

Characteristics and Energy Use Trends for Major Commercial Building Types

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ABSTRACT

The Commercial Buildings Energy Consumption Survey (CBECS) has collected building characteristics and energy use data from the commercial buildings sector in the United States since 1979. Five building activities—health care, office, retail and service, education, and food service—were selected to examine energy use patterns and trends in this diverse end-use sector.

Health care buildings used energy intensively—total energy (primary and site¹), site electricity, and natural gas intensities were each about twice the average for all commercial buildings. Electricity intensity in health care buildings increased between 1986 and 1995, and natural gas intensity increased between 1983 and 1995. Office buildings consumed the most total energy of all commercial building types. More than 50 percent of site energy in office buildings was consumed for lighting, office equipment, and cooling; consequently, electricity intensity was more than 40 percent higher than the average for all commercial buildings. Retail and service buildings consumed the second highest amount of energy, but total, electricity, and natural gas intensities were each less than average. Education buildings were the largest commercial buildings on average, but were not intensive consumers of energy. Their electricity intensity was less than average, while total and natural gas intensities were about average. Food service buildings, especially small ones, were very intensive users of energy. Electricity and natural gas intensities in food service buildings increased between 1986 and 1995 and were both about three times the average for all commercial buildings.

Introduction

The Commercial Buildings Energy Consumption Survey (CBECS) is a national-level sample survey of commercial buildings conducted by the Energy Information Administration (EIA) of the U.S. Department of Energy. The target population for the survey consists of all commercial buildings in the United States with more than 1,000 square feet of floorspace. Excluded are residential, industrial, and agricultural buildings. The survey, first conducted in 1979, was conducted triennially from 1983 through 1995 (EIA 1994, EIA 1995a, EIA 1995b, EIA 1998, and EIA 2000). The 1999 CBECS (with data collection in 2000) initiated a quadrennial cycle for the survey.

Between 1979 and 1995, total energy consumption remained flat, while total energy intensity declined (Figures 1 and 2). CBECS collected energy consumption data for four energy

¹ Over 3 Btu of input energy is used for every Btu of electricity delivered to customers—the rest is lost in the process of generating and transmitting the electricity. In this paper, primary total energy and primary electricity included the electricity losses, site total energy and site electricity excluded the electricity losses.

