 percent of the total 5.8 quadrillion Btu consumed in commercial buildings. Natural gas consumption accounted for 35.8 percent of that total, while fuel oil represented 6.2 percent and district heat represented 10.1 percent of that total.

Figure 2.2. Percent of Site Energy Consumption by Energy Source, 1992



Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A through F, 1992 Commercial Buildings Energy Consumption Survey.

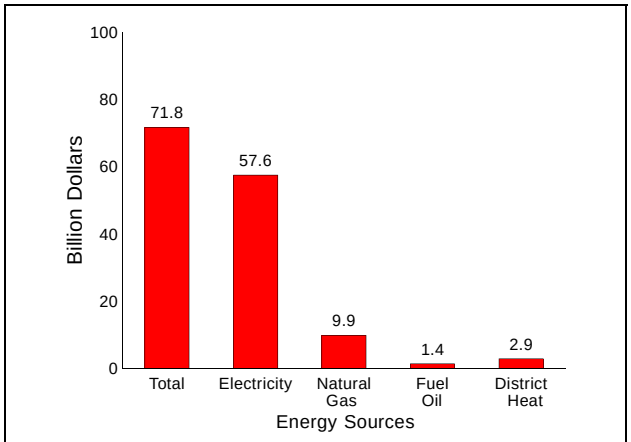
Figure 2.3. Percent of Primary Energy Consumption by Energy Source, 1992



Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A through F, 1992 Commercial Buildings Energy Consumption Survey.

Total expenditures for the four major energy sources amounted to $71.8 billion: $57.6 billion for electricity, $9.9 billion for natural gas, $1.4 billion for fuel oil, and $2.9 billion for district heat (Figure 2.4). The average energy expenditure for commercial floorspace was $1.06 per square foot. Energy expenditures are collected from the energy suppliers and, therefore, reflect the cost of energy at the site (the building). Between 1989 and 1992, there was no statistically significant difference in energy expenditures.

Figure 2.4. Total Energy Expenditures, 1992

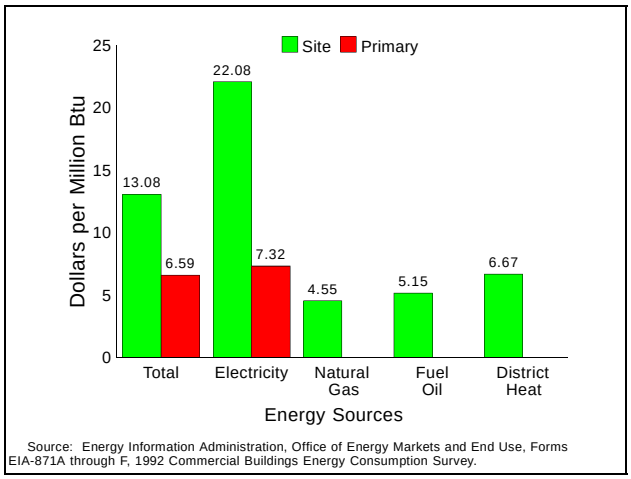


Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A through F, 1992 Commercial Buildings Energy Consumption Survey.

From the consumer's viewpoint, site electricity is the most expensive source of energy on a dollar-per-Btu basis. However, a major portion of this cost is associated with energy losses during the generation and distribution of electricity. This difference can be seen by calculating the approximate cost of this electricity per million Btu of input energy. For example, in 1992, total electricity expenditures were $57.6 billion. Site electricity consumption was 2.6 quadrillion Btu and primary electricity consumption was 7.9 quadrillion Btu. Expenditures for electricity at the site were about $22 per million Btu, while expenditures for primary energy were approximately $7 per million Btu, a figure comparable to expenditures for the other energy sources (Figure 2.5).

Energy Intensities

Figure 2.5. Energy Expenditures per Million Btu, 1992



Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A through F, 1992 Commercial Buildings Energy Consumption Survey.

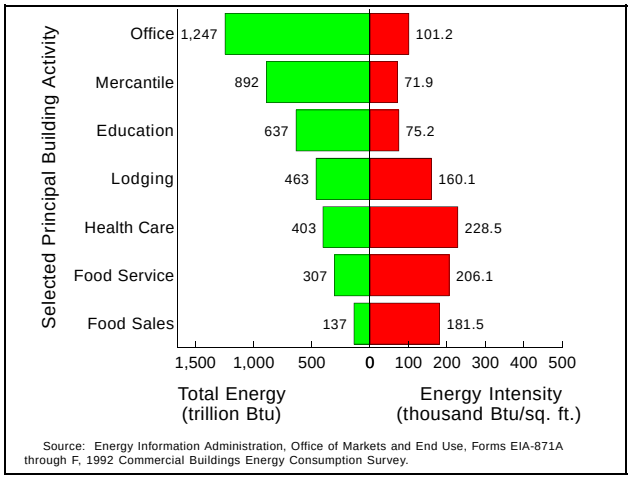
Energy intensities, or the amount of energy consumed per square foot of building floorspace, are useful measures for comparing the energy consumption of the various sizes and categories of buildings. (See the Introduction and Glossary for a definition of Energy Intensities.) In 1992, the gross or total energy intensity of commercial buildings was approximately 81 thousand Btu per square foot, with natural gas and site electricity showing moderate conditional intensities—48 thousand Btu per square foot and 39 thousand Btu per square foot, respectively.

Fuel oil had a relatively low intensity (21 thousand Btu per square foot), while the district heat intensity was high (83 thousand Btu per square foot). Beginning with the 1986 CBECS, intensities for fuel oil have declined somewhat, while other energy intensities have remained almost constant.

The relative difference in energy intensities remained the same even after controlling for heating degree-days: the natural gas intensity was 10.4 Btu per square foot-heating degree-day; the electricity intensity was 8.9 Btu per square foot-heating degree-day; the fuel oil intensity was 4.0 Btu per square foot-heating degree-day; and the district heat intensity was 15.8 Btu per square foot-heating degree-day.

Impacts of Building Characteristics on Total Fuel Consumption

Figure 2.6. Total Energy Consumption and Energy Intensities for Selected Principal Building Activities, 1992



Source: Energy Information Administration, Office of Markets and End Use, Forms EIA-871A through F, 1992 Commercial Buildings Energy Consumption Survey.

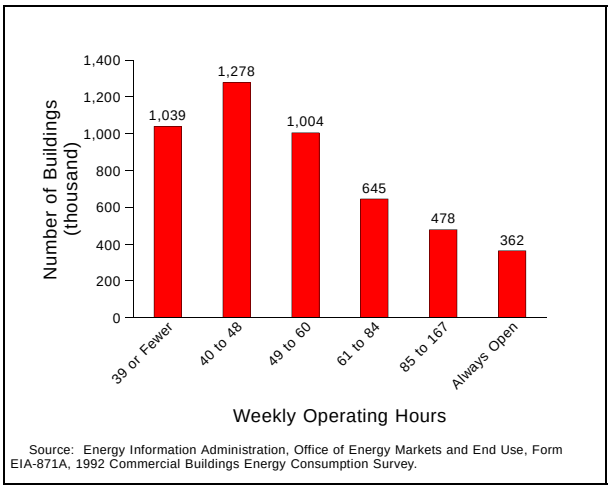
The total energy consumption of commercial buildings was affected by their size, principal building activity, operating hours, location, and year of construction.

- **Size**: The size of a building was the most important determinant of total energy consumption; the larger a building, the higher its total energy consumption. Because size is such a dominant factor in total energy consumption, energy intensities, or consumption per square foot, are used as a common measure to discuss energy use. Energy intensities for consumption of the sum of the four major energy sources did not show a pattern across the various building size categories.

- **Principal Building Activity**: The type of activity that occurs in a building affects how intensively a building uses energy. While office buildings, mercantile and service buildings, and education buildings consumed an overall greater amount of energy among building activities, buildings with these activities tended to use energy less intensively. Food sales, food service, health care, and lodging buildings used energy intensively (Figure 2.6). The energy expenditures per square foot for buildings with those activities were also relatively higher, ranging between $1.89 per square foot for lodging buildings to $3.16 per square foot for food sales buildings.

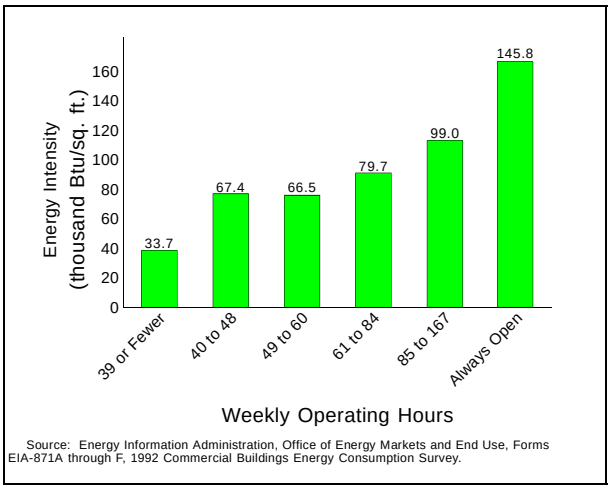
- **Weekly Operating Hours:** Commercial buildings are often characterized as operating on a 40-hour per week schedule. However, that is a misperception, as CBECS data indicate a wider range of operating hours. Only 27 percent of commercial buildings were open from 40 to 48 hours per week (Figure 2.7). Operating hours had a significant impact on total energy intensity in the building. The longer a building was open, the more intensively it used energy (Figure 2.8). This pattern also remained true for electricity and natural gas consumption.

Figure 2.7. Number of Buildings by Weekly Operating Hours Category, 1992



Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-871A, 1992 Commercial Buildings Energy Consumption Survey.