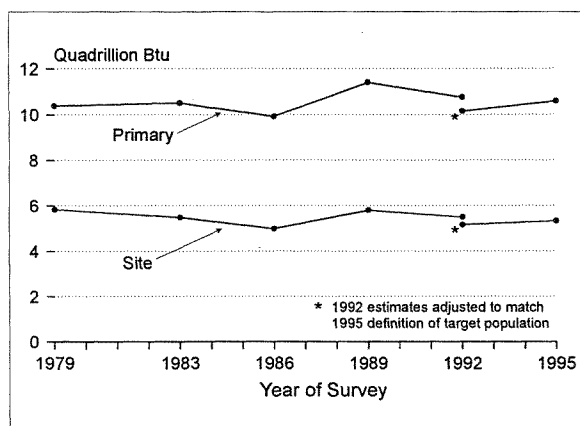


Figure 1. Total Site and Primary Energy Consumption, 1979 to 1995

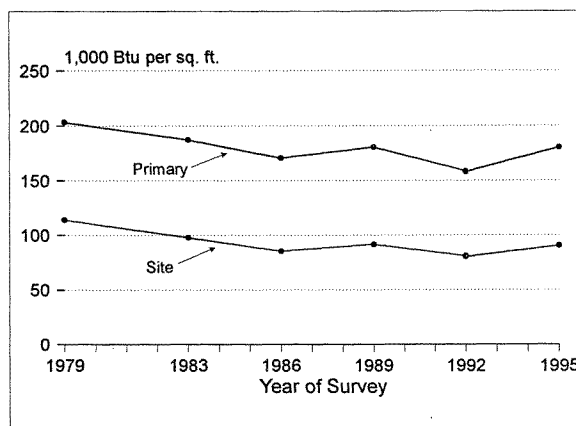


Figure 2. Total Site and Primary Energy Intensity, 1979 to 1995

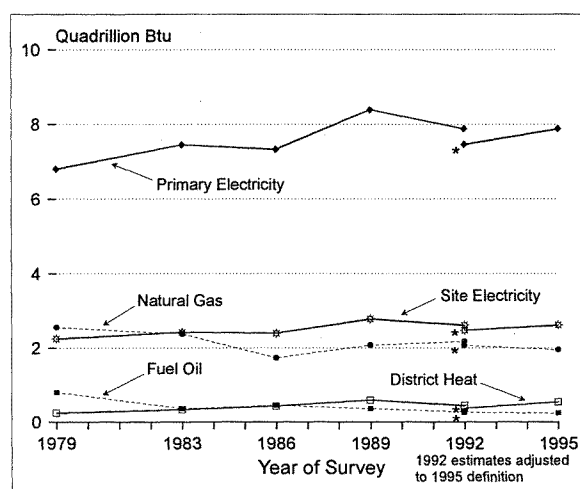


Figure 3. Energy Consumption by Source, 1979 to 1995

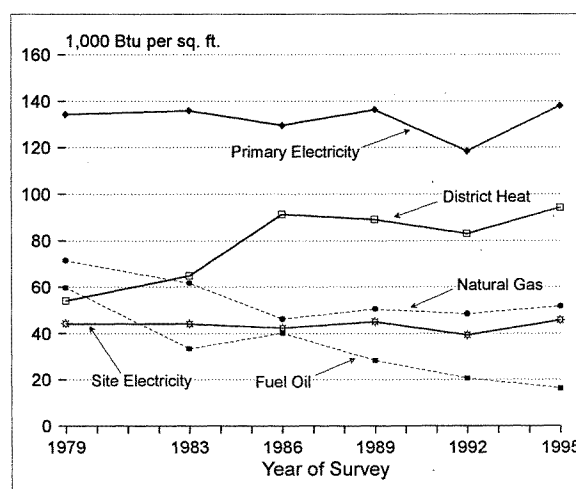


Figure 4. Energy Intensity by Source, 1979 to 1995

sources—electricity, natural gas, fuel oil, and district heat. Two major changes in consumption occurred; fuel oil consumption (and intensity) declined over the period 1979 to 1995 and, by 1995, site electricity consumption exceeded natural gas consumption (Figure 3). Primary electricity intensity greatly exceeded the intensities of other energy sources across the period, with district heat the second highest (Figure 4).

Commercial Buildings Activities

A wide variety of building characteristics data are collected by CBECS, including building activity, location, building size, energy sources used, and end-use equipment. In 1995, CBECS collected information for 20 different building activities; several of these were aggregated and 13 Principal Building Activities were published in the detailed tables (Table 1).

Retail and service buildings and office buildings occupied the most floorspace and consumed the most energy in the commercial buildings sector (Figures 5 and 6). These buildings combined for 40 percent of total floorspace, 41 percent of total primary consumption, and 37

Table 1. Building Activities Published and Collected by the 1995 CBECS

Building Activity—published	Building Activity—collected
Education	Education
Food Sales	Food Sales
Food Service	Food Service
Health Care	Hospital/Inpatient Health Services
	Outpatient Health Services/Clinic
Lodging	Hotel/Motel/Dormitory
	Skilled Nursing/Other Residential Care
Office	Office
Public Assembly	Public Assembly
Public Order and Safety	Public Order and Safety
Religious Worship	Religious Worship
Retail and Service	Enclosed Shopping Center/Mall
	Strip Shopping Center
	Other Retail
	Service, Other than Food Service
Warehouse and Storage	Refrigerated Warehouse or Storage
	Non-refrigerated Warehouse or Storage
Other	Laboratory
	Other Commercial
Vacant	Vacant

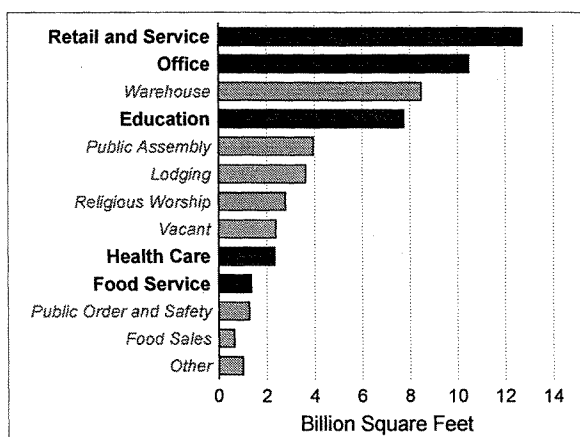


Figure 5. Total Floorspace by Building Activity, 1995

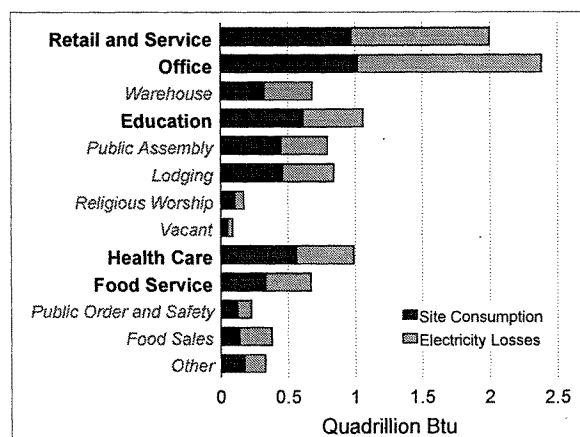


Figure 6. Total Site and Primary Consumption by Building Activity, 1995

percent of total site consumption. Three building types—food sales, food service, and health care—had significantly higher total primary energy intensities than other types (Figure 7).

In the following sections, five of these building activities will be examined in more detail—health care, office, retail and service, education, and food service (they are highlighted in Figures 5, 6, and 7). These activities were selected because of recent energy-related policy ini-