Figure 2.8. Energy Intensity by Weekly Operating Hours Category, 1992

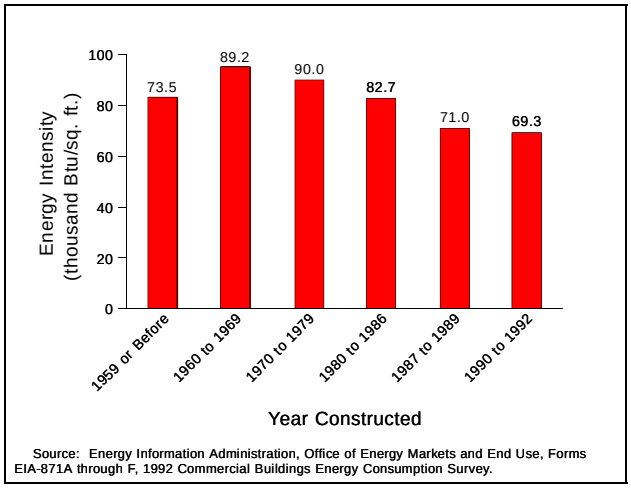


Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A through F, 1992 Commercial Buildings Energy Consumption Survey.

- **Location:** Buildings in the South accounted for about 33 percent of the total 5.5 quadrillion Btu of the site energy consumed in the commercial sector. Buildings in the Midwest consumed 29 percent of that total, while buildings in the Northeast consumed 20 percent and buildings in the West consumed 18 percent of the total. Buildings in the Midwest consumed more energy per square foot (91.3 thousand Btu) than was consumed by buildings in the other regions of the United States (77.3 thousand Btu per square foot).

- **Year of Construction**: Although it may appear there is a trend towards lower intensities in newer buildings (Figure 2.9), the conversion losses associated with electricity generation must be taken into account. The 1992 CBECS found that, although the site energy consumption of buildings constructed after 1986 was less than that of older buildings, the energy consumption of the two groups of buildings was about the same after accounting for conversion losses during the electricity generation process, due, in large part, to the increased use of electricity for a variety of energy services in newer buildings. Buildings constructed after 1986 consumed about 70 thousand Btu per square foot of energy, while buildings constructed in or before 1986 consumed about 82 thousand Btu per square foot of energy. In addition to newer buildings using more electricity for refrigeration, air conditioning, and office equipment, the number of new buildings using electricity for main space heating was 6 percent more than older buildings. Since approximately 3 Btu of fossil fuels are required to produce each Btu of electricity, the primary energy consumption of the older and newer buildings was about the same—164 thousand Btu per square foot for buildings constructed after 1986 and 158 thousand Btu per square foot for buildings constructed in or before 1986.

Figure 2.9. Energy Intensity by Year Constructed, 1992



Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A through F, 1992 Commercial Buildings Energy Consumption Survey.

Impact of Energy Efficiency Features and Energy Management Programs

In response to customer requests that EIA provide more information on energy efficiency and energy management, the 1992 CBECS included a number of new questions about energy efficiency features, energy management practices, and the reduction of equipment use during off-hours. The survey found that buildings that had undertaken energy conservation and management measures were, on average, larger, consumed more total energy, and had longer operating hours than buildings without those measures (Table 2.1). Those facts may have indeed provided the initial incentive to equip the buildings with conservation features, since buildings consuming more total energy would likely experience a shorter payback period on conservation investments.

Table 2.1 Summary Statistics of Buildings with and Without Conservation Features and Energy Management Practices, 1992

	Average Floorspace (square feet)		Average Sum of Major Fuel Consumption (million Btu)		Average Weekly Operating Hours	
	With	Without	With	Without	With	Without
Conservation Features						
Any	14,783	7,735	1,241	178	59	47
Building Shell	14,695	9,989	1,251	355	59	51
HVAC[a]	19,310	7,991	1,804	360	65	51
Lighting	25,004	10,592	2,377	742	68	55
Energy Management Practices						
EMCS[b]	60,725	11,720	6,663	858	68	58
Energy Audit	28,343	12,394	2,834	936	69	57
Energy Manager	46,846	13,785	6,013	1,092	69	58

[a]Heating, Ventilation, and Air Conditioning.
[b]Energy Management and Control System.
Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A through F, 1992 Commercial Buildings Energy Consumption Survey.

The data collected in the CBECS provide information on energy consumption in commercial buildings during 1992. Therefore, in its examination of the effects of conservation features, CBECS is limited to comparing the energy consumption of buildings with those features to buildings without those features. As presently collected, the CBECS data cannot be used to study the effectiveness of conservation measures. To study the effectiveness of those conservation features, it would be necessary to measure the energy consumption of a building before and after implementation. Conceivably, buildings with effective conservation features would have lower energy intensities than buildings without those features. However, because buildings with conservation and management features were, on average, larger, consumed more total energy, and had longer operating hours than buildings without conservation and management features, it is reasonable to suggest that those buildings consumed energy differently, and had different energy intensities, apart from the effectiveness of those features. CBECS data comparing the energy consumption of buildings with conservation features and buildings without those features provide a profile of those buildings but do not measure the effectiveness of energy efficiency or energy management programs.

It is not surprising, therefore, that the 1992 survey results revealed the energy intensities for buildings with energy efficiency or management features to be the same or even greater than the energy intensities of buildings without those features. Even when examined within different categories—size, region, ownership, year of construction, weekly operating hours, principal building activity, and level of energy consumption—the energy intensities of buildings with energy efficiency or management features were, with few exceptions, either the same or higher than buildings without these features.

Electricity Consumption

In 1992, commercial buildings consumed 2.6 quadrillion Btu of site electricity (765 billion kilowatthours), with expenditures for this electricity totaling $57.6 billion.[5]

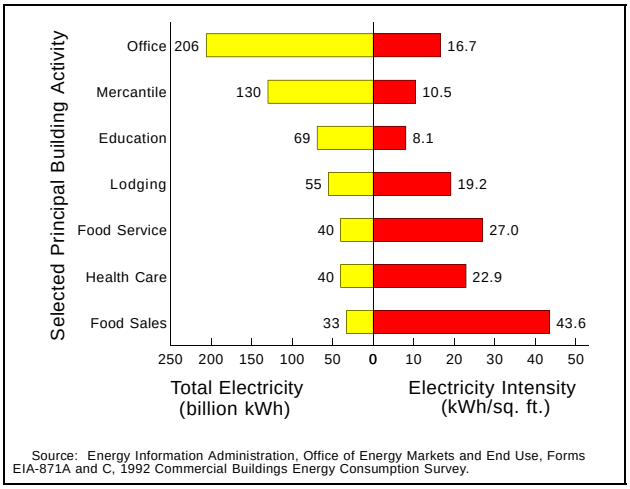
[5]In this discussion, estimates of electricity consumption are for site consumption.

Impacts of Building Characteristics on Electricity Consumption

The electricity consumption of commercial buildings was also affected by their principal activity, location, and year of construction. Size was not a major factor in determining how intensively the building used electricity.

- **Principal Building Activity:** Office buildings had the highest total electricity consumption, even though mercantile and service buildings accounted for slightly more of the total commercial floorspace. Food sales, food service, and health care buildings were the most electricity intensive CBECS buildings (Figure 2.10). The high intensities can be partly explained by the equipment associated with these building activities. All of these buildings were likely to use air conditioning; food sales and food service buildings were likely to use refrigeration. Although food sales and food service buildings made up only about 8 percent of commercial buildings, they held 44 percent of the total walk-in refrigerator or freezer units and 48 percent of the linear square feet of refrigeration or freezer cases or cabinets.

Figure 2.10. Electricity Consumption and Intensity for Selected Principal Buildings Activities, 1992

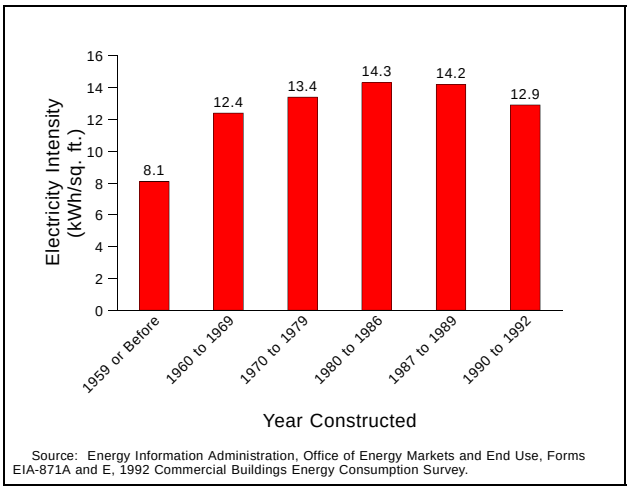


Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A and C, 1992 Commercial Buildings Energy Consumption Survey.

- **Location:** Buildings in the West and the South regions had a higher electricity intensity than buildings in the Midwest and the Northeast regions (12.6 kilowatthours per square foot and 10.1 kilowatthours per square foot, respectively), primarily due to greater use of air conditioning in the West and South. An analysis of end-use consumption based on the 1989 CBECS data showed that cooling accounted for 10 percent of electricity consumption in the West and 14 percent of electricity consumption in the South. In comparison, cooling made up 6 percent of electricity consumption in the Northeast and 8 percent in the Midwest.[6]

- **Year of Construction:** The newer the building, the more intensively it used electricity, due largely to the increased use of electrical equipment such as refrigeration and air conditioning in newer buildings (Figure 2.11). Although the 1990 to 1992 category seems to indicate that the trend might be reversing, the difference is not statistically significant. Later surveys will show if this is actually a trend. The end-use analysis of the 1989 CBECS data also showed that use of office equipment made up a higher percentage of electricity consumption in newer buildings than in older buildings.[7]

Figure 2.11. Electricity Intensity by Year Constructed, 1992



Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A and E, 1992 Commercial Buildings Energy Consumption Survey.