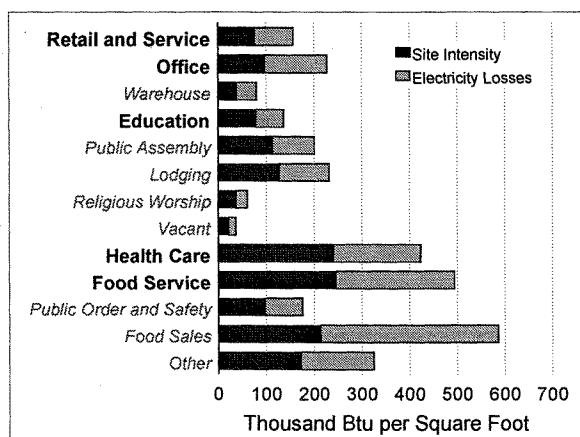


Figure 7. Total Site and Primary Energy Intensity by Building Activity, 1995

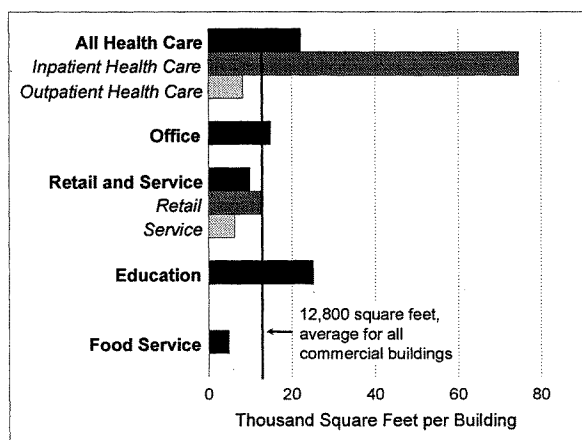


Figure 8. Average Building Size by Building Activity, 1995

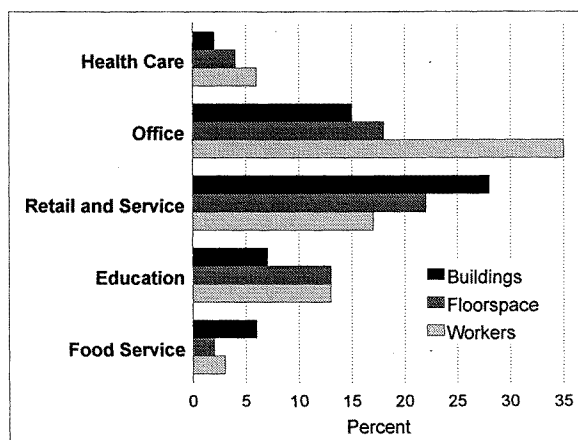


Figure 9. Percent of Buildings, Floorspace, and Workers by Building Activity, 1995

tiatives, public interest, or because they were intensive energy users; in addition, they reflect the diversity of building characteristics and patterns of energy use found in the sector.

Health Care Buildings

Health care buildings include buildings used as diagnostic and treatment facilities for both inpatient and outpatient care. Inpatient health care buildings include structures such as hospitals, psychiatric facilities, and rehabilitation centers; outpatient health care buildings include medical clinics, dental clinics, emergency walk-in centers, and veterinary facilities.

In 1995, there were approximately 105,000 health care buildings in the United States that comprised 2.3 billion feet of floorspace. Health care buildings were larger, on average, than commercial buildings as a whole, with an average of 22,200 square feet (Figure 8).

Inpatient health care buildings comprised 21 percent of all health care buildings, but because they were large buildings, they made up 70 percent of the health care floorspace. Their average size was approximately 75,000 feet. Outpatient health care buildings had an average size of 8,000 square feet (Figure 8). About 4.5 million people were employed in health care

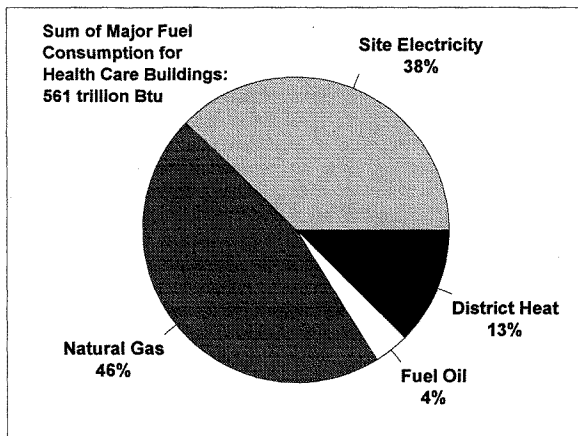


Figure 10. Percent of Site Consumption in Health Care Buildings by Type of Energy Source, 1995

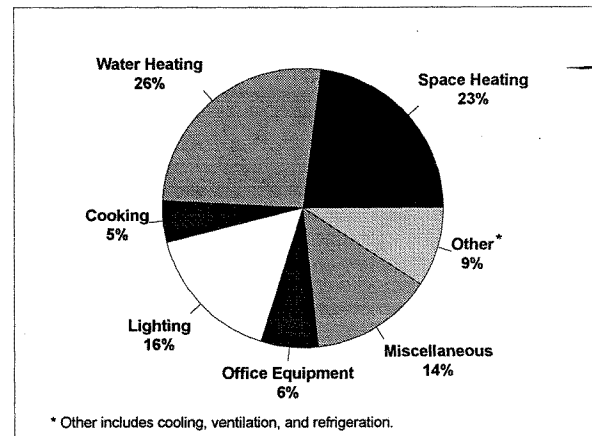


Figure 11. Percent of Site Consumption in Health Care Buildings by End Use, 1995

buildings, about 6 percent of the commercial workforce (Figure 9). Inpatient health care buildings averaged 138 workers (during the main shift), while outpatient health care buildings averaged only 17 workers.

The median age of health care buildings was 23.5 years, significantly newer than the 30.5 year median for all commercial buildings. Health care buildings in the Northeast and Midwest tended to be older, with medians of 39.5 and 42.5 years, respectively.

Inpatient health care buildings were more likely to be part of a multibuilding complex (84 percent were part of a complex) than were outpatient health care buildings (22 percent on complexes). Among those inpatient health care buildings on a complex, 67 percent were on a hospital or other health care complex. Most health care buildings were privately owned; only 18 percent were government-owned.