[6]Energy Information Administration, *Energy End-Use Intensities in Commercial Buildings*, DOE/EIA-0555(94)/2(Washington, DC, September 1994).

[7]op cit.

Estimates of DSM Program Participation

In 1992, questions about DSM participation were asked during both components of the CBECS. (See Appendix A, "How the Survey Was Conducted," for details about the Buildings Characteristics Survey and the Energy Suppliers Survey.) Both the building respondents and their electricity and natural gas suppliers were asked questions about their DSM program participation for the previous 3 years. The range of response choices to those questions in the building questionnaire included DSM programs that were sponsored by either an electricity or natural gas utility, by an in-house program, or by a third party such as an energy service company or contractor. DSM participation, as reported by the building respondent, meant that the building participated in at least one of these programs, but not necessarily all of the programs that were available to it. The only DSM question that the electricity and natural gas suppliers were asked was whether the building participated in a DSM program that they sponsored.

Nationwide, over 3.5 million buildings (76 percent of the CBECS buildings that used electricity) were served by an electric utility that offered a DSM program. Since the remaining 24 percent of commercial buildings that used electricity did not have the opportunity to participate in DSM, they were not included in this analysis.

The 1992 CBECS found that building respondents reported a much lower DSM participation rate than did energy suppliers. Of the buildings that were offered a DSM program, building respondents indicated that less than 6 percent of the buildings (representing 12 percent of the floorspace) participated in an electric utility sponsored program. On the other hand, of the buildings that were offered a DSM program, electricity suppliers indicated that almost 46 percent of the buildings (representing 50 percent of the floorspace) participated in a DSM program (Table 2.2). (See Appendix B, "Nonsampling and Sampling Errors," for a more detailed discussion of these discrepancies.) The remainder of this discussion is based on the responses from the electricity suppliers, because the data were based on actual records as opposed to respondent recall.

> With the exception of Table 3.49, the data on DSM participation presented in the Detailed Tables in Section 3 and in the companion volume to this report, *Commercial Buildings Characteristics 1992*, are based solely on information gathered from the building respondent and include programs sponsored by a utility, in-house or a third party, such as an energy service company (ESCO).
>
> The data presented in Table 3.49 are limited to electric utility DSM programs as reported by the building respondent and the electricity suppliers to those buildings.

DSM-participating buildings were, on average, larger (15,856 square feet per building for participants versus 13,923 square feet per building for nonparticipants). However, no statistically significant difference was found between electricity intensities for DSM-participating and non-DSM-participating buildings (11.6 kilowatthours per square foot and 11.5 kilowatthours per square foot, respectively). This should not be construed as an indication that participation in a DSM program has no effect, or even leads to higher use. It is impossible to state with certainty the reason for the absence of any real differences.

The Northeast showed a greater percentage of commercial floorspace in buildings participating in DSM programs sponsored by electric utilities than did buildings in the other Census regions and in the United States as a whole (Table 2.2).

Table 2.2. Participation in Electric Utility-Sponsored DSM Programs by Census Region as Reported by Building Respondent and Electric Utility Respondent, 1992

Building Characteristics	Participation in Electric Utility-Sponsored DSM Programs					
	According to Building Respondent			According to Utility Respondent		
	Number of Buildings Using Electricity (thousand)	Floorspace of Buildings Using Electricity (million square feet)	Electricity Consumption (billion kWh)	Number of Buildings Using Electricity (thousand)	Floorspace of Buildings Using Electricity (million square feet)	Electricity Consumption (billion kWh)
All Buildings[a]	**3,501**	**53,428**	**614**	**3,501**	**53,428**	**614**
Northeast	704	12,108	109	704	12,108	109
Midwest	948	14,753	165	948	14,753	165
South	1,082	14,936	183	1,082	14,936	183
West	767	11,631	157	767	11,631	157
DSM Participants	**205**	**6,572**	**93**	**1,596**	**26,898**	**311**
Northeast	77	2,721	34	426	7,771	71
Midwest	57	1,765	20	378	6,311	67
South	23	789	19	477	6,633	85
West	47	1,297	19	315	6,182	88
DSM Nonparticipants	**3,296**	**46,856**	**521**	**1,905**	**26,530**	**302**
Northeast	627	9,388	75	278	4,337	38
Midwest	890	12,988	145	569	8,441	98
South	1,059	14,147	164	605	8,303	98
West	720	10,334	138	452	5,449	69

[a]All buildings which were offered a DSM program by their electric utility.

Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A and E, 1992 Commercial Buildings Energy Consumption Survey.

Natural Gas Consumption

In 1992, commercial buildings consumed 2.2 quadrillion Btu of natural gas (2,113 billion cubic feet), with expenditures totaling $9.9 billion. The amount of natural gas per square foot consumed by a building varied according to the characteristics of the building. Natural gas transported for the account of others made up a small, but growing, part of the total natural gas consumption.