While health care buildings consumed only 11 percent of the total commercial site energy, they were the second most intensive users of site energy (and third most of primary energy) among building types (Figure 7). They consumed more natural gas than electricity and also consumed a substantial amount of district heat (Figure 10). They used almost half of their

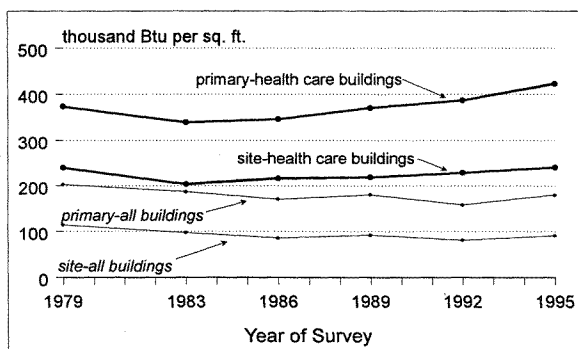


Figure 12. Total Primary and Site Intensity for Health Care Buildings, 1979 to 1995

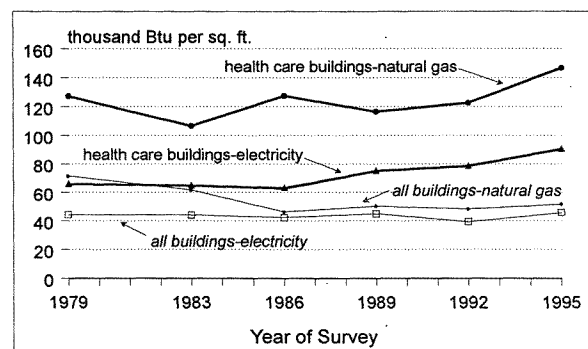


Figure 13. Site Electricity and Natural Gas Intensity for Health Care Buildings, 1979 to 1995

energy on water heating and space heating, with lighting and miscellaneous uses (which includes equipment for diagnoses and treatment) accounting for another third (Figure 11).

Inpatient health care buildings consumed energy more intensively than did outpatient health care buildings—inpatient health care buildings used 102,600 Btu of electricity per square foot, compared with 61,600 Btu of electricity per square foot for outpatient health care. Inpatient natural gas intensity was over twice the intensity for outpatient health care (164,800 Btu per square foot and 68,500 Btu per square foot, respectively).

Inpatient and outpatient health care buildings used energy in different ways. Inpatient health care buildings consumed a higher proportion of energy for water heating, cooking, refrigeration, and miscellaneous uses (presumably equipment) than did outpatient health care buildings. Outpatient health care buildings used a higher proportion for cooling, lighting, and office equipment.

Health care buildings were among the most intensive users of energy in the commercial buildings sector across the period from 1979 to 1995. Total (primary and site), site electricity, and natural gas intensities were each approximately two times greater than the average for all buildings (Figures 12 and 13). The trends in intensities for health care buildings run counter to the declining trends for all commercial buildings. Total and natural gas intensities increased between 1983 and 1995, while electricity intensity increased between 1986 and 1995.

Office Buildings

Office buildings include buildings used for general office space, professional offices, and administrative offices. For example, offices may be computer centers, banks, insurance offices, real estate offices, law offices, medical offices, or administrative buildings.

In 1995, approximately 705,000 office buildings comprised 10.5 billion feet of floorspace. They were the second most prevalent type of commercial building, both in terms of building counts and floorspace (Figure 5). Office buildings were slightly larger than commercial buildings as a whole, at an average of 14,900 square feet per building (Figure 8). Over half of all office buildings were smaller than 5,000 square feet and almost 95 percent were smaller than 25,000 square feet. A little over half of all office buildings had only one floor while only one percent of them had more than ten floors.

About 27 million workers were employed in office buildings in 1995, about 35 percent of the commercial workforce (Figure 9). The average office building employed 38 workers during its main shift. The median age of office buildings in 1995 was 23.5 years; they were somewhat newer than the stock of commercial buildings as a whole, for which the median age was 30.5 years.

Office buildings consumed the most total energy of all the building types, although they were not one of the most intensive users of energy (Figures 6 and 7). Large office buildings consumed energy more intensively than did smaller office buildings (buildings larger than 50,000 square feet consumed 109,000 Btu per square foot compared with 87,000 Btu per square foot for buildings 1,001 to 5,000 square feet and 82,600 Btu per square foot for buildings 5,001 to 50,000 square feet).

Office buildings are typically large users of electrical equipment such as computers, office equipment, and lighting. These pieces of equipment produce heat which increases the use of air conditioning, another predominantly electricity end use. It is not surprising that electricity

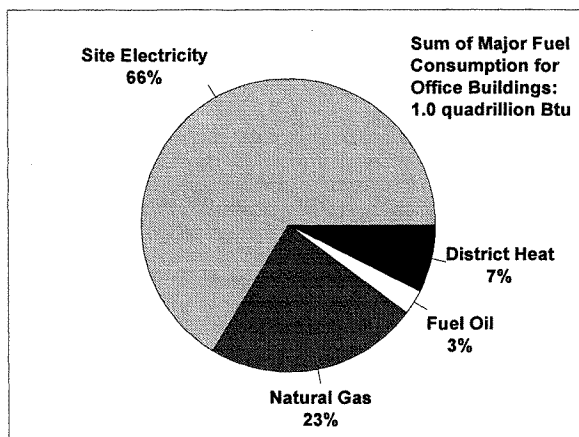


Figure 14. Percent of Site Consumption in Office Buildings by Type of Energy Source, 1995