Impacts of Building Characteristics on Natural Gas Consumption

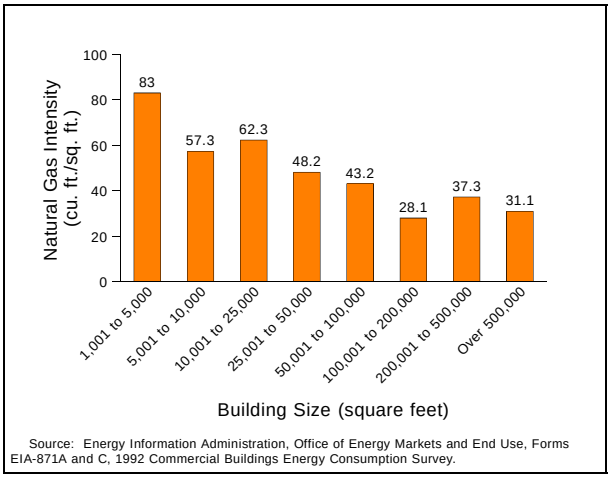
Similar to total energy and electricity consumption, the natural gas consumption of commercial buildings was affected by their size, principal activity, location, and year of construction.

- **Size:** Unlike the sum of major fuel consumption, the larger the building, the less intensively it used natural gas (Figure 2.12). This pattern was probably due to the use of natural gas mostly for space heating. Since the ratio of exterior surface to total floorspace was smaller in larger buildings, building interiors required less space heating to maintain a comfortable temperature.[8]

- **Principal Building Activity:** Food service buildings had higher natural gas intensities than other building activities (Figure 2.13). This high intensity may have been due to the fact that these buildings were generally smaller (87 percent of all food service buildings were 10,000 square feet or less), and tended to have longer weekly operating hours (57 percent of all food service buildings were open 85 hours per week or more). Furthermore, food service buildings using natural gas usually used it for cooking. Among food service buildings using natural gas, 86 percent used it for cooking, compared with only 11 percent of non-food service buildings using natural gas.

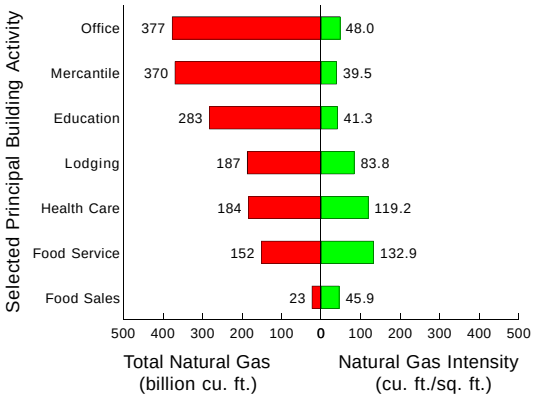
[8]Energy Information Administration, *Energy End-Use Intensities in Commercial Buildings*, DOE/EIA-0555(94)/2 (Washington, DC, September 1994).

Figure 2.12. Natural Gas Intensity by Building Size, 1992



Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A and C, 1992 Commercial Buildings Energy Consumption Survey.

Figure 2.13. Total Natural Gas Consumption and Natural Gas Intensities for Selected Principal Building Activities, 1992

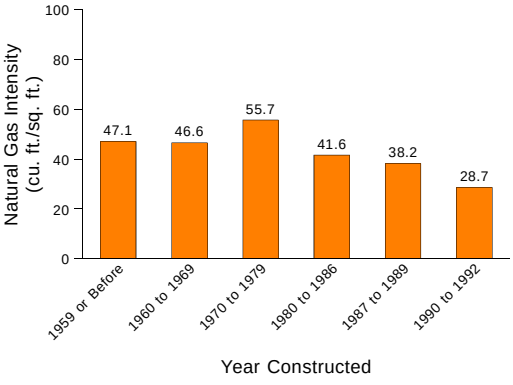


Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A and C, 1992 Commercial Buildings Energy Consumption Survey.

- **Location:** Natural gas intensities were highest in the Midwest, at 52.7 cubic feet per square foot, and in the South at 50.7 cubic feet per square foot. In the Northeast and West natural gas intensities were 40.2 cubic feet per square foot and 39.3 cubic feet per square foot, respectively. Natural gas was the dominant space heating energy source in the Midwest. In the Northeast, both natural gas and fuel oil were commonly used as space heating energy sources, with natural gas being used for cooking in buildings heated by fuel oil.

- **Year of Construction:** The newer the building, the less intensively it used natural gas, possibly due to higher efficiency heating equipment or improvements in building shell construction (Figure 2.14).

Figure 2.14. Natural Gas Intensity by Year Constructed, 1992



Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A and C, 1992 Commercial Buildings Energy Consumption Survey.

Natural Gas Transported for the Account of Others

The 1992 survey was the second CBECS to collect data on natural gas transported for the account of others (also called spot market gas), which is natural gas bought by customers directly from a gas producer or intermediary, such as a broker, rather than from a local distribution company (LDC). The LDC then delivers the gas to the building via its pipelines. Buildings that consume large amounts of natural gas often find natural gas bought from the source or through a broker to be less expensive.