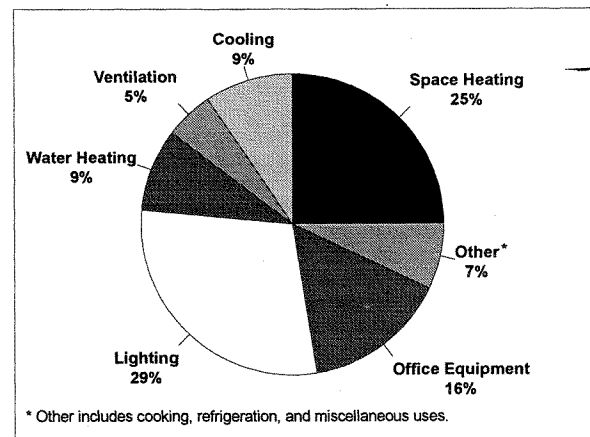


Figure 15. Percent of Site Consumption in Office Buildings by End Use, 1995

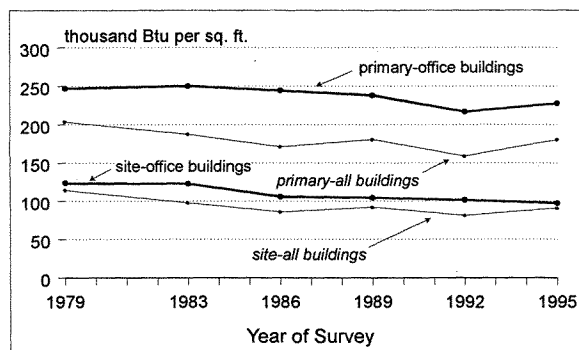


Figure 16. Total Primary and Site Intensity for Office Buildings, 1979 to 1995

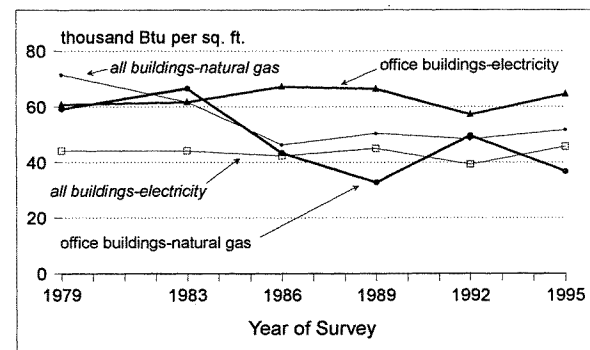


Figure 17. Site Electricity and Natural Gas Intensity for Office Buildings, 1979 to 1995

was the predominant energy source used in office buildings (Figure 14). Energy use was distributed among a number of different uses in office buildings. Lighting accounted for the most consumption, followed by space heating and office equipment (Figure 15).

The large use of electrical equipment is evident in the trend in electricity intensity for office buildings; they were significantly higher in electricity intensity than the average for all commercial buildings (Figure 17). Total energy intensity for office buildings also exceeded the average for all buildings (Figure 16). The natural gas intensity trend for office buildings declined, and roughly tracked the natural gas trend for all commercial buildings (Figure 17).

Retail and Service Buildings

Retail and service buildings are those used for sales and displays of goods and services. They include strip shopping malls, enclosed shopping malls, other retail buildings, and service buildings (other than food service). Retail buildings other than malls can be automobile dealers, department stores, drugstores, and home furnishing stores, for example. Service buildings include buildings such as dry cleaners, car washes, laundromats, service stations, and post offices.

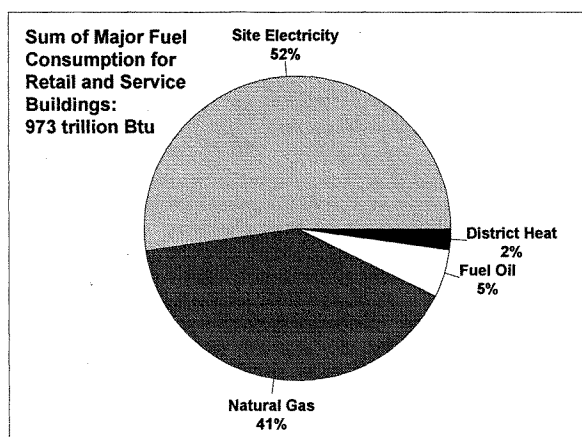


Figure 18. Percent of Site Consumption in Retail and Service Buildings by Type of Energy Source, 1995

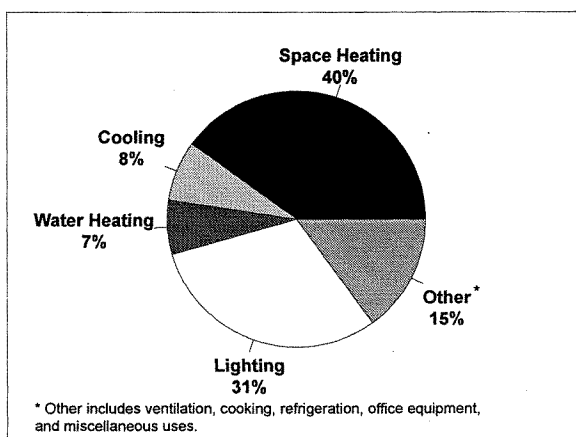


Figure 19. Percent of Site Consumption in Retail and Service Buildings by End Use, 1995

In CBECS publications, these types are all grouped in a single category that contained 1.3 million buildings and 12.7 billion square feet of floorspace. Retail and service buildings were the most prevalent building type and occupied the most floorspace of all building types (Figure 5). They averaged 14,900 square feet per building, slightly larger than the average commercial building (Figure 8).

The retail and service category, disaggregated into its subcategories, included an estimated 130,000 strip malls, 12,000 enclosed malls, 562,000 other types of retail buildings, and 585,000 service buildings. Enclosed malls were the largest type of retail building; although they made up only one percent of buildings in that category, they occupied 14 percent of the floorspace. About 13.5 million workers were employed in retail and service buildings, 17 percent of all commercial workers (Figure 9) with an average of 17 workers per building. The median age of retail and service buildings was 35.5 years. Enclosed malls were newer than this—their median age was 20.5 years.

CBECS is based on the entire *building*, so a CBECS building can contain more than one establishment. Retail and service buildings as a whole averaged 1.8 establishments per building. Retail buildings averaged 2.5 establishments per buildings; 22 percent of retail buildings had between 2 and 5 establishments and 7 percent had between 6 and 10. Strip malls averaged 6.2 establishments. Service buildings averaged just 1.1 establishments per building. Many retail and service buildings (77 percent) were occupied by the owner.

Retail and service buildings consumed the second highest amount of total energy of all building types, but they consumed it less intensively than did commercial buildings as a whole (Figures 6 and 7). Over half of their site energy consumption was electricity and most of the rest was natural gas, with just a small amount of district heat and fuel oil used (Figure 18). Space heating accounted for 40 percent of their energy use and lighting for 31 percent. Cooling and water heating accounted for another 15 percent; no other uses were substantial (Figure 19).

Total and electricity intensities for retail and service buildings were slightly less than the average for all commercial buildings and both trends were flat across the period (Figures 20 and 21). Natural gas intensity was less than the average for all buildings (Figure 21).

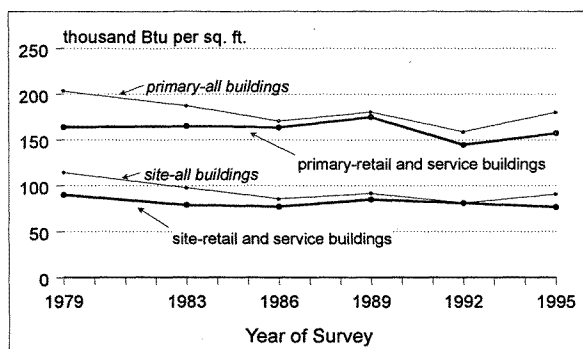


Figure 20. Total Primary and Site Intensity for Retail and Service Buildings, 1979 to 1995

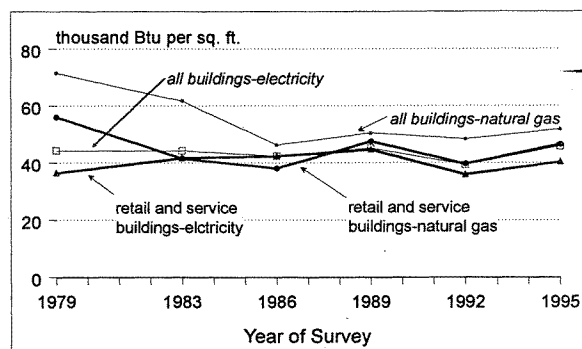


Figure 21. Site Electricity and Natural Gas Intensity for Retail and Service Buildings, 1979 to 1995

Education Buildings

Education buildings are those that are used for academic or technical *classroom* instruction. They include preschools, elementary schools, middle or junior high schools, high schools, vocational schools, and college or university classrooms.

In 1995, the approximately 309,000 education buildings comprised 7.7 billion square feet of floorspace—the fifth most common type of building and the fourth highest amount of floorspace (Figure 5). Education buildings were about twice as large as commercial buildings as a whole, at an average of 25,100 square feet per building (Figure 8).

About 10 million people were employed in all education buildings, 13 percent of all workers in commercial buildings (Figure 9). The average education building employed 33 workers. The median age of education buildings was 33.5 years, slightly older than commercial buildings as a whole.

The 1995 CBECS did not identify the different types of education buildings (for example, it was not asked whether a building was elementary or college education). However, 80 percent of education buildings were part of a multibuilding facility. Of these, 74 percent were on a primary or secondary complex and 8 percent were on a college or university campus. By looking at education buildings within these two categories, we can get an idea of the differences between primary and secondary education buildings and college and university buildings. For ease of discussion, these will be referred to as early education and higher education buildings.

About 183,000 early education buildings and 19,000 higher education buildings were estimated by CBECS. Early education buildings were smaller, an average of 16,400 square feet compared with 52,000 square feet for higher education buildings. Early education buildings averaged 224 seats while higher education buildings averaged 510 seats. Early education buildings averaged 20 workers while higher education buildings averaged 93 workers. Early education schools were open an average of 48 hours per week while higher education buildings were open an average of 93 hours per week. Higher education buildings used energy about twice as intensively as did early education schools.