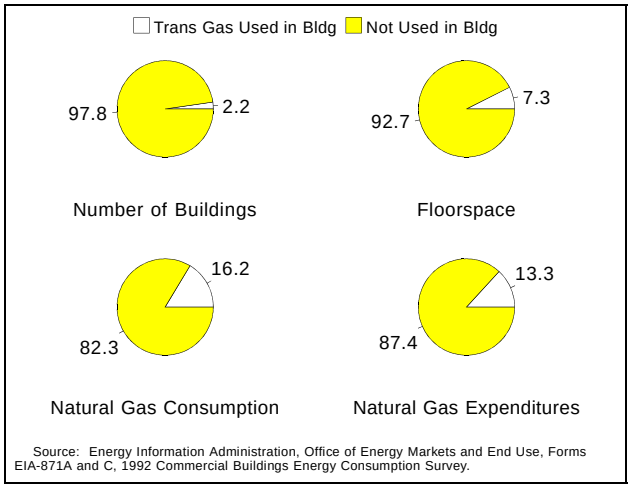
Of all commercial buildings using natural gas, only about 2 percent used natural gas transported for the account of others. However, buildings in which natural gas transported for the account of others was consumed (along with natural gas purchased from an LDC) comprised 7.3 percent of the floorspace and 16.2 percent of the total natural gas consumption. Those figures confirm that large buildings were the primary consumers of natural gas transported for the account of others in 1992. Buildings using natural gas transported for the account of others were responsible for only 13.3 percent of the 1992 natural gas expenditures, which may indicate that purchasing natural gas directly from a gas producer or intermediary was less expensive for those buildings (Figure 2.15). Comparable data from the 1989 CBECS indicated that less than 1 percent of all buildings using natural gas used natural gas transported for the account of others. Those buildings made up about 5.5 percent of all floorspace and 13.5 percent of all natural gas consumption.

In 1992, buildings that used natural gas transported for the account of others used 343 cubic feet of natural gas (16.2 percent of all natural gas consumption). Only 279 cubic feet of that natural gas was actually transported for the account of others (13 percent of all natural gas consumption). Therefore, in buildings that used natural gas transported for the account of others, 81 percent of the natural gas was transported and the remaining portion was purchased from the LDC.

The 1989 and 1992 CBECS revealed the following changes in the consumption of natural gas transported for the account of others:

- In 1989, natural gas transported for the account of others represented 12 percent of all natural gas consumption in commercial buildings. In 1992, natural gas transported for the account of others represented 13 percent[9] of all natural gas consumption in commercial buildings.

Figure 2.15. Summary Statistics of Natural Gas Transported for the Account of Other Among Buildings Supplied with Natural Gas, 1992 (Percent)



Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A and C, 1992 Commercial Buildings Energy Consumption Survey.

- In 1989, 24,000 commercial buildings, representing 2.3 billion square feet of floorspace, used natural gas transported for the account of others. By 1992, this number had risen nearly one and one-half times, to 58,000 buildings, representing 3.3 billion square feet of floorspace.

- The total consumption of natural gas transported for the account of others was 242 billion cubic feet in 1989 and 279 billion cubic feet in 1992; this increase was not statistically significant.

Fuel Oil and District Heat Consumption

The CBECS collects billing data from the energy suppliers on two other major energy sources—fuel oil and district heat. Among the CBECS findings on fuel oil:

- Approximately 12 percent of commercial buildings, representing almost 20 percent of commercial floorspace, used fuel oil. In 1992, those buildings consumed 0.3 quadrillion Btu of fuel oil, or 5 percent of the total site energy consumption in the U.S. commercial building sector.

- In 1992, 71 percent of the fuel oil consumption in the commercial buildings sector occurred in the Northeast Census region. About 10 percent of fuel oil consumption occurred in the Midwest and 18 percent occurred in the South. Almost all of the fuel oil consumption in the South was concentrated in the South Atlantic Census division. However, fuel oil consumption in the West was negligible (Figure 2.16).

- Fuel oil was used mainly for space heating. While fuel oil was used as a main heating source in the Northeast, it was more commonly used as a secondary heating source in the other three Census regions. About 96 percent of the fuel oil consumption occurred in commercial buildings that used fuel oil for main or secondary heating.

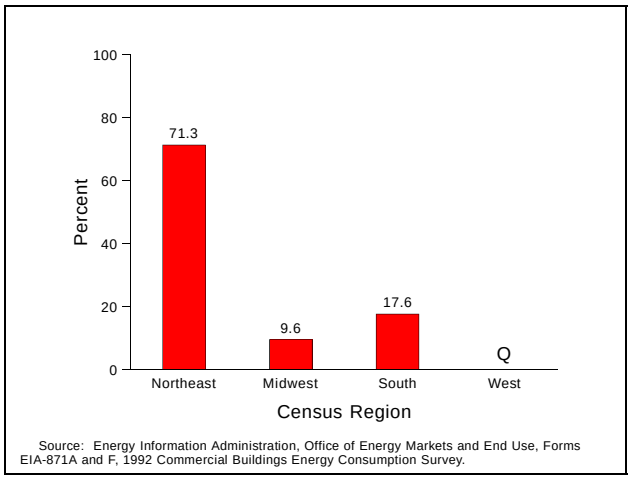
[9]In 1992, 17 percent of commercial natural gas deliveries were estimated to be for the account of others (Energy Information Administration, *Natural Gas Annual 1992*, DOE/EIA-0131(93)).