Education buildings consumed 12 percent of total commercial energy and were not intensive users of energy (Figure 7). They used the different sources more equally than any of the other types discussed here; they were the greatest consumers of district heat and fuel oil (Figure

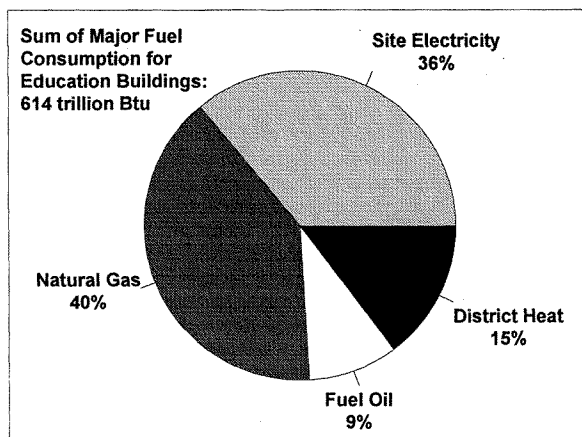


Figure 22. Percent of Site Consumption in Education Buildings by Energy Source, 1995

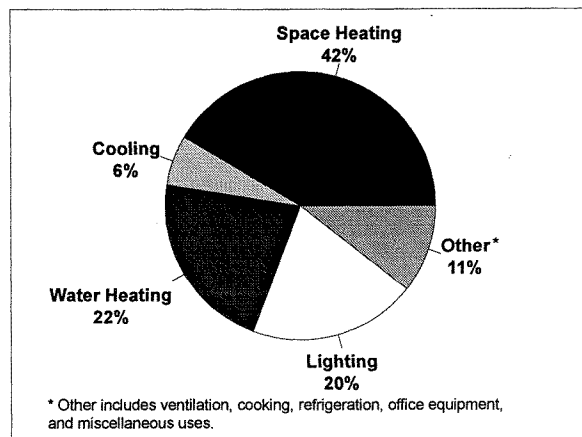


Figure 23. Percent of Site Consumption in Education Buildings by End Use, 1995

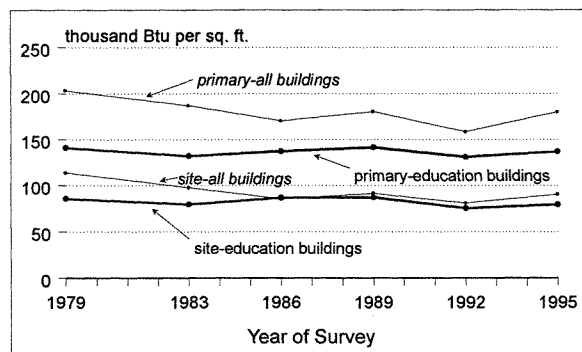


Figure 24. Total Primary and Site Intensity for Education Buildings, 1979 to 1995

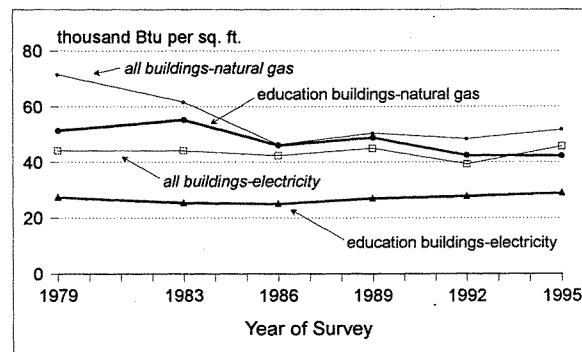


Figure 25. Site Electricity and Natural Gas Intensity for Education Buildings, 1979 to 1995

22). The majority of their consumption was for space heating, with water heating and lighting about equal (Figure 23).

Education buildings consistently showed less intensive electricity use than other commercial buildings (Figure 25). The trend for total energy, electricity, and natural gas intensities showed no significant change across the period (Figures 24 and 25).

Food Service Buildings

Food service buildings are those used for preparation and sale of food and beverages for consumption. These buildings include fast-food establishments, cafeterias, diners, bars, and full-service restaurants. In 1995, the approximately 285,000 food service buildings comprised 1.4 billion square feet of floorspace (Figure 5). They were much smaller than average, at 4,800 square feet per building (Figure 8). Most were only one floor (72 percent); 18 percent occupied two floors.

About 2.3 million workers were employed in food service buildings in 1995, only 3 percent of commercial workers (Figure 9), with an average of 8 workers per building during the

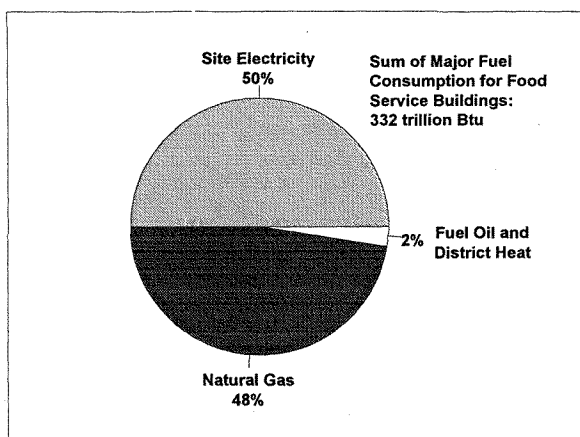


Figure 26. Percent of Site Consumption in Food Service Buildings by Energy Source, 1995

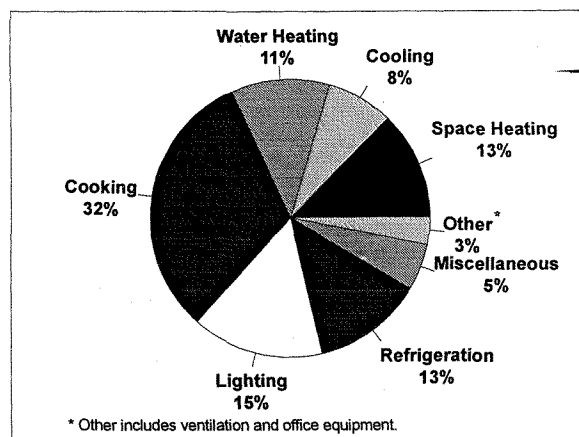


Figure 27. Percent of Site Consumption in Food Service Buildings by End Use, 1995

main shift. The median age of food service buildings was 22.5 years, newer than commercial buildings as a whole.

Eighty-three percent of food service buildings were owner-occupied. The owner-occupied buildings were slightly larger than the nonowner-occupied (an average of 5,000 square feet vs. 3,000 square feet). Food service buildings nearly always had only one establishment per building (92 percent of buildings).

Food service buildings consumed only 6 percent of total commercial energy, but were the most intensive users of site energy of all building types (Figure 7). They consumed predominantly electricity and natural gas, and used these about equally (Figure 26). They used both of these sources three times as intensively as commercial buildings as a whole. Small food service buildings used both of these sources even more intensively (buildings 1,001 to 5,000 square feet used 191,900 Btu of electricity per square foot and 253,300 Btu of natural gas per square foot compared with 75,400 Btu of electricity per square foot and 109,200 Btu of natural gas per square foot for buildings larger than 5,000 square feet).

In food service buildings, about one-third of the energy was consumed for cooking. Lighting, refrigeration, and space heating were used about equally and together accounted for

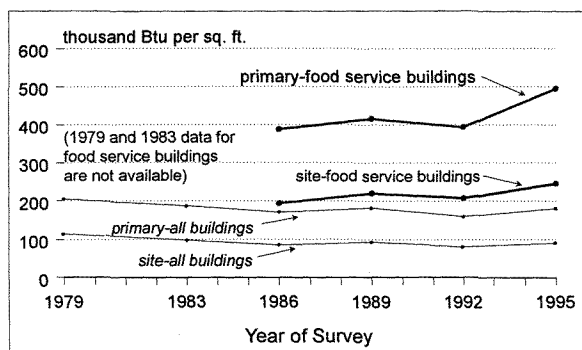


Figure 28. Total Primary and Site Intensity for Food Service Buildings, 1986 to 1995

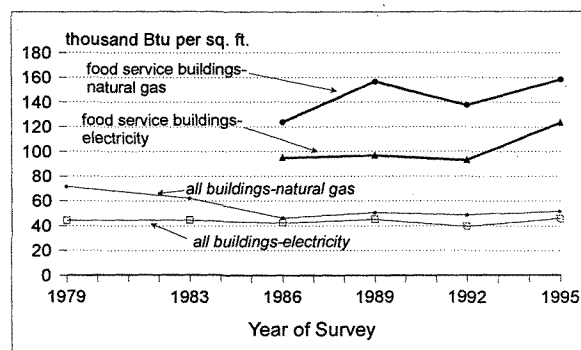


Figure 29. Site Electricity and Natural Gas Intensity for Food Service Buildings, 1986 to 1995

about another third of the energy use (Figure 27). Only food sales buildings had higher total primary energy intensities than food service buildings (Figures 7 and 28). Both electricity and natural gas intensities for food service buildings were much higher than average (Figure 29). Both electricity and natural gas intensities increased across the period 1986 to 1995 (food service and food sales buildings were collected as a single category in 1979 and 1983).

Summary

Total energy consumption stayed about the same while total energy intensity declined across the period from 1979 to 1995. The commercial buildings sector is very diverse, unlike the residential sector which is dominated by a single building type (the single family home). Building characteristics, energy sources used, and energy end uses vary widely between, and within, commercial building types.

Energy intensities increased in health care buildings, the most intensive users of energy in the commercial sector. Inpatient health care buildings were even more intensive users of energy than health care buildings as a whole. Office buildings, large users of electrical equipment, had a significantly higher electricity intensity than all commercial buildings. Retail and service buildings consumed electricity and natural gas almost exclusively; their intensities were lower than commercial buildings as a whole and their trends remained flat. Education buildings had a lower electricity intensity than other commercial buildings, but consumed more fuel oil and district heat energy. Food service buildings consumed about one-third of their energy for cooking and used energy very intensively, a trend that has been increasing.

References

- [EIA] Energy Information Administration. 1994. *Commercial Buildings Characteristics 1992*. DOE/EIA-0246(92). Washington, D.C.: U.S. Department of Energy.
(www.eia.doe.gov/emeu/cbecs/cbecs1a.html)
- [EIA] Energy Information Administration. 1995a. *Commercial Buildings Consumption and Expenditures, 1992*. DOE/EIA-0318(92). Washington, D.C.: U.S. Department of Energy.
(www.eia.doe.gov/emeu/cbecs/cbecs1b.html)
- [EIA] Energy Information Administration. 1995b. *Buildings and Energy in the 1980's*. DOE/EIA-0555(95)/1. Washington, D.C.: U.S. Department of Energy.
(www.eia.doe.gov/emeu/cbecs/cbecs1f.html)
- [EIA] Energy Information Administration. 1998. *A Look at Commercial Buildings in 1995: Characteristics, Energy Consumption, and Energy Expenditures*. DOE/EIA-0625(95). Washington, D.C.: U.S. Department of Energy.
(www.eia.doe.gov/emeu/cbecs/report_1995.html)
- [EIA] Energy Information Administration. 2000. *Trends in the Commercial Buildings Sector*. (Web only: www.eia.doe.gov/emeu/consumptionbriefs/cbecs/cbecs_trends/main_menu.html)