Among the CBECS findings on district heat:

- In 1992, district heat was used as an energy source in about 2 percent of commercial buildings. However, those buildings constituted about 8 percent of commercial building floorspace. In 1992, those buildings consumed about 0.4 quadrillion Btu, or 8 percent of the total site energy consumption.

- The overall consumption of district heat was relatively low in commercial buildings, when compared with the consumption of the other major energy sources. The conditional intensity for district heat was about 83 thousand Btu per square foot. In contrast, the conditional intensity for electricity was 39 thousand Btu per square foot. Natural gas had a conditional intensity of 48 thousand Btu, while the conditional intensity for fuel oil was 21 thousand Btu.

Figure 2.16. Percent of Fuel Oil Consumption by Census Region, 1992



Source: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-871A and F, 1992 Commercial Buildings Energy Consumption Survey.

Wood and Solar Energy Consumption

Information on the use of wood and solar energy was also obtained from building owners, managers, or tenants. The 1992 CBECS was the first survey in which building respondents who reported using wood as an energy source were asked how much wood was burned in their buildings and whether that wood was purchased or obtained free of charge. Building respondents were also asked about the use of various types of solar energy, including photovoltaic cells, solar thermal panels, or passive solar features. Among the CBECS findings on wood:

- Wood was used in about 2 percent (100,000 buildings) of the surveyed buildings; in 66 percent of those buildings, wood was used for main space heating.

- Almost 66 percent of the 100,000 buildings that used wood (2 percent of all respondents) indicated that they had used between one and nine cords of wood per building.

- About 32 percent of the respondents using wood indicated that they had purchased the wood; the other respondents were provided wood free of charge from another source.

- Buildings using wood consumed considerably less electricity, natural gas, fuel oil or district heat per square foot. Buildings using wood consumed 34.6 thousand Btu per square foot of the major energy sources compared with the national average of 80.9 thousand Btu per square foot for commercial buildings.

- Buildings using wood were predominantly mercantile and service buildings or nonrefrigerated warehouses. They also tended to be older and smaller, with few workers, and located in the Midwest and South regions.

Among the CBECS findings on solar energy:

- Less than 1 percent of the CBECS respondents used solar energy as a source of energy in 1992.

- The most common type of solar energy reported was passive solar features.

- Buildings using solar energy or having some passive solar features consumed the major energy sources slightly more intensively (94.4 thousand Btu per square foot) than all commercial buildings (80.9 thousand Btu per square foot).

- Buildings that used solar energy (either active or passive) were generally smaller and were predominantly either mercantile and service buildings or office buildings. They were located in all four Census regions of the United States.

Energy Consumption in Government Buildings

In 1992, government-owned buildings represented approximately 22 percent of the commercial floorspace and approximately 25 percent of major fuel consumption. Of all major fuel consumption in government-owned buildings, 9 percent occurred in buildings owned by the Federal government, 30 percent occurred in State-owned buildings, and 61 percent occurred in buildings owned by local governments. These data reflect the fact that the majority of government buildings in the CBECS were not Federal, but rather State or locally owned.

The 1992 CBECS found that for most energy-related characteristics the energy consumption between nongovernment-owned buildings and Federal, State, or local government-owned buildings differed little. This finding was rather surprising, in light of data from the *Commercial Buildings Characteristics 1992* report, which showed that government-owned buildings were more likely than nongovernment-owned buildings to practice energy management by installing EMCS's, participating in DSM programs, having energy audits performed, and employing building energy managers. However, there was a statistically significant difference in the gross energy intensities between government-owned buildings with energy managers and nongovernment-owned buildings with energy managers, 99 thousand Btu per square foot and 143 thousand Btu per square foot, respectively.

Federal Government: The passage of the Energy Policy Act of 1992 (EPACT) has led to increased interest in the amount of energy used in buildings owned by the Federal government. EPACT requires Federal buildings to reduce their energy consumption per square foot by 20 percent by the year 2000. The legislation also requires Federal buildings to install energy conservation features by 2005 that will pay for themselves in 10 years or less.

Although CBECS data can be somewhat useful in measuring the overall energy consumption in government-owned buildings, the relatively small sample size of the CBECS prevents the reporting of separate statistics for Federal buildings. Consequently, EIA, in conjunction with the DOE Office of Federal Energy Management Programs, recently conducted a survey of Federal buildings in three Federal regions: Philadelphia (Region 3), Dallas (Region 6), and San Francisco (Region 9). Data from this survey will be available in 1995.